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

(1 OCTOBER 1997 - 30 SEPTEMBER 1998)

Annual Report 1998

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

ANNUAL REPORT 1998

(1 OCTOBER 1997 - 30 SEPTEMBER 1998)

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EXECUTIVE SUMMARY

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

Objectives for FY 1998

1. Conduct pilot monitoring of PIT-tagged and color-marked fish.

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

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

4. Determine species composition, condition, and total number of juvenile fish transported from Westland Canal during low summer flows.

5. Estimate survival of hatchery juvenile salmonids from abundance estimates and conduct secondary mark-recapture tests to validate survival estimates.

6. Conduct reach-specific survival tests using PIT tags.

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

8. Assess smolt passage at the east-bank fish ladder at Three Mile Falls Dam using videography.

Accomplishments and Findings for FY 1998

We achieved all eight objectives in FY 1998. We monitored juvenile migration at two locations in the lower river from October 1997 through early July 1998. Throughout the rest of July until mid-August, we sampled at Westland Canal during juvenile fish transport operations. We did not monitor migration from mid-August through September due to low flows.

We used photonic and VI-jet color marks on the anal fins to identify PIT-tagged fish during monitoring, and on the dorsal fin of other test fish. We assessed the quality of color marks on each species to determine the effectiveness of specific colors. On fish used in reach survival and secondary survival tests, photonic pink was the best color mark; green, dark yellow, orange, and red were poorer colors. Subyearling fall chinook salmon and summer steelhead showed more poor marks than yearling chinook salmon. Marks were more visible on the anal fin than the dorsal fin. We found no difference in mark quality between photonic and VI-jet marks.

At the rotary-screw trap, trap retention efficiency was lower for spring chinook salmon than yearling fall chinook or coho salmon. Survival of fish held for 24 h prior to release in trap efficiency tests was > 99%. Collection efficiency of the rotary trap was near 4% for spring chinook salmon and near 2% for yearling fall chinook salmon and coho salmon. Fish were collected from 2 – 5 h after release.

Adjusted collection at the rotary trap up to 3 April was 10,224 hatchery fish and 161 natural fish. Most fish were spring chinook salmon. Natural fish were first captured in late December (spring chinook salmon) and mid- to late March (summer steelhead and coho salmon).

At West Extension Canal, holding survival was >99%. Trap collection efficiency estimates were higher for hatchery yearling spring and fall chinook and subyearling fall chinook salmon (20 – 32%) and lower for hatchery summer steelhead and coho salmon (9 – 11%). Efficiency estimates were 12% for both natural subyearling fall chinook salmon and natural summer steelhead. Fish were recaptured up to 37 d after release, but most were recaptured within a few days.

Adjusted collection of hatchery salmonids at West Extension Canal after 3 April was 1,352,053 fish. Nearly 37,000 natural salmonids were collected, mostly subyearling fall chinook salmon (71%), summer steelhead (17%), and yearling and subyearling spring chinook salmon (9%). We collected 45 natural summer steelhead between 295 - 378 mm FL, which were age 3 and 4 fish; most natural steelhead migrants were age 2 fish.

During juvenile fish transport from 7 July to 13 August at Westland Canal, hatchery and natural subyearling fall chinook salmon comprised most of the sample. An estimated 44,234 salmonids were transported to the river mouth, of which 27,500 were hatchery subyearling chinook and 16,100 were natural subyearling chinook salmon.

Of hatchery groups, yearling spring chinook salmon and subyearling fall chinook salmon migrated faster than summer steelhead, coho salmon, and yearling fall chinook salmon. Peak migration for summer steelhead and coho salmon was in early May, several weeks to several months after release. Passage of yearling spring and fall chinook salmon peaked in late April, one to two weeks after the last release; subyearling fall chinook salmon peaked in early June, one week after release. Migration duration extended from 2 months (coho salmon) to 3 months (summer steelhead).

Natural spring chinook salmon migrated from late December to early July and included both yearling and subyearling age groups. Peak capture was in late April as more yearling fish appeared smolted. Natural fall chinook salmon first appeared as fry in early April, peaked as smolts in mid-June, and continued migrating until mid-August. Most fish appeared smolted by late June. Natural coho salmon were collected from late March to mid-August, with peak capture in early June as fish transitioned to smolts; summer captures at Westland Canal were mostly parr fish. Natural summer steelhead were also detected from mid-March to mid-August (Westland Canal) with peak capture in late April and early May. Natural steelhead were mostly smolted after mid-June.

Smoltification of natural fish was significantly correlated with fork length for all species. Smolted natural coho salmon were usually > 80 mm in fork length (FL); smolted summer steelhead were usually > 200 mm FL.

Fish released at upriver sites for reach-specific survival tests generally migrated faster than those released in the lower reaches. Most yearling spring and subyearling fall chinook salmon moved through the lower river within 1 week of release. Steelhead released in mid-April from Bonifer at rivermile (RM) 79 and Reith (RM 48) were the last fish to be detected in late May. Steelhead released at Bonifer in mid-May were detected later than the mid- and lower release groups.

Hatchery salmonids showed a significantly larger mean fork length than natural conspecifics. Hatchery subyearling fall chinook salmon captured at Westland Canal in August averaged 55 mm greater in fork length than pre-released fish in late May. From scale sample analysis, mean lengths of 2-, 3-, and 4-year-old natural steelhead were 208 mm, 282 mm, and 315 mm FL.

Differential capture of fish with different fin clips was evident for yearling spring chinook and yearling and subyearling fall chinook salmon, but not for coho salmon or summer steelhead. Percent recapture of yearling spring and subyearling fall chinook salmon that were ventral fin-clipped was significantly greater than adipose and ventral fin-clipped fish. The opposite was true for yearling fall chinook salmon.

Of hatchery fish, summer steelhead were in poorest condition and spring chinook salmon were in best condition based on scale loss. Mortality was highest for yearling fall chinook salmon which showed prevalent signs of bacterial kidney disease (BKD). Scale loss on subyearling fall chinook salmon increased through summer. Bird marks were commonly observed on hatchery summer steelhead and spring chinook salmon. Of natural fish, subyearling fall chinook salmon were in poorest condition, which worsened with time. Bird marks were prevalent on natural summer steelhead; black spot disease and leeches were prevalent on natural chinook salmon.

Estimates of natural migration were 3,000 coho salmon, 19,000 spring chinook salmon, 141,000 subyearling fall chinook salmon, and 54,000 summer steelhead. Most of these estimates were higher than in previous years. Survival of hatchery yearling spring and fall chinook salmon (near 70%) was also higher than in previous years. Survival of hatchery summer steelhead was lower (50%). Survival estimates for subyearling fall chinook salmon and coho salmon were over 100%. Similarly, survival estimates for color-marked hatchery fish were lowest for summer steelhead and highest for spring chinook salmon.

Percent PIT-tag detection in the lower river of March-released spring chinook salmon from Umatilla Hatchery was half that of fish from Little White Salmon Hatchery. Percent detection was similar for April-released spring chinook salmon from Little White Salmon and Carson hatcheries. Percent detection of large-grade summer steelhead released from Bonifer in April was half that for Minthorn steelhead released in the same month and small-grade steelhead released from Bonifer in May. Percent detection was slightly greater for tagged Michigan-reared spring chinook salmon than Oregon-reared fish, and higher in the first raceway of the series than last two raceways. Percent detection of subyearling fall chinook salmon was lower for low and medium density rearing than high density rearing.

Reach-specific survival was inconclusive for yearling spring chinook salmon and May-released summer steelhead. For April-released steelhead, survival was highest for fish released at Reith (RM 48) and lowest for fish released at Bonifer; this difference was significant. Survival of subyearling fall chinook salmon successively increased with lower river releases. Only 0.4% of the tagged subyearling fall chinook salmon released into Westland Pond and transported downriver were detected at mainstem dams. Tags from fish released in reach survival tests were recovered at tern and gull colonies on mainstem islands. Highest tag recovery was from summer steelhead (4%).

No major flood events occurred in 1998. Suspended sediment greatly decreased water clarity during high flows to < 0.5 meter visibility when fish were actively migrating. Water temperatures reached 74 °F in July. Temperature was highly correlated with river flow.

Numbers of hatchery and natural juvenile salmonids generally peaked on the ascending or descending limb of the hydrograph. Passage of coho and yearling fall chinook salmon and summer steelhead was linearly correlated with flow. Hatchery and natural subyearling fall chinook salmon peaked as flows diminished to 700 ft^3/s and below in June.

Diversion at West Extension Canal influenced collection of hatchery coho salmon and yearling and subyearling fall chinook salmon. Phase I pump exchange generally curtailed collection. Fish migrants in June were dependent on water releases from McKay Reservoir, which supplied about 80% of the river flow.

Using video, we estimated nearly one-quarter million subyearling fall chinook salmon passed through the east-bank fish ladder at Three Mile Falls Dam the first week in June; most movement was in the morning. Diurnal movement was matched between the ladder and bypass facility until Phase I pump exchange at the canal eliminated nighttime movement at the canal bypass. More fish were also shunted toward the ladder immediately after the start of Phase I exchange. Of fish counted, 77% used the bypass and 23% used the ladder to pass Three Mile Falls Dam.

Juvenile lamprey were collected from December to May with smolted lamprey captured mostly in winter. Most juvenile lamprey were non-smolted and moved out with flow increases.

Primary avian predators included gulls, cormorants, great blue herons, and night herons. Gull activity was greatest during low flows and high fish abundance. Few piscivorous fish were collected at the canal bypass.

Management Implications and Recommendations

1. Continue the release of stored water from McKay Reservoir through June and possibly into July to allow in-river migration of natural and hatchery fish. This will reduce the number of fish trapped at Westland Canal and transported to the river mouth. Transport of fish appears to decrease survival; therefore, in-river migration is preferred for late-season migrants. Water releases also temper stressful thermal conditions.

2. Reduce reliance on transport of juvenile salmonids. Handling of fish is extremely stressful during mid-summer subsampling and transport operations. At times, mishandling can cause high mortality. Transporting collected juveniles also dislocates natural fish rearing in the area.

3. Continue new hatchery rearing strategies for spring chinook salmon implemented with the 1996 brood at Umatilla Hatchery. This strategy may improve in-basin survival by producing a smaller and healthier fish.

4. Continue transplanting adult fall chinook salmon from mid-Columbia hatcheries into the Umatilla River to increase natural production, especially when inadequate numbers return to the river for natural spawning. Initial monitoring suggests substantial numbers of juveniles are produced in some years.

5. Operate the lead gate at the east-bank fish ladder at Three Mile Falls Dam fully open to improve passage and hydraulic conditions for juvenile fish. Subyearling fall chinook salmon use the ladder as a major passage route during initiation of Phase I pumping at West Extension Canal.

6. Monitor Pacific lamprey year round. This would provide important information on lamprey life history patterns and their relationship to environmental parameters.

7. Provide bird deterrents such as water cannons, rainbird sprinklers, mylar balloons or strips, or noise makers (e.g. firecrackers) at Three Mile Falls Dam. These devices might be a cost-effective way to discourage avian predation on juvenile salmonids.

8. Research has shown that survival may be improved with lower river releases, especially with summer steelhead. Managers may want to consider releasing production groups lower in the river to boost in-basin survival.

9. Use PIT tags to estimate trapping efficiency, monitor the outmigration of juvenile salmonids, and to estimate migrant abundance and survival. Remote monitoring at West Extension Canal is recommended to reduce handling and to augment detections from mainstem dams.

10. Ensure that new acclimation facilities for coho salmon are completed to eliminate the practice of early direct releases. Acclimation will allow an additional period for smolt development, increase migration rates, and reduce bird predation.

11. Continue rearing yearling fall chinook salmon at off-site hatcheries with improved rearing profiles to increase their survival potential. Off-site rearing in 1998 boosted in-basin survival from previous years when fish were reared at Umatilla Hatchery.

12. Ensure all passage facilities are maintained during the general migration peak from late April through early June. Debris removal at diffusers and trashracks is critical to fish safety during high flows.

13. When color marking juvenile fish, use pink as a color mark and apply to the anal fin for best readability. Pink is easily detected and better retained in this location.

INTRODUCTION

Large runs of salmon (*Oncorhynchus spp*.) and steelhead (*O. mykiss*) once supported productive Tribal and sport fisheries in the Umatilla River prior to the 1900s. By the 1920s, unscreened irrigation diversions, reduced in-stream flows, poor passage conditions, and habitat degradation had extirpated the salmon run and drastically reduced the summer steelhead run (CTUIR and ODFW 1989). Reintroduction of chinook salmon (*O. tshawytscha*) and coho salmon (*O. kisutch*) and enhancement of summer steelhead populations in the Umatilla River were initiated in the early and mid-1980s (CTUIR and ODFW 1989). Complementing and supporting salmonid restoration is the Umatilla Basin Project, which provides flow enhancement during critical periods (USBR 1988). Measures to rehabilitate the fishery 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, 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 plans (CTUIR 1984; Boyce 1986). The Umatilla Hatchery Master Plan (CTUIR and ODFW 1990) provides the framework for hatchery production and evaluation activities.

Many agencies cooperate, coordinate, and exchange information in the Umatilla basin to ensure successful implementation of rehabilitation projects, including the U.S. Bureau of Reclamation (USBR), the Bonneville Power Administration (BPA), National Marine Fisheries Service (NMFS), Oregon Water Resources Department (OWRD), Oregon Department of Fish and Wildlife (ODFW), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and local irrigation districts (West Extension, Hermiston, and Stanfield-Westland). The Umatilla River Operations Groups and the Umatilla Management, Monitoring and Evaluation Oversight Committee coordinate river management and fisheries management and research in the Umatilla River basin. The driving force in improved river operations is the fisheries restoration program.

Monitoring and evaluation efforts to fine-tune specific fisheries restoration projects are ongoing or near completion. Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin is a necessary component for determining the success of these projects and the overall effectiveness of the restoration plan and flow enhancement strategies. A key critical uncertainty is whether juvenile salmonids are surviving and successfully migrating out of the Umatilla River basin. Although smolt-to-adult survival is being assessed through the Umatilla Hatchery Monitoring and Evaluation Project (Keefe et al. 1993, 1994; Hayes et al. 1995, 1996, 1999, 2000; Focher et al. 1998), results are broad in scope and reliant on long-term adult returns. Potential factors determining survival of juvenile salmon in the Umatilla basin include loss through in-river predation, cumulative effects of passage through passage facilities at irrigation diversion dams, effects of poor river conditions, water quality, and transport, and effects of hatchery rearing, release, and acclimation strategies.

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

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) are investigating the natural production potential of each race or species of salmonid in the Umatilla River basin and the effects of hatchery supplementation on native steelhead (CTUIR 1994; Contor et al. 1996, 1997, 1998). 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, migration timing, lower river abundance, and survival of naturally-produced salmonids originating in the upper river.

Previous outmigration monitoring of juvenile salmonids discerned different hatchery rearing groups through branded and color-marked fish (Knapp et al. 1996, 1998a, and 1998b). The advent of PIT-tag detection at John Day Dam in 1998 prompted the initial use of PIT tags on hatchery fish in the Umatilla River basin. To identify PIT-tagged fish during active interrogation at lower river traps, a color mark was applied to the anal fin to serve as a visual flag. Color marks were also used to mark trap efficiency test fish and fish used in secondary survival tests. The use of two types of color marks of various colors provided an opportunity to evaluate mark quality and operation of the marking equipment.

Estimates of survival have been poor for some groups of fish in past years (Knapp et al. 1996, 1998a, 1998b). Release site (rivermile distance) was thought to be a factor in survival. PIT tagging and monitoring in 1998 provided an opportunity to conduct reach-specific survival tests with PIT-tagged fish.

Survival of juvenile salmonids can be affected by poor conditions during their transport from Westland Canal (RM 27.3) to the lower Umatilla River. Juvenile salmon collected at Westland Canal undergo scale loss and stress during dip-net loading (Cameron et al. 1994) and crowding (Walters et al. 1994). The cumulative effect of collection, crowding, loading, and transport on the health of juvenile salmonids may result in poor survival after release. Testing the cumulative effects through treatment and control tests resulted in greater injury and mortality of transported fish versus non-transported fish (Knapp et al. 1998a, 1998b). Detecting transported PIT-tagged fish at mainstem dams would provide useful information.

A number of issues related to water use in the Umatilla River are associated with fisheries rehabilitation. Providing water for irrigators and anadromous fish is a desired goal of the Umatilla Basin Project (USBR 1988). An understanding of flow requirements for fish passage, rearing, and survival, and species-specific migration characteristics is critical to determine optimum canal operations, water release strategies, and flow enhancement strategies (USBR 1988; USBR and BPA 1989). Phase I pump exchange at West Extension Canal affects the efficiency of the bypass in routing fish past Three Mile Falls Dam (Knapp et al. 1996, 1998a).

During Phase I exchange, diversion ceases and Umatilla River water is exchanged for Columbia River water pumped into the irrigation canal. Water releases from McKay Reservoir are important in allowing in-stream migration of juvenile migrants in late spring and early summer (Knapp et al. 1998a). Assessing these effects is partly done through monitoring at the bypass sampling facility and partly through video monitoring at the east-bank ladder, both of which need further validation.

Fish using the east-bank fish ladder is an important issue because of previous findings on fish injury and delay at this structure (Cameron et al. 1994, 1995). Recommendations made to change the operation of the fish exit gate were carried out and fish condition improved (Knapp et al. 1998b). However, determining the extent of passage through the ladder during specific operating conditions required another year of video monitoring to validate findings in 1996 (Knapp et al. 1998a). We were concerned with the subyearling fall chinook salmon migrants.

The goal of the Outmigration and Survival Study is to evaluate the outmigration, estimate survival, and investigate factors affecting migration and survival of juvenile salmonids in the lower Umatilla River basin. General objectives for meeting this goal in the 1997-1998 project period were:

1. Conduct pilot monitoring of PIT-tagged and color-marked fish.

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

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

4. Determine species composition, condition, and total number of fish transported from Westland Canal during low summer flows.

5. Estimate survival of hatchery juvenile salmonids from abundance estimates and conduct secondary mark-recapture tests to validate survival estimates.

6. Conduct reach-specific survival tests using PIT tags.

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

8. Assess smolt passage at the east-bank fish ladder at Three Mile Falls Dam using videography.

In this report, we describe our fourth year activities and findings for the Umatilla River Outmigration and Survival Study from 1 October 1997 to 30 September 1998. We present information from outmigration monitoring, including species and origin of fish collected, lengths, fish health, smolt development of natural fish, color marks observed and PIT tags detected, migration patterns, migration performance, and environmental conditions. We present trapping efficiencies, estimations of migrant abundance and survival, information on reach-specific survival and transport effects, and observations of predators and other fish. We also describe our second year results in observing juvenile fish passage through the east-bank adult fish ladder at Three Mile Falls Dam with the use of video.

STUDY SITES

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

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).

We sampled at West Extension Canal from early April to early 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).

We also sampled at the canal screening facility at Westland Canal (RM 27.3; Figure 1) during juvenile fish transport operations. Trap efficiency tests were not performed at this site. Details of the Westland Canal juvenile collection facility and the Umatilla Trap and Haul Program can be found in Knapp et al. (1998b) and CTUIR and ODFW (1996).

Fish used in reach-specific survival tests were obtained from Umatilla Hatchery and PIT tagged at Irrigon Hatchery in Irrigon, OR. Releases for different groups of fish were made at RM 80, RM 79 (RM 2 of Meacham Creek), RM 64, RM 48, RM 42, and RM 27. The RM 80, 79, and 64 release sites were the standard acclimation sites.

We also used video equipment to monitor passage of hatchery subyearling fall chinook salmon through the viewing window of the east-bank fish ladder at Three Mile Falls Dam (Figure 1). Details on the location and placement of equipment are found in Knapp et al. (1998b).

METHODS

Color Marking and PIT Tagging

We color marked fish with photonic marks (New West Technologies, Santa Rosa, California) or visible implant (VI) jet marks (Northwest Marine Technology, Shaw Island, WA) for tests. Marks were comprised of a polymethylmethacrylate flourescent pigment encapsulated in latex microspheres. All PIT-tagged fish were color marked to serve as a visual flag during outmigration monitoring. We also color marked non-PIT-tagged fish for tests not requiring PIT tags (Table 1).

We color marked spring chinook salmon, summer steelhead, and subyearling fall chinook salmon for reach survival tests to determine specific survival for particular reaches of the Umatilla River. These fish were PIT tagged and color marked in the anal fin (Table 1). Tag loss was determined 48 h after tagging. All production fish with PIT tags were also color marked to monitor survival among different rearing and release strategies (Hayes et al. 2000). All PIT-tagged production fish were flagged with blue marks on the anal fin. Fish that were color marked but not PIT tagged included fish used in secondary survival tests and trap efficiency tests. Secondary survival tests were used as an additional indicator of survival in the Umatilla River basin; fish were marked in the dorsal fin (Table 1). Trap efficiency test fish were marked in various fin combinations.

Pre-release mark quality was assessed on production and reach survival fish, but not on fish used in secondary survival tests or trap efficiency tests. Mark assessment on production fish was conducted on the day of marking. If mark quality was not good, another mark was injected to ensure good mark quality. For reach survival fish, we evaluated mark quality at the end of the holding period at the hatchery (on the day of release) for each test group. The time from marking to initial mark quality checks was denoted as “mark loss days”.

During monitoring and recapture in the lower river, we re-assessed the mark quality on all color-marked fish to further determine mark retention. To assess mark quality, we categorized marks as “good” if two or three rays were clearly marked; “fair” if one ray was visibly marked, or “poor” if the mark was small and not clearly visible (Figure 3). On known marked fish (i.e. those with a PIT tag), the absence of a visible mark was also noted. Good and fair marks combined produced a readable mark; unreadable marks were those that were poor or lost.

Prior to any field marking, we test marked hatchery spring chinook salmon captured at the rotary-screw trap with red VI-jet paint in various fins for an initial mark retention evaluation of VI-jet paint. Each fish was marked in 7 fin locations: left and right pectoral, upper and lower caudal, anal, dorsal, and either the left or right pelvic fin. Marked fish were held for 24 h in a net pen in the river before evaluation.

For color marking, we used the Biometrix-1000 System injectors (BMX-1000; New West Technologies; Figure 4). These units were powered by pressurized CO_2 at approximately 500 - 600 lb/in^2. The paint was drawn into the marking unit through a siphon tube with one end submerged in the marking fluid (Figure 4). Once the injector head of the marking unit was filled with paint, the trigger could be depressed to inject a specified amount of paint into the fin of the fish. The dosage (0.05-1.0 ml) was regulated by gauging blades on the power unit, with incremental adjustments of 0.05 mL. We used marking trays filled with water and placed a marking table and ceramic tile in the water at approximately ¼-in depth. Marking was conducted under water to reduce airborne particles and potential respiratory problems. Fish were placed on the marking table with the fin spread on the ceramic tile. The tile served as a backing to improve the injection and spread of paint into the fin rays. The marking unit was held just off the surface of the fin at an approximate 45° angle (angle varied among taggers) and fired to inject a good mark. After marking, the fish was placed in a recovery container.

Equipment used during PIT tagging at the hatchery included a Biomark station with a portable computer, digitizer, and electronic scale, a Destron loop for detecting the PIT tag, and a reader to record the tag code. We used 400 kHz PIT tags in 1998. Fish were anesthesized with a stock solution of MS222 (tricaine methanosulfonate), tagged, weighed, measured, and returned to the recovery tank. At lower river traps, we used the portable Destron loop and reader to interrogate color-marked fish. Tag codes were stored in the reader or transcribed onto paper.

We created four types of files associated with PIT tagging: 1) tagging files (created on day of release), 2) release files (created after fish were released into the river), and 3) recapture and 4) mortality files (created after monitoring was completed). Mortality files were comprised of tag codes from released, tagged fish that were dead or died at recapture. All tagging and release files were edited, validated, and submitted to PTAGIS shortly after release. Recapture and mortality files were edited, validated, and submitted to PTAGIS after the field season was complete. We downloaded tag information from the PTAGIS database to determine tag detections of reach survival test fish at mainstem Columbia River dams (John Day and Bonneville dams) and in the Columbia River estuary, and tag recoveries at Columbia River islands.

Outmigration Monitoring

Trap Efficiencies

We used trap efficiencies to expand the catch of juvenile fish for an estimate of migrant abundance. The probability of survival of marked fish released for trap efficiency tests was determined by conducting 24-h mortality tests with all or a sub-sample of these fish. Retention efficiency of the rotary trap was determined to adjust the number of fish collected.

We determined trap collection efficiencies by releasing a known number of marked fish (*M*) upstream of the trap and recapturing them in the trap or collection facility (*m*) over the duration of the collection period. Numerous daily releases were made for each species or race of fish. For each test group, we compared daily trap efficiencies using Chi^2 analysis, and pooled the test data if the efficiency estimates were not significantly different at an alpha level of 0.05. If recaptures were < 5, daily test data was combined until the recapture size was ≥ 5 to satisfy the assumption of the Chi^2 test. If all daily estimates were not significantly different, a final pooled trap efficiency estimate was determined as the ratio of total fish recaptured to total fish released over the collection period (*TE* = *m/M*). On occasion, significant differences between days resulted in sub-pooling of trap efficiencies for specific periods. The final trap efficiency estimate was the weighted mean of the sub-pooled estimates. We expanded the collection of fish for the trapping period by the pooled estimate or the mean of sub-pooled estimates to derive an abundance estimate for that period.

For trap efficiency tests, we used healthy unmarked hatchery and natural fish from the trap or collection facility. We marked test fish from the rotary-screw trap by injecting a small amount of acrylic paint using a 3-cc disposable syringe equipped with a 26-gauge intradermal needle. We used two paint colors (red and blue) and 10 mark locations near the base of ventral fins to provide a unique mark for all fish releases. We marked fish throughout the 18-h sampling period and held them in net pens along the river shore for release the following day (or until we obtained an adequate sample size). We marked test fish from the West Extension Canal facility by injecting photonic or VI-jet paint into various fins (*see* **Color Marking and PIT Tagging**). We used eight colors (blue, green, yellow, dark yellow, red, pink, purple, and orange) and six marking locations (left and right pectoral fins, left and right ventral fins, and upper and lower caudal fin) to provide unique daily marks. We marked fish throughout the 24-h sampling period and held them in net pens for release the following day (or until we obtained an adequate sample size). Net pens at the canal were contained within circular tanks supplied with continuous inflow water from the canal.

To test holding survival (or 24-h latent mortality), all fish marked at the rotary trap were transported in the evening upriver to West Extension Canal and held in a circular tank near the bypass outfall (Knapp et al.1998b). We counted and removed dead fish after transport. After holding for 24 h, we counted the fish that died to assess the probability of survival (*s*) of remaining live fish released for trap efficiency tests. The number of live fish released (*R*) was adjusted for survival (*s*) to obtain the adjusted number of marked fish available for recapture (*M*; *R(s)* = *M*). The adjusted number of marked fish (*M*) was used to calculate trap efficiencies. As with the daily trap collection efficiencies, we compared daily survival estimates using Chi^2 analysis, and pooled the data if survival estimates were not significantly different.

Fish were released from the circular tank by guiding them into a funnel and 6-inch-diameter pipe leading to the river (Knapp et al. 1998b). Releases were generally made between 1600 and 1800 hours.

At West Extension Canal, a sub-sample of marked fish (10%) was held for 24 h to test holding survival; remaining fish were immediately transported to the release site. We could not hold fish at the release site near the Waste Water Treatment Plant due to poor water quality. We followed the same procedure used for fish marked at the rotary trap to assess the probability of survival of released fish.

We transported fish to release sites in 30-gal containers within a 250-gal aerated slip tank in the bed of a ¾-ton truck. For both release sites, we assumed release site distance (approximately 1.5 miles) allowed random distribution of fish in the river. At the Waste Water Treatment Plant, 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 (1600 - 1800 hours).

At the rotary trap, species-specific trap retention tests were also conducted to adjust the number of marked and unmarked fish captured according to the retention efficiency of the trap. We marked and released about 20 fish of each race or species into the trap live box and counted the number that were retained after a 12-h period. Fish were marked as in trap efficiency marking. We compared daily trap retention estimates using Chi^2 analysis, and pooled the data if retention estimates were not significantly different.

Collection

Juvenile fish were anesthetized with MS222 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 an adipose or ventral fin. Spring and fall chinook salmon were differentiated by the type of ventral fin clip. Only 5% of the hatchery coho salmon were adipose-fin clipped and were differentiated from natural fish by size or time of year when captured. Generally, coho salmon < 100 mm (FL) were considered naturally produced when both hatchery and natural fish were in the river (personal communication, G. Rowan, CTUIR, Mission, OR). However, we also indentified natural coho salmon > 100 mm in fork length by the presence of a naturally occurring parasite and by the unique coloration of natural fish.

We examined all fish for color marks and a subsample of fish for fin clips and condition. Fish marked in the anal fin with photonic marks were scanned for a PIT tag. Only natural fish were visually examined for smoltification. Scale samples were collected from natural summer steelhead smolts and analyzed by CTUIR biologists. We also collected scales from summer steelhead adults (kelts) that fell back through the sampling facility at West Extension Canal and from periodic captures of natural chinook salmon.

Sample data from the West Extension Canal facility was expanded for undersampled and non-sampled periods to account for sampling rates less than 100% and for periods when fish were bypassed. Sampling was conducted every few hours, not on an hourly basis. When more fish were collected in the sample tank than could be processed, we examined representative subsamples from several net loads; remaining fish were bypassed by net load and data was interpolated from subsampled data. In both methods, interpolation by species or race was carried out for origin, marks, and fin clips.

Data collected at the rotary trap was expanded to account for times when the trap was not sampling by dividing by the proportion of the time sampled. Data was expanded for species, race, origin, marks, and fin clips. Data was not interpolated for days when the trap was not sampling.

Trap and Haul

In conjunction with CTUIR, we examined species composition of juvenile fish collected at Westland Canal during Trap and Haul operations (CTUIR and ODFW 1998). Fish were collected with dipnets from the juvenile holding pond at Westland Canal, anesthetized, counted, and identified to species. We examined a subsample of salmonids for scale loss and injuries, color marks, smoltification, and fork length (mm).

We used species composition and fish-per-pound data to estimate the total number of fish transported from Westland Canal during Trap and Haul operations. Estimates of number of salmonids per pound multiplied by the total number of pounds transported provided total number of salmonids collected each day. Daily totals were summed to estimate total number of fish collected at Westland Canal. For days that fish were transported and no estimates of fish per pound data were determined, we averaged data collected from preceding and following dates on which sampling was conducted to interpolate missing data.

Migration Parameters

We determined migration duration, pattern, and timing, identified dates of peak movement, and calculated median travel speed for hatchery salmonids using expanded catch data from the traps. Travel speed was not determined for natural salmonids due to the unknown time of initial movement. For hatchery species, we further expanded catch data by daily trap efficiencies to provide daily passage estimates. Migration duration was the length of time from initial to final capture. Migration timing was the cumulative percent passage of a fish species over time. Migration pattern and periods of peak movement were identified from a plot of daily passage through time. Median travel speed (mi/d) was miles from release to recapture site divided by days from release to median (50%) passage. Additional information on migration patterns of hatchery salmonids was gained by recapture of fish that were color marked and PIT tagged. We determined a weighted mean travel speed for PIT-tagged fish using the travel speeds of individual tagged fish. We plotted daily passage of color-marked fish to determine migration parameters, as was done for total fish.

Smolt Status

Smolt development was estimated by examining body coloration and definition of parr marks on subsamples of natural salmonids. Fish were viewed from the side under ambient or artificial light during evaluation. Categories for smolt status were “parr” for fish with resident body coloration typified by dark, well-defined parr marks, “intermediate” for fish showing silvery body coloration and faded parr marks with distinct edges, and “smolt” identified by silvery body coloration with no parr marks or faint parr marks with poorly defined edges.

Lengths

We measured fork length (FL) to the nearest millimeter (mm) for all natural salmonids and a portion of hatchery salmonids. On a monthly basis, we estimated mean, minimum, and maximum fork length for each species and race of hatchery and natural fish. We developed length-frequency distributions on a monthly basis and determined length modes. We used the t-test to test lengths of hatchery fish and natural conspecifics over the collection period.

Fin Clips

We examined each hatchery species or race for fin clips. Spring chinook salmon were left-ventral (LV) fin clipped and fall chinook salmon were right-ventral (RV) fin clipped. Salmon with coded-wire tags were also adipose fin clipped (ADLV or ADRV). All summer steelhead were adipose fin clipped (AD) and steelhead with coded-wire tags were also left-ventral (ADLV) fin clipped. Coho salmon were either non-clipped (NC) or adipose fin clipped (AD) if coded-wire tagged. We determined the percent recovery of each group by species to ascertain collection differences between clips. We used count numbers that were not expanded by sample rate or unsampled periods. We used the binomial test (Snedecor and Cochran 1989) to test for differences in percent recapture of fish with different fin clips.

Fish Condition and Health

Subsamples of hatchery and natural fish were examined for scale loss and other bodily 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 also examined fish for external parasites and other injuries to the head, eyes, operculum, body, and tail. We noted fungal infections on the body surface, indications of bacterial kidney disease (BKD), and birds marks. Bird marks were identified by symmetrical bruises on each side of the fish.

Fish mortalities were noted by species and identified if they occurred prior to or during sampling. Sampling mortalities were omitted when computing percent mortality of collected fish. Percent mortality was determined from the total number of fish sampled, not just examined. 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 also noted.

Abundance and Survival

Migrant Abundance and Survival

We estimated migrant abundance for each race or species of salmonid to estimate total outmigration for natural and hatchery fish and to estimate survival of hatchery fish. Migrant abundance was determined from data collected at the rotary trap and at the West Extension Canal facility. We estimated migrant abundance (*A*) by multiplying the number of fish captured during the season at a specific trap site (*C*) by the reciprocal of the mean, pooled, or mean of sub-pooled efficiency estimates (*1/TE*) for the collection period ($A = C \times 1/TE$). Pooling of daily efficiency estimates was determined through the Chi^2 test of independence. We summed subtotals of abundance at each site for a total abundance estimate over the collection period. Prior to estimating abundance, data was adjusted by subtracting trap efficiency test fish from the daily collection. We also adjusted the number of fish captured at the rotary trap by the specific trap retention efficiency. If fish were captured during a prolonged period when no trap efficiency tests were conducted, we used the mean of all daily trap efficiency estimates to determine abundance for this time period. We used the Bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations to determine the variance of all abundance estimates. Variances for abundance subtotals were summed. Confidence intervals (95%) for the abundance estimate were calculated using the square root of the Bootstrap variance estimate ($CI = 1.96 \sqrt{V}$).

We estimated the abundance of natural coho salmon using the trap efficiency estimate for hatchery coho salmon at the rotary trap and the estimate for subyearling fall chinook salmon at West Extension Canal since natural coho were smaller later in the season. Abundance of natural summer steelhead collected at the rotary trap was estimated using the trap efficiency estimate of yearling fall chinook salmon. We determined abundance of natural steelhead collected at West Extension Canal from actual trap efficiency estimates of natural steelhead.

We estimated the combined abundance of natural spring and fall chinook salmon for the entire collection period. Trap efficiency estimates for hatchery spring chinook salmon captured at the rotary trap and West Extension Canal were used to expand natural chinook collection numbers in March, April, and May. We used the efficiency estimate for hatchery subyearling fall chinook salmon to derive natural chinook salmon abundance for most of June. The trap efficiency estimate for natural subyearling fall chinook salmon during late June and early July was used to expand the collection number during that period and to expand the number of fry collected earlier. To separate abundance estimates between the two races, we estimated the proportion each race contributed to each monthly collection total based on length data. Differentiation was important to determine the specific abundance of natural subyearling fall chinook salmon produced from a new natural production enhancement strategy (i.e. outplanting surplus hatchery adult fish; CTUIR and ODFW 1997, 1998). Due to the gross approximation and complexity in estimating abundance of most natural fish, we did not compute 95% confidence intervals for these estimates. However, 95% confidence intervals were determined for natural summer steelhead.

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 used this method to estimate survival of unmarked and color-marked fish. Marked fish included blue-marked production fish (anal fin mark with PIT tag), fish used in secondary survival tests (dorsal fin mark with no PIT tag) and reach survival test fish (anal fin mark with PIT tag).

Secondary survival tests were conducted at upriver canal facilities (RM 32 or RM 29) and entailed capturing, marking, and releasing active migrants for recapture at downriver trap sites. Fish were captured in the bypass downwell using specially designed incline plane traps (Hayes et al. 1992; Cameron et al. 1994). Color marks were applied to the dorsal fin to designate survival test fish. At these sites, we marked yearling spring and fall chinook salmon and subyearling fall chinook salmon. Coho salmon were obtained from the transport tanker at the time of release at RM 56. Color marks on coho salmon represented the rearing hatchery. Coho salmon from Herman Creek Hatchery were marked with green and orange; coho salmon from Cascade Hatchery were marked with pink. PIT-tagged fish intercepted during capture were noted.

Survival indices of color-marked and PIT-tagged production fish and color-marked test fish were determined from fish recoveries or tag detections at the lower river trap sites. Color-marked fish recoveries were expanded; tag detections were not.

Reach-Specific Survival

Reach-specific survival tests were conducted for spring chinook salmon, summer steelhead, and subyearling fall chinook salmon. To determine reach survival, fish were released at two lower river locations (RM 42 or 48 and RM 27) in addition to the standard release site(s) at the acclimation facility. PIT-tagged and color-marked groups were held separately at the hatchery in indoor circular tanks until release; therefore, test fish were not acclimated upriver. Mortality and tag loss at the hatchery was recorded on a daily basis.

Total number of releases per species was based on the number of release sites and replicate release days. Tests included three groups of spring chinook salmon (250 fish/group), seven groups of summer steelhead (250 fish/group), and three groups of subyearling fall chinook salmon (500 fish/group; Table 1). Steelhead were separated into four large-grade groups and three small-grade groups released in April and May, respectively. For each species, releases were split into three consecutive day releases, immediately following the normal production release from the acclimation facility. On the day of release, fish at the hatchery were scanned for a PIT-tag code, weighed and measured, placed in 30-gal containers, and transported in an aerated 250-gal slip tank to each release site. At recapture in the lower river, fish with color-marked anal fins were scanned for a tag code, weighed and measured, and the mark color noted. Tag detections at mainstem dams (John Day and Bonneville dams) were downloaded from the PTAGIS database and combined with the Umatilla River detections to derive an index of survival for each release group. We also used the count of color marks at Umatilla River traps to derive a survival estimate based on the migrant abundance method.

Another group of 500 PIT-tagged subyearling fall chinook salmon (no color mark) were released into the holding pond at Westland Canal (RM 27.3) in early July during Trap and Haul operations to determine minimum survival of transported fish. This group was split into three daily releases on days prior to transport. On the day of release, fish held at the hatchery were scanned for the tag code, weighed, and measured. After transport to the canal, they were briefly acclimated to pond temperatures by pumping warm (68-70 °F) river water into the transport tank for 15 - 20 min.

Environmental Conditions and Bypass Operations

We monitored river flow (ft^3/s), water temperature (°F), and Secchi depth (water clarity in meters) at each lower river trap site to characterize environmental conditions in the Umatilla River and to assess their relationship to fish migration. We obtained flow data below Three Mile Falls Dam (UMAO gauging station; RM 2.1) from the U.S. Geological Survey. Flow data from other upriver gauging stations for Water Year 1998 was obtained from the Oregon Water Resources Department. These gauging stations are located near Yoakum (YOKO, RM 37.6), McKay Creek (MCKO, RM 52), and Pendleton (PDTO, RM 55.3).

Canal flow data recorded at West Extension Canal and information on water releases from McKay Reservoir was provided by the U.S. Bureau of Reclamation. Maximum and minimum air and water temperature were recorded once daily at RM 1.2 and West Extension Canal with a Taylor Max-Min thermometer. Measurements were recorded at 0800 hours. We categorized debris level as low, medium, or high and river water color from shades of green to brown. River and canal elevations were read from staff gauges at the canal sampling facility to the nearest 0.10 ft (elevation above sea level). River elevation at the rotary trap was measured to the nearest 0.05 ft. We measured water clarity once daily using a 7-in-diameter Secchi disk. We recorded the depth at which the disk disappeared and reappeared from sight as it was lowered and raised, to obtain a mean Secchi depth. All measurements, except temperature and Secchi depth, were made at six-hour intervals, beginning at 0200 hours and ending at 2000 hours. At the rotary-screw trap we also recorded the number of cone rotations before and after cleaning.

Video Monitoring

We used 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 during peak movement (Knapp et al. 1998a). In conjunction with tribal monitoring of adult lamprey passage, we used their Panasonic camera to monitor subyearling movement from 1 - 9 June. Fish passage was recorded from 0030 to 0630 hours, 0730 to 1330 hours, and 1700 to 2300 hours. We chose these times based on previous knowledge of diel movement (Knapp et al. 1996, 1998a, 1998b). However, on 1 and 2 June, passage was only recorded from 1700 to 2300 hours, and on 9 June, from 0030 to 1330 hours. We used 6-hour long-play VHS tapes.

Tapes were reviewed at different speeds, depending on fish density. The number of subyearling fall chinook salmon was counted, and the number of hours for tape review were tracked. Counts of subyearling fall chinook salmon at the bypass facility on the west bank were compared with ladder counts during the same time. We compared diurnal movement through the ladder and bypass by expanding the counts to encompass a 24-hour period. To illustrate diurnal movement through the ladder only, we expanded data for unrecorded 1-hour time blocks, but not for the 3-hour unrecorded time block (1400 – 1600 hours). Passage during unrecorded time blocks was estimated by averaging the number of subyearlings passing through the ladder in the hour before and after the unrecorded period. Due to the large amount of time not recorded between 1 and 2 June (2300 - 1700 hours), we did not expand the data to fill in this time period. The final expanded data covers 2 June at 1700 hours to 9 June at 1400 hours. We characterized day from 0630 to 2030 hours and night from 2030 to 0630 hours, based on times of sunrise and sunset.

Resident Fish and Predators

All resident fish captured during the sampling season were identified and their presence noted. We identified and counted northern pikeminnow (*Ptychocheilus oregonensis*), bass (*Micropterus spp.*) and Pacific lamprey (*Lampetra tridentata*) at each trap check. We measured fork lengths of northern pikeminnow and bass and total lengths of Pacific lamprey to estimate mean lengths and develop length-frequency distributions. We identified lamprey with silvery coloration and visible eyes as metamorphosed juveniles (smolted) and lamprey with brown coloration and unidentified eyes and mouth as larvae (non-smolted).

We noted the presence of avian predators at both trap sites on an intermittent basis. We recorded species and number of each avian predator and the date and time observed. We standardized the number of avian predators observed per day by dividing the number of observed predators by the number of times observations were made.

Statistical Analyses

We used linear correlation to examine relationships between environmental variables and fish passage data, between canal diversion and fish collection data, and between fish length and smolt development.

We used Chi^2 tests of independence to determine significant differences between daily trap efficiency estimates, daily survival probabilities, and daily trap retention efficiency estimates. Differences in the proportion of PIT-tagged or fin-clipped fish recovered were tested with the binomial test (Snedacor and Cochran 1989). 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), MS Excel, and hand calculations to conduct our analyses. All tests were performed at a significance level of $\alpha = 0.05$.

RESULTS

Color Marking and PIT Tagging

Photonic or VI-jet mark readability for all colors on marked species (production fish and reach survival test fish) was similar at release and at capture (within 4 – 7% difference), except for hatchery summer steelhead marked with dark yellow and red (10% and 12% difference; Table 2). All marks for these fish were made in the anal fin.

Initial quality of blue-marked production fish at release was high (98% good); fish were not held for a mark retention evaluation (Table 2). Quality of blue marks at capture ranged from 96-100% readable (good + fair quality). Mark quality evaluations at capture were from 1 - 51 d after release for spring chinook salmon, 4 - 50 d after release for yearling fall chinook salmon, 2 - 48 d after release for subyearling fall chinook salmon, and 15 - 22 d after release for summer steelhead (Table 2). Poor marks were only found on hatchery subyearling fall chinook salmon which were marked at a smaller size than the other species (65-80 mm). Mark quality for all production species maintained high readability for more than 1.5 months.

Mark quality for hatchery spring chinook salmon used in reach survival tests was checked at release 52 d after marking (Table 2). Mark quality for all colors was greater than 96% readable; pink photonic marks were the best quality (99.8% readable). Mark quality at capture (1 - 5 d after release) were 100% readable.

Hatchery subyearling fall chinook salmon had the poorest quality marks at release of the three species tested, but marks were still greater than 92% readable (Table 2). Pink photonic marks were the best quality of the three colors evaluated and were 95.1% readable at release. Mark quality evaluations at capture were from 1 - 29 d after release and most marks were good or fair quality (≥ 90% readable).

Mark quality for hatchery summer steelhead ranged from 97.3 - 100% readable for all colors evaluated; pink photonic marks had the best quality (100% readable; Table 2). Mark quality checks at capture were from 1 - 34 d after release. Orange, dark yellow, and red marks deteriorated in quality after release.

Quality of marks in the dorsal fin of fish used in secondary survival tests were 100% readable for orange and pink marks (Table 2). Less readable were dark yellow marks on subyearling fall chinook salmon (95.3%) and green marks on coho salmon (87.5%). Quality checks were made from 1 to 61 d after release.

We also used photonic and VI-jet color marks in various fins of fish captured at West Extension Canal for trap efficiency tests. Mark quality on fish marked for trap efficiency tests was evaluated at recapture only. Left and right pectoral fin marks for all species and all colors were the most readable as there were no poor marks observed. Both upper and lower caudal and left pelvic fins had some poor quality marks observed.

Initial test marking of hatchery spring chinook salmon with red VI-jet paint resulted in less readable marks in the left or right pelvic fin and upper caudal fin (40% poor). The lower caudal fin also had a high percent of poor marks (24%). To a lessor extent, dorsal fin marks were 4% poor quality and left and right pectoral fin marks were both 8% poor quality. Anal fin marks were the most readable and had no poor marks.

Costs for marking juvenile fish were based on the cost of a liter of photonic solution ($800/L). Mark cost was higher for yearling steelhead (0.15/mark) than smaller subyearling chinook salmon (0.08/mark) because a higher dosage was required. For yearling chinook salmon, mark cost was $0.10/mark. Cost would be considerably reduced using the VI-jet solution ($560/L) which was sold as a concentrate and diluted by 50% prior to use. The cost of the BMX-1000 system (power unit, injector head, and nozzle) was $1,665. Each gas regulator for dispensing CO^2 was $194 and each gas line $125. Total approximate cost for each marking unit, excluding the cost of bottled CO^2, was near $2,000. Other incidental costs included cleaning fluid, replacement parts, and maintenance kits, all obtained from the vendor (New West Technologies).

During PIT tagging at the hatchery (reach survival tests), mortality during holding was low (< 1.6%) for all groups of tagged fish. PIT-tag retention of different release groups after 48 h was highest (99 - 100%) for subyearling fall chinook salmon which were marked at a smaller size (mean 75 - 80 mm FL**)** than other species. Steelhead had the lowest tag retention (74 - 95%) after 48 h and were the largest fish (mean 155 - 190 mm FL). Tag retention for spring chinook salmon (mean 150 mm FL) ranged from 91 – 95% for the site-release groups.

Outmigration Monitoring

Trap Efficiencies

Trap retention efficiencies for hatchery fish released in the rotary-screw trap live box are presented in Table 3. We syringe marked a total of 60 spring chinook salmon, 35 fall chinook salmon, and 45 coho salmon for retention tests. No significant differences were found among daily trap retention efficiencies for spring and fall chinook salmon and coho salmon. Pooled trap retention efficiency was 77% and 97% for spring and fall chinook salmon and 98% for coho salmon.

We syringe marked 2,130 hatchery spring chinook salmon, 339 hatchery fall chinook salmon, and 843 hatchery coho salmon for trap efficiency tests at the rotary-screw trap (Table 4). There were no significant differences in daily survival (24-h mortality tests) of these fish. Pooled survival was ≥ 99.5% for all species held (Table 4). Temperatures during holding ranged from 46.5 - 50.0 °F.

We released 11 hatchery groups of spring chinook and 5 groups of fall chinook salmon for trap efficiency tests at the rotary trap (Table 5). There were no recaptures from 3 of 11 groups of spring chinook and 1 of 5 groups of fall chinook salmon. Significant differences were found among daily trap efficiencies that precluded pooling for spring chinook salmon. Recapture of fall chinook salmon was too low to conduct valid tests to determine pooling. Mean of sub-pooled trap efficiencies for spring chinook salmon was 0.037 (SE=0.009) and mean of non-pooled trap efficiencies for fall chinook salmon was 0.021 (SE=0.008; Table 5). Recaptures were collected within 2 – 2.5 h after release for both races. We released 4 groups of coho salmon and recovered fish from all releases. Daily trap efficiencies were not significantly different; overall pooled trap efficiency for coho salmon was 0.024 (SE=0.077; Table 5). Recaptures were collected within 5 h of release. All test releases were made in the evening (1700 - 1800 hours). There was no transport mortality to the release site for 14 of 15 test days for chinook salmon; mortality that did occur was less than 6% (1-3 fish). There was no transport mortality to the release site for coho salmon. No trap efficiency tests were conducted for natural salmonids at RM 1.2.

At West Extension Canal (RM 3.0), we color marked 3,224 hatchery yearling spring chinook and 4,323 yearling fall chinook salmon, 5,286 coho salmon, 6,471 subyearling fall chinook salmon, and 1,664 steelhead for trap efficiency tests (Table 6). We also marked 918 natural summer steelhead and 1,432 natural subyearling fall chinook salmon. This was the first year we had substantial numbers of natural subyearling fall chinook salmon to conduct tests. Periodic losses occurred for all marked hatchery groups except steelhead which experienced no mortality. There were no significant differences in survival during daily holding within each hatchery species. Estimated pooled survival for hatchery species ranged from 99.1% to 100% (Table 6). There was no mortality during daily holding for natural subyearling fall chinook salmon and steelhead (Table 6). Temperatures ranged from 51.0 - 74.5 °F during holding (mid-April – early July). Transport mortality for all species to the release site ranged from 0.0 - 3.9%.

Significant differences were found among daily trap efficiencies for all groups; therefore, subpooling was required (Table 7). Estimates were higher for hatchery yearling and subyearling races of chinook salmon (0.201 - 0.315) than for hatchery coho salmon and summer steelhead (0.093 - 0.108) or natural subyearling fall chinook salmon and summer steelhead (0.124).

Twenty trap efficiency releases were made for hatchery yearling spring chinook salmon from 14 April to 5 May (Table 7). Of these, only one group had no recaptures. Recapture of marked fish ranged from 4 h to 19 d after release, with most fish recaptured within the first few days. There was no apparent pattern in recapture with time of day. Mean trap efficiency of sub-pooled values for yearling spring chinook salmon was 0.201 (SE=0.029***).***

Fourty-one trap efficiency releases were made for hatchery yearling fall chinook salmon from 5 April to 18 May (Table 7). All releases had some recaptures. Recapture of marked fish ranged from 1.5 h to 37 d after release with most fish recaptured within the first few days. There was no apparent pattern in recapture with time of day. Mean trap efficiency of sub-pooled values for yearling fall chinook salmon was 0.315 (SE=0.026).

