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EVALUATION OF JUVENILE SALMONID OUTMIGRATION AND SURVIVAL IN THE LOWER UMATILLA RIVER BASIN

(1 OCTOBER 1996 - 30 SEPTEMBER 1997)

Annual Report 1997

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EVALUATION OF JUVENILE SALMONID OUTMIGRATION AND SURVIVAL IN THE LOWER UMATILLA RIVER BASIN

ANNUAL REPORT 1997

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EXECUTIVE SUMMARY

This is the third annual report of a multi-year project that monitors the outmigration and survival of hatchery and naturally-produced juvenile salmonids in the lower Umatilla River. This project supplements and complements ongoing or completed fisheries projects in the Umatilla River basin. Knowledge gained on outmigration and survival assists researchers and managers in adapting hatchery practices, flow enhancement strategies, canal and fish ladder operations, and supplementation and enhancement efforts for natural and restored fish populations.

Objectives for FY 1997

1. Conduct tests to determine trap collection and retention efficiencies for use in estimating fish abundance.

2. Determine migration performance and pattern, migrant abundance, health, smolt status, and survival of hatchery and natural juvenile salmonids in the lower Umatilla River.

3. Identify environmental and biological variables that affect fish migration, survival, and health.

4. Determine the cumulative effects of trap and haul procedures on fish health and survival.

5. Assess smolt passage at the east-bank fish ladder at Three Mile Falls Dam.

6. Evaluate the technical feasibility of using photonic tags and remote photonic detectors to determine migrational characteristics of juvenile salmonids.

Accomplishments and Findings in FY 1997

We achieved most of all six objectives in FY 1997; some tasks of Objectives 5 and 6 were not completed. We were not able to test the remote detection system for detecting photonic marks (Objective 6) and video tapes of juvenile salmonids passing the viewing window at Three Mile Falls Dam were not reviewed (Objective 5). We sampled at one in-river location at river mile (RM) 1.2 with a rotary-screw trap from October 1996 until the end of June 1997. We sampled at Westland Canal in July during juvenile transport operations. We did not monitor the outmigration in August or September.

Retention efficiency of the rotray trap was highest for yearling coho salmon and subyearling fall chinook salmon (> 90%) and lowest for summer steelhead (none retained). Over 75% of the yearling chinook salmon were retained. Survival during 24-h holding tests prior to trap efficiency releases was > 97% for all yearling fish, but decreased to as low as 22% for subyearling fall chinook salmon. Ambient air and water temperatures rose during mid-June, creating poor holding conditions for fish.

Trap efficiencies were measured daily with hatchery fish at the rotary-screw trap and were low for all species. Estimates between days not significantly different were pooled resulting in one or more trap efficiency estimates per species for the season. The single pooled estimate for yearling spring chinook salmon was 1.7%; coho salmon estimates were 14.4%, 1.1%, and 2.8%. Six estimates for subyearling fall chinook salmon ranged from 2.1-6.6%. No summer steelhead were recaptured in the one test conducted.

Deflectors installed on the rotary trap during low flow in late May increased the percentage of flow sampled from 2.5% to 7.8%. Trap efficiencies for coho salmon and subyearling fall chinook salmon increased as a result.

We collected 44,749 hatchery fish at the RM 1.2 site, representing from 0.1% to 1.3% of the production groups released. Of 287 natural fish captured, most were summer steelhead. Natural fish were first captured in December (spring chinook and coho salmon), January (summer steelhead), and May (subyearling fall chinook salmon). We collected only 10 fry (< 50 mm). We collected 87 scale samples from natural fish which indicated that 76% of the natural summer steelhead migrants were age 2+.

We sampled 2,071 fish at Westland Canal and estimated that 50,829 and 466 hatchery and natural subyearling fall chinook salmon and 81 natural summer steelhead were transported to the river mouth during July. Natural subyearlings collected at Westland Canal peaked in samples on 21 July and resident fish dominated the sample composition by late July.

Only 0.05% (summer steelhead) to 0.9% (yearling spring and fall chinook salmon) photonically-marked fish were captured at the rotary trap. No natural chinook or summer steelhead marked by CTUIR were collected. Proportion of marked to unmarked fish was significantly lower at the trap site than at the release site for coho and subyearling fall chinook salmon. Two color groups of summer steelhead were not detected at the trap. From release to recapture, mark quality deteriorated for blue and dark orange marks on subyearling fall chinook salmon.

Percent recapture of subyearling fall chinook salmon released that were adipose and right-ventral clipped was significantly less than right-ventral clipped fish. Percent recapture of adipose-clipped coho salmon released was significantly less than non-clipped fish.

Median capture dates of natural salmonids were within 15d of their hatchery counterparts, even though migration duration was several months longer for natural salmonids. Peak capture of hatchery yearling chinook salmon (late March), coho salmon (mid-April), summer steelhead (late April), and subyearling chinook salmon (early June) was influenced by release times, travel speed, and environmental conditions. Median travel speed was fastest for yearling chinook salmon (33-54 miles/d) and slowest for coho salmon (2 miles/d). Peak capture of yearling natural salmonids varied from hatchery species by about one week; natural subyearling chinook salmon peaked later in June.

Collection of photonically-marked fish was slower for hatchery yearling spring chinook salmon after release (1-8 d) than yearling fall chinook salmon (2-4 d), and slowest for subyearling fall chinook salmon (2-34 d). Migration pattern was similar and recapture was not significantly different between yearling fall chinook salmon reared in Oregon and Michigan raceways or among subyearling fall chinook salmon reared at low, medium (standard), and high densities.

Most natural and hatchery salmonids were captured at night in the rotary-screw trap from March through June. Capture at night was highest for chinook and coho salmon and lowest for summer steelhead. Greater daytime movement was observed only for natural summer steelhead in May.

Smolt stage increased through time for natural and hatchery subyearling fall chinook salmon and natural and hatchery summer steelhead. Smolt level decreased through time for hatchery yearling chinook salmon. Most hatchery coho salmon and natural spring chinook salmon were intermediately smolted throughout their migration; coho salmon smolted by early June. Smolt level was significantly correlated ($P < 0.05$) with fork length for all species except hatchery spring chinook salmon and natural coho salmon.

Most fish examined were in good condition with minimal scale loss; however, condition of summer steelhead was poorest with 34% partially descaled and near 9% descaled. Subyearling fall chinook salmon were in the best condition, but suffered the highest mortality in the lower river (9%), particularly in mid-June. High flows and river debris in early spring caused increased scale loss and mortality for yearling chinook and coho salmon. Proportionately more partially descaled and descaled yearling chinook salmon were caught at the beginning of their migration than at the end. Injuries were most prevalent on fish that were descaled. All samples of fish examined by pathologists (42) were positive for the Rs antigen for BKD (ELISA test), but showed no signs of the disease.

Natural fish were in better condition than hatchery fish, particularly summer steelhead. Condition of subyearling fall chinook salmon deteriorated by July during trapping at Westland Canal as water quality decreased. Natural summer steelhead examined by pathologists (3) were positive for the Rs antigen , but the presence of the antigen was not necessarily indicative of the disease.

Survival to the lower river was higher for hatchery yearling spring and fall chinook salmon (71%; 95% CI = 40-102%) than for yearling coho salmon (34%; 15-53%) or subyearling fall chinook salmon (35%; 30-38%). We could not determine abundance or survival of hatchery or natural summer steelhead because few fish were captured. Confidence limits were within 44% of the abundance estimate for yearling chinook salmon, 56% for coho salmon, and 12% for subyearling fall chinook salmon. About 51,000 subyearling fall chinook salmon were transported from Westland Canal to the lower river, bringing their total survival estimate to 36%. An estimated 1,200 natural coho salmon, 1,151 natural spring chinook salmon, and 1,318 natural subyearling fall chinook salmon emigrated from the Umatilla River between December 1996 and July 1997.

Survival of specific rearing strategies at Umatilla Hatchery was assessed with photonic marks. Survival of photonic-marked fish was 54% for both yearling spring and fall chinook salmon reared in Oregon raceways, and 52% for yearling fall chinook salmon reared in Michigan raceways. Survival estimates for marked subyearling fall chinook salmon reared at low (11%), medium (14%), and high (12%) densities were similar.

At Diffuser 1 in the east-bank fish ladder at Three Mile Falls Dam, the nearby inflow gates were kept fully open this year. Through video, we observed that densities of yearling and subyearling salmonids were highest at 80% water depth and moderate water velocity (0.5-1.0 ft/s; yearlings) and low water velocity (<0.5 ft/s; subyearlings). Although most impacts on the diffuser were light, hard impacts were most frequent at 80% water depth and at moderate and high velocity (>1.0 ft/s) areas (yearlings) and at low and moderate velocity areas (subyearlings). Most yearling and subyearling fish passed tail-first through the diffuser with the improved hydraulics.

Peak river flow in 1997 reached 12,400 ft^3/s in early January. Average river flow steadily decreased from March (2,834 ft^3/s) to June (260 ft^3/s) during the major outmigration period. Water clarity greatly decreased with increasing flows. Flow was enhanced in June through releases of stored water from McKay Reservoir (RM 52). Water releases were pulsed up to 300 ft^3/s in late June to encourage fish movement, but results were inconclusive. Peak fish collections in mid-April and mid-June were associated with increasing river flow and declining water clarity. River flow and water clarity were significantly correlated with collections of natural summer steelhead and hatchery coho and subyearling fall chinook salmon.

Large (>200 mm) northern pikeminnow (formerly northern squawfish) were captured mostly in January. No adult bass (*Micropterus spp*.) were collected. Avian predators included gulls, great blue herons, kingfishers, and common mergansers.

Adult Pacific lamprey (7) were collected in January and May. Juvenile lamprey (297; 60-190 mm) were collected from late October through late June; highest movement coincided with periods of high flow from December - February. Juvenile lamprey included smolted (eyed) and non-smolted (non-eyed) stages.

Mortality of subyearling fall chinook salmon transported in July was 21.5% higher than non-transported fish and the net difference was significant ($P < 0.05$). Scale loss of transported fish was also significantly higher ($P < 0.05$) than non-transported fish on five of six test dates.

Management Implications and Recommendations

1. Continue the release of stored water from McKay Reservoir through June to allow the natural migration of natural and hatchery fish. This would reduce the number of fish trapped at Westland Canal and transported to the mouth of the river. Transport of fish appears to reduce survival and worsen condition.

2. Release several successions of pulsed flows from McKay Reservoir in mid- to late June to provide a greater influence on fish movement. Pulses should be at least 300 ft^3/s, or more than double the normal flow release, to achieve a flow increase in the lower river.

3. Change hatchery practices with yearling chinook salmon at Umatilla Hatchery to increase their survival. Acclimate and release yearling spring chinook salmon earlier when they are biologically ready to migrate.

4. Operate the inflow gate at the east-bank fish ladder at Three Mile Falls Dam fully open to reduce the number of juvenile fish impacts on the nearby diffuser gate and improve passage conditions for juvenile fish.

5. Continue transplanting adult fall chinook salmon from Priest Rapids Hatchery into the Umatilla River to sustain and increase natural production, especially when Umatilla stock are being taken for brood.

6. Consider releasing hatchery subyearling fall chinook salmon when they are larger and more smolted to reduce the number of late migrants and possibly improve survival. A later release would more closely mimic the migration pattern of natural migrants. Flows would need to be suitable for migration through June and July.

7. Allow a volitional release of later-released summer steelhead soon after transfer to the acclimation ponds and conduct a forced release one to two weeks earlier than usual. This strategy should improve survival in the Umatilla River for this group of fish.

8. Release hatchery coho salmon later in April, if possible. An April release would be closer to the peak migration of hatchery and natural coho and would decrease time spent in the river. Attempt to release coho salmon in the evening or at alternate release sites to reduce bird predation.

9. Operators of passage facilities should be aware that natural fish are in the lower river in late fall. They should ensure that these facilities are fish safe. Rigorous attention should be given to cleaning passage facilities of debris as freshets occur to reduce the potential for fish injury.

10. Consider using PIT tags to monitor the outmigration of hatchery fish. Less reliance on visual marks may increase the accuracy of survival estimates for specific rearing groups and for the total species outmigration.

INTRODUCTION

Large runs of salmon (*Oncorhynchus spp*.) and steelhead (*O. mykiss*) once supported productive fisheries in the Umatilla River. By the 1920's, irrigation diversion, poor passage conditions, and habitat degradation had extirpated the salmon run and drastically reduced the summer steelhead run (CTUIR and ODFW 1989). Reintroduction of chinook salmon (*O. tshawytscha*) and coho salmon (*O. kisutch*) and enhancement of summer steelhead populations in the Umatilla River was initiated in the early and mid-1980's (CTUIR and ODFW 1989). Measures to rehabilitate the fishery and improve flows in the Umatilla River are addressed in the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC 1987). These include habitat enhancement, hatchery production, holding and acclimation facilities, flow enhancement, passage improvement, and natural production enhancement. Detailed scope and nature of the habitat, flow, passage, and natural production projects are in The Umatilla River Basin Fisheries Restoration Plan (CTUIR 1984; Boyce 1986). The Umatilla Hatchery Master Plan (CTUIR and ODFW 1990) provides the framework for hatchery production and evaluation activities. Many agencies cooperate, coordinate, and exchange information in the Umatilla basin to ensure successful implementation of rehabilitation projects, including the U.S. Bureau of Reclamation (USBR), the Bonnville Power Administration (BPA), National Marine Fisheries Service (NMFS), Oregon Water Resources Deparment (OWRD), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and local irrigation districts (West Extension, Hermiston, and Stanfield-Westland). The Umatilla River Operations Groups and the Umatilla Management, Monitoring, and Evaluation Oversight Committee coordinate river management and fisheries management and research in the Umatilla River basin.

Monitoring and evaluation efforts to fine-tune specific restoration projects are ongoing or near completion. Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin is a necessary component for determining the success of these projects and the overall effectiveness of the rehabilitation plan. A critical uncertainty is whether juvenile salmonids are surviving and successfully migrating out of the Umatilla River basin. Although smolt-to-adult survival is being assessed through the Umatilla Hatchery Monitoring and Evaluation Project (Keefe et al. 1993, 1994, Hayes et al. 1995, 1996, Focher et al. 1998), results are broad in scope and reliant on long-term adult returns. Potential factors determining survival of juvenile salmon in the Umatilla basin include loss through in-river predation, cumulative effects of passage through passage facilities at irrigation diversion dams, effects of poor river conditions and transport on fish health, and effects of hatchery rearing and release strategies.

Information on migration success and performance of different rearing and release strategies for salmonid species within the Umatilla River will supplement evaluation of specific hatchery practices at Umatilla Hatchery. Strategies for rearing at Umatilla Hatchery include use of standard Oregon raceways and oxygenated Michigan raceways and rearing at different fish densities. Some production groups released into the Umatilla River are also reared at other hatcheries. Release strategies include yearling versus subyearling production and varying release times for graded summer steelhead.

The Confederated Tribes of the Umatilla Indian Reservation are investigating the natural production potential of each race or species of salmonid in the Umatilla River basin and the effects of hatchery supplementation on native steelhead (CTUIR 1994, Contor et al. 1995, 1996, 1997). Addressing these critical uncertainties has required the estimation and determination of survival, life history characteristics, distribution, composition, abundance, and production capacity of naturally-produced juvenile and adult salmonids in the Umatilla River basin. Monitoring in the lower river is crucial for determining movement patterns, arrival times, lower river abundance, and survival of naturally-produced salmonids originating in the upper river.

A number of issues related to water use in the Umatilla River are associated with fisheries rehabilitation. Providing water to irrigators and flows for anadromous fish is a desired goal of the Umatilla Basin Project (USBR 1988). An understanding of flow requirements for fish passage, rearing, and survival, and species-specific migration characteristics is critical to determine optimum canal operations, water release strategies, and flow enhancement strategies in the Umatilla basin (USBR 1988, USBR and BPA 1989).

Survival of juvenile salmonids can be affected by poor conditions during their transport from Westland Canal (RM 27.3) to the lower Umatilla River. Juvenile salmon that are collected at Westland Canal for transport undergo scale loss and stress during dip-net loading (Cameron et al. 1994) and crowding (Walters et al. 1994). The cumulative effect of collection, crowding, loading, and transport on the health of juvenile salmonids may result in poor survival after release.

A new marking technique (photonic mark) using a colored flourescent solution injected into the fin rays of fish is currently being developed by New West Technologies (Santa Rosa, CA). This marking technique has the potential for replacing freeze brands as a group mark on hatchery fish. The Umatilla Hatchery Monitoring and Evaluation study photonically marked groups of spring and fall chinook salmon, coho salmon, and summer steelhead in spring 1997. Outmigration monitoring in the lower Umatilla River provided an opportunity to assess mark quality on released hatchery fish and use mark capture information to evaluate migration characteristics of mark groups.

Studies to evaluate juvenile salmonid passage at fish bypasses and ladders on the lower Umatilla River identified potential passage problems for juvenile salmonids at Three Mile Falls Dam (Cameron et al. 1994, 1995). Subyearling fall chinook salmon that passed through the east-bank fish ladder at Three Mile falls Dam were injured and delayed and yearling salmonids were delayed (Cameron et al. 1994). A diffuser placed in the upper end of the fish ladder to direct adult fish into a trap was implicated as the primary cause of injury and delay to juvenile salmonids. Remedial measures to reduce injury and delay at this diffuser appeared ineffective (Cameron et al. 1995). In 1996, one of our objectives was to determine whether this diffuser was the main cause of injury and delay to juvenile salmonids passing though the ladder and the physical and biological factors that may be involved. We used an underwater video camera to document behavior of subyearling and yearling salmonids at the diffuser (Knapp et al. 1998). We found that fish impacts on and passage through the diffuser appeared to be associated with sweeping currents, turbulence, and high water velocity in front of the diffuser due to a partially open fish exit gate. In 1997, we suggested operating the fish exit gate fully open and continued to video document fish passage at the diffuser.

The goal of the Outmigration and Survival Study is to evaluate the outmigration, estimate survival, and investigate factors affecting survival of juvenile salmonids in the lower Umatilla River basin. General objectives for meeting this goal in the 1996-1997 project period were:

1. Conduct tests to determine trap collection and retention efficiencies for use in estimating fish abundance.

2. Determine migration performance and pattern, migrant abundance, health, smolt status, and survival of hatchery and natural juvenile salmonids in the lower Umatilla River.

3. Identify environmental and biological variables that affect fish migration, health, and survival.

4. Determine the cumulative effects of trap and haul procedures on fish health and survival.

5. Assess smolt passage at the east-bank ladder at Three Mile Falls Dam.

6. Evaluate the technical feasibility of using photonic tags and remote photonic detectors to determine migrational characteristics of juvenile salmonids.

In this report, we describe our third year activities and findings for the Umatilla River Outmigration and Survival Study from 1 October 1996 to 30 September 1997. We present information from outmigration monitoring, including species and origin of fish collected, lengths, fish condition and health, smoltification levels, marks and fin clips observed, diel movement, migration patterns, migration performance, and environmental conditions. We present trapping efficiencies, estimations of migrant abundance and survival, observations of predators and resident fish, information on transport effects, and results of photonic marking of fish. We also describe our second year results in observing juvenile fish passage through the diffuser at the east-bank adult fish ladder at Three Mile Falls Dam with the use of underwater video.

STUDY SITES

We collected outmigration data from one in-river sampling site and one canal screening facility during 1996-1997 (Figure 1). We used a 5-ft-diameter rotary-screw trap to collect fish in the lower Umatilla River at RM 1.2 beneath the Interstate-82 bridge near the town of Umatilla (Figure 2). Descriptions of the rotary-screw trap and its deployment are included in Knapp et al. (1998). Trap efficiency releases for this site were made on the west bank of the river immediately below Three Mile Falls Dam (RM 3.0; Figure 1).

Changes to the trapping site this year included construction of a ramp and cart to move trap efficiency-marked fish from the river up a hill to a transport vehicle (Figure 3). We constructed the 60-foot plywood ramp over a dimensional lumber frame and attached it to an existing staircase for stability. The cart was built to transport a 30-gallon garbage can for carrying fish. We used a rope and block-and-tackle pulley system to drag the cart up the ramp. We also modified a working shelter and added water holding troughs and a gravity-flow water supply system to provide water to the work area for fish processing (Figure 3). The working shelter was a wooden frame with a canvas tarp stretched over it. Supports built inside the shelter held two wooden water troughs measuring 1-ft-wide by 2-ft-deep by 8-ft-long. One trough was drained by a 2-in-diameter standpipe and flexhose (fish holding trough), and the other by a 6-in-diameter standpipe and flexhose (fish recovery and release trough). The flexhose from the release trough led to the river and allowed recovered fish to be released directly to the river without handling. Flowing water for the troughs was supplied by a large circular tank placed on a hill above the sampling site. River water was pumped up the hill to fill the tank, and allowed to drain by gravity through two garden hoses leading to the troughs.

We also sampled at the canal screening facility at Westland Canal (RM 27.0; Figure 1) during juvenile fish trap and haul operations. Trap efficiency tests were not performed at this site. Transport evaluation tests were conducted at Westland Canal and at the lower Umatilla River boat ramp (Figure 1). Details of the Westland Canal juvenile fish collection facility and the Umatilla Trap and Haul Program can be found in Knapp et al. (1998) and CTUIR and ODFW (1997).

We used video equipment to monitor juvenile fish passage through the east-bank fish ladder at Three Mile Falls Dam (Figure 4). The ladder incorporates both passage and auxiliary water sections to the total ladder structure (Figure 2). Adult fish migrate through the passage section, and the auxiliary water section provides additional flow at the ladder entrance for fish attraction. Downstream migrating juvenile fish may enter the ladder through either the passage or auxiliary water intakes. Fish entering the passage section of the ladder encounter Diffuser 1 approximately 30 ft downstream of the intake (Figure 4). Diffuser 1 diverts upstream migrating adult fish into a steeppass that leads to a trap (Figure 2). Diffuser slats have one-inch-wide openings to prevent gilling of small precocious (“jack”) salmon. Velocity of water sweeping across the diffuser (sweep velocity) ranges from 0.00 to 0.60 ft/s, and that passing through the diffuser (approach velocity) ranges from -0.10 to 1.64 ft/s (Appendix Figure A-1). Downstream of Diffuser 1, juvenile fish pass through either a one-foot-wide slot between the viewing window and backlighting chamber or through diffusers behind the backlighting chamber (Diffuser 3; Figure 4). Fish that pass through Diffuser 3 are not visible through the viewing window.

METHODS

Outmigration Monitoring

Trap Efficiencies

We used trap collection efficiencies to expand the catch of juvenile fish for an estimate of migrant abundance. A final trap collection efficiency estimate was a multi-step process. Species-specific trap retention tests were conducted to adjust the number of marked and unmarked fish captured according to the retention efficiency of the trap. The probability of survival of marked fish released for trap efficiency tests was determined by conducting 24-h mortality tests with these fish prior to each release.

We determined trap collection efficiencies by releasing a known number of marked fish (*M*) upstream of the trap and recapturing them in the trap (*m*) over the duration of the collection period. Numerous daily releases were made for each species or race of fish. For each test group, we compared daily trap efficiencies, using Chi^2 analysis, and pooled the test data if the efficiency estimates were not significantly diffferent at an alpha level of 0.05. If recaptures were < 5, daily test data was pooled until the recapture sample size was ≥ 5 to satisfy the assumption of the Chi^2 test. The final trap efficiency estimate(s) was the ratio of total fish recaptured to total fish released over the specific time period delineated by Chi^2 results ($TE = m/M$). We expanded the collection of fish for each time period by the corresponding trap efficiency to derive an abundance estimate for that period. We used trap efficiency estimates for hatchery fish to estimate abundance of natural conspecifics.

For these tests, we used unmarked hatchery fish from the trap. We marked test fish by injecting them with a small amount of acrylic paint using a 3-cc disposable syringe and 26-gauge intradermal needle. We used five paint colors and 10 mark locations near the base of ventral fins to provide a unique mark for each daily release (Knapp et. al 1996). We marked fish throughout the 24-h sampling period and held them in net pens until they were transported to the release site in the evening. For each release, we attempted to mark 50 or more fish of the most dominant species in the collection.

Prior to and after transport to the release site, we counted and removed dead fish from the test group to determine the final count of live fish. We transported fish to the release site (Figure 1) in a 250-gallon, aerated slip tank.

At the release site, we held fish in a large circular tank for 24 h to assess survival. A net liner was placed inside the tank for ease in crowding at release and netting dead fish. To release fish, we raised the water level in the tank, crowded fish with the liner, and guided fish into a funnel and 6-inch-diameter pipe leading to the river. We counted the number of fish that died during the 24-h holding period to assess the probability of survival (*s*) of remaining live fish released for trap efficiency tests. The number of live fish released (*R*) was adjusted for survival (*s*) to obtain the adjusted number of marked fish available for recapture (M; $R(s) = M$). The adjusted number of marked fish (*M*) was used to calculate trap efficiencies. Releases were made in the evening to coincide with diel movement patterns observed in previous years (Knapp et al. 1996 and 1998). As with the daily trap collection efficiencies, we compared daily survival estimates using Chi^2 analysis, and pooled the data if survival estimates were not significantly different.

We estimated trap retention efficiency of the rotary-screw trap by releasing approximately 20 marked fish in the trap live-box and counting the number that were retained over an 8-h to 12-h period. The daily capture of unmarked and marked fish was corrected for trap retention efficiency by species. We used Chi^2 analysis to determine significant differences in retention efficiency between days for each species of fish, and pooled the data if significant differences were not found. We used trap retention efficiency estimates for hatchery fish to correct the capture number of natural conspecifics.

We determined the percentage of total river flow sampled by the rotary-screw trap to compare with the trap's fish collection efficiency. We measured the velocity of water entering the trap (v) with a Marsh-McBirney (Model 2000) electronic flow meter periodically throughout the migration period. We calculated the flow (ft^3/s) entering the trap (F) by multiplying the water velocity (v) by the submerged area of the trap cone (a), so that $F = a(v)$. By dividing the flow entering the trap by the corresponding daily river flow obtained from the U.S.Geological Survey, we calculated the percentage of total river flow sampled by the trap. We used linear correlation to determine the relationship between percentage of flow sampled and daily trap efficiency for each species.

Collection

Fish retrieved from the rotary trap were placed in the fish processing trough inside the work shelter. After fish were processed, they were placed in the second trough for recovery and returned to the river via the 6-in flex hose.

Juvenile fish were anesthetized in a mild solution of tricaine methanesulfonate (MS-222) before evaluation. We identified and counted juvenile salmonids by species, race, and origin (hatchery or natural). Hatchery fish were differentiated from natural fish by the absence of either adipose or ventral fins. Spring and fall chinook salmon were clipped similarly and could not be differentiated by ventral clip in 1997. An initial release of coho salmon in early March was comprised of 95% unclipped fish and 5% adipose-clipped fish. Unclipped fish could not be differentiated from natural coho salmon. Therefore, coho salmon < 100 mm in fork length were considered naturally-produced when both hatchery and natural fish were in the river (personal communication, G. Rowan, CTUIR, Mission, OR). Subsequent releases of coho salmon in late March and early April were all adipose-clipped.

We identified and counted marks and fin clips, and evaluated fish condition and smolt coloration. We looked for trap efficiency marks and photonic marks on all races and species of fish. When large numbers of fish were collected, we omitted fin-clip counts and evaluation of condition and smolt coloration. On one occasion when large numbers of subyearling fall chinook salmon were collected, we only counted fish. Scale samples were collected mostly from natural summer steelhead that exhibited smolt coloration as these fish were actively migrating. Scale samples were analyzed by CTUIR biologists to determine fish age and growth characteristics.

During low flow in June, we modified the trap to increase trapping efficiency and fish collection. Two separate wooden pontoons were affixed to the front end of the aluminum pontoons and angled out to capture a greater proportion of the water flow (Figure 2).

Sample data collected at the rotary-screw trap was expanded to account for times when the trap was not sampling by dividing by the proportion of the time sampled. Data was expanded for species, race, origin, marks, and clips. When sampling was conducted only once within 24 h, data was not expanded.

Trap and Haul

We examined species composition of fish collected at Westland Canal during Trap and Haul operations (CTUIR and ODFW 1997). Fish were collected with dipnets from the juvenile holding pond at Westland Canal, anesthetized, counted, and identified to species. We examined a subsample of salmonids for scale loss and injuries (see **Fish Condition**), photonic marks, fin clips, and smolt index. Fish were released to the holding pond after recovery.

We used species composition and fish per pound data collected by CTUIR to estimate total number of fish collected at Westland Canal during Trap and Haul operations. Estimates of number of salmonids per pound were multiplied by the total number of pounds hauled to estimate the total number of salmonids collected each day. Daily totals were summed to estimate total number of fish collected at Westland Canal. For days that fish were hauled, but CTUIR did not collect fish per pound data, we averaged data collected from preceding and following dates on which sampling was conducted to interpolate missing data.

Photonic Marks

Photonic marks were placed on groups of hatchery salmonids by ODFW (Hayes et al. 1998) and natural salmonids by CTUIR (Contor et al. 1998) and counted on fish captured at lower river trapping sites (RM 1.2 and 27.3) to evaluate migration timing and survival. These marks replaced the freeze brand marks previously used on hatchery fish from Umatilla Hatchery. Different colored marks were used to distinguish yearling fall chinook salmon reared in Oregon and Michigan raceways, subyearling fall chinook salmon reared at varying densities, and the "smalls" release group of hatchery summer steelhead (Table 1). We also photonic marked a portion of hatchery coho salmon during their release (Table 1). Photonic marks were applied by injecting an aqueous solution of latex encapsulated fluorescent pigment (5-8-um-diameter microspheres, New West Technologies, Santa Rosa, CA) into the anal fin using a high-pressure spray gun. Marking guns were powered by portable tanks (2-20 lb) of compressed carbon dioxide gas that dispensed marking fluid in increments of 0.5 ml.

We compared quality of marks on hatchery subyearling fall chinook salmon captured at our trap to their quality 24 h after marking. Evaluation criteria followed Hayes et al. (1998) where marks were classified as good, fair, poor, or unreadable based on mark size (Figure 5). The unreadable category was not used in mark quality evaluations at the trap site because fish with undetectable marks could not be distinguished from unmarked fish. We also compared the proportion of photonic-marked fish captured in our trap to the proportion of photonic-marked fish at release for all marks.

Fin Clips

We examined each hatchery species or race for fin clips. Both spring and fall chinook salmon were right-ventral (RV) clipped. Chinook salmon with coded-wire tags were also adipose clipped (ADRV). All summer steelhead were adipose clipped (AD) and steelhead with coded-wire tags were also left-ventral (ADLV) clipped. Coho salmon were either non-clipped or adipose clipped, with most being adipose clipped. We determined the percent recovery of each clip by species to ascertain survival or collection differences between clips.

Migration Parameters

We determined migration duration and timing, identified dates of peak movement, and calculated median travel speed for hatchery and natural salmonids using expanded catch data from the lower river trap. Migration duration was the length of time from initial to final capture. Migration timing was the cumulative percent annual capture of a fish species over time. Periods of peak movement were identified from a plot of daily capture through time. Median travel speed was miles from release to recapture site divided by days from release to median capture. Additional information on migration timing of hatchery salmonids was gained by recapture of fish that were photonic marked.

Diel Capture

We examined diel movement of hatchery and natural salmonids by comparing daytime and nighttime trap collections. Daytime was the period from sunrise to sunset and nighttime was from sunset to sunrise. Collection data were only used if the trap operated 24h/day and discrete sampling intervals ended within two hours of sunrise and sunset.

Smolt Index

Smolt development was estimated by examining body coloration and definition of parr marks on subsamples of hatchery and natural salmonids. Categories for the smolt index were "*P*" for fish with resident body coloration typified by dark, well-defined parr marks, "*I*" for an intermediate phase showing silvery body coloration and faded parr marks with distinct edges, and "*S*" for silvery body coloration with no parr marks or barely visible parr marks with poorly defined edges.

Fish Condition and Health

Subsamples of hatchery and natural fish were examined for scale loss and other body injuries to determine fish condition. We categorized scale loss following criteria used by the Umatilla Hatchery Monitoring and Evaluation study (Keefe et al. 1994). We considered fish condition "good" if cumulative scale loss on either side of the fish was less than 3%. We considered fish "partially descaled" if cumulative scale loss exceeded 3% but was less than 20% on either side of the body and "descaled" if cumulative scale loss equaled or exceeded 20%. We determined the proportion each condition category comprised of total fish examined. We also examined fish for external parasites and other injuries to the head, eyes, operculum, body, and tail. We noted fungal infections on the body surface, indications of bacterial kidney disease (BKD), and predator attack marks. Bird marks were identified by symmetrical bruises on each side of the fish.

Fish mortalities were noted by species and identified as to whether they occurred during trapping or handling. Handling mortalities were omitted when computing percent mortality of collected fish. All dead natural fish and some diseased and dead hatchery fish were examined by the ODFW La Grande Pathology Lab to determine fish health status at death. Unusual marks or indications of disease on dead fish were noted.

Lengths

We measured fork length of all natural salmonids and a portion of hatchery salmonids to the nearest millimeter (mm). We developed length-frequency distributions, determined modal length, and estimated mean fork length for each species and race of hatchery and natural fish. We correlated fish length with smolt index to determine if fish size was associated with smolt stage. We also use ANOVA to test mean lengths among smolt stages.

Migrant Abundance and Survival

We estimated migrant abundance for each race or species of salmonid at the rotary trap sampling site to estimate total outmigration for natural and hatchery fish and to estimate survival of hatchery fish. We estimated migrant abundance (A) by multiplying the number of unmarked fish captured during a time period (C) by the reciprocal of the individual or pooled trap efficiency estimate ($1/TE$) for the that time period ($A = C \times 1/TE$). We summed subtotals of abundance for a total abundance estimate over the collection period. Prior to estimating migrant abundance, data was adjusted by subtracting recaptured marked fish from the daily collection and adjusting the number of unmarked fish captured by the specific trap retention efficiency. If fish were captured during a prolonged period when no trap efficiency tests were conducted, we used the mean of all daily trap efficiency estimates to determine abundance for this time period. We used the Bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations to determine the variance for all abundance estimates. Variances for abundance subtotals were summed. Confidence intervals (95%) for the abundance estimate were calculated using the square root of the Bootstrap variance estimate (CI = 1.96 $\sqrt{V}$).

We did not determine trap efficiency estimates for natural fish, due to low numbers captured. Therefore, we used the trap efficiency estimates of hatchery fish for natural fish of the same species to obtain a rough abundance estimate.

Survival estimates ($S = A/R$) for hatchery fish were based on the migrant abundance method (Burnham et al. 1987; Dauble et al. 1993) where survival (S) was estimated as the proportion of migrants that passed the sampling site (A) to the number of fish released at upriver sites (R). We also used this method to estimate survival of marked (photonic) groups of hatchery fish collected at the lower river trap throughout the migration season (*see* **Photonic Marks**). We estimated survival of marked fish (S_m) by multiplying the number of marked fish captured during a time period (C_m) by the reciprocal of the individual or pooled trap efficiency estimate ($1/TE$) for that time period, and divided by the total number of marked fish released from each mark group (R_m; $S_m = (C_m/TE/R_m)$.

Video Monitoring

We used underwater video to monitor juvenile salmonid passage through Diffuser 1 in the east-bank fish ladder at Three Mile Falls Dam. Separate sets of video recordings were collected when fish composition in front of the diffuser was dominated by yearling salmonids (12-31 May) and subyearling salmonids (1-14 June). We deployed the camera approximately three inches in front of and parallel to the diffuser at sampling locations along a 3 x 5 grid (Figure 6). Sampling locations on the grid corresponded with locations where water velocity was measured when the ladder inflow (fish exit) gates in front of the diffuser were partially open (Cameron et al. 1997) and full open (Appendix Figure A-1). We developed an experimental sampling design to assess the effects of water velocity and depth on fish passage through the diffuser. In this design, locations on the grid were grouped into 9 cells based on approach water velocity (low: < 0.5 ft/s, moderate: 0.5-1.0 ft/s, high: > 1.0 ft/s) and water depth (20%, 50%, and 80% of water depth). Three cells were not represented in the design due to the absence of appropriate conditions (low velocity at 20% depth, low velocity at 50% depth, and moderate velocity at 20% depth). We created sample blocks by recording 0.5-4.0 h of video in the morning (0700-1200 hours) and evening (1200-2000 hours) at a randomly selected location within each cell.

We also recorded video at Diffuser 3 from 15-26 June 1997 to estimate juvenile salmonid passage behind the backlighting chamber (i.e. fish not detected by the camera system in the viewing window; Figure 3). We deployed the camera approximately three inches in front of and parallel to the diffuser, at the west edge of the diffuser. We recorded video at 50% and 80% of water depth during two-hour periods in the morning (0700-0900 hours) and evening (1730-1930 hours).

The underwater video system is described in Knapp et al. 1998. We recorded video under natural lighting. A charge-coupled device at the camera focus allowed image detection at light intensities as low as 0.7 lux.

We reviewed a one-half hour video tape segment recorded in the morning and evening within each sampling strata at Diffuser 1 for both yearling and subyearling data sets. We determined diffuser area within the camera's field of view, density of salmonids in front of the diffuser, and frequency of fish impacting on or passing through the diffuser in each tape segment reviewed. Before deploying the camera in the field, we measured the width and height of the camera's field of view at varying distances to estimate these dimensions from the viewing distance in our recording. We calculated viewing distance by multiplying the number of diffuser bars visible on recordings by the distance between bars (1.25 in).

