Commissioners:
MICHAEL DONEEN
T. JAMES DAVIS
LYNN M. HEMINGER

ORIGINAL

Chief Executive Officer/Manager:
WILLIAM C. DOBBINS

Public Utility District No.1 of Douglas County

1151 Valley Mall Parkway • East Wenatchee, Washington 98802-4497 • 509/884-7191 • FAX 509/884-0553

April 26, 2001

Mr. David P. Boergers
Federal Energy Regulatory Commission
888 1st Street N.E.
Washington, D.C. 20426

Subject: Wells Hydroelectric Project – FERC No. 2149-093 WA
Annual Report – Fish Settlement Agreement

Dear Mr. Boergers:

In accordance with paragraph E of the order approving the Settlement Agreement issued January 24, 1991, Public Utility District No. 1 of Douglas County submits the enclosed annual report of activities related to this Settlement Agreement. A copy of the January 24, 1991 order is enclosed for your reference.

As directed by the order the annual report addresses activities during the previous year. This annual report covers activities performed in 2000 and those planned for 2001.

Very truly yours,

Robert W. Clubb, Ph.D.
Chief of Environmental & Regulatory Services

js/Enclosure

c: (with report, but not appendices)
Mr. Ron Boyce
Mr. Tim Brewer
Mr. Brian Cates
Mr. Robert Dach
Mr. Mike Erho
Mr. Cary Feldmann
Mr. William Frymire
Mr. Harry Hall
Mr. Stuart Hammond
Mr. Robert Heinith
Mr. Brett Joseph
Mr. Jerry Marco
Mr. Richard Nason
Mr. Mark Quehrn
Mr. Nolan Shishido
Mr. Tim Weaver
Mr. Rod Woodin
Mr. Ron Wright
Mr. Jim Hastreiter
Mr. Garfield Jeffers

54 FERC ¶ 61,056

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Martin L. Allday, Chairman;
Charles A. Trabandt, Elizabeth Anne Moler,
Jerry J. Langdon and Branko Terzic.

Public Utility District No. 1 of Douglas County, Washington	))	Project No. 2149-002 Docket No. E-9569-002

ORDER APPROVING SETTLEMENT AGREEMENT

(Issued January 24, 1991)

This is the most recent of a series of settlement agreements that have emerged from our consolidated proceeding on anadromous fish issues on the mid-Columbia River in Washington State. Before us today is a comprehensive, uncontested, long-term settlement of such issues arising out of the operation of Wells Project No. 2149, located in Douglas and Okanogan Counties, Washington. We will approve the settlement, with clarifications and conditions that are consistent with our approval of related recent settlements.

BACKGROUND

In 1979, the Commission consolidated and set for hearing in Docket No. E-9569 a set of related petitions seeking modification of the operation of five licensed projects on the mid-Columbia River to protect and enhance salmon and steelhead trout. 1/ The petitions were filed by various state and federal fishery agencies and Indian tribes, and sought to protect anadromous fish migration downstream through project facilities. Wells Project No. 2149 was one of the five projects. The proceeding has generated a series of interim and long-term settlements. Most recently, the Commission approved long-term settlements resolving the Vernita Bar Phase (Priest Rapids Dam) of the proceeding, 2/ and issues involving Rock Island Project No. 943-002 (Chelan County). 3/ We also have had occasion to approve a settlement of fishery issues in Project No. 2149-017, a related proceeding

1/ 6 FERC ¶ 61,210 (1979).

2/ 45 FERC ¶ 61,401 (1988).

3/ 46 FERC ¶ 61,033 (1989).

involving the raising of the surface elevation of the reservoir. 4/

On October 30, 1990, the parties in the above-captioned proceeding filed an offer of settlement with the presiding administrative law judge. On November 19, 1990, the Commission's trial staff filed comments in support of the settlement. On December 4, 1990, the presiding administrative law judge certified the settlement and the staff's comments to the Commission for decision.

The parties to the settlement are Public Utility District No. 1 of Douglas County, Washington (the PUD); Puget Sound Power & Light Company, Pacific Power and Light Company, the Washington Water Power Company, and Portland General Electric Company (collectively, the Power Purchasers); and the Washington Department of Fisheries, the Washington Department of Wildlife, the Oregon Department of Fish and Wildlife, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the Confederated Tribes and Bands of the Yakima Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Confederated Tribes of the Colville Reservation (collectively, the Joint Fishery Parties).

As summarized by the trial staff in its comments, the settlement agreement provides for the following.

The agreement has a term from its execution date to the expiration of the license (2012) plus any annual licenses. During that time, the agreement is intended to satisfy the PUD's obligations under Article 41 of the license. The agreement is not subject to modification prior to March 1, 2004. There are procedures (discussed, in part, below) for the resolution of disputes.

The PUD has agreed to provide juvenile and adult fish passage and a hatchery program. The juvenile fish passage system will be a program of controlled spills using five bypass baffles. The agreement specifies criteria for the operation, timing, and performance of the bypass system. The adult passage system will use the existing fish ladder. Criteria are established for water depth over the weirs, entrance gate settings, and jet and trashrack operations.

The PUD's hatchery program is designed to mitigate fish passage losses at the Wells Project. The physical structures include adult collection sites, a central hatchery facility and acclimation facilities. The amount of compensation is to be

4/ 30 FERC ¶ 61,285 (1985).

determined by a formula using a five-year running average of adult runs by species. In 1991, the PUD will produce spring chinook yearlings, sockeye juveniles, and steelhead smolts. The production will then be evaluated and, based on those results, the PUD will either increase sockeye production or eliminate sockeye production and add production of summer chinook juveniles.

At completion of a project juvenile mortality/survival study, adjustment will be made to production levels, except for steelhead, to reflect the differences between the mortality rate developed in the study and the mortality rate assumed in developing the original production amounts. Adjustments will also be made to compensate for any unavoidable and unmitigated adult losses.

Once the five-year rolling average estimate of the juvenile run size reaches 110 percent of the estimated juvenile production used to establish the original production, the Joint Fisheries Parties can request a compensation increase in juvenile run size, except for steelhead.

The settlement also provides for continued studies and evaluations of the program. Studies will also be conducted on the potential unutilized habitat and on establishing sockeye in new habitat. The studies will be conducted under the direction of the Wells Project Coordinating Committee, which will be composed of one technical representative of each signatory to the agreement.

The Joint Fisheries Parties agree with the PUD that the Wells Project portion of the proceeding in Docket No. E-9569 should be terminated. These parties also agree to support the PUD when it requests relicensing of the project. The Joint Fisheries Parties further are of the view that the PUD's performance of its responsibilities under the agreement satisfies the PUD's fish protection and compensation obligations under the Federal Power Act and all other applicable laws and regulations.

In their offer of settlement, the parties indicate that it represents the culmination of two years of intensive negotiation, and that it "is intended to resolve, at least until March 1, 2004, the anadromous fish issues" pending in the proceeding.

The trial staff, in its comments supporting the settlement, requests that the Commission "make clear that the Commission's authority to require changes in structures and operations, should the need arise, is preserved" during the period when the settlement is not subject to modification. The trial staff also suggests adding certain reporting requirements to enable the

Commission to monitor compliance with the settlement. The trial staff does not propose modification of any of the substantive terms of the settlement, and no party opposes the settlement.

DISCUSSION

As we noted in approving an earlier settlement in this proceeding, 5/ the issues have been thoroughly ventilated and debated, and the settlement agreement is the result of a concerted effort to resolve these important matters in a way that is acceptable to all of the participants. We commend the participants for their efforts. We believe the settlement agreement is in the public interest, and we will adopt it. The agreement balances the continued operation of the project with an effective, long-term program for protection, mitigation, and enhancement of the fishery resources affected by the project.

We will clarify the dispute resolution provisions of the settlement agreement in the same manner as we did in our above-cited 1988 and 1989 orders approving related settlements. 6/ Section I.D. of the settlement agreement provides that, if the Wells Project Coordinating Committee cannot resolve a dispute among the signatories and if the amount in controversy is less than $325,000, then any party may request the Commission to refer the dispute to (1) the presiding judge in the mid-Columbia Proceeding, Docket No. E-9569, (2) the Commission's Chief Administrative Law Judge, or (3) the Division of Project Compliance and Administration, Office of Hydropower Licensing, "in the order listed," for expedited review. For the reasons stated in our prior orders, the Commission will in most cases refer such disputes to the Division of Project Compliance and Administration, and will use its best efforts to resolve such disputes within the time frames set forth in the agreement. In appropriate circumstances, such as when there are material facts in dispute, we may refer a matter to an administrative law judge. In either event, the initial staff decision will be subject to _de novo_ review by the Commission. And, as we emphasized in our 1989 order, any resolution by the Coordinating Committee, or a third party, pursuant to Section I.D. that contemplates a change in the license or in the operation of the project thereunder shall result in the filing of an appropriate application therefor by the licensee as soon as practicable after the dispute is resolved.

5/ _See_ 45 FERC at p. 62,259.

6/ _See_ 45 FERC at pp. 62,259-60 and 46 FERC at p. 61,197.

As we noted in our prior orders with respect to the settlements approved therein, 7/ approval of the settlement agreement does not affect the Commission's authority, as reserved in the license, to require, after notice and opportunity for hearing, alterations to project facilities or operations that may be warranted by changed circumstances. We intend that any such reserved authority would be exercised only after full consideration of the benefit sought to be achieved thereby, balanced against the possibility that as a consequence the settlement could be voided, thereby eliminating the benefits obtained thereunder. If any party voids the agreement, the licensee shall, within 30 days, so inform the Commission in writing.

Finally, we will adopt the reporting provisions proposed by the trial staff in its comments.

The Commission orders:

(A) The settlement agreement filed in this proceeding on December 4, 1990, is approved and made a part of the license for Wells Project No. 2149.

(B) The Wells Project No. 2149 portion of the proceeding in Docket No. E-9569 is terminated.

(C) The Commission's approval of the settlement agreement shall not constitute approval of, or precedent regarding, any principle or issue in these or any other proceedings.

(D)(1) Whenever a violation of the settlement agreement occurs, the licensee shall, within 30 days of the occurrence, file with the Commission, and send a copy to the Regional Office, a report containing an explanation of the circumstances surrounding the violation and the licensee's plan to avoid any repetition thereof.

(2) Whenever a dispute arises under Section I.D. of the settlement agreement that is resolved without referral to the Commission, the licensee shall, within 30 days, file with the Commission, and send a copy to the Regional Office, a report containing an explanation of the dispute and the nature of the resolution.

7/ See 45 FERC at p. 62,260 and 46 FERC at p. 61,198.

(E) The licensee: (a) shall notify the Commission and the Commission's Portland Regional Office of all meetings of the Coordinating Committee; (b) shall file functional design drawings, including all information required by 18 C.F.R. § 380.3, at least 90 days prior to construction of any facilities under the agreement; (c) shall file for approval all changes in monitoring, evaluation, study and production plans, not specified in the agreement; and (d) shall file an annual report. The annual report shall be filed on April 30 of each year and shall include:

(1) A description of plans developed during the previous year for any studies, evaluations, monitoring programs, production programs, system operations, or fish passage efforts;

(2) The results of all studies, evaluations and monitoring of the previous year;

(3) An outline of all actions taken towards fulfillment of the terms of the agreement;

(4) An explanation of the reasons for exercising specific alternatives stipulated in the agreement;

(5) A chronology of compliance for the previous year, outlining schedule changes, the reasons for the changes, and documentation that the Joint Agencies were consulted prior to implementation of the changes;

(6) A schedule of activities for the next year; and,

(7) Summaries or meeting minutes from each of the meetings of the Coordinating Committee for the previous year.

(F) This order is final unless a request for rehearing is filed within 30 days from the date of its issuance, as provided in Section 313(a) of the Federal Power Act. The filing of a request for rehearing does not operate as a stay of the effective date of this order or of any other date specified in this order, except as specifically ordered by the Commission. The licensee's failure to file a request for rehearing shall constitute acceptance of the order.

By the Commission.

(S E A L)

Lois D. Cashell,
Secretary.

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426

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Report to
the Federal Energy Regulatory Commission
of activities under the Long-Term Settlement Agreement
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County
for the 2000 calendar year

Wells Hydroelectric Project

F.E.R.C. Project No. 2149

Public Utility District No. 1
of Douglas County, Washington
1151 Valley Mall Parkway
East Wenatchee, WA 98802-4497

April 2001

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Foreword

On January 24, 1991, the Federal Energy Regulatory Commission approved a Settlement Agreement to resolve anadromous fish issues for the Wells Hydroelectric Project on the Columbia River in Washington State. The Agreement was a product of negotiations with state and federal fisheries agencies and tribes on the operations of the Wells Project (No. 2149). The F.E.R.C. directed that the licensee of the Wells Project has certain reporting responsibilities. This document is intended to fulfill portion (E)(d) of the Order requiring an annual report to be filed by April 30. This is the eleventh annual report under the Agreement and will cover the period between January 1 to December 31, 2000.

Report to
the Federal Energy Regulatory Commission
of activities under the Long-Term Settlement Agreement
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County
for the 2000 calendar year

(1) Development of Studies, Plans and Evaluations

The Public Utility District No. 1 of Douglas County (District) worked closely with fisheries agencies and tribes to carry out various studies and obligations specified in the Settlement Agreement. These included various monitoring studies and operation plans.

1.1 Annual Bypass System Operations Plan for 2000

The Settlement Agreement calls for the District to provide an Annual Bypass System Operational Plan to members of the Wells Coordinating Committee (WCC) by December each year. The District submitted the 2000 plan in November 1999 to the WCC for review. The spring and summer migrations of juvenile salmonids in the Columbia River are monitored by hydroacoustics along with in-turbine fyke netting at Wells Dam. The Annual Bypass System Operational Plan was approved for the 2000 season (Appendix A).

The Bypass Team decides on bypass operations at Wells during both spring and summer migration periods. Representatives from the agencies, tribes and District make up the team (Agreement II.F.3). Brian Cates (US Fish and Wildlife Service; USFWS), Jerry Marco (Colville Confederated Tribes; CCT) and Rick Klinge for the District (00-3) were the 2000 Bypass Team members.

1.2 Project Survival Studies

The Settlement Agreement specified that the District, in consultation with the Joint Fisheries Parties (JFP), will develop a study of juvenile survival associated with Wells Dam (Agreement IV,C,5). Results from this work would adjust compensation levels of the hatchery programs and determine the ultimate success of the juvenile bypass system. The District supplied plans for a 2000 study in 1999. The 2000 survival study plan was approved by the Committee in November 1999 (99-9). The plan called for a release of 30,000 PIT tagged steelhead at Pateros and 30,000 tagged steelhead immediately downstream of the Wells Dam tailrace (Appendix B)

Plans for a 2001 Chinook Survival Study were discussed that would assess reservoir survival rates for fish releases into the Methow and Okanogan rivers using summer chinook yearlings (00-1; Appendix C). The complexity of the holding and releases of the Okanogan River group required an extended lead time and early approval by the Committee. There was discussion whether or not summer chinook yearlings were an appropriate surrogate for spring chinook. A comparison of summer chinook yearling and spring chinook yearling survival through common river reaches showed no difference (00-1). Data from studies in the Snake River showed comparable survival estimates between steelhead and yearling chinook release groups. Data from Winthrop spring chinook and coho. Wells summer chinook and Wells steelhead also showed similar survival (00-02). There was discussion about survival studies beyond 2001. There was interest in seeing studies under as many different environmental conditions as possible (00-1). Douglas wanted to establish No Net Impact (NNI), a key element in the Wells Habitat

Conservation Plan, from the survival studies before 2003 (00-1). Also, there was discussion about the issue of cumulative effects from multiple dam passage that needed to be looked at (00-9). A study plan for a 2001 chinook survival study was approved by the WCC on February 25 (01-2). Further details of the chinook study were discussed in June (00-08).

Based on the results of the 2000 study, Bob Dach with National Marine Fisheries Service (NMFS) felt an additional study with either steelhead or yearling chinook was not needed for the Wells Project, but would rather see efforts concentrated on sub-yearling chinook and sockeye (00-10). While the 2001 study had Committee approval, Dach believed it would likely not contribute any meaningful information. A question arose about what difference would be needed in survival from the Okanogan River to Pateros in order for the average survival estimate for the project to below the negotiated HCP survival levels. It was demonstrated that survival would have to be nearly 25% less than fish traveling from the confluence of the Methow to below Wells Dam (00-10). In subsequent WCC meetings, it was again felt that a study in 2001 with yearling chinook was not needed. A sockeye study through the mid-Columbia reach was discussed. Project specific mortality could not be determined, as fish would not be released in a rigorous paired release-recapture design (treatment and control) (00-11; Appendix D). Rod Woodin with the Washington Department of Fish and Wildlife and Bob Dach expressed comfort that Wells Dam had demonstrated it could meet survival criterion developed through the HCP negotiations for yearling chinook and steelhead (00-11). Information to date seemed sufficient to meet both the HCP and Wells Settlement Agreement requirements (00-11). Additional testing on the Okanogan River with sockeye and subyearling chinook could be done in the future.

1.3 Adult Radio Telemetry Studies

An adult radio telemetry study in the lower river planned for 2000 would provide tagged steelhead adults that could be assessed during passage at mid-Columbia projects in 2000. It was uncertain that with the extensive juvenile tracking scheduled for 2000 that telemetry equipment would be free to set up in ladders for an adult study (00-1). Possibly, if not at the dams, some effort to track tags to spawning grounds could be made. It was determined that insufficient numbers of radio-tagged steelhead would show up at Wells to be worth the effort (00-3).

NMFS approached the District about a steelhead telemetry study for 2001 (00-10). There was discussion about availability of equipment during months when juvenile studies were being conducted. Also the need for planning so not to have code or frequency overlaps. There was discussion about the need to track radio tagged steelhead to the spawning grounds and follow kelts back to the Columbia River (00-12). A plan for a mid-Columbia adult steelhead telemetry study was being discussed at the end of the calendar year.

1.4 Okanagan Sockeye Habitat Study

Since 1998, the District has worked with the Okanagan Basin Technical Working Group (OBTWG) comprised of Federal, Provincial and First Nations fisheries managers to develop several options that could shift the District's sockeye mitigation to an ecosystem approach in BC. In a February 2000 letter to the District, the OBTWG outlined six measures to be funded in 2000 "to effectively boost sockeye production and meet requirements for a multi-species ecosystem approach over an extended period of time" (Appendix E). This letter was forwarded to the WCC for review. The Colville Tribes requested a much larger process in the mid-Columbia be pursued for sockeye that should include a hatchery component (00-2). The District suggested that the proposals submitted by the OBTWG represented measures that had the best likelihood of success. Continuation of operating the Cassimer Bar Hatchery Program in addition to the Canadian effort would in effect double the District's expense and mitigation obligation for sockeye. The Colville Tribes was not supportive of eliminating the Cassimer Bar Program to move to Canada (00-2). Additional information from the OBTWG was requested on spawning channel evaluation methods, and possible Canadian based hatcheries and or egg boxes. A meeting between the WCC and OBTWG was scheduled for April 5, 2000. At the meeting, the Canadian fisheries parties explained their position in pursuing the path outlined in their letter. The WCC was concerned about how the current program would be shifted into Canada and wanted to know what the District was proposing through a transition period. The District responded that it had no intentions of funding multiple paths to meet it's sockeye obligation; thus if a channel or other options were constructed, the program at Cassimer Bar would be phased out (00-5). There was discussion about the time frame of events. The District requested WCC support of the Canadian package to research six potential areas of activity to meet the mitigation responsibility for sockeye of the District. The WCC gave their support to the Canadian initiative, though they wanted to keep open as many options open as possible (00-7). There was concern that action in British Columbia to meet the District's sockeye obligation could trigger catch allocation formulas of the Pacific Salmon Treaty (00-11).

1.5 Okanogan Sockeye Pilot Program

Since 1991, there have been several strategies tried for replacing unavoidable losses of sockeye smolts at Wells Dam. Initially, fingerlings reared at Cassimer Bar Hatchery were released into the south basin of Osoyoos Lake. The Cassimer Bar program also released yearling sockeye into the lower Okanogan River and pre-smolts were released in the fall in Osoyoos Lake. Adult sampling over many years have yielded very few records of fish from these efforts. Because of the lack of success of the program (adults on the spawning grounds with the natural population), options have been pursued in British Columbia.

The District proposed to not collect sockeye broodstock in 2000 and to suspend sockeye activity at Cassimer Bar after the 1999 broodyear fingerlings have been released (00-2). The Colville Tribe was not supportive of this proposed action and felt a comprehensive sockeye effort needed to include a hatchery component. A broodstock protocol was developed by the Colville Tribes and distributed to the WCC (00-8). The proposal called for collecting 140 adult sockeye at Wells Dam in 2000 (Appendix F).

1.6 Spring Chinook Broodstock Collection Protocol

The Washington Department of Fish and Wildlife (WDFW) distributed their annual run forecast for 2000 (01-1). Forecasts for all salmon were much stronger than recent years. A broodstock collection document was circulated in March (Appendix G). In May, a conflict became evident between WDFW's Section 10 Permit and the Biological Opinion Issues for the Wells Dam Operations (00-07). The Section 10 Permit allowed for broodstock collection by passive trapping for 24 hours a day, three days a week; while the Biological Opinion allowed for active trapping for 16 hours a day, three days a week. WDF&W personnel had experienced some problems in the past when they trapped for less than 24 hours and then closed off the trap. Those problems were corrected which should allow for 16 hour trapping. Scale samples from spring chinook that have an adipose fin were inspected for hatchery patterns, possibly inferring an Entiat Hatchery fish. These fish were returned to the Columbia below Wells Dam. When the run did not materializing as predicted, additional trapping of spring chinook was proposed on the east ladder (00-06). The Columbia River Intertribal Fisheries Commission (CRITFC) and Yakama Nation (YN) were concerned, not so much with allowing additional trapping effort, but with the disposition of surplus broodstock from the Winthrop National Fish Hatchery. The Tribes wanted to see these fish spawn naturally in the Methow River. The WCC agreed with extending the trapping to add the east ladder, for three days per week, 16 hours a day and to extend the trapping period one week to July 5 (00-06).

