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

ANNUAL REPORT 1996

Umatilla River Outmigration and Survival Evaluation

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EXECUTIVE SUMMARY

This is the second year 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 will assist researchers and managers in adapting hatchery practices, flow enhancement strategies, canal operations, and supplementation and enhancement efforts for natural and restored fish populations. We also report on tasks related to evaluating juvenile salmonid passage at Three Mile Falls Dam and West Extension Canal.

Umatilla River Outmigration and Survival Evaluation

Objectives for FY 1996

1. Conduct feasibility studies with traps and determine trapping efficiencies of collection facilities.

2. Determine migration performance and pattern, migrant abundance, and survival of hatchery-released spring and fall chinook salmon, coho salmon, and summer steelhead in the lower Umatilla River.

3. Determine migration performance and pattern, life history characteristics, migrant abundance, and survival of naturally-produced juvenile chinook salmon and summer steelhead within the lower Umatiila River.

4. Determine species composition, condition, and total weight of sampled fish at Westland Canal during trap and haul operations.

5. Investigate relationships between environmental parameters and fish migration performance and pattern.

6. Evaluate cumulative injury to hatchery and natural juvenile salmonids emigrating through the lower Umatilla River.

7. Determine biological and environmental variables that may affect in-river survival for hatchery and natural juvenile salmonids.

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

9. Investigate the utility of using visual implant jet marks on juvenile salmonids.

Accomplishments and Findings for FY 1996

We achieved all of our objectives in FY 1996. We sampled at one in-river location with the rotary-screw trap during most of fall, winter, and early spring, and with a floating net trap in late summer. We sampled at West Extension and Westland canals during the spring and summer irrigation season. Monitoring extended from October 1995 to September 1996.

Trap efficiency tests were conducted daily with hatchery fish at the in-river trap site and with hatchery and natural fish at West Extension Canal. Pooled trap efficiencies were low for hatchery spring chinook salmon (2.0%) and coho salmon (0.8%) at the rotary trap, with no recaptures for 30% of the test groups released. Efficiency of the trap in retaining collected fish was > 90% for both species. At West Extension Canal, pooled trap efficiencies were higher for hatchery yearling and subyearling fall chinook salmon (26.7% and 26.8%) than for hatchery coho salmon (18.8%) and hatchery and natural summer steelhead (14.2% and 7.2%). Hatchery subyearling fall chinook salmon and hatchery and natural summer steelhead had the quickest recapture (< 13 d); recapture of coho and yearling fall chinook salmon was protracted (34 d). Recapture for most species was greatest within the first day or two after release. Fish were not recaptured in <10% of each hatchery fish test group. Subyearling chinook salmon had higher marking mortality (<7%) because of higher water temperature in June.

We collected fall and spring chinook salmon, coho salmon, and summer steelhead. Subyearling and yearling fish and hatchery and natural stocks were represented for all groups. We collected 3,672 hatchery salmonids and 39 natural salmonids at the rotary screw trap from mid-October 1995 to end March 1996. From early April to mid-July, we collected 1,153,762 hatchery fish and 5,566 natural fish (mostly summer steelhead) at West Extension Canal. We captured 1% (spring chinook salmon) to 33% (subyearling fall chinook salmon) of the hatchery fish released. All but one of the 1,801 fish sampled from Westland Canal from mid-June to early August were hatchery subyearling fall chinook salmon. Few natural chinook and coho salmon were collected at any of the sites.

We collected 426 scale samples for age analysis, mostly from natural steelhead. Steelhead aged by tribal biologists indicated that 84% of the juvenile steelhead were 2' years of age and 15% were 3' years of age.

Date of first capture of hatchery salmonids ranged from l-3 d after release, with spring chinook salmon migrating the fastest at 79 miles per day (mi/d), summer steelhead migrating the slowest (32 mi/d), and yearling and subyearling fall chinook salmon migrating at 42-46 mi/d. Most hatchery spring chinook salmon and subyearling fall chinook salmon migrated immediately after release and passed through the lower river in l-4 d, peaking within a 48-h period. Hatchery and natural summer steelhead migrations were similar, peaking in mid-May, but the migration duration was longer for natural fish than hatchery fish. Hatchery yearling fall chinook and coho salmon migrated erratically from April to June. Coho salmon peaked in late April and fall chinook salmon peaked in mid-May. Most natural chinook and coho salmon migrated during the first three weeks of April. Natural chinook salmon and summer steelhead were first captured in mid-December and mid-March, respectively.

We marked 6,283 subyearling fall chinook salmon with red, orange, green, and yellow visual implant jet marks in the anal, ventral, and pectoral fins. Pectoral fin marks were predominant in the collection. The yellow, ventral fin mark was least noted. Most mark groups were captured on 4 June, four to five days after release. Marked fish were first detected at John Day Dam on 12 June.

Diel patterns of capture were different among races and species, Hatchery spring chinook salmon migrated mostly at night in March and during midday in April. Most natural spring chinook salmon migrated in early morning and midday in April. Hatchery yearling fall chinook salmon moved mostly during the afternoon and subyearling fall chinook salmon moved in the morning. Most coho salmon moved after sunrise. Hatchery and natural summer steelhead moved mostly during the day.

Most hatchery spring chinook salmon, yearling fall chinook salmon, and summer steelhead were smolted when first captured after release, but most hatchery coho salmon and subyearling fall chinook salmon were intermediate smolts at first capture. A large proportion of coho salmon released in late March and early April were not smolted until June. Not until late June did most hatchery subyearling fall chinook salmon appear smolted. We observed natural subyearling chinook salmon in the parr stage in May and June. Natural summer steelhead were most smolted by mid-May. Natural yearling chinook salmon were transitioning into smolts from March through May and natural coho salmon were intermediate smolts in April.

Condition of hatchery fish declined over time due to varying degrees of scale loss, attempted bird predation, disease, and other injuries. Natural salmonids were in better condition than hatchery fish. Hatchery summer steelhead were in poorest condition and bird marks were more prevalent than on other species, Leeches were commonly found on hatchery spring chinook salmon and black spot disease was observed on all natural species. Hatchery coho and yearling fall chinook salmon were in the best overall condition, although both showed signs of bacterial kidney disease. Condition of hatchery subyearling fall chinook salmon deteriorated greatly by mid-June; mortality of migrating fish rose to 50% by July.

Mean fork lengths of hatchery fish were significantly greater than those of naturally-produced fish. Hatchery subyearling fall chinook salmon attained a maximum length of 149 mm by August, Some natural coho salmon collected in March were between 112 mm and 13 1 mm in length.

Abundance and survival estimates were determined for most salmonids at the rotary trap and West Extension Canal. We estimated survival from release to recapture to be 34.4% (130,396 fish) for hatchery spring chinook salmon, 43.4% (640,557 fish) for hatchery coho salmon, 40.2% (226,767 fish) for hatchery yearling fall chinook salmon, and 93.7% (137,478 fish) for hatchery summer steelhead. Abundance was overestimated for subyearling fall chinook salmon by approximately 1 million fish (135.6%); this overestimation was probably due to subsampling bias during the peak outmigration or an inaccurate trap efficiency estimate. Natural summer steelhead abundance was estimated at 73,134 fish. Natural spring and fall chinook salmon and natural coho salmon abundance was near or less than 1,000 fish.

Survival of branded yearling fall chinook salmon from Umatilla Hatchery was significantly less (1.6%; $P < 0.05$) than survival of branded fall chinook salmon from Bonneville Hatchery (11.7%). Survival of the branded summer steelhead group released in May (10.1%) was better than survival of branded steelhead groups released in April (<8%). There was no significant difference in survival of branded subyearling fall chinook salmon reared in Oregon raceways and Michigan raceways at Umatilla Hatchery

Flow in the Umatilla River peaked in mid-February at over 14,000 cubic feet per second (ft^3/s), with secondary peaks in late November and late April near 8,000 ft^3/s. River flow decreased to < 250 ft^3/s in summer and fall. During maximum fish emigration from March to June, average river flow ranged from about 1,500 ft^3/s to 150 ft^3/s. Water temperature increased with decreasing flow, averaging near 46” F in March to 67” F in June; maximum temperature was 77” F in July. Water clarity was poor in March (0.5 1 m mean Secchi depth) but slowly increased to 1 m visibility in June. The two highest fish collection peaks in late April and mid-May coincided with rapid increases in river flow and rapid decreases in water clarity and temperature; however, linear correlations were not significant ($P > 0.05$). These peaks were comprised mostly of hatchery fall chinook and coho salmon. Hatchery summer steelhead movement responded to increased flow and decreased water clarity and temperature in mid-May but not in late April. Coho salmon movement had the highest correlation with river flow ($r = 0.46$, $P = 0.0001$). The peak in hatchery spring chinook salmon and subyearling fall chinook salmon movement did not appear to correspond with any environmental variables. Most natural chinook and coho salmon and natural summer steelhead moved when flow was either stable or increasing.

Dominant resident fish species were bridgelip and largescale suckers, redside shiners, northern squawfish, chiselmouth, speckled dace, and smallmouth and largemouth bass. We also captured adult and juvenile lamprey. Adult northern squawfish were most prevalent at the canal trap in June during the subyearling outmigration. Avian predators near trap sites included gulls, cormorants, and herons; their abundance changed throughout the season as fish releases were made.

Summer transport of subyearling fall chinook salmon resulted in scale loss and delayed mortality. Treatment (transport) groups had a 7% increase in descaling and a 9.6% increase in delayed mortality when compared to control (non-transported) groups For some groups, the difference was significant ($P < 0.05$). Descaling was significantly related to water temperature in the transport tank ($r = 0.80$, $P = 0.001$).

Management Implications and Recommendations

1. Flow augmentation through June would be beneficial to migrating juvenile salmonids and reduce the need to trap and transport fish. Transport of fish could be delayed until July when most salmonid species may have moved out of the system with improved flows.

2. When transport occurs, juvenile salmonids should be pump-loaded, instead of dip-netted, into the transport tank. Dip-netting causes scale loss and stress, and may be a factor in delayed mortality.

3. If storage water from McKay reservoir is released throughout June, we recommend a pulsed, rather than a uniform, water release strategy to more effectively stimulate fish movement.

4. The release of the "smalls" group of summer steelhead should be timed with an increase in river flows in late April or early May. Increased flow appears to stimulate steelhead movement, Rearing fish to 5/lb should continue, but acclimation time may need to be shortened, depending on the flow situation.

5. Discontinue the use of brands and use color marks to monitor the migration of juvenile salmonids in future years. Color marks were more visible and easier to detect.

6. Use bird deterrent measures (piano wire, noise, water spray) at passage facilities where fish may be most vulnerable to attack. Turn off bypass facility lights at night, which attract herons and other avian predators.

7. Ensure all facilities are fish safe during the outmigration period, particularly during the yearling spring chinook and subyearling fall chinook salmon releases.

8. At passage facilities, maintain or increase debris removal efforts and adjust facility operations more frequently during high river flows. Floods and freshets tend to increase fish movement through these facilities.

9. Continue and expand efforts to decrease sediment load in the river to improve the health and survival of migrating fish.

UMATILLA RIVER PASSAGE EVALUATION

Objectives for FY 1996

1. Determine effectiveness ofjuvenile salmonid passage at the east-bank fish ladder at Three Mile Falls Dam.

2. Complete a final report for the Juvenile Salmonid Passage Evaluation Study

Accomplishments and Findings for FY 1996

We achieved both objectives in 1996. We used underwater video to monitor fish behavior and passage at a diffuser grating in the upper end of the adult fish ladder. We also video recorded in the viewing window chamber to monitor subyearling fall chinook salmon passing downstream through the ladder. We completed the Juvenile Salmonid Passage Evaluation Study final report. In addition to these objectives, we continued evaluating the diversion of fish around the dam and through the bypass at West Extension Canal and determined attraction velocities at the canal entrance during canal operation.

We recorded nearly 80 h of underwater video at the ladder diffuser, monitoring both yearling and subyearling salmon. Fish densities (fish/m') were highest on 22 April (yearlings) and 4 June (subyearlings) as fish congregated in front of the diffuser. Fish impacts with the diffuser were mostly light. Impacts per unit of area increased as fish density increased. Yearling chinook salmon impacted the diffuser more in a lower corner where approach velocity was near 0.8 feet per second (f/s) and sweep velocity was low (0.3 f/s).

Most yearling and subyearling chinook salmon passed through the diffuser head-first. Based on diffuser area, passage increased as fish density increased. Based on fish density, passage decreased as fish density increased. Passage was higher at 80% water depth than 50% water depth for both species.

We video recorded nearly 205 h of fish passage at the east-bank ladder viewing window from 3 1 May to 14 June, requiring 202 h to review. A total of 328,542 subyearling salmon were counted on these recordings, Of the fish that were counted concurrently at the juvenile fish bypass and adult fish ladder, 28% used the ladder to pass Three Mile Falls Dam. Most fish were counted at the west-bank canal bypass, even after initiation of Phase I exchange pumping from the Columbia River. However, fish passage through the ladder was high on two dates, one of which was associated with reduced canal diversion (2 June). Fish movement was similar at the bypass and ladder on a diel basis, with most fish moving during the day and few at night.

Canal flow was essential for creating attraction velocities of > 1 f/s at the canal trashracks, headgates, and screen forebay. Without canal flow (Phase I exchange), operating the pumpback pumps and returning 5 ft^3/s of bypass flow to the river produced negligible attraction velocities (< 0.20 f/s) at key locations. Returning bypass flow to the river and 20 ft^3/s of water through the river-return pipe, in lieu of operating canal pumps, raised these velocities by about 0.20-0.50 f/s

Flow into West Extension Canal ranged from SO-100 ft^3/s throughout most of April and May. In early June, canal flow was reduced to < 20 ft^3/s as most water was pumped into the canal from the Columbia River. Daily trap efficiencies (percent of fish bypassed) for yearling species of salmon during April and May were low (mean < 25%) and fluctuated widely as diversion (percent river flow diverted into the canal) changed gradually. Coho trap efficiencies were positively correlated with diversion rate ($r = 0.45$, $P = 0.003$), but the correlation was non-existent for summer steelhead and yearling and subyearling fall chinook salmon. Trap efficiencies for subyearling fall chinook salmon dropped dramatically when Phase I exchange was fully on-line and was higher on average when the canal diverted water (24 3%) than during Phase I exchange (16.6%). River flow and trap efficiency were not correlated for yearling species, but trap efficiency for subyearling fall chinook salmon increased as river flow decreased ($r = -0.44$, $P = 0.03$).

Diversion changes at West Extension Canal did not generally affect the collection of hatchery and natural summer steelhead, yearling and subyearling chinook salmon, or coho salmon. However, a slight increase in diversion in mid-May was accompanied by a peak in collection of most species. Collection of subyearling chinook salmon peaked shortly after their release when diversion was 7% of river flow, as Phase I exchange was initiated.

We completed the final report for the Juvenile Salmonid Passage Evaluation Study in April 1997. In this report, we presented results on screening efficiency, fish injury and passage, and water velocities at passage facilities on the Umatilla River.

Management Implications and Recommendations

1. Operate fish exit gates of the east-bank fish ladder at Three Mile Falls Dam fully open to enhance juvenile fish passage through Diffuser 1.

2. Improve juvenile salmonid passage at Diffuser 1 by rounding the slat edges. replacing slats with bars, or widening the spacing between slats or bars.

3. Temporarily remove Diffuser 1 during the peak subyearling fall chinook salmon outmigration to allow unobstructed passage through the east-bank fish ladder at Three Mile Falls Dam. Document adult spring chinook salmon passage with video while the trap is not operating. Additional information on adults can be obtained from spawning ground surveys, depending on run size.

4. Install fish guidance systems (flow deflectors) upstream of Three Mile Falls Dam to repel juvenile salmonids from the east-bank fish ladder.

5. In 1997, measure water velocities and monitor juvenile fish behavior at Diffuser 1 with underwater video after gate operation or diffuser design is changed.

6. Maximize flow through the fish bypass facility at West Extension Canal during Phase I water exchange to attract fish to the bypass. Flow through the bypass pipe should be at least 25 ft^3/s during fish bypassing operations. Flow through the river-return pipe should be 20 ft^3/s (20% open, gate stem raised 5 inches) during fish trapping operations.

7. Operate the fish bypass facility at West Extension Canal at 35 ft^3/s during Phase I water exchange to enhance fish attraction to the bypass. Document changes in water velocity at the trashracks, headgates, screen forebay, and bypass channel entrance during a 35-ft^3/s bypass flow.

8. Update bypass operating criteria for West Extension Canal to attract more fish to the bypass during Phase I water exchange. Low-flow operating criteria for the bypass (5 ft^3/s bypass flow returned to the river with 20 ft^3/s pumpback flow) is ineffective for fish attraction during Phase I water exchange. An alternative could be to reduce auxiliary water flow at the east-bank fish ladder to maintain bypass flow at 25-35 ft^3/s when juvenile salmonids are migrating past Three Mile Falls Dam.

REPORT A

Umatilla River Outmigration and Survival Evaluation

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UMATILLA RIVER OUTMIGRATION AND SURVIVAL EVALUATION

INTRODUCTION

Reintroduction of chinook salmon (*Oncorhynchus tshawytscha)* and coho salmon (0. *kisutch*) and enhancement of summer steelhead (0. *mykiss*) 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 and entities 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 Bonneville Power Administration (BPA), National Marine Fisheries Service (NMFS), Oregon Water Resources Department (OWRD), the Confederated Tribes of the Umatilla Indian Reservation (CTUTR), and local irrigation districts (West Extension, Hermiston, and Stanfield-Westland). The Umatilla River Operations Groups and the Umatilla Monitoring and Evaluation Oversight Committee coordinate river management and fisheries research in the Umatilla River basin.

Monitoring and evaluation efforts to fine-tune specific restoration projects are ongoing or near completion. Evaluation ofjuvenile 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 smelt-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. 1997), results are broad in scope and reliant on long-term adult returns, Potential factors determining survival ofjuvenile salmon in the Umatilla basin include loss through in-river predation, cumulative effects of passage through a multitude of passage facilities at irrigation diversion dams, effects of poor river conditions and transport on fish health, and effects of hatchery rearing and release strategies and canal operations.

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. 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 is attempting to investigate the natural production potential of each race or species of salmonid in the Umatilla River basin and the effects of hatchery steeihead 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 of 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 ofjuvenile 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 ofjuvenile salmonids may result in poor survival after release.

Development of a new marking technique (Visual Implant Jet) using a colored fluorescent solution injected into the fin rays of fish is currently being tested by the Washington Department of Fish and Wildlife (Blankenship 1996). Outmigration monitoring in the lower Umatilla River provided an additional opportunity to test this mark on subyearling fall chinook salmon.

The goal of the Outmigration and Survival Study is to evaluate the outmigration, estimate survival, and investigate factors affecting survival ofjuvenile salmonids in the lower Umatilla River basin. General objectives for meeting this goal in the 1995-1996 project period were:

1. Determine migration performance and pattern and migrant abundance of hatchery and natural juvenile salmonids in the lower Umatilla River.

2. Estimate survival of hatchery and natural juvenile salmonids within the lower Umatilla River.

3. Identify environmental and biological variables affecting fish health and survival.

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

5. Investigate the utility and feasibility of using VI (Visual-Implant) Jet marks on juvenile salmonids in the Umatilla River.

In this report, we describe our second year activities and findings for the Umatilla River Outmigration and Survival Study from 1 October 1995 to 30 September 1996. We present information from outmigration monitoring, including species and origin of fish collected, lengths, fish condition and health, smoltification levels, brands and fin clips observed, diel movement, migration patterns, migration performance, and environmental conditions. We also present trapping efficiencies, estimations of migrant abundance and survival, observations of predators and resident fish, information on transport effects, and results of VI-Jet marking.

STUDY SITES

We collected outmigration data from three sampling sites during 1995-1996. These sites included one in-river location below Three Mile Falls Dam and two irrigation canal screening facilities. Considerations in selecting the in-river site included proximity to the river mouth, appropriate water depth and velocity, trap accessibility, suitable trap anchoring points, availability of a trap pull-out area, and landowner permission.

The in-river site was located under the Interstate-82 bridge near the town of Umatilla at RM 1.2 (Figure 1). We primarily used a rotary-screw trap at this location, and secondarily a floating trap net. Total river width at this point was approximately 250 ft. The river bottom was mainly bedrock with carved channels. A 6-ft-wide by 5-ft deep channel on the west bank of the river served as the trap sampling location. Trap efficiency releases for this site were made directly below Three Mile Falls Dam at rivermile (RM) 3.0 on the west bank of the river (Figure 1).

We sampled at canal screening facilities at West Extension Canal (RM 3.0) and Westland Canal (RM 27.2) during the spring-summer irrigation season (Figure 1). Both screening facilities have fish trapping and bypassing capabilities (Knapp et al. 1996). Sampling at West Extension Canal also enabled us to ascertain effects of canal operations on fish diversion *(see Umatilla River Passage Evaluation,* **Report B).** When we were not able to sample at this site, we sampled at Westland Canal or at the in-river trap.

We sampled at West Extension Canal from early April to mid-July. West Extension Canal is located on the west bank of the river at Three Mile Falls Dam (Figure 1). The canal generally operates from late March through mid-October with a maximum canal flow of 180 ft^3/s and a bypass flow of either 5 ft^3/s or 25 ft^3/s. Description of the juvenile fish trapping facility is provided in Knapp et al. (1996). Trap efficiency releases for this site were made at the Hermiston Wastewater Treatment Plant (RM 5.0) on the east bank of the river (Figure 1).

Fish collected at Westland Canal during juvenile fish trap and haul operations were sampled directly from the transport tank after transport to the river mouth, from mid-June to early August. Westland Canal is located at Westland Dam on the west bank of the river at RM 27.3 (Figure 1). Description of the juvenile fish trapping facility is provided in Knapp et al. (1996). No trap efficiency tests were performed for fish collected at this site.

METHODS

Migrant Traps

We used a rotary-screw trap to collect fish in the lower Umatilla River at RM I .2 (Figure 2). Due to constraints in operating the S-h-diameter trap in 1995 (Knapp et al. 1996), we used a 5-ft-diameter trap in 1996. Trap sampling area was 8.6 ft^2. The downstream end of the cone was attached to a 3-ft-long by 5-ft-wide, 12.8 ft^3 livebox wit:h a rotating drum screen to remove small debris. The cone and livebox assembly was mounted between two, 16-ft-long aluminum pontoons. The trap functioned as described in Knapp et al. (1996).

We used three bridge pillars supporting the Interstate-82 bridge to anchor the trap (Figure 2). We used a single, 1/2-in cable spanning 120 ft between two pillars as the main support line. A pulley line of 3/8-in cable was threaded through a pulley on each pillar and connected to a master link at midriver. A trap line of 3/8-in cable was routed from the trap, through another pulley at the master link, to a winch on the west-bank pillar. We used this winch to control upstream and downstream movement of the trap. We attached a small hand winch with 1/4-in cable to a post on the west-bank shore and used it to move the trap to shore when checking the livebox.

We briefly used a floating net trap to collect fish in the lower river at RM 1.2 (Knapp et al. 1996; Figure 2). We modified the trap by replacing the original Styrofoam floats with sealed lo-in-diameter, polyvinylchloride (PVC) pipe. We used ropes strung from the screw trap rigging to suspend the net trap in position. We pulled the trap to shore with ropes to access the livebox.

At West Extension Canal, we used the permanent fish collection facility to collect fish (Knapp et al. 1996). Several modifications were made to this facility in 1996, including the addition of a pressurized water line to the auxiliary water supply and improved lighting. The 6-in-diameter fish return pipe was replaced with an g-in-diameter pipe (Figure 3).

Trap Effkiencies

We used trap efficiencies to expand the catch ofjuvenile fish for an estimate of migrant abundance. We determined efficiencies by marking a known number of fish (*M*), releasing these fish upstream of the trap or collection facility, and recapturing them in the trap or collection facility (m) over the duration of the collection period. Numerous daily releases were made to obtain a pooled (weighted) trap efficiency estimate for each race or species of fish. Weighted trap efficiency was the ratio of total fish recaptured to total fish released over the entire trapping period ($TE = m/M$). Number of fish marked for a release was usually proportional to number of fish collected which "weighted" the trap efficiency estimates. For each release, we attempted to mark over 50 fish of the most dominant fish species in the collection. Abundance estimates were derived from weighted trap efficiency estimates.

For trap efficiency tests, we used unmarked and unbranded hatchery and natural fish from the trap or collection facility. We marked test fish by injecting them with a small amount of acrylic paint using a 3-cc disposable syringe equipped with a 26-gauge intradermal needle. We used five paint colors (red, blue, orange, purple, and green) and 10 mark locations near the base of ventral fins to provide a unique mark for nearly all fish releases. We marked fish throughout the 24-h sampling period and held them in net pens for release the following day. At the West Extension facility, net pens were contained within circular tanks supplied with constant inflow water. At the rotary trap site, net pens were held in the river in a calm spot.

Prior to and after transport, we counted and removed dead fish from the group of marked fish to determine a final count of live fish released and an estimated survival rate of marked fish. The estimated rate of survival for each daily release was used to adjust the daily and weighted trap efficiency estimates.

We transported fish to release sites in perforated 30-gal containers held within four large plastic totes filled with water and placed in the bed of a pickup truck. Aeration was supplied with a 12-volt portable compressor. Each marked species was transported in a separate container. Fish were held and transported at densities less than one pound per two cubic feet of water. Release site locations for the rotary-screw trap and West Extension facility were previously described. We assumed release site distance allowed random distribution of fish in the river. Fish were released from their containers and into the river via a 6-in-diameter PVC pipe and flex hose combination. Releases were made in the evening to coincide with observed diel movement patterns in 1995 (Knapp et al. 1996).

For the rotary-screw trap, we estimated trap retention efficiency by releasing less than 20 marked fish in the live-box and counting the number that were retained in the live-box over a 12-h period. Fish capture at the rotary trap was corrected for trap retention efficiency. Fish were marked as in trap efficiency marking.

Outmigration Monitoring

Collection

Juvenile fish were anesthetized in tricaine methanesulfonate (MS-222) before evaluation. We identified and counted juvenile salmonids by species, race, and origin (hatchery or natural). Hatchery fish (chinook salmon and summer steelhead) were differentiated from natural fish by the absence of either adipose or ventral fins. Spring and fall chinook salmon were differentiated by the type of ventral clip. Only 5% of the hatchery coho salmon were adipose clipped for coded-wire tag detection; otherwise, they were not clipped and were differentiated from natural fish based on size or time of year when captured. Prior to hatchery coho salmon releases, all captured coho salmon were considered natural. Coho salmon < 100 mm in fork length were considered naturally-produced when both hatchery and natural fish were in the river (G. Rowan, CTUIR, personal communication).

We identified and counted marks, brands, and fin clips, and evaluated fish condition and smolt coloration. We looked for trap efficiency marks on all species and VI-Jet marks on subyearling fall chinook salmon. When large numbers of fish were collected, we subsampled or omitted tin clip counts and evaluation of condition and smolt coloration. Scale samples were collected from natural summer steelhead, chinook salmon, and coho salmon to determine their age and growth characteristics. Scale samples were analyzed by CTUIR biologists.

Hourly sample data collected at the West Extension facility was expanded to account for sampling rates less than 100% and for less than full hour collections by dividing by the sample rate and proportion of the hour sampled, respectively. Data for whole hours not sampled within a 24-h period were interpolated by multiplying the mean count of each fish species from sampled hours preceding and following unsampled hours by the number of hours not sampled (Knapp et al. 1996). When more fish were collected in the sample tank than could be processed, we subsampled by examining fish from several netloads. Remaining fish were bypassed by netload and data was extrapolated from subsampled data. In both methods, data was estimated for species, race, origin, brands, marks, and clips.

Less than full hour collections were also expanded at the rotary-screw trap. When sampling was conducted only once within a 24-h period, data was not expanded.

Trap and Haul

We coordinated our efforts with CTUIR to sample fish when juvenile salmonids were being trapped and transported from Westland Canal during low river flows (Table 1). Although CTUIR obtained samples from the holding pond at Westland Canal (Figure 4), we sampled fish from the transport vehicle at the lower river release site. Fish were identified to species and salmonids were identified to origin. Salmonids were also examined for condition, fin clips, brands, VI-Jet marks, and smolt index and measured to fork length.

We sampled twice from each transport load, weighed each sample individually, and counted the number of salmonids and non-salmonids. We also weighed the non-salmonids as a group in each sample and subtracted this weight from the total weight to derive a salmonid weight. We used the salmonid weight to estimate the total number of salmonids transported, based on total pounds hauled. Density of salmonids and non-salmonids in each transport load was calculated by dividing the total number of salmonids and non-salmonids hauled by the capacity of the transport vehicle (in gallons).

To estimate the number of subyearling salmon collected and transported during times when we were not sampling, we used pounds of fish transported (CTUIR and ODFW 1996) and the estimated number of subyearlings per pound of fish transported determined by CTUIR (Rowan 1997). On days when no fish per pound samples were collected either by us or CTUIR, we computed an average fish per pound from the preceding and following day's data.

Brands

We documented readable freeze brands present on fish collected at our traps. Hatchery yearling fall and spring chinook salmon, subyearling fall chinook salmon, and summer steelhead were freeze branded by hatchery (Umatilla or Bonneville) and rearing pond (Oregon or Michigan). Natural summer steelhead and spring chinook salmon captured in the upper Umatilla River by CTUIR were differentially branded every two weeks beginning 1 October 1995 and ending late June 1996 (Contor et al. 1997). We computed the proportion of brands collected to total brands released for each species or race and brand. We expanded recoveries of each brand group by estimates of weighted trap efficiency, adjusted for expected survival of released fish, to estimate total brand recovery. We used expanded brand recovery information from hatchery and natural fish to derive an index of survival. Brand collection data was also plotted against time to discern movement patterns for hatchery fish.

VI-Jet Marks

We marked approximately 6,000 subyearling fall chinook salmon from Umatilla Hatchery with colored visual-implant jet marks on the ventral and anal fins. Marks were produced by injecting florescent microspheres suspended in an aqueous solution into the pectoral, pelvic, and anal fins using an electric-powered inoculator. Washington Department of Fish and Wildlife personnel assisted us in marking activities. We used orange, red, green, and yellow marks on the varying fins to represent the raceways (Michigan or Oregon) and passes (A,B,C) in which fish were raised. About 2% of the marked fish were held separately after marking to determine mark retention, Marked fish were acclimated and released with unmarked subyearlings and recaptured in the lower river trap. Capture of these marked fish at John Day Dam on the Columbia River was also noted by fish samplers with the National Marine Fisheries Service.

Fin Clips

We examined each hatchery species or race for fin clips, Spring chinook salmon were left-ventral (LV) clipped and fall chinook salmon were right-ventral (RV) clipped. Salmon with coded-wire tags were also adipose clipped (ADLV or 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 if coded-wire tagged. We determined the percent recovery of each clip by species to ascertain survival or collection differences between clips.

Migration Parameters

We determined migration rate, duration, and timing, median travel speed, and identified dates of peak movement for each species, race, and brand group of hatchery fish using expanded and interpolated data. Migration rate was calculated as the average miles traveled per day from release site to capture site for initial captures, Migration duration was the length of time from initial to final capture. Migration timing was the cumulative percent capture of a fish species over time. We also estimated median travel speed (miles/h) for initial capture of each fish species. Periods of peak movement were identified from a plot of daily capture.

We also determined migration timing, duration, and peaks for natural summer steelhead and spring chinook salmon. Additional information on migration rate of natural salmonids was gained by recapture of fish that were freeze-branded at upriver trapping sites by CTUIR (Contor et al. 1997).

Diel Capture

We used expanded hourly collection data from 24-h sampling to define hatchery and natural fish movement to time of day. Trap counts were only used from days when all hours were sampled. We plotted the number of fish captured by hour on a monthly basis for months when a salmonid species was abundant and compared these patterns with time 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. Fish were viewed from the side under bright light during evaluation. Categories for the smolt index were "*P*" for parr 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 smolts with silvery body coloration with no parr marks or faint 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 did not differentiate left side from right side scale loss, We 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 prior to arrival in the trap or during handling. 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 to the nearest mm for all natural salmonids and a subsample of hatchery salmonids. We measured total length of random samples of resident fish. We developed length-frequency distributions, determined modal length frequencies, and estimated mean fork length per species or race of hatchery fish and per species of natural fish.

Migrant Abundance and Survival

We estimated migrant abundance for each race or species of salmonid at each sampling site to estimate total outmigration for natural and hatchery fish and to estimate survival. We estimated overall migrant abundance (A) by multiplying the number of unmarked fish captured during the trapping season (C) by the reciprocal of the adjusted weighted trap efficiency ($1/TE$) for the collection period ($A = C \times 1/TE$). We subtracted recaptured marked fish from trap efficiency tests from the total daily collection prior to estimating migrant abundance. We did not determine trap efficiency estimates for natural fish, except summer steelhead, due to low numbers. Therefore, we used weighted trap efficiency estimates of hatchery fish for natural fish of the same species to obtain a rough abundance estimate. For branded natural spring chinook salmon captured at the rotary trap, we used the trap efficiency estimate for hatchery spring chinook salmon to obtain an estimate of survival for branded fish. We used the Bootstrap method (Efron and Tibshirani 1986; Murphy et al. in prep) with 1,000 iterations to determine the variance for most abundance estimates. For subyearling fall chinook salmon, we were limited to 500 iterations due to computer limitations. Confidence intervals (95%) for the abundance estimate were calculated using the square root of the Bootstrap variance estimate ($CI = 1.96 \sqrt{V}$).

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 branded groups of hatchery and natural fish **(see Brands).** Natural spring chinook salmon and summer steelhead marked bi-weekly by CTUIR at upriver traps (RM 48 and RM 73) and branded groups of hatchery fish were collected at lower river traps throughout the migration season. We totaled branded natural and hatchery fish collected (B_c), expanded this total by the reciprocal of the weighted trap efficiency ($1/TE$) during the period of collection, and divided by the total number of branded fish released (R_b) to obtain a survival estimate (S_b) for each brand group [$S_b = (B_c/TE)/R_b$]. We applied similar computations to fish marked with VI-Jet marks.

Environmental Conditions

We monitored river flow, water temperature, and Secchi depth (water clarity) near Three Mile Falls Dam to assess their relationship to fish movements in the Umatilla River. We obtained river flow data recorded below Three Mile Falls Dam by the U.S. Geological Survey and canal flow data recorded at West Extension Canal 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. We measured daily maximum and minimum water temperature (1.6 ft depth) at RM 1.2 and West Extension Canal using a Taylor Max-Min thermometer. Mean water temperature (1 .O m depth) at Three Mile Falls Dam was collected by CTUIR using either a hand-held thermometer (7 November 1995 to 27 February 1996) or a Ryan TempMentor digital recording thermometer (CTUIR and ODFW 1996). We categorized river flow, turbidity, color, and debris level and recorded river and canal elevations at sampling sites at six-hour intervals. Categories were very low, low, low-moderate, moderate, moderate-high, or high. River and canal elevations were read from staff gauges to the nearest 0.05 ft. 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.

Resident Fish and Predators

We counted resident fish species during monitoring of salmonid species. At West Extension Canal and the rotary-screw trap, we counted fish hourly when the trap was operated 24-h a day. Otherwise, counts were made once daily.

We measured fork lengths of fish predator species; primarily northern squawfish (*Ptychocheilus oregonensis*), smallmouth bass (*Micropterus dolomieui*), and largemouth bass (*M. salmoides*). Length measurements of other resident fish were also taken intermittently.

We noted the presence of avian predators at our sampling sites on an intermittent basis. We recorded species and number of each avian predator and the date and time observed.

Transport Evaluation

We evaluated mortality and condition of hatchery subyearling fall chinook salmon before and after transport from Westland Canal to the lower Umatilla River (Table 1). We randomly collected a control group of approximately 100 fish from the juvenile holding pond at Westland Canal prior to crowding to assess pre-transport condition and mortality. Pre-transport (control group) fish were collected from the pond using a dipnet. Fifty fish were randomly sampled and placed in a net pen for 24 h to test mortality. Another 5G fish were measured for fork length and examined for scale loss, bodily injuries, signs of internal bleeding, brands, clips, and marks, and then returned to the pond. Scale loss was evaluated as described in **Fish Condition.** After 24 h, fish held in the net pen were removed and dead, moribund, and live fish were counted; live fish were returned to the pond. Water temperature in the net pen was measured at the start and end of each 24-h holding period.

Post-transport (treatment) groups were collected from the transport vehicle at the release site (Umatilla River boat ramp, RM 0.2). These fish had been subjected to lowering of the pond water level, crowding, netting or pumping with a fish pump, and transport of approximately 27 river miles. We randomly collected fish from the transport tank with a dipnet. Fifty fish were placed in a second net pen, held in the river near the boat ramp, for 24 h to test mortality. Another 50 fish were measured for fork length and examined for scale loss, bodily injuries, internal bleeding, brands, clips, and marks and returned to the river. We recorded pounds of fish transported and type of transport vehicle (tanker truck or trailer) and measured water temperature in the net pen at the start and end of each 24-h holding test. Water temperature in the transport tank was obtained from transport records (CTUIR and ODFW 1996). After 24 h, fish held in the net pen were removed and dead, moribund, and live fish were counted.

Additional treatment groups were collected at Westland Canal to test the affect of fish handling on 24-h mortality. Treatment groups were collected after crowding but prior to loading, and after pump-loading. Fifty fish were collected for each treatment group and held in small net pens for 24 h. We used the initial control group as a control for this test.

For 24-h mortality tests, we counted dead and moribund fish as mortalities. Twenty-four-h mortality (M_{net}) was calculated as the percent mortality of the treatment group (M_t) minus the percent mortality of the control group (M,) so that $M_{net} = M_t - M_c$

Statistical Analyses

We used correlation analysis to examine relationships among environmental variables (river flow, water temperature, Secchi depth) and fish collection data. We used correlation analysis to examine the relationship between fish condition during transport or delayed mortality after transport and transport temperature.

We used Chi^2 tests of independence to determine significant differences among groups of trap efficiency estimates, brand or mark recovery groups, and in proportions of injured fish among weeks. 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 using the Yates correction factor 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 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 0.05.

RESULTS

Migrant Traps

Sampling periods and trapping operations are indicated in Table 1. The rotary-screw trap was inoperable for 60 d from November 1995 through February 1996 due to flooding and icing. We sampled at West Extension Canal from 2 April through 11 July 1996, when canal operations ceased. We used a floating net trap (Figure 2) at RM 1.2 during September when low river flows prohibited use of the rotary-screw trap.

Trap Efficiencies

We used hatchery yearling spring chinook and coho salmon for trap efficiency tests at RM 1.2 (Table 2). We released seven groups of spring chinook salmon, two of which had no recaptures (29%). Weighted trap efficiency for spring chinook salmon was 0.020 (SD = 0.006) Trap efficiency recaptures were collected from 1 to 84 h after morning releases. We released coho salmon on six days in the evening, at times with two different marks per day (Table 2). We recaptured fish from two of these daily releases (33%) within 22 to 113 h after release. Weighted trap efficiency for coho salmon was 0.008 (SD = 0.005). No trap efficiency tests were conducted for natural salmonids at RM 1.2. Trap retention efficiency was 95% for spring chinook salmon and 92% for coho salmon (Table 3).

At West Extension Canal, we used hatchery coho salmon, hatchery yearling and subyearling fall chinook salmon, and hatchery and natural summer steelhead for trap efficiency tests. Weighted trap efficiencies were similar for hatchery groups of yearling and subyearling fall chinook salmon and for summer steelhead and coho salmon (Tables 4 and 5). From 22 April - 27 April, we subsampled at 20% or bypassed through the night which resulted in overexpanded trap efficiency recaptures for some groups of fall chinook and coho salmon marked and released before or during that time (Table 4).

Fifty-three trap efficiency releases were made for hatchery coho salmon from 3 April to 30 May (Table 4). Of these, only three groups (6%) had no recaptures. Recapture of marked fish ranged from 1 to 34 d after release, with most fish recaptured within three days after release. Earliest recapture was one hour after release. Most marked fish were recaptured in the morning and evening hours. Weighted trap efficiency for coho salmon was 0.188 (SD = 0.005).

Forty-two trap efficiency releases were made for hatchery yearling fall chinook salmon from 8 April to 21 May (Table 4). Of these, only four groups (9%) had no recaptures; these occurred at the end of May when < 50 fish were released per group. Recapture of marked fish ranged from 1 to 34 d after release, with most fish recaptured within the first few days. Earliest recapture was one hour after release. There was no apparent pattern in recapture with time of day. Weighted trap efficiency for yearling fall chinook salmon was 0.267 (SD = 0.007).

Twenty-nine trap efficiency releases were made for hatchery subyearling fall chinook salmon from 23 May to 26 June (Table 4). Of these, two (7%) had no recaptures. Recapture of marked fish ranged from 1 to 12 d after release, with most fish recaptured within the first day. Earliest recapture was two hours after release. Fish were mostly recaptured during daylight. Weighted trap efficiency for subyearling fall chinook salmon was 0.268 (SD = 0.006).

Thirty-two trap efficiency releases were made for hatchery summer steelhead from 17 April to 3 June (Table 4). Of these, three groups (9%) had no recaptures. Recapture of mark groups ranged from 1 to 13 d after release, with most fish recaptured within the first week. Earliest recapture was two hours after release. Most fish were recaptured during morning and evening hours. Weighted trap efficiency for hatchery summer steelhead was 0.142 (SD = 0.007).

For natural summer steelhead, seven trap efficiency releases were made from 14 May to 1 June (Table 5). Of these, one (14%) had no recaptures. Recapture of marked fish ranged from l-6 d, with most fish recaptured within the first day. Earliest recapture was two hours after release. Fish were mostly recaptured during the morning and evening hours. Weighted trap efficiency for natural summer steelhead was 0.072 (SD = 0.013).

Mortalities for fish held after trap efficiency marking were minima1 for yearling fish but not for subyearling fish (Table 6). Most daily survival rates of marked yearling fish were between 95-100%. However, percent survival of marked yearling spring chinook salmon was low (75%) when held at the rotary-screw trap on the first day of capture in March. These fish appeared to be in poor and weak condition compared to later recaptures with 100% survival. Periodic high losses of yearling coho and fall chinook salmon also occurred. Survival rates of marked subyearling fall chinook salmon declined toward the end of June (Table 6). Mean mortality of subyearling chinook salmon during holding from 7 June to 26 June was near 10%. Estimated mean survival for each species during daily holding was 97.7% (SD = 7.0) for coho salmon, 96.2% (SD = 9.4) for spring chinook salmon, 96.5% (SD = 6.3) for yearling fall chinook salmon, 98.5% (SD = 2.5) for hatchery summer steelhead, 96.5% (SD = 4.3) for natural summer steelhead, and 93.6% (SD = 12.4) for subyearling fall chinook salmon. Transport mortality was low (Table 6).

Outmigration Monitoring

Collection

We monitored the outmigration ofjuvenile salmonids from mid-October 1995 through September 1996, with occasional periods of no trapping (Table 1; **see Migrant Traps).** We mostly collected hatchery groups of yearling spring chinook and coho salmon at the rotary-screw trap (RM 1.2) from mid-October 1995 to end March 1996 (Table 7). Few natural chinook salmon, coho salmon, or summer steelhead were captured during this period.

We intensively monitored at West Extension Canal from early April to mid-July, with over one million fish passing through the bypass facility (Table 7). Data collected was expanded for hours bypassed and hours subsampled, representing 4.5% and 14.5% of the total 2,405 h sampled, respectively. Of hatchery groups, total collection was comprised of subyearling fall chinook salmon (85%), coho salmon (8%), yearling fall chinook salmon (5%), summer steelhead (2%), and yearling spring chinook salmon (0.07%). Hatchery fish captured represented from 0.2% to 33% of the hatchery fish released. Of natural fish collected, summer steelhead was dominant (95%).

Nearly all fish sampled at Westland Canal were hatchery subyearling fall chinook salmon (Table 7). No natural subyearling fall chinook salmon and one natural summer steelhead were sampled. We captured only one fish in the floating net trap at RM 1.2 in September - a hatchery coho salmon.

Mortality of fish handled and held for 24 h at West Extension Canal was low for all species, except subyearling fall chinook salmon (Table 8). Beginning on 10 June, mortality of subyearling chinook held for 24 h ranged from 2% to 22% (14 June). Water temperatures were approaching 70” F during this time.

From 28 May to 1 June at West Extension Canal, we collected what we assumed to be unmarked hatchery rainbow trout that had been released in the Umatilla River near Pendleton from 23 May to 13 June (ODFW, unpublished data). Of the approximately 5,000 fish released, we captured 13. Mean length of fish caught was 240 mm (SD = 27.2), the same as the approximate length of fish released. These unclipped fish were larger than the natural summer steelhead being caught at the same time (174 mm mean length; SD = 19.5) and exhibited reddish coloration. Most trout were in good condition; one was partially descaled with bird marks,

We collected 426 scale samples from RM 1.2 and RM 3 for age analysis by CTUIR biologists (Table 9). Most scales were collected from natural summer steelhead/rainbow trout (3 12 samples), followed by natural chinook salmon (73 samples), and natural and hatchery coho salmon (41 samples). Of fish sampled, 18% were parr, 55% were intermediate smolt stage, and 27% were smolt. Size of fish sampled ranged from 65 mm (natural coho salmon) to 295 mm (natural summer steelhead).

Age analysis of scales from natural steelhead smolts indicated that most fish (84%) were 2’ years and 15% were 3^+ years of age. Four fish were aged as 1^+ and one fish was 4’ years (CTUIR, unpublished data).

Trap and Haul

We sampled fish from Westland Canal during trap and haul operations on nine occasions from 11 June through 9 August 1996 (Table 10). The nearly 1,800 salmonids sampled were all hatchery subyearling fall chinook salmon except for one natural steelhead captured on 5 August. Estimated numbers of salmonids transported were highest on 13 June (22,174 fish) and 2 July (21,600 fish). An estimated 87,593 salmonids were transported on the nine days we sampled. By the last day of sampling on 9 August, number of salmonids sampled was very low (4 fish). Non-salmonid species were not collected in our samples until they dominated the species composition in early August. An estimated 3,820 non-salmonids were transported on these last three days. Non-salmonid species composition was dominated by redside shiners (*Richardsonius balteatus*), largescale and bridgelip suckers (*Catostomus macrocheilus* and *C. columbianus*), northern squawfish (*Pytchocheilzrs oregonensis*), and chiselmouth (*Acrocheilus alutaceus*). On the last day of sampling (9 August) all fish were non-salmonids.

Brands

Brand groups of yearling fall chinook salmon and summer steelhead were not collected in similar proportions; however, they were for spring chinook salmon (Table 11). No significant difference (*P* = 0.11) was evident between these brand groups representing Oregon and Michigan raceways. Expanded by weighted trap efficiency and trap retention efficiency, brand survival indices for spring chinook salmon ranged from 28.3% to 42.9% (mean = 35.0%; SD = 5.0). Most of these fish were captured at the rotary-screw trap in March (Table 11).

Recovery of the "larges" group of summer steelhead (RAL2) released in late April was significantly lower (*P* < 0.0001) than either the "mediums" (LAL2) released on 12 April or "smalls" (LAL1) released on 9 May (Table 11). The "smalls" were collected in the same proportion as the "mediums" group (*P* = 0.66). Expanded by respective weighted trap efficiencies for the period of collection, the survival index for the LAL1 brand ("smalls") was more than twice the index for the RAL2 brand ("large?') and slightly greater than the LAL2 brand ("mediums"; Table 11). The mean survival index for all brands was 7.1% (SD = 2.6).

Brand group recaptures for yearling fall chinook salmon from Michigan raceways at Umatilla Hatchery (LAL1, RAB 1, RAL1) were significantly less (*P* < 0.0001) than brand recaptures from Bonneville Hatchery (Oregon raceways) releases (LAL2, RAL2; Table 11). Recapture of Bonneville Hatchery brand groups was 6 times the recapture of the two predominant Umatilla Hatchery brand groups (LAL1, RAB 1). Chi' tests indicated recapture of the Umatilla RAL1 brand group was significantly less (P = 0.028) than recapture of the LAL1 and RAB 1 brand groups. Bonneville Hatchery brand recoveries were not significantly different between groups (*P* = 0.24). Expanded by adjusted weighted trap efficiencies, the mean survival index for Bonneville Hatchery brands was 11.7% (SD = 1.1), whereas the mean survival index for Umatilla Hatchery brands was 1.6% (SD = 0.5). For all brand groups from both hatcheries, the mean survival index was 5.6% (SD = 5.0).

Approximately 17% (RA54) to 50% (RA52) of all brand groups of the subyearling fall chinook salmon releases were recaptured (Table 11). Brand recoveries were not significantly different (*P* = 0.90) between the Oregon raceway groups ("3" position) and the Michigan raceway groups ("4" and "2" positions), although recoveries within each of the respective groups were not homogeneous (P < 0.0001). Expanded by adjusted weighted trap efficiencies, survival indices for 7 of the 10 groups exceeded 100% (Table 11). Mean survival index was 117.7% (SD = 34.2) for all brand groups, 124.2% (SD = 30.2) for Oregon raceway brand groups, and 113.4% (SD = 35.9) for Michigan raceway brand groups.

Branded natural spring chinook salmon were collected in our traps from 20 March to 6 May, with most collected in April (Table 12). Fish marked and released at upper river traps from mid-November to mid-January were captured in greater proportions than those marked and released in October, ranging from near 4% to 10%. A minimum survival index of 18% was obtained for the RD7U1 brand group, where fish captured at the rotary-screw trap site were expanded by the weighted trap efficiency of hatchery spring chinook salmon. We were unable to expand captures at West Extension Canal. All but two of the eight brand groups were recovered in the lower river.