Density of salmonids in front of the diffuser was estimated for each one-half hour tape segment by pausing the tape at the start and middle of each recording minute and counting the number of salmonids either partially or fully in view. These counts were averaged and divided by diffuser area in view to calculate a mean density per unit area (ft^2) of diffuser.

We also counted salmonid impacts with the diffuser during tape reviews. Impacts were defined as head or body contact with the diffuser. Fin contact was not considered an impact. Impacts were classified as either "light" or "hard". Light impacts were fish that had partial control of their swimming abilities when contacting the diffuser. Fish were judged to have partial swimming ability if their head and anterior portion of their body was orientated to the flow when they impacted the diffuser. Hard impacts were recorded when fish had their head and body perpendicular to the flow when they impacted the diffuser. We also counted the number of salmonids that passed downstream through the diffuser. Passage was classified as either head-first or tail-first.

Varying amounts of diffuser area viewed and fish densities in recordings biased our comparisons of impacts and passages between recordings. We eliminated the effect of diffuser area on our counts by dividing the number of impacts/h and passages/h by the diffuser area (ft^2) viewed. Variable fish densities among recordings was standardized by dividing these counts ($number/h/ft^2$) by fish density ($fish/ft^2$). We referred to this quantity as the number of impacts or passages based on fish density (number/h/fish).

We installed a video recording system in front of the viewing window in the east-bank fish ladder at Three Mile Falls Dam to monitor hatchery subyearling fall chinook salmon passage through the ladder (Figure 7). We recorded 12-22 h of video per day from 30 May - 6 June 1997 with a “normal-time” video cassette recorder (VCR) and 20-23 h per day from 10-29 June 1997 with a “time-lapse” VCR. We also recorded 24 h of time-lapse video from 30-31 May to calibrate time-lapse counts with normal-time counts.

The normal-time video system and video camera set up is described in Knapp et al. 1998. We recorded video with the VCR set on long play (6 h per tape). For the time-lapse system, we connected a Panasonic AG-6720 time-lapse VCR to the camera and recorded in 24-h mode. The video camera was positioned 5 ft in front of the viewing window (Figure 7). Two florescent lights (40 Watt, 4-ft-long) fixed to either side of the window at about a 45° angle to the window provided light to the window front. Two incandescent lights (300 Watt, 4-ft-long) set inside a submerged plexiglass chamber light the backside of the viewing window.

We did not review the video recorded at the viewing window in 1997 due to limited time and personnel. These tapes will be reviewed along with tapes recorded in 1998.

Environmental Conditions

We monitored physical river conditions and meteorological conditions at river mile (RM) 1.2 to assess their relationship to fish movement. We measured daily maximum and minimum water temperature (0.5 m depth) using a Taylor Max-Min thermometer. We categorized river flow, turbidity, color, and debris level, precipitation, and wind velocity as low, moderate, or high. We recorded river elevation from a staff gauge to the nearest 0.05 ft. and sky cover to the nearest 25%. We measured water clarity using a 7-in-diameter Secchi disk. We averaged the depth at which the disk disappeared from sight as it was lowered and reappeared in sight as it was raised, to obtain a mean Secchi depth. We obtained additional river flow data recorded at RM 2.0 from the U.S. Geological Survey and flow data recorded at upriver sites from the Oregon Water Resources Department (OWRD, unpublished data). Information on water releases from McKay Reservoir was provided by the U.S. Bureau of Reclamation.

Resident Fish and Predators

We identified and counted resident fish by species during monitoring of salmonid species. Fish were counted at each trap check. We measured fork lengths of northern pikeminnow (*Ptychocheilus oregonensis*) and total lengths of Pacific lamprey (*Lampetra tridentata*). We also measured lengths on subsamples of other resident fish.

We noted the presence of avian predators at the rotary-screw trap site on an intermittent basis. We recorded species and number of each avian predator and the date and time observed.

Transport Evaluation

We evaluated condition and mortality of hatchery subyearling fall chinook salmon before and after transport from Westland Canal to the lower Umatilla River. Using a dipnet, we randomly collected a control group of approximately 100 fish from the juvenile holding pond to assess pre-transport condition and mortality. Fish were collected immediately after lowering of the pond and crowding. Fifty fish were sampled and placed in a net pen in the canal for 24 h to test mortality. Another 50 fish were immediately measured for fork length and examined for descaling, injuries, photonic marks, and fin clips. Scale loss was evaluated as described in **Fish Condition**. After 24 h, fish held in the net pen were removed and dead and live fish were counted. Moribund fish were counted as dead. Live fish were returned to the holding pond. After 24 July, the number of fish held for 24 h was reduced from 50 fish to 25 due to low fish numbers. Water temperature in the net pen was measured at the start and end of each holding period. In addition, we used a Max./Min. thermometer to record maximum and minimum water temperatures during the holding period. Post-transport (treatment) condition and mortality was assessed by collecting fish directly from the transport vehicle at the lower Umatilla River boat ramp. Treatment fish were collected and processed using the same methods as the control group. The transport tank temperature and number of pounds of fish hauled were recorded. Treatment fish were moved approximately 1/4-mile upriver of the boat ramp and held in a net pen in the river for mortality testing. Water temperatures for treatment groups were collected using the same methods as for the control groups.

For 24-h mortality tests, we calculated the net 24-h mortality (M_{net}) for each test as the percent mortality from the treatment group (M_t) minus the percent mortality from the control group (M_c) so that $M_{net} = M_t - M_c$. We analyzed differences between mortality and descaling in treatment and control groups using Chi-square analysis (Knapp et. al 1998).

Statistical Analyses

We used linear correlation to examine relationships among environmental variables (river flow, water temperature, Secchi depth) and fish collection data, between fish length and smolt level, and between percentage of river flow sampled and species trap efficiency.

We used Chi^2 tests of independence to determine significant differences between daily trap efficiency estimates, daily survival probability estimates, trap retention efficiency estimates, and recovery of photonic mark groups and fin-clipped fish. Chi^2 was also used on transport evaluation data to determine differences among samples in counts of fish with varying degrees of scale loss (good, partially descaled, and descaled) and in counts of dead/moribund and live fish in treatment and control groups. In the Chi^2 analysis of transport data, we tested the samples for heterogeneity, pooled the samples if they were homogenous, and tested the pooled samples. We used the Yates correction factor on pooled data for contingency tables with 1 degree of freedom (Zar 1974). We used t-tests to determine significant differences in fork lengths between hatchery and natural fish. We used single factor ANOVA to determine significant differences in mean lengths among levels of smoltification. We used SAS (Statistical Analysis Systems) for personal computers (SAS Institute 1990) to conduct most of our analyses. All tests were performed at a significance level of $\alpha = 0.05$.

RESULTS

Outmigration Monitoring

Trap Efficiencies

Trap retention efficiencies for hatchery yearling chinook salmon, coho salmon, summer steelhead, and subyearling fall chinook salmon are presented in Table 2. For yearling and subyearling chinook salmon and yearling coho salmon, retention efficiencies were not significantly different between tests and were pooled (Table 2). Yearling coho and subyearling fall chinook salmon had the highest trap retention (94 - 96%). The one test for hatchery summer steelhead resulted in no fish retained. Approximately 77% of the yearling chinook salmon were retained.

We marked 1,840 hatchery yearling chinook salmon, 5,023 subyearling fall chinook salmon, 2,593 coho salmon, and 13 summer steelhead for trap collection efficiency tests. Survival of these fish prior to release (24-h mortality tests) was not significantly different for yearling chinook salmon or coho salmon, but there were significant differences in survival for subyearling fall chinook salmon between days (Table 3). Pooled survival for all yearling fish was > 97% (only one test was conducted for summer steelhead). Subyearling fish had best survival in early June (99%), but by mid-June mortality during holding increased, reducing survival to as low as 22%. High ambient air and water temperatures during mid-June (Appendix Table A-1) created poor holding conditions for hatchery subyearling chinook salmon; subsequent 24-h mortality tests were not conducted for this species.

Daily trap collection efficiencies for yearling chinook salmon released from 27 March to 19 April varied between 0.006 and 0.053; 8 groups had no recaptures (Table 4). Marked fish were recaptured from 2 h - 18 d after release, with most fish captured within three days. Data adjusted for trap retention efficiency and combined from 28 - 29 March, 2 - 4 April and 5 - 19 April for Chi^2 analysis showed no significant differences among tests. We therefore pooled the data for a pooled trap efficiency estimate of 0.017 (Table 4).

Twenty-five groups of coho salmon were released for trap efficiency tests from 27 March - 3 June; 12 of these groups had no recaptures (Table 4). Fish were recaptured from 2 h - 17 d after release, with most fish captured within three days. Data adjusted for trap retention efficiency and combined on 27 March and 4 April, 6 - 8 April, 15 - 19 April, 27 - 30 April, 2 - 8 May, 11 - 12 May, and 13 May - 3 June for Chi^2 analysis showed significant differences among groups which precluded pooling the data. As a result, three separate estimates were derived, ranging from 0.011 to 0.144 (Table 4).

Due to low captures of hatchery summer steelhead, we performed only one trap efficiency test on this species. Of 13 fish released, none were recaptured (Table 4).

We released 16 groups of subyearling fall chinook salmon from 3 - 28 June; all had at least one recapture (Table 4). Daily trap efficiencies ranged from 0.007 to 0.075 and marked fish were recaptured from 2 - 40 h after release. Data adjusted for trap retention efficiency and combined on 9 - 10 June, 14 - 15 June, 23 - 24 June, and 26 - 28 June for Chi^2 analyses showed significant differences among some groups which precluded pooling of data. As a result, six separate estimates were derived, ranging from 0.021 to 0.066 (Table 4).

Trap efficiency tests were not conducted for natural chinook salmon, coho salmon, or summer steelhead due to low numbers of fish captured.

The plywood wings attached to the trap pontoons on 21 May maintained the velocity of water through the trapping cone when river flow greatly declined (Table 5). This effectively maintained flow through the trap, more than doubling the proportion of river flow sampled. Prior to the modification, an average of 2.5% of the river flow was sampled at the trap. Post-modification sampling averaged 7.8% of the river flow. Trap efficiency of coho salmon on 23 May increased to 6.3% from 3.3% ten days earlier (Table 4). The mean trap efficiency for subyearling fall chinook salmon captured after installation of the wings was 4.6%, compared to 1.2% for yearling chinook salmon and 3.2% for coho salmon prior to installation. Trap collection efficiency for coho salmon was linearly correlated with proportion of river flow sampled ($r = 0.92$; $P = 0.03$, $N = 5$). Trap efficiency data for other species was lacking for days when velocity measurements were made.

Collection

We monitored the outmigration of juvenile salmonids from 1 October 1996 to 3 July 1997 at the RM 1.2 trap. The trap did not operate for 15 days during this period primarily due to high flows. From 3 July to 30 July 1997, we sampled fish at the Westland Canal juvenile trap during Trap and Haul operations. We did not monitor or sample fish in August or September because of low river flows and few fish.

We collected 45,036 fish at the RM 1.2 site which expanded to 49,256 fish when adjusted for unsampled hours and trap retention efficiency (Table 6). Ninety-nine percent of the fish collected were hatchery salmonids, mostly subyearling fall chinook salmon. Hatchery fish captured represented 0.1 - 1.3% of the fish released. Only 287 natural salmonids were caught at the rotary trap and most were summer steelhead (Table 6). Natural spring chinook salmon were first captured on 23 December 1996, natural coho salmon on 26 December 1996, and natural summer steelhead on 10 January 1997. Natural subyearling fall chinook salmon were first caught on 15 May 1997.

We captured 10 naturally-produced salmon fry (<50 mm) in 1997. These were captured in January (1), March (1), April (3), May (1), and June (4). No natural summer steelhead fry were captured in 1996-97.

We collected 87 scale samples from natural fish for aging by CTUIR biologists; most were from natural summer steelhead ranging in length from 101 mm to 207 mm (Table 7). Of the smolted summer steelhead, 5% were age 1, 78% were age 2 and 17% were age 3. Of the steelhead that were intermediate in smolt status, 22% were age 1, 74% were age 2, and 4% were age 3 (CTUIR, unpublished data).

Trap and Haul

We sampled 2,071 fish from Westland Canal during Trap and Haul operations on 11 days from 3 - 30 July 1997 (Table 6). Hatchery subyearling fall chinook salmon was the dominant salmonid collected at Westland Canal, comprising 99.8% of all fish collected on 3 July to 42.0% of fish collected on 30 July (Table 8). Natural subyearling fall chinook salmon peaked on 21 July when they comprised 6.6% (N = 17) of fish sampled. Resident fish dominated the samples by late-July.

We estimated that 50,829 hatchery subyearling fall chinook salmon were captured at Westland Canal and transported to the mouth of the Umatilla River from 27 June - 30 July 1997 (Appendix Table A-2). Number of transported fish was highest on 3 July, with an estimated 13,000 fish transported. An estimated 466 natural subyearling fall chinook salmon, 81 natural summer steelhead, and 2,048 resident fish were also collected from 27 June - 30 July (Appendix Table A-2).

Photonic Marks

Number and percent of photonic-marked hatchery fish captured at lower river trap sites (RM 1.2 and RM 27.3) was highest for subyearling fall chinook salmon (182; 0.6%), yearling fall chinook salmon (92; 0.9%) and yearling spring chinook salmon (46; 0.9%) and lowest for coho salmon (6; 0.1%) and summer steelhead (3; 0.03%). No marked natural spring chinook salmon or natural summer steelhead were collected. Proportion of marked to unmarked fish detected at trap sites was significantly lower than the proportion of marked to unmarked fish released for coho salmon (yellow marks) and subyearling fall chinook salmon (dark orange, pink, and blue marks; Table 9). Proportion of marked to unmarked fish was not significantly different at release and recapture for yearling spring chinook (dark green mark) or fall chinook salmon (red and orange marks). Recapture of the dark yellow-marked group of summer steelhead was too low to conduct a Chi^2 test. We recaptured no summer steelhead marked with orange or red photonic marks (Table 9).

Comparison of mark quality prior to release and 28-38 d later at recapture for blue, dark orange, and pink marks on subyearling fall chinook salmon was inconclusive. Although the percentage of poor marks increased at recapture for blue and dark orange marks, sample sizes at recapture were too small for statistical analyses (Table 10).

We incorporated photonic marking into our outmigration studies this year primarily to evaluate a prototype remote mark detector in a field setting. Suitable remote detector sites were identified in the bypass channel at West Extension Canal and at the viewing window in the east-bank fish ladder at Three Mile Falls Dam. Remote detectors designed for these sites were constructed and laboratory tested by the manufacturer (New West Technologies, Santa Rosa, CA) in spring 1997. Unfortunately, the remote detectors were damaged during the final stages of field testing and could not be repaired for use in 1997.

Fin Clips

Percent recapture of fish with different fin clips was similar for yearling chinook salmon (RV and ADRV) and summer steelhead (AD and ADLV; Table 11). Percent recapture of RV-clipped subyearling fall chinook salmon was significantly greater than ADRV-clipped subyearlings. The percent recapture of non-clipped coho salmon was significantly greater than AD-clipped fish.

Migration Parameters

Most migration parameters varied between and among hatchery and natural salmonids (Table 12). A proportion of each hatchery release migrated immediately after release and were first captured the following day at RM 1.2. In contrast, migration of natural salmonids began 2-3 months earlier and extended 0-25 d later than migrations of their hatchery counterparts. Winter movement was a greater component of natural yearling chinook salmon and summer steelhead migrations than natural coho salmon migrations. Median capture dates of natural salmonids were within 15 d of their hatchery counterparts even though migration duration of natural and hatchery salmonids varied considerably. Migration parameters for spring and fall races of hatchery yearling chinook salmon were based on collection of relatively few photonic-marked fish (N = 138; Table 12). First, median, last, and peak capture dates based on all hatchery yearling chinook salmon collected (N = 6,863) were 26 March, 30 March, 9 May, and 1 April, respectively.

Timing of the most rapid increases in cumulative percent capture was similar for most natural salmonids and their hatchery counterparts (Figures 8 and 9). Cumulative percent capture of natural salmonids and their hatchery counterparts differed most during the early and later portions of their migration. Peak collection of hatchery and natural fish was in late March for yearling chinook salmon, late April for coho salmon and summer steelhead, and in early June for subyearling fall chinook salmon.

Collection of photonic-marked fish through time suggests migration patterns were different between spring and fall races of hatchery yearling chinook salmon. Almost all photonic-marked yearling fall chinook salmon (reared in either Oregon or Michigan raceways) were collected 2-4 d after release, whereas collection of most photonic-marked yearling spring chinook salmon was slightly more protracted (1-8 d after release; Figure 10). Collection of marked subyearling fall chinook salmon extended up to 34 d (Figure 11). Migration patterns were similar for yearling fall chinook salmon reared in Oregon and Michigan raceways (Figure 10) and for subyearling fall chinook salmon reared at low, medium, and high densities (Figure 11). For subyearling fall chinook salmon, peak collection of photonic-marked fish (low, medium, and high rearing densities) was two days later (4 June; Figure 11) than peak collection of unmarked fish (2 June; Figure 9).

Diel Capture

Natural and hatchery salmonids were predominantly captured at night in the rotary-screw trap from March through June (Table 13). Hours between sunrise and sunset increased from 1 March (06:50 - 18:13; 12.4 h) to 21 June (04:57 - 19:44; 14.8 h). Mean percent capture at night was highest for chinook and coho salmon and lowest for steelhead. Nighttime capture also tended to increase as spring progressed even though the number of nighttime hours was decreasing. Higher daytime movement was only observed for natural summer steelhead in May (Table 13).

Smolt Index

Seasonal changes in smolt indices varied among salmonid species captured at lower river trapping sites (Table 14). Smolt stage generally increased through time for natural and hatchery subyearling fall chinook salmon and summer steelhead. Most natural subyearling fall chinook salmon were classified as parr in May, intermediate in June, and smolt in July. Hatchery subyearling fall chinook salmon developed into smolts earlier than their natural counterparts; they were intermediate in early June and smolt by late June. Proportion of natural summer steelhead classified as smolted increased from 0% in early March to 100% by mid-June. Proportion of smolted hatchery summer steelhead increased from 69% in mid-April after the first release to 100% in early May. The proportion dropped to 80% after the second release in mid-May and increased to 100% by late June. In contrast, proportionally more hatchery yearling chinook salmon were smolted at release than at the end of their migration. Most hatchery coho salmon and natural spring chinook salmon were classified as intermediate throughout their migration. Only 37% of the coho salmon collected in early June were smolted and none of the natural spring chinook salmon were smolted.

Smolt status was significantly correlated ($P < 0.05$) with fork length for all species except hatchery spring chinook salmon and natural coho salmon (Table 15). Graphical analysis revealed subtle differences in the relationship between smolt status and length among species (Figures 12 and 13). Transition from intermediate to smolt status was abrupt for hatchery coho salmon, poorly defined for hatchery summer steelhead, and gradual for the remaining species. Results from ANOVA indicated that mean lengths were significantly different between intermediate and smolted hatchery summer steelhead ($F = 13.08$; $P = 0.001$), among parr, intermediate, and smolted natural summer steelhead ($F = 5.08$; $P = 0.011$), and between intermediate and smolted coho salmon ($F = 6.14$; $P = 0.020$). Mean length differences of hatchery yearling chinook salmon among smoltification levels were near significant ($P = 0.055$), but those for natural chinook salmon and hatchery subyearling fall chinook salmon were not.

Fish Condition and Health

Of the hatchery fish collected, we examined for condition 4,660 yearling chinook salmon, 13,533 subyearling fall chinook salmon, 4,734 coho salmon, and 161 summer steelhead. Most hatchery fish were in good condition with minimal scale loss (Table 16). Although condition of summer steelhead was poorest, mortality of summer steelhead was lowest among all hatchery species (2.3%). Highest mortality was for hatchery subyearling fall chinook salmon (8.6%). On the first day of collection (1 June) and from 10 - 17 June, mortality of subyearling fish collected daily ranged from 12.5% to 34.3% (Appendix Table A-3). During this time, maximum water temperature ranged from 68 - 74° F (Appendix Table A-1). Aside from the high mortality, subyearling fall chinook salmon were in the best condition (Table 16), although scale loss did worsen through time (Appendix Table A-3). Condition of yearling chinook salmon was slightly poorer than subyearling fish but mortality was relatively low overall (3.5%; Table 16). However, mortality was 15% and 40% on 17 April and 20 April when river flow and debris were high (Appendix Tables A-3 and A-1). In contrast to subyearlings, more partially and fully descaled yearling chinook salmon were caught at the beginning of their migration (late March) than at the end (Appendix Table A-3). About 29% of the coho salmon were either partially or fully descaled and mortality was second highest among hatchery fish (5.0%). As with the yearling chinook salmon, mortality increased to 33% in mid-April when river flow and debris were high. Scale loss also increased during this period and in early to mid-May (Appendix Table A-3).

Of the natural fish collected, we examined 87 yearling and subyearling chinook salmon, 10 coho salmon, and 193 summer steelhead. Most natural fish were in better condition than hatchery fish (Table 16; Appendix Table A-4). Nearly all natural summer steelhead were in good condition; all mortalities occurred in mid-April when fish were impinged on tumbleweeds in the trap during high flows. Condition of natural subyearling fall chinook salmon deteriorated by July when captured at Westland Canal, representing most of the scale loss observed on natural chinook salmon.

Other types of injuries or conditions were evident on fish. Injuries were most prevalent on descaled fish and included damage to the eyes, head, operculum, or body, torn caudal fins, bird marks, and other predator attack marks. Conditions included fungal infections, external parasites, and signs of bacterical kidney disease. We observed few cases of black spot disease on natural fish (*Neascus metacercariae*).

We collected 60 dead fish for pathological analysis; most were subyearling fall chinook salmon mortalities. We collected some subyearling mortalities at the base of the bypass outfall at West Extension Canal in mid- and late June. We collected 3 natural summer steelhead (on 4/20), 1 natural chinook salmon (on 5/31), and 1 natural coho salmon (on 6/16).

Natural chinook salmon (91 mm) had no signs of disease and was negative for the Rs antigen (BKD) by ELISA. No pathogens were detected in the natural coho salmon. All three natural summer steelhead were positive for the Rs antigen (ELISA); one was at a clinical level and two were low level positives. However, none of these fish had signs of BKD (ODFW, unpublished data). The heads of all natural fish were taken for *M. cerebralis* examination (whirling disease).

All of the hatchery subyearling fall chinook salmon were positive for the Rs antigen (by ELISA) at a low level, but did not show signs of the disease. The only hatchery coho salmon examined was also positive for the Rs antigen at a low/moderate level and showed no signs of the disease (ODFW, unpublished data).

Lengths

Mean fork lengths of hatchery salmonids captured at the rotary-screw trap were greater than those of their natural counterparts (Table 17). All t-tests indicated a significant difference ($P < 0.05$) between mean fork lengths of hatchery and natural yearling and subyearling chinook salmon, summer steelhead, and coho salmon.

Length-frequency distributions were unimodal for most species of hatchery and natural juvenile salmonids (Figure 14). The length-frequency distribution for natural chinook salmon showed two distinct modes (63 and 104 mm), reflecting the difference between spring and fall races.

Migrant Abundance and Survival

Abundance and survival estimates were determined for most hatchery and natural salmonids collected at the rotary-screw trap (RM 1.2; Table 18). We could not determine abundance estimates for hatchery or natural summer steelhead because few fish were collected. Abundance estimates for natural chinook salmon were near 1,000 fish, based on trap efficiencies of respective hatchery species. All survival estimates of specific hatchery release groups were less than 72% (Table 18).

For yearling chinook salmon, the abundance estimate represented 71.1% (Table 18) of the 519,921 fall chinook salmon released on 25 and 30 March and the 225,883 spring chinook salmon released on 26 March (745,804 total fish released). Upper and lower 95% confidence limits for this estimate represent respective survival estimates of 102.2% and 40.0%. The half width of the confidence interval was within 43.8% of the abundance estimate for yearling chinook salmon.

An estimated 476,378 hatchery coho salmon passed RM 1.2, representing 34.0% of the 1.4 million coho salmon released in early March and early April (Table 18; Appendix Table A-1). Upper and lower 95% confidence limits represent respective survival estimates of 52.9% and 15.1%. The half width of the confidence interval was within 55.6% of the abundance estimate for coho salmon.

Nearly 0.9 million subyearling fall chinook salmon were estimated to have migrated to the lower river, representing 34.9% of the 2.6 million fish released and not transported (Table 18). Upper and lower 95% confidence limits represent respective survival estimates of 38.4% and 30.0%. The half width of the confidence interval was within 12.2% of the abundance estimate for subyearling chinook salmon. Approximately 51,000 subyearlings were captured at Westland Canal and transported to the lower river (Appendix Table A-2). Combined with in-river fish, approximately 36.2% of the subyearling fall chinook salmon survived to the lower river. This estimate does not include the 9% mortality of fish collected at the lower river trap (Table 16).

An estimated 1,200 natural coho salmon and 1,151 natural spring chinook salmon (subyearling and yearling ages) emigrated from the Umatilla River between December 1996 and July 1997 (Table 18). The estimate of 852 natural subyearling fall chinook salmon at the rotary trap (Table 18) combined with the estimated 466 natural subyearlings transported from Westland Canal (Appendix Table A-2) yields a total migrant estimate of 1,318 fish.

Relative survival of different hatchery rearing strategies was indicated by the proportion of photonic-marked fish recaptured at lower river trapping sites. Recapture was not significantly different for yearling fall chinook salmon reared in Oregon (0.9%) and Michigan (0.9%) raceways ($P = 0.84$) or for subyearling fall chinook salmon reared at low (0.6%), medium (0.7%), and high (0.6%) densities ($P = 0.42$). Medium density is the standard rearing density for subyearling chinook salmon.

Survival of photonic-marked yearling chinook salmon was 54% for spring chinook salmon reared in Oregon raceways, and 54% and 52% for yearling fall chinook salmon reared in Oregon and Michigan raceways. These survival estimates were below the estimate for total abundance (71%), but within the 95% CI (40-102%). Survival of photonic-marked subyearling fall chinook salmon representing different rearing densities were similar (12% at high density; 14% at medium density; and 11% at low density). These survival estimates were below the estimate for total abundance (35%) and below the 95% CI (30-38%).

Video Monitoring

Densities of yearling salmonids estimated from underwater video recorded in front of Diffuser 1 at Three Mile Falls Dam ranged from 0.0 fish/ft^2 on 13, 14, 15, and 26 May to 8.2 fish/ft^2 on 30 May. Mean fish densities were lowest at 20% depth and in low velocity water at 80% depth and highest in moderate water velocity at 80% depth (Table 19). Frequency of fish impacts with the diffuser ranged from 0-49 impacts/h/fish and were predominantly light (Figure 15). Hard impacts were most frequent in moderate water velocity at 80% water depth. Light impacts were most frequent in turbulent flow behind the I-beam at 80% water depth (Transect 3). Most fish passed tail-first through Diffuser 1 (Figure 15). Frequency of combined head-first and tail-first passages ranged from 0.0 fish/h/ft^2 (3 sampling locations) to 25.3 fish/h/ft^2 (Transect 5, 80% depth at high velocity).

Densities of subyearling fall chinook salmon estimated from underwater video recorded in front of Diffuser 1 in the east-bank fish ladder at Three Mile Falls Dam ranged from 0.2 fish/ft^2 on 6 June to 91.7 fish/ft^2 on 3 June. Mean fish densities were lowest at 20% depth and in turbulent flow behind the I-beam and greatest in high water velocity at 50% water depth and in low water velocity at 80% water depth (Table 20). Frequency of fish impacts with the diffuser ranged from 0.0-7.2 impacts/h/fish and were predominantly light (Figure 16). Hard and light impacts were frequent at 80% water depth in low and moderate water velocities. Most fish passed tail-first through Diffuser 1 (Figure 16). Frequency of combined head-first and tail-first passages ranged from 0.0 fish/h/ft^2 (high water velocity at 20% water depth) to 5.5 fish/h/ft^2 (turbulent flow at 20% water depth).

Environmental Conditions

River flow, Secchi depth (water clarity), and water temperature recorded below Three Mile Falls Dam from 1 October 1996 through 30 August 1997 are presented in Figure 17. The annual hydrograph was characterized by a series of rises and declines in flow from December through May with peak flows ranging from 1,900-12,400 ft^3/s. Water clarity declined when river flow increased and clarity usually increased during periods of decreasing or stable flow. An increase in flow was usually accompanied by an increase in water temperature in the fall and winter and a decline in water temperature in the spring. High flow was sustained longest in March and April then declined in May. River flow at RM 2 averaged 2,834 ft^3/s in March, 2,201 ft^3/s in April, 756 ft^3/s in May, and 260 ft^3/s in June during the salmonid outmigration. Mean Secchi depth and water temperature gradually increased through the months of March (0.30 m, 43.5^o F), April (0.39 m, 48.5^o F), May (0.94 m, 60.0^o F), and June (1.12 m, 65.7^o F).

River flow was augmented at RM 52 (McKay Creek) in June by releases of stored water from McKay Reservoir to improve fish passage conditions in the lower river. Releases of 25-300 ft^3/s of water from 3-25 June helped sustain 200-370 ft^3/s of flow below Three Mile Falls Dam. Water release was pulsed from 150 ft^3/s on 22 June to 300 ft^3/s from 23-25 June to encourage fish movement.

Peaks in total fish collection were mostly a result of large numbers of fish that migrated immediately after each release of yearling chinook salmon (late March) and subyearling fall chinook salmon (early June), regardless of river conditions (Figure 18). However, increased collections of fish in mid-April and mid-June were associated with elevated river flows and declining Secchi depth.

After the initial peak in fish numbers following hatchery releases, collection of most individual fish species appeared to correspond with river conditions. Increased collection of hatchery and natural coho salmon and hatchery yearling chinook salmon in mid-April was associated with rising flow (Figure 19) and declining Secchi depth (Figure 17). Although the number of natural spring chinook salmon collected was low, the highest number of fish (5) was collected as flow increased in mid-March. Hatchery and natural summer steelhead were collected in highest numbers on the ascending and descending limb of the flow peak in late April (Figure 20). Natural subyearling fall chinook salmon migrated out as flows were near minimum target flows in June and July (Figure 19). Increased movement of hatchery subyearling fall chinook salmon in mid-June appeared to be stimulated by small increases in flow (< 75 ft^3/s) with the release of McKay water (Figure 20) and with corresponding declines in Secchi depth and water temperature (Figure 17). Most hatchery subyearling fall chinook salmon had outmigrated when water from McKay Reservoir was pulsed in late June. However, on the day of the pulsed release, fish numbers slightly increased at the trap (Figure 20).

Few linear correlations existed between collection of each fish species and river flow, Secchi depth, or water temperature (Table 21). Peak fish movements immediately following releases of most hatchery fish resulted in no correlation between total fish collection and river flow or Secchi depth. However, high fish collection following the largest release of hatchery fish (subyearling fall chinook salmon) in late spring when water temperature was coincidentally high resulted in a significant correlation between total fish collection and temperature. River flow and Secchi depth was positively correlated with collections of natural summer steelhead and hatchery coho salmon, but *r*-values were not high (0.37 to -0.42).

Resident Fish and Predators

We collected 5,650 resident, non-salmonid fish in the rotary-screw trap from 2 October 1996 - 3 July 1997. Suckers (*Catostomus spp.*), redside shiners (*Richardsonius balteatus*), and chiselmouth (*Acrocheilus alutaceus*) were the dominant species (Table 22). Of the 176 northern pikeminnow captured, 25 were greater than 200 mm (Figure 21). These larger-sized pikeminnows were captured mostly in January. Collected bass were all juveniles.

We captured 7 adult and 297 juvenile Pacific lamprey (*Lampetra tridentata*) in the rotary-screw trap. Adult lamprey were captured in January (2) and May (5). Two of the five adult lamprey captured in May were dead. Juvenile lamprey were collected from late October through late June and include smolted and non-smolted stages. Movement of juvenile lamprey coincided with high flow; winter freshets brought large numbers of fish into the trap from December 1996 - February 1997 (Figure 22). We captured two size classes of juvenile lamprey at 60-90 mm and 110-190 mm total length (Figure 23). The larger size range was dominant. Adult lamprey ranged from 420 - 600 mm total length.

We observed 106 avian predators at the rotary-screw trap site this year. Gulls (*Laryx spp.*) were the most commonly observed avian predator (67), with peak abundance mostly in October and June. We also observed great blue herons (*Ardea herodias*), kingfishers (*Ceryle alcyon*), and common mergansers (*Mergus merganser*), predominantly in October and November.

Transport Evaluation

We evaluated fish condition and 24-h mortality following juvenile salmonid transport from 3 July - 30 July (Tables 23 and 24). At times during mortality tests, fish held in net pens were tampered with or died due to decreasing river flow (Table 23). Low fish numbers in late July precluded additional testing of fish condition (Table 24).

Overall, 24-h mortality in treatment groups (transported) was 21.5% higher than in control groups (Table 23). Heterogeneity tests (Zar 1974) showed the six test replicates were homogeneous, justifying the use of a pooled Chi^2 analysis. Pooled Chi^2 tests showed that overall mortality of treatment fish was significantly greater ($P < 0.05$; df = 1) than mortality of control fish. ‘Net’ mortality was highest on 19 July (39.1%) and lowest on 18 July (8.0%; Table 23).

We evaluated scale loss before (control) and after (treatment) transport on six occasions (Table 24). On average, treatment groups had 12% fewer ‘good’ fish, 2% more ‘partial’ fish, and 10% more ‘descaled’ fish than control groups. The test replicates were not homogeneous (Chi^2 heterogeneity test; Zar 1974), precluding the use of a pooled Chi^2 analysis. Individual Chi^2 tests showed scale loss of treatment fish was significantly different ($P < 0.05$) than control fish on five of six test dates (Table 24).

DISCUSSION

Outmigration Monitoring

Low trap efficiencies for all hatchery fish species resulted in low capture rates at the rotary-screw trap. Because the trap capture efficiencies were relatively low, fewer fish were caught in 1997 during the outmigration monitoring than in 1995 or 1996 (Knapp et al. 1996, 1998), specifically summer steelhead. Daily trap efficiencies varied more for yearling than subyearling fish, possibly because flow was higher and more variable in early spring when yearling fish were captured. During tests with subyearling fish in June, flow was low and stable.

Summer steelhead appeared to avoid the trap throughout the season and were able to escape from the trap. Because we could not capture a sufficient number of steelhead at any one time, only one trap efficiency test was conducted for hatchery steelhead (with no recaptures) and no tests were conducted for natural steelhead. Similar studies have shown that larger migrants (notably steelhead) are able to avoid rotary traps (Kennen et al. 1994).

Auger or rotary traps usually sample a small proportion of the cross section of a river. Our trap sampled an average of 2.5% of the river flow. Accordingly, trap efficiency estimates for the yearling species in 1997 were near or below this value. In fact, trap efficiency estimates for yearling spring chinook salmon in March 1997 (0.017), 1996 (0.020; Knapp et al. 1998), and 1998 (0.026; Knapp et al. in preparation) were similar to the proportion of flow sampled. When the wood deflectors were installed, the percentage of river flow sampled nearly doubled. This could have `improved our trapping efficiency for subyearling fish. It is unknown what the trapping efficiency for subyearling fish would have been without the deflectors, but the trap could have been more efficient in trapping these smaller fish with weaker swimming abilities.

Diel patterns of fish collection with the rotary-screw trap in 1997 were opposite to those observed when we used the sampling facility at West Extension Canal in 1995 and 1996 (Knapp et al. 1996, 1998). Fish collection was predominantly at night with the rotary-screw trap and during the day at the sampling facility. This contrast in diel fish collection may be attributable to diel differences in capture efficiency of the two trapping methods or reflect behavioral differences of fish in free-flowing river sections (rotary-screw trap) compared with river sections with obstructions (the dam and fish passage facility at West Extension Canal). Once fish are near the bypass channel, capture efficiency of the sampling facility is close to 100%. Whereas, capture efficiency of the screw trap may be lower during daylight due to trap avoidance. Diel mark-recapture studies with subyearling fall chinook salmon in the Sacramento River, California indicated nighttime capture efficiency of a` rotary-screw trap was 3-15 times higher than daytime capture efficiency (Cramer et al. 1990, 1992). If salmonids are moving predominantly during the day in the Umatilla River, as suggested by two previous years of data collected at West Extension Canal, then our fish collections at the rotary-screw trap in 1997 were biased toward nighttime capture. However, predominant daytime movement at West Extension Canal is probably an aberration for diel fish movement in the Umatilla River. Diel capture of river-run salmonids documented during previous work at fish bypass facilities upriver (RM 14.8 - 32.5) was similar to the patterns observed at the rotary-screw trap when substantial numbers of fish (> 50/d) were collected (Cameron et al. 1994, 1995). Similarly, capture of salmonids was predominantly at night during evaluations of fish bypass facilities associated with most canals located on the Yakima River, Washington, except at Roza Canal (Neitzel et al. 1985, Hosey and Associates 1988a, 1988b, 1990). Roza Canal and West Extension Canal are both associated with tall dams and large slack-water dam pools which may affect the normal diel movement of fish.

Due to low trap capture efficiencies for all species sampled, the variability in trap efficiencies, possible trap avoidance, and the low number of fish captured overall, we plan to return to the West Extension Canal sampling facility in 1998 during the irrigation season. Previous monitoring at this site provided us with larger samples of fish and the opportunity to conduct more trap efficiency tests with larger test groups than was possible at the rotary trap (Knapp et al. 1996 and 1998).