1.7 Dissolved Gas Monitoring

The District used the identical system for reporting Total Dissolved Gas (TDG) for both the forebay and tailwater at Wells as the previous year. An automated system provided data on the hour to the Corps of Engineers. Early in the year, the system had communication problems with the Corps of Engineer's system (00-7).

1.8 Avian Predation

Because of concern about the impacts of bird predation on both steelhead and salmon, WDFW proposed to research means to relocate these bird populations (00-8). Information indicated that 10-20% of the mid-Columbia production was lost to terns (00-09). A new tern colony was also discovered at Potholes reservoir where numerous PIT-tags were recovered from mid-Columbia survival studies. There was discussion about the possibility of a mid-Columbia avian predation study. A proposal was submitted to the three PUD's for possible funding from Chris Thompson of WDFW (00-9). WDFW later decided to seek funding through the Salmon Recovery Board (00-10).

1.9 Bull Trout Study

A study to better understand movement and effect of large hydroelectric dams on migratory behavior of Bull Trout in the mid-Columbia was proposed for 2001 (00-09). Trapping of Bull Trout at Wells during spring chinook tapping was part of the study plan. With the forecast of large numbers of spring chinook returning to the Columbia in 2001, trapping of spring chinook broodstock would likely occur in the tributaries (00-12). Coordination of trapping Bull Trout for placement of radio tags would be worked out early in 2001. The bull trout study plan is included in Appendix H.

1.10 2001 Bypass Operational Plan

The District submitted to the WCC a Bypass Operational Plan for 2001, as per Section II.F.1 of the Settlement Agreement, on November 28, 2000. The plan outlined scheduled hatchery releases above Wells Dam and anticipated the starting and completion date of bypass operations (Appendix I).

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Operation of the Juvenile Bypass

Hydroacoustic sampling was started on March 15 to help collect background index levels of activity prior to the spring migration. The juvenile bypass was initiated on April 12 after a large number of hatchery released fish reached Wells Dam. Typically, hatchery managers who have fish rearing sites above Wells Dam will call the District as they release fish in the spring. This allows for initiation of bypass operations as the fish arrive at Wells. In 2000, one facility did not alert the District of their actions and the fish arrived without the benefit of the bypass. The following morning, when reviewing hydroacoustic information, it became evident that fish were at the project in large numbers. The bypass operations were started immediately. The juvenile bypass was operated for 63 days for the spring migration and 80 days for the summer migration. It was estimated the bypass operated during 96% of the juvenile migration. A total of 2.34 million acre feet (MAF) of water was used for operation of the bypass (Appendix J). In 2000, forced spill occurred during 6.0 % of the bypass operation.

2.2 Sockeye Pilot Program

Sockeye production from 1999 broodstock was held in the Cassimer Bar Hatchery at the beginning of the calendar year. The fish were selected from parents that had a low propensity for Bacterial Kidney Disease (BKD) (ELISA testing). There were 73,261 fish at 11 grams released into Osoyoos Lake from September 27 to 30, or a total of 1,800 pounds of production.

Collection of 2000 brood sockeye started on July 10 at Wells Dam with a collection goal of 140 adults. The entire brood goal was reached in two days of collection. The extremely strong returning run of Okanogan sockeye required very little time or effort to reach brood objective. There were 140,188 green eggs spawned from the program. Of these, 9,791 died before "eye-up" and 5,224 were transferred to NMFS for genetic analysis of the population. The balance of 125,203 was transferred to the Wells Hatchery to be placed on chilled water (39° F) until hatched and returned to Cassimer Bar Hatchery as fry after the calendar year.

2.3 Dissolved Gas Monitoring

Flows in the Columbia River from January through June of 2000 were at 97% of average at Grand Coulee Dam. Monitoring of total dissolved gas at Wells showed a range of 12-hour daily high values from 101.8% to 113.2% in the forebay and 102.2% to 125.4% in the tailrace (Appendix K). The operation of the bypass had little to no effect on TDG, even though 6.1% and 6.5% of the river was dedicated to bypass operations in the spring and summer respectively. Spill beyond bypass flow showed that there was approximately a 1% increase in tailwater TDG with every 4% of river that was spilled.

2.4 Spring Chinook Salmon Hatchery

The spring release of 1998 brood smolts was a total of 435,000 Methow River composite population released at 20 fpp and 179,000 Twisp River population released at 17 fpp. Total pounds of spring chinook released for this brood year was 32,280 pounds.

The 99 brood-year production by December 2000 had 180,878 fish at 14 fpp for the Methow Composite population and 67,702 fish at 17 fpp for the Twisp population. These fish will be released in the spring of 2001 from acclimation ponds in the Methow and Twisp. Discussions between NMFS and WDFW came to an agreement not to release fish from the composite population from the Chewuch ponds in 2001. There was concern with the high percentage of Carson stock parents that made up the '99 population (Memo from L. Brown 25 May 2000).

2000 year brood collection efforts at Wells Dam in June resulted in 291 adults and 42 jacks being collected (00-8). In addition 71 adults and 14 jacks with both adipose present fins and hatchery growth patterns scales were returned to the Columbia River below Wells Dam. Collection at Wells was suspended because of the large number of volunteers to both the State and Federal hatcheries in the Methow Basin (00-8). At the time of spawning, adults are killed and gametes are removed and held separately until the coded wire tag (CWT) could be removed and read. Gametes were retained at Methow only when corresponding CWT identify the fish as being from the Methow Composite population (combination of both Methow and Chewuch basin parents) or from the Twisp population. Also, adipose present adults that did not show a hatchery scale pattern were retained as part of the composite population. In 2000, 515,757 eggs were taken, of which 18,292 were lost from fertilization to "eye-up" and 229,806 were transferred to the Winthrop Hatchery, leaving 267,659 eggs on station. The average fecundity for the season was 3,500 eggs.

2.5 Survival Study

Information from the 1999 Steelhead Survival Study indicated that survival from Pateros to the Wells tailrace was 94.3%. Results from the 1998 study indicated that chinook survival was in excess of 99%. The 1999 study also showed that between 10 to 12% of the Wells steelhead production are subjected to tern predation on Rice Island in the lower Columbia River (00-7). Additional survival study steelhead were eaten by terns and gulls at other mid-Columbia and lower Columbia River bird colonies.

In the spring of 1999, the District conducted a side-by-side comparison of behavior and survival of radio-tagged and PIT tagged steelhead. The comparison was facilitated through the release of 269 radio tagged and 10,035 PIT tagged steelhead. The release site was located 42 miles upstream of Wells Dam in the Okanogan River. Radio tag survival from Crazy Rapids to the forebay of Rocky Reach Dam averaged 0.822. PIT tag survival from Crazy Rapids to the tailrace of Rocky Reach Dam averaged 0.878 (Appendix L). The radio-tag survival technique provides a considerable reduction in sample size over PIT-tag release recapture techniques. However, a lack of demonstrated precision, substantially higher study costs and a bias still impedes the application of radio-tag mark recapture technique at Wells Dam.

The 2000 survival study released steelhead during April and May. Fish traveled to McNary Dam in five days and to John Day Dam in seven days (00-7). The study called for 10 replicates with an additional five releases if fish were available. A high recovery rate at collector dams would help improve study precision (00-08). Because of a high rate of tag shed discovered in release groups 11 through 13, groups 14 and 15 were used to understand the tag shedding issue. Fish health through release group 10 was fine. Fish held later (groups 11-15) were emaciated and had very low fat levels. Subsequently, it was discovered that fish had not been fed for over 40 days (00-08). A final draft report was out at the end of the year (Appendix M).

2.6 1999 Adult Steelhead Ladder Passage Study

In 1999, the mid-Columbia PUD's funded research to follow passage of steelhead adults from below Priest Rapids Dam through the mid-Columbia projects and into tributaries. Tagging started on July 13 and continued through October. By November, 151 steelhead had passed Wells Dam with tracking into the Methow and Okanogan rivers. Radio tags provided information on reservoir and tributary movement well into the summer of 2000 (00-1, 00-7, 00-12). Median passage time for Wells Dam was 12 hours. Broodstock collection traps in ladders added 23 hours (35 hours total) to passage times at Wells (00-12). Karl English with LGL reported that steelhead were moving at a greater rate in the Columbia River that in the Fraser or Skeena systems in British Columbia (00-12). Fallback ranged from 1 to 3.5%. Of the fish detected at each of the mid-Columbia dams, 81% were observed on the spawning grounds. Tag duplication with the 2000 juvenile studies in the mid-Columbia complicated data interpretation particularly related to the assessment of steelhead kelting rates. (Appendix N).

2.7 East Ladder Trap Issues

The Columbia River Intertribal Fisheries Commission collected scales from sockeye at Wells Dam as a means to verify their scale analysis from sampling at Bonneville Dam. The Okanogan and Wenatchee populations migrate past Bonneville at the same time. Fresh water scale patterns between these two populations allow for stock separation. Part of the collection has been through broodstock for the Cassimer Bar Program. Dr. Jeff Fryer proposed to collect scales from 300 sockeye that were intercepted during sockeye and summer chinook broodstock efforts on the east ladder. The WCC approved the sampling of up to 300 adult sockeye for scales (WCC minutes July 11, 2000).

During the week of July 17 – 21, maintenance of the sorting paddle on the East Ladder Trap inadvertently left the paddle in a position that would route fish that were using the sorting flume into an empty live box. This caused a loss of 92 sockeye and 9 chinook jacks. There was discussion among the WCC how to assure that this would not occur again (00-9). While the operations at the dam have daily walk through of the ladders, there is no inspection of trapping facilities that are operated exclusively by State Fisheries personnel. Maintenance of the traps is performed by the mechanics at the dam. They will coordinate their maintenance activities with the hatchery staff to make sure trap operations will not harm fish.

2.8 2000 Pikeminnow Removal Program

Douglas PUD contracted to have Pikeminnow (*Ptychochelius oregonesis*) removed from the Wells tailrace and reservoir in 2000. Both long-line and sport gear were used. Between May 18 and September 30, there were 11,646 Pikeminnows over ten inches removed and 692 less than ten inches removed (Appendix O). The tailrace area had the highest catch per unit of effort (CPUE 3.09) followed by the lower reservoir (3.13) and Okanogan River (1.15).

(3) Outline of Action Taken Toward Fulfillment of the Settlement Agreement

3.1 Methow Spring Chinook Facility

The Settlement Agreement calls for a hatchery based compensation program for spring chinook composed of adult collection sites; a central hatchery facility for incubation, early rearing, and adult holding, and acclimation facilities for final rearing and release (Agreement IV). During 2000, hatchery personnel reared and released progeny from adults that returned in 1998.

The Settlement Agreement calls for evaluation of the hatchery program. Several aspects of the hatchery were evaluated.

3.2 Cassimer Bar Sockeye Hatchery

The Settlement Agreement calls for a pilot effort to culture Okanogan sockeye for three years at 8,000 pounds of production (IV.A.3.(a)(2)) with an evaluation to gauge the success of the program. Brood have been collected since 1993 at Wells Dam. Information on culture of sockeye at the Cassimer Bar facility was collected by the CCT.

3.3 Contract for Professional Services in Implementing the Settlement Agreement.

During 2000, the District contracted with Mike Erho to serve as chairman for the Wells Coordinating Committee. Mr. Erho also serves as chairman for the Mid-Columbia Coordinating Committee and Rock Island Coordinating Committee. The District also contracted with Dr. Skalski to provide statistical evaluation of methods and studies.

3.4 Juvenile and Adult Fish Passage Operations at Wells Dam

During 2000, the juvenile bypass system operated as per conditions outlined in the Settlement Agreement (II,C,D,and F). The bypass team recommended operations based upon information from hydroacoustics and fyke net samples at Wells.

The ladders operated during the year at the criteria established by the fisheries agencies and tribes (Agreement III. B; C; D; E; F). Annual maintenance was performed to both ladders outside of the fish passage times.

3.5 Steelhead Production at Wells Hatchery

The Settlement Agreement specified that the District will fund additional steelhead compensation of 30,000 pounds at 6 fish per pound after 1991 (IV.3.a), bringing the total obligation to 80,000 pounds. Records from the Wells Hatchery showed that 622,230 steelhead at 6 fish per pound or 102,632 pounds were liberated in 2000.

3.6 Other Actions Toward Fulfillment of the Settlement Agreement

The District funded evaluations and studies that are part of the District's responsibility in the Settlement Agreement. These were described in Sections 2 and 3.

(4) Explanation of Alternatives Chosen

4.1 Wells Ladder Operating Criteria

Information from telemetry studies of adult passage in 1992 and 1993 conducted by NMFS suggested a study to evaluate passage through the side entrance to both east and west fish ladders. In 1997,1998 and 1999 additional telemetry studies tested passage with the side gates opened and side gates closed to determine if there was a change in total project passage time between treatment and control side gate operations. Opened side gates showed a net loss of fish once they entered the attraction chamber of the fish ladders, thus increasing the total average passage time. Tests with summer chinook showed by closing the side gates at Wells, passage time was cut in half (00-8). A recommendation to modify ladder operations was presented to the JFP (Appendix P). There was discussion about the need for further evaluation of passage times. The WCC agreed to the change in ladder operations immediately and to discuss a follow-up evaluation in 2001 (00-8).

4.2 Sockeye Pilot Program

The District worked with the WCC and OBTWG to move the sockeye mitigation program currently at Cassimer Bar to British Columbia. The District believes that the highest probability of success to mitigate for unavoidable sockeye losses at Wells Dam lay with measures as close to the spawning area as possible. A workshop (April 5, Vancouver, BC) allowed the WCC to hear from Canadian fisheries parties about various research options to address sockeye mitigation in BC. A series of draft reports were provided to the WCC at the end of the year (Appendix S).

(5) Chronology of compliance for 2000

Items (3) and (4) above contain chronology of compliance in 2000. Documentation that the Joint Fisheries Parties were consulted prior to implementation of changes is provided in the minutes of the Wells Coordinating Committee. These records are included as Appendix Q.

(6) Schedule of Activities for 2001

The following schedule of activities is planned for 2001

Dec. (00)	Develop Annual Bypass System Operation Plan between District, Agencies and Tribes
January	Meeting with District, Agencies and Tribes on adult passage concerns
March 1	Annual Bypass System Operation Plan finalized
March 1	Determine Bypass Team members for bypass season
March 1	Develop Annual Passage Monitoring Plan between District, Agencies and Tribes
March 15	Begin monitoring juvenile migration via hydroacoustics
April 1	Bypass barriers in place
April 15	Anticipated start of the juvenile migration
May 1	Start collecting spring chinook broodstock at Wells Dam
October	Production Plan annual review between District, Agencies and Tribes
on going	Planning sockeye mitigative strategies
on going	Planning for operations and protocols of the Methow River Spring Chinook Facilities

(7) Minutes of Meetings

7.1 Minutes of the Wells Coordinating Committee for 2000

The Wells Project was removed from the mid-Columbia proceedings on January 24, 1991 as the Settlement Agreement between the fisheries agencies and tribes was approved by F.E.R.C. Minutes from the meetings of the WCC for 2000 are attached as Appendix Q.

Table of Appendices

Appendix P
Recommended Ladder Operating Criteria Wells Dam 2000

Appendix Q
Minutes of the Wells Coordinating Committee for 1999

Appendix R
2000 Membership list of the Wells Coordinating Committee

Appendix S
Okanagan Basin Technical Working Group Year 2000 draft reports

Appendix A

Annual Bypass Operation Plan, Year 2000

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 2000 Bypass Season

The Wells Long Term Settlement Agreement (II.F.1) specifies that Douglas PUD will submit an Annual Operations Plan for the bypass to the Wells Coordinating Committee by December prior to the spring migration. This plan will be reviewed and approved by the Committee by March 1.

The Bypass System
The PUD will install five bypass barriers in spill gates of the Wells Project. The bypass will operate per criteria in the Settlement Agreement (II.C, E).

Operation Criteria
The operation criteria includes operation of the bypass in partnership with adjacent turbine units, the amount of water required for bypass operation and criteria for full bypass system operation.

Bypass Operations Timing Criteria
The bypass will be in place from two weeks before predicted start of the migration until two weeks after the migration is complete.

Projected Hatchery Releases above Wells Dam
Estimated hatchery releases for 2000 above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	380	4/15
Methow (WDFW)	Spr. Chinook	450	4/15
Carlton (WDFW)	Sum. Chinook	206	4/15
Similkameen (WDFW)	Sum. Chinook	294	4/15
Wells (WDFW)	Sum. Steelhead	655	4/20
Winthrop (USFWS)	Sum. Steelhead	105	5/01
Winthrop (USFWS)	Coho	200	5/15
Cassimer Bar (CCT)	Sockeye	200	10/15

Starting Dates and Ending Dates
Bypass barriers will be in place between March 15 and September 15. Hydroacoustic sampling will start on March 15 and be collected until August 29. Fyke netting will be done between March 15 to either April 10 or the start of the Bypass, which ever occurs first and again from August 15 through 31.

The bypass team will decided the start and end of bypass operation. Hydroacoustics and fyke net information at Wells will be used to show the start and completion of the spring and summer migrations. Preseason dates for bypass operation for spring and summer migration are April 10 through May 30 and July 1 through August 15.

(3/22/00)

c :\Data Files\bypass\bypass00

Appendix B

Wells Dam Steelhead Survival Study Proposal, 2000

WELLS DAM STEELHEAD SURVIVAL STUDY 2000

STUDY PROPOSAL

Submitted: September 20, 1999

Modified: November 5, 1999

Shane Bickford
Fisheries Biologist
Public Utility District No. 1 of Douglas County

INTRODUCTION

The 1990 Wells Settlement Agreement and the proposed Wells Habitat Conservation Plan both require the Public Utility District No. 1 of Douglas County to conduct juvenile survival studies at the Wells Hydroelectric Project. The results of these studies will guide the implementation of future mitigative strategies for juvenile salmonids migrating through the Wells Project. The proposed Wells HCP agreement requires three years of survival studies to be conducted in order to determine the survival of plan species.

Results from the 1998 Wells survival study indicated that yearling hatchery chinook migrating from the mouth of the Methow River (Pateros) through and to 1,000 feet below Wells Dam averaged 0.997 ($\hat{SE} = 0.015$) in 1998 (Bickford et al., 1999a). A similar PIT-tag survival study was conducted in 1999 with yearling summer steelhead. The primary objective of the 1999 survival study was to estimate the relative survival of yearling steelhead smolts migrating from the mouth of the Methow River through and to 1,000 feet below Wells Dam. Steelhead survival averaged 0.943 ($\hat{SE} = 0.016$) in 1999 (Bickford et al., 1999b *Draft*).

The second objective of the 1999 survival study was to evaluate the feasibility of conducting paired PIT-tag survival studies in the Okanogan River. Problems encountered during 1999 included significant difficulty in handling and transporting fish to the Okanogan release site without incurring higher rates of pre-release stress relative to the Pateros and tailrace release groups. Sources of additional stress included longer transportation distances, different barge loading techniques and modified release protocols. Future survival studies in the Okanogan River will need to reduce these sources of bias. Particular issues to be addressed include improving river access, reducing pre-release stress, streamlining loading techniques and developing on-site acclimation prior to release. Additional challenges include modifying the existing transportation and release techniques at Pateros and in the tailrace to match those to be developed for the Okanogan River. This would include the development of on-site acclimation at all three release sites (Okanogan, Pateros and tailrace).

Unfortunately, construction of on-site acclimation sites at all three release locations cannot be competed in time for the survival study scheduled for 2000. Until on-site acclimation facilities can be established, the District proposes to study summer steelhead survival from the Methow River through and to the tailrace of Wells Dam. Estimates of survival generated from Pateros to the tailrace represent survival through the lower reservoir, forebay, Wells Dam and Wells tailrace for 100% of the naturally produced steelhead smolts and 85% of the composite (hatchery and natural) steelhead smolts passing Wells Dam. No weighting scenario is proposed for steelhead survival estimates generated from survival studies conducted in 2000.

Following the development of on-site acclimation in the summer of 2000, the District proposes to conduct a yearling chinook survival study in 2001. If the survival estimates from this study are sufficiently precise, the resultant survival estimates would be weighted at 75% Pateros/tailrace and 25% Okanogan/Pateros/Tailrace.

METHODS

Estimation Methodology

Survival estimates generated for the 2000 juvenile survival study will be based upon the single and paired single release-recapture model (Cormack, 1964; Jolly, 1965; Seber, 1965; Burnham et al., 1987). This particular release-recapture methodology has been successfully used to estimate project specific survival for juvenile chinook and steelhead passing through Snake and Mid-Columbia river dams. Chinook and steelhead survival studies based upon the Single release-recapture model were successfully implemented at the Wells Dam during the 1998 and 1999 spring outmigration (Bickford et al., 1999a; Bickford et al., 1999b *Draft*).

Collection, tagging, handling and release methodologies employed during the 2000 survival study will be identical to techniques utilized during the 1998 and 1999 survival studies. Steelhead smolts intended for tagging will be collected as they volitionally exit the earthen rearing ponds at the Wells Fish Hatchery. Collection efforts are anticipated to commence on April 20, 2000. Tagging will commence on April 24, 2000. Tagged fish will be released starting on April 26, 2000 and will be continue until at least May 14, 2000 (10 replicates). If additional steelhead continue to volitionally emigrate from the hatchery rearing ponds, the 2000 survival study will continue to mark and release fish until May 26, 2000 (15 replicates).