Branded natural summer steelhead were collected from 9 April to 30 May, with most collected in May (Table 12). Steelhead marked and released at the RM 79.5 trap site by CTUIR in April and early May were captured in greater proportions than those marked and released from mid-November (at RM 42.8) to early January (at RM 79.5). Expanded recaptures indicated survival rates ranged from 10% (RA7K 1) to 100% (LA7N1; Table 12). The LA7N1 brand was marked at RM 79.5 and released on 1 May as the natural summer steelhead migration was peaking. Only 4 of the 15 brand groups for natural summer steelhead were recovered in the lower river; three of these brand groups were marked at the RM 79.5 trap site (RA7K1, LA7K1, LA7N1).

VI-Jet Marks

We marked a total of 6,283 subyearling fall chinook salmon with the VI-Jet mark at Umatilla Hatchery in early May. Although all marks examined were readable, some marks were very small.

From 0.2% (YV) to 39% (RP) of the subyearling fall chinook salmon marked with VI-Jet marks were recaptured in the lower river (Table 13). Recovery was significantly higher for marks placed on the pectoral fin (RP, GP, OP) than marks placed on the ventral (pelvic) and anal fins ($P < 0.0001$). Recoveries of the red, green, and orange pectoral marks were not significantly different ($P = 0.69$) from each other. Recovery was lowest for the yellow, ventral mark. (The order of these marks in Table 13 corresponds to the order of the brand groups in Table 11.) Mark recoveries were significantly different ($P < 0.0001$) between the Oregon raceway groups (RA, RV, RP, GP) and Michigan groups (remaining 6 marks), but recoveries within each of the respective groups were not homogeneous ($P < 0.0001$). Expanded by weighted trap efficiencies, the survival index for most marks was between 20% and 66%.

Only six fish representing four VI-Jet marks were sampled at John Day Dam on the Columbia River (Table 14). These fish were detected from 12 June to 26 June. Expanded by subsampling rates and the proportion of total flow sampled, numbers of marked fish were highest for the RP and OV marks (Table 14).

Orange and red marks were the easiest colors for samplers to detect. Red was also most visible in turbid water. The yellow mark was hardest to see.

Fin Clips

Fin clips on most salmonid species were not observed in proportion to the number released (Table 15) and this dissimilarity was significant for these groups ($P < 0.0001$). However, clips on yearling spring chinook salmon (LV and ADLV) were observed in similar, non-significant proportions ($P = 0.060$). The percent recapture of coded-wire tagged fish (ADLV or ADRV for chinook salmon and summer steelhead, AD for coho salmon) was always less than the percent recapture of non-coded-wire tagged fish (Table 15).

Migration Parameters

Most migration parameters varied for hatchery and natural salmonids (Table 16). Hatchery salmonids were first captured from l-3 d after release. First capture of natural chinook salmon and natural summer steelhead preceded releases of their hatchery counterparts by three months and one month, respectively. First capture of natural coho salmon was within two days of the first release of hatchery coho salmon (Table 16).

Median capture date for natural chinook salmon was 28 d after the median capture date for hatchery spring chinook salmon (Table 16). However, last capture was 44 d later for hatchery chinook salmon than natural chinook salmon. Median capture dates were only one day apart for natural summer steelhead and hatchery summer steelhead. However, natural summer steelhead had a later date of last capture and longer migration than hatchery summer steelhead. Median capture for hatchery coho salmon was 18 d later than natural coho salmon. Hatchery coho salmon migrated about one month later and longer than natural coho salmon.

Most hatchery spring chinook salmon and hatchery subyearling fall chinook salmon migrated immediately after release and passed through the lower river within 1-4 d (Figure 6). Greater than 50% of the total lower river capture of each race occurred within 24 h. Peak movement of hatchery summer steelhead was 22 and 34 d after initial releases in April and 7 d after the last release in mid-May (Figure 7). During peak movement, 54% of the summer steelhead were captured in four days (15- 18 May). Cumulative capture was 25% prior to this peak movement. The natural summer steelhead migration mirrored hatchery summer steelhead except cumulative capture was 40% prior to peak movement (Figure 8). Migration of hatchery yearling fall chinook and hatchery coho salmon were characterized by multiple highs and lows in movement (Figures 6 and 7). The first peak movement was 7 d after release for fall chinook salmon and 15- 16 d after first release for coho salmon. In general, fluctuations in movement for both species were more extreme in April than in May. Both species exhibited a final peak in movement in mid-May, similar to summer steelhead. Migration patterns of natural chinook and coho salmon were difficult to decipher due to low capture rates (Figure 8). We captured the greatest numbers of these species during the first three weeks of April.

Migration patterns of brand groups of spring chinook salmon were similar for Michigan- and Oregon-reared fish (Figure 9). All brand groups moved quickly after release on 13 March, arriving at the lower river trap on 14 March. The LAB3 brand (Oregon raceway) was captured the latest (23 April).

Although migration patterns of brand groups of yearling fall chinook salmon were similar, fish reared at Umatilla Hatchery (Michigan raceway) moved out in lower numbers than fish reared at Bonneville Hatchery (Oregon raceway; Figure 10). Some Umatilla Hatchery fish (RAB 1 and RAL 1 brands) escaped from acclimation ponds in early April, prior to the 18 April release. The duration of migration was similar for both rearing strategies, ending in late May. The two brand groups from Bonneville Hatchery exhibited near identical peaks in movement, but at different magnitudes (Figure 10).

Collection of the three summer steelhead brand groups peaked during mid-May even though two of the brand groups (LAL2 and RAL2) were released nearly one month prior (Figure 11). First day of capture of the LAL2 and RAL2 brands was 24 April, twelve days after release (LAL2) and same day as release (RAL2). The LAL1 brand was first captured on 15 May, six days after release. Little movement was evident for the RAL2 brand group (larges) prior to or after the peak. The group of smalls (LAL1) dominated all brand captures after the first, major peak and was the last brand to be captured (5 June).

Brand groups of subyearling fall chinook salmon were tightly clustered within one primary and one secondary peak in early June (Figure 12). No difference in migration pattern between Oregon- and Michigan-reared fish was evident. Some fish from the LA52 and LAE4 brand groups (Michigan) escaped from acclimation ponds about one week prior to release. Capture of most brand groups extended to mid-June. Last capture at West Extension Canal (28 June) was an RAE3-branded fish (Oregon) and last capture at Westland Canal (25 June) was an LA54-branded fish (Michigan).

Fish marked with VI-Jet tags were first detected on 3 1 May (GV) and last detected at West Extension Canal on 15 June (RA and OP; Figure 13) and at Westland Canal on 2 July (OP). Most mark groups (9 of 10) were captured on 4 June. Collection of the OP mark (Michigan) and GP and RP marks (Oregon) was greatest on 3 June (near 200 fish per mark) when the outmigration peaked. Most other marks were collected at rates of < 30 fish/day. Three days before the last detection on the Umatilla River marked fish were detected at John Day Dam (12 June; Table 14).

Diel Capture

In March, hatchery spring chinook salmon were mainly captured at night in the rotary screw trap (Figure 14). Fish collection briefly peaked an hour after sunset and from 2400 hours to 0200 hours. Maximum capture during midday was half the magnitude of the night time peaks. In April at West Extension Canal, most spring chinook salmon were captured at midday, dissimilar to the night-time capture in March. Fish capture gradually increased after sunrise and peaked at 1300 hours. In April, most natural spring chinook salmon **were** captured in early morning (0700 hours) and midday (1300 hours).

Collection of yearling fall chinook salmon in April peaked at 1400 hours (Figure 15). However, fish numbers also peaked before (0200 hours) and after (0700 hours) sunrise. Fish capture was lowest from 1800-2400 hours. Fall chinook salmon capture in May was concentrated in the afternoon, peaking at 1500 hours. Few fish were captured during the night or morning in May.

Hatchery coho salmon capture in April peaked two hours after sunrise and was generally higher during daylight hours than at night (Figure 16). Diel patterns for natural coho salmon were not evident in April due to small sample sizes. However, a higher number of natural coho salmon (5 fish) was collected at 0700 hours and 0900 hours at approximately the same time as the peak in hatchery coho salmon capture in April. In May, the hatchery coho salmon migration peaked two hours after sunrise and at 1500 hours. Overall, hatchery coho salmon tended to move more at night in May than in April.

Diel patterns for hatchery and natural summer steelhead were similar (Figures 17 and 18). About 66% of the hatchery and natural summer steelhead in April were captured during the day. Capture of hatchery and natural steelhead peaked several hours before and after sunrise, and additionally during midday for natural steelhead. In May, about 80% of the hatchery steelhead and 75% of the natural steelhead were caught during the day. At 1000 hours , capture peaked for both hatchery and natural steelhead. In June, nearly 95% of the hatchery and natural summer steelhead were captured during the day. Both hatchery and natural fish were captured in higher numbers in midmorning (0900-1000 hours) and near sunset, Subsampling during the midmorning of 3 June overexpanded the collection numbers, influencing the midmorning peak.

In May, capture of subyearling fall chinook salmon peaked in the morning after sunrise (0600 - 0700 hours) and at noon (Figure 19). Capture decreased toward evening and was lowest at night. In June, most fish moved in the morning (0600 - 0900 hours) and very few fish moved at night. Subsampling during the midmorning of 3 June overexpanded the collection numbers, influencing the midmorning peak.

Smolt Index

Most hatchery spring chinook salmon (90%), yearling fall chinook salmon (80%), and summer steelhead (70%) were in the smolt stage when captured immediately after release (Figure 20). As the migration progressed, fewer spring chinook salmon were smolts and more **were** intermediate smolts. Yearling fall chinook salmon were nearly all smolted throughout their migration. Summer steelhead smolted over time. During peak capture in mid-May, over 90% of the steelhead were smolted compared to 70% in early April. In contrast, only 3.2 % of the hatchery coho salmon and 32 % of the hatchery subyearling fall chinook salmon were smolted in the first week after release. Nearly all hatchery coho salmon were intermediate smolts from time of release in late March and early April until mid-May. Coho salmon were nearly all smolted by June. Subyearling fall chinook salmon that escaped from acclimation ponds and were first captured in early June were mostly intermediate smolts. By late June nearly all fish collected were smolted.

Most natural chinook salmon collected were classified as intermediate smolts throughout the three-month migration (Figure 21). However, parr stages were also observed, particularly with the subyearling fall chinook salmon in May and June. Natural coho salmon classified as intermediate smolts increased from 55 - 100% from 8 April - 22 April. Natural summer steelhead transitioned from 36% smolts to > 60% smolts in mid-May.

Fish Condition and Health

Condition of hatchery fish declined due to varying degrees of scale loss, attempted bird predation, bacterial kidney disease, and other injuries including injury to the head, eyes, operculum, and body. Secondary fungal infections, parasites, and leeches were also present on hatchery fish (Table 17). Over time, fish condition deteriorated, more so with hatchery fish than natural fish.

In the few weeks after their release, hatchery spring chinook salmon at RM 1.2 exhibited increased mortality, descaling, bird marks, and other injuries (Table 17). Other injuries were comprised mostly of eye, operculum, and body injuries and signs of BKD. Overall, 67% of the fish were in good condition, 25% had partial scale loss, and 7% were considered descaled. Bird marks were present on 3.3% of the fish collected and leeches were commonly found on fish throughout the migration. Chi^2 tests indicated scale loss was not independent of time ($P < 0.0001$). Pathological analysis of five fish indicated three low level, one moderate level, and one clinical level of Rs antigen (BKD; ODFW unpublished data).

Hatchery yearling fall chinook salmon were in better condition than spring chinook salmon, with approximately 86% of the fish in good condition, 10% partially descaled, and 4% fully descaled. Mid-season captures of fall chinook salmon exhibited highest descaling (Table 17). Bird marks, other injuries (comprised mostly of injuries to the caudal fin, body, and eyes), and signs of BKD increased with time. Chi^2 tests indicated scale loss was not independent of time ($P < 0.0001$) for these fish. Pathological analysis of four yearling fall chinook salmon revealed clinical levels of BKD; one fish had motile bacterial gill disease (ODFW, unpublished data).

Yearling coho salmon were in the best condition overall, with similar proportions of good, partially descaled, and fully descaled fish as yearling fall chinook salmon. However, other injuries were rarely observed on coho salmon (0.6%). First and last captures of coho salmon showed highest descaling, but bird marks did not increase with time. Chi^2 tests indicated scale loss was not independent of time ($P < 0.000 1$). Pathological analysis of four coho salmon samples were positive for Rs antigen, ranging from low (2 fish), to moderate (1 fish), to clinical levels (1 fish).

Hatchery summer steelhead exhibited poorest condition among hatchery fish (Table 17). Overall, only 67% of the fish were in good condition. Partially descaled and descaled fish accounted for 22% and 10% of the fish collected, respectively. Greater than 10% of the steelhead collected after late May were descaled. On average, bird marks were more prevalent on steelhead (5%) than on other species. The weekly proportion of fish with bird marks increased from near 2% in early April to 100% by late June. A 7% increase in bird marks and partial descaling in late May and early June coincided with the release of over two million subyearling fall chinook salmon. Chi^2 tests indicated scale loss was not independent of time ($P < 0.0001$).

Condition of hatchery subyearling fall chinook salmon collected at West Extension Canal deteriorated by mid-June (Table 17). The percentage of fish in good condition decreased from 99% in mid-May to 20% by early July as descaling rates increased to 15%. Overall, 76% of the collected fish showed minimal scale loss, 19% showed partial scale loss, and 4% were fully descaled. Although only 0.4% of all fish were dead, the mortality rate rose to 50% by early July. Few bird marks, parasites, or other injuries were present. Chi^2 analysis indicated scale loss was not independent of time ($P < 0.0001$).

Subyearling fall chinook salmon collected at Westland Canal showed greater partial (63%) and full (13%) descaling than those collected at West Extension Canal (Table 17). Collection of dead fish was also higher (5%) overall; fish collected in early July had the highest mortality, as did those at West Extension Canal. Few bird marks and other injuries were present. Pathological analysis of over 50 fish collected at Westland Canal indicated varying levels of Rs antigen, with most in the low level range. These fish did not have BKD (ODFW, unpublished data).

Most natural salmonids (> 90%) had minimal scale loss and appeared in better condition than their hatchery counterparts. A small number of natural chinook and coho salmon were partially or fully descaled (Table 17). Parasites *(Neasctrs metacercariae* - black spot disease) were observed on all natural species, particularly summer steelhead collected in April and May, Summer steelhead was the only natural species that exhibited bird marks. Prevalence of bird marks increased from 1% in early April to 40% by mid-June. Other injuries (2%), mortalities (0.4%), partial scale loss (6%) and full scale loss (2%) were also more prevalent with natural summer steelhead than other species. Pathological analysis of one natural summer steelhead and one natural spring chinook salmon collected at West Extension Canal indicated low levels of Rs antigen (but no BKD) and the presence of low to moderate levels of black spot disease (ODFW, unpublished data).

Lengths

Mean fork lengths of hatchery salmonids captured were greater than natural fish (Table 18). T-tests indicated a significant difference ($P < 0.001$) between mean fork lengths of hatchery and natural yearling spring chinook salmon, subyearling fall chinook salmon (collected at West Extension Canal), and summer steelhead. Hatchery subyearling fall chinook salmon captured at Westland Canal in July and August attained a maximum length of 149 mm (Table 18). No natural subyearling chinook salmon were captured at Westland Canal. At West Extension Canal, we collected natural subyearlings smaller than 60 mm.

Length frequency distributions are presented in Figures 22 and 23. Most species had single, central modes (Table 18). Hatchery summer steelhead had four nearly equal modes; natural summer steelhead had two modes (Figure 22). The inclusion of small, unclipped hatchery coho salmon resulted in the high, off-centered mode for natural coho salmon (96 - 100 mm; Figure 22). The three larger natural coho salmon (112 mm, 127 mm, and 13 1 mm) were captured in mid-March before hatchery coho salmon were released.

Few fry-sized natural fish were collected in 1995-96. One natural steelhead fry (44 mm) was captured on 15 March and one natural chinook salmon fry (48 mm) was captured on 27 May.

Migrant Abundance and Survival

Abundance estimates were determined for all salmonids collected at the rotary-screw trap (RM 1.2) and West Extension Canal (RM 3; Table 19). Abundance of all natural fish, except summer steelhead, was near or less than 1,000 fish, based on weighted trap efficiencies of respective hatchery species. All estimates of survival for specific release groups were less than 100%, except for subyearling fall chinook salmon (Table 19).

The abundance estimate of hatchery spring chinook salmon at RM 1.2 represented 34.2% (Table 19) of the number released on 13 March (Appendix Table A-l). Upper and lower 95% confidence limits (Table 19) represent respective survival estimates of 60.3% and 8.2%. Collection of spring chinook salmon continued at West Extension Canal until mid-May (803 fish), but low capture rates precluded trap efficiency tests. The addition of unexpanded spring chinook salmon collected at the canal increased the survival estimate to 34.4% (130,396 fish).

An estimated 129,255 coho salmon passed RM 1.2, representing 27.8% of the coho salmon released in March (Table 19; Appendix Table A-l). The upper 95% confidence limit represents a survival estimate of 71%, but the lower limit was zero. Over half of the additional one million fish released in April passed West Extension Canal. Combining RM

1.2 and RM 3 estimates resulted in a total abundance estimate of 640,557 fish, or an overall survival estimate of 43.4% for the 1.5 million coho salmon released.

An estimated 226,767 yearling fall chinook salmon passed RM 3, representing 40.2% of the fish released in April (Table 19; Appendix Table 1). Upper and lower 95% confidence limits represent respective survival estimates of 42.3% and 38.0%.

The abundance estimate for subyearling fall chinook salmon at West Extension Canal (Table 19) was greater than the number released (2,960,413 fish). Furthermore, approximately 376,026 fish were transported from Westland Canal (Appendix Table A-2), leaving approximately 2,584,387 fish in the river. Based on fish numbers in the river, our estimate of survival was 140.8% (Table 19). Upper and lower survival estimates were within 5.6% of this estimate. Including transported fish with the abundance estimate, survival of released fish was 135.6%.

The abundance estimate for hatchery summer steelhead was near the number of fish released (146,703 fish), indicating a 93.7% survival rate (Table 19). Upper and lower 95% confidence limits represent respective survival estimates of > 100% and 83.9%. Natural summer steelhead abundance was estimated at 73,361 fish with an upper bound of 102,287 fish and a lower bound of 43,981 fish (Table 19).

Environmental Conditions

River flow, water temperature, and Secchi depth (water clarity) near Three Mile Falls Dam from 1 October 1996 through 30 September 1997 are presented in Figures 24 and 25. These environmental variables changed in response to daily and seasonal weather conditions. In winter and spring, gradual rainfall and snowmelt sustained river flows > 250 ft^3/s and heavy rainfall and snowmelt resulted in several floods > 2,000 ft^3/s (Figure 24). River flow decreased to < 250 ft^3/s in summer and fall. Rapid rises in river flow increased suspended sediment loads which caused water clarity to decrease. Water clarity increased during periods of declining or stable river flow (Figure 24). Mean water temperature increased from a winter low of 32” F on 30 January to a summer high of 77” F on 15 July (Figure 25). Water temperature responded quickly to daily changes in weather and rapid increases in river flow. Fluctuations in mean water temperature up to 10” F over a few days were common. Rapid increases in river flow were typically associated with a 5-10” F drop in mean water temperature within 24 h.

Rapid increases in river flow were accompanied in most cases by sharp declines in water temperature and clarity (Figures 26 and 27). During spring, river flow peaked at 3,600 ft^3/s on 13 March and 7,970 ft^3/s on 25 April at RM 3.0. River flow averaged 1,443 ft^3/s in March, 1,513 ft^3/s in April, 761 ft^3/s in May, and 154 ft^3/s in June. Water temperature averaged 46.5” F in March, 52.7” F in April, 57.7” F in May, and 66.9” F in June. Mean Secchi depth was 0.51 m in March, 0.66 m in April, 0.64 m in May, and 0.96 m in June.

Total number ofjuvenile salmonids collected at West Extension Canal appeared to correspond with river flow (Figure 28), Secchi depth, water temperature (Figure 29), and release times of hatchery fish. From late April through May, the two highest peaks in fish collection coincided with rapid increases in river flow and rapid decreases in water clarity and temperature. The linear correlation between fish collection and river flow was not significant (P=0.85), but it was near significant between fish collection and Secchi depth (r=0. 19, P=0.09, N=71) and water temperature (r=0. 19, P=0.06, N=90). Irrespective of environmental variables, fish collection peaked several times following releases of hatchery yearling fall chinook and coho salmon in early April, and in early June after releases of subyearling fall chinook salmon.

Collection of some salmonids at West Extension Canal corresponded with changes in river flow, Secchi depth, or water temperature. In particular, peak collections of hatchery yearling fall chinook and coho salmon were associated with the largest increases in river flow in late April and mid-May (Figure 30). The increase in river flow was accompanied by a decrease in water clarity and temperature. Collection of hatchery and natural summer steelhead peaked in mid-May when water clarity and temperature decreased rapidly in response to increasing river flow (Figure 30). Linear correlation between number of fish collected and river flow was non-significant for hatchery yearling fall chinook salmon (P=0.45), and summer steelhead (P=0.76), but significant for coho salmon (r=0.46, P=0.0001, N=69). Collection of hatchery spring chinook salmon (Figure 30) and subyearling fall chinook salmon (Figure 3 1) peaked shortly after release and did not appear to correspond with river flow, Secchi depth, or water temperature. Low capture rates precluded correlation analyses for all natural salmonids species except summer steelhead; natural summer steelhead collection was not correlated with river flow (P=0. 14). Most natural chinook and coho salmon were collected when river flow was relatively stable (April) or increasing (mid-May; Figure 3 1).

Resident Fish and Predators

Dominant resident fish species (non-salmonids) captured are presented in Table 20. Adult and juvenile lamprey were also captured at the sampling sites. Most were < 180 mm in length (Figure 32). Both Pacific lamprey (*Lampetra tridentata*) and Western brook lamprey (*L. richardsoni)* are present in the Umatilla River (personal communication, P. Kissner, CTUIR, Pendleton, OR), but lamprey caught were not identified to species in 1995 - 1996.

Northern squawfish and bass were the only known piscivorous predators captured in our traps (Table 20). Bass *spp.* captured were primarily juveniles and were not of sufficient size to prey upon salmonids (Figure 32).

Avian predators were observed throughout the spring and summer migration period (Figure 33). Gulls (*Larus sp.*) represented 56% of total avian fish predators observed

(Table 21). Abundance of species changed throughout the season (Figure 33), and appeared to be concomitant with releases of hatchery salmonids.

Transport Evaluation

We evaluated fish condition and 24-h mortality following trap and haul transports from 11 June through 26 July (Tables 22 and 23). At times during mortality tests, fish held in net pens where either stolen or died due to insufficient water (Table 23). On 30 June and 3 July, fish condition was examined but mortality tests were not performed.

Treatment and control groups differed mostly in the "good" and "descaled" classifications **(see Methods).** Overall, treatment groups had 8% fewer "good" fish, 1% more "partial" fish, and 7% more "descaled" fish than control groups. Seven test replicates did not meet test criteria for the Chi^2 heterogeneity test (Zar 1974). Heterogeneity testing on the remaining 15 replicates showed they were non-homogenous, precluding the use of a pooled Chi^2 analysis. However, individual Chi^2 tests showed scale condition of treatment fish was significantly worse ($P < 0.05$) than control fish on 20 June and 1, 11, and 23 July (Table 22). Loading procedure on these dates was with a dipnet, fish were hauled in a 375-gal transport trailer, and water temperature in the transport tank was between 60-70" F (Appendix Table A-3).

In contrast, the percentage of fish descaled in treatment groups was lower than those in control groups on 17, 2 1, 24, and 26 June, and 3 July (Table 22). On 17 and 24 June, fish were loaded with a fish pump and transported in a 3,000-gal tanker trailer. On remaining days, fish were loaded with a dipnet and transported in the trailer. Water temperature in the transport tank was 65" F on 21 and 26 June (Appendix Table A-3). Transport temperatures for remaining days were unavailable.

A significant correlation was found between descaling and water temperature in the transport tank ($r = 0.803$, $P = 0.001$, $N=13$), after the 60" F outlier on 20 June was removed (Appendix Table A-3). No correlation was found between descaling and loading density in the transport tank ($P = 0.173$).

Delayed mortality in treatment groups was 9.6% higher than in control groups. Nine test replicates did not meet test criteria for the Chi^2 heterogeneity test (Zar 1974). Heterogeneity tests of the remaining seven groups showed they were non-homogenous, precluding the use of a pooled Chi^2 analysis. However, individual Chi^2 tests showed mortality of treatment fish was significantly higher ($P < 0.05$) than mortality of control fish in six of these replicates (Table 23).

Net mortality (treatment minus control mortality) was highest on 24 July (26%; Table 23) when transport temperature was near 70" F and descaling of treatment fish was 18% higher than control group fish (Table 22). On 12, 13, and 15 June, net mortality was 22% (Table 23) when corresponding net descaling was 2%, 10%, and 0%, respectively (Table

22). There was no correlation between net mortality and loading density (P = 0.302) or transport tank temperature (P = 0.169).

DISCUSSION

Trap Effkiencies

Low recapture rates at the rotary-screw trap resulted in low trap efficiencies compared to those at West Extension Canal. However, the duration of recapture and the trapping period were much shorter (< 1 week) at the in-river trap than at the canal facility (1 month). The longer capture duration at the canal facility was probably due to fish holding in slack water areas above the dam. Because of the confounding effects of the dam and possibly the canal, we propose to conduct monitoring and trap efficiency activities at the rotary-screw trap throughout the 1996-97 trapping season.

A change in release strategy in 1996 may have improved recapture rates and reduced the incidence of no recaptures compared to 1995 (Knapp et al. 1996). We released fish in the evening in 1996 rather than in the morning (1995) to coincide with peak diurnal movement of their unmarked cohorts. Although flow patterns and percent diversion may also have been different, we believe release time was an influential factor.

Recapture was quickest for fall chinook subyearlings and summer steelhead released in trap efficiency tests; the last fish were captured 12 - 13 days after release. Duration of recapture may have been influenced by degree of smoltification. Nearly 70% of the hatchery steelhead were smolted when released into the river. Although subyearling fall chinook salmon were not as smolted, their quick recapture mimicked the quickness of their outmigration. Trap efficiency tests were conducted during the peak outmigration for natural summer steelhead in mid- to late May when about 70% of the fish were smolts; trap efficiency recapture occurred mostly within the first day. Coho salmon were the least smolted and required up to 34 days for last recapture during trap efficiency tests. In both 1995 and 1996, trap efficiencies for coho salmon and summer steelhead were lower than those for the chinook salmon.

In late April, we bypassed or subsampled at low rates through the night for several days (22 - 27 April). This resulted in overexpanded trap efficiency recaptures for yearling fall chinook and coho salmon marked and released during that time, or marked and released prior to late April but recaptured in late April. The higher recaptures necessarily increased the trap efficiency estimates for coho salmon on one day (0.770) and for yearling fall chinook salmon on two days (0.686 and 0.778).

Outmigration Monitoring

Few natural subyearling fall chinook and coho salmon were captured in our traps and in samples collected at Westland Canal in 1996. The absence of natural subyearling fall chinook and coho salmon clearly indicates that mainstem spawning and egg-to-fry or egg-to-smolt survival was not successful, probably due to several major flood events during the winter and spring of 1996. Additional sampling data collected by CTUIR at Westland Canal during times when we were not sampling indicated that only one natural chinook salmon and six natural coho salmon were present in all samples (CTUIR and ODFW 1996). Although numerous high water events occurred in 1995, the magnitude of these events were not as great as in 1996; in 1995 we captured 330 natural subyearling fail chinook and 5 natural coho salmon (Knapp et al. 1996).

We subsampled and bypassed fish more often in 1996 than in 1995 (Knapp et al. 1996) which resulted in more interpolation and expansion to derive final counts. On 3 June particularly, when the peak subyearling fall chinook salmon migration moved through the sampling facility at West Extension Canal, we were forced to subsample small portions of each hour's passage (as low as 11 seconds), Beginning at 0600 hours until 1800 hours, we subsampled at rates of 0.3% to 20%. Subsamples were taken at the top of the hour and not throughout the hour which may have biased our results further. Based on observations of fish entering our trap, it is unlikely fish moved uniformly through the facility within each hour. Thus, low sampling rates during periods of irregular fish movement might grossly overexpand or underexpand the hour's count. During hours of intense collection on 3 June (0600 - 1100 hours), when we subsampied from 11 seconds to 2 minutes out of the hour, 549,328 subyearling fall chinook salmon were collected (expanded count). This 6-h collection represented 92% of the total day's collection and 58% of the total collection at West Extension Canal. The overall count and estimate of survival for subyearling chinook salmon was probably influenced substantially by the necessary expansion and extrapolation.

Summer steelhead counts on 3 June were also probably biased, but the effect on their overall count and estimate of survival was probably not as great as with the subyearlings. The expanded number collected between 0600 - 1100 hours (46 1 fish) represented 69% of the day's collection and 2.4% of the total collection.

Most visual implant jet marks on subyearling fall chinook salmon were readily detected; the yellow mark was not. Studies at McNary Dam on the Columbia River also documented lower recovery for yellow visual implants in the adipose eyelid of yearling fall chinook salmon from Lyons Ferry compared with other colors (Wagner 1996). The absence of yellow mark recoveries at McNary Dam may have been due to a color distinction error or missed detections by samplers (Wagner 1996). We also noted that yellow marks were difficult to detect. Red marks were the easiest color for samplers to detect at John Day Dam, the Umatilla River, and McNary Dam (Wagner 1996).

The ability to easily and quickly detect color marks in fins makes them more suitable for outmigration monitoring than brands. Brands can be faint and require greater effort to locate, read, and decipher their position and rotation.

In 1995 and 1996, most hatchery salmonids migrated in about two months with several peak movements. However, yearling spring chinook salmon and subyearling fall chinook salmon migrated immediately after release with a single peak in both years. In 1996, peak capture of spring chinook salmon at the rotary trap was one day after release in mid-March and 70% cumulative capture was reached about ten days later. In 1995, spring chinook salmon were captured in peak numbers the day of release, migrating 50.8 miles in less than a day (Knapp et al. 1996). Seventy percent cumulative capture of subyearling fall chinook salmon was reached four days after release in 1995 (Knapp et al. 1996) and 1996. Their peak migration passed by the trap site within a day. Sixty percent cumulative capture was achieved at West Extension Canal in four hours in 1996.

The migration patterns of yearling spring chinook and subyearling fall chinook salmon increase their vulnerability to failures at screening facilities and potentially hazardous instream activities because many fish are in one place at one time. Prior to releases of these two species, it is important to monitor in-river activities, fish passage facilities, and pump screens to avoid large fish losses. In previous years, inadequate screening at an irrigation pump station and a hydroelectric diversion resulted in substantial losses of subyearling fall chinook salmon and yearling spring chinook salmon (CTUIR and ODFW 1992; ODFW, unpublished data).

When released in late March, most coho salmon were not smolted which may have caused them to remain in the basin longer than other species. With time, the proportion of coho salmon that were smolted increased as did their outmigration numbers. In 1995, coho salmon exhibited a similar smoltification and migration pattern (Knapp et al. 1996). However, the length of stay in the Umatilla River may expose these fish to greater predation, warmer water temperatures, lower flows, and ultimately increased mortality. It may be prudent to release coho salmon when they are more smolted later in the spring to ensure a rapid migration. On the other hand, a protracted outmigration may provide improved opportunity for imprinting since these fish are not acclimated.

Although the bulk of subyearling fall chinook salmon migrated quickly, the tail end of their migration was more protracted, Transport operations from Westland Canal lasted until early August, nearly three weeks longer than in 1995 (CTUIR and ODFW 1995). We also estimated that almost six times as many subyearling chinook salmon were trapped at Westland Canal in 1996 (376,026) than in 1995 (64,977; Knapp et al. 1996). In both years, 98% of the subyearling chinook salmon transported from Westland Canal were collected by 5 July. The longer outmigration in 1996 may have been due to slow smolt development and to a difference in size and condition factor of hatchery subyearling fall chinook salmon between the two years. In 1996, hatchery subyearling fall chinook salmon were released at 65.7 fish per pound, a mean fork length of 87.6 mm, and a condition factor of 1.07 (Focher et al. 1997). Duration of the outmigration was shorter in 1995 when fish were released at a larger size (63.6 fish per pound, 9 1.5 mm mean fork length) and a lower condition factor (0.95; Hayes et al. 1996). Body coloration and condition factor of subyearling fall chinook salmon at release may provide a gross prediction of the number of late migrating subyearlings. Ewing et al. (1984) suggested that juvenile chinook salmon must reach a critical size to begin their outmigration, and that outmigration may be stimulated by a sudden increase in growth brought about by environmental factors such as temperature. This indicates that smaller fish may migrate later than larger fish. Hatchery subyearling fall chinook salmon captured at Westland Canal averaged 6 mm longer than at release in late May, indicating growth after release. This growth may have brought them to the critical size for migration later in the summer. The apparent difference in smolt development for subyearling fall chinook salmon between 1995 and 1996 might also be associated with differences in broodstock collection, rearing, acclimation conditions, or other hatchery practices.

Flow augmentation throughout June and perhaps into the first week of July could provide improved conditions for subyearling fall chinook salmon to migrate naturally through the lower river. This could be achieved through water exchanges and releases of storage water which would be preferable to the current practice of trapping and transporting fish. Increased river flow in early summer would also benefit natural subyearling chinook salmon; their peak migration in the Umatilla River appears to be in June and July (Knapp et al. 1996). Adult spring chinook salmon may also benefit. Fish are still observed in the lower river below Three Mile Falls Dam in late June (CTUIR and ODFW 1995, 1996).

Smolt development and migration was also later for hatchery summer steelhead in 1996 compared with 1995 (Knapp et al. 1996). In 1995, cumulative capture of hatchery summer steelhead was 70% at West Extension Canal by the end of April when 100% of the steelhead sampled were smolts in mid-April. In contrast, cumulative capture was less than 10% at the end of April 1996 when only 70% of the summer steelhead were smolts. Summer steelhead were not > 90% smolted until mid-May in 1996. The two week delay in development of smolt characteristics in summer steelhead corresponded with a two week delay in median migration timing in 1996 compared with 1995. An important management concern is whether aspects of broodstock collection, rearing, acclimation environments, or release strategies affect the ability of hatchery summer steelhead to smolt and migrate in a manner similar to natural Umatilla River donor stock. Development of smolt characteristics and migration patterns of hatchery steelhead were very similar to natural steelhead in 1995 and 1996.

Daily movement of all fish species was generally after sunrise and near sunset in April and during mid-day in May and June in 1996 and 1995 (Knapp et al. 1996). Therefore, in-river activities (e.g. grave1 or debris removal) and potentially harmful operations at juvenile fish passage facilities (e.g. silt sluicing or dredging, forebay/canal dewatering) should be timed to avoid daily peak movements ofjuvenile salmonids. Optimal times for conducting maintenance activities to avoid impacting juvenile salmonids would be in mid-day or at night in April and from late afternoon to early morning in May and June.

Activities should also be timed to avoid peak movement of adult salmonids which occurs during the morning in April (summer steelhead) and throughout the day in May and June (spring chinook salmon; Kutchins 1990). Conducting activities in the early afternoon or at night in April and at night in May and June would minimize impacts on both juvenile and adult salmonids.

Collection of natural spring chinook salmon and summer steelhead during winter trapping indicates at least a portion of these populations overwinter in the lower river. Their movement from tributaries into the mainstem river begins in the fall (Contor et al. 1995, 1996). Although water diversion from the Umatilla River is infrequent in the fall and winter, unscreened diversions may have a negative impact on natural steelhead and chinook salmon populations present in the mainstem. Some of the smaller diversions are not screened during this time because of mechanical concerns with freezeup (personal communication, B. Duke, ODFW, Pendleton, OR).

Migrant Abundance and Survival

By sampling at only two sites in 1995-1996 and conducting long-term trap efficiency tests at West Extension Canal, we were better able to estimate overall migrant abundance and survival than in 1994-1995 (Knapp et al. 1996). Confidence limits were within 4% of the abundance estimate for hatchery subyearling fall chinook salmon, 5% for yearling fall chinook and coho salmon, 10% for hatchery summer steelhead, and 40% for natural steelhead collected at West Extension Canal. Variability increased for fish captured at the rotary-screw trap where fewer efficiency tests were conducted and fewer fish were recaptured. Confidence limits for spring chinook and coho salmon estimated from screw trap data were within 76% and 156% of the abundance estimate, respectively. Therefore, the estimates of migrant abundance and survival for those species collected at West Extension Canal are more reliable, with survival estimates ranging from near 40% for fall chinook and coho salmon to near 94% for summer steelhead. Survival for subyearling fall chinook salmon was overestimated.

As mentioned, the possible overexpansion of fish numbers on 3 June, particularly subyearling fall chinook salmon, would have influenced their survival estimate. We are less confident with'the survival estimates for spring chinook and coho salmon collected at the rotary trap, which were near 34% and 28%, respectively. Survival estimates in 1996 were considerably different than what was estimated in 1995 at West Extension Canal (Knapp et al. 1996). In 1995, survival for subyearling fall chinook salmon was much lower (17.7%) than in 1996, and survival for yearling fall and spring chinook salmon combined, coho salmon, and summer steelhead was overestimated.

Brands representing the "smalls" and "mediums" groups of hatchery summer steelhead were collected in similar proportions between 1996 (1.1%) and 1995 (1.0%, 1.6%; Knapp et al. 1996); however, the "larges" group was not (0.5% in 1996 and 2.3% in 1995). Fish from the "larges" group escaped from acclimation ponds during flooding in late April in 1996 and were not collected in substantial numbers until mid-May when flows increased again. The initial flooding and washout from acclimation ponds may have impacted their survival or reduced capture rates. The similar capture rate of "mediums" and "smalls" is of interest because of the 30-day difference in release time (mid-April for "mediums" and mid-May for "smalls"). As with the "larges" group, the "mediums" were in the river for over a month before their numbers peaked in collections during mid-May high flows. The "smalls" group were released about a week prior to high flows in mid-May which stimulated steelhead movement.

Although expanded percent recapture (survival index) for "smalls" was the lowest of the three brand groups in 1995 (12.6%; Knapp et al. 1996), it was the highest in 1996 (10.1%) even though release time was the same. Therefore, May releases of summer steelhead could be advantageous, given good flow conditions. Previous studies (Hayes et al. 1996) considered abandoning the May release of graded "smalls" due to poor smolt-to-adult survival. In contrast, the survival index for the "larges" was highest in 1995 (29.1%; Knapp et al. 1996), but lowest in 1996 (3.7%). The varying release strategies for the three steelhead groups may spread the risk of releasing during poor river conditions and ensure that at least one group will successfully migrate. The lower index of survival for steelhead brand groups (3.7% - 10.1%) compared to the estimated survival of all steelhead (93.9%) is an enigma. Brands on steelhead were very difficult to see at times and may have been underdetected.

Only the yearling spring chinook salmon had equivalent brand recoveries for the seven different groups, signifying no perceptible survival difference between rearing in Oregon or Michigan raceways. Unlike in 1995 when some fish from Bonneville Hatchery were released and recovered later in substantially greater numbers (Knapp et al. 1996), all brand groups in 1996 were from Umatilla Hatchery and released on the same day (13 March). The single, one-day release for these groups eliminated the potential for temporal and spatial variability among groups. Even so, the mean survival index of brand groups in 1995 (34%; Knapp et al. 1996) was very similar to that for 1996 (35%) and to the 1996 survival estimate (34%). The corroboration between the 1996 brand survival index and the survival estimate may have been due to good brand readability and good brand detection because of the low number of fish handled overall (3,427 fish).

In 1996, yearling fall chinook salmon were reared at Umatilla and Bonneville hatcheries, as was the case for spring chinook salmon in 1995. Similar to findings in 1995 (Knapp et al. 1996), the fall chinook salmon from Umatilla Hatchery did not survive in the Umatilla River as well as Bonneville Hatchery fish, based on brand recoveries Problems with BKD and poorer rearing conditions at Umatilla Hatchery may be contributing factors to poorer survival (personal communication, W. Groberg, ODFW Pathology, La Grande, OR). Rearing conditions at Umatilla Hatchery are not ideal for yearling chinook salmon due to warmer water temperatures, compared to that at Bonneville Hatchery (Focher et al. 1997), which may aggravate the BKD problem. Although levels of BKD prior to release were low, latent manifestation of clinical and deadly levels of BKD may occur after the stress of transport and release into the river (personal communication, W. Groberg, ODFW Pathology, La Grande, OR). As with the summer steelhead, the mean survival index from brand recoveries (5.6%) was much lower than the estimated survival of all yearling fall chinook salmon (40.2%). Again, brand detection may have been poor due to poor readability and the large number of fall chinook salmon collected (> 60,000 fish).

As with the collection numbers, brand recoveries for subyearling fall chinook salmon were overexpanded due to low subsample rates or to inaccurate trap efficiency estimates during their peak outmigration. Brand recoveries in 1996 (mean of 29%) were very different from brand recoveries in 1995 which averaged 2% (Knapp et al. 1996). Similarly, the survival estimate and mean brand survival index in 1996 (141%, 118%) were considerably greater than that for 1995 (18%, 14%). As with the spring chinook salmon, the 1996 brand survival index for subyearling fall chinook salmon corroborated the overall estimate of survival. Even with the extremely large number of fish collected (976,705) brand detection and readability must have been good.

The lengthy residence time in the river may have impacted coho salmon survival by subjecting them longer to predation and disease. However, these fish appeared to be in best condition. In contrast, summer steelhead appeared in worst condition, but were estimated to have the best survival. Due to their larger size, steelhead may have the best survival potential of all salmonid species. As discussed, condition and health factors including bird marks, disease, parasites, increasing scale loss, and warm water temperatures probably contributed to reduced survival, more so for some species than others.

Both natural and hatchery summer steelhead suffered most from bird attacks during their entire outmigration. Bird attacks tended to descale fish. As the outmigration season progressed, bird attack marks and scale loss increased, particularly in June after the subyearling fall chinook salmon were released. We noted similar findings in 1995 (Knapp et al. 1996). The millions of subyearlings released undoubtedly serve as a magnet to bird predators which take advantage of the easy opportunity to feed on vulnerable prey. The hatchery and natural steelhead present are attacked as well. In addition, water clarity tended to be better in late May and June which may have made fish more visible to bird predators. During acclimation, hatchery steelhead are also vulnerable to bird attacks. At the Bonifer acclimation pond, fish are particularly exposed to natural bird predators due to the unprotected location and shallow nature of the pond (personal communication, M. Hayes, ODFW, Hermiston, OR).

Both races of hatchery chinook salmon, hatchery coho salmon, and hatchery and natural summer steelhead had varying levels of the Rs antigen, an indicator of BKD. As mentioned, manifestation of this disease probably caused mortality among all species. Bird attacks, scale loss, and warm river temperatures later in the season probably caused additional mortality. Subyearling fall chinook salmon experienced increased mortality during handling, transport , and in-river migration as water temperatures rose to near 70” F by mid-June, During transport operations in summer, many subyearling chinook salmon were observed to have bacteria1 gill disease (CTUIR and ODFW 1996).

Leeches were found most commonly on spring chinook salmon, perhaps attaching to their hosts during acclimation in upriver ponds. These bloodsucking parasites were noted to cause sores on some fish. On natural fish, black spot disease (*Neascus metacecaria*) was again present in 1996 as it was in 1995 (Knapp et al. 1996). The effects of this parasite on natural fish survival is not known.

Coded-wire tagging of hatchery fish for research purposes may also affect fish survival. The percent recapture of coded-wire-tagged hatchery fish was always less than non-coded-wire-tagged fish. We found similar results in 1995 (Knapp et al. 1996). However, as with brands, adipose clips on coded-wire-tagged fish may be overlooked by samplers when fish collection numbers are large.

Environmental Conditions

Rapid changes in the river environment appeared to trigger mass downstream movement of most salmonid species, especially those with multiple peak migrations (hatchery and natural summer steelhead, hatchery coho salmon, and yearling fall chinook salmon). In 1995 and 1996, peak collection of these species usually coincided with rapid increases in river flow and associated drops in water clarity and temperature. The magnitude of increased fish movement was similar over a range of flow increases from about 50043,000 ft^3/s. Fish movement usually declined rapidly when river flow crested. However, collection of hatchery yearling fall chinook and coho salmon at West Extension Canal was high on the descending limb of an 8,000- ft^3/s flood. Low subsampling rates (20%) or bypassing of fish during night sampling may have biased our estimate of fish collection during this flood period.

Operators of fish passage facilities should be aware of the increased importance of operating facilities within criteria and maintaining debris levels when river flow increases rapidly. High numbers of weakened salmonids may pass through bypass and ladder facilities as freshets or floods arrive. Large numbers of juvenile salmonids passed through the east-bank fish ladder at Three Mile Falls Dam in 1991 (Hayes et al. 1992) and 1992 (Cameron and Knapp 1993). Changing river elevation and high debris loads during increasing flows will require more frequent facility adjustments and debris maintenance at all passage facilities.

Juvenile salmonids collected when river flow was rapidly increasing often appeared stressed. They were lethargic, more sensitive to anesthetic, and overnight mortality of fish held for trap efficiency releases was higher than the normal 0-10%. Overnight mortality rates for spring chinook salmon (25%), yearling fall chinook salmon (23%), and coho salmon (52%) were associated with rapid flow increases that peaked at about 3,600 ft^3/s in mid-March, 8,000 ft^3/s in late April, and 1,600 ft^3/s in mid-May, respectively. Gill irritation from suspended sediments was probably a major stressor (Redding 1987). Efforts to reduce suspended sediment loading in the river drainage would benefit the health and survival of juvenile salmonids.

Reduced river flow (< 100 ft^3/s) by irrigation withdrawals usually prevents instream migration ofjuvenile salmonids through the lower Umatilla River from June through August. Recently completed Phase I and Phase II water exchanges with irrigation canals and releases of stored water from McKay reservoir provide fishery managers the ability to enhance flows in the lower river for fish migration (USBR 1988). The amount of water available for flow enhancement will vary from year-to-year depending on annual variations in the amount of natural flow and stored water. Uncertainty currently exists over how to most efficiently and effectively release limited amounts of stored water (e.g. timing, magnitude, and duration of water releases) to enhance both juvenile and adult fish migrations in summer and fall. Enhancing river flow throughout June and into the first week in July would allow instream migration of hatchery and natural juvenile salmonids. We suggest a series of pulsed flows might be the most effective water release strategy to enhance juvenile salmonid migrations. Studies in the Stanislaus and Klamath rivers indicated pulsed releases of stored water was a better strategy for stimulating downstream movement ofjuvenile chinook salmon than uniform increased flow (Demko and Cramer 1995; Craig 1996; Demko 1996). In addition, lower magnitude pulses (100% flow increase) were as effective at stimulating fish movement as higher magnitude pulses (400% flow increase; Demko 1996). Our outmigration monitoring in 1995 and 1996 indicated increases in yearling hatchery salmonid movement were similar over a range of flow increases from about 500-8,000 ft^3/s in April and May. However, limited information is available on the relationship between changes in river flow and movements of hatchery and natural subyearling fall chinook salmon in the Umatilla River in late June and early July. Based on limited analysis of 1996 data, increases in flow from McKay Creek of 100 ft^3/s and 300 ft^3/s corresponded with increases in subyearling fall chinook salmon capture at Westland Canal in June and early July. Development of future water release strategies from mid-June to early July will also need to incorporate baseline flows that provide adequate flow and temperature regimes for adult spring chinook salmon migration.

Resident Fish and Predators

Juvenile lamprey (ammocoetes) were captured at the rotary-screw trap and West Extension Canal throughout the year. Ammocoete migrations appeared to be associated with high water events which may indicate repositioning within the stream or actual outmigration (Stan van de Wetering 1997). All adult lamprey were captured at West Extension Canal in May and June. Due to the design of this facility, upstream migration into the bypass and trap is not possible and all adult lamprey captured were assumed to be post-spawn fallbacks.

Northern squawfish were the only piscivorous predator captured of sufficient size to prey on juvenile saimonids. Although we captured only 9 squawfish over 250 mm, we captured 74 squawfish over 200 mm, mostly at West Extension Canal. Fish over 250 mm are considered potential predators (Collis et al. 1995) but it is possible that smaller squawfish could prey upon very small juvenile salmonids. Squawfish numbers were highest during the hatchery subyearling fall chinook salmon outmigration. We captured the highest number of squawfish over 200 mm after 24 June, which coincided with the removal of the separator bars at the West Extension Canal trap, resulting in the collection of all fish sizes. Northern squawfish were also collected at the east-bank ladder facility at Three Mile Fails Dam during the trapping season (CTUIR and ODFW 1996) and observed at the ladder viewing window.

We captured a large number ofjuvenile smallmouth and largemouth bass with none being of sufficient size to prey upon juvenile salmonids. A substantial fishery for smallmouth bass develops on the lower Umatilla River (RM. 0.5) near the time of the hatchery subyearling fall chinook salmon releases in late spring. It is unclear whether the bass reside in this area at other times of the year, or if they migrate into this area to spawn or feed. The timing of this fishery suggests a possible source of predation.

Avian predation on juvenile salmonids in the Umatilla River is probably high, especially for hatchery fish. Large numbers of gulls were observed during and after fish releases. Herons, osprey, cormorants, and mergansers were also common during the spring. Gulls and other piscivorous birds are opportunistic feeders and are often most active during periods of major fish movements or after fish stockings (Snelling 1997; Ruggerone 1986; Modde et al. 1996). Large numbers of gulls have been observed in upper river areas immediately following large fish releases early in the season (personal communication, B. Duke, ODFW, Pendleton, OR). High concentrations of seagulls have also been observed when floods strand juvenile salmonids in agricultural fields in the lower river. In late spring, hatchery fish from eariier releases are present in the lower river and low river flow probably increases the efficiency of avian predation.