Twenty-nine trap efficiency releases were made for hatchery subyearling fall chinook salmon from 31 May to 29 June (Table 7). Of these, one had no recaptures. Recapture of marked fish ranged from 1.5 h to 18 d after release, with most fish recaptured within the first day. There was no apparent pattern in recapture with time of day. Mean trap efficiency of sub-pooled values for subyearling fall chinook salmon was 0.235 (SE=0.027).

Fourty-one trap efficiency releases were made for hatchery coho salmon from 19 April to 3 June (Table 7). Of these, four groups had no recaptures. Recapture of marked fish ranged from 4 h to 33 d after release, with most fish recaptured within four days after release. There was no apparent pattern in recapture with time of day. Mean trap efficiency of sub-pooled values for coho salmon was 0.093 (SE=0.019).

Twenty-four trap efficiency releases were made for hatchery steelhead from 25 April to 28 May (Table 7). Of these, five groups had no recaptures. Recapture of mark groups ranged from 1.5 h to 12 d after release, with most fish recaptured within the first week. Most fish were recaptured from 0000-1100 hours and 1600-2400 hours. Mean trap efficiency of sub-pooled values for hatchery summer steelhead was 0.108 (SE=0.020).

We marked natural subyearling fall chinook salmon greater than 70 mm. Ten trap efficiency releases were made from 25 June to 6 July (Table 7). Of these, one had no recaptures. Recapture of marked fish ranged from 17 h to 5 d after release, with most fish recaptured within the first two days. All but one release (1540 hours) were made in the evening and most fish were recaptured from mid-day to late afternoon (1100 - 1700 hours). Mean trap efficiency of sub-pooled values for natural subyearling fall chinook salmon was 0.124 (SD=0.019).

For natural summer steelhead, 27 trap efficiency releases were made from 5 April to 28 May (Table 7). Of these, three had no recaptures. Recapture of marked fish ranged from 2 h to 17 d after release. Most fish were recaptured during the same hours as hatchery steelhead (0000-1000 hours and 1600-2400 hours). Mean trap efficiency of sub-pooled values for natural summer steelhead was 0.124 (SD=0.020).

Collection

We monitored the outmigration of juvenile salmonids from 1 October 1997 to 3 April 1998 at the rotary-screw trap (RM 1.2). The trap did not operate for 1 day during this period due to ice problems. We collected 7,530 fish at the rotary trap which expanded to 10,385 fish when adjusted for unsampled hours and trap retention efficiency (Table 8). Ninety-nine percent of collected fish were hatchery salmonids, mostly spring chinook salmon. Only 161 natural salmonids were caught at the rotary trap; most were natural spring chinook salmon. Natural spring chinook salmon were first captured on 21 December 1997, natural coho salmon on 28 March 1998, and natural summer steelhead on 15 March 1998.

We intensively monitored at West Extension Canal (RM 3.0) from 3 April to 9 July, with over 1.3 million fish passing through the bypass facility (Table 8). Actual number of fish handled was 501,933 fish. Data was expanded for hours bypassed (4% of total sample hours) and hours subsampled. Ninety-seven percent of the adjusted collection at West Extension Canal was hatchery salmonids (1,352,053 fish). Collection of natural juvenile salmonids totaled 36,931 fish, dominated by subyearling fall chinook salmon (71%; Table 8). Of the 2,868 natural steelhead sampled, 45 were > 295 mm FL (321 mm mean FL), with a maximum length of 378 mm FL. These fish were bright silver and in excellent condition; most were caught between early April and mid-May. We also sampled 7 hatchery rainbow trout (229 mm mean FL) in June which were released in May near Pendleton (RM 55).

Total adjusted collection of hatchery groups at both the rotary trap and West Extension Canal was comprised of subyearling fall chinook salmon (73%), coho salmon (14%), yearling spring chinook salmon (7%), yearling fall chinook salmon (6%), and summer steelhead (0.5%). Proportions at collection differed from proportions at release (47% for subyearling fall chinook salmon, 29% for coho salmon, 14% for yearling spring chinook salmon, 7% for yearling fall chinook salmon, and 2% for summer steelhead). Percent recapture for each release group was 36% for subyearling fall chinook salmon, 19% for yearling fall chinook salmon, 11% for spring chinook and coho salmon, and 5% for summer steelhead.

Adult summer steelhead were also captured in the trap at West Extension Canal. We changed to a larger bar spacing on the separator in late April to capture more of the larger natural steelhead smolts. In doing so, fallback summer steelhead kelts also were trapped. We sampled 40 adult steelhead from late April to mid-May (Table 9); 60% were of natural origin and 40% were hatchery. Of the natural steelhead, 63% were female.

Scale samples were collected from adult and juvenile steelhead (hatchery and natural origin) and natural juvenile chinook salmon (Table 10). Juvenile salmon and steelhead were mostly smolted. From scale analysis (CTUIR, unpublished data), most of the natural steelhead adults were 2-freshwater, 1-ocean fish. All of the natural juvenile steelhead > 300 mm FL were age 3 and 4 smolts. Remaining steelhead scale samples were from age 2 fish. Natural spring chinook salmon captured in winter were mostly age 1 fish. Scales from natural chinook salmon collected in May indicated that these fish (92.3 mm mean FL) were age 0 spring chinook salmon.

Trap and Haul

For 17 days from 7 July to 13 August 1998, we sampled fish collected at the Westland Canal juvenile trap during Trap and Haul operations. We sampled 2,815 fish, comprised mostly of hatchery and natural subyearling fall chinook salmon (51% and 48%, respectively; Table 8). Natural coho salmon were also present. Hatchery subyearling fall chinook salmon were dominant in the collections in early July and were replaced in dominance with natural chinook salmon by late July (Table 11). Natural coho salmon appeared consistently in the collections in late July and early August. Resident fish were present in collections beginning in mid-July.

We estimated 44,234 live juvenile salmonids were trapped at the canal and transported to the mouth of the Umatilla River (Table 11). Of these, almost 27,500 were hatchery subyearlings and 16,100 were natural subyearling fall chinook salmon. Number transported was highest on 7 July, with an estimated 20,200 juvenile salmonids transported. An estimated 3 hatchery summer steelhead, 3 hatchery coho salmon, 96 natural coho salmon, and 27 natural summer steelhead were also collected and transported (Table 11). On several occasions, handling mortality of collected juveniles was high (> 200 fish) and these fish were discarded to the river. An estimated 250 subyearling fall chinook salmon died on 10 July; natural and hatchery fish were present in equal proportions.

Once juvenile transport ended, we did not monitor or sample fish the rest of August or in September. Low river flows in the lower river and the preponderance of resident fish hindered sampling.

Migration Parameters

Production Fish: Migration patterns were similar for color-marked and total numbers of hatchery spring chinook salmon passing through the lower river (Figure 5). Yearling spring chinook salmon released at RM 80 in March (Umatilla and Little White Salmon hatcheries) and April (Carson and Little White Salmon hatcheries) were first captured at the lower river traps within 2 d of release (Figure 5; Table 12). Fifty percent cumulative passage (median passage) of color-marked fish and total fish from the release on 8 March occurred 6 – 8 d after release. Dates of median passage closely corresponded to date of peak passage on 14 March (Figure 5). Ninety-five percent passage of the March-release group occurred 31 – 32 d after release. Fifty percent cumulative passage of fish released on 14 April (total and marked) occurred 7 d after release on the day of peak passage (21 April; Figure 5); approximately 2.5 –3 weeks was required for 95% of these fish to pass. Median travel speed for both release groups was 10 - 11 mi/d. Of all spring chinook salmon passing the trap sites, 50% passed by 20 April and total time to migrate was 2.5 months from early March to mid-May (Figure 5).

PIT-tagged groups of spring chinook salmon allowed a more refined analysis of migration parameters (Table 12). Key parameters generally coincided with batch-marked and unmarked groups of fish. Mean travel speed of PIT-tagged fish from both release groups was slightly greater (11 - 13 mi/d; Table 12) than median travel speed indicated for batch-marked and unmarked fish. The group released in March migrated longer than the April-release group.

Yearling hatchery fall chinook salmon released at RM 73 on 13 March (Bonneville Hatchery) were first captured within 1 d of release (Figure 5). Fish that were color-marked were detected at the rotary-screw trap on only two days. The first and highest detected passage of color-marked fish was 10 d after release which corresponded to the median passage day of total fish (23 March). Total fish passage in March peaked 3 d and 11 d following release. Ninety-five percent passage of March-released fish was in 35 days. Fall chinook salmon released at RM 73 on 17 April (Willard Hatchery) peaked in 11 d (Figure 5) which corresponded with the date of median passage for total fish. Both median and peak passage of color-marked fish released in April occurred 9 d after release. Ninety-five percent of the April-release color-marked fish passed by 3 June, 47 d after release, whereas 95% of total fish passed in 21 d. Median travel speed for both March and April release groups was 6 – 7 mi/d. Of all yearling fall chinook salmon passing the trap sites, 50% passed by 27 April (Figure 5) and total time to migrate was 3 months from mid-March to mid-June.

PIT-tagged yearling fall chinook salmon released in March were detected in low numbers, precluding valid analysis of PIT-tag data (Table 12). Migration parameters of PIT-tagged fish released in April closely coincided with color-marked and unmarked fish in all aspects.

Hatchery subyearling fall chinook salmon from Umatilla Hatchery were released at RM 73.5 and RM 80 on 28 May and 1 June. First capture was 1 d after the first release; colored-marked fish were first detected 2 d after release (Figure 5). For both groups, 50% cumulative passage was achieved within 7 – 8 d after the first release, corresponding with peak passage on day 7 (4 June; Figure 5). Ninety-five percent passage for all fish was within 20 d, 24 d for color-marked fish. Using 30 May as a mid-release date, median travel speed was 12 – 15 mi/d for total and color-marked fish. Migration duration for all subyearling fall chinook salmon was 2.5 months, extending to mid-August when fish were trapped at Westland Canal (RM 27.3).

Migration of PIT-tagged subyearling fall chinook salmon varied from color-marked and unmarked groups because of the ability to separate out specific release groups (Table 12). Peak detection was earlier at 4 - 5 d after release. Mean detection was 11 d after release, 3 – 4 d later than median passage (50% cumulative passage). Mean travel speed of PIT-tagged fish was similar (Table 12) to median travel speed of all fish. Migration duration of the early release group (28 May) was 19 d longer than the second group released at RM 80 due to the detection of one PIT-tagged fish at Westland Canal during juvenile transport (Table 12).

Unmarked hatchery coho salmon from releases in late March (Herman Creek Hatchery) and early April (Cascade Hatchery) at RM 52 were first captured within one day of release, but most fish did not pass through the lower river until one month later in early May (Figure 6). Fifty percent cumulative passage and peak passage for all fish was on 6 May, 44 d after the first release. Ninety-five percent cumulative passage was in 64 d, with last capture in early August at Westland Canal. Color-marked fish from Herman Creek Hatchery (green and orange marks) reached 50% cumulative passage on 30 April (38 d after first release) and 95% passage and peak passage on 7 May. Color-marked fish from Cascade Hatchery (pink marks) reached 50% cumulative passage and peak passage on 6 May (37 d after first release) and 95% cumulative passage on 10 May. Migration duration for both color-marked fish groups was 2 months from date of first release (Figure 6). Median travel speed was 1 mi/d. No hatchery coho salmon were PIT tagged.

Hatchery summer steelhead from Umatilla Hatchery were released in mid-April (large-grade) at RMs 64.5 and 79 (Meacham Creek) and in early May (small-grade) at RM 79. Forced releases were preceded by volitional releases by about 1 week for large-grade steelhead (10 April) and 2 weeks for small-grade steelhead (20 April). Steelhead were first detected 4 d after the first volitional release; color-marked fish were detected within 15 d (Figure 6). Fifty percent cumulative passage of all steelhead occurred in 24 d on 4 May, the day of forced release of small-grade steelhead. Peak passage was 2 d later (6 May). Of color-marked steelhead passing the trap site, 50% passage and peak passage occurred on the same day (2 May). Ninety-five percent passage was achieved in 34 d for color-marked fish and 44 d for total fish, following the first volitional release. Median migration speed was 3 mi/d for both groups. Migration duration from first volitional release to last capture at West Extension Canal was 80 d. One steelhead was collected at Westland Canal (228 mm FL) on 29 July.

Migration of large-grade and small-grade summer steelhead was interpreted from PIT-tagged fish, although detections were few (Table 12). Of the large-grade summer steelhead, mean detection was 27 d after volitional release and date of peak detection mimicked that for color-marked fish (22 d; 2 May). Small-grade steelhead peaked 2.5 weeks later than large-grade steelhead, or 28 d after volitional release; mean detection was within 22 d. The large-grade steelhead migrated half as slow as the small-grade steelhead (Table 12).

Natural Fish: Natural spring chinook salmon were first captured in late December 1997 and continued emigrating from the basin until early July (Figure 7; Table 13). Peak capture (382 fish) and 50% cumulative capture were reached on 24 April, 125 d after first capture. Ninety-five percent capture was reached on 11 June, 173 d after first capture. The duration of migration for natural spring chinook salmon was 193 d.

Natural fall chinook salmon fry (< 50 mm FL) were first detected in early April; migrant fish > 50 mm were captured in late April (Figure 7; Table 13). Median capture of subyearling migrants was reached on 14 June, 1 d after peak capture (1,975 fish). Ninety-five percent cumulative capture occurred on 7 July, the first day of transport from Westland Canal. Natural subyearling fall chinook salmon continued to be collected at Westland Canal until mid-August when transport was discontinued. Total time for fall chinook subyearlings to emigrate from the basin was 111 d (Figure 7; Table 13).

Natural coho salmon were first captured in late March and last captured in mid-August (Figure 8; Table 13). Fifty percent and 95% cumulative capture were reached the first week in June, about 2 months after first capture. Peak capture was on 4 June (241 fish). Total time for natural coho salmon to emigrate from the basin was 139 d.

Natural summer steelhead were first captured in mid-March (Table 13), about one month before the first release of hatchery fish. Movement through the lower river showed two peaks on 25 April (512 fish) and 6 May (351 fish; Figure 8), 40 d and 51 d after first capture. Fifty percent cumulative capture was reached between these two dates on 1 May, with 95% cumulative capture achieved one month later on 1 June. Last capture of natural summer steelhead was in mid-August at Westland Canal. Total time for natural summer steelhead to emigrate from the basin was 152 d.

Reach Survival Test Fish: Release information for hatchery spring chinook salmon that were color marked on the anal fin and PIT tagged for reach survival tests is presented in Appendix Table A-1. Spring chinook salmon moved through the lower river while we were sampling at the rotary-screw trap, therefore, observations were low for all site releases (N = 9); no test fish were collected at West Extension Canal. The first collection (1 fish) was on 10 March from the Echo release site (Figure 9). Fish from the Barnhart release site were detected 2 d later and fish from the Imeques-c-minikem (Imeques) release site were detected 4 d later (14 March). Mean travel speed, based on PIT tags, was similar for all three releases (Appendix Table A-1).

Release information for hatchery subyearling fall chinook salmon that were color marked on the anal fin and PIT tagged for reach survival tests is presented in Appendix Table A-1. Fish from the Echo releases were sampled first on 3 June at West Extension Canal (Figure 9). Fish from the Reith and Imeques releases were collected on 4 June. Most fish (85%) from all three sites moved through the lower river within 5 d of release. Last capture from all releases was in late June. Peak passage was 4 June for fish released at Imeques (N = 284) and 5 June for fish released at Echo (N = 435) and Reith (N = 652; overestimated from data expansions). Based on PIT tags, mean travel speed was greatest for fish released at Reith (RM 48) and slowest for fish released at Echo (RM 27; Appendix Table A-1).

Release information for large-grade hatchery steelhead color marked on the anal fin and PIT tagged for reach survival tests is presented in Appendix Table A-1. Fish from the Reith releases were sampled first on 18 April and fish from the Echo releases were collected one day later (Figure 10). Fish from the Bonifer releases were sampled one week later (25 April), when passage was highest. Fish from the Minthorn releases were the last group to be collected on 27 April. All four release groups of large-grade steelhead were observed in the first week of May, particularly fish from the Minthorn and Echo release groups. Last fish to be collected in late May were from the Bonifer and Reith release groups. Based on PIT tags, mean travel speed was greatest for fish released at Reith (RM 48) and slowest for fish released at Minthorn (RM 64.5). Fish released at the furthest site (Bonifer) traveled faster than Echo- and Minthorn-released fish (Appendix Table A-1).

Small-grade steelhead marked and tagged for reach survival tests were released from 11 - 13 May (Appendix Table A-1). Fish from the Echo and Reith releases were collected first on 14 May and fish from the Bonifer releases were collected one week later on 21 May (Figure 10). Passage was proportionately greatest for all three release groups of small-grade steelhead from 31 May to 2 June. Last fish to be sampled in early June were from the Reith release groups. Based on PIT-tag data, mean travel speed incrementally increased from the lowest (RM 27) to the highest release site (RM 79; Appendix Table A-1).

Smolt Status

Most natural chinook salmon collected and examined for smolt status were classified as intermediate smolts (75%; Figure 11). The percent of fish classified in the parr and smolt stages was similar (12% and 13%). Smolted yearling chinook were most evident in May. Most of the natural chinook salmon classified as parr (87%) were observed in late May and early June which corresponds with subyearling fall chinook salmon movement. These fish appeared smolted by late June and July. Most (87%) natural chinook salmon from 61 - 180 mm FL were classified as intermediates or smolts, representing both yearling and subyearling ages (Figure 12). Smoltification was not significantly correlated with fork length for natural chinook salmon captured at the rotary-screw trap. However, smoltification was significantly correlated (P = 0.0001) with length at West Extension Canal for the months of April (r = 0.270, N = 556), May (r = 0.569, N = 373), and June (r = 0.480; N = 4,434).

Natural coho salmon were classified as 30% parr, 59% intermediate, and 11% smolt (Figure 11). Natural coho salmon progressed from 91% parr and intermediates in April and May to 78% intermediate and smolts in June and July. All three stages were observed in late May to mid-June when most coho salmon were collected. Fish classification proceeded from mostly parr stage (73%) at 55-65 mm in fork length to mostly intermediate stage (67%) at 66-120 mm FL (Figure 12). Natural coho salmon smolts were observed above 80 mm FL and one smolt was sampled at 170 mm in length (not shown). Smoltification was significantly correlated with fork length for natural coho salmon captured at the West Extension Canal for April (r = 0.971, *P* = 0.006, N = 5), May (r = 0.463, *P* = 0.0001, N = 146), and June (r = 0.638, *P* = 0.0001, N = 79).

Most natural steelhead collected and examined for smolt status were intermediate smolts (62%; Figure 11). The proportion of parr and smolt were 8% and 30%, respectively. All stages of smoltification were observed from late March to mid-June, after which all natural steelhead were intermediates or smolts. Length data showed a transition from the parr to intermediate stage above 100 mm, with most fish (70%) classified as intermediate smolts from 131 - 200 mm FL (Figure 12). Natural steelhead began their transition from the intermediate to smolt stage at 108 mm but most of the transition occurred at greater lengths (above 200 mm FL). Sixty-seven percent of fish above 200 mm FL were smolts. Smoltification was significantly correlated (*P* = 0.0001) with fork length for natural steelhead captured at the rotary-screw trap in March (r = 0.691, N = 55) and at West Extension Canal in April (r = 0.623, N = 1,061), May (r = 0.518, N = 1,248), and June (r = 0.658, N = 51).

Lengths

Monthly and overall mean lengths of natural and hatchery juvenile salmonids are presented in Table 14. All hatchery salmonids captured showed a significantly larger mean fork length overall ($P < 0.001$) than natural salmonids of the same species.

Natural chinook salmon included both spring and fall races of yearling and subyearling age classes. Mean lengths of natural chinook salmon in May, June, July, and August predominantly represented the subyearling fall chinook portion of the population (Table 14). Natural coho salmon fry (< 50 mm FL) were captured in March and May at RM 3. Mostly coho parr (75 - 95 mm FL) were also caught at Westland Canal. Natural summer steelhead captured in April and May included fish that were > 300 mm in length, increasing the mean fork lengths for those months. The smaller mean lengths for natural steelhead in July and August reflect fish caught at Westland Canal (RM 27.3). Most of these fish were small-sized parr.

Mean lengths of hatchery spring chinook salmon were similar throughout the three months they were captured and reflected their overall mean size at release (145 mm FL) in March and April. Fork lengths of hatchery yearling fall chinook salmon captured from March to May increased (Table 14). Mean length of fish captured in March (141 mm FL) reflects the March release of Bonneville-reared fish (149 mm mean FL). Mean length of fish captured in April (164 mm FL) reflects the releases of both Bonneville-reared (149 mm mean FL) and Willard-reared fish (172 mm mean FL) released in March and April, respectively. Mean lengths of hatchery subyearling fall chinook salmon collected over the four months also increased. By August, mean length had increased by 55 mm since release in late May and early June (85 mm mean FL). Mean lengths of hatchery coho salmon steadily increased over the 5-month collection period. The one hatchery steelhead captured in March escaped from upriver acclimation ponds. Steelhead captured in April (212 mm mean FL) were slightly larger than their size at release in April from the two upriver acclimation ponds (202 mm and 209 mm FL). Small-grade hatchery steelhead released in May (187 mm FL) were captured in May along with large-grade steelhead released in April, which elevated the mean length for that month (228 mm FL).

Length-frequency distributions for hatchery fish are presented in Figures 13 and 14. For hatchery spring chinook salmon, all months showed similar distributions with an overall length mode of 142 mm FL (Figure 13). The length-frequency distribution for hatchery yearling fall chinook salmon progressively advanced with each month (Figure 13). Lengths of hatchery subyearling fall chinook salmon captured from May to August showed an overall mode of 90 mm FL (Figure 13). Later migrants (July and August) measured much larger (maximum = 161 mm FL) than earlier migrants (minimum = 66 mm FL), which greatly expanded the distribution. Length data for hatchery coho salmon are presented in Figure 14. A definite shift in distribution is evident as fish released in late March moved out of the basin over the next three months. Length-frequency distributions for hatchery summer steelhead are presented from April through June (Figure14). Respective modal lengths were 207 mm, 226 mm, and 220 mm FL.

We compared mean lengths of hatchery fish acclimated at release (normal production) and not acclimated at release (reach survival test fish; Figure 15). Fish released for reach survival tests showed three of five groups having significantly different lengths ($P < 0.001$). Acclimated hatchery steelhead (small-grade) released at Bonifer (187 mm FL) and hatchery subyearling fall chinook salmon released at Imeques (85 mm FL) were smaller than their counterparts released in reach survival tests (197 mm and 90 mm FL, respectively). However, acclimated hatchery spring chinook salmon (149 mm FL) released at Imeques were larger than their non-acclimated counterpart (143 mm FL). Mean fork lengths of large-grade steelhead released at Bonifer and Minthorn were not significantly different between acclimated and non-acclimated (reach test) fish (Figure 15).

Subyearling fall chinook salmon released at Westland pond in July (108 mm FL) for transport survival tests were significantly smaller ($P < 0.001$) than subyearlings collected at Westland Canal from early July to mid-August (126 mm FL; Table 8). Test fish had been held and fed at the hatchery.

Length-frequency distributions for natural chinook salmon represent fish captured from March through August, which includes the spring and fall races (Figure 16). Natural spring chinook salmon were predominantly captured in March and April (mode = 110 mm FL), although a few fall chinook fry were also present (30 - 40 mm FL). Natural subyearling fall chinook salmon contributed more to the length-frequency distribution in May and dominated the distribution by June (mode = 70 mm FL). The length-frequency distribution in May shows the separation of spring (67.7 %, mode = 90 mm FL) and fall (32.3 %, mode = 55 mm FL) races; fish > 80 mm FL were considered spring chinook salmon. Chinook salmon captured in June were 4% spring chinook and 96% fall chinook salmon; spring fish (> 95 mm FL) extended into the tail end of the distribution. Length-frequency data for July was composed mostly of chinook subyearlings (97.8 %, mode =80 mm FL), with a few remnant spring chinook salmon (2.2 %, > 100 mm FL). All fish captured in August were considered subyearling fall chinook salmon (mode = 110 mm FL).

We compared the length-frequency distributions of natural spring chinook salmon captured at RM 81.7 and RM 1.2 (Figure 17). Fish captured upriver included fry, with most fish between 100 – 104 mm FL. Fish captured downriver were > 80 mm FL and up to 165 mm in fork length (mode = 95 mm FL). Smaller spring chinook salmon were captured mostly in winter 1997 (Table 13) and late spring 1998 (Figure 15).

The length-frequency distribution for natural coho salmon is for May and June, when most fish were captured (Figure 18). Mean fork lengths for each month were similar (79 mm and 79.5 mm), but the modes were not (94 and 82 mm FL). The largest fish was captured in June at 166 mm FL. Because it was difficult to distinguish non-clipped hatchery coho from natural coho salmon, fish > 100 mm FL usually were considered hatchery. However, a small portion of captures in May and June were comprised of fish > 100 mm FL (14.1 % and 7.2 %, respectively). These fish were identified as natural based on unique coloration and the presence of parasites found in the natural environment.

Length-frequencies of natural steelhead represent fish captured from March through June at West Extension Canal (Figure 18). Fish captured in April and May included 37 fish > 300 mm in fork length, widening the distribution. These large steelhead were aged as 3- and 4-year-old fish (CTUIR, unpublished data). The largest and smallest fish were caught at West Extension Canal in late April (378 mm FL; age 3) and May (61 mm FL). From scale samples, mean lengths of age 2, 3, and 4 fish were 208 mm, 282 mm, and 315 mm FL, respectively.

Fin Clips

Percent recapture of fish with different fin clips at all trap sites was similar for coho salmon (no clip and AD clip) and summer steelhead (AD and ADLV; Table 15). Percent recapture of LV-clipped spring chinook salmon (8.7%) was significantly greater than ADLV-clipped fish (4.2%). For subyearling fall chinook salmon, the percent recapture of RV-clipped fish (5.7%) was significantly greater than ADRV-clipped fish (5.0%). Conversely, percent recapture of RV-clipped yearling fall chinook salmon (7.2%) was significantly less than ADRV-clipped fish (12.5%). When proportions were tested separately by trap site, there was no significant difference between fin-clipped subyearlings at Westland Canal. At the rotary-screw trap, percent recapture of each fin-clip type for yearling fall chinook salmon was not significantly different, but it was for spring chinook salmon. ($P < 0.0001$)

Some fish clipped by CTUIR in the upper river for trap efficiency tests were detected at the lower traps (Table 15). Lower caudal-clipped fish were detected in lower proportions than upper caudal-clipped fish.

Fish Health and Condition

Of the hatchery fish collected, we examined for condition 25,890 yearling spring chinook salmon, 11,137 yearling fall chinook salmon, 43,450 subyearling fall chinook salmon, 21,616 coho salmon, and 2,659 summer steelhead. Most hatchery fish were in good condition with minimal scale loss (Table 16). Condition of steelhead was poorest, although mortality was relatively low (0.7%). Mortality was highest for yearling fall chinook salmon (2.3%) which occurred mostly in late April and early May (Appendix Table A-2). Yearling spring chinook salmon were in best condition overall with minimal mortality (Table 16). Condition of subyearling fall chinook salmon steadily worsened with time as a greater proportion of fish became partially and fully descaled by mid-June (Appendix Table A-2).

Of the natural fish collected, we examined for condition 7,382 chinook salmon, 254 coho salmon, and 2,580 summer steelhead. Both coho salmon and steelhead were in better condition than their hatchery counterparts (Table 16). The relatively high mortality for natural steelhead occurred mostly in late April and early May during their peak migration (Appendix Table A-3). Natural chinook salmon showed the poorest condition among natural species, primarily because of the condition of subyearling fall chinook. This group of fish deteriorated in condition toward mid-June and condition remained poor through July (Appendix Table A-3). All 5 subyearlings collected at West Extension Canal on the last day of sampling on 9 July were dead.

Other types of injuries were evident on fish including damage to eyes, head, operculum, or body, torn caudal fins, bird marks, and other predator attack marks (Table 17). We also observed fungal infections, external parasites, and signs of bacterial kidney disease (BKD). A large proportion of the injuries on hatchery fish were birds marks, especially on steelhead and spring chinook salmon. Hatchery subyearling fall chinook salmon had the largest proportion of bodily injuries. Both yearling fall chinook salmon and coho salmon exhibited a high proportion of BKD. Parasites were common on natural chinook salmon, including leeches and the metacercaria from black spot disease (*Neascus metacercariae*). Bird marks were also prevalent on natural summer steelhead, as well as black spot disease.

We submitted 7 natural chinook salmon and 85 natural summer steelhead to ODFW pathology for disease examination. All fish were collected dead or they died at West Extension Canal. Of the chinook salmon (mostly subyearling falls), no systemic bacteria were detected but one fish was low level positive for the Rs antigen (BKD; ODFW, unpublished data). Of the summer steelhead, no systemic bacteria were detected in the 42 fish analyzed. Sixty-nine of 73 steelhead tested positive for the Rs antigen. Of these, two were at the clinical level, 1 high level, 11 low level, and 55 barely detectable. The clinical level steelhead were collected on 10 and 29 April. The heads of all natural fish were taken for *M. cerebralis* examination (whirling disease).

Of hatchery species, we submitted 4 spring chinook salmon, 7 yearling fall chinook salmon, 2 coho salmon, and 1 steelhead for disease examination. Of the spring chinook salmon, one was at a clinical level for BKD (collected 20 April). No systemic bacteria were detected in the 7 yearling fall chinook salmon, but all 6 fish analyzed for Rs antigen tested positive (4 clinical, 2 low level). The clinical BKD fish were collected on 20 April and 4 May and exhibited gray and swollen kidneys, kidney pustules, and hemorrhaged pyloric caeca (ODFW, unpublished data). One coho salmon tested positive for the Rs antigen (high level). The hatchery steelhead was not examined.

Abundance and Survival

Migrant Abundance and Survival

Abundance estimates were determined for all natural and hatchery juvenile salmonids collected at the rotary-screw trap and West Extension Canal (Table 18). Two of the five groups of hatchery juvenile salmonids were overestimated in their abundance when compared with release numbers.

For hatchery spring chinook salmon, the abundance estimate represented 72.5% (Table 18) of the 872,612 spring chinook salmon released in March and April (Appendix Table A-4). The half width of the confidence interval was 9.2% of the abundance estimate for yearling spring chinook salmon.

An estimated 304,557 hatchery yearling fall chinook salmon migrated out of the basin, representing 69.9% of the 436,010 fish released from Bonneville and Willard hatcheries (Table 18; Appendix Table A-4). The half width of the confidence interval was within 22% of the abundance estimate for yearling fall chinook salmon.

The abundance estimate for hatchery subyearling fall chinook salmon (Table 18), was greater than the number released (2,777,442 fish; Appendix Table A-4). Furthermore, approximately 27,500 fish were transported from Westland Canal (Table 11), leaving approximately 2,749,942 fish in the river. Based on fish numbers in the river, our estimate of survival was 153.7% (Table 18). The half width of the confidence interval was within 4.8% of the abundance estimate.

The abundance estimate for hatchery coho salmon (Table 18) was also greater than the number released (1,606,786 fish; Appendix Table A-4) constituting a survival estimate of 128.8%. The half width of the confidence interval was 8.4% of the abundance estimate.

An estimated 68,670 hatchery steelhead migrated out of the basin, representing 49.9% of the 137,485 fish released in April and May (Table 18; Appendix Table A-4). The half width of the confidence interval was 14.2% of the abundance estimate.

We estimated 3,384 natural coho salmon and 143,228 natural chinook salmon (spring and fall races combined) emigrated from the Umatilla River between December 1997 and July 1998 (Table 18). An additional 16,620 natural subyearling fall chinook salmon were collected at Westland Canal in July and August (Table 10) bringing the total for this group to 141,124 fish. These fish were derived from the nearly 1,000 hatchery adults out-planted into the Umatilla River in November 1997. Of the total chinook salmon abundance, almost 19,000 were spring chinook salmon derived from natural spawning escapement.

We estimated 53,854 natural summer steelhead emigrated from the basin between March and July (Table 18). The upper and lower 95% confidence limits of the abundance estimate constituted nearly 63,000 and 45,000 fish, respectively. The half width of the confidence interval was 16.6% of the abundance estimate.

We used the adjusted recovery of color-marked fish (most were embedded with PIT tags) to derive another survival estimate for hatchery production releases (Table 19) Survival was high (92.1%) for color-marked spring chinook salmon (all releases combined) and for subyearling fall chinook salmon (83.8%). Survival of marked yearling fall chinook salmon (all releases combined) was overestimated (130.6%). Marked hatchery summer steelhead, representing both the large-grade and small-grade releases, had the lowest survival of the marked groups (28.6%).

We used PIT-tagged fish detected in the Umatilla River (unexpanded detections) to compare minimum survival of specific hatchery release groups (Table 20). Sample sizes were below minimum required to test statistical differences. Spring chinook salmon reared at Umatilla Hatchery and released in March had a lower percent detection than fish reared at Little White Salmon Hatchery. Percent detection was about equal for spring chinook salmon released in April from Little White Salmon and Carson hatcheries. Since yearling fall chinook salmon from Bonneville and Willard hatcheries were released in separate months, a comparison of minimum survival could not be made. However, few fall chinook salmon released in March from Bonneville Hatchery were detected. Percent detection of yearling fall chinook salmon released in April from Willard Hatchery was similar to that for April-released spring chinook salmon. We also had few detections of tagged summer steelhead to make valid comparisons. Subyearling fall chinook salmon released at RM 73 and RM 80 were detected in near equal proportions.

We further partitioned minimum survival of detected PIT-tagged fish from Umatilla Hatchery into production rearing strategies (Table 21). Spring chinook salmon from Umatilla Hatchery were reared in Michigan and Oregon raceways (Michigan are high density/oxygenated and Oregon are standard rearing raceways). Percent detection was slightly greater for Michigan-reared fish than Oregon-reared fish and higher in the first raceway of the series (A) than the remaining raceways (B, C). Percent detection of subyearling fall chinook salmon was similar for low and medium density rearing and highest for high density rearing. For low and medium rearing density, the last raceway in the series (C) had the highest detection. Detection was the same among all raceways in the high-density series. Sample sizes were below the minimum required to test statistical differences.

We captured emigrating hatchery juvenile salmonids at upriver canal facilities for a mark-release-recapture study as an additional method of estimating survival (Table 22). Expanding capture by corresponding trap efficiency estimates resulted in an overestimate of survival for subyearling fall chinook salmon and lowest survival for yearling fall chinook salmon. Overall survival for the three mark groups of coho salmon was 52% and survival for spring chinook salmon was 42%.

Reach-Specific Survival

Fish released for reach-specific survival tests had varying estimates of survival for each reach section based on capture of fish with color marks (Table 23). Spring chinook salmon released at three locations in early March were captured in few numbers at the rotary-screw trap. Although percent recapture indicated lower survival for the group released at RM 80, when expanded by corresponding trap efficiency, the survival estimate was higher (51.8%) than the lower two release groups, which had similar estimates of survival (Table 23).

Percent recapture of color-marked subyearling fall chinook salmon progressively increased with each lower release site (Table 23). However, when expanded by corresponding trap efficiency, survival was overestimated for the two lower groups released at RM 48 and RM 27. Survival of fish released at RM 80 (the acclimation release site) was near 71%.

Large-grade summer steelhead released at four locations were all recaptured at West Extension Canal. Percent recapture of color-marked fish was greatest for fish released at RM 48 (Reith), but survival was overestimated (Table 23). Survival estimates of groups released at RM 64.5 (Minthorn) and RM 27 (Echo) were comparable; survival of fish released at RM 79 (Bonifer) was lowest. Small-grade summer steelhead were released at three sites. Similar to the large-grade steelhead, the release at RM 48 (Reith) had the highest percent recapture and survival and the RM 79 release group (Bonifer) had the lowest.

Color-marked fish with PIT tags used in reach survival tests were detected at West Extension Canal and at mainstem dams (John Day and Bonneville dams; Table 24). Survival indices from these tag detections did not always proportionately match survival estimates derived from color-marked fish (Table 23). For spring chinook salmon, detection was lowest from fish released at RM 80 and highest from the RM 27 release group (Table 24). Percent detection between these two sites was significantly different (Table 24).

Little difference was seen in percent detection of subyearling fall chinook salmon released at the three release sites (Table 24), although the lowermost release site (RM 27) had the highest percent detection. There was no significant difference in the number of tags detected among release sites. Of the subyearling fall chinook salmon released into the Westland Canal holding pond, only 2 tagged fish (0.4%) were detected at John Day Dam. These fish were transported from Westland Canal to the mouth of the Umatilla River in mid-July.

Tagged steelhead (large-grade) showed progressively greater detection rates from the uppermost release site (RM 79) to the mid-reach site (RM 48; Table 24). Detections at RM 27 were 4% less than at RM 48. Difference in percent detection between RM 80 and RM 48 releases was significant and was near significant between RM 80 and RM 27. Near significance was also indicated for small-grade steelhead between tag detections from upper and lower releases. Although detections progressively increased from uppermost release site to the lowermost release site, they were less than the corresponding detections for large-grade steelhead.

Environmental Conditions and Bypass Operations

River flows at all main HYDROMET gauging stations during the project period are presented as stacked flows in Figure 19. No major floods occurred during this period. Highest flow was in late May near 3,000 ft^3/s, and increased flows between 1,000 – 2,000 ft^3/s were observed in January, March, and late April. Flows were lowest from October through November

1997 and from June through September 1998. Mean flows at the UMAO gauging station below Three Mile Falls Dam (RM 2.1) were lowest in August (25 ft^3/s) and highest in May (980 ft^3/s). September flows (not shown) averaged 154 ft^3/s.

Rapid rises in river flow increased suspended sediment loads and caused water clarity to decrease (Figure 20; Appendix Tables A-5, A-6). During lower flow, water clarity reached near 2 meters. During higher flows, Secchi depth decreased to less than 0.5 meters. Minimal water clarity occurred when juvenile salmonids were migrating in March and May.

Water temperatures in the lower Umatilla River ranged from a minimum low of 30 °F in January to a maximum high of 74 °F in July (Figure 21; Appendix Tables A-5, A-6). Water temperatures progressively increased through the spring overall, but declined when river flow increased. Mean water temperature was highly correlated with river flow ($r = 0.999$, $P = 0.0001$, $N = 175$).

Passage and flow relationships for hatchery yearling fall and spring chinook salmon were determined for both sampling sites (Figure 22). Passage was not linearly correlated with flow for either race at the rotary trap. Although it appeared more yearling chinook salmon migrated on the ascending limb of the March hydrograph, passage nearly ceased during higher flows (> 1,000 ft^3/s) in late March. At West Extension Canal, daily passage was correlated with river flow for fall chinook salmon ($r = 0.443$, $P = 0.002$, $N = 45$), but not for spring chinook salmon. Passage of fall chinook salmon peaked as river flow increased in late April; passage diminished with declining flows in early May. Passage of spring chinook salmon peaked in passage in mid-April prior to the late April freshet.

Passage of subyearling fall chinook salmon at West Extension Canal was not correlated with river flow. River flow was declining rapidly when subyearling chinook salmon were released in June; passage peaked as flows dropped to near 700 ft^3/s from a high of 3,200 ft^3/s one week earlier (Figure 23).

Daily passage of hatchery coho salmon was positively correlated with river flow ($r = 0.712$, $P = 0.021$, $N = 10$) in late March at the rotary-screw trap, but not at West Extension Canal from April to early June (Figure 24). Passage peaked in early and late May as flows were subsiding; passage also slightly increased in mid-April and early June as flows increased slightly. It appeared that as flows increased by 300 – 600%, passage of coho salmon nearly ceased (Figure 24).

Daily passage of hatchery steelhead sampled at West Extension Canal was negatively correlated with river flow ($r = -0.272$, $P = 0.049$, $N = 53$; Figure 25). Although passage slightly increased with elevated flows in late April, mid-May, and early June, most fish passed through the lower river as flows were dropping in late April and early May. This period corresponded to the release of small-grade steelhead.

Collection of most natural salmonids was not linearly correlated with river flow, except natural summer steelhead ($r = -0.239$, $P = 0.040$, $N = 74$). Collection of natural steelhead tended to peak on the descending limb of the hydrograph from late April to early June (Figure 26).

Although the initial peak in collection of natural spring chinook salmon corresponded with an increase in river flow in late April, other increases occurred as flows were dropping. Subyearling fall chinook peaked in mid-June as flows subsided to near 300 ft^3/s. The minimal collection of natural coho salmon in late May and early June precluded the ability to discern a relationship with flow.

Diversion of water at West Extension Canal varied throughout the season (Figure 27). At times irrigators were reliant on Phase I exchange pumping as flows decreased in the river to near or below 250 ft^3/s. Operations at West Extension Canal appeared to influence movement and collection of various species of hatchery and natural juvenile salmonids. In general, most yearling hatchery salmonids were collected at the canal through April and into early May when the canal was withdrawing from 70 – 140 ft^3/s (Figure 31). When Phase I pumping was first initiated on 7 May and diversion curtailed, collection of hatchery fish greatly diminished. When diversion was reinitiated on 20 May, a slight increase in collection was observed. Collection of yearling hatchery fish at the canal was correlated with canal diversion for fall chinook salmon (r = 0.295, P = 0.049, N = 45) and coho salmon (r = 0.575, P = 0.0001, N = 62), but not for spring chinook salmon or summer steelhead.

Collection of hatchery subyearling fall chinook salmon increased from first collection in late May to peak collection on 4 June as canal withdrawals increased from near 50 ft^3/s to 80 ft^3/s (Figure 27). When Phase I pumping was re-initiated on 6 June, canal withdrawals dropped by one-half, and collection numbers declined as well. Collection of subyearling fall chinook salmon was positively correlated with canal diversion (r = 0.641, P = 0.0005, N = 25).

Collection of natural fish was not correlated with diversion rate. Only natural coho salmon approached a weak association (r = 0.241, P = 0.102, N = 47)

Water was released from McKay Reservoir in mid-May and throughout June to improve passage for fish (Figure 27). River flows observed from 10 June to 1 July were mostly (83%) McKay release water. Once juvenile transport was initiated at Westland Canal on 7 July, Phase I pumping was discontinued, McKay releases halted, and diversion at West Extension Canal increased. By this time, collection of subyearling salmon had ended.

Video Monitoring

We recorded 132.2 h of fish passage at the viewing window in the east-bank fish ladder at Three Mile Falls Dam from 1 - 9 June 1998. Total review time was 124.7 h, or 0.9 review hours per hour of video.

Based on expanded data, approximately 225,654 subyearling fall chinook salmon passed through the fish ladder within the nine days of recording (Figure 28). Numbers of fish moving through the ladder peaked on 3 June (61,850), then progressively decreased with time. Approximately 115,323 subyearling fall chinook passed through the ladder during the day and 110, 331 during the night. On a day to day comparison, more fish moved through the ladder during the day; however, on 4 June, more fish passed through at night. Daily peaks in passage occurred from 0400 to 0900 hours and daily lows occurred from 1900 to 0100 hours.

Diurnal comparisons of fish passing through the west-bank fish bypass facility and the east-bank fish ladder are represented in Figure 29. More fish moved through both facilities during the day than at night. After the initiation of Phase I exchange at the canal on 6 June (0930 hours), the night passage through the bypass system was absent, but not at the ladder. By 8 June, day and night movement through the ladder had equilibrated, while daytime movement at the bypass remained dominant.

We also compared concurrent counts of subyearling fall chinook salmon through the fish ladder and fish bypass facility on a daily basis (Table 25). A total of 127.6 h of video passage data within the nine days was examined. During the hours compared, 76.8% of the subyearling fall chinook salmon passed through the fish bypass facility and 23.2% passed through the fish ladder. Although daily passage was mostly through the bypass facility, a distinct shift to the ladder was observed on 7 June. On this date, 67.0% of the fish used the fish ladder and only 33.0% used the fish bypass system. On 6 June, canal operations on the west bank changed to Phase I water exchange, reducing the amount of water diverted. On 8 June, percent fish passage through the bypass increased to 67.1%. By 9 June, fish counts were more evenly distributed through the ladder and bypass facilities. Overall, fish passing through both facilities peaked on 4 June (305,307 fish), 3 - 7 days after the two releases. Counts from 1 - 6 June revealed that 20.0% of the fish used the ladder, whereas from 7 - 9 June (during Phase I water exchange), 36.4% used the ladder.

Resident Fish and Predators

Data on resident fish species are presented in Table 26. Common species included suckers, redside shiner, and chiselmouth. Less frequently encountered species included peamouth, bass *spp.*, crappie, bluegill, and bullhead *spp.* The 64 bass *spp*. captured were all juveniles (120.2 mm mean fork length).

Pacific lamprey were mostly juveniles in the non-smolted and smolted life stages (90 - 184 mm). Only one adult lamprey (460 mm total length) was captured in early May. Juvenile lamprey were captured from December 1997 to May 1998 (Figure 30). Of the 568 juvenile lamprey captured, 103 were smolted and 465 were non-smolted. Of the 361 juvenile lamprey measured, 80 were smolted (149 mm) and 281 were non-smolted (153 mm). Smolted lamprey were captured from December through March, but mostly in December and January. Although there was no statistical correlation, captures of juvenile lamprey appeared to increase with river flows (Figure 31). High flows in May (> 3,000 ft^3/s) displaced many non-smolted lamprey.

Thirty-six northern pikeminnow were captured from March - June with a mean fork length of 105 mm (Table 26). Three fish captured in May and June were over 250 mm in fork length. Most small fish were captured in April (16); the smallest pikeminnow captured was 40 mm (Figure 32).

Avian predators observed at the trap sites included 2,147 gulls (*Laryx spp*.), 71 cormorants (*Phalacrocorax spp.*), 96 great blue herons (*Ardea herodias*), 156 night herons (*Nycticorax nycticorax*), and incidental sightings of kingfishers (*Ceryle alcyon*), common mergansers (*Mergus merganser*), and osprey (*Pandion haliaetus*). Gulls were observed from late March to early July and were present mainly during flows < 500 ft^3/s (Figure 33). Overall, gull observations at West Extension Canal coincided with high salmonid abundance in the river (Figure 34). Cormorants were present from early April to mid-June and great blue herons were present from mid-April to late June. Both of these species were also observed more frequently at lower river flows (Figure 35). The peak in cormorant observations coincided with the last increase in flows in mid-May. Night herons were observed from mid-April to early July (Figure 35). They were present at both high and low flows, but were noticeably absent or scarce during the low flow period in early May when other species were abundant.

DISCUSSION

Color Marking and PIT Tagging

Color marking is a relatively new technique that warranted assessment, especially the use of pressurized injectors. We found no difference in mark quality or application of photonic or VI-jet marks. However, applying either mark required certain considerations to prevent marking problems. The marking medium needed to be frequently agitated to keep it in solution. Otherwise the injector head would clog, requiring disassembly and flushing with distilled water. Also important was preventing air entrapment in the siphon tube when changing colors or nearing the end of a solution mixture to prevent loss of prime in the injector head and damage to interior parts. The fins of smaller fish (subyearling chinook salmon) tended to split when CO_2 pressure was at 600 psi; reducing the pressure to 500 psi kept the fin intact. Injecting the solution too close to the body of the fish resulted in accidental penetration. Maintenance was high on the marking guns, especially with frequent use and continual exposure to moist conditions. Internal O-rings deteriorated rapidly, requiring regular changing. The valve core in the trigger mechanism would also deteriorate and need replacing and these parts were only available through the vendor (New West Technologies). At times, the clutch on the power unit would not engage the plunger of the injector head properly, causing a misfiring. Lubrication with a petroleum jelly was important, especially in the damp environment in which the equipment was used. Over lubrication was also a problem. If the plunger of the injector was too slippery, the clutch could not grasp the plunger properly causing an inadequate dispersal of paint. During intensive marking, one person was required to maintain and repair the marking equipment and ensure that markers were using the equipment properly.

Fin thickness and tissue color of the caudal fin made it difficult to produce a good mark in this area. Fins of summer steelhead were also more difficult to mark than salmon fins because of their thickness; fin thickness required more paint to make a good quality mark. Mark quality was dependent on the angle of the injector and its proximity to the fin or body and the experience of the marker. Placement of fish in the marking tray to where the fin was flattened against the tile was difficult; improper placement often created a poor mark. Photonic pink was a good color mark as it was easily visible and discernable. Pink was also a good color in marking trials with adult chinook salmon (Hayes et al. in press). Other colors were difficult to differentiate (green vs. yellow, pink vs. purple) or were confused with bloody fins (red mark).

Outmigration Monitoring

Pooled trap retention efficiency for hatchery spring chinook salmon in 1998 (77%) was identical to the retention efficiency in 1997 for both spring and fall races combined (Knapp et al. 1998b). We believe this similarity was due to the larger contribution of spring chinook salmon to the efficiency estimate in 1997, as the 1998 retention efficiency estimate for fall chinook salmon was high (97%). Spring chinook salmon captured at the rotary trap had a larger mean length (205 mm FL) than fall chinook salmon (141 mm FL) which may have increased their ability to escape from the trap live box. Similar escape behavior of summer steelhead (221 mm mean FL) was evident in 1997 (Knapp et al. 1998b). High retention efficiencies for hatchery coho salmon in 1997 (96%) and 1998 (98%) may have been due to their smaller size (142 mm and 133 mm FL, respectively) which was similar to that of fall chinook salmon in 1998.

Trap collection efficiencies for spring chinook salmon at the rotary-screw trap were higher in 1998 (3.7%) than in 1996 (2.0%; Knapp et al. 1998a). The 1997 estimate (1.7%; Knapp et al. 1998b) was for both races of chinook salmon. The higher efficiency in 1998 may be due to lower March flows (847 ft^3/s mean flow) compared to 2,834 ft^3/s in 1997 and 1,443 ft^3/s in 1996. In fact, there was a negative linear relationship between flow and spring chinook salmon trap efficiency in 1998 ($r = -0.697$, $P < 0.05$). Rotary trap collection efficiency for coho salmon in 1998 (2.4%) was lower than the mean estimate in 1997 (3.2%; Knapp et al. 1998b). It is evident that most collection efficiencies for yearling salmon at the rotary-screw trap range around 2 - 4% (estimate for yearling fall chinook in 1998 was 2.1%). This coincides with the average proportion of river flow sampled by the trap (2.5%; Knapp et al. 1998b). Estimates of abundance for chinook and coho salmon at the rotary trap can probably be roughly calculated by expanding catch by 2.5%.