Precision Objectives

The primary objective of the 2000 survival study will be to estimate the survival of summer steelhead passing from the mouth of the Methow River to below Wells Dam at the specified precision level ± 0.05, 95% of the time (ie., $\varepsilon = 0.05$, $\alpha = 0.05$).

Sample Size

To accommodate the needs for this study, additional hatchery summer steelhead production was provided to compensate for the lost productivity associated with handling, tagging and release locations. These additional fish are being reared at the Wells Fish Hatchery. Goals of this study include the collection, tagging and release of at least 20,200 steelhead smolts at Pateros and 20,200 steelhead smolts in the Wells tailrace. Depending upon fish availability beyond May 14, 2000, up to 10,100 additional steelhead will be releases at each of the two release sites. At the Pateros and Wells tailrace release sites 10-15 replicate releases of PIT-tagged fish will take place. The study plan calls for a replicate release of fish at the primary release sites every other day until at least 10 replicates and as many as 15 replicate releases have been completed.

Study Animals

Yearling summer steelhead raised at the Wells Fish Hatchery (WFH) are the preferred stock for this study. Steelhead used for this study need to be representative of normal sized steelhead smolts. Steelhead less than 160 mm in fork length will not be tagged for use in the 2000 survival study to ensure that only migratory steelhead (smolts) are tagged. Steelhead smolts will be collected from the steelhead production at large as they volitionally exit the earthen rearing ponds at the WFH.

Tagging

Study animals will be PIT-tagged at the WFH facility. Tagging will take place in a manner similar to Bickford et al. (1999) and Prentice et al. (1987). ISO 134 kHz PIT-tags will be the utilized during the 2000 survival investigation.

Release Strategies

PIT-tagged fish will be released approximately 36 hours after being PIT-tagged at the Wells Fish Hatchery. Release sites and sample sizes for the proposed 2000 survival study can be found in Figure 1 and 2. The Methow and Wells tailrace release groups are referred to as the treatment and control (T & C) release groups, respectively. The treatment and control release groups will consist of 2,020 fish per replicate and between 10-15 replicates. The maximum number of steelhead released for the development of survival estimates through Wells Dam is 60,600 fish. To allow PIT-tagged fish to travel together through Wells Dam, the Pateros releases will occur 4-6 hours before the tailrace release group. Similar release strategies in 1998 and 1999 have resulted in almost identical passage distribution and timing at downstream dams.

Preliminary, release site and sample size information for a 2001 chinook survival study can be found in Figure 3.

SUMMARY

The 1990 Settlement Agreement and the proposed Wells HCP require Douglas County PUD to conduct survival studies on juvenile salmonid migrants passing through the Wells Hydroelectric Project. Results from survival studies in 1998 and 1999 indicate that PIT-tag survival studies are viable and accurate tools in assessing juvenile fish survival through Wells Dam. Hatchery steelhead migrants will be collected as they volitionally exit the earthen rearing ponds at the Wells Fish Hatchery. Tagging will take place at the Wells Fish Hatchery and fish will be released at one site above and one site below the dam. At least 40,400 and as many as 60,600 PIT-tagged steelhead will be released at two locations in order to estimate survival from Pateros to 1,000 feet below Wells.

Survival estimates generated from the 2000 steelhead survival study are expected to have a precision level of $\pm$ 0.05, 95% of the time (ie., $\varepsilon = 0.05$, $\alpha = 0.05$). Information related to the physiology and travel time of Wells Fish Hatchery steelhead will also be generated from this study.

The District's intent is to conduct a chinook survival study in 2001. The 2001 yearling chinook survival study will assess survival from Okanogan to Pateros and from Pateros to the Wells tailrace. On-site acclimation will be utilized to ensure that pre-release handling conditions are equalized for all three release locations proposed for study in 2001.

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Figure 1 : Steelhead release sites, 2000.

Minimum Sample Size = 40,400 fish

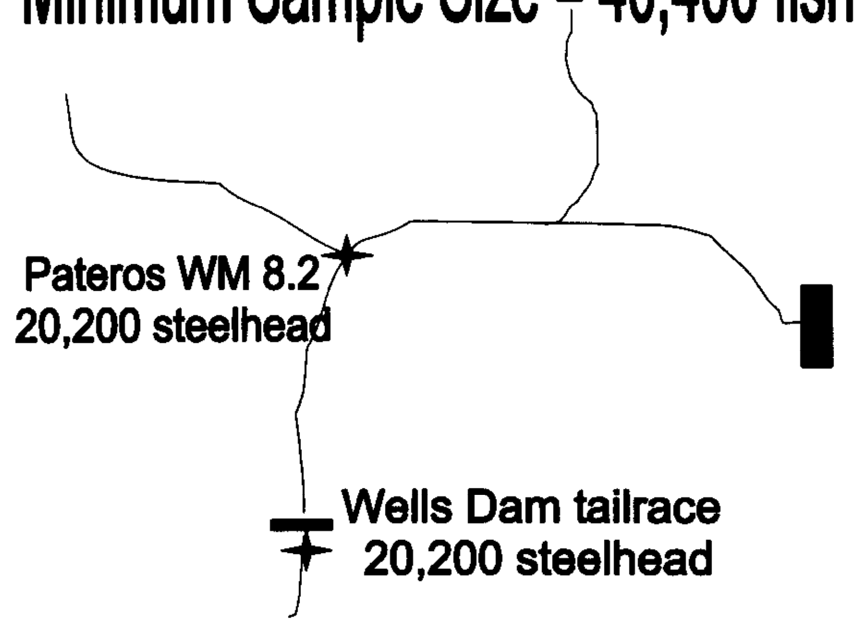


Figure 2 : Steelhead release sites, 2000.

Maximum Sample Size = 60,600 fish

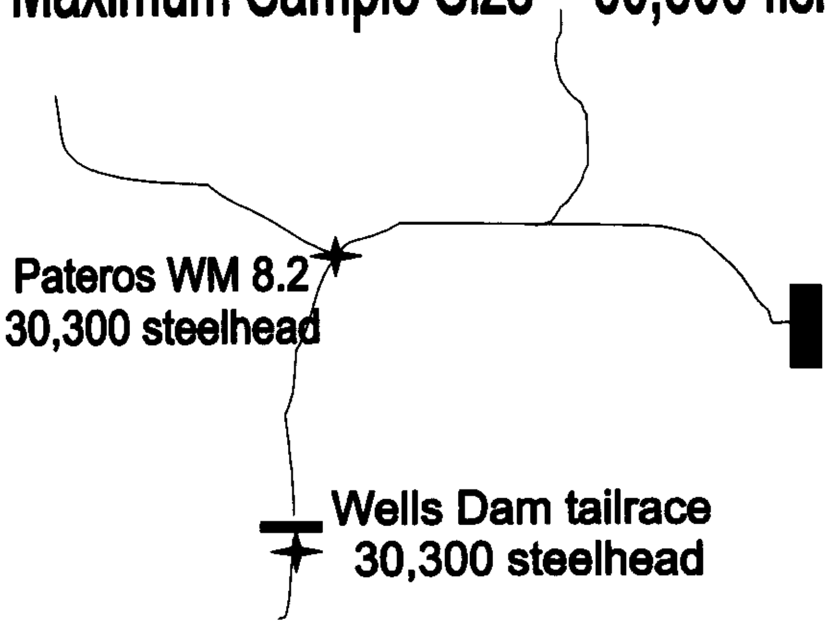
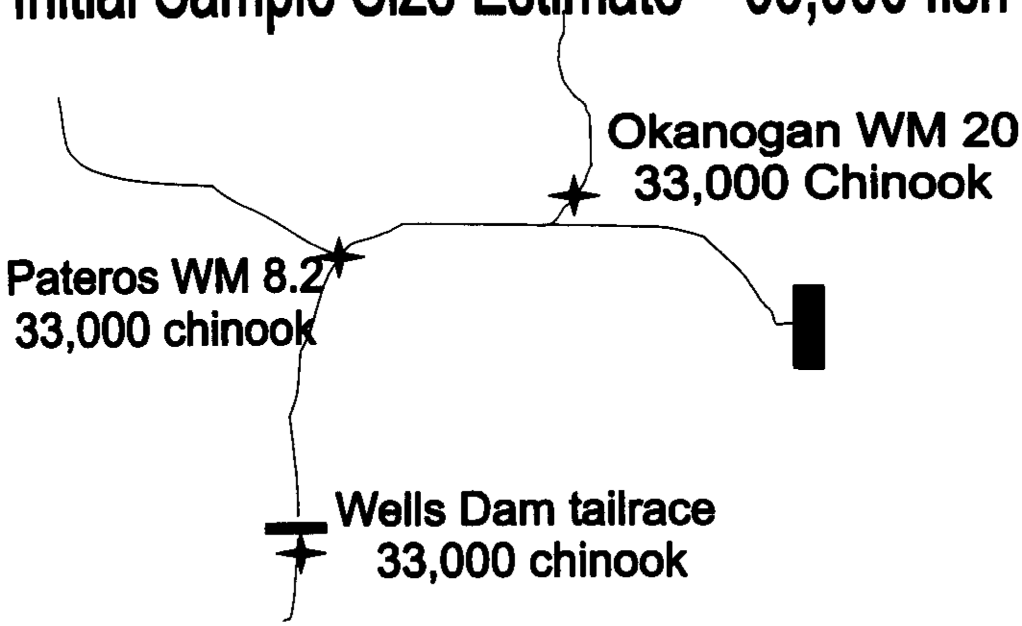


Figure 3 : Chinook release sites, 2001.

Initial Sample Size Estimate = 99,000 fish



Appendix C

Wells Dam Chinook Survival Study Proposal, 2001

WELLS DAM CHINOOK SURVIVAL STUDY
2001

STUDY PROPOSAL

Submitted: January 25, 2000
Modified: February 15, 2000
Approved: February 25, 2000

Shane Bickford
Fisheries Biologist
Public Utility District No. 1 of Douglas County

INTRODUCTION

The 1990 Wells Settlement Agreement and the proposed Wells Habitat Conservation Plan both require the Public Utility District No. 1 of Douglas County to conduct juvenile survival studies at the Wells Hydroelectric Project. The results of these studies will guide the implementation of future mitigative strategies for juvenile salmonids migrating through the Wells Project.

Results from the 1998 Wells survival study indicated that yearling hatchery chinook migrating from the mouth of the Methow River (Pateros) through and to 1,000 feet below Wells Dam averaged 0.997 ($\hat{SE} = 0.015$) in 1998 (Bickford et al., 1999). A similar PIT-tag survival study was conducted in 1999 with yearling summer steelhead. Steelhead survival averaged 0.943 ($\hat{SE} = 0.016$) in 1999 (Bickford et al., 2000). A second steelhead survival study will be conducted at Wells Dam in the spring of 2000.

In addition to these three survival studies, the District is proposing a forth survival study. The proposed 2001 survival study would attempt to assess the survival of yearling chinook migrating from the Okanogan River to Pateros and from Pateros to the tailrace of Wells Dam. A third component of survival, from Okanogan to the tailrace of Wells Dam, may also be generated from data collected during 2001.

The 2001 survival study is being proposed early so that the District may properly prepare acclimation and release facilities prior to the spring of 2001. The sooner the 2001 study plan can be approved the higher the probability of success.

An important element of the 2001 survival study plan is the need for component survival estimates to be weighted according to the proportion of yearling chinook produced in the Okanogan and Methow river drainages. If the survival estimates from this study are sufficiently precise, the component survival estimates would be weighted at 75% (Pateros-Tailrace) and 25% (Okanogan-Pateros-x-Pateros-Tailrace). Justification for the chinook production ratios can be found in Table 1.

The Okanogan-Tailrace survival estimate, if sufficiently precise, could be substituted for the (Okanogan-Pateros-x-Pateros-Tailrace) survival estimate for use in the weighting schedule.

METHODS

Study Animals

Yearling summer chinook raised at the Wells Fish Hatchery (WFH) are the preferred stock for this study. Chinook smolts will be collected and PIT-tagged in March and will be held in multiple concrete raceways until they are ready for transport to final release and acclimation facilities.

Estimation Methodology

Survival estimates generated for the 2001 juvenile survival study will be based upon the single release-recapture and the paired release-recapture models (Cormack, 1964; Jolly, 1965; Seber, 1965; Burnham et al., 1987). This particular release-recapture methodology has been successfully used to estimate project specific survival for juvenile chinook and steelhead passing through Snake and Mid-Columbia river dams. More specifically, chinook and steelhead survival studies, based upon the paired single release-recapture model, were successfully implemented at Wells Dam during 1998 and 1999 (Bickford et al., 1999; Bickford et al., 2000 *Draft*).

Precision Objectives

The primary objective of the 2001 survival study will be to estimate the survival of yearling chinook passing from the mouth of the Methow River to below Wells Dam and from the Okanogan River to Pateros at the specified precision level ± 0.05, 95% of the time (ie., $\varepsilon = 0.05$, $\alpha = 0.05$).

The secondary objective of the 2001 survival study will be to estimate, pending validation of all release-recapture assumptions, chinook survival from the Okanogan River to below Wells Dam at the specified precision level ± 0.05, 95% of the time (ie., $\varepsilon = 0.05$, $\alpha = 0.05$).

Sample Size

To accommodate the needs for this study, additional hatchery yearling chinook production will be provided at the Wells Fish Hatchery to compensate for losses resulting from the handling, tagging and release of fish during this study. Goals of this study include the collection, tagging and release of 33,000 chinook smolts at Pateros, 33,000 chinook smolts in the Wells tailrace and 33,000 chinook smolts in the Okanogan River. The study plan calls for a replicate release of fish at the three primary release sites every other day until 10 replicate releases have been completed (Figure 1).

Tagging

Study animals destine for the three release sites will be tagged at the WFH. Fish collection, tagging, recovery and releases will take place in a manner similar to Bickford et al. (1999) and Prentice et al. (1987). ISO 134 kHz PIT-tags will be the utilized during the 2001 survival investigation. Tagging will take place in March 2001.

Release Strategies

Release sites and sample sizes for the proposed 2001 survival study can be found in Figure 2 and Figure 3. Each of the ten replicate release groups at each release site will contain approximately 3,300 fish. The maximum number of chinook released for the development of component survival estimates through Wells Dam will be 99,000 fish.

Release Strategy: Okanogan
Day #1 - Fish collected and transported to release site (50 minute trip).
Day #2 - Fish allowed to recovery (46-hours) after transportation.
Day #3 - Continue recovery process.
Day #4 - Fish released.
Day #5 - *Okanogan fish swim to Pateros in time for Pateros release.*

Release Strategy: Pateros
Day #2 - Fish collected and transported to release site (50 minute trip).
Day #3 - Fish allowed to recover (46-hours) after transportation.
Day #4 - Continue recovery process.
Day #5 - Fish released.
Day #6 - *Pateros fish swim to tailrace in time for tailrace release.*

Release Strategy: Tailrace
Day #3 - Fish collected and transported to release site (50 minute trip).
Day #4 - Fish allowed to recover (46-hours) after transportation.
Day #5 - Continue recovery process.
Day #6 - Fish released.

SUMMARY

The 1990 Settlement Agreement and the proposed Wells HCP require Douglas County PUD to conduct survival studies on juvenile salmonid migrating through the Wells Hydroelectric Project. Results from survival studies in 1998 and 1999 indicate that PIT-tag survival studies are viable and accurate tools in assessing juvenile fish survival through Wells Dam. Hatchery chinook will be collected and PIT-tagged at the Wells Fish Hatchery prior to the beginning of the study. Tagging will take place at the Wells Fish Hatchery. PIT-tagged fish will be released at two sites above and one site below Wells Dam. As many as 99,000 PIT-tagged chinook will be released in order to estimate survival from the Okanogan River to Pateros, from Pateros to 1,000 feet below Wells. Additionally, a survival estimate from the Okanogan River to the tailrace of Wells Dam may also be estimated from fish released during this study.

Survival estimates generated from the 2001 chinook survival study are expected to have a precision level of $\pm$ 0.05, 95% of the time (ie., $\varepsilon = 0.05$, $\alpha = 0.05$). Information related to the physiology and travel time of Wells Fish Hatchery chinook will also be collected from PIT-tagged chinook in 2001.

Figure 1. Number of replicate release groups of specified release sizes required to meet precision requirements for a 2001 chinook survival study. Scenarios represent observed capture rates for PIT-tagged chinook released in 1998 (worst) and 1999 (best).

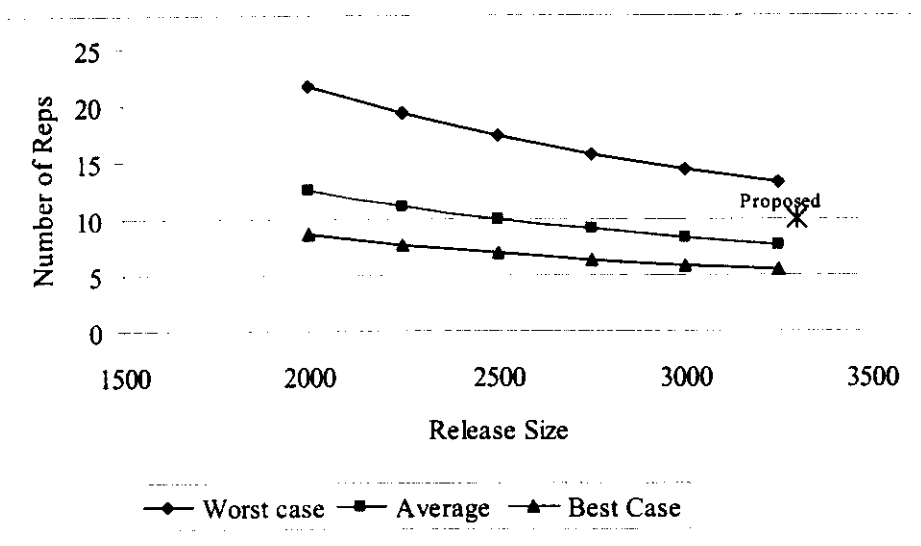


Figure 2. Schematic of release sites and PIT-tag detection facilities used for the 2001 Wells Dam Survival Study (Parameters that will be estimated from the release-recapture data are indicated).

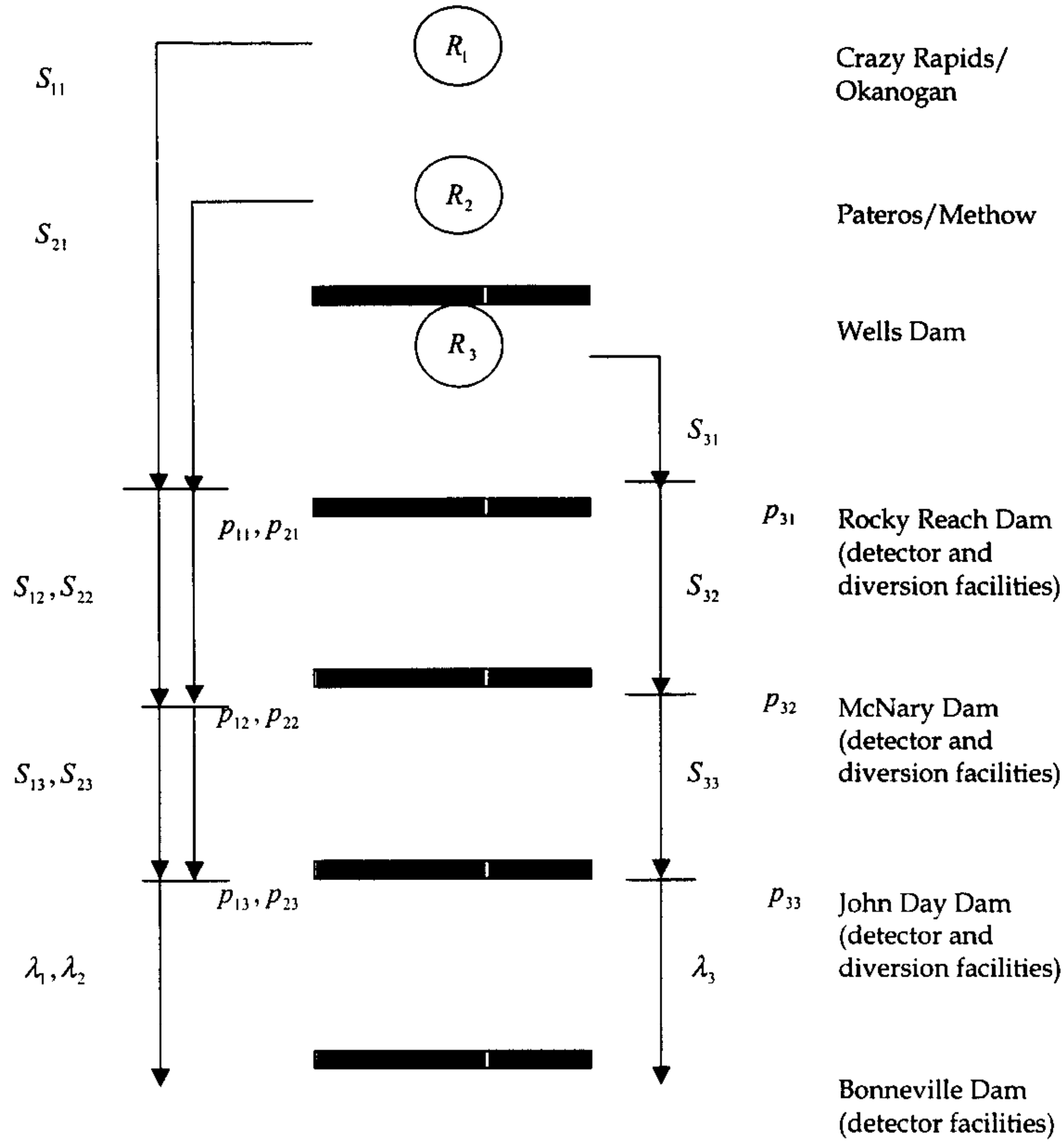


Figure 3: Wells Chinook Survival Study, 2001

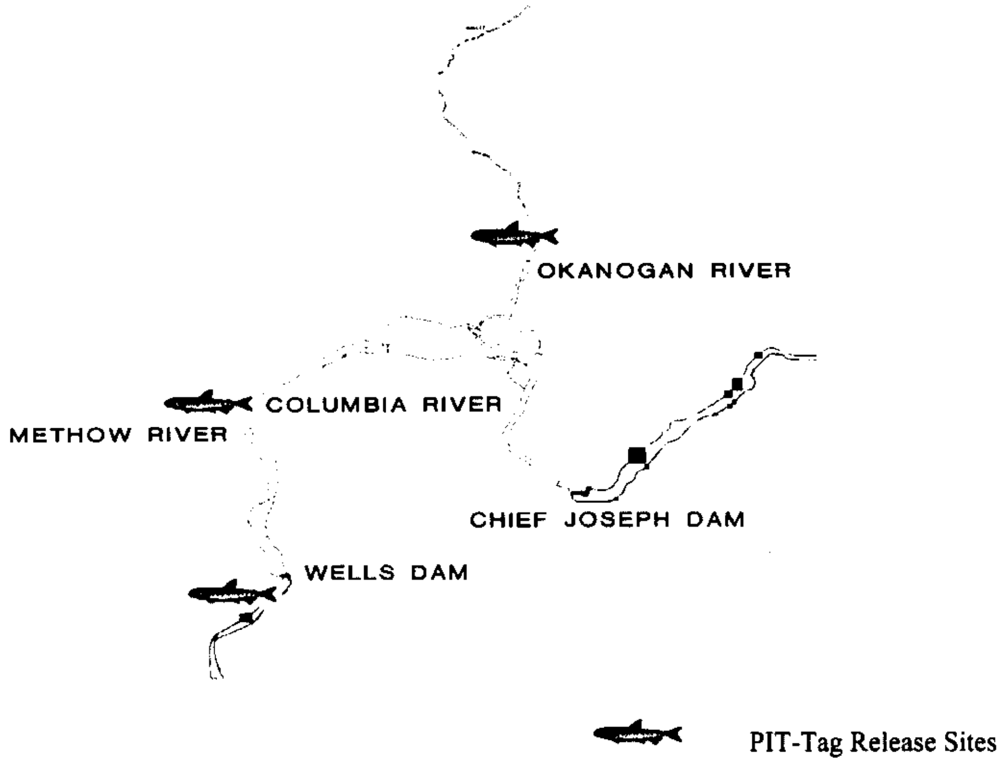


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Table 1: Production calculation for yearling chinook upstream of Wells Dam.