Generally, we found the highest number of avian predators in the lower river when hatchery subyearling fall chinook salmon were migrating during lower flows. Hatchery and natural steelhead exhibited more bird marks than any other hatchery or natural species, especially later in the season, Hatchery steelhead migrated over a longer period and were larger in size than other fish. These factors may have increased hatchery steelhead vulnerability to predator attacks. Due to their larger size, steelhead may also survive bird attacks more often than other species, resulting in a larger proportion of injured steelhead observed at our capture sites.

Transport Evaluation

Transport ofjuvenile salmonids has a detrimental effect on fish health and survival, particularly when water temperatures are elevated and subyearling fish are already suffering from disease and weakened condition. Based on results from correlation analysis, poor fish condition (descaling) during transport was significantly related to temperature. Temperature regimes in the Umatilla River during summer low flows are near the thermal threshold for juvenile salmon (77" F; Bell 1986). Transport temperatures approached 70" F on numerous occasions throughout the transport period (Appendix Table A-3). Water temperature at the Westland holding pond reached 75" F (personal communication, B. Duke, ODFW, Pendleton, OR). Poor environmental conditions can exacerbate the stressful physical handling during transport operations. In 1995 and 1996, poor water quality at the trapping facility exacerbated fish health problems and contributed to significant losses ofjuvenile fish during transport (Groberg 1995; CTUIR and ODFW 1995, 1996).

In addition, cumulative effects of collection, crowding, and loading fish also affect fish condition and possibly post-transport mortality. Previous evaluation of loading procedures on fish health showed that scale loss occurred during crowding (Walters et al. 1994) and dip-net loading (Cameron et al. 1994). The overall effect on fish health from first collection to final release during transport operations most likely results in lower survival after release than non-transported fish, as indicated by the nearly 10% increase in net mortality of transported fish. Maule et al. (1988) concluded that the stress effects of collection and transport from McNary Dam are cumulative. In their study, during relatively short transport trips by truck (3 - 4 h), fish had little time to recover from loading stress which presumably reduced their ability to respond to predators and other obstacles at release. Similar conditions and stressors undoubtedly occur during Westland transport operations.

We concur with CTUIR and ODFW (1996) that flow augmentation through June should be implemented to enhance natural flows to allow in-river migration ofjuvenile salmonids until July. Elevated flows may also provide more suitable water temperatures for fish migration. When transport is necessary, the Nielsen fish pump should be used for fish loading instead of dip nets, if possible. Although our results were inconclusive in this regard, significant scale loss occurred when dip-netting was used and not when the pump was used to load fish.

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Table 1. Trap operation and sampling periods at sampling sites on the lower Umatilla River, October 1995 - September 1996.

Site	River mile	Dates sampled	Total days sampled	Trap check intervals	Trap Operation
Screw Trap	1.2	10/17/95-3/13/96	88	Once per day	24-hours per day
		3/14-3/18/96	4	Hourly	24-hours per day
		3/19-4/2/96	15	Twice per day	24-hours per day
Floating Net Trap	1.2	9/9-10/1/96	22	Once per day	24-hours per day
West Extension Canal	3.0	4/2-4/23/96	21	Hourly	24-hours per day
		4/24-4/26/96	3	Hourly	Trap shut down overnight
		4/27-6/11/96	45	Hourly	24-hours per day
		6/12-7/11/96	29	Once per day	24-hours per day
Westland Canal	27.3	6/11,13,18,20,25 7/2 8/2,5,9/96	9	Once per day	Sampled from transport tank at lower Umatilla River”
Westland Transport Evaluation	27.3 and 0.5	6/1 l-14, 17-21, 24-26, 28 7/1-3,23,25/96	1s	Control and treatment once per day	Collected before loading and after transport[b]

[a] *Fish were collected at Westland Canal but sampled from the trap and haul transport tank at the lower Umatilla River boat ramp.*

[b] *Collected before loading at Westland Canal and after transport to the lower Umatilla River.*

Table 2. Recapture of hatchery fish released for trap efficiency tests at the rotary-screw trap and cumulative trap efficiency, Umatilla River, spring 1996. TE = trap efficiency.

Date	Species”	Mark[b]	Number released	Number recaptured (days after release)	Cumulative TE[c]
3/15/96	CHS	R1	144	3(1)	0.028
3/16/96	CHS	R2	1.50	1(1)	0.007
3/17/96	CHS	R3	135	3(1) 1(2) 1(4)	0.037
3/18/96	CHS	R4	152	2(1) 1(2)	0.020
3/19/96	CHS	R5	45	1(1)	0.022
3/20/96	CHS	R6	20	no recaptures	--
3/24/96	CHS	R10	34	no recaptures	--
3/20/96	COH	R6	32	no recaptures	--
3/22/96	COH	R7+R9	59	no recaptures	--
3/24/96	COH	RlO+Bl	63	no recaptures	--
3/26/96	COH	B2+B3	88	1(1)	0.011
3/27/96	COH	B4	44	1(4) 1(5)	0.045
4/01/96	COH	B8+B9	84	no recaptures	--

[a] *CHS = yearling spring chinook salmon, COH = yearling coho salmon.*
[b] *Mark colors: R = red, B = blue. Mark locations: i-l 0.*
[c] *Cumulative trap efficiency was adjusted for expected survival of released&h.*

Table 3. Retention of hatchery fish released into the rotary-screw trap livebox and trap retention efficiency, Umatilla River, spring 1996.

Date	Species”	Mark[b]	Number liveboxed	Number retained (hours after release)	Retention efficiency
3/19/96	COH	R6	8	7(7)	0.875
3/21/96	COH	R8	10	9(11)	0.820
3/26/96	CHS	B2	15	15(14)	1.000
3/26/96	CHS	B3	2	2(14)	1.000
3/29/96	CHS	B4	2	1(14)	0.500
3/30/96	COH	B5	15	14(14)	0.933
3/30/96	COH	B6	3	3(14)	1.000
3/30/96	CHS	B6	1	1(14)	1.000

[a] *COH = yearling coho salmon, CHS = yearling spring chinook salmon.*
[b] *Mark colors: R = red, B = blue. Mark locations: l-10.*

Table 4. Recapture of hatchery fish released for·trap effkiency tests at West Extension Canal and cumulative trap efficiencies, Umatilla River, spring 1996. TE = trap efficiency.

Date	Species [a]	Mark [b]	Number released	Number recaptured (days after release)	Cumulative TE'
4/3/96	COH	R1	229	20(1) 1(3) 3(4) 3(6) 1(8) 1(12) 1(13) 1(14) 1(15) 1(17) 1(18) 1(26)	0.153
4/4/96	COH	R2	200	4(1) 7(2) 3(3) 2(4) 3(5) 3(13) 2(14) 1(17) 5(20) 1(23) 1(24) 1(25)	0.160
4/5/96	COH	R3	201	11(1) 4(2) 7(3) 2(4) 2(11) 2(12) 1(13) 1(16) 1(20) 2(21) 1(24) 1(30) 1(39)	0.179
4/6/96	COH	R4	212	17(1) 7(2) 4(3) 1(4) 1(10) 1(11) 3(12) 1(15) 2(18) 1(20) 1(21) 1(26)	0.189
4/7/96	COH	R5	203	9(1) 6(2) 1(3)	0.079
4/8/96	COH	R6	182	6(1) 1(2) 1(4) 1(7) 2(8) 1(10) 10(20) 1(27)	0.126
4/9/96	COH	R7	191	3(1) 2(2) 2(3) 1(4) 4(5) 2(6) 1 (S) 1(12)	0.085
4/10/96	COH	RS	208	15(1) 1(3) 5(4) 3(6) 1(9) 1(16) 1(22)	0.130
4/11/96	COH	R9	103	2(3) 2(4) 1(5) i(7) 1(10) 1(14) 1(15) 2(16)	0.107
4/12/96	COH	R10	44	1(2) 1(6) 3(9) 1(19)	0.136
4/13/96	COH	B1	57	1(2) 1(3)	0.036
4/14/96	COH	B2	111	15(1) 9(2) 2(3) 2(4) J(7) 1(S)	0.297
4/15/96	COH	B3	102	1(1) 11(1) 2(3) 1(4) 1(6) 2(9)	0.167
4/16/96	COH	B4	105	6(1) 5(2) 1(3) 4(5) 1(9) 2(10) 1(28)	0.19s
4/17/96	COH	B5	104	1(1) 1(2) 3(4) 2(7)	0.071
4/18/96	COH	B6	106	1(1) 4(3) 6(6)	0.104
4/19/96	COH	B7	111	1(1) 10(2) 2(4) 3(5)	0.136
4/20/96	COH	BS	73	2(1) 2(2) 5(3) 2(4) 1(18)	0.16-i
4/21/96	COH	B9	103	15(2) 1(3)	0.155
4/22/96	COH	B10	104	2(2) 1(5) 1(10)	0.03s
4/23/96	COH	G1	103	2(1) 3(2) 69(3) 1(5) 1(13) 3(14)	0.797
4/24/96	COH	G2	105	no recaptures	--
4/27/96	COH	G3	113	1(5) 1(7) 1(12)	0.027
4/28/96	COH	G4	99	1(2) 1(3) 2(6) 2(7) 3(10)	0.099
4/29/96	COH	G5	102	1(1) 2(3) 1(4) 1(5) 3(6) 2(S) 3(9) 1(11)	0.139
4/30/96	COH	G6	103	4(2) 1(4) 2(8) 1(10)	0.078
5/1/96	COH	G7	118	7(1) 4(3) 1(4) 2(6) 2(7) 2(S) 2(9) 1(10)	0.179
5/2/96	COH	G8	100	7(1) 10(2) 4(3) 3(4) 1(5) 3(6) 2(7) 2(8) 1(11) 1(15)	0.36-I
5/3/96	COH	G9	99	5(1) 7(2) 6(3) 1(4) 5(5) 1(S) 2(9) 1(11)	0.291
5/4/96	COH	G10	101	S(1) 6(2) 3(3) 5(4) 1(6) 3(11)	0.252
5/5/96	COH	01	97	5(2) 8(3) 5(4) 6(5) 1(8)	0.276
5/6/96	COH	02	110	23(1) 15(2) 6(3) 12(4) 2(7) 1(9) 1(10) 1(13)	0.550
5/7/96	COH	03	88	9(1) 10(2) S(3) 6(5) 1(6)	0.400
5/8/96	COH	O4	100	13(1) 18(2) 2(3) 1(6)	0.333
5/9/96	COH	05	11s	32(1) 2(2) 9(3)	0.389
5/10/96	COH	06	92	4(2) 1(4)	0.054
5/11/96	COH	07	64	1(1) 5(2) 1(3) 2(4) 1(5)	0.168
5/12/96	COH	OS	109	5(1) 1(2)	0.058
5/13/96	COH	09	36	9(1) 5(2)	0.810
5/14/96	COH	010	50	2(1) 6(2)	0.160
5/15/96	COH	P1	58	6(1)	0.103
5/16/96	COH	P2	57	3(1)	0.053

Table 4. Continued.

Date	Species[a]	Mark[b]	Number released	Number recaptured (days after release)	Cumulative TE[c]
5/17/96	COH	P3	57	14(1)	0.271
5/18/96	COH	P4	66	1(1)	0.015
5/19/96	COH	P5	52	4(1)	0.077
5/20/96	COH	P6	53	2(1) 1(2)	0.057
5/21/96	COH	P7	50	no recaptures	--
5/22/96	COH	P8	12	no recaptures	--
5/23/96	COH	P9	36	1(2) 1(4) 1(7)	0.086
5/24/96	COH	P10	11	1(3) 1(4)	0.182
5/26/96	COH	R1	79	13(1) 3(2) 1(3)	0.221
5/28/96	COH	R2	75	35(1) 14(2) 1(3)	0.667
5/30/96	COH	R3	100	37(1) 9(2) 2(3)	0.480
4/8/96	CHF	R6	124	2(1) 1(2) 2(S) 1(9) 1(13)	0.059
4/9/96	CHF	R7	120	7(1) 1(2) 1(3) 2(S) 2(15) 68(17) 1(22)	0.700
4/10/96	CHF	RS	226	57(1) 1(5) 2(7) 1(22) 1(28) 1(31) 1(34)	0.283
4/11/96	CHF	R9	100	16(1) 2(2) 2(3) 5(4) 1(S) 1(10) 5(12) 2(13) 1(24) 1(25)	0.378
4/12/96	CHF	R10	117	22(1) 4(2) 6(3) 1(1) 1(5) 1(7) 1(16) 1(24) 2(32)	0.353
4/13/96	CHF	B1	99	4(1) 3(2) 2(3) 1(7) 7(1) 1(15)	0.132
4/14/96	CHF	B2	104	10(1) 9(2) 3(5) 2(S) 1(13)	0.247
4/15/96	CHF	B3	99	9(1) 1(3) 1(7)	0.123
4/16/96	CHF	B4	122	25(1) 5(2) 1(11) 1(17) 1(20)	0.350
4/17/96	CHF	B5	131	5(1) 2(3) 1(4) 2(7) 2(18)	0.096
4/18/96	CHF	B6	103	1(1) 4(3) 1(5)	0.049
4/19/96	CHF	B7	104	3(1) 8(2) 1(4)	0.115
4/20/96	CHF	BS	103	18(1) 1(2) 2(3) S(7)	0.291
4/21/96	CHF	B9	105	3(1) 68(5) 9(6) 1(21)	0.781
4/22/96	CHF	B10	110	11(1) 1(2) 1(6)	0.118
4/23/96	CHF	G1	107	10(5) 1(11)	0.103
4/24/96	CHF	G2	85	6(1)	0.071
4/27/96	CHF	G3	110	1(2)	0.009
4/28/96	CHF	G4	81	1(10) 1(21)	0.032
4/29/96	CHF	G5	111	2(3) 1(4) 2(5) 2(6) 1(S) 1(9) 2(10) 1(14) 2(15)	0.126
4/30/96	CHF	G6	65	1(2) 1(4) 1(10)	0.046
5/1/96	CHF	G7	108	1(2) 5(3) 2(4) 1(5) 1(6) 4(7) 3(S) S(9) 1(15)	0.254
5/2/96	CHF	GS	104	2(1) 2(2) 5(3) 1(4) 3(5) 2(7) 1(8) 1(10) 5(11) 1(12)	0.227
5/3/96	CHF	G9	91	4(1) 1(2) 1(3) 6(4) 6(6) 3(7) 2(8) 6(10) 1(11) 3(12) 1(17)	0.374
5/4/96	CHF	G10	110	3(1) 4(2) 3(3) 6(4) 2(5) 3(6) 2(7) 1(8) 1(9) 2(10) 8(11)	0.318
5/5/96	CHF	01	109	16(2) 7(3) 3(4) 1(5) 2(6) 2(7) 4(9)	0.327
5/6/96	CHF	02	130	13(1) 7(2) 15(3) S(4) G(5) 4(6) 4(7) 1(S) 9(9) 1(13)	0.523
5/7/96	CHF	03	83	6(1) 6(2) 3(3) 4(4) 11(5) S(6) 1(7) 6(8) 2(9)	

Table 4. Continued.

Date	Species[a]	Mark[b]	Number released	Number recaptured (days after release)	Cumulative TE[c]
				1(11) 2(12)	0.590
5/8/96	CHF	04	96	11(1) 8(2) 9(3) 26(4) 5(5) J(6) 3(7)	0.709
5/9/96	CHF	05	37	7(1) 3(2) 1(3) 2(4) 2(5) 1(6) 2(7) 1(10)	0.511
5/10/96	CHF	06	60	6(2) 4(3) 4(4) 6(5) 1(19)	0.362
5/11/96	CHF	07	106	2(1) 13(2) 11(3) 11(4) 4(5) 1(6) 2(8) 1(9)	0.425
5/12/96	CHF	08	120	2(1) 7(2) 5(3) 10(4) 3(5) 3(6) 4(7) 3(8) 1(11)	0.313
5/13/96	CHF	09	70	1(1) 9(2) 3(3) 1(4) 2(6) 1(7)	0.246
5/14/96	CHF	010	50	1(1) 2(2) 2(5) 1(6)	0.100
5/15/96	CHF	P1	53	2(1) 5(3) 3(4) 3(5) 1(11) 1(14)	0.283
5/16/96	CHF	P2	41	2(1) 1(2) 1(4) 1(8)	0.122
5/17/96	CHF	P3	40	3(1) 1(3)	0.103
5/18/96	CHF	P4	26	no recaptures	--
5/19/96	CHF	P5	43	no recaptures	--
5/20/96	CHF	P6	45	no recaptures	--
5/21/96	CHF	P7	32	no recaptures	--
4/17/96	STS	B5	53	2(1) 1(4) 1(6)	0.078
4/18/96	STS	B6	17	1(1)	0.066
4/19/96	STS	B7	16	2(1) 1(2)	0.188
4/21/96	STS	B9	69	5(1) 1(2) 10(3)	0.232
5/2/96	STS	G8	101	3(1) 2(2) 1(6) 3(7) 1(8) 1(11) 2(12)	0.120
5/3/96	STS	G9	91	3(1) 1(5) 3(6) 1(7) 2(9) 1(10) 1(13)	0.145
5/4/96	STS	G10	84	1(1) 5(4) 7(11)	0.155
5/5/96	STS	01	89	2(4) 1(5) 12(10) 1(13)	0.172
5/6/96	STS	02	105	6(1) 3(3) 1(5) 2(6) 1(7) 1(8) 9(9) 2(10)	0.238
5/7/96	STS	03	50	1(1) 1(2) 1(3) 1(5) 2(6) 2(7) 7(8) 2(9) 1(10) 1(11)	0.380
5/8/96	STS	04	47	1(5) 1(8)	0.045
5/9/96	STS	05	54	2(6) 12(7) 2(9)	0.296
5/10/96	STS	06	101	1(2) 1(3) 6(5) 1(6) 2(7)	0.110
5/12/96	STS	08	56	1(1) 2(3) 1(5) 1(6) 2(7)	0.129
5/13/96	STS	09	89	1(1) 7(2) 7(3) 1(4) 5(5)	0.236
5/14/96	STS	010	108	1(1) 8(2) 2(3) 1(4) 3(5)	0..139
5/15/96	STS	P1	79	6(2) 2(5) 1(6)	0.118
5/16/96	STS	P2	80	4(1) 2(2)	0.075
5/17/96	STS	P3	96	7(1) 3(2) 2(3) 1(12)	0.135
5/18/96	STS	P4	96	1(1) 2(2) 1(11)	0.045
5/19/96	STS	P.5	83	5(1) 1(2)	0.072
5/20/96	STS	P6	100	6(1) 1(3) 1(4)	0.081
5/21/96	STS	P7	81	3(1)	0.037
5/22/96	STS	P8	36	no recaptures	--
5/23/96	STS	P9	51	1(1) 1(2) 1(3) 1(4) 1(5)	0.098
5/24/96	STS	P10	20	2(1) 1(2)	0.150
5/26/96	STS	R1	80	10(1) 6(2) 2(3) 1(5)	0.246
5/28/96	STS	R2	104	25(1) 4(2) 2(3)	0.298
5/30/96	STS	R3	99	7(1) 4(2)	0.112

Table 4. Continued.

Date	Species[a]	Mark[b]	Number released	Number recaptured (days after release)	Cumulative TE[c]
5/31/96	STS	R4	56	2(1) 3(2)	0.089
6/1/96	STS	R5	38	no recaptures	—
6/3/96	STS	R7	19	no recaptures	--
5/23/96	CHF0	P7,P8, P9	77	no recaptures	—
5/24/96	CHF0	P10	7	1(1)	0.143
5/26/96	CHF0	R1	41	12(1) 1(1) 4(8)	0.390
5/28/96	CHF0	R2	142	95(1) 3(6) 10(11) 16(12)	0.866
5/30/96	CHF0	R3	224	120(1) 1(2) 14(6) 1(10) 2(11)	0.630
5/31/96	CHF0	R4	246	117(1) 2(10)	0.513
6/1/96	CHF0	R.5	93	17(1)	0.185
6/2/96	CHF0	R6	289	8(1)	0.024
6/3/96	CHF0	R7	514	52(1) 24(2) 10(3) 5(4)	0.183
6/4/96	CHF0	R8	503	200(1) 27(2) 7(3) 2(6) 4(8) 2(10) 3(11) 2(12)	0.492
6/5/96	CHF0	R9	436	39(1) 34(2) 22(3) 7(4) 6(5) 2(7) 2(10)	0.256
6/6/96	CHF0	R10	384	82(1) 10(2) 1(3) 1(4) 3(7) 1(11)	0.257
6/7/96	CHF0	B1	328	77(1) 1(2)	0.244
6/8/96	CHF0	B2	466	70(1) j(2) 1(5) 1(5)	0.169
6/9/96	CHF0	B3	398	65(1) 7(2) J(3) 3(4) 1(6)	0.216
6/10/96	CHF0	B4	263	74(1) 10(2) 2(3) 3(4) 2(5)	0.458
6/11/96	CHF0	B5	354	30(1) 16(2) 4(3) 1(6)	0.148
6/12/96	CHF0	B6	291	30(1) 3(2) 1(3) 4(5)	0.141
6/13/96	CHF0	B7	217	24(1) 5(2) 8(3)	0.178
6/14/96	CHF0	B8	287	46(1) 8(2) 3(3)	0.206
6/15/96	CHF0	B9	88	14(1) 1(2)	0.187
6/16/96	CHF0	B10	95	26(1) 3(2)	0.33 1
6/17/96	CHF0	G1	100	4(1) 3(2) 3(3) 1(5)	0.132
6/18/96	CHF0	G2	55	4(1) 1(2)	0.116
6/19/96	CHF0	G3	57	18(1) 1(3)	0.357
6/20/96	CHF0	G4	50	7(2)	0.143
6/22/96	CHF0	G5	7	no recaptures	—
6/25/96	CHF0	G6	83	17(1)	0.205
6/26/96	CHF0	G7	106	8(2) 1(3)	0.085

[a] *COH = yearling coho salmon, CHF = yearling fall chinook salmon, STS = summer steelhead, CHFO = subyearling fall chinook salmon.*

[b] *Mark colors: R = red, B = blue, G = green, 0 = orange, P = purple. Mark locations: I -1 0.*

[c] *Cumulative trap efficiency is adjusted for expected survival of marks based on holding tests (see Table 6).*

Table 5. Recapture of natural summer steelhead released for trap efficiency tests at West Extension Canal, Umatilla River, spring 1996. TE = trap efficiency.

Date	Species[a]	Mark[b]	Number released	Number recaptured (days after release)	Cumulative TE[c]
5/14/96	STS	010	42	1(1) 2(2)	0.077
5/15/96	STS	P1	57	1(6)	0.018
5/16/96	STS	P2	72	1(1)	0.016
5/18/96	STS	P3+P4	132	9(1) 4(2) 2(3)	0.120
5/19/96	STS	P5	36	1(1)	0.028
5/31/96	STS	R4	48	5(1) 2(2)	0.149
6/1/96	STS	R5	19	no recaptures	--

[a] *STS = summer steelhead.*
[b] *Mark colors: R = red, B = blue, G = green, 0 = orange, P = purple.*
Mark locations: 1-10.
[c] *Cumulative trap efficiency was adjusted for expected survival of released fish.*

Table 6. Holding and transport mortalities and percent survival ofjuvenile salmonids used in trap efficiency tests at the rotary-screw trap and West Extension Canal, Umatilla River, March - June 1996.

Date	Mark”	Number marked[b]	Holding mortalities	Transport mortalities	Percent survival[c]
		Hatchery spring chinook salmon -- Rotary-screw trap			
3/15/96	R1	192	48	0	75.0
3/16/96	R2	151	2	1	98.7
3/17/96	R3	137	0	2	100.0
3/18/96	R4	152	0	0	100.0
3/19/96	R5	45	0	0	100.0
3/20/96	R6	20	0	0	100.0
3/24/96	R10	34	0	0	100.0
		Hatchery coho salmon -- Rotary-screw trap			
3/20/96	R6	32	0	0	100.0
3/22/96	R7+R9	59	0	0	100.0
3/24/96	RlO+Bl	63	0	0	100.0
3/26/96	B2+B3	88	0	0	100.0
3/27/96	B4	44	0	0	100.0
4/01/96	B8+B9	84	0	0	100.0
		Hatchery coho salmon -- West Extension Canal			
4/03/96	R1	230	0	1	100.0
4/04/96	R2	200	0	0	100.0
4/05/96	R3	201	0	0	100.0
4/06/96	R4	214	0	2	100.0
4/07/96	R5	203	0	0	100.0
4/08/96	R6	182	0	0	100.0
4/09/96	R7	194	3	0	98.5
4/10/96	R8	209	1	0	99.5
4/11/96	R9	103	0	0	100.0
4/12/96	R10	46	0	0	100.0
4/13/96	B1	58	0	0	100.0
4/14/96	B2	112	0	1	100.0
4/15/96	B3	102	0	0	100.0
4116196	B4	109	4	0	96.3
4117196	B5	109	5	0	95.4
4/18/96	B6	106	0	0	100.0
4/19/96	B7	112	1	0	99.1
4/20/96	B8	73	0	0	100.0
4/21/96	B9	103	0	0	100.0
4/22/96	B10	104	0	0	100.0

Table 6. Continued.

Date	Mark"	Number marked[b]	Holding mortalities	Transport mortalities	Percent survival[c]
4/23/96	G1	107	4	0	96.3
4/24/96	G2	105	0	0	100.0
4/27/96	G3	115	2	0	98.3
4/28/96	G4	108	9	0	91.7
4/29/96	G5	103	1	0	99.0
4/30/96	G6	103	0	0	100.0
5/01/96	G7	119	1	0	99.2
5/02/96	G8	107	7	0	93.5
5/03/96	G9	102	3	0	97.1
5/04/96	G10	103	2	0	98.1
5/05/96	01	104	7	0	93.3
5/06/96	02	111	1	0	99.1
5/07/96	03	91	3	0	96.7
5/08/96	04	101	1	0	99.0
5/09/96	05	126	8	0	93.7
5/10/96	06	92	0	0	100.0
5/11/96	07	69	5	0	92.8
5/12/96	08	115	6	0	94.8
5/13/96	09	75	39	0	48.0
5/14/96	010	50	0	0	100.0
5/15/96	P1	. 58	0	0	100.0
5/16/96	P2	57	0	0	100.0
5/17/96	P3	63	6	0	90.5
5/18/96	P4	66	0	0	100.0
5/19/96	P5	52	0	0	100.0
5/20/96	P6	53	0	0	100.0
5/21/96	P7	50	0	0	100.0
5/22/96	P8	12	0	0	100.0
5/23/96	P9	37	1	0	97.3
5/24/96	P10	11	0	0	100.0
5/26/96	R1	81	2	0	97.5
5/28/96	R2	75	0	0	100.0
5/30/96	R3	100	0	0	100.0
Hatchery yearling fall chinook salmon -- West Extension Canal					
4/08/96	R6	129	5	0	96.1
4/09/96	R7	123	3	0	97.6
4/10/96	R8	226	0	0	100.0
4/11/96	R9	105	5	0	95.2
4/12/96	R10	124	7	0	94.4

Table 6. Continued.

Date	Mark[a]	Number marked[b]	Holding mortalities	Transport mortalities	Percent survival[c]
4/13/96	B1	108	9	0	91.7
4/14/96	B2	107	3	0	97.2
4/15/96	B3	110	11	0	90.0
4/16/96	B4	163	41	0	74.9
4/17/96	B5	137	6	0	95.6
4/18/96	B6	104	1	0	99.0
4/19/96	B7	104	0	0	100.0
4/20/96	B8	103	0	0	100.0
4/21/96	B9	105	0	0	100.0
4/22/96	B10	111	0	1	100.0
4/23/96	G1	107	0	0	100.0
4/24/96	G2	85	0	0	100.0
4/27/96	G3	110	0	0	100.0
4/28/96	G4	110	25	4	77.3
4/29/96	G5	111	0	0	100.0
4/30/96	G6	65	0	0	100.0
5/01/96	G7	114	6	0	94.7
5/02/96	G8	108	3	1	97.2
5/03/96	G9	91	0	0	100.0
5/04/96	G10	110	0	0	100.0
5/05/96	01	115	2	4	98.3
5/06/96	02	132	2	0	98.5
5/07/96	03	83	0	0	100.0
5/08/96	04	99	3	0	97.0
5/09/96	05	37	0	0	100.0
5/10/96	06	62	2	0	96.8
5/11/96	07	106	0	0	100.0
5/12/96	08	122	2	0	98.4
5/13/96	09	71	1	0	98.6
5/14/96	010	50	0	0	100.0
5/15/96	P1	53	0	0	100.0
5/16/96	P2	41	0	0	100.0
5/17/96	P3	41	1	0	97.6
5/18/96	P4	28	2	0	92.9
5/19/96	P5	44	1	0	97.7
5/20/96	P6	60	15	0	75.0
5/21/96	P7	32	0	0	100.0
	Hatchery summer steelhead -- West Extension Canal				
4/17/96	B5	55	2	0	96.4

Table 6. Continued.

Date	Mark"	Number marked[b]	Holding mortalities	Transport mortalities	Percent survival[c]
4/18/96	B6	19	2	0	89.5
4/19/96	B7	16	0	0	100.0
4/21/96	B9	69	0	0	100.0
5/02/96	G8	102	1	0	99.0
5/03/96	G9	92	1	0	98.9
5/04/96	G10	84	0	0	100.0
5/05/96	01	102	2	11	98.0
5/06/96	02	105	0	0	100.0
5/07/96	03	50	0	0	100.0
5/08/96	04	50	3	0	94.0
5/09/96	05	54	0	0	100.0
5/10/96	06	102	1	0	99.0
5/12/96	08	59	2	1	96.6
5/13/96	09	89	0	0	100.0
5/14/96	010	108	0	0	100.0
5/15/96	P1	82	3	0	96.3
5/16/96	P2	80	0	0	100.0
5/17/96	P3	96	0	0	100.0
5/18/96	P4	104	7	1	93.3
5/19/96	P5	83	0	0	100.0
5/20/96	P6	101	1	0	99.0
5/21/96	P7	81	0	0	100.0
5/22/96	P8	37	1	0	97.3
5/23/96	P9	51	0	0	100.0
5/24/96	P10	20	0	0	100.0
5/26/96	R1	83	3	0	96.4
5/28/96	R2	104	0	0	100.0
5/30/96	R3	100	1	0	99.0
5/31/96	R4	56	0	0	100.0
6/01/96	R5	38	0	0	100.0
6/03/96	R7	20	0	1	100.0
Hatchery subyearling fall chinook salmon -- West Extension Canal					
5/23/96	P7,P8,P9	84	7	0	91.7
5/24/96	P10	7	0	0	100.0
5/26/96	R1	41	0	0	100.0
5/28/96	R2	142	0	0	100.0
5/30/96	R3	229	5	0	97.8
5/31/96	R4	261	15	0	94.3
6/01/96	R5	94	1	0	98.9

Table 6. Continued.

Date	Mark"	Number marked[b]	Holding mortalities	Transport mortalities	Percent survival[c]
6/02/96	R6	291	2	0	99.3
6/03/96	R7	536	22	0	95.9
6/04/96	R8	506	3	0	99.4
6/05/96	R9	438	2	0	99.5
6/06/96	R10	386	2	0	99.5
6/07/96	B1	337	9	0	97.3
6/08/96	B2	479	12	1	97.5
6/09/96	B3	433	30	5	93.1
6/10/96	B4	312	45	4	85.6
6/11/96	B5	368	10	4	97.3
6/12/96	B6	325	23	11	92.9
6/13/96	B7	232	10	5	95.7
6/14/96	B8	300	11	2	96.3
6/15/96	B9	101	9	4	91.1
6/16/96	B10	104	8	1	92.3
6/17/96	G1	120	20	0	83.3
6/18/96	G2	75	16	4	78.7
6/19/96	G3	61	4	0	93.4
6/20/96	G4	51	1	0	98.0
6/22/96	G5	20	13	0	35.0
6/25/96	G6	93	0	10	100.0
6/26/96	G7	108	0	2	100.0
		Natural summer steelhead -- West Extension Canal			
5/14/96	010	45	3	0	93.3
5/15/96	P1	57	0	0	100.0
5/16/96	P2	‘81	9	0	88.9
5/18/96	P3+P4	139	7	0	95.0
5/19/96	P5	36	0	0	100.0
5/31/96	R4	49	1	0	98.0
6/01/96	R5	19	0	0	100.0

[a] *Mark colors: R = red!, B = blue, G = green, 0 = orange, P = purple. Mark locations: 1-IO.*
[b] *Number marked is number held for mortality tests.*
[c] *Percent survival is based on holding mortalities only and is the expected survival of fish after test release.*

Table 7. Actual and adjusted collection of hatchery and natural juvenile salmonids at three sampling sites on the lower Umatilla River, October 1995 - September 1996 (sites are ordered chronologically). Mean fork length is in milimeters.

Site[a] Species[b]	Origin	Age	Mean FL(SD)	Number collected[c]	Number released[d]	Release date[e]	Percent of release
Rotary-Screw Trap (RM 1.2)							
CHS	H	1^+	163.4(18.8)	2,624	378,561	3/13/96	*0.69%*
COH	H	1'	131.4(8.9)	1,048	465,784	3/25/96	*0.22%*
CH	N	1^+	112.8(15.9)	21	--	--	--
COH	N	1^+	113.0(15.9)	5	--	--	--
STS	N	1^{+g}	140.4(40.9)	13	--	--	--
Total Collected				3,711			
West Extension Canal (RM 3)							
CHS	H	1'	152.8(16.9)	803	378,561	3/13/96	0.21%
CHF	H	1^+	182.0(19.5)	60,613	564,403	4/18/96	10.74%
CHF	H	0^+	87.2(6.9)	976,705	2,960,413	5/31/96	32.99%
COH	H	1^+	136.3(10.8)	96,069	1,477,398	4/12/96	6.50%
STS	H	1^+	219.4(21.2)	19,572	147,543	5/09/96	13.27%
CH	N	0^{+f}	101.5(16.6)	219	--	--	--
COH	N	0^+	88.5(10.2)	65	--	--	--
STS	N	1^{+g}	176.1(23.9)	5,282	--	--	--
Total Collected				*I,159,328*			
Westland Canal (RM 27)							
CHF	H	0^+	93.2(10.8)	1,801	2,960,413	5/31/96	0.06%
STS	N	1^{+g}	103.0	1	--	--	--
Total Collected				*1,802*			
Trap Net (RM 1.2)							
COH	H	1^+	162.0	1	--	--	--
Total Collected				*1*			

[a] *See Table I for periods of collection.*
[b] *CHS = spring chinook salmon, CHF = fall chinook salmon, CH = combined spring and fall chinook salmon, COH = coho salmon, STS = summer steelhead.*
[c] *Number collectedwas expandedfor subsampled and non-sampled hours during d-f-hour collection at RM I.2 and West Extension Canal, and adjusted for trap retention efficiency at the rotary-screw trap (RM 1.2).*
[d] *Number released is the number of hatchery fish released during or before sampling at the specific site.*
[e] *Release date is the date of last release for the designated group of fish.*
[f] *Age of natural chinook includes 0+ and I + fish.*
[g] *Age of natural summer steelhead includes I $^+$, 2^+, and 3^+ fish.*

Table 8. Mortality of hatchery juvenile salmonids handled and held for 24-h at West Extension Canal, Umatilla River, April - June 1996.

	Start of Holding				End of Holding				
Species”	Date	Time	Temp. (“F)	Live fish	Date	Time	Temp. (°F)	Live fish	Dead fish
			--						
COH	4/13	1430	56	23	4/14	1445	56	23	0
COH	4/14	1330	--	50	4/15	1530	--	50	0
COH	4/22	1230	59	50	4/23	1245	56	50	0
COH	5/5	1345	54	51	5/6	1400	58	51	0
CHF	4/12	1420	--	43	4/13	1430	--	43	0
CHF	4/15	1530	54	50	4/16	1715	58	50	0
CHF	4/20	1515	63	52	4/21	1745	53	52	0
STS	5/13	1400	70	60	5/14	1400	70	60	0
CHF0	6/4	1200	68	50	6/5	1230	68	50	0
CHF0	6/5	1300	65	50	6/6	1740	68	50	0
CHF0	6/7	1200	67	50	6/8	1145	67	50	0
CHF0	6/8	1230	69	50	6/9	1330	70	50	0
CHF0	6/10	1130	65	50	6/11	1330	72	45	5
CHF0	6/11	1930	67.5	50	6/12	1940	69	49	1
CHF0	6/13	1525	--	71	6/14	1530	70	65	6
CHF0	6/14	1620	70	59	6/15	1555	--	46	13
CHF0	6/15	1215	69	60	6/16	1235	69	55	5
CHF0	6/16	1225	--	34	6/17	1240	66	33	1

[a] *COH = coho salmon, CHF =yearling fall chinook salmon, STS = summer steelhead, CHFO = subyearling fail chinook salmon.*

Table 9. Scale samples collected from natural juvenile salmonids at sampling sites on the Umatilla River, January - May 1996.

Site[a]	Species	Smolt index[b]	Number	Fork length (mm) Mean	Min.	Max.	Dates collected
WEID	Coho	S	2	188.0	176	200	5/08
		I	20	95.1	78	114	4/04 - 5/17
		P	5	83.5	75	95	4/04 - 5/02
		--	9	93.8	65	104	4/03 - 4/10
	Chinook	S	1	110.0	110	110	4/19
		I	50	105.0	76	128	4/04 - 5/18
		P	6	87.8	72	104	4/05 - 5/18
		--	6	107.8	101	115	4/02 - 4/10
	Steelhead	S	114	191.5	134	295	4/02 - 5/16
		I	158	166.4	76	271	4/02 - 5/16
		P	1	123.0	123	123	4/21
		--	35	177.3	115	256	4/02 - 5/08
RST	Coho	I	3	115.3	103	131	3/16 - 3/22
		--	2	111.5	96	127	3/19 - 4/01
	Chinook	I	6	109.8	93	155	3/16 - 4/01
		P	1	103.0	103	103	1/28
		--	3	113.3	102	135	3/15 - 4/01
	Steelhead	I	1	160.0	160	160	3/21
		P	1	140.0	140	140	3/10
		--	2	158.0	156	160	3/19 - 3/21

[a] *WEID = West Extension Irrigation District Canal (RM 3.0); RST = rotary-screw trap (RM 1.2).*
[b] *Smolt Index: S = smolt, I = intermediate, P = parr.*

Table 10. Number and weight of salmonids and non-salmonids transported from Westland Canal, Umatilla River, June - August 1996. Sal. = salmonids (hatchery subyearling fall chinook salmon); Res. = resident fish (non-salmonids).

Date	Sample	Pounds of fish in sample		Number of fish in sample		Number of fish per pound		Pounds hauled	Estimated number of fish hauled		Capacity of transport vehicle	Loading density in transport vehicle (fish/gal)[a]	
		Sal.	Res.	Sal.	Res.	Sal.	Res.		Sal.	Res.		Sal.	Res.
6/11/96	1	2.125	0	140	0	65.9	0	150	9,885	0	375 gal.	26.42	0
	2	2.25	0	149	0	66.2	0		9,930	0			
6/13/96	1	3.0	0	167	0	55.7	0	350	19,483	0	3,000 gal.	7.39	0
	2	3.125	0	222	0	71.0	0		24,864	0			
6/18/96	1	2.0	0	105	0	52.5	0	275	14,437	0	3,000 gal.	5.03	0
	2	2.25	0	129	0	57.3	0		15,767	0			
6/20/96	1	3.25	0	156	0	48.0	0	180	8,640	0	375 gal.	22.10	0
	2	4.125	0	182	0	44.1	0		7,938	0			
6/25/96	1	3.5	0	149	0	42.6	0	140	5,960	0	375 gal.	15.50	0
	2	2.25	0	91	0	40.4	0		5,662	0			
7/02/96	1	3.25	0	127	0	39.1	0	600	23,416	0	3,000 gal.	7.20	0
	2	3.25	0	107	0	32.9	0		19,754	0			
8/01/96	1	0.5[b]	1.25[b]	26	18	52.0	14.4	30	452	307	375 gal.	1.0	0.5
	2	2.5[b]	1.0[b]	36	8	14.4	8.0		306	70			
8/05/96	1	0	3.25	0	73	0’	22.5	150	0’	3,375	375 gal.	0.28	6.89
	2	0.5	4.5	7	60	14’	13.3		210[c]	1,796			
8/09/96	1	0	4.5	3	72	0’	16.0	100	0’	1,600	375 gal.	0	2.79
	2	0	4.25	1	21	0’	4.9		0’	490			

[a] Calculated using the daily ttrean of the estimated nuttrber of fish hauled and gallon capacity of transport vehicle.

[b] Scale malfunctioned: weight measurements and estimates of number of fish hauled are not accurate.

[c] Nuttrber of fish per pound and estimates of number of fish hauled are not accurate due lo low sample size.

Table 11. Collection and percent recapture of freeze-branded hatchery juvenile salmonids at the rotary-screw trap, West Extension Canal, and Westland Canal, Umatilla River, March - August 1996.

Species[a], Brand	Site, Number[b]	Site, Number	Site, Number	Total number	Expanded number[c]	Number released[d]	Percent recapture Total	Expanded
STS	RST[e]	WEID[e]	Westland					
RAL2	--	47	0	47	326	8,827	0.5	3.7
LAL2	--	93	0	93	645	8,615	1.1	7.5
LAL1	--	100	0	100	897	8,896	1.1	10.1
CHS	RST	WEID	Westland					
LAB1	34	9	0	43	1,688	5,083	0.8	33.2
LAB4	36	4	0	40	1,782	4,682	0.9	38.1
RAB4	33	5	0	38	1,635	5,275	0.7	31.0
RAB2	39	16	0	55	1,942	4,531	1.2	42.9
LAF33	34	11	0	45	1,690	4,232	1.1	39.9
LAB2	32	8	0	40	1,588	5,026	0.8	31.6
RAB3	29	9	0	38	1,441	5,092	0.7	28.3
CHF	RST	WEID	Westland					
LAL1	--	26	0	26	99	5,313	0.5	1.9
RAB1	--	27	0	27	102	5,197	0.5	2.0
RAL1	--	12	0	12	42	5,449	0.2	0.8
LAL2	--	163	0	163	544	5,111	3.2	10.6
RAL2	--	189	0	189	667	5,218	3.6	12.8
CHF0	RST	WEID	Westland					
RA53	--	3,279	2	3,281	13,992	10,252	32.0	136.5
LA53	--	2,569	1	2,570	10,991	10,420	24.7	105.5
RAE3	--	2,064	3	2,067	8,971	10,237	20.2	87.6
LAE3	--	3,901	6	3,907	16,694	9,980	39.1	167.3
RA54	--	1,761	1	1,762	7,514	10,557	16.7	71.2
LA54	--	2,541	4	2,545	10,846	9,407	27.1	115.3
RAE4	--	2,703	6	2,709	11,636	9,965	27.2	116.8
LAE4	--	2,394	4	2,398	8,635	10,389	23.1	83.1
RA52	--	5,101	5	5,106	19,005	10,316	49.5	184.2
LA52	--	3,142	4	3,146	11,396	10,378	30.0	109.8

[a] *STS = yearling summer steelhead, CHS = yearling spring chinook salmon, CHF = yearling fall chinook salmon, CHFO = subyearling fail chinook salmon.*
[b] *Number of CHS collected at the rotary-screw trap was adjusted by trap retention efficiency.*
[c] *Number expanded is the total number collected adjusted by weighted trap efficiency for the period(s) brandedfish were collected.*
[d] *Number of readable brands released.*
[e] *RST = rotary-screw trap; WEID = West Extension Irrigation District Canal.*

Table 12. Collection and percent recapture of freeze-branded natural juvenile salmonids at the rotary-screw trap and West Extension Canal, Umatilla River, March - June 1996.

Species[a], Brand	Site, Number	Site, Number	Dates recaptured	Dates released	Number released	Expanded number[b]	Percent recapture[c]
CHS	RST[d]	WEID[d]					
RD7T1	--	3	4/2/96	10/6/95-10/15/95	303	--	1.0%
RA7T1	--	3	4/2/96	10/16/95-10/31/95	693		0.4%
RD7U1	2	3	3/20/96-5/3/96	11/l/95-1 1/15/95	524	94	0.9%
RA7U2	--	1	4/7/96	11/16/95-11/22/95	27		3.7%
RD7K1	--	3	4/7/96-5/6/96	12/10/95-12/12/95	72	--	4.2%
RA7K1	--	2	4/2/96-4/6/96	12/19/95-1/2/96	72	--	2.8%
RDL1	--	1	4/15/95	1/3/96-1/10/96	10	--	10.0%
STS	RST	WEID					
RA7U2	--	1	4/9/96	11/16/95-11/22/95	22	14	4.5%
RA7K1	--	1	4/8/96	12/19/95-1/2/96	136	14	0.7%
LA7K1	--	4	5/4/96-5/30/96	4/2/96-4/30/96	61	58	6.6%
LA7N1	--	2	5/16/96-5/27/96	5/1/96	28	29	7.1%

[a] *CHS = spring chinook salmon, STS = summer steelhead.*
[b] *Expanded number is the total number collected adjusted by weighted trap efficiency for the period(s) branded fish were collected.*
[c] *Percent recapture of actual fish collected not expandedfor trap efficiency.*
[d] *RST = rotary-screw trap; WEID = West Extension Irrigation District Canal.*

Table 13. Collection and percent recapture of VI-Jet-marked subyearling fall chinook salmon at West Extension and Westland canals, Umatilla River, May - August 1996.

Mark[a]	Site, Number	Site, Number	Total number	Expanded number[b]	Number released	Percent recapture Total	Percent recapture Expanded
	WEID[c]	Westland					
RA	27	--	27	115	577	4.7	19.9
RV	93	--	93	373	606	15.3	61.6
RP	235	--	235	917	603	39.0	152.1
GP	230	--	230	933	647	35.5	144.2
OP	245	1	246	1,026	654	37.6	156.9
OV	36	1	37	145	729	5.1	19.9
YV	1	--	1	4	643	0.2	0.6
OA	41	1	42	157	576	7.3	27.3
GA	96	--	96	405	610	15.7	66.4
GV	67	1	68	258	624	10.9	41.3

[a] *RA = red anal, RV = red ventral, RP = redpectoral, GP = green pectoral, OP = orange pectoral, OV = orange ventral, YV = yellow ventral, OA = orange anal, GA = green anal, GV = green ventral.*

[b] *Number expanded is the total number collected adjusted by weighted trap efficiency for the period(s) marked fish were collected.*

[c] *WEID = West Extension Irrigation District Canal.*

Table 14. Collection of VI-Jet-marked subyearling fall chinook salmon at John Day Dam, Columbia River, June 1996.

Mark[a]	Date collected	Number collected	Expanded number[b]
RV	6/17	1	25
RP	6/13	1	40
	6/21	1	20
GP	6/16	1	25
OV	6/12	1	40
	6/26	1	20

[a] *RV = red ventral, RP = redpectoral, GP = green pectoral, OV = orange ventral.*

[b] *Expanded number is based on flows and subsampling rates at John Day Dam.*

Table 15. Fin clips documented on juvenile salmonids collected at three sampling sites on the Umatilla River, March 1996 - August 1996.

Species,[a] Clip[b]	Site, Number	Site, Number	Site, Number	Total number	Number marked released	Percent recapture
	RST[c]	WEID[c]	Westland			
CHS 1+						
LV	1,572	530	--	2,102	241,353	0.9
ADLV	864	250	--	1,114	137,208	0.8
CHF 1+						
RV	--	42,544	--	42,544	438,462	9.7
ADRV	--	8,115	--	8,115	125,941	6.4
CHF Of						
RV	--	422,007	1,458	423,465	2,662,357	15.9
ADRV	--	43,526	139	43,665	298,056	14.6
COHO 1+						
NC	964	92,125	--	93,089	1,402,398	6.6
AD	6	4,011	--	4,017	75,000	5.4
STS 1+						
AD	--	10,467	--	10,467	85,123	12.3
ADLV	--	5,345	--	5,345	61,580	8.7

[a] *CHS I+ = yearling spring chinook salmon, CHF 1+ = yearling fall chinook salmon, CHF 0+ = subyearling fall chinook salmon, COH 1+ = yearling coho salmon, STS 1+ = yearling summer steelhead.*

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

[c] *RST = rotary-screw trap; WEID = West Extension Irrigation District Canal.*

Table 16. Migration parameters of hatchery and natural juvenile salmonids in the Umatilla River determined from capture at lower river trapping sites from 1 October 1995 to 30 September 1996.

Species[a]	Release Date	Release RM	Capture at lower river[b] First (date)	Capture at lower river[b] 50% (date)	Capture at lower river[b] Last (date)	Capture at lower river[b] Duration (no. days)	Migration rate for first capture (miles/day)
HCHS	3/13	80	3/14	3/15	5/16	64	79
HCOH	3/18 - 3/25 4/2 - 4/3 4/3 - 4/12	42 60 42	3/19	4/26	6/30[c]	103	33
HSTS	4/12 4/24 - 4/26[d] 5/9	64 79[e] 73	4/14	5/16	6/26	75	32
HCHF	4/5 4/18	73 80	4/7	4/27	6/2	58	46
HCHFO	5/30 5/31	80 73	6/2	6/4	8/9	71	42
NCH	--	--	12/11	4/12	6/26	196	--
NSTS	--	--	3/10	5/15	8/5	148	--
NCOH	--	--	3/16	4/8	5/30	75	--

[a] *HCHS = hatchery yearling spring chinook salmon, HCOH = hatchery yearling coho salmon, HSTS = hatchery yearling summer steelhead, HCHF = hatchery yearling fall chinook salmon, HCHFO = hatchery subyearling fall chinook salmon, NCH = natural spring and fall chinook salmon, NSTS = natural summer steelhead, NCOH = natural coho salmon.*

[b] *Fish were captured at RM 1.2 from 1 October 1995 to I April 1996, RM 3.0 from 2 April 1996 to II July 1996, RM 27.3 from 12 July to 9 August 1996, and RM I. 2 from I9 August to 30 September 1996.*

[c] *One hatchery coho salmon was captured at RM 1.2 on 14 September 1996.*

[d] *Steelhead at Bonifer holding pond escaped over the three-day periodfrom 24 April to 26 April 1996.*

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

Table 17. Weekly condition of juvenile salmonids collected at the rotary-screw trap (11 December 1995 - 1 April 1996), West Extension Canal (2 April - 8 July 1996), and Westland Canal (11 June - 9 August 1996), Umatilla River.

