A FISHERIES EVALUATION OF THE WESTSIDE DITCH
AND TOWN CANAL FISH SCREENING FACILITIES
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Annual Report

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PREFACE

The Bonneville Power Administration, the United States Bureau of Reclamation, and the Washington State Department of Ecology are funding the construction of fish passage and protection facilities at irrigation and hydroelectric diversions in the Yakima River Basin, Washington State. This construction implements Sections 904(d) and 803(b) of the Northwest Power Planning Council's 1984 and 1987 Columbia River Basin Fish and Wildlife Programs. The programs provide offsite enhancement to compensate for fish and wildlife losses caused by hydroelectric development throughout the Columbia River Basin, and they address natural propagation of salmon to help mitigate the impact of irrigation withdrawals in the Yakima River Basin.

The Westside Ditch and Town Canal fish screening facilities are two juvenile screening facilities in the Yakima River Basin. This report evaluates the effectiveness of these screens in intercepting and returning juvenile salmonids unharmed to the Yakima River, from which the water was diverted. We conducted studies in which representative fish were released upstream of or within the screening facilities and captured in the bypass that returns them to the river. Results indicated that the screens safely diverted fish from the canals and returned them to the river.

Our study emphasized the collection and evaluation of salmonids. Test fish were steelhead Oncorhynchus mykiss smolts and rainbow trout O. mykiss fry. Evaluations were conducted during typical spring flows at each facility.

ACKNOWLEDGMENTS

The involvement and cooperation of many people during these studies were greatly appreciated. Thomas J. Clune, Bonneville Power Administration, was the Project Manager. Charles R. Keller and Edward J. Spigler, Bureau of Reclamation, and their operations and maintenance staffs provided critical support and assistance during site preparation. James L. Cummins and James E. Lee, Washington Department of Wildlife, helped us procure test fish. Jeanne C. Simpson helped with the statistical analysis. Robert W. Hanf and Dennis D. Dauble helped conduct the field tests. The manuscript was reviewed by Regina E. Lundgren and C. Dale Becker.
ABSTRACT

The Pacific Northwest Laboratory (PNL)(a) evaluated the effectiveness of new fish screening facilities in the Westside Ditch and Town Canal, near Ellensburg, in south-central Washington State. At the Town Canal, we estimated that 0.3% of steelhead Oncorhynchus mykiss smolts released during tests were significantly descaled. The time required for 50% of the fish in the two steelhead test groups to exit from the Town Screens forebay ranged from 12 hr to >85 hr.

Integrity tests at the Town Screens indicated that none of the rainbow trout fry released in front of the rotary drum screens passed through the screens, although 8.5% of the native zero-age chinook salmon fry diverted from the river into the screening facility were lost through the screens. At the Westside Screens, 16.8% of native zero-age chinook salmon fry passed through the screens. Most of the chinook salmon lost through the screens were small, <36 mm long.

The methods used in 1990 were first used at the Sunnyside Screens in 1985. These methods were used again in subsequent years in tests at the Richland, Toppenish/Satus, Wapato, and Toppenish Creek screens. The methods used from 1985 through 1989 have been reviewed by the Washington State Department of Fisheries, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Northwest Power Planning Council, and Yakima Indian Nation.

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INTRODUCTION

The Yakima River Basin has supported significant runs of anadromous salmonids over recorded history. During the late 1800s, 500,000 to 600,000 adult salmon and steelhead *Oncorhynchus spp.* returned to the Yakima River and its tributaries (Bureau of Reclamation 1984). Runs of salmon included chinook salmon *O. tshawytscha* (spring, summer, and fall races), coho salmon *O. kisutch*, sockeye salmon *O. nerka*, and steelhead *O. mykiss*.

Some runs (races) are now extinct, and those remaining are severely depleted. Spawning escapement averaged about 2000 salmonids in the early 1980s (Bureau of Reclamation 1984). There is no sockeye run in the Yakima River Basin today, and only 37 coho salmon passed the Prosser Diversion Dam in 1983 (Hollowed 1984). Recent efforts to manage and enhance salmonid runs in the Yakima River have increased the total spawning escapement to between 5000 and 10,000 adults in the mid-1980s (Fast et al. 1986).

Smaller returns of adult salmonids to the Yakima River Basin result from a combination of many factors. Reduced in-stream flow downstream from irrigation diversion dams has limited spawning and rearing habitat. Ineffective fish passage facilities for adults and juveniles at diversion dams have caused high mortality during migration. Additionally, many Yakima River fish are killed while passing hydroelectric dams on the mainstem Columbia River.

The Pacific Northwest Electric Power Planning and Conservation Act was passed to enable preparation and implementation of a regional Conservation and Electric Power Plan. The Northwest Power Planning Council administers the Plan and is responsible for developing a program to protect and enhance fish and wildlife populations, and to mitigate adverse effects from development, operation, and management of hydroelectric facilities.
The Yakima River Basin was selected as one site to enhance salmon and steelhead runs in the middle Columbia River. Under the Plan, the Bonneville Power Administration (BPA) and the Bureau of Reclamation (BR) are funding the construction of fish passage and protection facilities at irrigation and hydroelectric diversions in the Yakima River Basin (Figure 1). BPA also provides funds to the Yakima Indian Nation (YIN) to enhance natural production of spring chinook salmon in the Yakima River Basin.

The Westside Ditch and Town Canal fish screening facilities (Westside Screens and Town Screens, respectively) are two of the passage and protection facilities in the Yakima River Basin that were recently upgraded by BPA and BR. Construction of these fish diversions was completed in 1989. BPA asked the Pacific Northwest Laboratory (PNL) to evaluate the effectiveness of the screening facilities in returning fish that had entered the canals back to the river unharmed.

This report covers work performed by scientists from PNL at the Westside and Town screens in 1990. It describes each facility, methods used to evaluate the effectiveness of the screens, and test results. The findings are discussed and compared with results from previous tests at the Sunnyside Screens (Neitzel et al. 1985); the Richland and Toppenish/Satus screens (Neitzel et al. 1986); the Richland and Wapato screens (Neitzel et al. 1988); the Toppenish Creek, Wapato, and Sunnyside screens (Neitzel et al. 1990a); and the Wapato and Westside screens (Neitzel et al. 1990b).
Figure 1. Overview of the Yakima River Basin, Including Locations of the Westside Ditch and Town Canal Fish Screening Facilities and Other Fish Protection and Passage Facilities
DESCRIPTION OF THE STUDY AREAS

During 1990, studies were conducted at the Town and Westside screens. The study area for the Town Screens extended from the canal headgates to the area immediately downstream of the screens. The study area for the Westside Screens was limited to the forebay and the area behind the screens. Specific information on test conditions during the evaluations is in the Results and Discussion sections.