Consistencies have also emerged in trap efficiency estimates for species collected at West Extension Canal. In 1996 and 1998, yearling spring and fall chinook salmon had collection efficiencies between 20 - 31%. Collection efficiencies were slightly lower in 1995 (10 - 14%; Knapp et al. 1996). In all years, collection efficiencies for subyearling fall chinook salmon at the canal have been within 24 - 27%. Similarities in behavior between chinook races and age classes may account for these similarities. Summer steelhead and coho salmon have had similar, but lower, trap efficiencies in all years. Except for coho salmon in 1996 (19%; Knapp et al. 1998a), all estimates have been less than 15%, and most near 10%. Similarities between hatchery and natural summer steelhead are most striking. In 1998 and 1995, efficiency estimates were within 2 - 3%. In 1996, estimates were within 7% (Knapp et al. 1998a). The consistent contrast between the chinook races (higher efficiencies) and the steelhead and coho species (lower efficiencies) indicates that chinook salmon are captured more readily than summer steelhead or coho salmon.

Length of time to recapture fish in efficiency tests may indicate specific fish behavior or delay factors in passage. Most fish used in trap efficiency tests at the rotary trap (1996 - 1998) were recaptured within a few hours after release, with some yearlings captured up to 2 weeks after release with in-river sampling. Of these fish, subyearling chinook salmon were captured the quickest (maximum of 2 d). Conversely, yearling chinook and coho salmon used in tests at West Extension Canal in 1995, 1996, and 1998 were recaptured up to 2 - 5 weeks after release, although most were recaptured within a few days (Knapp et al. 1996, 1998a). Again, quickest recapture was with the fall chinook subyearlings (maximum of 18 d). Maximum recapture time for hatchery steelhead has been 26 d, and 17 d for natural steelhead. It is obvious that Three Mile Falls Dam delays movement of fish. Extended recapture may be a result of fish holding in slack water behind the dam or just above the trap facility. It is also evident that yearling salmon migrate slower than subyearlings. Similarly, steelhead, fall chinook, and coho salmon all have protracted outmigrations which are mimicked in their behavior during trap efficiency tests.

Holding survival at West Extension Canal was high (> 99%), which was an improvement from 1996 (93.6-98.5 %; Knapp et al. 1998a). This may be due to the photonic and VI-jet fin marking technique used in 1998 which was less invasive to fish than acrylic paint marks injected subdermally with a syringe in 1996. Even though temperatures reached 74.5 °F during marking and holding of subyearling chinook salmon, survival was high for both natural and hatchery origin fish.

Color marking fish in the fins for trap efficiency tests with photonic and VI-jet paint was an improvement over marking techniques from previous years because we could mark large numbers of fish in a shorter time. The fin marks were also more visible and less invasive than paints injected into the ventral side of the fish creating a pin-point mark. In addition, fish did not need to be held out of the water for marking. Given the improvement in marks and marking technique, we believe trap efficiency tests were greatly improved this year. Although fin color marking worked well for identifying trap efficiency (and other) test fish, handling large numbers of fish remains a concern. We envision transitioning to PIT tags and remote detection in the future to reduce handling and stress on fish and to obtain more reliable trap efficiency estimates.

We collected some unusual information this year that has helped to broaden our understanding of natural salmonid life histories and natural production success. This is the first year we collected thousands of natural subyearling fall chinook salmon. These fish were progeny from the adult fall chinook outplants made in November 1997. In this year, 940 adult upriver bright fall chinook salmon were collected from both Priest Rapids Hatchery (66%) and Ringold Hatchery (34%) and respectively transported to the Pendleton and Yoakum release sites at RMs 37 and 52 (CTUIR and ODFW 1998). Fish appeared healthy at release and spawning commenced almost immediately. Outplanted adults comprised most of the fall chinook spawning population in the Umatilla River in 1997 since returning adults were collected at Three Mile Falls Dam for broodstock (CTUIR and ODFW 1998). The success of this outplant and resultant production was undoubtedly affected by stable river flows throughout the year. A similar adult outplant attempted in the fall of 1996 (although with fewer adults) was not successful in producing progeny because of extremely high, scouring flows (Knapp et al. 1998b).

Transport of juvenile salmonids from Westland Canal was delayed until 7 July this year primarily because of the abundance of natural subyearlings. This beneficial delay in transport was possible due to an extended release of McKay Reservoir water. As a result, total number of hatchery subyearling fall chinook salmon transported in 1998 (1% of number released) was less than all prior years.

We observed the same pattern of collection at Westland Canal as in past years; natural subyearling fall chinook salmon replace the hatchery group in dominance by late July. However, the continued late collection of natural subyearlings jeopardizes their survival in this river system. If enhancing natural production through adult outplanting is a continuing strategy, then enhancement of river flows throughout June and into July is essential for providing suitable migration conditions. Transport of fish was intended to be a temporary strategy only. Research has shown that collection and transport is stressful and injurious to fish and increases acute and possibly latent mortality (Cameron et al. 1996; Knapp et al. 1998a, 1998b). We strongly encourage managers and river operators to seek additional means of enhancing flows through July to provide for natural in-river migration of mid-summer migrants.

Transport also unintentionally dislocates natural juvenile salmonids rearing in the area at Westland Canal. Most of the natural summer steelhead and coho salmon collected and transported were small-sized fish, indicating pre-smolts.

Natural spring chinook salmon exhibited an extended migration that lasted from December to June. During May and June, these fish were smaller than fish collected earlier in the year, but at least 20 mm larger in fork length than the known natural fall chinook subyearlings. From scale analysis, these fish were classified as age 0 spring chinook salmon (CTUIR, unpublished data). Although spring yearling migrants are more commonly observed in the Umatilla River, underyearling migrants may signify a redistribution of fish to more suitable rearing habitat during the summer (Groot and Margolis 1991). Some of these fish may also have been smolted migrants. These later migrants suffer the same poor water quality conditions as the subyearling fall chinook salmon in mid-summer (high temperatures).

Steelhead exhibited the greatest plasticity in juvenile life history patterns of all natural salmonids. We collected fish that were aged from 0 years (61 mm FL) to 4 years (> 350 mm FL). As in past years, the greatest proportion of steelhead that migrated from the basin were age 2 smolts, although not all fish of this age class were smolted. The large natural steelhead collected in April and May were mostly age 3 and 4 smolts based on scale analysis by Tribal biologists. Although this is the first year we observed these fish at our trap sites, others have observed large natural steelhead at Westland Canal during juvenile transport in July and August (personal communication, G. Rowan, CTUIR, Mission, OR). It is uncertain whether these fish normally emigrate during April and May and simply have not been detected, or unusual rearing conditions upriver produced more 3 and 4-year-old smolts. It was only after we changed the separator bars to a larger spacing in late April that more of these fish were collected.

The larger spaced bars also allowed the collection of fallback adult summer steelhead and provided information on spawning adults. Hatchery adults (post-spawn) were collected as well as natural steelhead, signifying that hatchery fish spawned. Most fish collected were females. Analysis of scales from the natural adult steelhead corroborated findings from juvenile steelhead scales in that 2 years of freshwater existence was predominant.

Smolt development may have been the leading factor in movement of natural salmonids. Median and peak movement of natural coho salmon was in early June, corresponding to their transition to intermediate and smolt development. Similarly, median capture of natural steelhead was in early May which corresponded to their transition to smolts. Most natural spring chinook salmon moved out as intermediate smolts in late April. Natural subyearling fall chinook salmon followed a similar pattern; most emigrants sampled at the lower river trap site were intermediate smolts. In late May and early June, most of these fish were parr. As water temperatures increased to about 70 °F in late June and early July, more natural chinook were identified as smolts. Transition to the smolt stage for most natural salmonids was also significantly correlated with an increase in length.

Smolt development was definitely a factor in the increased movement of hatchery coho salmon. As in past years, coho salmon released in late March and early April 1998 did not peak in the lower river until early May. At release, these fish are not fully smolted; at peak capture most fish are smolted (Knapp et al. 1998a, 1998b). Time in the river will be reduced in 2000 when acclimation facilities for coho salmon near RM 56 are completed. Early direct stream releases will be halted. Later releases, when fish are ready to migrate, will shorten the migration period and be more beneficial for the fish.

Spring chinook and subyearling fall chinook salmon marked for reach survival tests moved through the lower river quickly which is similar to movement of their unmarked counterparts. Some large- and small-grade summer steelhead marked for reach survival tests moved through the lower river quickly after release, but most fish from both releases took 2-3 weeks to emigrate. This pattern was also similar to their unmarked counterparts.

Travel speed generally increased with each upriver release. For subyearling chinook salmon, travel speed was 3.5 to 2.5 times faster for fish released in the two upper river sites than in the lower release site at Echo (RM 27). In general, all fish species released at Echo traveled the slowest. This difference may be due to the temperature change between the upper and lower release sites. During releases of spring chinook salmon in early March, temperature differential among sites was minimal (within 0.3 °F). Large-grade steelhead released in mid-April were exposed to temperature increases of 4 °F from upper to lower release sites. During releases of small-grade summer steelhead in mid-May and subyearling releases in early June, the temperature difference was 5 °F from the upper to the lower release sites on the river. Of interest, however, is the slower travel speed for large-grade steelhead released at Minthorn compared to all other release sites. Steelhead released at Minthorn must travel several hundred yards in Minthorn Springs before they reach the Umatilla River.

The trend from preceding years of lower recaptures of adipose fin and ventral fin-clipped fish compared to single fin-clipped fish held true for spring chinook and subyearling fall chinook salmon in 1998 and may signify a survival disadvantage (Knapp et al. 1996, 1998a, and 1998b). However, yearling fall chinook salmon recapture rates were the opposite with almost twice the proportion of double fin-clipped fish recaptured than single fin-clipped fish. The difference in recapture between single- and double-clipped fish may be due to non-random detection of fin clips or survival differences. However, studies by WDFW indicated that double-clipped juvenile fall chinook salmon had poorer smolt-to-adult survival than single-clipped or non-clipped fish

(WDFW, unpublished data). The lack of difference in recapture of adipose clipped and non-clipped coho salmon may be due to the minimal effect of adipose fin clips and coded wire tags on survival. A study by Alaska Department of Fish and Game with coho salmon indicated that fish marked with an adipose fin clip and a coded wire tag survived similar to unmarked fish (Vincent-Lang 1993). The same may hold true for summer steelhead. In the future, ventral fin clips on hatchery chinook salmon will be discontinued based on the belief that these clips are deleterious to the fish's ability to survive.

The common presence of black spot disease on natural spring chinook salmon and summer steelhead, and on some coho salmon, may indicate area of rearing. Black spot disease is actually the embedded and encysted metacercaria in the final life history stages of a parasitic intestinal trematode found in reptiles, birds, and mammals (Noble and Noble 1971). Since it is believed these trematodes exist primarily in areas of poor water quality, its presence on natural fish may indicate the prevalence of lower river rearing.

Abundance and Survival

The estimate of survival for hatchery spring chinook salmon was higher in 1998 (72.5%) than it had been in previous years (Appendix Table A-7). The survival estimate for all blue-marked spring chinook salmon (92.1%) was also relatively high. A change in rearing practices at Umatilla Hatchery and an earlier release date may have contributed to improved survival. These fish were incubated longer and ponded for a shorter period (one month less) to reduce growth (10 fish/lb). Fish were also in better condition at pre-release examination, with minimum levels of bacterial kidney disease, and were smolted at release rather than during acclimation (personal communication, J. Hurst, ODFW, Irrigon, OR). Migrant condition data also showed spring chinook salmon to be in better condition than other hatchery species with minimal mortality. Releases in March 1998 were also at least one week earlier than in past years. Prior releases of spring chinook salmon from Umatilla Hatchery were made in mid-March when fish were larger (8 fish/lb). Fish were also smolted early at pre-release, disease was more prevalent, and scale loss was common on migrants (Knapp et al. 1996, 1998a). These factors were attributed to the rearing profile at Umatilla Hatchery, which is characterized by unfavorably warm water (Hayes et al. 1999). The change with the 1996 brood may have served to counteract this poor rearing profile and produce a better product.

Spring chinook smolts from Little White Salmon Hatchery and Carson National Fish Hatchery also contributed to the overall survival estimate. The detection of spring chinook salmon released from Little White Salmon Hatchery in March was twice that of March-released Umatilla fish; this may be an indicator of good survival. The temperature profiles at Little White Salmon and Carson hatcheries are more favorable to yearling production (cooler water) than at Umatilla Hatchery.

Survival of yearling fall chinook salmon (70%) was near that for spring chinook salmon and improved from 1996 (40%; Appendix Table A-7). Unfortunately, survival of blue-marked fish cannot corroborate the survival estimate as it was overestimated (131%). Conversely, the secondary survival estimate from March releases was relatively low at 21%. No Umatilla-reared fish were released in 1998 as they were in 1996. Fall chinook salmon experience the same rearing profile problems as spring chinook salmon at Umatilla Hatchery. Fish released in 1998 were reared at Bonneville and Willard hatcheries with cooler water temperatures than at Umatilla Hatchery. However, survival may have been even better if fish from Willard Hatchery were in better condition. These fish suffered from high levels of BKD and cold-water disease at release (personal communication, S. Onjukka, ODFW Pathology, La Grande, OR). Assessment of condition at recapture indicated that of the fish examined for injuries, 63% showed signs of BKD. In addition, migrant mortality was high (2.3%) for fall chinook salmon captured in late April and early May - most likely fish from the mid-April Willard release. Analysis of pathology on dead fall chinook collected in late April corroborated the assumption of BKD.

The 1998 survival estimate for hatchery steelhead (50%) was lower than in 1996 (94%; Appendix Table A-7). (In 1995, survival was overestimated, and in 1997 we could not determine survival at the rotary trap.) Color-mark data also suggests survival was low for steelhead as a group (29%). Detections of tagged steelhead at West Extension Canal were too small for statistical analysis, but data from reach survival tests indicated reduced survival may be attributable to the Bonifer release site and the later release of small-grade fish. Umatilla Hatchery Monitoring and Evaluation studies (Hayes et al. 2000) showed that percent detection of Bonifer-released small-grade steelhead at mainstem dams was nearly half the detections of large-grade steelhead released at Minthorn and Bonifer.

Survival was overestimated for both subyearling fall chinook salmon and coho salmon. Overestimation of survival for subyearling salmon occurred in 1996 as well, but not in 1995 or 1997 (Appendix Table A-7). Therefore, it is extremely difficult to assess a survival trend for these fish. Overestimation undoubtedly occurs as fish are being sampled at West Extension Canal during their peak movement. Samplers are forced to reduce the sample rate to < 5% for many hours because of the masses of fish moving through the facility. Expansion of minimal count data during this time results in an over-inflated adjusted count, which is further adjusted by the trap efficiency estimate. Results obtained in 1997 (35% survival; Knapp et al. 1998b) may be the most reliable as we sampled at the rotary trap and did not contend with extremely large numbers of fish. In 1998, a similar overestimation occurred with secondary survival fish (157% survival). However, a lesser estimate was evident with color-marked fish (84%). Given the wide variability in results, we recognize the need to change methods for estimating survival. In 1999, we will attempt to remotely monitor PIT-tagged production fish at West Extension Canal to circumvent problems with count expansions.

Coho salmon survival was also overestimated in 1995, for probably the same reasons as for subyearling chinook salmon. In 1996 and 1997, survival ranged between 35-38% (Appendix Table A-7). Given their long residence time in the river prior to smolting and emigrating, it is feasible that survival is compromised by increased exposure to predators, poor water quality, and disease.

Survival of subyearling fall chinook salmon used to test the effects of transport from Westland Canal was very poor (0.4%). However, conditions during testing probably confounded the results. Fish were not acclimated sufficiently to ambient water temperature (68 °F) when transported from the hatchery (52 °F). This resulted in disoriented and stressed fish in the

Westland holding pond, and eventual death for some. We recognize the tenuousness of the test, but still contend results indicate a negative effect of transport, particularly when only 2 fish were detected on the mainstem of 488 fish transported. We plan to conduct an improved test in 1999.

Based on tag detections in the lower Umatilla River and at mainstem dams, and color-mark data in the Umatilla River, reach survival tests for spring chinook and subyearling fall chinook salmon, and large-grade and small-grade summer steelhead showed a general trend of increasing survival with lower river releases. For percent detections showing statistical significance, spring chinook salmon survival increased by 100% between the uppermost release site (RM 80) and lowermost release site (RM 27). Survival of large-grade steelhead improved by 38% between the Bonifer release site (uppermost site) and the Echo release site at RM 27 and by 60% between Bonifer and Reith (the mid-reach site at RM 48). The Reith area has been known to be a highly productive area for salmonids because of improved water quality (personal communication, C. Contor, CTUIR, Mission, OR). Based on abundance estimates of color marks, survival differences between upper and lower release sites were slightly different than what tag detections indicated, but survival was still improved with lower river releases.

Tag recoveries from islands in the mainstem Columbia River where bird colonies exist indicate a source of mortality for Umatilla fish, especially larger salmonids (Appendix Table A-8). Other sources of mortality outside the Umatilla basin are incidental to this report, but important in the overall understanding of survival. Recovery and interrogation of PIT tags at various locations underscores the versatility and exactness of this technique in migration and survival studies.

Given that migrant survival is better in lower river reaches, based on PIT-tag and color-mark data, we suggest that managers consider releasing fish lower in the basin, if possible. This may be possible with releases of subyearling fall chinook salmon with the completion of a new acclimation facility at RM 56. For steelhead, our results indicate that Bonifer Pond is not an optimal release site. A change in release site strategy for steelhead smalls, possibly to the Minthorn Springs site (RM 64), should be considered.

Expansion of count data collected at traps to determine abundance and survival has provided variable results over the years. Since it has been difficult to obtain data that shows a pattern in survival, the question remains whether survival is indeed variable or the method used to estimate survival is poor. With the test use of PIT tags this year, we are encouraged with the results and the ability to obtain additional tag data at mainstem dams. Mainstem interrogations increase the sample size from which analysis and interpretations can be made. Therefore, we propose using PIT tags and remote monitoring in the lower Umatilla River to validate or refute past estimates of survival.

No natural salmonids were PIT tagged by Tribal biologists in 1998, precluding the ability to estimate survival. However, we did estimate abundance of natural fish. After separating the spring and fall races of chinook salmon, we estimated approximately 19,000 spring chinook and 141,000 fall chinook salmon emigrated from the basin in 1998. These estimates exceed previous estimates in most years (the abundance of natural spring chinook salmon in 1995 was estimated near 74,000 fish; Appendix Table A-7). As with the subyearling fall chinook salmon, a combination of stable flows, suitable habitat, and sufficient spawners creates favorable conditions for good spring chinook salmon production. Brood for the 1995 spring chinook migrants returned to the Umatilla in 1993 (1,205 adults); brood for the 1998 migrants returned in 1996 (2,152 adults; Hayes et al. 1999). With the return of 2,194 adult spring chinook salmon in 1997 and stable flow conditions in 1998, we predict continued good production in 1999.

The abundance estimate for natural summer steelhead has consistently ranged between 54,000 and 73,000 fish (Appendix Table A-7). Given these migrant estimates and the return of nearly 1,000 - 2,000 natural steelhead each year for the last 8 years (Hayes et al. 1999), natural production may be at its maximum level.

Natural coho salmon were more abundant this year than in past monitoring years (Appendix Table A-7). Again, a combination of stable flows, suitable habitat, and sufficient spawners (approximately 600 in 1996 and 800 in 1997; Hayes et al. 1999) provided for successful recruitment.

Environmental Conditions and Bypass Operations

The Umatilla River has historically produced variable flows. From fall 1997 through fall 1998, the hydrograph was unusually moderate without any extremely high flow events. Unfortunately, we cannot forecast flow; however, flow can be a major factor limiting production. In 1998 the Umatilla River produced significant numbers of natural salmonids with favorable flow conditions.

Low flow in the river can also be a limiting factor in fish survival. During this ebb in water availability for fish, flow enhancement strategies have helped fill the void. A critical period for flow enhancement is during the outmigration of summer migrants, particularly natural and hatchery subyearling fall chinook salmon. Water releases from McKay Reservoir during June are requisite for a successful in-river migration. Reservoir releases constitute nearly 80% of the total water volume in the river in June. The more fish that move out in-river (versus transport), the better chance for survival, especially under thermally stressful conditions. Reservoir water releases through June were first made in 1997, and were even pulsed on one occasion up to 300 ft^3/s (Knapp et al. 1998b). Adult returns from migrants that experienced this change in river operations are expected in the next few years.

Low flows are accompanied by an increase in water temperature, even with the influx of enhanced flows. These conditions can be intolerable for juvenile salmon, affecting their survival. On the last day of collection at West Extension Canal in early July, the five natural subyearlings captured were all dead. Throughout July at Westland Canal, condition of live fish collected continued to worsen. Connor et al. (1998) stated that flow releases into the Snake River from Dworshak Reservoir and the Hells Canyon Complex are highly beneficial to the survival of the Snake River stock of fall chinook salmon. Flow augmentation comprises more than half the total water volume through Lower Granite Reservoir and effectively decreases water temperature throughout the water column. Survival is increased by limiting thermallyinduced mortality and reducing predation. Improvement in flows (and associated thermal regimes) in the Umatilla River is needed in July to optimize conditions for late summer migrants.

Subyearlings that arrive at Three Mile Falls Dam in early summer are faced with conditions that do not exist for the earlier arriving species. With minimal flow passing over the dam, these fish are forced to pass through the west-bank canal bypass or the east-bank fish ladder. At this time, degree of diversion is important in attracting fish to the west-bank bypass. Cessation of diversion with Phase I pump exchange appears to affect bypass efficiency. Because of the magnitude of fish arriving at the dam, it is important to ensure operations at both facilities are providing efficient and effective passage.

Video Monitoring

We video-recorded fish passage through the east-bank fish ladder at Three Mile Falls Dam because we suspected that subyearling fall chinook salmon migrants might use the ladder as a passage route when Phase I water exchange reduced the efficiency of the west-bank fish bypass facility. During video recording from 1 - 9 June 1998, approximately 225,654 subyearling fall chinook salmon passed through the viewing window, constituting 23.2% of the concurrent counts at the ladder and bypass facility. This suggests that subyearlings preferred the bypass as a passage route during this period. However, bypass estimates may have been overestimated during peak passage days because of low sample rates. Sample rate weighted averages for the bypass from 1 - 6 June ranged from 6.3% to 38.9%, whereas from 7 - 9 June, weighted averages were 50.3% - 72.1%. Smaller sample rates tend to cause over-expansion of count data.

Phase I operations appeared to affect the passage rates of subyearling fall chinook salmon past Three Mile Falls Dam. On 7 June, the day after Phase I was initiated, fish passage noticeably shifted to the fish ladder. In addition, total counts before and after the initiation of Phase I showed similar results, with more fish using the ladder during Phase I (36%) than before (20%). After 7 June, most fish switched back to the bypass facility; however, the night contingent of the fish using the bypass was absent.

Fish passage prior to Phase I exchange may have been enhanced by a higher velocity of water at the bypass entrance and canal withdrawals between 62 - 90 ft^3/s. Before initiation of Phase I, 40 ft^3/s was flowing into the bypass facility, 10 ft^3/s from each of two pumpback pumps and 20 ft^3/s from the river-return pipe that was inadvertently left open. This extra flow into the bypass and resultant higher velocity may have provided an extra draw for subyearling fall chinook salmon to enter the bypass facility. At the onset of Phase I, the pumpback pumps were shut down and canal withdrawals were reduced 31%; consequently, flow into the bypass dropped to 20 ft^3/s (the river-return pipe remained open). This change in operations may have caused the altered diurnal movement of fish at the bypass during Phase I exchange.

Overall, route selection of subyearling fall chinook salmon in 1998 was similar to route selection in 1996. In 1996, 28% of the subyearling fall chinook salmon used the fish ladder (Cameron et al. 1998a); in 1998, it was 23%. Implementation of Phase I exchange in 1996 also affected route selection. The day after implementation of Phase I in 1996, the proportion of fish using the ladder increased from 11% to 79%. Route selection by subyearling fall chinook salmon subsequently shifted back to the bypass facility for the remainder of the monitoring, as in 1998.

When the bypass facility is in a sampling mode and canal operations are switched to Phase I water exchange, passage route selection of subyearling fall chinook salmon is temporarily altered. Since subyearlings are using the fish ladder as a passage route at this time, we continue to recommend that the lead gate at the ladder exit remain fully open to minimize injury to these fish through improved hydraulic conditions (Knapp et al 1996, 1998a).

Resident Fish and Predators

Juvenile Pacific lamprey were captured in the lower Umatilla River from December through May. Most lamprey captured in 1998 were larvae (non-smolted), and their captures appeared to coincide with an increase in river flow. These larvae were not migrating, but were washed out of their burrows by the higher flows (Close et al. 1995). Non-smolted lamprey were larger than smolted lamprey, which is consistent with a decrease in size during metamorphosis (personal communication, D. Close, CTUIR, Mission, OR). Metamorphosed (smolted) lamprey were captured mostly in December and January, although a few were still being captured in March. Because smolted juvenile lamprey are known to migrate to the ocean between late fall and spring (Close et al. 1995; van de Wetering 1998), smolted lamprey captured in the Umatilla River were thought to be actively migrating. Lamprey smolts migrate more actively during the rise and fall of river flow, not necessarily the peak of the flow (van de Wetering 1998); most smolts were captured in the Umatilla River during a rise in flow.

Flows in the Umatilla River may be a limiting factor in lamprey outmigration. Due to low trap efficiencies of the rotary-screw trap in early fall, it is difficult to determine when metamorphosed Pacific lamprey are present in the lower river. If metamorphosed lamprey in the upper river are ready to migrate in early fall, flows may be too low in the Umatilla River to stimulate movement out of the system. Under these circumstances, it is possible for lamprey to be confined to fresh water. Metamorphosed lamprey can live up to 10 months in fresh water, but different populations vary in their ability to survive (Beamish 1980). Death can occur during confinement as a result of decreased plasma sodium concentration and condition factor (Clarke and Beamish 1988). Year-round monitoring is needed to determine when lamprey undergo metamorphosis in the Umatilla River and to subsequently determine the need to provide higher flows in early fall (Close, in preparation).

Only one adult lamprey was captured in early May. Data collected from 1995 through 1997 also shows adults being captured around this same time (Knapp et al. 1996, 1998a, 1998b). Adults are known to enter spawning streams between spring and fall and then overwinter before spawning in the summer of the following year (Close et al. 1995). Therefore, the status of the adult captured in May cannot be determined; it may have been a fish just entering the river, a pre-spawn fish, or a post-spawn fish.

The presence of northern pikeminnow at the bypass sampling facility and rotary-screw trap indicates possible predation on salmonids, especially subyearling fall chinook salmon. Although we captured only three pikeminnows of predator size (> 250 mm; Collis et al. 1995), these fish were captured in May and June when subyearling fall chinook are in the river. The data collected in 1996 also showed the capture of larger northern pikeminnows coinciding with the outmigration of subyearling fall chinook salmon (Knapp et al. 1998a). Capture of northern pikeminnows in 1998 was relatively low (36), leading to the assumption that they are not a serious threat to juvenile salmonids in the lower Umatilla River. On the other hand, northern pikeminnows may be a necessary predator on the resident fish community. Data collected in 1997 revealed predator-sized pikeminnows being captured in January at the rotary trap along with many resident juveniles (Knapp et al. 1998b). The practice of sacrificing all northern pikeminnows collected at the east-bank adult trap (CTUIR and ODFW 1998) may remove control on the resident fish population.

Although all bass *spp*. were considered juveniles (< age 3), 23 of 61 bass measured had mean fork lengths above 128 mm. According to Vigg et al. (1988), smallmouth bass between 128 – 314 mm FL have the highest consumption of fish in their diet, with roughly 1–7% of that diet comprised of salmonids. Larger bass *spp*. were collected from late May through June in the Umatilla River during the outmigration of subyearlings. It is possible resident bass rearing above Three Mile Falls Dam, as well as below, were preying on juvenile salmonids.

Avian predators may pose a serious threat to juvenile salmonids. Although few avian predators were observed during sampling at the rotary-screw trap, they were prevalent while sampling at West Extension Canal from April through June. Gulls were the dominant species, although cormorants, great blue herons, and night herons were also observed. Observations were highest from mid-April through June and coincided with hatchery fish presence in the river. Gulls were mostly observed in two periods, early May and June, when there were numerous salmonids and low river flows. The early May observations coincided with several hatchery releases upriver in mid-April of spring chinook salmon, yearling fall chinook salmon, and summer steelhead and a second release of steelhead on 4 May (Appendix Table A-4). The June observations corresponded with releases of hatchery subyearling fall chinook salmon. Cormorants and great blue herons were also observed from April through June and also at lower flows. All three species (gulls, cormorants, and great blue herons) were feeding mostly near the dam. Fish are more visible near the dam as they approach and spill over the dam, pass into the canal headworks, or surface in turbulent waters below the dam, making them more vulnerable to avian predation. Most blue herons stood in the river below the dam for easy feeding. Night herons were observed usually in the dam forebay or at the bypass outfall at higher river flows. Avian predators were also observed on the east-bank side of the dam feeding on smolts that were exiting the fish ladder.

Although feeding habits of these avian predators was not the main focus of this study, the effect on salmonid survival was a concern. Of the fish that were captured with visible injuries, bird marks were present on all species. Hatchery and natural steelhead exhibited the most damage inflicted by birds. Their migration peak in early to mid-May coincided with a period of high gull activity. Hatchery steelhead may also be incurring damage from birds during their residency in the Bonifer acclimation pond (personal communication, M. Hayes, ODFW, Hermiston, OR). Subyearling fall chinook salmon released in late May also showed a high percentage of bird injuries. During direct stream releases of coho salmon upriver in late March and early April, gull predation activity was extensive (April Monthly Report, B. Zimmerman, CTUIR, Mission, OR).

From these results, it can be suggested that avian predation on salmonids is a problem in the Umatilla basin. Therefore, it is recommended that efforts to decrease bird predation be focused on the area surrounding Three Mile Falls Dam where fish are most vulnerable. This dam has created an environment that causes fish to hold and be exposed to birds. Bird deterrents such as water cannons, rain bird sprinklers, mylar balloons or strips, or noise makers (i.e. firecrackers) are suggested as methods to discourage avian predators from feeding on salmonids. Future acclimation of hatchery coho salmon at RM 56, thereby eliminating direct stream releases, may reduce gull predation on this species.

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LITERATURE CITED

Beamish, R.J. 1980. Adult biology of the river lamprey (*Lampetra ayersi*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences. 37: 1906-1923.

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

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

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

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

Cameron, W.A., S.M. Knapp, and R.W. Carmichael. 1998a. Umatilla River passage evaluation. Pages 131-167 *in* S.M. Knapp, editor. Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin. Annual progress report 1995-1996 to Bonneville Power Administration, Portland, Oregon.

Clarke, W.C. and R.J. Beamish. 1988. Response of recently metamorphosed anadromous parasitic lamprey (Lampetra tridentata) from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences. 45: 42-47.

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

Close, D. In preparation. Restoration plan for Pacific lamprey (*Lampetra tridentata*) in the Umatilla River, Oregon. Confederated Tribes of the Umatilla Indian Reservation, Mission, Oregon.

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

Conner, W.P., H.L. Burge, and D.H.Bennett. 1998. Detection of PIT-tagged subyearling chinook salmon at a Snake River Dam: Implications for summer flow augmentation. North American Journal of Fisheries Management, Vol 18: 530-536.

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

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

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

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

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

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

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

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

CTUIR (Confederated Tribes of the Umatilla Indian Reservation) and ODFW (Oregon Department of Fish and Wildlife). 1998. Trapping and transportation of adult and juvenile salmon in the lower Umatilla River in northeast Oregon, Annual progress report 1997-1998 to Bonneville Power Administration, Portland, Oregon.

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

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

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

Groot, C. and L. Margolis (eds). 1991. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, British Columbia.

Hayes, M.C., S.M. Knapp, and A.A. Nigro. 1992. Pages 53-103 *in* S.M. Knapp, editor. Evaluation of juvenile fish bypass and adult fish passage facilities at water diversions in the Umatilla River. Annual and interim progress report to Bonneville Power Administration, Portland, Oregon.

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

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

Hayes, M.C., R.W. Carmichael, S.M. Focher, and R.W. Stonecyper, Jr. 1999. Umatilla Hatchery monitoring and evaluation. 1997 annual progress report to the Bonneville Power Administration, Portland, Oregon.

Hayes, M.C., W.A. Cameron, R.W. Stonecypher, Jr., and R.W. Carmichael. 2000. Umatilla Hatchery Monitoring and Evaluation. 1998 annual report to the Bonneville Power Administration, Portland, Oregon.

Hayes, M.C., S.M. Focher, and C. Contor. In Press. High-pressure injection of photonic paint to mark adult chinook salmon. North American Journal of Aquaculture.

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

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

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

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

Knapp, S.M., W.A. Cameron, J.C. Kern, and R.W. Carmichael. 1998b. Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin. Annual progress report *1996-1997* to Bonneville Power Administration, Portland, Oregon.

Noble, E.R., and G.A. Noble. 1971. Parasitology, The Biology of Animal Parasites. Lea & Febiger, Philadelphia, Pennsylvania.

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

SAS Institute, Inc. 1990. SAS language: reference, version 6.12. Cary, North Carolina.

Snedecor, G.W. and W.G. Cochran. 1989. Statistical Methods. 8th Edition. Iowa State University Press, Ames, Iowa.

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

USBR (U.S. Bureau of Reclamation). 1988. Umatilla basin project – planning report and final environmental impact statement. Statement Number FES 88-4, filed February 12, 1988.

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

van de Wetering, S.J. 1998. Aspects of Life History Characteristics and Physiological Processes in Smolting Pacific Lamprey, *Lampetra tridentata*, in a Central Oregon Coast Stream. A thesis submitted to Oregon State University, Corvallis, Oregon.

Vigg, S., T.P. Poe, L.A. Prendergast, and H.C. Hansel. 1988. Pages 56–115 *in* T.P. Poe and B.E. Rieman, editors. Predation by resident fish on juvenile salmonids in John Day Reservoir, 1983 – 1986. Final report (Contracts DE-AI79-82BP34796 and DE-AI79-82BP35097) to Bonneville Power Administration, Portland, Oregon.

Vincent-Lang, D. 1993. Relative survival of unmarked and fin-clipped coho salmon from Bear Lake, Alaska. The Progressive Fish Culturist 55(3): 141-148.

Walters, T.R., R.D. Ewing, M.A. Lewis, R.W. Carmichael, and M.L. Keefe. 1994. Evaluation effects of transporting juvenile salmonids in the Umatilla River at high temperatures. Pages 117-130 *in* S.M. Knapp, editor. Evaluation of juvenile fish bypass and adult fish passage facilities at water diversions in the Umatilla River. Annual progress report 1992 – 1993 to Bonneville Power Administration, Portland, OR.

Table 1. Color-mark information for fish used in various tests in the Umatilla River, spring - summer 1998.

Species [a]	Color	Fin mark location	Mark date	Number marked	Release date	Tagged released	Marked released
			Reach Survival				
HCHS	Yellow	anal	1/16/98	254	3/9-11/98	226	249
	Pink	anal	1/16/98	254		232	243
	Green	anal	1/16/98	255		238	253
HCHF0	Yellow	anal	5/7/98	508	6/1-3/98	506	508
	Green	anal	5/7/98	538		520	536
	Pink	anal	5/4/98	511		496	511
	No color	anal	5/7/98	535		527	0
HSTS	Yellow	anal	3/4/98	256	4/15-17/98	208	256
	Pink	anal	3/4/98	255		228	255
	Orange	anal	3/5/98	255		206	225
	Green	anal	3/4/98	324		239	323
	Dark yellow	anal	4/8/98	255	5/11-13/98	240	255
	Red	anal	4/8/98	255		239	255
	Purple	anal	4/8/98	255		221	255
			Secondary Survival				
HCHS	Orange	dorsal	3/9/98	1,978	3/9/98	1,978	1,978
HCHF	Pink	dorsal	3/14/98	863	3/14/98	863	863
HCHF0	Dark yellow	dorsal	6/4/98	1,065	6/4/98	1,063	1,063
HCOH	Green	dorsal	3/23/98	1,721	3/23/98	1,721	1,715
	Orange	dorsal	3/24/98	1,009	3/24/98	1,009	1,009
	Pink	dorsal	3/30/98	852	3/30/98	852	852
		dorsal	3/31/98	1,825	3/31/98	1,822	1,822

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

Table 2. Mark quality for juvenile salmonids marked with photonic and VI-jet paint in the anal fin (production and reach survival) and in the dorsal fin (secondary survival) and released in the Umatilla River, spring 1998.

Species[a], Color	Mark type	Number evaluated	Mark loss days[b]	Percent mark quality at release: Good	Fair	Poor	None	Number evaluated	Percent mark quality at capture: Good	Fair	Poor
				Production							
HCHS											
Blue	photonic / VI jet	2,546	0	98.0	2.0	0	0	112	90.2	9.8	0
HCHF											
Blue	photonic / VI jet	767	0	98.0	2.0	0	0	68	92.6	7.4	0
HCHF0											
Blue	photonic / VI jet	4,597	0	98.0	2.0	0	0	126	79.3	16.7	4.0
HSTS											
Blue	photonic / VI jet	765	0	98.0	2.0	0	0	14	85.7	14.3	0
				Reach Survival							
HCHS											
Yellow	photonic / VI jet	249	52	75.1	20.9	4.0	0	3	66.7	33.3	0
Pink	photonic	243	52	90.5	8.2	1.2	0	4	100.0	0	0
Green	photonic / VI jet	253	52	85.8	11.8	2.4	0	2	0	100.0	0
HCHF0											
Yellow	photonic / VI jet	508	28	66.9	26.2	6.7	0.2	16	93.8	6.2	0
Pink	photonic	511	25	61.8	33.3	4.9	0	20	75.0	20.0	5.0
Green	photonic / VI jet	538	25	51.9	40.5	6.9	0.7	22	68.2	22.7	9.1

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

[b] *Mark loss days = number of days between marking and mark quality check at release for Production and Reach Survival fish; number of days between marking and mark quality check at recapture for Secondary Survival test fish.*

Table 2. Continued.

Species[a], Color	Mark type	Number evaluated	Mark loss days[b]	Percent mark quality at release				Number evaluated	Percent mark quality at capture		
				Good	Fair	Poor	None		Good	Fair	Poor
HSTS											
Yellow	photonic / VI jet	252	42	85.7	13.1	1.2	0	6	83.3	16.7	0
Pink	photonic	257	42	90.3	9.7	0	0	10	100.0	0	0
Orange	photonic / VI jet	255	41	59.2	38.4	2.4	0	5	40.0	60.0	0
Green	photonic / VI jet	322	42	82.9	16.8	0.3	0	9	100.0	0	0
Dark yellow	photonic	254	33	79.1	19.7	1.2	0	9	44.5	44.4	11.1
Red	VI jet	251	33	86.5	13.1	0.4	0	8	87.5	0	12.5
Purple	photonic	253	33	79.8	19.4	0.8	0	4	100.0	0	0
Secondary survival											
HCHS											
Orange	photonic / VI jet	--	1-37	--	--	--	--	13	76.9	23.1	0
HCHF											
Pink	photonic	--	1-38	--	--	--	--	5	100.0	0	0
HCHF0											
Dark yellow	photonic	--	2-3	--	--	--	--	21	90.5	4.8	4.7
HCOH											
Green	photonic / VI jet	--	2-61	--	--	--	--	8	75.0	12.5	12.5
Orange	photonic / VI jet	--	2-42	--	--	--	--	10	70.0	3.0	0
Pink	photonic	--	24-61	--	--	--	--	22	86.4	13.6	0

Table 3. Retention of hatchery fish released into the rotary-screw trap live box and trap retention efficiency, lower Umatilla River, spring 1998.

Date	Number live boxed	Number retained	Length of test (h)	Retention efficiency
		Yearling spring chinook salmon		
3/11	15	10	8.6	0.667
3/12	15	9	6.5	0.600
3/13	15	13	8.5	0.867
3/17	15	14	8.4	0.933
				Pooled Retention = 0.767
				(Chi ^{2} =0.843; P = 0.839; df = 3)
		Yearling fall chinook salmon		
3/17	15	14	8.4	0.933
3/29	20	20	9.0	1.000
				Pooled Retention = 0.971
				(Chi ^{2} =0.000; P = 1.000; df = 1)
		Coho salmon		
3/26	15	14	14.7	0.933
3/27	15	15	9.4	1.000
3/28	15	15	18.6	1.000
				Pooled Retention = 0.978
				(Chi ^{2} =0.023; P = 0.988; df = 2)

Table 4. Marking, holding, and survival of hatchery juvenile salmonids used in trap efficiency tests at the rotary-screw trap (RM 1.2), lower Umatilla River, spring 1998.

Mark date	Mark[a]	Number marked	Number held[b]	Mean temperature (°F)	Hours held	Number mortalities	Percent survival[c]
			Yearling spring chinook salmon				
3/10	R1	57	57		23.8	0	100.0
3/11	R2	160	160		24.0	0	100.0
3/12	R3	297	297		23.7	3	99.0
3/13	R5	300	300		23.6	0	100.0
3/14	R6	329	329		23.8	0	100.0
3/15	R7	176	176		24.0	0	100.0
3/16	R8	254	254		23.8	0	100.0
3/17	R10	285	285		23.9	0	100.0
3/19	B1	115	115	50.0	24.5	5	97.0
3/23	B2	84	84	50.0	47.1	1	99.0
3/25	B3	73	53		23.6	1	98.0
							Pooled Survival = 0.995
							(Chi^2 =0.118; P = 1.000; df = 10)
			Yearling fall chinook salmon				
3/15	R7	10	10		24.0	0	100.0
3/17	R8	67	67		23.8	1	98.5
3/18	R10	122	122		23.9	0	100.0
3/20	B1	32	32	50.0	24.5	0	100.0
3/26	B3	40	40		23.6	0	100.0
3/28	B5	68	68		23.0	0	100.0
							Pooled Survival = 0.997
							(Chi^2 =0.006; P = 1.00; df = 5)
			Coho salmon				
3/28	B3	403	403	47.0	23.0	0	100%
3/29	B6	165	165	46.5	23.3	0	100%
3/30	B7	176	176	47.0	23.5	0	100%
4/1	B8	99	98	49.5	22.1	0	100%
							Pooled Survival = 1.000
							(Chi^2 =0.00; P = 0.00; df = 3)

[a] *Mark colors: R = red, B = blue. Mark locations 1-10 correspond to different marking positions on the ventral surface of the fish (see* ***Methods****).*

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

[c] *Percent survival is based on 24-h holding mortalities only and is the expected survival of test fish after release.*

Table 5. Mark, release, and recapture of hatchery juvenile salmonids and trap efficiency estimates at the rotary-screw trap (RM 1.2), lower Umatilla River, spring 1998.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Adjusted TE[d]
			Yearling spring chinook salmon		
3/11	R1	57	4 (1)	0.091	0.067
3/12	R2	159	8 (1), 2 (2), 2 (8)	0.074	0.067
3/13	R3	293	17 (1)	0.058	0.067
3/14	R5	299	5 (1)	0.017	0.023
3/15	R6	327	7 (1)	0.020	0.023
3/16	R7	175	3 (1)	0.015	0.023
3/17	R8	253	9 (1)	0.036	0.023
3/18	R10	284	0	0	
3/20	B1	109	1(1)	0.012	0.002
3/25	B2	83	0	0	
3/26	B3	52	0	0	
				Mean TE[e] = 0.037 (SE = 0.009)	
			Yearling fall chinook salmon		
3/17	R8	66	2 (1)	0.031	
3/18	R10	122	1 (1)	0.008	
3/20	B1	32	0	0	
3/26	B3	40	2 (1)	0.052	
3/28	B5	68	1 (1)	0.015	
				Mean TE[e] = 0.021 (SE = 0.008)	
			Coho salmon		
3/28	B3	403	10 (1)	0.025	
3/29	B6	165	5 (1), 1 (2)	0.036	
3/30	B7	176	2 (1)	0.011	
4/1	B8	99	1 (1), 1 (2)	0.020	
				Pooled TE[e] = 0.024 (SD = 0.077)	

[a] *Mark colors: R = red, and B = blue. Mark locations 1-10 correspond to different marking positions (see **Methods**).*
[b] *Number released was adjusted by expected survival of fish.*
[c] *Number recaptured was adjusted by the trap retention efficiency for each species.*
[d] *Adjusted TE was based on results of Chi ^{2} tests.*
[e] *Mean TE for CHS was based on pooled and weighted TEs. Mean TE for CHF was the mean of individual TEs. Pooled TE for coho was pooled release divided by pooled recapture.*

Table 6. Marking, holding, and survival of hatchery and natural juvenile salmonids used in trap efficiency tests at the West Extension Canal facility (RM 3.0), Umatilla River, spring 1998.

Mark date	Mark[a]	Number marked	Number held	Mean temperature (°F)	Hours held	Number mortalities	Percent survival[b]
			Hatchery				
			Yearling spring chinook salmon				
4/14	BULC	170	17	51.0	23.3	0	100.0
4/15	BLP	187	14		25.4	0	100.0
4/16	BRP	233	20	54.0	25.0	1	95.0
4/17	BRV	416	41	54.0	22.8	0	100.0
4/18	BLRP	194	19	54.5	23.3	0	100.0
4/19	YUC	237	23	56.5	25.5	0	100.0
4/20	YULC	168	17	59.0	24.2	0	100.0
4/21	YLP	153	15	60.0	24.5	0	100.0
4/22	YRP	138	14	59.0	21.4	0	100.0
4/23	YRV	161	16	56.0	26.5	0	100.0
4/24	RUC	207	23	53.5	22.9	1	96.0
4/25	RLC	140	14	54.5	25.2	0	100.0
4/28	RULC	114	11	61.5	27.9	0	100.0
4/29	RLP	107	11	63.0	22.4	0	100.0
4/30	RRP	165	17	64.0	21.8	0	100.0
5/1	RLRP	100	10	63.5	23.9	0	100.0
5/2	RRV	109	11	63.5	25.7	0	100.0
5/3	GUC	114	10	63.5	24.0	0	100.0
5/4	GLC	111	12	63.0	23.0	0	100.0
					Pooled Survival = 0.994		
					(Chi^2 =0.041; P = 1.000; df = 18)		
			Yearling fall chinook salmon				
4/14	BULC	103	10	51.0	23.3	0	100.0
4/15	BLP	103	10		25.4	0	100.0
4/16	BRP	125	15	54.0	25.0	1	93.0
4/17	BLV	183	18	54.0	22.8	0	100.0
4/18	BLRP	155	16	54.5	23.3	0	100.0

[a] *Mark colors: B = blue, G = green, MY = mustard yellow, O = orange, P = pink, Pu = purple, R = red, and Y = yellow. Fins marked: LP = left pectoral, RP = right pectoral, LRP = left and right pectoral, LV = left pelvic, RV = right pelvic, LC = lower caudal, UC = upper caudal, and ULC = upper and lower caudal.*

[b] *Percent survival is based on holding mortalities only and is the expected survival of fish after test release.*

Table 6. Continued.

Mark date	Mark[a]	Number marked	Number held	Mean temperature	Hours held	Number mortalities	Percent survival[b]
4/19	YUC	74	7	56.5	25.5	0	100.0
4/20	YULC	124	12	59.0	24.2	0	100.0
4/21	YLP	149	15	60.0	24.5	0	100.0
4/22	YRP	177	18	59.0	21.4	0	100.0
4/23	YLV	186	19	56.0	26.5	0	100.0
4/24	RUC	241	24	53.5	22.9	0	100.0
4/25	RLC	117	11	54.5	25.2	0	100.0
4/28	RULC	154	14	61.5	27.9	0	100.0
4/29	RLP	129	13	63.0	22.4	0	100.0
4/30	RRP	112	11	64.0	21.8	0	100.0
5/1	RLRP	116	12	63.5	23.9	0	100.0
5/2	RLV	101	10	63.5	25.7	0	100.0
5/3	GUC	131	12	64.0	24.0	0	100.0
5/4	GLC	133	13	63.0	23.0	0	100.0
5/5	GULC	122	12	69.0	24.9	0	100.0
5/6	GLP	130	14	69.0	23.9	0	100.0
5/7	GRP	83	8	66.5	22.3	0	100.0
5/8	GLRP	102	11	62.0	23.0	0	100.0
5/9	OUC	123	13	60.0	22.9	0	100.0
5/10	OULC	150	15	60.0	23.2	0	100.0
5/11	OLC	75	7	60.0	26.7	1	86.0
5/12	ORP	126	12	60.0	23.4	0	100.0
5/13	OLP	103	10	56.0	22.9	0	100.0
5/14	OLRP	124	13	56.5	26.0	0	100.0
5/15	OLV	163	16	56.5	21.8	0	100.0
5/16	BUC	107	11	55.5	23.7	0	100.0
5/17	BLC	167	17	53.5	23.8	1	94.0
5/18	BULC	135	13	55.5	25.1	0	100.0
					Pooled Survival = 0.993		
					(Chi^2 =0.131; P = 1.000; df = 32)		
			Subyearling fall chinook salmon				
5/31	RUC	392	40	62.5	23.7	0	100.0
6/1	RLP	271	27	65.0	24.3	0	100.0
6/2	RRP	318	32	65.5	26.5	0	100.0
6/3	RLV	241	24	66.5	23.1	0	100.0
6/4	BUC	264	26	67.5	23.8	0	100.0
6/5	BRP	158	15	69.0	21.9	0	100.0
6/6	BLP	260	26	69.0	27.0	0	100.0
6/7	BLV	267	26	69.0	22.0	0	100.0
6/8	YUC	256	26	71.0	23.3	0	100.0

Table 6. Continued.

Mark date	Mark[a]	Number marked	Number held	Mean temperature	Hours held	Number mortalities	Percent survival[b]
6/9	YRP	261	26	70.5	25.3	0	100.0
6/10	YLP	249	24	69.5	23.3	0	100.0
6/11	OUC	279	27	71.0	25.0	0	100.0
6/12	OLC	250	25	72.0	24.1	0	100.0
6/13	OLP	279	27	72.0	22.7	0	100.0
6/14	ORP	229	19	70.0	24.3	0	100.0
6/15	OLV	210	22	68.0	23.9	2	91.0
6/17	RUC	205	20	68.0	26.5	0	100.0
6/18	RLP	206	20	70.0	25.5	0	100.0
6/19	RRP	204	20	71.0	20.3	0	100.0
6/20	RLV	200	20	71.0	24.9	2	90.0
6/21	PuUC	210	21	70.0	24.8	0	100.0
6/22	PuLP	149	15	70.0	23.5	0	100.0
6/23	BUC	171	17	68.5	22.3	2	88.0
6/24	BLP	199	20	68.5	23.9	0	100.0
6/25	BRP	202	20	67.5	24.5	0	100.0
6/26	MYUC	202	19	65.0	24.0	0	100.0
6/27	MYLP	109	10	66.5	24.5	0	100.0
6/28	MYRP	113	10	69.0	23.0	0	100.0
6/29	MYLV	117	10	71.0	24.0	0	100.0
					Pooled Survival = 0.991		
					(Chi^2 =0.297; P = 1.000; df = 28)		
				Coho salmon			
4/19	YUC	137	14	56.5	25.5	0	100.0
4/20	YULC/YLC	101	10	59.0	24.2	0	100.0
4/21	YLP	136	15	60.0	24.5	0	100.0
4/22	YRP	130	13	59.0	21.4	0	100.0
4/23	YLV/YRV	171	17	56.0	26.5	0	100.0
4/24	RUC	160	20	53.5	22.9	0	100.0
4/25	RLC	102	11	54.5	25.2	1	91.0
4/28	RULC	143	13	61.5	27.9	0	100.0
4/29	RLP	136	14	63.0	22.4	0	100.0
4/30	RRP	204	20	64.0	21.8	0	100.0
5/1	RLRP	113	11	63.5	23.9	0	100.0
5/2	RLV	125	13	63.5	25.7	0	100.0
5/3	GUC	161	14	63.5	24.0	0	100.0
5/4	GLC	124	12	63.0	23.0	0	100.0
5/5	GULC	120	12	69.0	24.9	0	100.0
5/6	GLP	149	15	69.0	23.9	0	100.0

Table 6. Continued.