Date	Good No.	Good Per-cent	Partial No.	Partial Per-cent	Decaled No.	Decaled Per-cent	Mortality No.	Mortality Per-cent	Parasites No.	Parasites Per-cent	Bird marks No.	Bird marks Per-cent	Other injuries No.	Other injuries Per-cent	Total No.
							Natural spring chinook salmon								
12/11-1/28	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3
3/10-3/18	3	75.0	0	0.0	1	25.0	0	0.0	0	0.0	0	0.0	0	0.0	4
3/19-3/25	4	80.0	1	20.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5
3/26-4/1	7	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7
4/2-4/8	69	98.6	1	1.0	0	0.0	0	0.0	6	9.0	0	0.0	2	3.0	70
4/9-4/15	27	90.0	2	7.0	1	3.0	0	0.0	2	7.0	0	0.0	0	0.0	30
4/16-4/22	21	95.5	1	5.0	0	0.0	0	0.0	4	18.0	0	0.0	0	0.0	22
4/23-4/29	1	100.0	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1
							Natural fall chinook salmon								
4/30-5/6	7	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7
5/7-5/13	5	83.3	1	16.7	0	0.0	0	0.0	1	16.7	0	0.0	1	16.7	6
5/14-5/20	10	100.0	0	0.0	0	0.0	0	0.0	1	10.0	0	0.0	0	0.0	10
5/21-5/27	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
5/28-6/3	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3
6/4-6/10	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2
6/11-6/17	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3
6/18-6/24	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
6/25-7/1	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
							Natural coho salmon								
3/10-3/18	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
3/19-3/15	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
3/16-4/1	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
4/2-4/8	21	91.3	0	0.0	0	0.0	2	8.7	1	4.3	0	0.0	1	4.3	23
4/9-4/15	12	80.0	2	13.3	1	6.7	0	0.0	0	0.0	0	0.0	1	6.7	15
4/16-4/22	5	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5
4/23-4/29	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2
4/30-5/6	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2

Table 17. Continued

Date	Good No.	Good Per-cent	Partial No.	Partial Per-cent	Descaled No.	Descaled Per-cent	Mortality No.	Mortality Per-cent	Parasites No.	Parasites Per-cent	Bird marks No.	Bird marks Per-cent	Other injuries No.	Other injuries Per-cent	Total No.
Natural coho salmon															
5/7-5/13	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
5/14-5/20	3	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3
5/21-5/27	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
5/28-6/3	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
Natural summer steelhead															
3/10-3/18	7	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7
3/19-3/25	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2
3/16-4/1	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2
4/2-4/8	111	95.7	4	3.4	1	0.9	0	0.0	3	2.6	1	0.9	2	1.7	116
4/9-4/15	187	93.0	10	5.0	4	2.0	0	0.0	7	3.5	3	1.5	5	2.5	201
4/16-4/22	137	93.8	6	4.1	3	2.1	0	0.0	4	2.7	1	0.7	3	2.1	146
4/23-4/29	71	95.9	1	1.4	2	2.7	0	0.0	2	2.7	1	1.4	0	0.0	74
4/30-5/6	387	90.6	28	6.6	11	2.6	1	0.2	9	2.1	8	1.9	7	1.6	427
5/7-5/13	689	90.9	52	6.9	13	1.7	4	0.5	26	3.4	13	1.7	17	2.2	758
5/14-5/20	893	90.8	62	6.3	23	2.3	6	0.6	22	2.2	25	2.5	12	1.2	984
5/21-5/27	71	94.7	4	5.3	0	0.0	0	0.0	3	4.0	0	0.0	2	2.7	75
5/28-6/3	291	99.8	23	7.1	9	2.8	1	0.3	18	5.6	10	3.1	5	1.5	324
6/4-6/10	49	80.3	7	11.5	4	6.6	1	1.6	0	0.0	3	4.9	1	1.6	61
6/11-6/17	2	40.0	3	60.0	0	0.0	0	0.0	0	0.0	2	40.0	0	0.0	5
Hatchery spring chinook salmon															
3/10-3/18	1093	63.7	550	32.0	71	4.1	3	0.2	32	1.9	3	0.2	7	0.4	1717
3/19-3/25	192	64.6	47	15.8	54	18.2	4	1.3	42	14.1	4	1.3	9	3.0	297
3/26-4/1	29	52.7	12	21.8	9	16.4	5	9.1	0	0.0	1	1.8	3	5.5	55
4/2-4/8	494	78.4	86	13.7	49	7.8	1	0.2	15	2.4	17	2.7	38	6.0	630
4/9-4/15	64	71.1	19	21.1	7	7.8	0	0.0	0	0.0	0	0.0	7	7.8	90
4/16-4/22	12	50.0	8	33.3	4	16.7	0	0.0	1	4.2	0	0.0	3	12.5	24
4/23-4/29	4	100.0	0	0.0	0	0.0	0	0.0	1	25.0	0	0.0	0	0.0	4
4/30-5/6	4	66.7	1	16.7	1	16.7	0	0.0	1	16.7	0	0.0	2	33.3	6
5/7-5/13	2	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2
5/14-5/20	1	33.3	2	66.7	0	0.0	0	0.0	0	0.0	0	0.0	1	33.3	3

Table 17. Continued

Date	Good No.	Good Per-cent	Partial No.	Partial Per-cent	Descaled No.	Descaled Per-cent	Mortality No.	Mortality Per-cent	Parasites No.	Parasites Per-cent	Bird marks No.	Bird marks Per-cent	Other injuries No.	Other injuries Per-cent	Total No.
							Hatchery coho salmon								
3/19-3/25	305	81.1	27	7.2	43	11.4	1	0.3	9	2.4	5	1.3	2	0.5	376
3/26-4/1	444	78.2	82	14.4	36	6.3	6	1.1	3	0.5	14	2.5	2	0.4	568
4/2-4/8	8456	90.9	621	6.7	212	2.3	14	0.2	49	0.5	123	1.3	70	0.8	9303
4/9-4/15	4564	89.1	414	8.1	134	2.6	11	0.2	16	0.3	41	0.8	25	0.5	5123
4/16-4/22	7258	94.4	307	4.0	113	1.5	8	0.1	104	1.4	88	1.1	32	0.4	7686
4/23-4/29	8955	86.8	1022	9.9	316	3.1	19	0.2	64	0.6	143	1.4	56	0.5	10312
4/30-5/6	4839	82.4	773	13.2	252	4.3	7	0.1	26	0.4	46	0.8	42	0.7	5871
5/7-5/13	5329	78.1	1215	17.8	278	4.1	0	0.0	14	0.2	50	0.7	18	0.3	6822
5/14-5/20	7617	82.7	1196	13.0	385	4.2	13	0.1	16	0.2	78	0.8	54	0.6	9211
5/21-5/27	251	87.5	23	8.0	11	3.8	2	0.7	1	0.3	5	1.7	7	2.4	287
5/28-6/3	202	83.5	26	10.7	13	5.4	1	0.4	0	0.0	6	2.5	1	0.4	242
6/4-6/10	17	81.0	1	4.8	3	14.3	0	0.0	0	0.0	0	0.0	0	0.0	21
6/11-6/17	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0	0	0.0	0	0.0	2
6/18-6/24	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
6/25-7/1	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
7/2-7/8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
							Hatchery fall chinook salmon								
4/2-4/8	309	96.9	7	2.2	3	0.9	0	0.0	1	0.3	2	0.6	3	0.9	319
4/9-4/15	4560	88.9	454	8.9	110	2.1	5	0.1	29	0.6	25	0.5	22	0.4	5129
4/16-4/22	8582	90.7	637	6.7	233	2.5	14	0.1	38	0.4	55	0.6	60	0.6	9466
4/23-4/29	5576	91.9	352	5.8	110	1.8	31	0.5	10	0.2	58	1.0	48	0.8	6069
4/30-5/6	5076	77.3	991	15.1	485	7.4	13	0.2	8-1	1.3	108	1.6	124	1.9	6568
5/7-5/13	4727	80.8	657	11.2	459	7.8	9	0.2	37	0.6	112	1.9	105	1.8	5852
5/14-5/20	1641	85.5	190	9.9	74	3.9	14	0.7	42	2.2	35	1.8	80	4.2	1919
5/21-5/27	62	88.6	3	4.3	3	4.3	2	2.9	5	7.1	2	2.9	11	15.7	70
5/28-6/3	44	91.7	2	4.2	1	2.1	1	2.1	0	0.0	3	6.3	6	12.5	48
							Hatchery summer steelhead								
4/2-4/8	20	64.5	8	25.8	3	9.7	0	0.0	2	6.5	0	0.0	1	3.2	31
4/9-4/15	39	72.2	9	16.7	6	11.1	0	0.0	0	0.0	1	1.9	3	5.6	54
4/16-4/22	304	83.7	41	11.3	18	5.0	0	0.0	7	1.9	20	5.5	4	1.1	363
4/23-4/29	88	63.3	35	25.2	16	11.5	0	0.0	1	0.7	5	3.6	4	2.9	139

Table 17. Continued

Date	Good No.	Good Per-cent	Partial No.	Partial Per-cent	Descaled No.	Descaled Per-cent	Mortality No.	Mortality Per-cent	Parasites No.	Parasites Per-cent	Bird marks No.	Bird marks Per-cent	Other injuries No.	Other injuries Per-cent	Total No.
							Hatchery summer steelhead								
4/30-5/6	561	53.2	314	29.8	165	15.6	15	1.4	10	0.9	35	3.3	18	1.7	1055
5/7-5/13	1043	60.6	505	29.3	163	9.5	11	0.6	10	0.6	75	4.4	21	1.2	1722
5/14-5/20	3015	72.3	781	18.7	361	8.7	16	0.4	11	0.3	157	3.8	77	1.8	4173
5/21-5/27	353	73.5	76	15.8	49	10.2	2	0.4	12	2.5	18	3.8	7	1.5	480
5/28-6/3	510	62.4	189	23.1	113	13.8	5	0.6	3	0.4	90	11.0	31	3.8	817
6/4-6/10	138	60.0	56	24.3	35	15.2	1	0.4	4	1.7	39	17.0	5	2.2	230
6/11-6/17	8	50.0	2	12.5	6	37.5	0	0.0	0	0.0	5	31.3	0	0.0	16
6/18-6/24	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	1	100.0	1	100.0	1
6/25-7/1	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	1
							Hatchery subyearling fall chinook salmon								
5/14-5/20	127	99.2	1	0.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	128
5/21-5/27	246	98.8	2	0.8	0	0.0	1	0.4	1	0.4	1	0.4	2	0.8	249
5/28-6/3	12359	95.8	461	3.6	68	0.5	16	0.1	3	0.0	5	0.0	25	0.2	12904
6/4-6/10	23234	75.5	6413	20.8	1116	3.6	20	0.1	4	0.0	69	0.2	70	0.2	30783
6/11-6/17	6065	56.8	3562	33.4	937	8.8	112	1.0	2	0.0	50	0.5	26	0.2	10676
6/18-6/24	174	68.8	48	19.0	20	7.9	11	4.3	0	0.0	2	0.8	2	0.8	253
6/25-7/1	161	41.5	116	32.0	48	13.3	37	10.2	1	0.3	4	1.1	1	0.3	362
7/2-7/8	4	20.0	3	15.0	3	15.0	10	50.0	0	0.0	0	0.0	0	0.0	20
							Westland Canal								
							Hatchery subyearling fall chinook salmon								
6/11	25	8.7	218	75.4	46	15.9	0	0.0	0	0.0	0	0.0	0	0.0	289
6/13	113	27.6	202	49.4	59	14.4	35	8.6	0	0.0	1	0.2	1	0.2	409
6/18	63	26.9	125	53.4	46	19.7	0	0.0	0	0.0	1	0.4	1	0.4	234
6/20	43	12.5	236	68.4	36	10.4	30	8.7	0	0.0	2	0.6	1	0.3	345
6/25	28	11.7	187	78.2	18	7.5	6	2.5	0	0.0	0	0.0	0	0.0	239
7/2	20	20.2	54	54.5	5	5.1	20	20.2	0	0.0	0	0.0	0	0.0	99
8/2	9	14.5	40	64.5	13	21.0	0	0.0	0	0.0	1	1.6	1	1.6	62
8/5	2	33.3	3	50.0	1	16.7	0	0.0	0	0.0	0	0.0	0	0.0	6
8/9	0	0.0	2	50.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	4

Table 18. Mean, range, standard error, and mode of fork lengths from hatchery and natural juvenile salmonids captured at study sites in 1995-1996. Data from rotary-screw trap and West Extension Canal are combined, unless otherwise indicated.

Race/ Species	Age	Fork length (mm) Mean	Range	Standard error	Mode
Hatchery spring chinook	1+	160	82-254	0.52	152
Natural spring chinook	1+	106	82-195	1.04	104
Hatchery fall chinook	1+	182	99-294	0.30	182
Hatchery fall chinook”	0+	87	56-l 16	0.14	87
Hatchery fall chinook[b]	0+	93	74-149	0.29	90
Natural fall chinook	0+	68	48-84	2.94	52
Hatchery coho	1+	136	89-208	0.13	132
Natural coho[c]	1+	91	65-13 1	1.77	95
Hatchery summer steelhead	1+	219	118-361	0.41	210
Natural summer steelhead	1+[d]	176	44-3 14	0.44	172

[a] *Collected at West Extension Canal.*

[b] *Collected at Westland* ***Canal.***

[c] *Natural coho salmon were indistinguishable from unclipped hatchery coho salmon. Coho salmon were classed as natural if under 100 mm fork length or if they were captured before hatchery coho salmon were released.*

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

Table 19. Estimates of weighted trap effkiency and migrant abundance (+ 95% confidence interval) for hatchery and natural juvenile salmonids, and survival estimates for hatchery juvenile salmonids passing the RM 1.2 and RM 3.0 trap sites on the lower Umatilla River, October 1995 - June 1996.

Site, Species[a]	Origin	Age	Trap efficiency[b]	Abundance estimate	95% Confidence interval[c]	Percent survival
River Mile 1.2						
CHS	H	1^+	0.020	129,593	30,948 - 228,238	34.2%
COH	H	1^+	0.008	129,255	0 - 330,868	27.8%[d]
CH	N	1+	0.020	1,037		--
COH	N	o+	0.008	617		--
West Extension Canal						
COH	H	1^+	0.188	511,302	483,068 - 539,536	37.9%[d]
CHF	H	1^+	0.267	226,767	214,660 - 238,874	40.2%
CHF	H	0+	0.268	3,637,933	3,491,842 - 3,784,024	140.8%[e]
STS	H	1+	0.142	137,478	123,152 - 151,804	93.7%
CH	N	0+[f]	0.267	819		--
COH	N	o+	0.188	346		--
STS	N	1+[g]	0.072	73,134	43,981 - 102,287	--

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

[b] *Trap efficiency was based on the total number of fish recapturedfrom the total number of fish released that were expected to survive. Trap efficiency of hatchery fish was used to compute abundance of natural fish, except natural summer steelhead.*

[c] *Variance estimates for 95% confidence intervals were derivedfrom the Bootstrap method.*

[d] *Percent survivalfor coho salmon at RM 1.2 was based on the number released in March; percent survival of coho salmon at West Extension Canal was based on the overall total number of coho salmon released minus the abundance estimate at RM 1.2.*

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

[f] *Age of natural chinook salmon includes 0+ and I + fish.*

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

Table 20. Number and length range (mm) of resident fish captured at study sites on the lower Umatilla River, October 1995 - September 1996.

	West Extension Canal		Rotary-screw trap	
Family Common name (Genus species)	Number captured	Length range (mm)	Number captured	Length range(mm)
Catostomidae				
Bridgelip sucker *(Catostomus columbianus)*	63	--	37	84-288
Largescale sucker *(C. macrocheilus)*	29	--	66	66-3 60
Unidentified sucker *(Catostomus. spp.)*	2,439	82-178	10	33-86
Cyprinidae				
Redside shiner *(Richardsonius balteatus)*	258	20-65	193	43-150
Peamouth *(Mylocheilus caurinus)*	54	--	--	--
Chiselmouth *(Acrocheilus alutaceus)*	1774	35-257	814	35-165
Northern squawfish *(Ptychocheilus oregonensis)*	372	20-280	64	30-213
Common carp *(Cyprinus carpio)*	1	--	2	--
Speckled dace *(Rhinichthys osculus)*	102	--	136	40-65
Percidae				
Yellow perch *(Perca flavescens)*	1	145	1	100
Centrarchidae				
Smallmouth bass *(Micropterus dolomieu)*	1	--	10	40-l 10
Largemouth bass *(M. salmoides)*	3	--	7	45-123
Unidentified bass *(Micropterus spp.)*	39	50-168	--	--
Crappie *(Pomoxis spp.)*	472	--	18	55-82
Bluegill *(Lepomis macrochirus)*	1	161	--	--
Unidentified sunfish *(Lepomis spp.)*	8	32-127	--	--
Poeciliidae				
Unidentified gambusia *(Gambusia spp.)*	2	--	--	--
Ictaluridae				
Brown bullhead *(Ameirus nebulosus)*	33	47-154	--	--
Cottidae				
Unidentified sculpins *(Cottus spp.)*	7	--	--	--
Petromyzontidae				
Unidentified lamprey *(Lampetra spp.)*	197	90-505	29	50-230
Others				
Crayfish	1	--	--	--
Tadpoles	16	--	19	--

Table 21. Number of avian predators observed and frequency of observations at trap sites on the lower Umatilla River, October 1995 - September 1996.

	West Extension Canal		Rotary-screw trap	
Family Common name (Genus species)	Frequency of observations	Number observed	Frequency of observations	Number observed
Phalacrocoracidae				
Cormorant (*Phalacrocorax spp.*)	38	116	--	--
Ardeidae				
Great egret (*Casmerodius albus*)	1	1	--	--
Great Blue Heron (*Ardea herodias)*	54	94	3	3
Green Heron *(Butorides striatus)*	5	7	1	1
Night Heron (*Nycticorax nycticorax*)	21	63	--	--
Unidentified Herons	62	292	--	--
Laridae				
Gulls (*Larus spp.)*	73	776	7	86
Anatidae				
Merganser (*Mergus merganser)*	**10**	58	1	1
Accipitridae				
Osprey *(Pandion haliaetus*)	33	35	--	--
Alcedinidae				
Kingfisher (*Ceryle alcyon*)		--	4	4

Table 22. Scale condition ofjuvenile salmonids (hatchery fall chinook subyearlings) sampled for Westland Trap and Haul transport evaluation, Umatilla River, June and July 1996. (* indicates test dates with significant chi-square; $P < 0.05$).

	Control group			Treatment group		
Date test started	Percent good”	Percent partially descaled[b]	Percent descaled”	Percent good”	Percent partially descaled[b]	Percent descaled”
6/11/96	24	62	14	8	76	16
6/12/96	10	70	20	4	66	30
6/13/96	14	72	14	2	74	24
6/14/96	22	66	12	14	74	12
6/17/96	24	64	12	14	76	10
6/18/96	16	72	12	12	70	18
6/19/96	8	76	16	6	70	24
*6/20/96	22	64	14	2	72	26
6/21/96	22	68	10	24	68	8
6/24/96	22	64	14	18	78	4
6/25/96	18	76	6	14	76	10
6/26/96	6	78	16	4	84	12
6/28/96	28	62	10	28	60	12
6/30/96[d]	42	54	4	32	62	6
*7/01/96	22	78	0	6	74	20
7/02/96	24	72	4	21.7	60.8	17.4
7/03/96	14.3	71.4	14.3	26	60	14
7/05/96	26	66	8	18	72	10
7/09/96	8	80	12	10	60	30
*7/11/96	27	53	20	2	64	34
*7/23/96	26	56	18	0	64	36
7/25/96	50	44	6	28	54	18

[a] *Good = less than 3% of body surface descaled.*
[b] *Partial = between 3% and 20% of body surface descaled.*
[c] *Descaled = greater than 20% of body surface descaled.*
[d] *Descaling data collected but no mortality test performed.*

Table 23. Number of live fish, water temperatures, and net mortality from 24-h holding tests of control and treatment groups from Westland Trap and Haul transport evaluation, June and July 1996. Net mortality = dead fish from treatment group minus dead fish from control group. (* indicates test dates with significant chi-square; $P < 0.05$)

	Control group[C1]				Treatment group[T1]					
	Number of live fish		Water temperature (F)		Number of live fish		Water temperature (F)		Treatment minus control	
Date test ended	Start	End	Start	End	Start	End	Start	End	Net mortality	Net percent mortality
*6/12/96	50	50	61	61	50	39	65	66	11	22%
*6/13/96	50	44	61	61	50	33	66	66	11	22%
6/14/96	51	48	61	62	50	--[a]	67	64	--[a]	--[a]
*6/15/96	50	46	62	64	50	35	64	67	11	22%
6/18/96	50	47	57	52	50	47	63	60	0	0%
6/19/96	50	46	52	56	50	--[b]	65	--	--[b]	--[b]
6/20/96	50	47	56	59	50	45	61	65	2	4%
6/21/96	50	47	59	60	50	--[a]	65		--[a]	--[a]
6/22/96	50	47	60	66	50	49	64	--	-2	-4%
6/25/96	50	50	57	59	50	48	63	65	2	4%
6/26/96	50	49	59	61	50	46	65	66	3	6%
6/28/96	50	49	61	60	50	--[a]	66		[a]	--[a]
6/29/96	50	50	60	60	50	48	65	68	2	4%
7/02/96	50	40	68	72	50	44	68	76	-4	-8%
*7/03/96	50	43	72	70	50	33	76	74	10	20%
*7/06/96	50	49	61		50	39	67	--	10	20%
7/10/96	50	48	68		50	44	69		4	8%
7/12/96	50	50	66	--	50	46	70	--	4	8%
*7/24/96	50	50	70	72	50	37	71	72	13	26%
7/26/96	50	50	68	70	48	48	70	70	0	0%

Table 23. Continued

Date test ended	Control group[C1]				Treatment group				Treatment minus control	
	Number of live fish		Water temperature (F)		Number of live fish		Water temperature (F)			
	Start	End	Start	End	Start	End	Start	End	Net mortality	Net percent mortality
Additional treatment groups										
		Control group[C1]				Treatment group”			Treatment minus control	
6/13/96	50	*44*	*61*	*61*	*50*	--[a]	*67*	*66*	--[a]	--[a]
6/22/96	*50*	*47*	*59*	*60*	*50*	*49*	*65*	*65*	*-2*	*-4%*
		Control group”				Treatment group[T3]			Treatment minus control	
6/18/96	50	*47*	*57*	*52*	*50*	*48*	*57*	*52*	-1	*-2%*
6/22/96	*50*	*47*	*59*	*60*	*50*	*49*	*59*	*60*	*-2*	*-4%*
		Control group”				Treatment group[T4]			Treatment minus control	
6/18/96	50	*47*	*57*	*52*	*50*	*47*	*57*	*52*	*0*	*0%*

[C1] *Control group: fish taken from Westland Pond before crowding and held at Westland Canal.*
[T1] *Standard treatment group: fish taken from transport vehicle after hauling to lower Umatilla River boat ramp; fish held at boat ramp.*
[T2] *Treatment 2 group: fish taken from subsequent hauls to boat ramp after first haul was released; fish held at lower Umatilla Boat Ramp.*
[T3] *Treatment 3 group: fish taken from pond at Westland Canal after crowding and before loading; fish held at Westland Canal.*
[T4] *Treatment 4 group: fish taken from transport vehicle after loading and prior to transport; fish held at Westland Canal.*
[a] *Fish from treatment group at lower Umatilla River boat ramp were missing from net pens at 24-hour check.*
[b] *Treatment group net pen was out of water due to drop in water level; all fish dead at check.*

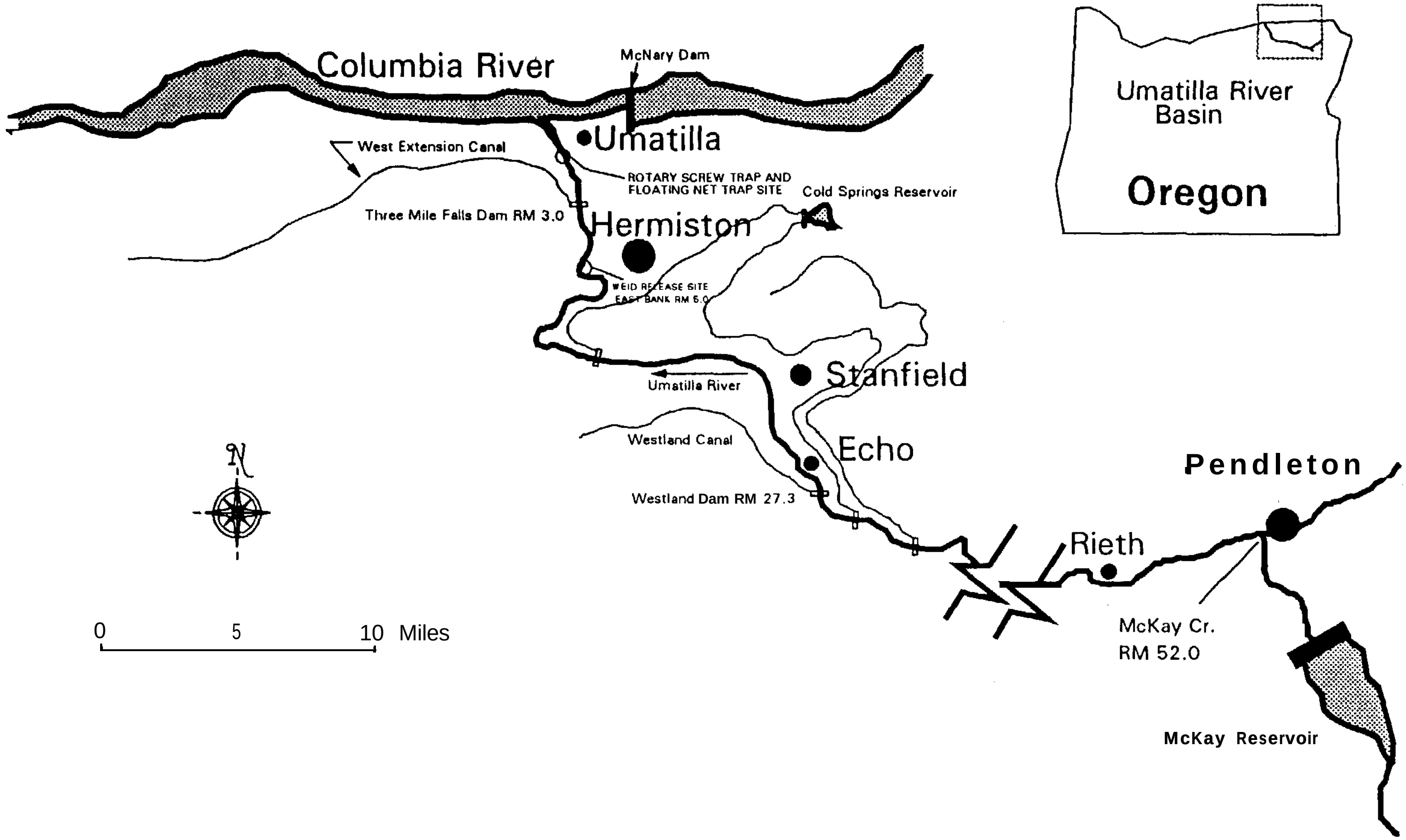


Figure 1. Study sites and trap efficiency release sites on the lower Umatilla River, October 1995 - September 1996.

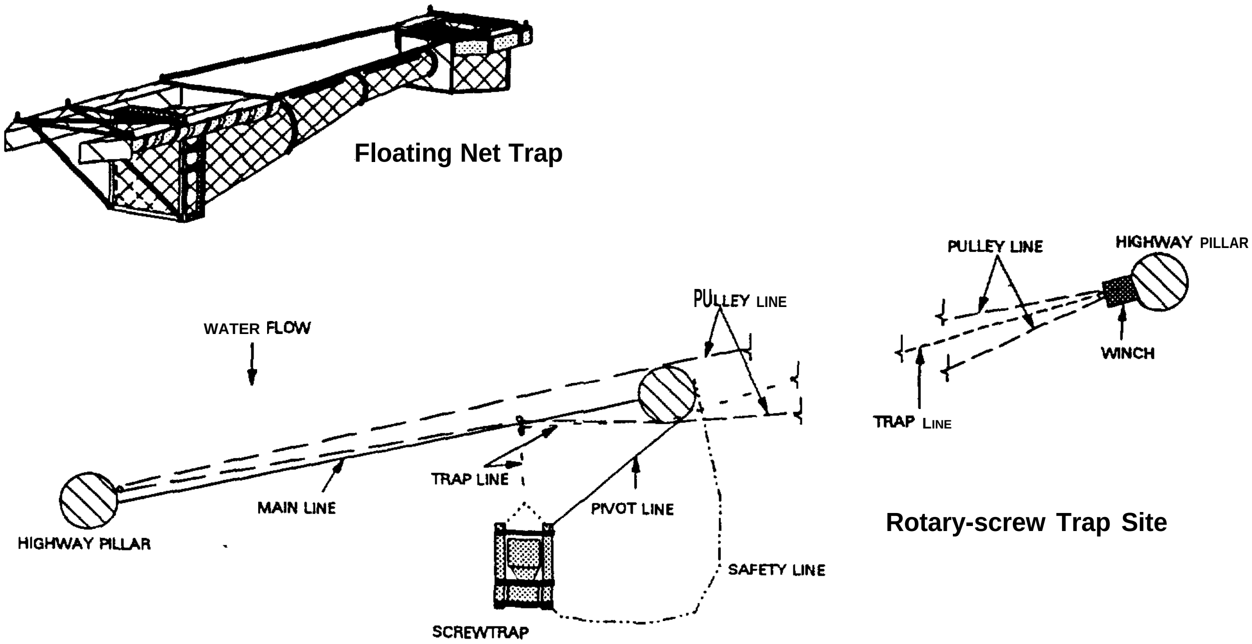


Figure 2. Rotary-screw trap and anchoring system and floating net trap used at RM **1.2,** Umatilla River.

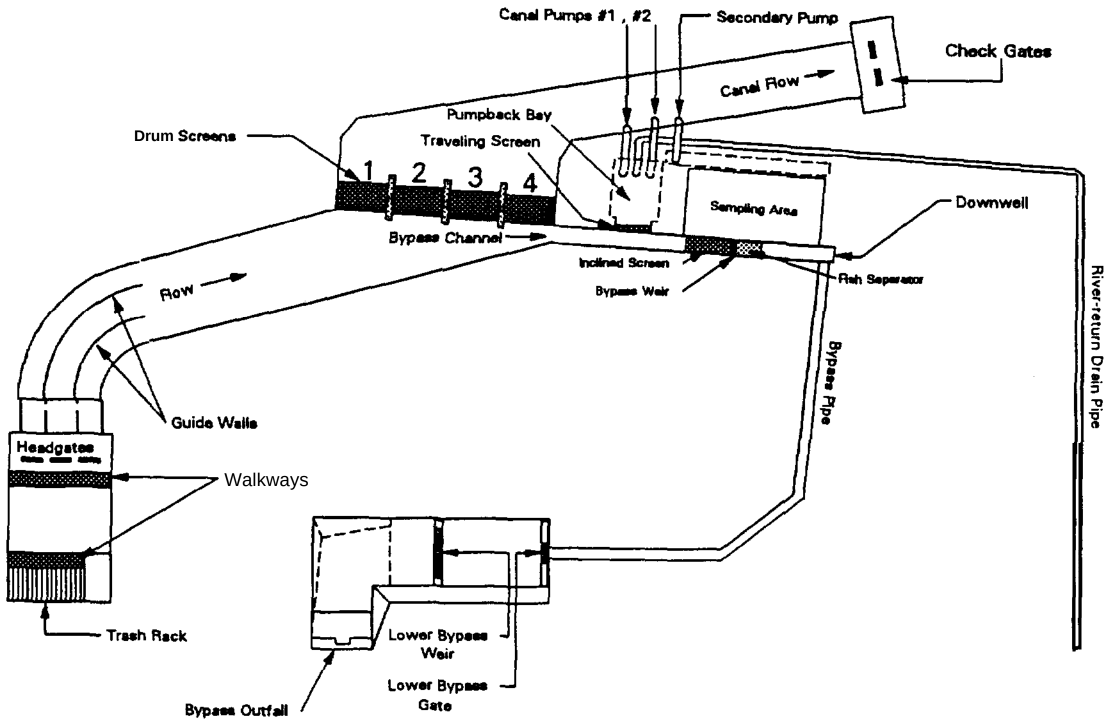


Figure 3. Schematic of West Extension Canal and screening/bypass facility, Umatilla River.

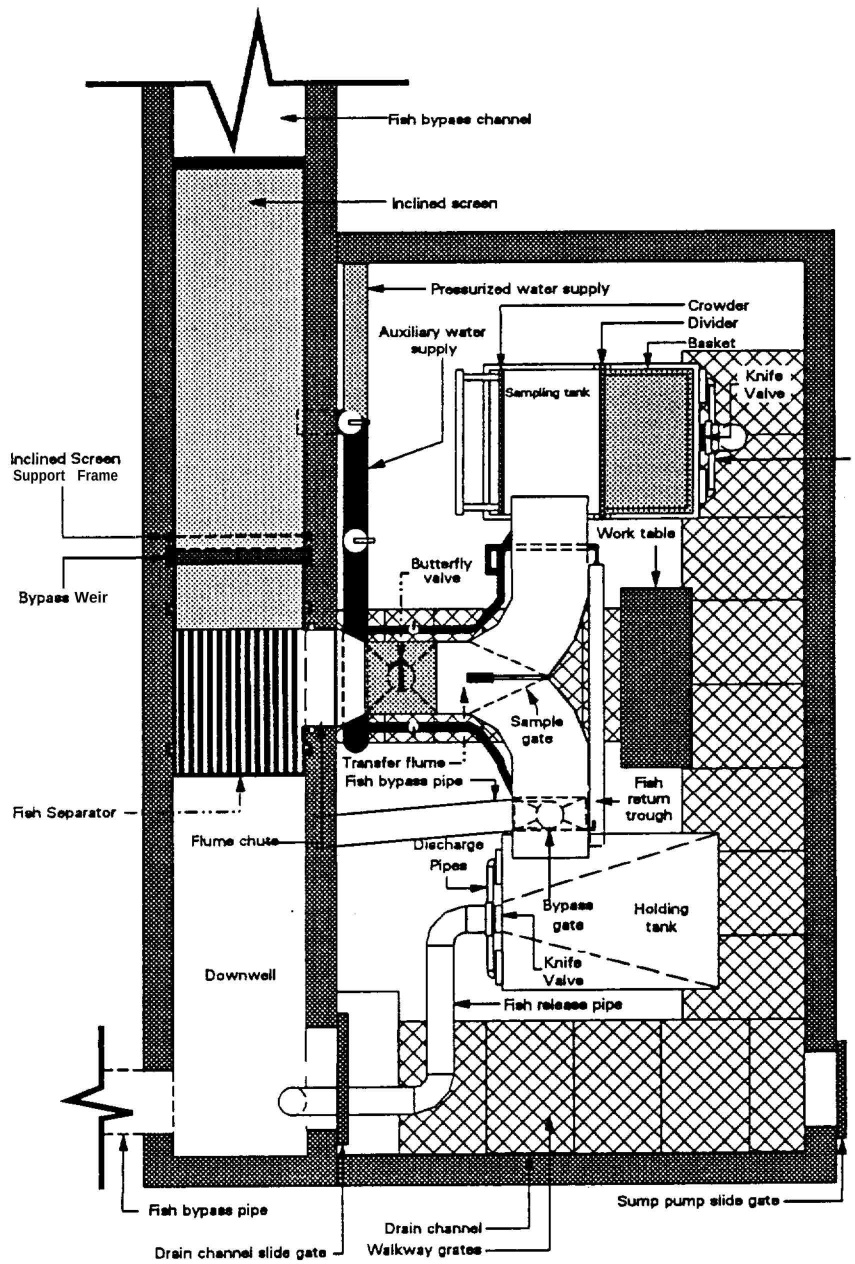


Figure 4. Schematic of the West Extension Canal juvenile fish sampling facility showing modified fish bypass pipe and auxiliary water line, Umatilla River.

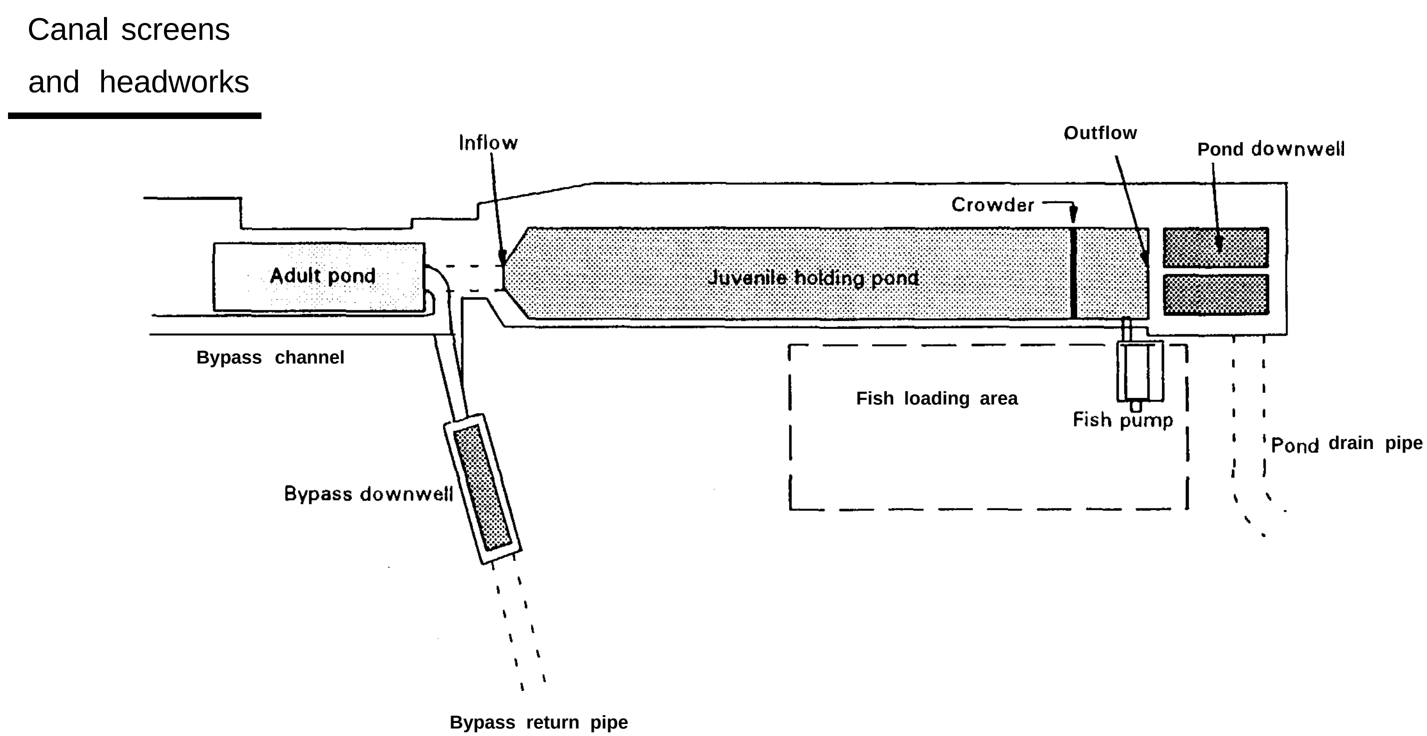


Figure 5. Juvenile fish holding pond and fish loading area at Westland Canal, Umatilla River.

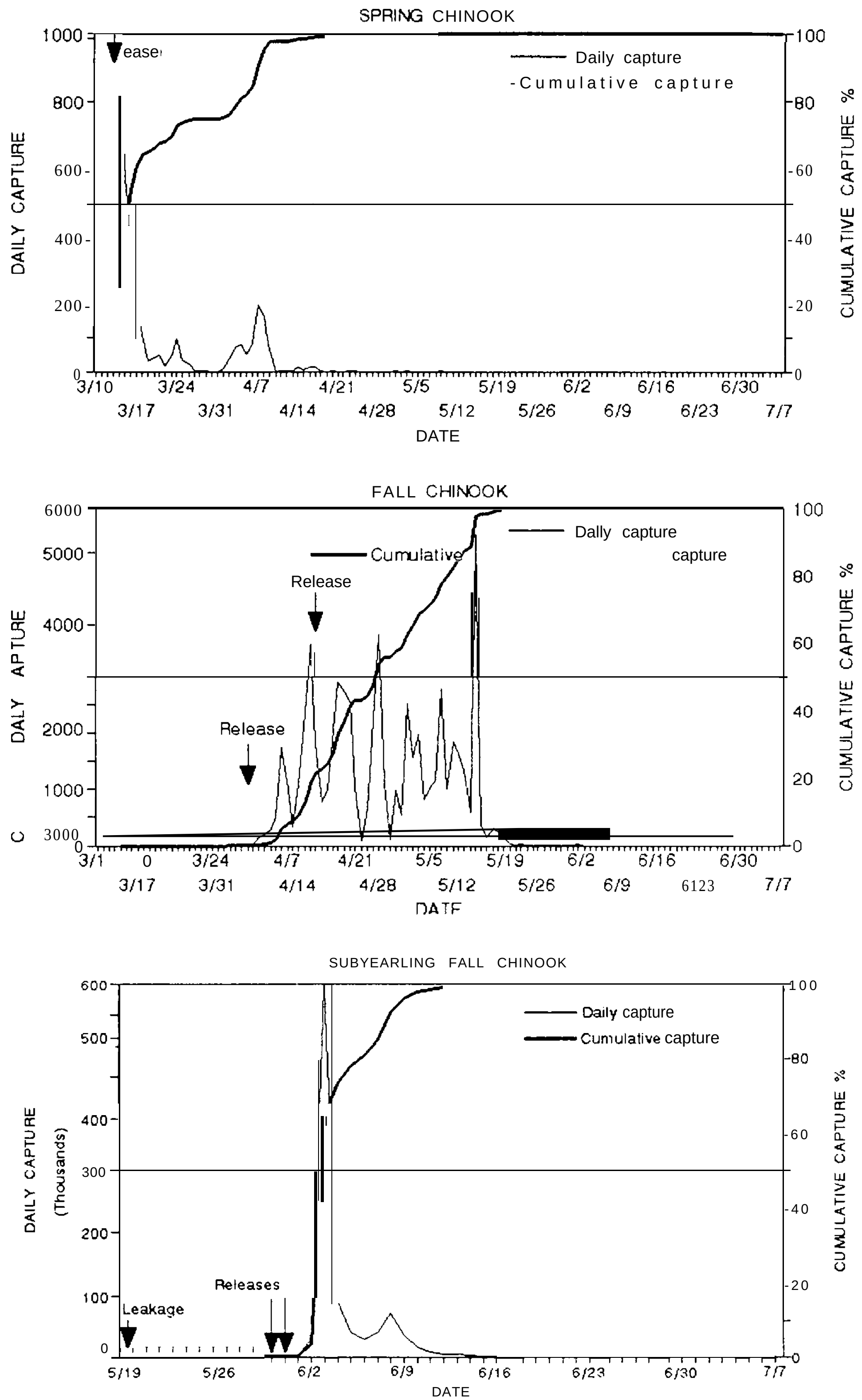


Figure 6. Daily capture and percent cumulative capture of hatchery yearling spring chinook salmon, and yearling and subyearling fall chinook salmon collected at the rotary-screw trap and West Extension Canal, Umatilla River, spring 1996.

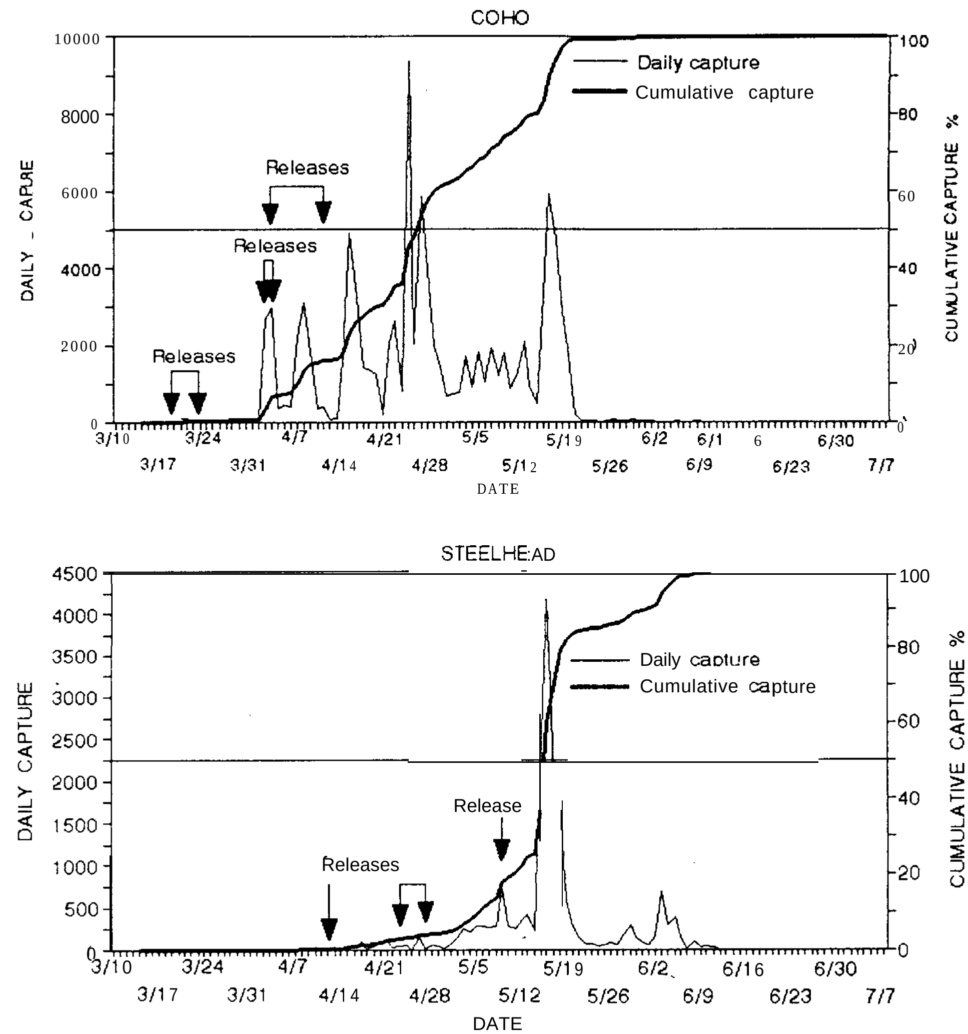


Figure 7. Daily capture and percent cumulative capture of hatchery coho salmon and summer steelhead collected at the rotary-screw trap and West Extension Canal, Umatilla River, spring 1996.

