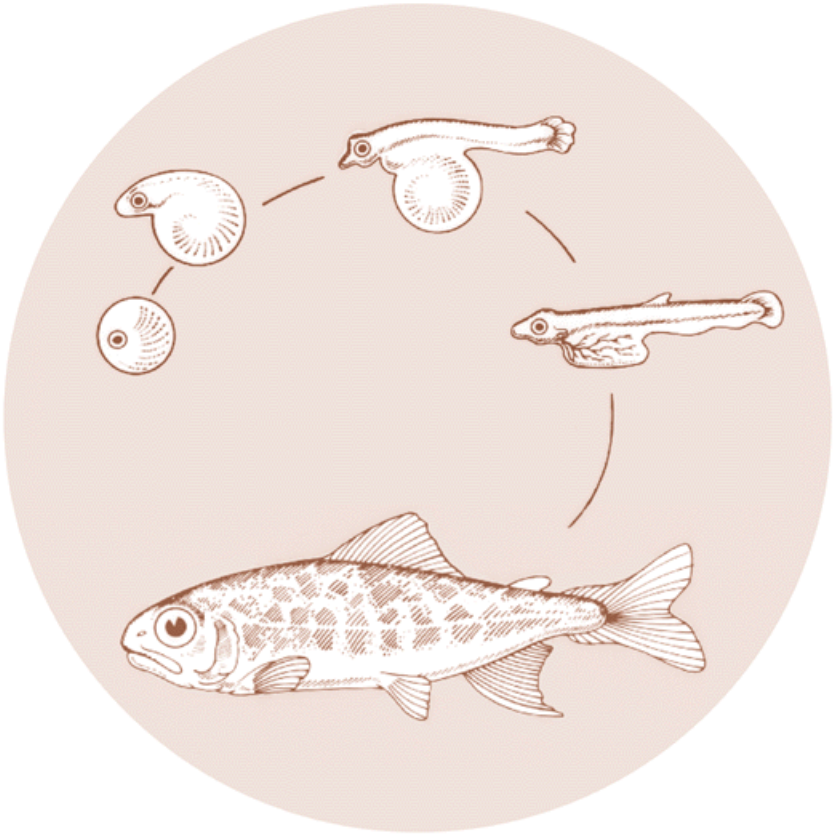
# UMATILLA HATCHERY MONITORING AND EVALUATION

November 1, 1995 - October 31, 1996

Annual Report 1996



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# UMATILLA HATCHERY MONITORING AND EVALUATION (NOVEMBER 1, 1995 - OCTOBER 3 1, 1996)

## ANNUAL REPORT 1996

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## EXECUTIVE SUMMARY

This report summarizes the monitoring and evaluation studies of salmonids reared at Umatilla Hatchery for the period November 1, 1995 to October 31, 1996. Studies at Umatilla Hatchery are designed to evaluate rearing of chinook salmon and steelhead in "Michigan raceways". Characteristics of Michigan raceways include high fish densities, rapid water turnover, oxygen supplementation, reuse of water, and baffles designed to reduce cleaning. Fish health at Umatilla Hatchery and other facilities associated with the Umatilla program is intensively monitored and evaluated as part of the overall research project. Further, under the Integrated Hatchery Operations Team guidelines, specific requirements for fish health monitoring are mandatory and have become the responsibility of the fish health staff conducting the studies at Umatilla Hatchery. Additional studies include evaluations of sport fisheries in the Umatilla River and mass marking and straying of fall chinook salmon. Juvenile rearing experiments have been completed for subyearling fall chinook salmon reared in Michigan and Oregon raceways. Although preliminary adult return data has been recovered, the most data on post-release survival is incomplete. Conclusions in this report should be viewed as preliminary and used in conjunction with additional information as it becomes available.

## Objectives for Fiscal Year 1996

### Hatchery Monitoring and Evaluation

1. Document egg-take, and egg-to-fry and egg-to-smelt survival for salmon and steelhead reared at Umatilla and Bonneville hatcheries and released into the Umatilla River.

2. Document rearing densities, loading, and cost of salmon and steelhead reared at Umatilla and Bonneville hatcheries and released into the Umatilla River.

3. Document number, size, time, and release location for salmon and steelhead reared at Umatilla and Bonneville hatcheries and released into the Umatilla River.

4. Monitor water quality parameters in Michigan and Oregon index raceways containing salmon and steelhead.

5. Collect and compare monthly length, weight, and condition factor estimates for salmon and steelhead reared in Michigan and Oregon raceways at Umatilla Hatchery.

6. Calculate growth for salmon and steelhead reared in Michigan or Oregon raceways at Umatilla Hatchery.

7. Determine fin condition, descaling, smolting, length, weight, and condition at pre-release or release for salmon and steelhead reared at Umatilla and Bonneville hatcheries and released into the Umatilla River.

8. Compare the physiological stress response of fall chinook salmon reared at three densities in Michigan raceways at Umatilla Hatchery.

9. Evaluate smolt migration performance of branded salmon or steelhead reared at Umatilla or Bonneville hatcheries, released in the Umatilla River and recovered at John Day dam.

10. Evaluate smolt-to-adult survival by fin marking, coded-wire-tag or blank-wire-tagging, and releasing replicate groups of salmon and steelhead.

11. Summarize catch and escapement information from coded-wire-tagged salmon and steelhead released in the Umatilla River.

12. Evaluate straying of adult fall chinook salmon from releases in the Umatilla River.

13. Evaluate and compare the effects of tagging and marking on smolt-to-adult survival of subyearling fall chinook salmon.

14. Estimate the sport harvest of salmon and steelhead in the Umatilla River with statistical creel methods.

15. Participate in the development of water quality sampling and monitoring in the Umatilla River basin.

16. Participate in planning the production and management activities of anadromous fish in the Umatilla River basin.

**Fish Health Monitoring and Evaluation**

1. Conduct monthly fish health examinations on fresh dead or moribund, and healthy juvenile fish from index raceways of each species and stock of fish reared at Umatilla Hatchery.

2. Conduct fish health examinations on 30 juvenile fish per index raceway of each species and stock reared at Umatilla Hatchery.

3. Conduct preliberation fish health examinations on 30 juvenile fish per evaluation raceway of 1994 yearling fall chinook salmon at Bonneville Hatchery.

4. Using data obtained from monthly and preliberation fish health examinations, assess what effects differing rearing strategies and environments have on fish health.

5. Examine fish when unusual loss or behavior occurs by appropriate diagnostic methods. Implement therapeutic or prophylactic measures to control, moderate or prevent disease outbreaks.

6. Continue implementation of Federal Drug Administration Investigation New Animal Drug protocols or erythromycin feeding of juvenile spring chinook salmon at Umatilla Hatchery.

7. Continue implementation of Federal Drug Administration Investigation New Animal Drug protocols for oxytetracycline, formalin, and chloramine-T as needed for disease treatment at Umatilla Hatchery.

8. Examine fish at acclimation facilities which are part of the Umatilla program for health problems or preliberation following extended acclimation.

9. Begin to collect *Renibacterium safmoninarum* ELISA data on adult spring chinook salmon reared under the Umatilla program.

10. Continue to develop expertise in statistical analyses pertinent to the epidemiological evaluations at Umatilla Hatchery. Use this to analyze trends in all data accumulated to date.

11. Investigate the use of polymerase chain reaction methodology for confirmatory diagnosis and identification of *Flexibacter psychrophilus*.

12. Conduct *in vitro* experiments to determine the survival of *R. salmoninarum* in water from Umatilla Hatchery.

## Accomplishments and Findings for Fiscal Year 1996

### Hatchery Monitoring and Evaluation

We achieved all of our objectives in fiscal year 1996 except comparisons of physiological stress response in subyearling fall chinook salmon. We continued the Michigan versus Oregon experiment to provide an additional year of replication because of poor smelt-to-adult survival from the 1991 brood. Our experimental design requires four years of replication.

### Fall Chinook Salmon

#### Subyearlings:

*Fish Culture Studies:* Approximately 3.0 million subyearling fall chinook salmon were released in the Umatilla River in 1996. Subyearling production exceeded the 1996 fiscal year goal (2.6M) and was within 10% of the size goal of 60 fish/lb. Cost averaged $0.04 per fish. More than three million salmon were coded or blank wire-tagged in 1995-96 ( > 95 % retention). Ventral fin clip quality was greater than 97% recognizably clipped. No subyearlings sampled were descaled in Oregon raceways compared to 4 % in Michigan raceways.

*Rearing and Survival Studies:* Approximately 100,000 fish were branded to monitor juvenile migration in 1996. An average of 2.7% of the branded fish were recovered at John Day Dam. Recovery was similar for fish reared in Michigan and Oregon raceways. Percent recovery ranged from 2.1-3.6 % for fish reared in Michigan raceways and increased from first to third pass. After release, smolts required an average of 10 days to travel to John Day Dam in 1996. Previous data suggested that travel time was related to Columbia River flow. Estimates of smolt-to-adult survival

were inconclusive for the 1991 brood because few adults were recovered. Total smolt-to-adult survival for the 1992 brood (through age four) averaged 0.03 % .

**Yearlings (Umatilla Hatchery):**

*Fish Culture Studies:* Approximately 143,000 yearling fall chinook salmon were released in the Umatilla River in 1996. Yearlings were reared in Michigan raceways for the first time in 199596. Production was below the 1996 fiscal year goal (150K) and exceeded the size goal of 8 fish/lb by 38%. Cost averaged $0.95 per fish. All yearlings were coded or blank wire-tagged ( > 98 % retention) and ventral fin clipped ( > 96% recognizably clipped). We estimated that 98-100% of fish were partially descaled or descaled. Yearlings in Michigan raceways were seriously infected with cold water disease.

*Rearing and Survival Studies:* Approximately 16,000 fish were branded to monitor juvenile migration in 1996. Only 4 brands (0.03%) were recovered at John Day dam. The median travel time for smolts to migrate to John Day Dam was 8 days in 1996.

**Yearlings (Bonneville Hatchery):**

*Fish Culture Studies:* Approximately 421,000 yearlings were reared in Oregon raceways at Bonneville Hatchery and released in the Umatilla River. Production was below the 1996 fiscal year goal (450K) and exceeded the size goal of 8 fish/lb by 12%. All yearlings were coded or blank wire-tagged ( > 93 % retention) and ventral fin clipped ( > 90 % recognizably clipped). We estimated that 69-86% fish were partially descaled or descaled.

*Rearing and Survival Studies:* Approximately 10,000 fish were branded and released in the Umatilla River to monitor juvenile migration in 1996. Only 13 brands (0.13 %) were recovered at John Day Dam and the median travel time was 15 days. Adult survival of fish reared at Bonneville Hatchery and released in the Umatilla River was 0.00% for the 1990 brood and 0.03% for the 1991 brood.

**Adult Returns**

More than 800 jack and adult (and 300 subjack) fall chinook salmon returned to the Umatilla River in 1995. Adult returns peaked in mid-October. Based on coded-wire tag recoveries, subyearling releases accounted for most hatchery adult returns. All subjacks originated from yearling releases. Most returning fish were age 3 or 5, and few were age 4. We collected fin clip and blank-wire tag data on returning adults and used a tunnel shaped wire-tag detector to detect body tags.

**Fishery**

Total angling effort was more than 2200 h during the 1995 fall chinook and coho salmon sport fishery. Catch rates for fall chinook salmon jacks and adults were 0.04 and 0.02 fish/h. Catch rates for coho salmon averaged 0.01 fish/h for jacks and adults. We estimated that 13% (41 fish) of the jack fall chinook salmon and 3 % (48 fish) of the coho salmon were harvested between Three Mile Falls Dam and the mouth of the Umatilla River.

**Straying**

More than 250 adult fall chinook salmon that were originally released as smolts in the Umatilla River were estimated to escape past Lower Granite Dam in 1995. Seventy wire-tagged fish were removed at Lower Granite Dam in 1995. Most strays originated from subyearlings that were released in the Umatilla River before Umatilla Hatchery was completed. Monitoring suggests that wire-tagging all fish will increase detection and removal of strays..

**Spring Chinook Salmon**

**Subyearlings:** No subyearling spring chinook salmon were released in the Umatilla River in 1996. No coded-wire-tags have been recovered from subyearling releases from 1992-94.

**Fall Release:** No spring chinook salmon were released in the Umatilla River in fall 1996. Few coded-wire-tags have been recovered from releases made from 1992-94. No adults have returned from fish reared at Umatilla Hatchery, but survival for fish reared at Bonneville Hatchery (1991 brood) ranged from 0.03-0.08%.

**Y earliugs:**

*Fish Culture Studies:* Approximately 379,000 yearling spring chinook salmon were reared at UH and released in the Umatilla River in 1996. Yearling production was slightly lower than the 1996 fiscal year goal (390K) and was 12% below the goal of 8 fish/lb. Cost averaged $0.74 per fish. Approximately 80,000 fish were coded wire-tagged in 1995-96 (98% retention). Ventral fin clip quality ranged from 99-100% recognizably clipped. Yearlings reared in Oregon raceways were larger and suffered less descaling than fish reared in Michigan raceways.

*Rearing and Survival Studies:* Approximately 20,000 yearlings were branded to monitor juvenile migration in 1996. The recovery of branded fish at John Day Dam was 9.7% for Oregon reared fish and 7.6% for Michigan reared fish. Smolt-to-adult survival of yearlings (1991 brood) reared at Umatilla Hatchery ranged from O.O-0.08% compared 0.13-0.20% for fish reared at Bonneville Hatchery through 1995.

**Adult Returns**

More than 2,200 jack and adult spring chinook salmon returned to the Umatilla River in 1996. Adult returns peaked in mid-May. The number of jacks returning in 1996 was 31% greater than in 1995 and regression analyses suggests a run of approximately 2,100 adults in 1997. Preliminary data indicates that the majority of returning adults originated from Bonneville Hatchery releases.

**Fishery**

Anglers fished more than 2900 h during the 1996 sport fishery for spring chinook salmon. Angling effort was 2471 h in the lower reach (Rieth to the Highway 11) and 429 h in the upper reach (CTUIR boundary to Umatilla Forks). Catch rates averaged 0.075 fish/h and 0.003 fish/h in the lower and upper river. We estimated that 9% (206 fish) of the total run was harvested.

**Summer Steelhead**

**Fish Culture Studies:** Approximately 146,000 steelhead were released in the Umatilla River in 1996. Steelhead production was slightly lower than the 1996 fiscal year goal (150,000) and was within 3% of the size goal of 5 fish/lb. Cost averaged $0.69 per fish. Approximately 60,000 fish were coded wire-tagged in 1995-96 ( > 97 % retention) and all fish were adipose fin clipped ( > 99 % recognizably clipped). We estimated that 32-72% of the fish were partially descaled or descaled when released.

**Rearing and Survival Studies:** Approximately 30,000 fish were branded to monitor juvenile migration in 1996. Only one brand (0.003%) was recovered at John Day Dam. Adult survival of small, medium, and large grade steelhead from the 1991 brood averaged 0.00%, 0.02%, and 0.20%, respectively. Incomplete CWT data suggests greater smolt-to-adult survival for groups released in April than for groups released in May.

**Adult Returns**

More than 2,000 steelhead returned to the Umatilla River in 1995-96. The number of hatchery fish that returned (785) was the greatest on record. Run timing for hatchery fish continued to emulate the run timing for wild fish. Although sex ratios for returning hatchery fish were near 1: 1, ratios for wild fish were approximately 1:2 male to female. Thirteen of 92 fish sampled for coded-wire-tags at Three Mile Falls Dam were strays.

**Fishery**

Total angling effort was more than 4500 h during the 1995-96 sport fishery. Catch rates were 0.05 fish/h in the lower river and 0.06 fish/h in the upper river. We estimated that only 2% of the summer steelhead entering the Umatilla River were harvested between Three Mile Falls Dam and the mouth of the Umatilla River in 1995-96.

**Fish Health Monitoring and Evaluation**

**Broodstock Monitoring**

Subsamples from the adult fall chinook salmon spawned at Priest Rapids on each spawning date for Umatilla Hatchery 95 brood year production had negligible or no *R. salmoninarum* antigen as determined by the enzyme-linked immunosorbent assay. They were also negative for culturable viruses.

Subsamples from the Carson spring chinook salmon spawned at Little White Salmon NFH on each spawning date for Umatilla Hatchery 96 brood year production had levels of *R. salmoninarum* antigen ranging from negligible to those indicative of clinical infection as determined by the enzyme-linked immunosorbent assay. There were also high prevalences of infectious hematopoietic necrosis virus detected from these fish on some spawning dates.

Samples from adult and jack spring chinook salmon reared as juveniles at Bonneville and Umatilla hatcheries and collected in the Umatilla River as returning adults had negligible or no *R. salmoninarum* antigen as determined by the enzyme-linked immunosorbent assay.

All adult summer steelhead spawned at Minthorn ponds for Umatilla Hatchery 96 brood year production were negative for infectious hematopoietic necrosis virus.

**Juvenile Monitoring**

Bacterial kidney disease was diagnosed both during monthly monitoring and loss investigations in the 94 brood year Carson spring chinook juveniles at Umatilla Hatchery. This was the third consecutive year of occurrences of BKD in this stock at Umatilla and mortality rates were statistically higher in the Michigan raceways over those in the Oregon raceways. These differences were also documented from preliberation analyses using the enzyme-linked immunosorbent assay to detect *R. salmoninarum* antigen.

Bacterial cold water disease was diagnosed both during monthly monitoring and loss investigations in the 94 brood year fall chinook juveniles at Umatilla Hatchery. These fish were in a Michigan series of raceways. The epidemiological data collected over the several months of this outbreak indicates the baffles in these raceways were likely responsible. The outbreak could not be controlled with standard treatments and cumulative loss for the entire episode was approximately 5 % . Following resolution of the cold water disease the fish in the lowermost raceway began to show clinical bacterial kidney disease. Preliberation analyses using the enzyme-linked immunosorbent assay to detect *R. salmoninarum* antigen indicated no differences among the three raceways.

A loss investigation at the Thornhollow acclimation facility on the 94 brood year fall chinook salmon smolts transferred from Bonneville Hatchery indicated bacterial cold water disease. This was probably exacerbated by the transport stress from Bonneville and infection by erythrocytic inclusion body syndrome virus.

**Investigational New Animal Drug Monitoring**

Toxicity tests following Aquamycin therapy on spring chinook salmon at Umatilla Hatchery continue to indicate toxic effects from this treatment even several days after the treatment has ended.

**Relevant Studies**

*In vitro* experiments using Umatilla Hatchery water seeded with the *R. salmoninarum* bacterium indicated survival of the bacterium in that water of over 60 days. Thus Umatilla Hatchery water would support horizontal transmission of the bacterium within fish in the same raceway and among fish in different raceways using the same water.

Polymerase chain reaction technology was tested to confirm isolates of ***R. salmoninarum*** and *Flexibacter psychrophilus* from fish at Umatilla Hatchery. The results indicate that PCR may be a useful tool for confirming such isolates or infections caused by these bacteria.

## Management Implications and Recommendations

### Hatchery Monitoring and Evaluation

1. Production of subyearling fall chinook salmon in Michigan raceways should continue. Approximately three times as many fish'can be produced per gallon of water in one series of Michigan raceways than in a series of Oregon raceways. Based on preliminary data, smolt-to-adult survival of Michigan and Oregon reared fish is similar. Subyearlings have contributed significantly to adult returns and accounted for most of the adult fall chinook salmon recovered in the Umatilla River in 1995.

**2.** We should continue wire tagging all subyearling fall chinook salmon. Although non-wire tagged salmon continue to stray into the Snake River, most wire tagged fish are removed at Lower Granite Dam. Removal of tagged fish should limit escapement of Umatilla strays past Lower Granite Dam and reduce strays to the 5 % or less goal established by NMFS. Subyearling releases produced most strays, therefore a reduction in the proportion of yearlings marked should be considered for future broods.

**3.** Production of yearling chinook salmon at Umatilla Hatchery should be reevaluated. Growth of yearlings at Umatilla Hatchery is slowed by delaying incubation; however, high water temperatures cause these fish to experience accelerated growth compared to fish reared at Bonneville Hatchery. Preliminary data indicates significantly greater survival of yearlings reared at Bonneville Hatchery than at Umatilla Hatchery. Higher water temperatures combined with extensive incubation may not be suitable for rearing yearlings.

4. The production of subyearling spring chinook salmon should not be resumed until size at release goals can be met. Smolt-to-adult survival data for three brood years will not be complete until 1999, but no jacks or adults have been recovered from any subyearling releases. Further evaluation of this release strategy could be initiated if size at release goals can be achieved.

5. Releases of spring chinook salmon in the fall should be resumed and evaluated if adequate numbers of eggs are available. Adults are being recovered from fish reared at Umatilla and Bonneville Hatchery.

**6.** The sport fishery for spring chinook salmon should be continued when sufficient numbers of adults return to Three Mile Falls Dam. Based on angling effort and comments, the spring fishery was popular and expanded fishing areas should be considered to reduce localized crowding.

7. Production of steelhead should continue in Michigan raceways. Although fish have not been reared in Oregon raceways, we estimate 40% greater production in Michigan raceways per gallon of water. Preliminary adult survival estimates of < 1% are below the management goal of 2.7%, but returns of hatchery steelhead to the Umatilla River in 199596 were the largest on record and contributed to the sport fishery. Studies with simultaneous rearing of steelhead in Michigan and Oregon raceways need to be completed before the success of the Michigan system can be fully evaluated.

8. Branding steelhead should be discontinued, except for in-basin studies. The number of fish collected at John Day Dam in 1995 and 1996 has been insufficient to make estimates of migration success. Because of the Columbia River spill program, we believe that releasing a greater number of branded fish would not produce sample sizes needed for analysis.

9. Use of hatchery steelhead as broodstock should be monitored. As many as 15 % of returning steelhead to the Umatilla River were strays. Reading coded-wire tags during spawning to selectively remove strays may be needed if straying or the use of hatchery fish as broodstock increases.

10. Steelhead released in May continue to perform poorly. Adult survival estimates from three brood years have been consistently poorer for May releases compared to April releases.

11. Alternative water supplies should be investigated at Umatilla Hatchery. Partial justification for the construction of Umatilla Hatchery was to compare the adult survival of salmonids reared in Michigan and Oregon raceways. Water shortages at the Umatilla Hatchery continue to limit production and experiments that could produce information for other Columbia River basin hatcheries.

**Fish Health Monitoring and Evaluation**

1. Data collected to date indicates higher infection rates with *R. salmoninarum* and severity of bacterial kidney disease in spring chinook salmon reared in the Michigan raceways at Umatilla Hatchery. Culling or segregation strategies of progeny based on infection levels in female adults would, at a minimum, be needed to decrease the impact of *R. salmoninarum* on spring chinook juveniles reared in Michigan raceways at Umatilla Hatchery. If Michigan raceways are to be used, consideration for reduced densities may be appropriate.

2. The configuration of the Michigan raceways having baffles in place as self-cleaning tools may promote a form of bacterial cold water disease that is impossible to control with standard therapies. Comparisons using the same fish populations in raceways with and without baffles, or between Oregon and Michigan raceways, should be made to confirm this. Monitoring indicators of chronic stress may provide clues as to when the baffles begin to create a potential problem and should be removed.

3. The lack of similar populations of fish in Oregon and Michigan raceways continues to limit the assessment of impacts that the Michigan rearing strategies could be having on fish health and disease. The lack of needed water to provide these comparisons continues to place major constraints on these assessments.

4. Segregation and culling rearing strategies for bacterial kidney disease continue to be recommended. The National Academy Press document, Upstream, recommends under hatchery programs that "diseased broodstock should be rigorously culled to minimize disease in the progeny. " Whether or not segregation or culling for bacterial kidney disease is implemented in the Umatilla program, 100% sampling of female adult chinook salmon for *R. salmoninarum* infection levels would be most desirable. Data using subsamples severely weakens the analyses of subsequent occurrences of bacterial kidney disease in the progeny.

5. Sampling of 100% of the coded-wire tagged returning adult chinook salmon, both male and female, as hatchery broodstock is also most desirable. This is to obtain sufficiently valid statistical sample sizes for comparison of *R. salmoninarum* infection levels versus rearing strategy.

6. Interagency Hatchery Operations Team guidelines apply to all facilities within the Umatilla River basin. Under these guidelines there are requirements for specific juvenile and adult fish health monitoring activities. Whether or not these are supported under the Umatilla Hatchery Fish Health Monitoring and Evaluation project needs to be addressed. These activities have been fulfilled under the M&E project however with reduced budgets this is no longer feasible without eliminating other activities related to the project.

**REPORT A**

# Umatilla Hatchery Monitoring and Evaluation

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## *UMATILLA HATCHERY MONITORING AND EVALUATION*

### INTRODUCTION

The Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program authorized construction of the Umatilla Hatchery (UH) in 1986. Measure 703 of the program amended the original authorization for the hatchery and specified evaluation of the Michigan (MI) raceways using oxygen supplementation to reach production goals of 290,000 lb of chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (0. *mykiss*). The hatchery was completed in the fall of 1991. Partial justification for the hatchery was to develop considerable knowledge and understanding of new production and supplementation techniques. MI raceways were used at UH to increase smolt production with a limited water supply and for comparison of MI raceways with Oregon (OR) raceways. Test results for MI raceways will have systematic application in the Columbia River basin.

The Umatilla Hatchery is the foundation for rehabilitating chinook salmon and enhancing steelhead in the Umatilla River (CTUIR and ODFW 1990) and is expected to contribute significantly to the Northwest Power Planning Council's goal of doubling salmon production in the Columbia Basin. Hatchery production goals and a comprehensive monitoring and evaluation plan were presented in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990). The Comprehensive Plan for Monitoring and Evaluation of Umatilla Hatchery (Carmichael 1990) was approved by the Northwest Power Planning Council as a critical adaptive management guide for fisheries rehabilitation in the Umatilla River. Monitoring and evaluation will be used to increase knowledge about uncertainties inherent in the fisheries rehabilitation and will complement the developing systematic monitoring and evaluation program.

The monitoring and evaluation goals are:

1. Provide information and recommendations for the culture and release of hatchery fish, harvest regulations, and natural escapement to accomplish long-term natural and hatchery production goals in the Umatilla River basin that are consistent with provisions of the Council's Columbia River Basin Fish and Wildlife Program.

2. Assess the success of achieving the management objectives in the Umatilla River basin that are presented in the Master Plan and the Comprehensive Rehabilitation Plan.

A substantial proportion of the production at UH is produced in MI raceways. This system has not been thoroughly evaluated to determine the effects on smolt-to-adult survival. In addition, the rearing strategies proposed for spring chinook salmon require an unusually extensive period of incubation in chilled well water.

Extensive background and justification for Umatilla Hatchery monitoring and evaluation is presented in Carmichael (1990). In this report, we present a review of our activities and findings for the Umatilla Hatchery Monitoring and Evaluation Project from 1 November 1995 to 31 October 1996. We designed our program to evaluate fish cultural practices, conduct rearing and survival studies, assess sport fisheries, and provide information for planning and coordination. In addition, for fall chinook salmon we are evaluating straying and the effects of tagging.

## STUDY SITE

Umatilla Hatchery is located approximately seven miles west of the town of Irrigon, Oregon (Figure 1). The hatchery is operated under a cooperative agreement among the Oregon Department of Fish and Wildlife (ODFW), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Bonneville Power Administration, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers.

The Umatilla Hatchery was designed for salmonid production in oxygen supplemented MI raceways and in non-oxygen supplemented OR raceways. Specific information about the hatchery is available in the Umatilla Hatchery Master Plan (CTUIR and ODFW 1990) and in the Environmental Assessment Report (Bonneville Power Administration 1987). The MI system consists of eight series of three concrete raceways. Water flows from the upper raceway to the middle raceway and then to the lower raceway within each series. Before the water enters each raceway, pure oxygen is supplemented through an oxygen contact column. More detailed descriptions of the raceways are presented in Hayes et al. (1996b).

The Umatilla River and tributaries are located in Umatilla, Morrow, and Union counties, Oregon. Facilities include acclimation ponds at Minthorn Springs (MS) at river mile 64, Thornhollow (TH) at river mile 73.5, Imeques C-mem-ini-kern (IC) at river mile 80, and Bonifer Springs (BS) at river mile 2 of Meacham Creek.

## METHODS

### Fall Chinook Salmon

#### Subyearlings

**Fish Culture Studies:** We monitored fish culture and hatchery operation practices at UH. We determined the number of eggs taken, egg mortality, fry mortality, and egg-to-smolt survival rates from UH records. Fish numbers and size at release for UH and BH production were determined from field sampling, hatchery records, and coded-wire tag release reports. Total cost per fish at release was calculated from hatchery accounting records. First, the hatchery operating cost was calculated by subtracting the marking costs for each group of fish from the annual budget. Group operating costs were based on the proportion of days each group of fish were reared in outside raceways (rearing days) times the hatchery operating cost. Total group cost was obtained by adding the group tag cost and the group operating cost. Cost per fish produced was the total group cost divided by the number of fish released. Methods for water quality monitoring were the same as previously reported (Hayes et al. 1996a).

**Rearing and Survival Studies:** Methods used in rearing and survival studies were described in the 1993-1996 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1996a, 1996b).

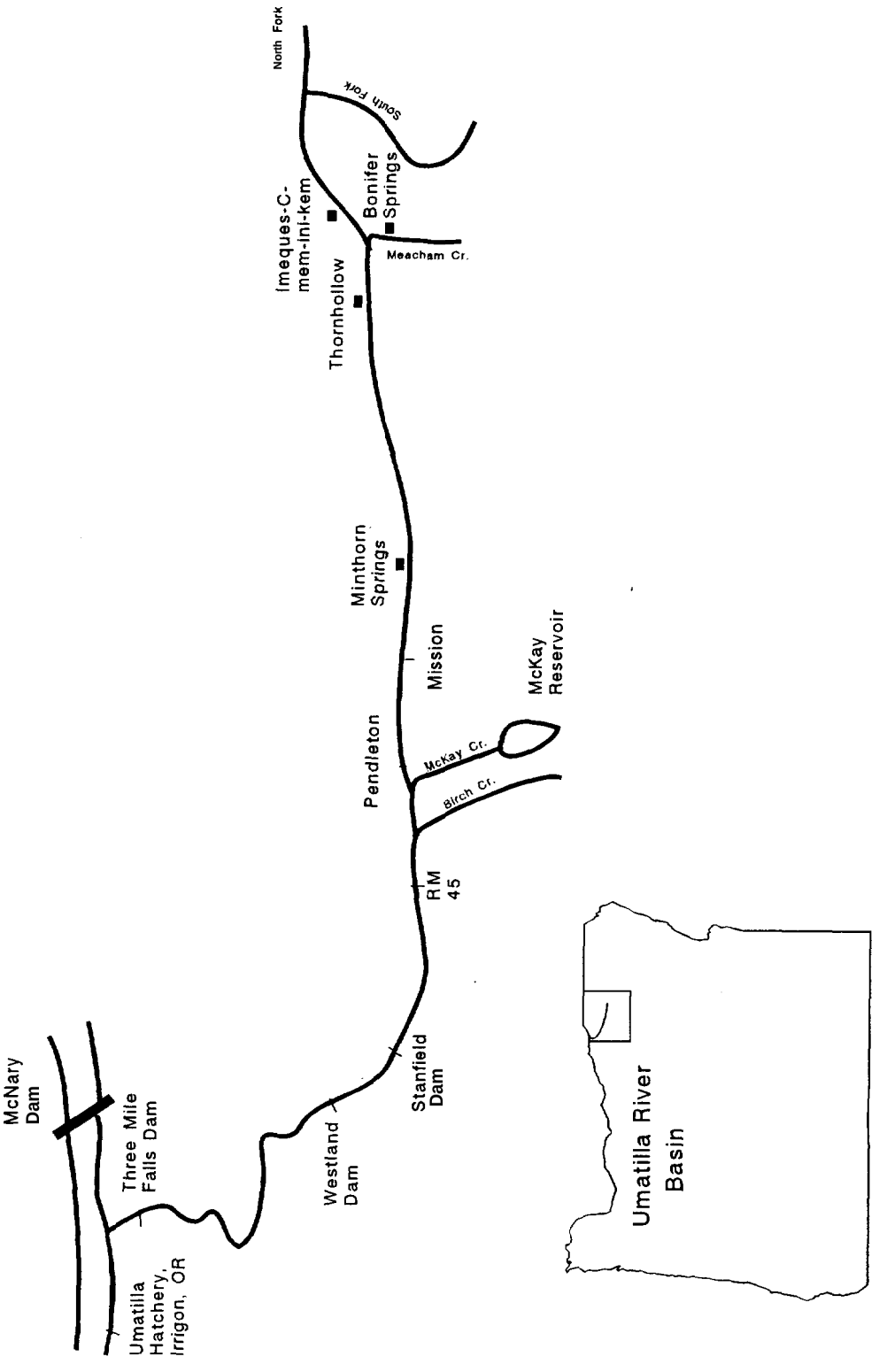


Figure 1. Location map, Umatilla River.

**Effects of Tagging and Marking:** Methods used in 1995 were described in the 1993-1996 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1996a, 1996b) except for the following modifications. Fall chinook salmon that returned to Three Mile Falls Dam (TMFD) after 18 October, 1995 were examined with a tunnel shaped tag detector. Brood year origin for fish that were not coded-wire-tagged was determined by length frequency data. Classification groups for length frequencies were 405-610 mm fork length (age 2), 611-800 mm (age 3), and > 801 mm (age 4).

**Yearlings**

**Fish Culture Studies:** Methods used in fish culture studies were the same as those for subyearling fall chinook salmon.

**Rearing and Survival Studies:** Methods used in rearing and survival were described in the 1993-1996 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1996a, 1996b).

**Adult Returns**

Methods used to calculate adult return and survival estimates were reported in Hayes et al. (1996b) Information for fall chinook salmon was downloaded from the Pacific States Marine Fisheries Commission (PSMFC) database in August 1996. When groups were released at approximately the same time, yearlings reared at UH were compared to control groups reared at Bonneville Hatchery (BH).

**Fishery**

Except for the following modifications, methods used to survey the fall chinook and coho salmon sport fishery in 1995 were described in the 1993-1996 annual reports (Keefe et al. 1993, 1994; Hayes et al. 1996a, 1996b). The fall chinook and coho salmon sport fishery was open 1 September to 30 November 1995. Fishing was allowed from Stanfield Dam downstream to the Highway 730 bridge in Umatilla. We did not survey between TMFD and Stanfield Dam because there was not a significant amount of effort observed during the 1995 season. However, spot checks did indicate occasional angling in this area. Anglers were allowed to harvest 2 adult coho salmon per day and 10 coho (16-20 in) or chinook (16-24 in) jacks per day. Anglers were restricted to barbless hooks.

**Straying**

Methods used to estimate fall chinook salmon strays into the Snake River were described in the 1995 annual report (Hayes et al. 1996b). Additional estimates were calculated with an unpublished model developed by the National Marine Fisheries Service.

## Spring Chinook Salmon

### Subyearlings

**Fish Culture Studies: No** broodstock was collected to produce subyearling spring chinook salmon in 1995.

**Rearing and Survival Studies:** Methods used in rearing and survival studies were the same as described for subyearling fall chinook salmon.

### Fall Release

**Fish Culture Studies:** No broodstock was collected to produce subyearling spring chinook salmon for release in the fall in 1995.

**Rearing and Survival Studies:** Methods used in rearing and survival studies were the same as described for subyearling fall chinook salmon.

### Yearlings

**Fish Culture Studies:** Methods used in fish culture studies were the same as described for subyearling fall chinook salmon.

**Rearing and** Survival **Studies:** Methods used in rearing and survival studies were the same as described for subyearling fall chinook salmon.

### Adult Returns

Methods used to collect information on spring chinook salmon returns and survival estimates were the same as described for subyearling fall chinook salmon. Information for spring chinook salmon was downloaded from the PSMFC database in September 1996.

### Fishery

Except for the following modifications, methods used to survey the spring chinook salmon fishery in 1996 were described in the 1993 annual report (Keefe et al. 1994). The spring chinook salmon sport fishery was open from 25 May to 15 June 1996. Fishing was allowed between the Rieth bridge and the Highway 11 bridge in Pendleton and between the upper CTUIR boundary (near Ryan Creek) and the confluence of the north and south forks of the Umatilla River. Anglers were allowed to harvest two adult salmon ($>$ 24 inches). Harvest of jacks was not legal.

## Summer Steelhead

### Fish Culture Studies

Methods used in fish culture studies were the same as described for the subyearling fall chinook salmon.

### Rearing and Survival Studies

Methods used in rearing and survival studies were the same as described for subyearling fall chinook salmon except for the following modification. In addition to a visual estimate, fin erosion was measured using a method described by Kindschi (1987) for quantifying the degree of fin erosion.

### Adult Returns

Methods used to collect information on steelhead returns and survival estimates were the same as described for fall chinook salmon. Information for steelhead was downloaded from the PSMFC database in September 1996.

### Fishery

Except for the following modifications, methods used to survey the steelhead sport fishery in 1996 were described in previous annual reports (Keefe et al. 1993, 1994; Hayes et al. 1996a, 1996b). The steelhead fishery was open from 1 September 1995 to 15 April 1996. Twenty three of the scheduled creel days were not sampled because of flooding and were considered to be zero effort and zero catch. Angling was allowed between the Highway 730 bridge in Umatilla and the lower CTUIR boundary above the Highway 11 bridge in Pendleton. Rainbow trout over 20 inches in length were considered steelhead. The legal harvest limit was two adipose clipped steelhead per day, or six in seven consecutive days, and only barbless hooks could be used.

Steelhead anglers were also interviewed at Irrigon and Umatilla hatchery outlets, and at boat ramps at Umatilla Marina, and McNary Dam on the Columbia River. We contacted anglers from 29 September 1995 to 25 January 1996 to recover coded-wire-tag data. No angling effort or expansions were determined.

### Statistical Analyses

Most tests comparing parameters between MI and OR systems and among passes within each system were analyzed using analysis of variance (ANOVA) at the 0.05 significance level. For tests of a single brood year we used a nested ANOVA to separate sources of variation within the MI and OR systems. Nesting levels included system, raceway within system, and pass within raceway.

Sources of variation among brood years were separated into brood year, system, and/or pass. Data with heterogeneous variances or listed as percentages were transformed as recommended (Sokal and Rohlf 1981). In some tests percentage data were compared with the Kruskall-Wallis or Wilcoxon non-parametric tests. Differences between pairs of means were tested by the Wilcoxon method.

Only A and B passes were compared in the OR and MI systems. Tests designed to examine differences within the MI system included A, B, and C passes. All other tests including planned comparisons of differences between means using the Sidak technique (Sokal and Rohlf 1981) were evaluated at an alpha level = 0.05.

## RESULTS

### Summary 199596

We monitored the culture and performance of more than 3.6 million chinook salmon and steelhead produced at UH during 1995-96 (Appendix Table 1). We also monitored the release of 450,000 chinook salmon reared at BH. Individual stock profiles, release, performance, and return data of previously released groups are presented in the following sections and Appendix Tables 2-8.

### Fall Chinook Salmon

#### Subyearlings

**Overview:** Five brood years of subyearling fall chinook salmon (1991-1995) have been reared in MI and OR system raceways at UH and released in the Umatilla River (Appendix Table 2). The objectives of this study are to compare rearing conditions, migration, cost, and smolt-to-adult survival for subyearlings produced in MI and OR systems and among fish reared in different MI passes. In addition yearling fall chinook salmon have been reared at BH and released in the Umatilla River to provide additional production and a comparison to the subyearling release strategy. Yearlings have been released from BH each year since 1992. Completed adult returns will be available in 2001.