Methow Yearling Chinook 1998 run-sizes		
Winthrop National Fish Hatchery		320,000
Carlton Acclimation Pond		400,000
Methow Fish Hatchery		371,306
SUB-TOTAL		1,090,306
Wild yearling chinook	(LaVoy, 1995)	279,400
SUB-TOTAL		1,369,706
Okanogan Yearling Chinook 1998 run-sizes		
Similkameen Acclimation Pond		450,000
Wild Yearling Chinook	Assumed	0
SUB-TOTAL		450,000
GRAND TOTAL		1,820,706

Percentage Yearling Chinook originating from Okanogan - (0.2472) ~ 25%*

* Based upon 1998 hatchery planting records, production estimates in Mullan et al. (1992), Chapman et al. (1995) and LaVoy (1995) a 25% weighting for Okanogan River chinook can be supported. Table 1 represents the numbers of yearling hatchery fish planted into the Methow and Okanogan river systems in 1998. Estimates of natural spring chinook production in the Methow River were derived by taking the 25 year average (1975 – 1994) number of natural spring chinook adults produced by the Methow River (1,397) and dividing this number by the average observed smolt-to-adult survival (0.005) (LaVoy, 1995). From this, an estimate of the average number of natural spring chinook smolts can be derived (279,400).

Appendix D

Comparative Survival Study Upper Columbia River 2001, Draft Proposal

COMPARATIVE SURVIVAL STUDY
UPPER COLUMBIA RIVER
2001

DRAFT

STUDY PROPOSAL

Prepared: September 20, 2000
Submitted: September 25, 2000
Modified: September 27, 2000
Terminated: November 1, 2000

Shane Bickford
Fisheries Biologist
Public Utility District No. 1 of Douglas County

INTRODUCTION

The Public Utility District No. 1 of Douglas County has completed three years of precise survival studies at the Wells Hydroelectric Project. Results from the 1998, 1999 and 2000 survival studies indicate that yearling chinook and steelhead survival through the Wells pool and dam is sufficiently high to meet the No Net Impact conditions of the proposed Wells Habitat Conservation Plan.

Survival for yearling chinook migrating from the mouth of the Methow River (Pateros) through and to 1,000 feet below Wells Dam averaged 0.997 ($S\hat{E} = 0.015$) in 1998 (Bickford et al., 1999). Similar PIT-tag survival studies were conducted in 1999 and 2000 with yearling summer steelhead. Steelhead survival averaged 0.943 ($S\hat{E} = 0.016$) in 1999 and 0.946 ($S\hat{E} = 0.015$) in 2000 (Bickford et al., 2000a; Bickford et al.2000b *Draft*).

Survival estimate from Douglas and Fish Passage Center PIT-tag release groups were compiled and compared to determine if significant differences in survival exist between stocks and between release years. Survival for yearling spring chinook, yearling summer chinook, yearling Methow run-of-river chinook, yearling steelhead and yearling coho have been assessed through a common section of river (Rocky Reach to McNary) (Table 1). To date, survival through this section of river has been very consistent between-stocks and between-years studied.

Based upon the results of Wells project and Mid-Columbia reach survival studies, the Wells Coordinating Committee has initiated discussion related to future survival studies at Wells Dam. The Wells Coodinating Committee approved a 2001 project survival study with yearling summer chinook during the spring of 2000. However based upon the results collected to date (1998-2000), additional yearling chinook project survival studies may not be required at the Wells Project. Instead, uncertainty associated with sockeye survival could be reduced through a single site release of yearling sockeye at Zosel Dam. Surrogacy survival studies would focus on comparing the relative reach survival of yearling spring and summer chinook and yearling coho with the reach survival of wild yearling sockeye.

Table 1. Summary of reach survival estimates from Rocky Reach tailrace to McNary Dam. Weighted averages reported for yearling chinook, steelhead and coho for the years 1998-2000.

Species	Source	Year	$\hat{\hat{S}}$	$\hat{SE}\left(\hat{\hat{S}}\right)$	95% C.I.
Steelhead	Douglas Hatchery	1999	0.686	0.010	0.666 – 0.706
Steelhead	Douglas Hatchery	2000	0.656	0.011	0.634 – 0.678
Summer-Spring Mixed Chinook	Douglas run-of-river	1998	0.720	0.084	0.555 – 0.885
Summer Chinook	Douglas Hatchery	1998	0.659	0.040	0.581 – 0.737
Coho	Winthrop Hatchery	2000	0.715	0.123	0.474 – 0.956
Summer Chinook	Douglas Hatchery	2000	0.731	0.063	0.608 – 0.854
Spring Chinook	Winthrop Hatchery	1998	0.720	0.091	0.542 – 0.898
Spring Chinook	Winthrop Hatchery	1999	0.727	0.053	0.623 – 0.831
Spring Chinook	Winthrop Hatchery	2000	0.692	0.088	0.520 – 0.864

METHODS

Estimation Methodology

Comparative survival estimates generated from the proposed 2001 juvenile survival study would be based upon the Single release-recapture model (Cormack, 1964; Jolly, 1965; Seber, 1965; Burnham et al., 1987). This particular release-recapture methodology has been successfully used to precisely estimate survival for juvenile chinook, steelhead and coho passing through Snake and Mid-Columbia river dams. Chinook and steelhead survival studies based upon the Single release-recapture model were successfully implemented at Wells Dam during the spring of 1998, 1999 and 2000 (Bickford et al., 1999; Bickford et al., 2000; Bickford et al. 2000b *Draft*). Results from these studies indicate that survival through Wells Dam is consistently high for yearling chinook and steelhead.

Precision Objectives

The primary objective of the proposed 2001 comparison studies would be to estimate the survival of various surrogate stocks of fish passing from the Tailrace of Rocky Reach to the tailrace of McNary Dam at the minimum specified precision level ± 0.05, 90% of the time (i.e., $\varepsilon = 0.05$, $\alpha = 0.10$).

Sample Size

To accommodate the needs for the original 2001 yearling project survival study, additional yearling chinook were raised at the Wells Fish Hatchery to compensate for the lost productivity associated with handling, tagging and release of hatchery fish. Goals of the proposed comparison studies include the collection, tagging and release of multiple groups of yearling chinook and sockeye in order to compare survival through a common section of river. Anticipated sample size requirements vary between stocks based upon anticipated capture and survival rates at downstream dams. A summary of preliminary species-specific sample size estimates can be found in Table 2.

Table 2. Sample size estimates for different stocks of fish migrating through the Mid-Columbia River in 2001.

Species	*Age*	*Origin*	*Preliminary Replicate Size*	*Replicate (Range)*	*Total Fish*	*Reach Survival Comparison*
Su. Chinook	Yearling	WFH	3,000	5 -10	15K - 30K	RRHt to MCNt
Sockeye	Yearling	Wild	2,000-4,000	7 - 10	14K - 40K	RRHt to MCNt
Sp. Chinook*	Yearling	WNFH	2,500	3	7.5K	RRHt to MCNt
Coho**	Yearling	WNFH	2,000	4	8K	RRHt to MCNt

** Fish scheduled to be marked by the Fish Passage Center – contact person: Larry Basham.*

** Fish proposed to be marked by the Yakama Indian Nation in 2001.*

Study Animals

Possible Collection, Tagging and Release Strategies

Yearling summer chinook smolts would be collected in February, tagged in March and released in April at Pateros. Wild sockeye smolts would be collected at Zosel Dam in May. These fish would be tagged one day after collection and released back into the Okanogan River within two days. Release sites were selected to provide returning adults access to suitable spawning habitat and to minimize handling mortality.

Collection, tagging, handling and release methodologies employed during the 2001 survival study will be similar to techniques utilized during the 1998, 1999 and 2000 survival studies. Fish stocks selected for comparison within 2001 would include yearling hatchery summer chinook, yearling hatchery spring chinook and yearling wild sockeye. In addition, if a proposed release of coho takes place from Winthrop in 2001 a comparison of coho survival could also be included in the comparison study objectives. The proposed between-year reach survival comparison will also include historical survival estimates of summer steelhead (1999-2000). Winthrop yearling spring chinook are scheduled to be PIT-tagged by the Fish Passage Center and as such the tagging and release of these fish is outside the scope of this proposal. A summary of proposed release sites and stocks of fish that could be compared under this proposal can be found in Table 2.

All PIT-tagging will take place in a manner similar to Prentice et al. (1987) and Bickford et al. (1999). ISO 134.2 kHz PIT-tags will be the tag utilized during the 2001 comparative survival investigation.

Table 2. Proposed fish stocks and release sites for the 2001 Comparison Survival Study.

Species	***Age***	***Disposition***	***Collection Site***	***Release Site***	***Reach Survival Comparison***
Su. Chinook	Yearling	WFH	Hatchery	Pateros	RRHt to MCNt
Sockeye	Yearling	Wild	Zosel Dam	Zosel	RRHt to MCNt
Sp. Chinook	Yearling	WNFH	Hatchery	Winthrop	RRHt to MCNt
Coho	Yearling	WNFH	Hatchery	Winthrop	RRHt to MCNt

Comparative Statistics

The concept of surrogacy survival tests proposed in this study plan require the establishment of Tolerance Intervals or what has been termed Decision Criteria. Tolerance Intervals, as proposed, would be used to quantitatively determine whether or not differences in survival exist between estimates of survival. As an example, survival between sockeye and yearling chinook (spring and summer) could be tested within a year (2001). A second set of Tolerance Intervals would be used to determine whether the existing (1998-2000) survival information for yearling spring chinook, yearling summer chinook, yearling Methow run-of-river chinook, yearling summer steelhead and yearling coho fits with the 2001 survival estimates for yearling spring chinook, yearling summer chinook, yearling sockeye and yearling coho (if coho are released). The primary null hypothesis of the experiment would be to determine if the reach survival for PIT-tagged sockeye in 2001 is similar to or higher than the reach survival estimates for other species of PIT-tagged fish studied to date. Tolerance Interval would provide the framework for testing the following two hypotheses. The primary null hypothesis would read as follows:

> H_o : Sockeye survival is greater than or equal to yearling chinook, steelhead and coho survival.
> H_a : Sockeye survival is lower than yearling chinook, steelhead and coho survival.

A second set of null hypotheses could be used to investigate within-year survival differences between stocks of fish tagged (yearling spring and yearling summer chinook, yearling coho and yearling sockeye). As an example a secondary type hypothesis might state:

> H_{o2} : Sockeye survival in 2001 is greater than or equal to yearling chinook survival in 2001.
> H_{a2} : Sockeye survival in 2001 is less than yearling chinook survival in 2001.

A multitude of additional within and between-year null hypotheses could be tested with the data derived from the proposed 2001 comparative survival study.

SUMMARY

Results from survival studies in 1998, 1999 and 2000 indicate that PIT-tag survival studies are viable and accurate tools for assessing juvenile fish survival through individual dams and through common reaches of the Mid-Columbia River. Fish stocks that have been compared to date include yearling hatchery summer chinook, yearling hatchery spring chinook, yearling Methow run-of-river chinook, yearling hatchery steelhead and yearling hatchery coho. The proposed 2001 comparison study would attempt to add yearling wild sockeye to the list of fish stocks with documented survival through the Mid-Columbia River.

Sufficient numbers and replicates of fish would be released in 2001 to have an estimated precision of ± 0.05, 90% of the time (i.e., $\varepsilon = 0.05$, $\alpha = 0.10$) about each stocks reach survival estimate. Additional information gained from the proposed research would include indices of physiology, estimates of capture at downstream dams and median travel times for the selected species of interest.

In order to implement Comparative Survival Studies in 2001, the Wells Coordinating Committee must unanimously support the "Comparison Study Concept" by October 16, 2000. If this or an alternative study plan is not approved by October 16th, the District will abandon the "Comparison Study Concept" and will pursue the 2001 Yearling Chinook Project Survival Study that has already been approved by the Wells Coordinating Committee.

The WCC must also agree to accept the 1998, 1999 and 2000 survival study results for determining survival as defined in the Wells Long-term Settlement Agreement and the proposed Wells HCP. The committee must also agree that the average of the three years of survival studies conducted at Wells Dam will be used to determine the District's initial contribution to the Tributary Habitat Fund under the HCP. The committee will also need to agrees that the Wells Project has met the survival standards required for Phase III of the HCP.

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1. Brownie, C. and D. S. Robson. 1983. Estimation of time-specific survival rates from tag-re-sighting samples: A generalization of the Jolly-Seber model. Biometrics 39:437-453.

2. Bickford, S. A. 1996. A retrospective analysis of Columbia and Snake River survival studies, 1971 to 1995. M. S. Thesis. University of Washington, Seattle.

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April 24, 2001

Shane Bickford
PUD No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, WA 98802

Dear Shane,

RE: Tolerance Limits for a Sockeye Survival Study

Tolerance limits attempt to put an upper and lower bound on values in a population distribution. In other words, what is the range of possible values that could be generated by a statistical population? These tolerance intervals focus on the individual values within the population and not their critical tendency. The tolerance limits have a three-point entry; they are:

1. n, the number of observations used in constructing the tolerance intervals
2. P, the proportion of the population bracketed by the interval estimate (e.g., 90, 95, or 99% of the population)
3. α, the probability that the interval estimate does not include the true proportion P (e.g., 0.10, 0.05, 0.01)

The tolerance interval is then calculated as

$$\bar{x} \pm K_{\alpha,n,P} \cdot s$$

where

$\bar{x}$ = sample mean,

s = standard deviation of the original observations.

Critical values of K were obtained from tables presented in Zwillinger and Kokoska (2000).

1325 FOURTH AVENUE • SEATTLE, WA • 98101-2509
PHONE: (206) 616-4851 • FAX: (206) 616-7452
EMAIL: JRS@FISH.WASHINGTON.EDU
OR
BOX 358218

Table 1 presents alternative tolerance intervals for various values of α and P.

α	P	TI
0.10	0.90	0.6090 – 0.7795
	0.95	0.5953 – 0.7933
	0.99	0.5588 – 0.8298
0.05	0.90	0.5928 – 0.7957
	0.95	0.5766 – 0.8120
	0.99	0.5330 – 0.8555
0.01	0.90	0.5615 – 0.8271
	0.95	0.5401 – 0.8484
	0.99	0.4832 – 0.9054

For example, a 90% TI (i.e., $P = 0.90$) identifies the 5% smallest and 95% largest individual values in the statistical population. Calculations were based on seven mean seasonal survival estimates for steelhead and chinook salmon and assuming comparison with a mean seasonal survival for sockeye in 2001.

Literature Cited

Zwillinger, D., and S. Kokoska. 2000. Standard probability and statistics tables and formulae. Chapman and Hall/CRC. New York, NY. 554 pp.

Sincerely,

John R. Skalski
Professor of Biological Statistics

2001-2002 Sockeye Survival Study
Decision Tree

2001 Sockeye Survival Estimate is - -

- **Higher than yearling survival within-a-year**
  - *Sockeye survival at Wells is assumed to be similar to species studied to date.*
- **Same as yearling survival within-a-year**
  - *Sockeye survival at Wells is assumed to be similar to species studied to date.*
- **Lower than yearling survival within-a-year**
  - **Equal or Higher than yearling survival between-years**
    - 2002
      Resolve confounded results with a second sockeye surrogacy test
  - **Lower than yearling survival between-years**
    - 2002
      Confirm results with a second sockeye surrogacy test
    - Or conduct a project specific sockeye survival study at Wells when technology allows for a precise/accurate study

Appendix E

Letter from Okanagan Basin Technical Working Group on Year 2000 Projects

Rick Klinge
Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, WA 98802
USA

Dear Mr. Klinge:

The Okanagan Basin Technical Working Group (OBTWG) is a coordinating body responsible for the Okanagan River watershed with membership from the British Columbia Ministry of Environment, Lands and Parks, Okanagan Nation Fisheries Commission, and Fisheries and Oceans Canada.

OBTWG met in Penticton, British Columbia on February 8/9, 2000 to discuss mitigative options outlined in the report entitled " Fisheries Habitat in the Okanagan River – Phase 2: Investigation of Selected Options". Representatives from the Province of British Columbia – Water Management Branch were also in attendance.

OBTWG reached consensus on a package of options we believe will effectively boost sockeye production in this watershed while meeting requirements for a multi-species ecosystem approach over an extended period of time. The ecosystem approach is the type we have consistently supported in this very important initiative.

In selecting our preferred options, we considered costs and benefits and consequently eliminated options such as the hypolimnetic siphon and set back dyking. We were also mindful of the specific needs of your agency and consequently set aside some of our broader interests for the restoration of tributary streams, the procurement of water licences, and the inventory of water diversions and screening.

The package we are recommending addresses our respective interests and the needs of fish. It includes the following options (not in order of priority):

- Trap, mark, transport and recover sockeye salmon on an experimental basis (possibly using radiotelemetry and/or other techniques) to investigate the sources of adult sockeye losses during migration between Wells Dam and the spawning grounds, and possible mitigative strategies;

- Conduct assessments and analyses to identify viable options to fine tune flow releases to reduce negative impacts on habitat and spawning adults, incubating eggs and pre-emergent fry;

- Construct a spawning channel;

- Restore portions of the flood control channel to a more natural state. This will include construction of two 'Newbury' riffles (pending regulatory review), restoration of one or more oxbows, and revegetation of streambanks.

The OBTWG suggests that these options be pursued as a single package to fit with our ecosystem approach to this initiative. However, we also appreciate that further work may show that some options are not feasible or cost effective, and may not sufficiently benefit fish.

We recommend that this year's work include feasibility studies as follows (not in order of priority):

- Assembly, review, analysis, and synthesis of existing data relevant to identifying mechanism(s) that influence survival of sockeye adults between Wells Dam and the spawning grounds;

- Investigation of the feasibility of employing an experimental trap and transport program in Year 2001 to identify specific migratory loss " bottlenecks". Subsequent work would be directed to reducing the impacts of factors causing these "bottlenecks" where possible;

- Evaluation of factors and techniques which would allow improved regulation of river flows to reduce negative impacts on sockeye and other species;

- Evaluation of spawning channel for possible construction in Years 2001 / 2002;

- Design of an oxbow restoration plan for possible construction in Year 2001;

- Design a revegetation program and set up a growing program for plugs to be planted in Year 2001;

- Construction of 2 'Newbury' riffles in August 2000 (pending regulatory review).

At the completion of this year's program, results from feasibility and analytical work will be reviewed to estimate costs, determine design requirements, and identify potential fish production benefits associated with the package of options under consideration. Final discussions would then be held with all appropriate parties in this initiative to determine which options to pursue further.