TOWN CANAL

The Town Diversion Dam and Canal are located on the left bank of the Yakima River at river km 259.5 [river mile (RM) 161.3], about 11 km (7 mi) northwest of Ellensburg, Washington. Water is diverted from the Yakima River into the Town Canal. The carrying capacity of the canal is about 7 m³/sec (250 cfs). Canal flow varies from 2.8 to 7.0 m³/sec (100 to 250 cfs) and is regulated by four headgates about 75 m upstream of the Town Screens. The screening facility (Figures 2 and 3) diverts fish drawn into the canal and directs them back to the Yakima River. Trash racks, located between the headgates and screen array, "filter" out large debris that could damage the screens or interfere with flow control through the screening facility.

The screening facility (Figure 3) houses ten rotary drum screens with axes parallel to the length of the structure. Each screen is about 3.7 m (12 ft) long and 1.7 m (5.5 ft) in diameter. Screen mesh openings are 3.2 mm (1/8 in.). Water depth in the forebay is maintained at about 1.3 m (4.2 ft). The fish bypass is located in the flow control structure at the downstream end of the screening facility. Water and fish diverted past the front of the screens pass through the fish bypass and out the fish return pipe. Flow through the fish bypass is 0.6 m³/sec (20 cfs).

The drum screens are installed at a 26 degree angle to canal flow. This angle provides a sweeping-velocity-to-approach-velocity ratio equal to or exceeding 2:1 (Easterbrooks 1984). The maximum allowable approach velocity is 0.15 m/sec (0.5 fps). Screen orientation and flow velocity differential help direct fish to the fish return pipe and back to the river.
Figure 2. Specific Location of the Town Canal and the Westside Ditch Fish Screening Facilities

Figure 3. Flow Control Structure and Fish Bypass System in the Town Canal Fish Screening Facility
A detailed description of the Westside Screens is presented in Neitzel et al. (1990b). Briefly, the Westside Ditch is located on the right bank of the Yakima River at river km 267.4 (RM 166.2) near Thorpe, Washington. Water is diverted from the Yakima River into the Westside Ditch (Figure 4). The carrying capacity of the canal is about 2.8 m$^3$/sec (100 cfs). Canal flow varies from 0.6 to 2.8 m$^3$/sec (20 to 100 cfs) and is regulated at headgates located about 0.5 km upstream of the Westside Screens. The screening facility houses four rotary drum screens with axes parallel to the length of the structure. Each screen is about 3.7 m (12 ft) long and 1.8 m (6 ft) in diameter. Water depth in the forebay is maintained at about 1.6 m (5 ft). Flow through the fish bypass is 0.6 m$^3$/sec (20 cfs). A waste water channel along the forebay's wall opposite the drum screens prevents flooding and canal bank erosion.

Figure 4. Flow Control Structure and Fish Bypass System in the Westside Ditch Fish Screening Facility
 METHODS

Two types of tests were conducted at the Westside and Town screens in 1990: descaling (Phase II) tests and screen integrity (Phase IV) tests. In descaling tests, fish were released in the canal upstream of the screening facility and captured as they entered the fish bypass. Some test fish were held for post-test observation. In screen integrity tests, fish were released in front of and/or behind the screens and were captured as they appeared in the fish bypass or in fyke nets mounted behind drum screens.

 TEST FISH

The fish species selected for tests were recommended by fisheries biologists from the Washington State Department of Fisheries, the U.S. Fish and Wildlife Service, and the YIN. Selection was based on the potential impact of an irrigation diversion on specific salmonid populations likely to encounter each screening facility during their rearing and outmigration periods. Therefore, the selection depended on the species, race, and size of salmonids that utilize the Yakima River drainage upstream of each diversion.

Resident rainbow trout *O. mykiss*, steelhead, and spring chinook salmon use the upper reaches of the Yakima River. Steelhead smolts were used for descaling tests at the Town Screens because spring chinook salmon of Yakima River origin were not available. Rainbow trout fry (less than 60 mm) were used in screen integrity tests at the Westside and Town screens.

Steelhead

Juvenile steelhead were obtained from the Yakima Trout Hatchery in Yakima, Washington, operated by the Washington Department of Wildlife. The fish were progeny of native steelhead captured from the Yakima River at the Chandler Adult Fish Trap at Prosser, Washington, operated by the YIN. The fish were transported to PNL in November 1989 and were held through the winter in ambient Columbia River water or well water. Fish were branded and acclimated to temperatures expected at the Town Screens at least 1 week before release. The fish weighed about 17 fish/kg (7.5 fish/lb) when released in our tests.

Rainbow Trout

Rainbow trout fry used in screen integrity tests at the Westside and Town screens came from PNL brood stock spawned in December 1989. Eggs were hatched in vertical flow incubators supplied with 10 degrees C well water. Fry were transferred to troughs and reared at 10 degrees C until testing commenced. Rainbow trout fry used in tests at the Westside Screens were not branded and averaged about 45 mm fork length (FL). Rainbow trout used at the Town Screens ranged from 50 to 60 mm and were branded at least one week before release.

 SAMPLING EQUIPMENT

Fish were captured within the screening facility and/or in the canal behind the screens, based on the objectives of each test. Inclined planes were custom-built for the fish bypass structure at each site. Fyke nets were mounted in stoplog slots behind the rotary drum screens to collect fish at the Westside and Town screens. Temporary fish-holding facilities were installed at each site to acclimate and hold fish.

Inclined Planes

Fish were captured on an inclined plane as they entered the fish bypass. The inclined plane used at the Town Screens was 3.7 m (12.0 ft) long and 0.6 m (2 ft) wide (Figure 5). The front face of the plane was hinged so that the slope of the plane could be changed to control the flow of water entering the fish live box. Solid walls, tapering from 0.9 m (3 ft) at the entrance to 0.41 m (1.3 ft) at the live box, acted as splash guards to reduce fish loss from the plane. The live box [0.38 m (1.3 ft) long by 0.6 m (2 ft) wide, 75-L (20-gal) volume] was attached to the end of the plane. The plane had an aluminum frame covered by a perforated aluminum sheet [0.32-cm-
(1/8-in.-) diameter holes, staggered centers, 40% open]. Dam boards in the upstream stoplog slot of the fish bypass directed flow over the plane surface. The height of the dam boards relative to the water depth determined the volume of water entering the fish bypass.

The inclined plane used at the Westside Screens was 2.1 m (7.0 ft) long and 1.0 m (3.3 ft) wide. A live box [0.38 m (1.3 ft) long by 1.0 m (3.3 ft) wide, 100-L (26-gal) volume] was attached to the end of the inclined plane. The plane is described in greater detail in Neitzel et al. (1990b).