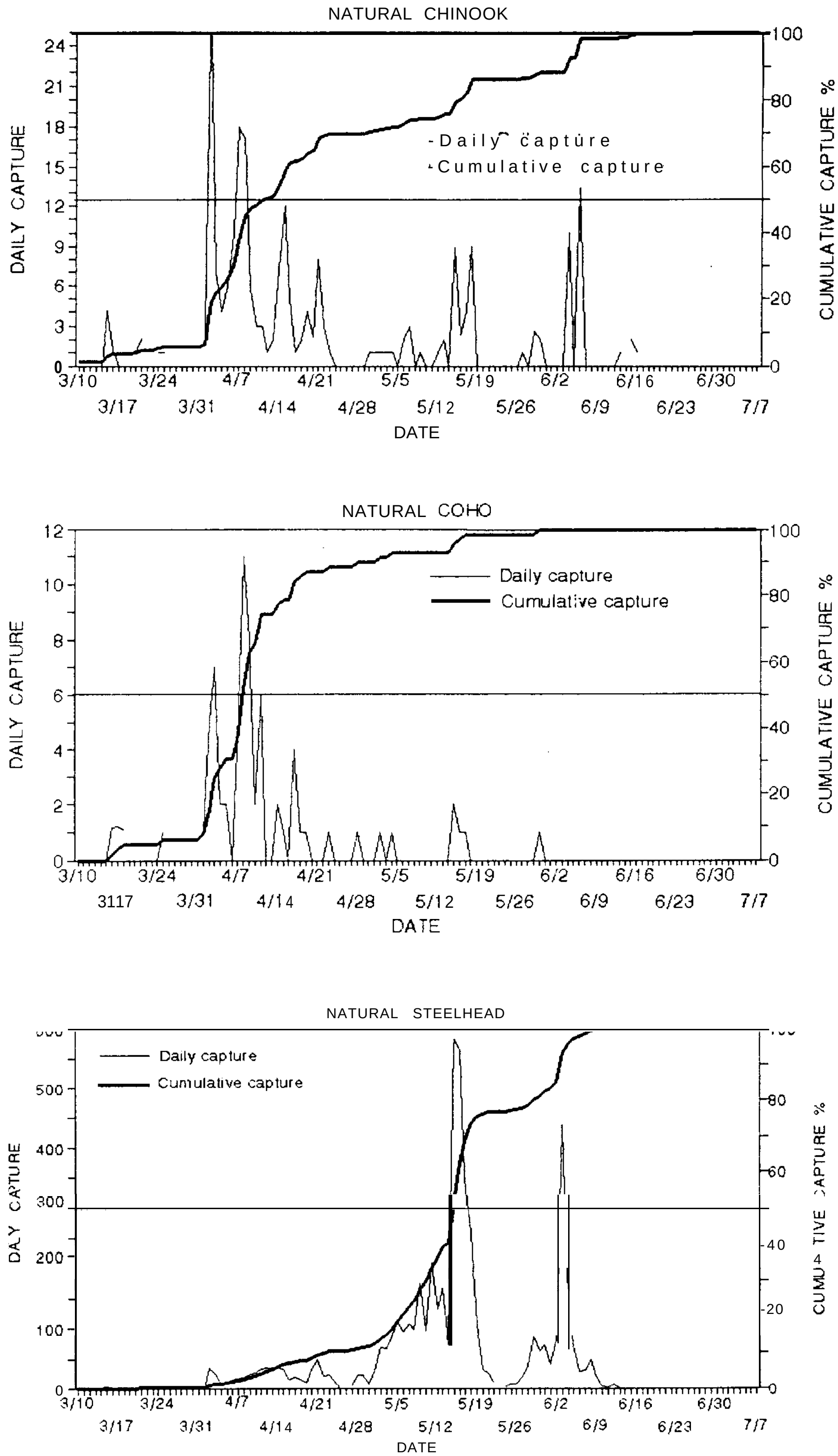
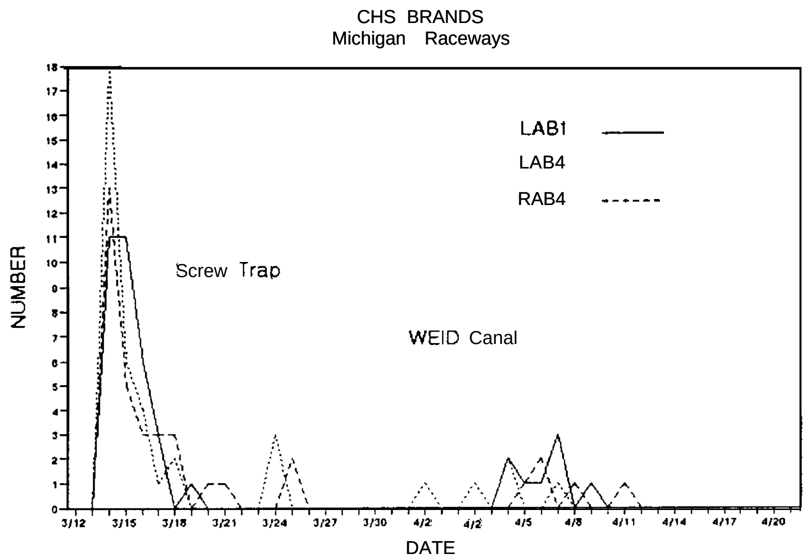


Figure 8. Daily capture and percent cumulative capture of natural chinook salmon, coho salmon, and summer steelhead collected at the rotary-screw trap and West Extension Canal, Umatilla River, spring 1996.



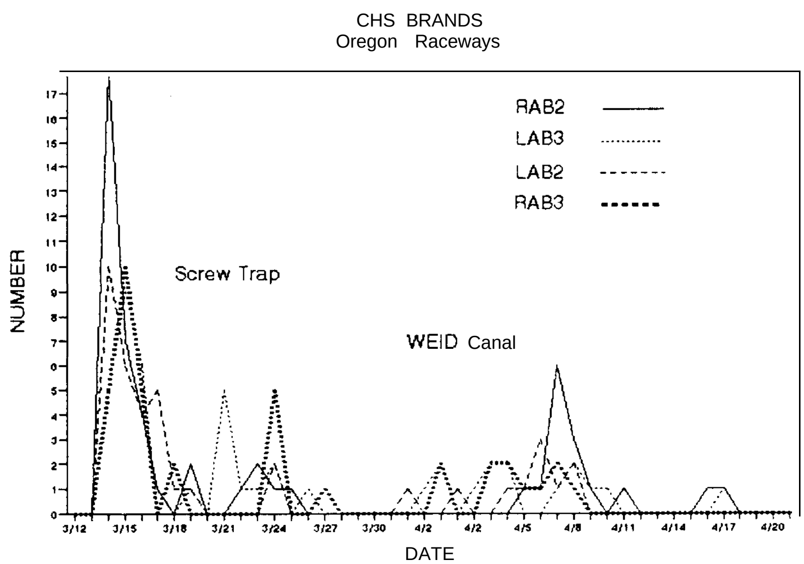
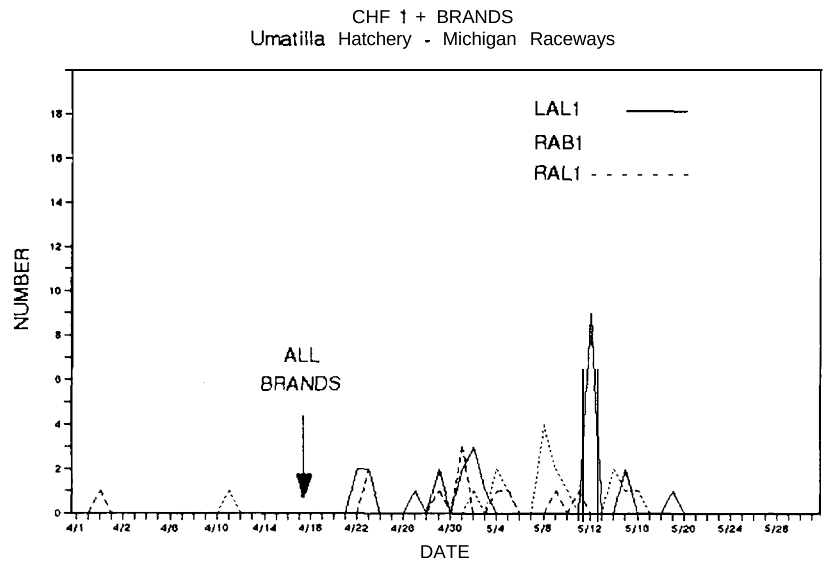


Figure 9. Migration patterns of brand groups of yearling spring chinook salmon from Umatilla Hatchery collected at the rotary-screw trap and West Extension Canal, Umatilla River, March - May 1996.



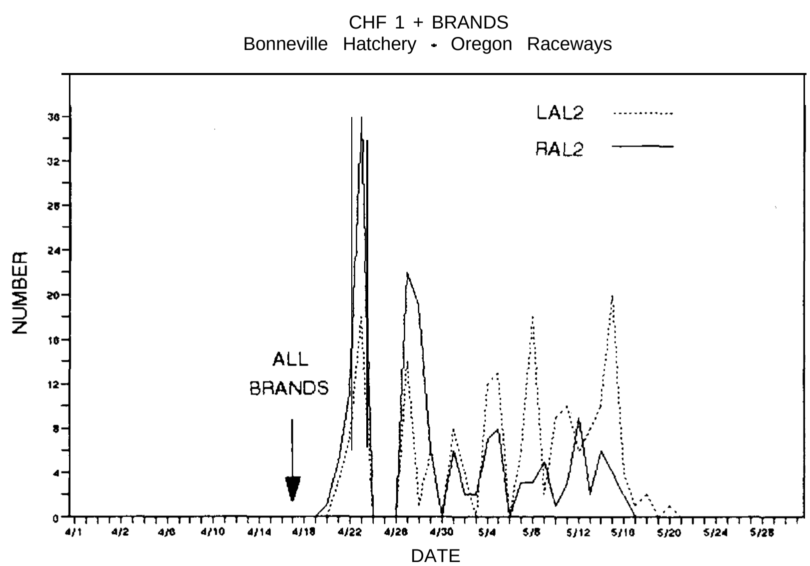


Figure 10. Migration patterns of brand groups of yearling fall chinook salmon from Umatilla and Bonneville hatcheries collected at West Extension Canal, Umatilla River, April and May 1996.

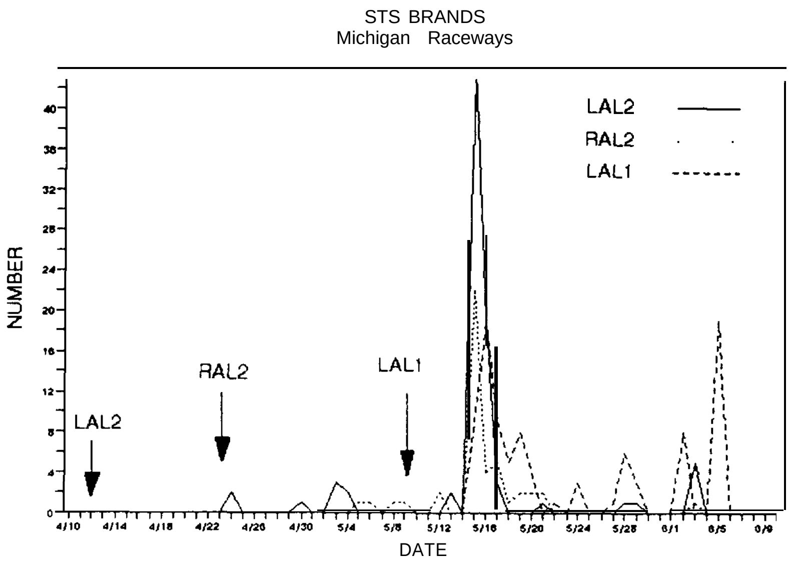


Figure 11. Migration patterns of brand groups of summer steelhead from Umatilla Hatchery collected at West Extension Canal, May and June 1996.

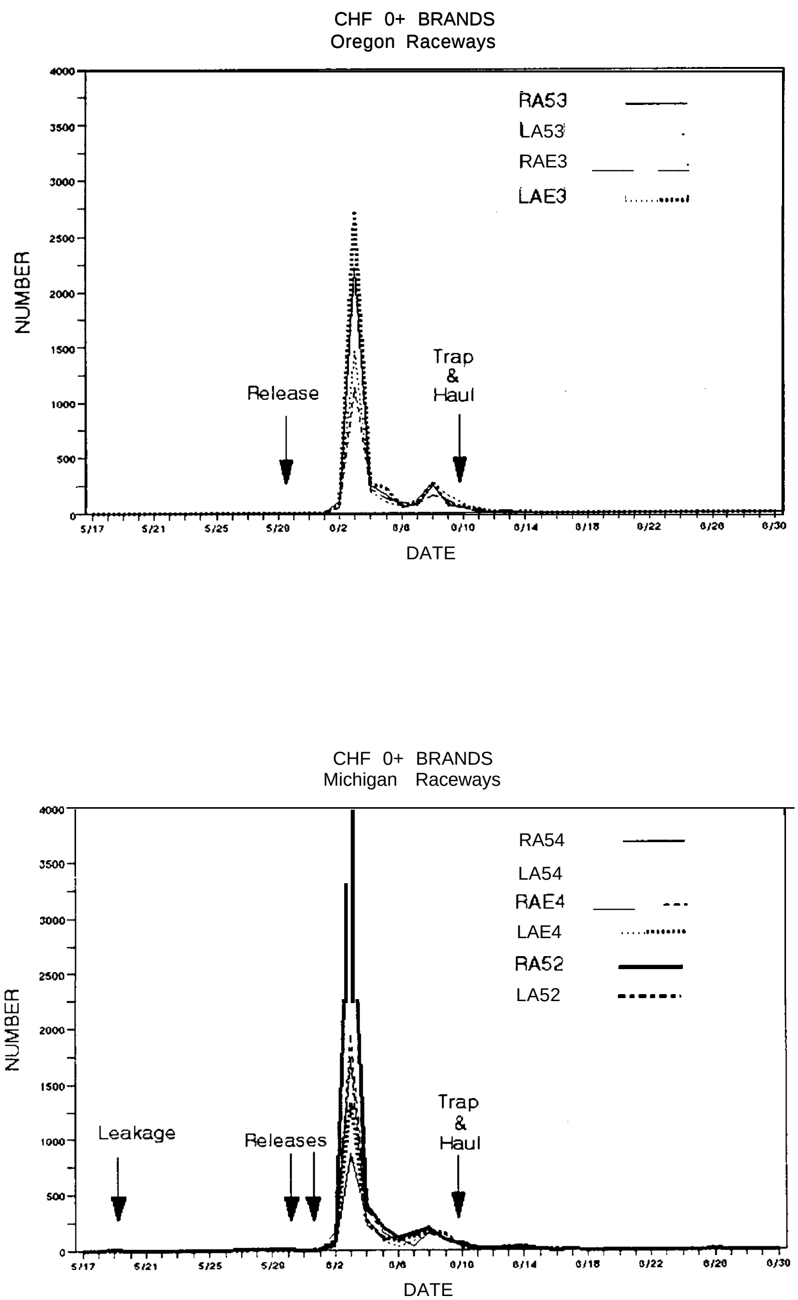


Figure 12. Migration pattern of brand groups of subyearling fall chinook salmon from Umatilla Hatchery collected at West Extension Canal, May and June 1996.

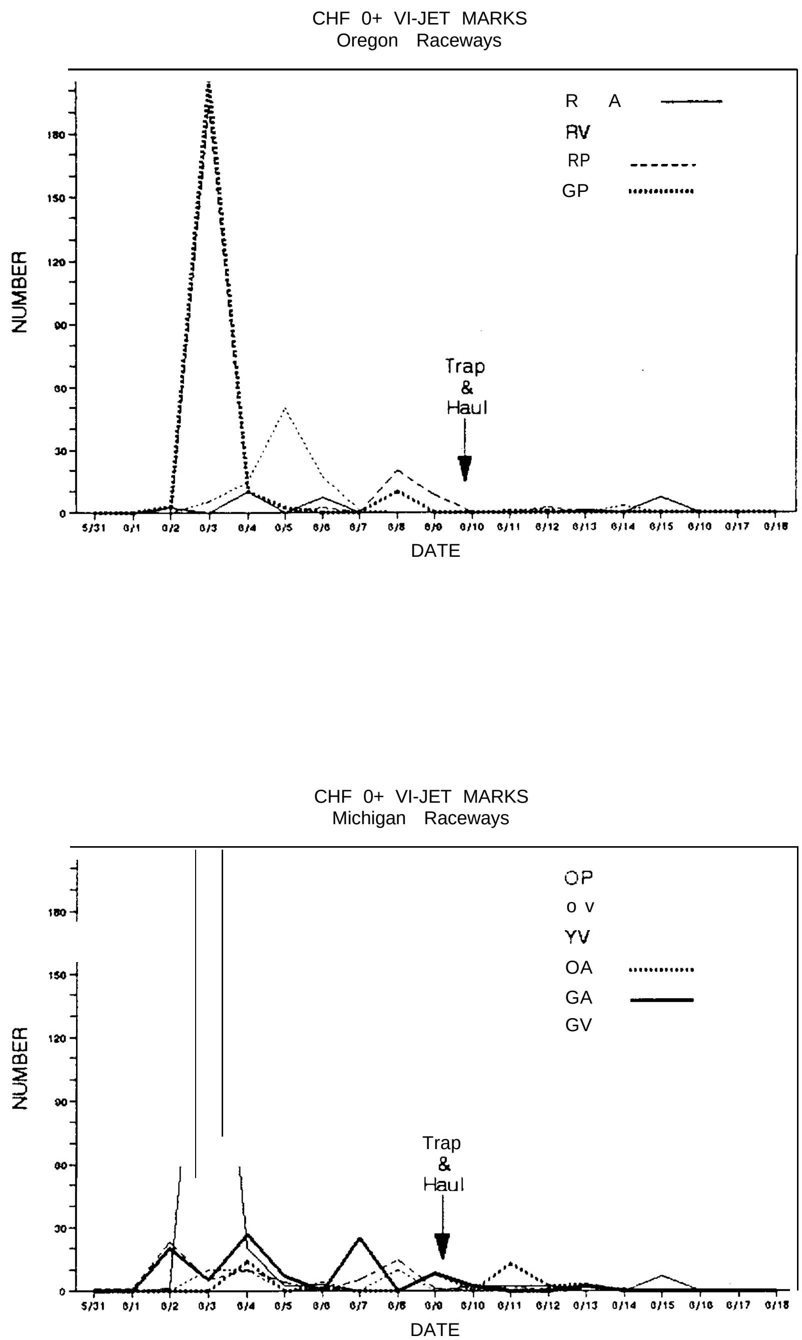


Figure 13. Migration patterns of subyearling fall chinook salmon marked with visual implant colored marks and collected at West Extension Canal, May and June 1996.

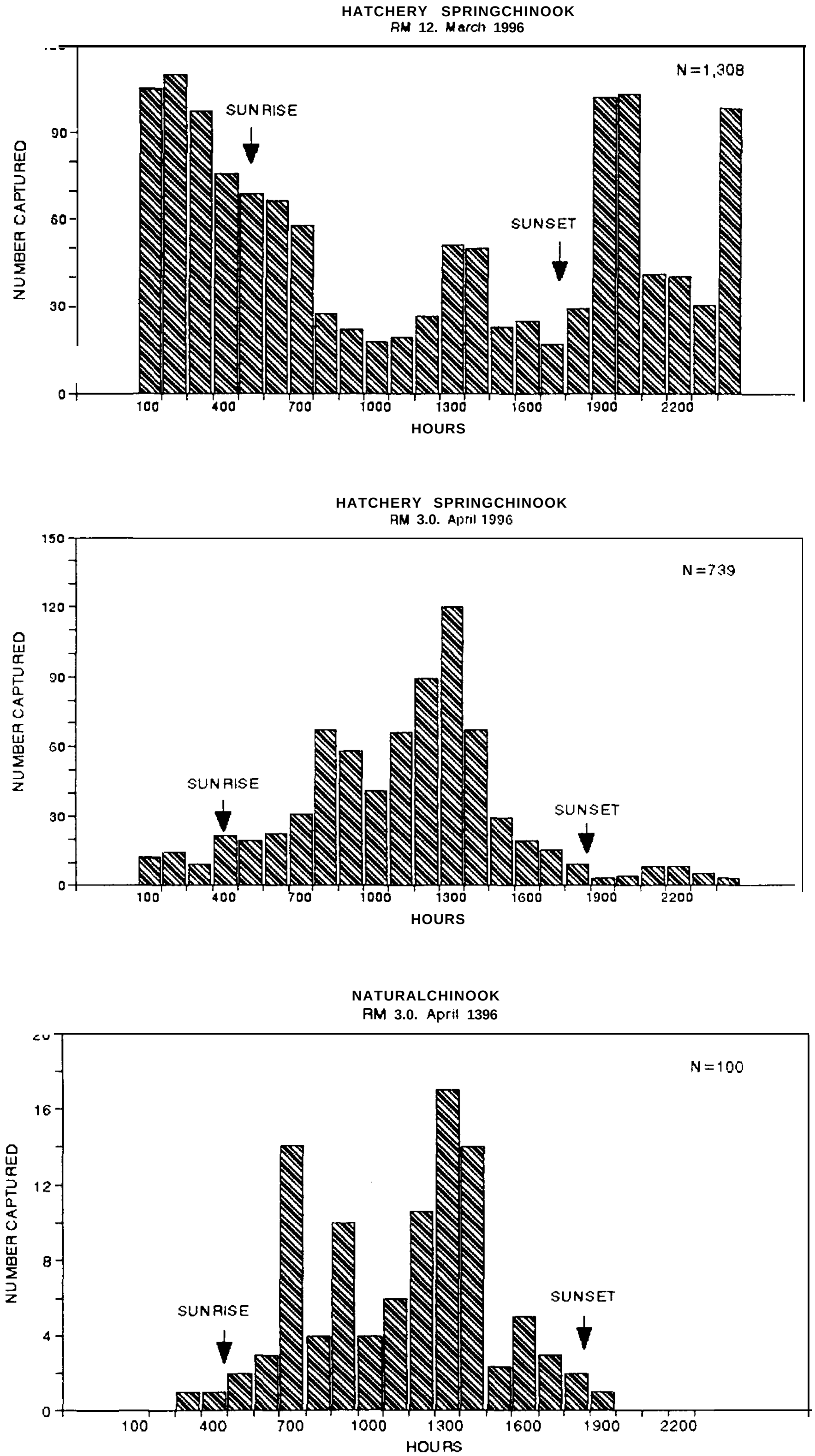


Figure 14. Diel capture of spring chinook salmon at the rotary-screw trap and West Extension Canal, Umatilla River, March - May 1996.

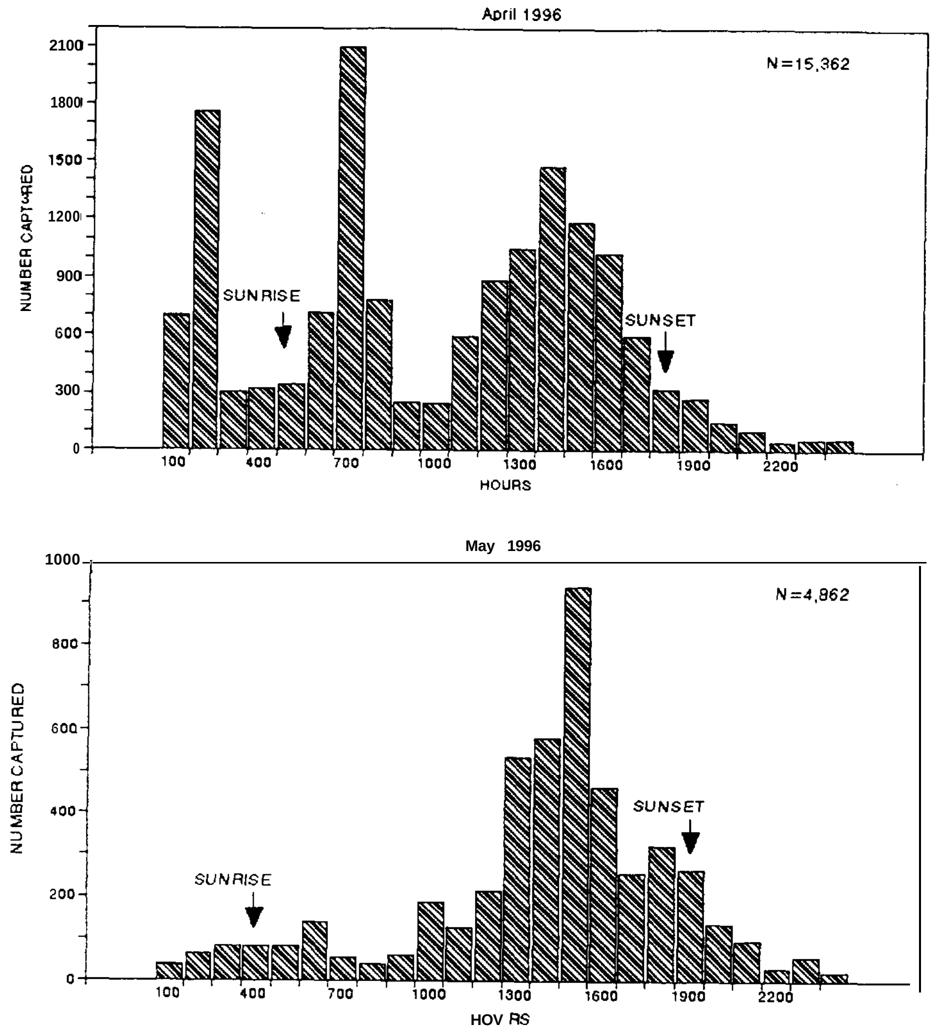


Figure 15. Diel capture of hatchery yearling fall chinook salmon at West Extension Canal, Umatilla River, April and May 1996.

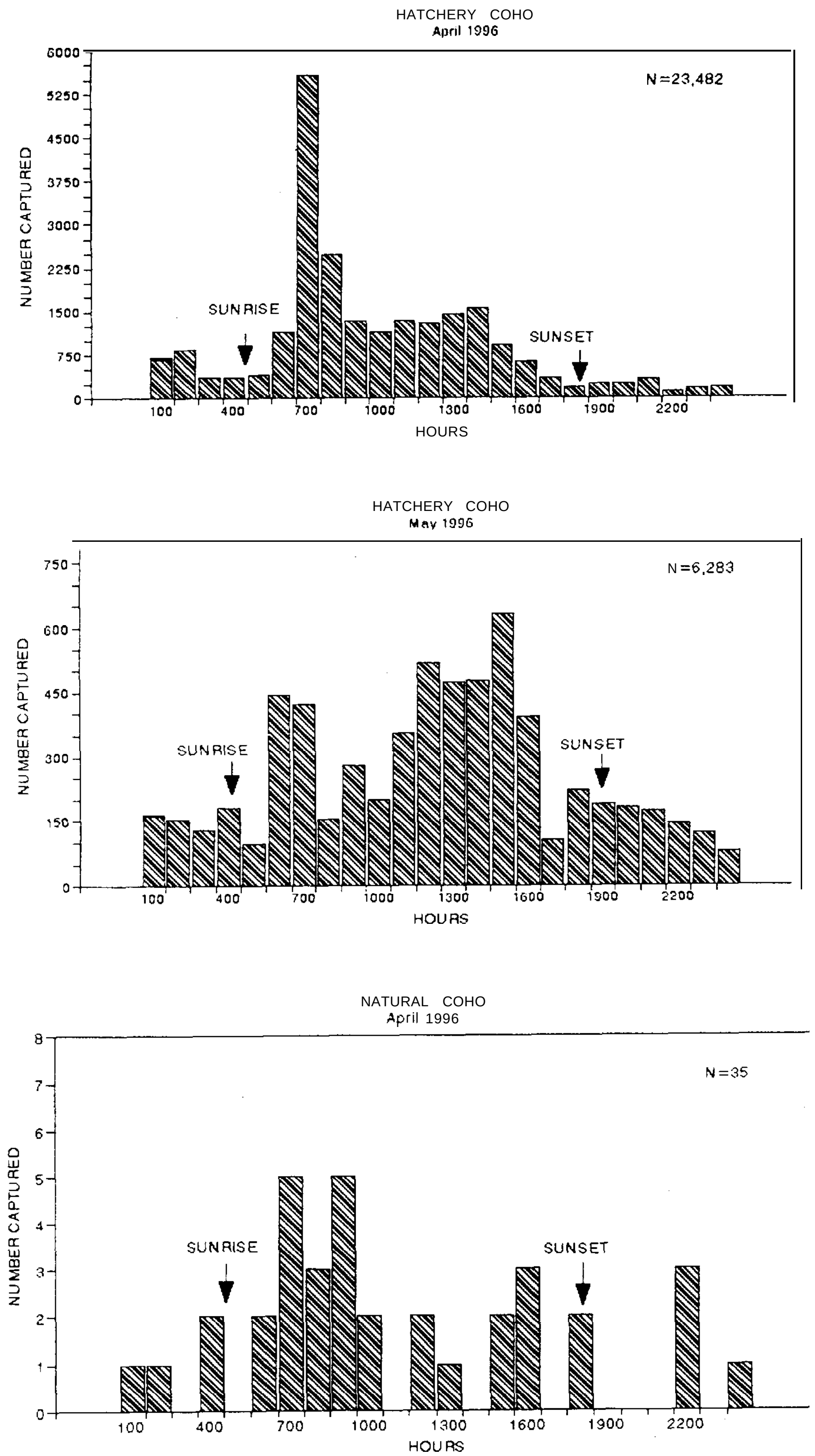


Figure 16. Diel capture of hatchery and natural coho salmon at West Extension Canal, Umatilla River, April and May 1996.

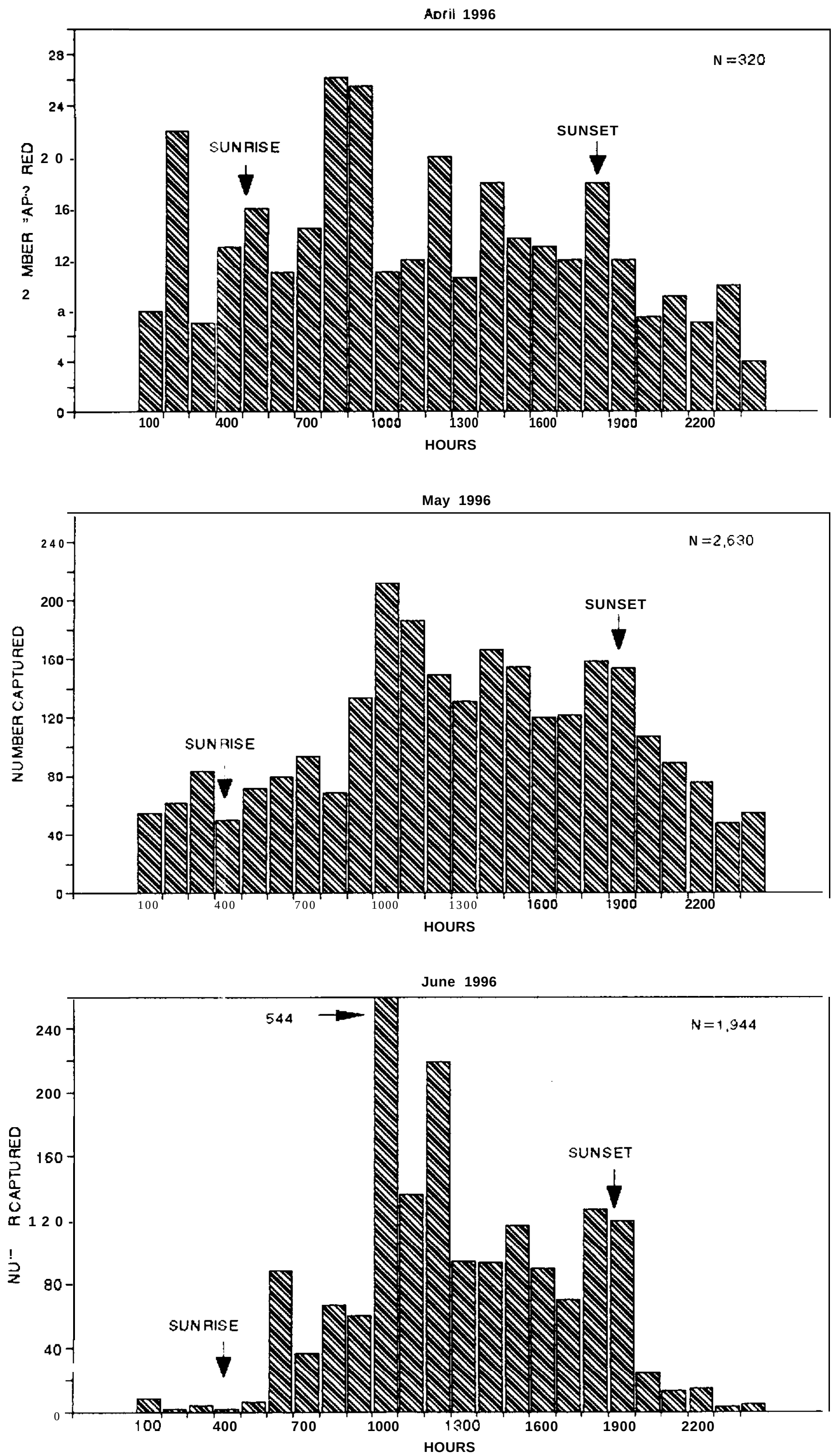


Figure 17. Diel capture of hatchery summer steelhead at West Extension Canal, Umatilla River, April - June 1996.

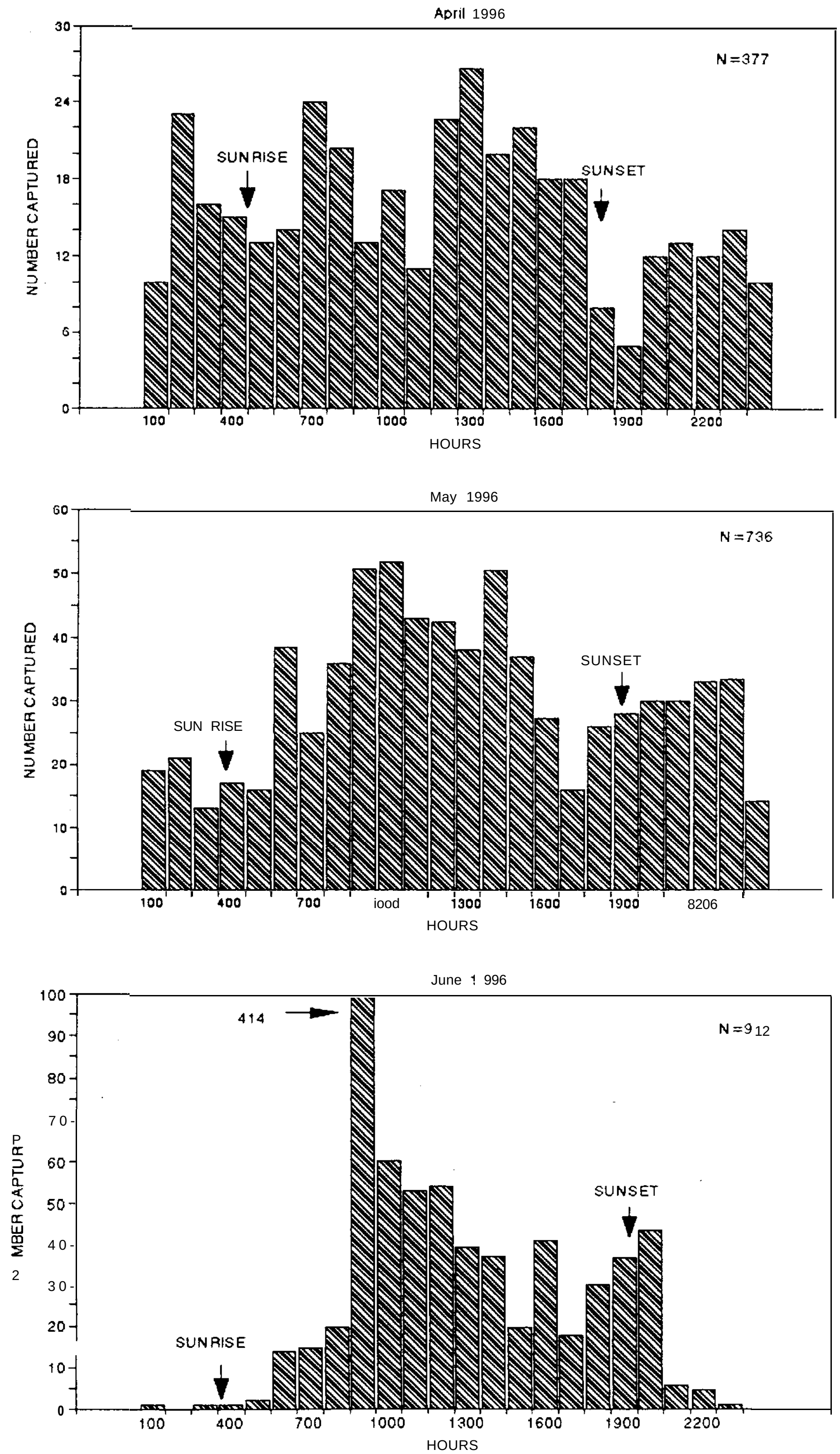


Figure 18. Diel capture of natural summer steelhead at West Extension Canal, Umatilla River, April - June 1996.

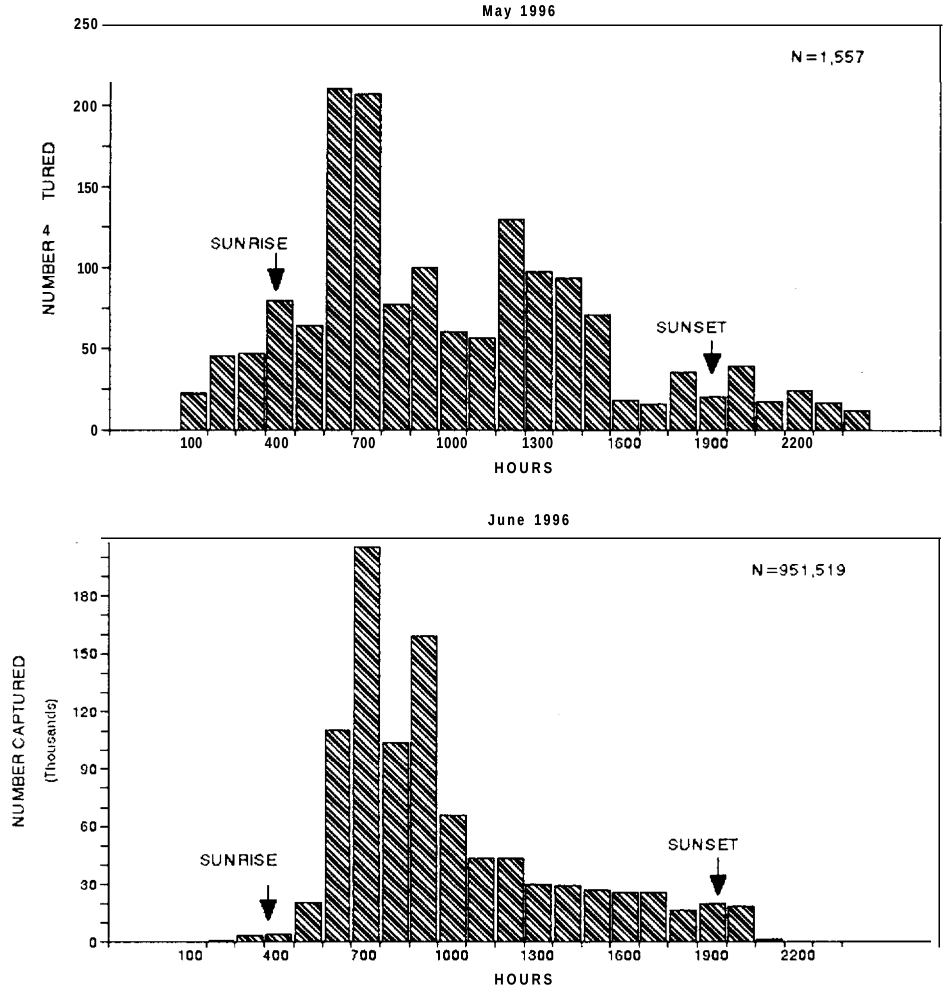


Figure 19. Diel capture of hatchery subyearling fall chinook salmon at West Extension Canal, Umatilla River, May and June 1996.

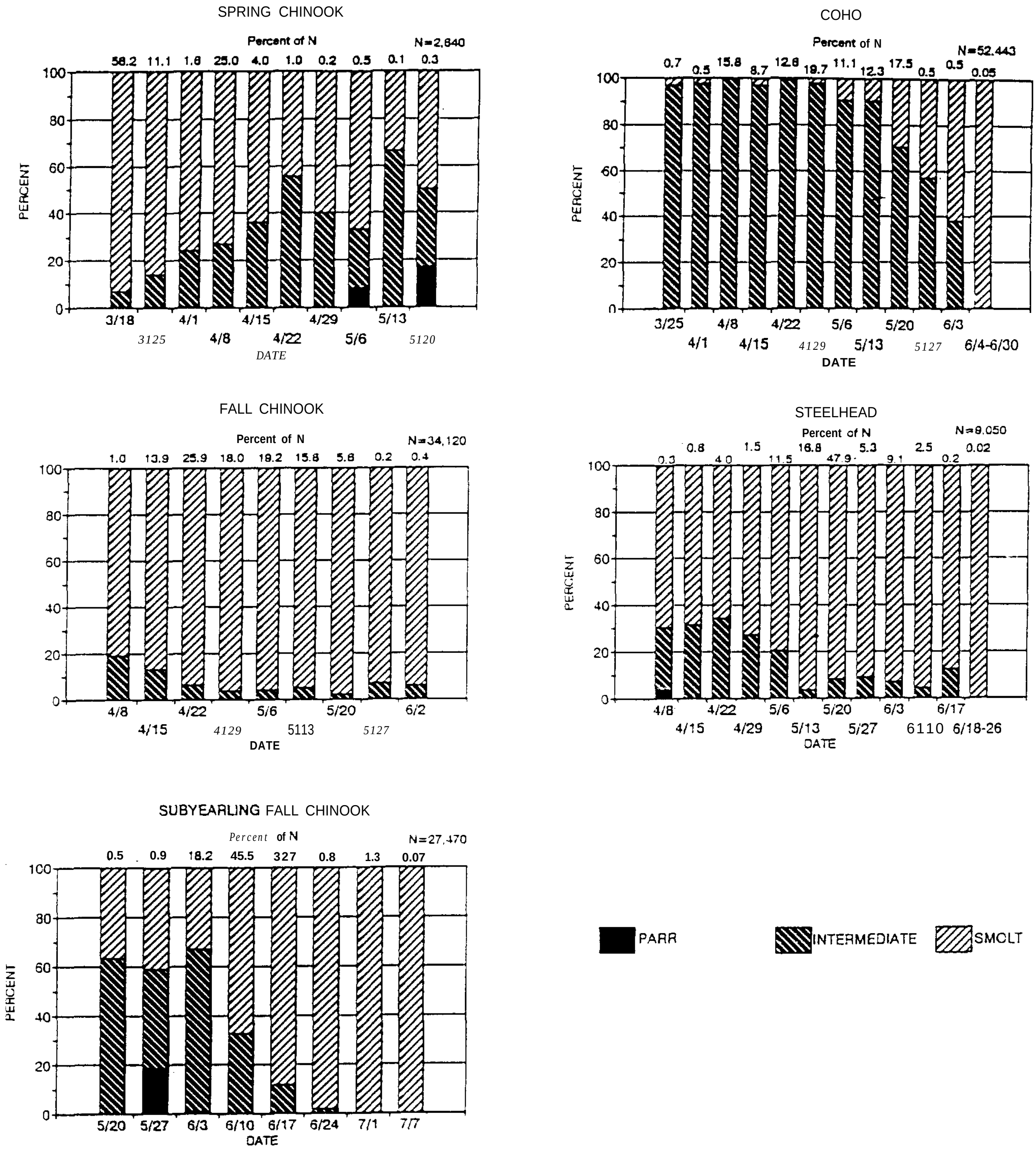


Figure 20. Smolt index for hatchery spring and fall chinook salmon, coho salmon, and summer steelhead collected at the rotary-screw trap and West Extension Canal, Umatilla River, March - August 1996.

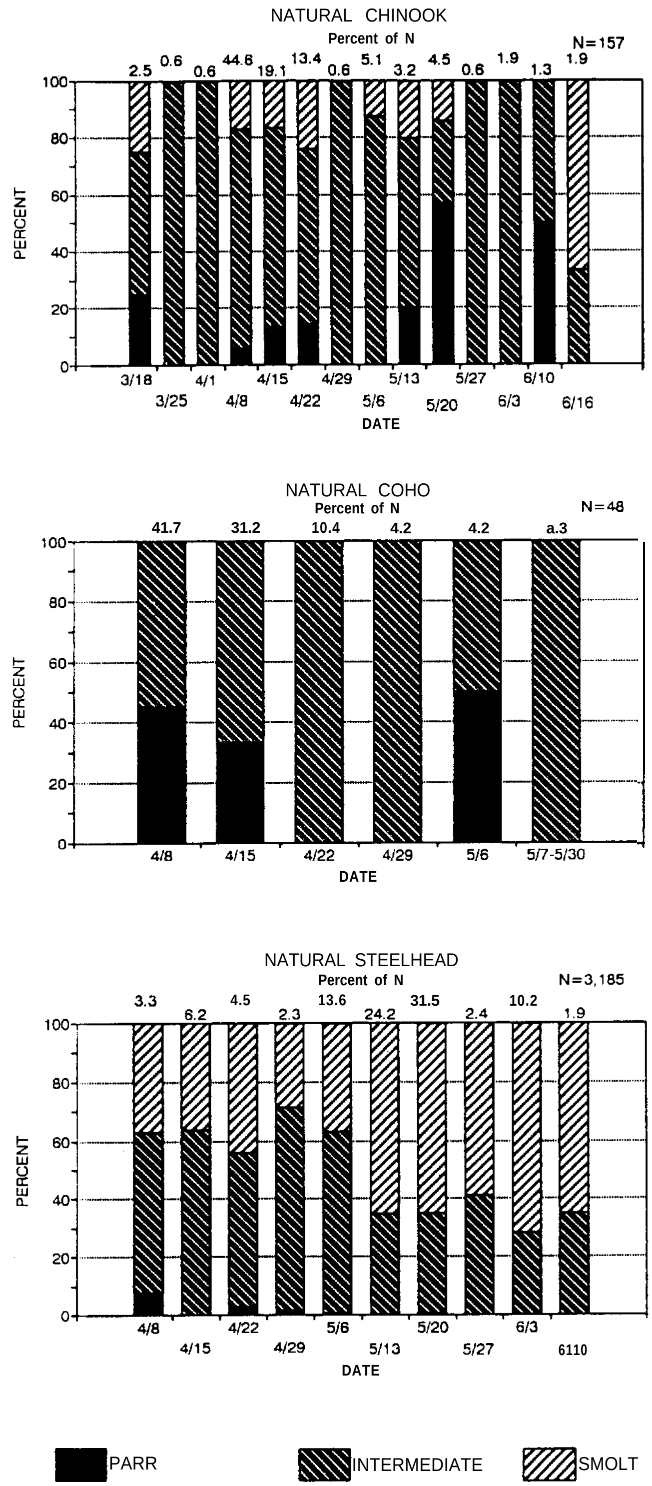


Figure 21. Smolt index for natural chinook and coho salmon and summer steelhead collected at the rotary-screw trap and West Extension Canal, Umatilla River, March - June 1996.

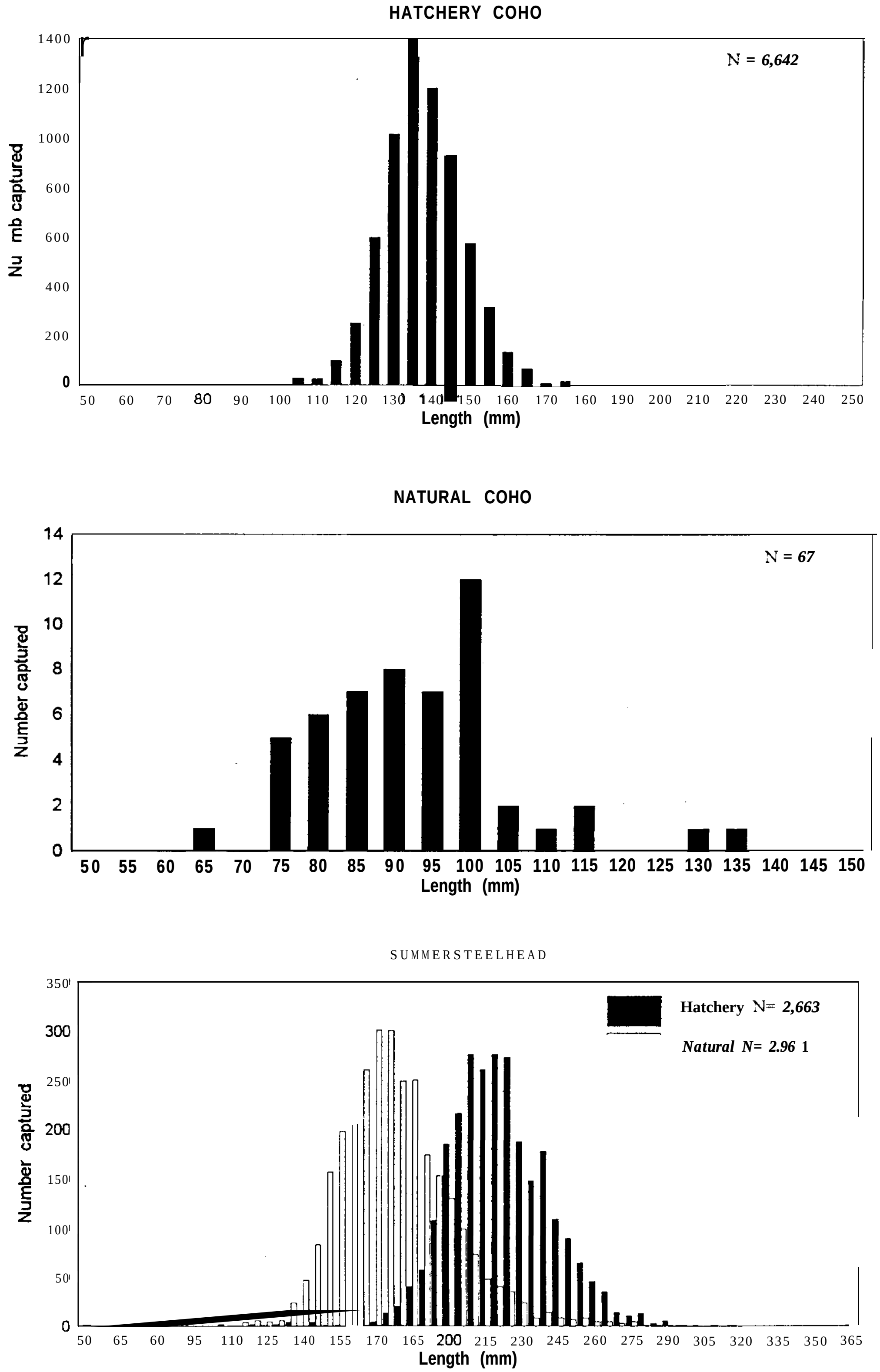


Figure 22. Length-frequency distribution of hatchery and natural coho salmon and summer steelhead collected at trap sites on the lower Umatilla River, October 1995 - September 1996. Distributions are in 5-mm increments.