At this point in time the OBTWG suggests that the DC PUD consider our suggestions and indicate whether you agree with this approach. Once we receive confirmation of your agreement we will supply you with a more detailed description of each of the facets of the work we have suggested for the Year 2000.

We appreciate the opportunity of working with you on this exciting program and look forward to your reply.

Elmer Fast
Chairperson
OBTWG

c.c. OBTWG Members:

Ian McGregor – MOELP
Steve Matthews – MOELP
Byron Louis – ONFC
Howie Wright – ONFC
Mike Flynn – DFO
Kim Hyatt – DFO
Keith Bolton – DFO
Bill Green – CCRITFC

c.c. Blair Hammond – British Columbia Conservation Foundation
Brian Symonds – MOELP – Water Management

Appendix F

Cassimer Bar Broodstock Collection Protocol, 2000

ATTACHMENT A

2000 Okanogan Sockeye Salmon Broodstock Protocol

Introduction

The protocol outlined below describes a procedure for collecting adult sockeye salmon at Wells Dam for meeting hatchery production requirements at the Cassimer Bar Sockeye Hatchery operated by the Colville Tribal Fish and Wildlife Department. Trapping operations will be conducted at the eastbank fishway trap and will be coordinated with WDFW's summer chinook broodstock collection operations. Currently, trapping for summer chinook begins in late June and continues through late August. The window for sockeye trapping fits well within this period.

Program Goal

The 2000 program goal is to rear 80,000 sub-yearling sockeye for release into Osoyoos Lake in the fall (October) of 2001. In order to meet this level of production based on past hatchery program results, 112,000 sockeye eggs will be required. This estimate assumes a 72% survival from egg to release, a fecundity rate of 2,000 eggs per female, a 1:1 male to female sex ratio and a pre-spawning mortality rate of 20%. Based on these assumptions, 140 adult sockeye need to be collected for this year's program.

Broodstock Collection Plan

Sockeye salmon will be collected over a four-week time frame this year in order to reduce impacts to adult summer chinook. Trapping will be conducted within the mid-80th percentile of the run at large. Daily ladder counts at Wells Dam indicate the run entry pattern for the mid-80th percentile occurs during a 40-day period between July 8th and August 16th. Trapping will occur during this window or in a manner that is proportional to weekly passage at the dam if the run pattern significantly changes. Broodstock collection will parallel the relative strength of weekly returns as much as possible through the collection period. Some modifications may be required in weekly quotas in the event of poor or truncated runs.

Collections will be made in concert with the summer chinook broodstock collection program operated by WDFW as much as possible. Currently this program traps two-days a week, therefore it is anticipated that eight/twelve total trapping days will be conducted during the four week sockeye broodstock collection period.

Sockeye salmon will be collected in a random fashion and no attempt will be made to select for a particular size of fish. No marked (hatchery-origin) sockeye will be collected for broodstock needs.

The pre-season forecast estimates a below average count of sockeye at Bonneville Dam, but expects the Okanogan stock to dominate the run. If this forecast is somewhat accurate, escapement to Wells Dam will exceed 25,000 adult sockeye this year, which is more than adequate to meet broodstock requirements without adversely impacting the population.

Appendix G

Spring Chinook Broodstock Collection Protocol, 2000

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
Mid-Columbia Field Office
610 North Mission St. Suite B8 • Wenatchee, WA 98801 • (509) 664-1227 • FAX (509) 662-6606

8 March 2000

To: Joint Fishery Parties / Mid-Columbia Coordinating Committee

From: Larry Brown

Subject: **SECOND DRAFT YEAR 2000 UPPER COLUMBIA RIVER SALMON AND STEELHEAD BROODSTOCK OBJECTIVES AND SITE-BASED BROODSTOCK COLLECTION PROTOCOLS**

Following is a revised draft adult broodstock collection schedule for year 2000, keyed on target numbers at various collection sites. Comments received on the 16 February draft have been incorporated. This protocol is necessary to allow adequate time for discussion and operational planning to achieve the desired hatchery program and species recovery objectives (BAMP 1998). This adult broodstock collection schedule is to be considered an interim and dynamic hatchery broodstock collection plan which may be altered following joint fishery party discussions. As such, there may be significant in-season changes in broodstock numbers, locations, or times, brought about through continuing co-manager consultation and in-season monitoring of the anadromous fish runs to the Columbia River above Priest Rapids Dam.

The year 2000 outlook for ESA-listed upper Columbia River spring chinook is encouraging. Low natural spawning escapements in 1995 and 1996 are projected to be at least partly offset by a major turnaround (improvement) in smolt survival. Record or near record runs of age-3 spring chinook (jacks) portends well for the 4 year old adult component in 2000, resulting in a TAC forecast representing a 347% increase from last year's run at the mouth of the Columbia River. Upper Columbia summer chinook and sockeye salmon are expected to be improved by 27% and 74%, respectively, over 1999. The A-run steelhead component, which includes Upper Columbia stocks, is forecast to increase 19% overall from last year's run to Bonneville Dam. The Priest Rapids steelhead forecast indicates a 32% to 51% increase in ESA-listed hatchery and wild steelhead.

Reference:

Biological Assessment and Management Plan (BAMP). 1998. *Mid-Columbia River Hatchery Program. National Marine Fisheries Service, U. S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Confederated Tribes of the Yakama Indian Nation, Confederated Tribes of the Colville Indian Reservation, Confederated Tribes of the Umatilla Indian Reservation, Chelan County Public Utility District, and Douglas County Public Utility District. Mid-Columbia Mainstem Conservation Plan. 176 pp.*

Year 2000 Upper Columbia Broodstock Trapping Protocols

Email Distribution List:

Mike Erho, for distribution to Mid-Columbia Coordinating Committee A-list
Robert Koch, NMFS

WDFW

Rod Woodin	Heather Bartlett	Kris Petersen	Cindy LeFleur
Rick Stilwater	Jerry Moore	Manuel Farinas	Bob Foster
Joe Foster	Andrew Murdoch	John Easterbrooks	Tami Black
Ross Fuller	Bruce Sanford	Craig Busack	Kevin Amos
Art Viola	Jon Anderson	Jim Ames	Andrew Murdoch
Bob Jateff	Charlie Snow		

The following year 2000 run sizes are forecast for the Columbia River (TAC, various).

Spring Chinook (TAC) 134,600 total run to Bonneville (347% increase from 1999 actual)
58,900 destined to Snake Basin
47,700 destined to Middle Columbia Basins
28,000 destined to Upper Columbia Basins (4,500 wild)

A. Viola, WDFW (Jack to adult regression)
28,613 to Rock Island Dam
20,716 to Wenatchee Basin
7,897 to above Rocky Reach Dam

L. Brown, WDFW (AAR + SAR methods)
23,595 to Priest Rapids Dam (19.8% ESA-listed stocks)
16,120 to Wenatchee Basin
14,464 to Icicle Creek (280 wild)
1,536 wild to upper Wenatchee tribs
119 hatchery origin to Chiwawa River
3,102 to Entiat River
481 wild
2,621 to Entiat NFH
4,373 to above Wells Dam
82 wild
2,002 Winthrop NFH stock (100% station release)
2,289 Methow FH stocks (55% station release)

Summer Chinook (TAC) 33,300 total run to Bonneville (27% increase from 1999 actual)
7,600 destined to Snake Basin (90% increase)
25,700 destined to above Priest Rapids (18% increase)

Sockeye (TAC) 31,200 total run to Bonneville (74% increase from 1999 actual)
5,500 destined to Wenatchee Basin* (below replacement)
25,500 destined to Okanogan Basin
168 destined to Snake Basin
L. Brown, WDFW, alternate for Lk Wenatchee is 0.7% of 1.49 million smolts = 10,430

Steelhead (TAC-Index) 210,000 A-run to Bonneville (19% increase from 1999 index)

L. Brown, WDFW (1s/2s ratio method)
11,053 to Priest Rapids Dam (32% increase from 1999 actual)
9,304 hatchery origin (84%) (range 5,664-15,030)
1,749 natural origin (16%) (range 1,375-2,554)

L. Brown, WDFW (SAR+1s/2s method)
12,626 to Priest Rapids Dam (51% increase from 1999 actual)
10,877 hatchery origin (86%)
1,749 natural origin (14%)

Year 2000 spring chinook forecasting assumptions, L. Brown, WDFW:

	98 smolt SAR (4's)	97 smolt SAR (5's)
Methow R hatchery smolts	0.005	0.0005
Entiat R hatchery smolts	0.006	0.0006
Wenatchee R hatchery smolts	0.007	0.0007

	Y2K age 4 adults	Y2K age 5 adults
All wild production	2.2(96 redds)8.0	2.2(95 redds)2.0
4/5 ratio = 4.0	8.0 AAR	2.0 AAR

Relative parsing of Y2K upper Columbia spring chinook forecasts:

	Age Four		Age Five		All Adults		
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Combined
Methow Basin							
Methow R	2,640	0	14	40	2,654	40	2,694
Chewuch R	460	0	0	9	460	9	469
Twisp R	385	0	0	18	385	18	403
Basin total					3,499	67	3,566

Back calculated to arrival at Priest Rapids Dam @0.96s/project 4,373

	Age Four		Age Five		All Adults		
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Combined
Entiat Basin	2,106	352	120	57	2,226	409	2,635

Back calculated to arrival at Priest Rapids Dam @ 0.96s/project 3,102

	Age Four		Age Five		All Adults		
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Combined
Wenatchee Basin							
Nason Cr	0	581	0	31	0	612	612
Chiwawa R	105	405	0	57	105	462	567
White R	0	211	0	9	0	220	220
Little Wen R	0	53	0	0	0	53	53
Upper Wen R	0	18	0	4	0	22	22
Upper Basin Total					105	1,359	1,464
Icicle Cr	11,914	211	636	37	12,550	248	12,798
Wenatchee Basin Total					12,655	1,607	14,262

Back calculated to arrival at Priest Rapids Dam @ 0.96s/project 16,120

Total Y2K upper Columbia spring chinook arriving at Priest Rapids Dam 23,595
Total Y2K upper Columbia spring chinook distributing into sub-basins 20,463

Year 2000 Upper Columbia Broodstock Collection Targets by Species and Program

Spring Chinook

Chiwawa River Trap Chiwawa spring chinook following BY94 through BY98 schedule (weir operates 4 days up and 3 days down), anticipating an effective extraction rate of about 13% of the run. Spring chinook retained will be transferred to Eastbank hatchery for holding in cool well water. If less than 20 salmon have been collected by 17 August, trapping will be discontinued and all fish will be released back to the Chiwawa River for natural spawning. All bull trout trapped at the Chiwawa weir will be transported by tank truck and released into a resting/recovery pool at least 1.0 km upstream from the Chiwawa River weir.

Chiwawa spring chinook hatchery program and assumptions:

R.I. Settlement Program	672,000 yearling smolts
Propagation survival	83% fertilization to release
Fecundity	4,400 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	97%
Broodstock required	379

Nason Creek Continue collection of BY00 eyed eggs for the captive broodstock. Up to 30 redds will be hydraulically sampled to obtain 50 individuals from each redd (BAMP 1998).

White River Continue collection of BY00 eyed eggs for the captive broodstock. Up to 25 redds will be hydraulically sampled to obtain 40 individuals from each redd (BAMP 1998).

Icicle Creek Leavenworth NFH — Trap volunteer returns

Entiat River Entiat NFH — Trap volunteer returns

Methow Basin The forecast spring chinook run to Wells Dam is 3,566 age 4 and 5 adults, which far exceeds the Mid Columbia Mainstem Conservation Plan's Tier 3 level of 1,415 fish, above which broodstock collection will be at levels required for the combined Methow FH and Winthrop NFH composite Methow stock production (Interim Production Objectives, BAMP 1998). We will trap approximately 18% of the spring chinook run at Wells Dam (target 640 fish) and transport them to the Methow and Winthrop hatcheries for maturation and spawning. Volunteer returns (swim-ins) to the two hatcheries will be managed as necessary (allowed/disallowed) to achieve joint composite Methow stock production objectives.

Twisp River Captive Brood: Within the trapped broodstock, there should be enough identifiable Twisp stock with which to maintain the Twisp captive brood program. In the event insufficient Twisp broodstock are available, we can augment any shortfall in BY00 captive brood families (objective is 45 eyed eggs from each of 30 families) by redd sampling in the Twisp River. There should be sufficient natural escapement to the Twisp River to allow captive brood eyed egg collections with minimal impact to overall natural production. **Depending on survival and BY96 maturation, Twisp stock BY00 eyed eggs may be transferred from captive brood spawners at the AquaSeed Facility and incorporated into the Twisp stock rearing program at Methow FH.**

Methow FH spring chinook program (BAMP 1998) and assumptions:

Wells Settlement Progam	738,000 yearling smolts
HCP Modified Program	550,000 yearling smolts
Propagation survival	90% fertilization to release
Fecundity	4,200 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	95%
Broodstock required	306

Winthrop NFH spring chinook program (BAMP 1998) and assumptions:

G.C. Mitigation Program	800,000 yearling smolts
HCP Modified Program	600,000 yearling smolts
Propagation survival	90% fertilization to release
Fecundity	4,200 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	95%
Broodstock required	334

Summer Chinook

Wenatchee Basin Trap **492** mixed origin, run-at-large (including jacks) summer chinook at **Dryden Dam**, representing an extraction rate of 5.4% of a TAC-based forecast of 9,100 summer chinook returning to the Wenatchee River.

Wenatchee summer chinook stock program and assumptions:

Program	864,000 yearling smolts
Propagation survival	78% fertilization to release
Fecundity	5,000 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	90%

Methow/Okanogan Trap **556** mixed origin, run-at-large (including jacks) at Wells Dam east ladder, representing an extraction rate of 4.6% of a TAC-based forecast of 12,200 summer chinook returning upstream of Wells Dam..

Methow/Okanogan (Eastbank) summer chinook program and assumptions:

Program	976,000 yearling smolts
Propagation survival	78% fertilization to release
Fecundity	5,000 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	90%

Wells Hatchery Collect **1,208** run-at-large (including jacks) **volunteers** to Wells Fish Hatchery outfall, (296 for yearling programs and 912 for sub yearling programs), representing zero impact to upriver runs.

Wells / Rocky Reach summer chinook programs and assumptions:

Wells program	320,000 yearling smolts
	484,000 sub yearlings
Lake Chelan program	100,000 late release sub yearlings
Rocky Reach program	200,000 yearling smolts
	450,000 accelerated sub yearlings
	628,000 normal sub yearlings
Propagation survival	81% fertilization to 0+ release
	78% fertilization to 1+ release
Fecundity	5,000 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	90%

Sockeye

Wenatchee Basin Trap **260** from run-at-large at Tumwater Dam, representing an extraction rate of 4.7% of a TAC forecast of 5,500 Wenatchee sockeye.

Lake Wenatchee / Eastbank program and assumptions:

R.I. Settlement Program	200,000 fall release sub yearlings
Propagation survival	79% fertilization to release
Fecundity	2,340 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	85%

Okanogan Basin CCT may trap up to **300** sockeye at Wells East Ladder (Cassimer Bar FH program), representing an extraction rate of only 1.2% of a TAC forecast of 25,500 Okanogan sockeye. This program is undergoing review for possible elimination.

Steelhead

Wenatchee Basin Trap **208** mixed origin, run-at-large steelhead at Dryden and Tumwater dams, representing an extraction rate of 5.4% of a Wenatchee River forecast of ±3,850 steelhead in the 2000/2001 cycle. In the event our steelhead collections run behind schedule, as has been the case due to trap inefficiency at Dryden, WDFW may capture some adult steelhead from the mainstem Wenatchee River by hook and line. While hook and line capture of broodstock is not specifically mentioned in Section 10 Permit #1094, such activity is consistent with proposed activities in WDFW's Section 10 Direct Take Permit Application (15 August 1997), describing the biological assessments and basis for the permitted steelhead recovery program.

Eastbank and Turtle Rock (Wenatchee stock) program and assumptions:

Program	400,000 yearling smolts
Propagation survival	75% fertilization to release
Fecundity	5,400 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	95%

Wells Dam Trap **395** mixed origin, run-at-large steelhead at Wells Dam west ladder, representing an extraction rate of 5.7% of a forecast ±6,910 steelhead returning to Wells Dam in the 2000/2001 cycle.

Wells Hatchery Programs and assumptions:

Methow R program	280,000 yearling smolts
Okanogan R program	200,000 yearling smolts
WNFH transfer (Methow R)	116,280 eyed eggs for 100,000 smolts
Ringold transfer (Col. R.)	209,303 eyed HxH eggs for 180,000 smolts
Propagation survival	87% fertilization to eyed egg
	86% eyed egg to yearling release
	75% fertilization to yearling release
Fecundity	5,400 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	95%

Entiat Basin There will be no hatchery supplementation program in the Entiat basin. The Entiat River has been selected as a steelhead natural production reference drainage in accordance with the Mid-Columbia Mainstem Conservation Plan (BAMP 1998) and the WDFW Fisheries Management Conservation Plan for Upper Columbia River Steelhead (in progress). The Rocky Reach mitigation objective for the Entiat River (40,000 Wenatchee stock smolts) has been shifted to the Wenatchee basin to maintain the overall Rocky Reach mitigation program.

Coho

Wenatchee Basin YIN biologists expect up to 600 adult coho to return to the Wenatchee River in the year 2000. Development of a local broodstock will depend on trapping as many of these returning coho as possible during trap operations at Dryden and Tumwater Dams. YIN evaluations personnel will coordinate with WDFW hatchery personnel ensure an adequate number of tank trucks and YIN personnel are present on trapping days to retain and transport for holding, all coho encountered while trapping efforts target on summer chinook and steelhead.

Year 2000 Upper Columbia Broodstock Collections and Operations by Trapping Site

Wenatchee Basin

Dryden Dam — **5 July - 17 Nov** — **7 days/week** — Passive operation at right and left bank 24 hours a day, checked daily.

Summer chinook target **492 mixed origin, run-at-large** fish, throughout the run. Up to 25% of brood (123 fish) may be taken at Tumwater Dam after 15 August. Broodstock held and spawned at Eastbank FH.
Steelhead target **208 mixed origin, run-at-large** fish, when combined with Tumwater Dam or hook and line collections. Broodstock held and spawned at Eastbank FH.
Coho will be collected as YIN personnel and trucks are available when the traps are emptied, primarily after mid-September.

Tumwater Dam — **19 July - 17 Nov** — **3 days/week** — Active operation 8 hours each day.

Steelhead target **208 mixed origin, run-at-large**, when combined with Dryden Dam or hook and line collections. Hold and spawn at Eastbank FH.
Up to **123 summer chinook** may be taken **after 15 August** to augment the Dryden summer chinook collection as necessary.
Sockeye target is **260 mixed origin, run-at-large**, after Rock Island Dam passage peak, but no earlier than 15 July. Hold and spawn sockeye brood at Lake Wenatchee net pens.
Coho will be collected as YIN personnel and trucks are available when the traps are emptied, primarily after mid-September.

Chiwawa Weir — **14 May - 14 Sept** — **4 days/week** — Operate weir and trap 24 hours a day for **4 days up** and then **3 days down**, maintaining a consistent schedule to ensure unimpeded escapement upstream.

Spring chinook target **not to exceed 379 mixed origin, run-at-large fish**. Spring chinook retained will be transferred to Eastbank Hatchery for holding in cool well water. **If less than 20 salmon have been collected by 17 August, trapping will be terminated and all Chiwawa spring chinook held in captivity will be returned immediately to the Chiwawa River for natural spawning.**
All **bull trout** trapped will be transported by tank truck and released into a quiet water area at least 1.0 km upstream of the weir.

Leavenworth NFH — **1 June - 31 Aug?** — continuous — per USFWS operating standards

Spring chinook volunteer collections, held and spawned at Leavenworth NFH.

Entiat Basin

Entiat NFH — **1 June - 31 Aug?** continuous per USFWS operating standards
Spring chinook volunteer collections, held and spawned at Entiat NFH.

Methow Basin

Foghorn Dam — **Do not operate in 2000** — Brood collection at Wells Dam.

Fulton Dam — **Do not operate in 2000** — Brood collection at Wells Dam.

Twisp Weir — **Do not operate in 2000** — Brood collection at Wells Dam.

Methow FH — **1 June - 25 Sept?** **TBD*** per WDFW operating standards
Primary spring chinook broodstock (640 fish) for Methow and Winthrop facilities will be captured at Wells Dam. Adult holding and spawning will be shared between Methow FH and Winthrop NFH. In-situ stock separation of Methow Composite, Carson-based Winthrop stock and stray fish via scales and CWTs during spawning operations. Twisp hatchery stock adults will be identified by CWT, spawned together, and if there are a sufficient number of families, will be reared separately at Methow FH until tagged. Twisp eyed eggs (45 eggs each from up to 30 families) may be used for captive brood. Chewuch and Methow hatchery stocks and all wild stocks will be combined into the composite Methow basin stock. Adults and/or gametes from all known Winthrop hatchery stock will be transferred to Winthrop NFH.

TBD* Volunteers (swim-ins) may be allowed at one or both of the Methow River facilities depending on Joint Fishery Parties determinations regarding phase-out protocols for the Carson-based Winthrop NFH stock. This issue is still in the discussion phase, and will be determined before the fish arrive.

Winthrop NFH — **1 June - 25 Sept?** **TBD*** per USFWS operating standards
Primary spring chinook broodstock (640 fish) for both facilities will be captured at Wells Dam. Joint protocols described above under Methow Fish Hatchery.

TBD* Volunteers (swim-ins) may be allowed at one or both of the Methow River facilities depending on Joint Fishery Parties determinations regarding phase-out protocols for the Carson-based Winthrop NFH stock. This issue is still in the discussion phase, and will be determined before the fish arrive.