**Figure 5. Inclined Plane Used at the Town Canal Fish Screening Facility, Spring 1990**

**Fyke Nets**

Fyke nets were used behind each of the four drum screens in screen integrity tests at the Westside Screens. The net mouths were 3.7 m (12 ft) wide and 1.8 m (6 ft) deep. The tops of the nets were above the water surface, and the bottoms of the nets settled into the mud on the canal floor. The net mouth tapered to the 0.91-m- (3-ft-) square cod net (the trap end) over a length of 4.6 m (15 ft). The two sides of the net had different lengths so that the net would hang parallel to canal flow without billowing on one side (Figure 6). The cod net was 1.8 m (6 ft) long, resulting in an overall net length of 6.4 m (21 ft). The end of the cod net was tied shut. These four nets and a fifth net of similar design were also used for screen integrity tests at the Town Screens. The nets were fished around the clock during integrity tests except for a 1- to 4-hr interval at the end of each test, when the nets were removed for fish retrieval and net cleaning.
HOLDING FACILITIES

Temporary facilities were installed to hold and handle fish during our tests. A mobile laboratory containing three troughs [3 m (10 ft) long by 0.6 m (1.8 ft) wide by 0.3 m (0.8 ft) deep, and 540-L (140-gal) volume] was used at each site. Two circular tanks [1.22 m (4 ft) in diameter by 0.6 m (2 ft) deep] were also used at the Town Screens to retain fish for 96 hr after capture. All tanks were supplied with canal water. The laboratory was equipped with fluorescent lighting so that descaling of fish captured during both day and night could be evaluated under similar light conditions.

DESCALING EVALUATION SYSTEM

The evaluation system developed by the U.S. Army Corps of Engineers (Basham et al. 1982) was used to quantify the condition of fish at each site. Evaluation criteria included modifications adopted in 1985 (Neitzel et al. 1985). Baseline descaling was determined by randomly sampling groups of test fish before their release. Descaling was evaluated in each of 10 areas of a fish, 5 on each side. When 40% or more scale loss was observed in any two areas on one side of a fish, the fish was classified as descaled (significant scale loss).
TEST PROCEDURE

Descaling at the Town Screens was evaluated by releasing branded groups of steelhead upstream of the screening facility and capturing the fish when they appeared on the inclined plane in the fish return. Tests were performed during the first week in May. Canal flows were maintained at 3.4 to 4.3 m3/sec (120 to 150 cfs) during the tests. Native salmonid populations were monitored during tests at the Town Screens. Integrity tests were conducted at the Town Screens by releasing branded groups of rainbow trout in front of and behind the screens, and at the Westside Screens by releasing rainbow trout behind the screens. Native chinook salmon fry were monitored in integrity tests at both sites. Fish were collected as they appeared on the inclined plane in the fish bypass or in fyke nets mounted behind the screens.

Test Stock Identification

Test fish were cold-branded with liquid nitrogen to identify specific test groups. Steelhead were marked on either the right or the left anterior region. Branding occurred at least one week before release. The brands, approved by the National Marine Fisheries Service (NMFS), were distinguishable from all other brands used to mark fish in the Columbia River Basin. Rainbow trout fry used for integrity tests at the Town Screens were marked in either the right or the left anterior region; however, fry used at the Westside Screens were not marked.

Fish Transport and Release

Test fish were transported to the screen sites in an insulated tank [400-L (125-gal) volume] supplied with oxygen. Transit times from PNL to the Town and Westside screens were 2.5 hr. Loading densities did not exceed 120 g of fish/L. Water temperature changed less than 1 degree C from the acclimation temperature (~8 degrees C) during transit. Test fish were netted from the transporter and placed in holding tanks for acclimation before release at the Town Screens, and fish at the Westside Screens were held in floating pens in the canal behind the screens. No losses resulted from fish transport.

Fish Release Locations

Test fish for evaluating descaling at the Town Screens were released from the south bank of the canal about 30 m upstream of the trash racks. Rainbow trout used in screen integrity tests at the Town Screens were released just upstream of the first screen and next to the structure wall, or just upstream of the sixth screen, depending on where the fyke nets were positioned (Figure 3). Control groups were released uniformly across the mouth of the fyke nets positioned...
on the downstream side of the screens and at the entrance of the fish bypass to test gear efficiency and effect.

Release Controls

For descaling tests at the Town Screens, we examined 150 steelhead smolts to determine baseline condition (condition at time of release) by sampling each group of test fish before release. Fish used for baseline evaluation were not used in a test. An additional 93 smolts released in the fish return were examined to measure descaling caused by the inclined plane. All descaling evaluations were conducted in the mobile laboratory under artificial light.

Fish Capture and Evaluation

Two groups of steelhead (699 fish total) were released in front of the screens. Fish captured during Phase IIa tests at the Town Screens were netted from the live box of the inclined plane and placed in a holding tank before evaluation. Evaluations were made at half-hour intervals at night and hourly during the day. The fish were anesthetized in tricaine methane sulfonate (MS-222), examined to determine the extent of scale loss, and returned to another holding tank. After fish recovered from the anesthetic, they were released into the fish return pipe. About 100 steelhead smolts were held for 96 hr to detect any delayed mortality.

Fish captured in Phase IVb tests were not evaluated for descaling. The purpose of Phase IVb tests was to determine if the screens prevented fish from passing through and entering the canal behind them and to monitor the rate at which fish moved through the fish bypass. At the Town Screens, fish were counted and identified by brand group as they appeared on the inclined plane in the fish return. The brands identified when and where the fish were released within the screening facility. At the Westside Screens, our Phase IVb evaluation was based on the recovery of native chinook salmon fry; therefore, no branded fish were released in front of the screens.

The inclined plane was fished continuously during our tests at the Town and Westside screens. Fish groups for Phase IVb tests were released in front of and behind the screens during the day, usually at mid-morning. Control groups were released at the entrance of the fish bypass during each test to estimate capture efficiency. Fyke nets were fished continuously for about 20 hr after the release of test fish, then removed for a 2- to 4-hr period to retrieve fish and clean the nets. The nets were then repositioned before the next test started.

STATISTICAL ANALYSIS

We estimated the percentage of fish killed or descaled and the length of time for 50% of the test fish to move from their release point to the inclined plane. We estimated capture efficiencies of the inclined plane and the fyke nets used during screen integrity tests from the number of control fish captured. Capture efficiencies were used to estimate the efficiency of the screen in preventing fish from passing from the screen forebay to the canal downstream of the screens.

Descaling and Mortality Estimates
Estimates of the percentage of fish descaled or killed depended on the number of test fish caught. Descaled fish were considered dead for the analyses. The lower and upper confidence intervals (LCI and UCI, respectively) were estimated as

$$\text{LCI} = \frac{B}{B+(n-B+1)F}$$

and

$$\text{UCI} = 1 - \frac{n-B}{n-B[n-(n-B)+1]F}$$

where $B$ equaled the number of dead or descaled fish, $n$ the number of fish caught, and $F$ a ratio of the estimates for the mean sample variance and the individual sample variance. The estimates were calculated from Mainland's Tables (Mainland et al. 1956).