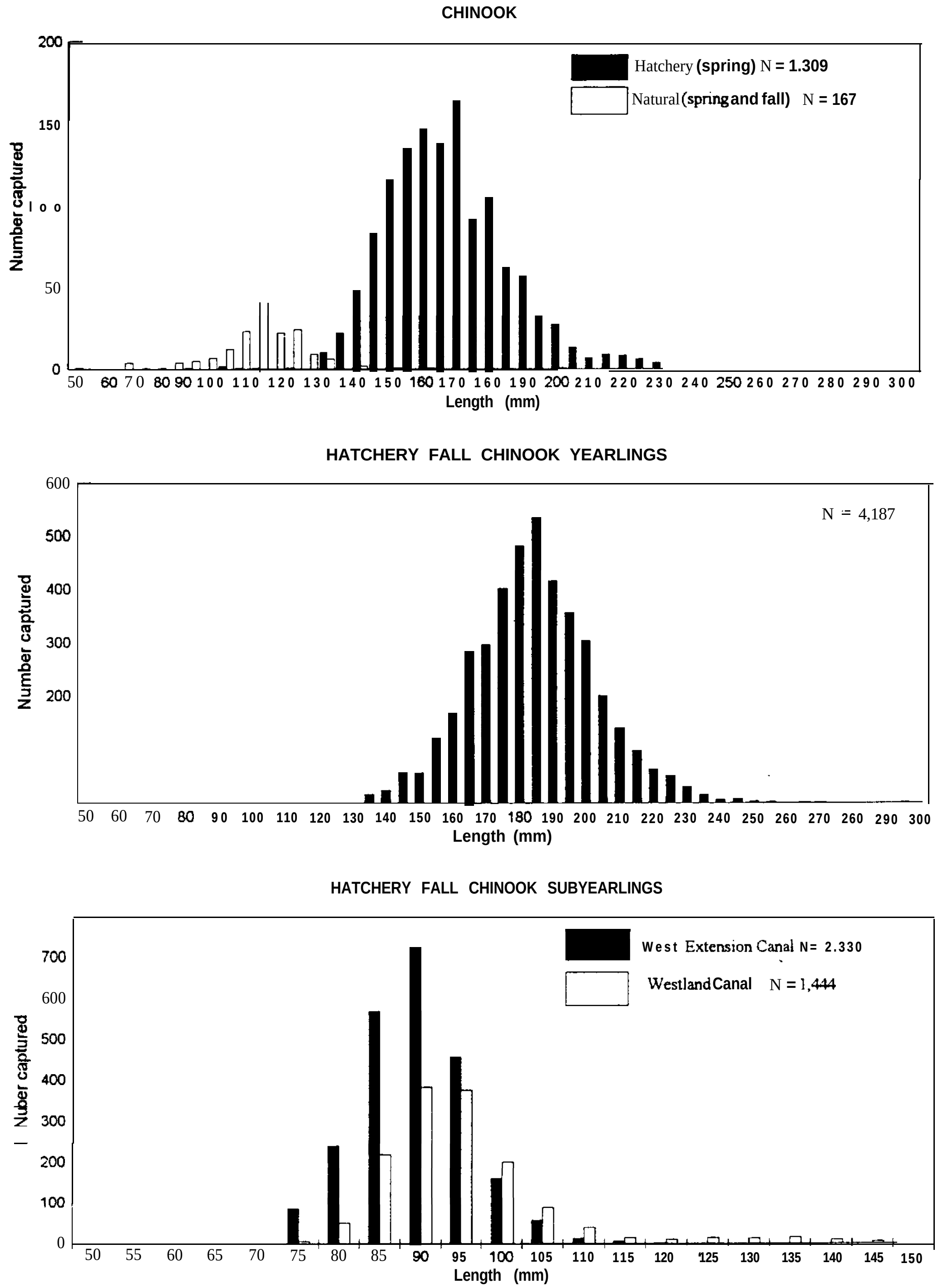


Figure 23. Length-frequency distribution of hatchery and natural chinook salmon collected at trap sites on the lower Umatilla River, October 1995 - September 1996. Distributions are in 5-mm increments.

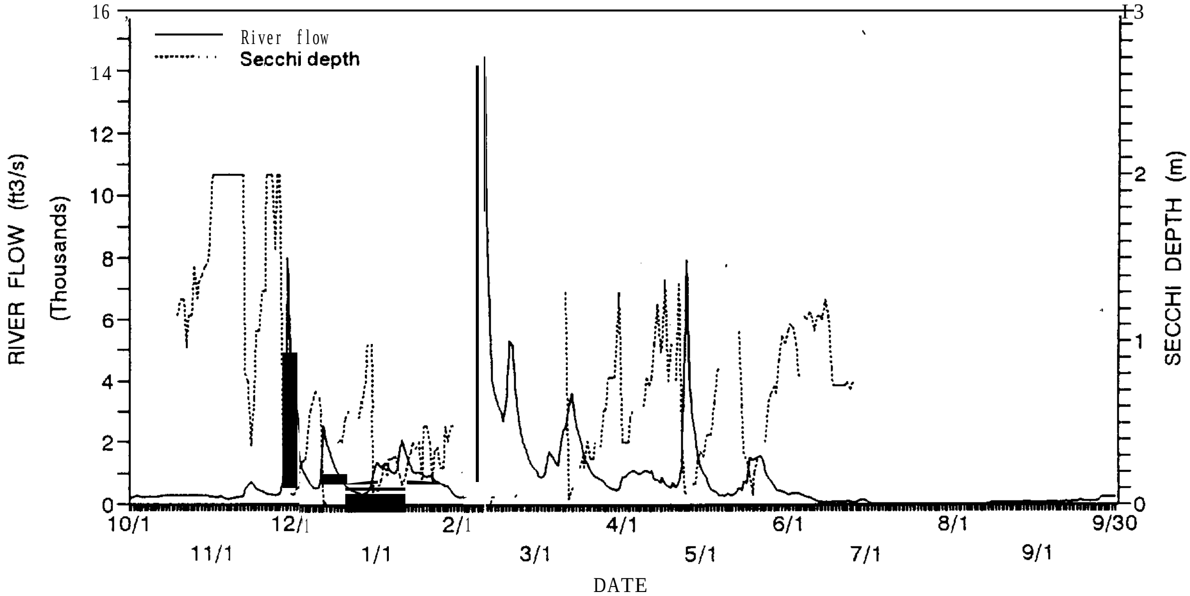


Figure 24. Mean daily river flow (ft^3/s) and Secchi depth (m) measured at RM 1.2 and 3.0, Umatilla River, 1 October 1995- 30 September 1996.

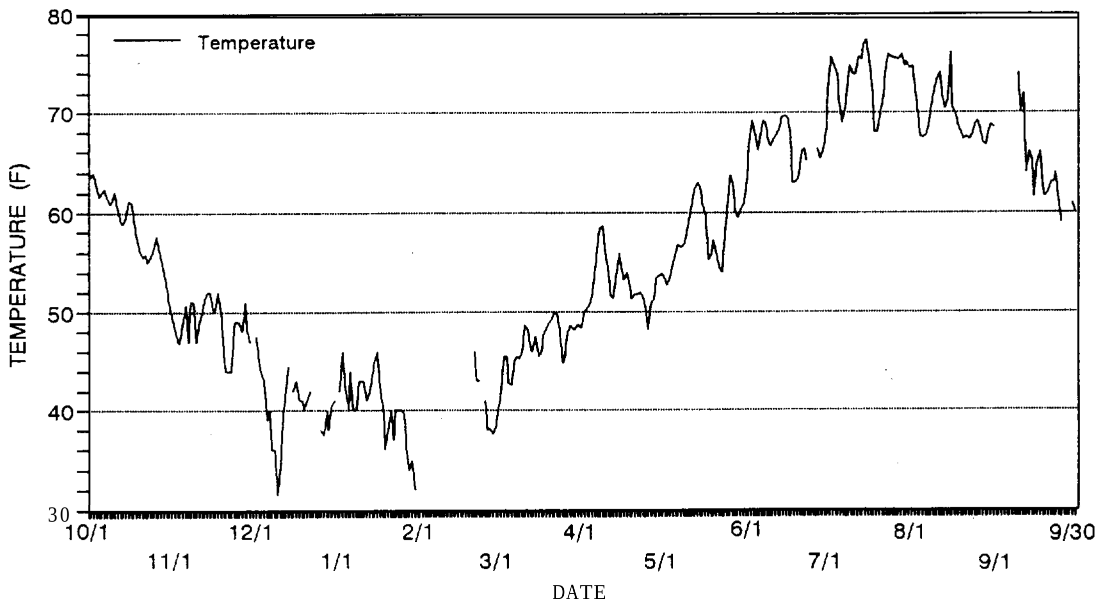


Figure 25. Mean daily water temperature (°F) at RM 3.0, Umatilla River, 1 October 1995 - 30 September 1996. Temperatures reported in CTUIR and ODFW (1996).

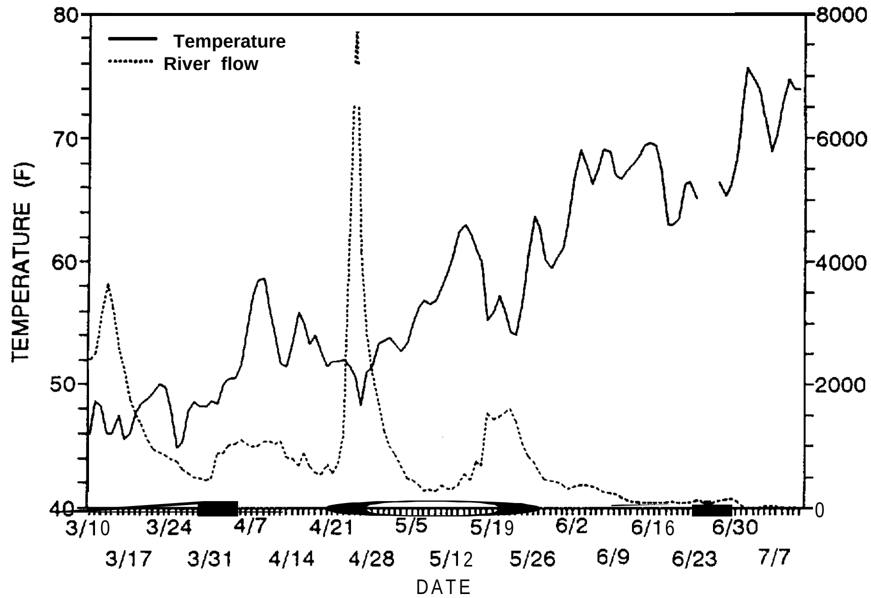


Figure 26. Mean daily water temperature (°F) at Three Mile Falls Dam and mean daily river flow (ft^3/s) near RM 3.0, Umatilla River, 10 March - 11 July 1996. Temperatures reported in CTUIR and ODFW (1996).

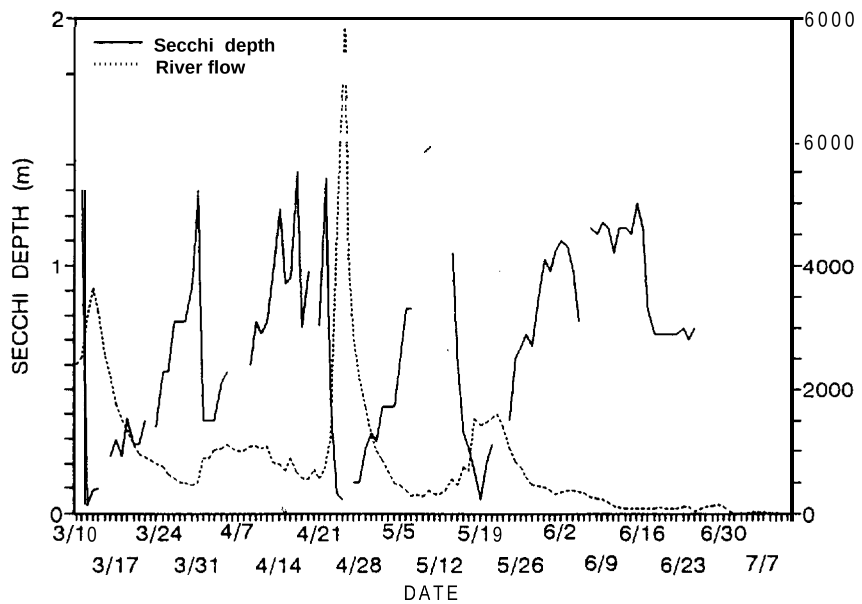


Figure 27. Mean Secchi depth (m) and mean daily river flow (ft^3/s) near RM 3 .0, Umatilla River, 10 March - 1 July 1996.

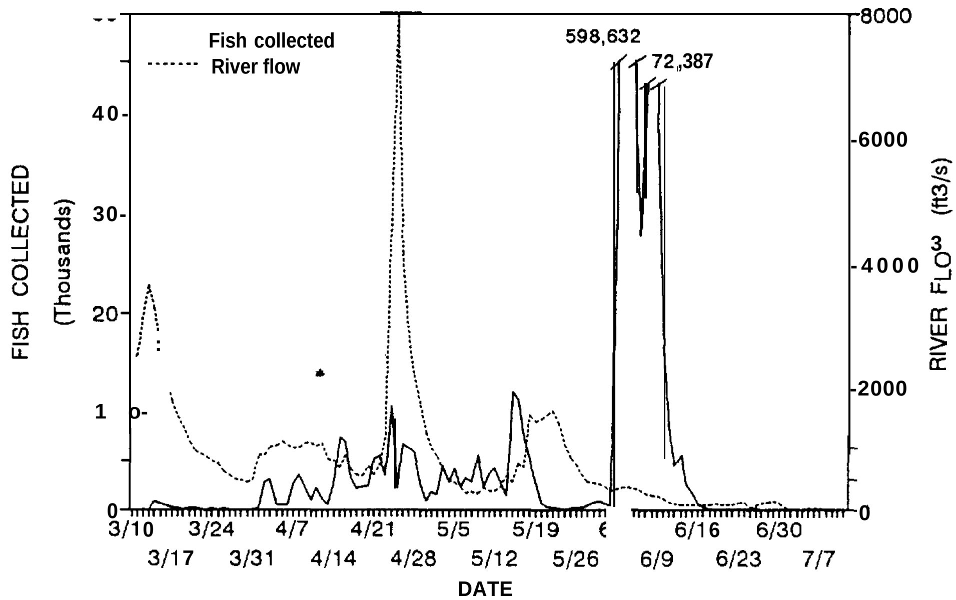


Figure 28. Number ofjuvenile salmonids collected at West Extension Canal and mean daily river flow (ft^3/s) near RM 3 .0, Umatilla River, 10 March - 11 July 1996.

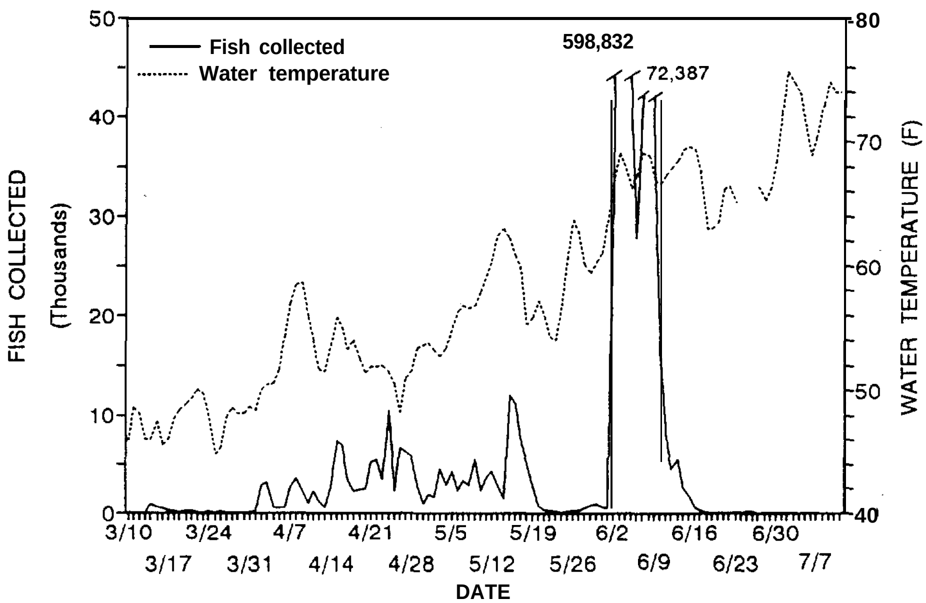


Figure 29. Number ofjuvenile salmonids collected at West Extension Canal and mean daily water temperature (“F) at Three Mile Falls Dam, Umatilla River, 10 March - 11 July 1996. Temperatures reported in CTUIR and ODFW (1996).

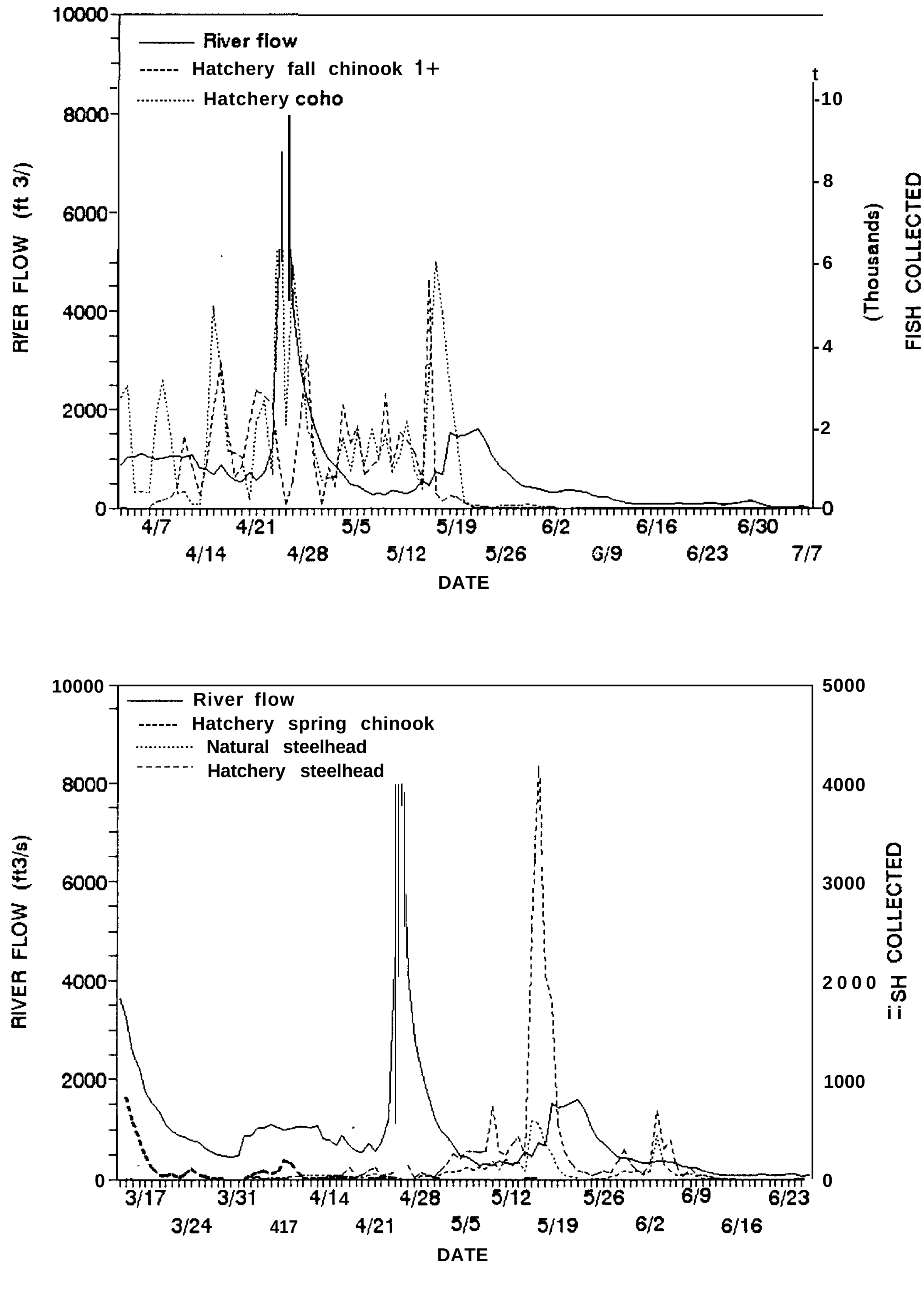


Figure 30. River flow and number of hatchery yearling fall chinook, coho, and spring chinook salmon and natural and hatchery summer steelhead collected at West Extension Canal, Umatilla River, 2 April - 25 June 1996. Hatchery spring chinook salmon were collected with the rotary-screw trap from 13 March - 1 April 1996.

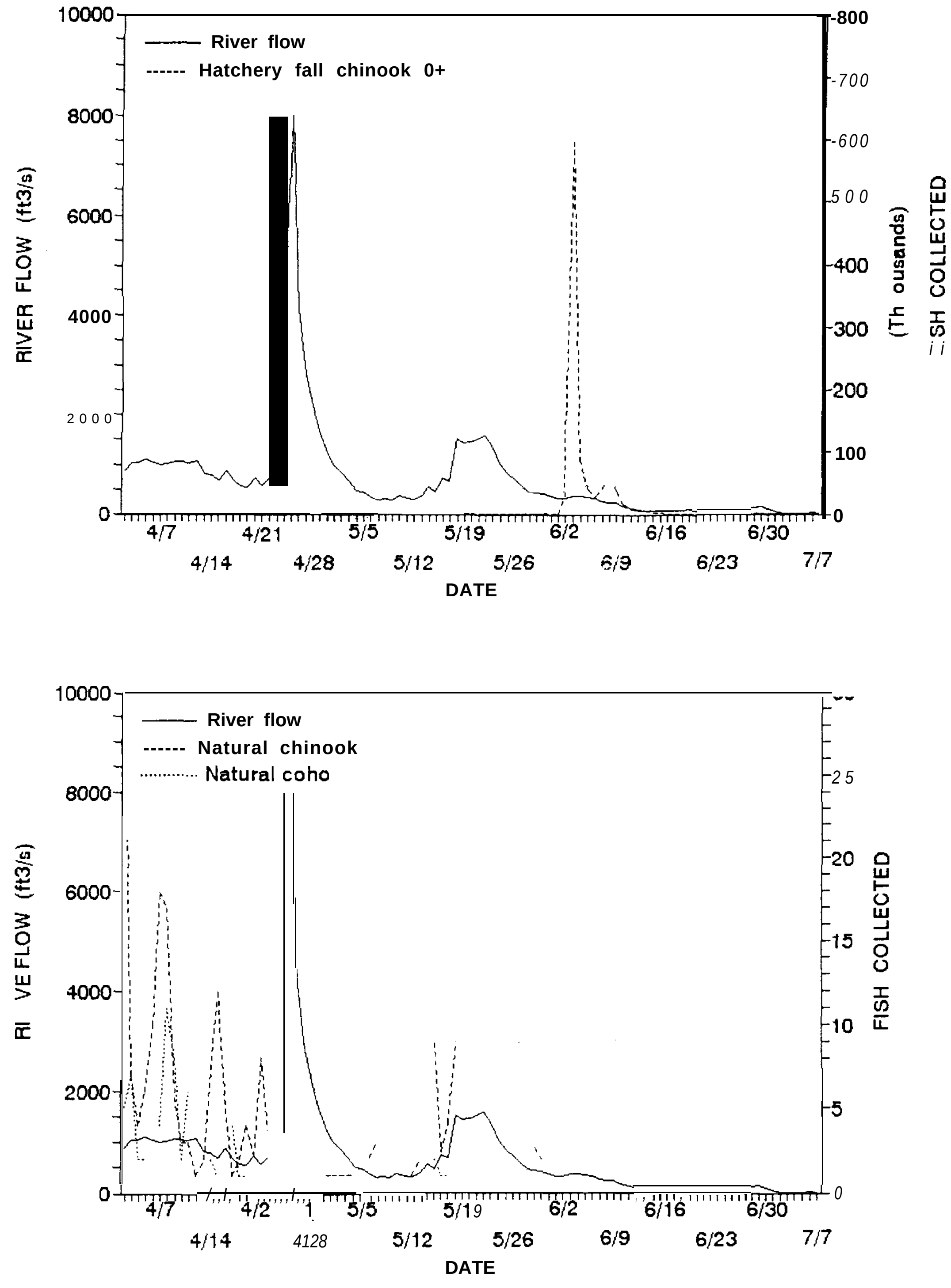


Figure 3 1. River flow and number of hatchery subyearling fall chinook salmon and natural chinook and coho salmon collected at West Extension Canal, Umatilla River, 2 April - 7 July 1996.

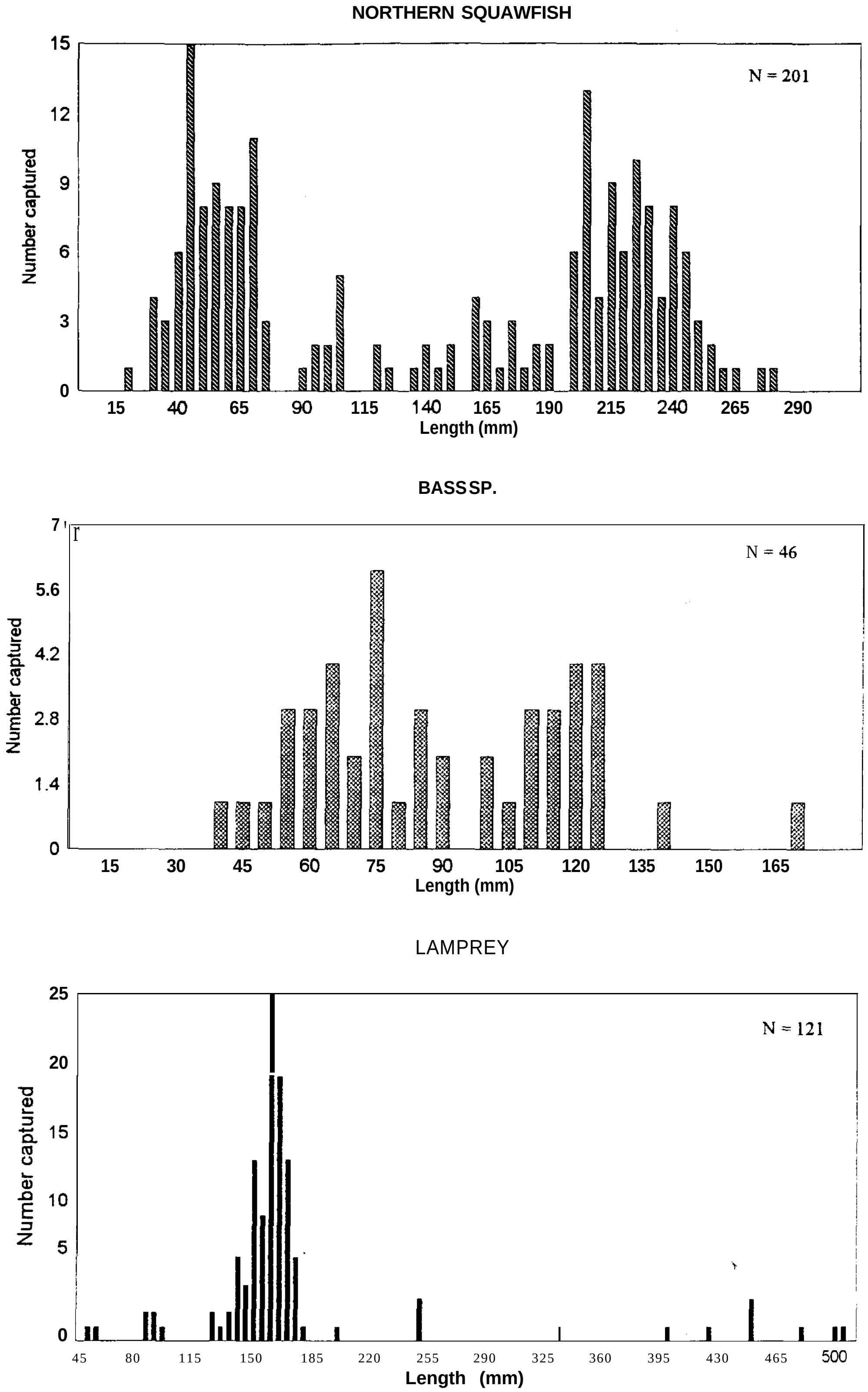


Figure 32. Length-frequency distribution of northern squawfish, bass, and lamprey species collected at trap sites on the lower Umatilla River, October 1995 - September 1996.

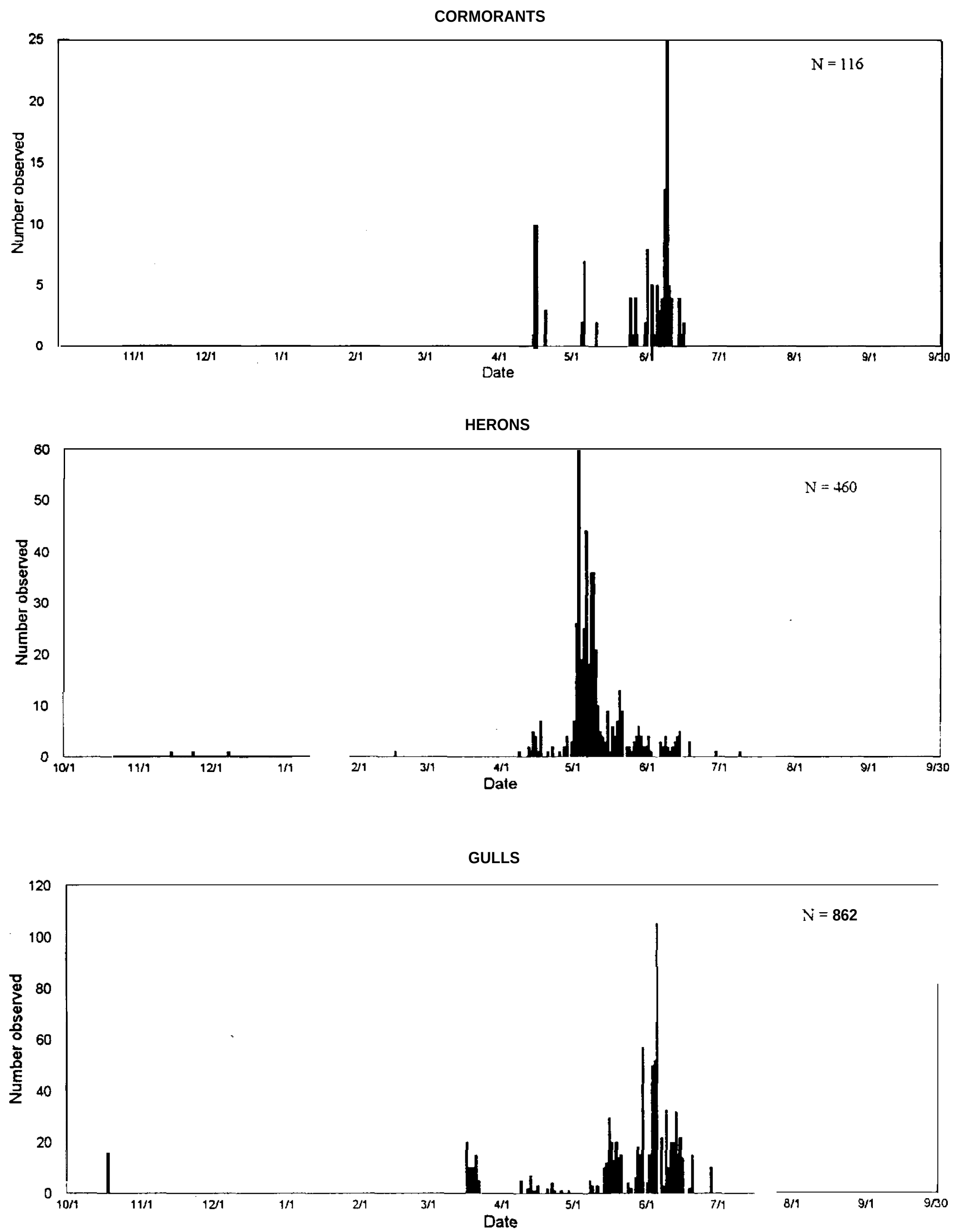


Figure 33. Number of avian predators observed by date at trap sites on the lower Umatilla River, October 1995 - September 1996.

APPENDIX A

Ancillary Information from Outmigration Studies

Appendix Table A-l. Releases of hatchery chinook salmon, coho salmon, and summer steelhead in the Umatilla River, March - May 1996.

Species[a]	Age	Hatchery origin	Release date(s)	Release location	River mile	Number released	Number CWT[b]
CHS	1+	Umatilla	3/13	Imeques	80.0	378,561	137,208
					Total	378,561	137,208
CHF	1+	Bonneville	4/5	Thornhollow	73.5	204,022	27,397
CHF	1+	Bonn./Umat.[c]	4/1 8	Imeques	80.0	360,381	98,544
					Total	564,403	125,941
CHF	0+	Umatilla	5/30	Imeques	80.0	2,106,815	239,728
CHF	0+	Umatilla	5/31	Thornhollow	73.5	853,598	58,328
					Total	2,960,413	298,056
STS	1+	Umatilla	4/12	Minthorn	64.5	47,543	19,742
STS	1+	Umatilla	4/24-4/26	Bonifer	2.0[d]	49,377	21,205
STS	1+	Umatilla	5/9	Thornhollow	73.5	49,783	20,633
					Total	146,703	61,580
COH	1+	L.H.C[e]	3/18-3/25	Barnhart	42.5	465,784	25,000
COH	1+	Cascade	4/2-4/3	Mission	60.0	500,005	25,000
COH	1+	Cascade	4/3-4/12	Barnhart	42.5	511,609	25,000
					Total	1,477,398	75,000

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

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

[c] *Bonneville and Umatilla hatcheries.*

[d] *River mile of Meacham Creek, river mile 79 on Umatilla River.*

[e] *Little Herman Creek Hatchery.*

Appendix Table A-2. Estimated numbers of subyearling fall chinook salmon transported from Westland Canal, Umatilla River, 10 June - 9 August 1996.

Date	Pounds of fish hauled from Westland	CTUIR estimate of fish per pound	ODFW estimate of fish per pound	Interpolated estimate of fish per pound	Number of fish transported
6/10/96	90	50.8	--	--	4,569
6/11/96	480	--	66.1	--	31,704
6/12/96	390	57.0	--	--	22,223
6/13/96	420	--	63.4	--	26,607
6/14/96	4.50	52.9	--	--	23,791
6/15/96	375	--	--	54.0	20,250
6/16/96	320	--	--	54.0	17,280
6/17/96	750	44.8	--	--	33,632
6/18/96	365	--	54.9	--	20,039
6/19/96	150	42.3	--	--	6,341
6/20/96	180	--	56.1	--	10,089
6/21/96	330	43.3	--	--	14,300
6/23/96	180	--	--	46.0	8,276
6/24/96	600	43.0	--	--	25,791
6/25/96	140	--	41.5	--	5,810
6/26/96	175	39.0	--	--	6,828
6/27/96	250	--	--	38.6	9,658
6/28/96	600	38.0	--	--	22,808
6/29/96	180	--	--	35.3	6,359
6/30/96	100	--	--	35.3	3,533
7/01/96	560	32:0	--	--	17,920
7/02/96	690	--	36.0	--	24,840
7/03/96	150	--	--	34.0	5,100
7/05/96	30	--	--	34.0	1,020
7/09/96	60	22.3	--	--	1,335
7/11/96	35	26.9	--	--	943
7/16/96	50	20.7	--	--	1,037
7/18/96	40	15.0	--	--	598
7/23/96	45	19.6	--	--	883
7/25/96	45	6.6	--	--	296
7/26/96	40	--	--	7.4	296
7/29/96	50	--	--	7.4	370
7/31/96	25	8.2	--	--	205
8/01/96	3 0	--	--	5.1	153
8/05/96	150	--	--	5.1	765
8/07/96	90	2.0	--	--	177
8/09/96	100	--	--	2.0	200

Appendix Table A-3. Transport data during transport evaluation tests for fish transported from Westland Canal to the lower Umatilla River, 11 June - 25 July 1996.

Date of transport	Transport vehicle	Capacity (gallons)	Pounds hauled	Density (lbs. of fish/gal)	Loading method	Water temp. in tank
6/11/96	Trailer	375	150	0.4	Dipnet	--
6/12/96	Trailer	375	160	0.4	Dipnet	68
6/12 T^2	Trailer	375	80	0.2	Dipnet	68
6/13/96	Tanker	3000	350	0.1	Fish pump	67
6/14/96	Tanker	3000	450	0.2	Fish pump	67
6/17/96	Tanker	3000	750	0.3	Fish pump	--
6/18/96	Tanker	3000	275	0.1	Fish pump	66
6/19/96	Trailer	375	150	0.4	Dipnet	65
6/20/96	Trailer	375	180	0.5	Dipnet	60
6/21/96	Trailer	375	200	0.5	Dipnet	65
6/21 T^2	Trailer	375	130	0.3	Dipnet	64
6/24/96	Tanker	3000	600	0.2	Fish pump	--
6/25/96	Trailer	375	140	0.4	Dipnet	66
6126196	Trailer	375	250	0.7	Dipnet	64
6/28/96	Trailer	375	200	0.5	Dipnet	65
7/01/96	Trailer	375	150	0.4	Dipnet	--
7/02/96	Tanker	3000	600	0.2	Fish pump	68
7/03/96	Trailer	375	150	0.4	Dipnet	--
7/05/96	Trailer	375	30	0.1	Dipnet	67
7/09/96	Trailer	375	60	0.2	Dipnet	69
7/11/96	Trailer	375	35	0.1	Dipnet	70
7/23/96	Trailer	375	45	0.1	Dipnet	--
7/25/96	Trailer	375	45	0.1	Dipnet	--

T^2 *Treatment group taken from subsequent loads of fish transported from Westland Canal to lower Umatilla River boat ramp.*

Appendix Table A-4. Observations of environmental and hydraulic parameters at West Extension Canal, Umatilla River, 2 April - 11 July 1996.

Date	Hour	River flow’	Water turbidity”	Debris level[a]	Water color	River elevation’	Canal elevation[b]	Air temperature’ Min.	Air temperature’ Max
4/02/96	1400	M	L	L	Green	404.8	403.9	--	--
	2000	M	L	L	Green	--	--	--	--
4/03/96	0800	M	MH	L	Green	404.9	404.1	36	57
	1400	M	M	L	Green	404.9	404.3	--	--
	2000	M	M	L	Green	404.9	404.2	--	--
4/04/96	0200	MH	--	L	Dk. green	404.9	404.2	--	--
	0800	MH	--	L	Green	404.9	404.1	30	60
	1400	M	M	L	Green	404.9	404.0	--	--
	2000	M	M	L	Green	404.8	404.1	--	--
4/05/96	0200	M	M	L	Green	404.9	404.2	--	--
	0800	M	M	L	Green	404.9	404.2	40	76
	1400	M	M	L	Green	404.9	404.1	--	--
	2000	M	M	L	Green	404.9	404.1	--	--
4/06/96	0200	M	M	L	Green	404.9	404.2	--	--
	0800	M	M	L	Green	404.9	404.1	42	74
	1400	M	M	L	Green	404.9	404.1	--	--
	2000	M	M	L	Green	404.9	404.1	--	--
4/07/96	0200	M	M	L	Green	404.9	404.1	--	--
	0800	M	M	L	Green	404.8	404.1	51	84
	1400	M	M	L	Green	404.8	404.1	--	--
	2000	M	L	L	Green	404.8	404.1	--	--
4/08/96	0200	M	L	L	Green	404.8	404.1	--	--
	0800	M	L	L	Green	404.8	404.1	52	82
	1400	M	L	L	Green	404.9	404.4	--	--
	2000	M	L	L	Green	404.8	404.3	--	--
4/09/96	0200	M	L	L	Green	404.9	404.3	--	--
	0800	M	L	L	Green	404.9	404.3	44	84
	1400	M	L	L	Green	404.9	404.2	--	--
	2000	M	L	L	Green	404.9	404.2	--	--
4/10/96	0200	M	L	L	Green	404.9	404.2	--	--
	0800	M	L	L	Green	404.9	404.2	48	77
	1400	M	L	L	Green	404.9	404.1	--	--
	2000	M	L	M	Green	404.9	404.2	--	--
4/11/96	0800	M	M	L	Lt. brown	404.9	404.1	50	66
	1400	M	M	L	Lt. brown	404.9	404.1	--	--
	2000	M	M	L	Lt. brown	404.9	404.1	--	--
4/12/96	0200	M	L	L	Green	404.9	404.1	--	--
	0800	M	L	L	Green	404.9	404.2	42	65

Appendix Table A-4. Continued.

Date	Hour	River flow[a]	Water turbidity’	Debris level’	Water color	River elevation[b]	Canal elevation’	Air temperature[c] Min.	Max.
4/12/96	1400	M	L	L	Green	404.9	404.2	--	--
	2000	M	L	L	Green	404.9	404.2	--	--
4/13/96	0200	M	M	M	Dk. green	404.8	404.1	--	--
	0800	M	M	M	Dk. green	404.8	404.1	47	60
	1400	M	L	L	Dk. green	404.7	404.1	--	--
	2000	M	L	L	Lt. green	404.7	404.1	--	--
4/14/96	0200	M	L	L	Lt. green	404.8	404.1	--	--
	0800	M	L	L	Lt. green	404.8	404.1	40	65
	1400	M	L	L	Lt. green	404.7	404.0	--	--
	2000	M	L	L	Lt. green	404.7	404.1	--	--
4/15/96	0200	M	L	M	Green	404.7	404.1	--	--
	0800	M	L	M	Green	404.7	404.1	42	74
	1400	M	L	--	Green	404.7	404.1	--	--
	2000	M	L	L	Lt green	404.7	404.1	--	--
4/16/96	0200	M	L	M	Lt green	404.9	404.3	--	--
	0800	M	L	L	Lt. green	404.9	404.3	54	75
	1700	M	L	L	Lt. green	404.9	404.2	--	--
	2000	M	L	L	Green	404.8	404.2	--	--
4/17/96	0200	M	M	L	Green	404.8	404.2	--	--
	0800	M	M	L	Green	404.7	404.2	40	68
	2000	M	L	L	Green	404.6	404.0	--	--
4/18/96	0200	M	L	L	Green	404.6	404.1	--	--
	0800	M	L	L	Green	404.6	404.1	43	64
	1400	M	L	L	Green	404.7	404.1	--	--
	2000	M	L	L	Green	404.6	404.1	--	--
4/19/96	0200	M	L	L	Green	404.6	404.1	--	--
	0800	M	L	L	Green	404.6	404.1	38	62
	1400	M	L	L	Green	404.6	404.1	--	--
	2000	M	L	L	Lt. green	404.6	404.1	--	--
4/20/96	0200	M	L	L	Green	404.6	404.1	--	--
	0800	M	L	L	Green	404.6	404.1	37	65
	1430	M	L	L	Green	404.8	404.3	--	--
4/21/96	0200	M	L	L	Green	404.6	404.1	--	--
	0800	M	L	L	Dk. green	404.6	404.1	39	62
	1400	M	L	L	Dk. green	404.6	404.1	--	--
	2000	M	L	L	Dk. green	404.6	404.1	--	--
4/22/96	0800	M	L	L	Green	404.7	404.1	41	67
	1400	M	L	L	Green	404.7	404.2	--	--
	2000	M	L	L	Green	404.7	404.0	--	

Appendix Table A-4. Continued.

Date	Hour	River flow[a]	Water turbidity”	Debris level’	Water color	River elevation[b]	Canal elevation’	Air temperature[c] Min.	Max.
4/23/96	0800	M	L	L	Lt. brown	404.9	404.2	30	66
	2000	M	L	L	Green	405.1	404.4	--	--
4/24/96	0430	H	H	H	Chocolate	406.1	405.4	--	--
	0800	--	--	--	--	--	--	34	72
	1300	H	H	H	Chocolate	406.3	404.1	--	--
	1500	H	H	H	Chocolate	406.2	404.2	--	--
	1930	H	H	H	Chocolate	406.5	403.5	--	--
4/25/96	0800	--	--	--	--	--	--	42	62
	1000	H	H	H	Chocolate	406.6	404.1	--	--
	1400	H	H	H	Chocolate	406.5	404.0	--	--
	2000	H	H	H	Chocolate	406.3	404.0	--	--
4/26/96	0900	H	H	H	Chocolate	405.7	404.2	58	68
	1400	H	H	H	Chocolate	405.8	404.1	--	--
	2000	H	H	H	Chocolate	405.7	404.0	--	--
4/27/96	0800	--	--	--	--	--	--	42	64
	1200	H	H	M	Brown	405.6	404.3	--	--
	1400	H	H	M	Bown	405.6	404.3	--	--
	2000	H	H	M	Brown	405.5	404.3	--	--
4/28/96	0200	MH	M	L	Lt. brown	405.5	404.3	--	--
	0800	H	M	M	Lt. brown	405.4	404.2	34	65
	1400	H	M	M	Lt. brown	405.3	404.1	--	--
	2000	--	M	L	Lt. brown	405.4	404.2	--	--
4/29/96	0200	MH	M	L	Lt. brown	405.4	404.2	--	--
	0800	MH	M	L	Lt. brown	405.2	404.2	49	70
	1400	MH	M	L	Lt. brown	405.1	404.1	--	--
	2000	M	M	L	Brown	405.1	404.1	--	--
4/30/96	0200	M	L	L	Lt. brown	405.0	404.2	--	--
	0800	M	L	L	Lt. brown	405.0	404.2	52	75
	1400	M	L	L	Lt. brown	405.0	404.0	--	--
	2000	M	L	L	Lt. brown	404.9	404.0	--	--
5/01/96	0200	M	L	L	Lt. brown	404.9	404.0	--	--
	0800	M	L	L	Lt. brown	404.9	404.0	50	76
	1430	M	L	L	Lt. brown	404.8	404.3	--	--
	2000	M	L	L	Lt. brown	404.8	404.3	--	--
5/02/96	0200	M	M	L	Brown	404.8	404.2	--	--
	0800	M	M	L	Brown	404.8	404.2	47	68
	1400	M	M	L	Brown	404.8	404.1	--	--
	2000	M	M	L	Brown	404.8	404.1	--	--
5/03/96	0200	M	M	L	Dk. green	404.7	404.1	--	--

Appendix Table A-4. Continued.

Date	Hour	River flow[a]	Water turbidity[a]	Debris level[a]	Water color	River elevation[b]	Canal elevation[b]	Air temperature[c] Min.	Max.
5/03/96	0800	--	--	--	Dk. green	404.7	404.1	39	63
	1400	M	M	L	Dk. green	404.6	404.1	--	--
	2000	M	L	L	Dk. green	404.6	404.0	--	--
5/04/96	0200	M	ML	L	Dk. green	404.5	404.0	--	--
	0800	M	ML	L	Dk. green	404.6	404.1	39	61
	1400	M	L	L	Brown	404.5	404.0	--	--
5/05/96	0200	M	L	L	Dk. green	404.5	404.1	--	--
	0800	M	L	L	Dk. green	404.5	404.1	54	65
	1400	M	L	L	Green	404.5	404.1	--	--
	2100	M	L	L	Lt. green	404.5	404.0	--	--
5/06/96	0200	M	L	L	Dk. green	404.5	404.0	--	--
	0800	M	L	L	Dk.green	404.4	404.1	54	69
	1400	M	L	L	Dk. green	404.4	404.0	--	--
	2130	M	L	L	Lt. green	404.4	404.0	--	--
5/07/96	0800	M	L	L	Green	404.4	404.0	47	70
	1400	ML	L	L	Green	404.3	404.0	--	--
	2000	L	L	L	Lt. green	404.4	404.1	--	--
5/08/96	0200	M	L	L	Green	404.4	404.1	--	--
	0800	M	L	L	Green	404.4	404.1	35	70
	1400	L	L	L	Green	404.4	404.2	--	--
	2000	L	L	L	Lt. green	404.3	404.1	--	--
5/09/96	0200	L	L	L	Green	404.4	404.0	--	--
	0800	L	L	L	Green	404.4	404.2	35	64
	1400	L	L	L	Green	404.4	404.2	--	--
	2000	L	L	L	--	404.4	404.1	--	--
5/10/96	0200	L	L	L	Green	404.4	404.2	--	--
	0800	L	L	L	Green	404.4	404.2	42	64
	1400	L	L	L	Green	404.4	404.2	--	--
	2000	--	--	--	Clear	404.5	404.1	--	--
5/11/96	0200	L	L	L	Green	404.5	404.1	--	--
	0800	L	L	L	Green	404.5	404.1	55	73
	1400	L	L	L	Green	404.4	404.0	--	--
	2000	L	L	L	Clear	404.5	404.2	--	--
5/12/96	0200	L	L	L	Green	404.4	404.1	--	--
	0800	L	L	L	Green	404.5	404.1	54	76
	1400	L	L	L	Green	404.6	404.1	--	--
	2000	L	L	L	Green	404.5	404.1	--	--
5/13/96	0200	L	L	L	Green	404.0	404.1	--	--
	0800	L	L	L	Green	404.5	404.1	58	72

Appendix Table A-4. Continued.