Mark date	Mark[a]	Number marked	Number held	Mean temperature	Hours held	Number mortalities	Percent survival[b]
5/7	GRP	132	13	66.5	22.3	0	100.0
5/8	GLRP	128	13	62.0	23.0	0	100.0
5/9	OUC	117	17	60.0	22.9	0	100.0
5/10	OULC	150	15	60.0	23.2	0	100.0
5/11	OLC	125	12	60.0	26.7	0	100.0
5/12	ORP	123	12	60.0	23.4	0	100.0
5/13	OLP	144	14	56.0	22.9	0	100.0
5/14	OLRP	58	6	56.5	26.0	0	100.0
5/15	OLV	139	14	56.5	21.8	0	100.0
5/16	BUC	135	14	54.5	23.7	0	100.0
5/18	BLC	64	8	55.5	25.1	0	100.0
5/19	BLP	136	13	57.0	26.8	0	100.0
5/21	BLRP	146	15	56.5	23.1	0	100.0
5/22	BRV	144	15	58.0	25.0	0	100.0
5/23	YUC	148	15	58.5	23.8	0	100.0
5/24	YLC	138	15	57.0	23.3	0	100.0
5/25	YLP	130	13	54.0	23.3	0	100.0
5/26	YRP	111	12	51.5	24.2	0	100.0
5/27	YRV	149	15	52.5	24.7	0	100.0
5/28	YLV	131	13	54.0	23.4	1	92.0
5/30	YULC	125	13	57.5	24.5	0	100.0
5/31	RUC	134	14	62.5	23.7	0	100.0
6/1	RLP	120	12	65.0	24.3	0	100.0
6/2	RRP	88	9	65.5	26.5	0	100.0
6/3	RLV	59	6	66.5	23.1	0	100.0
					Pooled Survival = 0.996		
					(Chi^2 =0.084; P = 1.000; df = 40)		
			Summer steelhead				
4/25	RLC	100	10	54.5	25.2	0	100.0
4/28	RULC	38	5	61.5	27.9	0	100.0
5/4	GLC	59	6	63.0	23.0	0	100.0
5/5	GULC	49	5	69.0	24.9	0	100.0
5/6	GLP	79	8	69.0	23.9	0	100.0
5/8	GRP	109	11	62.0	23.0	0	100.0
5/9	OUC	119	12	60.0	22.9	0	100.0
5/10	OULC	132	13	60.0	23.2	0	100.0
5/11	OLC	80	8	60.0	26.7	0	100.0
5/12	ORP	80	7	60.0	23.4	0	100.0

Table 6. Continued.

Mark date	Mark[a]	Number marked	Number held	Mean temperature	Hours held	Number mortalities	Percent survival[b]
5/14	OLP	54	6	56.5	26.0	0	100.0
5/15	ORV	101	11	56.5	21.8	0	100.0
5/16	BUC	54	6	54.5	23.7	0	100.0
5/18	BLC	127	13	55.5	25.1	0	100.0
5/19	BLP	141	14	57.0	26.8	0	100.0
5/21	BLRP	53	5	56.5	23.1	0	100.0
5/22	BRV	87	8	58.0	25.0	0	100.0
5/24	YUC	89	9	57.0	23.3	0	100.0
5/25	YLP	51	7	54.0	23.3	0	100.0
5/26	YRP	62	7	51.5	24.2	0	100.0
					Pooled Survival = 1.000		
					(Chi^2 =0.000; P = 1.000; df = 21)		
			Natural				
			Summer steelhead				
4/14	BULC	45	5	51.0	23.3	0	100.0
4/18	BLV	46	5	54.5	23.3	0	100.0
5/6	GLP	58	6	69.0	23.9	0	100.0
5/8	GRP	68	7	62.0	23.0	0	100.0
5/10	OUC	114	11	60.0	23.2	0	100.0
5/11	OLC	66	6	60.0	26.7	0	100.0
5/12	ORP	50	5	60.0	23.4	0	100.0
5/14	OLP	44	6	56.5	26.0	0	100.0
5/15	OLV	99	10	56.5	21.8	0	100.0
5/19	BLP	89	9	57.0	26.8	0	100.0
5/22	BRV	81	8	58.0	25.0	0	100.0
5/24	YUC	77	8	57.0	23.3	0	100.0
5/26	YLP	81	8	51.5	24.2	0	100.0
					Pooled Survival = 1.000		
					(Chi^2 =0.000; P = 1.000; df = 12)		
			Subyearling fall chinook salmon				
6/25	BUC	244	25	67.5	24.5	0	100.0
6/26	MYUC	194	19	65.0	24.0	0	100.0
6/27	MYLP	110	10	66.5	24.5	0	100.0
6/28	MYRP	108	9	69.0	23.0	0	100.0
6/29	MYLV	113	10	71.0	24.0	0	100.0
7/2	RLP	162	16	74.5	21.4	0	100.0
7/3	RD	104	10	73.0	24.0	0	100.0

Table 6. Continued.

Mark date	Mark [a]	Number marked	Number held	Mean temperature	Hours held	Number mortalities	Percent survival [b]
7/4	RLP	179	18	72.0	25.7	0	100.0
7/5	RLV	164	16	73.0	19.6	0	100.0
7/6	RRP	54	6	74.0	23.8	0	100.0
					Pooled Survival = 1.000		
					(Chi^2 =0.000; P = 1.000; df = 10)		

Table 7. Mark, release, and recapture of hatchery juvenile salmonids and trap efficiency estimates at the West Extension Canal facility (RM 3.0), spring 1998.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Pooled TE[d]
			Hatchery		
			Yearling spring chinook salmon		
4/14	BULC	150	9(1) 7(2) 2(3) 8(4) 1(6) 4(8) 1(10)	0.213	0.174
4/15	BLP	172	20(1) 1(2) 8(3) 3(5) 5(8)	0.215	0.174
4/16	BRP	211	21(1) 2(3) 1(4) 3(5)	0.128	0.174
4/17	BRV	373	53(1) 5(2) 1(3)	0.158	0.174
4/18	BLRP	174	12(1) 20(4) 1(11)	0.190	0.174
4/19	YUC	213	2(2)	0.009	
4/20	YULC	148	3(1) 4(5) 1(7)	0.054	0.028
4/21	YLP	136	18(1) 1(5)	0.140	0.108
4/22	YRP	123	7(1) 2(7)	0.073	0.108
4/23	YRV	143	52(1) 2(2)	0.378	0.378
4/24	RUC	183	12(1) 1(2) 2(7)	0.082	0.082
4/25	RLC	124	28(1) 3(2) 2(3) 2(6) 5(12)	0.322	0.322
4/28	RULC	102	8(1) 2(3) 4(4) 1(19)	0.147	0.147
4/29	RLP	93	11(1) 32(2) 1(12) 1(15)	0.484	0.435
4/30	RRP	146	18(1) 2(2) 11(3) 5(4) 20(5) 1(12) 1(15) 1(16)	0.404	0.435
5/1	RLRP	89	5(1) 4(2) 10(5) 1(9) 1(12) 1(14)	0.247	0.226
5/2	RRV	97	12(1) 1(6) 1(7) 1(8) 3(13) 2(16)	0.206	0.226
5/3	GUC	103	1(15)	0.005	
5/4	GLC	99	0	0	
5/5	GULC	59	10(1) 1(13)	0.186	0.046
				Mean TE [d] = 0.201 (SE = 0.029)	
			Yearling fall chinook salmon		
4/5	PUC	98	6(1) 13(2) 11(3) 1(4) 2(5) 3(7) 1(8) 1(9) 1(11) 11(12) 9(13) 5(14) 3(15) 6(16) 4(20) 1(21) 5(23) 4(25)	0.888	0.888

[a] *Mark colors: B = blue, G = green, MY = mustard yellow, O = orange, P = pink, Pu = purple, R = red, and Y = yellow. Fins marked: LP = left pectoral, RP = right pectoral, LRP = left and right pectoral, LV = left pelvic, RV = right pelvic, LC = lower caudal, UC = upper caudal, and ULC = upper and lower caudal.*

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

[c] *Number recaptured was adjusted for sample rate and non-sampled periods.*

[d] *Pooled TE was based on results of Chi ^{2} tests. Data on dates with no pooled values were combined with preceding data to achieve recapture values > 5. Mean TE was based on the sum of sub-pooled TE estimates*

Table 7. Continued.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Pooled TE[d]
4/6	PLC	222	6(1) 15(2) 1(3) 2(5) 1(7) 1(8) 2(9) 3(10) 18(11) 10(12) 3(13) 10(15) 10(16) 1(17) 5(18) 10(25)	0.441	0.399
4/7	PULC	229	12(1) 2(2) 3(3) 3(4) 3(5) 3(6) 1(7) 1(8) 4(9) 6(10) 1(11) 11(12) 3(13) 8(14) 1(16) 13(17) 1(19) 3(20) 1(21) 2(22)	0.358	0.399
4/8	PLP	228	7(1) 8(2) 4(3) 1(4) 1(5) 1(6) 2(7) 6(8) 6(9) 10(10) 10(11) 8(12) 6(13) 3(14) 1(15) 24(16) 24(17) 4(18) 4(20) 8(21)	0.605	0.595
4/9	PRP	140	5(1) 2(3) 1(5) 3(7) 23(8) 4(9) 8(10) 2(11) 3(12) 15(14) 5(15) 2(16) 1(20)	0.529	0.595
4/10	PLV	174	3(1) 4(2) 2(3) 5(6) 8(8) 15(9) 7(10) 15(11) 8(12) 5(13) 8(14) 7(16) 1(17) 19(18) 3(19) 4(27) 1(29) 1(37)	0.667	0.595
4/11	BUC	183	4(2) 1(3) 1(4) 1(5) 9(6) 1(7) 2(9) 10(11) 5(13) 1(15)	0.191	0.155
4/12	BLC	179	3(1) 5(2) 3(3) 2(4) 3(9) 5(11)	0.117	0.155
4/14	BULC	91	4(1) 10(2) 28(3) 1(4) 3(5)	0.505	0.452
4/15	BLP	89	7(1) 1(2) 2(4) 1(5) 12(6) 5(8) 3(9) 2(10)	0.371	0.452
4/16	BRP	105	22(1) 1(2) 4(3) 2(5) 10(6) 1(7) 13(8) 2(9) 1(10) 3(13)	0.562	0.452
4/17	BLV	162	29(1) 13(2) 1(3) 1(4) 14(5) 3(7) 1(9) 1(10) 1(11)	0.395	0.452
4/18	BLRP	138	5(1) 9(2) 7(3) 4(4) 4(7) 2(8) 3(10)	0.246	0.246
4/19	YUC	66	4(2) 4(8)	0.121	0.155
4/20	YULC	111	14(1)	0.126	0.155
4/21	YLP	132	9(1) 12(2) 2(4) 1(5) 2(9)	0.197	0.155
4/22	YRP	158	22(1) 13(2) 13(3)	0.304	0.400
4/23	YLV	165	53(1) 8(2) 1(3)	0.376	0.400
4/24	RUC	215	69(1) 16(20) 4(3) 1(4)	0.419	0.400
4/25	RLC	105	25(1) 11(2) 1(3) 4(6) 6(7) 10(10)	0.543	0.400
4/28	RULC	138	10(1) 10(4) 3(11)	0.167	0.167
4/29	RLP	113	22(1) 5(2) 4(3) 1(7) 2(9) 1(11) 1(13)	0.319	0.252
4/30	RRP	98	6(1) 4(3) 1(6) 3(8) 1(11) 1(17) 1(18)	0.173	0.252

Table 7. Continued.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Pooled TE[d]
5/1	RLRP	102	4(1) 4(3) 4(4) 4(6) 2(7) 1(8) 1(10) 1(11) 2(12) 1(13) 1(16) 1(17)	0.255	0.252
5/2	RLV	89	5(1) 1(2) 1(10) 1(12)	0.090	0.090
5/3	GUC	115	14(10) 2(2) 11(3) 2(12) 4(13) 1(14) 1(15)	0.304	0.254
5/4	GLC	119	12(1) 10(2) 2(5) 2(6) 1(7) 2(8) 2(11) 2(12) 1(13) 1(14)	0.294	0.254
5/5	GULC	108	10(1) 1(7) 1(8) 2(9) 1(10) 2(11)	0.157	0.254
5/6	GLP	115	27(1) 9(2) 5(3) 1(5) 1(6) 2(7) 3(9) 1(11) 2(12)	0.443	0.443
5/7	GRP	74	8(1) 1(2) 3(3) 1(7) 3(8) 1(9)	0.230	0.299
5/8	GLRP	90	12(1) 4(2) 1(3) 1(4) 2(5) 9(7) 1(8) 1(9) 1(10)	0.356	0.299
5/9	OUC	108	2(3) 2(4) 3(6) 1(7) 3(8) 2(9)	0.120	0.120
5/10	OULC	132	6(1) 3(2) 5(4) 14(5) 1(6) 3(7) 2(8)	0.258	0.228
5/11	OLC	67	2(1) 3(2) 1(3) 6(4) 2(5) 2(6) 1(7)	0.254	0.228
5/12	ORP	112	1(2) 9(3) 1(4) 2(5) 1(6)	0.125	0.228
5/13	OLP	89	6(1) 9(2) 3(3) 5(4) 3(5)	0.292	0.228
5/14	OLRP	109	24(1) 6(2) 8(3) 4(4) 1(5)	0.394	0.370
5/15	OLV	145	14(1) 20(2) 16(3) 1(5)	0.352	0.370
5/16	BUC	94	6(1) 10(2)	0.170	0.206
5/17	BLC	149	32(1) 2(2)	0.228	0.206
5/18	BULC	121	1(1)	0.008	0.008
				Mean TE[d] = 0.315	
				(SE = 0.026)	
			Subyearling fall chinook salmon		
5/31	RUC	349	60(1) 2(2)	0.178	0.178
6/1	RLP	241	43(1)	0.178	0.178
6/2	RRP	283	104(1)	0.367	0.363
6/3	RLV	215	59(1) 10(2) 2(4) 6(5)	0.358	0.363
6/4	BUC	235	19(1) 1(4)	0.085	0.109
6/5	BRP	140	15(1)	0.107	0.109
6/6	BLP	231	27(1)	0.117	0.109
6/7	BLV	223	25(1) 1(18)	0.117	0.109
6/8	YUC	225	27(1)	0.120	0.109
6/9	YRP	226	81(1)	0.358	0.358
6/10	YLP	216	32(1)	0.148	0.148
6/11	OUC	250	100(1)	0.400	0.400
6/12	OLC	222	30(1)	0.135	0.186
6/13	OLP	249	47(1) 2(2)	0.197	0.186

Table 7. Continued.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Pooled TE[d]
6/14	ORP	169	40(1)	0.237	0.186
6/15	OLV	183	58(1) 6(2)	0.350	0.350
6/17	RUC	179	120(1)	0.670	0.670
6/18	RLP	184	83(1)	0.451	0.426
6/19	RRP	178	65(1) 7(2)	0.404	0.426
6/20	RLV	178	74(1) 1(2)	0.421	0.426
6/21	PuUC	178	25(1) 1(3)	0.146	0.146
6/22	PuLP	133	8(1) 1(2) 1(3)	0.075	
6/23	BUC	153	0	0	0.035
6/24	BLP	177	22(1)	0.124	0.124
6/25	BRP	180	45(1)	0.250	0.202
6/26	MYUC	180	30(1)	0.167	0.202
6/27	MYLP	98	23(1) 1(3)	0.245	0.202
6/28	MYRP	102	14(1)	0.137	0.202
6/29	MYLV	106	5(1) 1(3) 1(6)	0.066	0.066
				Mean TE [d] = 0.235	
				(SE = 0.027)	
			Coho salmon		
4/19	YUC	123	4(7)	0.033	0.029
4/20	YULC	91	0	0	
4/21	YLP	121	4(1)	0.033	0.029
4/22	YRP	117	2(3) 1(4) 2(6)	0.043	0.029
4/23	YLV/ YRV	149	26(1) 16(2) 6(3) 9(5) 4(6) 8(32) 2(33)	0.476	0.476
4/24	RUC	139	4(1) 1(2) 1(3) 3(6) 1(11) 1(13)	0.079	0.091
4/25	RLC	91	1(1) 3(2) 1(3) 4(4) 1(11)	0.110	0.091
4/28	RULC	127	2(1) 4(7)	0.047	0.042
4/29	RLP	122	1(2)	0.008	
4/30	RRP	181	10(1) 1(3)	0.061	0.042
5/1	RLRP	102	7(1) 2(2) 10(4)	0.186	0.154
5/2/	RLV	112	12(1)	0.107	0.154
5/3	GUC	146	10(1) 4(2) 10(3)	0.164	0.154
5/4	GLC	112	16(1) 1(3) 1(21)	0.161	0.154
5/5	GULC	100	1(2)	0.010	0.022
5/6	GLP	133	2(2)	0.015	
5/7	GRP	119	6(1)	0.050	
5/8	GLRP	115	1(3) 1(4) 1(7) 1(17)	0.035	0.022
5/9	OUC	105	2(1) 1(2) 1(4)	0.038	
5/10	OULC	135	2(2) 1(10)	0.022	0.022
5/11	OLC	113	2(1)	0.018	

Table 7. Continued.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Pooled TE[d]
5/12	ORP	106	1(1)	0.009	
5/13	OLP	130	1(2) 2(3)	0.023	0.022
5/14	OLRP	49	2(2) 1(5)	0.061	
5/15	OLV	125	0	0	0.022
5/16	BUC	120	1(2)	0.008	
5/18	BLC	54	0	0	
5/19	BLP	123	1(1) 2(2) 1(5)	0.033	
5/21	BLRP	131	4(1) 10(2) 6(3)	0.153	0.153
5/22	BRV	129	6(1) 3(2) 2(3) 1(4)	0.093	0.070
5/23	YUC	133	1(1) 1(2)	0.015	0.070
5/24	YLC	119	7(1) 1(7) 3(8)	0.092	
5/25	YLP	117	9(1) 1(2)	0.085	0.070
5/26	YRP	99	1(2)	0.010	0.020
5/27	YRV	134	2(5)	0.015	
5/28	YLV	117	4(4)	0.034	
5/30	YULC	111	11(1) 6(2)	0.153	0.159
5/31	RUC	120	8(1) 7(2)	0.125	0.159
6/1	RLP	108	22(1)	0.204	0.159
6/2	RRP	79	1(1)	0.013	0.008
6/3	RLV	53	0	0	
				Mean TE[d] = 0.093 (SE = 0.019)	
			Summer steelhead		
4/25	RLC	88	2(1) 3(2)	0.057	0.057
4/28	RULC	32	6(7)	0.188	0.188
4/29	RLP	31	0	0	0.158
5/2	RRP	109	2(1)	0.018	
5/3	GUC	71	0	0	
5/4	GLC	53	0	0	
5/5	GULC	44	0	0	
5/6	GLP	71	3(2) 1(12)	0.056	
5/8	GRP	98	0	0	0.060
5/9	OUC	107	3(1) 1(6) 4(9) 1(10)	0.084	
5/10	OULC	119	5(2) 1(3) 2(8) 1(11)	0.076	0.060
5/11	OLC	72	3(1) 1(2) 1(5) 2(7)	0.097	
5/12	ORP	72	1(1) 1(2) 1(6)	0.042	0.060
5/14	OLP	48	1(1) 4(2) 2(4)	0.146	0.146
5/15	ORV	90	2(1) 1(2)	0.033	
5/16	BUC	48	2(2) 1(3)	0.063	
5/18	BLC	113	1(1)	0.009	0.028

Table 7. Continued.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Pooled TE[d]
5/19	BLP	126	12(1) 2(2) 1(3) 2(4) 1(6) 1(7)	0.159	0.217
5/21	BLRP	48	4(1) 5(2) 3(3)	0.250	0.217
5/22	BRV	79	13(1) 9(2) 2(3)	0.291	0.217
5/24	YUC	80	4(1)	0.050	0.050
5/25	YLP	44	7(1)	0.159	0.159
5/26	YRP	55	2(1)	0.036	0.038
5/28	YRV	25	1(1)	0.040	
				Mean TE [d] *= 0.108* *(SE = 0.020)*	
			Natural Subyearling fall chinook salmon		
6/25	BUC	219	23(1)	0.105	0.119
6/26	MYUC	175	21(1) 3(2)	0.137	0.119
6/27	MYLP	100	21(1) 1(2) 1(3) 2(4)	0.250	0.250
6/28	MYRP	99	6(1) 3(2)	0.091	0.082
6/29	MYLV	103	2(2) 1(3) 1(5)	0.039	0.082
6/30	RUC	107	1(1) 5(2) 2(4)	0.075	0.082
7/3	RD	94	5(1) 7(2)	0.128	0.082
7/4	RLP	161	14(1) 9(2) 10(3)	0.205	0.205
7/5	RLV	146	2(1) 15(2) 1(4)	0.123	0.093
7/6	RRP	48	0	0	
				Mean TE [d] *= 0.124* (SE = 0.019)	
			Summer steelhead		
4/5	PUC	26	5(1) 1(3)	0.230	0.215
4/6	PLC	22	1(1) 1(3)	0.091	
4/8	PULC	45	1(1) 1(7) 4(17)	0.133	0.215
4/9	PRP	29	1(1) 1(2) 10(13)	0.414	0.215
4/11	PLV	53	8(1) 2(2) 2(3)	0.226	0.215
4/12	BLC	30	3(1) 1(2) 2(4)	0.200	0.215
4/14	BULC	40	2(1)	0.050	0.072
4/16	BLP	31	2(1)	0.065	
4/18	BLV	41	2(1)	0.049	
4/29	RLP	34	4(2) 1(3)	0.147	0.072
5/2	RRP	76	4(1) 1(5)	0.066	0.072
5/3	GUC	41	0	0	0.022
5/4	GLC	37	0	0	

Table 7. Continued.

Release date	Mark[a]	Number released[b]	Number recaptured[c] (days after release)	Trap efficiency	Pooled TE[d]
5/5	GULC	32	1(11)	0.031	
5/6	GLP	52	2(2) 1(12)	0.058	
5/8	GRP	61	1(1)	0.016	
5/10	OUC	103	2(2) 1(4) 1(5) 1(6) 1(8)	0.058	0.074
5/11	OLC	60	1(1) 3(4) 2(7)	0.100	0.074
5/12	ORP	45	1(2) 1(4)	0.044	0.029
5/14	OLP	38	2(1)	0.053	
5/15	OLV	89	1(1) 1(2)	0.022	
5/17	BUC	35	0	0	
5/19	BLP	80	6(1) 1(5) 2(6)	0.113	0.113
5/22	BRV	73	15(1) 3(2) 1(3)	0.260	0.260
5/24	YUC	69	4(1)	0.058	0.061
5/26	YLP	73	3(1)	0.041	0.061
5/28	YRV	6	2(1)	0.333	
				Mean TE [d] *= 0.124 (SE = 0.020)*	

Table 8. Adjusted collection and percent recapture of hatchery (H) and natural (N) juvenile salmonids at RM 1.2, RM 3.0, and RM 27.3, lower Umatilla River, October 1997 - August 1998. Mean fork length is in millimeters.

Site, Species[a]	Origin	Age	Mean FL(SE)	Number collected[b]	Number released[c]	Release date[d]	Percent recapture
Rotary Screw Trap at RM 1.2 (10/1/97 - 4/3/98)							
CHS	H	1^+	205.0 (0.32)	8,033	555,713	3/08/98	1.4%
CHF	H	1^+	141.4 (1.09)	988	256,910	3/13/98	0.4%
CH[e]	H	1^+	141.0 (4.03)	5	--	--	--
COH	H	1^+	132.9 (0.42)	1,197	1,700,850	3/23/98	0.07%
STS	H	1^+	210.0 (--)	1	--	--	
CHS	N	1^{+f}	107.6 (1.0)	96	--	--	--
COH	N	0^+	39.0 (--)	1	--	--	--
STS	N	1^{+f}	160.5 (4.11)	64	--	--	--
Total Adjusted Collected				10,385			
West Extension Canal at RM 3.0 (4/3/98 - 7/9/98)							
CHS	H	1^+	143.2 (0.23)	82,942	271,899	4/14/98	30.5%
CHF	H	1^+	167.8 (0.34)	81,289	179,100	4/17/98	45.4%
CH[e]	H	1^+	123.0 (13.82)	56	--	--	--
CHF	H	0^+	91.4 (0.12)	991,671	2,777,442	6/01/98	35.7%
COH	H	1^+	148.6 (0.24)	188,678	1,700,850	3/31/98	11.1%
STS	H	1^+	224.4 (0.71)	7,417	137,485	5/04/98	5.4%
CHS	N	1^{+f}		3,488	--	--	--
CHF	N	0^+		26,218	--	--	--
FRY	N	0	46.3 (1.24)	251	--	--	--
COH	N	0^+	79.5 (1.04)	784	--	--	--
STS	N	0^{+f}	186.4 (0.67)	6,190	--	--	--
Total Adjusted Collected				*1,388,984*			

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

[b] *Number collected was adjusted for trap retention efficiency, non-sampled periods, and sample rate, where applicable.*

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

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

[e] *CH comprised of unclipped spring and fall races of chinook salmon.*

[f] *Age of natural spring chinook salmon includes 0^+ and 1^+ fish. Age of natural summer steelhead includes 0^+, 1^+, 2^+, 3^+, and 4^+ fish.*

Table 8. Continued.

Site, Species[a]	Origin	Age	Mean FL(SE)	Number collected[b]	Number released[c]	Release date[d]	Percent recapture
Westland Canal at RM 27.3 (7/7/98 - 8/13/98)							
CHF0	H	0^+	125.7 (0.96)	1,423	2,777,442	6/01/98	0.05%
COH	H	1^+	136.0 (--)	1			
STS	H	1^+	228.0 (--)	1			
CHF	N	0^+	101.4 (0.64)	1,354	--	--	--
COH	N	0^+	96.2 (3.02)	29	--	--	--
STS	N	0^{+f}	72.5 (7.75)	7	--	--	--
Total Sampled					*2,815*		

Table 9. Adult summer steelhead collected at RM 3.0, Umatilla River, spring 1998.

Date	Time[a]	Origin	Condition[b]	Clip[c]	Length (mm)	Comments
4/30	--	W	--	--	560	Female
5/1	0231	W	G	--	620	Female
5/1	2355	W	G	--	686	
5/1	--	W	--	--	710	Female
5/2	0805	W	G	--	528	
5/2	--	W	--	--	560	Female
5/3	0539	W	G	--	551	
5/3	--	W	--	--	600	Male
5/3	--	W	--	--	570	Post-spawn female
5/5	0845	W	--	--	563	
5/5	1100	W	--	--	615	Post-spawn female
5/5	--	W	--	--	535	Post-spawn female
5/8	1005	W	G	--	610	
5/8	--	W	--	--	483	Female
5/9	1955	W	--	--	585	Post-spawn female
5/10	1340	W	G	--	610	Male
5/11	0945	W	G	--	635	Female
5/13	0946	W	G	--	445	
5/13	--	W	--	--	430	Post-spawn female
5/14	1452	W	G/E/O	--	560	Female
5/14	--	W	--	--	535	Post-spawn female
5/15	0951	W	G	--	560	
5/16	--	W	--	--	560	Post-spawn female
5/24	2154	W	--	--	560	Post-spawn female
4/28	--	H	--	ADLV	535	Female
5/1	0406	H	G	ADLV	564	
5/3	0539	H	G	AD	576	
5/6	0506	H	Dead	ADLV	787	
5/8	1940	H	G	AD	595	Female
5/9	1236	H	--	AD	610	
5/10	0830	H	--	AD	570	Male
5/10	1125	H	G	AD	585	Male
5/10	1125	H	G	ADLV	585	Male
5/10	1836	H	G	ADLV	520	Post-spawn female
5/12	1245	H	G	ADLV	534	
5/12	--	H	--	--	535	Female
5/15	0951	H	F	ADLV	605	
5/16	--	H	--	ADLV	600	Post-spawn female
5/18	1113	H	F	AD	590	Female, injured
5/24	0610	H	--	ADLV	560	Post-spawn female

[a] *Hours are in military time.*
[b] *G = Good condition, E = Eye injury, O = Operculum injury, F = Fungus.*
[c] *ADLV = adipose and left-ventral fin clip, AD = adipose fin clip.*

Table 10. Scale samples from natural juvenile salmonids and hatchery and natural adult summer steelhead collected at RM 1.2 and RM 3.0 on the Umatilla River, December 1997 - June 1998.

Species[a]	Age[b]	Number	Fork length (mm) Min.	Max.	Dates collected
HSTS	A	10	520	600	4/28/98 – 5/24/98
NSTS	A	17	430	710	4/30/98 – 5/24/98
NSTS	J	95	140	375	3/29/98 – 5/9/98
NCHS	J	4	96	110	12/24/97 – 2/3/98
NCH	J	10	87	220	5/23/98 – 6/7/98

[a] *HSTS = hatchery summer steelhead, NSTS = natural summer steelhead, NCHS = natural spring chinook salmon, NCH = natural chinook salmon.*
[b] *A = Adult, J = juvenile.*

Table 11. Hatchery and natural juvenile salmonids and other resident fish species captured at Westland Canal (RM 27.3), Umatilla River, 7 July - 13 August 1998. Data combined from ODFW and CTUIR samples.

	Species[a]																
	HCHFO		HSTS		HCOH		NCOH		NCHFO		NSTS		Whitefish		Other		Pounds
Date	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Hauled
7/7	13908	70	0	0	0	0	0	0	6292	31	0	0	0	0	0	0	505
7/8	1450	59	0	0	0	0	0	0	1025	41	0	0	--	--	--	--	75
7/9	2417	59	0	0	0	0	0	0	1708	41	0	0	--	--	--	--	125
7/10	2408	55	0	0	0	0	0	0	1987	45	0	0	0	0	0	0	125
7/14	3608	71	0	0	0	0	0	0	1454	29	0	0	--	--	--	--	175
7/15	899	46	0	0	0	0	6	0	1003	51	0	0	0	0	55	3	60
7/17	270	40	0	0	0	0	0	0	360	53	3	0	0	0	47	7	25
7/20	574	45	0	0	0	0	0	0	651	51	11	1	0	0	50	4	40
7/22	583	54	0	0	0	0	0	0	491	46	0	0	--	--	--	--	40
7/24	282	46	0	0	0	0	0	0	255	41	0	0	0	0	81	13	30
7/27	150	38	0	0	0	0	7	2	184	46	0	0	0	0	54	14	15
7/29	114	40	3	0	0	0	9	3	159	56	0	0	--	--	--	--	15
7/31	159	34	0	0	0	0	24	5	230	50	3	1	0	0	45	10	20
8/3	147	46	0	0	3	1	3	1	164	52	0	0	--	--	--	--	15
8/5	51	25	0	0	0	0	19	9	134	66	0	0	--	--	--	--	15
8/10	341	48	--	--	--	--	26	4	285	40	4	1	9	1	47	7	45
8/13	127	23	--	--	--	--	3	1	237	43	5	1	3	1	173	32	55
Total	*27488*	*61*	*3*	*0*	*3*	*0*	*97*	*0*	*16619*	*37*	*26*	*0*	*12*	*0*	*552*	*1*	*1380*

[a] *HCHFO = hatchery subyearling fall chinook salmon, HSTS = hatchery summer steelhead, HCOH = hatchery coho salmon,* NCOH = natural coho salmon, NCHFO = natural subyearling fall chinook salmon, and NSTS = natural summer steelhead.

Table 12. Migration parameters of PIT-tagged hatchery juvenile salmonids captured at lower river trapping sites (RM 1.2, 3.0, and 27.3), Umatilla River, 1 October 1997 - 30 September 1998.

Species[a], hatchery[b]	Release		Detection at lower river						Mean travel speed (mi/d)[c]
	Date	RM	N	First (date)	Mean (date)	Last (date)	Peak (date)	Duration (d)	
CHS									
UFH/LWS	3/8,	80	50	3/10	3/28	4/28	3/14	51	13
CAR/LWS	4/14		53	4/16	4/27	5/15	4/19	31	11
CHF									
BON	3/13,	73.5	3	3/23	4/6	4/22	[d]	40	4
WIL	4/17		54	4/21	4/27	5/18	4/26	31	8
CHF0									
UFH	5/28	73.5	31	5/31	6/8	7/15	6/1	48	10
UFH	5/28, 6/1	80	84	5/30	6/11	6/29	6/6	30	15
STS									
UFH (large)	4/10[e], 4/16-17	63, 79 [f]	7	4/26	5/7	5/18	5/2	38	3
UFH (small)	4/20[e], 5/4	79 [f]	5	4/25	5/12	5/20	5/18	30	6

[a] *CHS = spring chinook salmon, CHF = fall chinook salmon, CHF0 = subyearling fall chinook salmon, STS = summer steelhead.*
[b] *UFH = Umatilla Fish Hatchery, LWS = Little White Salmon Fish Hatchery, CAR = Carson Fish Hatchery, BON = Bonneville Fish Hatchery, WIL = Willard Fish Hatchery.*
[c] *Mean travel speed calculated from point of release to lower river trap sites.*
[d] *No peak date due to only three fish collected.*
[e] *Volitional release date.*
[f] *Bonifer holding pond at RM 2 of Meacham Creek (RM 79 of Umatilla River).*

Table 13. Migration parameters of natural juvenile salmonids captured at lower river trapping sites (RM 1.2, 3.0, and 27.3), Umatilla River, 1 October 1997 - 30 September 1998.

Species[a]	First (date)	Mean (date)	Last (date)	Peak (date)	Duration (days)
NCHS	12/21	4/24	7/1	4/24	193
NCHF0	4/25	6/23	8/13[b]	7/7	111
NCOH	3/28	6/4	8/13[b]	6/4	139
NSTS	3/15	5/1	8/13[b]	4/25	152

[a] *NCHS = natural spring chinook salmon, NCHF0 = natural subyearling fall chinook salmon, NCOH = natural coho salmon, NSTS = natural summer steelhead.*
[b] *Last day of sampling at Westland Canal.*

Table 14. Maximum, minimum, and mean fork lengths (mm) of natural and hatchery juvenile salmonids, lower Umatilla River, December 1997 - August 1998.

Species[a]		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Totals
NCH	N	3	1	6	75	661	429	4,741	347	82	6,345
	Max	106	96	140	123	169	191	180	120	142	191
	Min	96	96	91	84	30	34	37	60	85	30
	Mean	100	96	105	107	110	85	73	87	82	79
NSTS	N	0	0	0	61	1,108	1,317	59	6	1	2,552
	Max				271	378	370	267	215	95	378
	Min				83	81	61	63	60	95	60
	Mean				161	190	184	177	91	95	186
NCOH	N	0	0	0	1	6	156	83	7	11	264
	Max				39	102	126	166	135	106	166
	Min				39	75	40	51	76	75	39
	Mean				39	91	79	79	99	95	81
HCHF	N	0	0	0	271	1,741	857	5	0	0	2,874
	Max				190	215	231	185			231
	Min				82	99	84	86			82
	Mean				141	164	176	142			165
HCHF0	N	0	0	0	0	0	295	2,961	177	54	3,487
	Max						108	115	149	161	161
	Min						70	66	88	109	66
	Mean						89	92	118	140	93
HCHS	N	0	0	0	1,551	2,530	308	0	0	0	4,389
	Max				205	230	220				230
	Min				110	102	94				94
	Mean				143	143	145				143
HSTS	N	0	0	0	1	217	794	73	2	0	1,087
	Max				210	325	298	278	275		325
	Min				210	168	115	150	228		115
	Mean				210	212	228	219	251		224

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

Table 14. Continued.

Species[a]		Month									Totals
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	
HCOH	N	0	0	0	637	579	2,416	217	2	1	3,852
	Max				163	195	200	220	192	136	220
	Min				93	95	100	85	170	136	85
	Mean				133	142	149	158	181	136	146

[a] *HCOH = hatchery coho salmon.*

Table 15. Fin clips on juvenile salmonids collected at lower river trapping sites (RM 1.2, 3.0, and 27.3), Umatilla River, October 1997 - August 1998. Binomial probabilities are given for the difference in recapture proportions of differently clipped fish.

Species[a], clip[b]	Number by trap site: RST	WEID	Westland	Total number recaptured	Total number released	Percent recapture	*P*
HCHS							
LV	4,284	35,048	0	39,332	452,642	8.7	<0.001
ADLV	2,504	5,981	0	8,485	202,712	4.2	
HCHF							
RV	817	25,538	0	26,355	363,661	7.2	<0.001
ADRV	167	8,843	0	9,010	72,349	12.5	
HCHF0							
RV	0	140,921	310	141,231	2,490,010	5.7	<0.001
ADRV	0	14,376	28	14,404	287,432	5.0	
HCOH							
NC	1,147	51,609	1	52,757	1,527,269[c]	3.5	0.201
AD	71	2,720	0	2,791	79,517	3.5	
HSTS							
AD	0	1,870	0	1,870	74,443	2.5	0.323
ADLV	1	1,557	1	1,559	63,042	2.5	
NCH							
UC				4	68	5.9	
LC				2	22	9.1	
NSTS							
UC				3	442	0.7	
LC				0	296	0	

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

[b] *LV = left ventral fin clip, ADLV = adipose and left ventral fin clip, RV = right ventral fin clip, ADRV = adipose and right ventral fin clip, AD = adipose fin clip, and NC = no fin clip, UC = upper caudal clip, LC = lower caudal clip.*

[c] *26,833 of these fish were coded-wire tagged but were not adipose fin clipped so were included in the no clip group.*

Table 16. Summary of scale loss and mortality of hatchery and natural juvenile salmonids collected at RM 1.2, RM 3, and RM 27.3, Umatilla River, December 1997 - July 1998.

	Condition[a]							
	Good		Partial		Descaled		Mortality[c]	
Species[b]	Number	Percent	Number	Percent	Number	Percent	Number	Percent
				Hatchery				
CHS	24,961	96.4	710	2.7	153	0.6	66	0.5
CHF	10,262	92.1	626	5.6	241	2.2	260	2.3
CHF0	39,100	90.0	3,572	8.2	593	1.4	155	0.1
COH	20,178	93.3	1,069	4.9	366	1.7	143	0.3
STS	2,169	81.6	362	13.6	128	4.8	24	0.7
				Natural				
CH[d]	6,551	88.7	538	7.3	103	1.4	37	0.2
COH	244	96.1	9	3.5	1	0.4	0	0.0
STS	2,423	93.9	131	5.1	26	1.0	27	1.0

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

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

[c] *Mortality does not include handling or trap-caused mortality.*

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

Table 17. Summary of injuries, parasites, and diseases on hatchery and natural juvenile salmonids collected at RM 1.2, RM 3, and RM 27.3, Umatilla River, December 1997 - July 1998.

	Condition[a]							
	Bird marks		Injuries		Parasites		BKD[c]	
Species[b]	Number	Percent	Number	Percent	Number	Percent	Number	Percent
				Hatchery				
CHS	264	54.5	142	29.3	43	8.9	35	7.2
CHF	134	14.4	204	21.9	8	0.9	587	62.9
CHF0	37	38.1	59	60.8	0	0.0	1	1.0
COH	267	39.9	224	33.5	13	1.9	165	24.7
STS	128	72.3	38	21.5	4	2.3	7	4.0
				Natural				
CH[d]	20	18.3	39	35.8	50	45.9	0	0.0
COH	0	0.0	3	100.0	0	0.0	0	0.0
STS	53	38.7	57	41.6	25	18.2	2	1.5

[a] *Condition refers to the presence of bird marks, body injuries, and external parasites, and signs of bacterial kidney disease. Body injuries include damaged eyes, operculum, head, body, and fins and presence of fungus. Parasites include leeches and nematode metacercaria. Some fish with bird marks, parasites, and BKD also had body injuries.*

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

[c] *BKD = Bacterial kidney disease*

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

Table 18. Estimates of migrant abundance for hatchery and natural juvenile salmonids, and survival estimates for hatchery juvenile salmonids passing the lower river trap sites on the Umatilla River, October 1997 - July 1998.

Species[a]	Age	Abundance estimate[b]	95% Confidence interval[c]	Percent Survival (+ 95% CI)
		Hatchery		
CHS	1+	632,358	573,962 – 690,754	72.5% (65.8 – 79.2%)
CHF	1+	304,557	237,953 – 371,161	69.9% (54.6 – 85.1%)
CHF	0+	4,227,783	4,026,817 – 4,428,749	152.2%[d] (145 – 159.5%)
COH	1+	2,069,720	1,895,121 – 2,244,319	128.8% (117.9 – 139.7%)
STS	1+	68,670	58,907 – 78,433	49.9% (42.8 – 57.0%)
		Natural		
CHS	1+	18,724	--	--
CHF	0+	124,504	--	--
COH	0+	3,384	--	--
STS	1+[e]	53,854[e]	44,906 – 62,802	--

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

[b] *Abundance estimates of natural salmon were adjusted by the live box retention efficiency and trap collection efficiency estimates of similar length hatchery fish.*

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

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

[e] *Age of natural summer steelhead includes 0^+ to 4^+ fish.*

Table 19. Color-marked fish (blue mark on anal fin) released as normal production and recovered at RM 1.2, RM 3.0, and RM 27.3, Umatilla River, March - July 1998. These fish were tagged with PIT tags.

Species[a]	Fin mark	Number released	Release location	Number recovered[b]	Recover location	Passage estimate[c]	Percent survival
CHS	Blue	2,516	RM 80	40	RM 1.2	1,091	92.1
				246	RM 3.0	1,226	
			Total	*286*		*2,317*	
CHF	Blue	723	RM 73	3	RM 1.2	90	130.6
				269	RM 3.0	854	
			Total	*272*		*944*	
CHF0	Blue	4,564	RM 73/80	897	RM 3.0	3,824	83.8
				1	RM 27.3	1	
			Total	*898*		*3,825*	
STS	Blue	760	RM 79/63	20	RM 3.0	217	28.6

[a] *CHS = spring chinook salmon, CHF = yearling fall chinook salmon, STS = summer steelhead, CHF0 = subyearling fall chinook salmon.*

[b] *Number recovered at RM 1.2 (rotary-screw trap) was adjusted for trap retention efficiency. Number recovered at RM 3.0 (West Extension Canal) was adjusted for sample rate and non-sampled periods.*

[c] *Passage estimate was derived from trap efficiency estimates for the specific period in which marks were collected.*

Table 20. Pit-tagged fish released as normal production and detected at RM 1.2, RM 3.0, and RM 27.3, Umatilla River, March - July 1998. Detection data is not expanded.

Species[a]	Hatchery	Number released	Release date	Release location	Number detected[b]	Percent detection
CHS	Umatilla	1,692	3/8	RM 80	38	2.2
	Little White	235	3/8	RM 80	12	5.1
	Little White	244	4/14	RM 80	26	10.7
	Carson	241	4/14	RM 80	27	11.2
CHF	Bonneville	217	3/13	RM 73	3	1.4
	Willard	440	4/17	RM 73	54	12.3
CHF0	Umatilla	1,517	5/28	RM 73	31	2.0
	Umatilla	3,047	6/1	RM 80	84	2.8
STS	Umatilla	250	4/16	RM 79	2	0.8
	Umatilla	244	4/16	RM 64	5	2.0
	Umatilla	242	5/4	RM 79	5	2.1

[a] *CHS = spring chinook salmon, CHF = yearling fall chinook salmon, STS = summer steelhead, CHF0 = subyearling fall chinook salmon.*
[b] *Number detected does not include fish with lost tags or tagged fish that could not be assigned to a tag file.*

Table 21 . PIT-tagged fish from different rearing strategies at Umatilla Hatchery detected in the lower Umatilla River at RM 1.2, RM 3.0, RM 27.3, and RM 29, March 1998 – July 1998.

Species[a]	Rearing[b] strategy	Raceway section	Number released	Release[c] location	Number[d] detected	Percent detection	Total detection
CHS	Michigan	A	248	RM 80	8	3.2	
	Michigan	B	243	RM 80	7	2.9	
	Michigan	C	240	RM 80	4	1.7	2.6%
	Oregon	A	484	RM 80	10	2.1	
	Oregon	B	477	RM 80	9	1.9	2.0%
CHF0	Low density	A	520	RM 73	8	1.5	
	Low density	B	505	RM 80	10	2.0	
	Low density	C	508	RM 80	17	3.3	2.3%
	Med. density	A	493	RM 73	8	1.6	
	Med. density	B	510	RM 80	12	2.4	
	Med. density	C	509	RM 80	15	2.9	2.3%
	High density	A	504	RM 73	15	3.0	
	High density	B	507	RM 80	15	3.0	
	High density	C	508	RM 80	15	3.0	3.0%

[a] *CHS = spring chinook salmon, CHF0 = subyearling fall chinook salmon.*

[b] *Rearing strategy for CHS was in oxygenated Michigan raceways and standard Oregon raceways; rearing strategy for CHF0 was by density in Michigan raceways.*

[c] *CHS were released on 8 March; CHF0 were released on 28 May at RM 73 and 1 June at RM 80.*

[d] *Number detected does not include fish with lost tags or tagged fish that could not be assigned to a tag file.*

Table 22. Number of hatchery fish color marked (dorsal fin) and released for secondary survival tests and adjusted collection, percent recapture, and percent survival at RM 1.2 and RM 3.0, Umatilla River, spring 1998.

Species[a]	Mark[b]	Number released	Number collected RST[c]	Number collected WEID[c]	Release location	Release date	Percent recapture	Percent survival
CHS	OD	1,978	30	1	RM 29	3/9	1.2	41.6%
CHF	PD	863	3	16	RM 29	3/14	2.2	21.0%
CHF0	DYD	1,063	-	182	RM 32	6/4	17.1	157%
COH	GD	1,721	5	51	RM 52	3/23	3.3	44.0%
	OD	1,009	2	71	RM 52	3/24	7.2	69.9%
	PD	2,674	0	125	RM 52	3/30 + 3/31	4.7	51.1%

[a] *CHS = yearling spring chinook salmon, CHF = yearling fall chinook salmon, CHF0 = subyearling fall chinook salmon, COH = yearling coho salmon.*
[b] *Marks were applied to the dorsal fin. OD = orange dorsal, PD = pink dorsal, DYD = dark yellow dorsal, GD = green dorsal.*
[c] *RST = rotary-screw trap, WEID = West Extension Irrigation District Canal.*

Table 23. Number of hatchery fish color marked (anal fin) and released for reach-specific survival tests and adjusted collection, percent recapture, and percent survival at RM 1.2 and RM 3.0, Umatilla River, spring 1998.

Species[a]	Mark[b]	Number released	Number collected RST[c]	Number collected WEID[c]	Release location	Release date	Percent recapture	Percent survival
CHS	GA	255	3	--	RM 80	3/9-3/11	0.8	51.8
CHS	PA	250	5	--	RM 42	3/9 – 3/11	1.6	30.0
CHS	YA	249	5	--	RM 27	3/9 – 3/11	1.6	30.1
CHF0	PA	508	--	82	RM 80	6/1 – 6/3	16.1	70.7
CHF0	GA	522	--	145	RM 48	6/1 – 6/3	27.8	115.3
CHF0	YA	507	--	157	RM 27	6/1 – 6/3	31.0	132.3
STS	GA	323	--	15	RM 79	4/15 – 4/17	4.6	50.2
STS	OA	225	--	12	RM 64	4/15 – 4/17	5.3	60.4
STS	PA	257	--	31	RM 48	4/15 – 4/17	12.1	130.7
STS	YA	252	--	13	RM 27	4/15 – 4/17	5.2	59.5
STS	PuA	250	--	9	RM 79	5/11- 5/13	3.6	26.4
STS	RA	251	--	14	RM 48	5/11 – 5/13	5.6	49.0
STS	MYA	255	--	12	RM 27	5/11 – 5/13	4.7	35.3

[a] *CHS = yearling spring chinook salmon, STS = summer steelhead, CHF0 = subyearling fall chinook salmon.*

[b] *Marks were appled to the anal fin. GA = Green anal, PA = Pink anal, YA = Yellow anal, OA = Orange anal, PuA = Purple anal, MYA = Mustard yellow anal.*

[c] *RST = rotary-screw trap, WEID = West Extension Irrigation District Canal. Number collected at the rotary-screw trap was adjusted for trap retention efficiency.*

Table 24. Tag detections at Umatilla River and mainstem interrogation sites of PIT-tagged fish released for reach-specific survival tests, March - July 1998. *P* is the binomial probability of a significant difference in percent detected between the uppermost and designated release sites. Detection does not include duplicate mainstem detections.

Species[a]	Fin mark	Number released	Release location	Number detected[b] Umatilla	Mainstem	Percent detected	*P*
CHS	Green	238	RM 80	2	23	10.5	
CHS	Pink	232	RM 42	4	28	13.8	
CHS	Yellow	226	RM 27	3	42	19.9	0.002
CHF0	Pink	491	RM 80	19	32	10.4	
CHF0	Green	518	RM 48	22	34	10.8	
CHF0	Dk Yellow	505	RM 27	16	42	11.5	0.288
CHF0	No color	488	RM 27[e]	0	2	0.4	
STS[c]	Green	240	RM 79	4	43	19.6	
STS[c]	Orange	206	RM 63	4	41	21.8	
STS[c]	Pink	228	RM 48	8	60	29.8	0.005
STS[c]	Yellow	208	RM 27	6	48	26.0	0.064
STS[d]	Purple	221	RM 79	4	32	16.3	
STS[d]	Red	239	RM 48	7	35	17.6	
STS[d]	Dk Yellow	240	RM 27	7	44	21.3	0.085

[a] *CHS = yearling spring chinook salmon, STS = summer steelhead, CHF0 = subyearling fall chinook salmon*

[b] *Tag detections within the Umatilla River were at RM 1.2 and RM 3.0. Tag detections in the mainstem included John Day and Bonneville dams, the estuary, and Three Mile Canyon (RM 256) and Rice islands (RM 21).*

[c] *Large-grade and medium-grade steelhead released in mid-April.*

[d] *Small-grade steelhead released in early May.*

[e] *Subyearling fall chinook salmon were released into Westland pond from 7 – 9 July during juvenile fish transport operations. Transported fish were released below RM 3.*

Table 25. Passage estimates of subyearling fall chinook salmon from video recordings at the east-bank fish ladder and fish trapping at the West Extension Canal bypass facility at Three Mile Falls Dam, Umatilla River, 1 June - 9 June 1998.