We combined data from replicate tests to obtain a mean estimate. The estimate assumed each fish behaved independently (i.e., fish within a test did not behave more similarly than fish between tests, and there were no interactions among fish within a test). Although some interaction was expected among fish, the analytical methods required this assumption. All tests were conducted in the same manner to reduce nonindependent behavior of fish.

**Screen Efficiency Estimates**

Three tests with four groups of fish were conducted at the Westside Screens. Screen efficiency estimates were computed for each test in addition to an overall estimate. Fyke nets were mounted behind each screen in all tests.

Two quantities were computed to estimate screen efficiency: inclined plane efficiency ($\text{EFF}_{ip}$) and net capture efficiency ($\text{EFF}_{nc}$). Net retention was assumed to be equal to net efficiency at the Westside Screens. Thus, net retention ($\text{EFF}_{nr}$) equaled 1. Given this, the formula for computing screen efficiency ($\text{EFF}_{sc}$) was

$$\text{EFF}_{sc} = 1 - \frac{X_{\text{net}}}{\text{EFF}_{nc}N}$$

where $X_{\text{net}}$ equaled the number of fish released upstream of the screens and caught in the nets, and $N$ was defined as

$$N = \frac{X_{\text{net}}}{\text{EFF}_{nc}} + \frac{X_{\text{ip}}}{\text{EFF}_{ip}}$$

where $X_{\text{ip}}$ equaled the number of fish released upstream of the screens and caught in the inclined plane. $N$ represented the total number of fish released in a test. For some estimates
and the overall estimate, some fish were not accounted for after the efficiencies (EFFip and EFFnc) were considered. To avoid making assumptions about what might have happened to these fish, an effective N was computed that was smaller than the actual number of fish released. It must be noted that N was not an actual accounting of all fish caught in different locations (inclined plane, fyke nets, bypass), but an estimate based on the actual numbers, adjusted by efficiencies for net losses and human error.

The efficiencies per set were defined. The input data for each section were as previously explained, combining across relevant tests. The general forms were

$$\text{EFF}_{ip} = \frac{n_{ip}}{N_{ip}} \quad \text{and} \quad \text{EFF}_{nc} = \frac{n_{nc}}{N_{nc}}$$

where

- \( n_{ip} \) = the number of fish released in the bypass or the entrance to the fish return slot and caught in the inclined plane for the section being estimated
- \( N_{ip} \) = the number released in the bypass
- \( n_{nc} \) = the number released in the net mouth and caught in the net
- \( N_{nc} \) = the number released in the net mouth.

For determining the overall efficiency, it should be noted that individual test efficiencies were not simply averaged; rather, the efficiency was computed by combining all data. Averaging the separate tests would assume equal numbers were released in each test and would weight them as such. By computing the overall estimates from all data lumped as one test, the varying N values were incorporated and differences in test size were compensated.

The confidence intervals were computed using the standard normal approximation method (Mood et al. 1974). For a 95% confidence interval

$$P \left[ \text{EFF}_{sc} - 1.96 \sqrt{\text{var}(\text{EFF}_{sc})} \leq \text{true[EFF}_{sc}] \leq \text{EFF}_{sc} + 1.96 \sqrt{\text{var}(\text{EFF}_{sc})} \right] = 0.95.$$  

Here EFFsc indicated our estimate while true [EFFsc] indicated the true or actual value of the screen efficiency. EFFsc was a binomial proportion, and the form for its variance was EFFsc \((1-\text{EFFsc})/N\). However, because we used efficiencies (EFFip, EFFnc, EFFnr) in the computation of EFFsc with their own inherent errors, these errors must be propagated and incorporated into the variance of EFFsc. If EFFncr was defined to be the combined catch and retain efficiency (EFFnc \times EFFnr), then the variance of EFFsc was

$$\text{var}[\text{EFF}_{sc}] = \left( \frac{\partial \text{EFF}_{sc}}{\partial \text{Eff}_{ncr}} \right)^2 \text{var}[\text{EFF}_{ncr}] + \left( \frac{\partial \text{EFF}_{sc}}{\partial \text{EFF}_{ip}} \right)^2 \text{var}[\text{EFF}_{ip}] + \left( \frac{\partial \text{EFF}_{sc}}{\partial X_{net}} \right)^2 \text{var}[X_{net}]$$

where all variables are as previously defined. This formula is the first term of a Taylor's series.
expansion (Holman 1971). Second-order and higher-order effects were neglected. The assumption was made that EFFip and Xnet were independent of each other, which was reasonable in this case.

The variances of EFFip and EFFnc were computed by assuming them to be binomial proportions and using the appropriate N for the section in the EFF(1-EFF)/N formula as stated previously. The variable Xnet, the number of fish caught in the nets that were released upstream of the screens, was a distributed binomial (N,EFFsc), making its variance equal to N[EFFsc (1-EFFsc)].
RESULTS

Fish that passed through the fish bypass system at the Town Screens were not descaled or killed. Fish were not "flushed" from the screen forebay, but moved out of their own volition. The angled rotary drum screen design prevented test fish from passing to the canal behind the screens at the Town Screens; however, some native chinook salmon fry were able to pass through, over, or around the screens. Chinook salmon fry were caught behind the screens at the Westside Screens despite repairs made to the side seals before we performed our tests. Data are presented as they relate to the objectives of each phase outlined in the work plan. All phases of our work plan were considered when we evaluated the Westside Screens in 1989 (Neitzel et al. 1990b); only Phase IVb tests were repeated at the Westside Screens in 1990.

PHASE I

Phase I tests were designed to evaluate components within the fish diversion system other than the rotary drum screens. The fish bypass system at the Town Screens contained no structures other than the drum screens; therefore, no Phase I tests were conducted there.

PHASE II

Phase II tests evaluated either the entire fish bypass system from the trash racks through the fish return pipe (Phase IIa) or specific components of the fish return system (Phase IIb). We initiated our evaluations with Phase IIa testing at the Town Screens. We released fish upstream of the screening facility and captured them at the entrance to the fish bypass. In addition to obtaining fish descaling and mortality data, we determined how long released fish remained upstream of or within the Town Screens.

Phase IIa

Tests at the Town Screens were performed in early May 1990. We released two groups of branded steelhead upstream of the screen forebay. One group of 350 fish was released in the morning, and the other group of 349 fish was released in the evening. Of the morning release, 214 steelhead (61.1%) were captured on the inclined plane in the fish bypass during the next 96 hr. Of the evening release, 127 steelhead (36.4%) were caught in the following 85 hr. Of 341 steelhead examined for descaling, only one fish (0.3%) was descaled (Table 1). The descaling rate of 1.8% for steelhead was well within the 95% confidence intervals for the condition controls. None of the 93 steelhead held to determine possible delayed mortality died in 96 hr.