Date	Hour	River flow[a]	Water turbidity[a]	Debris level[a]	Water color	River elevation[b]	Canal elevation[b]	Air temperature[c] Min.	Air temperature[c] Max.
5/13/96	1400	L	L	L	Green	404.5	404.1	--	--
	2000	L	L	L	Green	404.5	404.1	--	--
5/14/96	0200	L	L	L	Green	404.6	404.2	--	--
	0800	L	L	L	Green	404.6	404.2	57	78
	1400	L	L	L	Lt. green	404.7	404.2	--	--
	2000	L	L	L	Green	404.7	404.3	--	--
5/15/96	0200	L	L	L	Green	404.7	404.2	--	--
	0800	--	--	L	Green	--	404.1	58	76
	1400	--	--	--	Lt. green	--	404.1	--	--
	2000	--	--	--	--	--	--	--	--
5/16/96	0200	L	ML	L	Green	404.5	404.1	--	--
	0800	L	ML	L	Green	404.9	404.6	56	76
	1400	--	--	--	Green	404.9	404.3	--	--
5/17/96	0200	L	L	L	Green	404.6	404.1	--	--
	0800	L	L	L	Green	404.6	404.2	59	78
	1400	L	L	L	Green	404.6	404.3	--	--
	2000	L	L	L	Green	--	--	--	--
5/18/96	0200	L	L	L	Green	405.0	404.5	--	--
	0800	H	M	L	Chocolate	405.2	404.4	47	74
	1400	M	H	L	Chocolate	405.1	404.4	--	--
5/19/96	0200	MH	H	L	Chocolate	405.1	404.3	--	--
	0800	H	H	L	Chocolate	405.1	404.3	48	68
	1400	M	H	M	Chocolate	405.1	404.4	--	--
	2000	M	H	M	Chocolate	405.1	404.4	--	--
5/20/96	0200	MH	H	L	Brown	405.1	404.4	--	--
	0800	MH	M	L	Lt. brown	405.1	404.3	46	68
	1400	--	--	--	Lt. brown	405.0	404.3	--	--
	2000	M	M	M	Dk. green	405.0	404.4	--	--
5/21/96	0200	M	M	L	Brown	405.1	404.4	--	--
	0800	M	M	L	Brown	405.1	404.4	48	71
	1400	M	M	L	Brown	405.1	404.4	--	--
	2000	--	--	--	Dk. green	405.2	404.3	--	--
5/22/96	0800	M	M	H	Brown	405.2	404.1	48	68
	1400	M	H	H	Chocolate	405.2	404.1	--	--
	2000	M	H	H	Chocolate	405.2	404.3	--	--
5/23/96	0800	M	H	M	Chocolate	405.2	404.3	42	64
	1400	M	H	M	Chocolate	405.2	404.3	--	--
	2000	M	MH	M	Chocolate	405.1	404.1	--	--
5/24/96	0200	M	M	M	Lt. brown	405.0	404.1	--	--

Appendix Table A-4. Continued.

Date	Hour	River flow[a]	Water turbidity[a]	Debris level[a]	Water color	River elevation[b]	Canal elevation[b]	Air temperature[c] Min.	Max.
5/24/96	0800	M	M	M	Lt. brown	404.9	404.2	42	72
	1400	M	L	L	Brown	404.9	404.2	--	--
	2000	M	L	L	Brown	404.9	404.2	--	--
5/25/96	0200	M	L	L	Dk. green	404.9	404.2	--	--
	0800	M	L	L	Dk. green	404.8	404	54	78
	1400	M	L	L	Dk. green	404.8	404.1	--	--
	2000	M	L	L	Dk. green	404.8	404.1	--	--
5/26/96	0200	M	L	L	Lt. brown	404.8	404.3	--	--
	0800	M	L	L	Lt. brown	404.7	404.1	50	82
	1400	M	L	L	Brown	404.8	404.2	--	--
5/27/96	0200	ML	L	L	Dk. green	404.7	404.1	--	--
	0800	ML	L	L	Dk. green	404.7	404.1	55	82
	1400	ML	L	L	Lt. brown	404.6	404	--	--
	2000	ML	--	--	Green	404.6	404	--	--
5/28/96	0200	L	L	L	Dk. green	404.5	404.1	--	--
	0800	L	L	L	Dk. green	404.5	404.1	50	73
	1400	L	L	L	Dk. green	404.5	404.0	--	--
	2000	L	L	L	Dk. green	404.5	404.1	--	--
5/29/96	0200	L	L	L	Dk. green	404.5	404.1	--	--
	0800	L	L	L	Green	404.6	404.1	44	71
	1400	M	L	L	Green	404.5	404.1	--	--
	2000	M	L	L	Green	404.5	404.1	--	--
5/30/96	0200	M	L	L	Lt. green	404.5	404.1	--	--
	0800	M	L	L	Lt. green	404.5	404.1	49	72
	1400	M	L	L	Lt. green	404.5	404.1	--	--
	2000	M	L	L	Green	404.5	404.0	--	--
5/31/96	0200	M	L	L	Green	404.5	404.1	--	--
	0800	M	L	L	Green	404.5	404.1	48	73
	1400	M	L	L	Green	404.5	404.2	--	--
	2000	M	L	L	Green	404.4	404.3	--	--
6/01/96	0200	M	L	L	Green	404.4	404.2	--	--
	0800	M	L	L	Green	404.2	404.2	50	77
	1400	L	L	L	Green	404.5	404.5	--	--
	2000	L	L	L	Green	404.5	404.7	--	--
6/02/96	0200	L	L	L	Green	404.5	404.3	--	--
	0800	L	L	L	Green	404.5	404.3	55	85
	1400	L	L	ML	Green	404.5	404.2	--	--
	2000	L	L	L	Green	404.5	404.3	--	--
6/03/96	0200	L	L	L	Green	404.6	404.3	--	--

Appendix Table A-4. Continued.

Date	Hour	River flow[a]	Water turbidity[a]	Debris level’	Water color	River elevation[b]	Canal elevation[b]	Air temperature[c] Min.	Max.
6/03/96	0800	L	L	L	Green	404.6	404.3	73	92
	2000	L	L	L	Green	404.5	404.2	--	--
6/04/96	0200	L	L	L	Green	404.5	404.2	--	--
	0800	L	L	L	Green	404.5	404.2	64	92
	2000	L	L	L	Green	404.5	404.3	--	--
6/05/96	0200	L	L	M	Green	404.5	404.2	--	--
	0800	L	L	M	Green	404.5	404.2	50	80
	2000	L	L	L	Green	404.5	404.2	--	--
6/06/96	--	--	--	--	--	--	--	50	--
	0200	L	L	L	Green	404.5	404.3	--	--
	2000	L	L	L	Green	404.5	404.2	--	--
6/07/96	0200	L	L	L	Green	404.5	404.2	--	--
	0800	L	L	L	Green	404.5	404.2	50	92
	1400	L	L	L	Green	404.4	404.2	--	--
	2000	L	L	L	Green	404.4	404.2	--	--
6/08/96	0200	L	L	L	Green	404.4	404.2	--	--
	0800	L	L	L	Green	404.4	404.2	57	95
	2000	L	L	L	Green	404.4	404.2	--	--
6/09/96	0200	L	L	L	Green	404.4	404.2	--	--
	0800	L	L	L	Green	404.4	404.2	53	87
	1400	L	L	L	Green	404.4	404.2	--	--
	2000	L	L	L	Green	404.4	404.2	--	--
6/10/96	0800	L	L	L	Green	404.3	404.2	52	78
	1400	L	L	L	Green	404.3	404.2	--	--
	1930	L	L	L	Green	404.3	404.2	--	--
6/11/96	0800	L	L	L	Lt. green	404.3	404.1	62	82
	1400	L	L	L	Green	404.3	404.1	--	--
	2000	L	L	L	Green	404.3	404.1	--	--
6/12/96	0730	L	L	L	Lt. green	404.3	404.1	56	88
	2000	L	L	L	Green	404.2	404.1	--	--
6/13/96	0800	L	L	L	Lt. green	404.2	404.1	52	90
	1400	L	L	L	Green	404.2	404.1	--	--
	2000	L	L	L	Green	404.3	404.2	--	--
6/14/96	0800	L	L	L	Green	404.2	404.2	51	91
	1400	L	L	L	Green	--	--	--	--
	2000	L	L	L	Green	404.3	404.2	--	--
6/15/96	0800	L	L	L	Green	404.3	404.2	53	91
	1400	L	L	L	Green	404.3	404.2	--	--
6/16/96	0800	L	L	L	Green	404.2	404.2	52	85

Appendix Table A-4. Continued.

Date	Hour	River flow'	Water turbidity"	Debris level[a]	Water color	River elevation[b]	Canal elevation'	Air temperature[c] Min.	Air temperature[c] Max.
6/16/96	1400	L	L	L	Green	404.2	404.1	--	--
6/17/96	0900	L	L	L	Lt. green	404.2	404.1	52	84
	1530	L	L	L	Lt. green	404.2	404.3	--	--
6/18/96	0800	L	L	L	Green	404.3	404.3	45	71
	1400	L	L	L	Green	404.3	404.3	--	--
6/19/96	0845	L	L	L	Green	404.3	404.3	43	73
6/20/96	0930	L	L	L	Green	404.3	404.3	--	--
6/21/96	1400	L	L	M	Green	404.3	404.3	--	--
6/22/96	0800	L	L	M	Green	404.3	404.3	--	--
6/23/96	0800	L	L	M	Green	404.3	404.3	--	--
6/24/96	1000	L	L	L	Green	--	--	--	--
	1400	L	L	M	Green	404.4	404.3	--	--
6/26/96	1400	L	L	M	Green	404.4	404.3	--	--
6/28/96	1100	L	L	L	Green	404.4	404.4	--	--
6/29/96	1145	--	--	L	Green	404.3	404.3	--	--
6/30/96	1310	--	--	L	Lt. green	404.3	404.3	--	--
7/01/96	1300	--	--	L	Green	403.8	403.8	--	--
7/02/96	1330	--	--	M	Green	403.6	403.5	--	--
7/03/96	1500	--	--	M	Green	403.9	403.7	--	--
7/04/96	0900	--	--	M	Green	404.2	404.1	--	--
7/05/96	1000	--	--	M	Green	404.2	404.1	52	82
7/06/96	1200	--	--	M	Green	404.2	404.2	50	88
7/07/96	13 00	--	--	M	Green	404.1	404.1	52	86
7/08/96	0830	--	--	M	Green	404.1	404.0	58	86
7/09/96	0830	--	--	M	Green	404.0	404.0	58	98
	1600	--	--	MH	Green	403.9	403.8	--	--
7/10/96	0900	--	--	M	Green	403.7	403.5	56	102
7/11/96	0930	--	--	L	Green	403.5	403.4	64	92

[a] *H = high, MH = moderate to high, A4 = moderate, ML = moderate to low, L = low*

[b] *Elevation in feet of water above sea level as measured on facility staff gauge.*

[c] *Temperatures in degrees Farenheit.*

REPORT B

Umatilla River Passage Evaluation

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INTRODUCTION

Evaluations ofjuvenile salmonid passage at fish bypasses and ladders on the lower Umatilla River were conducted from 1989 to 1995 (Knapp and Ward 1990; Hayes et al. 1992; Cameron and Knapp 1993; Cameron et al. 1994, 1995). These studies identified potential passage problems for juvenile salmonids at Three Mile Falls Dam. 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). A primary objective of our passage work in 1996 was to determine whether this diffuser was the main cause of injury and delay to juvenile salmonids passing through the ladder. In addition, we desired a better understanding of the physical and biological factors that may cause injury and delay to juvenile salmonids at the diffuser. To accomplish these objectives, we documented behavior of subyearling and yearling salmonids at the diffuser with an underwater video camera.

Juvenile salmonids pass Three Mile Falls Dam either through the west-bank fish bypass at West Extension Canal, the east-bank fish ladder, or by spilling over the dam. If most juvenile salmonids pass through the ladder, then a substantial proportion of their populations may be delayed and injured as indicated by previous studies (Cameron et al. 1994, 1995). In past years, thousands ofjuvenile salmonids have used the ladder to pass Three Mile Falls Dam (Hayes et al. 1992; Cameron and Knapp 1993; Knapp et al. 1996). However, we are uncertain whether these fish numbers represented a substantial proportion of the juvenile salmonid populations because fish passage over the dam and through the bypass was not adequately quantified. In 1996, we estimated the proportion of the subyearling fall chinook salmon population that used the ladder by video recording their movement at the ladder viewing window while fish passage was monitored at the west-bank bypass.

Operational changes at West Extension Canal could affect the proportion of fish that utilize the bypass (bypass efficiency) to'pass Three Mile Falls Dam. This is particularly important if the desired goal is to prevent juvenile fish from using the adult fish ladder. In 1994, West Extension Canal began Phase I operations where water is pumped into the canal from the Columbia River when flow in the Umatilla River is low (USBR and BPA 1989). Phase I operations were implemented to provide adequate flows for both adult and juvenile salmonid migrations below Three Mile Falls Dam. However, Phase I operations may negatively impact juvenile salmonid migrations. Fish attraction to the bypass is expected to decline when canal withdrawal is curtailed during Phase I pumping. During Phase I, most juvenile salmonids may be attracted to the relatively high amount of flow passing through the fish ladder. Phase I operations usually coincide with the outmigration of natural and hatchery subyearling fall chinook salmon which are most susceptible to injury if they select the fish ladder as a passage route instead of the bypass.

In this report, we present findings from video monitoring ofjuvenile fish within the east-bank ladder at Three Mile Falls Dam. We also describe the proportion ofjuvenile salmonids that use the bypass at West Extension Canal during various canal operations and illustrate the effect of canal flow on water velocity at key locations for attracting fish to the bypass.

STUDY SITES

Three Mile Falls Dam at river mile (RM) 3 .O is the lowermost, tallest (24 ft), and widest (915 ft) dam on the Umatilla River. River flow passing the dam from 1947-1984 averaged approximately 1,000 ft^3/s in March and April, 650 ft^3/s in May, 100 ft^3/s in June, and < 5 ft^3/s in July and August (USBR 1988). River flow passes Three Mile Falls Dam over the dam crest, through West Extension Canal (180 ft^3/s maximum flow) and the fish bypass facility (25 ft^3/s maximum flow) on the west bank, and through the fish ladder on the east bank (190 ft^3/s maximum flow). During low river flow, fish passage below the dam is enhanced by pumping Columbia River water into West Extension Canal in lieu of diverting Umatilla River water (Phase I exchange). Water can be exchanged from mid-March through June and mid-August through October if river flow below the dam drops below 250 ft^3/s. Water exchange in the spring usually begins in late May. When Phase I is initiated, West Extension Canal is usually supplied by a combination of pumping and water diversion ("partial exchange") for a day or two. During full Phase I exchange, all canal flow is supplied by pumping and the bypass continues to return 25 ft^3/s or 5 ft^3/s to the river. River flow is also augmented at times to improve conditions for fish migration by releasing stored water from McKay Reservoir **(see Report A;** Figure 1).

West Extension Canal and the fish bypass facility are described in Knapp et al. 1996. The canal intake located on the west bank of the river consists of three headgates about 30 ft downstream of a trashrack. Flow drawn through the headgates enters an 18-ft-wide x 6.4-ft-deep screen forebay and passes four 12-ft-long x 8-ft-diameter rotating drum screens before reaching the bypass channel entrance 100 ft downstream of the headgates.

The east-bank fish ladder at Three Mile Falls Dam is described in Cameron et al. (1997). The ladder incorporates both passage and auxiliary water sections to the total ladder structure (Figure 1). Adult fish migrate through the passage section; the auxiliary water section provides additional flow at the fish 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. Diffuser 1 diverts upstream migrating adult fish into a steeppass that leads to a trap (Figure 1). The diffuser was designed with one-inch openings between the slats to prevent gilling of small precocious ("jack") salmon. Diffuser 1 was modified in 1995 by removing half of the horizontal supports to improve fish passage and reduce debris accumulation. Flow approaches Diffuser l at an angle and is turbulent when inflow gates to the fishway are not fully open. The component of water velocity sweeping across the diffiser (sweep velocity) ranges from 0.20-l .89 ft/s and that passing through the diffuser (approach velocity) ranges from 0.44-2.03 ft/s (Cameron et al. 1997; Appendix Figure A-l). Downstream of Diffuser 1, juvenile fish pass through either a one-foot slot between the viewing window and backlighting chamber or through diffusers behind the backlighting chamber

(Diffuser 3; Figure 1). Fish that pass through Diffuser 3 are not visible through the viewing window.

METHODS

Video

We used underwater video to monitor juvenile salmonid passage through Diffuser 1 in the fish ladder at Three Mile Falls Dam. We recorded video at varying times of the day in April when yearling fall chinook salmon were the predominant species and in early June when subyearling fall chinook salmon were predominant. Initially, we deployed the camera at varying distances upstream of Diffuser 1 at a perpendicular orientation to the diffuser (front view). We moved the camera closer to or further away from the diffuser when water clarity changed to maximize the amount of diffiser visible in the camera's field of view. Later, we recorded with the camera deployed approximately three inches in front of and parallel to the diffuser (side view). Six recordings were made at Diffiser 3 to estimate juvenile salmonid passage behind the backlighting chamber (i.e. fish not detected by the camera system in the viewing window).

The underwater video system consisted of a Sony (model HMV-352) camera with a 3.7 mm lens, Sony (model WPC-140) water-proof camera case, Sony (model EV-A50) S-mm video cassette recorder, and Sony (model AWM-2921) video cable. The camera had a wide field of view (105 °) and remained in focus over the distances recorded (0.1-5.0 ft). We recorded video under natural lighting. A charge coupled device (CCD) at the camera focus allowed image detection at light intensities as low as 0.7 lux. We deployed a device described by Cameron et al. (1995) to position the camera within a grid system in front of Diffuser 1. Viewing locations were at 50% and 80% of water depth on five equidistant vertical transects (Figure 2). The sampling grid corresponded to locations where water velocity measurements had previously been collected (Cameron et al. 1997). We recorded video on Fugi HG P6-120 tapes.

We reviewed seven video tape segments recorded from 1500-1530 hours to determine diffiser 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. Before deploying the camera in the field, we measured the width and height of the camera's field of view at varying distances so we could later estimate these dimensions from the viewing distance in our recording. For front-view recordings, we measured viewing distance during camera deployment. For side-view recordings, 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 the field of 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. Number of light and hard impacts and head-first and tail-first passage counted on one-half hour tape segments were presented in numbers per hour.

Varying amounts of diffuser area viewed 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. We referred to these quantities as the number of impacts or passages based on diffuser area (number/h/ft^2). Standardizing these counts to diffuser area allowed us to compare the total number of impacts or passages at varying sampling locations. However, these total counts of impacts and passages were also affected by fish densities in front of the diffuser. We eliminated the effect of varying fish densities among recordings by dividing these counts (number/h/ft^2) by fish density (fish/ft^2). We referred to these quantities as the number of impacts or passages based on fish density (number/h/fish). Standardizing these counts to fish density allowed us to compare the numbers of impacts and passages at varying sampling locations irrespective of fish density.

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. The system consisted of a Panasonic D-5000 camera with a 0.24-in fixed-focus lens connected to an RCA VR-503 (VHS) video cassette recorder (VCR) using Panasonic WV-CA-10 video cable. We recorded three, five- or six-hour blocks per day during the hours of peak fish movement from 3 1 May to 9 June and two, six-hour blocks from 10 June to 14 June 1996. Video was recorded on Maxell T-120 tapes with the VCR set on long play (six hours per tape). The camera was positioned 5 ft in front of the viewing window to optimize image resolution and field of view (Figure 3). The camera's field of view encompassed all but the top and bottom 10% of the window. Front- and back-lighting was used continuously to enhance image quality. Two florescent lights (40 Watt, 4-A-long) fixed to the upstream side of the window at about a 45 ° angle to the window lighted the front, and two incandescent lights (300 Watt, 4-ft-long) set inside a submerged plexiglass chamber lighted the back.

We counted hatchery subyearling fall chinook salmon on tapes recorded at the viewing window. Juvenile salmonids were easily distinguished from other fish species based on their size, coloration, and morphology. For counting purposes, we assumed salmonids < 5 in total length were hatchery subyearling fall chinook salmon (during sampling, more than 99.99% of the small salmonids [< 5 in] captured at West Extension Canal were hatchery subyearling fall chinook salmon). We reviewed tapes at slow, normal, or fast forward playback speeds when passage rates of subyearling fall chinook salmon were high (> 150 fish/min), moderate (25-l 50 fish/min), or low (< 25 fish/min), respectively.

Velocity

We measured water velocity at the trashracks, headgates, screen forebay, and bypass channel entrance at West Extension Canal to assess velocity changes that may affect fish attraction to the canal and bypass. Velocities were measured on 17 May 1996 when canal flow was 99 ft^3/s and each headgate was open 20 in. These findings were compared with velocity measurements collected on 3 October 1995 when the canal was not diverting water and each headgate was open five inches (Cameron et al. 1996). Bypass flow was 5 ft^3/s during both sets of measurements. Measurements were collected with a Marsh McBirney (Model 2000) electromagnetic flowmeter at 50% of water depth at the trashracks, headgates, and screen forebay, and at 20%, 50%, and 80% of water depth at the bypass channel entrance. We used the same sampling and data analysis methods as described in Cameron et al. (1996).

Bypass Efficiency

The proportion of fish that use the west-bank bypass to pass Three Mile Falls Dam (bypass efficiency) was determined by conducting mark-recapture tests (trap efficiency) for different races or species of salmonids. We conducted trap efficiency tests during various canal operations from early April to late June (see **Report A).** We correlated and plotted daily trap efficiencies against daily river flow and percent diversion (percent of river flow diverted into the canal and bypass) to assess the relationship between these variables. We also correlated and plotted total fish collection against percent diversion.

RESULTS

Video

We recorded 47 h of underwater video in front of Diffuser 1 from 5-24 April when hatchery yearling fall chinook salmon were the dominant fish species present (Table 1). We recorded 32 h of underwater video from 3 1 May - 4 June when hatchery subyearling fall chinook salmon were the dominant fish species present (Table 1). Time required to review one-half hour of tape was approximately one hour. Fish densities in front of Diffuser 1 corresponded with changes in fish collection at West Extension Canal in April and early June. Yearling fall chinook salmon released on 5 and 18 April increased in density in front of Diffuser 1 from 0 $fish/ft^2$ on 6 April to 18.3 $fish/ft^2$ on 22 April. Subyearling fall chinook salmon released on 30 and 3 1 May increased in density in front of Diffuser 1 from 0 $fish/ft^2$ on 1 June to 37.6 $fish/ft^2$ on 4 June.

Impacts with the diffuser were predominantly classified as light for both yearling chinook and subyearling chinook salmon (Figure 4). Number of impacts based on diffuser area increased when fish densities increased in front of the diffuser. However, number of impacts based on fish density varied among locations for yearling chinook salmon; they were highest at Transect 1, 80% water depth (263 impacts/h/fish) compared to other sampling locations (5-26 impacts/h/fish). For subyearling chinook salmon, number of impacts based on fish density was approximately equal (29 and 30 impacts/h/fish) at the two locations sampled (Transect 1, 50% and 80% depths).

Yearling and subyearling fall chinook salmon usually approached Diffuser 1 tail-first and ceased downstream movement when they touched or came within a couple of inches of the diffuser. However, they predominantly passed head-first through Diffuser 1 (Figure 5). Number of passages based on diffuser area increased when fish density increased. However, number of passages based on fish density usually decreased when fish densities increased. Number of passages based on fish density was higher at 80% water depth than 50% water depth for yearling and subyearling fall chinook salmon.

We recorded 12 h of underwater video at Diffuser 3 from 4-7 June when hatchery subyearling fall chinook salmon were the dominant fish species present (Table 1). We video-recorded in the morning (0600-1000 hours) and late afternoon (1700-1900 hours). No subyearling fall chinook salmon were recorded.

We video-recorded 204.8 h at the viewing window in the east-bank fish ladder at Three Mile Falls Dam from 31 May - 14 June 1996 (Table 2). We generally recorded six-hour time blocks in the morning (0400-1100 hours), afternoon (1100-1800 hours), and evening (1700-2400 hours). No video was recorded between 2400-0400 hours, We eliminated the evening video recording when subyearling fall chinook salmon passage declined (7 June). An hour of video tape required from 0.3-4.0 h to review and all 204.8 h of video tape required 202 h to review.

Number of subyearling fall chinook salmon that passed through the fish ladder and the fish bypass facility at West Extension Canal varied by date and hour (Figure 6). Counts at the ladder and bypass peaked on 3 June, 48-72 h after subyearling fall chinook salmon were released upriver. Diurnal patterns of fish movement at the ladder and bypass were similar; peak movement was during the day. A total of 328,542 subyearling fall chinook salmon were counted on all 204.8 h of video recorded at the viewing window. Hourly sampling at the bypass coincided with 164 h of the video. Of the subyearling fall chinook salmon counted concurrently at the bypass and ladder, 27.8% passed the ladder viewing window and 72.2% passed through the bypass (Table 3). Percent of daily passage was mostly lower for the ladder (4.6-23.0%) and higher for the bypass (77.0-95.4%). However, percent of fish using the bypass dropped from 89.5% to 21.0% and percent of fish using the ladder increased from 10.5% to 79.0% when canal operations changed from partial to full Phase I water exchange on 1-2 June (headgate openings were reduced when full Phase I exchange eliminated flow diversion into the canal; Appendix Table A-l). Percent of fish using the ladder increased again from 3 June (17.2%) to 4 June (47.1%) when there were no significant changes in facility operations or river flow, During peak migration on 3 June, passage of subyearling fall chinook salmon was approximately four times higher through the bypass (82.8%, 577,325 fish) than the fish ladder (17.2%, 119,573 fish). However, passage estimates at the bypass were expanded from extremely low samples (0.33-0.56%) during the four-hour period of peak movement on 3 June.

Velocity

We measured water velocity at the trashracks, headgates, screen forebay, and bypass channel entrance at West Extension Canal to assess velocity changes that may affect fish attraction to the canal and bypass. Velocities were measured on 17 May 1996 when canal flow was 99 ft^3/s and each headgate was open 20 in. These findings were compared with velocity measurements collected on 3 October 1995 when the canal was not diverting water and each headgate was open five inches (Cameron et al. 1996). Bypass flow was 5 ft^3/s during both sets of measurements. Measurements were collected with a Marsh McBirney (Model 2000) electromagnetic flowmeter at 50% of water depth at the trashracks, headgates, and screen forebay, and at 20%, 50%, and 80% of water depth at the bypass channel entrance. We used the same sampling and data analysis methods as described in Cameron et al. (1996).

Bypass Efficiency

The proportion of fish that use the west-bank bypass to pass Three Mile Falls Dam (bypass efficiency) was determined by conducting mark-recapture tests (trap efficiency) for different races or species of salmonids. We conducted trap efficiency tests during various canal operations from early April to late June **(see Report A).** We correlated and plotted daily trap efficiencies against daily river flow and percent diversion (percent of river flow diverted into the canal and bypass) to assess the relationship between these variables. We also correlated and plotted total fish collection against percent diversion.

RESULTS

Video

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Velocity

Water velocities at the trashracks, headgates, and screen forebay of West Extension Canal were higher when the canal diverted 99 ft^3/s of river flow compared with operations with no canal flow (Figure 7). With canal flow and two pumps on, water velocity at the trashracks, headgates, and screen forebay (1.02- 1.6 1 ft/s) was 5-22 times greater than when there was no canal flow and two pumps on (0.07-0.20 ft/s). It was also 2-5 times greater than water velocities with no canal flow and a 20%-, 30%-, and 40%-open river-return pipe (0.23-0.74 ft/s). Design criteria for water velocity at the bypass channel entrance (2 ft/s) was met when two canal pumps operated or the river-return drain pipe was 20% open.

Bypass Effkiency

We expected the proportion ofjuvenile salmonids using the fish bypass at West Extension Canal (bypass efficiency) to be affected by percent of river flow diverted into the canal (percent diversion) and total river flow. We tested this hypothesis by plotting and correlating our estimate of bypass efficiency (daily trap efficiency) against percent diversion and river flow. We also conducted these analyses using total fish collection as a surrogate for bypass efficiency.

Percent diversion at West Extension Canal corresponded with changes in canal and bypass operation (Figure 8). Percent diversion dropped sharply when Phase I water exchange was implemented on 10 May, 1 June, and 26 June and when bypass flow was reduced from 25 ft^3/s to 5 ft^3/s on 18 June. Decreasing river flow during Phase I water exchange in early June caused percent diversion to increase even though a constant amount of flow was diverted into the canal (25 ft^3/s bypass flow).

Most yearling hatchery fall chinook and coho salmon and summer steelhead passed Three Mile Falls Dam when West Extension Canal was diverting water from the river in April and May. Mean trap efficiency was low for yearling fall chinook salmon (24.4%) coho salmon (19.5%) and summer steelhead (13.4%). Daily trap efficiency for these yearling salmonids fluctuated widely even when changes in percent diversion were gradual (Figure 9). Correlation between daily trap efficiency and percent diversion was significant for coho salmon (r=0.45, P=0.003, N=43) but was not significant for yearling fall chinook salmon (P=0.56) or summer steelhead (P=0.50). Subyearling fall chinook salmon passed Three Mile Falls Dam when West Extension Canal diverted water from the river (24-3 1 May) and when it operated on Phase I water exchange (l-24 June). Mean daily trap efficiency for subyearling fall chinook salmon was 2.5 times higher when the canal diverted water from the river (42.3%) than during Phase I water exchange (16.6%). Daily trap efficiency decreased quickly from 48% on 3 1 May to 18% on 1 June and to 3% on 2 June as canal operations changed from water diversion to partial and full Phase I water exchange (Figure 9). Daily trap efficiencies for subyearling fall chinook salmon ranged from 4-40% for the remainder of June. Correlation between daily trap efficiency and percent diversion for subyearling fall chinook salmon was not significant (P=0.24).

River flow did not correspond with daily trap efficiency for all hatchery yearling salmonids at West Extension Canal (Figure 10). Correlation between river flow and daily trap efficiency was not significant for coho salmon (P=0.24), yearling fall chinook salmon (P=0.99) and summer steelhead (P=0.86). However, correlation between river flow and trap efficiency was significant for subyearling fall chinook salmon (I=-0.44, P=0.03, N=25).

Relationships between collection of fish species at West Extension Canal and percent diversion were inconsistent. Peak collections of hatchery and natural summer steelhead and hatchery yearling fall chinook and coho salmon coincided with an increase in percent diversion in mid-May (Figure 11). However, collection of these species varied irrespective of percent diversion throughout the remainder of their migration. Collection of subyearling fall chinook salmon varied substantially over a short period in early June even though percent diversion was relatively stable (Figure 12). Correlation of fish collection and percent diversion was not significant for hatchery steelhead (P=0.94), natural steelhead (P=0.25), yearling fall chinook salmon (P=0.68), coho salmon (P=0.15), and subyearling fall chinook salmon (P=0.38). Low numbers of natural chinook and coho salmon were collected mainly in April. Collection of these species also fluctuated irrespective of percent diversion (Figure 12).

Collections of most species of hatchery salmonids were also influenced by their release time. Immediate migration of most subyearling fall chinook and yearling spring chinook salmon caused peak collections a few days after release that overwhelmed subsequent collections. Collection peaks were also observed for yearling fall chinook and coho salmon a few days after their release.

DISCUSSION

Video

Diffuser 1 interrupted downstream movement ofjuvenile salmonids through the fish ladder at Three Mile Falls Dam. Our observations are consistent with laboratory experiments that indicated normal movement ofjuvenile salmon is interrupted when they encounter bars spaced less than 3 in apart (Hanson and Li 1983). Interruption of normal movement is further supported by the observation that most fish turned 180” to pass head-first though the diffuser. As fish held their distance from the diffuser, currents sweeping across the diffuser moved them toward the left side (facing downstream) of the diffiser (Appendix Figure A-l). In effect, sweeping flow caused the diffuser to act as a louver that guided fish across the diffuser and discouraged passage. When fish arrived at the left portion of the diffuser where flow was orientated more perpendicular to the diffuser, most swam upstream and out of camera view; but some passed through the diffuser. Overall, the highest fish densities and most passages were at the left side of the diffuser. Swimming behavior and higher passage on the left side of the diffuser suggests flow perpendicular to the diffuser was more conducive to passage than flow sweeping across the face of the diffuser.

Fish impacts with the diffuser appeared to be associated with turbulence and flow sweeping across the diffuser. Light impacts were usually observed when fish were swept across the diffuser. Although hard impacts were less frequent, they usually occurred when fish encountered turbulence or an area of high approach velocity during their lateral movement across the diffuser. Yearling chinook salmon lightly impacted the diffuser more often than subyearling chinook salmon even though their highest densities were similar. This was unexpected because larger yearling fish have greater swimming abilities than subyearling fish (Easterbrooks 1984). More frequent impacts for yearling chinook than subyearling chinook salmon may have been associated with behavioral differences or reduced swimming performance in crowded conditions. Crowding probably has a greater effect on swimming performance of yearling chinook than subyearling chinook salmon because of their larger body size. Lower passage rates at higher fish densities for both yearling and subyearling chinook salmon further suggest crowded conditions reduce swimming performance.

Underwater video observations suggest Diffuser 1 was the primary cause of delayed passage and descaling reported in passage evaluations at the ladder (Cameron et al. 1994, 1995). Based on our video observations, passage delay and injury was probably associated with sweeping currents, turbulence, and high water velocity in front of the diffuser. Partially open fish exit gates accelerated inflow velocity and appeared to generate hydraulic conditions associated with passage delay and injury at Diffiser 1. We suggest operating the fish exit gates fully open to determine whether juvenile fish passage conditions improve at Diffuser 1. Water velocity should be measured and underwater video recorded to evaluate the effect of a fully open gate on juvenile fish passage. We also suggest considering alternative designs for Diffuser 1 that may improve juvenile salmonid passage and reduce injury, such as slats with rounded edges, replacement of slats with bars, or wider spacing between slats or bars. Temporary removal of Diffuser 1 during the peak subyearling fall chinook salmon outmigration should be considered to allow unobstructed passage through the fish ladder. However, temporary removal of Diffuser 1 will disable the adult fish trap at the ladder and cause the loss of some adult fish data. During the time the adult fish trap is inoperative, video could be recorded at the viewing window to document passage of adult spring chinook salmon through the fish ladder.

We video-recorded fish passage through the east-bank fish ladder at Three Mile Falls Dam because we suspected a large proportion of the subyearling fall chinook salmon migration might use the ladder as a passage route if Phase I water exchange reduced the efficiency of the west-bank fish bypass facility. We counted 328,542 subyearling fall chinook salmon at the viewing window in the fish ladder from 3 1 May to 14 June 1996. Even though this count was high, concurrent passage counts at the ladder and bypass indicated less than one-third of the subyearling fall chinook salmon used the ladder (28%) compared with the bypass (72%) during Phase I water exchange in 1996. Daily passage counts suggest even fewer subyearling fall chinook salmon pass through the ladder (523%) compared with the bypass (77-95%) on most days. However, juvenile fish passage was higher through the ladder (79%) than the bypass (21%) when Phase I water exchange was fully implemented on 2 June. This response to changes in canal operation was temporary as the proportion of subyearling fall chinook salmon that passed through the ladder dropped to 17% on 3 June.

Overall, relatively few subyearling fall chinook salmon passed through the ladder in 1996 when the bypass at West Extension Canal returned 25 ft^3/s to the river. However, we observed mass movement of subyearling fall chinook salmon through the ladder in 1995 when the bypass returned only 5 ft^3/s to the river (Cameron et al. 1996). In addition, fewer subyearling fall chinook salmon were collected at the bypass in 1995 than 1996 by a factor of 24. High bypass flow may not have been the only factor that influenced fish movement. A large debris jam on the east-half of the dam may have guided subyearling fall chinook salmon away from the ladder in 1996. We suggest video monitoring at the ladder viewing window in 1997 to provide a stronger data base for evaluating how bypass operations and river conditions influence passage route selection by subyearling fall chinook salmon at Three Mile Falls Dam. Methods for guiding fish past the ladder such as upstream flow deflectors also should be considered.

Velocity

Low water velocity near the headgates caused by the reduction of canal flow during full Phase I water exchange will probably reduce fish attraction and bypass efficiency. Water velocity near the headgates is produced by diverting flow into the canal and returning flow to the river through the bypass and river-return pipes. Canal withdrawals have a greater capacity for increasing water velocity near the headgates because the canal can withdraw up to 180 ft^3/s compared with only 25 ft^3/s for the bypass. Water velocity near the headgates was severely reduced when the canal no longer diverted water from the river during full Phase I water exchange. Increasing bypass flow from 25 ft^3/s to 35 ft^3/s should be considered to increase fish attraction to the bypass during Phase I water exchange. Water velocity measurements should be recollected if the bypass is operated at 35 ft^3/s. Flow through the river-return pipe should not exceed 20 ft^3/s during fish trapping operations (5-in gate opening) to ensure velocity criteria at the traveling belt screen is met.

Bypass Effwiency

Most yearling salmonids migrated past Three Mile Falls Dam prior to Phase I water exchange at West Extension Canal when river flow was relatively high. High river flow appeared to negate any potential effect of canal and bypass operations on bypass efficiency. Bypass efficiencies were low (13.4-24.4%) for yearling salmonids throughout most of their migration. Many yearling salmonids probably passed over the dam with the high river flows.

Most subyearling fall chinook salmon migrated past Three Mile Falls Dam during Phase I water exchange at West Extension Canal when river flow was relatively low. We expected low water velocity at the canal trashracks and headgates during Phase I water exchange to compromise bypass efficiency. Fish not attracted to the west-bank bypass spill over the dam or pass through the east-bank fish ladder. Passage over the dam is not as attractive to fish at low river flow because the extensive length of the dam results in minimal spill. Under these conditions, fish may be attracted to the relatively large amount of fish ladder flow (80- 120 ft^3/s).

Many factors potentially affected bypass efficiency for subyearling fall chinook salmon at West Extension Canal, including canal and bypass operations, river flow, debris accumulation on the dam, and trap efficiency methodology. However, canal flow appeared to be the primary factor that affected bypass efficiency for subyearling fall chinook salmon prior to Phase I water exchange when river flow was moderate (250-400 ft^3/s). After river flow dropped below 250 ft^3/s and Phase I water exchange was implemented, amount of bypass flow appeared to be the primary factor that affected bypass efficiency. In 1995 and 1996, respective mean daily trap efficiency for subyearling fall chinook salmon was 5 1.9% and 42.3% when the canal diverted water from the river compared with only 9.5% and 16.6% during full Phase I water exchange. Daily trap efficiency immediately responded to the transition in canal operations from water diversion to full Phase I water exchange by dropping from 56% to 4% in 1995 and from 48% to 3% in 1996. After this initial response, daily trap efficiencies increased to 6-26% in 1995 and 4-40% in 1996. During Phase I water exchange, bypass efficiency was higher in 1996 when 25 ft^3/s was returned to the river through the river-return (20 ft^3/s) and bypass (5 ft^3/s) pipes compared to 1995 when canal pumps operated and only 5 ft^3/s was returned to the river through the bypass pipe (Knapp et al. 1996). Comparison of the numbers of subyearling fall chinook salmon collected over a 15-day period during full Phase I water exchange in 1995 (40,352 fish) and 1996 (973,975 fish) also suggests higher bypass efficiency in 1996. These 15-day collections represent about 2% and 36% of the subyearling fall chinook salmon released in 1995 and 1996, respectively. River flow may have also affected bypass efficiency for subyearling fall chinook salmon during Phase I water exchange. In 1995, an increase in bypass efficiency from 5-20% corresponded with an increase in river flow from 50-200 ft^3/s (Knapp et al. 1996). However, bypass efficiency did not correspond with river flow in 1996. Release of stored water from McKay Reservoir to enhance passage conditions during the subyearling fall chinook salmon migration may have the added benefit of increasing bypass efficiency at West Extension Canal during Phase I water exchange. Differences in physical conditions at the dam or changes in trap efficiency methodology are other potential explanations for higher estimates of bypass efficiency in 1996 than 1995. An extensive accumulation of debris on the east-half of the dam may have effectively guided more fish to the bypass in 1996. Almost no debris accumulated on the dam in 1995. Higher estimates of bypass efficiency in 1996 may have also been associated with a change in release time of trap efficiency fish from morning in 1995 to evening in 1996.

Water velocity near the trashracks and headgates of West Extension Canal generated by bypass flow appeared to be the primary factor that attracted fish to the bypass during Phase I water exchange. Increasing flow through the bypass pipe to 35 ft^3/s might substantially increase water velocity and attract fish to the bypass during Phase I water exchange. Increases in bypass flow greater than 35 ft^3/s would not be feasible without major modification of the bypass. Operating criteria for the bypass at West Extension Canal should be updated to reflect current fish attraction needs during Phase I water exchange. Information collected over the past two years suggests a low-flow bypass operation, where only 5 ft^3/s is returned to the river, is ineffective for attracting fish into the bypass. An alternative operation would be to reduce auxiliary water flow at the east-bank fish ladder to maintain bypass flow at 25-35 ft^3/s when juvenile salmonids are migrating past Three Mile Falls Dam.

Daily trap efficiency estimates for subyearling fall chinook salmon underestimated true bypass efficiency. Daily trap efficiency estimates averaged 1-8% lower than trap efficiency estimates based on cumulative recapture beyond the first day (cumulative trap efficiency). Nevertheless, daily trap efficiencies were relative measures that were useful for describing the effects of daily changes in canal operation and river conditions on bypass efficiency. Additional underestimation of trap efficiency probably resulted from mortality and predation of test fish after release. Aberrant behavior of trap efficiency fish associated with handling, transport stress, and release location may have also biased trap efficiency estimates, Underestimated trap efficiency was evident in the overestimation of subyearling fall chinook salmon survival in 1996 (see **Report A).**

Other 1996 data also suggests bypass efficiency may have been considerably higher than indicated by trap efficiency estimates. From 2-14 June, 72.2% of the subyearling fall chinook salmon counted at the bypass and fish ladder viewing window passed through the bypass. However, mean daily trap efficiency for subyearling chinook salmon from 2-14 June was only 16.6%. Counts at only the bypass and ladder will overestimate bypass efficiency because they do not account for fish passing over the dam or through the auxiliary water system of the fish ladder. We periodically observed subyearling fall chinook salmon passing over the dam in the early morning and late evening, but not in large quantities. Mean bypass efficiency during Phase I water exchange in 1996 was probably higher than 16.6% but lower than 72.2%.

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Table 1. Dates, times, sampling locations, and camera orientations for underwater video recordings at diffusers 1 and 3 in the east-bank fish ladder at Three Mile Falls Dam, Umatilla River, spring 1996.

Date	Recording time: Start	Recording time: End	Sampling location: Transect	Sampling location: Percent of water depth	Orientation and location of camera relative to diffuser [a]
			Yearling chinook salmon		
4/5	1830	2030	1	50	Perpendicular, upstream of D- 1
4/6	0600	0800	1	50	Perpendicular, upstream of D- 1
4/7	1830	2030	3	50	Perpendicular, upstream of D- 1
4/8	0600	0800	3	50	Perpendicular, upstream of D- 1
4/8	1830	2030	4	80	Perpendicular, upstream of D- 1
4/9	0600	0800	4	80	Perpendicular, upstream of D- 1
4/9	1730	1930	4	80	Perpendicular, upstream of D- 1
4/10	0630	0830	4	80	Perpendicular, upstream of D-l
4/10	1455	1600	4	80	Perpendicular, upstream of D-l
4/10	1600	1900	5	80	Perpendicular, upstream of D-l
4/11	1515	1715	5	50	Perpendicular, upstream of D-l
4/12	1330	1530	5	50	Perpendicular, upstream of D- 1
4/12	1700	1800	1	50	Parallel, upstream of D-l
4/13	1300	1430	1	50	Parallel, upstream of D- 1
4/14	1300	1430	1	50	Parallel, upstream of D- 1
4/15	1500	1700	1	50	Parallel, upstream of D- 1
4/16	1530	1830	1	80	Parallel, upstream of D- 1
4/17	1530	1730	1	80	Parallel, upstream of D- 1
4/18	1430	1630	1	80	Parallel, upstream of D- 1
4/19	0630	0830	1	80	Parallel, upstream of D- 1
4/22	1415	1615	1	80	Parallel, upstream of D- 1
4/23	1330	1530	1	80	Parallel, upstream of D-l
4/23	1630	1830	1	80	Parallel, upstream of D-l
4/24	0800	1000	1	80	Parallel, upstream of D- 1
			Subyearling fall chinook salmon		
5/31	1715	1915	1	80	Parallel, upstream of D-l
6/1	0930	1130	1	80	Parallel, upstream of D-l
6/1	1205	1605	1	80	Parallel, upstream of D-l
6/2	1200	1600	1	80	Parallel, upstream of D-l
6/3	1200	1600	1	50	Parallel, upstream of D-l
6/4	0600	1000	1	50	Parallel, upstream of D- 1
6/4	1700	1900	mid-diffuser	80	Perpendicular, downstream of D-3
6/5	0600	0800	mid-diffuser	80	Perpendicular, downstream of D-3
6/5	1700	1900	mid-diffuser	80	Parallel, upstream of D-3
6/6	0800	1000	mid-diffuser	80	Parallel, upstream of D-3
6/6	1700	1900	mid-diffuser	50	Parallel, upstream of D-3
6/7	0800	1000	mid-diffuser	50	Parallel, upstream of D-3

[a] *D-I = Diffuser I,* ***D-3 = Diffuser 3.***

Table 2. Dates, times, and number of hours per day video was recorded at the viewing window in the east-bank fish ladder at Three Mile Falls Dam, Umatilla River, spring 1996.

	Recording time		Recording time		Recording time		Hours
Date	Start	End	Start	End	Start	End	recorded
5/31	0500	1100	1200	1800	1900	2400	17.0
6/1	0500	1100	1200	1800	1900	2400	17.0
6/2	0500	1100	1200	1800	1900	2400	17.0
6/3	0500	1100	1200	1800	1900	2400	17.0
6/4	0500	1100	1200	1800	1900	2400	17.0
6/5	--	--	1200	1445	1700	2300	8.8
6/6	0400	1000	1100	1600	1700	2300	17.0
6/7	0400	1000	1100	1600	--	--	11.0
6/8	--	--	1100	1700	--	--	6.0
6/9	0400	1000	1100	1600	1700	2300	17.0
6/10	0400	1000	1100	1700	--	--	12.0
6/11	0400	1000	1100	1700	--	--	12.0
6/12	0400	1000	1100	1700	--	--	12.0
6/13	0400	1000	1100	1700	--	--	12.0
6/14	0400	1000	1100	1700	--	--	12.0

Table 3. Concurrent counts of subyearling fall chinook salmon from video recordings at the east-bank fish ladder and fish trapping at the west-bank fish bypass facility at Three Mile Falls Dam, Umatilla River, 31 May - 14 June 1996.

Date	Number of subyearling fall chinook salmon		Percent of subyearling fall chinook salmon		Number of hours compared
	Ladder	Bypass	Ladder	Bypass	
5/31	10	208	4.6	95.4	11
6/1	30	256	10.5	89.5	17
6/2	102,394	27,182	79.0	21.0	17
6/3	119,573	577,325	17.2	82.8	16
6/4	70,027	78,805	47.1	52.9	17
6/5	4,632	17,030	21.4	78.6	8
6/6	7,096	23,776	23.0	77.0	17
6/7	8,760	35,603	19.7	80.3	11
6/8	3,486	36,860	8.6	91.4	6
6/9	5,939	29,949	16.5	83.5	16
6/10	1,119	5,278	17.5	82.5	5
6/11	572	3,411	14.4	85.6	6
6/12	267	1,410	15.9	84.1	2
6/13	183	3,213	5.4	94.6	7
6/14	88	1,266	6.5	93.5	8
Total	324,176	841,572			164
Percent	27.8	72.2			

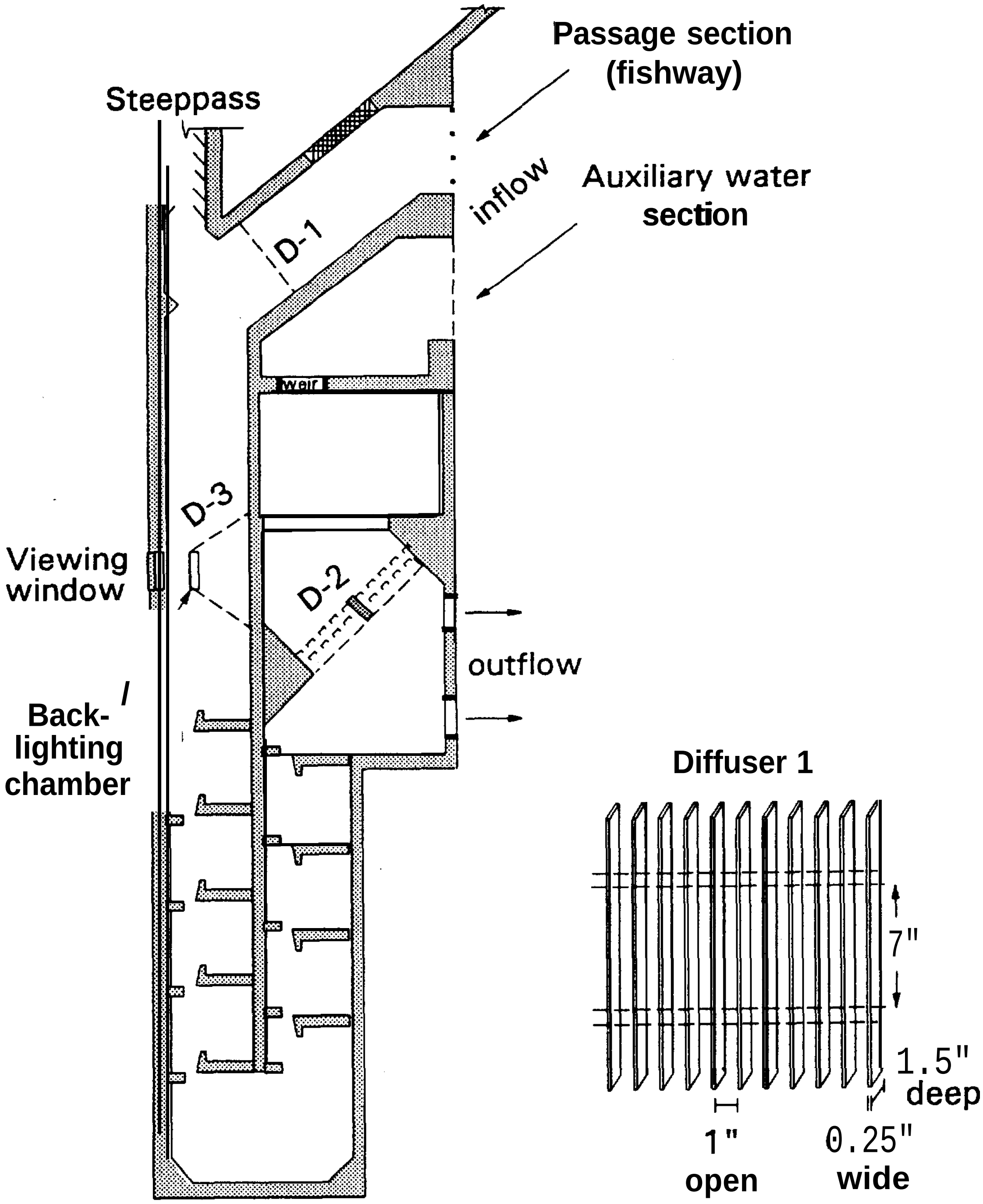


Figure 1. Schematic of the east-bank fish ladder and Diffiser 1 at Three Mile Falls Dam, Umatilla River, 1996.