	Number		Percent		Hours
Date	Ladder	Bypass	Ladder	Bypass	compared[a]
6/1	11	646	1.7	98.3	6
6/2	93	4,184	2.2	97.8	5.5
6/3	60,144	138,372	30.3	69.7	18
6/4	44,314	260,993	14.5	85.5	18
6/5	36,783	162,937	18.4	81.6	18
6/6	29,437	73,102	28.7	71.3	16.0
6/7	18,824	9,290	67.0	33.0	17.1
6/8	11,022	22,471	32.9	67.1	16.9
6/9	5,297	7,797	40.4	59.6	12
Total	205,925	679,792			127.6
Percent	23.2	76.8			

[a] *Hours compared corresponded to the most closely matched sampling data for the fish bypass facility and the fish ladder.*

Table 26. Number and length range (mm) of resident fish species captured at the rotary-screw trap (RM 1.2) and the West Extension Canal facility (RM 3.0), lower Umatilla River, October 1997 - July 1998.

Family Common name (*Genus species*)	Number [a] captured	Length range [b] (mm)
Catostomidae		
Unidentified sucker (*Catostomus spp.*)	--	--
Cyprinidae		
Redside shiner *(Richardsonius balteatus*)	--	--
Peamouth (*Mylocheilus caurinus*)	--	--
Chiselmouth (*Acrocheilus alutaceus*)	--	--
Northern pikeminnow (*Ptychocheilus oregonensis*)	36	40-286
Centrarchidae		
Unidentified bass (*Micropterus spp.*)	3	100-112
Smallmouth bass (*M. dolomieu*)	61	74-172
Crappie (*Pomoxis spp.*)	--	--
Bluegill (*Lepomis macrochirus*)	--	--
Ictaluridae		
Unidentified Bullhead (*Ictalurus spp.*)	--	--
Petromyzontidae		
Pacific lamprey (*Lampetra tridentata*)	569	90-460[c]

[a] *Only northern pikeminnow, bass spp., and lamprey were counted on a regular basis.*
[b] *Lamprey were measured to total length; pikeminnow and bass were measured to fork length.*
[c] *One adult lamprey measured 460 mm. Lengths of juvenile lamprey ranged from 90 - 184 mm.*

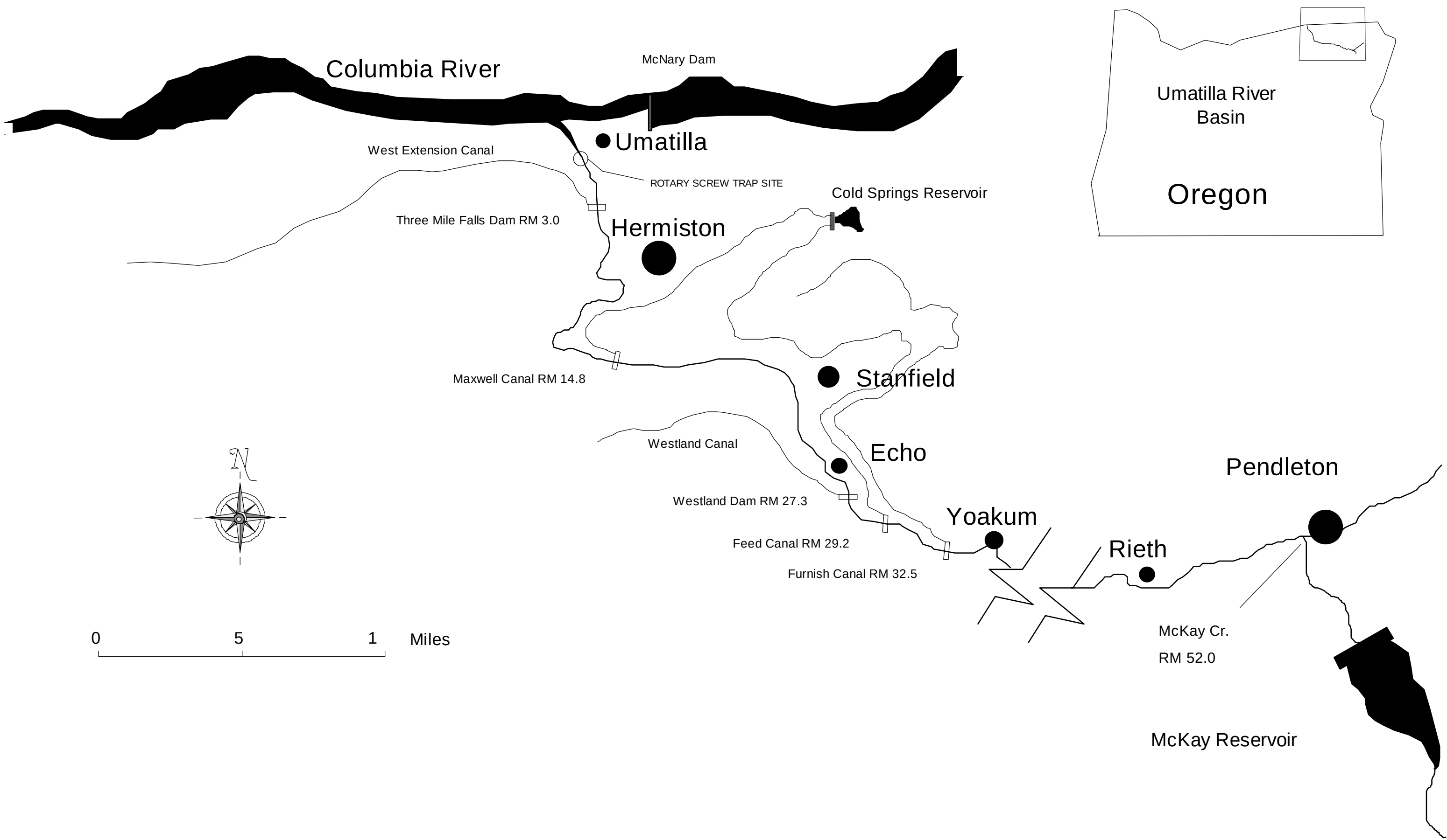
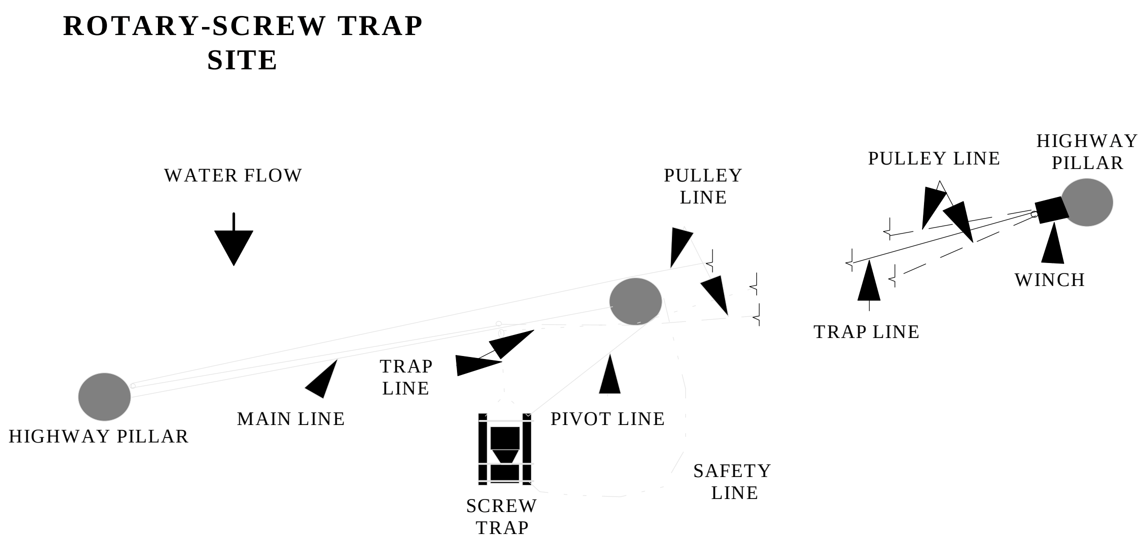


Figure 1. Study and activity sites on the lower Umatilla River, October 1997 - Septebmer 1998.



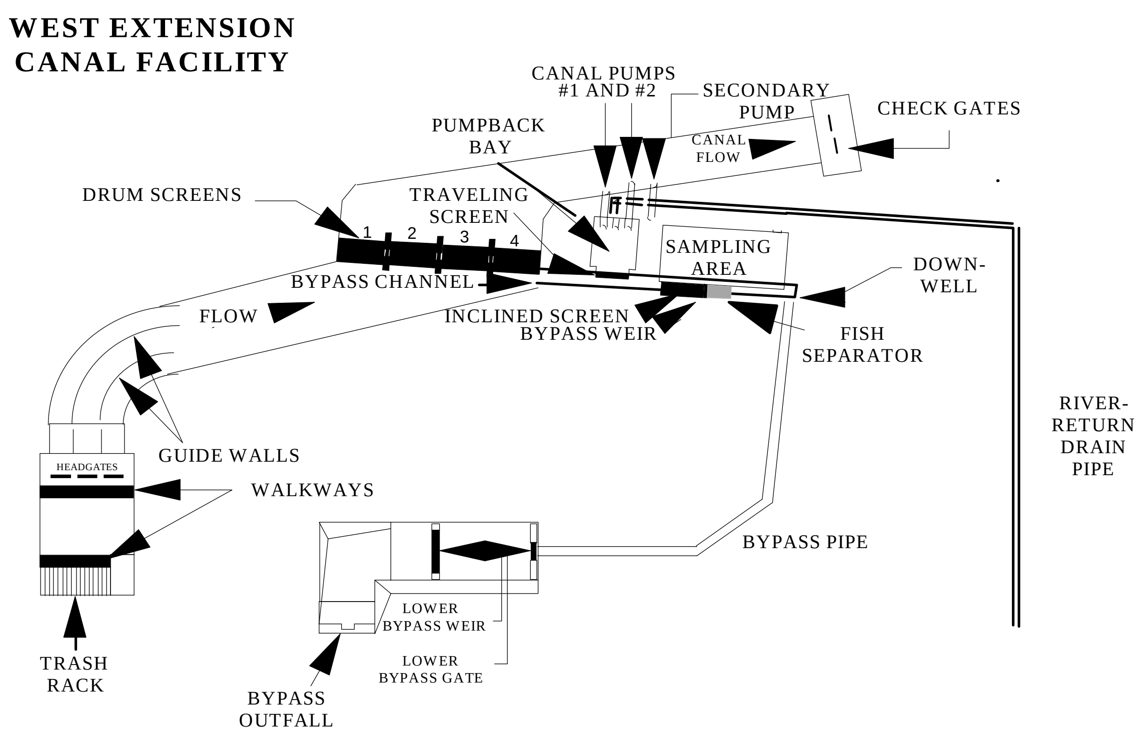


Figure 2. Schematic of the rotary-screw trap and anchoring system and the West Extension Canal screening and bypass facility, Umatilla River, 1998.

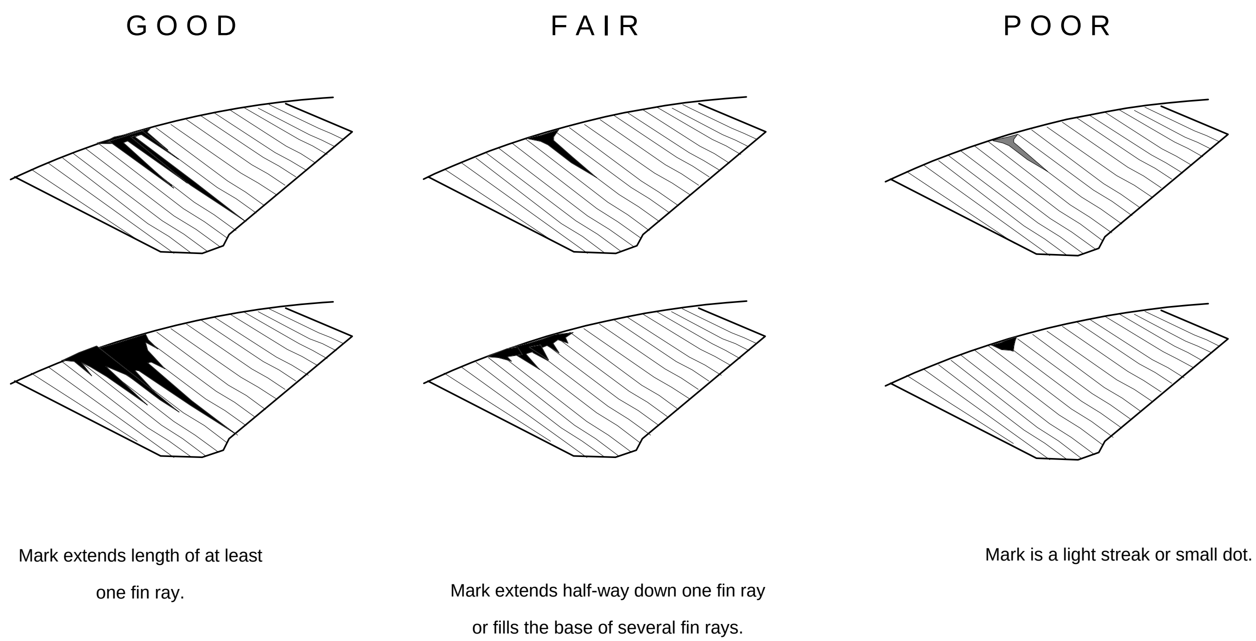


Figure 3. Criteria used to evaluate color mark quality on the fins of fish used in specific tests, Umatilla River, spring 1998.

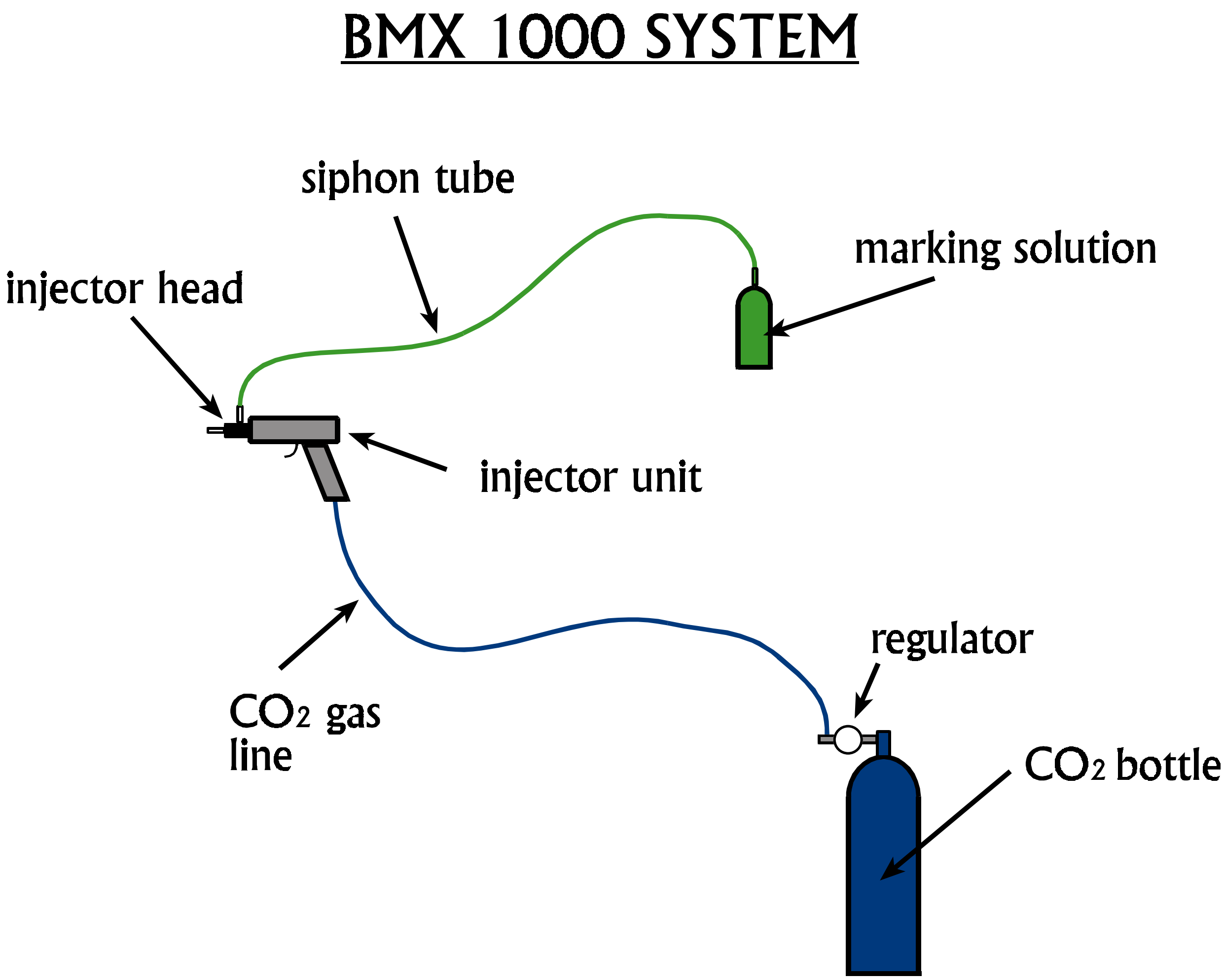


Figure 4. Biometrix-1000 System and other equipment used to inject photonic or VI-jet color marks into the fins of juvenile salmonids, spring 1998.

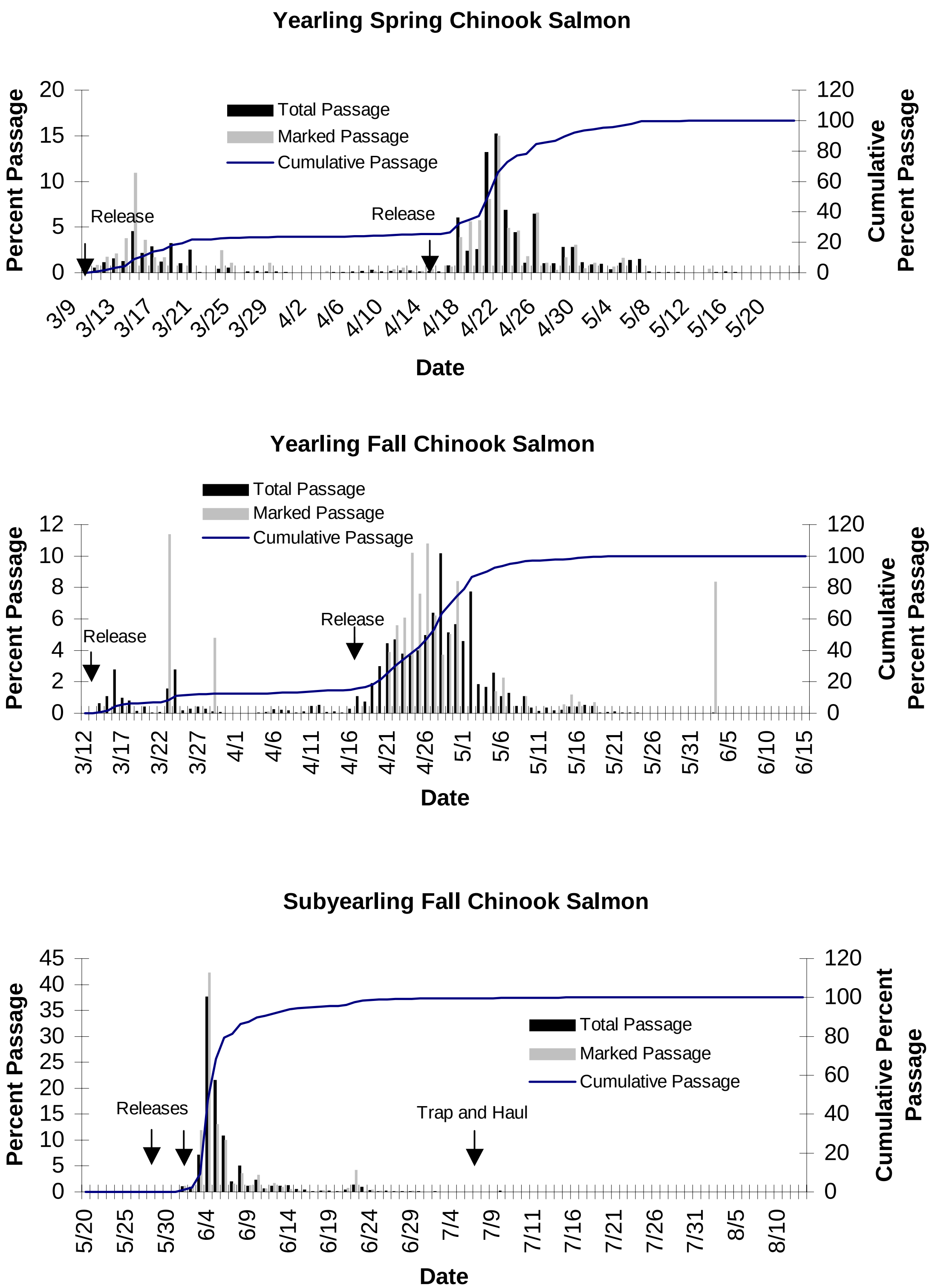
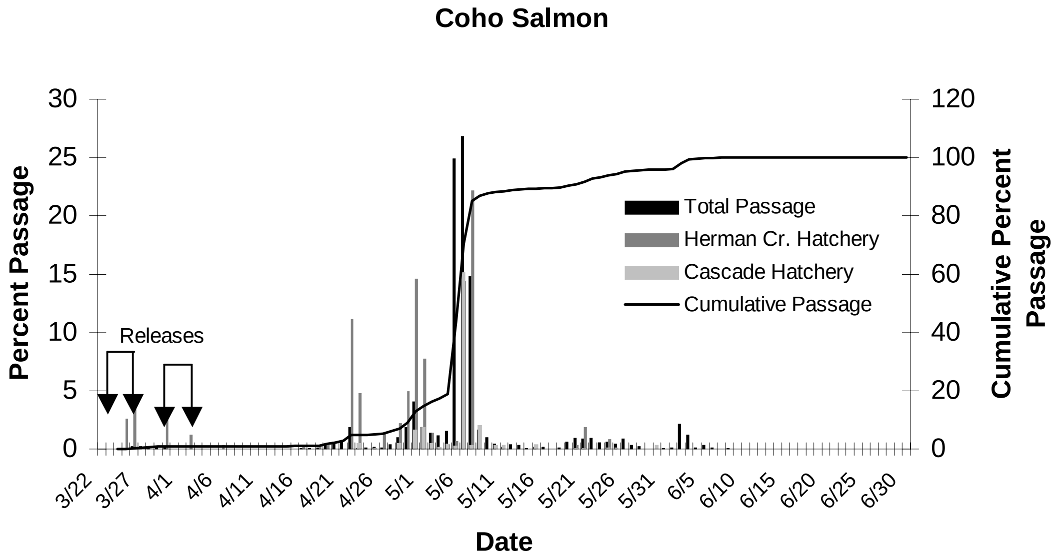


Figure 5. Percent and cumulative percent passage of total and color-marked yearling spring and fall chinook and subyearling fall chinook salmon at lower river trapping sites (RM 1.2, 3.0, 27.3), Umatilla River, March - August 1998.



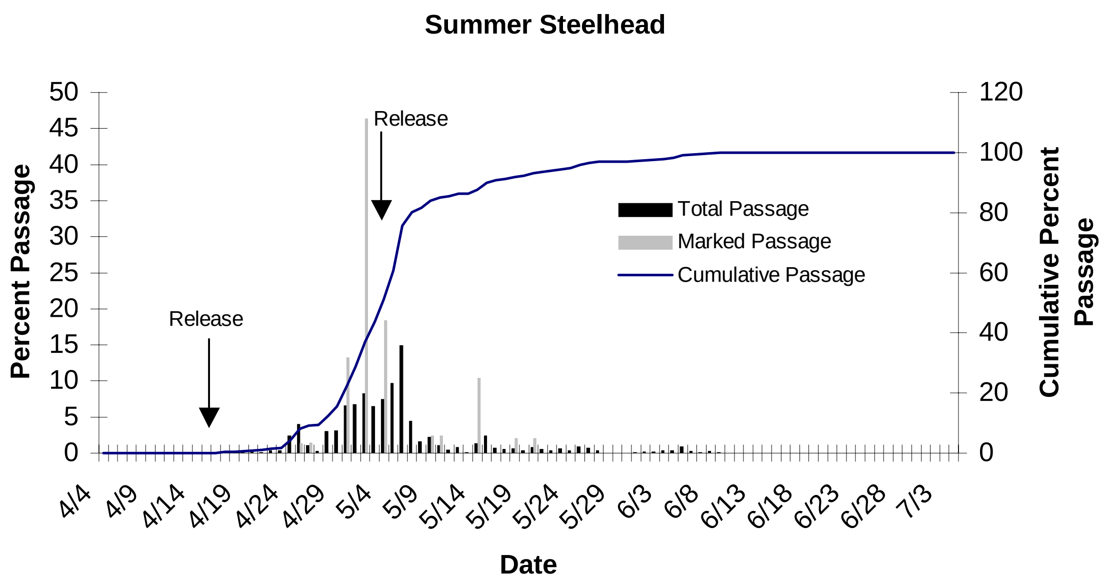


Figure 6. Percent and cumulative percent passage of total and color-marked hatchery coho salmon and summer steelhead at lower river trapping sites (RM 1.2 and 3.0), Umatilla River, March - July 1998. Coho were marked according to rearing hatchery.

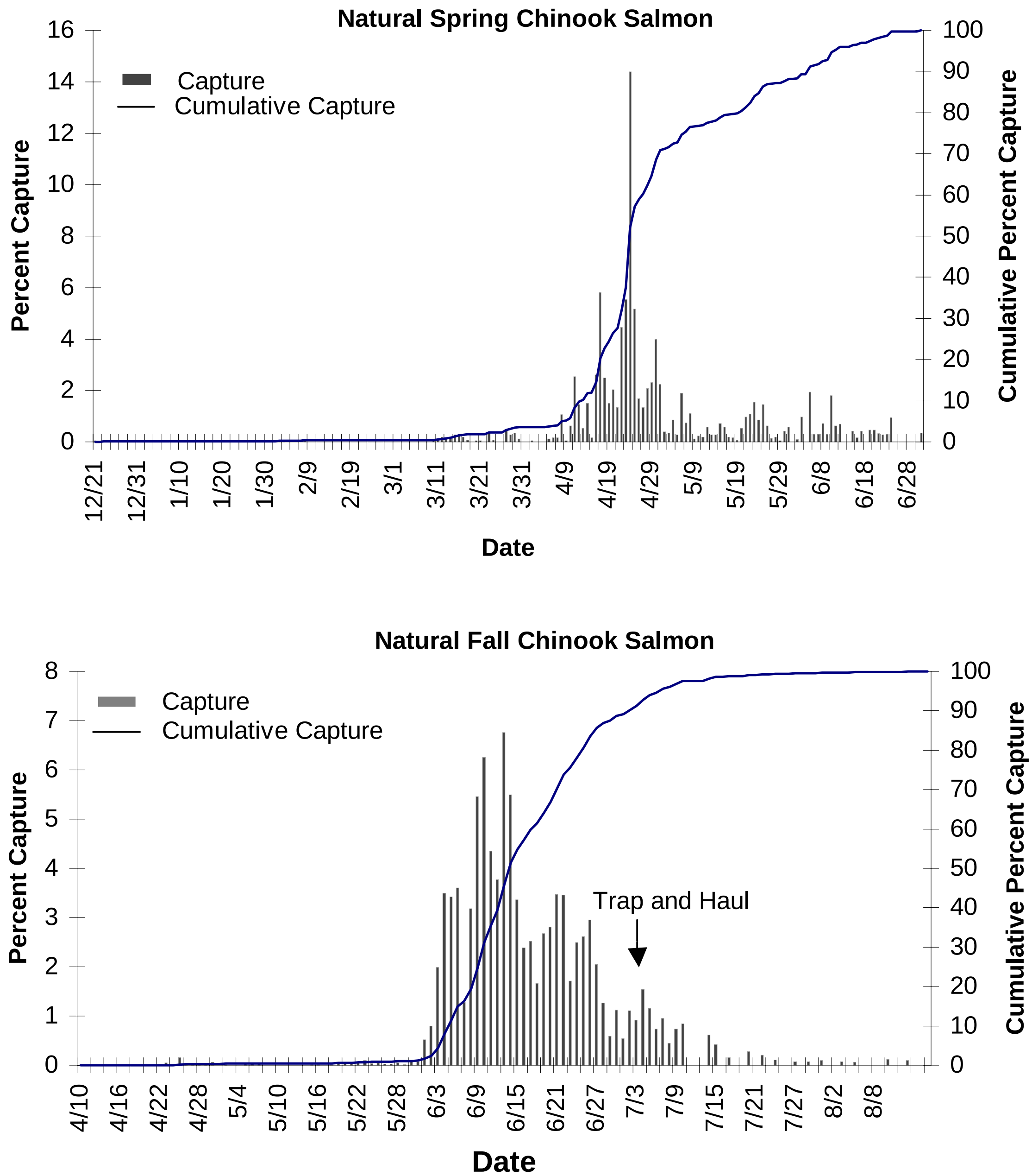
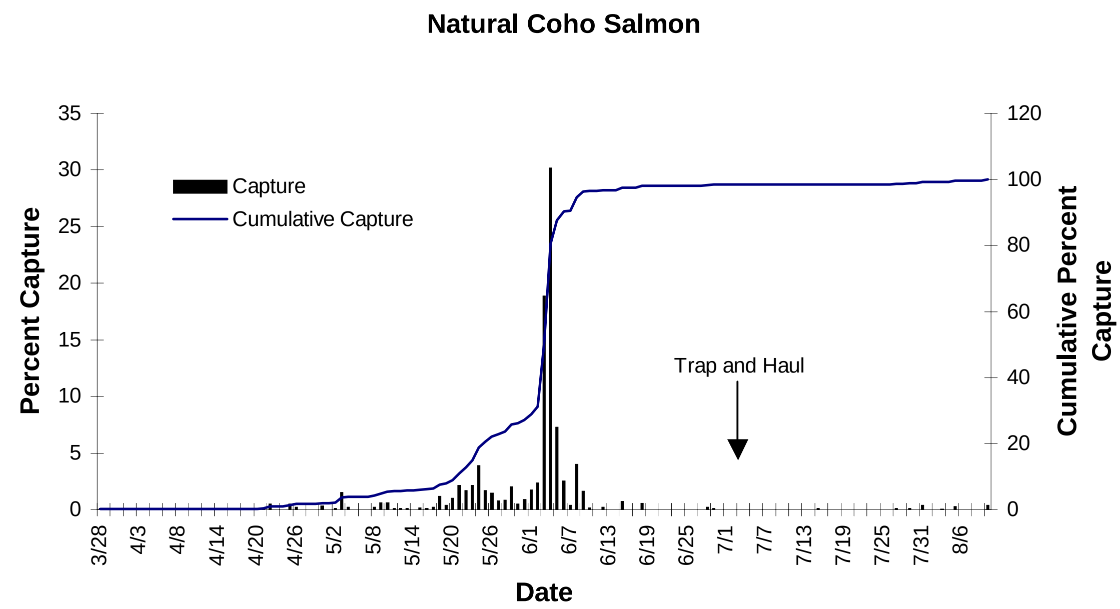


Figure 7. Percent and cumulative percent capture of natural spring chinook and fall chinook salmon collected at lower river trapping sites (RM 1.2, 3.0, and 27.3), Umatilla River, December 1997 - August 1998.



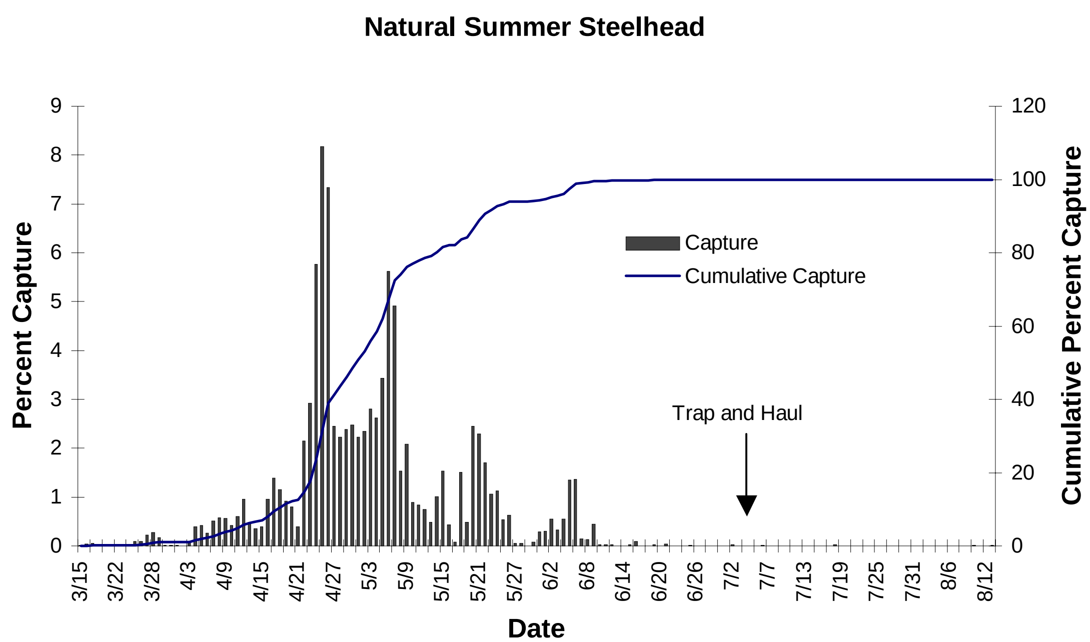
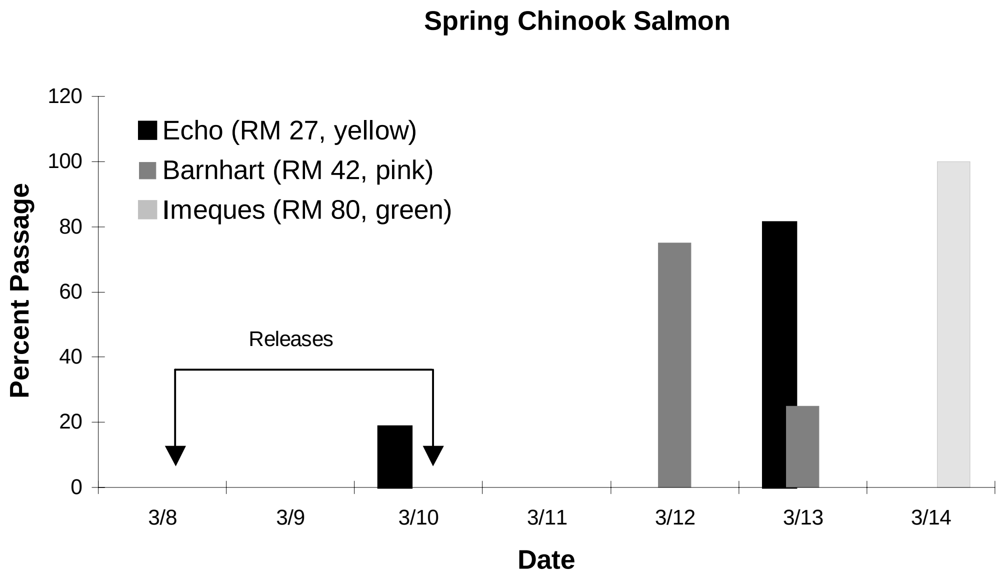


Figure 8. Percent and cumulative percent capture of natural coho salmon and summer steelhead collected at lower river trapping sites (RM 1.2, 3.0, and 27.3), Umatilla River, March - August 1998.

Spring Chinook Salmon



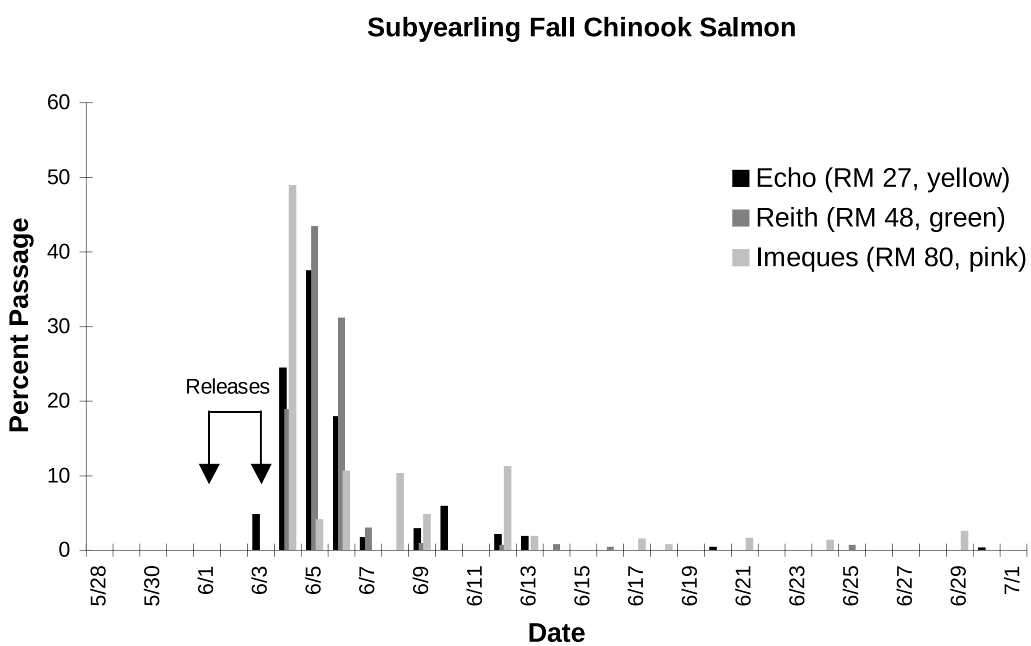
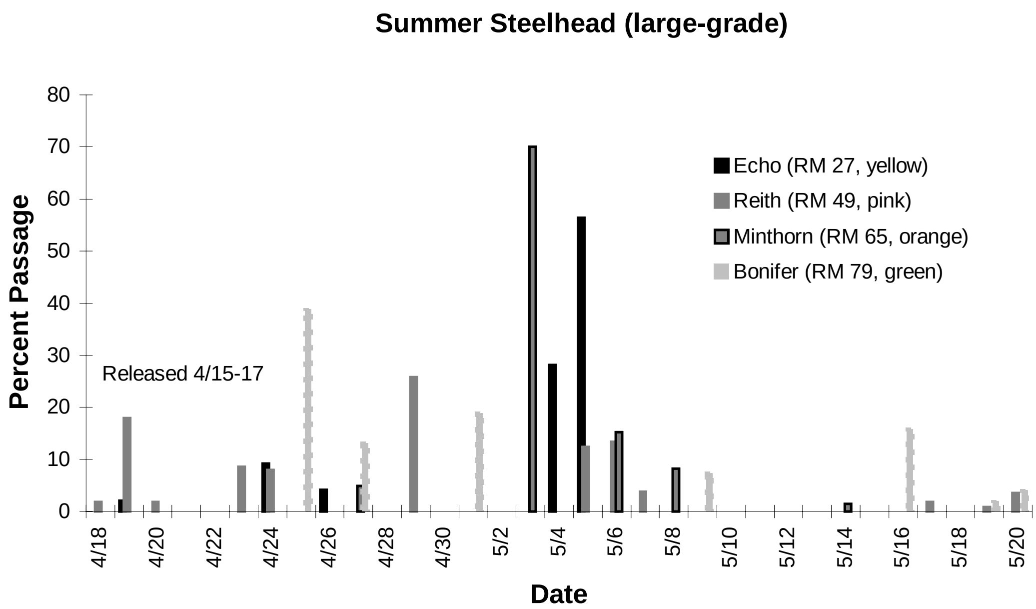


Figure 9. Percent passage of hatchery yearling spring chinook and subyearling fall chinook salmon color marked for reach survival tests and captured at lower river trapping sites (RM 1.2 and 3.0), Umatilla River, March - July 1998. Color denotes release site.



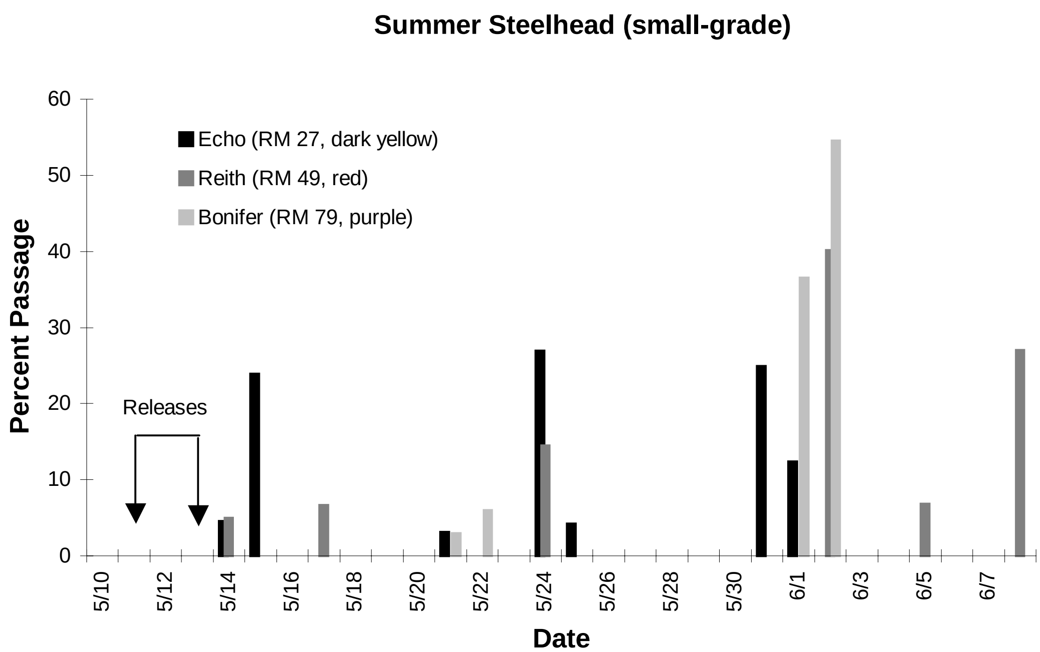


Figure 10. Percent passage of large- and small-grade hatchery summer steelhead color marked for reach survival tests and captured at RM 3.0, Umatilla River, April - June 1998. Color denotes release site.

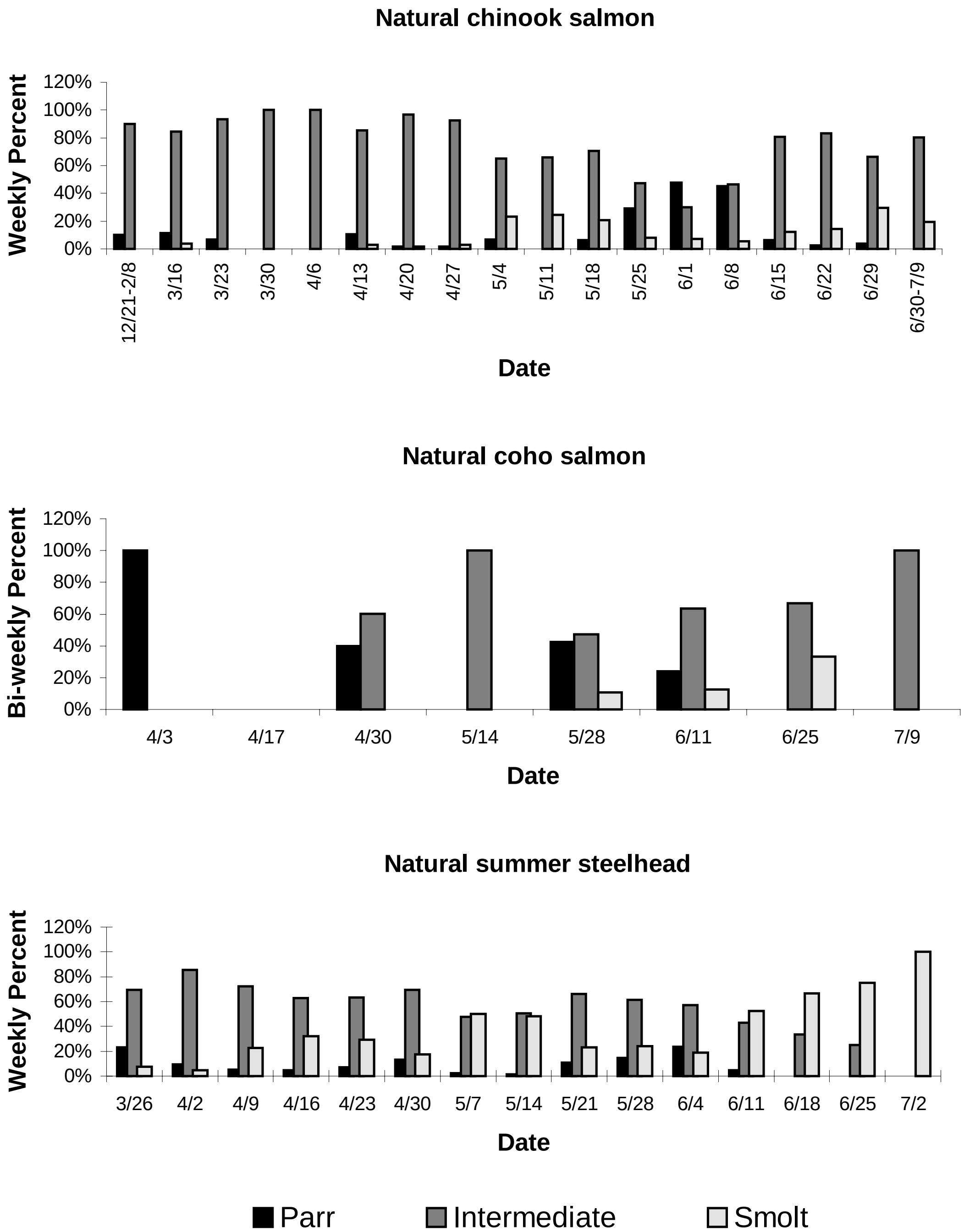


Figure 11. Smolt development by date of natural chinook and coho salmon and summer steelhead captured at lower river trapping sites (RM 1.2 and 3.0), Umatilla River, 1 October 1997 - 30 July 1998.

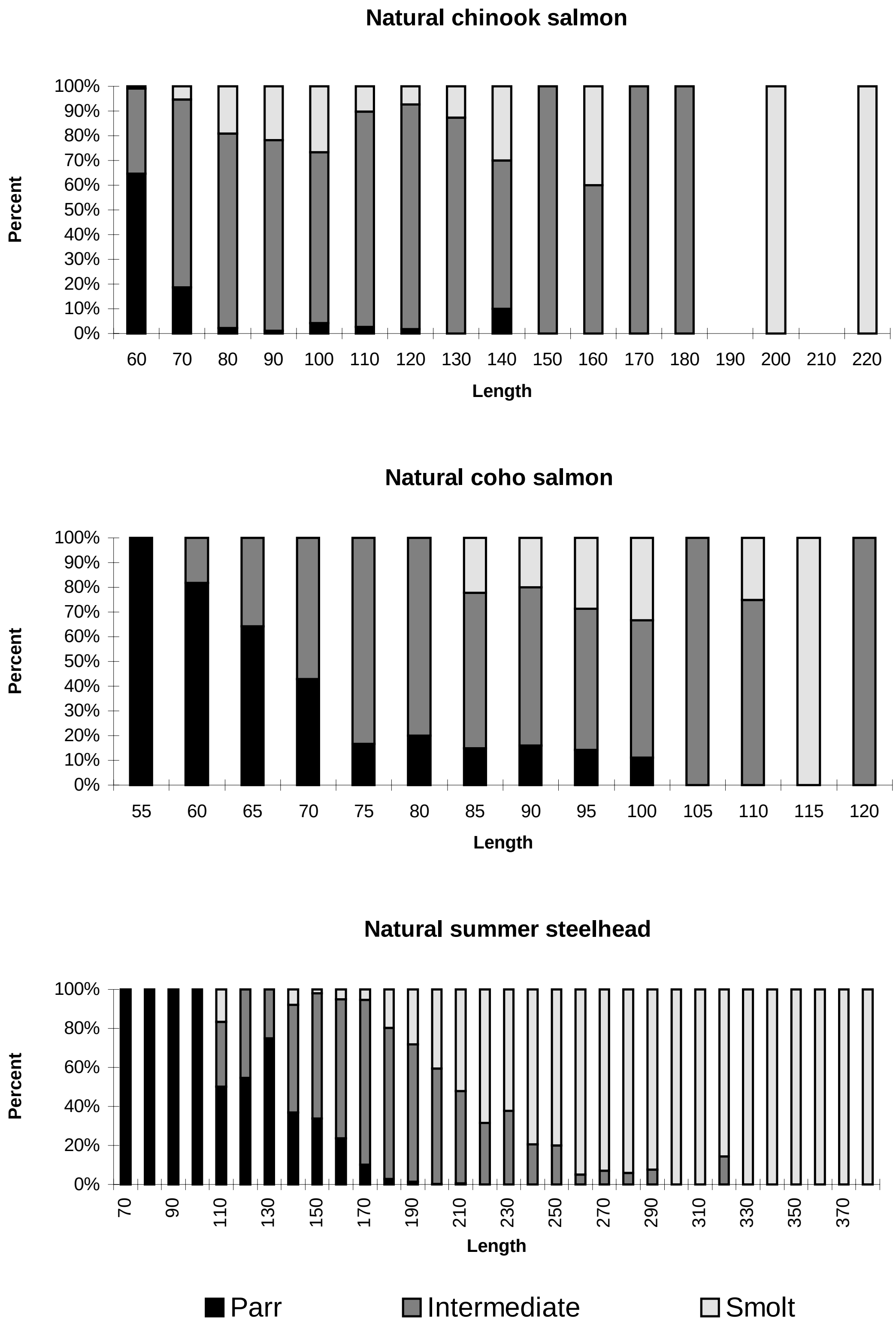


Figure 12. Smolt development by fork length of natural chinook and coho salmon and summer steelhead captured at lower river trapping sites (RM 1.2 and 3.0), Umatilla River, 1 October 1997 - 30 July 1998.