<table>
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<tr>
<th>Species</th>
<th>Group</th>
<th>Released</th>
<th>Captured</th>
<th>Descaled</th>
<th>Dead</th>
<th>Percent Captured</th>
<th>Percent Descaled</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steelhead</td>
<td>1</td>
<td>350</td>
<td>214</td>
<td>1</td>
<td>0</td>
<td>61.1</td>
<td>0.5</td>
<td>0 - 3</td>
</tr>
<tr>
<td>Steelhead</td>
<td>2</td>
<td>350</td>
<td>127</td>
<td>0</td>
<td>0</td>
<td>36.3</td>
<td>0.0</td>
<td>0 - 3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>700</td>
<td>341</td>
<td>1</td>
<td>0</td>
<td>48.7</td>
<td>0.3</td>
<td>0 - 2</td>
</tr>
<tr>
<td>Sockeye</td>
<td></td>
<td></td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>0.0</td>
<td>0 - 21</td>
</tr>
<tr>
<td>Rainbow</td>
<td>(Native)</td>
<td></td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>0.0</td>
<td>0 - 17</td>
</tr>
</tbody>
</table>

The downstream movement of steelhead released for descaling evaluations was monitored as the fish appeared on the sampling plane in the fish bypass. The movement rate for steelhead (Figure 7, Table 2) indicated that salmonid smolts were not flushed from the forebay at the Town Screens; rather, they moved through the forebay of their own volition.
Phase IIb

Phase IIb tests evaluated specific components of the fish bypass system. However, the fish return at the Town Screens is a basic bypass system: it does not use intermediate bypass pipes, a separation chamber, a pumpback system, or traveling screens. The bypass pipe is void of sharp bends or changes in elevation. Therefore, no Phase IIb tests were conducted at the Town Screens.

**PHASE III**

Our tests at the Town Screens were performed about one week after startup of the canal in the spring. Irrigation demand usually increases later in the summer, but a canal flow of 3.7 m3/sec (130 cfs) is normal for May. Because of a fixed irrigation demand during our tests, no Phase III tests could be conducted at the Town Screens, nor were they considered necessary.
PHASE IV

The goal of Phase IV tests was to evaluate predation and determine whether screening facilities allow fish to enter the canal behind the screens. Predatory fish populations and the abundance and condition of native salmonids were monitored at the Town Screens as fish were captured on the inclined plane during release and capture tests. The drum screens were also monitored to determine if fish were impinged. Rainbow trout fry were released at the Town Screens to test for passage through, around, or over the screens. Native chinook salmon fry populations were monitored at the Westside Screens.

Phase IVa

Few native juvenile salmonids were captured during tests at the Town Screens; however, chinook salmon fry (32 to 60 mm FL) were common. None of the 21 juvenile rainbow trout/steelhead or 14 hatchery-reared sockeye salmon smolts we caught were descaled. Few of the rainbow trout had developed typical smolt characteristics. One northern squawfish Ptychocheilus oregonensis (22.5 cm) and one yellow perch Perca flavescens were caught on the inclined plane and examined: no fish were found in their stomachs. Other species captured were sculpin Cottus spp., red-sided shiner Richardsonius balteatus, whitefish Prosopium williamsoni, dace Rhinichthys spp., and suckers Catostomas spp. We saw no activity by predacious birds at the Town Screens.

Phase IVb

Phase IVb tests were conducted at both the Westside and the Town screens. At the Westside Screens, the passage of native chinook salmon fry was monitored. At the Town Screens, we monitored the passage of rainbow trout fry that we released as well as native chinook salmon fry.

Westside Screens

No test fish were released in front of the screens in Phase IVb tests at the Westside Screens. The passage of native chinook salmon fry was monitored by comparing the number of fry captured in the fish bypass to the number caught in fyke nets behind the drum screens. We released control groups of rainbow trout fry in the mouth of the fyke nets and in the fish return during each test to evaluate capture efficiency.

Of the 1200 rainbow trout planted in the fyke nets during 3 days of testing, 474 (39.5% ) were recovered from the fyke nets (Table 3). Three hundred rainbow trout were released near the entrance to the inclined plane to measure plane efficiency, and all were captured. The capture efficiency of nets ranged from 24.5% to 57.3% among the three tests, and the capture rate varied from 32% to 58% behind individual screens during the tests. In all, 19 chinook salmon fry were recovered in the fyke nets, compared to 236 fry recovered in the bypass. The 19 fish represent 13.4% of the total number of fish captured, resulting in a passage efficiency of 83.2% for the Westside Screens (Table 4).

Chinook salmon fry captured in the nets behind the drum screens represented the lower end of the size range of fish captured in the fish bypass (Figure 8). The average length of fish caught behind the screens was 36.1 (± 2.2) mm (N = 19 fish), while the average length of fish caught in the bypass was 39.8 (± 5.2) mm (N = 164 fish).

To compare the size of the chinook salmon with the mesh size of the screens, we took head-depth measurements on all salmon fry caught behind the screens and on 52 fry captured in the fish bypass (Figure 9). Head-depths averaged 4.95 mm (range 4.37 to 6.35 mm) for fish caught behind the screens and 5.88 mm (range 4.37 to 9.0 mm) for fish caught in the bypass. About 150 fish captured on the plane were held in a basket (made of the mesh material used to construct the screens) for up to 24 h. Only one fish escaped through the mesh.
### TABLE 3. Capture Data for Rainbow Trout *Oncorhynchus mykiss* and Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught During Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1990

<table>
<thead>
<tr>
<th>Screen</th>
<th>Number of Control Fish Released</th>
<th>Number of Control Fish Captured</th>
<th>Chinook Salmon Captured Fyke Net</th>
<th>Chinook Salmon Captured Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>54</td>
<td>0</td>
<td>71</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>58</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>47</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>70</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>400</strong></td>
<td><strong>229</strong></td>
<td><strong>7</strong></td>
<td><strong>71</strong></td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>24</td>
<td>0</td>
<td>88</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>30</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>30</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>63</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>400</strong></td>
<td><strong>147</strong></td>
<td><strong>8</strong></td>
<td><strong>88</strong></td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>22</td>
<td>2</td>
<td>77</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>16</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>20</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>40</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>400</strong></td>
<td><strong>100</strong></td>
<td><strong>4</strong></td>
<td><strong>77</strong></td>
</tr>
<tr>
<td><strong>Total Screen 1</strong></td>
<td><strong>300</strong></td>
<td><strong>100</strong></td>
<td><strong>2</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Screen 2</strong></td>
<td><strong>300</strong></td>
<td><strong>104</strong></td>
<td><strong>7</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Screen 3</strong></td>
<td><strong>300</strong></td>
<td><strong>97</strong></td>
<td><strong>8</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Screen 4</strong></td>
<td><strong>300</strong></td>
<td><strong>173</strong></td>
<td><strong>2</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1200</strong></td>
<td><strong>474</strong></td>
<td><strong>19</strong></td>
<td><strong>236</strong></td>
</tr>
</tbody>
</table>