**Fish culture studies:** Information on fish culture and releases are presented in Tables l-6 and Appendix Tables 1 and 2. Subyearlings from the 1995 brood were ponded outside in four OR raceways on 15 February 1996 at 665-685 fish/lb. These groups were split into four OR and six MI raceways at the end of March. Marking with wire tags and right ventral fin clips started in early April

and was completed in early May. Because of overproduction, fish were removed in equal proportions from all raceways and combined into an additional MI raceway (M4C). Subyearlings in this raceway were fin marked and blank-wire-tagged. We were unable to calculate food conversion ratios for each raceway because of the additional pond splits. Michigan raceways produced an average of 951 fish per gallon per minute (gpm) and OR raceways produced an average of 361 fish/gpm. Production costs were $0.10 per fish with marking costs and $0.04 per fish without marking costs.

**Rearing and Survival Studies:** Smolt condition data at pre-release and release for 1991-95 brood years appear in Tables 5-10. Most subyearlings were classified as intermediate smolts with 0-29% classified as smolts at pre-release in 1995. Right ventral fin clip quality was 97.2% recognizably clipped.

Brand, coded-wire-tag, and production release and recovery information is presented in Tables 11-14 and Figure 2. Brand recoveries at John Day dam ranged from 3-16 fish for each raceway with estimated daily passage of 84-408 fish. The first branded subyearling was observed on 7 June and the last on 3 July. Fifty percent of the fish were recovered within 12 days and 90% within 19 days of release. Smolt-to-adult survival estimates from previous releases are presented in Table 14.

**Effects of Tagging and Marking:** Information on the effects of tagging and marking subyearling fall chinook salmon appears in Table 15. The acquisition of a tunnel detector midway through the run improved our detection of wire tags.

**Yearlings**

**Overview:** One brood year (1994) of yearling fall chinook salmon has been reared in MI raceways at UH and released in the Umatilla River. The objectives of this study are to monitor rearing conditions, migration, cost, and smolt-to-adult survival for yearlings produced in the MI system and among fish reared in different MI passes. Egg incubation and rearing is designed to produce smolts that are approximately 8 fish per pound at release. When space is available, we will continue yearling production to evaluate the release strategy, however, propagation of yearling spring chinook salmon is a priority at UH. Completed adult returns will be available in 2001.

**Umatilla Hatchery:**

*Fish Culture Studies:* Information on fish culture and releases is presented in Tables 16-17 and Appendix Tables 1 and 3. We received 484,386 green eggs from Priest Rapids Hatchery for the yearling program. Egg-to-fry survival was 53.1% and egg-to-smolt survival was 29.5 % . Yearlings were ponded outside in one OR raceway on 13 June 1995 at approximately 150 fish/lb. They were

Table 1. Egg-take and survival of subyearling fall chinook salmon reared at Umatilla Hatchery.

| Egg source | Brood year | Number of eggs taken or received | Egg-to-fry survival (%) | Egg-to-smolt survival (%) |
|---|---|---|---|---|
| Bonneville Hatchery[b] | 1991 | 2,872,000 | 88.2 | 84.9 |
| Umatilla River[c] | 1991 | 601,548 | 85.4 | 84.8 |
| Total | | 3,473,548 | | |
| Bonneville Hatchery | 1992 | 1,615,003 | 99.0 | |
| Little White Salmon NFH | 1992 | 992,668 | 99.0 | |
| Umatilla River | 1992 | 181,419 | 92.0 | |
| Total[d] | | 2,189,090 | 98.6 | 94.3 |
| Priest Rapids | 1993 | 3,181,000 | 81.7 | |
| Umatilla River | 1993 | 352,000 | 76.1 | |
| Total | | 3,533,000 | 81.1 | 80.4 |
| Priest Rapids | 1994 | 3,877,000 | 67.4 | 63.6 |
| Priest Rapids[e] | 1995 | 4,547,108 | 78.1 | 75.7 |

[a] ***Survival estimate is based on green egg-to-smolt stage.***

[b] ***Eggs incubated at Bonneville Hatchery. Survival estimate does not include 2,403 parr removed for passage evaluation.***

[c] ***Survival estimate does not include 5,401 smolts removed for passage evaluation.***

[d] ***Survival estimate does not include 31,600 smolts removed for passage evaluation.***

[e] ***Survival estimate adjusted for 602,100 excess eggs destroyed.***

Table 2. Rearing conditions immediately before transfer for subyearling fall chinook salmon in Michigan and Oregon raceways at Umatilla Hatchery.

| Brood year | System | Maximum density ($lb/ft^3$) | Maximum loading (lb/gal/min) |
|---|---|---|---|
| 1991 | Michigan | 2.0-2.4 | 5.4-6.6 |
| 1991 | Oregon | 0.5-0.7 | 2.6-3.5 |
| 1992 | Michigan | 2.0-2.4 | 5.4-6.6 |
| 1992 | Oregon | 0.5-0.7 | 5.4-6.6 |
| 1993 | Michigan | 2.2-2.5 | 4.8-5.5 |
| 1993 | Oregon | 0.5-0.8 | 2.6-3.7 |
| 1994 | Michigan | 1.5-1.9 | 3.7-4.5 |
| 1994 | Oregon | 0.4-0.6 | 1.9-2.9 |
| 1995 | Michigan | 1.5-1.7 | 3.6-4.0 |
| 1995 | Oregon | 0.4-0.7 | 2.0-3.5 |

Table 3. Water quality comparisons in Michigan and Oregon raceways used to rear subyearling fall chinook salmon during 1996 (1995 brood). Means are combined values for first and second pass raceways (* = significant difference between systems, NS = no significant difference, $P > 0.05$).

| | Mean parameter value | | | | |
|---|---|---|---|---|---|
| Parameter measured | N | Michigan | N | Oregon | t-test |
| Sampling period | 29 Mar-15 May | | 29 Mar-15 May | | |
| Temperature head (“C) | 14 | 12.3 | 14 | 12.5 | NS |
| Temperature tail (“C) | 14 | 12.6 | 14 | 12.3 | NS |
| pH head | 14 | 8.1 | 14 | 8.0 | NS |
| pH tail | 14 | 8.0 | 14 | 8.0 | NS |
| Oxygen head (ppm) | 14 | 12.0 | 14 | 10.1 | * |
| Oxygen tail (ppm) | 14 | 9.4 | 14 | 8.6 | * |
| Nitrogen head (mmHg) | 10 | 573 | 10 | 596 | * |
| Nitrogen tail (mmHg) | 10 | 577 | 10 | 603 | * |
| Total pressure-head (mmHg) | 14 | 749 | 14 | 743 | NS |
| Total pressure-tail (mmHg) | 14 | 720 | 14 | 724 | NS |
| Unionized ammonia ($\mu$g/l) | 6 | 0.17 | 6 | 0.06 | NS |
| Alkalinity (mg/l $CaCO_3$) | 6 | 129 | 6 | 128 | NS |

Table 4. Water quality comparisons between first, second, and third pass Michigan raceways used to rear subyearling fall chinook salmon during 1996 (1995 brood). Means with same letter or without letters are not significantly different at $P > 0.05$.

| | | Mean parameter value | | |
|---|---|---|---|---|
| Parameter measured | N | A pass | B pass | C pass |
| Sampling period | | 29 Mar-10 May | 29 Mar-10 May | 29 Mar-10 May |
| Temperature head (“C) | 7 | 12.0 | 12.5 | 12.6 |
| Temperature tail (“C) | 7 | 12.5 | 12.7 | 12.7 |
| pH head | 7 | 8.0xy | 8.1x | 7.8y |
| pH tail | 7 | 8.1x | 8.0xy | 7.7y |
| Oxygen head (ppm) | 2 | 11.9 | 12.0 | 12.1 |
| Oxygen tail (ppm) | 2 | 9.3 | 9.5 | 9.9 |
| Nitrogen head (mmHg) | 2 | 580x | 566xy | 549y |
| Nitrogen tail (mmHg) | 2 | 584x | 571xy | 559y |
| Total pressure-head (mmHg) | 2 | 755x | 743xy | 731y |
| Total pressure-tail (mmHg) | 2 | 726x | 714xy | 709y |
| Unionized ammonia ($\mu$g/l) | 2 | 0.11 | 0.23 | 0.10 |
| Alkalinity (mg/l $CaCO_3$) | 3 | 130 | 129 | 129 |

Table 5. Mean length, weight, and condition factor for subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery and released in spring 1996 (1995 brood). Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P > 0.05$.

| | | Length(mm) | | Weight(g) | | Condition Factor | |
|---|---|---|---|---|---|---|---|
| Sample | System' | N | Mean(SE) | N | Mean(SE) | N | Mean(SE) |
| March: | Michigan | 502 | 58.8(0.2) | 222 | 2.2(0.4) | 222 | 1.07(0.01) |
| | Oregon | 208 | 60.1(0.3) | 121 | 2.5(0.6) | 121 | 1.12(0.01) |
| Pre-release: | | | | | | | |
| | Michigan | 1220 | 76.2(0.2)y | 407 | 5.4(0.1)y | 407 | 1.18(0.01)y |
| | Oregon | 1253 | 81.0(0.2)z | 430 | 6.2(0.1)z | 430 | 1.13(0.01)z |
| Release': | | | | | | | |
| | Michigan | | 85.2 | | 6.8 | | 1.09 |
| | Oregon | | 90.0 | | 7.6 | | 1.04 |

[a] *First and second pass Michigan raceways*

[b] *Release length was calculated from 1247 sample fish and length and weight condition factor from 868 fish released on 31 May 1996.*

Table 6. Mean length, weight, and condition factor for subyearling fall chinook salmon reared in Michigan and Oregon passes at Umatilla Hatchery during 1996 (1995 brood). Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P > 0.05$.

| | | Length(mm) | | Weight(g) | | Condition Factor | |
|---|---|---|---|---|---|---|---|
| Sample | Pass | N | Mean(SE) | N | Mean(SE) | N | Mean(SE) |
| | | | | **Michigan** | | | |
| March: | A | 272 | 59.2(0.2) | 114 | 2.2(0.1) | 114 | 1.05(0.02) |
| | B | 230 | 58.2(0.3) | 108 | 2.2(0.1) | 108 | 1.10(0.01) |
| | C | 224 | 58.1(0.3) | 116 | 2.4(0.1) | 116 | 1.18(0.02) |
| Pre-release: | A | 608 | 75.7(0.2)y | 203 | 5.2(0.1)z | 203 | 1.17(0.01)y |
| | B | 612 | 76.7(0.2)z | 204 | 5.5(0.1)y | 204 | 1.20(0.01)x |
| | c | 649 | 76.2(0.2)yz | 230 | 5.0(0.1)z | 230 | 1.11(0.01)z |
| Release[a]: | A | | 84.7 | | 6.6 | | 1.08 |
| | B | | 85.7 | | 7.0 | | 1.10 |
| | C | | 85.3 | | 6.4 | | 1.03 |
| | | | | **Oregon** | | | |
| April: | A | 220 | 76.5(0.4) | 140 | 5.6(0.1) | 140 | 1.22(0.01) |
| | B | 210 | 76.5(0.4) | 107 | 5.2(0.1) | 107 | 1.15(0.01) |
| Pre-release: | A | 621 | 84.7(0.2)z | 207 | 6.7(0.1)y | 207 | 1.11(0.01)y |
| | B | 603 | 84.8(0.3)z | 218 | 7.2(0.1)z | 218 | 1.19(0.01)z |
| Release[a] | A | | 90.5 | | 7.1 | | 0.96 |
| | B | | 93.3 | | 7.6 | | 0.91 |

[a] *Release length was calculated from 1,247 sample fish and length and weight condition factor from 868 fish released on 31 May 1996.*

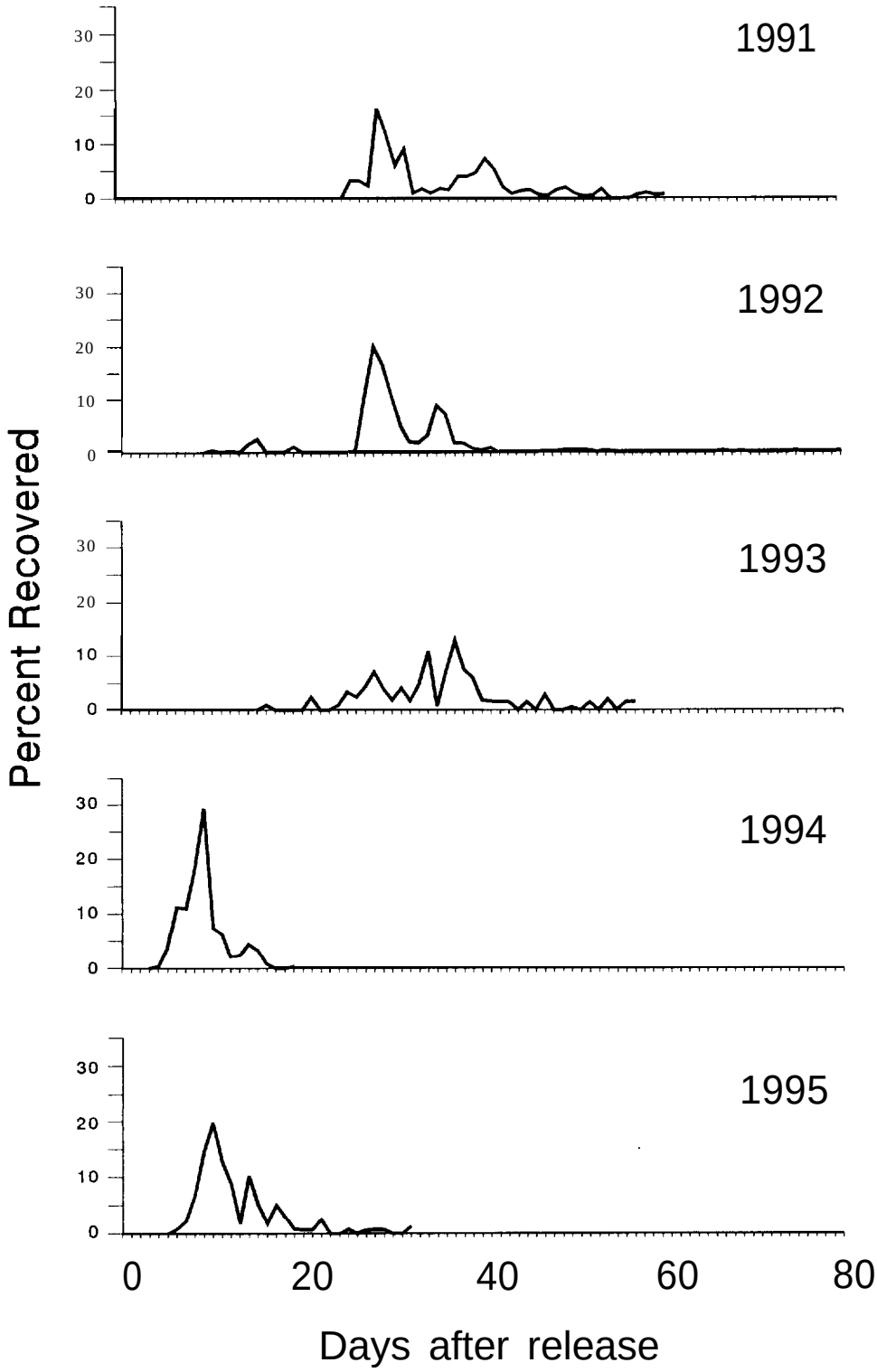


Figure 2. Recovery of branded subyearling fall chinook salmon that were reared and marked at Umatilla Hatchery, released in the Umatilla River, and recovered at John Day Dam from 1992-95. Years indicate brood year.

Table 7. Mean length, weight, and condition factor at prerelease or release for subyearling fall chinook salmon reared in Oregon and Michigan raceways at Umatilla Hatchery (standard error in parentheses).

| Brood year | System | Length (mm) | Weight (g) | Condition factor |
|---|---|---|---|---|
| 1991 | Michigan | 83.6(0.7) | 7.0(0.2) | 1.17(0.01) |
| | Oregon | 82.5(1.5) | 7.0(0.4) | 1.21(0.02) |
| 1992 | Michigan | 85.8(0.8) | 7.5(0.2) | 1.19(0.01) |
| | Oregon | 85.6(0.2) | 7.4(0.2) | 1.17(0.06) |
| 1993 | Michigan | 82.5(0.9) | 6.8(0.2) | 1.19(0.02) |
| | Oregon | 85.3(1.1) | 7.4(0.3) | 1.18(0.04) |
| 1994[a] | Michigan | 89.7 | 7.0 | 0.98 |
| | Oregon | 93.2 | 7.5 | 0.92 |
| 1995[a] | Michigan | 85.2 | 6.8 | 1.09 |
| | Oregon | 90.0 | 7.6 | 1.04 |

[a] *Fish from the 1994 and 1995 brood years were measured at release after acclimation, standard errors were not available. Other brood years were not acclimated and were released directly into the Umatilla River.*

Table 8. Mean length, weight, and condition factor at pre-release or release for subyearling fall chinook salmon reared in first, second, and third pass Michigan raceways at Umatilla Hatchery (standard error in parentheses).

| Brood year | Pass | Length (mm) | Weight (g) | Condition factor |
|---|---|---|---|---|
| 1991 | A | 83.2(0.2) | 7.2(0.1) | 1.18(0.01) |
| | B | 83.8(0.2) | 6.9(0.1) | 1.16(0.01) |
| | C | 83.8(0.3) | 7.5(0.1) | 1.20(0.01) |
| 1992[a] | A | 85.6(0.3) | 7.5(0.1) | 1.20 |
| | B | 85.7(0.3) | 7.2(0.1) | 1.15 |
| | C | 86.5(0.3) | 7.5(0.1) | 1.16 |
| 1993 | A | 81.7(0.3) | 6.9(0.1) | 1.22(0.01) |
| | B | 83.2(0.3) | 6.7(0.1) | 1.15(0.01) |
| | C | 82.0(0.3) | 6.4(0.1) | 1.11(0.01) |
| 1994[b] | A | 88.9 | 7.0 | 1.00 |
| | B | 90.5 | 7.1 | 0.96 |
| | C | 88.3 | 6.9 | 0.98 |
| 1995[b] | A | 84.7 | 6.6 | 1.08 |
| | B | 85.7 | 7.0 | 1.10 |
| | c | 85.3 | 6.4 | 1.03 |

[a] Standard errors for condition factor could not be calculated

[b] Measurements for the 1994 and 1995 brood year at release after acclimation. Other brood years were not acclimated and were released directly into the Umatilla River.

Table 9. Mean proportion of descaled, partially descaled, and undamaged subyearling fall chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery.

| Brood year | System | Descaled[a] | Partially Descaled[b] | Undamaged[c] |
|---|---|---|---|---|
| 1991 | Michigan[d] | 0.03 | 0.36 | 0.62 |
| 1991 | Oregon | 0.04 | 0.61 | 0.35 |
| 1991 | Michigan | 0.04 | 0.62 | 0.35 |
| 1992 | Oregon | 0.01 | 0.74 | 0.26 |
| 1993 | Michigan | 0.12 | 0.54 | 0.34 |
| 1993 | Oregon | 0.00 | 0.12 | 0.88 |
| 1994 | Michigan | 0.08 | 0.06 | 0.29 |
| 1994 | Oregon | 0.00 | 0.39 | 0.61 |
| 1995 | Michigan | 0.04 | 0.27 | 0.69 |
| 1995 | Oregon | 0.00 | 0.25 | 0.75 |

[a] ***More than 0.20 descaling on either side of the fish.***
[b] ***Descaling = 0.03 to 0.20 on either side of the fish.***
[c] ***Less than 0.03 descaling on either side of the fish.***
[d] ***Combined first and second pass raceways.***

Table 10. Mean proportion of descaled, partially descaled, and undamaged subyearling fall chinook salmon reared in Michigan passes at Umatilla Hatchery.

| Brood year | Pass | Descaled[a] | Partially descaled[b] | Undamaged[c] |
|---|---|---|---|---|
| 1991 | A | 0.04 | 0.33 | 0.64 |
| 1991 | B | 0.03 | 0.38 | 0.60 |
| 1991 | C | 0.04 | 0.50 | 0.47 |
| 1992 | A | 0.06 | 0.41 | 0.53 |
| 1992 | B | 0.01 | 0.82 | 0.17 |
| 1992 | C | 0.02 | 0.62 | 0.36 |
| 1993 | A | 0.17 | 0.51 | 0.32 |
| 1993 | B | 0.08 | 0.57 | 0.35 |
| 1993 | C | 0.04 | 0.60 | 0.36 |
| 1994 | A | 0.04 | 0.52 | 0.40 |
| 1994 | B | 0.12 | 0.70 | 0.18 |
| 1994 | C | 0.11 | 0.45 | 0.44 |
| 1995 | A | 0.06 | 0.42 | 0.52 |
| 1995 | B | 0.01 | 0.13 | 0.87 |
| 1995 | C | 0.01 | 0.33 | 0.66 |

[a] ***More than 0.20 descaling on** either **side of the fish.***
[b] *Descaling* ***= 0.03 to 0.20 on either side of** the fish.*
[c] ***Less than 0.03 descaling on either side of the fish.***

Table 11. Coded-wire tag and brand (3/16") information for subyearling fall chinook salmon (1995 brood) marked at Umatilla Hatchery and released in 1996 (CWT = coded-wire-tag, LOC = location of brand, RA = right anterior, LA = left anterior, POS = brand rotation, RV = right ventral clip).

| Race -way | CWT code | Number CWT[a] | Readable brand | LOC | Brand | POS | Fin clip | Number released |
|---|---|---|---|---|---|---|---|---|
| M2A | 07 1320 | 30,015 | 10,557 | RA | 5 | 4 | RV | 303,803 |
| M3A | 071221 | 28,997 | 9,407 | LA | 5 | 4 | RV | 299,233 |
| M2B | 071323 | 29,914 | 9,965 | RA | E | 4 | RV | 300,377 |
| M3B | 071325 | 30,220 | 10,389 | LA | E | 4 | RV | 300,895 |
| M2C | 071157 | 29,852 | 10,316 | RA | 5 | 2 | RV | 300,548 |
| M3C | 071327 | 28,476 | 10,378 | LA | 5 | 2 | RV | 30 1,468 |
| M4C | | | | | | | RV | 251,582 |
| 02A | 071322 | 29,646 | 10,252 | RA | 5 | 3 | RV | 266,913 |
| 02B | 071326 | 30,238 | 10,237 | RA | E | 3 | RV | 272,594 |
| 03A | 071324 | 30,243 | 10,420 | LA | 5 | 3 | RV | 181,291 |
| Q3B | 071328 | 30,455 | 9,980 | LA | E | 3 | RV | 181,709 |

[a] *Number recognizably coded-wire tagged and* ***released. All*** *CWT fish are* ***also*** *adipose fin* ***clipped.*** *All fish received* ***a right*** *ventral fin* ***clip and all*** *non-CWT fish were* ***marked with a blank-wire tag.***

Table 12. Recovery information for branded subyearling fall chinook salmon reared in Michigan or Oregon raceways at Umatilla Hatchery, released in the Umatilla River, and recaptured at John Day Dam (number of observed recoveries in parentheses).

| Brood year | Number of replicate groups | Mean percent of number released by System | |
|---|---|---|---|
| | | Michigan[a] | Oregon |
| 1991 | 4 | 2.8 (67) | 1.6 (45) |
| 1992 | 4 | 6.5 (195) | 5.0 (157) |
| 1993 | 4 | 1.5 (52) | 1.7 (54) |
| 1994 | 4 | 12.5 (130) | 9.3 (97) |
| 1995 | 4 | 2.4 (34) | 2.9 (48) |
| Mean | | 5.1 (478) | 4.1 (401) |

[a] ***First and second pass Michigan raceways.***

Table 13. Recovery information for branded subyearling fall chinook salmon reared in A, B, and C pass Michigan raceways at Umatilla Hatchery, released in the Umatilla River, and recaptured at John Day Dam (number of observed recoveries in parentheses).

| Brood year | Number of replicate groups | Mean percent of number released by Pass | | |
|---|---|---|---|---|
| | | A | B | C |
| 1991 | 2 | 2.3 (24) | 3.3 (43) | 2.2 (25) |
| 1992 | 2 | 6.0 (88) | 7.0 (107) | 6.9 (102) |
| 1993 | 2 | 1.2 (30) | 1.2 (21) | 1.4 (24) |
| 1994 | 2 | 10.5 (57) | 14.5 (73) | 11.5 (59) |
| 1995 | 2 | 2.1 (15) | 2.7 (19) | 3.6 (27) |
| Mean | | 4.4 (214) | 5.7 (263) | **5.1 (237)** |

Table 14. Total catch, escapement, and survival of subyearling fall chinook salmon that were coded-wire-tagged (CWT) and released in the Umatilla River (1991-1993 broods). Recoveries include age 2 and older fish and are incomplete for all brood years. Estimates of number of jacks and adults recovered are based on total production in each raceway. Sample size (N) based on expanded recoveries.

| Brood year, CWT code | Raceway | N | Total exploitation rate (%) | Umatilla return rate (% of release) | Total survival rate (% of release) | Number of jacks and adults recovered |
|---|---|---|---|---|---|---|
| 1991 | | | | | | |
| 071433 | M2A | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 071434 | M3A | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 071435 | M2B | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 071436 | M3B | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 071437 | M2C | 1 | 0.0 | 0.003 | 0.003 | 7 |
| 071438 | M3C | 0 | 0.0 | 0.000 | 0.000 | 0 |
| subtotal | | 1 | 0.0 | 0.001 | 0.001 | 7 |
| 071430 | 02A | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 071429 | 03A | 1 | 0.0 | 0.003 | 0.003 | 9 |
| 071432 | 02B | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 071431 | O3B | 0 | 0.0 | 0.000 | 0.000 | 0 |
| subtotal | | 1 | 0.0 | 0.003 | 0.001 | 9 |
| Total | | 2 | 0.0 | 0.001 | 0.003 | 16 |
| 1992 | | | | | | |
| 076330 | M2A | 5 | 40.0 | 0.007 | 0.017 | 51 |
| 07633 1 | M3A | 7 | 28.6 | 0.014 | 0.024 | 67 |
| 070127 | M2B | 9 | 66.7 | 0.011 | 0.033 | 90 |
| 076333 | M3B | 7 | 57.1 | 0.007 | 0.024 | 64 |
| 076334 | M2C | 5 | 0.0 | 0.017 | 0.017 | 47 |
| 076332 | M3C | 7 | 0.0 | 0.020 | 0.024 | 66 |
| subtotal | | 40 | 35.0 | 0.013 | 0.023 | 385 |
| 070126 | 02A | 6 | 0.0 | 0.020 | 0.020 | 54 |
| 070125 | 03A | 16 | 56.3 | 0.020 | 0.053 | 145 |
| 076329 | 02B | 6 | 50.0 | 0.007 | 0.020 | 40 |
| 076335 | 03B | 13 | 30.8 | 0.030 | 0.043 | 89 |
| subtotal | | 41 | 39.0 | 0.019 | 0.034 | 328 |
| Total | | 81 | 37.0 | 0.015 | 0.027 | 713 |

Table 14 (continued)

| Brood year, CWT code | Raceway | N | Total exploitation rate (%) | Umatilla return rate (% of release) | Total survival rate (% of release) | Number of jacks and adults recovered |
|---|---|---|---|---|---|---|
| 1993 | | | | | | |
| 070663 | M2A | 2 | 0.0 | 0.006 | 0.006 | 21 |
| 0707 19 | M3A | 4 | 0.0 | 0.009 | 0.013 | 41 |
| 070720 | M2B | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 070723 | M3B | 2 | 0.0 | 0.003 | 0.007 | 21 |
| 070722 | M2C | 2 | 0.0 | 0.003 | 0.006 | 20 |
| 07072 1 | M3C | 0 | 0.0 | 0.000 | 0.000 | 0 |
| subtotal | | 10 | 0.0 | 0.004 | 0.005 | 103 |
| 070662 | 02A | 0 | 0.0 | 0.000 | 0.000 | 0 |
| 0707 18 | 03A | 2 | 0.0 | 0.006 | 0.006 | 18 |
| 070716 | 02B | 2 | 100.0 | 0.000 | 0.007 | 13 |
| 0707 17 | 03B | 2 | 0.0 | 0.006 | 0.006 | 12 |
| subtotal | | 6 | 33.3 | 0.003 | 0.005 | 42 |
| Total | | 16 | 12.5 | 0.004 | 0.005 | 145 |

Table 15. Recovery of marked adult fall chinook salmon that returned to Three Mile Falls Dam in the Umatilla River, 1992-1995. The 1990 brood was marked at Irrigon Hatchery, 1991 and 1992 broods marked at Umatilla Hatchery (AD = adipose fin clip, BT = body tag, CWT = coded-wire-tag, LV = left ventral fin clip, and RV = right ventral fin clip).

| Brood year[a] | Mark | Number released | CWT code | Number Recovered 1992 | 1993 | 1994 | 1995 | Total | (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | BT | 147.586 | | - | 2 | 13 | 15 | 30 | 0.020 |
| | AD+CWT | 51,814 | 075450 | 1 | 2 | 15 | 5 | 23 | 0.044 |
| | | 52,444 | 07545 1 | 2 | 3 | 6 | 2 | 13 | 0.025 |
| | AD+CWT+RV | 52,252 | 075225 | 0 | 1 | 10 | 4 | 15 | 0.029 |
| | | 51,728 | 075226 | 0 | 2 | 3 | 3 | 7 | 0.014 |
| | AD+CWT+BT | 48,266 | 075328 | 3 | 3 | 6 | 4 | 16 | 0.033 |
| | | 48,481 | 075499 | 2 | 1 | 12 | 4 | 19 | 0.039 |
| | | 48,301 | 070016 | 0 | 1 | 5 | 4 | 10 | 0.021 |
| 1991 | LV | 69,816 | - | - | 1 | 4 | 1 | 6 | 0.004 |
| | | 74.408 | - | - | | | | | |
| | BT+LV | 67,144 | | - | 0 | 0 | 0 | 0 | 0.000 |
| | | 65,749 | - | - | | | 0 | | |
| | BT | 65,184 | - | - | 2 | 5 | 1 | 8 | 0.012 |
| | | 70,435 | - | - | | | | | |
| | AD+CWT+RV | 32,278 | 07 1430 | - | 0 | 0 | 9 | 0 | 0.000 |
| | | 31.892 | 07 1429 | - | 0 | 1 | 0 | 1 | 0.003 |
| 1992 | LV | 61,801 | - | - | | 12 | 9 | 21 | 0.016 |
| | | 66,204 | - | - | | | | | |
| | BT+LV | 68,644 | - | - | | 7 | 7 | 14 | 0.020 |
| | | 70,442 | - | - | | | | | |
| | BT | 69,225 | - | - | | 7 | 12 | 19 | 0.027 |
| | | 69,518 | - | - | | | | | |
| | AD+CWT+RV | 29,594 | 070126 | - | | 0 | 5 | 5 | 0.017 |
| | | 29,360 | 070125 | - | | 2 | 4 | 6 | 0.020 |

[a] ***Fish not coded-wire tagged were assigned to a brood year by length frequency data.***

Table 16. Water quality comparisons between first, second, and third pass Michigan raceways used to rear yearling fall chinook salmon (1994 brood) during 1995-96,. Means with same letter or without letters are not significantly different at P > 0.05.

| Parameter measured | N | Mean parameter value | | |
|---|---|---|---|---|
| | | A pass | B pass | C pass |
| Sampling period | | 20 Jul-15 Mar | 20 Jul-15 Mar | 20 Jul-15 Mar |
| Temperature head (“C) | 7 | 14.0 | 14.0 | 14.0 |
| Temperature tail (“C) | 7 | 14.0 | 14.1 | 14.1 |
| pH head | 7 | 7.9 | 7.9 | 7.8 |
| pH tail | 7 | 7.8 | 7.9 | 7.8 |
| Oxygen head (ppm) | 2 | 11.2 | 11.2 | 11.4 |
| Oxygen tail (ppm) | 2 | 8.9 | 9.2 | 9.0 |
| Nitrogen head (mmHg) | 2 | 584 | 574 | 569 |
| Nitrogen tail (mmHg) | 2 | 593 | 585 | 581 |
| Total pressure-head (mmHg) | 2 | 754 | 745 | 741 |
| Total pressure-tail (mmHg) | 2 | 731 | 725 | 720 |
| Unionized ammonia ($\mu$g/l) | 2 | 0.18 | 0.34 | 0.43 |
| Alkalinity (mg/l $CaCO_3$) | 3 | 139 | 141 | 141 |

Table 17. Mean length, weight, and condition factor for yearling fall chinook salmon (1994 brood) reared in Michigan or Oregon passes at Umatilla and Bonneville hatcheries during 1995-96. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P > 0.05$.

| | | Length(mm) | | Weight(g) | | Condition Factor | |
|---|---|---|---|---|---|---|---|
| Sample | Pass | N | Mean(SE) | N | Mean(SE) | N | Mean(SE) |
| | | | **Umatilla Hatchery** | | | | |
| | | | **Oregon** | | | | |
| Jun: | A | 121 | 68.6(0.5) | 78 | 3.8(0.1) | 78 | 1.15(0.01) |
| | | | **Michigan** | | | | |
| Jul : | A | 115 | 90.5(0.5) | 76 | 8.3(0.2) | 76 | 1.28(0.01) |
| | B | 114 | 90.0(0.5) | 54 | 8.9(0.2) | 54 | 1.21(0.02) |
| | c | 109 | 90.8(0.6) | 76 | 8.5(0.2) | 76 | 1.17(0.03) |
| Aug: | A | 115 | 99.9(0.7) | 56 | 11.0(0.4) | 56 | 1.07(0.02) |
| | B | 100 | 102.6(0.7) | 56 | 12.4(0.3) | 56 | 1.13(0.01) |
| | c | 105 | 103.0(0.7) | 65 | 11.9(0.3) | 65 | 1.09(0.01) |
| Sep: | A | 144 | 116.4(0.8) | 51 | 19.0(0.6) | 51 | 1.19(0.01) |
| | B | 123 | 16.86(0.8) | 53 | 19.4(0.6) | 53 | 1.18(0.01) |
| | C | 125 | 120.8(0.9) | 68 | 19.4(0.6) | 68 | 1.09(0.01) |
| Oct: | A | 117 | 127.5(1.3) | 58 | 26.3(0.9) | 58 | 1.18(0.01) |
| | B | 99 | 131.8(1.0) | 54 | 26.6(0.9) | 54 | 1.17(0.01) |
| | c | 101 | 130.0(1.2) | 59 | 26.7(0.9) | 59 | 1.20(0.01) |
| Nov: | A | 129 | 144.6(1.2) | 51 | 38.7(1.5) | 51 | 1.18(0.01) |
| | B | 105 | 146.2(1.4) | 60 | 36.1(1.2) | 60 | 1.15(0.01) |
| | C | 103 | 146.0(1.4) | 47 | 37.9(1.4) | 47 | 1.18(0.05) |
| Dec: | A | 105 | 164.6(1.3) | 53 | 53.0(2.0) | 53 | 1.16(0.01) |
| | B | 97 | 163.6(2.0) | 51 | 51.3(2.0) | 50 | 1.14(0.01) |
| | C | 109 | 162.3(1.6) | 60 | 51.7(1.7) | 60 | 1.15(0.01) |
| Jan: | A | 101 | 171.3(1.8) | 55 | 58.4(2.3) | 55 | 1.17(0.01) |
| | B | 104 | 172.9(2.1) | 75 | 65.2(2.5) | 75 | 1.16(0.01) |
| | c | 111 | 172.0(1.7) | 53 | 60.9(2.4) | 53 | 1.14(0.01) |
| Feb: | A | 108 | 187.8(1.8) | 54 | 77.2(3.4) | 54 | 1.20(0.01) |
| | B | 105 | 199.8(1.7) | 54 | 91.2(3.2) | 54 | 1.15(0.01) |
| | C | 111 | 193.7(1.5) | 64 | 83.1(2.7) | 64 | 1.15(0.01) |

Table 17 (continued)

| Sample | Pass | Length(mm) N | Length(mm) Mean(SE) | Weight(g) N | Weight(g) Mean(SE) | Condition Factor N | Condition Factor Mean(SE) |
|---|---|---|---|---|---|---|---|
| Pre-release: | A | 307 | 187.1.(1.1) | 107 | 78.1(2.5) | 107 | 1.16(0.01) |
| (19 Mar 96) | B | 303 | 196.5(1.O) | 101 | 89.8(2.4) | 101 | 1.14(0.01) |
| | c | 314 | 190.8(1.1) | 111 | 78.7(1.9) | 111 | 1.11(0.01) |
| | A | | | | | | |
| Release": | B | | 193.7 | | 85.0 | | 1.17 |
| (18 Apt 96) | | | 202.7 | | 96.7 | | 1.16 |
| | C | | 197.7 | | 85.6 | | 1.11 |
| | | | **Bonneville Hatchery** | | | | |
| Pre-release: | 8 | 316 | 172.2(0.8) | 108 | 61.7(1.4) | 108 | 1.13(0.01) |
| (19 Mar 96) | 9 | 31.5 | 172.6(0.8) | 106 | 60.8(1.7) | 106 | 1.14(0.01) |
| Release": | 8 | | 177.5 | | 64.5 | | 1.15 |
| | 9 | | 175.0 | | 64.7 | | 1.09 |

[a] ***Release length was*** *calculated from* ***approximately*** *1200 fish; weight* ***and*** *condition factor from* ***approximately 400*** *fish released* ***on April*** *18,,* ***1996.***

split into three MI raceways in mid-July and marking with wire tags and right ventral fin clips was completed in July. Final rearing densities ranged from 3.9-4.0 lb/ft$^3$ and loading factors were 9.5 lb/gal/min. Food conversion ratios were 1.40, 1.33, and 1.34 in raceways M3A, M3B, and M3C, respectively. Michigan raceways produced an average of 153 fish/gpm. Production costs were $1.04 per fish with marking costs and $0.95 per fish without marking costs.

***Rearing and Survival Studies:*** Smolt condition data at pre-release and release appear in Tables 17-18. The percentage of smolts ranged from 93-97% at pre-release. We found that 2547% of the fish examined had split or torn caudal fins. Ventral fin clip quality ranged from 96-99% recognizably clipped.

Brand, coded-wire-tag, and production release and recovery information is presented in Table 19 and Appendix Table 3. Only 4 brands (2.0%) were recovered at John Day Dam with an estimated daily passage of 185. All brands recovered were from the third pass raceway (M3C). Fish were released on 18 April and first recovered on 30 April at John Day Dam.

**Bonneville Hatchery:**

***Fish Culture Studies:*** Information on fish culture and releases is presented in Table 17 and Appendix Tables 1 and 3. Yearlings were ponded outside between 24 January 1995 and 10 March 1996 at an average of 924 fish/lb. They were split into 12 OR raceways. Marking and tagging was completed in June and July 1995. The estimated egg-to-smolt survival was 83.7%. Final rearing densities ranged from 0.8-l .O lb/ft$^3$ and loading factors ranged from 6.0-7.0 lb/gal/min. Production per gpm was 58 fish and cost was $0.26 per fish without marking costs.