Successful mainstem spawning of fall chinook salmon would be indicated by the capture of juvenile fish at lower river traps. In 1995, we sampled 800 fish at West Extension and Maxwell (RM 14) canals and several thousand fish at Westland Canal (Knapp et al. 1996). In 1996, we sampled only 29 subyearling fish at West Extension Canal and none at Westland Canal at RM 27 (Knapp et al. 1998). In 1997, we caught few natural subyearling fall chinook salmon at all trap sites (about 500). We speculate that the flow scenario in the Umatilla River can affect the spawning success of fall chinook salmon. The low number of fall chinook subyearlings captured in 1996 was probably due to floods during the winter of 1995-96 (>14,000 ft^3/s) and spring of 1996 (8,000 ft^3/s) that buried eggs, scoured redds, or displaced natural salmonids rearing in the mainstem. Mid-winter flooding in 1997 exceeded 10,000 ft^3/s at Yoakum (RM 37) which may have had the same affect. In 1995, late winter and early spring flows were less than 6,500 ft^3/s.

Another component of production is the number of adult and jack fall chinook salmon available to spawn. In 1994 and 1995, approximately 800 adult and jack fall chinook salmon returning to the Umatilla River were available to produce 1995 and 1996 migrants (CTUIR and ODFW 1995, 1996). In 1996, most adults were collected for broodstock and only 141 fish were released above Three Mile Falls Dam. However, excess adult fall chinook salmon from Priest Rapids Hatchery (712 fish) were transplanted into the Umatilla River at and below Pendleton in fall 1996. These fish were observed to spawn soon after release within a 7-mile reach upstream from the release site (CTUIR and ODFW 1997). Their progeny were detected in our trap in 1997. Transplanting adult salmon may be a successful strategy for increasing fall chinook salmon production if river conditions are conducive to successful egg incubation and juvenile rearing.

Transport from Westland Canal began on 27 June and ended on 30 July 1997, beginning later and ending sooner than in 1996. This was the latest start date due to the extended release of flow augmentation from McKay Reservoir. Releases of stored water from McKay Reservoir from 3-26 June provided adequate flow in the lower Umatilla River to allow nearly 883,000 of the hatchery fall chinook salmon to migrate naturally. Most of the hatchery subyearling fall chinook salmon sampled (74% or 655,305 fish) migrated quickly after release and passed through the lower river by 10 June. River flow before July 10 has been adequate in most years to allow fish to migrate naturally before they are collected at Westland Canal and transported to the river mouth (Trap and Haul). Release of stored water from 10 June to the initiation of trap and haul operations on 27 June allowed approximately one-quarter of the hatchery fall chinook salmon migration (26% or 226,058 fish) to migrate naturally. This part of the migration normally would have been trapped and transported. Only 2% (50,829 fish) of the hatchery fall chinook salmon released were trapped and transported to the river mouth this year. This compares to 376,000 fish (13%) in 1996 (Knapp et al. 1998) and about 96,500 fish (4%) in 1995 (Knapp et al. 1996). However, the migration of natural subyearling fall chinook salmon peaks in late June and early July. Without continued water releases from McKay Reservoir for fish passage during June, the natural fish are dependent on transport for survival out of the basin.

Migration parameters for salmonids in 1997 followed the same general pattern as in preceding years (Knapp et al. 1996, 1998). Median and peak migration timing of hatchery salmonids have been similar to their natural counterparts for all species except subyearling fall chinook salmon. Similar migration timing suggests release times for these hatchery groups are adequate to mimic “natural” migration patterns. Release date is the primary determinant of migration timing for hatchery yearling chinook salmon and subyearling fall chinook salmon since most of these fish have consistently migrated immediately after release. However, differences between the migration timing of hatchery and natural subyearling fall chinook salmon suggest this species would benefit from a release date closer to the peak natural fall chinook salmon migration (mid-June), assuming natural fish are adapted to the Umatilla River environment. Delaying the release of hatchery subyearling chinook salmon into June would also allow them to reach a larger size that may increase their overall survival. However, river conditions in the lower river usually deteriorate rapidly in June due to low river flow from irrigation withdrawals and warm water temperature. A later release for subyearling fall chinook salmon should be considered if additional water exchange projects (Phase III) are implemented in the future or if McKay water releases are extended to provide suitable fish passage conditions in the lower river through June and into July.

Release date has less effect on migration timing of hatchery coho salmon and summer steelhead since many of these fish hold in the river until environmental conditions or the level of smoltification stimulate migration. Timing releases just prior to changes in environmental conditions that stimulate migration may benefit these two species. Releasing fish too early is probably detrimental because river conditions are usually poor for holding in March (high flow and turbidity) and fish are more vulnerable to predators in-river than at hatchery facilities. Over the past three years, substantial movement through the lower river has begun in early April for hatchery coho salmon and mid-April for hatchery summer steelhead, after their initial releases.

But migrations of both species usually peak 2-4 weeks after these initial movements. However, the later release of summer steelhead “smalls” may also be detrimental. Low smolt-to-adult survival of the mid-May release of summer steelhead compared with a mid-April release (Focher et al. 1998) may be associated with the late release timing. We recommend allowing volitional release of the late group of steelhead soon after transfer to acclimation ponds and conducting the forced release at an earlier date.

We usually collect natural salmonids (chinook and coho salmon, and summer steelhead) in the lower river during the winter months. Winter collection of natural salmonids has been associated with rising or descending flows prior to and after a high water event. We are uncertain whether fish captured in the winter are actively migrating or displaced from upstream reaches. On two previous occasions, winter capture of natural salmonids was associated with movement of hatchery fish. In December 1994, first capture of natural spring chinook salmon was concurrent with movement of hatchery spring chinook salmon released in the fall. In 1995, natural coho salmon movement coincided with a late February release of hatchery coho salmon (Knapp et al. 1996). In either case, winter capture has accounted for 10-30% of the annual capture of natural salmonids. Managers should assume natural salmonids are present in the lower river as early as late November.

Trends in smolt development and migration timing of most salmonids in 1997 were similar to 1996 and 1995 trends. Most hatchery yearling chinook salmon were classified as smolts and migrated immediately after release; late migrants were usually less smolted and smaller than early migrants. We are uncertain whether these later migrants are smaller fish from each release group or mostly smaller spring chinook salmon from Little White Salmon Hatchery. Most hatchery subyearling fall chinook salmon also migrated immediately after release but later migrants were more smolted than early migrants. There were more late-migrating subyearling fall chinook salmon in 1997 (67.0 fish/lb) and 1996 (66.1 fish/lb; Knapp et al. 1998), when fish were less smolted and smaller at release, than in 1995 (63.6 fish/lb; Knapp et al. 1996). Subyearling fall chinook salmon that migrate late probably suffer higher mortality than early migrants due to poorer river conditions. Increased size at release would probably reduce the number of late migrants and perhaps increase survival.

Relatively few hatchery coho salmon and summer steelhead migrated immediately after release. Their peak movements usually coincided with a sharp increase in the proportion of smolted fish as well as changes in river flow. Coho salmon, in particular, required several months to smolt and move out of the basin. This corresponded to a significant increase in mean length.

Even though our main objective of testing a remote photonic mark detector was not met, we gained information on the performance of photonic marking for use in juvenile salmonid outmigration monitoring. Photonic marking was an efficient technique for mass marking juvenile salmonids in most respects. Minimal training was required to produce marks readable to the naked eye and photonic marking rates (450 fish/h/marker) were comparable to freeze-brand marking rates (550 fish/h/marker) used at Umatilla Hatchery in previous years (personal communication, S. Focher, Oregon Department of Fish and Wildlife, Hermiston, OR). Although we had difficulty consistently producing large-sized marks that are preferred for remote detection, the marks were easily visible to the naked eye. We attributed inconsistent mark quality primarily to marking technique and marking gun performance. Marking technique usually improved with experience and we were able to improve poor marks with repeated injections. However, poor gun performance was a more difficult problem to resolve. Marking guns frequently broke-down under the stress of continuous fast-paced use. Replacement of an internal O-ring or valve-stem were the most frequent repairs. One person was usually required for gun repair during mass marking operations with three to six markers.

Our data suggested the effectiveness of photonic marks for monitoring migration patterns and survival of juvenile salmonids was influenced by fish size or by the number of fish captured. Proportion of marked to unmarked fish was essentially identical at release and recapture for yearling chinook salmon but the proportion of marked fish decreased at recapture by 44-54% for smaller subyearling chinook salmon. A significantly lower proportion of marked subyearling fish at recapture could result from poor mark retention or detection, increased vulnerability of marked fish to predation, or mortality associated with the marking process. In recent studies with coho salmon, mark retention after four months in freshwater was 98-99% (personal communication, C. Mallette, ODFW, Clackamas, OR). In addition, mortality associated with photonic marking has been negligible for juvenile coho salmon (personal communication, C. Mallette, ODFW, Clackamas, OR) and chinook salmon (personal communication, D. Thompson, WDFW, Olympia, WA). Differential recovery of marked and unmarked fish would limit the effectiveness of photonic marks for estimating total survival of subyearling chinook salmon. However, photonic marks would still be effective for comparing migration patterns and relative survival of hatchery groups of subyearling chinook salmon provided declines in mark recovery are equal among the varying mark colors or locations used to distinguish these groups. The peak collection of marked subyearling fish was two days later than unmarked fish, possibly because of the inability to discern marks when processing large numbers of fish during peak collection.

The lower relative recapture of adipose fin and ventral fin-clipped fish versus single fin-clipped fish has been a consistent trend in past years (Knapp et al. 1996, 1998) and may signify a survival disadvantage. This has been particularly true with subyearling fall chinook salmon. Unfortunately, these fish are generally collected in such high numbers that accurate and representative fin clip detection is difficult. The difference in relative recapture between ad-clipped and non-clipped coho salmon may also be due to poorer detection of ad-clipped fish, poor fin-clip quality, the confounding presence of natural, non-clipped coho salmon, or marking affects on survival. A study by the Washington Department of Fish and Wildlife with fall chinook salmon indicated lower survival for fish that are ventral-fin clipped or adipose and ventral-fin clipped than fish that are adipose-fin clipped only (WDFW, unpublished data). In fact, adipose-clipped fish had similar smolt-to-adult survival rates as non-clipped fish.

Migrant Abundance and Survival

Confidence intervals (95%) on survival estimates continue to be wide for yearling species collected at the rotary trap because of the difficulty achieving good trap efficiency estimates. We will encounter this same problem in 1998 as yearling spring and fall chinook salmon released in March will be captured at the rotary trap; the West Extension Canal sampling facility comes on-line in early April. However, confidence intervals of abundance estimates for subyearling fall chinook salmon were narrow in 1995 (16-19%; Knapp et al. 1996) and 1997 (30-38%).

For subyearling fall chinook salmon in 1997, in-river survival (35%) and total survival (36%) was similar to the 1995 estimate and indicated a survival problem for this group of fish. Survival estimates for subyearlings in 1995 were 18% for in-river fish only and 21% for in-river and transported fish combined (Knapp et al. 1996). In 1996, we overestimated the abundance of this group of fish. Even though their overall condition was good, mortality was the highest of all species captured, especially as lower river temperatures rose above 70° F. Anecdotal information on dead fish exiting the outfall at the West Extension Canal bypass indicated that fish were dying in-river above the dam. (We collected approximately a dozen dead fish in a shoreline net pen after their exit from the outfall.) We acknowledge that our trap probably caused some of the mortality in the lower river. Because of extremely low flows into the livebox, the high prevalence of aquatic vegetation, and warm water temperatures, holding conditions were poor for these fish. Nonetheless, water quality in June for outmigrating subyearlings will need to be improved if we hope to achieve optimum survival for this species. As it is currently operated, the Umatilla River does not provide good summer passage conditions for juvenile salmon, hatchery or natural. The condition of both groups of fish deteriorated greatly by July.

The 71% survival of yearling chinook salmon represented the combined survival of spring and fall chinook salmon from Umatilla Hatchery (484,836) and fall chinook salmon from Little White Salmon Hatchery (260,968 fish). This estimate is similar to the estimate derived in 1995 where 67% of the combined releases of spring chinook salmon from Umatilla and Bonneville hatcheries survived (Knapp et al. 1996). In addition, the 95% confidence interval for 1995 (37-96%) was similar to 1997 (40-102%).

When we looked at brand recoveries for the separate groups in 1995, branded yearling spring chinook salmon reared at Umatilla Hatchery showed poor smolt survival (19%); whereas, survival of branded spring chinook salmon reared at Bonneville Hatchery was substantially greater (80%; Knapp et al. 1996). In 1996, spring chinook salmon were reared only at Umatilla Hatchery; we estimated their survival to be 34% (Knapp et al. 1998). In the same year, combined releases of yearling fall chinook salmon from Bonneville Hatchery and Umatilla Hatchery had a slightly improved survival (40%; Knapp et al. 1998). Results from photonic-marked fish in 1997 indicated that survival was better for yearling spring and fall chinook salmon reared at Umatilla Hatchery (52-54%). Nonetheless, we attribute the apparent poorer survival of fish reared at Umatilla Hatchery to the hatchery rearing profile which is characterized by unfavorably warm water (Hayes et al. 1998). When releases of yearling chinook salmon from Umatilla Hatchery were combined with fish reared at Bonneville Hatchery, survival estimates increased. Bonneville Hatchery has a better rearing profile (cooler water) than Umatilla Hatchery. It is probable that the presence of yearling chinook salmon from Little White Salmon Hatchery improved the overall survival estimate in 1997 for the same reason. The rearing profile at Little White Salmon Hatchery is similar to that at Bonneville Hatchery and fish were in better condition and less smolted at pre-release than those reared at Umatilla Hatchery (Hayes et al.

1998). Unfortunately, the separate rearing strategies at Umatilla and Little White Salmon hatcheries could not be differentiated during monitoring in 1997 because fish were not differentially marked. We surmise that if the entire yearling production for the Umatilla River were reared at either Bonneville or Little White Salmon hatcheries, survival of yearling chinook salmon would be greater.

Also of importance was the poor condition of yearling chinook salmon at the beginning of their migration in late March. The higher proportion of partially and fully descaled fish coincided with peak movement when fish were most smolted. These fish were probably Umatilla Hatchery fish released on 25 March. Pre-release data for yearling chinook reared at Umatilla Hatchery indicated that 98-100% of the fish were smolted and up to 65% of the fish reared in Michigan raceways were partially descaled (Hayes et al. 1998). These fish would probably benefit from an earlier release as they begin to show signs of being ready to migrate.

The survival estimate and confidence interval for coho salmon (34%; 15-53%) was similar to the estimate derived in 1996 (43%; 30-57%) when we sampled at both the rotary trap and West Extension Canal (Knapp et al. 1998). In 1995, coho salmon abundance was overestimated. The protracted outmigration of this group of fish may contribute to low survival. Past observations have indicated that these fish are preyed on by seagulls. Gull predation activity is intense during coho salmon releases and when river flow is low and water clarity good. The fact that they are in the river over a prolonged period (several months) probably exposes them to higher predation and variable river conditions that are injurious to health. Condition of coho salmon in 1997 was poorer than in 1996 when they were in the best condition of all fish species (Knapp et al. 1998). Twenty-five percent of the fish examined in 1997 were partially descaled and 7% were considered descaled.

In-river conditions, when flow and debris levels are high, affect survival of yearling fish from March to May. In mid-April, debris in the trap caused the death and descaling of some fish, but we also noted dead and descaled fish not influenced by trap conditions. We have observed trashracks at upriver passage facilities occluded with debris (including tumbleweeds) during high flow events. With the releases of yearling chinook and coho salmon during the typical high flow period, it is important to maintain debris-free passage facilities while these fish are moving out. Maintenance personnel need to be available for frequent cleaning of all trashracks as freshets occur.

During three years of outmigration monitoring, only one year provided sufficient data for a plausible survival estimate for summer steelhead. In 1995, abundance was overestimated for summer steelhead (Knapp et al. 1996). In 1996, we estimated that nearly 94% of the hatchery steelhead survived to the lower river (Knapp et al. 1998). In 1997, we were unable to derive abundance estimates because of poor capture and the lack of trap efficiency data. Resumption of sampling at West Extension Canal in 1998 should provide sufficient data on collection numbers and trap efficiency estimates to derive an estimate of abundance and survival. Although summer steelhead tend to be in poor condition compared to other species of fish, they show promise of migrating successfully through the basin. Summer steelhead had the best smolt-to-adult survival this decade compared to other species of salmon (Hayes et al. 1998).

Survival estimates of photonic-marked yearling and subyearling groups were less than the respective survival estimates for total abundance. This may indicate an affect on survival of marking fish or the inability to completely detect all marks on sampled fish. Without good mark detection, it is difficult to assess survival of different rearing strategies, although relative differences between strategies can be ascertained. It may be prudent to use PIT tags in future years to determine survival of hatchery groups as PIT tags can be remotely and more accurately detected.

The samples of natural summer steelhead that were pathologically examined showed positive values for the Rs antigen through ELISA testing. However, these ELISA values may or may not indicate the presence of the Rs antigen for the true BKD bacterium (personal communication, W. Groberg, ODFW Pathology, La Grande, OR). Natural summer steelhead commonly show positive ELISA values, but the implications are unknown. Further investigation is needed.

Abundance of natural chinook (2,469) and coho (1,200) salmon in 1997 was similar to abundance estimates derived in 1996 for the same species. In that year, we estimated that 1,856 yearling and subyearling chinook salmon and 963 coho salmon emigrated from the basin (Knapp et al. 1998). In 1995, natural production for chinook salmon greatly exceeded 1996 and 1997 estimates (74,351 fish), and capture of 328 coho salmon indicated limited production (Knapp et al. 1996). The number of adult and jack fall and spring chinook salmon available to spawn in 1994 (806; 240), 1995 (770; 440), and 1996 (853; 2,216) (CTUIR and ODFW 1994, 1995, 1996, 1997) and the flow scenarios for each year undoubtedly contributed to variable production. The Umatilla River has the potential to produce natural chinook salmon if conditions are favorable. Preliminary counts in 1998 indicate that production of natural chinook salmon will far exceed the 1995 estimate of 74,000 fish, primarily because of favorable flows and secondly because of available spawners (near 2,500 fish; Knapp et al. in preparation).

Video Monitoring

Underwater video monitoring indicated juvenile salmonid passage through Diffuser 1 in the east-bank fish ladder at Three Mile Falls Dam was improved by operation of fish exit gates full open compared with previous operation of the gates about half open. Fully-open gates eliminated the venturi effect of partial gate openings that accelerated inflow velocity and created considerable turbulence. Velocity of water approaching Diffuser 1 was reduced and more uniform and sweeping flow across the diffuser was nearly eliminated when the fish exit gates were fully open. Fish impacts with the diffuser were reduced approximately five-fold for both yearling and subyearling salmonids when fish exit gates were fully open compared to partial-open gates (Knapp et al. 1998). Improved passage was also suggested by the higher proportion of fish passing more “normally” (tail-first) through the diffuser, particularly in locations where fish densities were relatively high. Reduction of sweeping flow across the diffuser appeared to be the primary reason juvenile salmonid passage through the diffuser improved. Swift sweeping flow likely makes passage through the small openings (1 in) between diffuser slats more difficult.

In addition, delayed passage may lead to fatigued fish which increases their probability of impacting the diffuser. We recommend continued operation of the fish exit gates fully open to improve juvenile salmonid passage.

Environmental Conditions

Most patterns of fish movement in relation to environmental conditions have been consistent over the past three years, but results of statistical correlations have vaired. In all three years, yearling and subyearling hatchery chinook salmon and some coho salmon have moved immediately after release regardless of environmental conditions. However, with the prolonged outmigration of coho salmon, their post-release movement is influenced more by environmental variables as increased movement has corresponded with increased flow and associated decreases in water clarity and temperature. Collection of coho salmon was significantly correlated with river flow in both 1997 and 1996 (Knapp et al. 1998). Although correlations were not significant, movement of hatchery summer steelhead increased during rising flows in 1995 (Knapp et al 1996) and 1996 (Knapp et al. 1998); movement was variable in 1997 but few fish were captured. Movement of natural steelhead was significantly correlated with river flow in 1997 but not in 1996 (Knapp et al. 1998). Too few natural chinook and coho salmon were collected at the rotary trap in 1997 to define a valid relationship. The lack of significant correlations for most hatchery species may be a result of hatchery releases obscuring true movement patterns. For species that migrate out over a long period, a definitive relationship between fish movement and environmental parameters is more likely to be found. In general, the overall pattern over the years has been large movements of juvenile salmonids following release and during rising river flow. We reiterate previous recommendations that operators of fish passage facilities be aware of the increased importance in operating facilities within criteria and preventing debris from accumulating on screens and in fish passageways when river flow increases.

The pulsed release of stored water from McKay Reservoir was conducted too late (23-25 June) to determine whether it would stimulate increased movement of subyearling fall chinook salmon. Most late-migrating hatchery subyearling fall chinook salmon had already moved through the lower river before the water release was pulsed. Only a slight response was observed in the movement of hatchery subyearlings on the first day of the pulsed release and no response was observed in the movement of natural subyearling fall chinook salmon. The flow increase in the upper river was dampened by the time it reached the lower river. However, natural increases in flow caused by rainstorms in early June did appear to increase movements of subyearling fall chinook salmon in mid-June. These natural increases in flow were relatively small (< 75 ft^3/s) and accompanied by decreases in water clarity and temperature. Uncertainty remains whether pulsed release of stored water without accompanying decreases in water clarity and temperature will stimulate increased movement of subyearling fall chinook salmon. In addition, it is unknown where late-migrating subyearling fall chinook salmon tend to hold; pulsed release of stored water will only affect fish below the confluence of the Umatilla River and McKay Creek (RM 52). Pulsed water release should be conducted earlier (mid-June) to determine whether this strategy can stimulate movement of subyearling fall chinook salmon.

Resident Fish and Predators

Capture of Pacific lamprey ammocetes was common in 1997. In 1997 and 1996 (Knapp et al. 1998), we captured more ammocetes in the rotary-screw trap during the fall and winter than we captured during spring and summer sampling at West Extension Canal in 1996. The difference in numbers captured may be due to seasonal differences in ammocete abundance, to differential capture between the two sampling sites, or to their location.

The rotary-screw trap is approximately 2 miles downstream of Three Mile Falls Dam. If lamprey ammocetes were rearing primarily below the dam, higher captures in that area would be expected. However, when we operated only the rotary-screw trap in 1997, we observed a seasonal variation in ammocete movement. Ammocete captures were high during the fall and winter, especially during high river flows and increased turbidity. Since ammocetes rear in river bottom sediments (Close et al. 1995), high flows and disturbances to the river bottom would wash some ammocetes from their burrows. A portion of the ammocetes captured were fully developed juvenile migrants with silvery coloration and visible eyes. Others were pre-metamorphosis larvae with brown coloration and undefined eyes and mouths. This suggests the pre-metamorphosis juveniles were not as prepared to migrate as the fully developed juveniles were. The two types of ammocetes were captured at the same time, suggesting that the pre-metamorphosis ammocetes were being washed out of their burrows and the developed ammocetes were actively migrating.

Adult Pacific lamprey overwinter in the Columbia Basin typically enter the spawning streams between spring and fall and overwinter before spawning in the summer of the following year (Close et al. 1995). Therefore, adult Pacific lamprey captured in the rotary-screw trap were probably pre-spawn fish. The capture of two dead adult lamprey in the spring was unusual, since adults sampled at other sites in previous years were captured live (Knapp et al. 1996, 1998). These fish were both partially decomposed, indicating that they were dead when captured, and were probably pre-spawn mortalities.

The only piscine predator of a significant size to prey upon juvenile salmonids captured in 1997 was northern pikeminnow. Northern pikeminnow are considered potential predators if they are over 200 mm in length (Collis et al. 1995). We captured fish of this size in January. Although few hatchery fish are present in the river at this time, we were collecting natural chinook salmon and summer steelhead.

We observed fewer avian predators in 1997 than in 1995 or 1996 (Knapp et al. 1996, 1998). The limited observations were probably due to the fact that we sampled in the river and not at a canal facility. Fish are more vulnerable to predation near West Extension Canal where they are visible as they approach and spill over the dam, pass through narrow passageways, and surface in turbulent waters. Conditions near the rotary-screw trap appeared to be less favorable to avian predators and not serve as a good index site for monitoring bird predation activity.

Transport Evaluation

Transport mortality was higher in 1997 (22%) than in 1996 (10%; Knapp et al. 1998). However, fewer tests were replicated in 1997 because of the brief period of Trap and Haul operations. We modified our study protocol slightly in 1997 in an attempt to limit losses because of poor holding conditions in the lower river and vandalism. Treatment fish were relocated upriver from the boat dock to a more protected area with improved flow for 24-h holding. However, the extra handling required to transport fish to this site may have affected their survival potential. Nonetheless, average net mortality in 1996 and 1997 combined was 13%. The loss of survivability and increased scale loss during transport emphasizes the need to reduce reliance on transport. We continue to recommend prolonged release of McKay Reservoir water through June to allow the bulk of the subyearling fall chinook salmon to migrate out in-river. Although fish may die in river, the stress of handling would be eliminated.

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LITERATURE CITED

Boyce, R.R. 1986. A comprehensive plan for rehabilitation of anadromous fish stocks in the Umatilla River basin. Final report of Oregon Department of Fish and Wildlife to the Bonneville Power Administration, Portland, Oregon.

Burnham, K.P., D.R. Anderson, G.C. White, C. Brownie, and K.H. Pollock. 1987. Design and analysis methods for fish survival experiments based on release-recapture. American Fisheries Society Monograph 5:1-437.

Cameron, W.A., S.M. Knapp, and B.P. Schrank. 1994. Evaluation of juvenile fish bypass and adult fish passage facilities at water diversions in the Umatilla River. 1993 annual progress report to Bonneville Power Administration, Portland, Oregon.

Cameron, W.A., S.M. Knapp, and B.P. Schrank. 1995. Evaluation of juvenile fish bypass and adult fish passage facilities at water diversions in the Umatilla River. 1994 annual progress report to Bonneville Power Administration, Portland, Oregon.

Cameron, W.C., S.M. Knapp, and R.W. Carmichael. 1997. Evaluation of juvenile salmonid bypass facilities and passage at water diversions on the lower Umatilla River. Final report to Bonneville Power Administration, Portland, Oregon.

Close, D., M. Fitzpatrick, H. Li, B. Parker, D. Hatch, and G. James. 1995. Status report of the Pacific Lamprey (*Lampetra tridentata*) in the Columbia River Basin. Report to Bonneville Power Administration, Portland, Oregon.

Collis, K., R.E. Beaty, B.Ashe, B. Parker, K. McRae, and G. Lee. 1995. Report E *in* C.Willis and D. Ward, editors. Development of a systemwide predator control program: Stepwise implementation of a predation index, predator control fisheries, and evaluation plan in the Columbia River basin. Volume 1-Implementation. 1993 annual progress report to Bonneville Power Administration, Portland, Oregon.

Contor, C.R., E. Hoverson, P. Kissner, and J. Volkman. 1996. Umatilla basin natural production and evaluation. Annual progress report 1994-1995 to Bonneville Power Administration, Portland, Oregon.

Contor, C.R., E. Hoverson, P. Kissner, and J. Volkman. 1997. Umatilla basin natural production and evaluation. Annual progress report 1995-1996 to Bonneville Power Administration, Portland, Oregon.

Contor, C.R., E. Hoverson, and P. Kissner. 1998. Umatilla basin natural production and evaluation. Annual progress report 1996-1997 to Bonneville Power Administration, Portland, Oregon.

Cramer, S.P., D. Demko, D. Fleming, and T. Loera. 1990. Survival of juvenile chinook salmon at the Glenn-Colusa Irrigation District's intake. Progress report, April-July 1990, to Glenn-Colusa Irrigation District, Willows, California.

Cramer, S.P., D. Demko, C. Fleming, T. Loera, and D. Neeley. 1992. Juvenile chinook passage investigations at Glenn-Colusa Irrigation District Diversion. 1991 Annual report submitted to the Glenn-Colusa Irrigation District, Willows, California.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation). 1984. Umatilla basin recommended salmon and steelhead habitat (hatchery and passage) improvement measures. Pendleton, Oregon.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1989. Umatilla River subbasin - salmon and steelhead plan. Prepared for the Northwest Power Planning Council for Columbia Basin system planning.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1990. Umatilla hatchery master plan. Prepared for the Northwest Power Planning Council, Portland, Oregon.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation). 1994. Umatilla basin natural production monitoring and evaluation. Annual progress report 1992-1993 to Bonneville Power Administration, Portland, Oregon.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1992. Trapping and transportation of adult and juvenile salmon in the lower Umatilla River in Northeast Oregon. Umatilla River Basin trap and haul program. Annual progress report to Bonneville Power Administration, Portland, Oregon

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1994. Trapping and transportation of adult and juvenile salmon in the lower Umatilla River in northeast Oregon, 1993 - 1994. Umatilla River basin trap and haul program. Annual progress report to the Bonneville Power Administration, Portland, Oregon.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1995. Trapping and transportation of adult and juvenile salmon in the lower Umatilla River in northeast Oregon, 1994 - 1995. Umatilla River basin trap and haul program. Annual progress report to the Bonneville Power Administration, Portland, Oregon.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1996. Trapping and transportation of adult and juvenile salmon in the lower Umatilla River in northeast Oregon, 1995-1996. Umatilla River basin trap and haul program. Annual progress report to the Bonneville Power Administration, Portland, Oregon.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1997. Trapping and transportation of adult and juvenile salmon in the lower Umatilla River in northeast Oregon, 1996-1997. Umatilla River basin trap and haul program. Annual progress report to the Bonneville Power Administration, Portland, Oregon.

Dauble, D.D., J. Skalski, A. Hoffman, and A.E. Giorgi. 1993. Evaluation and application of statistical methods for estimating smolt survival. Report to the Bonneville Power Administration, Portland, Oregon.

Efron, B. and R. Tibshirani. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science 1(1): 54-77.

Focher, S.M., R.W. Carmichael, M.C. Hayes, and R.W. Stonecypher, Jr. 1998. Umatilla hatchery monitoring and evaluation. 1996 annual progress report to Bonneville Power Administration, Portland, Oregon.

Hayes, M.C., R.W. Carmichael, S.M. Focher, M.L. Keefe, and G.W. Love. 1995. Umatilla Hatchery monitoring and evaluation. 1994 annual progress report to Bonneville Power Administration, Portland, Oregon.

Hayes, M.C., R.W. Carmichael, S.M. Focher, and R.W. Stonecypher, Jr. 1996. Umatilla Hatchery monitoring and evaluation. 1995 annual progress report to Bonneville Power Administration, Portland, Oregon.

Hayes, M.C., R.W. Carmichael, S.M. Focher, and R.W. Stonecypher, Jr. 1998. Umatilla Hatchery monitoring and evaluation. 1997 annual progress report to Bonneville Power Administration, Portland, Oregon.

Hosey and Associates. 1988a. Evaluation of the effectiveness of fish protection facilities, Chandler facility evaluation. Report to U.S. Bureau of Reclamation, Yakima, Washington.

Hosey and Associates. 1988b. Evaluation of effectiveness of fish protection facilities, Columbia facility evaluation. Report to U.S. Bureau of Reclamation, Yakima, Washington.

Hosey and Associates. 1990. Evluation of effectiveness of Chandler, Columbia, Roza, and Easton screening facilities. Report to U.S. Bureau of Reclamation, Yakima, Washington.

Keefe, M.L., R.W. Carmichael, R.A. French, W.J. Groberg, and M.C. Hayes. 1993. Fish research project - Oregon. Umatilla Hatchery monitoring and evaluation. 1992 annual progress report to Bonneville Power Administration, Portland, Oregon.

Keefe, M.L., R.W. Carmichael, S.M. Focher, W.J. Groberg, and M.C. Hayes. 1994. Umatilla Hatchery monitoring and evaluation. 1993 annual progress report to Bonneville Power Administration, Portland, Oregon.

Kennen, J.G., S.J. Wisniewski, N.H. Ringler, and H.M. Hawkins. 1994. Application and modification of an auger trap to quantify emigrating fishes in Lake Ontario tributaries. North American Journal of Fisheries Management 14:828-836.

Knapp, S.M., J.C. Kern, W.A. Cameron, S.L. Shapleigh, and R.W. Carmichael. 1996. Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin. Annual progress report 1994-1995 to Bonneville Power Administration, Portland, Oregon.

Knapp, S.M., J.C. Kern, W.A. Cameron, S.M. Snedaker, and R.W. Carmichael. 1998. Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin. Annual progress report 1995-1996 to Bonneville Power Administration, Portland, Oregon.

Knapp, S.M., S.M. Focher, J.C. Kern, and R.W. Carmichael. In preparation. Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin. Annual progress report 1997-1998 to Bonneville Power Administration, Portland, Oregon.

Neitzel, D.A., C.S. Abernethy, E.W. Lusty, and L.A. Prohammer. 1985. A fisheries evaluation of the Sunnyside Canal fish screening facility. Report to Bonneville Power Administration, Portland, Oregon.

NPPC (Northwest Power Planning Council). 1987. Columbia River basin fish and wildlife program (as amended). Northwest Power Planning Council, Portland, Oregon.

Rowan, G. 1997. Minthorn Springs Creek summer juvenile release and adult collection facility. 1996 annual progress report to Bonneville Power Administration, Portland, Oregon.

SAS Institute, Inc. 1990. SAS language: reference, version 6, first edition. Cary, North Carolina.

Thedinga, J.F., M.L. Murphy, S.W. Johnson, J.M. Lorenz, and K.V. Koski, 1994. Determination of smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14: 837-851.

USBR (U.S. Bureau of Reclamation). 1988. Umatilla Basin Project - Planning report and final environmental impact statement. Statement Number FES 88-4, filed February 12, 1988.

USBR (U.S. Bureau of Reclamation) and BPA (Bonneville Power Administration). 1989. Umatilla basin project. Initial project workplan presented to the Northwest Power Planning Council, May 1989.

Walters, T.R., R.D. Ewing, M.A. Lewis, R.W. Carmichael, and M.L. Keefe. 1994. Evaluation of effects of transporting juvenile salmonids on the Umatilla River at high temperatures. Pages 117-130 *in* S.M. Knapp, editor. Evaluation of juvenile fish bypass and adult fish passage facilities at water diversions in the Umatilla River. Annual progress report to Bonneville Power Administration, Portland, Oregon.

Zar, J.H. 1974. Biostatistical Analysis, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Table 1. Rearing, marking, and release information for photonic-marked hatchery and natural salmonids, Umatilla River, spring 1997.

Species[a]	Hatchery[b]	Rearing System	Rearing Density	Mark Color	Marking date	Release date	Number[c] marked	Total[d] release
HCHS	UFH	Oregon	normal	dark green	11 March	26 March	5,012	225,883
HCHF	UFH	Michigan	normal	red	13 March	25 March	5,109	153,043
HCHF	UFH	Oregon	normal	orange	19 March	25 March	5,114	105,910
HCOH	LHC + GC	Oregon	normal	yellow	1, 2, 5 April	1, 2, 5 April	4,980	1,400,929
HSTS	UFH	Michigan	normal	orange	27 March	6-15 May	2,528	
HSTS	UFH	Michigan	normal	red	27 March	6-15 May	1,849	48,944
HSTS	UFH	Michigan	normal	dark yellow	27, 28 March	6-15 May	5,706	
HCHF0	UFH	Michigan	low	dark orange	6 May	30 May	9,905	586,621
HCHF0	UFH	Michigan	intermediate	pink	5 May	30 May	10,144	893,453
HCHF0	UFH	Michigan	high	blue	6 May	30 May	10,067	1,100,759
NCHS	--	--	--	cryptic blue	1996-97	1996-97	1,397[e]	--
NSTS	--	--	--	cryptic green	1996-97	1996-97	57[e]	--

[a] *HCHS = hatchery spring chinook salmon, HCHF = hatchery yearling fall chinook salmon, HCOH = hatchery coho salmon, HSTS = hatchery summer steelhead, HCHF0 = hatchery subyearling fall chinook salmon, NCHS = natural spring chinook salmon, NSTS = natural summer steelhead.*
[b] *LHC = Lower Herman Creek Hatchery, GC = Gnat Creek Hatchery, UFH = Umatilla Hatchery.*
[c] *Number of marked fish at time of release.*
[d] *Total number of photonic-marked and non-photonic-marked fish released by species, rearing system, and rearing density.*
[e] *Data from Contor et al. 1998.*

Table 2. Retention of hatchery fish released into the rotary-screw trap live box and trap retention efficiency, lower Umatilla River, spring 1997.

Date	Number live boxed	Number retained	Length of test (h)	Retention efficiency
		Yearling chinook salmon (fall and spring races combined)		
3/31	24	14	9.0	0.58
4/05	18	17	8.5	0.94
4/22	5	3	--	0.60
4/27	9	9	11.3	1.00
			Pooled retention efficiency	*0.77*
				($X^2 = 1.48$; $P = 0.69$; $df = 3$)
		Coho salmon		
4/09	14	14	13.0	1.00
4/11	6	6	13.5	1.00
4/21	23	23	11.5	1.00
4/22	25	24	--	0.96
4/23	9	8	--	0.89
4/24	11	11	--	1.00
5/19	10	8	18.0	0.80
			Pooled retention efficiency	*0.96*
				($X^2 = 0.22$; $P = 1.00$; $df = 6$)
		Summer steelhead		
5/22	3	0	17	0.00
		Subyearling fall chinook salmon		
6/04	20	19	9.5	0.95
6/05	20	19	11.0	0.95
6/07	25	25	11.5	1.00
6/16	20	15	9.0	0.75
6/17	20	19	4.0	0.95
6/17	5	5	8.5	1.00
6/18	20	20	4.0	1.00
6/18	20	19	10.5	0.95
6/19	20	20	12.0	1.00

Table 2. Continued

Date	Number live boxed	Number retained	Length of test (h)	Retention efficiency
		Subyearling fall chinook salmon (continued)		
6/19	20	20	6.5	1.00
6/20	20	17	10.0	0.85
6/23	4	4	11.0	1.00
			Pooled retention efficiency	*0.94*
				($X^2 = 0.67$; $P = 1.00$; $df = 8$)

Table 3. Marking, holding, and survival of hatchery juvenile salmonids used in trap efficiency tests at the rotary-screw trap (RM 1.2), lower Umatilla River, spring 1997.