Columbia River

Wells Dam East Ladder — **10 July - 30 Aug** — **3 days/week** — Active trapping 16 hours a day with the ladder open to passage at night.

Target is **556 Methow/Okanogan summer chinook** from the run at large for transfer to and holding/spawning at Eastbank FH.
CCT sockeye target may be 300 fish for the Cassimer Bar FH. This Okanogan sockeye program is currently in review and may be eliminated.

Wells Dam West Ladder — **1 May - 5 July** — **3 days/week** — Passive trapping 24 hours a day on a Monday-Wednesday schedule.

Spring chinook broodstock target is 640 fish (18% of the forecast run of 3,566 fish at Wells Dam. In a perfect world, 3 days of trap operation weekly in one of two ladders should intercept about 21% of the run (3 of 14 possible trapping days). In reality, fish passage is seldom randomly or evenly distributed across all days and passage routes. Therefore in-season monitoring of trapped and passed (counted) spring chinook will be utilized to indicate whether in-season adjustments to the trapping protocol (more or fewer trapping days) are necessary. **NMFS has requested that WDFW consider using in-situ scale examination at the Wells Dam west ladder to ensure that adipose-present hatchery origin adults (strays) are excluded from broodstock collections and returned to the river below Wells Dam.** All spring chinook retained will be transported to Methow FH and Winthrop NFH for maturation and coordinated concurrent spawning. In the event the collection falls short at Wells Dam, we still have options available for managing volunteer swim-ins at the two hatcheries.

10 July - 22 Nov — **3 days/week** — Passive trapping 24 hours a day on a Monday-Wednesday schedule.

Steelhead target is 395 mixed origin fish from the run-at-large, spaced throughout the summer cycle. The steelhead broodstock will be held and spawned at Wells FH to satisfy recovery and production requirements for the Methow and Okanogan River basins, and for Ringold FH.

Wells FH — **10 July - 31 Aug** — **continuous** — per WDFW operating standards

Summer chinook volunteer collection target is 1,208 salmon, including jacks, to satisfy Wells FH and Turtle Rock FH programs. There are no provisions for any "extra" yearling smolts for 2002 survival studies (if any) in this protocol. Broodstock holding and spawning is at Wells FH. In the event excess fish are collected, they will be returned to the Columbia River below Wells Dam.

Appendix H

A Revised Proposal to Study Bull Trout in the Chelan, Douglas and Grant PUD Project Area

A REVISED PROPOSAL TO STUDY BULL TROUT IN THE CHELAN, DOUGLAS, AND GRANT COUNTY PUD PROJECT AREA

Submitted To:

Chelan County Public Utility District
327 N. Wenatchee Ave.
Wenatchee, WA 98801

Prepared by:

BioAnalysts, Inc.
3653 Rickenbacker, Suite 200
Boise, Idaho 83705
(208) 383-3401

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PROPOSAL SUMMARY

In our initial study proposal submitted to Chelan PUD in May 2000, we proposed to examine the effects of operations at Rocky Reach Dam on the distribution, abundance, and movement of bull trout in the Rocky Reach Project Area. Since the submittal of that proposal, the scope of the project has expanded to include hydro-projects owned and operated by Grant and Douglas County PUD's. In addition to the original scope of work, the study has been modified to include an assessment of the movements of radio-tagged bull trout through Wanapum, Priest Rapids, and Wells dams. It will also assess whether or not bull trout use the Wells and Colville hatchery outfalls as temperature refugia when Columbia River water temperatures increase.

To meet our objectives, we will use a two-phased approach. First, we will compile and examine existing information on the relative abundance and distribution of bull trout and their habitat use in the study area, which includes the Columbia River from the Priest Rapids tailrace to the Chief Joseph tailrace, and portions of the Wenatchee, Entiat, Methow and Okanogan rivers. This will include a review of adult counts at fish ladders, incidental catch during northern pikeminnow removal, captures during operation of the Rocky Reach surface collector and bypass system, and occurrence of bull trout in other sampling programs (e.g., fyke-net surveys). The second approach will monitor the movements and migrations of adult bull trout tagged with radio transmitters.

For the second phase of the study, a total of 40 adult bull trout will be tagged at Rock Island (n = 10), Rocky Reach (n = 20), and Wells dams (n = 10). Fish will not be tagged at either Wanapum or Priest Rapids dams since historical data show very few fish have been observed in the adult ladders, where collection would take place. To assess the movement and migrations of adult bull trout, all five hydro-projects in the study area will be monitored with telemetry equipment. In addition, boat and ground surveys will be conducted within the Chelan PUD area of interest (i.e., boat and ground surveys from the Rock Island forebay to the Wells tailrace) and aerial surveys of the entire study area.

We will summarize the results of this work in a report, which will include a description of the distribution and abundance of bull trout, their habitat use, movements, and migrations. In addition, we will describe any information we find or collect on bull trout permanence of station, rearing, and feeding. We will identify data gaps, and, if necessary, offer recommendations to improve data collection and monitoring protocols.

JUSTIFICATION

On June 10, 1998, the U.S. Fish and Wildlife Service (Service) listed bull trout within the Columbia River basin as threatened under the Endangered Species Act (ESA) (50 CFR 63(111)). Later (November 1, 1999), the Service listed bull trout within the coterminous United States as threatened under the ESA (50 CFR 64(210)). Among other factors, the Service listed dams as a major factor affecting the distribution and abundance of bull trout. They noted that dams (and natural barriers) have isolated population segments resulting in a loss of genetic exchange among these segments (50 CFR 63(111):31657). Populations are now isolated and disjunct.

Recently, in a letter to the Federal Energy Regulatory Commission (FERC), the Service requested consultation under Section 7 of the ESA regarding impacts to bull trout resulting from operations of FERC licensed hydroelectric projects on the Columbia River (letter from Mark G. Miller, USFWS to Mark Robinson, FERC, dated January 10, 2000). The request for consultation is based on the impacts associated with facilities owned and operated by Grant, Chelan, and Douglas PUDs. In its reply to the Service, the FERC noted that there was virtually no information on bull trout in the mainstem Columbia River.

Because bull trout within the mid-Columbia River area are listed under the ESA (50 CFR 63(111):31651), and they may be affected by the operation of hydro-projects owned and operated by Grant, Chelan and Douglas PUD's, we believe that an extensive and intensive evaluation of the status of bull trout in the project area is necessary. Currently, little is known about the life-history characteristics (e.g., movements, distribution, habitat use, etc.) of bull trout in the project area. Therefore, in order to assess the operational effects of hydroelectric projects in the project area on bull trout, we will compile and examine existing information and conduct field studies. To the extent possible, we will use existing information to describe life-history characteristics of bull trout in the project area. We will supplement this information with field studies (radio telemetry). Although this work will focus on bull trout in the project area, we will also review and incorporate relevant studies outside the project area.

OBJECTIVES

The purpose of this study is to assess the effects of the operation of the Chelan, Douglas, and Grant PUD hydroelectric projects on bull trout in the project area. Our specific objectives of this study are to:

- Describe the distribution and relative abundance of bull trout and their habitat use in the project area.
- Describe the movements and migrations of bull trout in the project area.
- Identify missing information or data gaps.
- If possible, relate (correlate) distribution, abundance, habitat use, and movements with operation of the PUD hydroelectric projects.

STUDY AREA

For the purposes of the expanded study, the project area will include the segment of the Columbia River from the Priest Rapids Tailrace (RM 397.1) to the tailrace of Chief Joseph Dam (RM 545.1). In addition, important bull trout rearing basins (i.e., Wenatchee, Entiat, Methow and Okanogan basins) would be included in the study area.

APPROACH

In this study we propose to assess the effects of operations of hydroelectric facilities on bull trout in the project area. We divided this study into two major phases. The first is to compile and examine existing information on bull trout in the project area. We will also review relevant information from areas outside the project area. Under the second phase we will perform two important tasks. First, we will work with the PUDs in designing and developing an effective/efficient trap for the capture of migrant bull trout at Rock Island and Rocky Reach dams. Second, we will monitor the movement and migration of radio-tagged bull trout with fixed and mobile receivers.

At this time, it is unknown to what extent BioAnalysts, Inc. will be involved with the Chelan PUD juvenile survival study in 2001. Likewise, at this time Grant PUD has not committed to conducting a juvenile survival study in 2001. The outcome of both of these events will ultimately affect how the field portion of the bull trout study is implemented, as well as the overall cost of the project. Due to this uncertainty, we will describe how the field research will be conducted and provide a budget for the scenario that appears most likely at this time, which assumes that BioAnalysts will be involved with the Chelan juvenile survival evaluation in 2001 and Grant PUD will conduct a survival study at their projects. Below, we describe these phases in more detail.

PHASE I: Review of Existing Information

We propose to compile and examine all available information collected on bull trout in the project area. We will search all available databases and reports for the occurrence of bull trout in the project area. The search will cover dam passage records, surface collection reports, fyke net studies, angler surveys, and northern pikeminnow removal work. We will also review snorkel, electrofishing, and cyanide work and trapping studies conducted in tributaries to the project area. In addition, we will review historical studies for information on the occurrence of bull trout in the basin.

Although the work described above focuses on the Chelan, Douglas, and Grant PUD hydroelectric project areas, we will also review relevant studies conducted outside the region. For example, researchers have studied adult bull trout movements in the Clark Fork, Flathead, Green, Salmon, McKenzie, and other river systems. These studies will provide general background on bull trout migration patterns and habitat use. In addition, we will describe general life-history characteristics of bull trout based on information collected within and outside the project area. These sources will help us better understand the effects of hydroelectric project operations on bull trout.

Phase II: Field Studies

Under this phase of the study we will work with the PUD's to develop an efficient trap for the capture of migrant bull trout at Rock Island and Rocky Reach dams. We will then capture and surgically implant radio tags in adult bull trout. Both fixed and mobile (air, boat, and ground) receivers will monitor the movements of tagged trout.

Fish Capture Alternatives

The current strategy is to collect and radio-tag ten adult bull trout at Rock Island Dam, twenty at Rocky Reach, and ten at Wells Dam. Presently, these projects are not equipped with facilities to adequately collect bull trout without harming or harassing non-target species. It is possible that alternative methods could be used to capture bull trout. For example, alternative methods could include incidental catch of bull trout during the northern pikeminnow removal program (use of angling methods), intentional catch of bull trout using traditional angling methods, and incidental catch of adult bull trout within juvenile collection facilities at all three projects. While two of the three methods are currently being implemented (operation of the juvenile traps and the northern pikeminnow removal program), it is unlikely that the three programs collectively would provide the desired number of test fish. Therefore, we propose that the best option to collect adult bull trout in adequate numbers without unduly harming other species is to install new collection facilities.

At Wells Dam, it appears that bull trout are caught incidentally in sufficient numbers during brood stock collection for hatchery operations to meet the tagging objective at that project.

Therefore, there may be no need to install a collection facility at Wells Dam. For the purpose of developing the attached budget, we have assumed that the Chelan PUD will be largely responsible for designing, constructing, and testing trapping facilities. We also assume that they (and Douglas PUD) will provide the personnel to man all collection facilities.

Tag Description

We propose to use a digitally-encoded transmitter developed by Lotek Engineering. The tag (model MCFT-3EM) is 11 mm in diameter, 49 mm in length, and weighs 4.3 grams in water and 8.9 grams in air. The Study Plan identifies a criterion of 2 percent for the ratio of tag to body weight (in air) as being acceptable (Winter 1983). However, more recent literature suggests that a radio tag that is as much as 5 to 10 percent of the fishes body weight will not adversely affect fish behavior (Adams et al. 1998). Accepting the more conservative approach (say, 2-5%) will allow tagging of fish as small as 178 grams.

Although the model MCFT-3EM may be the tag of choice, other digitally-encoded transmitters may provide more useful information. Lotek Engineering is currently testing a radio transmitter that is 11mm in diameter and 57 mm in length that not only produces a signal allowing identification of unique fish, but also transmits depth and temperature data. These data would allow us to better describe the habitat use and energetics of adult bull trout in the project area. However, at this time it is unclear whether the prototype tag will be compatible with the firmware currently installed in the receivers. Should the prototype tag be incompatible, depth and temperature data would not be collected at the hydroprojects, but would be gathered at the tributary sites. We intend to investigate further the most appropriate tags to use in this study.

Surgical Techniques

We will conduct surgical implantation at existing tagging and holding facilities at Wells, Rocky Reach, and Rock Island dams. These tagging facilities are close to potential capture sites and offer convenient holding. In addition, we have used them successfully to tag numerous juvenile steelhead and chinook salmon in recent and ongoing survival studies (Stevenson et al. 2000). However, we are prepared to surgically implant tags at alternate, remote sites (tributaries) with the aid of a mobile surgical kit. Because the capture of bull trout in the project area may be a rare event, we will have a surgical team on call at all times. BioAnalysts has both the experience and local personnel to conduct this procedure on short notice.

With bull trout in hand, we will surgically implant radio tags into the body cavity using methods described in Summerfelt and Smith (1990). At this time we are considering the use of staples rather than sutures for closing the incision. A recent study indicates that staples have a lower rate of epidermal infection and abdominal bloating than sutures (Swanberg et al. 1999). We see the advantage of stainless steel staples in a long-term radio-telemetry study such as this one.
Tag implantation will proceed by placing sedated fish in a V-shaped cradle supplied with anesthetic. We will make a half-inch incision placed just off the mid-ventral line anterior to the pelvic fins for tag insertion. A cannula inserted into the body cavity through the incision will be used to insert the tag so that the antenna trails posterior to the pelvic fins. Several drops of Oxtet © brand oxytetracycline will be placed in the body cavity to prevent infection. We will then use veterinary tissue glue and two to three sutures or staples to close and seal the incision. We will place fish in a holding tank for recovery. After recovery, the fish will be transported back to the site of capture and released.

Fish Monitoring

To assess the movement of tagged bull trout within the study area, we will implement multiple-telemetry techniques throughout the study period. Below we describe in more detail the telemetry systems and methods.

Fixed Telemetry Systems

Chelan PUD – Currently, both Rocky Reach and Rock Island dams are equipped with radio telemetry systems to evaluate survival of juvenile steelhead and chinook. Chelan PUD intends to conduct the juvenile survival study in 2001. Since these telemetry systems will be in operation, they can also be used to monitor bull trout movements (assuming both juvenile and bull trout tags are on the same frequency range). At both Rocky Reach and Rock Island dams, dual systems monitor the major passage routes (i.e., powerhouses and spillways). These systems consist of both aerial antenna systems with 3- or 4-element Yagi antennas and underwater antenna systems with either dipole or turnstile antennas. At other locations (i.e., surface collectors, dewatering structures, adult ladder exits, video flumes, and the juvenile bypass facilities), single aerial or underwater systems detect migrating juvenile salmonids (Stevenson et al. 2000). In addition, aerial antennas monitor the tailrace to confirm project passage. Collectively, these systems would allow determination of when bull trout enter the tailrace area, when they exit the adult ladder, and the extent of fallback. In addition to the systems described at Rocky Reach and Rock Island dams, three transects monitored down-river from Rock Island Dam (approximately 20 to 25 miles downstream of the project) would allow detection of downstream migrants.

The systems described above require a total of 33 receivers and 18 DSP units, which exceed the numbers owned by the PUD. Therefore, to conduct the juvenile survival study, additional receivers have been rented in the past. Since this is a requirement of the juvenile survival study, the number and cost of these receivers will not be included in our budget. However, to monitor the tributary sites (the Wenatchee and Entiat rivers), two additional receivers will be required. It will be the responsibility of the PUD to purchase or rent the two additional receivers. Should the units be purchased, the cost will be approximately $10,500 per unit. Rental costs will be a function of the source and availability.

In the original study proposal, we suggested that if Chelan PUD wishes to examine ladder movement at Rocky Reach and Rock Island dams in greater detail, the adult ladders could be monitored similarly as in 1997. However, since such as system would require as many as 7 to 10

SRX/DSP units, and potentially more (to achieve the same level of resolution as in 1997), we recommend reserving such detailed evaluations for subsequent years, after the initial data have been gathered.

In addition to the systems at Rocky Reach and Rock Island dams, we propose to set up fixed-telemetry sites on the Wenatchee and Entiat rivers near their confluences with the Columbia River. These sites either existed previously or are still in use. Re-establishment of these sites will require little work.

Grant PUD – Grant PUD's interest in the bull trout study is to assess whether bull trout migrate through their projects (Wanapum and Priest Rapids dams). At this time they have not committed to conducting a juvenile survival study in 2001. However, if they decide to conduct a survival study, we would simply include the bull trout channel(s) into the frequency table of the SRX units. Our analytical team would then query the database to see if bull trout were detected at the projects. On the other hand, if Grant decides not to conduct a juvenile survival study, we would need to install basic aerial systems in the forebay and tailrace of each project. Since Grant currently owns all of the necessary equipment, the only cost would be associated with setup.

Douglas PUD – Douglas PUD's interest in the bull trout study is two-fold: (1) examine the migration of bull trout through Wells Dam and (2) document whether bull trout use the Colville and Wells hatchery outfalls as temperature refugia during periods of high Columbia River water temperatures. Douglas PUD currently has no interest in conducting other telemetry studies. Therefore, telemetry systems needed to meet their interests will be new. We will install telemetry systems in the tailrace and forebay of Wells dam and in the Colville and Wells hatchery outfalls. In addition to the systems identified above, we propose to set up fixed-telemetry sites on the Methow (about RM 6.5, at the tail-end of Black Canyon) and Okanogan (about RM 7.2, across from the Crazy Rapids pumping station) rivers near their confluences with the Columbia River. These sites have been used in past telemetry studies by Douglas PUD.

Aerial Surveys

Fixed sites located within the tributaries will assess when individual bull trout enter those waterways. We will use information gathered at those sites to guide aerial surveys, which will track individual trout. We propose as many as two fixed-wing surveys per month during the study period (for a minimum of one year). The surveys will encompass the entire study area (i.e., from Priest Rapids Dam to the Chief Joseph tailrace, and the four tributaries). If data indicate little movement by bull trout during non-spawning periods, aerial surveys may be reduced to one per month. Aerial surveys will be conducted using either 3 or 4-element Yagi antennas mounted to the aircraft struts.

Boat Surveys

Monthly boat surveys (both day and night) will be used to supplement aerial surveys. Surveys will be conducted in the Rocky Reach and Rock Island pools using a powerboat. As with the aerial surveys, either 3- or 4-element Yagi antennas will be used to track bull trout.

Ground Surveys

In addition to aerial and boat surveys, we will conduct monthly ground surveys (which may include vehicle, raft, or foot surveys) within the four tributaries and at Rocky Reach and Rock Island dams. As with the other surveys, we will use either 3- or 4-element Yagi antennas to conduct the surveys.

Movement Patterns

Bull trout behavior in the project area will be compiled based on individual fish and then combined for final analysis. We will describe seasonal and diel movement patterns and habitat use by examining location, timing, and movement of individual bull trout in the project area and in tributaries. Specifically, this work will describe movement patterns, spawning migration and destination, habitat use, residence time in and around each project, ladder entrance and exit times, fallback, and possibly rearing and foraging behaviors.

Seasonal Movement

We will assess seasonal movement in the project area using aerial, boat, and ground surveys. Aerial flights will be used twice a month and will help to guide boat and ground surveys. We will use boat and ground surveys to refine exact locations and descriptions of habitat use. We will use field notebooks and maps to record information on each radio-tagged fish encountered. Each tagged fish will be assigned a unique ID number as a log for survey information. Information will be entered into an electronic database for analysis. Time and locations will be compiled using map-scrolling software on electronic USGS maps. We will use the best resolution (1:100k or 1:250k) to encompass total seasonal movement within the project area. We will append these maps to the report to better illustrate seasonal movement patterns. Total movement will be calculated from successive surveys (time and location) for each fish and displayed in a graph or table.

Diel Movement

Diel movement patterns within the project area will be assessed by boat and ground surveys and compiled on 1:24,000 scale USGS maps. These sampling events will encompass 8-12 hr intervals to track selected fish. Because of the uncertainty of the total number of fish that can be captured, we will develop a rotating schedule to get information on each fish's movement in the project area. The number of tagged fish will determine the amount of time that can be expended on each fish for qualitative observations during any given survey. Successive survey observations will help to explain bull trout behavior in the project area. On these maps we will note the date and location of each fish detected. Each tagged fish will be assigned a unique identification code and coupled with specific information such as habitat, depth, location, time, water temperature, and direction of movement. Comparison of day and night surveys will better describe migratory, rearing or foraging behavior.

Fallback

We will assess fallback with aerial, boat, ground, and fixed station survey methods. We will conclude that fallback has occurred if a fish detected in the tailrace of a project is later detected in the forebay, and shortly thereafter found downstream of that project. However, if the fish was known to have spawned upstream in a tributary during the interim after passing the project, we would consider this normal migratory behavior, not fallback.

Ladder Monitoring

We will monitor the tailrace and forebay areas at all projects, and at Rocky Reach and Rock Island dams, the ladder exits. We will calculate from tailrace, forebay and ladder exit times total and mean passage time for each project. Ladder monitoring combined with tailrace fixed stations can be used to assess the incidence of fallback of radio-tagged fish.

PROJECT TIME TABLE

Our proposed timetable for this study differs from that described in the Request for a Proposal for two reasons. First, Section 10 permits could not be acquired in time to conduct fieldwork in 2000. And second, we are proposing a field study that will last much longer than the one described in the Request for a Proposal. Based on our experience with movements and migrations of adult bull trout in other systems (e.g., Blackfoot River basin), we believe that confining data collection to the period May through July will not capture the seasonal migration patterns of bull trout. These fish can move at any time during the year, but tend to be more active during the late fall–early winter and spring–early summer. Therefore, our study is designed to assess movements of bull trout during all seasons for one year. Below we describe in more detail the schedule of events by task.