***Rearing and Survival Studies:*** Smolt condition data at pre-release and release is provided in Tables 17-18. Most fish were classified as intermediate smolts and 27-49% were classified as smolts. Although fin condition was generally good, 18-21% of the fish had split caudal fins. Ventral fin clip quality ranged from 91-97% recognizably clipped.

Brand, coded-wire-tag, and production release and recovery information is presented in Table 19 and Appendix Table 3. Thirteen brands (8.3%) were recovered at John Day Dam with daily passage estimates of 289 and 567 fish. Fish were released on 18 April and first recovered on 30 April at John Day Dam. Fifty percent of the fish were recovered by 8 May and 90% by 15 May. Smolt-to-adult survival estimates from previous releases are presented in Table 20.

## Adult Returns

The number of fall chinook salmon returning to TMFD in 1995 was 1,229 (Appendix Table 8). Vital statistics on returns and run timing appear in Tables 21-22 and Figure 3. The first fish was trapped on 8 September 1995 and peak jack (31) and adult (62) returns were on 18 October 1995. The last fish was collected on 27 November 1995. The run consisted of 180 coded wire-tagged fish and 26 of these were strays. Twenty two of the strays originated from Lyons Ferry Hatchery (8 subjacks and 14 jacks). Additional strays were from Bonneville Hatchery (2), Spring Creek National Fish Hatchery (1) and Trinity River, California (1).

### Fishery

Catch and harvest data from the fall chinook and coho salmon sport fishery is provided in Tables 23-24. Most anglers resided in Umatilla and Morrow counties (88%) with 8.1% from other Oregon counties, and 3.9% from out of state. Three CWT fish (code 070658) were observed in the fishery with an expanded estimate of 9 fish.

### Straying

Based on estimates by Lavoy and Mendel (1996), 23 jack and 252 adult fall chinook salmon of Umatilla origin strayed to Lower Granite Dam (LGD) in 1995. Of these, 0 jacks and 194 adults escaped past LGD. All fish originated from subyearling releases. Most fish (78%) were from the 1990 brood with additional strays from the 1989 (8%) and 1992 (14%) broods. Approximately 58 fish with wire tags or fin clips were removed at LGD. Twenty of these were jacks from the 1993 brood and marked with blank-wire tags. In addition, nine marked fish that strayed to Lyons Ferry Hatchery were also collected.

We used two models to estimate future numbers of strays escaping past LGD. Each assumes that all fall chinook salmon are wire-tagged. The ODFW model estimated that 33 fall chinook salmon of Umatilla origin would escape past LGD each year. The NMFS model estimated that 20 fish of Umatilla origin would escape past LGD each year (Table 25).

## Spring Chinook Salmon

### Subyearlings

Overview: One brood year (1991) of subyearling spring chinook salmon has been reared in OR raceways and three brood years (1991-1993) have been reared in MI raceways at UH and released in the Umatilla River (Appendix Table 4). The objectives of this study were to compare rearing conditions, migration, cost, and smolt-to-adult survival for subyearlings produced in MI and OR systems and among passes within the MI system. Completed adult returns will be available in 1999.

**Fish 'Culture Studies:** No 1995 brood subyearlings were reared at UH.

**Rearing and Survival Studies: No** coded-wire-tagged adults from subyearling releases have been recovered.

Table 18. Mean proportion of descaled, partially descaled, and undamaged yearling fall chinook salmon (1994 brood) reared at Umatilla and Bonneville Hatcheries and released in 1996,.

| System | Pass | Descaled[a] | Partially descaled[b] | Undamaged[c] |
|---|---|---|---|---|
| | | **Umatilla Hatchery** | | |
| Michigan | A | 30.5 | 69.5 | 0.0 |
| Michigan | B | 38.6 | 61.4 | 0.0 |
| Michigan | C | 14.8 | 82.8 | 2.5 |
| | | **Bonneville Hatchery** | | |
| Oregon | B8 | 10.1 | 73.4 | 16.4 |
| Oregon | B9 | 5.3 | 63.6 | 31.1 |

[a] ***More than 0.20 descaling on either side of the fish.***
[b] ***Descaling = 0.03 to 0.20 on either side of the fish.***
[c] ***Less than 0.03 descaling on either side of the fish.***

Table 19. Coded-wire-tag and brand (1/4") information for yearling fall chinook salmon (1994 brood) marked at Umatilla or Bonneville hatcheries and released in 1996 (CWT = coded-wire-tag, LOC = location of brand, POS = position of brand, RA = right anterior, LA = left anterior, RV = right ventral clip)

| Race -way | CWT. code | Number CWT[a] | Readable brand | LOC | Brand | POS | Fin clip | Number released |
|---|---|---|---|---|---|---|---|---|
| | | | **Umatilla Hatchery** | | | | | |
| M3A | 071039 | 23,238 | 5,197 | RA | B | 1 | RV | 48,499 |
| M3A | 071040 | 23,442 | 5,449 | RA | L | 1 | RV | 47,463 |
| M3C | 071041 | 23,343 | 5,313 | LA | L | 1 | RV | 47,125 |
| | | | **Bonneville Hatchery** | | | | | |
| A9[b] | 071038 | 27,397 | 5,218 | RA | L | 2 | RV | 204,022 |
| A8 | | | 5,111 | LA | L | 2 | RV | |
| A4[c] | 071037 | 27.397 | | RV | | | | 217.294 |

[a] ***Number recognizably coded-wire-tagged and released. All CWT fish are also adipose fin clipped. All fish received a right ventral fin clip and all non-CWT fish were marked with a blank-wire tag.***

[b] ***Represents production in raceways A3, A5-A9.***

[c] ***Represents production in raceways A2, Al 1 -Al 3.***

Table 20. Total catch, escapement, and survival of yearling fall chinook salmon (1990-93 broods) that were reared at Bonneville Hatchery, coded-wire-tagged (CWT), and released in the Umatilla River,. Recoveries include age 3 and older fish and are incomplete for all brood years. Estimates of number of jacks and adults recovered are based on total production in each raceway. Sample size (N) based on expanded recoveries.

| Brood year, CWT code | Raceway | N [a] | Total exploitation rate (%) | Umatilla return rate (% of release) | Total survival rate (% of release) | Number of jacks and adults recovered |
|---|---|---|---|---|---|---|
| 1990 | | | | | | |
| 075618 | A8 | 0 | 0.00 | 0.00 | 0.00 | |
| 075619 | A9 | 0 | 0.00 | 0.00 | 0.00 | |
| | | 0 | | | | |
| 1991 | | | | | | |
| 071460 | A5 | 4 | 75.0 | 0.00 | 0.02 | 12 |
| 071461 | A6 | 9 | 44.4 | 0.02 | 0.04 | 25 |
| | | 13 | | | | 37 |
| 1992 | | | | | | |
| 070252 | A5 | 3 | 33.3 | 0.01 | 0.01 | 6 |
| 070255 | A6 | 17 | 64.7 | 0.03 | 0.07 | 168 |
| | | 20 | | | | 174 |
| 1993 | | | | | | |
| 070658 | A2 | 0 | 0.00 | 0.00 | 0.00 | |
| 070659 | A6 | 0 | 0.00 | 0.00 | 0.00 | |

[a] Additional recoveries of age two subjacks (< 381 mm FL) for each tag code were: 071460 - 3, 071461 -3, 070252 - 15, 070255 - 33, 070658 - 47, 070659 - 27.

Table 21. Vital statistics for fall chinook salmon that returned to the east-bank fish ladder, Three-Mile Falls Dam, Umatilla River, 1995.

| Age[a] | Male | % | Female | % | Unknown | % | Total | % |
|---|---|---|---|---|---|---|---|---|
| Subjack | 338 | 100.0 | 0 | 0.0 | 0 | 0.0 | 338 | 27.5 |
| Jack | 286 | 99.3 | 2 | 0.7 | 0 | 0.0 | 288 | 23.4 |
| Adult | 360 | 59.7 | 243 | 40.3 | 0 | 0.0 | 603 | 49.1 |
| Total | 984 | 80.1 | 245 | 19.9 | 0 | 0.0 | 1229 | 100.0 |

[a] *Age designation based on fork length: subjacks < 381 mm, jacks 382-610 mm, adults > 610 mm.*

Table 22. Vital statistics of fall chinook salmon that returned to the Umatilla River in 1995 by release strategy. Data was determined from coded-wire tag recovery (sex was determined visually, all age 2 fish were assumed to be male).

| Brood year | Age | Number | Sex | Fork length (mm) mean | min | max |
|---|---|---|---|---|---|---|
| | | | **Subyearling** | | | |
| 1990 | 5 | 16 | male | 981 | 840 | 1120 |
| 1990 | 5 | 20 | female | 917 | 685 | 1010 |
| 1991 | 4 | 2 | female | 840 | | |
| 1992 | 3 | 26 | male | 706 | 615 | 890 |
| 1992 | 3 | 4 | female | 718 | 660 | 765 |
| 1993 | 2 | 13 | male | 472 | 386 | 545 |
| | | | **Yearling** | | | |
| 1992 | 3 | 6 | male | 547 | 505 | 625 |
| 1992 | 3 | 2 | female | 615 | 580 | 650 |
| 1993 | 2 | 66 | male | 349 | 282 | 400 |

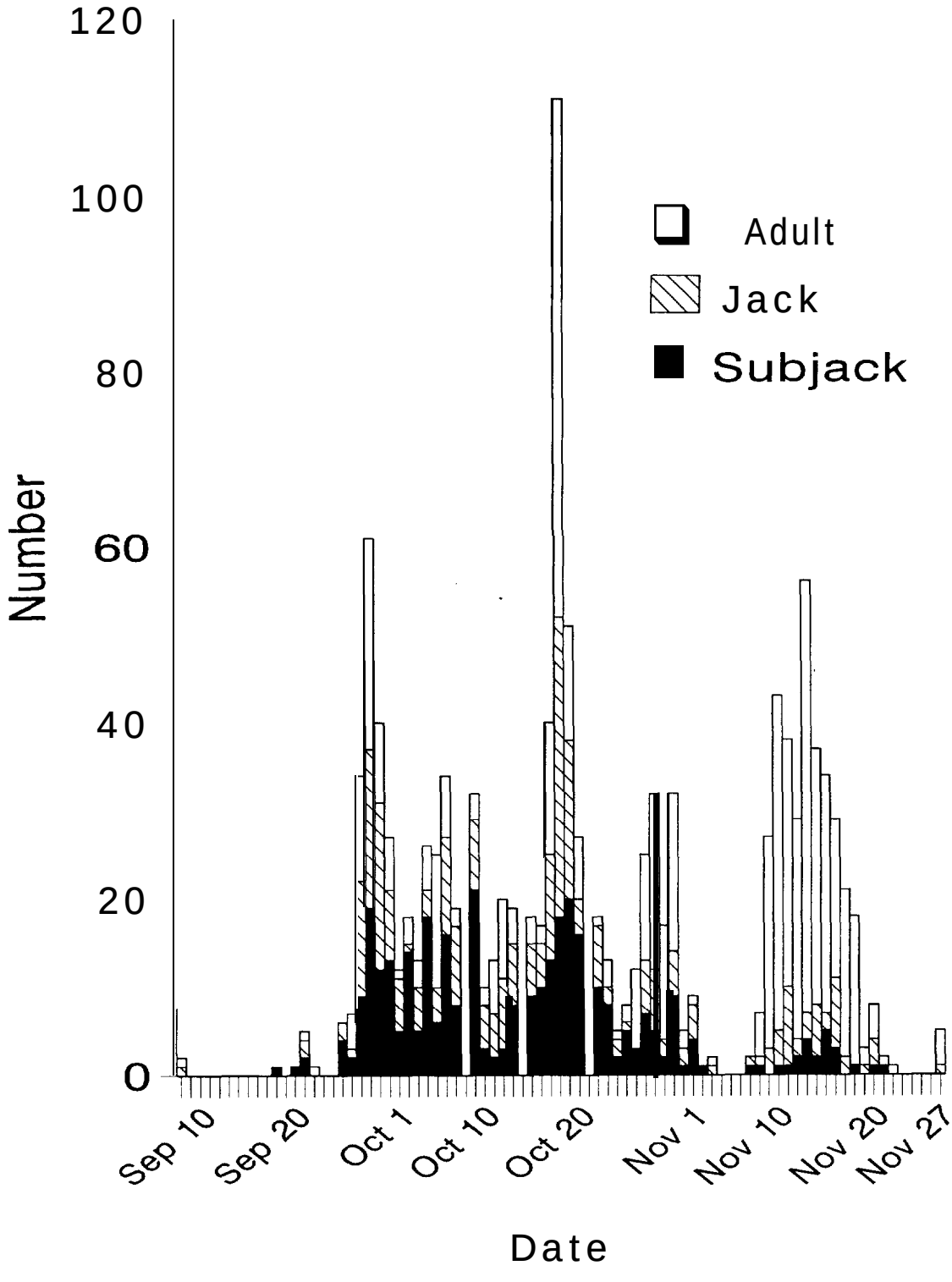


Figure 3. Numbers of subjack, jack, and adult fall chinook salmon counted at the east-bank fish ladder, Three Mile Falls Dam, Umatilla River, 1995 (subjack < 381 mm, jack 382-610 mm, adult > 610 mm, fork length).

Table 23. Estimated catch statistics for fall chinook salmon in the lower Umatilla River from the mouth to Three Mile Falls Dam during 1995[a]. Number caught and number harvested includes ± 95% confidence interval.

| | | | | Fall Chinook Salmon | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Adult Salmon | | | Jack Salmon | | |
| Month, Daytype | Number days | Sampled anglers | Hours fished | Number caught | Number harvested[a] | Catch rate fish/h | Number caught | Number harvested | Catch rate (fish/h) |
| September | | | | | | | | | |
| Weekday | 7 | 22 | 257 | 0 ± 0 | *Of 0* | *0.000* | 19 ± 33 | 19 ± 33 | 0.074 |
| Weekend | 10 | 85 | 309 | 1 ± 1 | 1 ± 1 | 0.004 | 6 ± 2 | 6 ± 2 | 0.019 |
| Total | 17 | 107 | 566 | 1 ± 1 | 1 ± 1 | 0.002 | 25 ± 33 | 25 ± 33 | 0.044 |
| October | | | | | | | | | |
| Weekday | 13 | 67 | 350 | 0 ± 0 | 0 ± 0 | *0.000* | 44 ± 56 | 6 ± 11 | 0.126 |
| Weekend | 10 | 176 | 581 | 7 ± 12 | 4 ± 8 | 0.011 | 15 ± 7 | 10 ± 7 | 0.026 |
| Total | 23 | 243 | 931 | 7 ± 12 | 4 ± 8 | 0.007 | 59 ± 56 | 16 ± 13 | 0.063 |
| November | | | | | | | | | |
| Weekday | 11 | 55 | 252 | 14 ± 14 | 0 ± 0 | 0.055 | *Of 0* | 0 ± 0 | *0.000* |
| Weekend | 10 | 112 | 452 | 12 ± 4 | 0 ± 0 | 0.027 | 3 ± 4 | 0 ± 0 | 0.007 |
| Total | 21 | 167 | 704 | 26 ± 15 | 0 ± 0 | 0.037 | 3 ± 4 | 0 ± 0 | 0.004 |
| Season | | | | | | | | | |
| Total | 61 | 517 | 2201 | 33 ± 19 | 5 ± 8 | 0.015 | 87 ± 65 | 41 ± 36 | 0.040 |

[a] *Harvest of adult fall chinook salmon was legal below Highway 730.*

Table 24. Estimated catch statistics for coho salmon in the lower Umatilla River from the mouth to Three Mile Falls Dam during 1995. Number caught and number harvested includes ± 95 % confidence interval.

| | | | | Coho Salmon | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Adult Salmon | | | Jack Salmon | | |
| Month, Day type | Number days | Sampled anglers | Hours fished | Number caught | Number harvested | Catch rate fish/h | Number caught | Number harvested | Catch rate (fish/h) |
| September | | | | | | | | | |
| Weekday | 7 | 22 | 557 | 0 ± 0 | 0 ± 0 | 0.000 | 6 ± 11 | 6 ± 11 | 0.023 |
| Weekend | 10 | 85 | 309 | 0 ± 0 | 0 ± 0 | 0.000 | 2 ± 1 | 2 ± 1 | 0.006 |
| Total | 17 | 107 | 566 | 0 ± 0 | 0 ± 0 | 0.000 | 8 ± 11 | 8 ± 11 | 0.014 |
| October | | | | | | | | | |
| Weekday | 13 | 67 | 350 | 11 ± 9 | l l f 9 | 0.030 | 14 ± 10 | 14 ± 10 | 0.040 |
| Weekend | 10 | 176 | 581 | 8 ± 4 | 8 ± 4 | 0.014 | 3 ± 3 | 3 ± 3 | 0.006 |
| Total | 23 | 243 | 931 | 19 ± 10 | 19 ± 10 | 0.020 | 17 ± 11 | 17 ± 11 | 0.018 |
| November | | | | | | | | | |
| Weekday | 11 | 55 | 252 | 6 ± 10 | 0 ± 0 | 0.025 | Of 0 | Of 0 | 0.000 |
| Weekend | 10 | 112 | 452 | 5 ± 8 | 4 ± 6 | 0.011 | 0 ± 0 | 0 ± 0 | 0.000 |
| Total | 21 | 167 | 704 | 11 ± 12 | 4 ± 6 | 0.016 | 0 ± 0 | 0 ± 0 | 0.000 |
| Season | | | | | | | | | |
| Total | 61 | 517 | 2201 | 30 ± 16 | 23 ± 12 | 0.014 | 25 ± 15 | 25 ± 15 | 0.011 |

Table 25. Number of fall chinook salmon planned for release in the Umatilla River and predicted escapement of returning adults above Lower Granite Dam using a model developed by the Oregon Department of Fish and Wildlife and a model develooed by the National Marine Fisheries Service.

Oregon Department of Fish and Wildlife model

| Group | Juveniles released into the Umatilla River | Strays above Lower Granite Dam | | |
|---|---|---|---|---|
| | | Low | Mean | High |
| Subyearlings | 2,682,000 | 3 | 28 | 78 |
| Yearlings | 600,000 | 0 | 5 | 19 |
| Total | 3,282,000 | 3 | 33 | 97 |

National Marine Fisheries Service model

| Return year | Stray fish to Lower Granite Dam | | Strays above Lower Granite Dam | | | Juveniles released into the Umatilla River | |
|---|---|---|---|---|---|---|---|
| | Umatilla | Other | Umatilla | Other | Total | Number | Years |
| 1992 | 41 | 2 | 4 | 2 | 6 | 3,450,000 | 1988-1991 |
| 1993 | 195 | 10 | 20 | 10 | 30 | 3,430,000 | 1989-1992 |
| 1994 | 268 | 18 | 27 | 18 | 45 | 3,279,000 | 1990-1993 |
| 1995 | 285 | 114 | 29 | 114 | 143 | 3,201,000 | 1991-1994 |
| Average | 198 | 36 | 20 | 36 | 56 | 3,340,000 | 1988-1994 |

**Fall Release**

**Overview:** Two brood years (1992 and 1993) of subyearling spring chinook salmon were reared in MI raceways and released in the Umatilla River during fall. Three brood years (1991-1993) were reared in OR raceways at UH and released (Appendix Table 5). One brood year (1991) was reared at BH (Appendix Table 5). The objectives of this study were to compare rearing conditions, migration, cost, and smolt-to-adult survival for subyearlings produced in MI and OR systems and among passes within the MI system. In addition, comparisons will be made between fish reared in OR raceways at UH and OR raceways at BH. Completed adult returns will be available in 1999.

**Fish Culture Studies: No** 1995 brood subyearlings released in the fall were reared at UH.

**Rearing and Survival Studies:** No coded-wire-tagged adults have returned from UH fall releases but one jack from the 1992 brood and four jacks from the 1993 brood have returned. Smolt-to-adult survival for fall releases from BH ranged from 0.03 to 0.08%.

**Yearlings**

**Overview:** Two broods reared in MI raceways (1993 and 1994) and 4 broods (1991-1994) reared in OR raceways have been released in the Umatilla River (Appendix Table 6). Four broods (1991-1994) have also been reared at BH (Appendix Table 6). The objectives of this study are to compare rearing conditions, migration, cost, and smolt-to-adult survival for yearlings produced in MI and OR raceways at UH and in OR raceways at BH. Completed adult returns will be available in *2000.*

**Umatilla Hatchery:**

*Fish Culture Studies:* Information on fish culture and releases is presented in Tables 26-31 and Appendix Table 6. Yearlings were ponded outside in one OR raceway on 15 April 1995 at 673 fish/lb. In July they were marked and split into four OR raceways at 44.3-45.5 fish/lb and three MI raceways at 42.3-45.0 fish/lb. Food conversion ratios ranged from 1.41 to 1.44 in MI raceways and 1.72 to 1.92 in OR raceways. Michigan raceways produced an average of 154 fish/gpm and OR raceways produced an average of 94 fish/gpm. Production costs were $0.82 per fish with marking and $0.74 per fish without marking.

*Rearing and Survival Studies:* Smolt condition data at pre-release and release are presented in Tables 30-35. The percentage of smolts ranged from 27-39% in MI raceways and from 10-24% in OR raceways. Ventral fin clip quality was greater than 99% recognizably clipped.

Brand, coded-wire-tagged, and production release and recovery information is presented in Tables 36-37 and Figure 4. Smolt-to-adult survival estimates from previous releases are presented in Table 38.

Table 26. Egg-take and survival of subyearling, fall release, and yearling spring chinook salmon reared at Umatilla Hatchery. All eggs are Carson stock.

| Egg source | Brood year | Release strategy | Number of eggs taken or received | Egg-to-fry survival (%) | Egg-to-smolt[a] survival (%) |
|---|---|---|---|---|---|
| | | **Umatilla Hatchery** | | | |
| Carson NFH | 1991 | Yearling | 332,000 | 97.2 | 93.4 |
| Carson NFH | 1992 | Subyearling | 957,000 | 81.0 | 69.7 |
| | | Fail release | 640,000 | 83.4 | 72.0 |
| | | Yearling | 319,000 | 71.3 | 67.4 |
| Carson NFH | 1993 | Subyearling | 1,100,000 | 80.1 | 76.4 |
| | | Fall release | 1,103,000 | 79.9 | 65.0 |
| | | Yearling | 3 14,000 | 66.6 | 61.8 |
| Carson Ringold/Lyons Ferry | 1994 | Yearling | 602,000 | 71.8 | 58.8 |

[a] ***Survival is based on green egg-to-smelt stage.***

Table 27. Rearing conditions immediately before transfer for yearling spring chinook salmon in Michigan and Oregon raceways at Umatilla and Bonneville hatcheries.

| Brood year | System | Maximum density ($lb/ft^3$) | Maximum loading (lb/gal/min) |
|---|---|---|---|
| | Umatilla | | |
| 1991 | Oregon | 1.0 | 5.0 |
| 1992 | Oregon | 0.9-1.1 | 4.6-5.4 |
| 1993 | Michigan | 2.4-2.6 | 5.7-6.2 |
| | Oregon | 0.9-l .o | 4.2-4.6 |
| 1994 | Michigan | 2.4-2.7 | 5.9-6.6 |
| | Oregon | 1.2-1.3 | 5.6-6.2 |
| | Bonneville | | |
| 1991 | Oregon | 0.6-0.7 | 5.0-5.3 |
| 1992 | Oregon | 0.8-l .O | 6.8-9.8 |
| 1993 | Oregon | 0.7-0.8 | 4.9-6.2 |

Table 28. Water quality comparisons in Michigan and Oregon raceways used to rear yearling spring chinook salmon (1994 brood) during 1995-1996. Means are combined values for first and second pass raceways and standard error is in parentheses (* = significant difference between systems, NS = no significant difference, $P > 0.05$).

| Parameter measured | Mean parameter value | | | | t-test |
|---|---|---|---|---|---|
| | N | Michigan | N | Oregon | |
| Sampling period | | | 20 Apr-20 Jul | | |
| Temperature head (“C) | | | 20 | 13.9 | |
| Temperature tail (“C) | | | 20 | 14.0 | |
| pH head | | | 20 | 8.0 | |
| pH tail | | | 20 | 8.0 | |
| Oxygen head (ppm) | | | 16 | 10.2 | |
| Oxygen tail (ppm) | | | 16 | 9.5 | |
| Nitrogen head (mmHg) | | | 13 | 570.2 | |
| Nitrogen tail (mmHg) | | | 13 | 579.4 | |
| Total pressure-head (mmHg) | | | 13 | 728.1 | |
| Total pressure-tail (mmHg) | | | 13 | 726.4 | |
| Unionized ammonia ($\mu$g/l) | | | 8 | 0.13 | |
| Alkalinity (mg/l $CaCO_3$) | | | 10 | 162.5 | |
| Sampling period | 25 Jul-16 Feb | | 25 Jul-16 Feb | | |
| Temperature head (“C) | 57 | 14.1 | 56 | 14.3 | NS |
| Temperature tail (“C) | 57 | 14.2 | 56 | 14.3 | NS |
| pH head | 47 | 7.8 | 46 | 7.9 | NS |
| pH tail | 47 | 7 . 8 | 46 | 7.8 | NS |
| Oxygen head (ppm) | 57 | 11.0 | 56 | 9.7 | * |
| Oxygen tail (ppm) | 57 | 9.5 | 53 | 8.2 | * |
| Nitrogen head (mmHg) | 57 | 584.3 | 56 | 597.4 | * |
| Nitrogen tail (mmHg) | 57 | 592.7 | 56 | 620.1 | * |
| Total pressure-head (mmHg) | 57 | 751.5 | 56 | 745.7 | NS |
| Total pressure-tail (mmHg) | 57 | 736.4 | 56 | 740.4 | NS |
| Unionized ammonia ($\mu$g/l) | 26 | 0.38 | 26 | 0.3 | NS |
| Alkalinity (mg/l $CaCO_3$) | 28 | 143.0 | 28 | 142.5 | NS |

Table 29. Water quality comparisons between first, second, and third pass Michigan raceways used to rear yearling spring chinook salmon (1994 brood) during 19951996. Means with same letter or without letters are not significantly different at $P > 0.05$.

| Parameter measured | N | Mean parameter value | | |
|---|---|---|---|---|
| | | A pass | B pass | C pass |
| Sampling period | | 25 Jul-16 Feb | 25 Jul-16 Feb | 25 Jul-16 Feb |
| Temperature head (“C) | 29 | 14.1 | 14.2 | 14.3 |
| Temperature tail (“C) | 29 | 14.1 | 14.2 | 14.3 |
| pH head | 24 | 7.9yz | 7.8y | 7.8 |
| pH tail | 24 | 7.8 | 7.8yz | 7.7 |
| Oxygen head (ppm) | 29 | 11.1 | 10.9 | 11.0 |
| Oxygen tail (ppm) | 29 | 9.5 | 9.4 | 9.5 |
| Nitrogen head (mmHg) | 29 | 588.7y | 579. lyz | 575. lz |
| Nitrogen tail (mmHg) | 29 | 595.9y | 588.9yz | 582.9z |
| Total pressure-head (mmHg) | 29 | 755.9y | 745.5yz | 742.8z |
| Total pressure-tail (mmHg) | 29 | 739.5y | 732.3yz | 728.7z |
| Unionized ammonia ($\mu$g/l) | 14 | 0.24y | 0.52yz | 0.59z |
| Alkalinity (mg/l $CaCO_3$) | 15 | 141.1 | 143.1 | 139.7 |

Table 30. Mean length, weight, and condition factor for yearling spring chinook salmon (1994 brood) reared in Michigan and Oregon raceways at Umatilla Hatchery and released in spring 1996. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not sianificantlv different at P > 0.05.

| | | Length(mm) | | Weight(g) | | Condition Factor | |
|---|---|---|---|---|---|---|---|
| Sample | System[a] | N | Mean(SE) | N | Mean(SE) | N | Mean(SE) |
| July: | Michigan | 224 | 88.9(0.3) | 139 | 8.8(0.1) | 139 | 1.24(0.01) |
| | Oregon | 103 | 89.8(0.5) | 76 | 9.5(0.2) | 76 | 1.27(0.01) |
| August: | Michigan | 218 | 97.3(0.4) | 142 | 12.2(0.2) | 142 | 1.31(0.01) |
| | Oregon | 451 | 97.0(0.3) | 269 | 12.1(0.1) | 269 | 1.32(0.01) |
| September: | Michigan | 214 | 110.2(0.5) | 111 | 19.1(0.4) | 111 | 1.37(0.01) |
| | Oregon | 405 | 112.6(0.3) | 206 | 20.3(0.3) | 206 | 1.39(0.01) |
| October: | Michigan | 208 | 121.7(0.6) | 106 | 25.6(0.6) | 106 | 1.41(0.01) |
| | Oregon | 415 | 125.5(0.5) | 235 | 27.1(0.4) | 235 | 1.35(0.01) |
| November: | Michigan | 212 | 135.3(0.8) | 113 | 36.1(1.1) | 113 | 1.40(0.01) |
| | Oregon | 402 | 136.1(0.5) | 217 | 36.5(0.6) | 217 | 1.38(0.01) |
| December: | Michigan | 207 | 143.7(0.9) | 113 | 43.2(1.2) | 113 | 1.36(0.01) |
| | Oregon | 416 | 150.1(0.6) | 216 | 46.1(0.7) | 216 | 1.35(0.01) |
| Pre-release: | Michigan | 623 | 157.8(0.7)y | 214 | 53.3(2.2)y | 214 | 1.30(0.1) |
| | Oregon | 1277 | 163.2(0.5)z | 432 | 59.7(0.9)z | 432 | 1.28(0.0) |
| Transfer: | Michigan | 204 | 162.5(1.1) | 101 | 54.9(1.8) | 101 | 1.24(0.01) |
| | Oregon | 429 | 169.4(1.0) | 222 | 61.6(1.4) | 222 | 1.23(0.01) |
| Release[b]: | Michigan | | 160.9 | | 46.4 | | 1.11 |
| | Oregon | | 167.7 | | 53.0 | | 1.12 |

[a] ***First and second pass raceways.***

[b] ***Release length, weight, and condition factor was calculated from 300 sample Umatilla fish released on March 13, 1996.***

Table 31. Mean length, weight, and condition factor for yearling spring chinook salmon (1994 brood) reared in Michigan raceways at Umatilla Hatchery during 199596. Letters indicate statistical groupings for tests at pre-release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at $P > 0.05$.

| | | Length(mm) | | Weight(g) | | Condition Factor | |
|---|---|---|---|---|---|---|---|
| Sample | Pass | N | Mean(SE) | N | Mean(SE) | N | Mean(SE) |
| | | | | **Michigan** | | | |
| July: | A | 110 | 89.0(0.4) | 81 | 8.8(0.2) | 81 | 1.23(0.01) |
| | B | 114 | 89.0(0.5) | 58 | 8.7(0.2) | 58 | 1.25(0.02) |
| | C | 105 | 89.5(0.4) | 75 | 9.5(0.1) | 75 | 1.30(0.01) |
| August: | A | 113 | 97.7(0.6) | 57 | 12.3(0.3) | 57 | 1.33(0.01) |
| | B | 105 | 97.0(0.5) | 85 | 12.1(0.2) | 85 | 1.30(0.01) |
| | C | 123 | 97.0(0.5) | 87 | 12.0(0.2) | 87 | 1.30(0.01) |
| September: | A | 101 | 109.8(0.7) | 56 | 18.6(0.5) | 56 | 1.33(0.01) |
| | B | 113 | 110.6(0.7) | 55 | 19.7(0.7) | 55 | 1.42(0.01) |
| | C | 102 | 111.1(0.7) | 50 | 20.2(0.6) | 50 | 1.41(0.01) |
| October: | A | 103 | 122.8(0.7) | 50 | 26.9(0.9) | 50 | 1.40(0.01) |
| | B | 105 | 120.6(0.9) | 56 | 24.4(0.7) | 56 | 1.41(0.01) |
| | C | 101 | 130.0(1.2) | 59 | 26.7(0.9) | 59 | 1.20(0.01) |
| November: | A | 110 | 135.0(1.1) | 59 | 36.6(1.6) | 59 | 1.42(0.01) |
| | B | 100 | 135.1(1.2) | 52 | 34.9(1.5) | 52 | 1.39(0.01) |
| | C | 104 | 136.8(1.0) | 56 | 35.5(1.1) | 56 | 1.39(0.01) |
| December: | A | 104 | 143.9(1.3) | 53 | 43.9(2.0) | 53 | 1.38(0.01) |
| | B | 105 | 144.1(1.2) | 62 | 43.3(1.4) | 62 | 1.35(0.01) |
| | C | 106 | 146.1(1.2) | 56 | 44.3(1.5) | 56 | 1.38(0.01) |
| Pre-release: | A | 312 | 156.3(0.9)x | 110 | 50.9(1.7) | 110 | 1.27(0.04) |
| | B | 311 | 159.4(1.0)xy | 104 | 55.9(4.1) | 104 | 1.33(0.11) |
| | C | 313 | 155.7(1.0)x | 99 | 51.4(1.9) | 99 | 1.27(0.01) |
| Transfer: | A | 103 | 164.4(1.7) | 50 | 59.2(2.7) | 50 | 1.25(0.01) |
| | B | 101 | 160.7(1.4) | 51 | 50.7(2.1) | 51 | 1.23(1.01) |
| | C | 103 | 166.9(2.0) | 53 | 59.3(3.6) | 53 | 1.19(0.01) |
| Release | | | 160.9 | | 46.4 | | 1.11 |

Table 3 1 (continued)

| Sample | Pass | Length(mm) N | Length(mm) Mean(SE) | Weight(g) N | Weight(g) Mean(SE) | Condition Factor N | Condition Factor Mean(SE) |
|---|---|---|---|---|---|---|---|
| | | | Oregon | | | | |
| May: | 5A | 155 | 68.0(0.3) | 55 | 4.0(0.1) | 55 | 1.30(0.01) |
| June : | 5A | 108 | 79.5(0.5) | 51 | 6.1(0.1) | 51 | 1.26(0.01) |
| | 5B | 103 | 79.5(0.3) | 56 | 6.5(0.1) | 56 | 1.27(0.01) |
| July: | 5A | 103 | 89.8(0.5) | 76 | 9.5(0.2) | 76 | 1.27(0.01) |
| August: | A | 208 | 96.7(0.4) | 134 | 12.0(0.2) | 134 | 1.32(0.01) |
| | B | 243 | 97.3(0.3) | 135 | 12.2(0.2) | 135 | 1.32(0.01) |
| September: | A | 202 | 112.9(0.5) | 102 | 20.4(0.4) | 102 | 1.38(0.01) |
| | B | 203 | 112.4(0.5) | 104 | 20.4(0.4) | 104 | 1.41(0.01) |
| October: | A | 205 | 124.5(0.7) | 118 | 26.4(0.6) | 118 | 1.35(0.01) |
| | B | 210 | 126.5(0.6) | 117 | 27.7(0.6) | 117 | 1.35(0.01) |
| November: | A | 188 | 136.1(0.7) | 106 | 36.6(0.8) | 106 | 1.39(0.01) |
| | B | 214 | 136.2(0.7) | 111 | 36.3(0.8) | 111 | 1.37(0.01) |
| December: | A | 207 | 149.7(0.9) | 102 | 46.7(1.2) | 102 | 1.35(0.01) |
| | B | 209 | 150.4(0.7) | 114 | 45.6(0.9) | 114 | 1.35(0.01) |
| Pre-release: | A | 632 | 162.9(0.7)x | 212 | 61.0(1.3)x | 212 | 1.28(0.01)x |
| | B | 645 | 163.5(0.7)x | 220 | 58.6(1.3)x | 220 | 1.28(0.01)x |
| Transfer: | A | 215 | 172.4(1.3) | 101 | 65.3(1.9) | 101 | 1.23(0.01) |
| | B | 214 | 166.3(1.2) | 121 | 58.5(1.9) | 121 | 1.23(0.01) |
| Release? | | | 167.7 | | 53.0 | | 1.12 |

[a] ***Release length was calculated from 600 sample fish and length and weight condition factor from 200 fish released on March 13, 1996.***

Table 32. Mean length, weight, and condition factor at pre-release or release for yearling spring chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery (standard error in parentheses).

| Brood year | System | Length (mm) | Weight (g) | Condition factor |
|---|---|---|---|---|
| 1991 | Oregon | 158.8(0.5) | 50.5(0.8) | 1.20(0.06) |
| 1992 | Oregon | 163.0(0.7) | 55.2(1.3) | 1.23(0.01) |
| 1993[a] | Michigan | 166.9 | 57.8 | 1.24 |
| | Oregon | 171.0 | 56.9 | 1.16 |
| 1994[a] | Michigan | 160.9 | 46.4 | 1.11 |
| | Oregon | 167.7 | 53.0 | 1.12 |

[a] ***Fish from the 1993 and 1994 brood years were measured at release after acclimation, standard errors were not available. Other brood years were not acclimated and were released directly into the Umatilla River.***

Table 33. Mean length, weight, and condition factor at release for yearling spring chinook salmon reared in first, second, and third pass Michigan raceways at Umatilla Hatchery (standard error is in parentheses).

| Brood year | Pass | Length (mm) | Weight (g) | Condition factor |
|---|---|---|---|---|
| 1993 | A | 138.7(1.0) | 38.0(1.3) | 1.31(0.01) |
| | B | 138.0(0.9) | 36.2(1.3) | 1.67(0.34) |
| 1994 | A | 156.3(0.9) | 50.9(1.7) | 1.27(0.04) |
| | B | 159.4(1.0) | 55.9(4.1) | 1.34(0.11) |
| | C | 155.7(1.0) | 51.4(1.9) | 1.27(0.01) |

Table 34. Mean proportion of descaled, partially descaled, and undamaged yearling spring chinook salmon reared in Michigan and Oregon raceways at Umatilla Hatchery.

| Brood year | System[d] | Descaled[a] | Partially Descaled[b] | Undamaged[c] |
|---|---|---|---|---|
| 1991 | Oregon | 0.01 | 0.01 | 0.99 |
| 1992 | Oregon | 0.01 | 0.18 | 0.81 |
| 1993 | Michigan | 0.03 | 0.24 | 0.74 |
| | Oregon | 0.00 | 0.15 | 0.85 |
| 1994 | Michigan | 0.13 | 0.54 | 0.33 |
| | Oregon | 0.01 | 0.12 | 0.87 |

[a] *More than 0.20 descaling on either side of the jish.*
[b] *Descaling = 0.03 to 0.20 on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish.*
[d] *Combined first and second pass raceways.*

Table 35. Mean proportion of descaled, partially descaled, and undamaged yearling spring chinook salmon reared in Michigan passes at Umatilla Hatchery.

| Brood Year | Pass | Descaled[a] | Partially descaled[b] | Undamaged[c] |
|---|---|---|---|---|
| 1993 | | | | |
| | A | 0.44 | 0.20 | 0.36 |
| | B | 0.30 | 0.53 | 0.18 |
| | C | 0.30 | 0.49 | 0.20 |
| 1994 | A | 0.31 | 0.54 | 0.15 |
| | B | 0.05 | 0.64 | 0.31 |
| | C | 0.02 | 0.43 | 0.54 |

[a] *More than 0.20 descaling on either side of the fish.*
[b] *Descaling = 0.03 to 0.20 on either side of the fish.*
[c] *Less than 0.03 descaling on either side of the fish,*