				24-h Holding at West Extension Canal		
Mark date	Mark[a]	Number marked	Number transported	Number held[b]	Number of mortalities	Percent survival[c]
			Yearling chinook salmon (fall and spring races combined)			
3/27	R1	210	210	202	0	100%
3/27	R2	161	160	160	4	98%
3/28	R3	244	163	128	4	97%
3/29	R4	238	225	218	2	99%
4/01	R6	156	154	153	0	100%
4/02	R7	177	175	175	0	100%
4/03	R8	98	98	98	2	98%
4/04	R9	133	132	130	0	100%
4/06	B1	3	32	32	3	91%
4/07	B2	13	13	12	0	100%
4/09	B3	32	30	28	3	89%
4/11	B4	34	34	34	2	94%
4/14	B5	56	54	54	2	96%
4/16	B6	126	123	122	0	100%
4/18	B7	22	22	21	2	90%
4/18	B8	26	26	25	0	100%
4/20	B9	49	49	49	0	100%
4/20	B10	32	28	26	0	100%
				Pooled Estimate		*99%*
				(X^2 = 0.49; P = 1.00; df = 17)		
			Coho salmon			
3/26	R1	4	4	4	0	100%
4/03	R8	52	50	48	2	96%
4/04	R9	42	41	32	0	100%
4/05	R10	72	72	72	0	100%
4/06	B1	64	63	63	0	100%
4/07	B2	16	16	16	0	100%

[a] *Mark colors: R = red, B = blue, G = green, O = orange, P = purple.*
*Mark locations 1-10 correspond to different marking positions (see **Methods**).*

[b] *Number held reflects mortalities after marking and during transport, and escape of fish from holding tank at West Extension Canal.*

[c] *Percent survival is based on 24-h holding mortalities only and is the expected survivalof test fish after release. Survival values listed singly were not pooled.*

Table 3. Continued

Mark date	Mark[a]	Number marked	Number transported	24-h Holding at West Extension Canal: Number held[b]	Number of mortalities	Percent survival[c]
			Coho salmon (continued)			
4/14	B5	51	51	51	0	100%
4/16	B6	165	164	164	6	96%
4/17	B7	150	147	147	3	98%
4/18	B8	122	122	121	0	100%
4/20	B9	111	111	111	1	99%
4/20	B10	214	177	160	30	81%
4/26	G4	107	107	107	2	98%
4/27	G5	81	81	81	0	100%
4/29	G6	182	167	165	6	96%
5/01	G7	126	126	124	0	100%
5/02	G8/G9	86	86	86	0	100%
5/04	G10	55	53	53	0	100%
5/06	O1	69	69	69	0	100%
5/07	O2	97	95	95	0	100%
5/08	O3	71	71	71	0	100%
5/10	O4	117	117	117	0	100%
5/11	O5	137	137	137	0	100%
5/12	O6	154	154	154	0	100%
5/13	O7	70	70	70	11	84%
5/15	O8	44	44	44	0	100%
5/18	O9	80	80	80	0	100%
5/22	P1	18	17	17	1	94%
5/26	P2	21	21	--	--	--[d]
6/02	P3	15	14	14	3	79%
				Pooled Estimate		*97%*
				(X^2 *= 3.89; P = 1.00; df =28*)		
			Summer steelhead			
5/15	O8	13	13	13	0	100%
			Subyearling fall chinook salmon			
6/02	P3	647	619	619	1	99%

6/03	P4	684	670	670	7	99%
6/04	P5	357	330	330	3	99%

Table 3. Continued

				24-h Holding at West Extension Canal		
Mark date	Mark[a]	Number marked	Number transported	Number held[b]	Number of mortalities	Percent survival[c]
		Subyearling fall chinook salmon (continued)				
6/05	R1	399	397	397	1	99%
6/06	R2	563	556	556	14	97%
				Pooled Estimate		*99%*
				($X^2 = 0.10; P = 0.99; df = 4$)		
6/07	R3	528	527	505	133	74%
6/08	R4	231	228	227	17	93%
6/09	R5	232	223	223	42	81%
				Pooled Estimate		*87%*
				($X^2 = 0.89; P = 0.35; df = 1$)		
6/10	R6	61	58	58	45	22%
6/12	R7	155	117	117	47	60%
6/13	R8	284	200	--	--	--[d]
6/14	R9	272	189	--	--	--[d]
6/15	R10	264	166	--	--	--[d]
6/23	B1	114	110	--	--	--[d]
6/24	B2	102	94	--	--	--[d]
6/26	B3	98	83	--	--	--[d]
6/28	B4	32	28	--	--	--[d]

[d] *No holding tests were conducted; fish were immediately released after marking due to poor holding conditions.*

Table 4. Mark, release, and actual recapture of hatchery juvenile salmonids and trap efficiency estimates at the rotary-screw trap (RM 1.2), lower Umatilla River, spring 1997.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency
		Yearling chinook salmon (spring and fall races combined)		
3/27	R1	199	2 (1) 2 (3)	0.020
3/28	R2	154	1 (1)	0.006
3/29	R3	122	1 (3) 1 (5) 1(18)	0.025
3/30	R4	213	1(1) 2 (2) 1 (7)	0.019
4/02	R6	151	0	--
4/03	R7	172	0	--
4/04	R8	95	5 (1)	0.053
4/05	R9	128	2 (1)	0.016
4/07	B1	29	1 (1)	0.038
4/08	B2	12	0	--
4/10	B3	25	0	--
4/12	B4	32	0	--
4/15	B5	51	0	--
4/17	B6	120	0	--
4/19	B7/B8	44	0	--
			Pooled Estimate	*0.017*
				(X^2 = 3.148; P = 0.533; df = 4)
		Coho salmon		
3/27	R1	4	1 (34)	0.250
4/04	R8	45	4 (1)	0.089
4/05	R9	31	6 (1)	0.194
			Pooled Estimate	*0.144*
				(X^2 = 0.452; P = 0.501; df = 1)
4/06	R10	70	0	--
4/07	B1	61	1 (6)	0.016
4/08	B2	16	0	--
4/15	B5	50	1 (1)	0.020
4/17	B6	154	0	--
4/18	B7	140	2 (1)	0.014
4/19	B8	118	0	--

[a] *Mark colors: R = red, B = blue, G = green, O = orange, P = purple.*
*Mark locations 1-10 correspond to different marking positions (see **Methods**).*

[b] *Number released was adjusted by expected survival of fish.*

[c] *Number recaptured was adjusted by the expected retention of fish in the trap.*

Table 4. Continued.

Release date	Mark	Number released[b]	Number recaptured (days after release)[c]	Trap efficiency
			Coho salmon (continued)	
4/27	G4	102	1 (1)	0.010
4/28	G5	79	1 (3)	0.013
4/30	G6	155	1 (1) 1 (3) 1 (17)	0.019
5/02	G7	121	2 (1) 1 (2)	0.025
5/03	G8/G9	84	0	--
5/05	G10	52	0	--
5/07	O1	67	2 (1)	0.030
5/08	O2	93	0	--
			Pooled Estimate	*0.011*
				(X^2 = 1.161; P = 0.656; df = 3)
5/09	O3	69	3 (1) 1 (9)	0.058
5/11	O4	114	2 (1)	0.018
5/12	O5	133	2 (1) 1 (6)	0.023
5/13	O6	150	5 (1)	0.033
5/14	O7	57	0	--
5/16	O8	43	0	--
5/19	O9	78	0	--
5/23	P1	16	1 (1)	0.063
5/27	P2	20	0	--
6/03	P3	11	0	--
			Pooled Estimate	*0.028*
				(X^2 = 2.755; P = 0.252; df = 2)
			Summer steelhead	
5/16	O8	13	0	--
			Subyearling fall chinook salmon	
6/03	P3	612	11 (1) 9 (2)	0.033[d]
6/04	P4	656	43 (1)	0.066[d]
6/05	P5	324	9 (1) 1 (2)	0.029[d]

[d] *Trap efficiency estimates listed singly were not pooled.*

Table 4. Continued.

Release date	Mark[a]	Number released[b]	Number recaptured (days after release)[c]	Trap efficiency
		Subyearling fall chinook salmon (continued)		
6/06	R1	391	17 (1) 8 (2)	0.065
6/07	R2	536	23 (1) 2 (2)	0.047
6/08	R3	274	16 (1)	0.058
			Pooled Estimate	*0.055*
				(X^2 = 1.222;P = 0.543; df = 2)
6/09	R4	182	6 (1)	0.035
6/10	R5	157	1 (1)	0.007
			Pooled Estimate[e]	*0.021*
6/13	R7 + R8	162	9 (1) 1 (2)	0.066
6/14	R9	113	2 (2)	0.019
6/15	R10	99	4 (1)	0.043
6/23	B1	66	1 (1)	0.016
6/24	B2	56	4 (1)	0.075
6/26	B3	50	1 (1) 2 (2)	0.064
6/28	B4	17	1 (1)	0.063
			Pooled Estimate	0.046
				(X^2 = 3.365; P = 0.339; df = 3)

[e] *Estimate was pooled to eliminate the single recapture on 6/10. No Chi^2 test conducted.*

Table 5. Water velocity measurements, river flow, and percent of river flow sampled at the rotary-screw trap (RM 1.2), lower Umatilla River, December 1996 - June 1997.

Date	Velocity at trap (ft/s)	Flow through trap (ft^3/s)	River flow (ft^3/s)	Percent of river flow sampled
12/09/96	4.6	39.5	1440	2.7%
1/07/97	5.7	49.0	1890	2.6%
1/29/97	2.4	20.4	641	3.2%
2/06/97	4.0	34.7	1880	1.9%
2/10/97	3.2	27.5	1050	2.6%
2/21/97	4.9	41.8	1930	2.2%
3/06/97	2.9	25.1	871	2.9%
4/08/97	2.9	25.5	905	2.8%
4/15/97	4.6	39.6	1330	2.9%
4/29/97	4.6	39.6	2620	1.5%
5/13/97	2.5	21.4	844	2.5%
5/22/97 [a]	2.2	19.2	235	8.2%
5/28/97	2.0	17.2	266	6.5%
6/10/97	2.4	20.6	242	8.5%
6/19/97	2.2	18.9	226	8.4%

[a] *Deflector wings were installed on 21 May 1997.*

Table 6. Actual and adjusted collection of hatchery and natural juvenile salmonids at two sampling sites on the lower Umatilla River, October 1996 - July 1997. Mean fork length is in millimeters.

Site, Species[a]	Origin	Age	Mean FL(SE)	Number collected[b]	Number released[c]	Release date[d]	Percent of release
Rotary Screw Trap (RM 1.2)							
CH	H	1^+	152(1.02)	8,938	745,804	3/26/97	1.2%
CHF	H	0^+	91 (0.20)	33,479	2,580,833	5/30/97	1.3%
COH	H	1^+	142(0.33)	6,367	1,400,929	4/05/97	0.5%
STS	H	1^+	221(2.85)	177	137,287	5/15/97	0.1%
CHS	N	1^{+e}	105(2.11)	22	--	--	--
CHF	N	0^+	64(2.79)	35			
COH	N	0^+	69(12.98)	16	--	--	--
STS	N	1^{+e}	157(1.67)	222	--	--	--
Total Adjusted Collected				*49,256*			
Westland Canal (RM 27.3)							
CHF	H	0^+	106(1.01)	2,017	2,580,833	5/30/97	0.1%
CHF	N	0^+	89(1.44)	53	--	--	--
STS	N	1^{+e}	79(--)	1	--	--	--
Total Collected				*2,071*			

[a] *CH = chinook salmon, CHF = fall chinook salmon, CHS = spring chinook salmon, COH = coho salmon, STS = summer steelhead.*

[b] *Number collected was expanded for non-sampled hours during 24-h collection and adjusted for trap retention efficiency at the rotary-screw trap (RM 1.2). Natural fish collection was adjusted by the trap retention efficiency estimates of hatchery conspecifics.*

[c] *Number released is the number of hatchery fish released during or before sampling at the specific site.*

[d] *Release date is the date of last release for the designated group of fish.*

[e] *Age of natural spring chinook salmon includes 0^+ and 1^+ fish. Age of natural summer steelhead includes 1^+, 2^+, and 3^+ fish.*

Table 7. Scale samples from natural juvenile salmonids collected at RM 1.2 on the Umatilla River, December 1996 - June 1997.

Species[a]	Smolt index[b]	Number	Fork length (mm) Min.	Fork length (mm) Max.	Dates collected
NSTS	I	38	101	203	1/13/97 - 4/5/97
NSTS	S	38	146	207	4/7/97 - 6/5/97
NCHS	I	4	97	116	12/23/96 - 3/17/97
NCHS	S	1	111		4/14/97
NCHF	P	1	92		5/14/97
NCHF	I	3	88	90	5/9/97 - 5/31/97
NCOH	I	2	110	134	4/16/97 - 4/19/97

[a] *NSTS = natural summer steelhead, NCHS = natural spring chinook salmon, NCHF = natural fall chinook salmon, NCOH = natural coho salmon.*
[b] *I = intermediate smolt status, S = smolt status, P = parr.*

Table 8. Species composition of fish sampled from Westland Canal during ~~Trap and Haul~~ transport evaluation tests, Umatilla River, 3 July - 30 July 1997.

Date	Hatchery subyearling fall chinook salmon		Natural subyearling fall chinook salmon		Natural summer steeelhead		Resident fish	
	Numbe r	Percent	Numbe r	Percent	Numbe r	Percent	Number	Percent
7/03	393	(99.8%)	--	--	--	--	1	(0.3%)
7/10	321	(97.9%)	2	(0.6%)	--	--	5	(1.5%)
7/11	216	(88.9%)	2	(0.8%)	--	--	25	(10.3%)
7/14	363	(96.0%)	4	(1.1%)	--	--	11	(2.9%)
7/17	262	(93.9%)	7	(2.5%)	--	--	10	(3.6%)
7/18	141	(91.6%)	3	(2.0%)	--	--	10	(6.5%)
7/21	119	(46.5%)	17	(6.6%)	--	--	120	(46.9%)
7/24	95	(57.6%)	9	(5.5%)	1	(0.6%)	60	(36.4%)
7/28	65	(31.0%)	7	(3.3%)	--	--	138	(65.7%)
7/30	42	(42.0%)	2	(2.0%)	--	--	56	(56.0%)
Total	*2,017*	*(80.5%)*	*53*	*(2.1%)*	*1*	*(0.1%)*	*436*	*(17.4%)*

Table 9. Number of photonic marked fish and proportion of marked to unmarked fish at release and recapture at lower river trapping sites (RM 1.2 and 27.3), Umatilla River, spring 1997. Chi^2 probabilities are given for the difference in proportion of marked to unmarked fish at release and recapture.

	Hatchery rearing			Photonic-marked fish			Marked / unmarked fish			
Species[a]	System	Density	Mark color	Number released	Number recaptured	Percent recaptured	Release (%)	Recapture (%)	Percent change	Chi^2 *P*
HCHS	Oregon	normal	dark green	5,012	46	0.92	0.67	0.67	0	0.93
HCHF	Michigan	normal	red	5,109	45	0.88	0.68	0.66	-4	0.72
HCHF	Oregon	normal	orange	5,114	47	0.92	0.69	0.69	0	0.94
HCOH	Oregon	normal	yellow	4,980	6	0.12	0.36	0.10	-72	<0.001
HSTS	Michigan	normal	orange	2,528	0	0.00	1.08	0.00	-100	--
HSTS	Michigan	normal	red	1,849	0	0.00	1.32	0.00	-100	--
HSTS	Michigan	normal	dark yellow	5,706	3	0.05	4.06	2.23	-44	--[b]
HCHF0	Michigan	low	dark orange	9,905	57	0.58	0.38	0.18	-53	<0.001
HCHF0	Michigan	medium	pink	10,114	69	0.68	0.39	0.22	-44	<0.001
HCHF0	Michigan	high	blue	10,067	56	0.56	0.39	0.18	-54	<0.001

[a] *HCHS = hatchery spring chinook salmon, HCHF = hatchery fall chinook salmon, HCOH = hatchery coho salmon, HSTS = hatchery summer steelhead, HCHF0 = hatchery subyearling fall chinook salmon.*

[b] *Chi^2 statistical test could not be conducted due to low recapture of photonic-marked fish.*

Table 10. Quality of photonic marks on the anal fin of hatchery subyearling fall chinook salmon prior to upstream release (RM 80 and 73) and after recapture at the rotary-screw trap (RM 1.2), Umatilla River, spring 1997.

Mark	Number evaluated		Good marks (%)		Fair marks (%)		Poor marks (%)	
color	Rel.[a]	Recap.[b]	Rel.[a]	Recap.[b]	Rel.[a]	Recap.[b]	Rel.[a]	Recap.[b]
blue	538	21	61	62	28	10	11	29
dark orange	409	20	66	75	29	15	5	10
pink	314	20	60	65	27	30	13	5

[a] *Rel. = release.*
[b] *Recap. = recapture.*

Table 11. Fin clips on juvenile salmonids collected at lower river trapping sites (RM 1.2 and 27.3), Umatilla River, March - July 1997. Chi^2 probabilities are given for the difference in recapture proportions of differently clipped fish.

Species[a], Clip[b]	Site, Number	Site, Number	Total number recaptured	Total number released	Percent recapture	Chi^2 *P*
	RST[c]	Westland[c]				
CH 1$^+$						
RV	2,924	0	2,924	477,948	0.61	0.429
ADRV	1,598	0	1,598	267,856	0.60	
CHF 0$^+$						
RV	11,629	160	11,789	2,289,018	0.52	0.009
ADRV	1,384	11	1,395	291,815	0.48	
COH 1$^+$						
NC	581	0	581	77,373	0.75	<0.001
AD	4,222	0	4,222	1,323,556	0.32	
STS 1$^+$						
AD	90	0	90	78,588	0.11	0.974
ADLV	70	0	70	58,699	0.12	

[a] *CH 1$^+$ = yearling chinook salmon, CHF 0$^+$ = subyearling fall chinook salmon, COH 1$^+$ = yearling coho salmon, STS 1$^+$ = yearling summer steelhead.*

[b] *RV = right ventral fin clip, AD = adipose fin clip, LV = left ventral fin clip, NC = no fin clip.*

[c] *RST = rotary-screw trap (RM 1.2), Westland = Westland Canal (RM 27.3).*

Table 12. Migration parameters of hatchery and natural juvenile salmonids in the Umatilla River captured at lower river trapping sites (RM 1.2 and 27.3) from 1 October 1996 to 30 September 1997.

Species[a]	Release Date	Release RM	Capture at lower river: First (date)	Media (date)	Last (date)	Peak (date)	Duration (d)	Median travel speed (mi/d)
HCOH	3/10, 3/31 4/1 - 4/5	80 / 73	3/11	4/20	6/7	4/17	89	2
HCHS[b]	3/26	80	3/27	3/28	4/26	3/27	31	33
HCHF[b]	3/25	80 /73	3/26	3/26	4/9	3/26	15	54
HSTS	4/8 - 4/10 4/3, 4/4 5/6 - 5/15	79[c] 63 79[c]	4/8	4/29	6/29	4/20	87	3[d]
HCHF0	5/29, 5/30	80 / 73	6/1	6/3	7/30[h]	6/2	62	19
NCHS[e]	--	--	12/23	3/17	5/31	3/17	159	--
NCOH	--	--	12/26	4/23	6/23	4/23	179	--
NSTS	--	--	1/10	4/23	7/24	4/28	195	--
NCHF[f]	--	--	3/25	6/18	7/30[g]	6/18	127	--

[a] *HCOH = hatchery coho salmon, HCHS = hatchery spring chinook salmon, HCHF = hatchery fall chinook salmon, HSTS = hatchery summer steelhead, HCHF0 = subyearling hatchery fall chinook salmon, NCHS = natural spring chinook salmon, NCOH = natural coho salmon,*
NSTS = natural summer steelhead, NCHF = natural fall chinook salmon.

[b] *Analyses were based on collection of photonic-marked fish.*

[c] *Bonifer holding pond at RM 2 of Meacham Creek (RM 79 of Umatilla River).*

[d] *Median travel speed for HSTS was based on recapture of photonic marked fish ("smalls" group) released 5/6-5/15.*

[e] *Natural chinook salmon > 80 mm captured prior to 6/1, none were captured after 6/1.*

[f] *Natural chinook salmon < 80 mm captured prior to 6/1, and between 42-86 mm in June.*

[g] *Last day of trapping at Westland Canal (RM 27.3).*

Table 13. Percent capture of juvenile salmonids during the day and night at the rotary-screw trap (RM 1.2), Umatilla River, spring 1997.

	March			April			May			June			Mean		
Species[a]	Day	Night	*N*	Day	Night	*N*	Day	Night	*N*	Day	Night	*N*	Day	Night	*N*
HCH1	23	77	679	6	94	2,581	0	100	3	--	--	--	10	90	3,263
NCHS	--	--	--	0	100	1	--	--	--	--	--	--	--	--	--
HCOH	0	100	2	25	75	2,385	13	87	23	16	84	51	25	75	2,461
NCOH	0	100	3	--	--	--	--	--	--	0	100	1	0	100	4
HSTS	--	--	--	41	59	54	25	75	4	24	76	17	36	64	75
NSTS	38	62	8	40	60	80	67	33	6	0	100	7	39	61	101
HCHF0	--	--	--	--	--	--	--	--	--	8	92	19,750	--	--	--
NCHF0	--	--	--	--	--	--	--	--	--	30	70	10	--	--	--

[a] *HCH1 = hatchery yearling chinook salmon, NCHS = natural spring chinook salmon, HCOH = hatchery coho salmon, NCOH = natural coho salmon, HSTS = hatchery summer steelhead, NSTS = natural summer steelhead, HCHF0 = hatchery subyearling fall chinook salmon, NCHF0 = natural subyearling fall chinook salmon.*

Table 14. Percent of juvenile salmonids classified as parr (P), intermediate (I), and smolt (S) based on body coloration observed at lower river trapping sites (RM 1.2 and 27.3), Umatilla River, 21 December 1996 - 30 July 1997.

	NCHS[a]			HCH1[a]			NCOH[a]			HCOH[a]			NSTS[a]			HSTS[a]			NCHF0[a]			HCHF0[a]		
DATE	P	I	S	P	I	S	P	I	S	P	I	S	P	I	S	P	I	S	P	I	S	P	I	S
12/21/96 -	0	100	0	--	--	--	0	0	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/10/97 -	0	100	0	--	--	--	--	--	--	--	--	--		83	17	--	--	--	--	--	--	--	--	--
1/20/97 -	--	--	--	--	--	--	--	--	--	--	--	--		100	0	--	--	--	--	--	--	--	--	--
1/30/97 - 2/9/97	0	100	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/9/97 - 2/19/97	--	--	--	--	--	--	--	--	--	--	--	--		100	0	--	--	--	--	--	--	--	--	--
2/19/97 - 3/1/97	--	--	--	--	--	--	--	--	--	--	--	--		100	0	--	--	--	--	--	--	--	--	--
3/11/97 -	0	100	0	--	--	--	--	--	--	0	100	0		100	0	--	--	--	--	--	--	--	--	--
3/21/97 -	--	--	--	0	13	87	--	--	--	0	100	0		80	13	--	--	--	100	0	0	--	--	--
3/31/97 -	0	100	0	2	54	44	--	--	--	0	90	10		69	31	--	--	--	--	--	--	--	--	--
4/10/97 -	0	100	0	0	68	32	0	50	50	0	96	4		89	11	0	31	69	--	--	--	--	--	--
4/20/97 -	--	--	--	0	19	81	0	0	100	0	79	21		75	21	0	8	93	--	--	--	--	--	--
4/30/97 -	0	100	0	0	47	53	--	--	--	0	86	14		50	50	0	0	100	--	--	--	--	--	--
5/10/97 -	10	0	0	--	--	--	--	--	--	0	92	8		71	29	0	20	80	100	0	0	--	--	--
5/20/97 -	--	--	--	--	--	--	--	--	--	0	86	14	--	--	--	--	--	--	--	--	--	--	--	--
5/30/97 - 6/9/97	0	100	0	--	--	--	0	0	100	0	63	37		13	88	0	7	93	100	0	0	0	63	37
6/9/97 - 6/19/97	--	--	--	--	--	--	--	--	--	--	--	--		0	100	--	--	--	47	47	6	0	43	57
6/19/97 -	--	--	--	--	--	--	0	100	0	--	--	--	--	--	--	0	0	100	0	80	20	0	23	77
6/29/97 - 7/8/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	100	--	--	--	0	5	96
7/8/97 - 7/18/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	13	87	0	2	96
7/18/97 -	--	--	--	--	--	--	--	--	--	--	--	--	10	0	0	--	--	--	0	8	92	0	21	85
7/28/97 -	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	100	--	--	--
MEAN	7.7	92.	0	0.	30.3	69.	0.	33.	66.	0.	88.1	11.	2.	71.	26.	0.	12.	87.	15.	20.	65.	0.	49.9	50.
SAMPLE SIZE		13			418			9			392			187			157			80			1055	

[a] *NCHS = natural spring chinook salmon, HCH1 = hatchery yearling chinook salmon, NCOH = natural coho salmon, HCOH = hatchery coho salmon, NSTS = natural summer steelhead, HSTS = hatchery summer steelhead, NCHF0 = natural subyearling fall chinook salmon, HCHF0 = hatchery subyearling fall chinook salmon.*

Table 15. Correlation statistics (*r* = correlation coefficient, *P* = probability, *N* = sample size) for relationships between smolt index and fork length of salmonids collected at lower river trapping sites (RM 1.2 and 27.3), Umatilla River, 23 December 1996 - 30 July 1997.

Species[a]	Smolt index vs. fork length			Species[b]	Smolt index vs. fork length		
	r	*P*	*N*		*r*	*P*	*N*
HCH	.52	.0001	504	NCH	.55	.0003	39
HCHS[c]	.39	.15	15	NCHS	.74	.0001	24
HCHF1[c]	.96	.0001	10	--	--	--	--
HCHF0	.28	.0001	1,213	NCHF	.67	.009	14
HCOH	.29	.0001	1,666	NCOH	.57	.14	8
HSTS	.19	.04	117	NSTS	.48	.0001	182

[a] *HCH = spring and fall races of hatchery yearling chinook salmon, HCHS = hatchery yearling spring chinook salmon, HCHF1 = hatchery yearling fall chinook salmon, HCHF0 = hatchery subyearling fall chinook salmon, HCOH = hatchery coho salmon, HSTS = hatchery summer steelhead.*

[b] *NCH = spring and fall races of natural chinook salmon, NCHS = natural spring chinook salmon, NCHF = natural fall chinook salmon, NCOH = natural coho salmon, NSTS = natural summer steelhead.*

[c] *Spring or fall race determined by photonic mark.*

Table 16. Summary of scale loss and mortality of hatchery and natural juvenile salmonids collected at RM 1.2 and RM 27.3, Umatilla River, December 1996 - July 1997.

	Condition[a]							
	Good		Partial		Descaled		Mortality[c]	
Species[b]	Number	Percent	Number	Percent	Number	Percent	Number	Percent
				Hatchery				
CH	3,728	80.0	628	13.5	142	3.0	161	3.5
CHF0	9,386	69.4	1,075	7.9	183	1.4	2,889	8.6
COH	3,042	64.3	1,084	22.9	299	6.3	309	5.0
STS	86	53.4	55	34.2	16	9.9	4	2.3
				Natural				
CH[d]	60	68.9	16	18.4	8	9.2	3	3.4
COH	7	100.0	--	--	--	--	3	20.0
STS	172	89.1	10	5.2	4	2.1	7	3.1

[a] *Condition refers to the extent of scale loss on live fish captured and fish mortalities. Good = scale loss < 3%; Partial = scale loss >3% and < 20%; Descaled = scale loss > 20%.*

[b] *CH = yearling chinook salmon, CHF0 = subyearling fall chinook salmon, COH = coho salmon, STS = summer steelhead.*

[c] *Mortality does not include handling mortality.*

[d] *CH = natural chinook salmon includes yearling and subyearling age groups.*

Table 17 . Mean, range, standard error, and mode of fork lengths of hatchery and natural juvenile salmonids collected in the Umatilla River, October 1996 - July 1997.

		Fork length (mm)				
Species	Age	Mean	Range	SE	Mode	N
		Hatchery				
Chinook salmon (races combined)	1+	152	84-213	1.0	155	440
Fall chinook salmon	1+	174	92-190	9.5	190	10
Spring chinook salmon	1+	161	136-179	3.0	--	14
Fall chinook salmon						
rotary-screw trap	0+	91	70-114	0.2	87	1215
Westland Canal	0+	106	81-132	1.0	117	150
Coho salmon	1+	142	97-184	0.3	140	920
Summer steelhead	1+	221	179-265	2.9	210	55
		Natural				
Chinook salmon	1+	105	98-116	2.1	104	9
Chinook salmon	0+	64	36-92	2.8	63	31
Coho salmon	1+	69	35-134	13.0	35	9
Summer steelhead[a]	1+	157	81-250	1.7	160	183

[a] *Natural summer steelhead age classes included 1+, 2+, and 3+ fish.*

Table 18. Estimates of migrant abundance for hatchery and natural juvenile salmonids, and survival estimates for hatchery juvenile salmonids passing the RM 1.2 trap site on the lower Umatilla River, October 1996 - June 1997.

Species[a]	Age	Abundance estimate[b]	95% Confidence interval[c]	Percent Survival (+ 95% CI)
		Hatchery		
CH	1+	530,321	298,125 - 762,517	71.1% (40.0 - 102.2%)
CHF	0+	882,902	775,046 - 990,758	34.9%[d] (30.0 - 38.4%)
COH	1+	476,378	211,298 - 741,458	34.0% (15.1 - 52.9%)
STS	1+	--[e]	--	--
		Natural		
CHS	1+[f]	1,151	--	--
CHF	0+	852	--	--
COH	0+	1,200	--	--
STS	1+[g]	--[e]	--	--

[a] *CH = spring and fall chinook salmon, CHF = fall chinook salmon, COH = coho salmon, STS = summer steelhead.*

[b] *Number of collected natural salmon were adjusted by the livebox retention efficiency and trap collection efficiency estimates of hatchery conspecifics to estimate abundance.*

[c] *Variance estimates for 95% confidence intervals were derived from the Bootstrap method. Variances were summed when populations were subtotaled.*

[d] *Percent survival of fish migrating in-river and not transported.*

[e] *Abundance of hatchery and natural summer steelhead could not be estimated.*

[f] *Age of natural spring chinook salmon includes 0^+ and 1^+ fish.*

[g] *Age of natural summer steelhead includes 1^+, 2^+, and 3^+ fish.*

Table 19. Mean density of yearling salmonids at varying depths and flow conditions in front of Diffuser 1 in the fish ladder at Three Mile Falls Dam, Umatilla River, spring 1997. Fish density was calculated per unit area of diffuser surface.

Percent water depth	Mean fish density (Number/ft^2): Low velocity (<0.5 ft/s)	Moderate velocity (0.5-1.0 ft/s)	High velocity (>1.0 ft/s)	Turbulence (behind I-beam)	Mean density per depth
20%	NA[a]	NA[a]	0.03	0.00	0.02
50%	NA[a]	1.53	2.95	2.20	2.23
80%	0.05	5.56	3.15	1.99	2.69
Mean density per flow condition	0.05	3.55	2.04	1.40	

[a] *NA = appropriate flow condition was not present at that depth.*

Table 20. Mean density of subyearling fall chinook salmon at varying depths and flow conditions in front of Diffuser 1 in the fish ladder at Three Mile Falls Dam, Umatilla River, spring 1997. Fish density was calculated per unit area of diffuser surface.

Percent water depth	Mean fish density (Number/ft^2): Low velocity (<0.5 ft/s)	Moderate velocity (0.5-1.0 ft/s)	High velocity (>1.0 ft/s)	Turbulence (behind I-beam)	Mean density per depth
20%	NA[a]	NA[a]	0.2	4.7	2.4
50%	NA[a]	14.0	67.2	4.8	28.7
80%	61.5	23.1	18.1	NS[b]	34.2
Mean density per flow condition	61.5	18.5	28.5	4.8	

[a] *NA = appropriate flow condition was not present at that depth.*
[b] *NS = not sampled.*

Table 21. Correlation statistics (*r*= correlation coefficient, *P* = probability, *N* = sample size) for relationships between river flow, Secchi depth, and temperature and collection of salmonids at the lower river trapping site (RM 1.2), Umatilla River, 1 December 1996 - 30 June 1997. (* denotes a significant correlation).

	River flow (ft^3/s)			Secchi depth (m)			Temperature (°F)		
Species[a]	*r*	*P*	*N*	*r*	*P*	*N*	*r*	*P*	*N*
HCH	.04	.81	43	-.19	.23	43	-.20	.20	43
NCHS	.36	.28	11	.40	.33	8	-.01	.98	10
HCOH	.39	.001*	70	-.42	.001*	64	-.005	.97	64
NCOH	.44	.23	9	-.29	.44	9	-.18	.64	9
HSTS	.12	.43	42	-.22	.18	40	.05	.75	40
NSTS	.37	.002*	68	-.32	.01*	64	.07	.57	61
HCHF0	-.001	.96	30	-.22	.28	26	.48	.09	13
NCHF0	-.26	.35	15	.13	.66	15	.07	.74	26
Total collection	-.13	.16	117	.11	.25	105	.26	.01*	103

[a] *HCH = hatchery yearling chinook salmon, NCHS = natural spring chinook salmon, HCOH = hatchery coho salmon, NCOH = natural coho salmon, HSTS = hatchery summer steelhead, NSTS = natural summer steelhead, HCHF0 = hatchery subyearling fall chinook salmon, NCHF0 = natural subyearling fall chinook salmon.*

Table 22. Number and length range (mm) of resident fish species captured at the rotary-screw trap (RM 1.2), lower Umatilla River, October 1996 - July 1997.

Family Common name (*Genus species*)	Number captured	Length range[a] (mm)
Catostomidae		
Unidentified sucker (*Catostomus spp.*)	1,693	--
Cyprinidae		
Redside shiner (*Richardsonius balteatus*)	1,327	--
Peamouth (*Mylocheilus caurinus*)	117	--
Chiselmouth (*Acrocheilus alutaceus*)	1,441	--
Northern pikeminnow (*Ptychocheilus oregonensis*)	176	27-390
Common carp (*Cyprinus carpio*)	18	--
Unidentified dace (*Rhinichthys spp.*)	469	--
Percidae		
Yellow perch (*Perca flavescens*)	3	--
Centrarchidae		
Unidentified bass (*Micropterus spp.*)	15	60-113
Largemouth bass (*M. salmoides*)	7	83-116
Smallmouth bass (*M. dolomieu*)	31	60-103
Crappie (*Pomoxis spp.*)	1	--
Bluegill (*Lepomis macrochirus*)	3	--
Ictaluridae		
Brown bullhead (*Ameirus nebulosus*)	8	--
Cottidae		
Unidentified sculpin (*Cottus spp.*)	2	--
Petromyzontidae		
Pacific lamprey (*Lampetra tridentata*)	304	60-600
Others		
Tadpoles	35	--

[a] *Only northern pikeminnow, bass spp., and lamprey were measured for lengths. Lamprey were measured to total length; pikeminnow and bass were measured to fork length.*

Table 23. Transport conditions, fish mortality, and water temperature of control and treatment groups from Trap and Haul evaluation tests, Umatilla River, July 1997.

			Control group			Treatment group			
Date	Pounds hauled	Transport temp.	Max. temp. [a]	No. of mortalities	Percent mortality	Max. temp. [a]	No. of mortalities	Percent mortality	Net percent mortality
7/04	350	64	--	4	8.0	--	--	--	-- [b]
7/11	100	64	66	0	0.0	66	--	--	-- [b]
7/12	25	64	68	2	4.0	76	7	14.0	10.0
7/15	60	68	74	1	2.0	76	12	24.0	22.0
7/16	20	68	77	0	0	76	--	--	-- [b]
7/18	40	68	77	3	6.0	79	7	14.0	8.0
7/19	20	68	76	7	14.0	79	26	53.1	39.1
7/22	30	70	78	8	17.0	78	17	34.7	17.7
7/25	35	67	75	--	-- [b]	79	13	37.1	-- [b]
7/29	45	71	75	0	0.0	78	8	32.0	32.0
7/31	50	64	73	0	0.0	83	--	--	-- [b]
								Mean	*21.5*

[a] *Maximum temperature at holding site.*
[b] *Groups in which fish were lost.*

Table 24. Scale loss on hatchery subyearling fall chinook salmon sampled for Trap and Haul evaluation tests, Umatilla River, July 1997. (* indicates tests with significant Chi^2; $P < 0.05$).