Literature Review

The literature review will begin as soon as possible. Although we would prefer to extend the review to the end of the project, thereby allowing us to review studies conducted in the future (i.e., 2001), we are not opposed to completing this phase by the end of 2000.

Develop Capture Methodology

The process to design and develop a viable capture methodology will begin in July 2000, with the intent to finalize a design as early as possible to ensure construction and installation by April 1, 2001. Based on the implementation date, the final design would be completed by October 31, 2000. At this time, it is unclear whether Chelan PUD will provide engineering expertise to design new facilities or whether an outside consulting firm will be used. Regardless, BioAnalysts will coordinate the engineering effort. We assume that if an outside consulting firm is secured, it will contract directly with the PUD (i.e., we have not included that expense in the attached budget). The attached budget assumes that Chelan PUD (and Douglas, if necessary) will construct and install the collection facilities, or will contract with some outside firm to provide those services.

Secure Section 10 Permits

Because of the large number of permits requested and reviewed by agencies, we believe that applications for take permits should be submitted to the appropriate agencies during 2000. We are currently proposing to secure permits through BioAnalysts. However, if the PUD desires to secure the permits, we would offer our assistance. The latter seems reasonable given the magnitude of studies conducted by the PUD. Since acquisition of the appropriate permits by the PUD seems most likely, we have budgeted a moderate amount of time to assist in this task.

Capture, Tag, and Collect Biological Data

Collection and tagging of bull trout will be ready to begin approximately April 15, 2001, to coincide with the beginning of the juvenile survival study, and continue through July 31, 2001. If necessary, collection and tagging may continue throughout the summer and into the fall to acquire the desired number of test animals. Data collection will begin as soon as test animals are tagged and continue for 12 months to capture seasonal migration patterns (see Table 1 for a more detailed accounting of field sampling events). Should BioAnalysts conduct the juvenile survival study for Chelan PUD in 2001, our staff will be on site to tag bull trout as they are collected. Alternatively, if BioAnalysts is not involved with the juvenile study, we will still have a biologist on call to tag fish.

Data Analysis

Data analysis will be an ongoing process throughout the study period. However, the main thrust of data analysis will occur after the conclusion of the field study in March 2002. Because the scope of the work has expanded to five hydroprojects, plus four tributaries, it may be more efficient to have one of the analytical teams associated with the juvenile study analyze the data with their program. Since LGL Limited has been conducting adult surveys within the project area, and their Telemetry Manager program has been configured to assess the information that is desired, we recommend that the PUD contract with them to analyze the data.

Report Writing

We propose to provide the PUD with monthly progress reports (letters) on field studies. The PUD will receive progress reports each month following the first capture and tagging of bull trout. We will submit an inclusive draft report to the PUD by April 2002. We would expect to receive comments from agencies and tribes by the end of May 2002. We would then submit a final report to the PUD by June 30, 2002.

PROJECT BUDGET

The attached budget and supporting information assumes that the PUDs currently own, or will purchase or rent, all the necessary equipment to conduct the study. If Chelan PUD determines that it is necessary to monitor the adult fishways at Rocky Reach and Rock Island dams in detail during the juvenile survival study, then it will be necessary to either rent or purchase additional SRX/DSP units. Considering other telemetry studies conducted concurrently with the bull trout study, it may not be possible to acquire rental units. Should rental units be available, however, they would only be needed from about April 1 to June 30, 2001. After that time period, District owned equipment could be substituted for rental equipment. Depending on the level of resolution required by the PUD, approximately 7 to 10 SRX/DSP units would be needed. Should the PUD decide to purchase new SRX/DSP units, the cost would be about $22,000 per unit. The attached budget also assumes that: (1) Chelan and Douglas PUDs will provide personnel to man collection facilities at their respective projects and (2) they will either provide engineering and mechanical services to design and construct collection facilities (or will contract with firms directly to carry out those tasks).

The cost estimates to each of the three PUDs is based on the assumption that all three will pay for the setup and monitoring of equipment at their respective projects. Specifically, Douglas and Chelan will split the costs of tags, tagging, and capture of fish at Wells Dam. Douglas will cover costs associated with setup and monitoring at Wells Dam and costs associated with monitoring fixed stations on the Methow and Okanogan rivers. Chelan will cover costs associated with setup and monitoring of Rocky Reach and Rock Island dams and costs associated with capture and tagging fish at those projects. Chelan will also cover expenses associated with monitoring fixed stations on the Entiat and Wenatchee rivers. Grant will be responsible for costs associated with the setup and monitoring of Wanapum and Priest Rapids dams. The three PUD's will split costs associated with tracking surveys. Grant will be responsible for 25%, Chelan 45%, and Douglas 30% of survey expenses (percentages calculated as the fraction of the total river miles for which each District is responsible).

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Appendix I

Draft Annual Bypass Operation Plan, Year 2001

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 2001 Bypass Season

The Wells Long Term Settlement Agreement (II.F.1) specifies that Douglas PUD will submit an Annual Operations Plan for the bypass to the Wells Coordinating Committee by December prior to the spring migration. This plan will be reviewed and approved by the Committee by March 1.

The Bypass System
The PUD will install five bypass barriers in spill gates of the Wells Project. The bypass will operate per criteria in the Settlement Agreement (II.C, E).

Operation Criteria
The operation criteria includes operation of the bypass in partnership with adjacent turbine units, the amount of water required for bypass operation and criteria for full bypass system operation.

Bypass Operations Timing Criteria
The bypass will be in place from two weeks before predicted start of the migration until two weeks after the migration is complete.

Projected Hatchery Releases above Wells Dam
Estimated hatchery releases for 2001 above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	215	4/11
Methow (WDFW)	Spr. Chinook	250	4/15
Carlton (WDFW)	Sum. Chinook	415	4/15
Similkameen (WDFW)	Sum. Chinook	630	4/15
Wells (WDFW)	Sum. Steelhead	547	4/20
Winthrop (USFWS)	Sum. Steelhead	100	5/01
Winthrop (USFWS)	Coho	250	4/25
Cassimer Bar (CCT)	Sockeye	84	10/15

Starting Dates and Ending Dates
Bypass barriers will be in place between March 15 and September 15. Hydroacoustic sampling will start on March 15 and be collected until August 29. Fyke netting will be done between March 15 to either April 10 or the start of the Bypass, which ever occurs first and again from August 15 through 31.

The bypass team will decide the start and end of bypass operation. Hydroacoustics and fyke net information at Wells will be used to show the start and completion of the spring and summer migrations. Preseason dates for bypass operation for spring and summer migration are April 10 through May 30 and July 1 through August 15.

(11/31/00)

:\Data Files\bypass\bypass01

Appendix J

Memorandum on Summary of Wells Bypass Operations in 2000

Memorandum

TO: Brian Cates, USFWS
Jerry Marco, Colville Confederated Tribes
FROM: Rick Klinge, Douglas PUD
DATE: September 18, 2000
SUBJECT: Summary of Bypass Operations at Wells Dam, 2000

==================================

Flows in the Columbia River were average in 2000. Wells Dam had all ten units available during the most of the bypass operations. This season, highest hourly discharge occurred on April 24 at 2400 hours with 289.6 kcfs.

The 2000 outmigration was from brood year 1998 for the spring migration and 1999 for the summer migration. Spring chinook natural escapement was negligible since in 1998 the entirely run was intercepted at Wells Dam. Sockeye outmigration was also low since the adult return to Wells in 1998 was only 4,135 adults. Natural escapement of summer / fall chinook in 1999 on the other hand was above average. This was reflective in the juvenile summer migration. Compared to the 1999 hydroacoustics, the amplitude of the combined day and night index in 2000 was much lower for the spring migration while higher for the summer migration.

The bypass team used a combination of fyke net catch ratios of salmonids and historical fyke net data to adjust the hydroacoustic index for non-salmonids. From March 15 through April 10 and after August 15, actual fyke net data were used to adjust the index. Between the initiation of the bypass through May 30, it was assumed the index represented 100% salmonids. A ten-year average correction for salmonids was applied to the index from June 1 until August 15.

Hydroacoustic sampling started at Wells on March 15 to collect background data prior to the start of the spring migration. Initial levels were low. Levels spiked on April 11 as releases from the USFWS Winthrop Hatchery reached Wells Dam. The bypass was initiated on April 12. The spring bypass operated until June 13 for a total of 63 days and with a total discharge of 1.13 MAF, or 6.1% of total project discharge. During the spring bypass operation, there were 173 hours (11.5%) that had forced spill.

When the hydroacoustics indicate a pause between the spring and summer migrations, the bypass is suspended temporarily. The bypass team could not discern this phenomenon in 2000.

Summer bypass started on June 14 at 0000h and ran until September 1 at 2400h, for a total of 80 days of bypass. There was 1.21 MAF or 6.5 % of the total discharge dedicated to summer bypass. During the summer operation, there were 28 hours (1.5%) that had forced spill.

There were nine occasions for fyke netting this year to aid in adjustment of the raw index. Fyke netting was done on March 16, 23, 30 and April 6 in the spring and August 16, 23, 29, September 5 and 12 for the summer. The ratios of salmonids from the catch and the composition of the catch are shown in Table 1.

Appendix K

Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 2000

Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 2000

Rick Klinge

Douglas County Public Utility District No. 1

1151 Valley Mall Parkway

East Wenatchee, WA 98802

February 2001

Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 2000

Introduction

Total dissolved gas (TDG) levels at mid-Columbia dams have been monitored during the spring and summer months since the early 1980's. These data provide information on how projects affect TDG in the Columbia River. Spill at hydroelectric dams can increase TDG during months when adult and juvenile salmonids are migrating in the river. It has been well documented that fish can be injured or die from sustained exposure to elevated dissolved gas (Ebel, et al., 1975; Weitkamp and Katz, 1980). Today, TDG in the Columbia River is monitored at the forebay of all hydroprojects and at least one point in the tailrace.

Initial review in 1996 of TDG generation at Wells Dam compared forebay to forebay data between Wells and Rocky Reach Dam. This initial comparison showed a reduction of gas levels. In 1997, the third highest flow year on record, Wells tailrace TDG transects were made at least once a week. The data showed spill events ranging between 6% and 55%, an increase in TDG was seen over eight weeks (Klinge, 1998). A fixed tailrace monitor in 1998 and 1999 also showed an increase in TDG when spill events occurred (Klinge, 1999, 2000).

Wells Dam was built as a hydrocombine; that is the spillway is situated directly above the powerhouse. The eleven spill gates at Wells have vertical lift gates with bottom discharge. The water level of the tailrace is within five feet of the spill ogee elevation under most spring and summer flow conditions. Thus, there is little to no vertical plunge of spill. The juvenile bypass system modified five spillway entrances to increase attraction velocity for guidance of salmon and steelhead smolts. The even numbered gates (2,4,6,8,and 10) are dedicated for bypass operation. Two of the five modified spillways have top spill trash sluiceways. Bypass flow through top gates (less than 2,000 cfs) drops approximately 65 feet. All forced spill and nitrogen replacement spill is passed through the remaining odd numbered gates.

In 2000, TDG was recorded at 15 minute intervals from the forebay and tailrace at Wells. This report describes methods and results of TDG data collection along with river discharge and spill volumes.

Methods

Two Hydrolab MiniSonde sensors equipped with a dissolved gas and temperature probe collected data approximately every fifteen minutes from April 1 to September 15. The forebay sensor was located midway across the face of the dam at Unit 5 and the tailrace sensor was located on the left bank approximately 2 miles below the dam (Figure 1 & 2). Both sensors were placed at 15 feet below normal forebay and tailwater levels. Data from both stations were automatically transmitted by radio and stored in a file on a personal computer. Data on the hour were sent via the Internet to the Army Corps of Engineers for posting at various Web pages. Hourly values are based upon that reading at the top of the hour rather than an average of the four 15 minute interval data points. Hydrolab Incorporated calibrated the sensors at the beginning of the season. Columbia River Environmental provided in-season calibrations on a monthly basis starting April 13 and through August. Barometric data were recorded from a Capricorn 2000 weather station with an electronic barometer located on the deck of the dam at approximately elevation 810. These data were used in both forebay and tailwater calculations of percent TDG. The Douglas PUD Power Operations provided hydraulic data for discharge and spill.

Results

There were potentially over 16,000 fifteen minute intervals of records collected between April 1 and September 15. The systems for transmitting and logging data had intermittent problems as records were not logged, were stuck (repeated values), or logged in shorter than 10 minute intervals. A review of the records at the end of the season for these anomalies (repeat values, short logging cycle) provided the needed quality control. Data were also removed at the onset

Figure 1. Location of Wells Dam on the Columbia River.

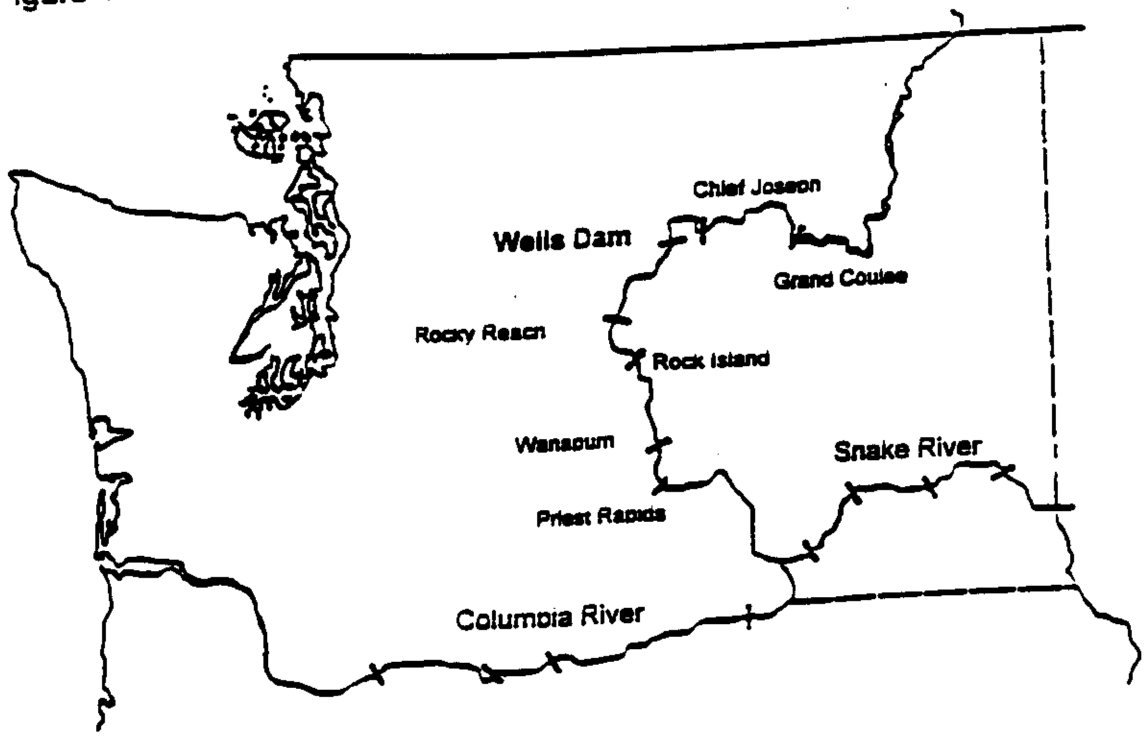
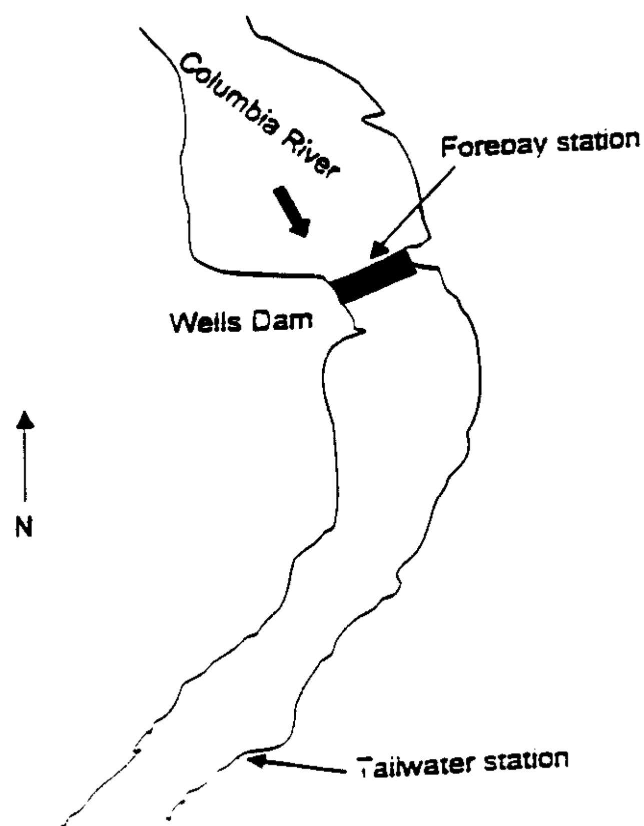


Figure 2. Wells Dam and the TDG sampling locations.



of sensor calibration for a period of two hours. This allowed time for needed service plus at least an hour of acclimation of the new probe membrane to the river environment. After quality control, there were 15,600 usable records. Guidelines for state and federal water quality standards are based upon an average from the twelve highest hourly values during a 24 hour day (12h). Data for this analysis will be presented in 15 minute records, hourly and daily 12 hour values.

Forebay TDG

TDG levels are plotted on Figure 3 and 4. The ranges of values from the 15 minute records were 101.3% on April 7 at 0745 hours and 114.1% on July 22 at 1458 hours. The 12h values from the forebay exceeded 110% on 60 of 168 days of the monitoring season. The longest continuous stretch being from July 16 - 31. The highest 12h value for the forebay was 113.2% on June 5 (Figure 4; Appendix A).

Tailrace TDG

Tailrace TDG values for the 15 minute interval ranged between 101.1% on September 11, at 0313 hours to 131.9% on April 25 at 0043 hours (Figure 3). The 12h value exceeded 110% for 99 of the 168 day season, the longest continuous period being from June 7 until August 30. The 12h value exceeded 115% for 5 days and 120% for one day (April 25 at 125.4%; see Figure 4, Appendix A).

Columbia River flows at Wells Dam were average during the spring and summer of 2000. The volume of water released at Grand Coulee between January and July was 61.1 million acre feet (MAF). This works out to be 97% of the forty year average. The Wells Dam daily average discharge and all spills are shown in Figure 5. Peak hourly discharge occurred on April 24 at 2400 hours at 289.6 thousand cubic feet per second (kcfs). Daily average flow between April 1 and September 15 ranged from 52 to 213 kcfs (Figure 5; Appendix B).

Figure 3. TDG 15 minute values for forebay and tailrace, Wells Dam 2000.

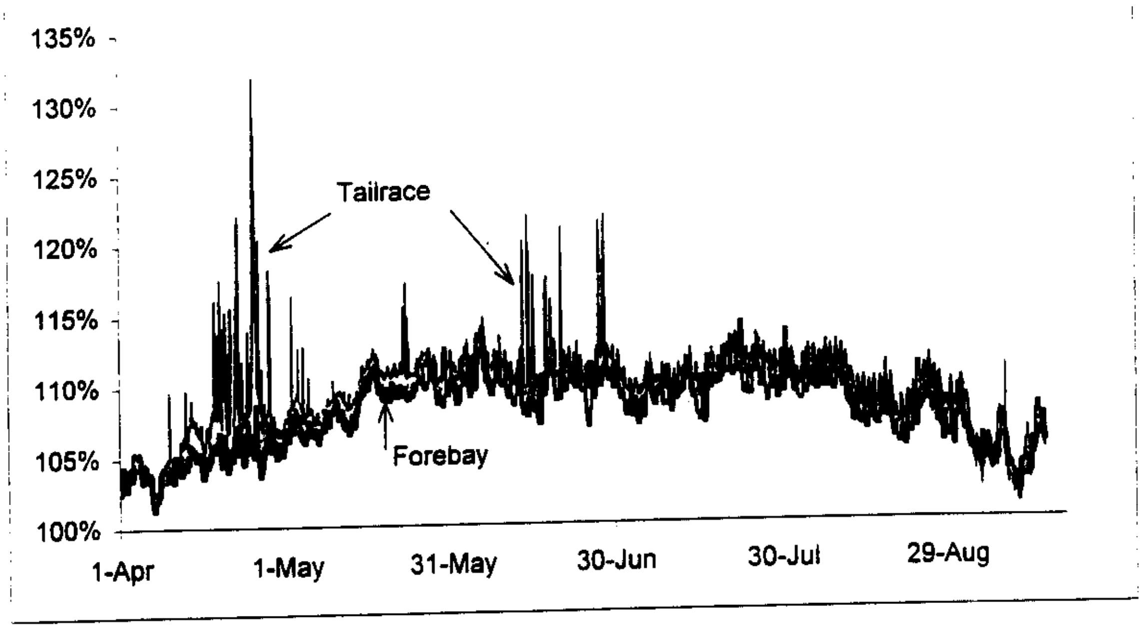
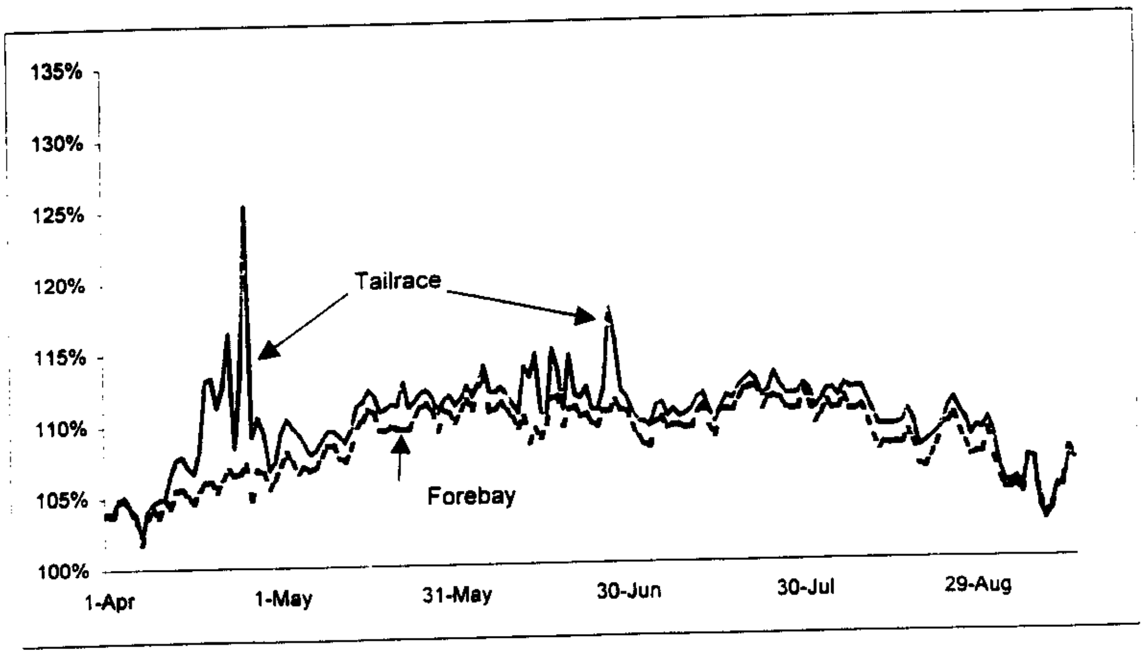


Figure 4. TDG 12 hour values for forebay and tailrace, Wells Dam 2000.