### TABLE 4. Capture Efficiency of the Inclined Plane and Fyke Nets Used During Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1990

<table>
<thead>
<tr>
<th>Test</th>
<th>Capture Probability Estimate</th>
<th>Screen Efficiency</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inclined Plane</td>
<td>Fyke Net</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.000</td>
<td>0.573</td>
<td>0.853</td>
</tr>
<tr>
<td>2</td>
<td>1.000</td>
<td>0.368</td>
<td>0.802</td>
</tr>
<tr>
<td>3</td>
<td>1.000</td>
<td>0.245</td>
<td>0.825</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.000</strong></td>
<td><strong>0.395</strong></td>
<td><strong>0.832</strong></td>
</tr>
</tbody>
</table>
Figure 8. Length Measurements (FL) for Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught in Fyke Nets and in the Fish Bypass During Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1990

Figure 9. Head-Depth Measurements (mm) of Chinook Salmon *Oncorhynchus tshawytscha* Fry Captured During Integrity Tests at the Westside Ditch Fish Screening Facility, Spring 1990

**Town Screens**

A total of 4024 rainbow trout fry (55 mm FL) were released in front of the screens, and 2000 fry were released in the fyke nets behind the screens to evaluate screen effectiveness in preventing fish from entering the canal (screen integrity). Of the 4024 fish released in front of the screens, we recovered 1209 fish (30.0%) in the fish return and none (0.0%) in the fyke nets (Table 5). Of the 2000 branded rainbow trout fry released behind the drum screens, we recovered 1017 fish (50.9%) in the fyke nets.
We did not recover about 70% of the rainbow trout fry released in front of the screens. The fry were not flushed from the forebay of the Town Screens. Most of the fry held in the forebay; however, the steelhead we released for descaling tests may have eaten some of the trout fry. The recovery rate on the inclined plane decreased markedly for fish groups released near screen 1 compared to fish groups released near screen 6. In the days following releases near screen 1, we observed many of the fry holding in an eddy at the base of the access ramp along the south wall of the canal just upstream of the trash racks. Fish from each of the four test groups were still being caught in the fish bypass when our tests terminated, although catches of each group decreased daily. Movement was slow during the day and increased at sunset (Figure 10).

In addition to our control fish, we caught a total of 15 chinook salmon fry in fyke nets behind the screens in 4 days, compared to 311 fry caught in the fish bypass (Table 6). The capture rate for chinook salmon fry in fyke nets varied. In replicate tests of screens 6 through 10, no fry were captured in the fyke nets during the first test, and four fry were captured in the second test. In replicate tests of screens 1 through 5, 10 fry were caught in the first test and only one in the second test. Most of the chinook salmon fry moved through the fish bypass at night.

Based on the number of fish caught on the inclined plane and our estimates of sampling efficiency (Table 7), none of the rainbow trout released in front of the drum screens passed over, around, or through the drum screens. The 15 fall chinook salmon fry captured in the fyke nets represented 4.6% of the total number of fry captured during our tests. Based on our capture efficiencies with rainbow trout fry, we estimate that 8.5% (±5.5) of the chinook salmon fry entering the Town Canal passed over, around, or through the drum screens.

### Table 5: Capture Data for Rainbow Trout *Oncorhynchus mykiss* Fry Released During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

<table>
<thead>
<tr>
<th>Test Group</th>
<th>Screen Number</th>
<th>Number of Control Fish Released</th>
<th>Captured</th>
<th>Number of Test Fish Released</th>
<th>Captured In Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6-10</td>
<td>500</td>
<td>13</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>6-10</td>
<td>500</td>
<td>352</td>
<td>100</td>
<td>479</td>
</tr>
<tr>
<td>3</td>
<td>1-5</td>
<td>500</td>
<td>373</td>
<td>100</td>
<td>190</td>
</tr>
<tr>
<td>4</td>
<td>1-5</td>
<td>500</td>
<td>279</td>
<td>100</td>
<td>66</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2000</td>
<td>1017</td>
<td>300</td>
<td>1295</td>
</tr>
</tbody>
</table>

### Table 6: Capture Data for Chinook Salmon *Oncorhynchus tshawytscha* Fry Caught During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

<table>
<thead>
<tr>
<th>Test</th>
<th>Screens Tested</th>
<th>Captured In</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fyke Nets</td>
</tr>
<tr>
<td>1</td>
<td>6-10</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>6-10</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>1-5</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>1-5</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Four-Test Total</td>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>
Chinook salmon fry recovered from the fyke nets were small when compared to fry caught in the fish bypass (Figure 11), averaging 35.7 mm (range of 32 to 37 mm), while fish captured in the bypass averaged 42.1 mm (range of 33 to 58 mm). Comparison of the head-depths of chinook salmon fry caught during the first two tests at the Town Screens to those of fry caught in the fish bypass at the Town Screens, or to fry caught in nets at the Westside Screens, showed that only the smaller fish with the smallest heads passed through, over, or around the screens (Figure 12).

<table>
<thead>
<tr>
<th>Test</th>
<th>Screens</th>
<th>Capture Probability Estimate</th>
<th>Screen Efficiency</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6-10</td>
<td>1.000</td>
<td>0.026</td>
<td>1.000</td>
</tr>
<tr>
<td>2</td>
<td>6-10</td>
<td>0.950(a)</td>
<td>0.704</td>
<td>0.949</td>
</tr>
<tr>
<td>3</td>
<td>1-5</td>
<td>0.950</td>
<td>0.746</td>
<td>0.844</td>
</tr>
<tr>
<td>4</td>
<td>1-5</td>
<td>1.000</td>
<td>0.558</td>
<td>0.947</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>0.983</td>
<td>0.509</td>
<td>0.915</td>
</tr>
</tbody>
</table>

(a) No plane control fish were released in Test 2; we assumed a 95% capture efficiency.

Figure 10. Movement of Rainbow Trout *Oncorhynchus mykiss* Fry Based on the Capture of Test Fish in the Bypass During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990
Figure 11. Size Distribution of Chinook Salmon *Oncorhynchus tshawytscha* Fry Captured During Integrity Tests at the Town Canal Fish Screening Facility, Spring 1990

Figure 12. The Relationship Between Head-depth and Fork Length for Chinook Salmon *Oncorhynchus tshawytscha* Fry Captured During Integrity Tests at the Westside Ditch and Town Canal Fish Screening Facilities, Spring 1990
DISCUSSION

Fish screening facilities in the Yakima Basin were designed to direct fish diverted from the river into irrigation canals back to the river without killing or injuring them or delaying their migration. The work plan for this study was designed to determine if the diverted fish can be safely and expeditiously returned to the river. Tests following the work plan were conducted to determine 1) the conditions or circumstances that affect fish survival as fish pass through the screening facility; 2) if a screening facility provides conditions under which diverted fish may become more susceptible to predation; 3) whether fish are delayed at or upstream of the screening facilities; and 4) if fish pass through, around, or over rotary drum screens and become trapped in the irrigation canal.