	Control Groups						Treatment Groups					
	Good [a]		Partial [b]		Descaled [c]		Good [a]		Partial [b]		Descaled [c]	
Date	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
*7/03	34	(68%)	16	(32%)	0	(0%)	28	(56%)	14	(28%)	8	(16%)
*7/10	25	(51%)	19	(39%)	5	(10%)	7	(14%)	32	(64%)	11	(22%)
*7/11	27	(54%)	18	(36%)	5	(10%)	2	(5%)	24	(56%)	17	(40%)
*7/14	23	(46%)	25	(50%)	2	(4%)	5	(10%)	21	(42%)	24	(48%)
*7/17	11	(44%)	11	(44%)	3	(12%)	7	(14%)	30	(60%)	13	(26%)
7/18	4	(20%)	13	(65%)	3	(15%)	3	(14%)	8	(38%)	10	(48%)
Overall	*124*	*(27%)*	*102*	*(62%)*	*18*	*(11%)*	*52*	*(15%)*	*129*	*(64%)*	*83*	*(21%)*

[a] *Good = less than 3% scale loss.*
[b] *Partial = between 3% and 20% scale loss.*

[c] *Descaled = greater than 20% scale loss.*

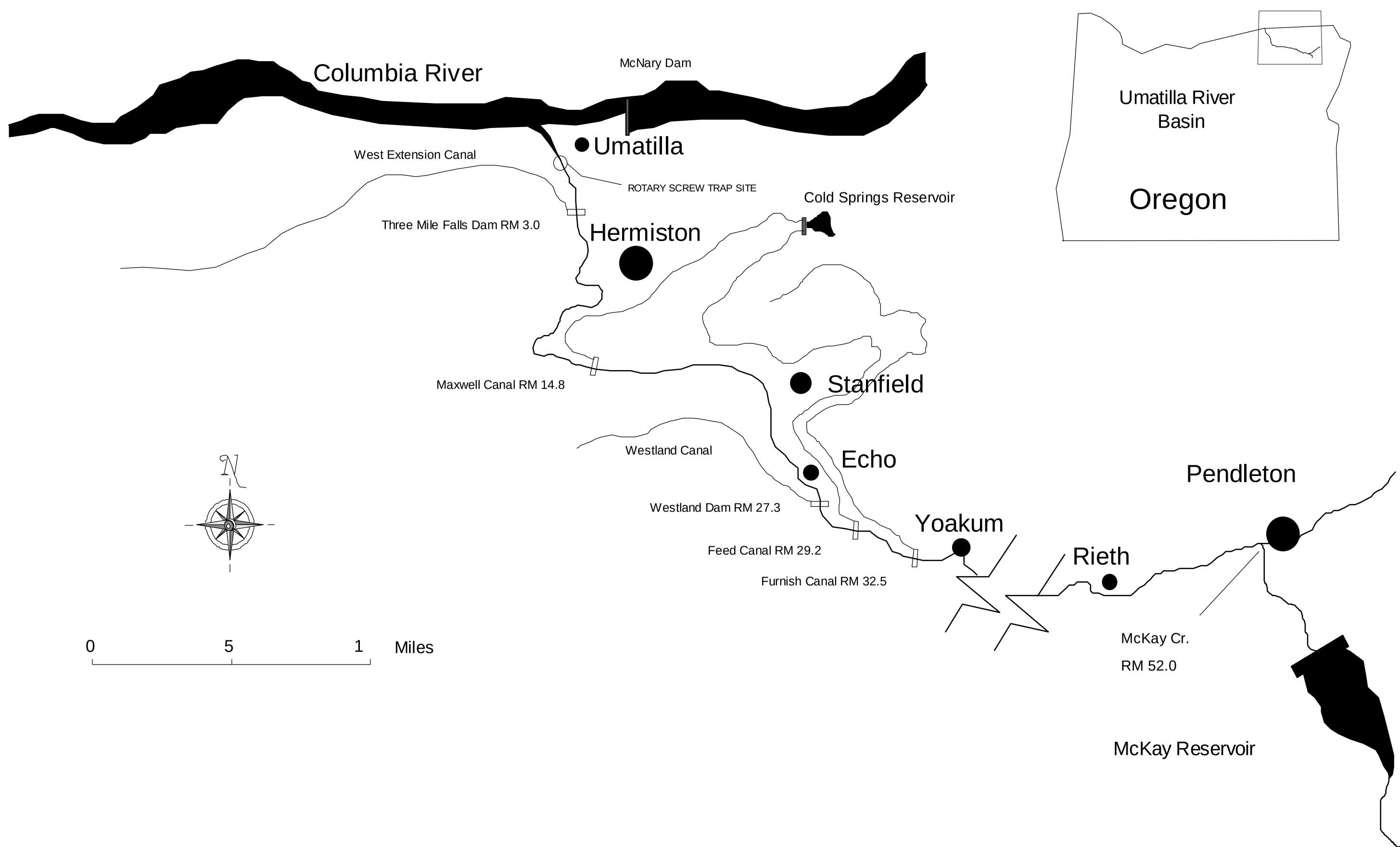


Figure 1. Study sites and trap efficiency release site on the lower Umatilla River, October 1996 - Septebmer 1997.

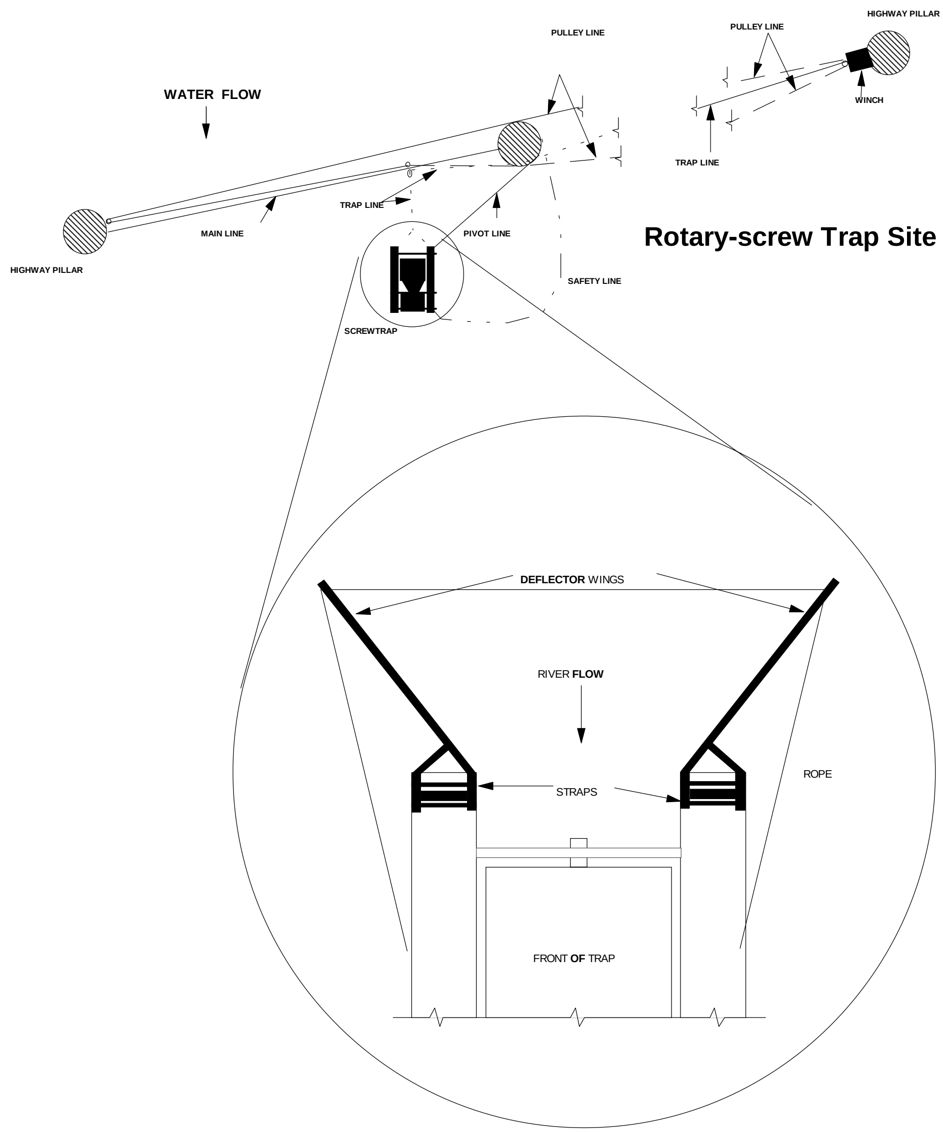


Figure 2. Rotary-screw trap and anchoring system at RM 1.2, lower Umatilla River, October 1996 - June 1997. Enlargement shows detail of deflector wing assembly used to increase efficiency during low river flow.

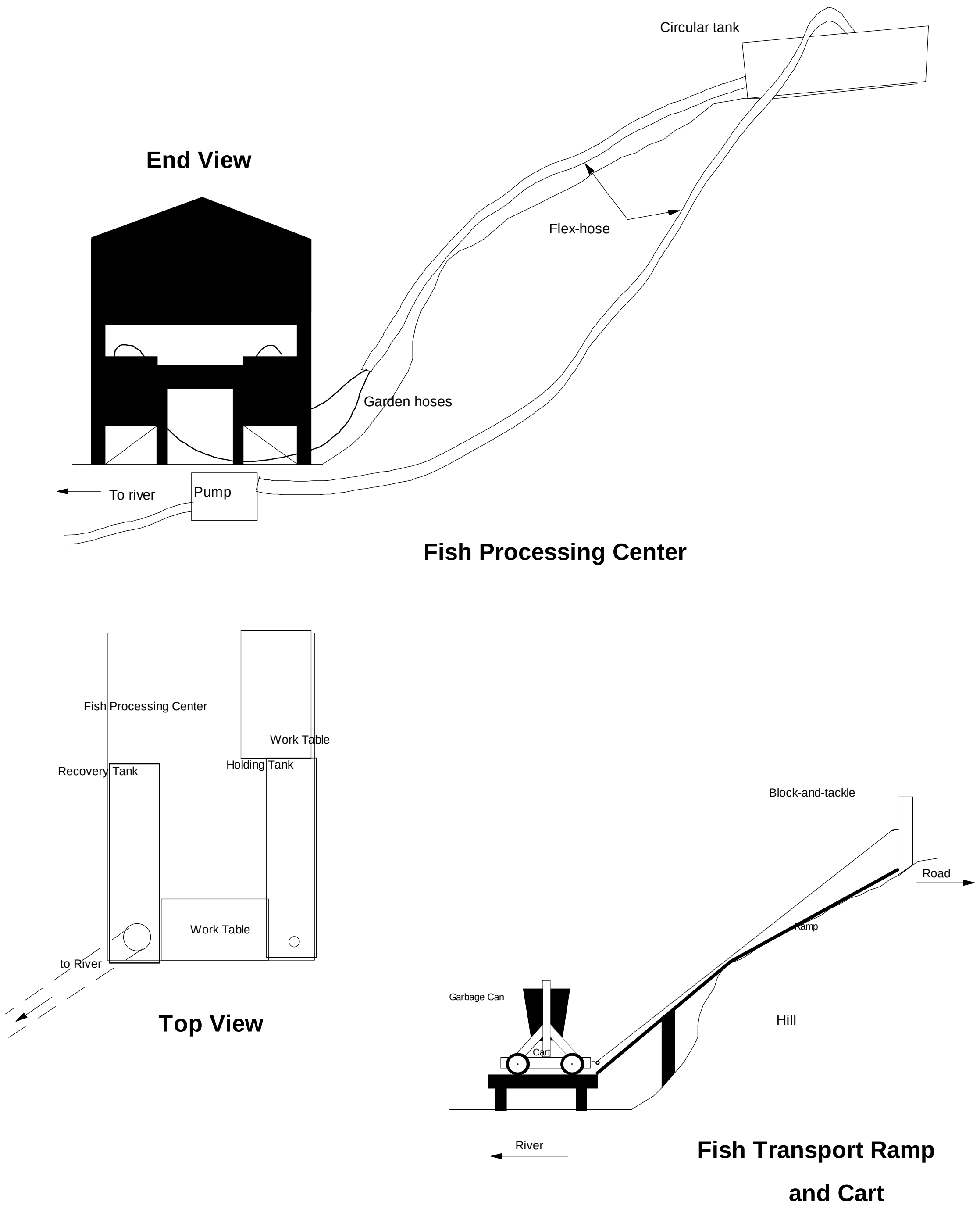


Figure 3. Fish processing center, fish transport ramp, and cart used at the rotary trap site at RM 1.2, lower Umatilla River, October 1996 - June 1997.

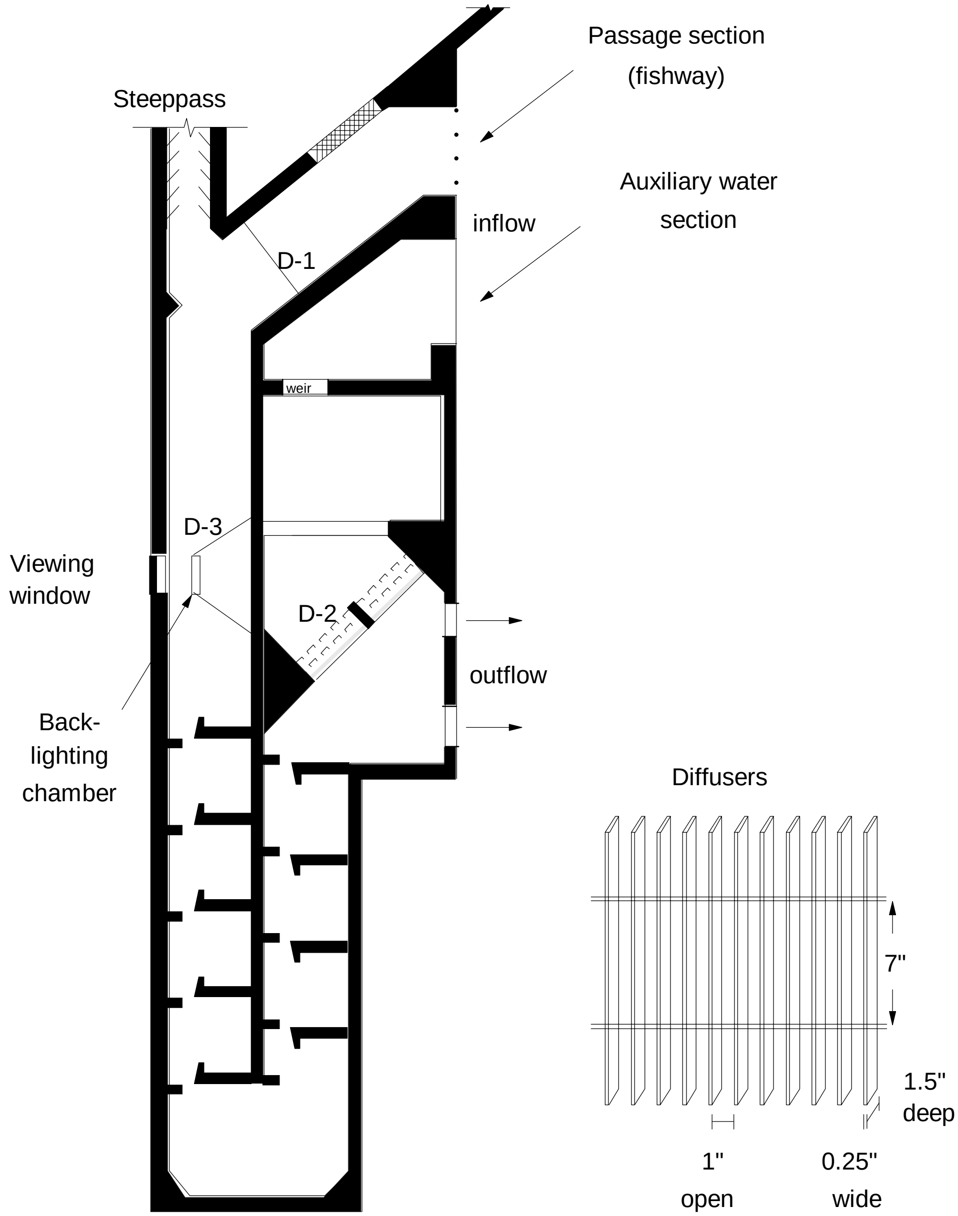


Figure 4. Schematic of the east-bank fish ladder and Diffuser 1 at Three Mile Falls Dam, Umatilla River, 1997.

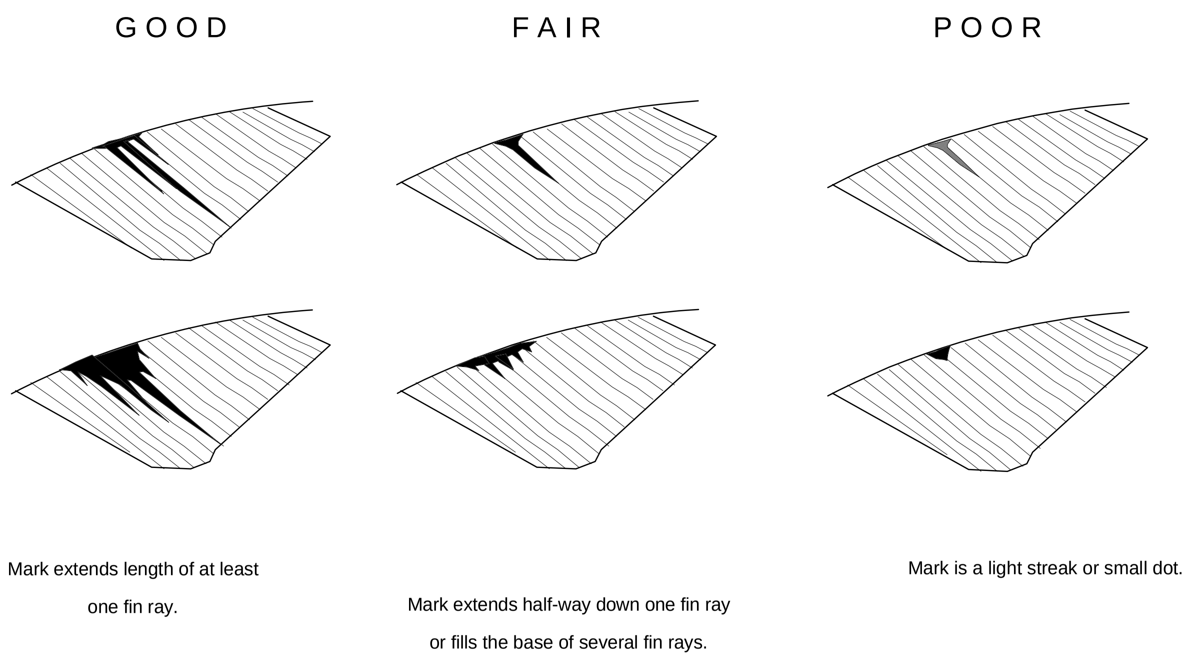


Figure 5. Criteria used to evaluate photonic mark quality on the anal fin of fish at release and capture, Umatilla River, spring 1997.

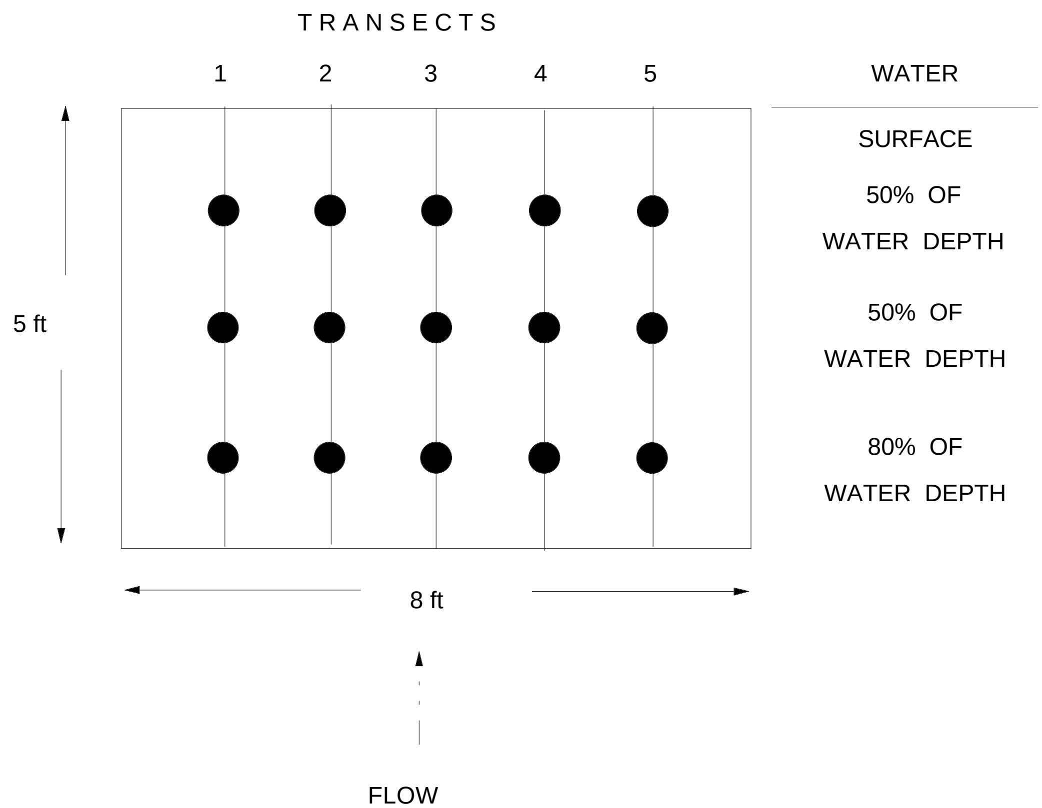


Figure 6. Sampling sites for underwater video recordings at Diffuser 1 in the passage section of the east-bank fish ladder at Three Mile Falls Dam, Umatilla River, 1997.

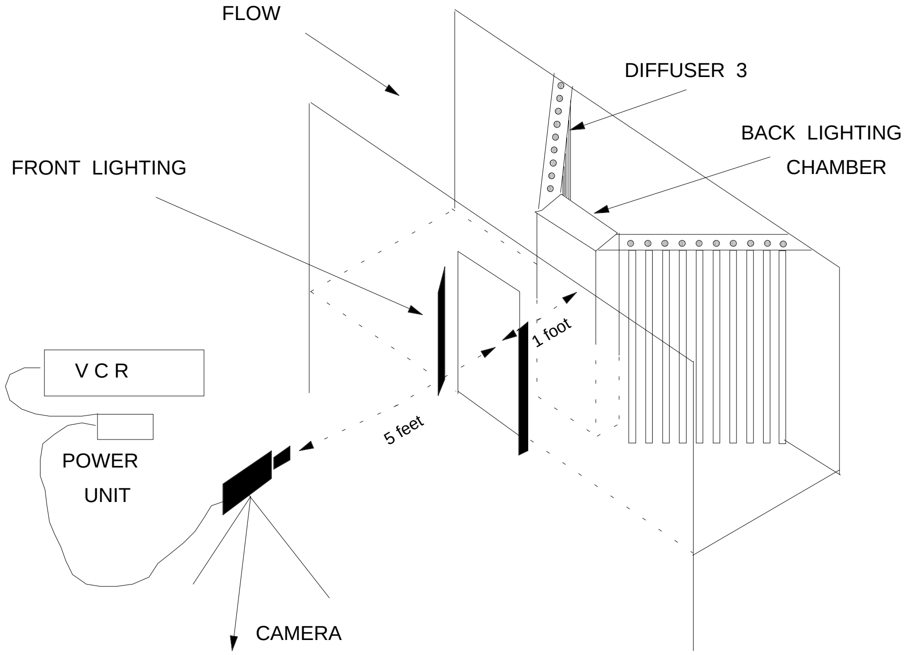


Figure 7. Schematic of the video recording system in the viewing room of the east-bank fish ladder at Three Mile Falls Dam, Umatilla River, 1997.

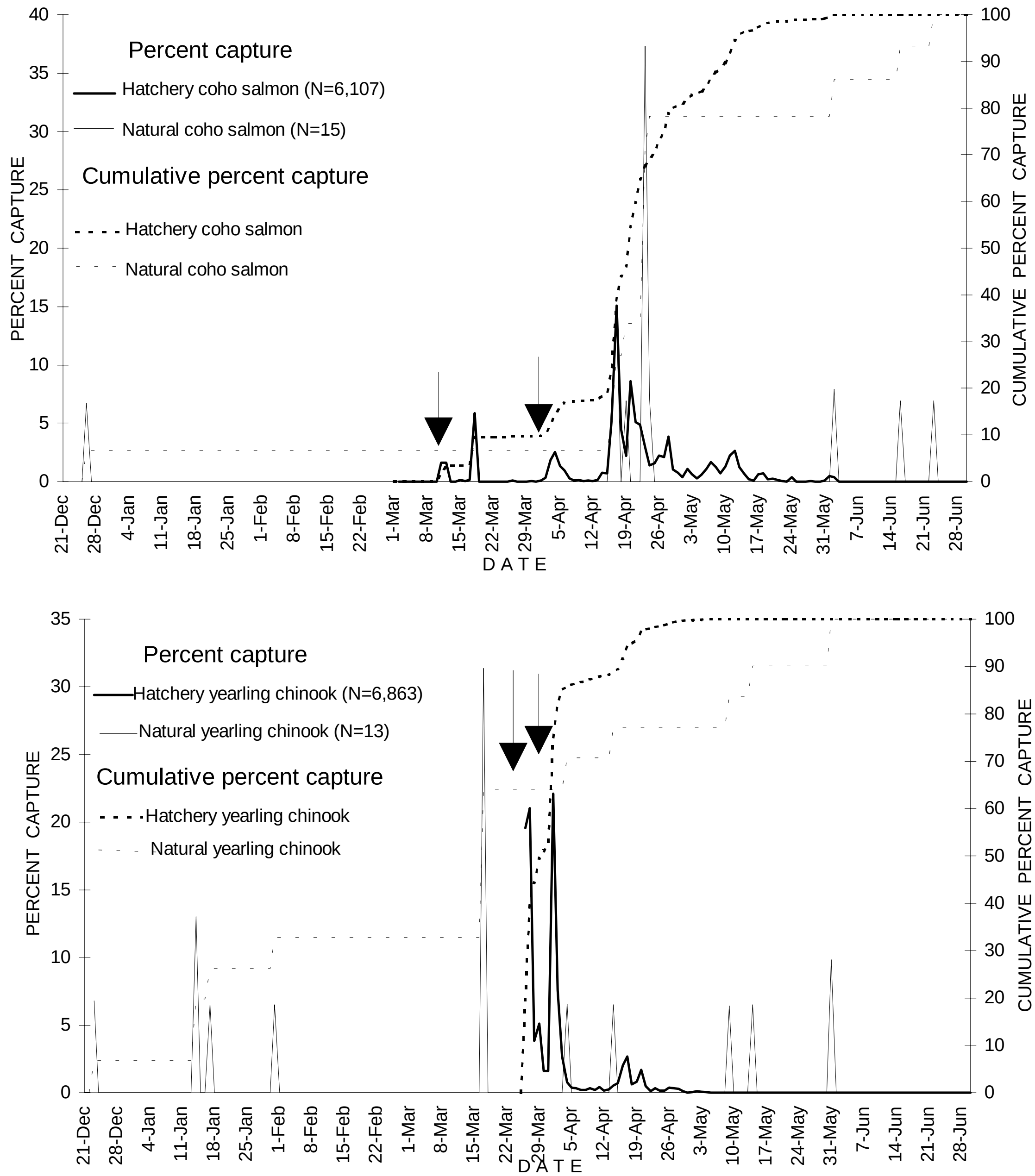


Figure 8. Percent and cumulative percent capture of hatchery and natural coho salmon and yearling chinook salmon collected at the rotary-screw trap (RM 1.2), Umatilla River, December 1996 - June 1997.

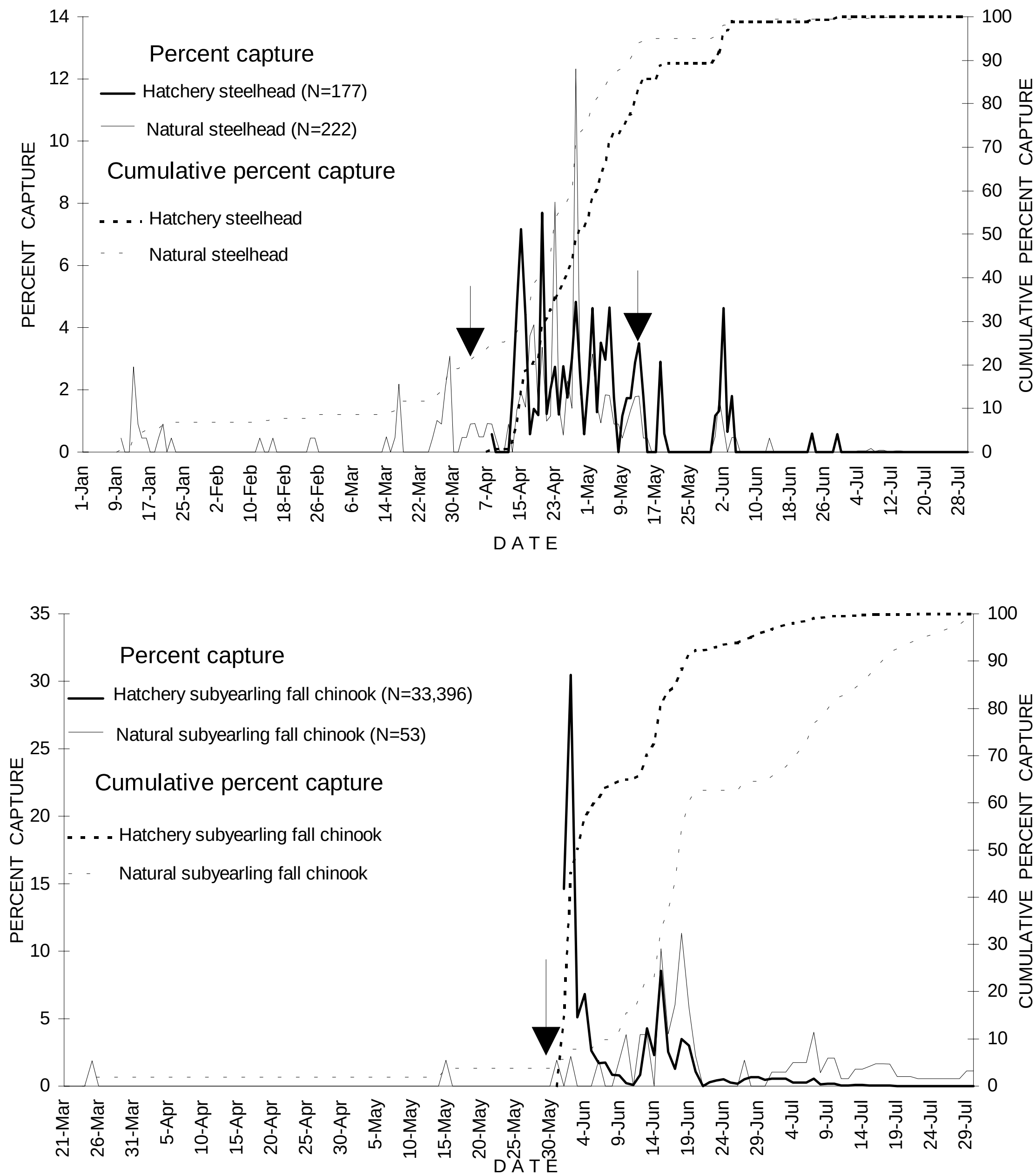


Figure 9. Percent and cumulative percent capture of hatchery and natural summer steelhead and subyearling fall chinook salmon collected at lower river trapping sites (RM 1.2 and 27.3), Umatilla River, January - July 1997

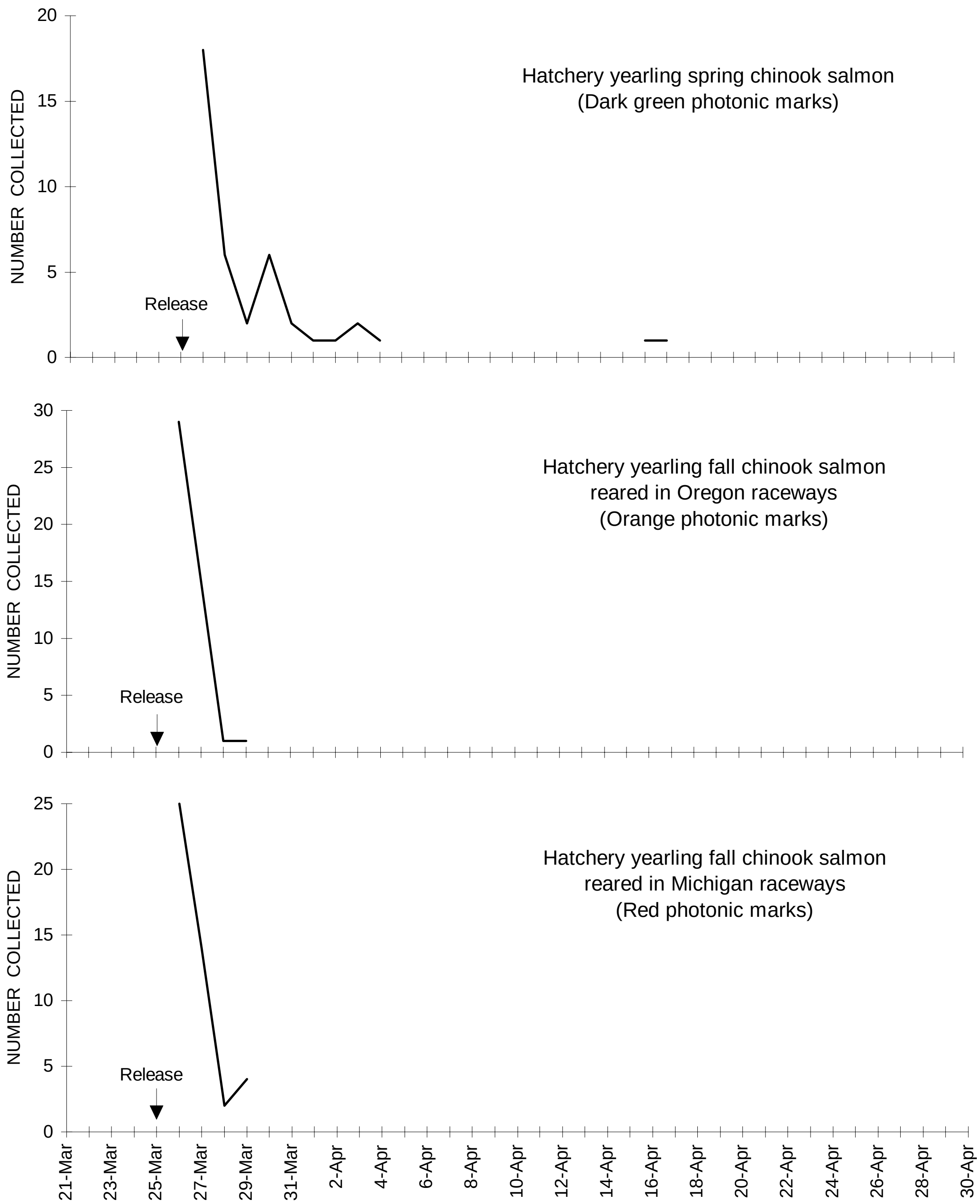


Figure 10. Capture of photonic-marked yearling spring chinook salmon (top) and fall chinook salmon reared in Oregon (middle) and Michigan (bottom) raceways, RM 1.2, Umatilla River, spring 1997

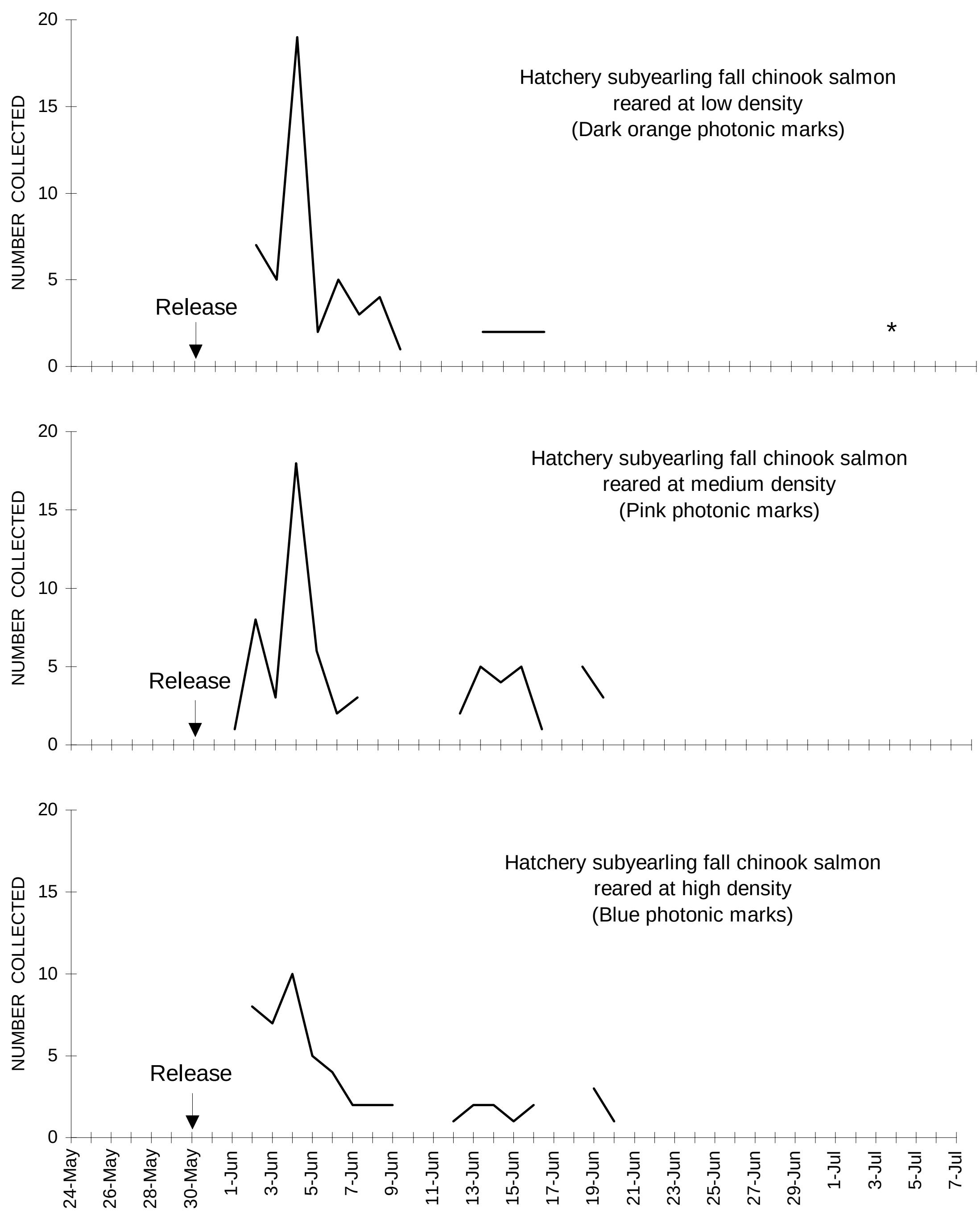


Figure 11. Capture of photonic-marked subyearling fall chinook salmon reared at low (top), medium (middle), and high (bottom) densities, RM 1.2, Umatilla River, spring 1997.