Table 36. Coded-wire-tag and brand (1/4") information for yearling spring chinook salmon (1994 brood) marked at Umatilla Hatchery and released in 1996 (CWT = coded-wire-tag, LOC = location of brand, POS = position of brand, RA = right anterior, LA = left d, LV = left ventral clip).

| Race -way | CWT code | Number CWT" | Readable brand | LOC | Brand | POS | Fin clip | Number released |
|---|---|---|---|---|---|---|---|---|
| M6A | 071027 | 19,622 | 5,083 | LA | B | 1 | LV | ***49,032*** |
| M6B | 071028 | 18,844 | 4,682 | LA | B | 4 | LV | 45,887 |
| M6C | 071029 | 19,258 | 5,275 | RA | B | 4 | LV | 49.121 |
| 04A | 071030 | 19,961 | 4,531 | RA | B | 2 | LV | ***60,599*** |
| 04B | 071033 | 20,066 | 4,232 | LA | B | 3 | LV | ***56,709*** |
| O5A | 071031 | 19,871 | 5,026 | LA | B | 2 | LV | 60,137 |
| O5B | 071032 | 19.583 | 5.092 | RA | B | 3 | LV | 57.076 |

[a] ***Number recognizably coded-wire-tagged and released. All CWT fish are also adipose fin clipped and all fish received a left ventral fin clip.***

Table 37. Recovery information for branded yearling spring chinook salmon reared in Michigan or Oregon raceways at Umatilla and Bonneville hatcheries, released in the Umatilla River, and recaptured at John Day Dam.

| Brood year | Number of replicate groups | Mean percent of number released (N) System | |
|---|---|---|---|
| | | Michigan' | Oregon |
| | | **Umatilla Hatchery** | |
| 1991 | 0/4 | | 3.9 (70) |
| 1992 | 0/4 | | 4.4 (77) |
| 1993 | 2/4 | 15.8 (48) | 12.9 (147) |
| 1994 | 3/4 | 7.6 (29) | 9.7 (60) |
| | | **Bonneville Hatchery** | |
| 1992 | 0/2 | | 5.4 (42) |
| 1993 | 0/2 | | 10.8 (19) |

[a] ***First and second pass Michigan raceways.***

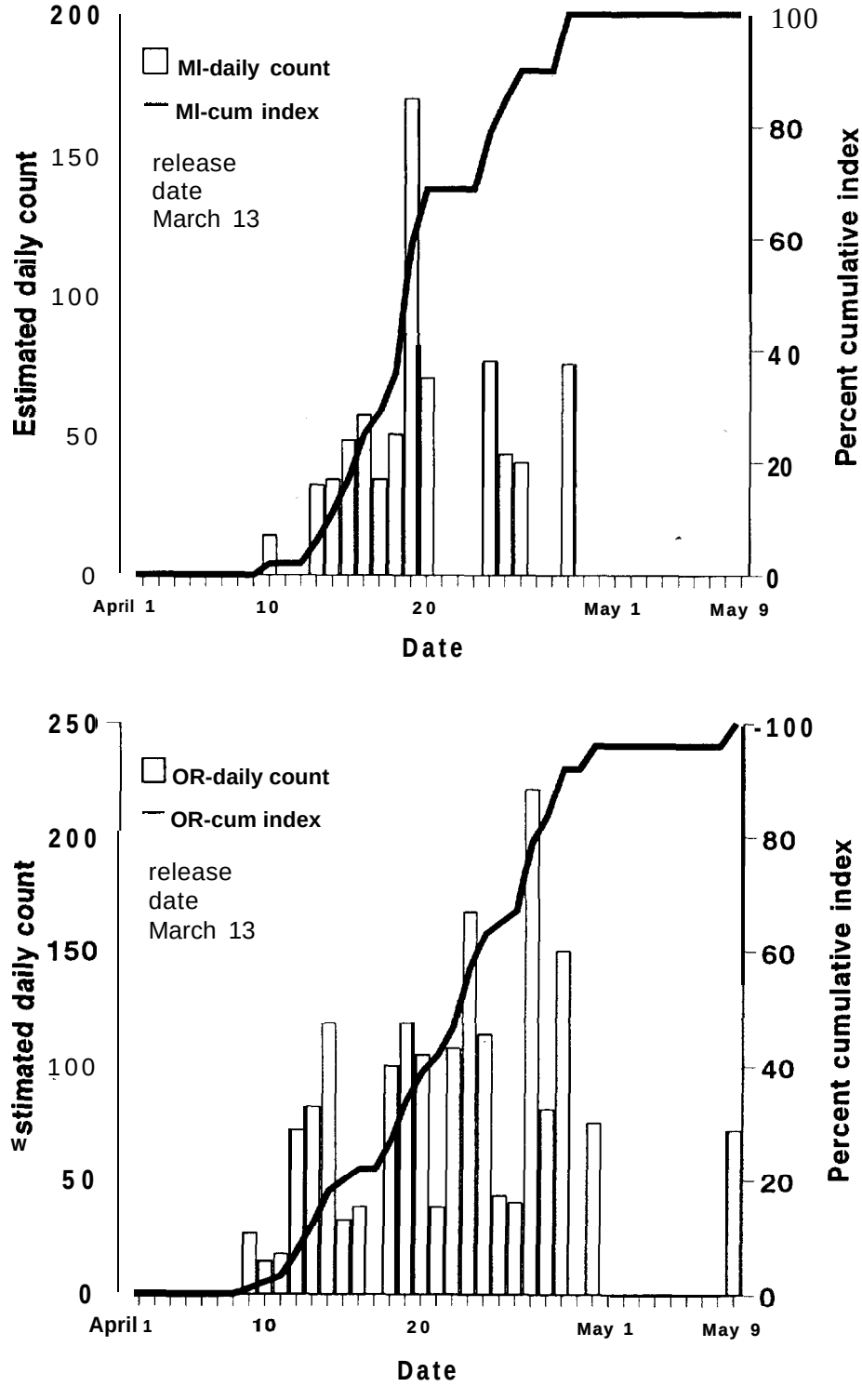


Figure 4. Recovery of branded yearling spring chinook salmon that were reared and marked at Umatilla Hatchery, released in the Umatilla River, and recovered at John Day Dam in 1996.

Table 38. Total catch, escapement and survival of yearling spring chinook salmon that were coded-wire-tagged (CWT) and released in the Umatilla River, 1990-1993 broods. Recoveries include age 3 and older fish. All brood years are incomplete. Estimates of number of jacks and adults recovered are based on total production in each raceway. Sample size (N) based on expanded recoveries.

| Brood year, CWT code | Raceway | N | Total exploit-tation rate | Umatilla return rate (% of release) | Total survival rate (% of release) | Number of jacks and adults recovered |
|---|---|---|---|---|---|---|
| | | | **Umatilla Hatchery** | | | |
| 1991 | | | | | | |
| 075739 | 05B | 0 | 0.0 | 0.00 | 0.00 | 0 |
| 075740 | 04B | 3 | 0.0 | 0.01 | 0.01 | 7 |
| 07574 1 | 04A | 16 | 0.0 | 0.08 | 0.08 | 41 |
| 075742 | 05A | 8 | 0.0 | 0.04 | 0.04 | 21 |
| | | 27 | | | | 69 |
| 1992 | | | | | | |
| O-70217 | 05A | 0 | 0.0 | 0.00 | 0.00 | 0 |
| 070218 | 05B | 0 | 0.0 | 0.00 | 0.00 | 0 |
| 070219 | 04B | 0 | 0.0 | 0.00 | 0.00 | 0 |
| 070220 | 04A | 0 | 0.0 | 0.00 | 0.00 | 0 |
| | | 0 | | | | 0 |
| | | | **Bonneville Hatchery** | | | |
| 1991 | | | | | | |
| 07 1455 | 1A | 39 | 0.1 | 0.18 | 0.20 | 89 |
| 07 1456 | 2B | 27 | 0.0 | 0.13 | 0.13 | 62 |
| | | 66 | | | | 151 |
| 1992 | | | | | | |
| 070250 | B6 | 5 | 0.0 | 0.02 | 0.02 | 19 |
| 07025 1 | B5 | 6 | 0.0 | 0.02 | 0.02 | 23 |
| 075944 | B8 | 2 | 0.0 | 0.01 | 0.01 | 10 |
| 075945 | B7 | 3 | 0.0 | 0.01 | 0.01 | 15 |
| | | 16 | | | | 67 |

**Bonneville Hatchery:**

*Fish Culture Studies: No* 1994 brood yearlings were reared at BH.

*Rearing and Survival Studies:* Smolt-to-adult survival estimates from previous releases are presented in Table 38.

**Adult Returns**

Statistics from spring chinook salmon that returned to TMFD in 1995 and 1996 are presented in Tables 39-40 and Figure 5. Most tag recoveries of jack and adult salmon in 1995 were from fish reared at BH. Other returning fish in 1995 included two strays from Lyons Ferry Fish Hatchery and one from Clackamas Fish Hatchery. Coded wire tags from 1996 have not been decoded.

**Fishery**

Catch and harvest data for the spring chinook salmon fishery in 1996 is presented in Table 41. All 20 coded-wire-tags collected were from the 1992 brood year (18-BH, 2-UH). Most anglers in the river were from Umatilla and Morrow counties (92.5 % and 86.5 % in the lower and upper river, respectively). Other Oregon resident anglers made up 4.5 and 9.0 % of the lower and upper river survey. The remaining anglers resided out of state.

## Summer Steelhead

**Overview**

Five brood years of steelhead (1991-1995) have been reared in MI raceways at UH and released in the Umatilla River (Appendix Table 7). The objective of this study is to monitor rearing conditions, migration, cost, and smolt-to-adult survival for steelhead produced in the MI system and compare these parameters among MI passes. Comparisons were made with Wallowa stock steelhead reared in OR raceways at Irrigon Fish Hatchery. The original production goal of 210,000 fish was reduced to 150,000 fish after the first year because high densities were hypothesized to be causing poor fish condition. Adult returns will be complete in 1999.

**Fish Culture Studies**

Information on fish culture and releases is presented in Tables 42-45 and Appendix Tables 1 and 7. Steelhead from the 1995 brood were ponded in one OR raceway on 15 August 1995 at 430 fish/lb. This group was split into two OR raceways on 28 September 1995 at 74 fish/lb. On 27 October 1995, fish from two OR raceways were split into three MI raceways by small, medium, or large grade at 51, 37, and 27 fish/lb: Marking with coded-wire tags and fin clips was completed in mid-November. Dry feed conversion ratios were similar for all passes and ranged from 0.94-1.07. Michigan raceways produced an average of 157 fish/gpm. Production cost was $0.69 per fish without marking costs and $0.78 with marking costs.

Table 39. Vital statistics for spring chinook salmon that returned to the east-bank fish ladder, Three-Mile Falls Dam. Umatilla River. 1995 and 1996.

| Age[a] | Male | % | Female | % | Unknown | % | Total | % |
|---|---|---|---|---|---|---|---|---|
| | | | | **1995** | | | | |
| Subjack | 26 | 100.0 | 0 | 0.0 | 0 | 0.0 | 26 | 5.2 |
| Jack | 82 | 100.0 | 0 | 0.0 | 0 | 0.0 | 82 | 16.5 |
| Adult | 162 | 41.8 | 224 | 57.7 | 2 | 0.0 | 388 | 78.2 |
| Total | 270 | 54.4 | 224 | 45.2 | 2 | 0.4 | 496 | 100.0 |
| | | | | **1996** | | | | |
| Subjack | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Jack | 121 | 100.0 | 0 | 0.0 | 0 | 0.0 | 121 | 16.5 |
| Adult | 948 | 44.1 | 1204 | 55.9 | 0 | 0.0 | 2152 | 94.8 |
| Total | 1066 | 47.0 | 1203 | 53.0 | 0 | 0.0 | 2273 | 100.0 |

[a] *Age designation based on fork length: mini-jacks < 381 mm, jacks 382-610 mm, adults > 610 mm)*

Table 40. Vital statistics of spring chinook salmon that returned to the Umatilla River in 1995 by release strategy and hatchery. Data was determined from coded-wire tag recovery (sex was determined visually, all age 2 fish were assumed to be male).

| Hatchery, brood year | Age | Number | Sex | Fork length (mm) mean | min | max |
|---|---|---|---|---|---|---|
| Umatilla Hatchery | | | | | | |
| 1992 | 3 | | | | | |
| 1993 | 2 | 4 | male | 291 | 250 | 341 |
| Bonneville Hatchery | | | | | | |
| 1991 | 4 | 6 | male | 888 | 780 | 945 |
| 1991 | 4 | 15 | female | 810 | 765 | 881 |
| | | | **Yearling** | | | |
| Umatilla Hatchery | | | | | | |
| 1991 | 4 | 2 | male | 788 | 780 | 795 |
| 1991 | 4 | 7 | female | 771 | 725 | 830 |
| 1993 | 2 | 26 | male | 293 | 279 | 302 |
| Bonneville Hatchery | | | | | | |
| 1989 | 6 | 1 | female | 900 | | |
| 1990 | 5 | 2 | male | 910 | 900 | 920 |
| 1990 | 5 | 1 | female | 840 | | |
| 1991 | 4 | 9 | male | 808 | 720 | 920 |
| 1991 | 4 | 13 | female | 802 | 740 | 845 |
| 1992 | 3 | 16 | male | 547 | 475 | 605 |
| 1993 | 2 | 3 | male | 279 | 251 | 313 |

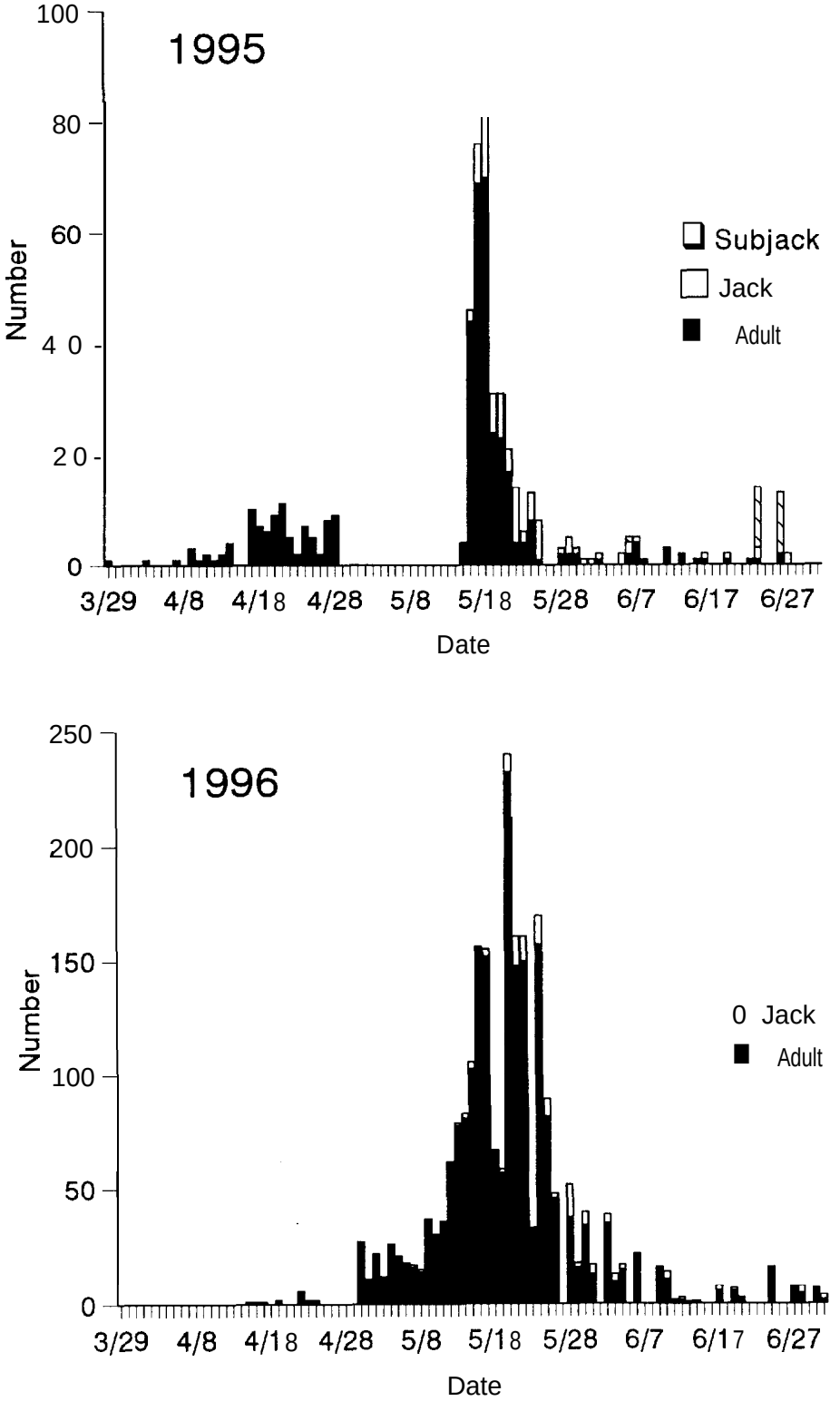


Figure 5. Numbers of subjack, jack, and adult spring chinook salmon counted at the east-bank fish ladder, Three Mile Falls Dam, Umatilla River, 1995 and 1996 (subjack < 381 mm, jack 382-610 mm, adult > 610 mm, fork length).

Table 41. Estimated catch statistics for spring chinook salmon in the Umatilla River in 1996. Lower river = Rieth bridge to 1 lth street bridge in Pendleton. Upper River = Upper boundary of the Confederated Tribes of the Umatilla Indian Reservation to the forks of the Umatilla River.

| Day type | Number sampled days | Number sampled anglers | Hours fished | Number caught | Number harvested | Catch rate (fish/h) |
|---|---|---|---|---|---|---|
| | | | **Lower River** | | | |
| Weekday | 8 | 191 | 1455 | 152 | 152 | 0.105 |
| Weekend | 7 | 237 | 1016 | 53 | 53 | 0.053 |
| Total | 15 | 428 | 2471 | 205 | 205 | 0.083 |
| | | | **Upper River** | | | |
| Weekday | 5 | 12 | 167 | 0 | 0 | **0.000** |
| Weekend | 7 | 55 | 262 | 1 | 1 | 0.005 |
| Total | 12 | 67 | 429 | 1 | 1 | 0.003 |
| | | | **Combined Total** | | | |
| Weekday | 13 | 203 | 1622 | 152 | 152 | 0.094 |
| Weekend | 14 | 292 | 1278 | 54 | 54 | 0.042 |
| Total | 27 | 495 | 2900 | 206 | 206 | 0.071 |

Table 42. Egg-take and survival of summer steelhead reared at Umatilla Hatchery, brood years 1991-1995.

| Egg source | Brood year | Number of eggs taken or received | Egg-to-fry survival (%) | Egg-to-smolt[a] survival (%) |
|---|---|---|---|---|
| Umatilla River | 1991 | 340.674 | 78.4 | 66.6[b] |
| Umatilla River | 1992 | 423.810 | 47.2 | 43.3[c] |
| Umatilla River | 1993 | 255,000 | 73.7 | 60.0 |
| Umatilla River | 1994 | 234,000 | 84.6 | 63.1 |
| Umatilla River | 1995 | 223.525 | 86.1 | 65.6 |

[a] ***Survival estimate is based on green egg-to-smolt stage.***

[b] ***Survival estimate does not include 5,443 smolts removed for passage evaluation nor 27,860 that were graded off.***

[c] ***Survival estimate does not include 25,090 sac fry that were destroyed because of a reduction in program goals.***

Table 43. Rearing conditions immediately before transfer for summer steelhead in Michigan raceways at Umatilla Hatchery and in Oregon raceways at Irrigon Hatchery.

| Brood year | System | Maximum density (lb/ft$^3$) | Maximum loading (lb/gal/min) |
|---|---|---|---|
| 1991 | Michigan | 5.4-6.7 | 11.8-14.6 |
| 1991 | Oregon | 1.3 | 6.6 |
| 1992 | Michigan | 4.0-4.5 | 8.9-9.9 |
| 1992 | Oregon | 1.3 | 6.6 |
| 1993 | Michigan | 3.8-4.6 | 8.4-10-l |
| 1993 | Oregon | 1.4-1.5 | 6.7-7.4 |
| 1994 | Michigan | 4.0-4.2 | 9.7-10.2 |
| 1994 | Oregon | 1.3-1.4 | 7.3-10.4 |
| 1995 | Michigan | 4.1-4.3 | 9.8-10.4 |
| 1995 | Oregon | 1.2-1.4 | 5.9-6.9 |

Table 44. Water quality measurements in Michigan and Oregon raceways used to rear summer steelhead (1995 brood) during 1995-1996. Means are combined values for first and second pass raceways

| | Mean parameter value (N) | | | |
|---|---|---|---|---|
| Parameter measured | N | Michigan | N | Oregon |
| Sampling period | 03 Nov-1 1 Apr | | 23 Aug-27 Oct | |
| Temperature head (“C) | 14 | 12.1 | 15 | 15.5 |
| Temperature tail (“C) | 14 | 12.1 | 15 | 15.6 |
| pH head | 14 | 7.9 | 11 | 7.9 |
| pH tail | 14 | 7.8 | 11 | 7.9 |
| Oxygen head (ppm) | 14 | 12.0 | 15 | 9.5 |
| Oxygen tail (ppm) | 4 | 9.8 | 15 | 8.6 |
| Nitrogen head (mmHg) | 4 | 562 | 15 | 597 |
| Nitrogen tail (mmHg) | 4 | 594 | 15 | 604 |
| Total pressure-head (mmHg) | 4 | 732 | 15 | 744 |
| Total pressure-tail (mmHg) | 4 | 734 | 15 | 738 |
| Unionized ammonia ($\mu$g/l) | 4 | 0.23 | 6 | 0.45 |
| Alkalinity (mg/l $CaCO_3$) | 6 | 135 | 6 | 144 |

Table 45. Water quality comparisons between first, second, and third pass Michigan raceways used to rear summer steelhead (1995 brood) during 1995-1996. Means with same letter or without letters are not significantly different at $P > 0.05$.

| | | Mean parameter value | | |
|---|---|---|---|---|
| Parameter measured | N(A pass) | A pass | B pass | C pass |
| Sampling period | | 3 Nov- 11 Apr | 30 Nov-7 Mar | 30 Nov-7 Mar |
| Temperature head (“C) | 19(22) | 13.1 | 13.1 | 13.1 |
| Temperature tail (“C) | 19(23) | 13.0 | 13.1 | 13.0 |
| pH head | 17(22) | 8.0a | 7.8b | 7.6b |
| pH tail | 17(22) | 7.8 | 7.7 | 7.6 |
| Oxygen head (ppm) | 17(20) | 12.0 | 12.7 | 12.7 |
| Oxygen tail (ppm) | 18(21) | 8.7 | 9.3 | 9.1 |
| Nitrogen head (mmHg) | 19(22) | 582 | 571 | 557 |
| Nitrogen tail (mmHg) | 19(23) | 588 | 578 | 570 |
| Total pressure-head (mmHg) | 19(23) | 765x | 760xy | 746y |
| Total pressure-tail (mmHg) | 19(23) | 720 | 720 | 708 |
| Unionized ammonia ($\mu$g/l) | 9(12) | 0.14x | 0.39xy | 0.42y |
| Alkalinity (mg/l $CaCO_3$) | 9(12) | 135 | 147 | 148 |

**Rearing and Survival Studies**

Smolt condition data at release for 1991-1995 brood steelhead is presented in Tables 46-48. The percentage of smolts ranged from 8.1-8.4% in 1995 and the remaining fish were classified as intermediate smolts. Adipose fin clip quality was greater than 98% recognizably clipped. To quantitatively estimate the length of the dorsal and caudal fins we measured 28 hatchery fish (mean FL=210 mm) and 29 wild fish (mean FL=201 mm). Dorsal fin length measured 6.2 mm for hatchery fish and 10.0 mm for wild fish. The mean length of the top and bottom lobe of the caudal fin was 11.6 mm and 11.8 mm for hatchery fish and 15.2 mm and 13.9 mm for wild fish.

Brand, coded-wire-tagged, and production release and recovery information is presented in Tables 49-50. Only one brand was recovered at John Day Dam and two at Bonneville Dam in 1996, therefore, survival indices were not calculated. All brand recoveries were from fish reared in the third pass raceway. Smolt-to-adult survival estimates from previous releases are presented in Table 5 1.

**Adult Returns**

The number of steelhead that returned to TMFD in 1995-96 was 2,081 (Appendix Table 8). Vital statistics on adults and run timing are presented in Tables 52-53 and Figure 6. The first fish was trapped on 5 September 1995. Peak counts of 67 wild and 40 hatchery steelhead occurred on 5 December 1995 and 16 January 1996, respectively. The last fish was collected on 24 June 1996. We sampled 92 of 281 coded-wire tagged fish that returned to TMFD. Of these fish, 12 of 13 were strays from Lyons Ferry Hatchery, CWT codes 634815(3), 635313(l), 635314(l), 635408(4), 635409(2) and 635942(l). One stray fish was identified as Lower Snake River stock (231958).

**Fishery,**

Catch and harvest data from the 1995-96 steelhead sport fishery is presented in Table 54. Angler residency from 880 interviews was 90.8 % Umatilla and Morrow counties, 6.6% other Oregon counties, and 2.6% out of state. The observed catch of 42 steelhead below TMFD consisted of 43 % hatchery and 57% wild (all wild fish were released). Seven coded-wire tagged steelhead were recovered in the fishery. Six originated from Umatilla Hatchery (070058, 070141, 070142, 070144, 076055, and 076060) and one from Lyons Ferry Hatchery (634817). Four of the fish were from the 1992 brood and three from the 1993 brood. We contacted 1,733 anglers between the Umatilla Hatchery outlet and the McNary Dam boat ramp on the Columbia River from 30 September 1995 to 25 January 1996 (Table 55). Anglers caught 208 steelhead, 116 chinook salmon, and 9 coho salmon. From nine coded-wire tag recoveries we found two steelhead of Umatilla Hatchery origin (076060 and 070142).

Table 46. Mean length, weight, and condition factor for summer steelhead (1995 brood) reared in Michigan passes at Umatilla Hatchery in 1995-96. Letters indicate statistical groupings for tests at release based on Sidak's multiple comparison test. Means with the same letter are not significantly different at P > 0.05.

| | | Length(mm) | | Weight(g) | | Condition Factor | |
|---|---|---|---|---|---|---|---|
| Sample | Pass | N | Mean(SE) | N | Mean(SE) | N | Mean(SE) |
| October: | A | 100 | 89.8(0.9) | 56 | 8.8(0.4) | 56 | 1.13(0.01) |
| | B | 103 | 102.3(1.3) | 62 | 12.9(0.6) | 62 | 1.13(0.01) |
| | C | 118 | 113.3(1.0) | 61 | 16.8(0.6) | 61 | 1.12(0.01) |
| November: | A | 109 | 104.3(1.0) | 62 | 13.8(0.6) | 62 | 1.21(0.01) |
| | B | 106 | 116.3(1.3) | 53 | 21.0(1.0) | 53 | 1.26(0.01) |
| | c | 109 | 133.0(1.0) | 62 | 27.8(1.0) | 62 | 1.20(0.02) |
| December: | A | 109 | 134.8(1.3) | 51 | 28.6(1.3) | 51 | 1.15(0.01) |
| | B | 106 | 153.2(1.6) | 55 | 42.1(1.8) | 55 | 1.15(0.01) |
| | c | 105 | 159.3(1.5) | 50 | 43.6(1.5) | 50 | 1.10(0.01) |
| January : | A | 117 | 155.0(1.5) | 59 | 44.9(1.9) | -59 | 1.14(0.02) |
| | B | 100 | 170.9(1.8) | 58 | 63.4(2.9) | 58 | 1.14(0.01) |
| | C | 106 | 173.7(2.2) | 51 | 57.2(2.8) | 51 | 1.04(0.01) |
| February: | A | 101 | 176.4(2.0) | 66 | 66.4(3.2) | 66 | 1.15(0.01) |
| | B | 102 | 194.3(2.0) | 50 | 84.7(4.2) | 50 | 1.11(0.01) |
| | c | 101 | 196.5(1.7) | 51 | 85.4(3.2) | 51 | 1.11(0.01) |
| March: | A | 201 | 197.2(1.4) | 200 | 88.1(2.0) | 200 | 1.11(0.01) |
| Release[a]: | A | 303 | 207.9(1.1)y | 100 | 87.3(2.4)z | 100 | 0.99(0.01)y |
| | B | 312 | 206.8(1.3)z | 102 | 89.9(2.9)z | 102 | 0.98(0.01)z |

[a] ***The 1995 brood steelhead from pond M8C escaped from the acclimation pond prior to sampling.***

Table 47. Mean length, weight, and condition factor at release for summer steelhead reared in first, second, and third pass Michigan raceways at Umatilla Hatchery (standard error in parentheses).

| Brood year | Pass | Length (mm) | Weight (g) | Condition factor |
|---|---|---|---|---|
| 1991 | A | 194.3(1.4) | 91.0(3.2) | 1.13(0.01) |
| | B | 200.0(1.1) | 90.2(2.4) | 1.09(0.01) |
| | C | 186.9(1.O) | 76.7(2.1) | 1.12(0.01) |
| 1992 | A | 199.6(1.1) | 74.8(2.1) | 0.93(0.01) |
| | B | 198.2(1.2) | 80.9(2.7) | 1.01(0.01) |
| | C | 220.1(1.0) | 102.4(2.5) | 0.93(0.01) |
| 1993 | A | 205.9(1.2) | 86.7(2.5) | 0.97(0.01) |
| | B | 198.3(1.2) | 88.7(2.4) | 1.05(0.01) |
| | C | 214.2(1.1) | 93.3(2.3) | 0.94(0.01) |
| 1994 | A | 206.3(1.1) | 82.6(2.2) | 0.90(0.01) |
| | B | 209.7(1.O) | 96.2(2.7) | 1.00(0.01) |
| | C | 205.9(0.8) | 81.4(1.8) | 0.90(0.01) |
| 1995 | A | 207.9(1.1) | 87.3(2.4) | 0.99(0.01) |
| | B | 206.8(1.3) | 89.9(2.9) | 0.98(0.01) |
| | C[a] | | | |

[a] *The 1995 brood steelhead from pond M8C escaped from the acclimation pond prior to sampling.*

Table 48. Mean proportion of descaled, partially descaled, and undamaged summer steelhead reared in Michigan passes at Umatilla Hatchery.

| Brood year | Pass | Descaled[a] | Partially Descaled[b] | Undamaged[c] |
|---|---|---|---|---|
| 1991 | A | 0.01 | 0.43 | 0.56 |
| 1991 | B | 0.05 | 0.39 | 0.61 |
| 1991[d] | C | | | |
| 1992 | A | 0.08 | 0.30 | 0.62 |
| 1992 | B | 0.03 | 0.56 | 0.41 |
| 1992 | C | 0.02 | 0.58 | 0.40 |
| 1993 | A | 0.05 | 0.13 | 0.82 |
| 1993 | B | 0.01 | 0.50 | 0.49 |
| 1993 | C | 0.11 | 0.33 | 0.56 |
| 1994 | A | 0.13 | 0.39 | 0.48 |
| 1994 | B | 0.00 | 0.21 | 0.79 |
| 1994 | C | 0.09 | 0.42 | 0.50 |
| 1995 | A | 0.03 | 0.70 | 0.28 |
| 1995 | B | 0.01 | 0.31 | 0.69 |
| 1995[e] | C | | | |

[a] ***More than 0.20 descaling on either side of the fish.***
[b] ***Descaling = 0.03 to 0.20 on either side of the fish.***
[c] ***Less than 0.03 descaling on either side of the fish.***
[d] ***Data not available.***
[e] ***The 1995 brood steelhead from pond M8C escaped from the acclimation pond prior to sampling.***

Table 49. Coded-wire-tag and brand (1/4") information for steelhead (1995 brood) marked at Umatilla Hatchery and released in 1996 (CWT = coded-wire-tag, LOC = location of brand, POS = position of brand, RA = right anterior, LA = left anterior, AD = right ventral clip).

| Race -way | CWT code | Number CWT" | Readable brand | LOC | Brand | POS | Fin clip | Number released |
|---|---|---|---|---|---|---|---|---|
| M8A | 071034 | 20,633 | 8,896 | LA | L | 1 | AD | 49,783 |
| M8B | 071035 | 19,742 | 8,615 | LA | L | 2 | AD | 47,543 |
| M8C | 071036 | 21,205 | 8,827 | RA | L | 2 | AD | 49,377 |

[a] ***Number recognizably coded-wire-tagged and released. All CWT fish are also left ventral fin clipped. All fish received an adipose fin clip.***

Table 50. Recovery information for branded steelhead reared in A, B, and C pass Michigan raceways at Umatilla Hatchery, released in the Umatilla River, and recaptured at John Day Dam (number of observed recoveries in parentheses).

| Brood year | Number of replicate groups | Mean percent of number released | | |
|---|---|---|---|---|
| | | Pass | | |
| | | A | B | C |
| 1992 | 1 | | 28.7 (67) | 19.5 (59) |
| 1993 | 1 | 2.0 (53) | 8.4 (51) | 3.7 (22) |
| 1994 | 1 | 2.0 (6) | 3.0 (4) | 2.0 (3) |
| 1995 | 1 | 0.0 (0) | 0.0 (0) | 0.8 (1) |
| Mean | | 1.3 (59) | 10.0 (122) | 6.5 (85) |

Table 5 1. Total catch, escapement and survival of steelhead that were coded-wire-tagged (CWT) and released in the Umatilla River, 1991-1993 broods. Recoveries are incomplete for all brood years. Estimates of number of adults recovered are based on total production in each raceway. Sample size (N) based on expanded recoveries.

| Brood year, CWT code | Raceway | N | Total exploi-tation rate (%) | Umatilla return rate (% of release) | Total survival rate (% of release) | Number adults recovered |
|---|---|---|---|---|---|---|
| 1991 | | | | | | |
| 075838 | M5A | 1 | 0.0 | 0.01 | 0.00 | 2 |
| 075839 | M5A | 1 | 0.0 | 0.01 | 0.00 | 2 |
| 075840 | M5A | 1 | 0.0 | 0.01 | 0.00 | 2 |
| 075841 | M5B | 2 | 100.0 | 0.00 | 0.02 | 4 |
| 075842 | M5B | 0 | 0.0 | 0.00 | 0.00 | 0 |
| 075843 | M5B | 4 | 100.0 | 0.00 | 0.04 | 9 |
| 074127 | M5C | 27 | 0.0 | 0.26 | 0.26 | 58 |
| 073862 | M5C | 14 | 43.0 | 0.08 | 0.13 | 14 |
| 073759 | M5C | 23 | 57.0 | 0.13 | 0.22 | 50 |
| Total | | 73 | 34.0 | 0.06 | 0.07 | 141 |
| 1992 | | | | | | |
| 076052 | M5A | 8 | 0.0 | 0.06 | 0.06 | 15 |
| 076053 | M5A | 11 | 0.0 | 0.10 | 0.10 | 21 |
| 076054 | M5A | 8 | 0.0 | 0.08 | 0.08 | 16 |
| 076055 | M5B | 58 | 7.0 | 0.55 | 0.58 | 93 |
| 076056 | M5B | 56 | 32.0 | 0.41 | 0.59 | 95 |
| 076057 | M5B | 58 | 14.0 | 0.56 | 0.60 | 96 |
| 076058 | M5C | 71 | 23.0 | 0.59 | 0.70 | 105 |
| 076059 | M5C | 41 | 12.0 | 0.40 | 0.42 | 62 |
| 076060 | M5C | 74 | 22.0 | 0.76 | 0.78 | 116 |
| Total | | 385 | 12.2 | 0.39 | 0.43 | 619 |
| 1993 | | | | | | |
| 070139 | M5A | 4 | 0.0 | 0.05 | 0.05 | 13 |
| 070140 | M5A | 0 | 0.0 | 0.00 | 0.00 | 0 |
| 070141 | M5B | 23 | 17.0 | 0.19 | 0.23 | 57 |
| 070142 | M5B | 29 | 90.0 | 0.08 | 0.29 | 72 |
| 070143 | M5C | 26 | 15.0 | 0.21 | 0.25 | 66 |
| 070144 | M5C | 16 | 44.0 | 0.15 | 0.17 | 42 |
| Total | | 98 | 27.7 | 0.11 | 0.17 | 250 |

Table 52. Vital statistics for steelhead that returned to the east-bank fish ladder, Three-Mile Falls Dam, Umatilla River, 1995-96.

| Origin[a] | Male | % | Female | % | Unknown | % | Total | % |
|---|---|---|---|---|---|---|---|---|
| Hatchery | 338 | 43.1 | 447 | 56.9 | 0 | 0.0 | 785 | 37.7 |
| Wild | 374 | 28.9 | 922 | 71.1 | 0 | 0.0 | 1296 | 62.3 |
| Total | 712 | 34.2 | 1369 | 65.8 | 0 | 0.0 | 2081 | 100.0 |

[a] *Origin determined by presence or absence of adiposejin. Thirteen hatchery fish were strays from coded-wire tags.*

Table 53. Vital statistics of wild and hatchery origin summer steelhead that returned to the Umatilla River, run year 1995-1996. Data of hatchery origin fish was determined from coded wire tag recovery. Wild fish were collected for broodstock, sex was determined visually, age and length data from P. Kissner, CTUIR (personal communication).

| Brood year | Age | Number | Sex | Fork length (mm) mean | min | max |
|---|---|---|---|---|---|---|
| | | | **Wild** | | | |
| 1990 | 3.2 | 1 | female | 680 | | |
| 1991 | 3.1 | 6 | male | 626 | 565 | 670 |
| | 2.2 | 1 | male | 790 | | |
| | 3.1 | 1 | female | 665 | | |
| | 2.2 | 7 | female | 727 | 629 | 799 |
| 1992 | 2.1 | 12 | male | 609 | 540 | 660 |
| | 2.1 | 16 | female | 611 | 562 | 670 |
| | | | **Hatchery** | | | |
| 1991 | 1.3 | 1 | female | 730 | | |
| 1992 | 1.2 | 4 | male | 739 | 690 | 765 |
| | 1.2 | 35 | female | 720 | 620 | 789 |
| 1993 | 1.1 | 22 | male | 600 | 510 | 653 |
| | 1.1 | 17 | female | 600 | 558 | 680 |

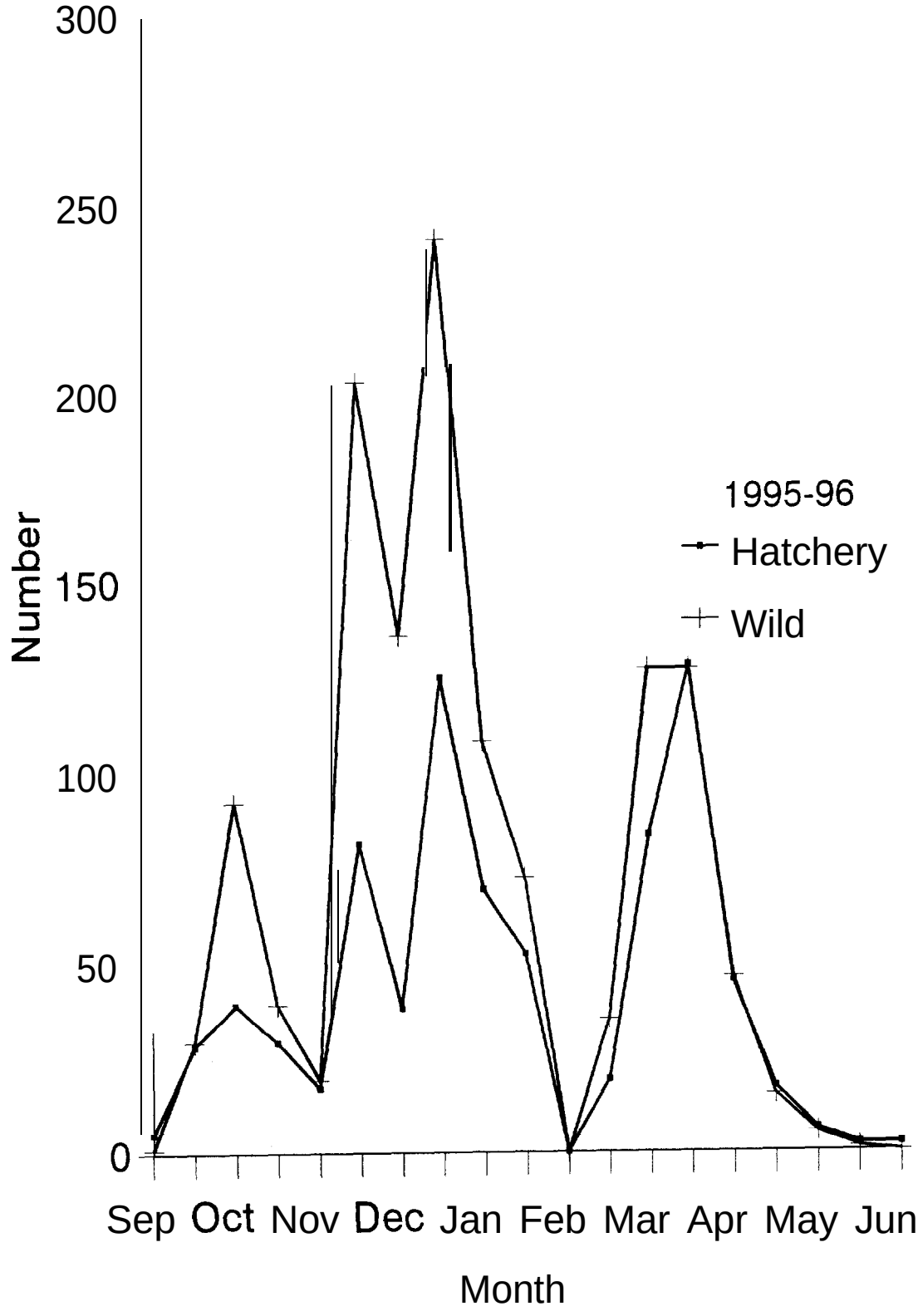


Figure 6. Numbers of wild and hatchery steelhead counted at the east-bank fish ladder, Three Mile Falls Dam, Umatilla River, 1995-96.