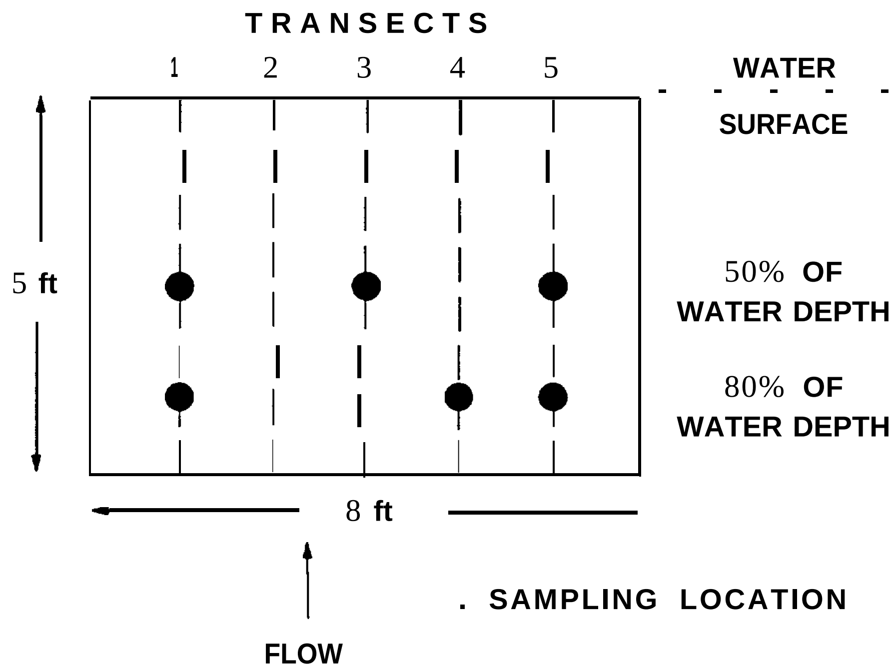


Figure 2. Underwater video sampling sites at Diffuser 1 located in the passage section of the east-bank fish ladder at Three Mile Falls Dam, Umatilla River, 1996.

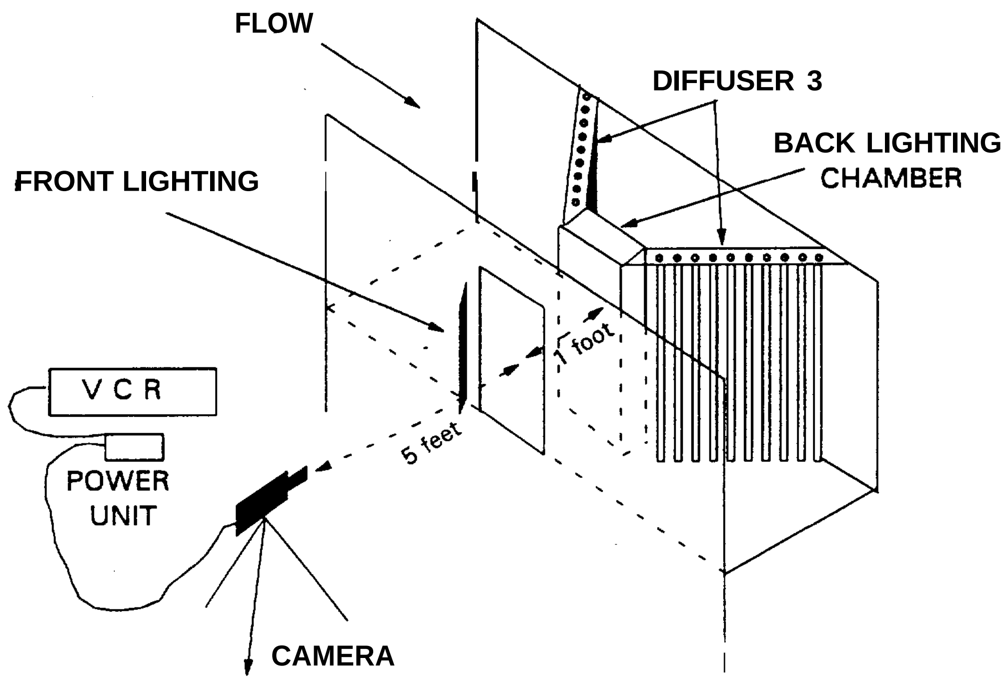
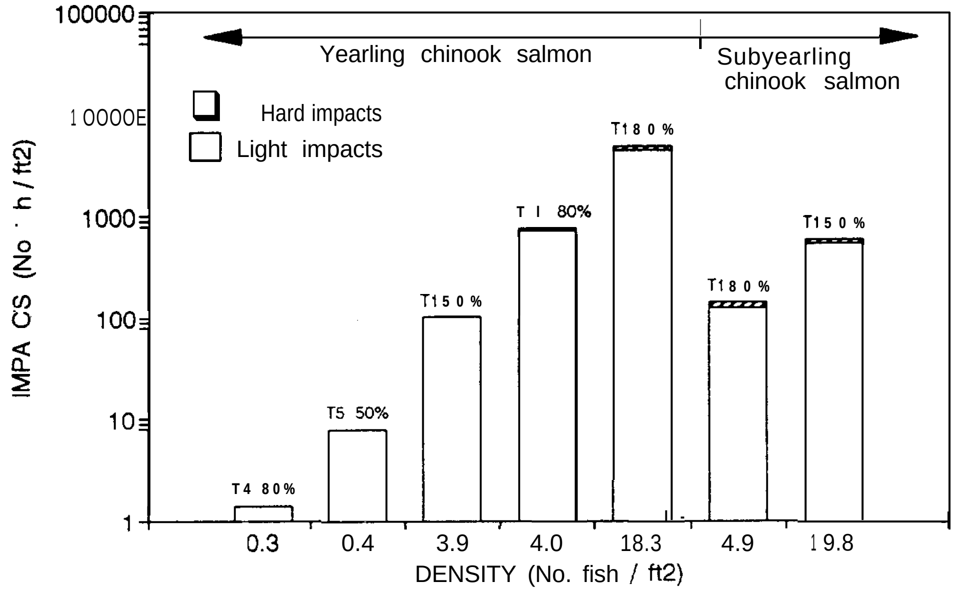


Figure 3 Schematic of the video recording system in the viewing room of the fish ladder at Three Mile Falls Dam, Umatilla River, 1996.



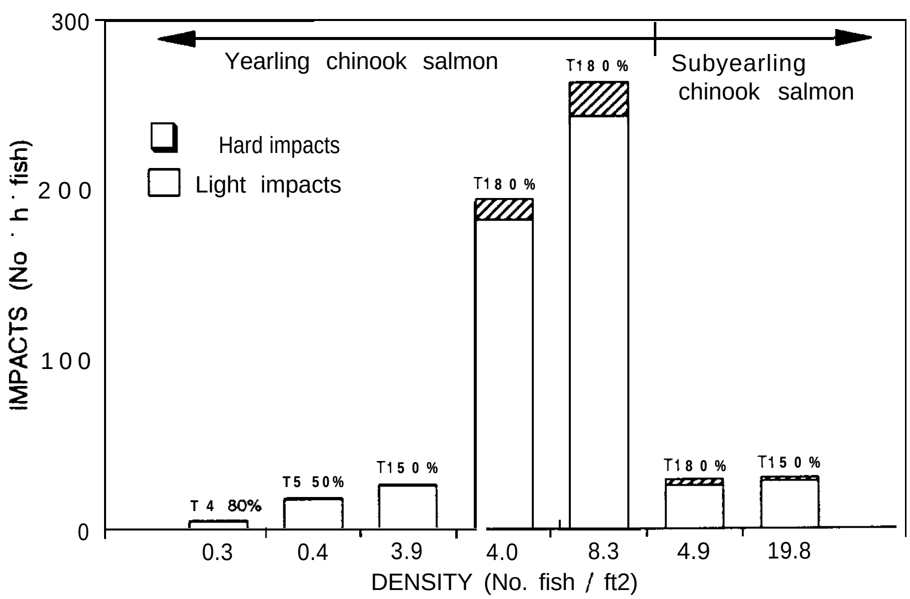


Figure 4. Number of hard and light fish impacts on Diffiser 1 for yearling chinook and subyearling chinook salmon based on diffuser area (top) and fish density in front of the diffuser (bottom), Three Mile Falls Dam fish ladder, Umatilla River, spring 1996. Sampling transects and percent of water depth are shown above bars.

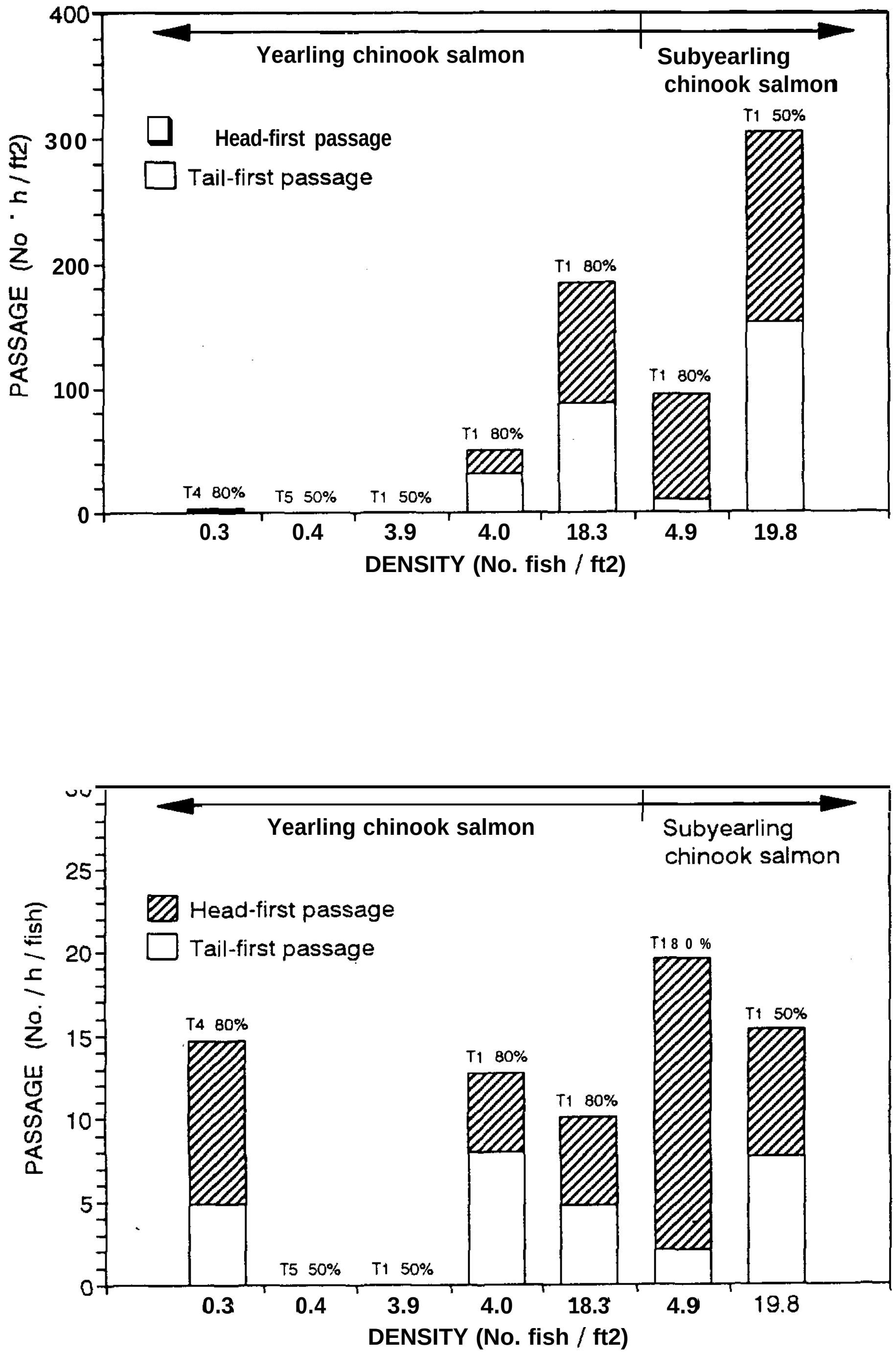


Figure 5. Number of head-first and tail-first fish passages through Diffuser 1 for yearling chinook and subyearling chinook salmon based on diffuser area (top) and fish density in front of the diffuser (bottom), Three Mile Falls Dam fish ladder, Umatilla River, spring 1996. Sampling transects and percent of water depth are shown above bars.

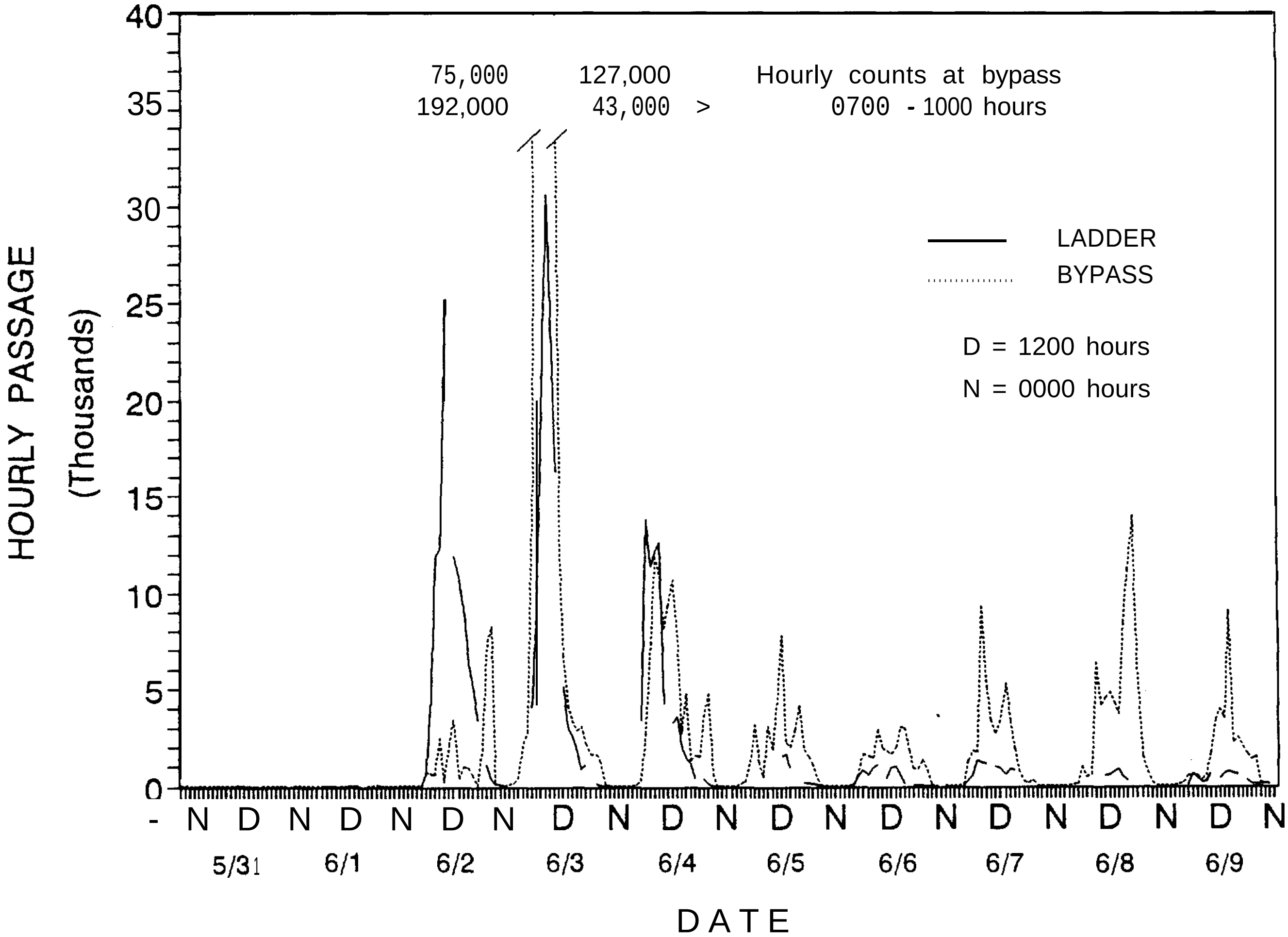


Figure 6. Hourly passage of subyearling fall chinook salmon from video recordings at the east-bank fish ladder and fish trapping at the west-bank fish bypass facility at Three Mile Falls Dam, Umatilla River, 3 1 May - 9 June 1996.

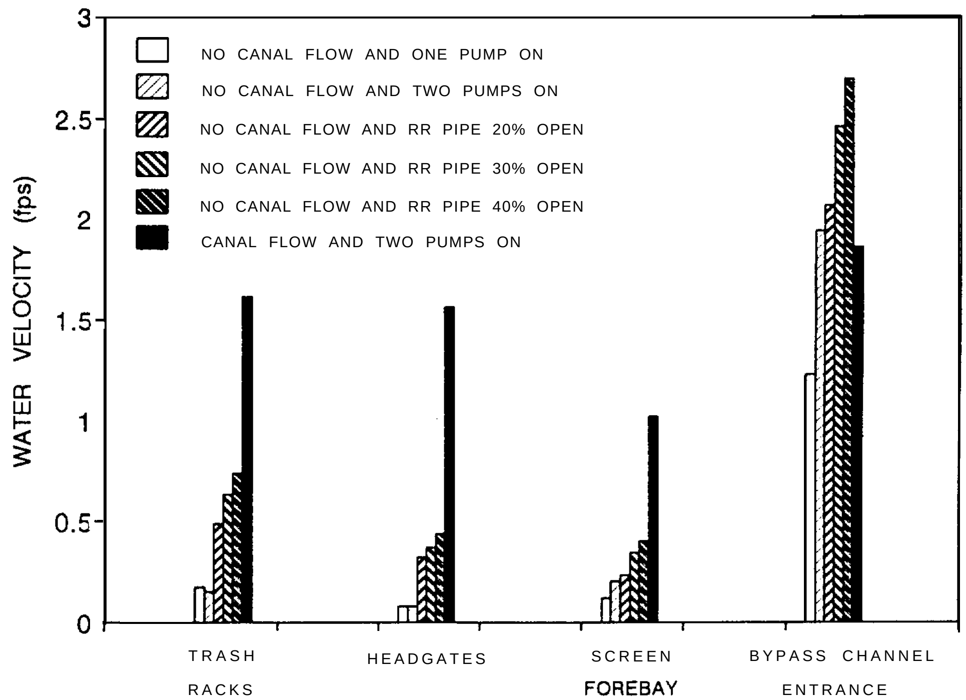


Figure 7. Changes in water velocity (ft/s) at the trashracks, headgates, screen forebay, and bypass channel entrance of West Extension Canal at varying bypass operations with and without canal flow. Water velocity was measured on 3-4 October 1995 when canal flow was 0 cfs (Cameron et al. 1996) and on 17 May 1996 when canal flow was 99 ft^3/s.

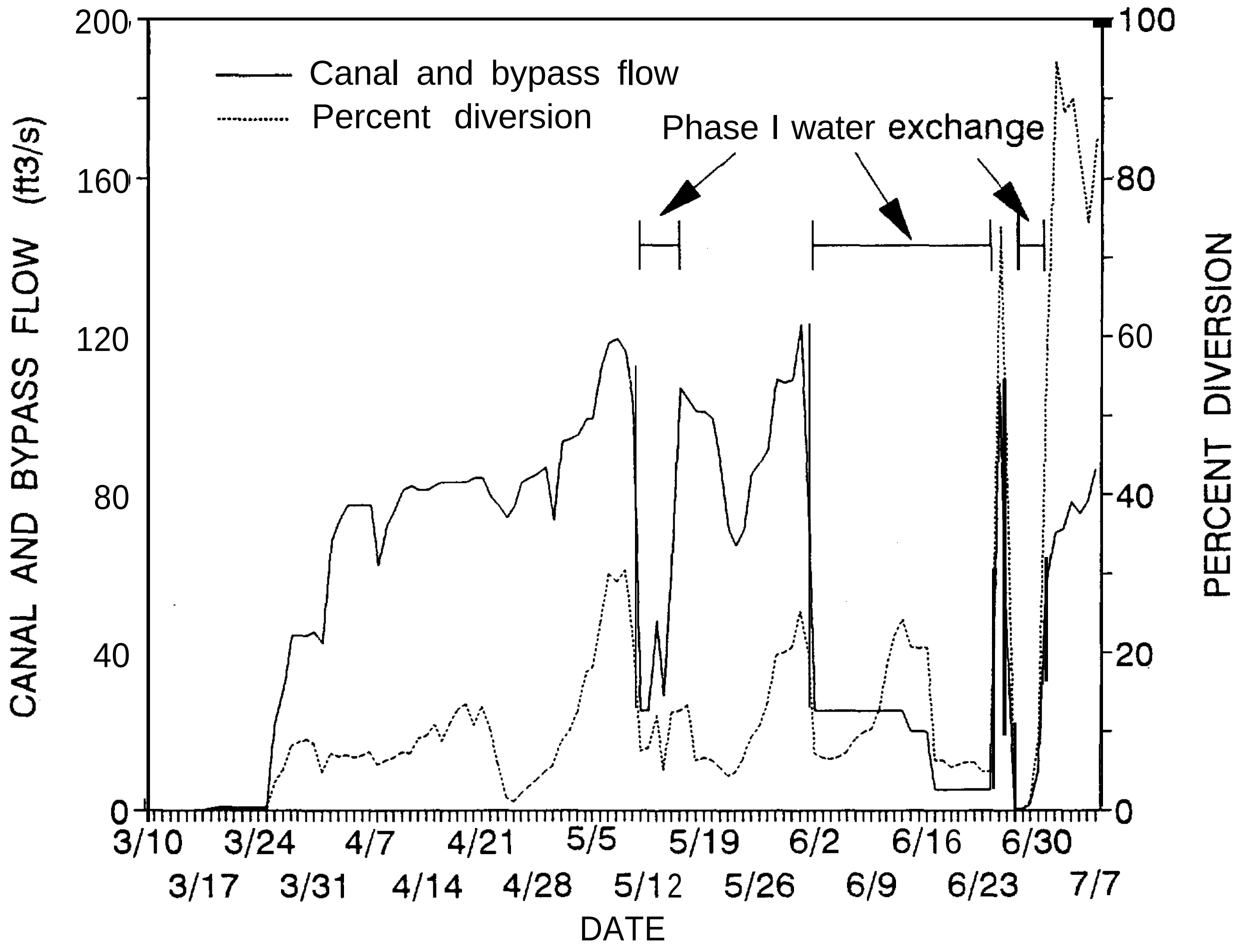


Figure 8. Canal flow (ft^3/s) and percent diversion (canal flow plus bypass flow as a percent of river flow at RM 3) at West Extension Canal, Umatilla River, 10 March - 7 July 1996.

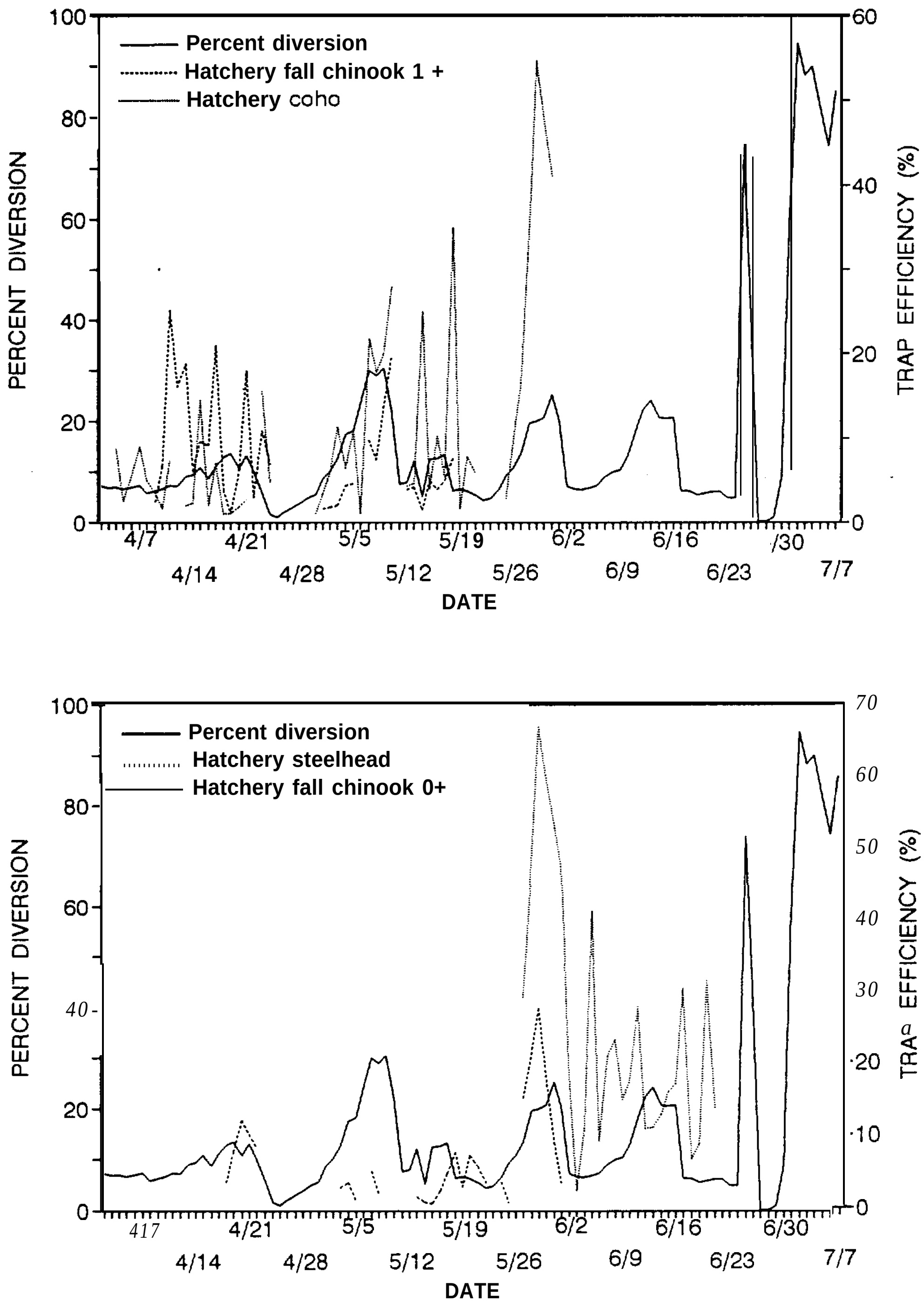
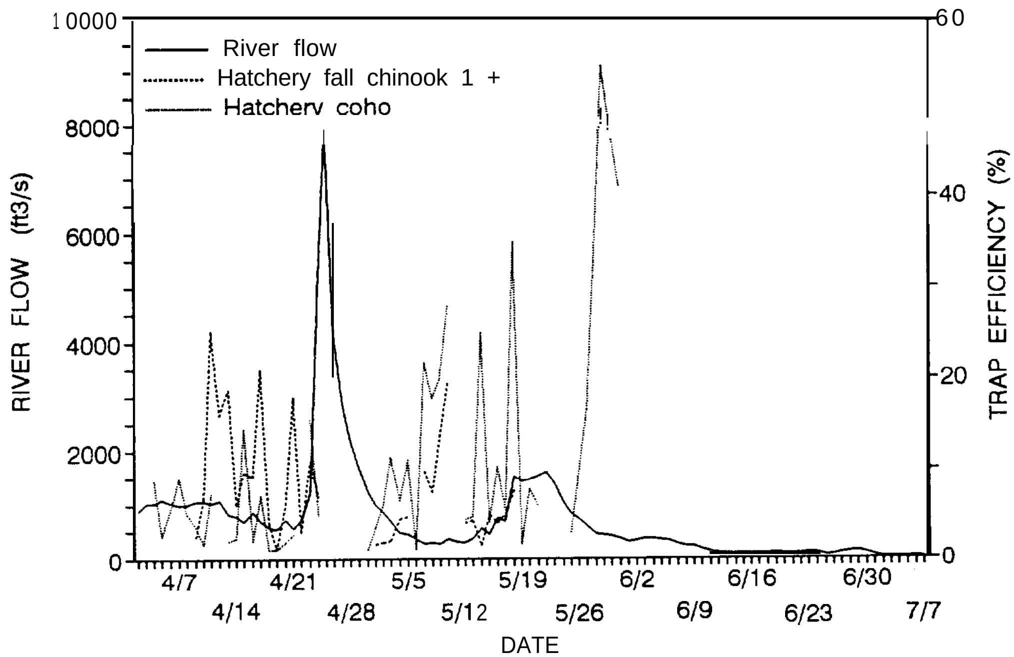


Figure 9. Percent diversion (canal flow plus bypass flow as a percent of river flow at RM 3) and trap efficiency of hatchery yearling fall chinook salmon, coho salmon, summer steelhead, and subyearling fall chinook salmon at West Extension Canal, Umatilla River, 2 April - 7 July 1996.



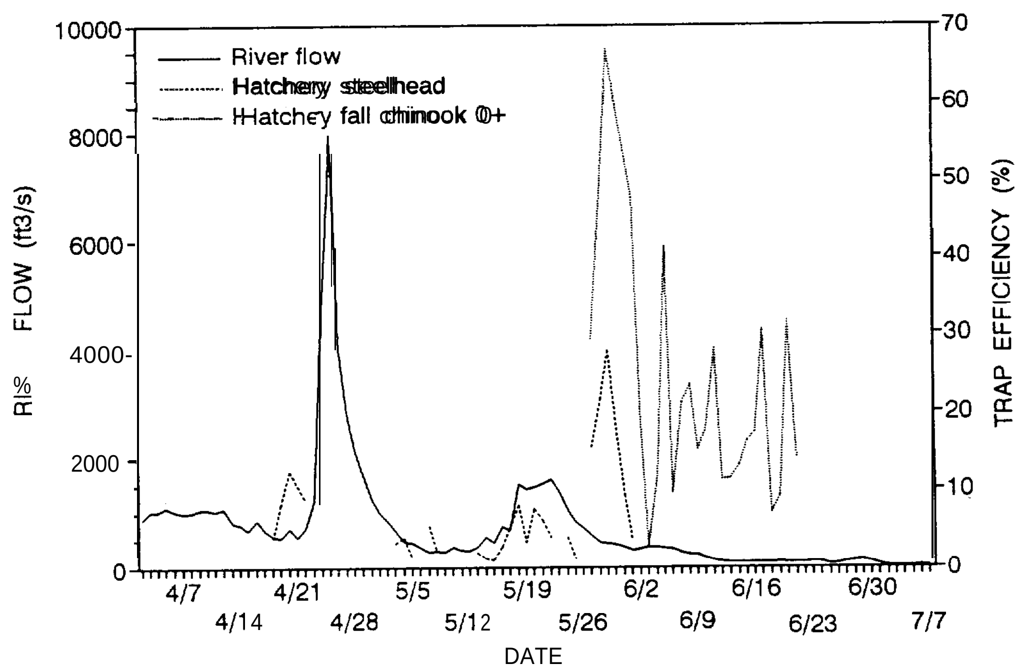
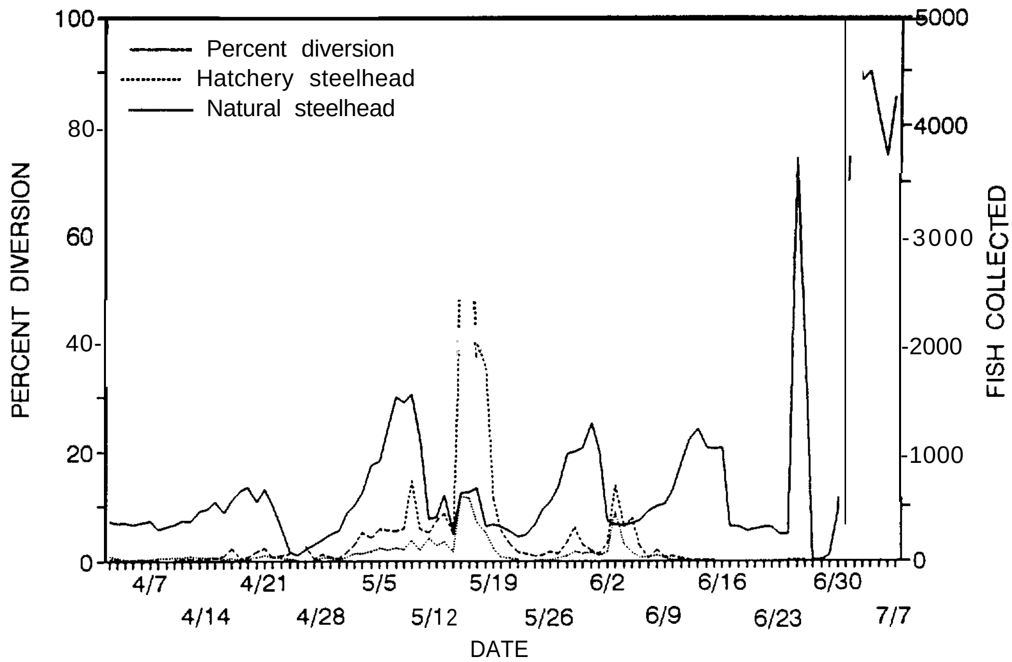


Figure 10. River flow (ft^3/s) at RM 3 and trap efficiency of hatchery yearling fall chinook salmon, coho salmon, summer steelhead, and subyearling fall chinook salmon at West Extension Canal, Umatilla River, 2 April - 7 July 1996.



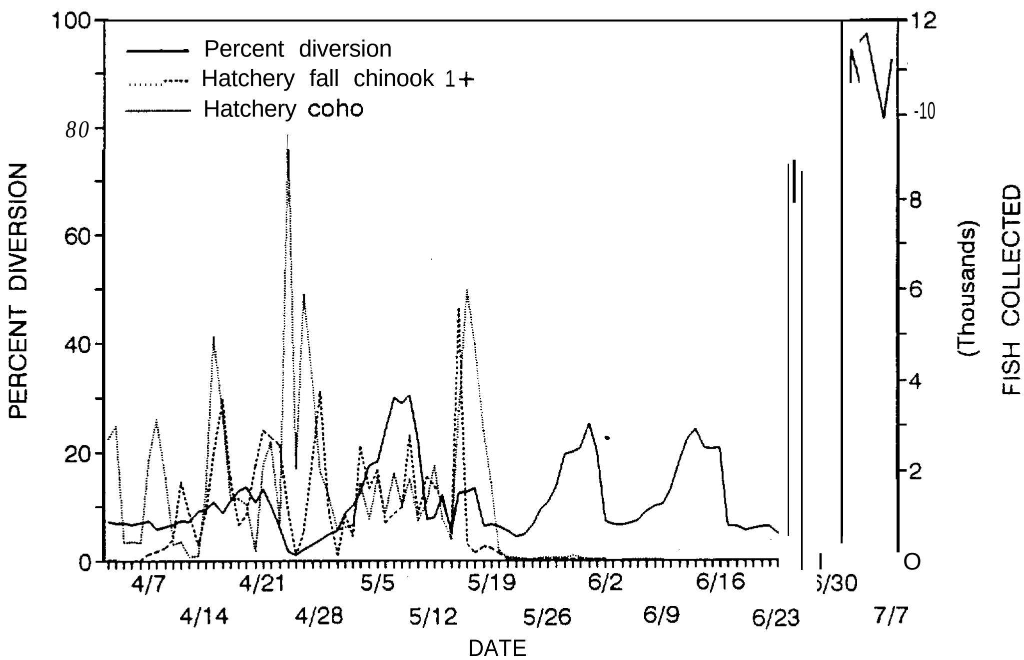


Figure 11. Percent diversion (canal flow plus bypass flow as a percent of river flow at RM 3) and collection of natural and hatchery summer steelhead, hatchery yearling fall chinook salmon, and hatchery coho salmon at West Extension Canal, Umatilla River, 2 April - 7 July 1996.

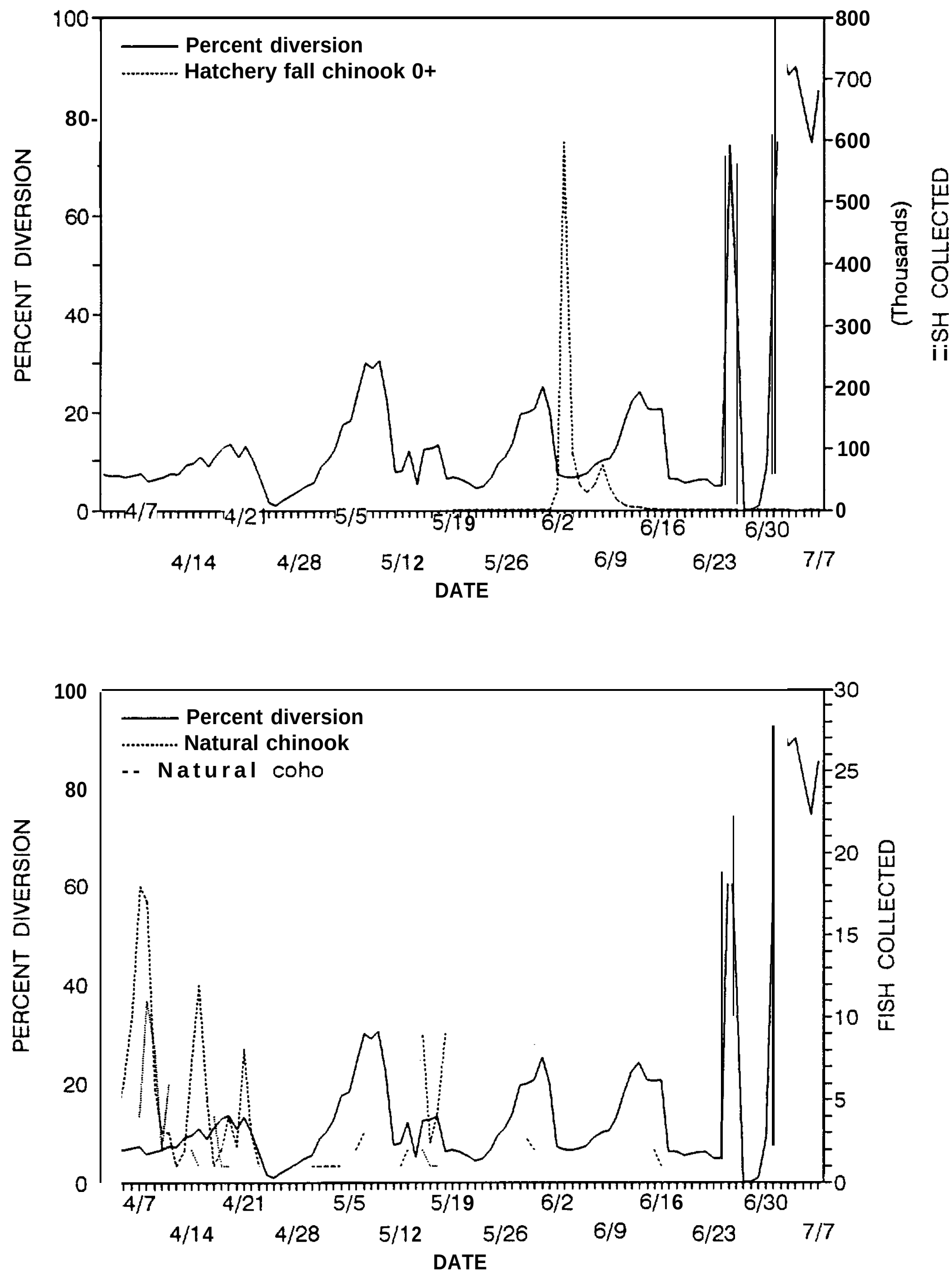


Figure 12. Percent diversion (canal flow plus bypass flow as a percent of river flow at RM 3) and collection of hatchery subyenrling fall chinook salmon, natural chinook salmon, and natural coho salmon at West Extension Canal, Umatilla River, 2 April - 7 July 1996.

APPENDIX A

Canal Operations and Ladder Water Velocities

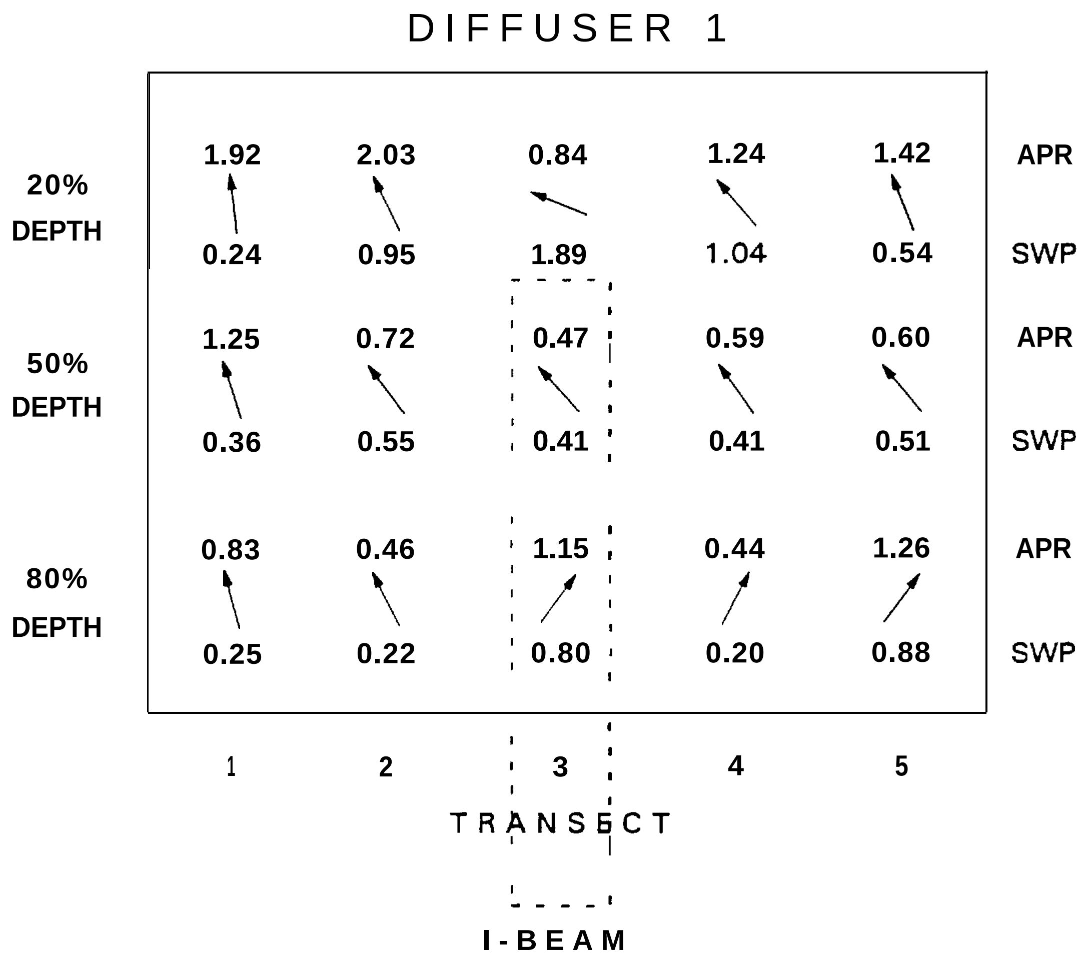
Appendix Table A-l. Daily operations at West Extension Canal, Umatilla River, 2 April - 29 June 1996.

	Pump operations		Drain	Headgate opening[b]		
Date	Pump 1	Pump 2	opening”	East	Middle	West
4/02/96	off	off	5	12	12	12
4/03/96	off	off	5	17	16	16.25
4/04/96	off	off	5	16.75	15.75	16.25
4/05/96	off	off	5	16.75	15.75	16.25
4/06/96	off	off	5	16.75	15.75	16.25
4/07/96	off	off	5	16.75	15.75	16.25
4/08/96	off	off	5	16.75	15.75	16.25
4/09/96	on	on	0	16.75	15.75	16.25
4/10/96	on	on	0	16.75	15.75	16.25
4/11/96	on	on	0	18	18	18
4/12/96	on	on	5	18	18	18
4/13/96	on	on	5	18	18	18
4/14/96	on	on	0	18	18	18
4/15/96	on	on	0	18	18	18
4/16/96	on	on	0	18	18	18
4/17/96	on	on	0	18	18	18
4/18/96	on	on	0	20	20	20
4/19/96	on	on	0	20	20	20
4/20/96	on	on	0	20	20	20
4/21/96	on	on	0	20	20	20
4/22/96	on	on	0	1s	18	18
4/23/96	on	on	0	18	18	18
4/24/96	on	on	0	9	9	9
4/25/96	on	on	0	8.5	8.5	8.5
4/26/96	on	on	0	10	10	10
4/27/96	on	on	0	13	13	13
4/28/96	on	on	0	13	13	13
4/29/96	on	on	0	14	14	14
4/30/96	on	on	0	17	17	17
5/01/96	on	on	0	17	17	17
5/02/96	on	on	0	21	21	21
5/03/96	on	on	0	21	21	21
5/04/96	on	on	0	21	21	21
5/05/96	on	on	0	21	21	21
5/06/96	on	on	0	40	40	40
5/07/96	on	on	0	46	46	46
5/08/96	on	on	0	46	48	46
5/09/96	on	on	0	48	48	48
5/10/96	on	on	5	11	11	0
5/11/96	off	off	7	11	11	0
5/12/96	off	off	7	12	12	0
5/13/96	off	off	7	12	12	0
5/14/96	off	off	7	12	12	0
5/15/96	on	on	0	38	38	38
5/16/96	on	on	0	25	25	25
5/17/96	on	on	0	25	25	25
5/18/96	on	on	0	20	20	20
5/19/96	on	on	0	20	20	20
5/20/96	on	on	0	20	20	20

Appendix Table A-l. Continued.

5/18/96	on	on	0	20	20	20
5/19/96	on	on	0	20	20	20
5/20/96	on	on	0	20	20	20
5/21/96	on	on	0	20	20	20
5/22/96	on	on	0	12	12	12
5/23/96	on	on	0	12	12	12
5/24/96	on	on	0	12	12	12
5/25/96	on	on	0	12	12	12
5/26/96	on	on	0	12	12	12
5/27/96	on	on	0	12	12	12
5/28/96	on	on	0	22	22	22
5/29/96	on	on	0	29	29	29
5/30/96	on	on	0	29	29	29
5/31/96	on	on	0	29	29	29
6/01/96	off	off	5	24	24	24
6/02/96	off	off	6	0	14	14
6/03/96	off	off	6	0	14	14
6/04/96	off	off	6	0	14	14
6/05/96	off	off	6	0	14	14
6/06/96	off	off	6	0	14	14
6/07/96	off	off	6	0	15	15
6/08/96	off	off	6	0	15	15
6/09/96	off	off	6	0	15	15
6/10/96	off	off	6	0	17	17
6/11/96	off	off	6	0	17	17
6/12/96	off	off	6	0	17	17
6/13/96	off	off	4	0	17	17
6/14/96	off	off	4	0	17	17
6/15/96	off	off	4	0	17	17
6/16/96	off	off	4	0	17	17
6/17/96	off	off	4	0	17	17
6/18/96	on	on	0	0	17	17
6/19/96	on	on	0	0	17	17
6/20/96	on	on	0	0	17	17
6/21/96	on	on	0	0	17	17
6/22/96	on	on	0	17	17	0
6/23/96	on	on	0	17	17	0
6/24/96	on	on	0	17	17	0
6/25/96	on	on	0	17	17	0
6/26/96	on	on	0	17	17	0
6/27/96	on	on	0	17	17	0
6/28/96	on	on	0	17	17	0
6/29/96	on	on	0	17	17	0

[a] *River-return drain pipe in pumpback bay; opening measured in inches*
[b] *Headgate openings measured in inches*



Appendix Figure A- 1. Approach (above arrows) and sweep (below arrows) water velocity (ft/s) measured in front of Diffuser 1 located in the passage section of the east-bank fish ladder at Three Mile Fails Dam, Umatilla River. Arrows indicate direction of flow Flow perpendicular to the diffuser is depicted by arrows pointing straight up. Water velocity reported by Cameron et al. **(1997).**

Bonneville Power Administration

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