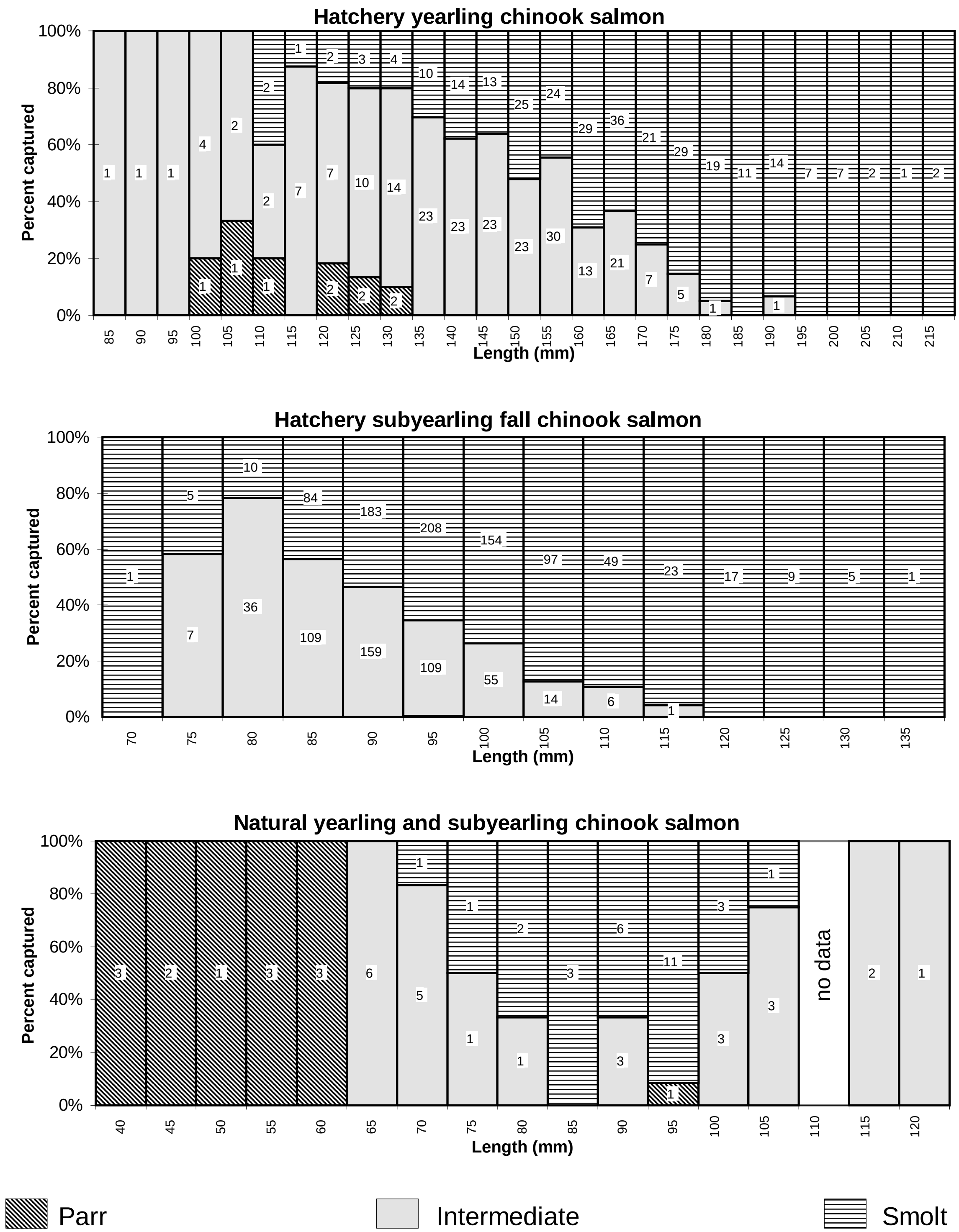


Figure 12. Smolt status relative to fork length for hatchery yearling chinook, hatchery subyearling fall chinook, and natural chinook salmon captured at lower river trapping sites (RM 1.2 and 27.3), Umatilla River, 1 October 1996 - 30 July 1997. Sample size is given inside bars.

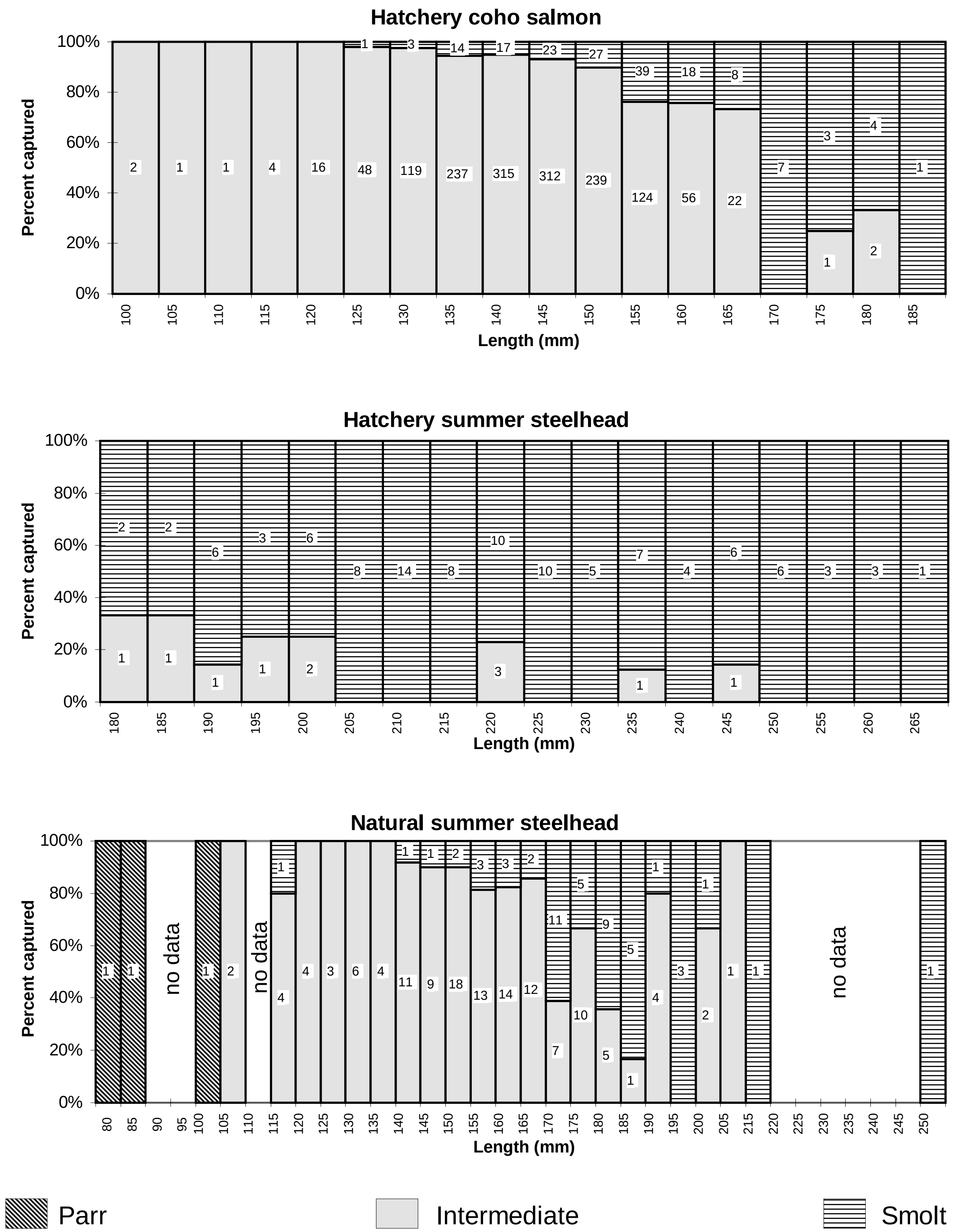


Figure 13. Smolt status relative to fork length for hatchery coho salmon and hatchery and natural summer steelhead captured at lower river trapping sites (RM 1.2 and 27.3), Umatilla River, 1 October 1996 - 30 July 1997. Sample size is given inside bars.

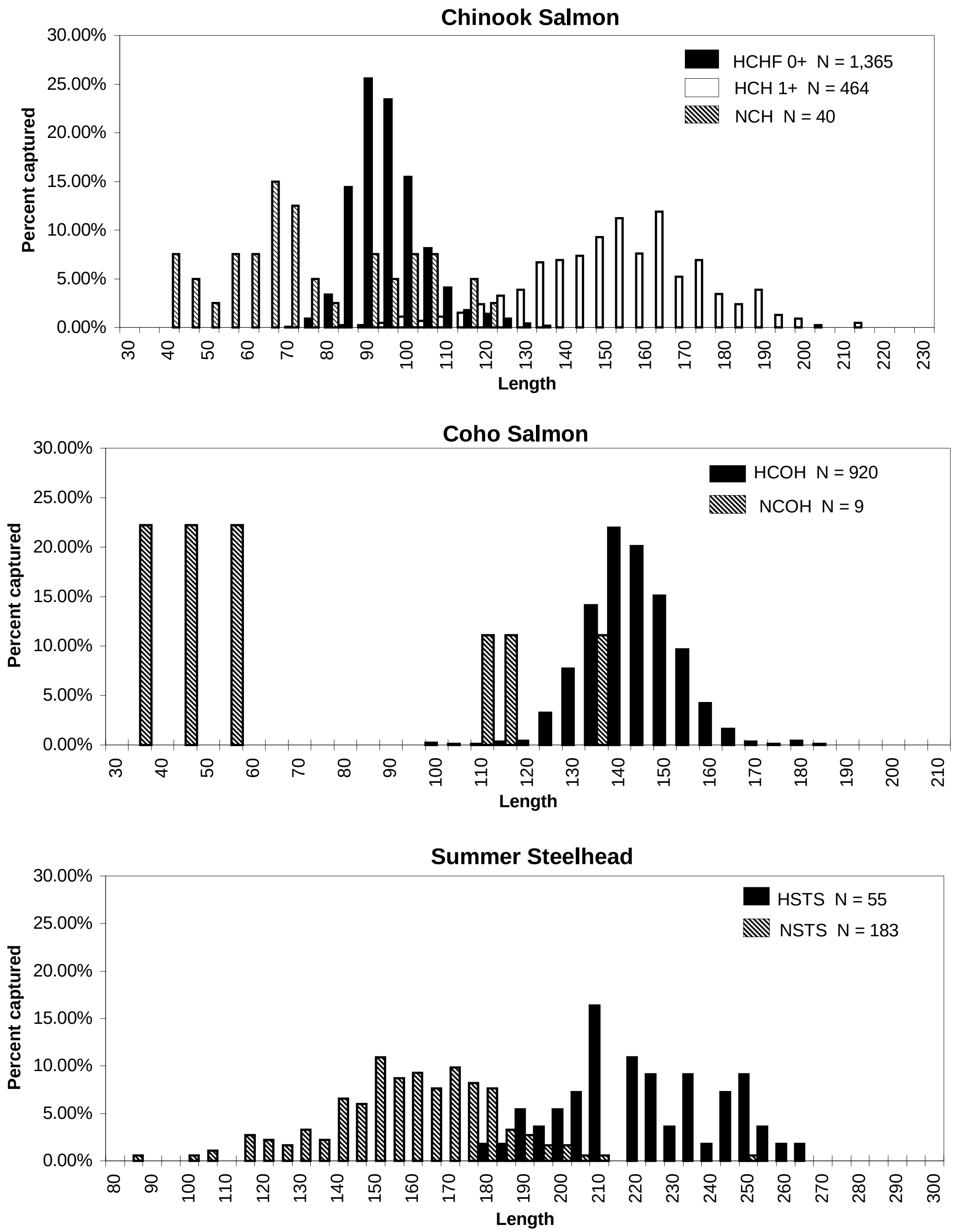


Figure 14. Length-frequency distribution of hatchery and natural juvenile salmonids collected at the rotary-screw trap (RM 1.2), Umatilla River, October 1996 - June 1997. Distributions are in 5-mm increments. HCHF = hatchery fall chinook salmon, HCH = hatchery chinook salmon, NCH = natural chinook salmon, HCOH = hatchery coho salmon, NCOH = natural coho salmon, HSTS = hatchery summer steelhead, NSTS = natural summer steelhead.

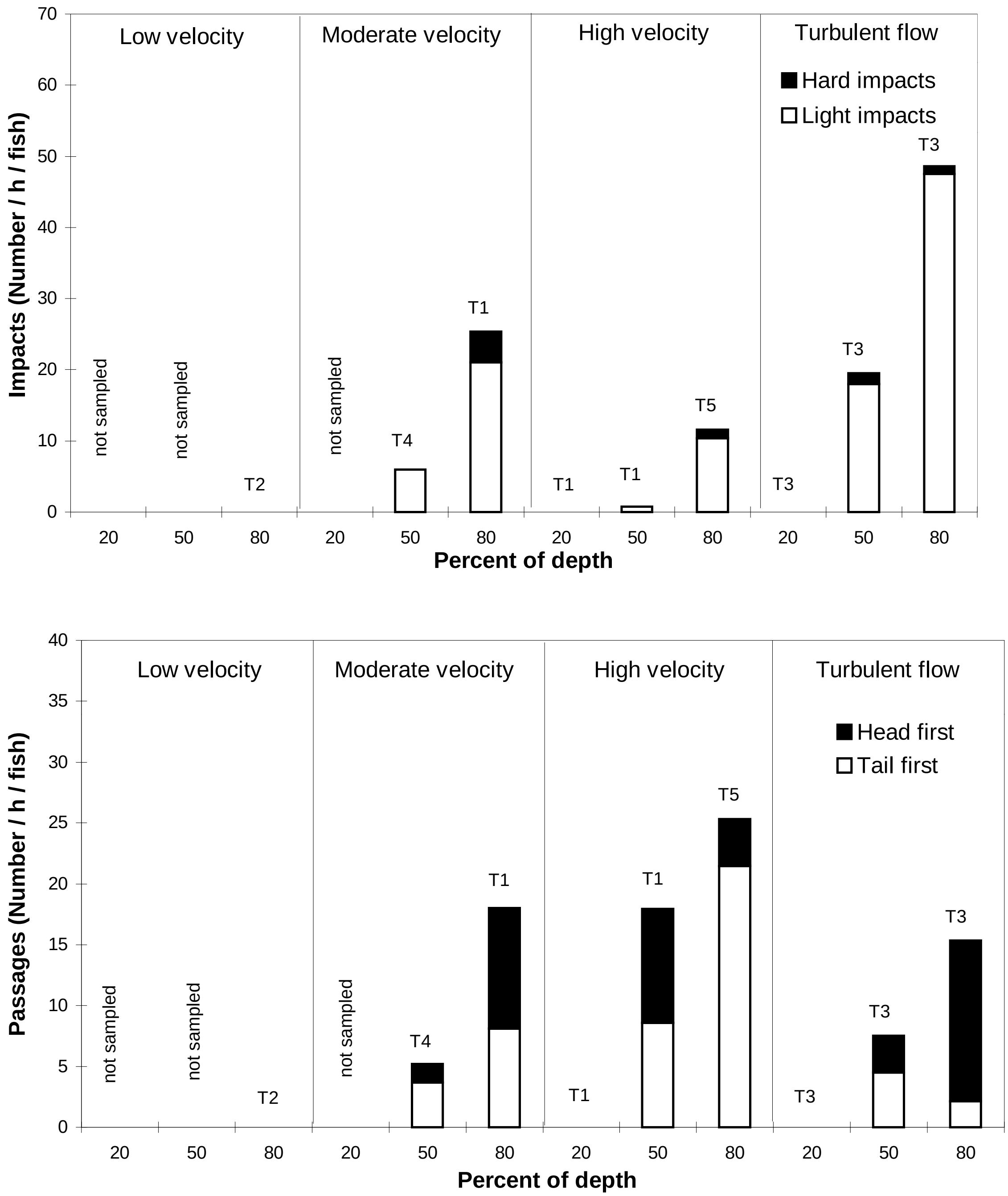


Figure 15. Hard and light impacts (top) and head-first and tail-first fish passage (bottom) for yearling salmonids (chinook and coho salmon, and summer steelhead) at Diffuser 1, Three Mile Falls Dam east-bank fish ladder, Umatilla River, spring 1997. Sampling transects are shown above bars.

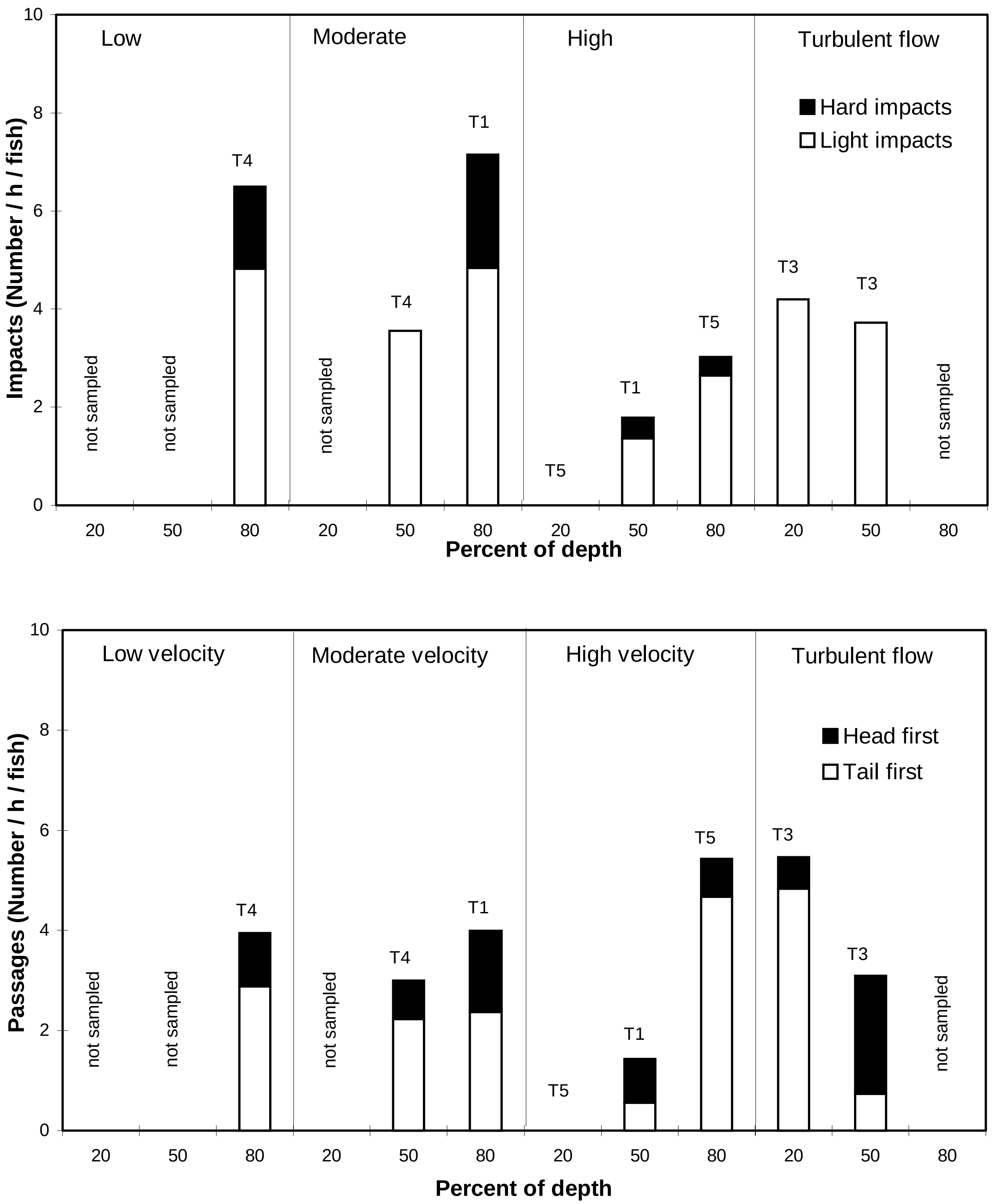


Figure 16. Hard and light impacts (top) and head-first and tail-first fish passage (bottom) for subyearling fall chinook salmon at Diffuser 1, Three Mile Falls Dam east-bank fish ladder, Umatilla River, spring 1997. Sampling transects are shown above bars.

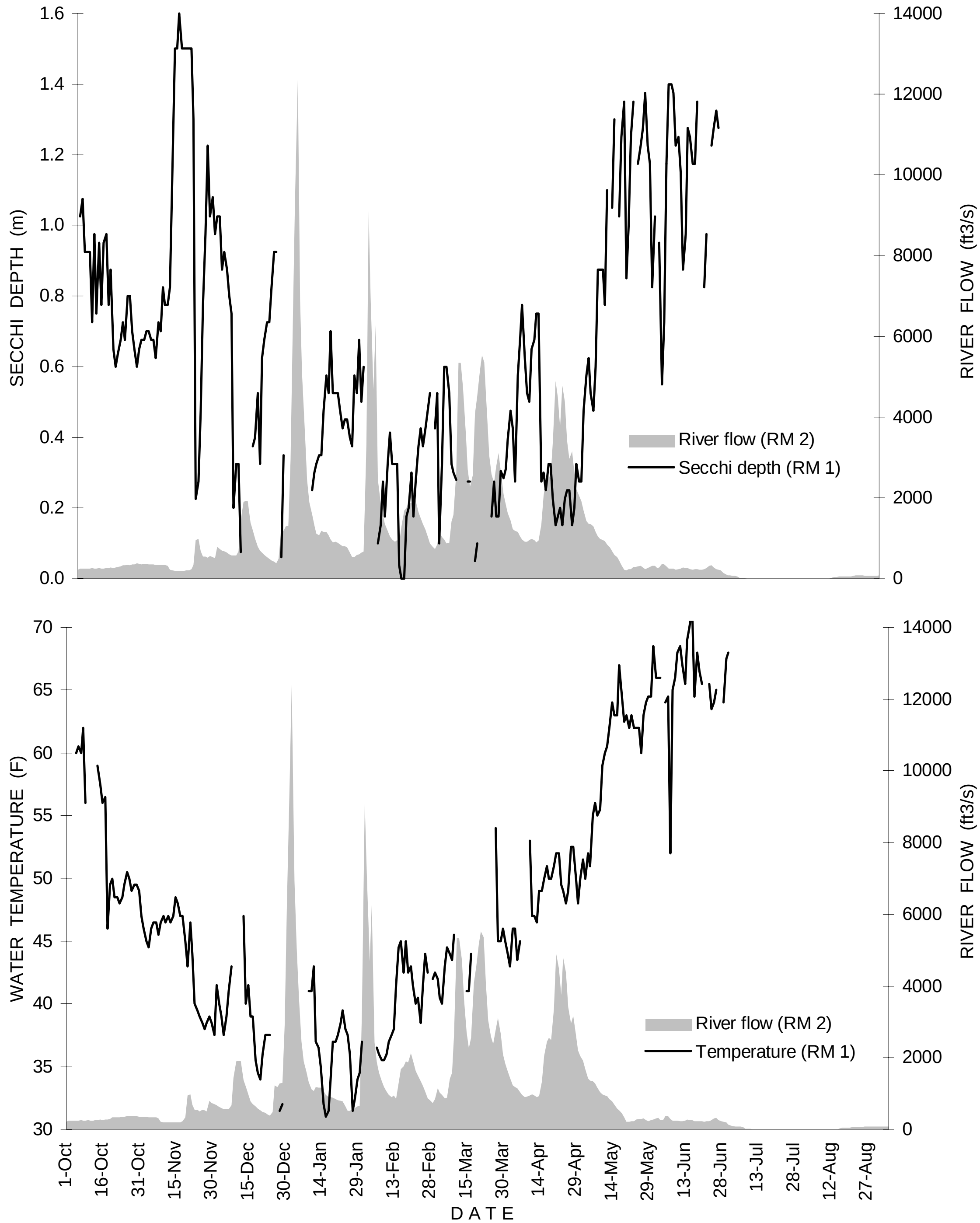


Figure 17. Mean daily river flow (ft^3/s) plotted against Secchi depth (top) and water temperature °F (bottom), Umatilla River, 1 October 1996 - 30 August 1997.

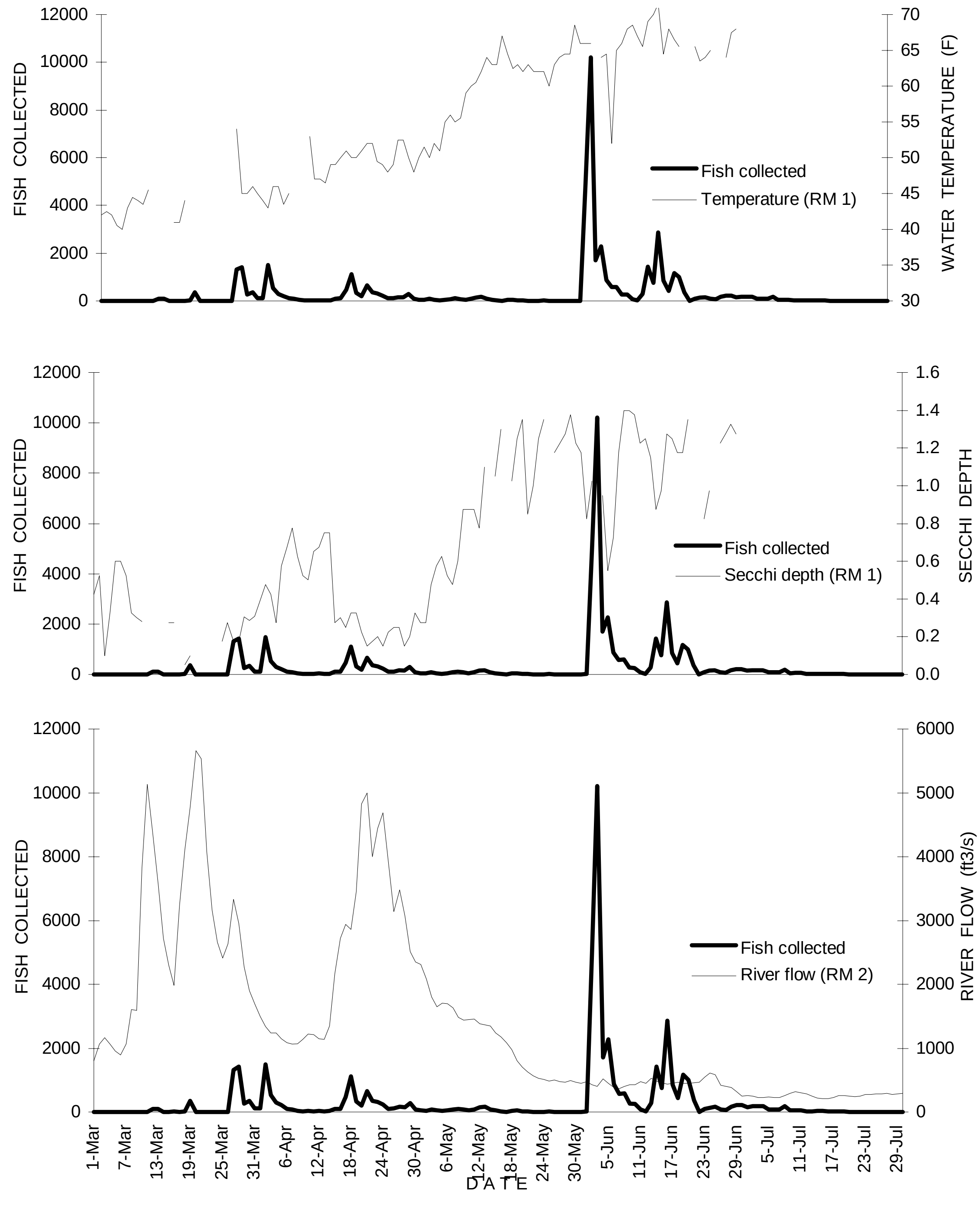


Figure 18. Number of juvenile salmonids collected at lower river trapping sites (RM 1.2 and 27.3) plotted against daily temperature (top), Secchi depth (middle), and mean daily river flow (bottom), Umatilla River, 1 March - 30 July 1997.

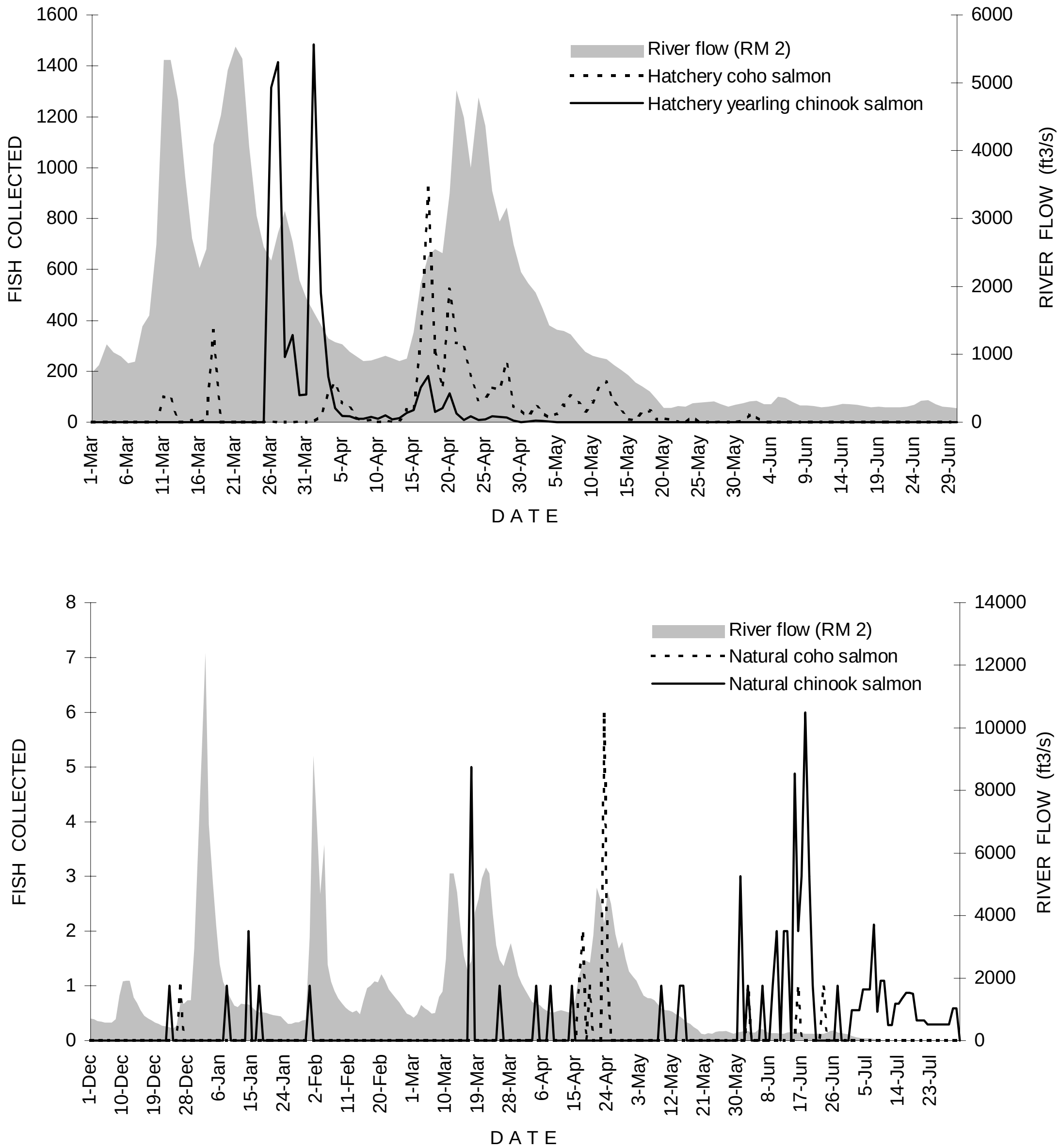
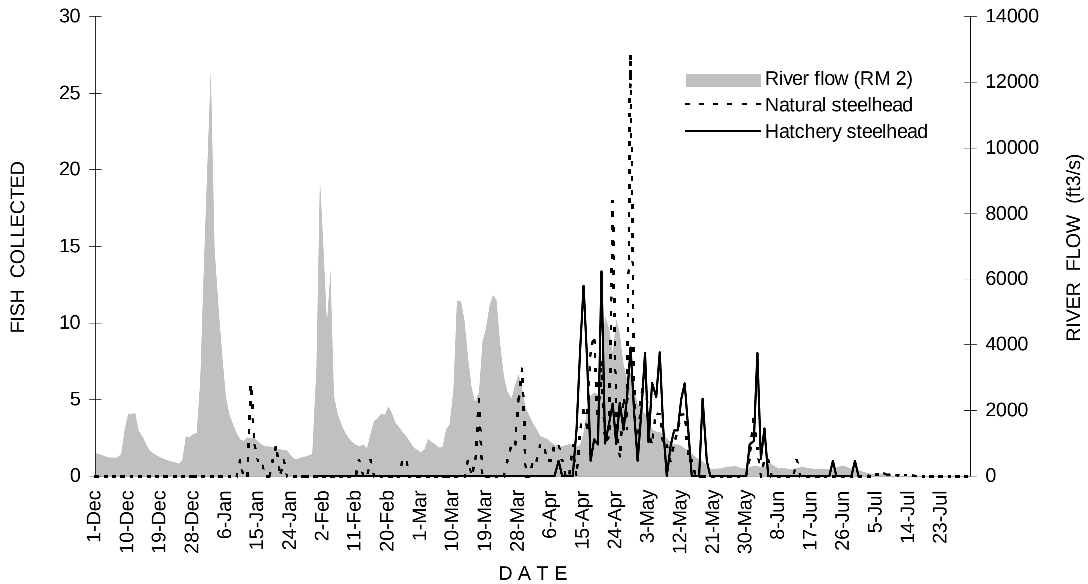


Figure 19. Number of hatchery and natural chinook and coho salmon collected at lower river trapping sites (RM 1.2 and RM 27.3) plotted against river flow (ft^3/s), Umatilla River, 1 December 1996 - 30 July 1997. Spring and fall races were combined for natural chinook salmon and hatchery yearling chinook salmon.



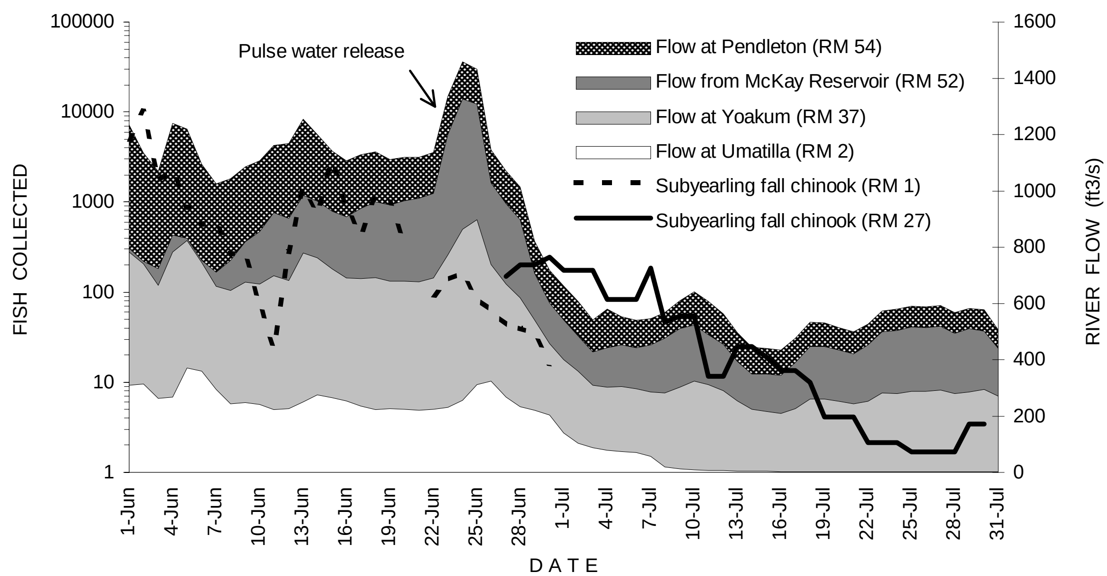


Figure 20. Number of hatchery and natural summer steelhead and hatchery subyearling fall chinook salmon collected at lower river trapping sites (RM 1.2 and 27.3) plotted against river flow (ft^3/s), Umatilla River, 1 December 1996 - 30 July 1997. Water releases from McKay Reservoir (RM 52) and flows at other river sections are shown in the bottom graph.