Table 54. Estimated catch statistics for wild and hatchery steelhead in the Umatilla River in 199596. Lower river = Mouth of the Umatilla River to Three Mile Falls Dam. Upper River = Stanfield Dam to the lower boundary of the Confederated Tribes of the Umatilla Indian Reservation boundary. Number caught and number harvested includes ± 95% confidence interval.

| Month<br>Day type | Number sampled<br>days | <br>anglers | Hours<br>fished | Number<br>caught | Number<br>harvested | Catch<br>rate<br>(fish/h) |
|---|---|---|---|---|---|---|
| | | | **Lower River** | | | |
| September | | | | | | |
| Weekday | 7 | 22 | 257 | 13±22 | 6±12 | **0.049** |
| Weekend | 10 | 85 | 309 | 2±1 | 2+1 | 0.007 |
| Total | 17 | 107 | 566 | 15±22 | 8±12 | 0.026 |
| October | | | | | | |
| Weekday | 13 | 67 | 342 | 32+22 | 2± 5 | **0.093** |
| Weekend | 10 | 176 | 581 | 6±14 | 5±11 | 0.010 |
| Total | 23 | 243 | 923 | 38±26 | 7±12 | 0.041 |
| November | | | | | | |
| Weekday | 11 | 55 | 258 | 22±24 | 5± 9 | 0.085 |
| Weekend | 10 | 112 | 459 | 17±28 | 10±16 | 0.036 |
| Total | 21 | 167 | 717 | 39±37 | 15±18 | 0.054 |
| December | | | | | | |
| Weekday | 7 | 14 | 67 | 0± 0 | 0±0 | **0.000** |
| Weekend | 4 | 9 | 36 | 19±15 | 5±7 | 0.521 |
| Total | 11 | 23 | 103 | 19±15 | 5±7 | 0.183 |
| January | | | | | | |
| Weekday | 6 | 2 | 12 | 0± 0 | 0±0 | **0.000** |
| Weekend | 4 | 5 | 16 | 0± 0 | 0±0 | **0.000** |
| Total | 10 | 7 | 28 | 0± 0 | 0±0 | **0.000** |
| February | | | | | | |
| Weekday | 1 | 0 | 0 | 0± 0 | 0±0 | **0.000** |
| Weekend | 0 | 0 | 0 | 0± 0 | 0±0 | **0.000** |
| Total | 1 | 0 | 0 | 0± 0 | 0±0 | **0.000** |
| March | | | | | | |
| Weekday | 2 | 2 | 45 | 0± 0 | 0±0 | **0.000** |
| Weekend | 1 | 0 | 0 | 0± 0 | 0±0 | **0.000** |
| Total | 3 | 2 | 45 | Of 0 | 0±0 | **0.000** |
| April | | | | | | |
| Weekday | 2 | 2 | 22 | 0± 0 | 0±0 | **0.000** |
| Weekend | 0 | 0 | 0 | 0± 0 | 0±0 | **0.000** |
| Total | 2 | 2 | 22 | 0± 0 | 0±0 | **0.000** |
| Total | 88 | 551 | 2404 | 111±52 | 35±26 | 0.046 |

Table 54 (continued).

| Month<br>Day type | Number sampled<br>days | <br>anglers | Hours<br>fished | Number<br>caught | Number<br>harvested | Catch<br>rate<br>(fish/h) |
|---|---|---|---|---|---|---|
| | | | **Upper River** | | | |
| December | | | | | | |
| Weekday | 4 | 20 | 210 | 0±0 | 0±0 | **0.000** |
| Weekend | 4 | 21 | 130 | 0±0 | 0±0 | **0.000** |
| Total | 8 | 41 | 340 | 0±0 | 0±0 | **0.000** |
| January | | | | | | |
| Weekday | 6 | 26 | 252 | 32±60 | 0±0 | **0.000** |
| Weekend | 5 | 79 | 453 | 17±18 | 0±0 | **0.000** |
| Total | 11 | 105 | 705 | 49±63 | 0±0 | **0.000** |
| February | | | | | | |
| Weekday | **0** | **0** | **0** | 0± **0** | 0± 0 | **0.000** |
| Weekend | 6 | **0** | **0** | 0± **0** | 0± 0 | **0.000** |
| Total | 6 | **0** | **0** | 0± **0** | 0± 0 | **0.000** |
| March | | | | | | |
| Weekday | 5 | 25 | 381 | 39±62 | 17±31 | 0.103 |
| Weekend | 10 | 95 | 328 | 19± 9 | 6± 6 | 0.058 |
| Total | 15 | 120 | 709 | 58±63 | 23±32 | 0.082 |
| April | | | | | | |
| Weekday | 3 | 20 | 247 | 7±12 | 0± 0 | 0.027 |
| Weekend | 4 | 43 | 155 | 7± 3 | 2± 3 | 0.045 |
| Total | 7 | 63 | 402 | 14±12 | 2± 3 | 0.034 |
| Total | 47 | 329 | 2156 | 121 L-90 | 25±32 | 0.056 |

## DISCUSSION

### Fall Chinook Salmon

#### Subyearlings

Subyearling fall chinook salmon continue to be produced more efficiently in MI raceways than in OR raceways. In 1996 the number of fish produced per gpm was approximately three times greater in MI raceways than in OR raceways. Although fish culture studies continue to indicate differences in the rearing performance of subyearlings reared in MI and OR raceways, these differences have not been consistent and may not substantially affect adult survival. Fish reared in OR raceways in 1996 were significantly longer and heavier than MI reared fish. In addition, the proportion of fish that were descaled continued to be slightly greater for fish reared in MI raceways.

Although the percent of branded fish recovered at John Day Dam was significantly greater for OR fish in 1996, percent recovery was usually greater for MI fish in prior years. Few differences have been observed among fish reared in first, second, or third pass MI raceways during five study years. Percent recovery for all groups at John Day Dam was lower in 1996 than in 1995. These values may reflect actual declines in survival or simply reduced collection efficiency at the dam because of greater Columbia River flow. Brand recoveries suggest that Columbia River flow affects downstream travel time. In 1995 and 1996 travel time to John Day Dam was 10-20 days compared to 20-40 days for fish released from 1992-1994. Average Columbia River flow during June at John Day Dam was 280 kcfs in 1995 and 395 kcfs in 1996. In comparison, flows ranged from 187-227 kcfs from 1992-1994 (US Army Corps of Engineers 1992- 1995).

Data is incomplete, but preliminary returns indicate that total survival for the 1991 brood will be below the goal of 0.3% (CTUIR 1990) or the maximum historic rate of 0.9% (Rowan 1996). However, data from fish returning to TMFD in 1995 shows' fish released as subyearlings contribute to the fishery. In 1995 nearly all CWT recoveries of jacks and adults were from subyearlings reared at Umatilla Hatchery (1991 and 1992 brood years) and Irrigon Hatchery (1990 brood year).

The study to evaluate the effects of marks and body tags on fall chinook salmon is incomplete. The experimental design for the 1990 brood year was different than for succeeding broods. Preliminary data from the 1990 brood suggests little difference between fish marked with a body tag compared to fish marked with an adipose fin clip and a coded-wire tag. It appears that poor survival and small sample sizes will prevent analysis of the 1991 brood. Data from the 1992 brood should be complete by 1997.

#### Yearlings

Yearling fall chinook salmon were reared at UH for the first time in 1995-96. Umatilla yearlings were more descaled (28%) compared to yearlings reared at BH (8%), and required disease treatment (see Report B, this volume) and the removal of the baffles to complete the rearing cycle. An additional concern was the weight of yearlings at UH (87g) which exceeded the rearing goal (57g). The rearing profile showed that the average weight of fish reared at BH and UH was similar through

December. After December, growth for fish reared at UH was substantially greater than at BH because of higher water temperatures (54" F compared to 39-45" F at BH). Yearlings released at large sizes may residualize in Columbia River pools and fail to migrate to the ocean, thereby reducing the potential for adult returns. In 1995 subjacks comprised 28% of the fall chinook salmon that returned to the Umatilla River. Coded-wire tag data from fish that returned to the Umatilla River in 1995 showed that all fish identified as subjacks ( < 381 mm FL) originated from yearling releases. Delaying incubation and hatching or reducing growth rates to reduce the final size at release should be considered.

No adults have been recovered from 1990 brood yearlings reared at BH and released in March 1992. This was similar to the fate of 1991 brood subyearlings released in May 1992 and suggests poor post-migration conditions as a cause of reduced survival rather than hatchery rearing factors. Poor survival of the 1991 brood yearlings may also be related to a BKD epizootic in February 1993 (Groberg et al. 1996a).

**Fishery**

Total fishing effort for fall chinook and coho salmon in 1995 (2201 h) was similar to previous years (1666-2210 h). Catch rates (0.055 and 0.025 fish/h) for chinook and coho salmon were lower compared to past years (mean 0.061 and 0.038 fish/h). Harvest estimates below TMFD represented 9 % and 5 % of the total 1995 adult fall chinook and coho salmon runs. Catch estimates from the 1995 punch cards (x fish) mimic catch estimates (33 + 19 and 30+ 16 fish) from creel survey data. This is similar to previous comparisons of punch card data to creel survey data. During the Columbia River creel survey between Umatilla Hatchery outlet and McNary Dam boat ramp, we sampled 54 coded wire tagged fish, but no fall chinook or coho salmon were Umatilla origin.

**Straying**

Fall chinook salmon continue to stray into the Snake River system. The number of Umatilla origin fish estimated to escape past LGD in 1995 was greater than in previous years. However, 78% of the strays originated from the 1990 brood year. Estimates for this group were based on a small number
of recoveries and high expansion rates. Reliability of these expansions is unknown. The removal of 20 fish at LGD suggests that marking fish with blank-wire tags is a valid method to reduce escapement.

## Spring Chinook Salmon

### Subyearlings

The smolt-to-adult survival goal of 0.2 % (CTUIR and ODFW 1990) for subyearlings will not be attained. Poor survival of subyearlings may be partially explained by the failure to reach the size-at-release goals of 15 fish/lb (Keefe et al. 1993, 1994 and Hayes et al. 1995, 1996). Since no tagged adults have been recovered, the subyearling release strategy has been curtailed at UH. Reductions in available water and eggs will further limit investigations of the subyearling release strategy.

### Fall Release

For the 1991 brood, only adults from fish reared at BH have been recovered at TMFD. No adults have been recovered from fish reared at UH and it is unlikely that the smolt-to-adult survival goal of 0.4 % (CTUIR and ODFW 1990) will be attained for either group. Possible causes for differential survival between fish reared at BH and UH include rearing profiles, fish health, and size at release. Rearing temperatures at UH ranged from 52-62°F (Hayes et al. 1995) compared to a range of 49-56°F at BH (L. Jensen, ODFW personal communication). According to Brett et al. (1969) chinook salmon fry prefer 53°F and have an upper lethal temperature of 77°F. High rearing temperatures at UH may produce a rearing profile that influences diseases tolerance or causes poor performance through growth development or smoltification. Spring chinook salmon from the 1991 brood at UH were also smaller at release (19 fish/lb) than BH fish (10 to 13 fish/lb). These fish were released into the Umatilla River at the same time suggesting greater size may increase adult survival.

Only one jack has been recovered from 1992 brood reared at UH. Poor survival of this group may also be related to size at release (20 fish/lb). Additional information on fish health and size at release will be acquired as adults from the 1993 brood return. Fish from the 1993 brood at UH experienced bacterial kidney disease (BKD), especially in the MI raceways (Groberg et al. 1996b). However, size-at-release averaged 9 fish/lb and adult survival may improve for this group.

### Yearlings

Data from 1995-96 indicates significantly greater performance for yearlings reared in OR raceways than those reared in MI raceways. We found that smolts reared in OR raceways were significantly larger and suffered less descaling than MI reared fish. In addition, recovery of branded fish at John Day Dam in 1996 was significantly greater for OR reared fish (9.7%) than for MI reared fish (7.6 %). In comparison, brand recoveries averaged 13.9 % in 1995 (Hayes et al. 1995) and were not significantly different between rearing systems.

Preliminary data indicates smolt-to-adult survival of yearlings from BH is greater than the survival of UH yearlings. As discussed previously, survival differences between fish reared at BH and UH may be caused by different rearing profiles. Higher rearing temperatures at UH may increase stress and promote BKD. Bacterial kidney disease infection of the 1991-1993 broods at UH and subsequent treatment with erythromycin may have delayed mortality until fish are downstream of the John Day and Bonneville dams. In contrast to chinook salmon released in the fall, yearlings from UH

were heavier (8-9 fish/lb) than BH yearlings (11-15 fish/lb). Data for all comparisons is incomplete and additional information is required to determine if the smolt-to-adult survival goal of 0.75 % (CTUIR and ODFW 1990) can be attained.

The number of jack and adult spring chinook salmon returning to the Umatilla River in 1996 was the greatest on record. Preliminary regression analyses using jack to adult relationships suggests a run of more than 2,000 adults in 1997.

Sport fishing for spring chinook salmon was legal in 1996. This was first time the fishery was opened since 1993. In contrast to the 1993 fishery, angler effort was concentrated in the lower river rather than in the upper river as anglers targeted several productive locations. Anglers effort was greater in the upper reach in 1993 because more fish were hauled to that area from TMFD. In 1996 most fish were hauled and released below Pendleton and few fish were hauled upstream. Total angler effort was twice as great in 1996 (2900 h) as in 1993 (1528 h) and the catch rate was also greater (0.07 fish/h) than in 1993 (0.02 fish/h). Some anglers complained about crowding in the lower reach; therefore, expansion of the fishing area should be considered for future years. The estimated harvest of 206 fish represented 9% of the adult run. Punch card data was not available for comparisons with creel survey data.

**Steelhead**

Fish culture and smolt condition for steelhead were similar to previous years with few differences among passes. Juvenile steelhead from the first pass raceway (1995 brood) suffered greater partial descaling (70 %) compared to previous broods (mean 3 1%). These fish were acclimated and released at the Thornhollow facility because of flood damage to the Bonifer Springs facility. Flooding took place while fish from the third pass raceway were being acclimated at Bonifer Springs, consequently, most fish from that group escaped and we were not able to sample smolt condition at release.

Fin erosion of steelhead was similar to previous years with most fish suffering moderate to severe erosion of the dorsal fin (Keefe et al. 1993 and 1994, Hayes et al. 1995 and 1996). Similar results were obtained with visual estimates of fin erosion compared to quantitative methods. We recommend using quantitative measurements to provide a more objective evaluation. With this method we can improve the evaluations and reduce stress to fish by decreasing sample sizes.

Data from recovery of branded steelhead was inconclusive. Only-one brand was recovered at John Day Dam in 1996. Collection efficiency at Columbia River dams may be partially affected by river flows and the amount of spill. Mean Columbia River flows during May and June at John Day Dam were 261 and 281 kcfs in 1995 and 353 and 399 kcfs in 1996 (U.S. Army Corps of Engineers 1992, 1993, 1994, 1995, and 1996). Mean spills for May and June of 1995 and 1996 ranged from 9.5-94.9 kcfs and from 0.3-65 kcfs for 1992, 1993, and 1994. Unexpanded brand recoveries ranged from zero to six for 1995 and 1996. In comparison, average flows during May and June of 1992-1994 ranged from 180-300 kcfs and unexpanded brand recoveries ranged from 22-67. Because few brands were recovered at John Day Dam in 1995 and 1996, we recommend eliminating branding except for in-basin studies.

The return of 2,081 adult steelhead in 1995-96 was similar to the 15 year average of 2,076. Numbers of returning hatchery fish (785) were the greatest on record and the run timing of hatchery fish continued to emulate wild fish. The percentage of hatchery and wild steelhead for 1995-96 was 38 % and 62 % compared to a mean of 27 % and 73 % for the previous six years. However, present trend data (1989-96) does not suggest a relationship between adult returns of hatchery and wild steelhead. Although the male to female ratio of hatchery steelhead approximated 1: 1 (44% versus 56%), the wild ratio was almost 1:2 (30% versus 70%). Low numbers of wild males may lead to increased use of hatchery males for broodstock. Twenty-two hatchery steelhead from the 1995 brood were spawned (Rowan 1996) and we estimated that three of these fish were strays. Currently, acceptable rates of straying are 5 % .

Most adult hatchery steelhead that returned to TMFD in 1995-96 were age 2 + and 3 + (98 %) compared to 98% age 3 + and 4 + for wild adult steelhead (C. Contor, CTUIR, personal communication). Age difference of returning adults was associated with the length of freshwater residency for juvenile fish. Growth rates of hatchery steelhead are accelerated and they reach smolt size and begin their migration to the ocean immediately as yearlings (Knapp et al. 1996). Therefore, hatchery juveniles spend one year in freshwater compared with two or three years in freshwater for most wild juvenile steelhead (Contor et al. 1995). Although the rearing time in freshwater is different, the life history of hatchery and wild fish in the ocean appears to be similar. Both groups spend one or two years rearing in saltwater and the mean fork length of one ocean or two ocean adults of hatchery or wild origin was similar.

Smolt-to-adult survival of 1991 brood steelhead reared at UH ranged from 0.0-0.3 % , well below the goal of 2.7% (ODFW and CTUIR 1990). Preliminary CWT data for 1992 and 1993 broods suggests greater adult survival rates (up to 0.78%) compared to the 1991 brood. There continues to be uncertainty about poor survival for fish reared in the first pass raceway. These fish are graded for a small size, but when released in May, mean length and length frequency distributions are similar to groups released in April. They begin their migration immediately after release (S. Knapp, ODFW personal communication) and pass John Day Dam at approximately the same time as groups released in April (Keefe et al. 1993 and Hayes et al. 1994). In-basin survival studies may help to identify if mortality occurs within the Umatilla River.

Total fishing effort in 1995-96 was low (608 h/month) compared to previous years (823-1323 h/month). However, catch rates for 1995-96 (0.05 fish/h) were greater than previous years (0.02-0.04 fish/h). Harvest estimates below TMFD represented 2% of the 1995-96 adult steelhead run. Catch estimates from punch cards in fall 1995 (76 fish) mimic catch estimates (111 +or- 52 fish) from fall creel survey data. This is similar to previous years comparisons of punch card data to creel survey data. Data from 1996 punch card estimates were not available.

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Appendix Table 1. Release information for salmon and steelhead reared at Umatilla and Bonneville hatcheries and released into the Umatilla River in 1996 (Acclimation facilities: BS =Bonifer Springs; IM = Imeques-c-mem-ini-kern; MI= Minthorn; TH = Thornhollow).

| Race-species, release strategy, system | Brood year | Date released | Number released | Mean fork length (mm) | Mean weight (g) | Acclimation days | Release location |
|---|---|---|---|---|---|---|---|
| **Umatilla Hatchery** | | | | | | | |
| Fall chinook salmon | | | | | | | |
| Subyearlings | 1995 | | | | | | |
| Michigan | | 30-31 May 1996 | 2,057,906 | 85.2 | 6.8 | 14 | TH/IM |
| Oregon | | 30 May 1996 | 902,507 | 90.0 | 7.6 | 14 | IM |
| Total | | | 2,960,413 | | | | |
| Year1 ings | 1994 | 18 Apr 1996 | 143,087 | 198.0 | 89.1 | 29 | IM |
| Spring chinook salmon | | | | | | | |
| Yearlings | 1994 | | | | | | |
| Michigan | | 13 Mar 1996 | 144,040 | 160.9 | 46.4 | 21 | IM |
| Oregon | | 13 Mar 1996 | 234,521 | 167.7 | 53.0 | 22 | IM |
| Total | | | 378,561 | | | | |
| Summer steelhead | 1995 | | | | | | |
| Michigan[a] | | 24-26 Apr 1996 | 49,377 | 196.5 | 85.4 | 42 | BS |
| Michigan | | 12 Apr 1996 | 47,543 | 206.8 | 89.9 | 29 | MI |
| Michigan | | 9 May 1996 | 49.783 | 207.9 | 87.3 | 22 | TH |
| Total | | | 146.703 | | | | |
| **Bonneville Hatchery** | | | | | | | |
| Fall chinook salmon | | | | | | | |
| Yearlings | 1994 | | | | | | |
| Oregon | | 5 Apr 1996 | 204,022 | 177.5 | 64.5 | 43 | TH |
| Oregon | | 18 Apr 1996 | 217,294 | 181.1 | 64.7 | 28 | IM |
| Total | | | 451,316 | | | | |

[a] *Fish escaped from Bonifer Springs during acclimation and could not be sampled at release. Mean length and weight data is from pre-release.*

Appendix Table 2. Release data for subyearling fall chinook salmon reared at Umatilla Hatchery and released in the Umatilla River (RM = river mile, TH = Thornhollow acclimation facility, RM 73.5; IC = Imeques-C-mem-ini-kem acclimation facility, RM 80).

| Brood year, CWT code | Release date | Race-way | Number released[a] | Number CWT | Number branded | Fish per pound | Release location |
|---|---|---|---|---|---|---|---|
| 1991 | | | | | | | |
| 071433 | 05 1892 | M2A | 305,878 | 29,066 | 7,445 | 61.0 | 42.5 |
| 07 1434 | 05 1892 | M3A | 306,802 | 3 1,224 | 6,917 | 65.7 | 42.5 |
| 071435 | 05 1892 | M2B | 297,331 | 30,326 | 9,643 | 60.9 | 42.5 |
| 071436 | 051892 | M3B | 302,555 | 30,365 | 7,049 | 61.9 | 42.5 |
| 071437 | 051892 | M2C | 223,830 | 30,508 | 7,526 | 55.2 | 42.5 |
| 071438 | 05 1892 | M3C | 301.831 | 30.924 | 7,656 | 64.5 | 42.5 |
| subtotal | | | 1,738,227 | 182,413 | 46,236 | 61.8 | |
| 071430 | 051992 | 02A | 28 1,350 | 32,287 | 9,174 | 65.1 | 42.5 |
| 071429 | 052092 | 03A | 286,578 | 31,892 | 6,272 | 70.6 | 42.5 |
| 071432 | 051992 | 02B | 191,257 | 29,425 | 8,558 | 58.3 | 42.5 |
| 071431 | 051992 | 03B | 182.93 1 | 28.95 1 | 8,863 | 56.2 | 42.5 |
| subtotal | | | 942,116 | 122,555 | 32,867 | 63.7 | |
| Total | | | 2,680,343 | 304.968 | 79,103 | 62.5 | |
| 1992 | | | | | | | |
| 076330 | 052493 | M2A | 292,895 | 28,964 | 10,027 | 63.0 | 73.5 |
| 07633 1 | 052493 | M3A | 282,125 | 29,537 | 10,053 | 67.0 | 73.5 |
| 070127 | 052493 | M2B | 269,336 | 27,063 | 10,150 | 63.4 | 73.5 |
| 076333 | 052493 | M3B | 273,662 | 29,718 | 10,020 | 60.3 | 73.5 |
| 076334 | 052493 | M2C | 282,175 | 29,958 | 9,434 | 68.0 | 73.5 |
| 076332 | 052493 | M3C | 277.93 1 | 29.451 | 9.894 | 61.5 | 73.5 |
| subtotal | | | 1,678,124 | 174,691 | 59,578 | 63.9 | |
| 070126 | 052593 | 02A | 268,001 | 29,594 | 10.458 | 59.3 | 73.5 |
| 070125 | 052593 | 03A | 272,496 | 29,360 | 9,828 | 59.4 | 73.5 |
| 076329 | 052593 | 02B | 203,731 | 30,706 | 10,278 | 59.4 | 73.5 |
| 076335 | 052593 | 03B | 207.565 | 30.462 | 10.547 | 59.4 | 73.5 |
| subtotal | | | 95 1,793 | 120,820 | 41,173 | 59.4 | |
| Total | | | 2,629,917 | 295,511 | 101,361 | 62.3 | |
| 1993 | | | | | | | |
| 070663 | 52394 | M2A | 322,867 | 31,162 | 10,171 | 63.0 | 73.5 |
| 070719 | 52394 | M3A | 327,700 | 3 1,658 | 9,725 | 72.4 | 73.5 |
| 070720 | 52394 | M2B | 314,518 | 30,528 | 10,008 | 65.4 | 73.5 |
| 070723 | 52394 | M3B | 326,408 | 30,447 | 10,217 | 68.2 | 73.5 |
| 070722 | 52394 | M2C | 303,843 | 30,950 | 9,769 | 68.0 | 73.5 |
| 07072 1 | 52394 | M3C | 306.105 | 28,474 | 9.373 | 68.7 | 73.5 |
| subtotal | | | 1,901,441 | 183,219 | 59.263 | 65.5 | |

[a] *All fish were RV fin clipped und all coded-wire tagged fish were adipose fin clipped. Beginning with the 1993 brood, all non coded-wire tagged fish were tagged with blank-wire.*

Appendix Table 2 (continued)

| Brood year CWT code | Release date | Race-way | Number released | Number CWT | Number branded | Fish per pound | Release location (RM) |
|---|---|---|---|---|---|---|---|
| 1993 | | | | | | | |
| 070662 | 52494 | 02A | 280,046 | 31,239 | 10,158 | 60.1 | 73.5 |
| 0707 18 | 52494 | 03A | 279,965 | 3 1.040 | 10,220 | 64.2 | 73.5 |
| 070716 | 52494 | 02B | 191,321 | 30,502 | 10,906 | 59.1 | 73.5 |
| 070717 | 52494 | 03B | 190,439 | 32,481 | 10.260 | 60.0 | 73.5 |
| subtotal | | | 941.771 | 125,262 | 41,544 | 61.1 | |
| Total | | | 2,843,212 | 308,481 | 103,331 | 65.4 | |
| 1994 | | | | | | | |
| 071019 | 53195 | M2A | 286,459 | 29,353 | 10,665 | 63.5 | IC |
| 071017 | 53195 | M3A | 271,129 | 29,736 | 10,172 | 68.0 | IC |
| 071022 | 53195 | M2B | 280,406 | 28,472 | 10,323 | 64.4 | IC |
| 071020 | 53195 | M3B | 275,613 | 29,460 | 10,183 | 67.8 | IC |
| 071025 | 53195 | M2C | 274,110 | 29,784 | 10,176 | 66.5 | TH |
| 07 1023 | 53195 | M3C | 287,313 | 28,623 | 10,249 | 59.8 | TH |
| subtotal | | | 1,675,030 | 175,428 | 61,768 | 64.9 | |
| 071018 | 53195 | 01A | 245,883 | 30,192 | 10,378 | 57.0 | IC |
| 071024 | 53195 | O1B | 151,943 | 30,204 | 10,248 | 63.6 | IC |
| 071021 | 53195 | 03B | 152,098 | 29,327 | 11,104 | 57.5 | IC |
| subtotal | | | 791,268 | 118,769 | 42,167 | 60.9 | |
| Total | | | 2,466,298 | 294,197 | 103,946 | 63.6 | |
| 1995 | | | | | | | |
| 071320 | 053096 | M2A | 303,803 | 30,015 | 10,557 | 69.5 | IC |
| 071321 | 053096 | M3A | 299,233 | 28,997 | 9,407 | 68.4 | IC |
| 071323 | 053096 | M2B | 300,377 | 29,914 | 9,965 | 62.8 | IC |
| 071325 | 053096 | M3B | 300,895 | 30,220 | 10,389 | 67.4 | IC |
| 071157 | 053196 | M2C | 393,339 | 29,852 | 10,316 | 72.8 | TH |
| 071327 | 053196 | M3C | 460.259 | 28.476 | 10.378 | 69.5 | TH |
| | 053196 | M4C | 251,582 | | | 66.3 | TH |
| subtotal | | | 2,309,488 | 177,474 | 61,012 | 68.3 | |
| 071322 | 053096 | 02A | 266,913 | 29,646 | 10,252 | 57.2 | IC |
| 071324 | 053096 | 03A | 272,594 | 30,243 | 10,420 | 66.4 | IC |
| 071326 | 053096 | 02B | 181,291 | 30,238 | 10,237 | 56.5 | IC |
| 071328 | 053096 | 03B | 181.709 | 30,455 | 9,980 | 60.3 | IC |
| subtotal | | | 902,507 | 120,582 | 40,889 | 60.5 | |
| Total | | | 2,960,413 | 298,056 | 101,901 | 66.1 | |

Appendix Table 3. Release data for yearling fall chinook salmon reared at Bonneville and Umatilla Hatcheries and released in the Umatilla River (RM= river mile, TH=Thornhollow acclimation facility, RM 73.5).

| Brood year, CWT code | Release date | Race-way | Number released[a] | Number CWT | Number branded | Fish per pound | Release location (RM) |
|---|---|---|---|---|---|---|---|
| **Bonneville Hatchery** | | | | | | | |
| 1990 | | | | | | | |
| 075619 | 031992 | A8 | 122,639 | 26,160 | | 7.5 | 56.0 |
| 075618 | 031792 | A9 | 97.801 | 26,178 | | 7.5 | 70.0 |
| Total | | | 220,440 | 52,338 | | 7.7 | |
| 1991 | | | | | | | |
| 071461 | 031893 | A5 | 66,345 | 23,239 | | 8.7 | 73.5 |
| 071460 | 031893 | A6 | 68,492 | 23,863 | | 9.1 | 73.5 |
| Total | | | 134,837 | 47,102 | | 8.9 | |
| 1992 | | | | | | | |
| 070252 | 041994 | A5 | 49,824 | 23,470 | | 8.5 | 73.5 |
| 070255 | 032394 | A6 | 233,629 | 23.699 | | 10.4 | 73.5 |
| Total | | | 283,453 | 47,169 | | 9.5 | |
| 1993 | | | | | | | |
| 070658 | 040795 | A2 | 111,817 | 24,865 | | 7.8 | TH |
| 070659 | 040795 | A5 | 115.271 | 24,374 | | 8.2 | TH |
| Total | | | 227,088 | 49,239 | | 8.0 | |
| 1994 | | | | | | | |
| 071037 | 040596 | A4 | 204,022 | 27,397 | 5,218 | 7.0 | TH |
| 071038 | 041896 | A3 | 217,294 | 28.521 | 5.111 | 7.0 | IM |
| Total | | | 421,316 | 55,918 | 10,329 | 7.0 | |
| **Umatilla Hatchery** | | | | | | | |
| 1994 | | | | | | | |
| 071039 | 041896 | M3A | 48,499 | 23,238 | 5,197 | 5.3 | IM |
| 071040 | 041896 | M3B | 47,463 | 23,442 | 5,449 | 4.7 | IM |
| 071041 | 041896 | M3C | 47.125 | 23.343 | 5.313 | 5.3 | IM |
| Total | | | 143,087 | 70,023 | 15,959 | 5.1 | |

[a] ***All fish were RV fin clipped and all coded-wire taggedjish were adipose fin clipped. Beginning with the 1992 brood, all non coded-wire taggedjish were tagged with blank-wire.***

Appendix Table 4. Release data for subyearling spring chinook salmon reared at Umatilla Hatchery and released in the Umatilla River (RM = river mile)

| Brood year, CWT code | Release date | Race-way | Number released | Number CWT | Number branded | Fish per pound | Release location (RM) |
|---|---|---|---|---|---|---|---|
| 1991 | | | | | | | |
| 071443 | 051392 | 04A | 97,013 | 50,611 | 8,392 | 32.1 | 80 |
| 071444 | 05 1292 | 04B | 63,585 | 48,051 | 8,384 | 31.2 | 80 |
| 071445 | 05 1292 | 05B | 63,305 | 49,498 | 6,572 | 32.2 | 80 |
| 071446 | 051392 | 05A | 95,456 | 50,045 | 8,195 | 32.1 | 80 |
| subtotal | | | 319,359 | 198,205 | 31,544 | 31.9 | |
| 071447 | 051292 | M6A | 104,670 | 50,047 | 9,877 | 36.4 | 80 |
| 071448 | 051292 | M7A | 104,929 | 5 1,707 | 9,903 | 36.3 | 80 |
| 071449 | 051192 | M6B | 109,528 | 51,518 | 10,442 | 38.3 | 80 |
| 071450 | 05 1292 | M7B | 109,997 | 51,271 | 9,816 | 37.8 | 80 |
| 071451 | 051192 | M6C | 98,617 | 52,128 | 10,148 | 39.2 | 80 |
| 071452 | 051192 | M7C | 108,652 | 51,659 | 9.609 | 36.8 | 80 |
| subtotal | | | 636,393 | 308,330 | 59,256 | 37.5 | |
| Total | | | 955,752 | 506,535 | 90,800 | 35.6 | |
| 1992 | | | | | | | |
| 076132 | 060193 | M6C | 113,852 | 52,893 | 10,033 | 28.4 | 80 |
| 076133 | 060193 | M7C | 116,316 | 52,335 | 10,372 | 27.7 | 80 |
| 076134 | 060193 | M7B | 111,333 | 51,963 | 10,139 | 27.9 | 80 |
| 076135 | 060193 | M6B | 109,473 | 51,680 | 9,961 | 28.2 | 80 |
| 076136 | 060293 | M6A | 105,290 | 52,588 | 9,127 | 28.6 | 80 |
| 076137 | 060293 | M7A | 111.103 | 52.172 | 9,137 | 26.9 | 80 |
| Total | | | 667,367 | 318,706 | 58,929 | 27.6 | |
| 993 | | | | | | | |
| 070734 | 052094 | M6A | 140,255 | 49,726 | 8,889 | 30.7 | 80 |
| 070735 | 052094 | M7A | 142,237 | 52,298 | 9,217 | 30.7 | 80 |
| 070736 | 052094 | M6B | 140,227 | 52,636 | 9,998 | 30.3 | 80 |
| 070737 | 052094 | M7B | 142,003 | 53,172 | 10,182 | 30.3 | 80 |
| 070738 | 052094 | M6C | 138,665 | 51,042 | 9,872 | 30.5 | 80 |
| 070739 | 052094 | M7C | 135.990 | 52.317 | 9,925 | 30.5 | 80 |
| Total | | | 839,377 | 311,191 | 58,083 | 30.4 | |

[a] *All fish from even numbered brood years were LV fin clipped andjish from odd numbered brood years were RV fin clipped. All coded-wire tagged fish were adipose fin clipped.*

Appendix Table 5. Release data for spring chinook salmon released in the fall. Fish were reared at Umatilla and Bonneville Hatcheries and released in the Umatilla River (IC - Imeoues-C-mem-ini-kern)

**Bonnveville Hatchery**

| Brood year, CWT code | Release date | Race-way | Number released | Number CWT | Number branded | Fish per pound | Release location (RM) |
|---|---|---|---|---|---|---|---|
| 1991 | | | | | | | |
| 076042 | 110592 | A11 | 25,104 | 25,104 | | 13.0 | 80 |
| 076043 | 110592 | A10/11 | 25,075 | 24,992 | | 13.0 | 80 |
| 076044 | 110492 | A10 | 15,730 | 15,423 | | 13.1 | 80 |
| 076045 | 110392 | A9 | 24,638 | 24,638 | | 9.9 | 80 |
| 076046 | 110392 | A8/9 | 24,715 | 24,221 | | 10.0 | 80 |
| 076047 | 110392 | A8 | 17.667 | 17,269 | | 10.1 | 80 |
| Total | | | 132,929 | 131,647 | | 11.5 | |

**Umatilla Hatchery**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1991 | | | | | | | |
| 071542 | 110592 | 03B | 50,736 | 26,135 | | 19.3 | 80 |
| 071543 | 110592 | 03A | 50,680 | 25,633 | | 19.5 | 80 |
| Total | | | 101,416 | 51,768 | | 19.4 | |
| 1992 | | | | | | | |
| 070155 | 111793 | 02A | 40,661 | 35,710 | | 18.5 | 80 |
| 070156 | 111793 | 03A | 42,734 | 33,999 | | 18.8 | 80 |
| 070157 | 111793 | 02B | 39,656 | 34,857 | | 18.0 | 80 |
| 070158 | 111793 | 03B | 41,244 | 34,130 | | 19.2 | 80 |
| subtotal | | | 164,295 | 138,696 | | 18.6 | |
| 070159 | 111693 | M2A | 49,694 | 34,541 | | 20.3 | 80 |
| 070160 | 111793 | M3A | 49,081 | 35,408 | | 20.9 | 80 |
| 070161 | 111793 | M2B | 52,211 | 35,657 | | 21.5 | 80 |
| 070162 | 111693 | M3B | 48,343 | 35,467 | | 20.2 | 80 |
| 070163 | 111793 | M3C | 49,318 | 36,157 | | 20.8 | 80 |
| 070216 | 111693 | M2C | 47.867 | 36,102 | | 20.8 | 80 |
| subtotal | | | 296,514 | 213,332 | | 20.8 | |
| Total | | | 460,809 | 352.028 | | 20.0 | |