FISH SURVIVAL AT SCREENING FACILITIES

Based on release and capture tests at seven screening facilities, fish are not descaled or killed during passage in front of the rotary drum screens or through the fish bypass systems. As in previous descaling evaluations at the Sunnyside, Richland, Toppenish/Satus, Toppenish Creek, Wapato, and Westside screens, the descaling rate for test fish at the Town Screens is within the confidence limits for control fish.

POTENTIAL FOR PREDATION AT SCREENING FACILITIES

On the basis of the samples we have collected, loss to predation does not appear to be a problem at screening facilities when only native species are involved. However, hatchery-released salmonids that take up temporary residence in a screen forebay may increase predation pressure at screen sites. Screening facilities could affect the predator/prey relationship if the screens concentrate predators or prey, or increase the exposure of prey to predators because of stress, injury, or delay in migration.

Westside Screens

No predation was observed at the Westside Screens. Few fish other than zero-age chinook salmon were captured. The Westside Screens had been in operation for only about a week before our tests, and the few smolt-size salmonids we caught during 3 days of monitoring indicate that actively migrating smolts do not take up temporary residence in the screen forebay, or they had already migrated from the reach of the Yakima River upstream of the Westside Screens.

Town Screens

No predation was observed at the Town Screens. Few salmonid smolts were caught during 4 days of continuous sampling, indicating that actively migrating salmonid smolts do not congregate in the screen forebay. However, about 50% of the steelhead we released for descaling evaluations were not captured in the fish bypass. We observed that smolt-sized salmonids, presumably our test fish, held and actively fed in a large eddy along the north wall of the canal between the headgates and the trash rack.

During our tests, most of the water was entering the canal through the two motor-operated headgates next to the south wall. The manually operated headgates closer to the north wall were closed. The operating criteria for the Town Canal call for equal flow through all headgates to avoid creating the eddy.

POTENTIAL FOR FISH DELAY AT SCREENING FACILITIES

One of the basic objectives of redesigning and constructing new screening facilities is to provide a fish bypass that is easily found by fish and is safe for fish passage (Easterbrooks 1984). Although fish are not "flushed" from the screen forebay back to the river, the screening facilities do not impede voluntary movement and migration under normal operating conditions. Conversely, inadequate bypass flows resulting from improper
operation, inoperable components in the bypass system, low canal flows or forebay elevations, or blockages in
the fish return pipe can impair the movement of fish through the fish bypass system and contribute to delays in
migration.

Flow through the fish return pipe at the Westside Screens appeared to be normal the week before we initiated
our tests, although the water level in the fish bypass was somewhat high in conjunction with high river levels,
an expected condition described in the operating criteria. Before the 1989 tests we conducted (Neitzel et al.
1990b), the head of the fish return pipe was plugged with debris that either washed into the fish return slot
when the canal was filled or was not removed before startup. The restricted bypass flow could have caused a
migration delay. We observed several small emaciated chinook salmon fry in the fish bypass before the
blockage was removed. No chinook fry were observed in the fish bypass this year, and fewer chinook salmon
fry were caught during our tests this year than in 1989. The smaller catch rate may be related to natural
variability in the population or emergence timing, but may also reflect improved efficiency when the fish bypass
is unobstructed.

Bypass flow was inadequate at the Town Screens before our tests started because the surface elevation of the
water in the screen forebay was low. The concrete sills of the check structure downstream of the screens were
too short to build an adequate head level during low canal flows. We raised the forebay elevation by partially
closing the flow control gates at the check station and increasing canal flow slightly at the headgates before we
started our tests. Hydrologists from the NMFS visited the site during our tests and are aware of the problem.

FISH PASSAGE THROUGH OR OVER ROTARY DRUM SCREENS

The sweeping-velocity-to-approach-velocity ratio designed into the facilities helps guide fish into the fish
bypass, and screen mesh openings (3.2 mm, 1/8 in.) were small enough to prevent most salmonid fry from
passing through the drum screens. Tests were completed at the Westside and Town screens to determine if
any fish might be impinged by or pass over, around, or through the drum screens.

Although fewer fish were caught in fyke nets behind the drum screens at the Westside Screens than during our
1989 tests, the proportion of fish that passed through, over, or around the drum screens remains high when
compared to the number of fry caught in the fish bypass. Modifications to the end seals of the drum screens did
not dramatically decrease fish loss through the drum screens. Chinook salmon fry were caught behind all four
of the drum screens. Screens 1 and 4 were more efficient at preventing fish passage this year, whereas only
screen 1 prevented passage in 1989. No rollover was observed; therefore, fish caught in the nets presumably
passed around or through the drum screens.

The screen integrity tests at the Westside and Town screens showed that the few chinook salmon fry captured
behind the screens were small in size compared to the general population of chinook salmon fry captured in the
fish bypasses. Additionally, the head-depth of fish caught behind the screens appeared to be smaller in relation
to their fork length compared to fry caught in the bypasses, although measurement data for fish behind the
screens were limited.

The 3.2-mm (1/8-in.) screen mesh used in the construction of the drum screens at the Town and Westside
screens and most other screening facilities is believed to be small enough to prevent salmonid fry from passing
through the mesh. Fisher (1978) concluded that chinook salmon fry 32 to 40 mm in length could not pass
through a 4.0-mm (5/32-in.) screen opening; however, his tests were conducted with perforated plate, rather
than with the coarse woven wire mesh used to construct drum screens in the Yakima Basin. The diagonal
measurement (hypotenuse) of a square mesh with 3.2-mm (1/8-in.) sides is 4.5 mm. Many of the smaller
chinook salmon fry had head-depth measurements less than or equal to 4.5 mm. Additionally, the tissues in the
heads of salmonids are flexible, so some salmonids could conceivably pass through the mesh. Although only
one salmon fry (32 mm FL, head-depth of 4.4 mm) passed through a basket constructed from the 1/8-in. screen
mesh in static water conditions, we conclude that if spawning occurs near a screen site, some emergent
chinook salmon fry, as well as fry of other species, can pass through drum screens constructed from 3.2-mm
mesh.
SUMMARY

Release and capture tests and other monitoring studies have been conducted at seven diversion screen facilities in the Yakima Basin: the Sunnyside Screens (Neitzel et al. 1985), the Richland and Toppenish/Satus screens (Neitzel et al. 1986), the Wapato Screens (Neitzel et al. 1988), the Toppenish Creek Screens (Neitzel et al. 1990a), the Westside Screens (Neitzel et al. 1990b), and the Town Screens. The objective of our evaluations was to determine whether fish that have entered an irrigation canal are safely diverted back to the river. The objective was met by determining if 1) fish that pass through the diversion were killed, injured, or eaten by predators; 2) fish migration was delayed at the screen structure; and 3) fish were prevented from passing through or over the screens. These questions are addressed in the various phases of the work plan.