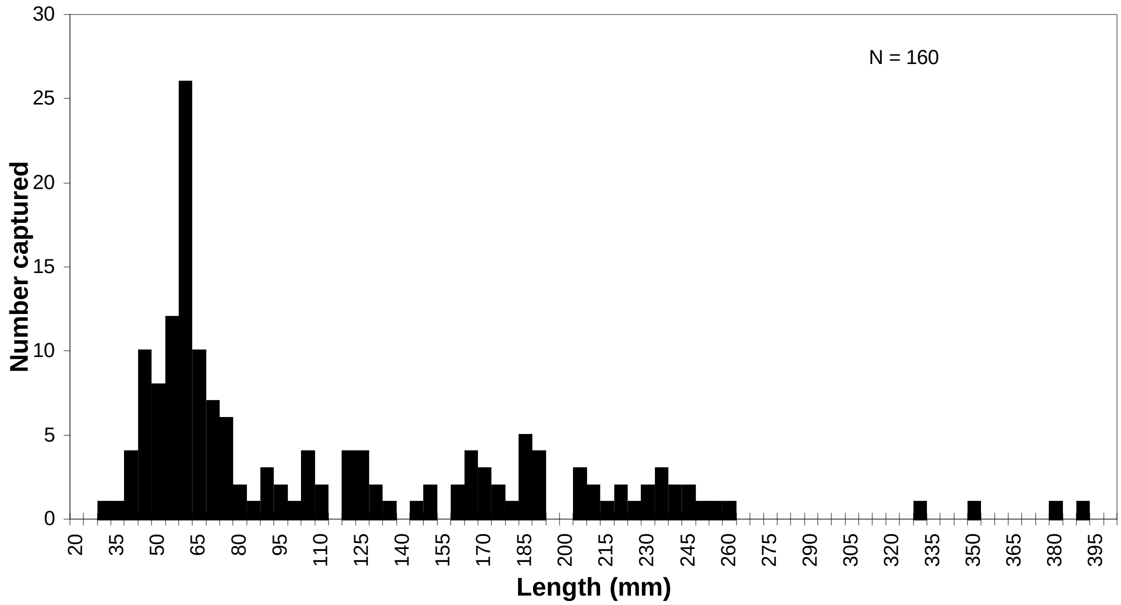


Figure 21. Length-frequency distribution of northern pikeminnows collected at the rotary-screw trap (RM 1.2), Umatilla River, October 1996 - June 1997. Distributions are in 5-mm increments.

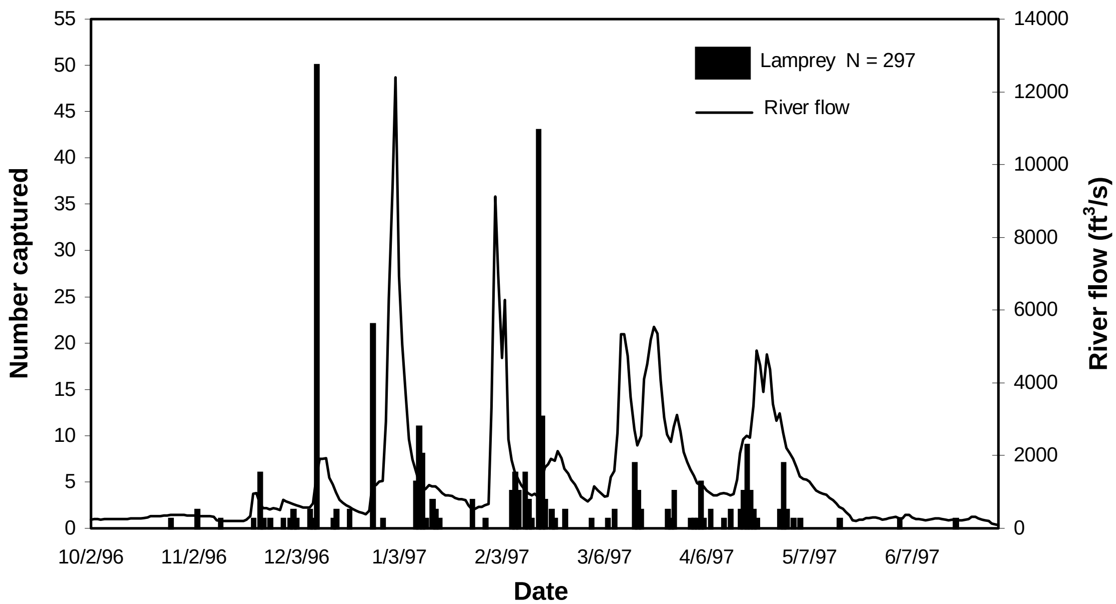


Figure 22. River flow (ft^3/s) and juvenile lamprey captured at the rotary-screw trap (RM 1.2), Umatilla River, October 1996 - June 1997.

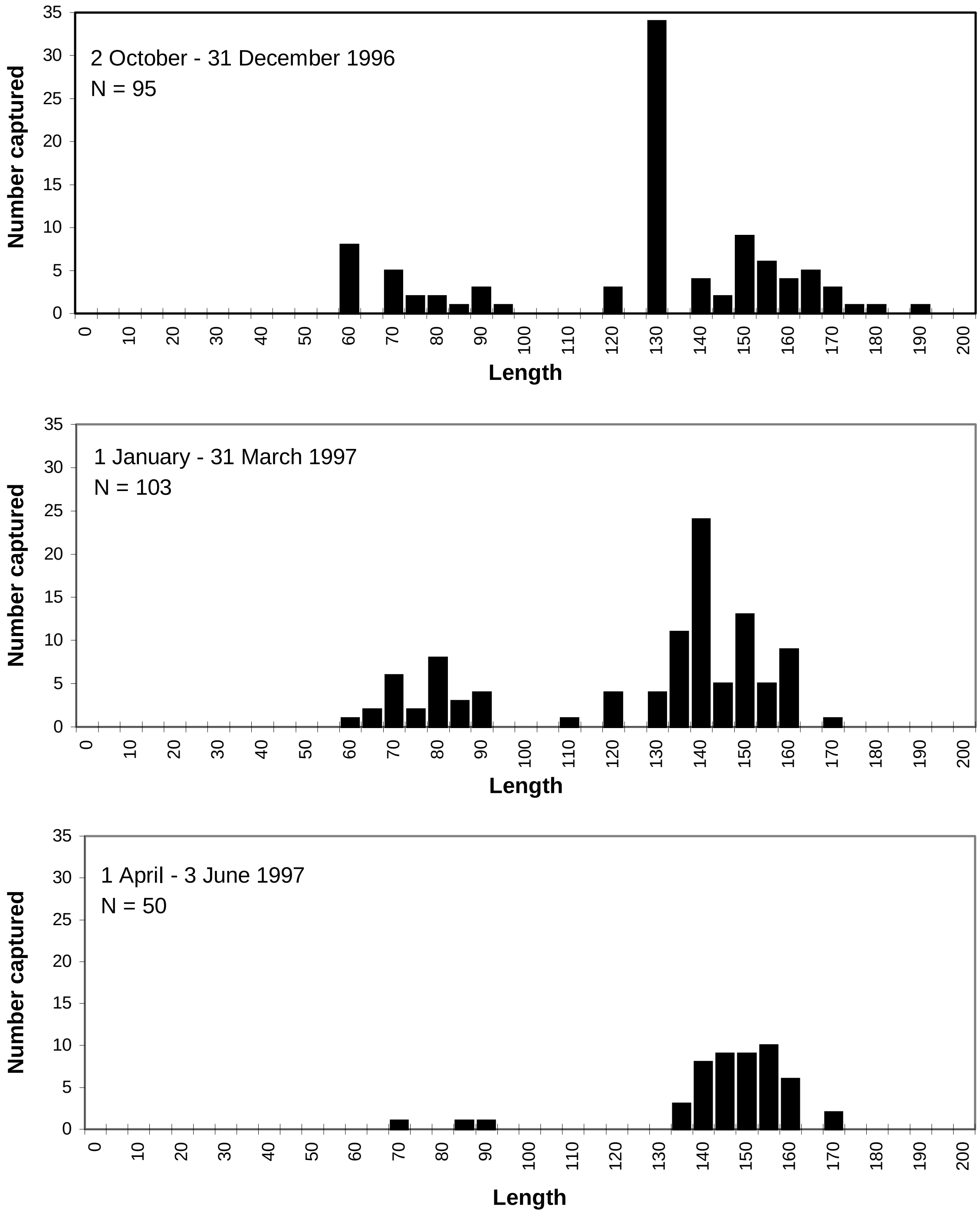


Figure 23. Length-frequency distribution by calendar quarter of juvenile lamprey collected at the rotary-screw trap (RM 1.2), Umatilla River, October 1996 - June 1997. Distributions are in 5-mm increments.

APPENDIX A

Ancillary Information from Outmigration Studies

Appendix Table A-1. Daily environmental and other observations at the rotary-screw trap site (RM 1.2), lower Umatilla River, 2 October 1996 - 3 July 1997.

Date	Time	Cloud cover (%)	Precip.[a]	Wind Veloc.[a]	Wind Direc.	River flow[a]	Turbid.[a]	Debris[a]	Water color[b]	Cone RPM[c] Before	Cone RPM[c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
10/02/96	1048	25	--	L	SE	--	--	M	GRN	0	0.25	2.70	--	60	--	--
10/03/96	0905	0	--	L	SE	--	--	M	GRN	0	1.00	2.65	56	60	--	--
10/04/96	0958	100	--	--	N	--	--	M	GRN	0	1.00	2.70	--	59	--	--
10/05/96	1100	75	--	L	--	--	--	M	GRN	3.25	4.00	2.75	58	62	--	--
10/06/96	1015	100	--	0	--	--	--	M	GRN	3.00	3.50	2.75	59	62	--	--
10/07/96	1420	0	--	0	--	--	--	MH	DGRN	0	1.00	2.70	58	62	--	--
10/08/96	1350	0	--	0	--	--	--	M	GRN	3.50	3.50	2.70	60	64	--	--
10/09/96	1200	0	--	L	NW	--	--	M	DGRN	2.50	6.00	2.60	60	52	--	--
10/10/96	1232	25	--	L	SW	--	--	M	GRN	2.50	4.00	2.60	--	--	--	--
10/11/96	1400	25	--	L	NW	--	--	M	GRN	3.50	4.50	2.65	--	--	--	--
10/12/96	1420	75	--	--	N	--	--	M	GRN	0	0	2.60	--	--	--	--
10/13/96	0845	100	--	--	N	--	--	M	GRN	3.25	3.00	2.65	--	59	--	--
10/14/96	1400	100	--	L	N	--	--	M	GRN	0	2.75	2.68	58	60	--	--
10/15/96	0915	0	--	L	NW	--	--	M	GRN	3.75	4.00	2.68	56	59	--	--
10/16/96	1210	0	--	--	N	--	--	M	GRN	2.50	1.50	2.68	54	58	--	--
10/17/96	0910	100	--	--	N	--	--	ML	GRN	0.50	0.50	2.69	56	57	--	--
10/18/96	1115	75	--	MH	N	--	--	ML	GRN	0	4.5 0	2.69	42	50	--	--
10/19/96	1530	100	--	MH	N	--	--	ML	GRN	0	0.50	2.69	46	53	--	--
10/20/96	1300	25	--	L	N	--	--	L	DGRN	0	1.00	2.80	45	55	--	--
10/21/96	1015	75	--	L	N	--	--	M	GRN	0	3.00	2.77	47	50	--	--
10/22/96	0900	100	--	--	N	--	--	M	GRN	0	4.00	2.79	47	50	--	--
10/23/96	0930	50	--	--	N	--	--	M	GRN	4.50	4.25	2.78	47	49	--	--
10/24/96	1015	25	--	L	SW	--	--	M	GRN	0	3.00	2.80	47	50	--	--
10/25/96	0930	0	--	L	S	--	--	M	DGRN	4.00	3.00	2.80	47	52	--	--
10/26/96	0800	0	--	0	--	--	--	M	DGRN	0	3.50	2.80	50	51	--	--
10/27/96	1030	0	--	0	--	--	--	M	DGRN	0	3.00	2.82	49	51	--	--
10/28/96	1030	100	--	0	--	--	--	M	DGRN	3.50	3.00	2.82	48	50	--	--
10/29/96	1020	100	--	L	--	--	--	M	DGRN	3.50	3.50	2.85	48	51	--	--
10/30/96	1030	100	--	L	NE	--	--	M	LBRN	0	2.25	2.82	48	51	--	--
10/31/96	0915	25	--	L	N	--	--	M	DGRN	2.00	2.25	2.80	48	50	--	--
11/01/96	1130	0	--	0	--	--	--	M	DGRN	2.75	2.00	2.75	45	49	--	--
11/02/96	1030	0	--	0	--	--	--	ML	DGRN	2.10	3.80	2.79	44	48	--	--
11/03/96	0900	0	--	0	--	--	--	ML	DGRN	3.60	3.90	2.79	44	46	--	--
11/04/96	1450	75	--	M	N	--	--	ML	DGRN	3.50	3.50	2.82	44	45	--	--

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip.[a]	Wind Veloc.[a]	Wind Direc.	River flow[a]	Turbid.[a]	Debris[a]	Water color[b]	Cone RPM[c] Before	Cone RPM[c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
11/05/96	1130	25	--	0	--	--	--	ML	DGRN	3.50	3.65	2.79	45	47	--	--
11/06/96	1030	75	--	M	SW	--	--	M	DGRN	3.50	3.85	2.79	45	48	--	--
11/07/96	1200	100	--	L	SW	--	--	M	DGRN	3.75	--	2.79	45	48	--	--
11/08/96	0900	50	--	0	--	--	--	L	GRN	0	3.50	2.80	45	46	--	--
11/09/96	0800	0	--	0	--	--	--	ML	GRN	2.13	2.00	2.60	46	47	--	--
11/10/96	0930	100	--	0	--	--	--	L	GRN	1.70	1.75	2.58	45	49	--	--
11/11/96	1030	100	--	M	S	--	--	L	GRN	2.00	2.00	2.58	45	48	--	--
11/12/96	1335	0	--	0	--	--	--	L	GRN	2.00	2.00	2.58	46	48	--	--
11/13/96	0900	0	--	0	--	--	--	L	CLR	0	1.20	2.57	45	48	--	--
11/14/96	1545	25	--	0	--	--	--	L	CLR	1.50	1.50	2.57	47	47	--	--
11/15/96	1230	100	--	0	--	--	--	L	CLR	2.00	2.00	2.58	48	49	--	--
11/16/96	1600	100	--	L	--	--	--	L	GRN	0.75	1.00	2.59	47	49	--	--
11/17/96	0930	100	--	0	--	--	--	L	GRN	0	1.50	2.59	47	47	--	--
11/18/96	1520	100	--	0	--	--	--	L	GRN	0	2.00	2.65	46	48	--	--
11/19/96	1000	100	--	L	S	--	--	MH	GRN	0	3.00	2.78	44	46	--	--
11/20/96	0900	25	--	0	--	--	--	H	BRN	0	0	3.50	41	45	--	--
11/21/96	0900	100	--	0	--	--	--	M	LBRN	0	6.00	3.55	41	52	--	--
11/22/96	0945	100	--	0	--	--	--	M	LBRN	5.00	4.75	3.26	41	47	--	--
11/23/96	1325	100	--	L	SE	--	--	L	DGRN	3.25	2.00	3.10	39	41	--	--
11/24/96	1430	100	--	0	--	--	--	L	DGRN	2.00	2.00	3.05	38	41	--	--
11/25/96	1045	100	--	L	SW	--	--	L	DGRN	1.33	1.33	3.00	38	40	--	--
11/26/96	1115	100	--	L	W	--	--	L	DGRN	3.00	2.50	3.10	38	39	--	--
11/27/96	1430	100	--	L	W	--	--	L	DGRN	2.00	2.00	3.05	38	38	--	--
11/28/96	1530	100	--	H	NW	--	--	L	DGRN	2.60	3.20	3.15	38	39	--	--
11/29/96	1430	75	--	L	W	--	--	L	DGRN	2.80	3.30	3.24	38	40	--	--
11/30/96	1500	50	--	L	W	--	--	L	DGRN	2.40	2.60	3.28	38	39	--	--
12/01/96	1100	75	--	H	SW	--	--	L	DGRN	2.40	2.80	3.16	37	38	--	--
12/02/96	0930	75	--	0	--	--	--	M	GRN	3.75	3.85	3.25	39	44	--	--
12/03/96	1030	0	--	L	W	--	--	M	GRN	4.00	3.60	3.18	39	41	--	--
12/04/96	1045	100	--	0	--	--	--	L	DGRN	3.25	2.60	3.10	38	40	--	--
12/05/96	1000	75	--	0	--	--	--	L	DGRN	0	1.33	3.02	37	38	--	--
12/06/96	1000	75	--	0	--	--	--	M	DBRN	0	3.90	3.22	38	40	--	--
12/07/96	1120	100	--	0	--	--	--	M	DBRN	5.00	5.00	3.10	40	42	--	--
12/08/96	1330	75	--	0	--	--	--	M	DBRN	5.50	5.50	3.20	42	44	--	--
12/09/96	1030	100	--	0	--	--	--	H	CHOC	2.00	--	3.90	37	42	--	--
12/10/96	--	--	--	--	--	--	--	--	--	--	--	4.20	--	--	--	--
12/11/96	0900	--	--	--	--	--	--	H	CHOC	--	--	4.65	--	--	--	--

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind Veloc. [a]	Wind Direc.	River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM [c] Before	Cone RPM [c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
12/12/96	1341	0	--	0	--	--	--	H	BRN	--	--	4.10	37	42	--	--
12/13/96	0900	--	--	--	--	--	--	--	BRN	0	6.00	3.80	46	48	--	--
12/14/96	1100	0	--	0	--	--	--	M	BRN	5.75	5.33	3.68	40	40	--	--
12/15/96	1130	100	--	0	--	--	--	M	BRN	5.33	5.05	3.52	39	44	--	--
12/16/96	1030	0	--	L	SW	--	--	L	DGRN	4.75	4.00	3.40	38	40	--	--
12/17/96	0900	0	--	0	--	--	--	L	DGRN	4.50	4.50	3.30	38	40	--	--
12/18/96	1145	100	--	L	--	--	--	L	DGRN	4.00	4.00	3.20	35	36	--	--
12/19/96	1100	100	--	L	W	--	--	L	DGRN	3.25	3.75	3.18	34	35	--	--
12/20/96	0845	0	--	0	--	--	--	L	DGRN	4.00	4.00	3.10	33	35	--	--
12/21/96	1330	75	--	0	--	--	--	L	DGRN	3.00	3.00	2.95	35	37	--	--
12/22/96	1215	100	--	0	--	--	--	L	DGRN	3.00	3.00	2.90	37	38	--	--
12/23/97	1045	75	--	0	--	--	--	L	DGRN	2.50	2.50	2.85	37	38	--	--
12/24/97	1045	100	--	L	N	--	--	L	DGRN	2.00	2.00	2.85	37	38	--	--
12/26/96	1100	100	--	0	--	--	--	MH	CHOC	4.75	--	3.75	33	38	--	--
12/27/96	--	--	--	--	--	--	--	--	CHOC	6.00	--	3.70	--	--	--	--
12/28/96	1630	100	--	L	W	--	--	M	BRN	6.00	6.50	3.80	31	32	--	--
12/29/96	1200	100	--	--	N	--	--	M	BRN	7.26	6.75	3.70	31	33	--	--
12/30/96	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
01/08/97	1130	100	--	--	N	--	--	M	BRN	7.50	7.00	--	--	39	--	--
01/09/97	0945	100	--	--	N	--	--	M	LBRN	6.75	6.75	3.75	40	42	--	--
01/10/97	0900	25	--	--	N	--	--	ML	LBRN	6.25	5.75	3.60	40	42	--	--
01/11/97	1200	50	--	--	N	--	--	L	DGRN	5.75	5.25	3.50	42	44	--	--
01/12/97	1300	0	--	M	N	--	--	L	DGRN	5.00	5.00	3.50	36	38	--	--
01/13/97	1420	0	--	--	N	--	--	L	DGRN	4.75	6.00	3.45	33	40	--	--
01/14/97	1600	0	--	L	--	--	--	L	DGRN	6.00	6.00	3.60	32	38	--	--
01/15/97	1100	0	--	L	NW	--	--	L	LBRN	6.25	5.80	3.60	31	33	--	--
01/16/97	1400	75	--	--	N	--	--	L	DGRN	0	5.75	3.45	30	32	--	--
01/17/97	1130	100	--	L	--	--	--	L	DGRN	5.00	5.00	3.30	31	32	--	--
01/18/97	1600	100	--	0	--	--	--	L	DGRN	5.00	5.00	3.40	33	35	--	--
01/19/97	1515	100	--	0	--	--	--	L	DGRN	4.50	4.50	3.35	36	38	--	--
01/20/97	1420	100	--	0	--	--	--	L	DGRN	4.25	4.25	3.35	36	38	--	--
01/21/97	0930	50	--	--	N	--	--	L	DGRN	4.30	--	3.30	37	38	--	--
01/22/97	0930	75	--	H	SW	--	--	L	DGRN	--	4.00	3.30	37	40	--	--
01/23/97	1000	75	--	L	SW	--	--	L	DGRN	4.25	4.33	3.30	38	41	--	--
01/24/97	1000	0	--	M	SW	--	--	L	DGRN	4.00	4.35	3.20	37	39	--	--
01/25/97	1200	100	--	L	SW	--	--	ML	DGRN	4.25	4.00	3.15	36	39	--	--
01/26/97	1200	100	--	--	N	--	--	L	GRN	3.75	3.00	3.05	35	37	--	--

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind Veloc. [a]	Wind Direc.	River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM[c] Before	Cone RPM[c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
01/27/97	0920	100	--	L	--	--	--	L	GRN	0	1.00	3.10	31	32	--	--
01/28/97	1315	0	--	L	--	--	--	L	GRN	2.50	2.50	3.10	32	33	--	--
01/29/97	0930	100	--	M	N	--	--	L	DGRN	3.50	4.00	3.20	34	34	--	--
01/30/97	0930	100	--	--	N	--	--	L	DGRN	4.25	4.00	3.15	33	36	--	--
01/31/97	0900	100	--	--	N	--	--	--	CHOC	0	--	4.50	35	39	--	--
02/01/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
02/02/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
02/03/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
02/04/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
02/05/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
02/06/97	0900	100	--	L	S	--	--	H	BRN	8.00	8.25	4.00	35	38	--	--
02/07/97	0930	100	--	L	S	--	--	MH	BRN	7.25	7.00	3.75	35	37	--	--
02/08/97	1500	100	--	L	SW	--	--	M	BRN	7.25	7.00	3.75	35	36	--	--
02/09/97	1030	100	--	L	W	--	--	ML	LBRN	--	6.00	3.75	35	36	--	--
02/10/97	1020	100	--	L	SW	--	--	L	LBRN	6.25	6.80	3.50	35	37	--	--
02/11/97	0930	100	--	--	N	--	--	L	DGRN	6.25	6.00	3.40	36	38	--	--
02/12/97	1000	100	--	M	S	--	--	L	LBRN	5.80	4.75	3.35	37	38	--	--
02/13/97	1030	50	--	L	SW	--	--	L	BRN	--	5.75	3.50	37	39	--	--
02/14/97	1050	75	--	L	S	--	--	L	CHOC	6.00	6.00	3.40	39	44	--	--
02/15/97	1300	25	--	M	N	--	--	MH	CHOC	6.50	6.50	3.75	43	46	--	--
02/16/97	1145	0	--	0	--	--	--	M	CHOC	--	7.00	4.00	44	46	--	--
02/17/97	1030	25	--	H	W	--	--	ML	CHOC	6.50	6.50	3.90	42	43	--	--
02/18/97	1000	100	--	0	--	--	--	M	BRN	8.75	9.00	4.05	43	47	--	--
02/19/97	0930	100	--	M	W	--	--	M	BRN	9.50	--	4.05	42	43	--	--
02/20/97	0900	100	--	L	S	--	--	MH	DBRN	8.50	9.75	4.25	42	44	--	--
02/21/97	0930	50	--	--	N	--	--	H	BRN	9.00	10.00	4.15	41	42	--	--
02/22/97	1130	0	--	0	--	--	--	M	LBRN	9.00	9.00	3.90	39	41	--	--
02/23/97	1430	0	--	--	N	--	--	ML	DGRN	7.00	8.60	3.80	39	42	--	--
02/24/97	0945	0	--	L	W	--	--	ML	DGRN	7.00	7.00	3.70	38	39	--	--
02/25/97	1400	50	--	L	S	--	--	L	DGRN	7.30	--	3.60	40	43	--	--
02/26/97	1330	100	--	H	S	--	--	L	DGRN	6.50	6.50	3.60	43	45	--	--
02/27/97	1230	50	--	L	S	--	--	L	GRN	5.50	5.50	3.30	41	44	--	--
03/01/97	1400	100	--	H	N	--	--	M	LGRN	5.00	5.00	3.20	41	43	--	--
03/02/97	1100	100	--	M	N	--	--	M	LGRN	5.00	5.00	3.20	42	43	--	--
03/03/97	1600	75	--	L	SW	--	--	M	CHOC	6.00	6.30	3.55	41	43	--	--
03/04/97	1110	50	--	L	SW	--	--	ML	LGRN	6.00	6.00	3.55	40	41	--	--
03/05/97	1600	100	--	L	S	--	--	L	LGRN	6.00	6.00	3.40	40	40	--	--

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind		River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM [c]		Gage height	Water temp.		Air temp.	
				Veloc. [a]	Direc.					Before	After		Min.	Max.	Min.	Max.
03/06/97	1000	100	--	L	--	--	--	L	LGRN	6.00	--	3.40	43	43	--	--
03/07/97	1300	100	--	M	S	--	--	L	GRN	7.50	7.25	3.60	43	46	--	--
03/08/97	0930	0	--	--	N	--	--	M	DGRN	8.30	9.00	3.80	43	45	--	--
03/09/97	1030	100	--	L	S	--	--	MH	LBRN	9.25	9.00	3.90	43	44	--	--
03/10/97	1440	100	--	L	--	--	--	H	LBRN	11.50	10.50	4.30	45	46	--	--
03/11/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
03/12/97	1500	50	0	--	--	H	H	MH	DBRN	9.75	--	--	--	--	--	--
03/13/97	1400	75	0	L	--	H	M	ML	LBRN	8.00	--	--	34	48	--	--
03/14/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
03/15/97	0930	100	0	0	--	M	M	MH	LBRN	9.00	--	--	40	42	--	--
03/15/97	1530	50	0	0	--	M	M	M	LBRN	10.50	--	--	--	--	--	--
03/16/97	1000	75	0	0	--	M	M	L	LBRN	9.75	--	--	40	42	--	--
03/17/97	0800	0	0	L	--	M	M	H	LBRN	9.00	--	4.25	42	46	--	--
03/18/97	0910	0	0	0	--	H	H	H	DBRN	--	--	--	--	--	--	--
03/18/97	0930	100	0	L	--	H	H	H	DBRN	7.00	--	5.00	--	--	--	--
03/18/97	1530	100	0	0	--	H	H	H	DBRN	--	--	6.00	--	--	--	--
03/24/97	1500	75	0	0	--	M	MH	ML	DOLV	10.25	--	4.50	--	--	--	--
03/25/97	0910	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
03/26/97	0200	--	--	--	--	M	M	L	LBRN	10.50	--	--	--	--	--	--
03/26/97	0800	75	0	L	--	M	M	M	LBRN	--	11.00	--	48	49	--	--
03/26/97	1400	75	0	L	--	M	M	M	LBRN	11.00	11.00	--	--	--	--	--
03/26/97	2100	100	0	H	--	M	M	M	LBRN	--	11.25	--	--	--	--	--
03/27/97	0200	--	--	MH	--	M	M	M	LBRN	--	--	--	--	--	--	--
03/27/97	0900	25	0	M	--	M	M	M	LBRN	11.00	11.50	4.70	54	54	--	--
03/27/97	1500	50	0	L	--	M	M	MH	LBRN	--	7.75	--	--	--	--	--
03/27/97	2100	100	L	L	--	M	M	MH	LBRN	--	--	--	--	--	--	--
03/28/97	0200	0	0	M	--	M	M	L	LBRN	7.75	--	--	--	--	--	--
03/28/97	0900	25	0	H	--	M	M	ML	LBRN	8.00	8.00	--	44	46	--	--
03/28/97	2100	0	0	H	--	M	M	M	LBRN	--	9.25	--	--	--	--	--
03/29/97	0930	0	0	0	--	M	M	L	LBRN	9.50	--	4.50	44	46	--	--
03/29/97	1425	25	0	0	--	M	M	L	LBRN	10.00	--	4.50	--	--	--	--
03/29/97	2000	25	0	L	--	M	M	L	LBRN	10.50	10.00	4.50	--	--	--	--
03/30/97	0830	100	0	0	--	M	M	L	LBRN	8.50	--	4.40	46	46	--	--
03/30/97	1400	50	0	0	--	M	M	L	LBRN	8.50	--	4.40	--	--	--	--
03/31/97	0800	25	0	M	--	M	M	L	LBRN	7.50	--	4.40	44	46	--	--
03/31/97	2000	25	0	L	--	M	M	MH	LBRN	10.00	--	4.00	--	--	--	--
04/01/97	0900	50	0	L	--	M	M	--	LBRN	9.50	--	4.00	44	44	--	--

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind Veloc. [a]	Wind Direc.	River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM[c] Before	Cone RPM[c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
04/01/97	1540	50	0	0	--	M	M	L	LBRN	7.75	--	4.20	--	--	--	--
04/01/97	2000	0	0	0	--	M	M	L	LBRN	8.25	--	4.20	--	--	--	--
04/02/97	0800	0	0	L	--	M	M	L	LBRN	8.75	--	4.00	42	44	--	--
04/02/97	1525	50	0	0	--	M	M	L	LOLV	8.25	--	4.10	--	--	--	--
04/02/97	1900	25	0	0	--	M	M	L	LBRN	7.75	--	4.00	--	--	--	--
04/03/97	0800	25	0	M	--	M	M	L	LBRN	7.75	--	4.00	46	46	50	62
04/03/97	1525	50	0	H	--	M	M	H	LBRN	5.50	--	4.00	--	--	--	--
04/03/97	2000	50	0	M	--	M	M	H	LBRN	5.75	--	4.20	--	--	--	--
04/04/97	0800	50	0	L	--	M	M	ML	LBRN	7.75	--	4.00	44	48	30	62
04/04/97	1600	50	0	L	--	ML	L	ML	DOLV	7.33	--	3.70	--	--	--	--
04/04/97	2300	50	0	0	--	ML	L	L	DOLV	7.50	--	3.70	--	--	--	--
04/05/97	1000	0	0	L	--	M	ML	L	OLIV	7.50	--	--	42	45	30	58
04/05/97	1500	0	0	L	--	ML	L	L	DOLV	7.00	--	3.70	--	--	--	--
04/05/97	2050	0	0	L	--	ML	ML	L	LOLV	7.00	--	3.50	--	--	--	--
04/06/97	0800	0	0	0	--	M	M	L	OLV	7.00	--	3.60	44	46	24	64
04/06/97	1900	50	0	0	--	ML	L	L	LOLV	--	--	3.50	--	--	--	--
04/07/97	1440	50	0	M	--	ML	L	L	DGRN	6.00	--	3.50	--	--	--	--
04/07/97	2000	50	0	ML	--	L	L	L	DGRN	6.00	--	3.40	--	--	--	--
04/08/97	0745	75	0	0	--	M	M	L	LOLV	6.00	--	3.50	50	50	28	68
04/08/97	1450	50	--	L	--	L	L	L	LGRN	4.00	--	3.45	--	--	--	--
04/09/97	0830	25	0	0	--	M	M	L	LOLV	5.25	--	3.40	49	56	36	68
04/09/97	1500	50	0	L	--	ML	ML	L	LOLV	5.50	--	3.45	--	--	--	--
04/10/97	0800	50	0	0	--	M	M	M	LBRN	5.00	--	3.50	48	58	36	68
04/10/97	1430	25	0	L	--	M	M	L	DOLV	6.25	--	3.50	--	--	--	--
04/11/97	0800	0	0	L	--	M	L	--	LOLV	6.30	--	3.50	44	50	30	57
04/11/97	1430	0	0	L	--	M	ML	ML	LOLV	7.25	--	3.60	--	--	--	--
04/12/97	0800	0	0	L	--	L	L	L	DGRN	5.67	--	3.40	45	49	23	60
04/12/97	1445	25	0	L	--	ML	ML	L	DGRN	6.00	--	3.45	--	--	--	--
04/13/97	0900	100	0	L	--	L	L	L	DGRN	6.25	--	3.40	44	49	39	65
04/13/97	1500	100	0	0	--	L	M	L	DGRN	5.67	--	3.40	--	--	--	--
04/13/97	1940	100	0	L	--	L	M	M	LBRN	5.67	--	3.40	--	--	--	--
04/14/97	0800	75	L	L	--	M	L	L	OLV	7.00	--	3.60	48	50	44	58
04/14/97	1655	100	L	0	--	M	L	L	DOLV	5.75	--	3.50	--	--	--	--
04/15/97	0800	50	0	0	--	M	M	ML	LBRN	8.25	--	3.75	48	50	44	60
04/15/97	1600	25	0	0	--	MH	M	MH	LBRN	9.25	--	4.10	--	--	--	--
04/15/97	2000	50	0	0	--	MH	MH	M	LBRN	10.50	--	4.20	--	--	--	--
04/16/97	0800	50	0	0	--	H	H	H	BRN	10.75	--	4.30	50	50	48	72

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind Veloc. [a]	Wind Direc.	River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM [c] Before	Cone RPM [c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
04/16/97	1530	75	0	0	--	H	H	H	BRN	9.75	--	4.50	--	--	--	--
04/17/97	0815	75	0	0	--	H	H	H	DBRN	10.25	--	4.45	50	52	48	72
04/17/97	1500	25	0	0	--	H	H	H	BRN	10.50	--	4.60	--	--	--	--
04/18/97	0915	100	0	L	--	H	H	H	DBRN	10.50	--	4.45	50	50	42	68
04/18/97	1900	100	0	0	--	H	MH	H	LBRN	10.50	--	4.50	--	--	--	--
04/19/97	0900	100	0	0	--	H	H	M	BRN	10.50	--	4.35	50	50	48	62
04/19/97	1700	100	0	0	--	MH	MH	M	LBRN	11.25	--	4.60	--	--	--	--
04/20/97	0900	50	0	H	--	H	H	H	BRN	--	--	5.10	50	52	52	64
04/20/97	1600	25	0	H	--	H	H	H	DBRN	10.00	--	5.00	--	--	--	--
04/20/97	1900	25	0	M	--	H	H	H	DBRN	--	--	5.25	--	--	--	--
04/21/97	0900	0	0	0	--	H	H	H	DBRN	--	10.50	5.30	50	54	34	68
04/21/97	1330	75	0	0	--	H	H	H	DBRN	11.00	--	5.30	--	--	--	--
04/21/97	1930	100	L	0	--	H	H	H	DBRN	--	--	5.50	--	--	--	--
04/22/97	0745	75	0	0	--	H	H	H	DBRN	10.75	--	5.30	52	52	46	65
04/22/97	1420	50	0	0	--	H	H	M	DBRN	11.00	--	5.00	--	--	--	--
04/22/97	1935	100	L	L	--	H	H	M	DBRN	10.75	--	5.00	--	--	--	--
04/23/97	0900	100	0	L	--	H	H	M	BRN	11.25	--	4.90	49	50	44	68
04/23/97	1635	100	0	L	--	H	H	H	DBRN	10.50	--	5.00	--	--	--	--
04/24/97	0845	25	0	L	--	H	H	H	DBRN	11.50	--	5.30	48	50	39	74
04/24/97	1635	25	0	L	--	H	H	H	DBRN	11.00	--	5.30	--	--	--	--
04/24/97	2130	25	0	0	--	H	H	--	DBRN	11.50	--	5.30	--	--	--	--
04/25/97	0900	50	0	0	--	MH	MH	ML	BRN	11.50	--	5.00	46	50	40	73
04/25/97	1500	50	0	0	--	MH	MH	M	BRN	11.50	--	4.90	--	--	--	--
04/25/97	1920	25	0	0	--	H	H	M	BRN	11.00	--	4.80	--	--	--	--
04/26/97	0800	50	0	0	--	MH	MH	M	LBRN	11.00	11.00	4.50	48	50	46	72
04/26/97	1545	50	0	0	--	MH	MH	MH	LBRN	10.50	--	4.50	--	--	--	--
04/26/97	2045	100	L	0	--	MH	MH	--	BRN	10.75	--	4.50	--	--	--	--
04/27/97	0900	0	0	H	--	M	M	M	LBRN	7.00	7.00	4.50	52	53	49	76
04/27/97	1400	25	0	L	--	M	M	M	LBRN	10.50	--	4.50	--	--	--	--
04/27/97	1900	75	0	0	--	M	H	H	DBRN	9.50	--	4.70	--	--	--	--
04/28/97	0845	100	0	M	--	M	M	M	BRN	10.00	10.00	4.70	50	55	39	66
04/28/97	1330	0	L	0	--	H	M	H	DBRN	9.25	--	4.60	--	--	--	--
04/29/97	0645	75	L	0	--	MH	MH	MH	DBRN	9.50	--	4.70	50	50	42	60
04/29/97	1430	25	0	0	--	M	MH	MH	DBRN	9.75	10.00	--	--	--	--	--
04/29/97	1900	25	0	L	--	M	M	M	DBRN	8.50	9.00	--	--	--	--	--
04/30/97	0645	100	L	L	--	M	M	MH	BRN	8.00	9.50	4.50	48	48	40	70
04/30/97	1345	25	0	L	--	M	M	M	LBRN	9.00	9.00	4.50	--	--	--	--