[a] *All fish from even numbered brood years were LV fin clipped and fish from odd numbered brood years were RV fin clipped. All coded-wire tagged fish were adipose fin clipped.*

Appendix Table 5 (continued)

| Brood year, CWT code | Release date | Race-way | Number released | Fish Number CWT | Release Number branded | per pound | location (RM) |
|---|---|---|---|---|---|---|---|
| 1993 | | | | | | | |
| 070724 | 111594 | M2C | 39,548 | 34,124 | | 9.0 | IC |
| 070725 | 111594 | M3C | 39,517 | 34,827 | | 9.3 | IC |
| 070726 | 111594 | M2B | 39,551 | 35,156 | | 10.5 | IC |
| 070727 | 111594 | M3B | 39,487 | 34,819 | | 9.2 | IC |
| 070728 | 111594 | M2A | 38,234 | 34,808 | | 9.5 | IC |
| 070729 | 111594 | M3A | 40,383 | 35,160 | | 9.4 | IC |
| subtotal | | | 236,720 | 208,894 | | 9.6 | |
| 070730 | 111594 | 02A | 37,073 | 34,915 | | 7.2 | IC |
| 070731 | 111594 | O1A | 37,096 | 35,750 | | 7.8 | IC |
| 070732 | 111594 | 02B | 32,687 | 32,251 | | 7.4 | IC |
| 070733 | 111594 | O1B | 34.649 | 34,220 | | 9.6 | IC |
| subtotal | | | 141,505 | 137,136 | | 8.0 | |
| Total | | | 378,225 | 345,030 | | 9.0 | |

Appendix Table 6. Release data for yearling spring chinook salmon. Fish were reared at Umatilla and Bonneville hatcheries and released in the Umatilla River (IC - Imeques-C-mem-ini-kern)

| Brood year, CWT code | Release date | Race-way | Number released | Number CWT | Number branded | Fish per pound | Release location (RM) |
|---|---|---|---|---|---|---|---|
| | | | **Bonneville Hatchery** | | | | |
| 1991 | | | | | | | |
| 071455 | 032393 | B1 | 45,430 | 19,951 | | 14.8 | 80 |
| 071456 | 032293 | B2 | 46.112 | 20,022 | | 14.3 | 80 |
| Total | | | 91,542 | 39,973 | | 14.5 | |
| **992** | | | | | | | |
| 070250 | 032594 | B6 | 99,616 | 26,716 | | 11.7 | 80 |
| 07025 1 | 032594 | B5 | 101,830 | 26,305 | | 11.7 | 80 |
| 075944 | 032594 | B8 | 103,980 | 20,109 | 4,818 | 12.5 | 80 |
| 075945 | 032594 | B7 | 99,676 | 20,219 | 5.200 | 12.2 | 80 |
| Total | | | 405,102 | 93,349 | 10,018 | 12.0 | |
| 1993 | | | | | | | |
| 070649 | 042195 | B7 | 123,257 | 22,189 | 5,137 | 10.5 | 80 |
| 070650 | 042195 | B8 | 124,614 | 24,088 | 4,878 | 10.2 | 80 |
| 070660 | 031395 | B5 | 74,735 | 23,607 | | 13.9 | 80 |
| 07066 1 | 041495 | B6 | 74,921 | 28,765 | | 11.4 | 80 |
| Total | | | 397,527 | 98,649 | 10,015 | 11.2 | |
| | | | **Umatilla Hatchery** | | | | |
| 1991 | | | | | | | |
| 075739 | 032393 | 05B | 50,312 | 21,499 | 5,300 | 8.2 | 80 |
| 075740 | 032393 | 04B | 50,109 | 20,880 | 4,934 | 8.1 | 80 |
| 07574 1 | 032493 | 04A | 54,347 | 21,157 | 5,548 | 8.3 | 80 |
| 075742 | 032493 | 05A | 54.014 | 20,307 | 5,242 | 8.6 | 80 |
| Total | | | 208,782 | 83,843 | 21,085 | 8.3 | |
| 1992 | | | | | | | |
| 070217 | 032194 | 05A | 51,210 | 20,070 | 5,082 | 8.5 | 80 |
| 070218 | 032194 | 05B | 49,375 | 19,920 | 5,142 | 8.1 | 80 |
| 070219 | 032194 | 04B | 52,620 | 20,971 | 5,151 | 8.8 | 80 |
| 070220 | 032294 | 04A | 51,938 | 20.982 | 5,419 | 8.4 | 80 |
| Total | | | 205,143 | 81,053 | 20,797 | 8.5 | |

[a] *All fish from even numbered brood years were LV fin clipped and fish from odd numbered brood years were RV fin clipped. All coded-wire tagged fish were adipose fin clipped.*

Table 6 (continued)

| Brood year, CWT code | Release date | Race-way | Number released | Number CWT | Number branded | Fish per pound | Release location (RM) |
|---|---|---|---|---|---|---|---|
| 1993 | | | | | | | |
| 07 1453 | 031395 | M5A | 50,007 | 20,315 | 4,910 | 8.3 | 80 |
| 071454 | 031395 | M5B | 40,685 | 15,661 | 4,436 | 8.9 | 80 |
| subtotal | | | 90,692 | 35,876 | 10,015 | 7.8 | |
| 07065 1 | 03 1395 | 04A | 49,001 | 18,864 | 5,176 | 9.1 | 80 |
| 070652 | 03 1395 | 04B | 44,077 | 19,052 | 4,975 | 8.2 | 80 |
| 070653 | 031395 | 05B | 44,188 | 18,175 | 5,133 | 9.0 | 80 |
| 070654 | 031395 | 05A | 47,846 | 19,091 | 5,063 | 8.7 | 80 |
| subtotal | | | 185,112 | 75,182 | 20,347 | 8.0 | |
| Total | | | 275,804 | 111,058 | 29,673 | 7.9 | |
| 1994 | | | | | | | |
| 071027 | 031396 | M6A | 49,032 | 19,622 | 5,083 | 9.0 | IC |
| 071028 | 031396 | M6B | 45,887 | 18,844 | 4,682 | 10.8 | IC |
| 071029 | 031396 | M6C | 49,121 | 19,258 | 5,275 | 9.0 | IC |
| subtotal | | | 144,040 | 57,724 | 15,040 | 9.6 | |
| 071030 | 031396 | 04A | 60,599 | 19,961 | 4,531 | 7.5 | IC |
| 071031 | 031396 | 05A | 60,137 | 20,066 | 5,026 | 8.8 | IC |
| 071032 | 031396 | 05B | 57,076 | 19,874 | 5,092 | 8.7 | IC |
| 071033 | 031396 | 04B | 56,709 | 19,583 | 4,232 | 9.5 | IC |
| subtotal | | | 234,521 | 79,484 | 18,881 | 8.6 | |
| Total | | | 378,561 | 137,208 | 33,921 | 9.0 | |

Appendix Table 7. Release data for summer steelhead reared at Umatilla Hatchery and released in the Umatilla River (RM= river mile; acclimation facilities: BS - Bonifer Springs, RM=63.5; MC - Meacham Creek; MI - Minthorn, RM=68.5; TH - Thornhollow, RM=68.5)

| Brood year, CWT code | Release date | Race-way | Number released[a] | Number CWT | Number branded | Fish per pound | Release location (RM) |
|---|---|---|---|---|---|---|---|
| 1991 | | | | | | | |
| 075 840 | 050192 | M5A | 22,288 | 10,105 | | 5.5 | MC |
| 075838 | 050192 | M5A | 22,469 | 10,562 | | 5.5 | MC |
| 075839 | 050192 | M5A | 22,662 | 10,275 | | 5.0 | MC |
| 075841 | 043092 | M5B | 22,262 | 10,108 | | | MC |
| 075842 | 043092 | M5B | 21,365 | 9,498 | | 5:o | MC |
| 075843 | 043092 | M5B | 20,923 | 9,747 | | 5.0 | MC |
| 074127 | 032992 | M5C | 22,059 | 10,203 | | 5.8 | BS & MI |
| 073 862 | 032992 | M5C | 22,902 | 10,594 | | 5.8 | BS & MI |
| 073759 | 032992 | M5C | 22.474 | 10,394 | | 5.8 | BS & MI |
| Total | | | 199,404 | 91,486 | | 5.4 | |
| 1992 | | | | | | | |
| 076052 | 05 1393 | M5A | 65,465 | 13,117 | 9,055 | 6.1 | BS |
| 076053 | 05 1393 | M5A | | 11,410 | | | BS |
| | | | | | | 6.1 | BS |
| 076054 | 05 1893 | M5B | 47,979 | 10,031 | 9,641 | 5.6 | MI |
| 076056 | 041693 | M5B | | 9,418 | | | MI |
| | | | | | | 5.6 | MI |
| 076057 | 041893 | M5C | 44,824 | 10,694 | 8,863 | 4.5 | BS |
| 076059 | 041893 | M5C | | 9,792 | | 4.5 | BS |
| 076060 | 041893 | M5C | | 9.440 | | 4.5 | BS |
| Total | | | 158,268 | 92,952 | 27,559 | 5.5 | |
| 1993 | | | | | | | |
| 070139 | 051294 | M5A | 26,411 | 8,595 | 7,700 | 5.2 | BS |
| 070140 | 05 1294 | M5A | 25,686 | 8,400 | | 5.1 | BS |
| 070141 | 041494 | M5B | 24,692 | 9,952 | 7,827 | 5.1 | MI |
| 070142 | 041494 | M5B | 24,906 | 9,965 | | | MI |
| 070143 | 041194 | M5C | 26,481 | 10,470 | 7,718 | 4.9 | BS |
| 070144 | 041194 | M5C | 24,922 | 9.651 | | 4.9 | BS |
| Total | | | 153,098 | 57,033 | 23,346 | 5.1 | |
| -1994 | | | | | | | |
| 070655 | 051295 | M8A | 47,941 | 19,782 | 8,908 | 4.7 | BS |
| 070656 | 041395 | M8B | 49,983 | 18,812 | 8,134 | 5.6 | MI |
| 070657 | 041195 | M8C | 48.539 | 19.290 | 7.771 | | BS |
| Total | | | 146,463 | 57,884 | 24,813 | 5.3 | |
| 1995 | | | | | | 5.1 | |
| 071034 | 050996 | M8A | 49,783 | 20,633 | 8,896 | 5.1 | TH |
| 07 1035 | 041296 | M8B | 47,543 | 19,742 | 8,615 | | MI |
| 071036 | 042496 | M8C | 49.377 | 2 1.205 | 8.827 | 5.3 | BS |
| Total | | | 146,703 | 61,580 | 26,338 | | |

[a] *All fish were adipose clipped and all CWT fish were also left ventral fin clipped*

Appendix Table 8. Numbers of spring and fall chinook salmon, coho salmon, and steelhead counted at Three Mile Falls Dam, 1981 to present (chinook subjacks were < 381 mm FL; chinook jacks were 382-610 mm FL; coho jacks were 382-508 mm FL).

| | Spring chinook salmon | | | Fall chinook salmon | | | |
|---|---|---|---|---|---|---|---|
| Year | Jack | Adult | Total | Subjack | Jack | Adult | Total |
| 1985 | | | | | 6 | 79 | 85 |
| 1986 | | | | | 407 | 28 | 435 |
| 1987 | | | | | 348 | 125 | 473 |
| 1988 | | | 13 | | 1466 | 94 | 1,560 |
| 1989 | | | 164 | 76 | 247 | 279 | 602 |
| 1990 | 32 | 2,158 | 2,190 | 621 | 107 | 333 | 1,061 |
| 1991 | 39 | 1,291 | 1,330 | 274 | 468 | 522 | 1,264 |
| 1992 | 4 | 450 | 454 | 0 | 64 | 239 | 303 |
| 1993 | 16 | 1,205 | 1,221 | 15 | 27 | 370 | 412 |
| 1994 | 8 | 263 | 271 | 368 | 236 | 688 | 1,292 |
| 1995 | 108 | 388 | 496 | 338 | 288 | 603 | 1,229 |
| 1996 | 121 | 2,152 | 2,273 | | | | |
| Average | 47 | 1130 | 935 | 242 | 333 | 305 | 792 |

| | Steelhead | | | Coho Salmon | | | |
|---|---|---|---|---|---|---|---|
| Run year | Hatchery | Wild | Total | Year | Jack | Adult | Total |
| 1981-82 | | | 768 | 1982 | | | |
| **1982-83** | | | 1,264 | 1982 | | | |
| 1983-84 | | | 2,062 | 1983 | | | |
| 1984-85 | | | 3,346 | 1984 | | | |
| 1985-86 | | | 2,959 | 1985 | | | |
| 1986-87 | | | 3,124 | 1986 | | | |
| 1987-88 | | | 2,782 | 1987 | | | **29** |
| 1988-89 | | | 2,474 | 1988 | | | 1,683 |
| 1989-90 | 246 | 1,422 | 1,668 | 1989 | 521 | 4,102 | 4,623 |
| 1990-91 | 387 | 724 | 1,111 | 1990 | 174 | 410 | 922 |
| 1991-92 | 523 | 2,246 | 2,769 | 1991 | 187 | 1,733 | 1,920 |
| 1992-93 | 617 | 1,297 | 1,914 | 1992 | 184 | 355 | 529 |
| 1993-94 | 345 | 945 | 1,290 | 1993 | 18 | 1,531 | 1,549 |
| 1994-95 | 656 | 875 | 1,531 | 1994 | 62 | 984 | 1,046 |
| 1995-96 | 785 | 1,296 | 2,081 | 1995 | 53 | 946 | 999 |
| Average | 508 | 1257 | 2,076 | | 171 | 1,437 | 1478 |

**REPORT B**

Fish Health Monitoring and Evaluation

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## *FISH HEALTH MONITORING AND **EVALUATION***

### INTRODUCTION

Fish health investigations in the fifth year of study were consistent with the previous' four years. Additionally, through cooperative efforts with the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), samples for *Renibacterium salmoninarum* (Rs), the agent of bacterial kidney disease (BKD), were collected from marked Carson adult spring chinook salmon now beginning to return from juvenile releases under the Umatilla Hatchery program. Analyses of these samples for Rs antigen are an important final step in evaluating the effect that different rearing strategies might have on the prevalence and severity of Rs infection in spring chinook salmon juveniles reared under the Umatilla program.

Broodstock fish health sampling was done at facilities where eggs were taken and fertilized for Umatilla Hatchery. The 95 brood year fall chinook salmon production at Umatilla Hatchery was from adults spawned at Priest Rapids Hatchery. The 96 brood year spring chinook salmon production was from Carson adults spawned at Little White Salmon National Fish Hatchery, and as in previous years, the 96 brood year summer steelhead production was from Umatilla adults spawned at Minthorn Ponds.

For the third consecutive brood year BKD proved to be a major disease problem in the Carson spring chinook salmon, programmed as yearlings, during rearing at Umatilla Hatchery. Clinical BKD was also diagnosed in Priest Rapids 94 brood year fall chinook, programmed as yearlings, undergoing a low-grade chronic loss in February of 1996 following an earlier episode of bacterial cold water disease (CWD). The CWD outbreak had its onset in these fall chinook salmon juveniles in late August and early September of 1995 in Michigan raceways. After two ineffective treatments with oxytetracycline (OTC) and one with chloramine-T (CHT), a modification to the raceways was tried. This involved removal of the baffles, which partition these raceways into ten 3.05 m sections, under two different configurations. This, and an additional CHT treatment, finally brought this ongoing disease outbreak under control after considerable losses.

The four treatments for CWD in the fall chinook salmon juveniles and prophylactic Aquamycin treatments for BKD in spring chinook salmon juveniles were all conducted under the Investigational New Animal Drug (INAD) process. Formalin treatments on adult summer steelhead at Minthorn Ponds and adult fall chinook salmon at the new Three Mile Dam adult facility were also under INAD protocols. The INAD requirements produce not only considerable administrative responsibility but also some specific animal husbandry practices and diagnostic procedures for fish culture and fish health personnel while the INAD is in effect.

Preliberation examinations were conducted as scheduled on all stocks and species at Umatilla Hatchery, and also at the Thornhollow and Imeques C-mem-ini-kern acclimation facilities. These examinations were on 94 brood year fall chinook salmon smolts at Thornhollow and Imeques, and on 94 brood year spring chinook salmon smolts at Imeques.

Loss investigations were requested and done on 94 brood year fall chinook salmon juveniles in November 1995 at Umatilla Hatchery and in March 1996 at the Thornhollow acclimation ponds on smolts from Bonneville. The November episode was diagnosed as CWD and the March loss at Thornhollow had no specific etiology although CWD bacteria and erythrocytic inclusion body syndrome (EIBS) were implicated (an earlier preliberation examination at Bonneville had indicated a high prevalence of EIBS). Effects from these conditions which were exacerbated by transport appear

to have caused this minor episode. In November 1995 an increased loss investigation was conducted concurrent with the monthly monitoring on the juvenile 94 brood year spring chinook salmon in Michigan raceways at Umatilla Hatchery during which BKD was diagnosed.

In studies related to the Umatilla program, the polymerase chain reaction (PCR) was evaluated as state-of-the-art technology to confirm the identity of both ***R.*** *salmoninarum* and *Flexibacter* ***psychrophilus*** bacteria as etiological agents in BKD and CWD outbreaks, respectively, at Umatilla Hatchery. The PCR could prove to be a useful substitute for the rapid slide agglutination test for *F.* ***psychrophilus*** which requires the availability of a specific antiserum and requires subjective interpretation.

In a separate study, ***in vitro*** experiments were conducted investigating the survival of Rs in water from Umatilla Hatchery (Peacock et al. 1996). It was determined that Rs had long-term ($>60$ days) viability in the hatchery water. Therefore the potential for horizontal transmission within and between raceways of fish at Umatilla Hatchery would not be expected to be reduced because of poor survival of the bacterium in this water.

## METHODS

Antiserum specific for ***F. psychrophilus*** was once again available (courtesy of Dr. Richard A. Holt, ODFW Supervising Fish Pathologist) and used for confirmatory diagnosis of the CWD bacterium in most cases. Otherwise, methods previously described were used (Keefe et al. 1993, Keefe et al. 1994 and Groberg et al. 1996).

Fisheries personnel of the CTUIR collected kidney samples from adult and jack spring chinook salmon returning to the Three Mile Dam collection facility to determine Rs antigen levels in these by the ELISA. They were sampled either as killed-not-spawned jacks at the facility, or as adult carcasses in the Umatilla River following release for natural spawning. These are from populations that will be future broodstock for the Umatilla program. The samples were frozen at $-20^0$C until processed and analyzed by the ELISA.

### Juvenile Monthly Monitoring

One-way analysis of variance (ANOVA) (Triola 1992) was used for statistical analysis of cumulative percent monthly mortality from 94 brood year Carson spring chinook salmon yearlings in Oregon raceways O4A-B and O5A-B and Michigan raceways M6A-C. An ANOVA was also used to determine differences among Michigan raceway series M6A-C, and among Oregon raceways O4A-B and O5A-B. A t-test (Triola 1992) was used to compare Oregon raceways (O4A-B and O5A-B) to Michigan raceways (M6A-C) of this same stock.

### Juvenile Preliberation Monitoring

An ANOVA was used for statistical analysis of the log transformed ELISA values (Ott 1977) from 94 brood year Carson spring chinook salmon yearlings in three Michigan raceways (M6A-C). A t-test was used to compare Oregon O4A-B and O5A-B to Michigan series M6A-C of this same stock.

### Juvenile Disease Outbreak Monitoring

An ANOVA was used for statistical analysis of daily percent CWD mortality from September 1, 1995 to March 19, 1996 in 94 brood year fall chinook salmon yearlings in Michigan raceways M3A-C.

### Investigational New Animal Drug Monitoring

The four treatments for non-systemic CWD in the fall chinook salmon juveniles and prophylactic Aquamycin treatments for BKD in spring chinook salmon juveniles were all conducted under Investigational New Animal Drug (INAD) protocols. Formalin treatments on adult summer steelhead at Minthorn Ponds and adult fall chinook salmon at the new Three Mile Dam adult facility were also under INAD protocols.

### Broodstock Monitoring

Adult fall chinook salmon for the 95 brood year program at Umatilla were sampled at Priest Rapids on November 9, 13, 16, and 20, 1995. Adult spring chinook salmon for the 96 brood year production at Umatilla were sampled at Little White Salmon Hatchery. Brood year 96 adults were sampled on August 7, 14, 21, and 28, 1996. Adult summer steelhead for the 96 brood year program at Umatilla were sampled at Minthorn as they have been since the program started. Marked Carson adult spring chinook salmon returning to the Umatilla River were sampled throughout the summer of 1996.

## RESULTS

### Juvenile Monthly Monitoring

#### Necropsies

No parasites were detected in wet mounts of gill and body scrapings from a total of 300 moribund/fresh-dead and 180 grab-sampled fish of all species and stocks examined by microscopy. Gill aneurysms were occasionally observed in all species but they were particularly evident in moribund/fresh-dead 95 brood year steelhead juveniles on the same day (October 25, 1995) they were graded and transferred from an Oregon pond to Michigan ponds when 6/10 fish examined showed various degrees of such aneurysms.

Heavy loads of bacteria were observed in body scrapings of the 94 brood year fall chinook salmon juveniles, programmed as yearlings, during monthly monitoring on September 26, 1995. These fall chinook were in Michigan raceways and all of 13 moribund and 2/5 grab-sampled fish had high levels of bacteria in body scrapings. Mucus loss, de-scaling and opaque scales were also noted on several of these fish at that time. During monthly monitoring in late October heavy bacterial loads, including long filamentous bacteria typical of ***F. psychrophilus,*** were observed on 15/15 moribund and 2/5 grab-sampled of these fall chinook. At that time there was a diagnosed epizootic of CWD in these fish. In November, 10/10 moribund/fresh-dead fish had heavy bacterial loads in body scrapings and numerous muscle fibers were noted in body scrapings from grab-sampled fish. The outbreak of CWD was uncontrolled and ongoing at this time. In late December's monthly monitoring there were still heavy bacterial loads in body scrapings with the continued presence of ***F. psychrophilus*** type bacteria in these. Fifteen of 15 moribund and 1/5 grab-sampled fish had this type of bacterium. Extensive loss of mucus and scales in both moribund and grab-sampled fish continued to be a common pathological

feature. From October through mid-January many fish in affected raceways showed caudal-peduncle erosion, skin and muscle lesions, and severely eroded fins. Subsequently, there was widespread fungus on the caudal-peduncle region and the fish were in a generally poor condition (thin and long bodies). Monthly monitoring on February 27, 1996 revealed all 13 moribund/fresh-dead fish with various combinations of distended abdomens, opaque and exopthalmic eyes, ascities fluid, and kidney pustules. Four of these had kidney pustules and clinical levels of Rs antigen by ELISA (Appendix Table A-10). Body scrapings were negative for the heavy loads of bacteria seen earlier during the CWD outbreak which had now finally been brought under control. At no time during this epizootic were levels of bacteria seen on the gills that would be considered higher than normal by microscopy and gill condition was good with occasional slight hyperplasia and swelling of filaments noted.

None of 27 moribund/fresh-dead summer steelhead juveniles produced systemic ***F. psychrophilus*** bacteria from kidney smears on agar medium (Appendix Table A-5). Presumptive or confirmed systemic CWD bacteria were only identified from 9/118 kidneys of moribund/fresh-dead fall chinook salmon (Appendix Table A-6), programmed as yearlings, even though they suffered a prolonged epizootic of CWD from September 1995 through January 1996. *Flexibacter psychrophilus* was only isolated from 3/ 15 kidneys in November 1995, 4/15 in December 1995, and 2/15 in January 1996. Cultures from gills of many of these same fish (Table A-6) yielded four confirmed ***F. psychrophilus*** isolates and it is most likely that most of the other 27 fish yielding predominant yellow colony types harbored the same bacterium on their gills. One of nine fish in August had these bacteria on their gills, 2/15 in September, 1/15 in October, 9/15 in November, 7/15 in December, 7/14 in January, and 4/13 in February. This pattern of detection followed the profile of the CWD epizootic in these fall chinook salmon (Figure 2). Confirmed or presumptive systemic CWD bacteria were also isolated from 4/29 kidney smears from moribund/fresh-dead 95 brood year subyearling fall chinook salmon juveniles during their only monthly examination on April 5, 1996 (Appendix Table A-7). Bacteria producing yellow colonies were isolated from the gills of 4/29 of these same fish and these were most likely ***F. psychrophilus.*** Of 176 moribund/fresh-dead 94 spring chinook salmon juveniles sampled from May through December 1995, only one kidney smear from the first five fish sampled in May produced ***F. psychrophilus*** on culture media (Appendix Table A-8). Gill cultures from 10 of these had predominantly yellow pigmented colonies and one was positive for ***F. psychrophilus*** by the agglutination test; the other nine were not tested.

Blood smears from 155 grab-sampled and 109 moribund juvenile chinook were examined during monthly monitoring and all were negative for cytoplasmic inclusions typical of erythrocytic inclusion body syndrome (EIBS). Anemia and pale gills associated with this infection were not observed.

**Assays for *Renibacterium salmoninarum* by the ELISA and DFAT**

Kidneys from six moribund/fresh-dead and six grab-sampled 95 brood year summer steelhead juveniles were negative by the DFAT (Appendix Table A-9). By the ELISA, 21 kidneys from moribund/fresh-dead summer steelhead had OD values ranging from 0.000-0.095 and kidneys from 29 grab-sampled ranged from 0.001-0.053.

Five moribund/fresh-dead and five grab-sampled 94 brood year fall chinook salmon juveniles, programmed as yearlings, sampled in June of 1995 were negative by the DFAT (Appendix Table A-10) while in Oregon raceways. After transfer to the M3 Michigan series of raceways, 40 grab-sampled from M3C assayed from July of 1995 through February of 1996 had ELISA OD's ranging from 0.008-0.11 1. In raceway M3A during July of 1995, one fresh-dead fish had a high ELISA value of 0.822.

The remaining 39 moribund/fresh-dead fish assayed from M3A over eight months from July of 1995 through February of 1996 were at 0.183 OD units or less. In M3B, one fresh-dead fish had a reading of 0.331 in July of 1995, one had a clinical level of 1.542 in January of 1996, and another was at 0.259 OD units in January. During the eight months of monthly monitoring the remaining 34 moribund/fresh-dead fish in M3B had OD values of 0.139 or less. Raceway M3C had four moribund/fresh-dead fish with very high clinical levels of Rs antigen, from 3.139 to 3.409 OD units, during the last monthly monitoring in February of 1996. During the first monthly sampling of moribund/fresh-dead fish in this raceway in July of 1995, one fish had an ELISA value of 0.196, another was at 0.197, and another at 0.367 OD units. In November of 1995, a moribund/fresh-dead fish in this raceway had an ELISA value of 0.227. Twenty-eight others assayed during the eight months had ELISA readings at 0.092 or less.

Only one monthly monitoring was done on the 94 brood year subyearling fall chinook salmon juveniles in April of 1996 (Appendix Table A-l 1). All 29 moribund/fresh-dead fish and 10 grab-sampled were negative by the DFAT.

Monthly monitoring for Rs on the 94 brood year spring chinook salmon, programmed as yearlings, was done from May through December of 1995 (Appendix Tables A-12 and A-13). Five moribund/fresh-dead and five grab-sampled fish were negative by the DFAT in May. A single fish of six moribund/fresh-dead sampled in June had clinical BKD along with an ELISA value of 1.257. During July and August two moribund/fresh-dead fish of 38 assayed had ELISA OD's greater than 0.166; these were both in Oregon raceways and had OD values of 0.305 and 0.507. The other 36 fish tested had ELISA values of 0.166 or less. Thirty sub-sampled fish during the June-August period had ELISA values between 0.009 and 0.066. From September through December of 1995 clinical BKD signs and clinical ELISA levels of Rs antigen were documented throughout both Oregon and Michigan raceways (Figure 1 and Appendix Table A-13). For Oregon raceways during this period the proportion and prevalence (%) of clinical BKD in moribund/fresh-dead fish was 48/68 and 70.6 %, respectively. In Michigan raceways these same parameters were 40/58 and 69.0%, respectively. No statistical analyses were done because these values are nearly identical.

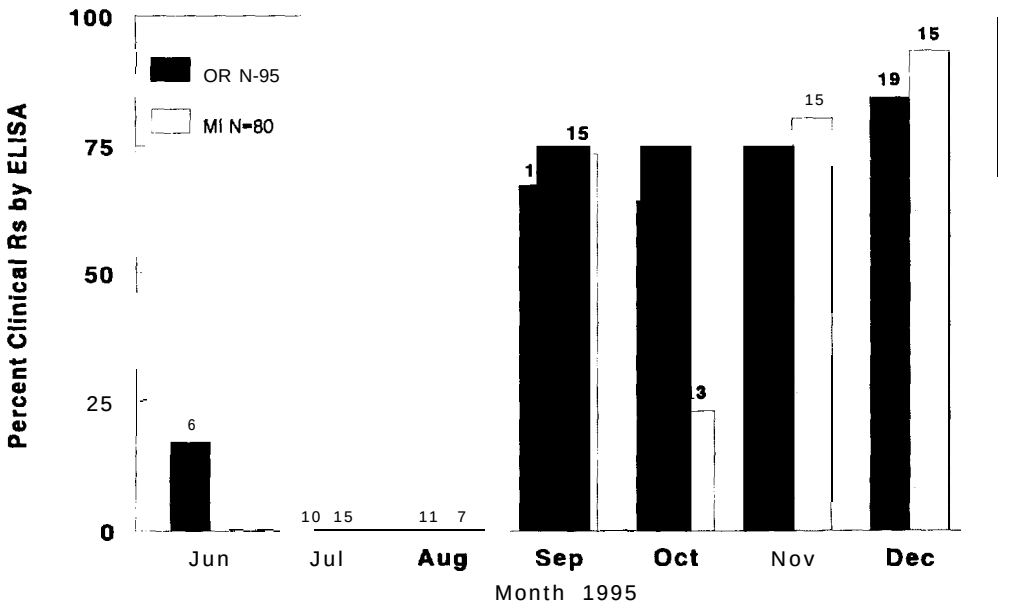


Figure 1. Percent of 94 brood year moribund/fresh-dead spring chinook salmon, programmed as yearlings, with clinical *levels* of *Renibacterium salmoninarum (*Rs) antigen determined by the enzyme-linked immunosorbent assay (ELISA). These fish were sampled from Oregon (OR) raceways O4A, O4B, O5A and O5B, and Michigan (MI) raceways M6A, M6B and M6C at Umatilla Hatchery from June through December of 1995. The total number of fish examined per OR and MI raceway per month is indicated by the number above the bar for that month. A clinical ELISA value is 1 .OOO optical density (OD) units or greater.

## Juvenile Preliberation Monitoring

### Necropsies

External parasites were not detected in wet mounts of gills or body scrapings from a total of 25 fish from all species and stocks at Umatilla Hatchery and yearling fall chinook salmon at Bonneville Hatchery. Gill condition was normal by gross examination although occasional gill aneurysms were observed. No culturable viral agents were detected by cell culture assays. Six-hundred blood smears from chinook salmon stocks at Umatilla Hatchery were negative for EIBS inclusions. At Bonneville, 53.3 % (32/60) of the 94 brood year fall chinook yearlings had typical EIBS inclusions ranging from less than 1 per microscope field to as high as 5-9 per field. Hematocrits were not done.

Five grab-sampled 94 brood year spring chinook salmon yearlings from each of the four ponds at Imeques were negative for EIBS and for external parasites in body scraping and gill wet mounts on March 12, 1996. Eleven moribund/fresh-dead fish from all ponds were negative for pathogenic bacteria by culture and one moribund was negative for EIBS. Kidney pustules typical of BKD were observed in five (45.5%) of these. All the fish at Imeques were reared at Umatilla Hatchery.

Also at Imeques, 94 brood year Priest Rapids stock of fall chinook salmon yearlings reared at Umatilla Hatchery were acclimated in the same four acclimation ponds following release of the spring chinook described above. Five grab-sampled from each of the four ponds and 17 moribund/fresh-dead were examined at preliberation on April 10, 1996. The 20 grab-sampled and 3 moribund were negative for EIBS inclusions and external parasites. A single ***F.*** *psychrophilus* colony was obtained from the kidney smear of one of the 17 moribund/fresh-dead cultured on medium. Pustules typical of BKD were seen in two of these. Gill cultures produced no significant levels or types of bacteria.

At Thornhollow, five grab-sampled 94 brood year fall chinook salmon yearlings per each of the two ponds were examined. These fish were all from Bonneville Hatchery. One fish in pond 2 had EIBS inclusions at a level of four per microscope field and heavy bacterial loads on the gills. The other four fish from pond 2 had a normal blood cell profile. All five fish from pond 1 had bi-lobed and mottled erythrocyte nuclei. One moribund fish in pond 2 was anemic and had five EIBS inclusions per microscope field as well as gill bacteria producing yellow colonies by culture. Of four fresh-dead fish from pond 1 and five from pond 2, eight produced ***F. psychrophilus*** bacteria from kidney smears on culture medium. Colony numbers ranged from a few to very high levels indicative of clinical CWD. Five of these also had high levels of long, filamentous bacteria on the gills; probably the same ***F. psychrophifus*** bacterium that was in the kidneys. A yellow exudate in the visceral cavity was seen in four of these.

Assays for ***Renibacterium salmoninarum*** by the **ELISA**

Values obtained for the 95 brood year Umatilla summer steelhead in raceway M8C and 28 fish in M8B were at 0.026 OD units or less (Appendix Table A-14), comparable to previous years. All the readings obtained with the 30 fish from M8A (0.034-0.358) and 2 fish from M8B (0.078 and 0.094) tended to be unusually high. A review of the ELISA procedures indicated that the ELISA plate used for the M8A samples and the two high value fish from M8B had an anomaly at one step in the ELISA procedure. There was a delay of several minutes between the time the wells were rinsed after samples were added, and the time the conjugated antibody was added. This could have resulted in some drying of the wells and possibly increased non-specific binding of the conjugated antibody or the milk proteins it is suspended in. The conjugate control wells, in fact, showed more that twice normal OD values, supporting this possibility. Based on this and the data from monthly monitoring (Appendix Table A-9), it is likely that the values in these samples were generally in the same range as M8C and were not nearly as high is indicated

Of 90 Priest Rapids 94 brood year fall chinook salmon, sampled as yearlings in the Michigan 3 series of raceways (M3A, B and C), one had a clinical ELISA OD value of 1.136, two were in the 0.200-0.250 range, and the remaining 87 were at 0.108 OD units or less (Appendix Table A-15). Ten fish from each of these raceways were sampled seven days before the other 20 and appeared to be randomly distributed within the range for each raceway. No justification for statistical analyses was evident from the values obtained as the three raceways appear not to be different, other than the single clinical fish in M3B.

Sixty Bonneville 94 brood year fall chinook were sampled as yearlings from two ponds (A3 and A9) prior to their transfer to Thornhollow acclimation ponds (Appendix Table A-16). All values were at or below 0.067 OD units. No differences between the two raceways are indicated.

Three-hundred 95 brood year Priest Rapids fall chinook subyearlings were sampled from two Oregon series (02A and B, and 03A and B) and two Michigan series (M2A, B and C, and M3A, B

and C) of raceways (Appendix Table A-17). The ELISA range for the entire 300 fish was only from 0.000-0.033. No differences among any of the raceways are indicated.

Carson 94 brood year spring chinook were sampled as yearlings from two Oregon series (04A and B, and O5A and B) and one Michigan series (M6A, B and C) of raceways (Appendix Table A-18). The ELISA range of values for the Oregon raceways was 0.004-0.329 and for Michigan raceways it was 0.012-l .454. Of the 120 fish sampled from Oregon raceways, two were in the 0.100-O. 199 range and two were in the 0.200-0.399 range; the remaining 116 (96.7%) were at 0.065 OD units or less. Of 90 fish sampled from Michigan raceways, four were in the 0.100-O. 199 range, one was at 0.291, two were in the 0.700-0.799 range, one was at 0.859, and one had a clinical ELISA value of 1.454; the remaining 81 (90.0%) were at 0.074 OD units or less. Statistical differences were found between the Oregon and Michigan raceways ($p \leq 0.05$) but not among the Michigan raceways.

At the Imeques acclimation facility, 6/11 (54.6%) moribund/fresh-dead 94 brood year spring chinook salmon smolts had clinical levels of Rs antigen by the ELISA (Appendix Table A-19). Eighteen grab-sampled were at 0.077 OD units or less, one was at 0.166, and one was at 0.256 OD units. Sampling of fall chinook salmon smolts acclimated one month later at Imeques showed 5/17 (29.4%) moribund/fresh-dead and 1/20 (5%) grab-sampled with clinical ELISA values (Appendix Table A-20). From the remaining 19 grab-sampled, 17 were at or below 0.072 OD units, one was at 0.198 and one was at 0.421 OD units. At Thornhollow on April 2, 1996, 10 grab-sampled and 9 moribund/fresh-dead 94 brood year fall chinook salmon smolts reared at Bonneville had ELISA values of 0.152 OD units or less (Appendix Table A-21).

**Juvenile Disease Outbreak Monitoring**

During November of 1995 losses in the 94 brood year spring chinook salmon juveniles increased to well above abnormal levels in the Michigan series (M6A, B and C) of raceways and one of four of the Oregon raceways (04B). The average daily percent mortality was in the 0.02-0.05 % range, well above typical daily mortality range of O-0.01 % . Clinical BKD had been documented in fresh-dead/moribund fish from all raceways of this stock during monthly monitoring in September and October (Appendix Table A-13) but mortality rates were not substantially elevated until November (Table 1). Clinical BKD based on gross pathological signs was diagnosed in 22/29 (75.9%) of fresh-dead/moribund fish examined on-site which was confirmed by the ELISA (Appendix Table A-13). No other causes for the increased loss were found. In December, BKD-associated losses increased in all raceways, however 04B and M6A, M6B and M6C continued to sustain the highest mortality (Table 1). An Aquamycin treatment scheduled for January 1996 was given in December 1995 and losses declined significantly during January. Fish in M6B and M6C continued to sustain the highest mortality in January and until transfer to acclimation ponds on February 2 l-22, 1996. These two raceways also showed the highest total mortality from September 1995 through January 1996 (5.25 and 4.95% for M6B and M6C, respectively), followed by M6A (2.42 %) and 04B (2.41%), then followed by 05B (1.81%), 04A (1.33 %) and 05A (1.28%). Statistically there were no differences in total mortality among Oregon raceways nor among Michigan raceways. Mortality rates were, however, statistically higher in Michigan raceways than in Oregon raceways.