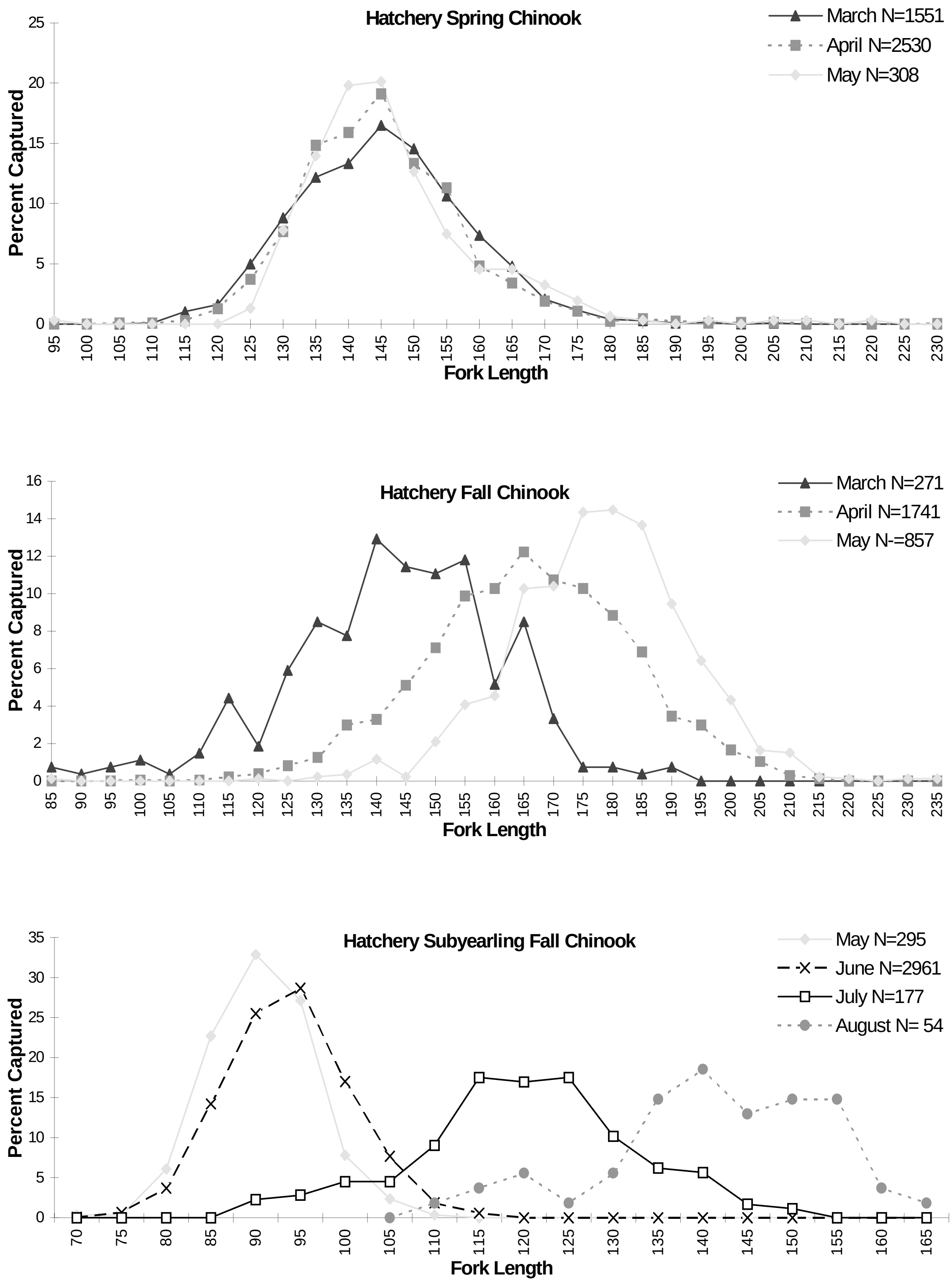


Figure 13. Length-frequency distribution of hatchery yearling spring chinook salmon, yearling fall chinook salmon, and subyearling fall chinook salmon captured in the lower Umatilla River, March - August 1998.

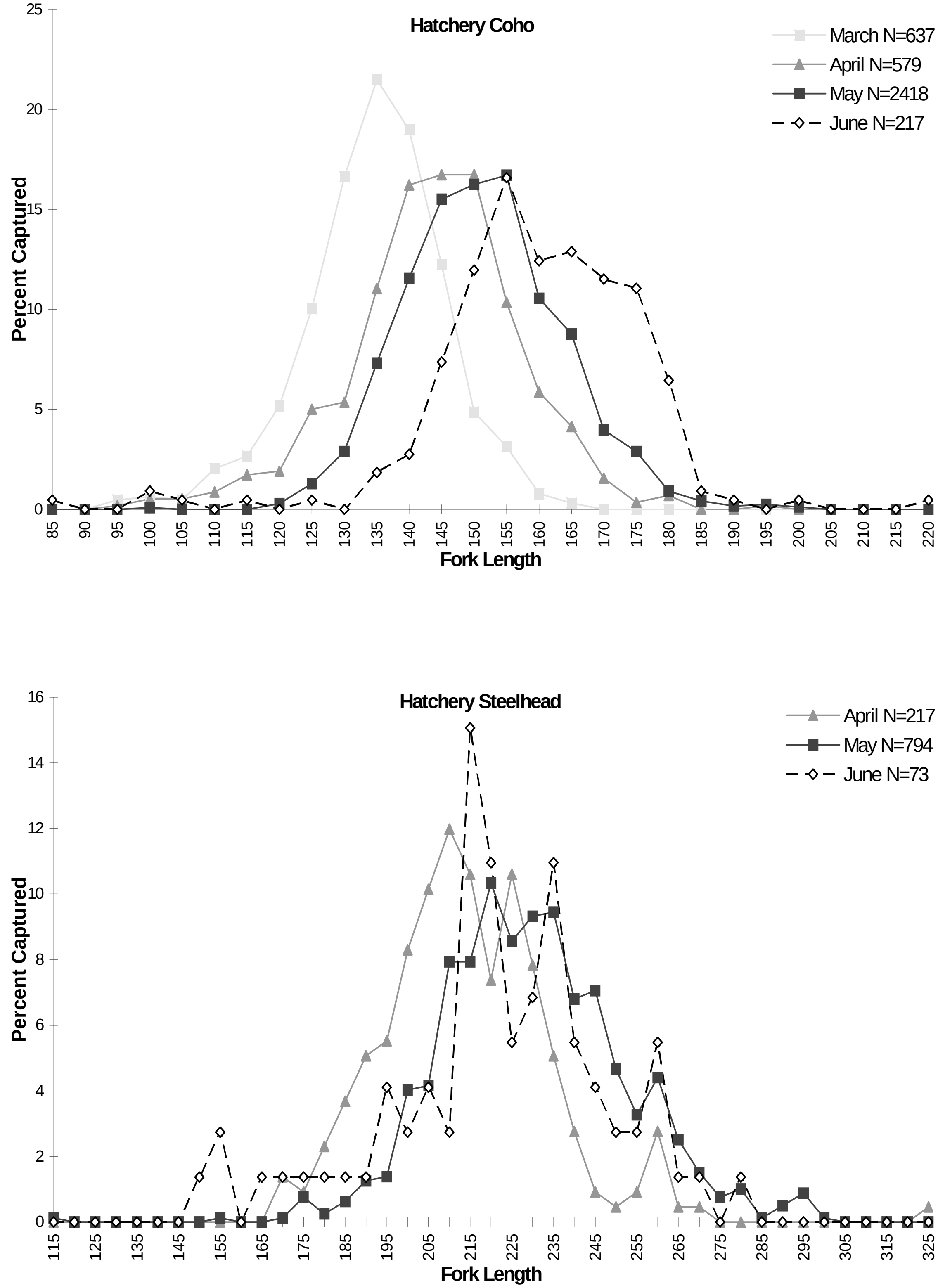


Figure 14. Length-frequency distribution of hatchery coho salmon and summer steelhead captured in the lower Umatilla River, March - June 1998.

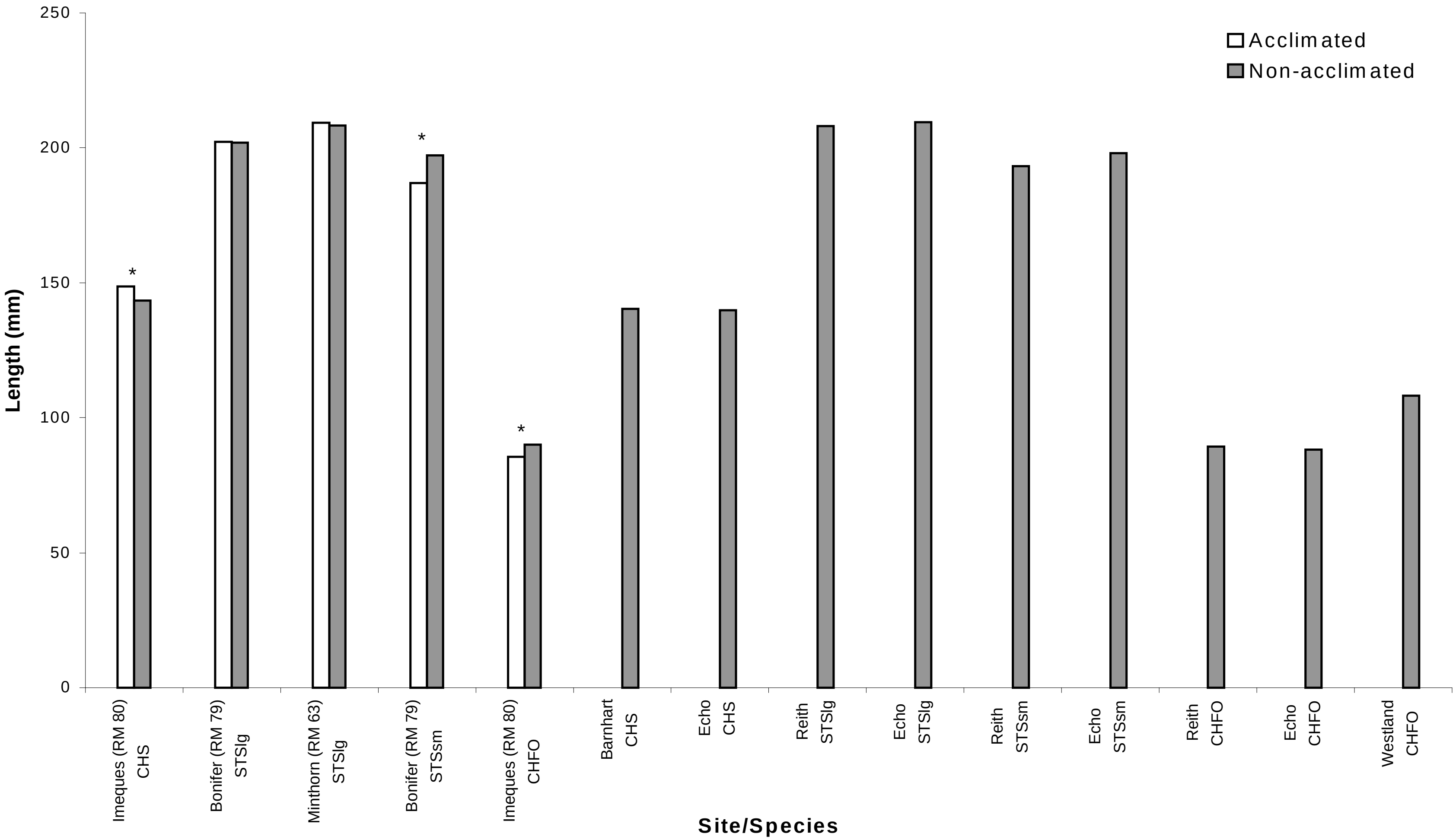


Figure 15. Mean lengths of acclimated and non-acclimated hatchery salmonids released into the Umatilla River, March - July 1998. CHS = spring chinook salmon, STSlg = large-grade summer steelhead, STSsm = small-grade summer steelhead, CHFO = subyearling fall chinook salmon. * Denotes significant differences between mean lengths.

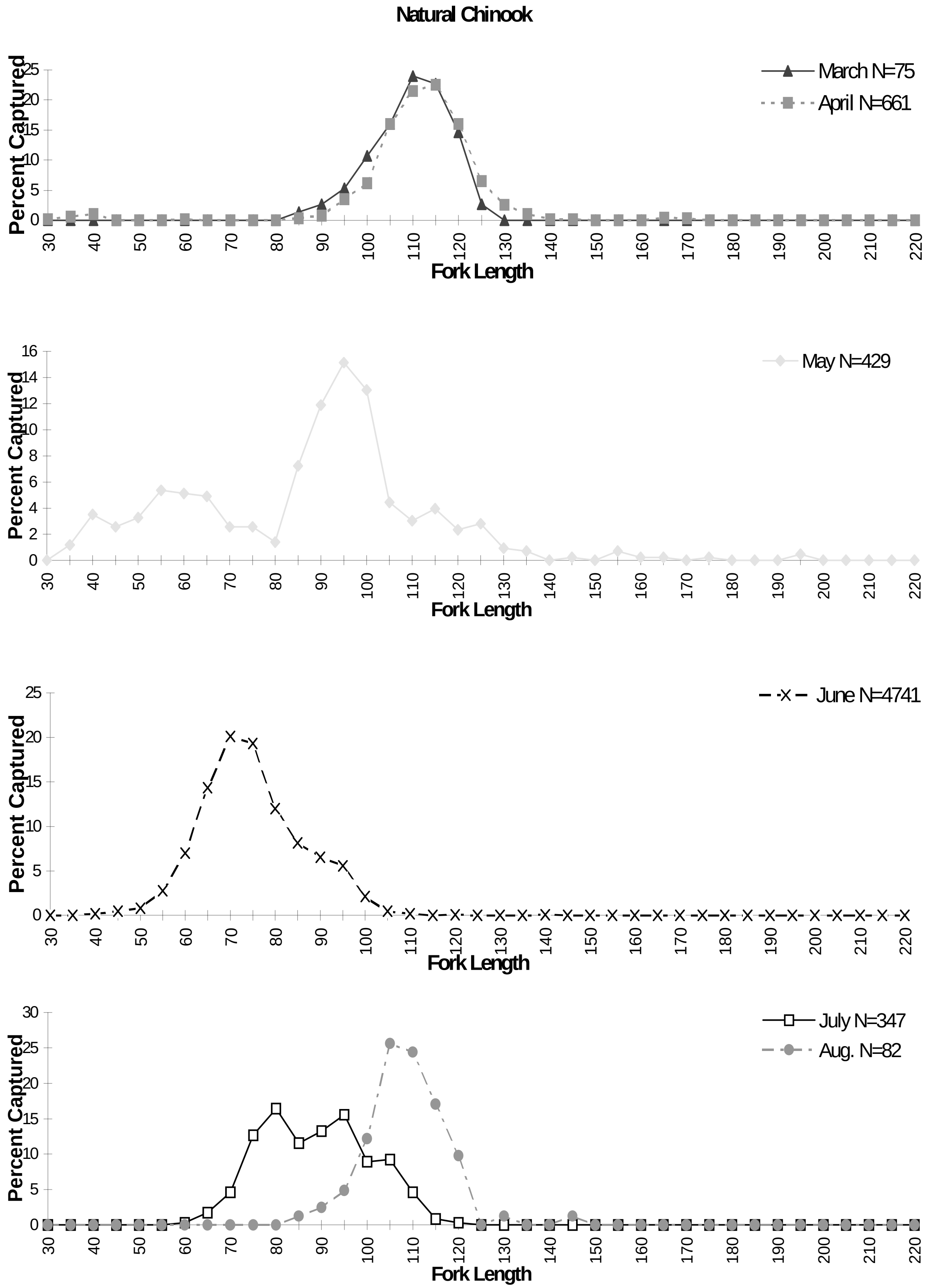


Figure 16. Length-frequency distribution of natural chinook salmon captured in the lower Umatilla River, March - August 1998.

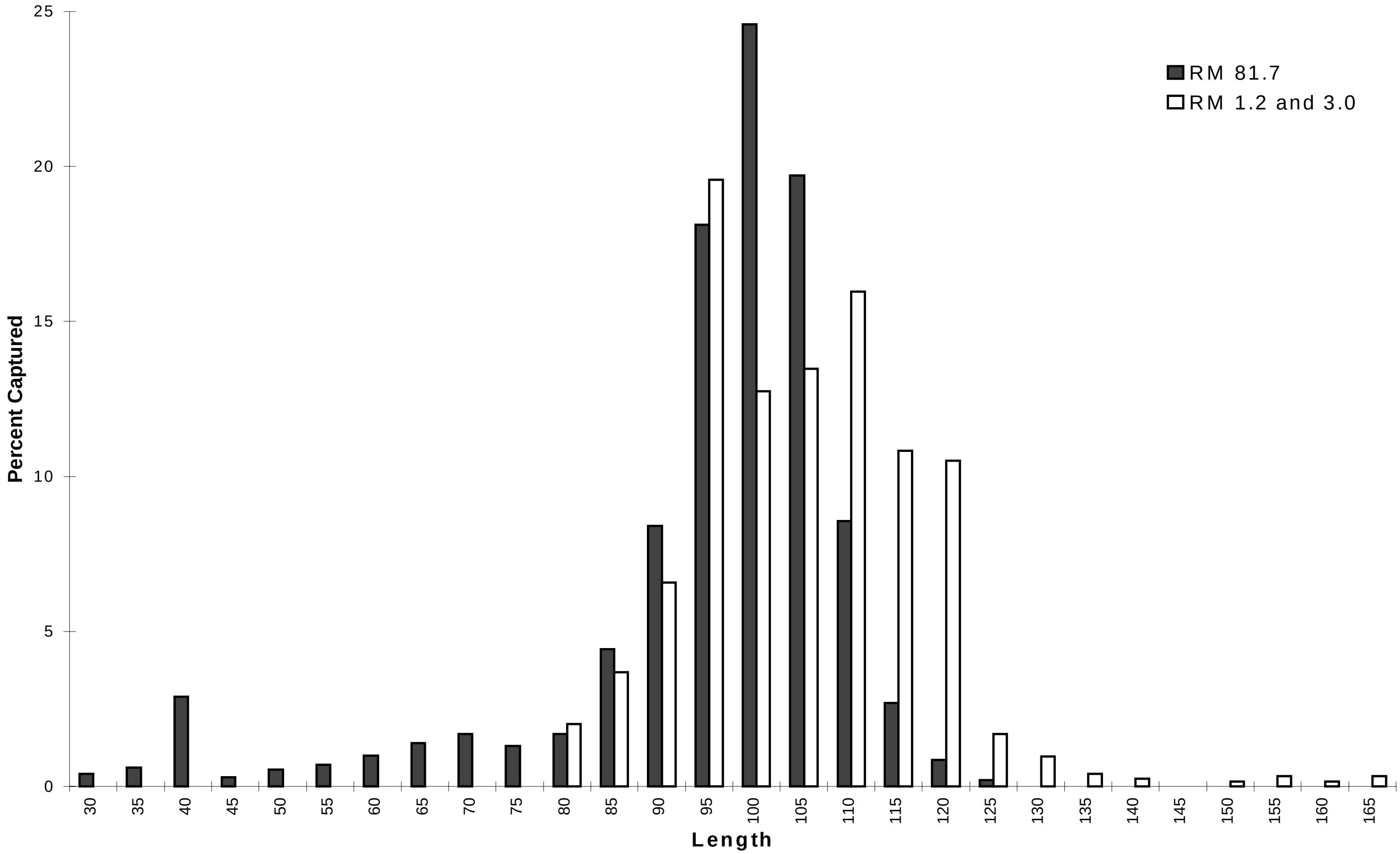


Figure 17. Length-frequency distribution of natural spring chinook salmon captured at upriver traps (RM 81.7) and downriver traps (RM 1.2 and 3.0), Umatilla River, October 1997 - June 1998. Upriver data is from CTUIR (unpublished).

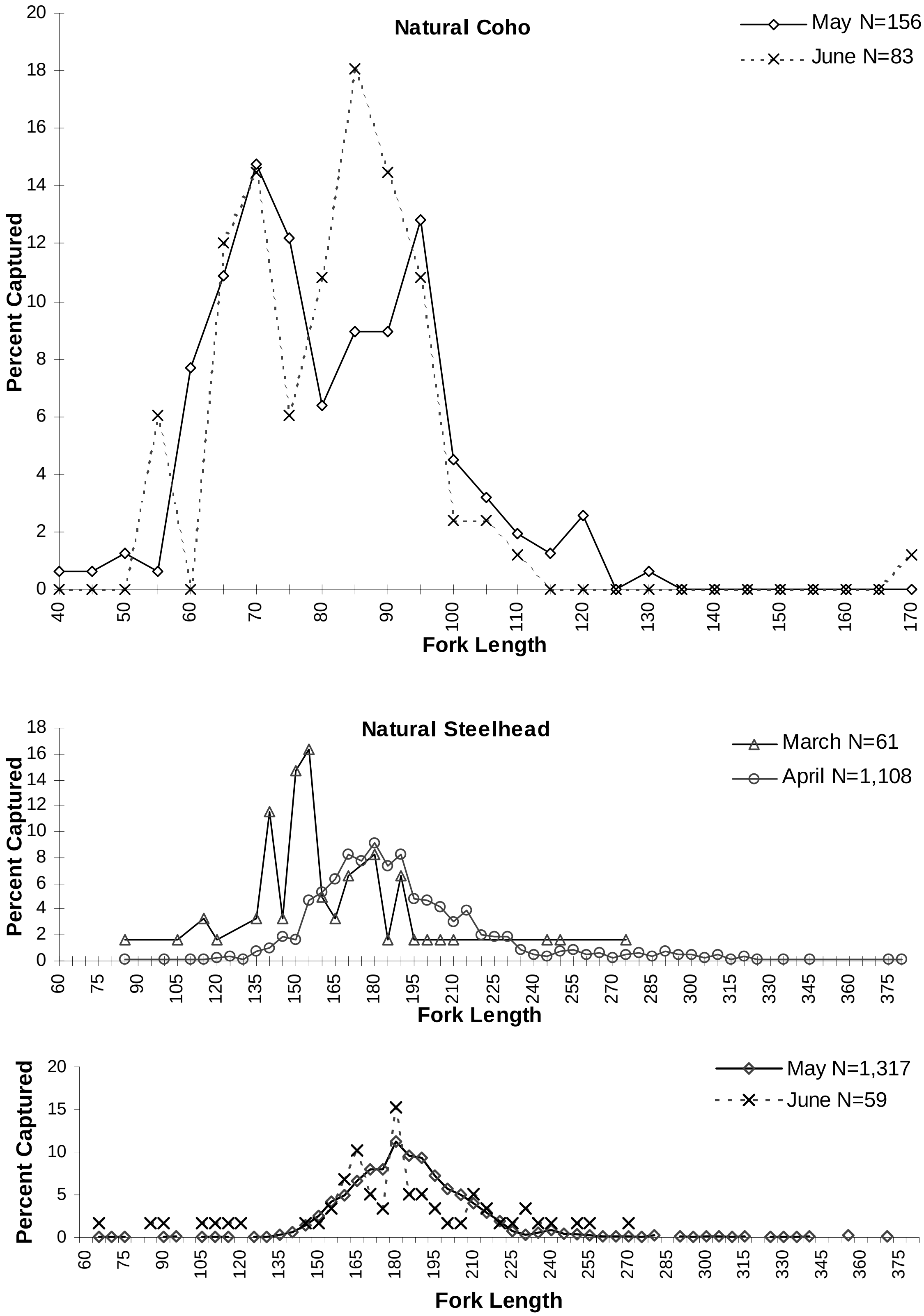


Figure 18. Length-frequency distribution of natural coho salmon and natural summer steelhead captured in the lower Umatilla River, March – June 1998.

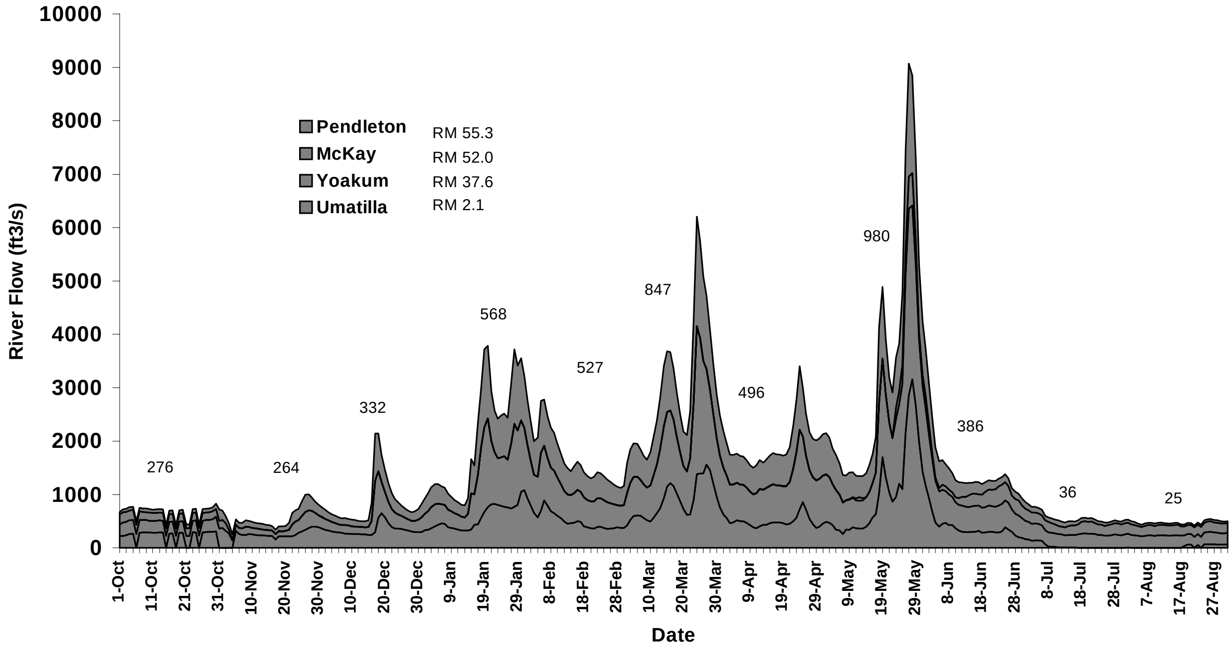


Figure 19. Mean daily river flow (ft^3/s) recorded at four gauging stations on the Umatilla River, October 1997 – August 1998. Monthly mean flow is indicated.

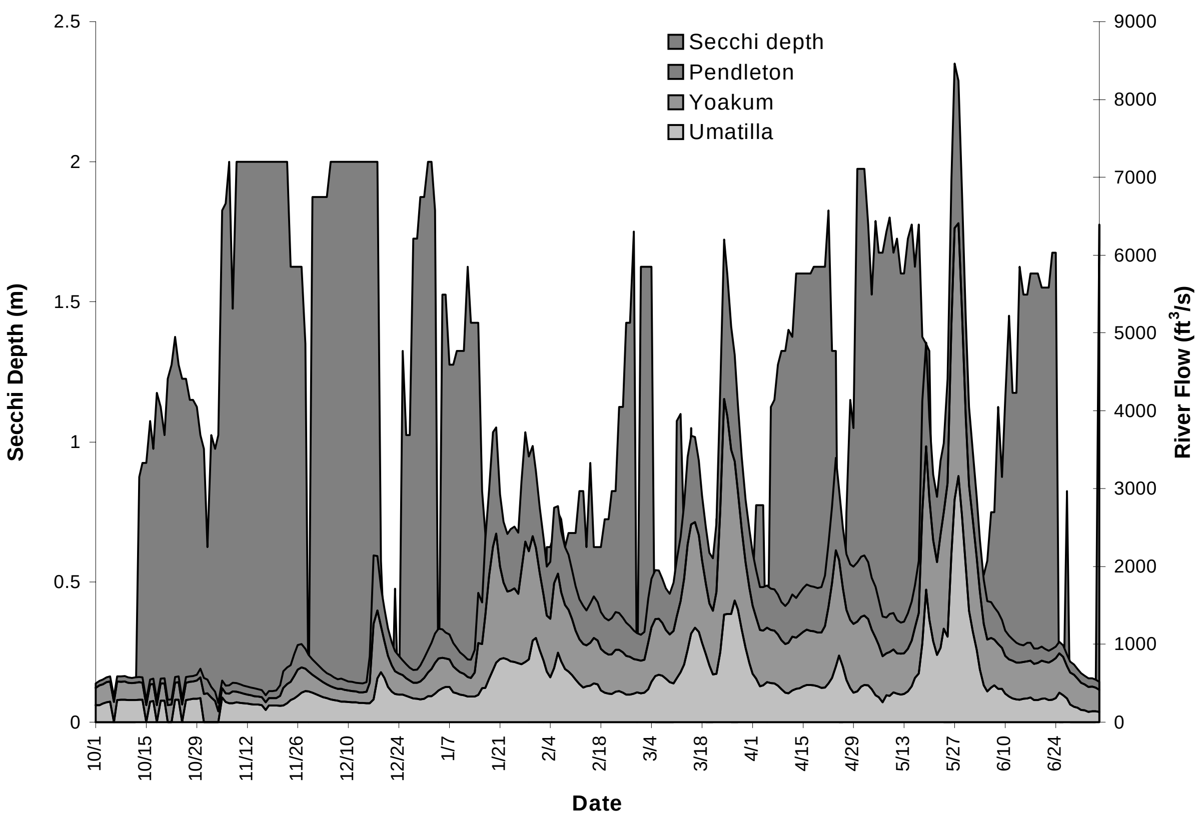


Figure 20. Mean daily river flow (ft^3/s) at three gauging stations plotted against Secchi depth (m), lower Umatilla River, October 1997 – July 1998.

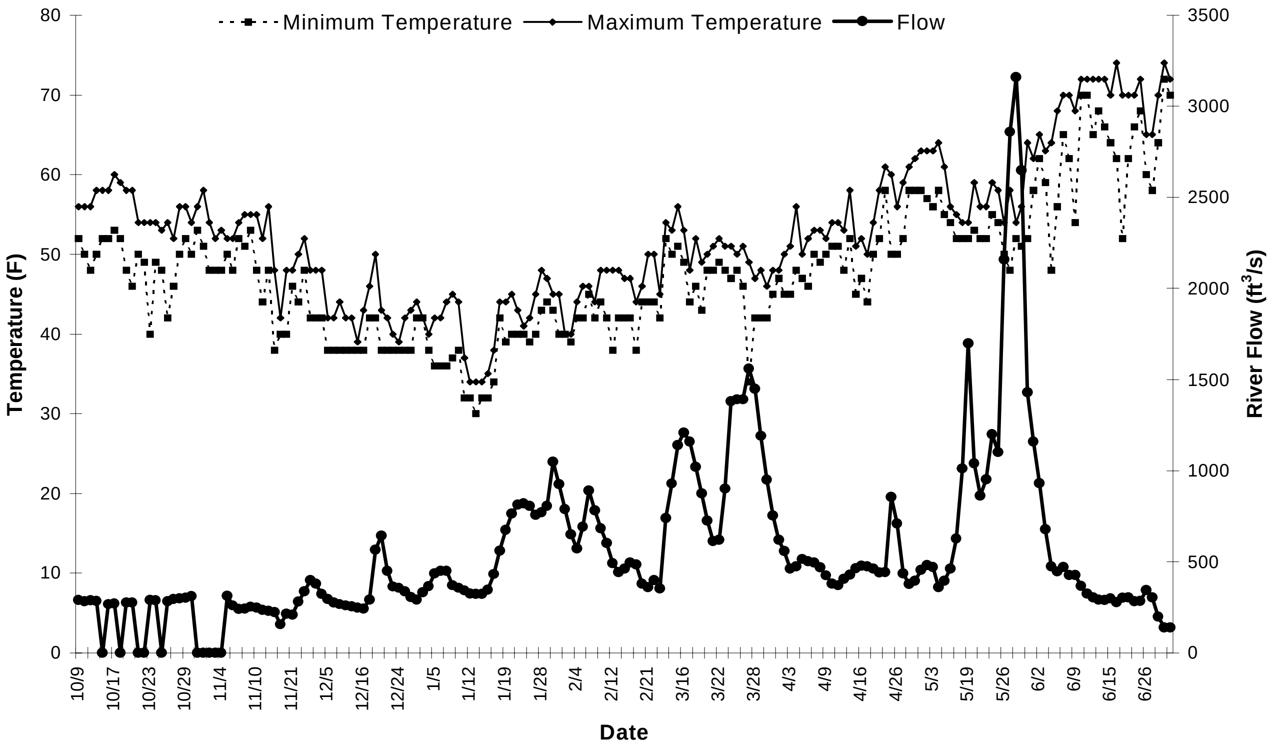
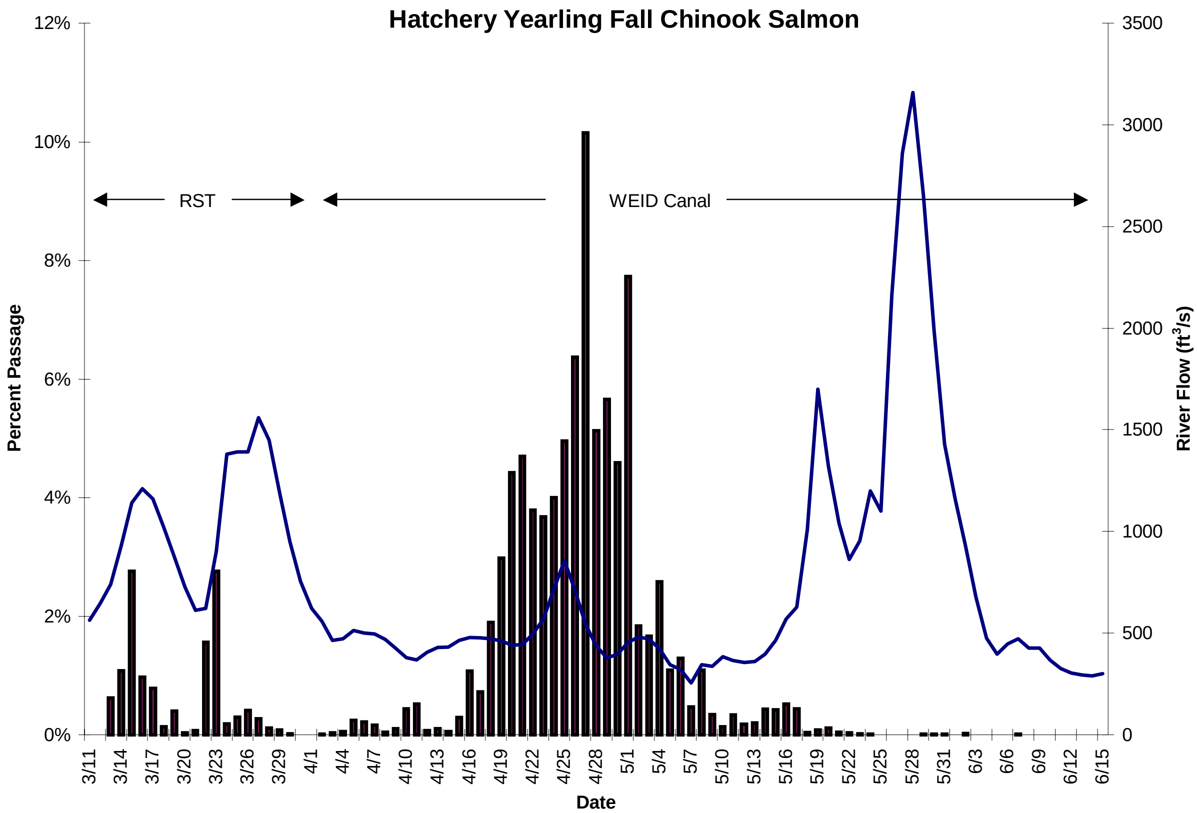


Figure 21. Maximum and minimum water temperatures (°F) plotted against river flow (ft^3/s), lower Umatilla River, October 1997 – June 1998.



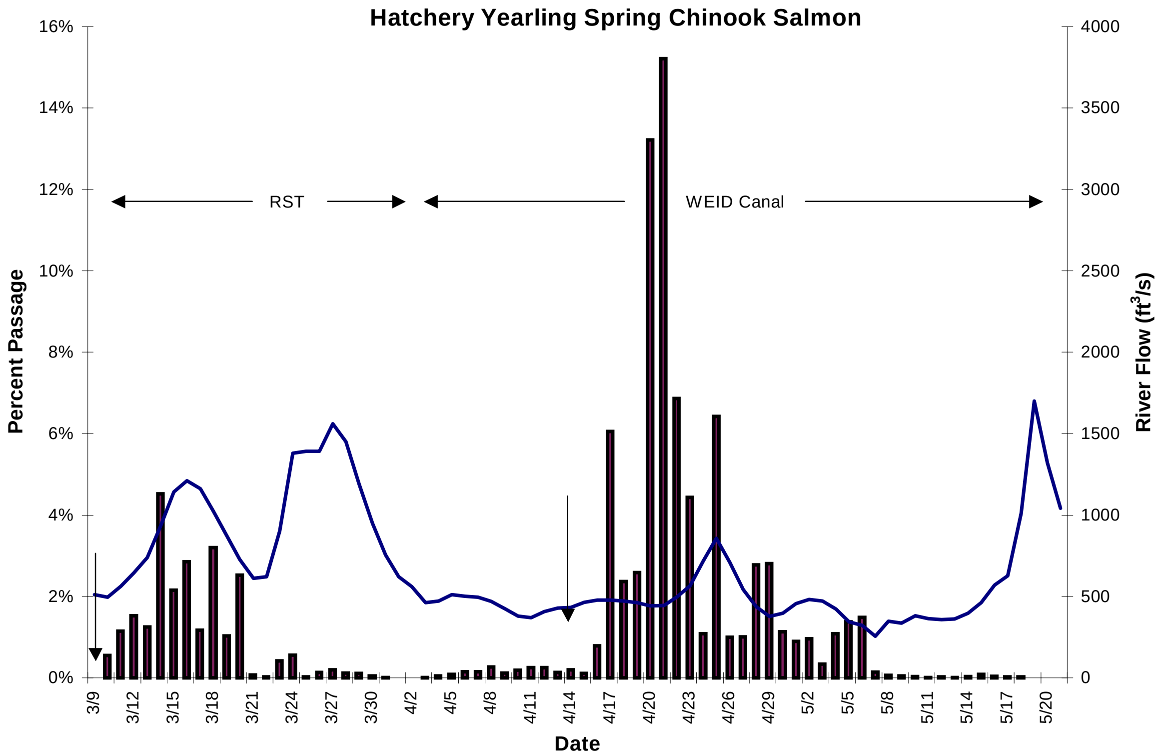


Figure 22. Daily river flow (ft^3/s) recorded at the UMAO gauging station (RM 2.1) and daily passage of hatchery yearling fall chinook and spring chinook salmon at the rotary trap (RM 1.2) and West Extension Canal (RM 3.0), lower Umatilla River, March – June 1998.

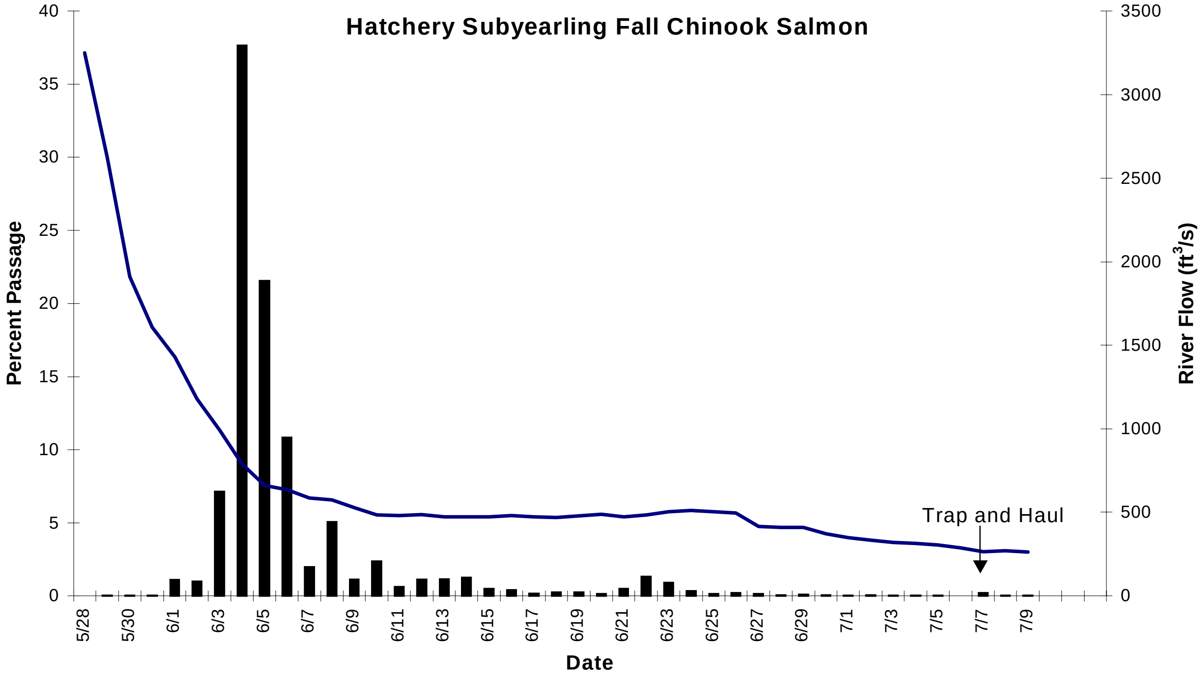


Figure 23. Daily river flow (ft^3/s) recorded at the UMAO gauging station (RM 2.1) and daily passage of hatchery subyearling fall chinook salmon at West Extension Canal (RM 3.0), lower Umatilla River, June – July 1998.

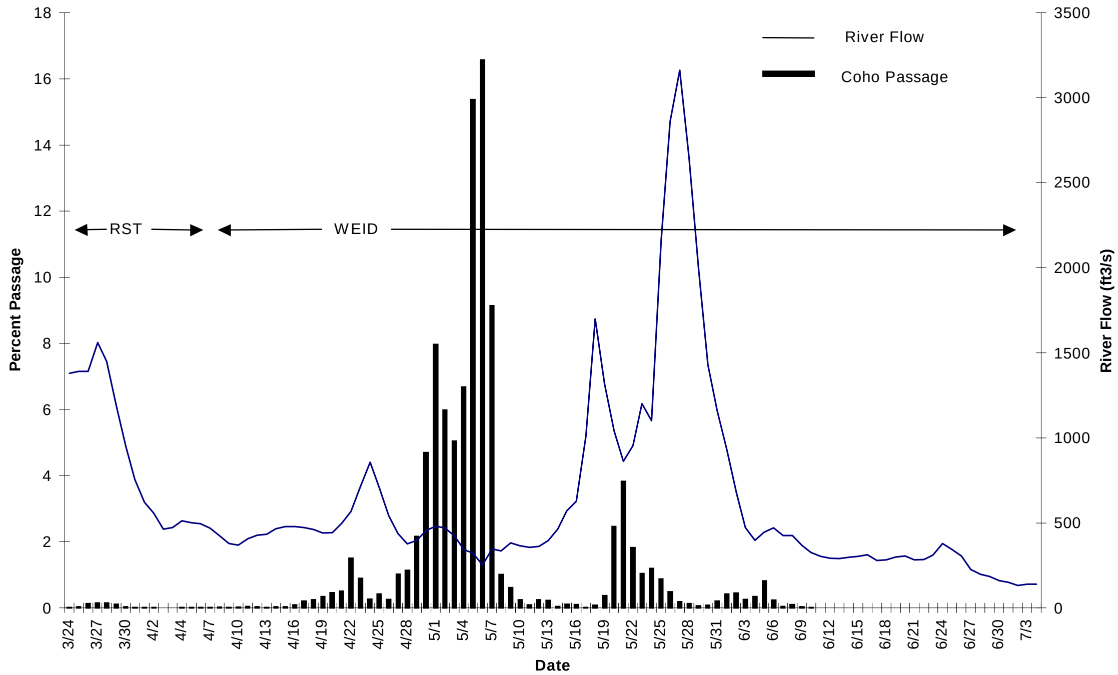


Figure 24. Daily river flow (ft^3/s) recorded at the UMAO gauging station (RM 2.1) and daily passage of hatchery coho salmon at the rotary trap (RM 1.2) and West Extension Canal (RM 3.0), lower Umatilla River, March – July 1998.

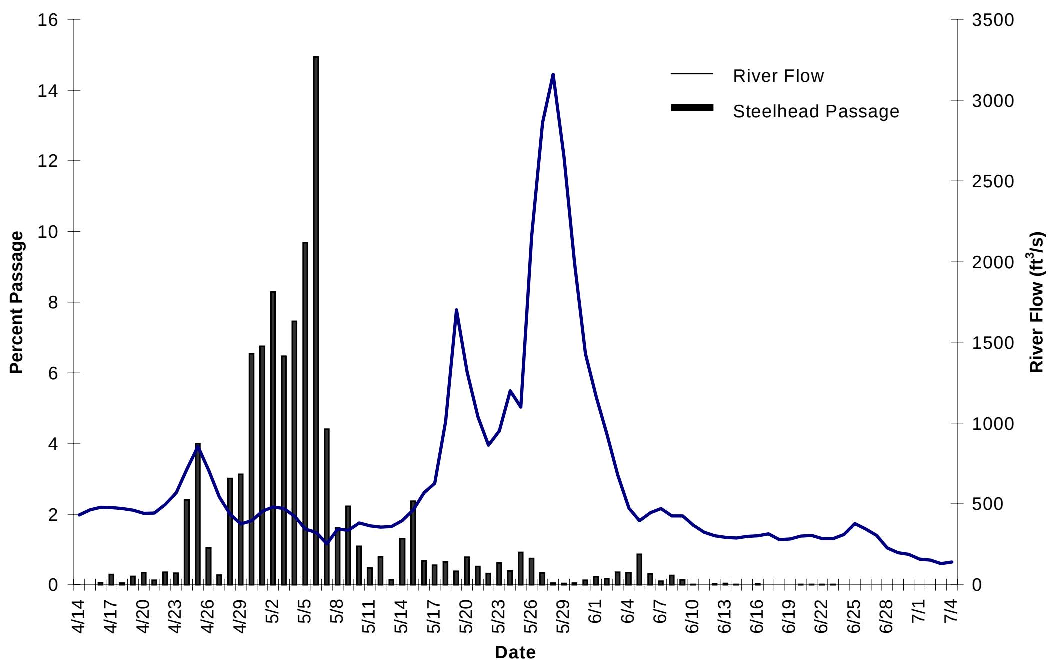


Figure 25. Daily river flow (ft^3/s) recorded at the UMAO gauging station (RM 2.1) and daily passage of hatchery summer steelhead at West Extension Canal (RM 3.0), lower Umatilla River, April – July 1998.

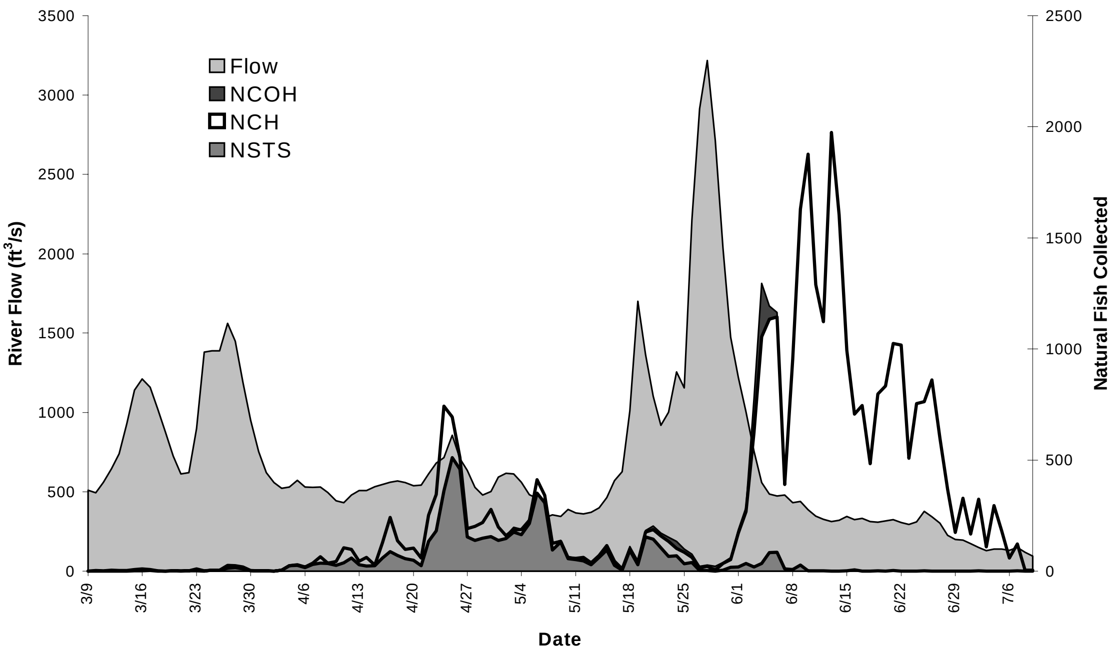


Figure 26. Daily river flow (ft^3/s) recorded at the UMAO gauging station (RM 2.1) and daily collection of natural coho salmon, chinook salmon, and summer steelhead at the rotary trap (RM 1.2) and West Extension Canal (RM 3.0), lower Umatilla River, March – July 1998.

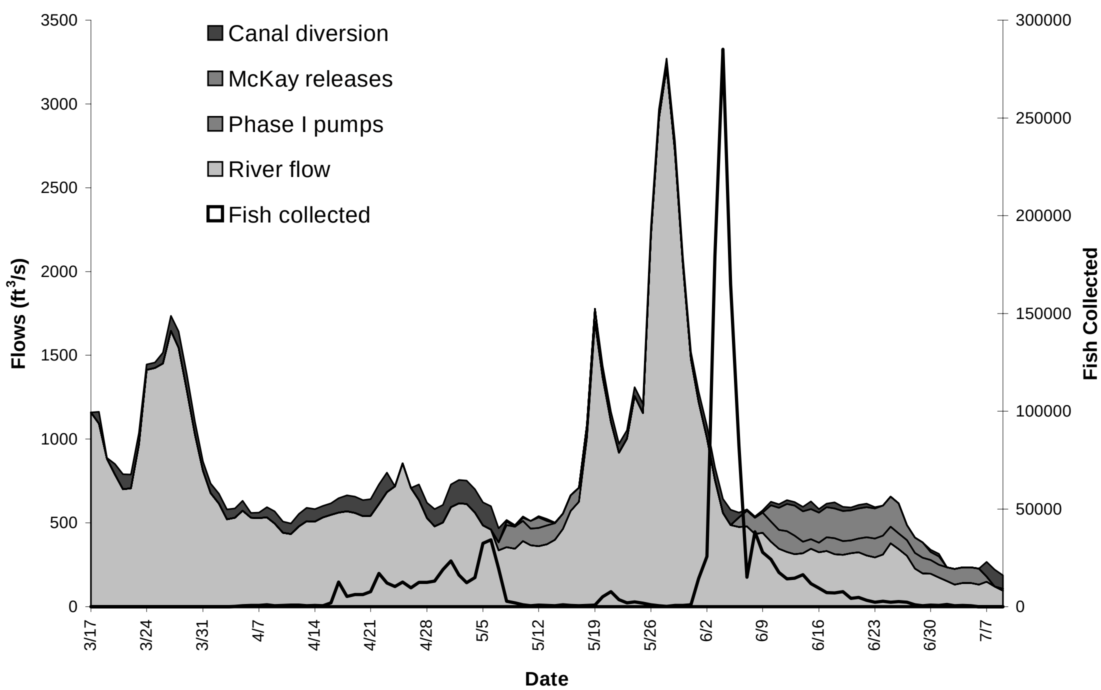


Figure 27. Mean daily flow (ft^3/s) for river discharge at UMAO (RM 2.1), Phase I exchange pumping and canal diversion at West Extension Canal (RM 3.0), McKay Reservoir water releases (RM 52.0), and total number of hatchery fish collected at West Extension Canal, lower Umatilla River, March – July 1998.