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind Veloc. [a]	Wind Direc.	River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM [c] Before	Cone RPM [c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
04/30/97	1900	25	0	H	--	M	M	M	BRN	8.50	8.25	4.50	--	--	--	--
05/01/97	0650	25	0	M	--	MH	MH	M	BRN	8.50	9.00	4.50	48	52	40	62
05/01/97	1450	25	0	L	--	M	M	M	BRN	9.00	9.00	4.40	--	--	--	--
05/02/97	1030	50	0	0	--	M	M	M	BRN	8.75	8.25	4.40	50	53	31	72
05/02/97	1600	50	0	0	--	M	M	M	BRN	8.75	--	4.40	--	--	--	--
05/03/97	1010	75	L	L	--	M	M	M	LBRN	8.00	8.25	4.00	50	50	48	68
05/03/97	1420	75	0	L	--	M	M	L	LBRN	8.25	8.00	4.00	--	--	--	--
05/04/97	1000	25	0	L	--	ML	ML	M	DOLV	7.75	7.75	4.00	52	52	44	78
05/04/97	1530	25	0	L	--	ML	ML	L	DOLV	7.75	8.00	4.00	--	--	--	--
05/05/97	0730	75	0	L	--	ML	ML	ML	OLV	7.75	8.00	4.00	46	56	48	70
05/05/97	1745	75	0	L	--	ML	ML	L	DOLV	7.75	8.00	4.00	--	--	--	--
05/06/97	0800	25	0	L	--	M	ML	ML	OLV	7.25	7.00	4.00	54	56	47	74
05/06/97	1720	25	0	M	--	M	M	ML	OLV	7.75	8.00	4.00	--	--	--	--
05/07/97	0700	0	0	0	--	M	M	ML	OLV	7.50	7.50	4.00	55	57	38	72
05/07/97	1705	0	0	L	--	M	M	L	OLV	7.50	7.75	4.00	--	--	--	--
05/08/97	0630	25	0	0	--	L	L	ML	OLV	6.75	6.75	3.80	54	56	38	78
05/08/97	1710	0	0	0	--	L	L	L	LOLV	6.75	7.00	3.80	--	--	--	--
05/09/97	1445	--	--	--	--	--	--	--	--	--	--	--	53	58	44	83
05/09/97	1400	50	0	0	--	L	L	L	LGRN	6.00	6.00	3.50	--	--	--	--
05/10/97	0930	0	0	0	--	M	L	L	OLV	5.25	5.50	4.00	58	60	44	88
05/10/97	1550	0	0	0	--	M	L	L	OLV	6.00	6.00	4.00	--	--	--	--
05/11/97	0920	0	0	0	--	M	L	L	DGRN	5.25	5.00	3.80	60	60	46	90
05/11/97	1700	0	0	0	--	M	L	L	OLV	6.00	6.25	3.80	--	--	--	--
05/12/97	0845	0	0	0	--	M	L	L	GRN	5.00	5.25	3.80	60	61	44	90
05/12/97	1530	0	0	0	--	M	L	L	GRN	5.25	5.25	3.80	--	--	--	--
05/13/97	0645	0	0	0	--	L	L	ML	GRN	4.75	4.50	3.80	62	62	44	90
05/13/97	1820	25	0	0	--	L	L	L	GRN	4.75	4.50	3.80	--	--	--	--
05/14/97	0640	25	0	0	--	L	L	L	GRN	3.25	3.13	3.80	64	64	54	90
05/14/97	1800	100	0	0	--	L	L	L	GRN	2.00	2.25	3.80	--	--	--	--
05/15/97	0630	25	0	0	--	L	L	L	GRN	0	1.75	3.15	62	64	54	88
05/15/97	0800	0	0	0	--	L	L	M	GRN	0	2.00	3.10	--	--	--	--
05/16/97	1020	0	0	0	--	L	L	ML	GRN	0	2.75	3.10	60	66	56	90
05/16/97	1635	25	0	L	--	L	L	M	GRN	3.63	3.75	3.10	--	--	--	--
05/17/97	1345	0	0	0	--	L	L	MH	GRN	1.75	--	3.00	66	68	52	90
05/18/97	1445	0	0	L	--	L	L	MH	LGRN	0	0.75	2.85	62	67	47	84
05/19/97	1050	0	0	0	--	L	L	M	LGRN	0	3.25	2.80	60	65	40	84
05/19/97	1715	0	0	M	--	L	L	M	LGRN	3.00	3.25	2.80	--	--	--	--

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind Veloc. [a]	Wind Direc.	River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM [c] Before	Cone RPM [c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
05/20/97	1100	25	0	H	--	L	L	M	GRN	2.00	2.00	2.50	60	66	48	88
05/20/97	1630	25	0	H	--	L	L	L	GRN	0	1.50	2.50	--	--	--	--
05/21/97	0900	0	0	L	--	L	L	MH	GRN	0	3.13	2.70	60	64	38	80
05/21/97	1510	25	0	L	--	L	L	H	GRN	2.75	2.75	2.70	--	--	--	--
05/22/97	0700	50	0	0	--	L	L	M	LGRN	0	1.75	2.70	62	64	40	74
05/22/97	1505	75	0	L	--	L	L	M	GRN	2.00	2.00	2.70	--	--	--	--
05/23/97	0825	100	0	L	--	L	L	M	DGRN	0	3.00	2.75	60	64	52	80
05/23/97	1525	50	0	L	--	L	L	--	GRN	2.88	2.75	2.75	--	--	--	--
05/24/97	0840	50	0	M	--	L	L	H	GRN	0	1.25	2.80	60	64	46	72
05/24/97	1610	50	0	L	--	L	L	M	GRN	2.50	--	2.75	--	--	--	--
05/25/97	0810	50	0	L	--	L	L	L	GRN	--	1.00	2.80	60	64	52	72
05/26/97	1030	75	0	0	--	L	L	H	LGRN	1.50	--	2.70	58	62	58	73
05/27/97	0930	50	0	0	--	L	L	M	LGRN	0	3.00	2.70	62	64	48	84
05/28/97	0840	100	0	0	--	L	L	H	GRN	1.75	2.00	2.75	64	64	54	80
05/29/97	0855	50	0	0	--	L	L	H	LGRN	1.88	2.25	2.70	64	65	55	76
05/30/97	0900	100	L	0	--	L	L	M	--	0	2.00	2.80	63	66	49	87
05/30/97	1445	75	0	0	--	L	L	M	GRN	3.00	2.25	2.80	--	--	--	--
05/31/97	0700	50	0	0	--	L	L	M	GRN	3.00	1.25	2.80	67	70	62	84
05/31/97	1400	75	ML	L	--	L	L	MH	LGRN	3.00	3.00	2.85	--	--	--	--
05/31/97	1900	25	0	L	--	L	L	MH	GRN	3.00	3.00	2.80	--	--	--	--
06/01/97	0815	25	0	L	--	L	L	ML	GRN	1.75	2.00	2.80	64	68	52	90
06/01/97	1400	75	0	L	--	L	L	M	LGRN	2.50	--	2.80	--	--	--	--
06/02/97	0815	50	0	L	--	L	L	M	LGRN	--	2.75	2.80	64	68	46	85
06/03/97	0200	100	0	L	--	L	ML	L	GRN	1.50	--	2.70	--	--	--	--
06/03/97	1050	100	L	0	--	L	L	L	GRN	1.75	1.00	2.70	64	68	55	82
06/03/97	2000	100	M	L	--	L	ML	L	GRN	2.00	3.25	2.65	--	--	--	--
06/04/97	0800	100	L	L	--	M	L	M	DGRN	3.00	--	2.80	--	--	54	62
06/04/97	1330	100	L	M	--	M	L	M	DGRN	2.50	--	2.85	--	--	--	--
06/04/97	2000	50	M	0	--	L	L	M	DGRN	2.25	--	2.95	--	--	--	--
06/05/97	0800	25	L	L	--	M	M	M	LOLV	2.50	--	2.95	62	66	50	88
06/05/97	1700	50	0	L	--	L	L	M	LGRN	2.00	--	2.95	--	--	--	--
06/06/97	0815	50	0	0	--	L	L	M	LGRN	1.00	--	2.85	62	67	47	76
06/06/97	1600	25	0	0	--	L	L	ML	LGRN	2.00	--	2.95	--	--	--	--
06/06/97	2130	25	0	0	--	L	L	L	LGRN	2.50	--	3.00	--	--	--	--
06/07/97	0825	25	0	0	--	L	L	M	LGRN	3.25	2.25	2.80	40	64	50	86
06/07/97	2140	0	0	MH	--	L	L	L	GRN	2.50	--	2.70	--	--	--	--
06/08/97	0725	0	0	0	--	L	L	MH	GRN	3.00	3.00	2.70	62	68	48	86

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip. [a]	Wind Veloc. [a]	Wind Direc.	River flow [a]	Turbid. [a]	Debris [a]	Water color [b]	Cone RPM[c] Before	Cone RPM[c] After	Gage height	Water temp. Min.	Water temp. Max.	Air temp. Min.	Air temp. Max.
06/08/97	2100	25	0	0	--	L	L	M	GRN	3.75	--	2.75	--	--	--	--
06/09/97	0720	25	0	L	--	L	L	M	GRN	2.50	2.75	2.75	64	68	44	85
06/09/97	2000	25	0	0	--	L	L	L	LGRN	3.50	3.50	2.80	--	--	--	--
06/10/97	0730	50	0	0	--	L	L	M	GRN	2.75	2.00	2.80	66	70	52	84
06/10/97	2000	75	0	0	--	L	L	L	LGRN	2.50	--	2.70	--	--	--	--
06/11/97	0725	50	0	0	--	L	L	M	GRN	3.00	2.75	2.68	68	69	55	86
06/11/97	2145	75	L	MH	--	L	L	L	LGRN	3.00	--	2.70	--	--	--	--
06/12/97	0725	75	0	M	--	L	L	MH	GRN	2.75	2.75	2.70	64	70	56	87
06/12/97	2200	50	0	0	--	L	L	ML	LGRN	3.00	--	2.70	--	--	--	--
06/13/97	0725	50	0	0	--	L	L	MH	LGRN	2.25	2.50	2.80	62	69	56	79
06/13/97	2125	0	0	L	--	L	L	ML	LGRN	3.00	--	3.00	--	--	--	--
06/14/97	1300	25	0	L	--	L	M	M	LGRN	2.50	--	3.80	64	74	56	91
06/14/97	2000	25	0	0	--	L	L	L	LGRN	2.50	--	3.75	--	--	--	--
06/15/97	1000	25	0	0	--	L	L	ML	LGRN	2.50	--	2.75	68	72	58	90
06/15/97	2000	25	0	L	--	L	L	ML	GRN	2.50	--	2.80	--	--	--	--
06/16/97	0845	50	0	L	--	L	L	M	GRN	2.25	--	2.70	70	73	64	92
06/17/97	0800	75	L	L	--	L	L	M	LGRN	2.75	--	2.70	57	72	59	86
06/17/97	1500	75	0	L	--	L	L	L	LGRN	2.50	--	2.70	--	--	--	--
06/17/97	2130	0	0	L	--	L	L	L	LGRN	2.50	--	2.70	--	--	--	--
06/18/97	0800	25	0	ML	--	L	L	ML	--	2.75	--	2.65	66	70	55	83
06/18/97	1430	25	0	M	--	L	L	L	LGRN	2.50	--	2.65	--	--	--	--
06/19/97	0800	0	0	L	--	L	L	L	GRN	3.25	--	2.70	64	69	48	78
06/19/97	2000	25	0	L	--	L	L	L	GRN	3.50	--	2.75	--	--	--	--
06/20/97	0800	0	0	L	--	L	L	L	LGRN	3.00	--	2.70	64	67	47	80
06/20/97	1630	0	0	0	--	L	L	L	LGRN	2.50	--	2.65	--	--	--	--
06/21/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
06/22/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
06/23/97	0800	25	0	L	--	L	L	L	GRN	3.50	--	2.70	63	68	46	86
06/23/97	1630	50	0	L	--	L	L	L	LGRN	3.00	--	2.65	--	--	--	--
06/23/97	2000	50	0	L	--	L	L	L	LGRN	3.00	--	2.70	--	--	--	--
06/24/97	0800	0	0	L	--	L	L	L	GRN	3.00	--	2.95	62	65	45	82
06/24/97	1700	25	0	L	--	L	L	L	GRN	2.50	--	2.95	--	--	--	--
06/25/97	0700	0	0	L	--	L	L	L	LGRN	2.00	--	2.95	--	--	--	--
06/25/97	1000	0	0	L	--	L	L	L	GRN	2.00	--	2.95	64	64	52	70
06/25/97	1700	25	0	L	--	L	L	L	GRN	2.50	--	2.95	--	--	--	--
06/25/97	2000	50	0	M	--	L	L	L	GRN	3.00	--	2.95	--	--	--	--
06/26/97	0800	0	0	M	--	L	L	L	LGRN	2.25	--	2.80	62	68	48	87

Appendix Table A-1. Continued.

Date	Time	Cloud cover (%)	Precip.[a]	Wind		River flow[a]	Turbid.[a]	Debris[a]	Water color[b]	Cone RPM[c]		Gage height	Water temp.		Air temp.	
				Veloc.[a]	Direc.					Before	After		Min.	Max.	Min.	Max.
06/26/97	1450	25	0	ML	--	L	L	L	GRN	3.00	--	2.70	--	--	--	--
06/27/97	1050	0	0	0	--	L	L	L	GRN	2.50	--	2.70	--	--	--	--
06/28/97	1300	0	0	0	--	L	L	L	GRN	2.50	--	2.70	--	--	--	--
06/29/97	1200	25	0	L	--	L	L	L	GRN	2.50	--	2.70	58	70	46	85
06/30/97	1015	50	0	0	--	L	L	L	LGRN	2.00	--	2.60	65	70	50	78
07/01/97	0900	25	L	L	--	L	L	L	GRN	0	0	2.55	64	72	58	80

[a] *Categories are: 0 = none; L = low; ML = moderately low; M = moderate; MH = moderately high; H = high.*

[b] *Colorations are: CLR = clear; LGRN = light green; GRN = green; DGRN = dark green; LBRN = ligth brown; BRN = brown; DBRN = dark brown; LOLV = light olive; OLV = olive; DOLV = dark olive; CHOC = chocolate brown.*

[c] *Cone RPM's are for before and after trap check to account for debris removal.*

Appendix Table A-2. Estimated number of fish captured at the Westland Canal juvenile fish facility and transported to the mouth of the Umatilla River, 27 June - 30 July 1997. Data was obtained from CTUIR (unpublished data).

	All fish species			Number of fish by species[a]			
Date	Pounds hauled	Number per lb.	Number hauled	Hatchery CHF0[b]	Natural CHF0[b]	Natural STS[b]	Resident fish
6/27[c]	105	35.2	3,696	3,685	0	0	11
6/29[c]	280	35.2	9,856	9,826	0	0	30
6/30	170	35.2	5,984	5,966	0	0	18
7/03	350	37.1	12,999	12,958	41	0	0
7/06[c]	185	33.6	6,216	6,068	69	20	59
7/07[c]	139	33.6	4,670	4,558	52	15	45
7/08[c]	35	33.6	1,176	1,148	13	4	11
7/10	92	30.1	2,774	2,648	54	18	54
7/12[c]	23	26.5	610	573	14	5	18
7/14	58	22.9	1,326	1,228	33	12	53
7/15[c]	25	22.0	506	463	19	3	21
7/17	35	21.1	740	666	43	0	31
7/18[c]	24	18.1	434	245	21	1	167
7/21[c]	30	18.1	543	306	27	1	209
7/24	35	15.1	529	158	22	2	347
7/28	45	15.0	675	164	29	0	482
7/30[c]	46	15.0	690	169	29	0	492
Total	*1,675*		*53,424*	*50,829*	*466*	*81*	*2,048*

[a] *Number of salmonids and resident fish species transported were estimated using species composition from fish per pound subsamples and total number of all species hauled.*

[b] *CHF0 =subyearling fall chinook salmon, STS = summer steelhead.*

[c] *Days on which transport occurred, but fish per pound sampling did not. Number of fish per pound was estimated by averaging data from sampled days preceding and following unsampled days.*

Appendix Table A-3. Condition of hatchery juvenile salmonids collected at the rotary-screw trap (RM 1.2) and Westland Canal (RM 27.3) on the Umatilla River, March - July 1997.

	Condition[a]															
Date	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	Total
								Coho Salmon								
3/12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/15	6	0	0	0	1	0	0	0	0	1	0	0	0	0	0	8
3/16	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
3/17	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3/18	6	0	0	0	15	1	1	0	2	0	0	0	1	0	0	26
3/25	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
3/26	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4
3/30	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/01	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
4/02	14	0	0	0	1	0	0	0	0	0	0	0	0	0	0	15
4/03	109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109
4/04	139	0	5	0	3	0	0	0	0	0	0	0	2	0	0	149
4/05	75	0	2	0	0	1	0	0	0	0	0	0	0	0	0	78
4/06	39	0	1	0	11	0	0	0	1	0	0	0	0	0	0	52
4/07	16	0	1	0	1	0	0	0	0	0	0	0	0	0	0	18
4/08	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
4/09	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
4/10	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
4/11	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	5
4/12	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
4/13	4	0	2	0	1	0	0	0	1	0	1	0	0	0	0	9
4/14	36	0	0	0	9	1	0	0	0	1	0	0	0	0	0	47
4/15	28	0	1	0	5	0	0	0	3	1	0	0	0	0	1	40
4/16	271	5	2	0	7	3	0	0	3	1	1	0	2	0	0	299
4/17	510	3	1	0	245	4	1	0	44	9	0	0	55	2	1	875
4/18	146	1	1	0	12	4	0	0	7	4	0	0	53	0	0	228
4/19	100	0	1	0	11	0	1	0	10	1	0	0	1	0	0	127
4/20	140	0	1	0	113	2	0	0	55	2	0	0	173	0	0	486
4/21	42	0	1	0	14	0	3	0	4	1	0	0	0	0	0	65
4/22	102	1	3	0	7	1	1	0	2	1	0	0	0	0	0	121
4/23	79	0	0	0	8	1	0	1	0	1	0	0	2	0	0	92
4/24	53	0	2	0	6	0	1	0	1	0	0	0	0	0	0	63
4/25	27	0	0	0	30	1	1	0	19	1	0	1	0	0	0	81
4/26	65	0	0	0	46	0	1	0	19	0	1	0	0	0	0	132
4/27	70	0	0	0	42	0	1	1	12	0	1	0	0	1	0	128
4/28	71	1	0	0	88	0	1	0	33	1	2	0	0	0	0	197

[a] *Condition codes: G = Good (minimal scale loss), GB = Good + bird marks, GI = Good + other injuries, GBI = Good + bird marks + other injuries, P = Partial scale loss, PB = Partial + bird marks, PI = Partial + other injuries, PBI = Partial + bird marks + other injuries, D = Descaled, DB = Descaled + bird marks, DI = Descaled + other injuries, DBI = Descaled + bird mark + other injuries, M = Mortality, MB = Mortality + bird marks, MI = Mortality + other injuries.*

Appendix Table A-3. Continued.

Date	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	Total
	Condition[a]															
4/29	57	0	1	0	3	0	0	0	0	0	0	0	0	0	0	62
4/30	40	0	3	0	4	0	0	0	0	0	0	0	0	0	0	47
5/1	15	0	1	0	5	0	0	0	1	0	0	0	0	0	0	23
5/2	42	0	0	0	20	0	1	0	1	0	0	0	1	0	0	65
5/3	28	0	0	0	6	0	0	0	0	0	0	0	0	0	0	34
5/4	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
5/5	23	0	0	0	9	0	1	0	0	1	0	0	0	0	0	34
5/6	40	0	0	0	21	0	21	0	1	0	0	0	0	0	0	64
5/7	39	2	1	0	43	1	3	0	4	0	0	0	2	0	0	95
5/8	66	0	1	0	3	1	1	0	3	0	0	0	0	0	0	75
5/9	11	0	0	0	29	0	0	0	2	0	0	0	0	0	0	43
5/10	45	0	0	0	27	1	0	0	3	0	0	0	0	0	0	76
5/11	80	1	0	0	51	0	0	0	1	0	0	0	0	0	0	133
5/12	73	0	1	0	78	0	1	0	4	1	0	0	0	0	0	159
5/13	59	0	0	0	12	0	0	0	3	1	0	0	0	0	0	74
5/14	31	0	0	0	5	1	1	0	3	0	0	0	0	0	0	41
5/15	7	0	0	0	4	0	0	0	1	0	0	0	0	0	0	12
5/16	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6
5/17	29	0	2	0	5	0	0	0	1	0	0	0	0	0	0	37
5/18	30	0	0	0	7	1	0	0	3	0	0	0	1	0	0	42
5/19	6	0	0	0	4	0	0	0	1	0	0	0	0	0	0	11
5/20	3	0	0	0	6	0	0	0	0	0	0	0	0	0	0	9
5/21	7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	8
5/22	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3
5/24	15	0	0	0	2	1	0	0	3	0	0	0	0	0	0	21
5/28	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
5/29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/31	2	0	0	0	1	0	0	0	1	0	0	0	2	0	0	6
6/1	15	0	0	0	2	1	0	0	1	0	0	0	5	1	0	27
6/2	10	0	0	0	3	0	0	0	0	0	0	0	0	0	0	13
6/7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
									Yearling Chinook Salmon							
3/26	728	0	14	0	150	1	5	0	11	3	3	0	22	0	3	940
3/27	840	1	11	0	185	5	0	0	23	1	1	0	1	0	0	1068
3/28	153	1	0	0	50	0	1	0	29	2	0	0	1	0	0	237
3/29	194	1	21	0	68	0	2	0	7	0	0	0	0	0	3	296
3/30	74	0	4	0	13	1	1	0	3	0	0	0	0	0	1	97
3/31	42	0	0	0	37	0	1	0	13	1	1	0	0	0	13	108
4/1	446	4	0	0	12	0	0	0	3	0	0	0	8	0	2	481
4/2	284	1	8	0	19	1	0	0	6	1	0	0	43	0	0	363
4/3	151	0	5	0	6	2	0	0	2	0	1	0	4	0	0	171
4/4	45	0	2	0	2	1	1	0	0	0	0	0	1	0	0	52
4/5	18	0	0	0	2	1	0	0	1	0	1	0	0	0	0	23
4/6	16	0	1	0	4	0	0	0	0	0	0	0	0	0	0	21

Appendix Table A-3. Continued.

	Condition[a]															
Date	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	Total
4/7	12	0	1	0	0	0	1	0	0	0	0	0	0	0	0	14
4/8	12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	13
4/9	19	0	1	0	0	0	0	0	0	0	0	0	1	0	0	21
4/10	10	0	3	0	0	0	0	0	0	0	0	0	0	0	0	13
4/11	18	0	1	0	3	2	1	0	1	0	0	0	0	1	0	27
4/12	9	0	0	0	2	0	1	0	0	0	0	0	0	0	0	12
4/13	9	0	2	0	3	0	1	0	0	0	0	0	0	0	0	15
4/14	27	0	1	0	4	1	0	0	1	0	2	0	0	0	0	36
4/15	37	0	2	0	1	0	2	0	1	1	0	0	0	0	1	45
4/16	121	1	0	0	8	0	0	0	1	0	0	0	2	0	0	133
4/17	109	0	1	0	21	0	0	0	11	2	0	0	28	0	0	172
4/18	32	0	1	0	0	0	0	0	1	0	0	0	0	0	0	34
4/19	46	0	0	0	2	1	0	0	1	2	0	0	0	0	0	52
4/20	62	1	0	0	0	0	0	0	1	1	0	0	46	0	0	111
4/21	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7
4/22	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8
4/23	11	0	0	0	1	0	0	0	0	0	0	0	0	0	0	12
4/24	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
4/25	7	0	0	0	0	0	0	0	1	0	0	0	1	0	0	9
4/26	19	0	1	0	2	0	0	0	0	1	0	0	0	0	0	23
4/27	18	0	1	0	0	0	0	0	0	0	0	0	1	0	0	20
4/28	15	0	0	0	0	0	0	0	1	0	0	0	0	0	0	16
4/29	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
4/30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
5/2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
5/3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5/4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
5/7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
								Subyearling Fall Chinook Salmon								
6/1	436	0	0	0	8	0	0	0	0	0	0	0	641	0	3	1088
6/2	1659	1	7	0	29	2	0	0	1	0	6	0	9	1	3	1721
6/3	1039	0	0	0	17	1	0	0	3	0	0	0	0	0	0	1060
6/4	737	1	0	0	63	0	0	1	6	0	0	1	4	0	4	817
6/5	458	0	0	0	80	2	2	0	4	1	1	0	4	0	0	552
6/6	532	1	1	0	19	7	0	0	4	0	0	0	0	0	0	564
6/7	565	1	1	0	17	2	1	0	3	0	0	0	1	0	0	589
6/8	238	0	2	0	8	1	0	0	3	1	0	0	1	0	0	254
6/9	227	0	0	0	13	3	0	0	1	1	0	0	2	0	1	248
6/10	60	0	0	0	1	0	0	0	0	0	0	0	15	0	0	76
6/11	16	0	0	0	5	0	0	0	0	0	0	0	3	0	0	24
6/12	191	0	0	0	13	2	0	0	8	0	1	0	53	0	5	273
6/13	772	0	1	0	29	2	0	0	5	2	0	0	335	4	3	1153

~~Appendix Table A-3. Continued.~~

Date	Condition[a]															Total
	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	
6/14	95	0	0	0	69	0	0	0	15	0	0	0	262	0	0	441
6/15	40	0	0	0	18	0	0	0	3	0	0	0	946	0	0	1007
6/16	28	0	0	0	60	2	2	0	9	0	0	0	292	0	0	393
6/17	207	0	2	0	77	1	0	0	4	0	0	0	73	0	0	364
6/18	670	0	1	0	108	5	1	0	19	0	0	0	105	0	0	909
6/19	772	0	1	0	79	4	1	0	14	1	0	1	94	0	0	967
6/20	225	0	1	0	66	2	0	0	11	0	0	0	11	0	0	316
6/22	34	0	0	0	19	0	0	0	3	0	0	0	0	0	0	56
6/23	123	1	0	0	8	1	0	1	1	0	0	0	2	0	0	137
6/24	92	0	0	0	56	0	0	0	1	0	0	0	3	0	0	152
6/25	55	0	0	0	25	0	0	0	2	0	0	0	2	0	0	84
6/26	20	0	0	0	16	0	0	0	2	0	0	0	0	0	0	38
6/27	7	0	0	0	12	0	0	0	3	0	0	0	0	0	0	22
6/28	6	0	0	0	8	0	0	0	2	0	0	0	4	0	0	20
6/29	2	0	0	0	8	0	0	0	5	0	0	0	2	0	0	17
6/30	4	0	0	0	3	0	0	0	0	0	0	0	1	0	0	8
7/3	28	0	1	0	31	0	0	0	13	0	0	0	0	0	0	73
7/10	3	0	0	0	6	0	0	0	3	0	0	0	0	0	0	12
7/14	8	0	0	0	32	0	0	0	5	0	0	0	1	0	0	46
7/17	8	0	0	0	13	0	0	0	5	0	0	0	2	0	0	28
7/21	8	0	0	0	8	0	0	0	1	1	0	0	5	0	0	23
7/24	0	0	0	0	4	0	1	0	1	0	2	0	2	0	0	10
								Summer Steelhead								
4/8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4/14	4	0	1	0	2	0	0	0	0	0	1	0	0	0	0	8
4/15	11	0	0	0	1	0	0	0	0	0	0	0	0	0	0	12
4/16	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7
4/17	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
4/18	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/19	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/20	3	0	0	0	1	0	0	0	2	0	0	0	4	0	0	10
4/21	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/22	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4/23	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4
4/24	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/25	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4
4/26	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
4/27	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	5
4/28	3	0	0	0	4	0	0	0	0	0	0	0	0	0	0	7
4/29	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4
4/30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/1	2	0	0	0	2	0	1	0	0	0	0	0	0	0	0	5
5/2	0	0	0	0	5	0	0	0	2	1	0	0	0	0	0	8
5/3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2

~~Appendix Table A-3. Continued.~~

	Condition[a]															
Date	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	Total
5/4	4	0	0	0	0	0	1	0	1	0	0	0	0	0	0	6
5/5	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	5
5/6	0	0	0	0	5	0	1	0	1	0	1	0	0	0	0	8
5/7	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	3
5/9	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	3
5/10	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
5/11	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
5/12	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	5
5/13	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	6
5/14	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
5/18	3	0	0	0	1	0	0	0	0	0	1	0	0	0	0	5
5/19	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
5/31	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
6/1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
6/2	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4
6/3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/4	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
6/5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
6/23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix Table A-4. Condition of natural juvenile salmonids collected at the rotary-screw trap (RM 1.2) and Westland Canal (RM 27.3) on the Umatilla River, December 1996 - July 1997.

	Condition[a]															
Date	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	Total
								Coho Salmon								
12/26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
4/19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
6/23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
								Chinook Salmon								
12/23	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1/8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
1/14	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
1/17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3/17	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
5/14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/31	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
6/2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6/12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6/13	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6/16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6/17	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6/18	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
6/19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
6/20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

[a] *Condition codes: G = Good (minimal scale loss), GB = Good + bird marks, GI = Good + other injuries, GBI = Good + bird marks + other injuries, P = Partial scale loss, PB = Partial + bird marks, PI = Partial + other injuries, PBI = Partial + bird marks + other injuries, D = Descaled, DB = Descaled + bird marks, DI = Descaled + other injuries, DBI = Descaled + bird mark + other injuries, M = Mortality, MB = Mortality + bird marks, MI = Mortality + other injuries.*

Appendix Table A-4. Continued.

Date	Condition[a]															Total
	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	
6/27	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/10	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
7/11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
7/14	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4
7/17	1	0	0	2	0	0	0	0	1	0	1	0	2	0	0	7
7/18	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
7/21	11	0	0	0	4	0	0	0	2	0	0	0	0	0	0	17
7/24	0	0	2	0	0	0	0	0	3	1	3	0	0	0	0	9
7/28	3	0	0	0	2	0	0	0	0	0	0	0	2	0	0	7
7/30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
								Summer Steelhead								
1/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/13	4	0	1	0	1	0	0	0	0	0	0	0	0	0	0	6
1/14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1/15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/19	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1/20	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1/22	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
2/12	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
2/15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
2/24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2/25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3/14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3/16	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
3/17	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3/26	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/27	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/28	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
3/29	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	6
4/1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
4/4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/8	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
4/9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/14	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4/15	2	0	0	0	1	0	0	0	1	0	0	0	0	0	0	4

Appendix Table A-4. Continued.

	Condition[a]															
Date	G	GB	GI	GBI	P	PB	PI	PBI	D	DB	DI	DBI	M	MB	MI	Total
4/16	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4/17	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
4/18	5	0	0	0	1	0	0	0	0	0	0	0	2	0	0	8
4/19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
4/20	4	0	0	0	0	0	0	0	0	0	0	0	3	0	0	7
4/21	2		0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/22	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
4/23	4	0	2	0	0	0	0	0	0	0	0	0	2	0	0	8
4/24	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
4/25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/26	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
4/27	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	3
4/28	19	0	2	0	0	0	1	0	0	0	0	0	0	0	0	22
4/29	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
4/30	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
5/1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5/2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
5/3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
5/4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
5/5	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4
5/6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5/7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
5/8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
5/9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
5/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
5/11	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
5/12	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	4
5/13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5/14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
6/2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix Table A-5. Releases of hatchery chinook salmon, coho salmon, and summer steelhead in the Umatilla River, March - May 1997.

Species[a]	Age	Hatchery origin	Release dates(s)	Release location	River mile	Number released	Number CWT[b]
CHS	1+	Umatilla	3/26	Imeques	80.0	225,883	80,546
					Total	*225,883*	*80,546*
CHF	1+	L.W.S.[c]	3/30	Thornhollow	73.5	260,968	60,327
				Imeques	80.0		
CHF	1+	Umatilla	3/25	Thornhollow	73.5	53,993	25,250
CHF	1+	Umatilla	3/25	Imeques	80.0	51,917	25,260
CHF	1+	Umatilla	3/25	Thornhollow	73.5	153,043	76,473
					Total	*519,921*	*187,310*
CHF	0+	Umatilla	5/30	Thornhollow	73.5	983,953	97,469
				Imeques	80.0		
CHF	0+	Umatilla	5/29	Imeques	80.0	1,399,852	160,791
CHF	0+	Umatilla	5/30	Thornhollow	73.5	197,028	33,555
					Total	*2,580,833*	*291,815*
STS	1+	Umatilla	4/10+5/15	Bonifer	2.0[d]	90,499	39,596
STS	1+	Umatilla	4/11	Minthorn	64.5	46,788	19,103
					Total	*137,287*	*58,699*
COH	1+	Klaskanine	3/10	Barnhart	42.5	81,445	4,072
COH	1+	L.H.C.[c]	3/31-4/3	Barnhart	42.5	438,143	--[e]
COH	1+	Gnat Cr.	4/1-4/5	Barnhart	42.5	881,341	--[e]
					Total	*1,400,929*	--[e]

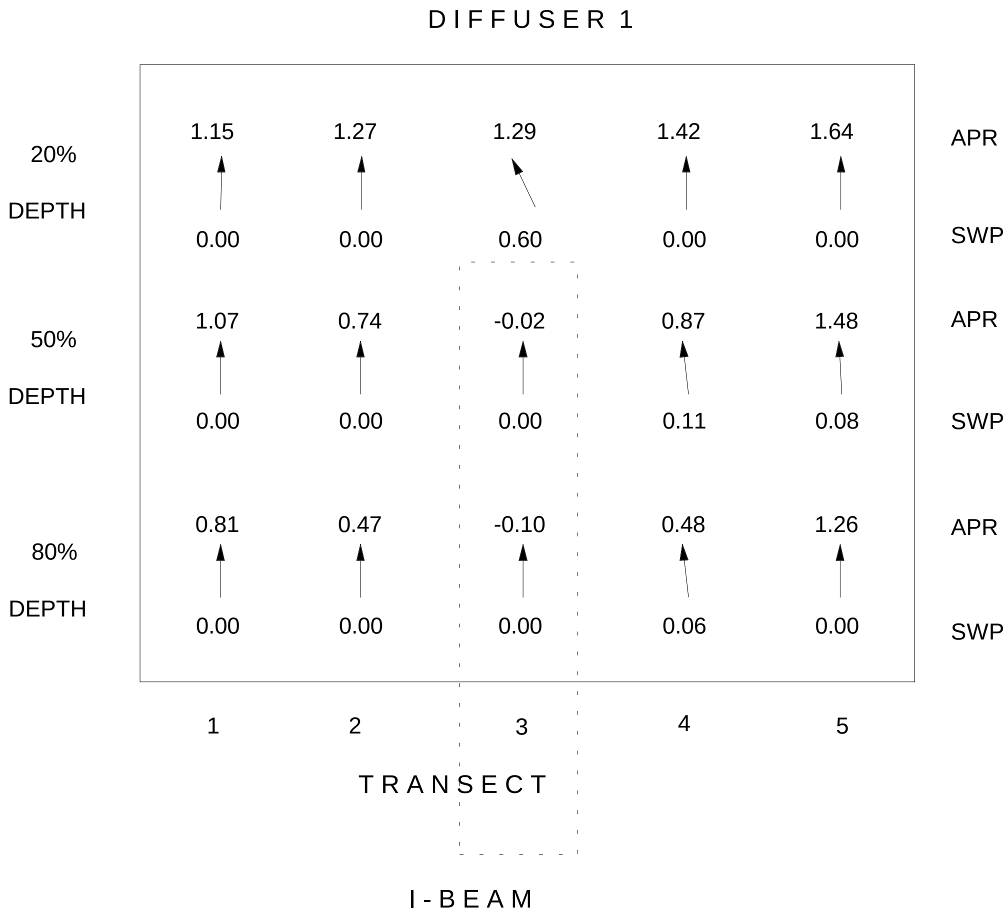
[a] *CHS = spring chinook salmon, CHF = fall chinook salmon, COH = coho salmon, STS = summer steelhead.*

[b] *CWT = coded-wire tagged.*

[c] *L.W.S. = Little White Salmon Hatchery, L.H.C. = Lower Herman Creek Hatchery.*

[d] *River mile of Meacham Creek at river mile 79.0 on the Umatilla River.*

[e] *Number of CWT fish unknown because fish were not differentially marked.*



Appendix Figure A-1. Approach (above arrows) and sweep (below arrows) water velocity (ft/s) measured in front of Diffuser 1, Three Mile Falls Dam east-bank ladder, Umatilla River, 17 January 1997. Arrows indicate direction of flow; flow perpendicular to the diffuser is depicted by arrows pointing straight up. Fish exit gate was fully open.