Table 1. Monthly and total cumulative percent monthly mortality of 94 brood year spring chinook salmon juveniles in four Oregon raceways (O4A, O4B, O5A and 05B) and three Michigan raceways (M6A, M6B and M6C) at Umatilla Hatchery from September 1995 through January 1996. Oral Aquamycin therapy was administered from December 7 through 27, 1995 under an Investigational New Animal Drug protocol.

| | Raceway | | | | | | |
|---|---|---|---|---|---|---|---|
| | Percent Mortality | | | | | | |
| Month | O4A | O4B | O5A | O5B | M6A | M6B | M6C |
| Sep | 0.13 | 0.21 | 0.13 | 0.17 | 0.16 | 0.23 | 0.22 |
| Oct | 0.28 | 0.62 | 0.34 | 0.42 | 0.28 | 0.44 | 0.29 |
| Nov | 0.25 | 0.56 | 0.25 | 0.33 | 0.59 | 0.84 | 0.73 |
| Dec | 0.54 | 0.83 | 0.39 | 0.68 | 1.11 | 2.61 | 2.79 |
| Jan | 0.13 | 0.19 | 0.17 | 0.21 | 0.28 | 1.13 | 0.92 |
| Total | 1.33 | 2.41 | 1.28 | 1.81 | 2.42 | 5.25 | 4.95 |

On August 28, 1995 hatchery personnel reported de-scaling and increased loss in the 94 brood year Priest Rapids fall chinook salmon in Michigan raceway M3A. This was suspected as being a post-fin clipping and handling related problem. Necropsies did indeed confirm severe de-scaling but *F. psychrophilus* bacteria were also isolated at low levels from the kidneys of 3/6 fish examined, and from the gills of two of these. Similar increased losses subsequently occurred over the next few days, first in M3B, and then in M3C. During the first half of September the daily average mortality in these three raceways was 0.03 1% while in the last half of September it was 0.019 %, although the overall appearance of the fish indicated continued de-scaling and mucus loss during the last half of September (Figure 2). De-scaling, mucus loss, and a high prevalence of caudal-peduncle erosion was noted during monthly monitoring on September ***26,*** 1995. *Flexibacter psychrophilus* bacteria were not isolated from the kidneys of any of 15 fresh-dead/moribund fish cultured on that day. During the first half of October losses continued at a daily average of 0.018 % but increased rapidly to 0.1% or greater in all three raceways by October 25th (Figure 2). A second loss investigation on October 23, 1995 revealed the presence of high levels of bacteria in wet mounts of body scrapings as determined by microscopy. These were not observed on the gills and only low levels of bacteria were detected on the gills by culture. Only one of six kidneys from moribund fish cultured on TYE agar produced ***F.*** *psychrophilus* bacteria and only two colonies grew from that fish. These fish were also negative for EIBS inclusions. Severe caudal-peduncle erosion with scale and mucus loss continued to be the predominant gross pathological signs. Walk-by observations of fish in all three raceways indicated the problem was widespread throughout and some measure of remediation was immediately needed. These observations were confirmed during monthly monitoring two days later on October 25, 1995 when heavy loads of filamentous bacteria were observed in body scrapings of 15 moribund fish, but again no bacteria were isolated from kidney smears on culture medium. Two of five grab-sampled fish also had these bacteria in body scrapings.

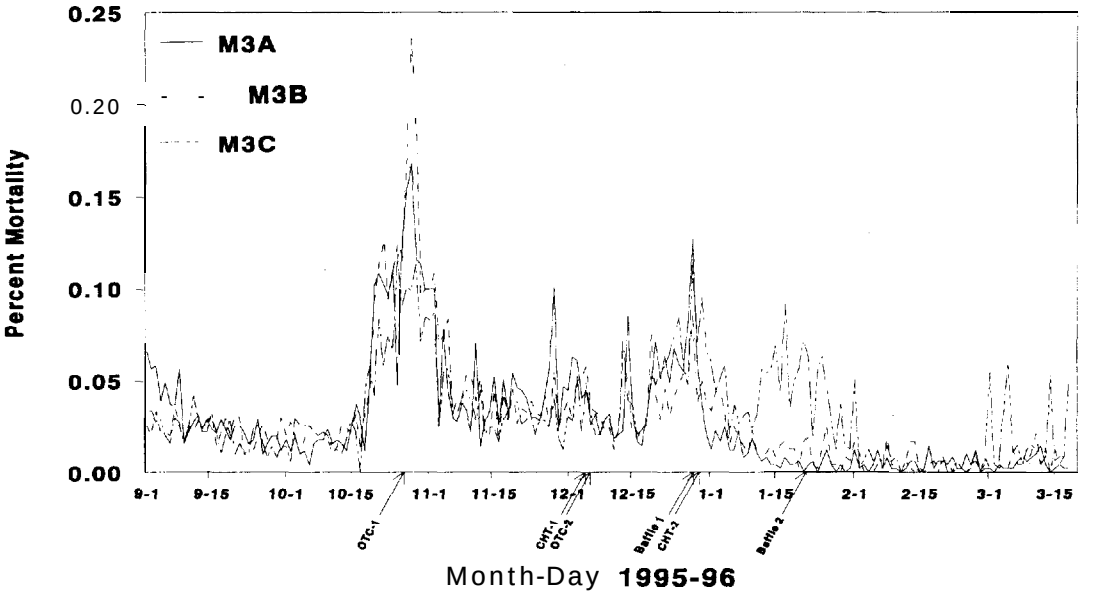


Figure 2. Daily percent mortality in 94 brood year fall chinook salmon juveniles in the Michigan 3 series of raceways (M3A, B and C) at Umatilla Hatchery from September 1, 1995 through March 18, 1996. The OTC-l arrow indicates the beginning date (October 27, 1995) of a ten-day oral oxytetracycline (OTC) regimen at 3.0 g of OTC/100 lbs of fish/day. The CHT-1 arrow indicates the beginning day (December 4, 1995) of three consecutive days of chloramine-T (CHT) flush treatments at 15 mg/L/hr. The OTC-2 arrow indicates the beginning date (December 5, 1995) of a second OTC regimen for 14 days at 7.0 g/100 lbs of fish/day. The Baffle 1 arrow indicates the date (December 28, 1995) on which all baffles were removed from M3A, ***every*** other baffle was removed from M3B, and all the baffles were left in place in M3C. The CHT-2 arrow indicates the beginning date (December 29, 1995) on which a second three consecutive day series of CHT flushes were given at 20 mg/L/hr. The Baffle 2 arrow indicates the date (January 24, 1996) on which all baffles were removed from M3B and M3C. Clinical BKD in February among fish in M3C, in part, accounts for the daily loss in that raceway.

A 10-day oral OTC regimen at 3.0 g OTC/100 lbs of fish/day was begun on October 27, 1995 under an INAD protocol. This was implemented as a treatment for what all the data indicated was a non-systemic manifestation of ***F. psychrophilus*** (CWD) infection when losses were averaging 0.14 % per day. By the seventh day of treatment on November 3, there was a perceptible decline in the average daily mortality to 0.04% where it generally continued, with slightly less or greater loss (0.04% plus or minus 0.02%) on some days, throughout November. There was no improvement in fish condition however, in fact it appeared to be declining in the populations as a whole. A combined monthly monitoring/continuing loss investigation was done on November 28, 1995. Only 3/15 kidney smears from fresh-dead/moribund fish produced ***F. psychrophilus*** bacteria by culture, and these only yielded one, two and eight colonies. Heavy bacterial loads were again seen in body scrapings and cultures of these from 7/8 moribund fish produced large numbers of ***F. psychrophilus*** bacteria. Cultures from 10/15 gill smears also yielded low-to-heavy levels of these bacteria by culture.

As a result of the deteriorating condition of all of the fish in these three raceways a simultaneous treatment with CHT and OTC was done under two other INAD protocols. This was to provide both systemic and cutaneous modes of antibacterial therapy. The OTC dose was increased to ***7.0*** g of OTC/100 lbs of fish/day and the CHT was given as a one-hour flow-through bath at 15 mg CHT/L of water for three consecutive days on December 4, 5 and 6, 1995. The OTC was given daily as a 14-day treatment from December 5 through 18, 1995. From December 1 through 5 the average daily mortality was 0.044%. From the third day of CHT treatment on December 6 through December 12 the average daily mortality was 0.026%. It then jumped briefly for two days to an average of 0.054%, only to decline again to an average of 0.024% until December 19. From December 19 through December 28 it averaged 0.061% per day. Monthly monitoring on December 28, 1995 of 15 moribund (5 per raceway) continued to show heavy bacterial loads on the body and little or no ***F. psychrophilus*** bacteria in kidneys: four of 15 produced only l-3 colonies from kidney smears and the remainder were negative. Eleven of 15 cultures made from skin smears produced low-to-high levels of typical ***F. psychrophilus*** colony types. Five grab-sampled fish had caudal-peduncle and skin lesions along with mucus and scale loss. The situation was judged to be critical after two treatments with OTC, one with CHT, and continued degradation of all fish in these three Michigan raceways. A nearly total loss of these populations appeared possible. The percent loss attributed to this ongoing CWD episode since its onset (September 1- December 28, 1995) was 5.0% and was not statistically different between any of the three raceways (Figure 3).

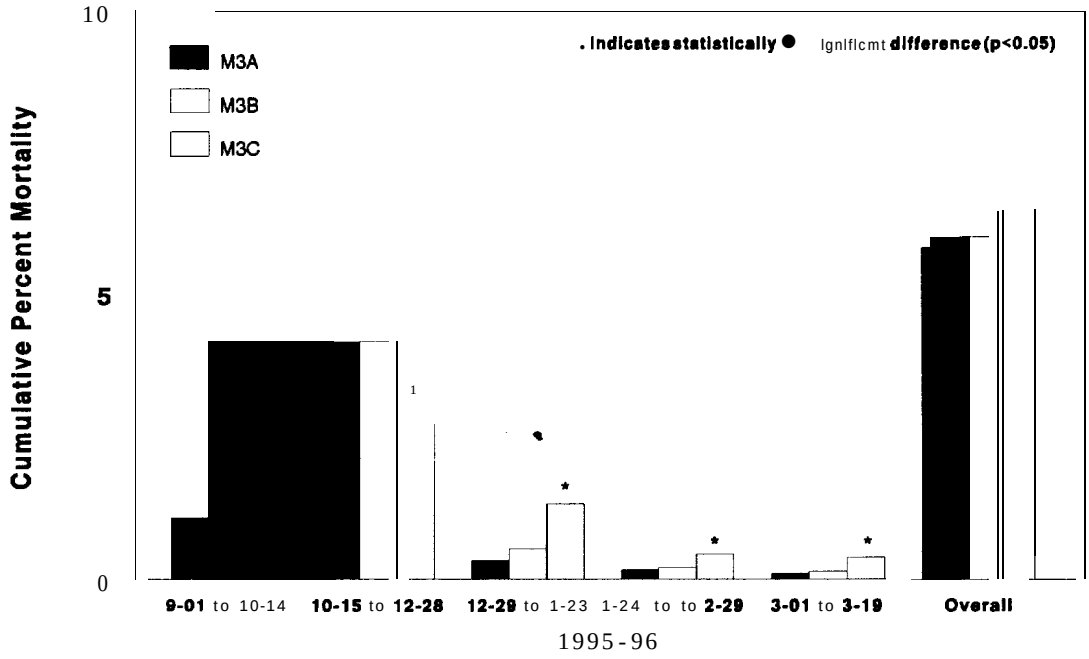


Figure 3. Cumulative percent mortality in 94 brood year fall chinook salmon juveniles in the Michigan 3 series of raceways (M3A, B and C) at Umatilla Hatchery from September 1, 1995 through March 18, 1996. This mortality is bracketed into selected dates. The combined total for the entire period is shown as the overall bars to the far right. During the 12-29 to l-23 interval all raceway baffles were removed from M3A, every other baffle was removed from M3B, and all the baffles were left in place in M3C. On l-24 all baffles were removed from M3B and M3C. M3C had significantly higher cumulative mortality than both M3A and M3B from 12-29 to l-23, from l-24 to 2-29, and from 3-01 to 3-19.

Hatchery management and fish pathology conceived a plan to determine if the baffles in the Michigan raceways were an inherent component of the problem, as was suspected early on, and nullifying the efficacy of therapeutic treatments. There are nine baffles per Michigan raceway which partition these raceways into ten, approximate 3 m sections. The fish can only pass between sections by swimming under the approximate 130 mm opening between the bottom of the baffle and the racewaybottom. It was agreed upon to remove all of the baffles from the upper raceway (M3A), every other baffle from the middle raceway (M3B), and leave all the baffles in place in the lower raceway (M3C). At the same time another CHT treatment would be given. The baffles were removed as described on December 28, 1995 and the CHT treatment was begun on December 29 at 20 mg of CHT/L of water as flow-through for one hour for three consecutive days.

A daily mortality pattern immediately developed which correlated to the presence or absence of baffles, and to the number of baffles present (Figures 2 & 3). From December 29, 1995 through January 23, 1996 the cumulative mortality was 0.34, 0.54 and 1.32% for raceways M3A (all baffles removed), M3B (every other baffle removed), and M3C (all baffles left in place), respectively (Figure

3). There was a significant difference between M3C and both M3A and B, but not between M3A and B. Based on these results it was decided to remove all the baffles from M3B and C on January 24, 1996. From that date until February 29, 1996 the cumulative mortality was 0.17, 0.21 and 0.45 % for M3A, M3B and M3C, respectively (Figure 3). Again, M3C was significantly higher than M3A and B although most of that difference was from January 24 through February 1, 1996 (Figure 2). During these later stages of the epizootic the fish were succumbing to severe external fungal infestations which were secondary to the earlier CWD lesions. The effect was greater in the lower raceway, probably because the all the baffles had been in longer. It carried over into the March 1 to March 18, 1996 interval when cumulative losses for M3A, B and C were 0.11, 0.14 and 0.39, respectively, and M3C was significantly higher again (Figure 3). The four peaks in percent mortality for M3C from March 1 through March 18, 1996 are days on which hatchery personnel removed moribund fish with severe caudal-peduncle fungus (Figure 2). Finding fish with clinical BKD in February indicates that Rs infection may have contributed to the higher cumulative loss in M3C. The overall cumulative mortality over the course of the entire episode was 5.83, 6.01 and 6.49% for M3A, M3B and M3C, respectively (Figure 3). There were no significant differences among these. The fish were transported to acclimation ponds beginning on March 19, 1996.

Another increased loss investigation was done at the Thornhollow acclimation facility on March 20, 1996 on 94 brood year fall chinook salmon yearling that had been transferred from Bonneville Hatchery. Cold water disease bacteria were isolated from the kidneys of 4/11 moribund/fresh-dead fish examined. One fish had moderate levels of this bacterium and the other three produced only l-4 colonies by culture. Six of these had yellow or yellow-green ascities fluid of unknown causation, however all four fish with *F. psychrophilus* bacteria also had this fluid. Twelve grab-sampled fish were negative for EIBS at this time but at preliberation on April 2, 1996 one moribund and 1/10 grab-sampled were positive for EIBS.

**Investigational New Animal Drug Monitoring**

The two OTC and two CHT therapeutic protocols for 94 brood year fall chinook salmon are described above. Additionally, oral erythromycin (Aquamycin) was administered to the 94 brood year spring chinook salmon, programmed as yearlings, as two 21-day therapeutic regimens. The first was given in May of 1995 while the fish were in one Oregon raceway. Based on drug assays the dose was from 158-206 mg/kg body weight/day, well above the recommended level of 100 mg/kg. This was, in part, because the fish were being fed at 3.8 % body weight/day. Hatchery personnel reported that the fish were extremely sensitive to any type of stress during the treatment and on a day-one toxicity test of 60 fish, 15 displayed a non-lethal toxicity response. A second feeding was given during December of 1995 at 68 mg/kg body weight/day, 32 mg/kg below the recommended daily level of 100 mg. Hatchery personnel reported that during this feeding the fish fed poorly during the entire treatment and rejected the food. Some handling was done during the later days of treatment and some fish showed signs of toxicity. Signs of toxicity, both lethal and non-lethal, were documented on day one, three, seven and fourteen of toxicity testing.

**Broodstock Monitoring**

The 72 female summer steelhead spawned for the 96 brood year production had ELISA values of 0.167 or less (Appendix Table A-22). All males and females were negative for IHN and other culturable viruses (Appendix Table A-24).

Twenty-female sub-samples of fall chinook salmon spawned at Priest Rapids on each spawning date for Umatilla Hatchery 95 brood year production had ELISA values of 0.029 or less (Appendix Table A-25). Twenty sex fluid sub-samples from males and females, either as individual or three-fish pools, on each spawning date were negative for IHN and other culturable viruses (Appendix Table A-26) and for EIBS inclusions (Appendix Table A-27).

Twenty-female sub-samples of spring chinook salmon sampled at Little White Salmon National Fish Hatchery on four spawning dates during August of 1996 had a wide range of ELISA values from negative to clinical (Appendix Table A-28). Sixty-two were at 0.100 OD units or less, seven were from 0.101-o. 199 OD units, five were in the 0.200-0.800 range, and six had clinical levels of antigen at greater than 1 .000 OD units. Twenty-fish ovarian fluid sub-samples on the same spawning dates had IHN virus prevalences ranging from 0% on the first spawn to 80% on the last spawn (Appendix Table A-29). No EIBS inclusions were detected in the blood smears from these same females (Appendix Table A-30).

In samples from adult carcasses of spring chinook salmon sampled on the Umatilla River, 17 fish reared at Bonneville Hatchery had ELISA values that ranged from 0.014-o. 147 OD units; five fish reared in Oregon raceways at Umatilla Hatchery had a range of 0.009-0.218; and one fish reared in a Michigan raceway at Umatilla had a value of 0.070 (Appendix Table A-31). In returning jacks sampled at the Three Mile Dam collection facility, 16 reared at Bonneville had an ELISA range of 0.003-0.058; 11 reared in Oregon raceways at Umatilla were in the 0.003-0.078 range; nine from Michigan raceways at Umatilla had a range of 0.000-0.029; and three strays were in the 0.011-0.082 range (Appendix Table A-32).

## DISCUSSION

After five years of intensive monthly and preliberation monitoring no ectoparasites or viral agents have been detected on or in any juvenile salmonids reared at Umatilla Hatchery. Nor have environmental (Klontz 1993) or bacterial gill disease been indicated at any time even though high density rearing occurs each year in Michigan raceways. During monthly monitoring of juvenile steelhead on October 25, 1995, 60% (6/10) of moribund/fresh-dead fish examined had far more than the occasional aneurysm in the secondary gill lamellae. Hatchery personnel indicated the fish had been transferred from an Oregon pond to Michigan raceways that same day. The term “aneurysmal gill disease” was coined by Eller (1975) to describe what were probably similar lesions, caused by pesticides and toxicants in the water, documented by other investigators. In the Umatilla Hatchery case, it could be important to determine if the vasculature vessel walls are weakened for some reason (i.e. pesticides or herbicides), or whether these aneurysms were simply induced by handling trauma.

Only four females providing eggs for the 94 brood year Carson spring chinook salmon production at Umatilla Hatchery were positive for IHN virus (Groberg et al. 1996). These were among 24 females spawned at Wallowa Hatchery to supplement the egg-takes at Lyons Ferry Hatchery. All adults sampled there were virus-negative. Most evidence suggests that under this scenario, vertical transmission of IHN virus would be unlikely and, indeed, there was no evidence for IHN infection in the progeny reared at Umatilla for the fifth consecutive year. In addition, progeny from the 95 brood year Umatilla summer steelhead, for the first time, were reared from broodstock with a high prevalence of IHN virus (Groberg et al. 1996). These were reared to smolts with no evidence of IHN virus infection, and thus without evidence for vertical transmission.

Assays for Rs by the DFAT and ELISA during monthly and preliberation monitoring of the 95 brood year summer steelhead juveniles and the 95 brood year Priest Rapids fall chinook subyearlings indicated negative or very low Rs infection levels. These results are typical of Rs infection levels detected in these same stocks in the previous four brood years. There have been no BKD outbreaks nor losses to Rs in either of these stocks over the five years of monitoring.

For the third consecutive year, however, there have been BKD losses in juvenile spring chinook salmon at Umatilla Hatchery. Rearing strategies and broodstock sources have varied during this time and the data collected suggests that Rs infection levels and prevalence have also varied in the broodstock populations. Significantly, however, an outbreak of BKD occurred in the 93 brood year juveniles when ELISA results for Rs antigen were very low or negative from adults spawned at Carson National Fish Hatchery (Groberg et al. 1996). It is important to reiterate that these data represent sub-samples of the total adult population providing eggs to the Umatilla program and some high level Rs females could have been missed. For the BKD outbreaks in the 92 and 94 brood year spring chinook at Umatilla, there were portions of the broodstock population from which one would expect vertical transmission and subsequent BKD in their progeny (Keefe et al. 1994 and Groberg et al. 1996). The requirement for 100% sampling of females in an Rs segregation or culling program is certainly emphasized from these data, or lack thereof.

Based on cumulative mortality and ELISA preliberation data, the severity of Rs infection was unquestionably greater in the Michigan raceways than the Oregon raceways. Because the fish are at approximately three times higher density in the Michigan raceways, stress effects leading to increased susceptibility to infection, and a higher degree of horizontal transmission due to crowding, could account for these results. Trends towards higher mortality rates in lower Oregon and middle and lower Michigan raceways than in the upper raceway of a series were noted for the 94 brood year spring chinook juveniles although this was not supported by statistics in among-raceway comparisons (Table 1). Perhaps a more sensitive indicator for real differences could be survival-to-adult data combined with ELISA profiles of returning adults. Efforts were begun in the 1996 to collect sufficient numbers of samples for ELISA from marked returning adults so the entire spectrum of data from juvenile to adult can be used to make assessments of how rearing strategies might be affecting BKD and ultimately, survival.

The CWD bacterium, ***Flexibacter psychrophilus,*** has frequently been isolated from moribund/fresh dead fish of all stocks at Umatilla Hatchery since the fish health monitoring project began. Typically these fish have clinical signs but cases of increased loss have not resulted. An exception to this was in the 94 brood year Priest Rapids fall chinook salmon, programmed as yearlings, documented in this report. Prior to this, the only other case of increased loss to CWD was in the 91 brood year Bonneville fall chinook programmed as sub-yearlings and in this case the disease simply "ran its course" following handling procedures (Keefe et al. 1993). This episode in the 94 yearlings was far more severe and problematical. Following two OTC treatments and one with CHT, daily mortality remained very high and the condition of all fish in the raceways continued to decline. In this case condition means loss of scales and body mucus, and development of skin lesions. The clinical data indicated this infection was confined to the cutaneous and sub-cutaneous tissues and was not systemic or disseminated internally. This suggested the fish were becoming infected through abrasions of the skin, most likely from contact with the edge of the baffles that they must swim back-and-forth under. This effect was exacerbated as the fish became larger and when the fish were disturbed and moved frantically between compartments which the baffles create.

To test this hypothesis and also attempt a cure to this ongoing problem, all the baffles were removed from the upper Michigan raceway of fish with this problem, one-half of the baffles were removed from the middle Michigan raceway, and all the baffles were left in the lower Michigan raceway of this series. Additionally, a CHT treatment was begun on fish in all three raceways the day following removal of the baffles as described. Chloramine-T was chosen for therapy rather than a systemically acting antibiotic such as OTC because the infection was deemed to be superficial and not systemic. There was immediate improvement in the fish in the upper raceway from which the baffles had been removed, and there was delayed but observable improvement in fish in the middle raceway from which half the baffles were removed. The lower raceway continued to have fish with the poorest condition. The daily mortality data confirmed these observations (Figure 2) and after 27 days all the baffles were removed from the middle and lower raceways. The fish in these raceways showed recovery to a normal condition and mortality rates continued to decline. There was a continued higher mortality in the lower Michigan raceway, however, associated with BKD.

All the data from this episode of CWD in the fall chinook at Umatilla supports a conclusion that the baffles were a primary factor. It would have been more conclusive had there been the same stock and size of fall chinook in Oregon raceways during this time that did not experience the same clinical course of CWD. Future plans are to try different baffle configurations along with clinical assays including plasma glucose to further evaluate how the baffles might affect the chronic stress response and disease outbreaks. The function of the baffles installed at Umatilla Hatchery is also being reviewed.

The baffles and the CWD epizootic described above are a prime example of the now classic model described by Snieszko (1974) in which infectious disease results from an interaction of the host, the pathogen, and the environment. It is quite likely that the baffles, as a component of the environment of these fall chinook salmon, were the overriding factor leading to this unusual CWD episode at Umatilla Hatchery. This may never had occurred had the baffles not been in place.

Time and resources permitting, continued studies for applying PCR technology to the Umatilla fish health evaluations will be pursued. Two advantages of PCR are that it is less subjective and many isolates of a suspected agent can be tested in a single run. ‘Disadvantages are the cost of the technology and supplies, and the time required to perform PCR assays. The high sensitivity and specificity of the methodology, however, offers numerous opportunities for improved fish health and disease assessments in populations of fish, cultured and wild.

## ACKNOWLEDGMENTS

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## APPENDIX A

Appendix Table A-l. Number of 95 brood year Umatilla summer steelhead juveniles sampled per raceway in Oregon raceway 02A and Michigan series M8 (A, B and C) during monthly monitoring.

| Date sampled | O2A[1] | O2A[2] | M8A[1] | M8A[2] | M8B[1] | M8C[1] | M8C[2] |
|---|---|---|---|---|---|---|---|
| 08-95 | 5 | 5 | | | | | |
| 09-95 | 2 | 5 | | | | | |
| 10-95 | | | 5 | | 5 | 0 | 5 |
| 1 l-95 | | | 2 | | ND[3] | 1 | 5 |
| 12-95 | | | 1 | | ND[3] | ND[3] | 5 |
| 01-96 | | | 1 | | 4 | 1 | 5 |
| 02-96 | | | ND[3] | 5 | | | |

[1] *Moribund or fresh-dead fish.*
[2] *Normal, healthy appearing fish.*
[3] *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

Appendix Table A-2. Number of 94 brood year Priest Rapids fall chinook salmon juveniles, released as yearlings, sampled per raceway in Oregon raceway 03A and Michigan series M3 (A, B and C) during monthly monitoring.

| Date sampled | O3A[1] | O3A[2] | M3A[1] | M3B[1] | M3C[1] | M3C[2] |
|---|---|---|---|---|---|---|
| 06-95 | 5 | 5 | | | | |
| 07-95 | | | 5 | 5 | 5 | 5 |
| 08-95 | | | 5 | 4 | 1 | 5 |
| 09-95 | | | 5 | 5 | 5 | 5 |
| 10-95 | | | 5 | 5 | 5 | 5 |
| 1 l-95 | | | 5 | 5 | 5 | 5 |
| 12-95 | | | 5 | 5 | 5 | 5 |
| 01-96 | | | 5 | 5 | 5 | 5 |
| 02-96 | | | 5 | 3 | 5 | 5 |

*[1]Moribund or fresh-dead fish.*
*[2]Normal, healthy appearing fish.*

Appendix Table A-3. Number of 95 brood year Priest Rapids fall chinook salmon juveniles, released as subyearlings, sampled per raceway in Oregon series 02 (A and B) and 03 (A and B), and Michigan series M2 (A, B and C) and M3 (A, B and C) during monthly monitoring.

| Date sampled | 02A | 02B | 03A | 03B | M2A[1] | M2B[1] | M2C[1] | M2C[2] | M3A[1] | M3B[1] | M3C[1] | M3C[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *04-96* | ND[3] | ND[3] | ND[3] | ND[3] | *4* | 5 | *5* | *5* | *5* | *5* | *5* | *5* |

[1] *Moribund or fresh-dead fish.*
[2] *Normal, healthy appearingjish.*
[3] *Coded-wire tagging and fin clipping in this raceway during monthly monitoring, no normal mortality.*

Appendix Table A-4. Number of 94 brood year Carson spring chinook salmon juveniles, released as yearlings, sampled per raceway in Oregon series 04 (A and B) and 05 (A and B) and Michigan series M6 (A, B and C) during monthly monitoring.

| Date sampled | O4A[1] | O4B[1] | O4B[2] | O5A[1] | O5A[2] | O5B[1] | O5B[2] | M6A[1] | M6B[1] | M6C[1] | M6C[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 05-95 | | | | 5 | 5 | | | | | | |
| 06-95 | | | | 4 | | 2 | 5 | | | | |
| 07-95 | | | | 5 | 5 | | | 5 | 5 | 5 | 5 |
| 08-95 | 4 | 3 | 5 | 3 | | 1 | 5 | 2 | 1 | 4 | 5 |
| 09-95 | 4 | 4 | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 5 |
| 1 o-95 | 2 | 5 | 5 | 5 | | 5 | 5 | 3 | 5 | 5 | 5 |
| 1 l-95 | 4 | 5 | 5 | 1 | | 4 | 5 | 5 | 5 | 5 | 5 |
| 12-95 | 5 | 4 | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 5 |

[1] *Moribundor- fresh-dead fish.*
[2] *Normal, healthy appearing fish.*

Appendix Table A-5. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 95 brood year Umatilla summer steelhead during monthly juvenile fish health monitoring. Unless indicated otherwise, the prevalence was 0% ,

| | | Systemic bacteria[1] | | Gill bacteria[2] |
|---|---|---|---|---|
| Date sampled | Raceway | *F. psychrophilus* | APS | |
| 08-95 | 02A | 0/5 | 3/5 (60%) | 0/5 |
| 09-95 | 02A | 0/2 | 1/2 (50%) | 0/2 |
| 10-95 | M8A | 0/5 | 0/5 | 0/5 |
| | M8B | 0/5 | 0/5 | 0/5 |
| | M8C | ND[3] | ND[3] | ND[3] |
| 1 l-95 | M8A | 0/2 | 0/2 | 0/2 |
| | M8B | ND[3] | ND[3] | ND[3] |
| | M8C | O/l | O/l | O/l |
| 12-95 | M8A | O/l | O/l | ND[3] |
| | M8B | ND[3] | ND[3] | ND[3] |
| | M8C | ND[3] | ND[3] | ND[3] |
| 01-96 | M8A | O/l | l/l (100%) | O/l |
| | M8B | 0/4 | 0/4 | 0/3 |
| | M8C | O/l | O/l | l/l (100%) |
| 02-96 | M8A | ND[3] | ND[3] | ND[3] |

[1] *The only systemic bacteria isolated from kidney smear inocula were* Flexibacter psychrophilus *and aeromonad-pseudomonad (APS) types.*

[2] *These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*

[3] *Indicates not done (ND) because no moribund or fresh-dead fish were available.*

Appendix Table A-6. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 94 brood year Priest Rapids fall chinook salmon, released as yearlings, during monthly juvenile fish health monitoring. Unless indicated otherwise, the prevalence was 0%.

| Date sampled | Raceway | Systemic bacteria[1] | | Gill bacteria* |
|---|---|---|---|---|
| | | *F. psychrophilus'* | APS | |
| ***06-95*** | 03A | 0/5 | 2/5 (40%) | 0/5 |
| 07-95 | M3A | 0/5 | 3/5 (60%) | 0/3 |
| | M3B | 0/5 | 3/5 (60%) | 0/4 |
| | M3C | 0/5 | 4/5 (80%) | 0/3 |
| ***08-95*** | M3A | 0/5 | 0/5 | 0/4 |
| | M3B | 0/4 | 1/4 (25%) | 1/4 (25%)[4] |
| | M3C | O/l | O/l | O/l |
| ***09-95*** | M3A | 0/5 | 0/5 | 0/5 |
| | M3B | 0/5 | 0/5 | 0/5 |
| | M3C | 0/5 | 0/5 | 2/5 (40%) |
| 10-95 | M3A | 0/5 | 0/5 | 1/5 (20%)[4] |
| | M3B | 0/5 | 0/5 | 0/5 |
| | M3C | 0/5 | 0/5 | 0/5 |
| 1 l-95 | M3A | 0/5 | 0/5 | 5/5 (100%)[4] |
| | M3B | 3/5 (60%) | 0/5 | 2/5 (40%)[4] |
| | M3C | 0/5 | 0/5 | 2/5 (40%)[4] |

[1] *The* ***only systemic bacteria*** *isolated from* ***kidney smear inocula were*** Flexibacter psychrophilus ***and*** *aeromondad-pseudomonad* ***(APS) types.***

[2] ***These were determined to be*** *significant* ***only if yellow pigmented colonies were the prevalent type on*** *smears made from* ***gill inocula.***

[3] ***Two of these 9 isolates were tested by the rapid slide agglutination test using*** Flexibacter psychrophilus *polyclonal* ***rabbit antiserum and were.positive.***

[4] ***Four of these 31 gill isolates were tested by the rapid slide agglutination test using*** Flexibacter psychrophilus ***polyclonal rabbit antiserum and were positive.***

Appendix Table A-6. Continued.

| Date sampled | Raceway | Systemic bacteria[1] | | Gill bacteria[2] |
|---|---|---|---|---|
| | | *F. psychrophilus*[3] | APS | |
| 12-95 | M3A | 2/5(40%) | 0/5 | 3/5 (60%) |
| | M3B | 0/5 | 1/5 (20%) . | 1/5 (20%) |
| | M3C | 2/5 (40%) | 0/5 | 3/5 (60%)' |
| 01-96 | M3A | 1/5 (20%) | 2/5 (40%) | 1/4 (25%) |
| | M3B | 0/5 | 2/5 (40%) | 2/5 (40%)[4] |
| | M3C | 1/5 (20%) | 0/5 | 4/5 (80%)[4] |
| ***02-96*** | M3A | 0/5 | 0/5 | 1/5 (20%)[4] |
| | M3B | 0/3 | 0/3 | 2/3 (66%)[4] |
| | M3C | 0/5 | 1/5 (20%) | 1/5 (20%) |

Appendix Table A-7. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 95 brood year Priest Rapids fall chinook salmon, released as subyearlings, during monthly juvenile fish health monitoring. Unless indicated otherwise, the prevalence was 0%.

| Date sampled | Raceway | Systemic bacteria | | Gill bacteria' |
|---|---|---|---|---|
| | | ***F. psychrophilus***[3] | APS | |
| ***04-96*** | 02A | ND[4] | ND[4] | ND[4] |
| | 02B | ND[4] | ND[4] | ND[4] |
| | 03A | ND[4] | ND[4] | ND[4] |
| | 03B | ND[4] | ND[4] | ND[4] |
| | M2A | 0/4 | 1/4 (25%) | 0/4 |
| | M2B | 0/5 | 0/5 | 0/5 |
| | M2C | 1/5 (20%) | 0/5 | 2/5 (40%) |
| | M3A | 1/5 (20%)[3] | 0/5 | 0/5 |
| | M3B | 2/5 (40%)[3] | 0/5 | 1/5 (20%) |
| | M3C | 0/5 | 2/5 (40%) | 1/5 (20%) |

[1] ***The only systemic bacteria isolatedfrom kidney smear inocula were*** Flexibacter psychrophilus ***and*** *aeromondad-pseudomonad* ***(APS) types.***

[2] ***These were determined to be significant only*** *if* ***yellow pigmented colonies were the prevalent type on*** *smears* ***made from gill inocula.***

[3] ***Two of these 4 isolates were tested by the rapid slide agglutination test using*** Flexibacter psychrophilus *polyclonal* ***rabbit antiserum and were positive.***

[4] ***Coded-wire tagging*** *and fin* ***clipping in this raceway during monthly monitoring, no normal mortality.***

Appendix Table A-8. Proportions and prevalences (%) of bacterial agents isolated from moribund or fresh-dead 94 brood year Carson spring chinook salmon, released as yearlings, during monthly juvenile fish health monitoring. Unless indicated otherwise, the prevalence was 0%.

| Date sampled | Raceway | Systemic bacteria[1] | | Gill bacteria* |
|---|---|---|---|---|
| | | *F. psychrophilus* | APS | |
| 05-95 | 05A | 1/5 (20%)[3] | 2/5 (40%) | 2/5 (40%)[4] |
| 06-95 | 05A | 0/4 | 2/4 (50%) | 0/4 |
| | 05B | 0/2 | 0/2 | 0/2 |
| 07-95 | 05A | 0/5 | 3/5 (60%) | 0/5 |
| | M5A | 0/5 | 0/5 | 0/2 |
| | M5B | 0/5 | 1/5 (20%) | 0/2 |
| | M5C | 0/5 | 0/5 | or2 |
| 08-95 | 04A | 0/4 | 0/4 | 2/4 (50%)[4] |
| | 04B | 0/3 | 0/3 | 0/3 |
| | 05A | 0/3 | 0/3 | 0/3 |
| | 05B | 0/1 | O/l | 0/1 |
| | M6A | 0/2 | 0/2 | 0/2 |
| | M6B | O/l | O/l | 1/1 (100%)[4] |
| | M6C | 0/4 | 2/4 (50%) | 1/4 (25%)[4] |
| 09-95 | 04A | 0/4 | 0/4 | 0/2 |
| | 04B | 0/4 | 1/4 (25%) | 0/4 |
| | 05A | 0/5 | 3/5 (60%) | 0/2 |
| | 05B | 0/5 | 5/5 (100%) | 0/2 |
| | M6A | 0/5 | 5/5 (100%) | 0/2 |
| | M6B | 0/5 | 1/5 (20%) | 0/4 |
| | M6C | 0/5 | 4/5 (80%) | 1/4 (25)[4] |

*'The only systemic bacteria isolatedfrom kidney smear inocula were* Flexibacter psychrophilus *and aeromondad-pseudomonad (APS) types.*

[2]*These were determined to be significant only if yellow pigmented colonies were the prevalent type on smears made from gill inocula.*

[3]*This isolate was determined to be* Flexibacter psychrophilus *by growth inhibition at 30°C.*

[4]*The rapid slide agglutination test on 1/10 of these isolates using* Flexibacter psychrophilus *polyclonal rabbit antiserum was positive.*

Appendix Table A-8. Continued.

| Date sarripled | Raceway | Systemic bacteria[1] | | Gill bacteria[2] |
|---|---|---|---|---|
| | | *F. psychrophilus* | APS | |
| 10-95 | 04A | 0/2 | 0/2 | O/l |
| | 04B | 0/5 | 2/5 (40%) | 0/5 |
| | 05A | 0/5 | 1/5 (20%) | 0/5 |
| | O5B | 0/5 | 0/5 | 0/5 |
| | M6A | 0/3 | 0/3 | 0/3 |
| | M6B | 0/5 | 1/5 (20%) | 0/5 |
| | M6C | 0/5 | 1/5 (20%) | 0/2 |
| 1 l-95 | 04A | 0/4 | 1/4 (25%) | 0/4 |
| | 04B | 0/5 | 0/5 | 0/5 |
| | 05A | O/l | O/l | 0/1 |
| | 05B | 0/4 | 0/4 | 0/4 |
| | M6A | 0/5 | 0/5 | 0/5 |
| | M6B | 0/5 | 1/5 (20%) | 2/5 (40%)[4] |
| | M6C | 0/5 | 0/5 | 1/5 (20%)[4] |
| 12-95 | 04A | 0/5 | 1/5 (20%) | 0/2 |
| | 04B | 0/4 | 0/4 | 0/4 |
| | 05A | 0/5 | 1/5 (20%) | 0/5 |
| | 05B | 0/5 | 0/5 | 0/5 |
| | M6A | 0/5 | 0/5 | 0/2 |
| | M6B | 0/5 | 0/5 | 0/5 |
| | M6C | 0/5 | 0/5 | 0/5 |

Appendix Table A-9. DFAT results and ELISA readings ($OD_{405}$) of kidney samples' from 95 brood year Umatilla summer steelhead juveniles sampled during monthly monitoring from Oregon raceway 02A and Michigan series M8 (A, B and C).

| | ELISA $OD_{405}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| Date sampled | O2A[2] | O2A[3] | M8A[2] | M8A[3] | M8B[2] | M8C[2] | M8C[3] |
| 08-95 | 0/5[4] | 0/5[4] | | | | | |
| ***09-95*** | .037<br>.070 | 0/1[4]<br>.014<br>.016<br>.029<br><br>.053 | | | | | |
| ***10-95*** | | | .009<br>.010<br>.011<br>.014<br>.050 | | .013<br>.016<br>.039<br>.067<br>.095 | | .006<br>.006<br>.008<br>.010<br>.011 |
| 1 l-95 | | | .007<br>.046 | | | .006 | .004<br>.005<br>.006<br>.006<br>.014 |
| 12-95 | | | .000 | | | | .001<br>.002<br>.005<br>.005<br>.010 |