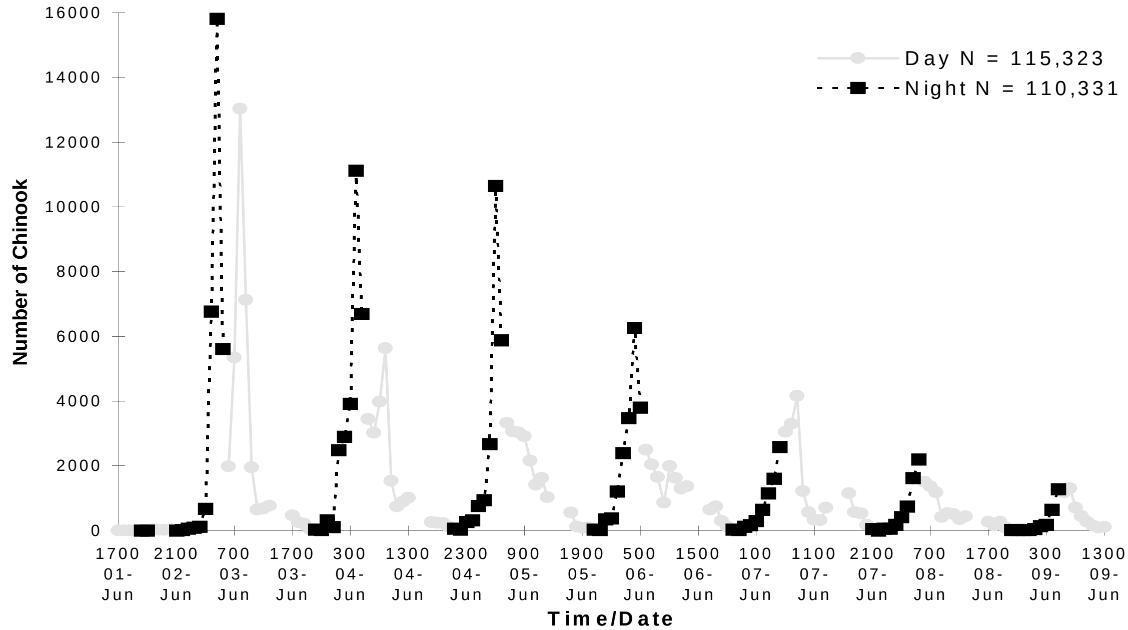


Figure 28. Hourly passage estimates of subyearling fall chinook salmon at the east-bank fish ladder at Three Mile Falls Dam as observed from video recordings, Umatilla River, 1 - 9 June 1998. Day = 0600 - 2030 hours, Night = 2030 - 0600 hours.

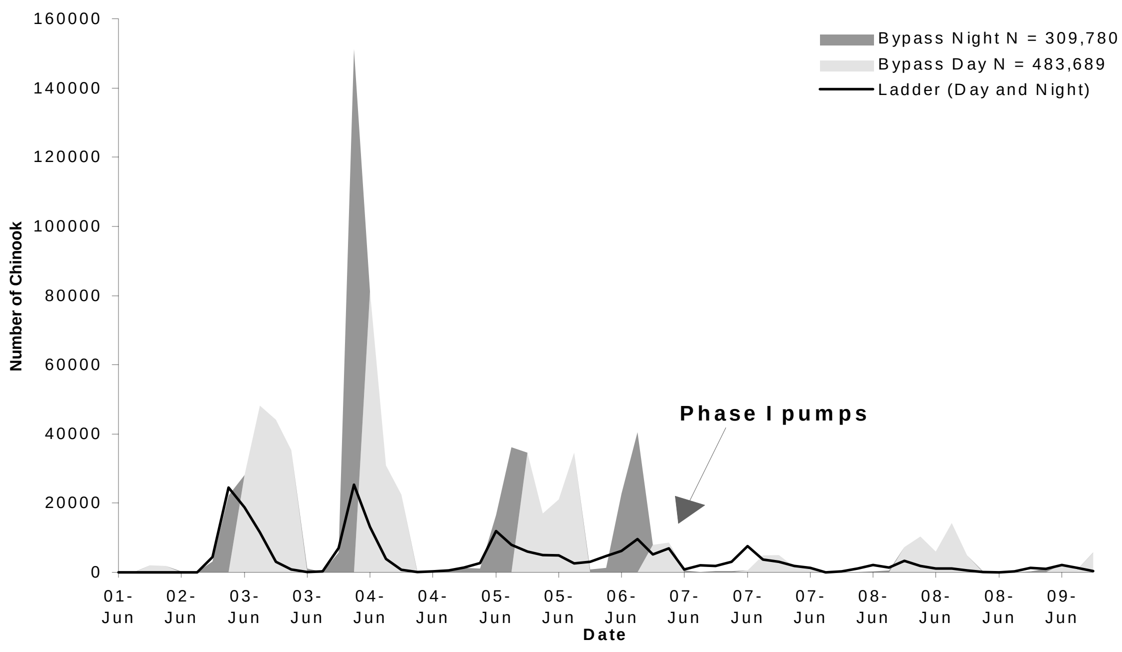


Figure 29. Daily passage estimates of subyearling fall chinook salmon at the east-bank fish ladder and the west-bank fish bypass facility at Three Mile Falls Dam (3.0), Umatilla River, 1 - 9 June 1998. Day = 0600 - 2030 hours, Night = 2030 - 0600 hours.

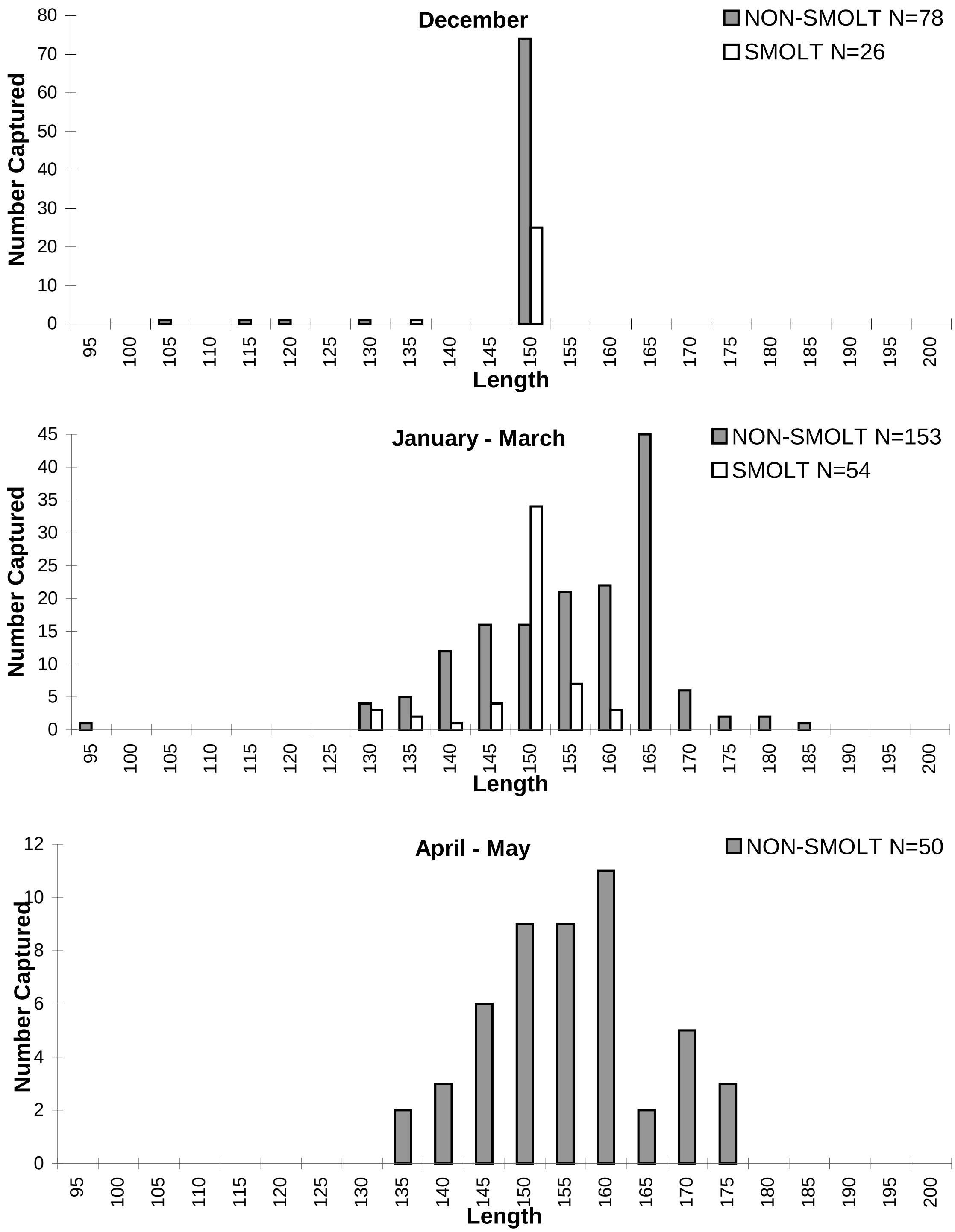


Figure 30. Length-frequency distributions by calendar quarter of juvenile lamprey, lower Umatilla River, December 1997 - May 1998. Distributions are in 5-mm increments.

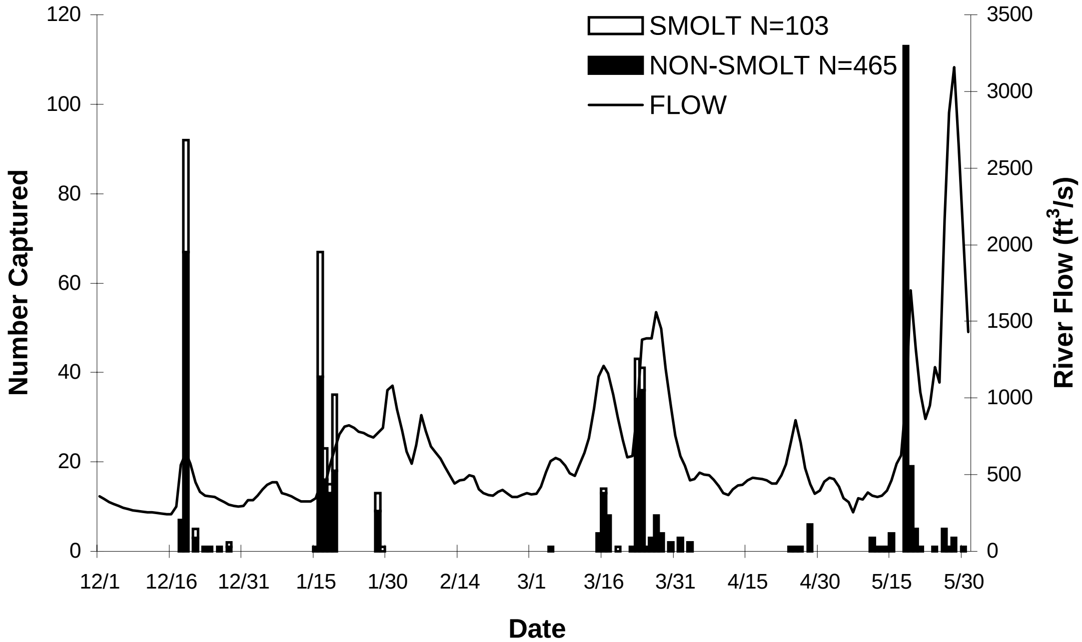


Figure 31. River flow (ft^3/s) and juvenile lamprey captured at the rotary-screw trap (RM 1.2) and West Extension Canal (RM 3.0), Umatilla River, December 1997 – May 1998.

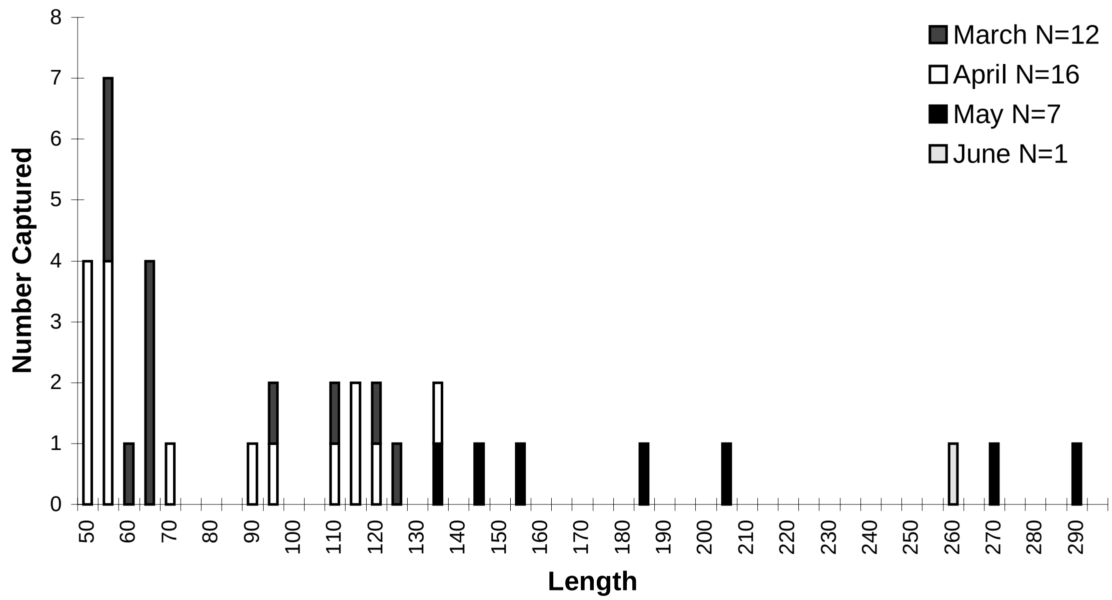


Figure 32. Length-frequency distributions by month of northern pikeminnow, lower Umatilla River, March - June 1998. Distributions are in 5-mm increments.

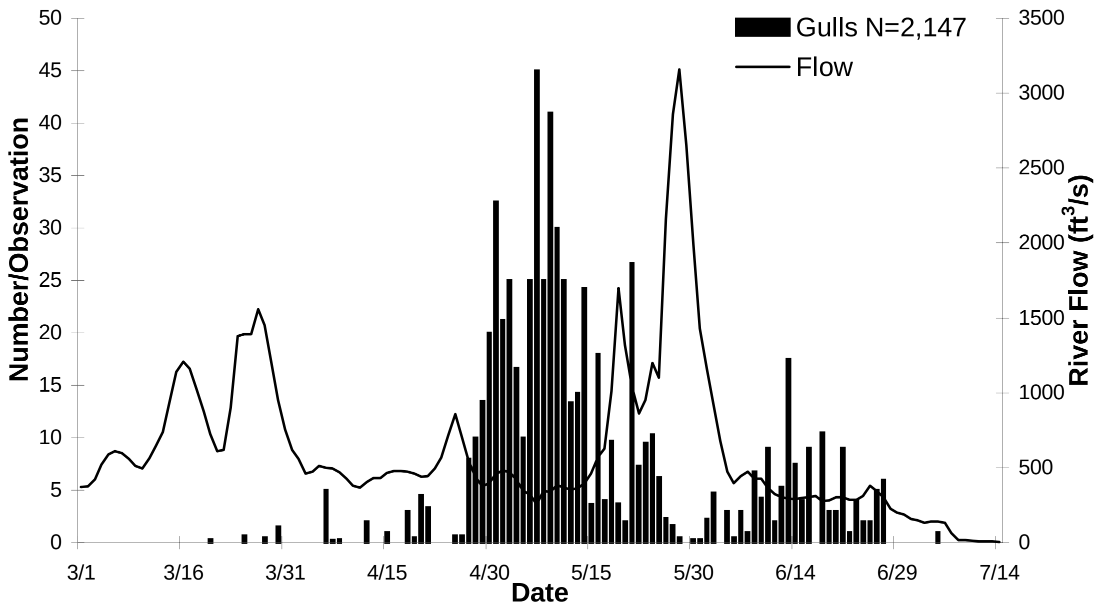


Figure 33. Number of gulls observed at trap sites per observation plotted against river flow (ft^3/s), lower Umatilla River, March - July 1998.

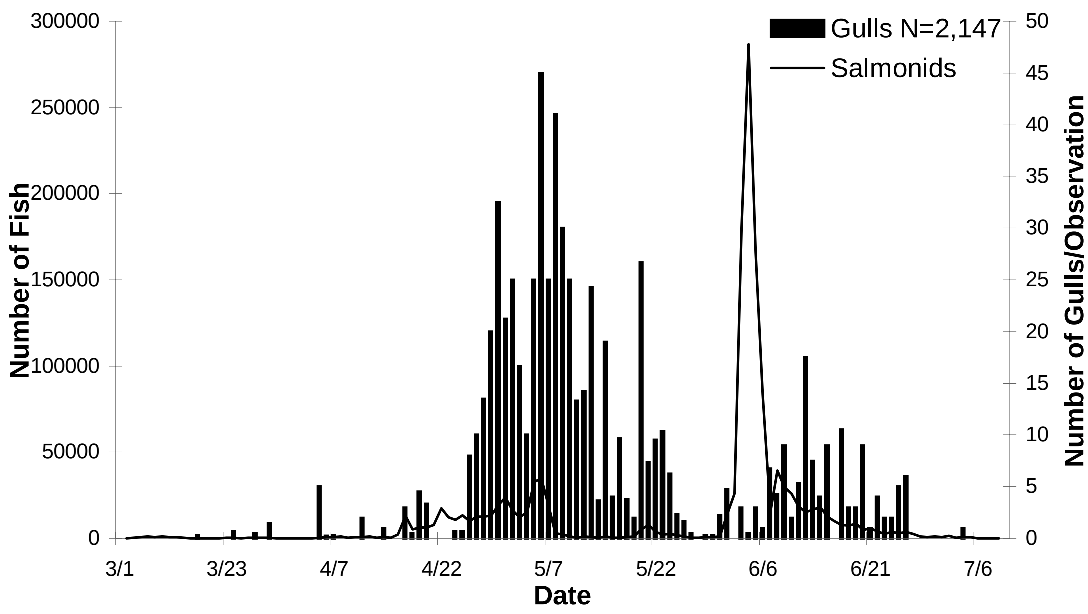


Figure 34. Total numbers of salmonids captured at trap sites plotted against number of gulls observed, lower Umatilla River, March - July 1998.

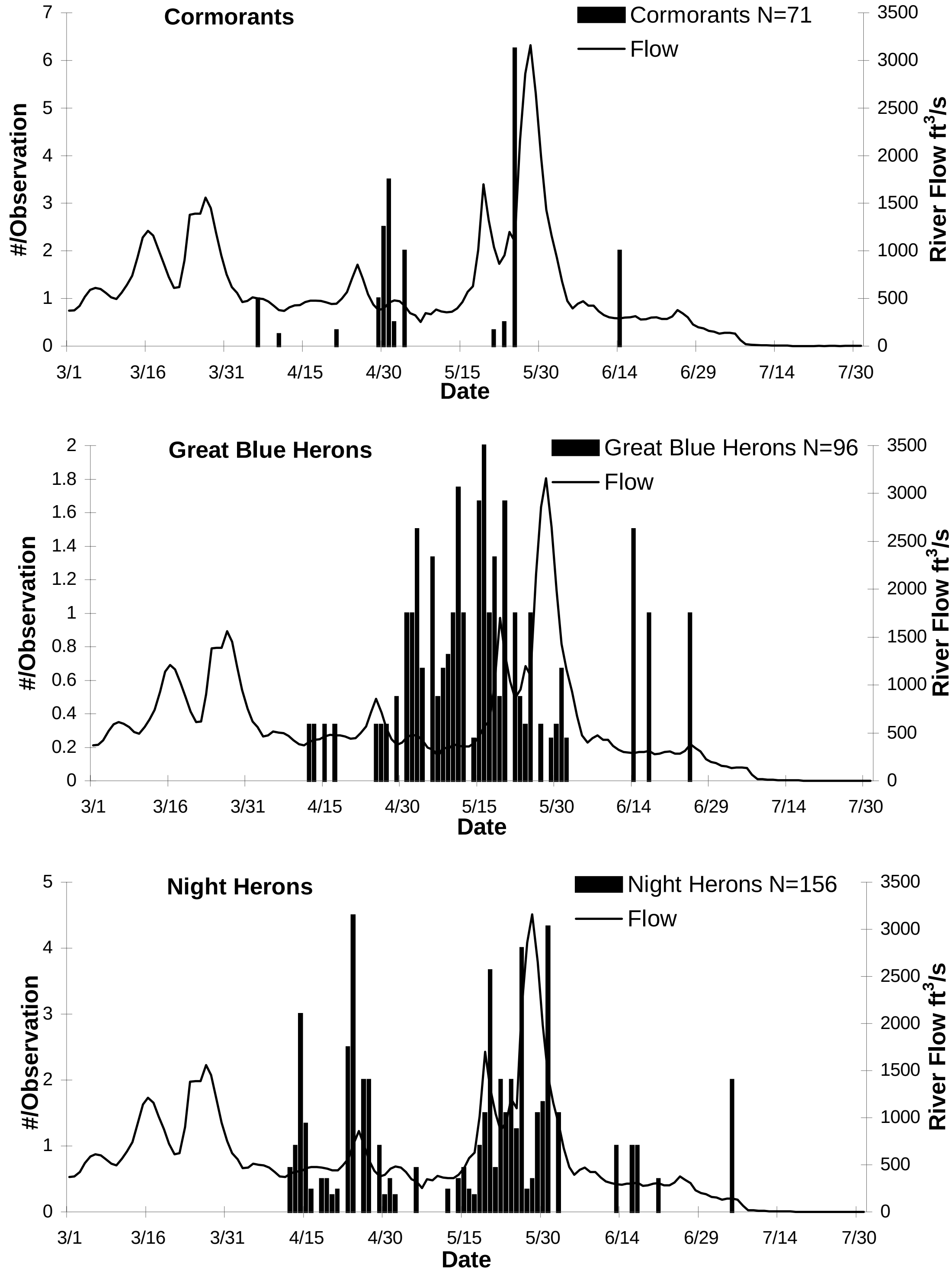


Figure 35. Number of avian predators observed at lower river trap sites and river flow (ft^3/s), lower Umatilla River, March - July 1998. Y-values < 1 result from standardizing observations.

APPENDIX A

Ancillary Information from Outmigration Studies

Appendix Table A-1. PIT-tag detections at lower Umatilla River trapping sites, mainstem Columbia River dams, and in the estuary for hatchery spring chinook and subyearling fall chinook salmon and summer steelhead released for reach-specific survival tests, spring 1998.

File name[a]	Release date	Release site	Number of detections at interrogation site					Total[c] detected	Number released	Percent detected	Mean travel speed (mi/d)		Mean travel time (days) to interrogation site		
			RST[b]	WEID[b]	JDA[b]	BON[b]	CRE[b]				RST	WEID	JDA	BON	CRE
								Spring chinook salmon							
SMF98016.YEL	3/9	Echo	1	-	10	3	2	16	76	21.1	25.5	-	37.98	39.13	49.30
SMF98016.YL2	3/10	(RM 27)	0	-	10	8	0	16	81	19.8	-	-	36.51	41.93	-
SMF98016.YL3	3/11		2	-	10	2	0	13	69	18.8	12.8	-	34.36	38.95	-
Yellow Total			**3**	**-**	**30**	**13**	**2**	**45**	**226**	**19.9**	**17.0**	**-**	**36.28**	**40.82**	**49.30**
SMF98016.PNK	3/9	Barnhart	2	-	6	6	0	11	86	12.8	13.5	-	36.65	43.03	-
SMF98016.PK2	3/10	(RM 42)	1	-	8	2	0	10	79	12.7	20.3	-	36.06	41.30	-
SMF98016.PK3	3/11		1	-	8	1	0	10	67	14.9	20.3	-	37.81	47.50	-
Pink Total			**4**	**-**	**22**	**9**	**0**	**31**	**232**	**13.4**	**16.9**	**-**	**36.86**	**43.14**	**-**
SMF98016.GRN	3/9	Imeques-C	1	-	10	4	0	12	81	14.8	15.7	-	34.60	40.53	-
SMF98016.GR2	3/10	-Minikum	1	-	4	0	1	5	80	6.3	19.6	-	36.78	-	51.30
SMF98016.GR3	3/11	(RM 80)	0	-	6	0	0	6	77	7.8	-	-	37.12	-	-
Green Total			**2**	**-**	**20**	**4**	**1**	**23**	**238**	**9.7**	**17.7**	**-**	**35.79**	**40.53**	**51.30**
								Subyearling fall chinook salmon							
SMF98127.YEL	6/1	Echo	-	8	4	4	0	16	163	9.8	-	4.1	19.10	19.33	-
SMF98127.YL2	6/2	(RM 27)	-	5	10	11	0	24	161	14.9	-	3.1	17.68	16.52	-
SMF98127.YL3	6/3		-	3	9	4	0	16	181	8.8	-	3.9	18.49	20.65	-
Yellow Total			**-**	**16**	**23**	**19**	**0**	**56**	**505**	**11.1**	**-**	**3.3**	**18.24**	**17.98**	**-**
SMF98127.GRN	6/1	Reith	-	6	8	10	0	20	164	12.2	-	8.0	19.10	19.40	-
SMF98127.GR2	6/2	(RM 48)	-	7	2	2	0	11	169	6.5	-	12.8	19.45	18.26	-
SMF98127.GR3	6/3		-	9	8	4	0	20	185	10.8	-	13.0	22.82	14.65	-
Green Total			**-**	**22**	**18**	**16**	**0**	**51**	**518**	**9.8**	**-**	**11.6**	**20.79**	**18.07**	**-**

[a] *File name extension represents the color applied to the anal fin of the specific tag group.*

[b] *RST = rotary trap (RM 1.2 on Umatilla River), WEID = West Extension Irrigation Canal (RM 3 on Umatilla River), JDA = John Day Dam (RM 216), BON = Bonneville Dam (RM 145), CRE = Columbia River Estuary (RM).*

[c] *Total number detected = the total number of fish detected minus duplicate tag detections.*

Appendix Table A-1. Continued

File name[a]	Release date	Release site	Number of detections at interrogation site: RST[b]	WEID[b]	JDA[b]	BON[b]	CRE[b]	Total[c] detected	Number released	Percent detected	Mean travel speed (mi/d): RST	WEID	Mean travel time (days) to interrogation site: JDA	BON	CRE
							Subyearling fall chinook salmon								
SMF98124.PNK	6/1	Imeques-C	-	6	14	4	0	22	163	13.5	-	10.5	18.63	26.76	-
SMF98124.PK2	6/2	-Minikum	-	8	5	3	0	15	167	9.0	-	10.8	29.50	19.37	-
SMF98124.PK3	6/3	(RM 80)	-	5	5	2	0	12	161	7.5	-	6.4	30.16	17.70	-
Pink Total			-	**19**	**24**	**9**	**0**	**49**	**491**	**10.0**	-	**8.4**	**23.30**	**22.28**	-
SMF98127.188	7/7	Westland	-	-	0	0	0	0	164	0.0	-	-	-	-	-
SMF98127.189	7/8	Trap	-	-	1	1	0	2	168	1.2	-	-	7.13	8.46	-
SMF98127.190	7/9	(RM 27)	-	-	0	0	0	0	149	0.0	-	-	-	-	-
Westland Total			-		**1**	**1**	**0**	**2**	**481**	**0.4**	-	**-**	**7.13**	**8.46**	-
							Summer steelhead (large grade)								
SMF98063.YEL	4/15	Echo	-	0	4	5	0	9	41	22.0	-	-	24.78	29.74	-
SMF98063.YL2	4/16	(RM 27)	-	2	14	7	0	20	85	23.5	-	1.8	21.95	24.81	-
SMF98063.YL3	4/17		-	4	15	4	1	20	82	24.4	-	4.9	21.52	23.63	28.90
Yellow Total			-	**6**	**33**	**16**	**1**	**49**	**208**	**23.6**	-	**3.9**	**22.10**	**26.06**	**28.90**
SMF98063.PNK	4/15	Reith	-	1	8	5	0	13	45	28.9	-	1.4	30.68	34.90	-
SMF98063.PK2	4/16	(RM 48)	-	3	12	14	0	26	91	28.6	-	3.7	23.86	25.33	-
SMF98063.PK3	4/17		-	4	14	8	0	24	92	26.1	-	8.7	24.49	27.35	-
Pink Total			-	**8**	**34**	**27**	**0**	**63**	**228**	**27.6**	-	**5.9**	**25.73**	**27.70**	-
SMF98064.ORG	4/15	Minthorn	-	0	2	1	0	3	15	20.0	-	-	35.80	23.90	-
SMF98064.OR2	4/16	(RM 64.5)	-	2	10	4	0	16	94	17.0	-	4.2	31.23	29.95	-
SMF98064.OR3	4/17		-	2	14	7	0	21	97	21.6	-	2.8	26.41	28.91	-
Orange Total			-	**4**	**26**	**12**	**0**	**40**	**206**	**19.4**	-	**3.5**	**28.98**	**28.84**	-
SMF98063.GRN	4/15	Bonifer	-	0	2	2	0	4	39	10.3	-	-	36.95	27.65	-
SMF98063.GR2	4/16	(RM 79[d])	-	1	10	1	0	12	69	17.4	-	5.2	32.01	39.00	-
SMF98063.GR3	4/17		-	3	17	9	0	25	132	18.9	-	5.3	30.42	31.04	-
Green Total			-	**4**	**29**	**12**	**0**	**41**	**240**	**17.1**	-	**5.3**	**31.42**	**31.14**	-

Appendix Table A-1. Continued

File name[a]	Release date	Release site	Number of detections at interrogation site: RST[b]	WEID[b]	JDA[b]	BON[b]	CRE[b]	Total[c] detected	Number released	Percent detected	Mean travel speed (mi/d): RST	WEID	Mean travel time (days) to interrogation site: JDA	BON	CRE
Summer steelhead (small grade)															
SMF98098.MYL	5/11	Echo	-	5	10	6	0	18	80	22.5	-	3.0	18.15	19.90	-
SMF98098.MY2	5/12	(RM 27)	-	2	6	2	0	9	81	11.1	-	5.0	14.47	17.70	-
SMF98098.MY3	5/13		-	0	13	3	0	15	79	19.0	-	-	15.40	14.60	-
Dark Yellow Total			-	**7**	**29**	**11**	**0**	**42**	**240**	**17.5**		**3.6**	**16.16**	**18.05**	-
SMF98098.RED	5/11	Reith	-	2	5	2	0	9	79	11.4	-	11.3	15.96	24.60	-
SMF98098.RE2	5/12	(RM 48)	-	3	11	5	0	18	87	20.7	-	3.4	15.88	15.32	-
SMF98098.RE3	5/13		-	2	8	3	0	12	73	16.4	-	2.3	18.68	23.27	-
Red Total			-	**7**	**24**	**10**	**0**	**39**	**239**	**16.3**		**5.3**	**16.83**	**19.56**	-
SMF98098.PUP	5/11	Bonifer	-	1	11	0	0	11	79	13.9	-	3.7	18.46	-	-
SMF98098.PU2	5/12	(RM 79[d])	-	2	7	6	0	13	82	15.9	-	8.2	15.99	15.86	-
SMF98098.PU3	5/13		-	1	4	1	0	6	60	10.0	-	4.1	21.06	16.33	-
Purple Total			-	**4**	**22**	**7**	**0**	**30**	**221**	**13.6**		**6.1**	**18.15**	**15.93**	-

[d] *Rivermile 2 of Meacham Creek which flows into the Umatilla River at rivermile 79.*

Appendix Table A-2. Condition of hatchery juvenile salmonids collected at RM 1.2, RM 3.0, and RM 27.3 on the Umatilla River, March – August 1998.

	Species[a] and Condition[b]																			
	COHO				CHS				CHF				CHF0				STS			
Date	G	P	D	M	G	P	D	M	G	P	D	M	G	P	D	M	G	P	D	M
3/9	-	-	-	-	1	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-
3/10	-	-	-	-	269	23	0	0	-	-	-	-	-	-	-	-	-	-	-	-
3/11	-	-	-	-	271	21	0	0	-	-	-	-	-	-	-	-	-	-	-	-
3/12	-	-	-	-	558	31	1	0	-	-	-	-	-	-	-	-	-	-	-	-
3/13	-	-	-	-	430	23	1	2	-	-	-	-	-	-	-	-	-	-	-	-
3/14	-	-	-	-	698	43	0	0	34	1	0	0	-	-	-	-	-	-	-	-
3/15	-	-	-	-	276	15	2	0	53	0	0	0	-	-	-	-	-	-	-	-
3/16	-	-	-	-	348	21	1	0	97	3	2	0	-	-	-	-	-	-	-	-
3/17	-	-	-	-	203	8	3	0	69	3	1	0	-	-	-	-	-	-	-	-
3/18	-	-	-	-	50	7	1	0	17	3	3	0	-	-	-	-	-	-	-	-
3/19	-	-	-	-	17	2	0	0	4	0	0	0	-	-	-	-	-	-	-	-
3/20	-	-	-	-	40	6	0	1	10	0	0	2	-	-	-	-	-	-	-	-
3/21	-	-	-	-	18	4	1	0	2	0	0	0	-	-	-	-	-	-	-	-
3/22	-	-	-	-	4	1	1	0	5	0	0	0	-	-	-	-	-	-	-	-
3/23	-	-	-	-	104	12	1	5	50	3	2	3	-	-	-	-	-	-	-	-
3/24	2	0	1	0	38	30	8	0	42	15	0	0	-	-	-	-	-	-	-	-
3/25	55	2	0	0	6	2	0	0	13	0	0	0	-	-	-	-	-	-	-	-
3/26	216	9	2	0	39	4	0	0	44	3	2	0	-	-	-	-	-	-	-	-
3/27	228	33	2	0	56	11	3	0	27	1	1	0	-	-	-	-	-	-	-	-
3/28	233	17	2	1	33	7	2	0	14	0	0	0	-	-	-	-	-	-	-	-
3/29	181	10	3	2	32	3	1	0	5	1	1	0	-	-	-	-	-	-	-	-
3/30	49	2	0	0	17	0	0	0	5	1	0	0	-	-	-	-	-	-	-	-
3/31	14	3	0	0	4	0	0	0	1	0	0	0	-	-	-	-	-	-	-	-
4/1	10	0	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/2	10	1	0	0	0	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-
4/3	6	0	0	0	17	1	0	1	4	0	2	1	-	-	-	-	-	-	-	-
4/4	11	0	2	0	80	10	1	0	27	4	1	1	-	-	-	-	-	-	-	-
4/5	10	1	0	0	150	12	9	1	159	0	4	0	-	-	-	-	-	-	-	-
4/6	13	0	1	0	157	16	9	1	323	9	3	0	-	-	-	-	-	-	-	-
4/7	7	0	2	0	153	29	3	0	155	12	1	0	-	-	-	-	-	-	-	-
4/8	29	1	0	1	310	13	4	1	185	5	0	1	-	-	-	-	-	-	-	-
4/9	8	1	0	0	208	14	4	1	75	3	3	1	-	-	-	-	-	-	-	-
4/10	27	0	1	0	361	12	4	0	201	4	2	1	-	-	-	-	-	-	-	-
4/11	64	1	1	0	467	11	4	1	232	3	2	0	-	-	-	-	-	-	-	-
4/12	32	1	1	0	200	11	6	0	79	5	2	0	-	-	-	-	-	-	-	-
4/13	13	1	1	0	131	22	3	0	35	9	0	0	-	-	-	-	-	-	-	-
4/14	39	1	0	0	272	13	4	1	116	3	1	0	-	-	-	-	1	0	0	0
4/15	53	1	1	0	177	8	3	0	78	1	0	0	-	-	-	-	1	0	0	0
4/16	139	0	0	0	965	5	0	0	327	6	3	2	-	-	-	-	7	1	0	0
4/17	42	0	0	0	1057	19	10	3	91	9	3	0	-	-	-	-	10	1	0	0
4/18	24	3	0	0	6934	9	0	0	64	2	1	0	-	-	-	-	7	0	0	0

[a] *COHO = yearling coho salmon, CHS = yearling spring chinook salmon, CHF = yearling fall chinook salmon, CHF0 = subyearling fall chinook salmon, STS = summer steelhead.*

[b] *G = Good (minimal scale loss), P = Partial scale loss, D = Descaled, M = Mortality.*

Appendix Table A-2. Continued.

	Species[a] and Condition[b]																			
	COHO				CHS				CHF				CHF0				STS			
Date	G	P	D	M	G	P	D	M	G	P	D	M	G	P	D	M	G	P	D	M
4/19	213	10	1	0	5755	21	5	12	130	6	0	5	-	-	-	-	11	3	0	0
4/20	208	5	2	1	614	34	2	1	238	132	3	4	-	-	-	-	16	4	1	2
4/21	47	0	0	1	112	7	1	1	175	1	0	2	-	-	-	-	12	0	0	0
4/22	73	4	4	0	198	6	1	0	298	4	2	0	-	-	-	-	7	1	0	1
4/23	60	1	0	0	188	9	0	1	310	9	2	2	-	-	-	-	5	0	0	0
4/24	18	2	1	0	205	12	5	1	210	6	1	2	-	-	-		12	1	0	1
4/25	80	2	0	0	375	7	2	2	141	5	3	10	-	-	-	-	97	11	3	4
4/26	27	3	1	1	204	17	5	0	306	29	7	9	-	-	-	-	22	7	0	0
4/27	392	5	1	0	539	30	10	3	1350	80	16	3	-	-	-	-	32	2	3	1
4/28	54	3	1	1	42	2	2	3	103	14	2	34	-	-	-	-	14	6	2	1
4/29	169	12	2	21	140	12	3	6	137	20	6	11	-	-	-	-	19	2	3	0
4/30	153	148	0	0	127	5	3	1	165	8	1	8	-	-	-	-	37	2	0	1
5/01	307	19	8	14	128	16	0	2	232	20	6	28	-	-	-	-	38	3	1	0
5/02	745	17	4	16	207	5	6	4	317	20	3	17	-	-	-	-	50	6	0	0
5/03	1555	15	7	1	176	3	4	0	290	25	6	8	-	-	-	-	36	8	3	3
5/04	1329	8	3	11	158	3	0	0	344	45	5	24	-	-	-	-	29	9	1	1
5/05	990	39	22	13	83	1	2	2	291	30	8	27	-	-	-	-	38	12	3	0
5/06	1344	35	9	9	60	4	1	1	178	14	6	8	-	-	-	-	36	9	2	0
5/07	922	0	20	9	21	1	0	0	133	17	13	16	-	-	-	-	51	35	4	1
5/08	267	20	8	2	26	2	1	0	147	11	6	7	-	-	-	-	49	4	4	1
5/09	665	23	4	0	68	1	3	1	344	21	3	5	-	-	-	-	183	12	1	1
5/10	459	9	4	0	59	7	1	0	249	13	13	1	-	-	-	-	108	10	6	1
5/11	166	7	4	1	18	2	1	2	81	9	17	1	-	-	-	-	36	13	5	0
5/12	415	6	5	4	40	3	1	0	235	9	17	1	-	-	-	-	54	24	9	0
5/13	287	20	5	0	26	0	1	1	116	14	11	2	-	-	-	-	26	7	3	0
5/14	60	20	0	1	51	13	3	0	214	28	16	1	-	-	-	-	49	14	2	0
5/15	139	4	2	1	40	3	0	0	141	17	8	1	-	-	-	-	98	11	3	0
5/16	180	1	0	0	69	2	0	0	200	3	7	0	-	-	-	-	31	3	1	0
5/17	22	1	1	0	42	0	0	0	250	4	5	0	-	-	-	-	26	1	2	0
5/18	146	2	1	1	30	2	0	0	203	13	1	1	-	-	-	-	228	24	7	1
5/19	397	33	12	1	1	0	0	0	17	1	0	0	-	-	-	-	97	47	15	0
5/20	456	38	4	20	1	0	0	0	18	1	1	1	1	0	0	0	94	8	6	2
5/21	1103	48	24	4	1	0	0	0	12	2	1	0	-	-	-	-	98	6	1	0
5/22	1000	99	40	0	-	-	-	-	11	0	1	0	-	-	-	-	71	4	12	0
5/23	539	35	21	1	-	-	-	-	7	0	1	0	1	0	0	0	35	7	4	0
5/24	1281	72	23	1	-	-	-	-	6	1	1	1	-	-	-	-	80	9	10	0
5/25	785	47	28	0	-	-	-	-	2	0	1	0	-	-	-	-	47	6	2	0
5/26	435	21	40	0	-	-	-	-	1	0	0	0	-	-	-	-	33	6	2	1
5/27	193	27	8	0	-	-	-	-	-	-	-	-	-	-	-	-	10	6	0	0
5/28	110	26	12	0	-	-	-	-	-	-	-	-	-	-	-	-	5	1	0	0
5/29	106	13	3	0	-	-	-	-	-	-	-	-	307	3	0	1	4	2	0	0
5/30	68	4	1	1	-	-	-	-	1	0	0	0	393	7	0	1	7	1	0	0
5/31	224	22	7	0	-	-	-	-	0	0	1	0	1041	24	5	2	22	0	1	0
6/01	173	7	1	1	-	-	-	-	-	-	-	-	1294	5	4	7	13	5	1	0
6/02	52	4	3	0	-	-	-	-	-	-	-	-	1593	5	10	10	8	2	0	0

Appendix Table A-2. Continued.

Date	COHO G	COHO P	COHO D	COHO M	CHS G	CHS P	CHS D	CHS M	CHF G	CHF P	CHF D	CHF M	CHF0 G	CHF0 P	CHF0 D	CHF0 M	STS G	STS P	STS D	STS M
	Species[a] and Condition[b]																			
6/03	26	1	0	0	-	-	-	-	2	0	0	0	3794	3	1	19	1	0	0	0
6/04	21	2	1	0	-	-	-	-	-	-	-	-	3172	6	2	1	2	0	0	0
6/05	98	5	4	1	-	-	-	-	1	0	0	0	5660	2	2	2	25	2	1	0
6/06	29	3	0	0	-	-	-	-	-	-	-	-	1049	9	0	14	5	0	0	0
6/07	20	0	1	0	-	-	-	-	-	-	-	-	905	11	5	7	8	1	0	0
6/08	15	0	7	0	-	-	-	-	0	1	0	0	3302	54	2	2	12	0	1	0
6/09	10	0	2	0	-	-	-	-	-	-	-	-	2881	37	4	1	2	0	0	0
6/10	3	0	0	0	-	-	-	-	-	-	-	-	2992	63	7	2	0	1	0	0
6/11	-	-	-	-	-	-	-	-	-	-	-	-	1794	35	13	1	-	-	-	-
6/12	-	-	-	-	-	-	-	-	-	-	-	-	160	90	10	1	0	1	0	0
6/13	2	0	0	0	-	-	-	-	-	-	-	-	26	58	11	5	0	0	1	0
6/14	-	-	-	-	-	-	-	-	-	-	-	-	45	20	3	4	-	-	-	-
6/15	1	0	0	0	-	-	-	-	1	0	0	0	1238	107	30	3	-	-	-	-
6/16	4	0	0	0	-	-	-	-	-	-	-	-	1910	358	56	0	2	0	0	0
6/17	0	1	0	0	-	-	-	-	-	-	-	-	1452	289	67	0	-	-	-	-
6/18	-	-	-	-	-	-	-	-	-	-	-	-	1211	353	55	0	-	-	-	-
6/19	-	-	-	-	-	-	-	-	-	-	-	-	478	1046	58	0	-	-	-	-
6/20	2	0	0	0	-	-	-	-	-	-	-	-	23	59	6	0	0	1	0	0
6/21	3	0	0	0	-	-	-	-	-	-	-	-	180	75	20	0	1	1	0	0
6/22	-	-	-	-	-	-	-	-	-	-	-	-	21	17	3	0	1	0	0	0
6/23	-	-	-	-	-	-	-	-	-	-	-	-	661	164	43	0	1	0	0	0
6/24	-	-	-	-	-	-	-	-	-	-	-	-	1046	148	53	2	-	-	-	-
6/25	1	0	0	0	-	-	-	-	-	-	-	-	35	5	0	5	1	0	0	0
6/26	2	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/27	2	0	0	0	-	-	-	-	-	-	-	-	1	0	0	0	-	-	-	-
6/28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/29	-	-	-	-	-	-	-	-	-	-	-	-	0	2	0	0	-	-	-	-
6/30	2	0	0	0	-	-	-	-	-	-	-	-	1	0	0	0	-	-	-	-
7/02	1	1	0	0	-	-	-	-	-	-	-	-	2	0	0	7	-	-	-	-
7/03	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	8	-	-	-	-
7/04	-	-	-	-	-	-	-	-	-	-	-	-	18	23	10	6	-	-	-	-
7/05	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	7	-	-	-	-
7/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/07	-	-	-	-	-	-	-	-	-	-	-	-	5	6	6	4	-	-	-	-
7/08	-	-	-	-	-	-	-	-	-	-	-	-	1	0	1	15	-	-	-	-
7/09	-	-	-	-	-	-	-	-	-	-	-	-	5	6	3	1	-	-	-	-
7/10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/14	-	-	-	-	-	-	-	-	-	-	-	-	16	36	8	7	-	-	-	-
7/15	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-
7/16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/17	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	1	-	-	-	-
7/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

.

Appendix Table A-2. Continued.

Date	COHO G	COHO P	COHO D	COHO M	CHS G	CHS P	CHS D	CHS M	CHF G	CHF P	CHF D	CHF M	CHF0 G	CHF0 P	CHF0 D	CHF0 M	STS G	STS P	STS D	STS M
7/19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/20	-	-	-	-	-	-	-	-	-	-	-	-	1	2	3	0	-	-	-	-
7/21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/22	-	-	-	-	-	-	-	-	-	-	-	-	16	27	0	8	-	-	-	-
7/23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/27	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	0	-	-	-	-
7/28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/29	-	-	-	-	-	-	-	-	-	-	-	-	20	12	5	1	0	0	1	0
7/30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03	1	0	0	0	-	-	-	-	-	-	-	-	28	16	2	0	-	-	-	-
8/04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/05	-	-	-	-	-	-	-	-	-	-	-	-	8	2	1	0	-	-	-	-
8/06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/10	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	0	-	-	-	-

Species[a] and Condition[b]

Appendix Table A-3. Condition of natural juvenile salmonids collected at RM 1.2, RM 3.0, and RM 27.3 on the Umatilla River, December 1997 - August 1998.

	Species and Condition[a]											
	Chinook				Coho				Steelhead			
Date	G	P	D	M	G	P	D	M	G	P	D	M
12/21	1	0	0	0	-	-	-	-	-	-	-	-
12/23	1	0	0	0	-	-	-	-	-	-	-	-
12/24	1	0	0	0	-	-	-	-	-	-	-	-
1/11	1	0	0	0	-	-	-	-	-	-	-	-
2/1	1	0	0	0	-	-	-	-	-	-	-	-
2/2	2	0	0	0	-	-	-	-	-	-	-	-
2/3	1	1	0	0	-	-	-	-	-	-	-	-
2/8	1	0	0	0	-	-	-	-	-	-	-	-
3/10	2	1	0	0	-	-	-	-	-	-	-	-
3/11	2	0	0	0	-	-	-	-	-	-	-	-
3/12	4	0	0	0	-	-	-	-	-	-	-	-
3/13	3	0	0	0	-	-	-	-	-	-	-	-
3/14	3	0	0	0	-	-	-	-	-	-	-	-
3/15	4	2	0	0	-	-	-	-	1	0	0	0
3/16	7	0	0	0	-	-	-	-	2	0	0	0
3/17	4	1	0	0	-	-	-	-	3	0	0	0
3/18	2	0	0	0	-	-	-	-	-	-	-	-
3/19	-	-	-	-	-	-	-	-	-	-	-	-
3/20	1	0	0	0	-	-	-	-	1	0	0	0
3/21	1	0	0	0	-	-	-	-	-	-	-	-
3/22	-	-	-	-	-	-	-	-	0	1	0	0
3/23	8	0	0	0	-	-	-	-	1	0	0	0
3/24	2	0	0	0	-	-	-	-	-	-	-	-
3/25	-	-	-	-	-	-	-	-	5	0	0	0
3/26	-	-	-	-	-	-	-	-	5	0	0	0
3/27	10	2	0	0	-	-	-	-	10	3	0	0
3/28	6	1	0	0	-	-	-	-	14	2	0	0
3/29	6	2	0	1	-	-	-	-	8	2	0	0
3/30	3	0	0	0	-	-	-	-	1	0	0	0
3/31	-	-	-	-	-	-	-	-	1	0	0	0
4/1	-	-	-	-	-	-	-	-	-	-	-	-
4/2	1	0	0	0	-	-	-	-	1	0	0	0
4/3	-	-	-	-	-	-	-	-	4	1	0	0
4/4	-	-	-	-	1	0	0	0	21	2	0	0
4/5	3	0	0	0	-	-	-	-	23	1	0	0
4/6	4	0	0	0	-	-	-	-	13	2	0	0
4/7	4	0	0	0	-	-	-	-	30	2	0	0
4/8	27	1	0	0	-	-	-	-	33	2	0	0
4/9	1	0	0	0	-	-	-	-	31	2	0	0
4/10	13	3	0	0	-	-	-	-	23	1	1	0
4/11	61	4	0	0	-	-	-	-	34	2	1	0
4/12	26	0	0	0	-	-	-	-	46	2	1	0
4/13	13	0	0	0	-	-	-	-	26	4	0	0

[a] *G = Good (minimal scale loss), P = Partial scale loss, D = Descaled, M = Mortality*

Appendix Table A-3. Continued.