PHASE I

Phase I tests conducted at the Sunnyside Screens in 1985 used chinook salmon and steelhead smolts. The test data indicated that fish safely pass through all components of the fish bypass system. No Phase I tests have been conducted at the Richland, Toppenish/Satus, Toppenish Creek, Westside, or Town screens, because the fish bypass systems did not incorporate intermediate and terminal bypasses, traveling screens, or fish water pumpback systems in their designs. No Phase I tests were conducted at the Wapato Screens, because none of the components of the facility differed significantly from components at the Sunnyside Screens, which were proven safe for fish passage.

PHASE II

Phase IIa tests evaluate either the entire fish bypass system from the trash racks through the fish return pipe (Phase IIa) or specific components of the fish return system (Phase IIb). Phase IIa tests have been completed at all seven screening facilities. At the Sunnyside Screens, fish were released at either the trash racks or the headgates. Fish captured after moving through the screen forebay and diversion system were not injured or killed. At the Richland, Toppenish/Satus, Wapato, and Toppenish Creek screens, fish were released only at the trash racks. Fish were released midway between the trash racks and the headgates at the Town Screens and in the canal upstream of the screens at the Westside Screens. The condition of test fish did not differ from the controls. Tests at the Sunnyside, Wapato, Richland, and Westside screens were conducted with chinook salmon and steelhead smolts. Tests at the Toppenish/Satus, Toppenish Creek, and Town screens were conducted with steelhead smolts only.

Phase IIb tests have been conducted at the Sunnyside, Richland, Toppenish Creek, and Wapato screens. At Sunnyside, tests were conducted to evaluate the intermediate bypass system, the terminal bypass system, the secondary separation chamber, and the primary fish return pipe. At the Richland, Toppenish Creek, and Wapato screens, the fish return pipe was evaluated. Fish successfully passed through each of the components without significant injury or delay.

PHASE III

Phase III tests have been conducted at the Richland, Toppenish Creek, and Wapato screens. Pipe tests were conducted under two bypass flows at the Richland Screens. Fish were not injured or killed at either bypass flow. Evaluations at the Toppenish Creek and Wapato screens were conducted during low and full canal flow conditions. Fish were not injured or killed in either test; however, movement rate was slower during low canal flow. Opportunities to conduct tests under different canal flows were limited because of delays in construction and startup at the Sunnyside, Richland, and Toppenish/Satus screens. The Sunnyside, Toppenish/Satus, and Westside screens were evaluated only at full canal flow conditions and the Richland Screens only at minimum flow conditions. The Town Screens were evaluated under flow conditions occurring during normal irrigation demand in early May.
PHASE IV

We collected native fish during all bypass tests and examined the gut contents of predacious fish. Increased predation does not occur at screening facilities, except where hatchery-released salmonid smolts sometimes congregate in the screen forebay and prey on salmonid fry. Activity by predacious birds has been monitored at each screening facility. Predatory birds do not congregate at most of the facilities; however, at the Richland Screens, sea gulls preyed on fish released during the day as they exited the fish return pipe.

We examined drum screens during our tests to determine if any fish were impinged on or passed over the screens. Successful screen integrity tests were completed at the Richland, Toppenish Creek, Sunnyside, Wapato, Westside, and Town screens. The Richland Screens are effective at preventing fish from entering the irrigation canal; however, some fish passed over or through the screens or through faulty screen seals at the Toppenish Creek, Sunnyside, Wapato, Westside, and Town screens. Screen integrity tests initiated at the Toppenish/Satus Screens were unsuccessful because we did not have nets to capture fish downstream of the drum screens.

RECOMMENDATIONS

Fisheries evaluations have been conducted at seven diversion screen facilities: the Sunnyside, Richland, Toppenish/Satus, Wapato, Toppenish Creek, Westside, and Town screens. Data were collected to address five areas of concern: fish survival, predation, migration delays, screen passage, and effects of operating conditions. The results of tests addressing each concern were integrated to evaluate the effectiveness of the screens.

The data indicate that fish were not descaled or killed as they were diverted by the screening facilities. Descaling tests should be given a low priority in future evaluations unless there are changes in facility design or site-specific concerns.

Canal operating level did not appear to affect the injury rate for fish. Operating criteria should be evaluated to ensure that maximum bypass efficiency is achieved through the operating range at each screening facility. The periods when canal operating conditions were of greatest concern at each screening facility were during 1) canal startup and 2) peak migration of native salmonid stocks.

Increased predation did not appear to occur at screening facilities except when hatchery-released salmonids were present in the screen forebay and preyed on smaller salmonids. The potential impact of predation on fish diverted through screening facilities can be assessed only if the predation rate for fish passing through a screening facility is compared to predation rates in the river.

Fish were not "flushed" from the screen forebays; however, fish successfully passed through the fish bypass of their own volition. The potential impact of migration delay at screening facilities can be assessed only when migration timing through the facilities is compared to migration timing in the river.

Tests to evaluate screen integrity should retain high priority. The screen integrity tests we completed at the Toppenish Creek, Sunnyside, Wapato, Westside, and Town screens indicate that screen seals play a vital role in preventing fish from entering the irrigation canal. Annual inspection and replacement of screen seals might reduce losses, and a new seal design may be necessary if the present loss rate is not acceptable.

Concerns over screen mesh size and early-season operations must be addressed at screening facilities downstream of major spawning areas in the Yakima River Basin to minimize loss of emergent salmonids. The 3.2-mm (1/8-in.) screen mesh may be too coarse to provide protection to smaller salmonid fry. As fish runs are introduced and enhanced in the tributaries and mainstem of the Yakima River, the protection of emergent salmonid fry will likely become a more widespread concern.

Optimal flow for fish passage through bypass systems is contingent on proper maintenance of flow through headgates, flow control gates, fish return pipes, and other bypass structures. Operating criteria were
established to maximize bypass efficiency and to protect fish that move through the system. It is imperative that the operating criteria are met at each facility, especially when major fish movements are occurring at the diversions. Operating criteria should cover all operating conditions for each facility. Facility structures (such as water elevation markers) must be installed at all facilities so that site maintenance personnel can make the adjustments specified in the operating criteria to provide optimal fish passage conditions.

The fish bypass system at each screening facility should be thoroughly checked and calibrated at the beginning of each irrigation season. Operating criteria should stress that flow through the fish bypass is very important in achieving effective fish return to the river.

REFERENCES


Fisher, D. W. 1978. Protection of King Salmon and American Shad with Perforated Plate and Wire Mesh Screens. 78-18, California Fish and Game, Sacramento, California.