[1] ***Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 or 1:15 weight/volume dilution for ELISA.***

[2] *Moribund* ***or fresh-dead jish.***

[3] ***Normal, healthy appearing*** *fish.*

[4] *Examined* ***by the DFAT because*** *of* ***the small fish size.***

Appendix Table A-9. Continued

| Date sampled | ELISA $OD_{405}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | O2A[2] | O2A[3] | M8A[2] | M8A[3] | M8B[2] | M8C[2] | M8C[3] |
| 01-96 | | | .016 | | 0/1[4] | .083 | .014 |
| | | | .007 | | | | .018 |
| | | | .016 | | | | .027 |
| | | | .018 | | | | .032 |
| | | | | | | | .038 |
| 02-96 | | | | .010 | | | |
| | | | | .011 | | | |
| | | | | .012 | | | |
| | | | | .013 | | | |
| | | | | .013 | | | |

Appendix Table A-10. DFAT results and ELISA readings ($OD_{405}$) of kidney samples' from 94 brood year Priest Rapids fall chinook salmon juveniles, released as yearlings, sampled per raceway in Oregon raceway O3A and Michigan series M3 (A, B and C) during monthly monitoring.

| Date sampled | O3A[2] | O3A[3] | M3A[2] | M3B[2] | M3C[2] | M3C[3] |
|---|---|---|---|---|---|---|
| ***06-95*** | 0/5[3] | 0/5[3] | | | | |
| 07-95 | | | .040 | .038 | .042 | .008 |
| | | | ,042 | .038 | .072 | .009 |
| | | | .045 | .045 | .196 | .014 |
| | | | .131 | .063 | .197 | .030 |
| | | | .822 | .331 | .367 | .035 |
| ***08-95*** | | | .009 | .029 | .016 | .017 |
| | | | .011 | .031 | | .022 |
| | | | .013 | .033 | | .025 |
| | | | .023 | .034 | | .031 |
| | | | .045 | | | .032 |
| ***09-95*** | | | .022 | .030 | .018 | .017 |
| | | | .033 | .036 | .020 | .018 |
| | | | .071 | .040 | .027 | .019 |
| | | | .074 | .083 | .034 | .039 |
| | | | .183 | .095 | .061 | .044 |
| 10-95 | | | .007 | .012 | .006 | .014 |
| | | | .012 | .012 | .007 | .024 |
| | | | .012 | .020 | .020 | .029 |
| | | | .015 | .022 | .026 | .076 |
| | | | .023 | .023 | .035 | .111 |

*Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 or 1:15 weight/volume dilution for ELISA.*

[3] *Moribund or fresh-dead fish.*

[3] *Normal, healthy appearing fish.*

[4] *Examined by the DFAT because of the small fish size.*

Appendix Table A-10. Continued.

| Date sampled | O3A[2] | O3A[3] | M3A[2] | M3B[2] | M3C[2] | M3C[3] |
|---|---|---|---|---|---|---|
| 11-95 | | | .016 | .027 | .039 | .020 |
| | | | .034 | .029 | .049 | .034 |
| | | | .061 | .033 | .058 | .056 |
| | | | .077 | .048 | .062 | .058 |
| | | | .114 | .139 | .227 | .080 |
| 12-95 | | | .014 | .027 | .020 | .018 |
| | | | ,016 | .031 | .039 | .021 |
| | | | .020 | .039 | .043 | .044 |
| | | | .024 | .045 | .057 | .060 |
| | | | .033 | .074 | .092 | .084 |
| 01-96 | | | .025 | .040 | .023 | .028 |
| | | | .028 | .048 | .024 | .034 |
| | | | .032 | .060 | .025 | .038 |
| | | | .035 | .259 | .030 | .065 |
| | | | .048 | 1.542 | .031 | .102 |
| 02-96 | | | .023 | .010 | .026 | .010 |
| | | | .026 | .010 | 3.139 | .013 |
| | | | .027 | .014 | 3.225 | .015 |
| | | | .032 | | 3.265 | .018 |
| | | | .060 | | 3.409 | .019 |

Appendix Table A-l1. Number of 95 brood year Priest Rapids fall chinook salmon juveniles, released as subyearlings, assayed by the DFAT for *Renibacterium salmoninarum* during monthly monitoring from Michigan raceways, all were negative.

| Date sampled | 02A | 02B | 03A | 03B | M2A[1] | M2B[1] | M2C[1] | M2C[2] | M3A[1] | M3B[1] | M3C[1] | M3C[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04-96 | ND[3] | ND[3] | ND[3] | ND[3] | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

[1] *Moribund or fresh-dead fish.*

[2] *Normal, healthy appearing fish.*

[3] *Not done (ND) because of coded-wire tagging and fin clipping in these raceways during monthly monitoring.*

Appendix Table A-12. DFAT results and ELISA readings ($OD_{405}$) for ***Renibacterium safmoninarum*** of kidney samples' from 94 brood year Carson spring chinook salmon juveniles, released as yearlings, sampled during monthly. monitoring from Oregon series 05 (A and B) and Michigan series M5 (A, B and C) of raceways. The fish were in these raceways prior to their distribution among the Oregon 04 and 05 series and the Michigan M6 series for completion of rearing, as shown in Appendix Table A-l 3.

| Date sampled | O5A[2] | O5A[3] | O5B[2] | O5B[3] | M5A[2] | M5B[2] | M5C[2] | M5C[3] |
|---|---|---|---|---|---|---|---|---|
| 05-95[4] | 0/5 | 0/5 | | | | | | |
| 06-95 | .017 | | .020 | .024 | | | | |
| | .028 | | 1.257 | .029 | | | | |
| | .043 | | | .047 | | | | |
| | .052 | | | .049 | | | | |
| | | | | .057 | | | | |
| 07-95 | .000 | .009 | | | .012 | .002 | .005 | .014 |
| | .000 | .013 | | | .016 | .020 | .008 | .022 |
| | ,003 | .014 | | | .019 | .041 | .010 | .024 |
| | .005 | .018 | | | .024 | .067 | .013 | .036 |
| | .305 | .027 | | | .059 | .166 | .017 | .038 |

***Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 or 1:15 weight/volume dilution for ELISA.***

***Moribund or fresh-dead fish.***

***Normal, healthy appearing jish.***

[4] ***Examined by the DFAT because of the small fish size.***

Appendix Table A-13. ELISA readings ($OD_{405}$) for *Renibucterium salmoninarum* of kidney samples' from 94 brood year Carson spring chinook salmon juveniles, released as yearlings, sampled during monthly monitoring from Oregon series 04 (A and B) and 05 (A and B), and Michigan series M6 (A, B and C) of raceways. The fish were in these raceways following their distribution from the Oregon 05 series and the Michigan M5 series of raceways, as shown in Appendix Table A-12, for completion of rearing.

| Date sampled | O4A[2] | O4B[2] | O4B[3] | O5A[2] | O5B[2] | O5B[3] | M6A[2] | M6B[2] | M6C[2] | M6C[3] |
|---|---|---|---|---|---|---|---|---|---|---|
| 08-95 | .014 | .010 | .018 | .012 | .124 | .014 | .034 | .015 | .007 | .025 |
| | .019 | .033 | .023 | .020 | | .016 | .034 | | .024 | .028 |
| | .020 | .507 | .031 | .133 | | .019 | | | .039 | .048 |
| | .032 | | .064 | | | .022 | | | .076 | .062 |
| | | | .065 | | | .046 | | | | .066 |
| 09-95 | .008 | 2.965 | .015 | .025 | .023 | .011 | 3.049 | .119 | .005 | .003 |
| | .095 | 3.024 | .016 | .027 | 1.171 | .012 | 3.174 | 3.208 | .021 | .011 |
| | 3.184 | 3.214 | .040 | .265 | 3.147 | .015 | 3.186 | 3.297 | .097 | .017 |
| | 3.390 | 3.313 | .141 | 3.173 | 3.244 | .021 | 3.311 | 3.377 | 3.21 I | .020 |
| | | | .142 | 3.410 | 3.427 | .032 | 3.341 | 3.533 | 3.258 | .035 |
| 10-95 | .079 | .119 | .027 | .052 | .054 | .033 | .029 | .023 | .036 | .011 |
| | 1.809 | 3.304 | .028 | .059 | 3.206 | .039 | .050 | .036 | .037 | .017 |
| | | 3.455 | .034 | .090 | 3.386 | .075 | 2.343 | .060 | .042 | .021 |
| | | 3.474 | .041 | 3.140 | 3.391 | .097 | | .115 | .057 | .032 |
| | | 3.481 | .053 | 3.220 | 3.503 | .114 | | 3.253 | 3.319 | .054 |

[1] *Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 or I:15 weight/volume dilution for ELISA.*

[2] *Moribund or fresh-dead fish.*

[3] *Normal, healthy appearing fish.*

Appendix Table A- 13. Continued.

| Date sampled | O4A[2] | O4B[2] | O4B[3] | O5A[2] | O5B[2] | O5B[3] | M6A[2] | M6B[2] | M6C[2] | M6C[3] |
|---|---|---|---|---|---|---|---|---|---|---|
| 11-95 | .060 | .017 | .010 | 3.378 | .026 | .025 | .147 | .107 | .076 | .031 |
| | .078 | 3.317 | .022 | | .965 | .029 | 3.278 | 3.129 | 3.388 | .037 |
| | 3.504 | 3.420 | .026 | | 3.502 | .042 | 3.484 | 3.465 | 3.410 | .489 |
| | 3.515 | 3.457 | .048 | | 3.579 | .048 | > 4.000 | 3.565 | 3.484 | 1.126 |
| | | 3.530 | .069 | | | .100 | > 4.000 | 3.603 | > 4.000 | 1.723 |
| 12-95 | 1.758 | 3.142 | .005 | .000 | .308 | .011 | 3.478 | .031 | 3.363 | .018 |
| | 3.119 | 3.355 | .011 | .952 | 3.266 | .018 | 3.479 | 3.397 | 3.368 | .020 |
| | 3.449 | 3.368 | .019 | 3.347 | 3.341 | .025 | 3.515 | 3.476 | 3.372 | .022 |
| | 3.474 | 3.555 | .019 | 3.518 | 3.466 | .043 | 3.538 | 3.569 | 3.444 | .041 |
| | 3.504 | | .074 | 3.593 | 3.498 | .048 | 3.634 | 3.617 | 3.554 | .086 |

Appendix Table A-14. Preliberation ELISA readings ($OD_{405}$) for *Renibacterium salmoninarum* of kidney samples' from 30 Umatilla 95 brood year summer steelhead juveniles from Michigan series M8 (A, B and C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish in M8B and M8C were sampled on 02-27-96 at a mean body weight of 69.9 gms/fish. M8A was sampled on 04-10-96 at a mean body weight of 85.7 gms/fish.

| Sample number | ELISA $OD_{405}$ | | |
|---|---|---|---|
| | M8A | M8B | M8C |
| **01** | .034 | .003 | .004 |
| 02 | .047 | .003 | .004 |
| 03 | .049 | .003 | .004 |
| 04 | .049 | .004 | .004 |
| 05 | .050 | .004 | .004 |
| 06 | .051 | .005 | .004 |
| 07 | .051 | .008 | .005 |
| 08 | .054 | .008 | .005 |
| 09 | .059 | .008 | .005 |
| 10 | .059 | .009 | .005 |
| 11 | .067 | .009 | .005 |
| 12 | .074 | .009 | .005 |
| 13 | .075 | .010 | .006 |
| 14 | .076 | .010 | .006 |
| 15 | .079 | .010 | .007 |
| 16 | .080 | .011 | .007 |
| 17 | .081 | .012 | .008 |
| 18 | .084 | .012 | .008 |
| 19 | .107 | .012 | .009 |
| 20 | .113 | .013 | .009 |
| 21 | .115 | .014 | .009 |
| 22 | .116 | .015 | .010 |
| 23 | .119 | .015 | .010 |
| 24 | .123 | .015 | .010 |
| 25 | .130 | .016 | .010 |
| 26 | .133 | .016 | .011 |
| 27 | .137 | .017 | .011 |
| 28 | .139 | .018 | .012 |
| 29 | .143 | .078 | .016 |
| 30 | .358 | .094 | .026 |
| Mean | .095 | .015 | .008 |
| Range | .034-.358 | .003-.094 | .004-.026 |

*'Kidney samples were homogenized in PBS-Tween 20 buffer at a I :7 weight/volume dilution for ELISA.*

Appendix Table A-15. Preliberation ELISA readings ($OD_{405}$) for *Renibacferium salmoninarum* of kidney samples[1] from 30 Priest Rapids 94 brood year fall chinook salmon juveniles per raceway, released as yearlings, from Michigan series M3 (A, B and C). Means and ranges for each raceway are shown below the 30 individual sample readings. Fish were sampled on 03-05-96[2] and 03-12-96 at a mean body weight of 87.3 gms/fish.

| Sample number | ELISA OD 405 | | |
|---|---|---|---|
| | M3A | M3B | M3C |
| 01 | .008 | .022[2] | .014[2] |
| 02 | .012 | .022[2] | .017[2] |
| 03 | .015[2] | .024 | .018[2] |
| 04 | .015 | .025[2] | .019[2] |
| 05 | .016[2] | .028[2] | .022 |
| 06 | .017[2] | .029 | .023[2] |
| 07 | .020[2] | .029 | .023 |
| 08 | .021 | .029 | .024[2] |
| 09 | .021[2] | .030[2] | .024[2] |
| 10 | .022 | .032 | .028 |
| 11 | .022 | .033 | .031 |
| 12 | .024 | .033 | .032[2] |
| 13 | .024[2] | .037 | .034[2] |
| 14 | .025[2] | .037 | .034 |
| 15 | .027[2] | .038 | .036 |
| 16 | .028[2] | .039 | .037 |
| 17 | .028 | .039 | .039 |
| 18 | .028 | .040 | .040[2] |
| 19 | .030 | .041 | .040 |
| 20 | .031 | .042[2] | .040 |
| 21 | .033 | .043[2] | .044 |
| 22 | .036[2] | .043 | .044 |
| 23 | .036 | .045[2] | .045 |
| 24 | .037 | .047 | .049 |
| 25 | .038 | .048[2] | .052 |
| 26 | .039 | .056 | .053 |
| 27 | .040 | .060[2] | .070 |
| 28 | .043 | .097 | .080 |
| 29 | .054 | .250 | .097 |
| 30 | .108 | 1.136 | .235 |
| Mean | .030 | .083 | .045 |
| Ranee | .008-.108 | .022-1.136 | .014-.235 |

*'Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution for ELISA.*

Appendix Table A-16. Preliberation ELISA readings ($OD_{405}$) for *Renibacferium salmoninarum* of kidney samples[1] from 30 Bonneville 94 brood year fall chinook salmon juveniles per raceway, released as yearlings, from raceways A3 and A9. Means and ranges for each raceway are shown below the 30 individual sample readings. Fish were sampled on 03-05-96 at a mean body weight of 59.4 gms/fish.

| Sample number | ELISA OD 405 | |
|---|---|---|
| | A3 | A9 |
| 01 | .007 | .010 |
| 02 | .012 | .011 |
| 03 | .013 | .011 |
| 04 | .014 | .013 |
| 05 | .014 | .014 |
| 06 | .015 | .015 |
| 07 | .015 | .017 |
| 08 | .015 | .017 |
| 09 | .016 | .017 |
| 10 | .016 | .019 |
| 11 | .017 | .020 |
| 12 | .017 | .021 |
| 13 | .017 | .021 |
| 14 | .018 | .022 |
| 15 | .019 | .022 |
| 16 | .019 | .024 |
| 17 | .021 | ,024 |
| 18 | .022 | .025 |
| 19 | .023 | .025 |
| 20 | .024 | .026 |
| 21 | .026 | .026 |
| 22 | .028 | .026 |
| 23 | .028 | .028 |
| 24 | .029 | .028 |
| 25 | .029 | .030 |
| 26 | .036 | .030 |
| 27 | .041 | .030 |
| 28 | .045 | .035 |
| 29 | .054 | .035 |
| 30 | .067 | .040 |
| Mean | ,024 | .023 |
| Range | .007-.067 | .010-.040 |

*'Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution for ELISA.*

Appendix Table A-17. Preliberation ELISA readings ($OD_{405}$) for *Renibacterium salmoninarum* of kidney samples[1] from 30 Priest Rapids 95 brood year fall chinook salmon juveniles, released as subyearlings, from Oregon series 02 (A and B) and 03 (A and B), and Michigan series M2 (A, B and C) and M3 (A, B and C). Means and ranges for each raceway are shown below the individual sample readings. Fish from four Oregon and six Michigan raceways were sampled on 05-08-96 at mean body weights of 6.8 gms/fish and 5.5 gms/fish, respectively.

| | ELISA $OD_{405}$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample number | 02A | 02B | 03A | 03B | M2A | M2B | M2C | M3A | M3B | M3C |
| 01 | .000 | .001 | .001 | .001 | .002 | .002 | .000 | .000 | .000 | .001 |
| 02 | .000 | .002 | .002 | .001 | .002 | .002 | .003 | .001 | .001 | .002 |
| 03 | .000 | .002 | .003 | .002 | .002 | .002 | .004 | .002 | .001 | .004 |
| 04 | .000 | .002 | .003 | .002 | .002 | .002 | .004 | .003 | .002 | .004 |
| 05 | .001 | .002 | .003 | .003 | .003 | .003 | .005 | .004 | .002 | .004 |
| 06 | .002 | .003 | .003 | .003 | .003 | .003 | .006 | .004 | .003 | .006 |
| 07 | .002 | .004 | .003 | .003 | .003 | .003 | .007 | .005 | .003 | .007 |
| 08 | .003 | .004 | .004 | .004 | .003 | .003 | .007 | .005 | .004 | .007 |
| 09 | .003 | .004 | ,004 | .004 | .004 | .003 | .008 | .006 | .004 | .008 |
| 10 | .003 | .004 | .004 | .005 | .005 | .004 | ,008 | .006 | ,005 | .008 |
| 11 | .004 | .005 | .005 | .005 | .005 | .004 | .008 | .006 | .005 | .008 |
| 12 | .006 | .006 | .005 | .006 | .005 | .004 | .009 | .007 | .005 | .010 |
| 13 | .006 | .007 | .005 | .006 | .007 | .005 | .009 | .007 | .006 | .010 |
| 14 | .006 | ,007 | .005 | .006 | .007 | .006 | .010 | .007 | .006 | .010 |
| 15 | .006 | .007 | .005 | .006 | .007 | .006 | .010 | .007 | .007 | .010 |
| 16 | .007 | .008 | .006 | .006 | .008 | .006 | .011 | .007 | .007 | .010 |
| 17 | .007 | .008 | .007 | .007 | .008 | .007 | .011 | .007 | .007 | .010 |
| 18 | .007 | .008 | .007 | .008 | .008 | .007 | .012 | .008 | .008 | .011 |
| 19 | .007 | ,008 | .007 | .009 | .008 | .007 | .012 | .008 | .008 | .011 |
| 20 | .007 | .009 | .007 | .009 | .009 | .009 | .012 | .008 | .009 | .012 |

*[1]Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:15 weight/volume dilution for ELISA.*

Appendix Table A- 17. Continued.

| Sample number | ELISA $OD_{405}$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 02A | 02B | 03A | 03B | M2A | M2B | M2C | M3A | M3B | M3C |
| 21 | .007 | .009 | .008 | .010 | .010 | .009 | ,013 | .008 | .009 | .012 |
| 22 | .007 | .009 | .008 | .011 | .010 | .010 | .013 | .008 | .010 | .013 |
| 23 | .008 | .009 | .009 | .011 | .010 | .010 | .013 | .008 | .010 | .013 |
| 24 | .008 | .010 | .010 | ,011 | .011 | .011 | .014 | .009 | .011 | .014 |
| 25 | .008 | .011 | .010 | ,012 | .012 | .012 | .015 | .010 | .012 | .015 |
| 26 | .009 | .012 | .010 | .013 | .012 | .012 | .016 | .010 | .014 | .015 |
| 27 | .009 | ,012 | .012 | .015 | .013 | .016 | .016 | .010 | .014 | .015 |
| 28 | .009 | ,015 | .012 | .016 | .013 | .017 | .017 | .010 | .016 | .016 |
| 29 | .009 | .016 | .014 | .016 | .014 | .018 | .017 | .013 | .021 | .018 |
| 30 | .010 | .023 | .016 | .020 | .014 | .019 | .021 | .016 | .033 | .020 |
| Mean | .005 | .008 | .007 | .008 | .007 | .007 | .010 | .007 | .008 | .010 |
| Range | .000-.010 | .001-.023 | .001-.016 | .001-.020 | .002-.014 | .002-.019 | .000-.021 | .000-.016 | .000-.033 | .001-.020 |

Appendix Table A-18. Preliberation ELISA readings ($OD_{405}$) for *Renibacterium salmoninarum* of kidney samples[1] from 30 Carson 94 brood year spring chinook salmon juveniles, released as yearlings, from Oregon series 04 (A and B) and 05 (A and B) and Michigan series M6 (A, B and C). Means and ranges for each raceway are shown below the individual sample readings. Fish from four Oregon and three Michigan raceways were sampled on 02-01-96 at mean body weights of 49.2 gms/fish and 44.4 gms/fish, respectively.

| Sample number | ELISA $OD_{405}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | 04A | 04B | 05A | O5B | M6A | M6B | M6C |
| 01 | .014 | .016 | .011 | .004 | .014 | .018 | .012 |
| 02 | .015 | .016 | .012 | .008 | .015 | .019 | .014 |
| 03 | .017 | .017 | .013 | .010 | .015 | .019 | .014 |
| 04 | .018 | .018 | .015 | .014 | .018 | .020 | .016 |
| 05 | .019 | .019 | .016 | .014 | .019 | .020 | .017 |
| 06 | .019 | .019 | .016 | .015 | .019 | .021 | .017 |
| 07 | .019 | .021 | .017 | .016 | .019 | .021 | .018 |
| 08 | .020 | .022 | .017 | .016 | .020 | .022 | .018 |
| 09 | .020 | .023 | .018 | .017 | .021 | .022 | .019 |
| 10 | .020 | .023 | .018 | ,018 | .022 | .023 | .019 |
| 11 | .020 | .025 | .019 | .018 | .022 | .023 | .021 |
| 12 | .020 | .025 | .019 | .018 | .023 | .024 | ,021 |
| 13 | .021 | .025 | .020 | .019 | .024 | .024 | .023 |
| 14 | .022 | .026 | .020 | .019 | .024 | .028 | .024 |
| 15 | .022 | .027 | .021 | .020 | .028 | .029 | .026 |
| 16 | .022 | .027 | .021 | .021 | .029 | .030 | .029 |
| 17 | .022 | .029 | .023 | .022 | .030 | .031 | .029 |
| 18 | .023 | .030 | .023 | .023 | .030 | .032 | ,029 |
| 19 | .023 | .031 | .026 | .023 | .031 | .033 | .032 |
| 20 | .023 | .036 | .026 | .025 | .031 | .034 | .033 |
| 21 | .026 | .037 | .026 | .025 | .033 | .035 | .033 |
| 22 | .027 | .038 | .028 | .026 | .033 | .038 | .033 |
| 23 | .027 | .039 | .030 | .026 | .038 | .038 | .036 |
| 24 | .028 | .042 | .031 | .027 | .044 | .040 | .040 |
| 25 | .030 | .056 | .033 | .033 | .060 | .044 | .040 |
| 26 | .035 | .056 | .039 | .039 | .073 | .044 | .068 |
| 27 | .036 | .074 | .042 | .041 | .074 | .055 | .198 |
| 28 | .036 | .080 | .054 | .042 | .145 | .056 | .784 |
| 29 | .044 | .168 | .149 | .047 | .291 | .120 | .859 |
| 30 | .045 | .329 | .273 | .065 | .726 | .123 | 1.454 |
| Mean | .024 | .047 | .036 | .024 | .066 | .036 | .133 |
| Range | .014-.045 | .016-.329 | .011-.273 | .004-.065 | .014-.726 | .018-.123 | .012-1.454 |

[1]*Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution for ELISA.*

Appendix Table A-19. Preliberation ELISA readings ($OD_{405}$) for ***Renibacterium salmoninarum*** of kidney samples[1] from 11 moribund/fresh-dead (Mt/Mb) and 20 grab-sampled (He) Carson 94 brood year spring chinook salmon juveniles, released as yearlings, from Imeques C-mem-ini-kern acclimation ponds. The fish were sampled on 03-12-96 and were reared at Umatilla Hatchery.

| Pond 1 | | Pond 2 | | Pond 3 | | Pond 4 | |
|---|---|---|---|---|---|---|---|
| Mt/Mb | He | Mt/Mb | He | Mt/Mb | He | Mt/Mb | He |
| .158 | .021 | 2.979 | .013 | .012 | .012 | .040 | .013 |
| 3.234 | .025 | 3.278 | .030 | .027 | .013 | .301 | .020 |
| | .040 | | .063 | | .022 | 2.281 | .022 |
| | .056 | | .077 | | .039 | 3.201 | ,036 |
| | .068 | | .256 | | .166 | 3.383 | .077 |

***[1]Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution for ELISA.***

Appendix Table A-20. Preliberation ELISA readings ($OD_{405}$) for ***Renibacterium salmoninarum*** of kidney samples[1] from 17 moribund/fresh-dead (Mt/Mb) and 20 grab-sampled (He) Priest Rapids 94 brood year fall chinook salmon juveniles, released as yearlings, from Imeques C-mem-ini-kern acclimation ponds. The fish were sampled on 04-10-96 and were reared at Umatilla Hatchery.

| Pond 1 | | Pond 2 | | Pond 3 | | Pond 4 | |
|---|---|---|---|---|---|---|---|
| Mt/Mb | He | Mt/Mb | He | Mt/Mb | He | Mt/Mb | He |
| .019 | .033 | .094 | .022 | .025 | ,024 | .019 | .012 |
| .050 | .052 | 2.501 | .044 | .032 | .027 | .023 | .018 |
| 1.220 | .071 | 2.813 | .047 | .036 | .027 | .024 | .020 |
| 2.684 | .198 | | .051 | .043 | .035 | .085 | .031 |
| | .421 | | 1.329 | .048 | .037 | 1.888 | .072 |

***[1]Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution for ELISA.***

Appendix Table A-21. Preliberation ELISA readings ($OD_{405}$) for ***Renibacterium*** *salmoninarum* of kidney samples[1] from 9 moribund/fresh-dead (Mt/Mb) and 10 grab-sampled (He) Bonneville 94 brood year fall chinook salmon juveniles, released as yearlings, from Thornhollow acclimation ponds. These fish were sampled on 04-02-96 and were reared at Bonneville Hatchery.

| Pond 1 | | Pond 2 | |
|---|---|---|---|
| Mt/Mb | He | Mt/Mb | He |
| .017 | .027 | .008 | .023 |
| .049 | .027 | .010 | .024 |
| .056 | .030 | .011 | .025 |
| | .032 | .018 | .044 |
| | .032 | .020 | .071 |
| | | .020 | |

***[1]Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:7 weight/volume dilution for ELISA.***

Appendix Table A-22. ELISA readings ($OD_{405}$) for ***Renibacterium safmoninarum*** of kidney samples' from 72 Umatilla summer steelhead adults spawned in 1996 for Umatilla Hatchery 96 brood year production.

| Sample number | ELISA $OD_{405}$ | Sample number | ELISA $OD_{405}$ |
|---|---|---|---|
| 01 | .006 | 37 | .028 |
| 02 | .006 | 38 | .028 |
| 03 | .007 | 39 | .028 |
| 04 | .008 | 40 | .031 |
| 05 | .008 | 41 | .032 |
| 06 | .008 | 42 | .037 |
| 07 | .009 | 43 | .037 |
| 08 | .012 | 44 | .037 |
| 09 | .013 | 45 | .037 |
| 10 | .013 | 46 | .038 |
| 11 | .013 | 47 | .038 |
| 12 | .013 | 48 | .039 |
| 13 | .015 | 49 | .039 |
| 14 | .016 | 50 | .040 |
| 15 | .016 | 51 | .042 |
| 16 | .016 | 52 | .043 |
| 17 | .017 | 53 | .043 |
| 18 | .018 | 54 | .044 |
| 19 | .019 | 55 | .045 |
| 20 | .019 | 56 | .046 |
| 21 | .019 | 57 | .048 |
| 22 | .020 | 58 | .048 |
| 23 | .020 | 59 | .049 |
| 24 | .021 | 60 | .049 |
| 25 | .021 | 61 | .050 |
| 26 | .021 | 62 | .050 |
| 27 | .023 | 63 | .053 |
| 28 | .023 | 64 | .055 |
| 29 | .024 | 65 | .055 |
| 30 | .024 | 66 | .056 |
| 31 | .025 | 67 | .060 |
| 32 | .025 | 68 | .069 |
| 33 | .026 | 69 | .098 |
| 34 | .026 | 70 | .111 |
| 35 | .028 | 71 | .113 |
| 36 | .028 | 72 | .167 |

***Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution for ELISA.***

Appendix Table A-23. ELISA readings ($OD_{405}$) for *Renibacterium safmoninarum* of kidney samples' from 15 Umatilla summer steelhead adult mortalities in 1996.

| Sample number | ELISA $OD_{405}$ |
|---|---|
| 01 | .013 |
| 02 | .014 |
| 03 | .018 |
| 04 | .024 |
| 05 | .026 |
| 06 | .028 |
| 07 | .031 |
| 08 | .034 |
| 09 | .036 |
| 10 | ,043 |
| 11 | .054 |
| 12 | .066 |
| 13 | .085 |
| 14 | .103 |
| 15 | .104 |

*'Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution for ELISA.*

Appendix Table A-24. Date and number of spawned adult summer steelhead sampled at Minthorn for culturable viruses in 1996 for Umatilla 96 brood year production. Culturable viruses were sampled for as individual ovarian fluid (OF) and milt (M) samples, and three-fish pooled pyloric caeca/kidney/spleen (PKS) samples. All samples were negative for infectious hematopoietic necrosis and other culturable viruses.

| Date Sampled | OF | M | PKS |
|---|---|---|---|
| 04-02-96 | 9 | 8 | 6 |
| 04-10-96 | 2 | 2 | 2 |
| 04-17-96 | 4 | 3 | 4 |
| 04-26-96 | 6 | 6 | 4 |
| 05-01-96 | 4 | 5 | 2 |
| 05-08-96 | 2 | 3 | 4 |
| 05-15-96 | 6 | 6 | 3 |
| 05-22-96 | 2 | 3 | 1 |
| 05-29-96 | 5 | 5 | 4 |

Appendix Table A-25. ELISA readings ($OD_{405}$) for *Renibacterium salmoninarum* of 80 kidney samples from Priest Rapids fall chinook salmon female adults spawned in 1995 for Umatilla Hatchery 95 brood year production.

| Date sampled | ELISA $OD_{405}$ | Date sampled | ELISA $OD_{405}$ |
|---|---|---|---|
| 11-09-95 | .000 | 11-13-95 | .006 |
| | .002 | | .007 |
| | .002 | | .008 |
| | .004 | | .008 |
| | .006 | | .008 |
| | .007 | | .009 |
| | .007 | | .009 |
| | .008 | | .009 |
| | .009 | | .010 |
| | .009 | | .010 |
| | .010 | | .011 |
| | .011 | | .012 |
| | .011 | | .013 |
| | .013 | | .013 |
| | .013 | | .014 |
| | .014 | | .017 |
| | .014 | | .017 |
| | .014 | | .017 |
| | .015 | | .028 |
| | .016 | | .029 |

*Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution for ELISA.*

Appendix Table A-25. Continued.

| Date sampled | ELISA $OD_{405}$ | Date sampled | ELISA $OD_{405}$ |
|---|---|---|---|
| 11-16-95 | .000 | 1 l-20-95 | .002 |
| | .000 | | .002 |
| | .000 | | .003 |
| | .000 | | .003 |
| | .002 | | .004 |
| | ,004 | | .004 |
| | ,005 | | .004 |
| | .005 | | .005 |
| | .005 | | .005 |
| | .005 | | .006 |
| | .005 | | .006 |
| | .006 | | .006 |
| | .006 | | .006 |
| | .006 | | .007 |
| | .006 | | .008 |
| | .006 | | .008 |
| | .006 | | .009 |
| | .007 | | .012 |
| | .007 | | .017 |
| | .009 | | .018 |

Appendix Table A-26. Date and number of samples from spawned adults sampled for culturable viruses from Priest Rapids fall chinook salmon spawned in 1995 for Umatilla Hatchery 95 brood year production. Culturable viruses were sampled for as either three-fish pooled' or individual' ovarian fluid (OF) and milt (M) samples, and three-fish pooled pyloric caeca/kidney/spleen (PKS) samples. All samples were negative for infectious hematopoietic necrosis and other culturable viruses.

| Date Sampled | OF | M | PKS |
|---|---|---|---|
| 1 l-09-95 | 20' | 20' | 20 |
| 11-13-95 | 20[1] | 20' | 0 |
| 11-16-95 | 20[2] | 20[2] | 0 |
| 1 l-20-95 | 20[2] | 20[2] | 0 |

Appendix Table A-27. Date and number of spawned females sampled for erythrocytic inclusion body syndrome (EIBS) during spawning of Priest Rapids fall chinook salmon spawned in 1995 for Umatilla Hatchery 95 brood year production. All were negative for EIBS inclusions.

| Date sampled | Number of fish sampled |
|---|---|
| 1 l-09-95 | 20 |
| 11-13-95 | 20 |
| 11-16-95 | 20 |
| 1 l-20-95 | 20 |

Appendix Table A-28'. ELISA readings ($OD_{405}$) for ***Renibacterium*** *salmoninarum* of 80 kidney samples from Carson spring chinook salmon female adults spawned at Little White Salmon NFH in 1996 for Umatilla Hatchery 96 brood year production.

| Date sampled | ELISA $OD_{405}$ | Date sampled | ELISA $OD_{405}$ |
|---|---|---|---|
| ***08-07-96*** | .065 | 08-14-96 | .061 |
| | .065 | | .062 |
| | .068 | | .063 |
| | .068 | | .065 |
| | .069 | | .067 |
| | .071 | | .067 |
| | .071 | | .069 |
| | .072 | | .070 |
| | .078 | | .071 |
| | .084 | | .074 |
| | .085 | | .074 |
| | .095 | | .074 |
| | .100 | | .076 |
| | .110 | | .077 |
| | .131 | | .079 |
| | .194 | | .080 |
| | .249 | | .082 |
| | .504 | | .086 |
| | 3.305 | | .796 |
| | 3.664 | | 2.824 |

[1] ***These analyses were done and data provided by the ODFW Corvallis Fish Pathology Laboratory.***
[2] *Kidney* ***samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution for ELISA.***

Appendix Table A-28. Continued.

| Date sampled | ELISA $OD_{405}$ | Date sampled | ELISA $OD_{405}$ |
|---|---|---|---|
| 08-21-96 | ,070 | 08-28-96 | .073 |
| | ,072 | | .073 |
| | .072 | | .073 |
| | .073 | | .074 |
| | .073 | | .075 |
| | .075 | | .075 |
| | .075 | | .076 |
| | .075 | | .076 |
| | .076 | | .076 |
| | .077 | | .076 |
| | .078 | | .078 |
| | .078 | | .079 |
| | .078 | | .079 |
| | .078 | | .081 |
| | .080 | | .097 |
| | .166 | | .098 |
| | .673 | | .114 |
| | 1.327 | | .138 |
| | 1.405 | | .179 |
| | 2.064 | | .776 |

Appendix Table A-29. Proportions and prevalences of infectious hematopoietic necrosis virus (IHNV) detected in individual ovarian fluid (OF) samples collected from Carson spring chinook salmon spawned at Little White Salmon NFH in 1996 for Umatilla Hatchery 96 brood year production.

| Date sampled | OF samples IHNV Positive Proportion (Prevalence %) |
|---|---|
| 08-07-96 | 0/20 (0%) |
| 08- 14-96 | 10/20 (50%) |
| 08-2 l-96 | 12/20 (60%) |
| 08-28-96 | 16/20 (80%) |

Appendix Table A-30. Date and number of spawned females sampled for erythrocytic inclusion body syndrome (EIBS) during spawning of Carson spring chinook salmon at Little White Salmon NFH in 1996 for Umatilla Hatchery 96 brood year production. All were negative for EIBS inclusions.

| Date sampled | Number of fish sampled |
|---|---|
| 08-07-96 | 20 |
| 08-14-96 | 20 |
| 08-2 l-96 | 20 |
| 08-28-96 | 20 |

Appendix Table A-31. ELISA readings ($OD_{405}$) for ***Renibacterium salmoninarum*** of kidney samples' from 23 carcasses of adult spring chinook salmon collected from the Umatilla River in 1996. These fish were sampled between September 9 and September 16, 1996 and were identified by hatchery of origin, either Bonneville or Umatilla, using coded-wire tag recovery data. All fish were identified as 92 brood year fish except for one fish from Bonneville which was a 91 brood year fish. Fish were sampled courtesy of fisheries personnel of the Confederated Tribes of the Umatilla Indian Reservation. For Umatilla Hatchery the type of rearing raceway, Oregon (OR) or Michigan (MI), is indicated.

| ELISA $OD_{405}$ | | |
|---|---|---|
| Bonneville Hatchery | Umatilla Hatchery | |
| | OR | MI |
| .014 | .009 | .070 |
| .016 | .043 | |
| .017 | .094 | |
| .020 | .122 | |
| .036[2] | .218 | |
| .051 | | |
| .054 | | |
| .064 | | |
| .068 | | |
| .075 | | |
| .082 | | |
| .082 | | |
| .083 | | |
| .087 | | |
| .114 | | |
| .147 | | |
| .147 | | |

[1]***Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution for ELISA..***
[2]***Identified as a 91 brood year-fish by coded-wire tag data.***

Appendix Table A-32. ELISA readings ($OD_{405}$) for ***Renibacterium*** *salmoninarum* of kidney samples' from 39 killed-not-spawned spring chinook salmon jacks collected from Three Mile Dam in 1996. These fish were collected between May 10 and June 26, 1996 and were identified by hatchery of origin, either Bonneville or Umatilla, or as a stray using coded-wire tag recovery data. All fish were identified as 93 brood year fish and were sampled courtesy of fisheries personnel of the Confederated Tribes of the Umatilla Indian Reservation. For Umatilla Hatchery the type of rearing raceway, Oregon (OR) or Michigan (MI), is indicated.

| ELISA $OD_{405}$ | | | |
|---|---|---|---|
| Bonneville Hatchery | Umatilla Hatchery | | Stray |
| | OR | MI | |
| .003 | .003 | .000 | .011 |
| .006 | .005 | .001 | .015 |
| .006 | .007 | .010 | .082 |
| .011 | .012 | .014 | |
| .012 | .013 | .015 | |
| .013 | .013 | .017 | |
| .014 | .013 | .017 | |
| .014 | .017 | .025 | |
| .018 | .022 | .029 | |
| .019 | .032 | | |
| .023 | .078 | | |
| .027 | | | |
| .030 | | | |
| .038 | | | |
| .051 | | | |
| .058 | | | |

***Kidney samples were homogenized in PBS-Tween 20 buffer at a 1:3 weight/volume dilution for ELISA.***