	Species and Condition[a]											
	Chinook				Coho				Steelhead			
Date	G	P	D	M	G	P	D	M	G	P	D	M
4/14	39	0	0	0	-	-	-	-	21	1	0	0
4/15	4	0	0	0	-	-	-	-	22	2	0	0
4/16	65	2	0	0	-	-	-	-	54	4	0	0
4/17	51	0	0	0	-	-	-	-	26	2	0	2
4/18	12	1	0	0	-	-	-	-	28	3	2	0
4/19	23	3	0	0	-	-	-	-	28	3	1	0
4/20	14	2	9	9	-	-	-	-	19	0	0	1
4/21	16	6	0	0	1	0	0	0	18	0	0	0
4/22	29	2	0	1	-	-	-	-	29	3	0	2
4/23	45	3	1	0	-	-	-	-	32	3	0	1
4/24	79	2	0	0	-	-	-	-	67	5	1	0
4/25	28	3	0	0	1	0	0	0	93	5	0	0
4/26	23	1	0	0	1	0	0	0	161	11	0	3
4/27	8	2	1	0	-	-	-	-	49	2	0	0
4/28	12	1	0	1	-	-	-	-	27	2	0	0
4/29	10	0	0	0	-	-	-	-	40	2	1	3
4/30	13	0	0	0	1	0	0	0	40	1	1	0
5/1	8	0	0	0	-	-	-	-	25	2	2	2
5/2	4	0	0	0	1	0	0	0	32	1	0	1
5/3	2	0	0	0	3	0	0	0	34	2	0	2
5/4	6	0	0	1	-	-	-	-	29	1	0	4
5/5	2	0	0	0	-	-	-	-	39	2	0	1
5/6	5	1	0	0	-	-	-	-	48	1	0	0
5/7	7	0	0	0	-	-	-	-	45	1	0	1
5/8	12	1	1	11	1	0	0	0	55	1	0	1
5/9	2	0	0	0	4	0	0	0	93	5	0	0
5/10	6	0	0	0	5	0	0	0	52	2	1	0
5/11	5	0	0	0	1	0	0	0	48	4	0	0
5/12	13	2	0	1	1	0	0	0	44	0	1	1
5/13	6	1	0	0	1	0	0	0	23	2	0	0
5/14	8	0	0	0	-	-	-	-	53	1	2	0
5/15	18	0	0	0	1	0	0	0	77	2	0	2
5/16	15	0	0	0	1	0	0	0	24	1	0	0
5/17	4	0	0	0	1	1	0	0	4	0	0	0
5/18	6	0	0	0	9	0	0	0	88	1	2	0
5/19	11	0	0	0	3	0	0	0	28	2	0	0
5/20	19	1	1	0	8	0	0	0	92	2	1	0
5/21	24	0	0	0	8	0	0	0	86	4	1	0
5/22	34	0	0	0	12	0	0	0	70	3	2	0
5/23	40	0	0	0	9	0	0	0	39	2	0	0
5/24	28	0	0	0	26	1	0	0	62	2	0	0
5/25	43	0	0	0	12	0	0	0	26	3	0	0
5/26	22	0	0	0	9	0	0	0	32	1	1	0
5/27	5	1	0	0	4	0	0	0	2	0	0	0
5/28	11	0	0	0	6	0	0	0	1	0	1	0
5/29	4	0	0	0	12	1	0	0	-	-	-	-
5/30	11	0	0	0	4	0	0	0	5	0	0	0

Appendix Table A-3. Continued.

	Species and Condition[a]											
	Chinook				Coho				Steelhead			
Date	G	P	D	M	G	P	D	M	G	P	D	M
5/31	24	0	0	0	5	0	0	0	0	1	0	0
6/1	103	0	0	0	9	0	0	0	8	1	0	0
6/2	93	2	0	0	10	0	0	0	11	0	0	0
6/3	47	0	0	0	15	0	0	0	1	0	0	0
6/4	36	0	0	1	8	1	0	0	0	0	1	0
6/5	91	3	0	0	13	0	0	0	6	0	0	0
6/6	122	0	0	0	3	0	0	0	9	0	0	0
6/7	231	1	0	0	3	0	0	0	4	0	0	0
6/8	151	0	1	0	5	0	0	0	2	0	0	0
6/9	190	3	2	0	2	1	0	0	4	1	0	0
6/10	304	1	0	0	1	0	0	0	0	1	0	0
6/11	153	3	0	0	-	-	-	-	1	0	0	0
6/12	270	14	1	0	0	1	0	0	1	0	0	0
6/13	234	11	1	1	-	-	-	-	-	-	-	-
6/14	243	12	2	0	-	-	-	-	-	-	-	-
6/15	167	12	2	0	3	0	0	0	0	0	1	0
6/16	331	7	2	1	-	-	-	-	2	1	0	0
6/17	208	14	1	2	-	-	-	-	-	-	-	-
6/18	137	9	1	0	2	0	0	0	-	-	-	-
6/19	97	6	2	0	-	-	-	-	1	0	0	0
6/20	123	11	2	0	-	-	-	-	-	-	-	-
6/21	275	10	6	0	-	-	-	-	2	0	0	0
6/22	254	22	2	1	-	-	-	-	-	-	-	-
6/23	187	7	0	1	-	-	-	-	-	-	-	-
6/24	188	13	0	0	-	-	-	-	-	-	-	-
6/25	101	2	0	4	-	-	-	-	1	0	0	0
6/26	55	9	2	2	-	-	-	-	-	-	-	-
6/27	31	4	1	0	-	-	-	-	-	-	-	-
6/28	57	7	1	0	2	0	0	0	-	-	-	-
6/29	23	4	1	0	1	0	0	0	-	-	-	-
6/30	101	5	0	0	-	-	-	-	-	-	-	-
7/1	84	5	5	0	-	-	-	-	-	-	-	-
7/2	9	3	0	2	-	-	-	-	2	0	0	0
7/3	45	5	0	0	-	-	-	-	-	-	-	-
7/4	42	7	0	0	-	-	-	-	-	-	-	-
7/5	-	-	-	-	-	-	-	-	-	-	-	-
7/6	17	5	9	0	-	-	-	-	-	-	-	-
7/7	17	11	0	1	-	-	-	-	1	0	0	0
7/8	0	1	3	1	-	-	-	-	-	-	-	-
7/9	4	4	2	6	-	-	-	-	-	-	-	-
7/10	-	-	-	-	-	-	-	-	-	-	-	-
7/11	-	-	-	-	-	-	-	-	-	-	-	-
7/12	-	-	-	-	-	-	-	-	-	-	-	-
7/13	-	-	-	-	-	-	-	-	-	-	-	-
7/14	11	13	1	2	-	-	-	-	-	-	-	-
7/15	4	2	1	2	1	0	0	0	-	-	-	-
7/16	-	-	-	-	-	-	-	-	-	-	-	-

Appendix Table A-3. Continued.

	Species and Condition[a]											
	Chinook				Coho				Steelhead			
Date	G	P	D	M	G	P	D	M	G	P	D	M
7/17	4	1	1	1	-	-	-	-	1	0	0	0
7/18	-	-	-	-	-	-	-	-	-	-	-	-
7/19	-	-	-	-	-	-	-	-	-	-	-	-
7/20	2	1	1	0	-	-	-	-	2	0	0	0
7/21	-	-	-	-	-	-	-	-	-	-	-	-
7/22	24	13	6	0	-	-	-	-	-	-	-	-
7/23	-	-	-	-	-	-	-	-	-	-	-	-
7/24	-	-	-	-	-	-	-	-	-	-	-	-
7/25	-	-	-	-	-	-	-	-	-	-	-	-
7/26	-	-	-	-	-	-	-	-	-	-	-	-
7/27	2	1	1	0	3	0	0	0	-	-	-	-
7/28	-	-	-	-	-	-	-	-	-	-	-	-
7/29	37	13	3	0	3	0	0	0	-	-	-	-
7/30	-	-	-	-	-	-	-	-	-	-	-	-
7/31	-	-	-	-	-	-	-	-	-	-	-	-
8/01	-	-	-	-	-	-	-	-	-	-	-	-
8/02	-	-	-	-	-	-	-	-	-	-	-	-
8/03	31	22	2	0	1	0	0	0	-	-	-	-
8/04	-	-	-	-	-	-	-	-	-	-	-	-
8/05	19	9	1	0	1	2	1	0	-	-	-	-
8/06	-	-	-	-	-	-	-	-	-	-	-	-
8/07	-	-	-	-	-	-	-	-	-	-	-	-
8/08	-	-	-	-	-	-	-	-	-	-	-	-
8/09	-	-	-	-	-	-	-	-	-	-	-	-
8/10	1	2	1	0	5	1	0	0	1	0	0	0

Appendix Table A-4. Releases of hatchery chinook salmon, summer steelhead, and coho salmon in the Umatilla River, March - June 1998.

Species[a]	Age	Hatchery origin	Release date(s)	Release location	River mile	Number released	Number CWT[b]
CHS	1+	Umatilla	3/8	Imeques	80.0	382,714	162,228
CHS	1+	Carson	4/14	Imeques	80.0	99,641	18,721
CHS	1+	LWSH[c]	3/8	Imeques	80.0	172,999	19,403
CHS	1+	LWSH	4/14	Imeques	80.0	172,258	19,255
					Total	872,612	219,607[d]
CHF	1+	Bonneville	3/13	Thornhollow	73.5	256,910	27,402
CHF	1+	Willard	4/17	Thornhollow	73.5	179,100	44,330
					Total	436,010	71,732
CHF	0+	Umatilla	5/28 & 6/1	Thornhollow	73.5	2,777,442	285,726
				Imeques	80.0		
					Total	2,777,442	285,726[d]
STS	1+	Umatilla	4/17[e]	Minthorn	64.5	49,084	20,646
STS	1+	Umatilla	4/16[e]	Bonifer	79.0[f]	41,088	20,800
STS	1+	Umatilla	5/4[g]	Bonifer	79.0	47,313	19,739
					Total	137,485	61,185[d]
COH	1+	Cascade	3/30-4/2	Pendleton	52.0	1,078,436	79,591
COH	1+	LHCH[c]	3/23-3/27	Pendleton	52.0	528,350	26,759
					Total	1,606,786	106,350[d]

[a] *CHS = spring chinook salmon, CHF = fall chinook salmon, STS = summer steelhead, COH = coho salmon.*
[b] *CWT = Number recognizably coded-wire tagged.*
[c] *LWSH = Little White Salmon Hatchery, LHCH = Lower Herman Creek Hatchery.*
[d] *796 CHS, 865 CHF (0+), 271 STS, and 26,833 COH were not fin clipped.*
[e] *Volitional release began on 10 April 1998.*
[f] *Bonifer holding pond at RM 2 of Meacham Creek (RM 79.0 on the Umatilla River).*
[g] *Volitional release began on 20 April 1998.*

Appendix Table A-5. Daily observations at the rotary-screw trap (RM 1.2), lower Umatilla River, 7 October 1997 – 3 April 1998.

Date	Time	Debris[a]	Water color[b]	Cone RPM[c] Start	Cone RPM[c] End	River gauge (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.
10/7/97	0845	L	LGRN	2.0	--	2.65	--	--	--	--
10/8/97	0910	M	LGRN	3.0	--	2.65	--	--	--	--
10/9/97	0845	M	LGRN	3.0	--	2.65	52	56	--	--
10/10/97	0840	M	LGRN	3.0	--	2.7	50	56	--	--
10/13/97	0835	M	LGRN	3.0	--	2.8	48	56	--	--
10/14/97	1610	M	LGRN	0	1.5	2.7	50	58	--	--
10/15/97	0830	M	LGRN	2.0	--	2.7	52	58	--	--
10/16/97	1430	L	LGRN	1.0	2.8	2.75	52	58	--	--
10/17/97	1515	L	LGRN	--	--	2.7	53	60	--	--
10/18/97	1545	L	LGRN	--	--	2.8	52	59	--	--
10/19/97	0830	L	LGRN	3.3	3.3	2.7	48	58	--	--
10/20/97	1450	L	GRN	2.8	3.3	2.7	46	58	--	--
10/21/97	1530	L	LGRN	--	--	2.75	50	54	--	--
10/22/97	1515	L	LGRN	--	--	2.8	49	54	--	--
10/23/97	1035	L	LGRN	3.0	3.3	2.75	40	54	--	--
10/24/97	1600	L	LGRN	3.0	--	2.7	49	54	--	--
10/25/97	1045	L	LGRN	3.3	3.3	2.7	48	53	--	--
10/26/97	1600	L	LGRN	3.2	3.3	2.75	42	54	--	--
10/27/97	1140	L	LGRN	3.0	3.0	2.75	46	52	--	--
10/28/97	0840	L	LGRN	3.0	3.0	2.75	50	56	--	--
10/29/97	0850	L	LGRN	3.0	--	2.75	52	56	--	--
10/30/97	0900	L	LGRN	0	3.0	--	50	54	--	--
10/31/97	0850	L	LGRN	0	3.0	--	53	56	--	--
11/1/97	1155	L	DGRN	0	3.0	--	51	58	--	--
11/2/97	--	L	LGRN	0	3.0	--	48	54	--	--
11/3/97	1600	L	DGRN	2.5	3.8	--	48	52	--	--
11/4/97	1500	L	DGRN	0	3.5	--	48	53	--	--
11/5/97	1100	L	LGRN	3.0	3.0	2.7	50	52	--	--
11/6/97	0940	L	LGRN	3.0	3.0	2.65	48	52	--	--
11/7/97	0940	L	LGRN	3.5	3.5	2.7	52	54	--	--
11/8/97	1200	L	LGRN	3.0	3.2	2.7	51	55	--	--
11/9/97	1130	M	LGRN	1.5	3.0	2.7	53	55	--	--
11/10/97	1145	L	CLR	2.4	2.4	2.7	48	55	--	--
11/12/97	1530	L	CLR	2.5	2.3	2.65	44	52	--	--
11/13/97	0940	M	CLR	3.0	3.3	2.65	48	56	--	--
11/15/97	1130	H	CLR	2.0	2.8	2.65	38	48	--	--
11/17/97	0845	H	CLR	0.8	2.8	2.65	40	42	--	--

[a] *L = low, ML = moderately low, M = moderate, MH = moderately high, H = high.*

[b] *CLR = clear, LGRN = light green, GRN = green, DGRN = dark green, LBRN = light brown, BRN = brown, DBRN = dark brown, LOLV = light olive, OLV = olive, DOLV = dark olive.*

[c] *Cone RPM's (rotations per minute) are before and after trap check and debris removal.*

Appendix Table A-5. Continued.

Date	Time	Debris[a]	Water Color[b]	Cone RPM[c] Start	Cone RPM[c] End	River gauge(ft.)	Water Temp. Min.	Water Temp. Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.
11/19/97	0845	H	CLR	2.0	3.0	2.65	40	48	--	--
11/21/97	0845	H	CLR	1.0	2.0	2.65	46	48	--	--
11/24/97	1045	H	LGRN	0	2.5	2.85	44	50	--	--
11/26/97	1100	H	LGRN	0	3.0	2.95	48	52	--	--
11/28/97	1030	L	LGRN	0	3.8	2.95	42	48	--	--
11/30/97	0900	MH	LGRN	3.3	3.3	2.8	42	48	--	--
12/3/97	0840	MH	LGRN	0	2.0	2.65	42	48	--	--
12/5/97	0945	M	LGRN	2.5	3.0	2.75	38	42	--	--
12/7/97	1100	M	LGRN	2.5	2.5	2.7	38	42	--	--
12/8/97	1040	M	LGRN	2.5	2.5	2.7	38	44	--	--
12/10/97	1330	M	LGRN	2.5	2.0	2.7	38	42	--	--
12/12/97	0840	M	LGRN	2.0	2.0	2.7	38	42	--	--
12/14/97	1100	M	LGRN	2.0	2.0	2.7	38	39	--	--
12/16/97	1100	M	GRN	2.0	2.5	2.7	38	43	--	--
12/17/97	1500	H	DGRN	0	4.0	3.3	42	46	--	--
12/18/97	1000	H	LBRN	0	5.5	3.5	42	50	--	--
12/19/97	0915	M	LBRN	3.5	4.0	3.2	38	43	--	--
12/21/97	1530	ML	LBRN	2.0	2.5	2.75	38	42	--	--
12/23/98	1145	L	GRN	<1.0	2.0	2.8	38	40	--	--
12/24/98	0930	M	LGRN	2.0	2.5	2.9	38	39	--	--
12/26/98	1530	L	LGRN	3.0	3.0	2.8	38	42	--	--
12/28/98	1520	L	GRN	3.0	3.0	2.75	38	43	--	--
12/30/98	1240	L	GRN	3.0	3.0	2.8	42	44	--	--
1/1/98	1540	M	LGRN	0	2.5	2.9	42	42	--	--
1/3/98	1100	M	LGRN	0	2.0	3	38	40	--	--
1/5/98	1000	M	LGRN	0	2.0	3	36	42	--	--
1/6/98	0950	M	LGRN	2.0	2.0	3	36	42	--	--
1/7/98	1045	M	LGRN	2.0	2.0	3	36	44	--	--
1/9/98	0930	M	LGRN	0	1.8	3	37	45	--	--
1/10/98	1430	M	LGRN	2.0	2.0	2.9	38	44	--	--
1/11/98	1400	M	LGRN	<1.0	1.8	3	32	37	--	--
1/12/98	1050	M	LGRN	0	2.0	3	32	34	--	--
1/13/98	0920	M	LGRN	trap	frozen	3	30	34	--	--
1/14/98	1300	M	LOLV	0	2.5	2.8	32	34	--	--
1/15/98	0915	MH	LBRN	<1.0	2.5	3	32	35	--	--
1/16/98	0840	M	BRN	1.0	4.0	3.2	34	38	--	--
1/17/98	1315	M	BRN	2.5	4.0	3.1	--	--	--	--
1/18/98	1620	H	DBRN	0	5.0	3.7	42	44	--	--
1/19/98	1200	M	BRN	5.5	6.0	3.6	39	44	--	--
1/20/98	1100	H	BRN	0	7.5	4	40	45	--	--
1/21/98	0930	L	LBRN	0	4.0	3.7	40	43	--	--
1/22/98	0900	L	BRN	6.0	6.0	3.4	40	41	--	--
1/23/98	0930	L	LBRN	4.0	4.0	3.3	39	42	--	--

Appendix Table A-5. Continued.

Date	Time	Debris[a]	Water color[b]	Cone RPM[c] Start	Cone RPM[c] End	River gauge (ft)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.
1/26/98	0800	L	LBRN	4.0	4.0	3.3	40	45	--	--
1/28/98	1630	MH	DBRN	6.0	6.0	3.8	43	48	30	48
1/29/98	1400	M	DBRN	6.0	6.0	3.6	44	47	37	47
1/30/98	1030	M	DBRN	6.0	6.0	3.6	43	45	33	54
2/1/98	1045	L	GRN	5.0	5.0	3.4	40	45	28	66
2/2/98	0915	L	GRN	4.0	4.0	3.3	40	40	30	40
2/3/98	0930	L	GRN	4.0	4.0	3.2	39	40	32	40
2/4/98	1430	L	GRN	3.5	3.5	3	42	44	39	48
2/5/98	1340	M	GRN	4.0	4.0	3.3	42	46	32	57
2/6/98	0900	L	GRN	3.0	5.0	3.4	45	46	40	58
2/7/98	1100	L	GRN	3.5	4.0	3.3	42	44	46	56
2/8/98	1145	L	GRN	4.0	4.0	3.2	44	48	34	68
2/10/98	1030	L	GRN	3.5	3.5	3.1	42	48	30	58
2/12/98	1300	L	GRN	2.5	2.5	3	38	48	32	62
2/13/98	1500	L	LGRN	2.0	1.0	2.9	42	48	36	70
2/14/98	1200	L	LGRN	0	1.0	3	42	47	38	57
2/16/98	1030	L	LGRN	1.0	1.0	3	42	47	28	65
2/17/98	1015	L	LGRN	1.0	1.0	3	38	44	34	60
2/19/98	1100	L	LGRN	0	1.0	2.9	44	46	30	66
2/21/98	1240	L	LGRN	0	<1.0	2.9	44	50	40	60
2/23/98	0940	L	LGRN	1.0	1.0	2.9	--	50	28	67
2/25/98	1130	L	LGRN	0	1.0	2.9	42	45	28	72
2/27/98	1415	L	LGRN	0	<1.0	2.8	--	--	25	78
3/2/98	1150	M	LGRN	<1.0	1.0	2.9	--	--	30	78
3/5/98	1535	M	LOLV	1.5	<2.0	3.3	--	--	--	--
3/6/98	1430	M	LOLV	2.0	2.0	3.3	--	--	--	--
3/9/98	1230	M	LGRN	2.8	--	3	--	--	--	--
3/9/98	2000	L	LOLV	2.8	--	3	--	--	--	--
3/10/98	0800	L	LGRN	2.8	--	3	--	--	--	--
3/10/98	2030	L	LGRN	3.8	--	3.1	--	--	--	--
3/11/98	0800	LM	LOLV	3.5	--	3.1	--	--	--	--
3/11/98	1315	L	LOLV	4.0	--	3.2	--	--	--	--
3/11/98	2000	L	LOLV	4.5	--	3.2	--	--	--	--
3/12/98	0800	L	LGRN	4.0	--	3.2	--	--	--	--
3/12/98	1300	L	LGRN	4.5	--	3.2	--	--	--	--
3/12/98	2025	L	LGRN	4.8	--	3.3	--	--	--	--
3/13/98	0800	L	LGRN	4.3	--	3.3	--	--	39	64
3/13/98	2000	M	LOLV	4.3	--	3.4	52	54	48	73
3/14/98	0800	M	LOLV	6.0	--	3.5	50	51	42	56
3/14/98	2000	M	LBRN	6.5	--	3.6	50	53	50	74
3/15/98	0950	M	--	5.8	--	3.7	52	54	46	65
3/15/98	1930	M	OLV	7.3	--	3.4	51	56	46	74
3/16/98	0800	M	LBRN	7.5	--	3.7	49	53	40	73

Appendix Table A-5. Continued.

Date	Time	Debris[a]	Water color[b]	Cone RPM[c] Start	Cone RPM[c] End	River gauge (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.
3/16/98	2000	M	LBRN	7.8	--	3.7	46	50	52	68
3/17/98	0800	L	LOLV	5.8	--	3.6	44	48	32	53
3/17/98	2000	L	OLV	7.0	--	3.6	44	48	46	66
3/18/98	0800	L	LBRN	6.0	--	3.5	46	48	30	52
3/18/98	2000	L	LBRN	4.5	--	3.5	46	52	42	62
3/19/98	0800	L	LOLV	4.8	--	3.4	45	48	30	47
3/19/98	2000	L	LOLV	4.0	--	3.3	43	49	40	63
3/20/98	0800	L	LOLV	4.0	--	3.2	47	48	36	52
3/20/98	1450	L	LOLV	3.8	--	3.2	--	--	--	--
3/20/98	2000	L	LOLV	4.0	--	3.1	48	50	46	66
3/21/98	0800	L	LOLV	3.5	--	3.1	48	50	40	56
3/21/98	2000	L	LOLV	3.5	--	3.1	48	51	50	60
3/22/98	0800	M	LOLV	3.5	--	3.2	50	52	46	54
3/22/98	2000	ML	LOLV	5.0	--	3.3	49	52	53	65
3/23/98	0800	M	LBRN	6.8	--	3.6	50	52	50	58
3/23/98	2000	H	BRN	7.0	--	4	48	51	52	62
3/24/98	0800	H	LBRN	0	10.0	4.3	47	51	40	52
3/24/98	1400	H	BRN	trap out		4.7	--	--	--	--
3/24/98	2155	--	BRN	trap out		4.6	48	49	49	66
3/25/98	0800	M	LBRN	7.0	--	4.5	48	50	42	51
3/25/98	1400	M	LBRN	9.0	--	4.5	--	--	--	--
3/25/98	2200	M	DBRN	9.5	--	4.3	--	--	--	--
3/26/98	0800	H	DBRN	8.3	--	4.2	46	51	43	67
3/26/98	1700	M	DBRN	10.0	--	4.1	--	--	--	--
3/26/98	2100	M	DBRN	9.0	--	4	--	--	--	--
3/27/98	0800	H	LBRN	7.5	--	4	34	49	42	61
3/27/98	1700	L	LBRN	7.0	--	3.9	--	--	--	--
3/27/98	2200	L	LBRN	7.3	--	3.85	--	--	--	--
3/28/98	0800	MH	BRN	7.0	--	3.8	42	47	29	59
3/28/98	2200	L	LBRN	6.8	--	3.7	--	--	--	--
3/29/98	0800	ML	LOLV	7.5	--	3.6	42	48	35	48
3/29/98	2150	L	LBRN	6.0	--	3.5	--	--	--	--
3/30/98	0800	--	LBRN	5.8	--	3.5	42	46	33	60
3/30/98	2210	ML	LBRN	5.0	--	3.4	--	--	--	--
3/31/98	0800	L	LGRN	4.5	--	3.3	45	48	43	64
3/31/98	2145	L	LOLV	4.3	--	3.2	--	--	--	--
4/1/98	0800	L	LGRN	3.5	--	3.1	47	48	39	57
4/1/98	1745	M	LGRN	2.8	--	3.1	--	--	--	--
4/1/98	2100	L	LGRN	4.0	--	3.1	--	--	--	--
4/2/98	0800	L	LGRN	3.3	--	3.1	45	50	36	62
4/2/98	2030	L	LGRN	3.0	--	3	--	--	--	--
4/3/98	0800	L	LGRN	3.0	--	3	45	51	45	62

Appendix Table A-6. Daily observations at the West Extension Canal sampling facility (RM 3.0), 4 April - 5 July 1998.

			Water	River	Canal	Water Temp. (F°)		Air Temp. (F°)		Pumpback[c]				Headgate Openings[d]		
Date	Time	Debris[a]	color[b]	gauge (ft.)	height (ft.)	Min.	Max.	Min.	Max.	P1	P2	P3	RR	S	M	N
4/4/98	0800	L	LGRN	404.5	404.4	48	56	36	62	ON	ON	--	--	24	24	24
4/4/98	1400	L	LGRN	404.5	404.4	--	--	--	--	ON	ON	--	--	24	24	24
4/4/98	2000	L	LGRN	404.6	404.5	--	--	--	--	ON	ON	--	--	24	24	24
4/5/98	0200	L	LGRN	--	404.5	--	--	--	--	ON	ON	--	--	24	24	24
4/5/98	0800	L	LGRN	404.6	404.5	47	50	36	71	ON	ON	--	--	24	24	24
4/5/98	1400	L	LGRN	404.6	404.5	--	--	--	--	ON	ON	--	--	24	24	24
4/5/98	2000	L	LGRN	404.5	404.5	--	--	--	--	ON	ON	--	--	24	24	24
4/6/98	0200	L	--	404.6	404.4	--	--	--	--	ON	ON	OFF	--	24	24	24
4/6/98	0800	L	LGRN	404.6	404.4	46	52	34	80	ON	ON	OFF	--	24	24	24
4/6/98	1400	L	LGRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	24	24	24
4/6/98	2000	L	LGRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	24	24	24
4/7/98	0200	L	LGRN	404.6	404.4	--	--	--	--	ON	ON	--	--	24	24	24
4/7/98	0800	L	LGRN	404.5	404.4	50	53	44	78	ON	ON	--	--	24	24	24
4/7/98	1400	L	LGRN	404.5	404.4	--	--	--	--	ON	ON	--	--	24	24	24
4/7/98	2000	L	LGRN	404.5	404.4	--	--	--	--	ON	ON	--	--	24	24	24
4/8/98	0200	L	--	404.6	404.4	--	--	--	--	ON	ON	OFF	--	24	24	24
4/8/98	0800	L	LGRN	404.6	404.4	49	53	30	68	ON	ON	OFF	--	24	24	24
4/8/98	2000	L	LGRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	24	24	24
4/9/98	0200	L	--	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/9/98	0800	L	LGRN	404.6	404.4	50	52	36	71	ON	ON	OFF	--	30	28	28
4/9/98	2000	L	LGRN	404.5	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/10/98	0200	L	--	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/10/98	0800	L	LGRN	404.5	404.4	51	54	44	66	ON	ON	OFF	--	30	28	28
4/10/98	1530	L	GRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/10/98	2000	L	GRN	404.6	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/11/98	0200	L	--	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28

[a] *L = low, ML = moderately low, M = moderate, MH = moderately high, H = high.*

[b] *CLR = clear, LGRN = light green, GRN = green, DGRN = dark green, LBRN = light brown, BRN = brown, DBRN = dark brown, LOLV = light olive, OLV = olive, DOLV = dark olive.*

[c] *Pumpback operations for three pumps (P1, P2, and P3) and a river-return drain pipe (RR) in the pumpback bay; river-return pipe opening is measured in inches.*

[d] *Headgate openings are: S = south gate, M = middle gate, N = north gate; openings are measured in inches.*

Appendix Table A-6. Continued.

Date	Time	Debris[a]	Water color[b]	River gauge (ft.)	Canal height (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.	Pumpback[c] P1	Pumpback[c] P2	Pumpback[c] P3	RR	Headgate Openings[d] S	Headgate Openings[d] M	Headgate Openings[d] N
4/11/98	0800	L	GRN	404.6	404.4	51	54	37	76	ON	ON	OFF	--	30	28	28
4/11/98	2000	L	LGRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/12/98	0200	L	--	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/12/98	0800	L	GRN	404.6	404.4	48	53	32	68	ON	ON	OFF	--	30	28	28
4/12/98	2000	L	GRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/13/98	0200	L	GRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/13/98	0900	L	LGRN	404.6	404.4	52	58	44	69	ON	ON	OFF	--	30	28	28
4/13/98	2000	L	LGRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/14/98	0200	L	GRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/14/98	2000	L	GRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/15/98	0200	L	--	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/15/98	0800	L	GRN	404.5	404.4	45	51	41	74	ON	ON	OFF	--	30	28	28
4/15/98	2000	L	GRN	404.6	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/16/98	0200	L	--	404.5	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/16/98	0800	L	--	--	--	47	52	38	74	ON	ON	OFF	--	30	28	28
4/16/98	1400	L	LGRN	404.5	404.45	--	--	--	--	ON	ON	OFF	--	30	28	28
4/17/98	0200	L	LGRN	404.5	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/17/98	0800	L	LGRN	404.5	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/17/98	2000	L	LGRN	404.5	404.3	--	--	--	--	ON	ON	OFF	--	30	28	28
4/18/98	0200	L	LGRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/18/98	0800	L	--	404.6	404.4	44	50	33	76	ON	ON	OFF	--	30	28	28
4/19/98	0200	L	GRN	404.6	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/19/98	0800	L	LGRN	404.5	404.3	50	54	46	78	ON	ON	OFF	--	30	28	28
4/20/98	0200	L	GRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/20/98	0800	L	GRN	404.5	404.4	52	58	36	76	ON	ON	OFF	--	30	28	28
4/20/98	1400	L	GRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/20/98	2000	L	GRN	404.5	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/21/98	0200	L	GRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/21/98	0800	L	GRN	404.6	404.4	58	61	42	89	ON	ON	OFF	--	30	28	28
4/21/98	2045	L	GRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/23/98	0200	L	GRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/23/98	2000	L	DGRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/24/98	0200	L	GRN	404.6	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28

Appendix Table A-6. Continued.

Date	Time	Debris[a]	Water color[b]	River gauge (ft.)	Canal height (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.	Pumpback[c] P1	Pumpback[c] P2	Pumpback[c] P3	RR	Headgate Openings[d] S	Headgate Openings[d] M	Headgate Openings[d] N
4/24/98	2000	L	GRN	404.8	404.5	--	--	--	--	ON	ON	OFF	--	30	28	28
4/25/98	0800	L	OLV	404.7	404.4	50	60	38	88	ON	ON	OFF	--	30	28	28
4/25/98	1400	L	OLV	404.7	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/25/98	2000	L	OLV	404.7	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/26/98	0200	L	OLV	404.7	404.4	--	--	--	--	ON	ON	OFF	--	30	28	28
4/26/98	0800	L	OLV	404.6	404.3	50	56	36	74	ON	ON	OFF	--	30	28	28
4/26/98	2000	L	GRN	404.6	404.3	--	--	--	--	ON	ON	OFF	--	30	28	28
4/27/98	0200	M	GRN	404.6	404.3	--	--	--	--	ON	ON	OFF	--	30	28	28
4/27/98	0800	L	GRN	404.6	404.3	--	--	--	--	ON	ON	OFF	--	30	28	28
4/27/98	2000	L	OLV	404.5	404.3	--	--	--	--	ON	ON	OFF	--	30	28	28
4/28/98	0200	L	GRN	404.5	404.2	--	--	--	--	ON	ON	OFF	--	30	28	28
4/28/98	0800	--	--	--	--	52	59	40	88	ON	ON	OFF	--	30	28	28
4/28/98	1400	L	CLR	404.5	404.3	--	--	--	--	ON	ON	OFF	--	30	28	28
4/29/98	0200	L	GRN	404.5	404.3	--	--	--	--	OFF	ON	OFF	--	30	28	28
4/29/98	0933	L	GRN	404.5	404.2	58	61	56	83	OFF	ON	OFF	--	30	28	28
4/30/98	0200	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
4/30/98	0800	--	--	--	--	58	62	50	90	OFF	ON	OFF	--	30	28	28
4/30/98	1400	L	CLR	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
4/30/98	2000	L	CLR	404.5	404.3	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/1/98	0200	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/1/98	0800	L	LGRN	404.5	404.2	58	63	47	86	OFF	ON	OFF	--	30	28	28
5/1/98	1400	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/1/98	2000	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/2/98	0200	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/2/98	0800	L	LGRN	404.5	404.2	57	63	39	92	OFF	ON	OFF	--	30	28	28
5/2/98	1400	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/2/98	2000	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/3/98	0200	L	LGRN	404.5	404.1	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/3/98	0800	L	LGRN	404.5	404.2	56	63	44	88	OFF	ON	OFF	--	30	28	28
5/3/98	1400	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/3/98	2000	L	LGRN	404.5	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/4/98	0200	L	GRN	404.4	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/4/98	0800	L	GRN	404.4	404.2	--	--	42	82	OFF	ON	OFF	--	30	28	28

Appendix Table A-6. Continued.

Date	Time	Debris[a]	Water color[b]	River gauge (ft.)	Canal height (ft.)	Water Temp. (F°)		Air Temp. (F°)		Pumpback[c]				Headgate Openings[d]		
						Min.	Max.	Min.	Max.	P1	P2	P3	RR	S	M	N
5/4/98	1400	L	GRN	404.4	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/5/98	0200	L	GRN	404.4	404.1	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/5/98	0800	L	GRN	404.4	404.2	--	--	59	87	OFF	ON	OFF	--	30	28	28
5/5/98	2000	L	LGRN	404.4	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/6/98	0200	L	LGRN	404.4	404.2	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/6/98	1400	L	LGRN	404.3	404.1	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/6/98	2000	L	LGRN	404.3	404.1	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/7/98	0200	L	LGRN	404.3	404.1	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/7/98	0800	L	LGRN	404.3	404.1	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/7/98	1400	L	LGRN	404.3	404.1	--	--	--	--	OFF	ON	OFF	--	30	28	28
5/7/98	2000	L	LGRN	404.3	404.1	--	--	--	--	OFF	ON	OFF	5	30	28	28
5/8/98	0200	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/8/98	1400	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/8/98	1930	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/9/98	0200	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/9/98	0800	L	GRN	404.5	404.5	--	--	52	84	OFF	OFF	OFF	5	30	28	28
5/9/98	1400	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/9/98	2000	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/10/98	0200	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/10/98	0800	L	GRN	404.5	404.5	--	--	49	88	OFF	OFF	OFF	5	30	28	28
5/10/98	1400	L	GRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/10/98	2000	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/11/98	0200	L	LGRN	404.4	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/11/98	0800	L	LGRN	404.4	404.5	--	--	52	76	OFF	OFF	OFF	5	30	28	28
5/11/98	1400	L	LGRN	404.4	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/11/98	2000	L	LGRN	404.4	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/12/98	0200	L	LGRN	404.4	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/12/98	0800	L	LGRN	404.4	404.5	--	--	48	74	OFF	OFF	OFF	5	30	28	28
5/12/98	1400	--	--	404.4	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/13/98	0200	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/13/98	0800	L	LGRN	404.5	404.5	58	64	48	74	OFF	OFF	OFF	5	30	28	28
5/13/98	1400	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28
5/13/98	2000	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	30	28	28

Appendix Table A-6. Continued.

Date	Time	Debris[a]	Water color[b]	River gauge (ft.)	Canal height (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.	Pumpback[c] P1	P2	P3	RR	Headgate Openings[d] S	M	N
5/14/98	0200	L	LGRN	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/14/98	0800	--	LGRN	404.5	404.5	55	61	48	70	OFF	OFF	OFF	5	44	40.5	39
5/14/98	1400	--	--	404.5	404.5	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/14/98	2000	L	LGRN	404.5	404.6	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/15/98	0200	L	LGRN	404.5	404.6	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/15/98	0800	L	LGRN	404.5	404.6	54	56	43	62	OFF	OFF	OFF	5	44	40.5	39
5/15/98	2000	L	LGRN	404.6	404.5	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/16/98	0800	L	LGRN	404.6	404.6	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/16/98	1400	L	GRN	404.6	404.6	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/16/98	2000	L	GRN	404.7	404.7	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/17/98	0200	L	GRN	404.7	404.7	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/17/98	0800	L	GRN	404.7	404.7	52	55	46	74	OFF	OFF	OFF	5	44	40.5	39
5/17/98	1400	L	GRN	404.7	404.7	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/17/98	2000	L	GRN	404.7	404.7	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/18/98	0200	L	GRN	404.7	404.7	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/18/98	0800	L	GRN	404.8	404.8	52	54	38	75	OFF	OFF	OFF	5	44	40.5	39
5/18/98	2000	ML	DBRN	405.1	405.1	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/19/98	0200	M	DBRN	405.2	405.2	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/19/98	0800	M	DBRN	405.2	405.2	52	54	50	74	OFF	OFF	OFF	5	44	40.5	39
5/19/98	1400	M	DBRN	405.0	405.0	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/19/98	2000	M	DBRN	405.0	405.1	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/20/98	0200	M	BRN	405.0	405.0	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/20/98	1400	M	DBRN	405.0	405.2	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/20/98	2036	M	LBRN	404.8	404.2	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/21/98	1020	M	BRN	404.8	404.4	53	59	54	90	OFF	OFF	OFF				
5/21/98	1400	MH	BRN	404.8	404.4					OFF	OFF	OFF				
5/21/98	2000	MH	BRN	404.8	404.4											
5/22/98	0800	M	BRN	404.7	404.3	52	56	52	75							
5/22/98	1400	H	DBRN	404.7	404.3											
5/22/98	2000	M	OLV	404.7	404.3											
5/23/98	0800	H	BRN	404.8	404.4	52	56	53	78	OFF	OFF	OFF				
5/23/98	2000	H	OLV	404.8	404.4											
5/24/98	0200	H	LBRN	404.8	404.4					OFF	OFF	OFF				

Appendix Table A-6. Continued.

Date	Time	Debris[a]	Water color[b]	River gauge (ft.)	Canal height (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.	Pumpback[c] P1	Pumpback[c] P2	Pumpback[c] P3	RR	Headgate Openings[d] S	Headgate Openings[d] M	Headgate Openings[d] N
5/24/98	0800	H	LBRN	404.8	404.4	5	59	53	83							
5/24/98	2000	MH	LBRN	404.8	404.4											
5/25/98	0200	H	BRN	404.8	404.4	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/25/98	0800	H	BRN	404.8	404.4	54	58	50	76	OFF	OFF	OFF	5	44	40.5	39
5/25/98	1400	H	BRN	404.8	404.4	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/25/98	2000	H	BRN	404.9	404.5	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/26/98	0200	H	DBRN	405.2	404.5	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/26/98	0800	H	DBRN	405.2	404.5	50	54	52	82	OFF	OFF	OFF	5	44	40.5	39
5/26/98	2000	H	DBRN	405.4	404.1	--	--	--	--	OFF	OFF	OFF	5	44	40.5	39
5/27/98	0200	H	DBRN	405.4	404.1	--	--	--	--	ON	ON	OFF	5	44	40.5	39
5/27/98	1200	H	DBRN	405.6	404.2	48	58	47	78	ON	ON	OFF	5	41	38	36
5/27/98	2000	H	DBRN	405.6	404.1	--	--	--	--	ON	ON	OFF	5	41	38	36
5/28/98	0200	H	DBRN	405.5	404.1	--	--	--	--	ON	ON	OFF	5	41	38	36
5/28/98	0800	H	DBRN	405.5	404.0	52	54	43	71	ON	ON	OFF	5	6	16	14
5/28/98	1400	H	DBRN	405.5	404.0	--	--	--	--	ON	ON	OFF	5	6	16	14
5/28/98	2000	H	DBRN	405.5	404.0	--	--	--	--	ON	ON	OFF	5	6	16	14
5/27/98	1200	H	DBRN	405.6	404.2	48	58	47	78	ON	ON	OFF	5	41	38	36
5/27/98	2000	H	DBRN	405.6	404.1	--	--	--	--	ON	ON	OFF	5	41	38	36
5/28/98	0200	H	DBRN	405.5	404.1	--	--	--	--	ON	ON	OFF	5	41	38	36
5/28/98	0800	H	DBRN	405.5	404.0	52	54	43	71	ON	ON	OFF	5	6	16	14
5/28/98	1400	H	DBRN	405.5	404.0	--	--	--	--	ON	ON	OFF	5	6	16	14
5/28/98	2000	H	DBRN	405.5	404.0	--	--	--	--	ON	ON	OFF	5	6	16	14
5/29/98	0200	MH	LBRN	405.4	403.9	--	--	--	--	ON	ON	OFF	5	15	17.5	13.75
5/29/98	0800	MH	LBRN	405.3	404.1	51	56	54	86	ON	ON	OFF	5	15	17.5	13.75
5/29/98	1500	MH	LBRN	405.3	404.1	--	--	--	--	ON	ON	OFF	5	15	17.5	13.75
5/29/98	2000	MH	LBRN	405.3	404.0	--	--	--	--	ON	ON	OFF	5	15	17.5	13.75
5/30/98	0200	M	LBRN	405.2	404.0	--	--	--	--	ON	ON	OFF	5	15	17.5	13.75
5/30/98	0800	M	LBRN	405.2	404.0	--	--	52	60	ON	ON	OFF	5	15	17.5	13.75
5/30/98	2000	M	LBRN	405.0	403.9	--	--	--	--	ON	ON	OFF	5	15	17.5	13.75
5/31/98	1030	M	LOLV	405.0	403.9	52	64	54	87	ON	ON	OFF	5	6	17.5	13.75
5/31/98	1400	M	LOLV	404.9	403.9	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
5/31/98	2000	ML	LOLV	404.9	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/1/98	0200	M	OLV	404.9	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75

Appendix Table A-6. Continued.

Date	Time	Debris[a]	Water color[b]	River gauge (ft.)	Canal height (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.	Pumpback[c] P1	Pumpback[c] P2	Pumpback[c] P3	RR	Headgate Openings[d] S	Headgate Openings[d] M	Headgate Openings[d] N
6/1/98	0800	ML	OLV	404.9	404.0	58	62	54	95	ON	ON	OFF	5	6	17.5	13.75
6/1/98	1400	ML	OLV	404.9	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/1/98	2000	ML	LOLV	404.8	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/2/98	0200	L	LOLV	404.8	404.1	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/2/98	0800	L	LOLV	404.8	404.1	62	65	54	100	ON	ON	OFF	5	6	17.5	13.75
6/2/98	1400	L	LOLV	404.8	404.1	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/2/98	2000	L	LOLV	404.7	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/3/98	0200	L	LOLV	404.5	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/3/98	0800	L	LOLV	404.5	404.0	59	63	65	100	ON	ON	OFF	5	6	17.5	13.75
6/3/98	1400	L	LOLV	404.5	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/4/98	0200	L	CLR	404.5	403.9	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/4/98	0800	L	CLR	404.5	404.0	48	64	58	100	ON	ON	OFF	5	6	17.5	13.75
6/4/98	1400	L	CLR	404.4	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/4/98	2000	L	CLR	404.4	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/5/98	0200	L	CLR	404.5	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/5/98	2000	L	CLR	404.5	403.9	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/6/98	0200	L	CLR	404.0	404.0	--	--	--	--	ON	ON	OFF	5	6	17.5	13.75
6/6/98	0930	L	LGRN	404.6	404.3	56	68	52	81	OFF	OFF	OFF	5	10	9.5	10
6/6/98	1400	L	LGRN	--	404.3	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/6/98	2000	L	LGRN	404.5	404.3	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/7/98	0200	L	LGRN	404.5	404.3	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/7/98	0800	L	LGRN	404.5	404.3	65	70	57	77	OFF	OFF	OFF	5	10	9.5	10
6/8/98	0200	L	LGRN	404.4	404.3	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/8/98	0800	L	LGRN	404.5	404.3	62	70	61	78	OFF	OFF	OFF	5	10	9.5	10
6/8/98	1400	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/8/98	2000	L	GRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/9/98	0200	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/9/98	0800	L	LGRN	404.6	404.1	54	68	62	80	OFF	OFF	OFF	5	10	9.5	10
6/9/98	1400	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/9/98	2000	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/10/98	0800	M	GRN	404.5	404.2	70	72	62	86	OFF	OFF	OFF	5	10	9.5	10
6/10/98	1400	L	GRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/11/98	0800	L	LGRN	404.5	404.2	70	72	62	86	OFF	OFF	OFF	5	10	9.5	10

Appendix Table A-6. Continued.

Date	Time	Debris[a]	Water color[b]	River gauge (ft.)	Canal height (ft.)	Water Temp. (F°) Min.	Water Temp. (F°) Max.	Air Temp. (F°) Min.	Air Temp. (F°) Max.	Pumpback[c] P1	Pumpback[c] P2	Pumpback[c] P3	RR	Headgate Openings[d] S	Headgate Openings[d] M	Headgate Openings[d] N
6/11/98	1400	L	GRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/12/98	0800	L	LGRN	404.4	404.1	65	72	56	87	OFF	OFF	OFF	5	10	9.5	10
6/12/98	1400	L	LGRN	404.4	404.1	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/12/98	2000	L	LGRN	404.4	404.1	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/13/98	1050	L	LGRN	404.4	404.2	68	72	64	82	OFF	OFF	OFF	5	10	9.5	10
6/13/98	2000	L	LGRN	404.4	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/14/98	0800	L	LGRN	404.4	404.2	66	72	55	81	ON	ON	OFF	5	10	9.5	10
6/14/98	1400	L	GRN	404.4	404.1	--	--	--	--	ON	ON	OFF	5	10	9.5	10
6/15/98	0800	L	LGRN	404.4	404.2	64	70	40	79	OFF	OFF	OFF	5	10	9.5	10
6/15/98	1400	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/15/98	1800	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/16/98	0800	L	LGRN	404.4	404.2	--	--	52	80	OFF	OFF	OFF	5	10	9.5	10
6/16/98	2000	L	LGRN	404.4	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/17/98	2000	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/18/98	0800	L	LGRN	404.5	404.2	62	74	65	85	OFF	OFF	OFF	5	10	9.5	10
6/18/98	1400	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/19/98	2000	L	LGRN	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/20/98	0800	L	LOLV	405.5	404.2	52	70	54	82	OFF	OFF	OFF	5	10	9.5	10
6/20/98	2000	L	LOLV	404.5	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/21/98	0800	L	LGRN	404.4	404.2	62	70	55	82	OFF	OFF	OFF	5	10	9.5	10
6/21/98	1400	L	LGRN	404.4	404.2	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/22/98	0800	L	LGRN	404.5	404.2	66	70	62	84	OFF	OFF	OFF	5	10	9.5	10
6/23/98	0800	L	LGRN	404.5	404.2	68	72	62	84	OFF	OFF	OFF	5	10	9.5	10
6/23/98	1400	L	LGRN	404.5	404.3	--	--	--	--	OFF	OFF	OFF	5	10	9.5	10
6/24/98	2000	L	LGRN	404.5	404.3	--	--	--	--	OFF	OFF	OFF	5	3	6	6
6/25/98	0900	L	LGRN	404.5	404.4	--	--	56	86	OFF	OFF	OFF	5	3	6	6
6/26/98	0800	L	LGRN	404.5	404.4	60	65	54	75	OFF	OFF	OFF	5	3	6	6
6/27/98	0800	L	GRN	404.5	404.3	58	65	50	75	OFF	OFF	OFF	5	3	6	6
6/27/98	1400	L	GRN	404.5	404.3	--	--	--	--	OFF	OFF	OFF	5	3	6	6
6/29/98	1500	L	LGRN	404.4	404.3	64	70	52	88	OFF	OFF	OFF	5	3	6	6
7/4/98	1400	L	LGRN	404.3	404.2	72	74	60	92	OFF	OFF	OFF	5	3	6	6
7/5/98	1930	L	LGRN	404.3	404.2	70	72	60	84	OFF	OFF	OFF	5	3	6	6

Appendix Table A-7. Estimates of survival and/or abundance for hatchery and natural juvenile salmonids migrating from the Umatilla River basin, 1995 – 1998.

	Year							
	1995		1996		1997		1998	
Species[a]	Abund.[b]	Survival	Abund.[b]	Survival	Abund.[b]	Survival	Abund.[b]	Survival
				Hatchery				
CH1$^+$	2,341,223	426%	--	--	530,321	71.1%	--	--
CHS 0$^+$	9,657	3%	--	--	--	--	--	--
CHS 1$^+$	294,052	67%	129,593	34%	--	--	413,303	73%
CHF 1$^+$	--	--	226,767	40%	--	--	258,296	70%
CHF 0$^+$	420,608	18%	3,637,933	141%	2,902	35%	4,227,783	152%
COH	33,967,417	2,243%	554,501	38%	476,378	34.0%	2,020,387	129%
STS	225,139	154%	137,478	94%	--	--	68,670	50%
				Natural				
CHS	74,342		1,856		1,151		18,724	
CHF	--		--		1,318		124,504	
COH	--		346		1,200		3,384	
STS	58,876		73,134		--		53,854	

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

[b] *Abund. = abundance.*

Appendix Table A-8. PIT-tag recoveries at mainstem Columbia River islands from hatchery juvenile salmonids released for reach-specific survival tests in the Umatilla River, 1998. Islands are sites of bird colonies.

Species[a]	Release site	Release date	Number released	Recovery date	Recovery site[b]	Number recovered	Percent recovery
CHS	RM 80	3/9-3/11	238	12/11	RICEIS	4	1.7
	RM 42	3/9-3/11	232	12/11	RICEIS	2	0.9
STS	RM 79	4/15-4/17	240	9/14	3MILIS	1	
(larges)				8/31, 12/11	RICEIS	9	4.2
	RM 64.5	4/15-4/17	206	8/31, 12/11	RICEIS	7	3.4
	RM 48	4/15-4/17	228	9/14	3MILIS	1	
				12/11	RICEIS	8	3.9
	RM 27	4/15-4/17	208	9/14	3MILIS	1	
				12/11	RICEIS	7	3.8
STS	RM 79	5/11-5/13	221	12/11	RICEIS	6	2.7
(smalls)	RM 48	5/11-5/13	239	9/14, 10/28	3MILIS	3	
				12/11	RICEIS	2	2.1
	RM 27	5/11-5/13	240	12/11	RICEIS	12	5.0
CHF0	RM 80	6/1-6/3	491	9/14	CRESIS	1	
				8/31, 12/11	RICEIS	2	0.6
	RM 48	6/1-6/3	518	9/14	3MILIS	1	
				12/11	RICEIS	4	1.0
	RM 27	6/1-6/3	505	9/14, 12/11	CRESIS	2	
				12/11	RICEIS	2	0.8
	RM 0[c]	7/9	481	12/11	CRESIS	1	0.2

[a] *CHS = spring chinook salmon, STS = summer steelhead, CHF0 = subyearling fall chinook salmon.*

[b] *RICEIS = Rice Island (RM 21), 3MILIS = Three Mile Island (RM 256), CRESIS = Crescent Island (RM 317).*

[c] *RM 0 release was from juvenile salmon transported from Westland Canal (RM 27.3) to the mouth of the Umatilla River.*