Spill at Wells was a combination of juvenile bypass flow and forced spill. There was a modest amount of spill (1.7 kcfs) as a top spill gate of Gate 2 malfunction on April 6. This spill continued until spring bypass operation on April 12 at 1000 hours. The juvenile bypass operated for the spring migration from April 12 through June 13 and for the summer migration from June 14 to September 1. Bypass operation in 2000 used between 5% and 11% of the daily average project flow. Forced spill occurred on 41 days. The high hourly spill was 153.6 kcfs on April 24 at 2400 hour. There was no nitrogen replacement spill in 2000. Combined spill was analyzed with regards to how it changed TDG between forebay to tailrace sensors. Percent spill verses the change in forebay to tailrace TDG suggests that every 4% of river spilled, TDG would increase by 1% (R^2 = 0.56, $p<0.001$; Figure 6).

Of the 4,032 hourly readings collected in the 2000 season, 9% of the records occurred with no spill. On the average, there was no difference in TDG from forebay to tailrace for non-spill hours.

Columbia River Environmental calibrated the sensors monthly starting in April. There was little movement or drift in between calibrations (Appendix C)

Other hydraulic conditions

The spring and summer water temperatures in the Columbia River at Wells Dam were slightly above normal (Figure 7). The solubility of air in water is inversely proportional to the temperature of the water. While temperature can explain changes in TDG, other factors such as wind action on a reservoir can degas the river.

Figure 5. Daily average flows for power, spill and juvenile bypass operations at Wells Dam, 2000.

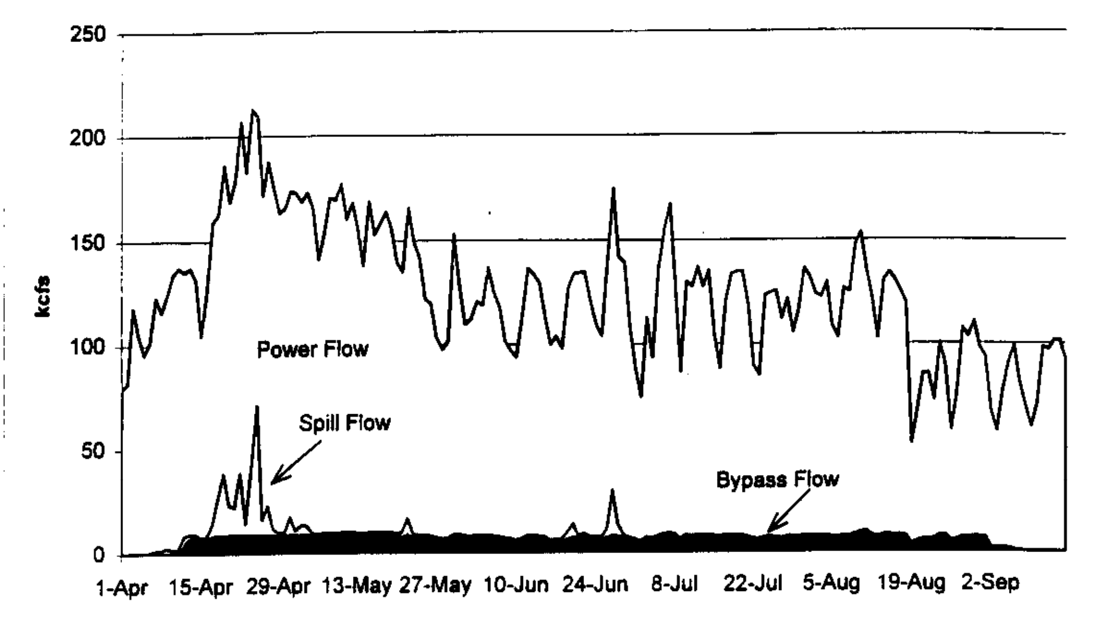


Figure 6. Relation of percent spill to percent change in TDG between tailrace and forebay, Wells Dam, 2000.

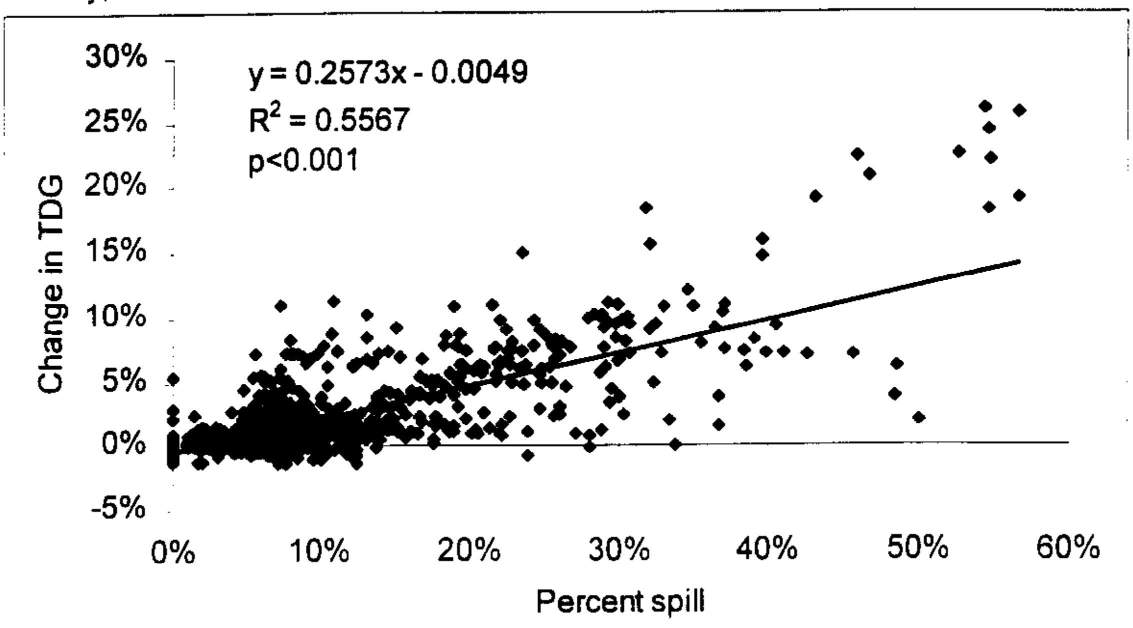


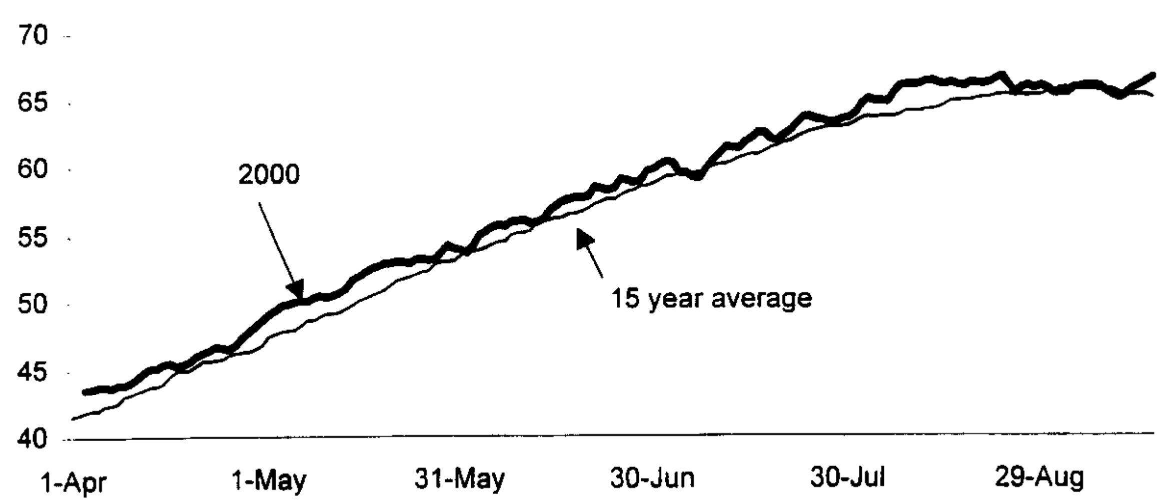
Table 1. Percent spill and percent change TDG from tailwater to forebay for data on the hour.

% spill	Occurrences	TDG Change	Min Change	Max Change
0 – 5%	708	0.3%	-1.2%	5.4%
5 – 10%	2949	1.2%	-1.4%	11.0%
10 – 15%	182	1.8%	-1.4%	11.3%
15 – 20%	59	3.9%	0.2%	10.9%
20 – 30%	84	6.0%	-0.7%	15.1%
30 – 40%	32	8.4%	0.0%	18.4%
>40%	17	15.5%	2.0%	26.0%

Discussion

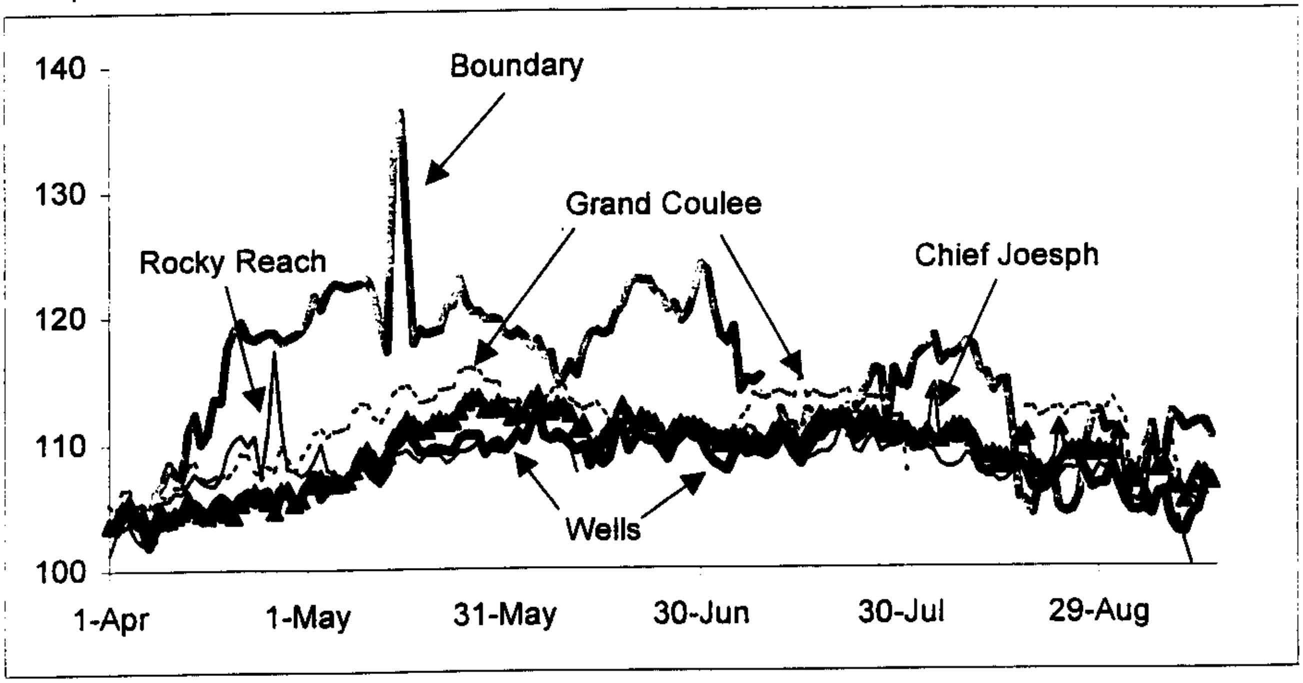
Forebay TDG levels at Wells are driven by operations upstream, namely from Chief Joseph and Grand Coulee dams or projects upstream of the International Boundary. Figure 8 shows records of receiving TDG for 2000 as posted on the DART Page[1] as water reached the Boundary station (RM 745), Grand Coulee (RM 597) Chief Joseph (RM 545), Wells (RM 515) and Rocky Reach (RM 474). Data generally show a drop in TDG levels from station to station moving downstream (Figure 8). The operators at both Grand Coulee and Chief

Figure 7. Columbia River temperatures in 2000 and 15 year average, Wells Dam.



[1]University of Washington DART page (**http://www.cbr.washington.edu/dart/river.html**).

Figure 8. TDG at International Boundary and the forebay of Grand Coulee, Chief Joseph, Wells and Rocky Reach dams, 2000.



Joseph dams in the past five years have dramatically improved TDG condition of the Columbia River through the mid-Columbia reach.

The operations of dams to meet the daily power loads will change the volume of water discharged past the dam. These changes will affect travel time of water from the dam to the tailwater sensor. The arrival of water at the tailwater sensor from a 30% spill event is slower with flows at 80 kcfs compared to 240 kcfs. The comparison of percent spill to change in percent TDG between tailwater and forebay monitors was done for data at the same hour. There was no attempt to correct for the lag time an action at the dam would reflect at the tailwater sensor.

In 2000, operations at Wells from late April through May appeared to add 1.1% TDG to the receiving levels at Rocky Reach Dam. Between April and September, there was only one day, April 26, where forebay TDG at Rocky Reach exceeded 115%. The Washington Department of Ecology has modified water quality standards to allow a maximum of 120% saturation in the tailrace below a dam and 115% in the forebay of the next project. On April 24 and 25 several hours of high spill (up to 56%) occurred during the late night and early morning hours. The 12h average tailwater values at Wells was 125.4% on April 25. This was the only occasion where Wells exceeded water quality criteria at both the tailwater and forebay of the downstream dam for the season.

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Appendix A. TDG Sampling at Wells Dam, 2000.

Wells Dam 2000 Forebay

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr
1-Apr	103.4%	103.8%	104.3%	20	1-May	106.8%	107.2%	107.9%	24	1-Jun	110.0%	110.9%	111.3%	24	1-Jul	109.1%	109.5%	110.1%	24
2-Apr	103.4%	103.7%	104.1%	21	2-May	107.6%	108.0%	108.3%	24	2-Jun	110.9%	111.5%	112.4%	24	2-Jul	108.4%	108.8%	109.1%	24
3-Apr	104.2%	104.6%	105.2%	20	3-May	105.7%	107.3%	107.8%	24	3-Jun	110.2%	110.8%	111.6%	24	3-Jul	108.1%	108.3%	108.7%	24
4-Apr	104.8%	105.0%	105.2%	19	4-May	106.4%	106.6%	107.3%	24	4-Jun	111.4%	112.5%	113.4%	24	4-Jul	107.7%	108.1%	108.5%	24
5-Apr	103.9%	104.1%	104.3%	22	5-May	106.9%	107.1%	107.4%	24	5-Jun	112.6%	113.2%	113.9%	24	5-Jul	108.8%	109.8%	110.2%	24
6-Apr	103.5%	103.6%	103.8%	16	6-May	106.5%	106.7%	106.9%	24	6-Jun	110.3%	110.7%	111.3%	23	6-Jul	109.7%	110.1%	110.4%	24
7-Apr	101.8%	101.8%	102.3%	13	7-May	106.8%	107.0%	107.2%	24	7-Jun	110.2%	110.9%	111.3%	24	7-Jul	109.0%	109.4%	109.9%	24
8-Apr	103.2%	103.7%	104.0%	21	8-May	107.6%	107.8%	108.1%	24	8-Jun	110.8%	111.4%	112.1%	24	8-Jul	109.3%	109.6%	109.9%	24
9-Apr	103.9%	104.2%	104.6%	18	9-May	108.3%	108.5%	108.8%	24	9-Jun	110.4%	110.7%	111.1%	24	9-Jul	109.1%	109.6%	110.5%	24
10-Apr	103.6%	103.7%	103.9%	22	10-May	108.2%	108.5%	108.8%	24	10-Jun	109.8%	110.2%	110.4%	24	10-Jul	108.9%	109.4%	109.8%	24
11-Apr	104.7%	104.8%	105.0%	22	11-May	107.4%	107.7%	108.1%	24	11-Jun	109.3%	109.6%	109.9%	24	11-Jul	109.3%	109.4%	109.5%	24
12-Apr	104.2%	104.3%	104.5%	22	12-May	107.0%	107.3%	107.8%	24	12-Jun	109.8%	110.3%	110.7%	24	12-Jul	110.1%	110.5%	110.8%	24
13-Apr	105.1%	105.4%	105.9%	19	13-May	107.8%	108.3%	108.8%	24	13-Jun	108.2%	108.5%	108.7%	24	13-Jul	110.5%	110.9%	111.4%	24
14-Apr	105.3%	105.5%	105.7%	23	14-May	109.5%	109.9%	110.4%	24	14-Jun	109.0%	109.4%	109.7%	24	14-Jul	108.9%	109.4%	109.7%	24
15-Apr	104.9%	105.1%	105.2%	24	15-May	110.1%	110.3%	110.5%	24	15-Jun	108.4%	108.8%	109.5%	24	15-Jul	108.3%	108.8%	109.8%	24
16-Apr	104.2%	104.6%	104.9%	24	16-May	110.9%	111.0%	111.2%	24	16-Jun	108.6%	109.8%	110.5%	24	16-Jul	109.1%	110.5%	111.6%	24
17-Apr	105.2%	105.5%	105.7%	23	17-May	110.2%	110.7%	111.4%	24	17-Jun	110.7%	111.5%	112.2%	24	17-Jul	110.3%	110.7%	111.1%	24
18-Apr	105.8%	106.0%	106.6%	23	18-May	109.3%	109.5%	109.9%	24	18-Jun	111.2%	111.7%	112.9%	24	18-Jul	110.3%	110.6%	110.9%	24
19-Apr	105.4%	106.0%	106.6%	24	19-May	109.3%	109.5%	109.7%	24	19-Jun	109.4%	109.6%	110.0%	24	19-Jul	111.0%	111.4%	111.9%	24
20-Apr	104.8%	105.3%	105.9%	24	20-May	109.6%	109.8%	110.0%	24	20-Jun	110.2%	110.8%	111.2%	24	20-Jul	111.5%	111.9%	112.4%	24
21-Apr	105.8%	106.3%	107.1%	24	21-May	109.5%	109.6%	109.8%	24	21-Jun	110.5%	110.9%	111.5%	24	21-Jul	111.5%	112.1%	112.9%	24
22-Apr	106.2%	106.9%	107.3%	24	22-May	109.4%	109.5%	109.7%	24	22-Jun	110.1%	110.3%	110.4%	24	22-Jul	111.5%	112.2%	113.8%	24
23-Apr	105.7%	106.4%	107.4%	24	23-May	109.4%	109.6%	109.7%	44	23-Jun	110.1%	110.4%	110.8%	24	23-Jul	110.1%	110.7%	111.3%	24
24-Apr	106.1%	106.7%	107.4%	24	24-May	110.3%	110.6%	110.8%	24	24-Jun	109.5%	109.9%	110.2%	24	24-Jul	110.3%	111.3%	111.6%	24
25-Apr	106.3%	107.2%	108.6%	24	25-May	110.6%	111.0%	111.8%	24	25-Jun	108.6%	109.6%	111.0%	24	25-Jul	111.2%	111.5%	112.4%	24
26-Apr	104.4%	104.8%	105.2%	24	26-May	110.7%	111.3%	112.0%	24	26-Jun	109.9%	110.6%	111.0%	23	26-Jul	110.8%	111.3%	111.6%	24
27-Apr	106.2%	106.8%	107.3%	24	27-May	110.6%	110.8%	111.1%	24	27-Jun	110.4%	110.6%	110.9%	24	27-Jul	110.2%	110.7%	111.1%	24
28-Apr	106.2%	106.6%	107.0%	24	28-May	109.1%	109.4%	110.0%	24	28-Jun	111.0%	111.3%	111.9%	24	28-Jul	110.1%	110.5%	111.1%	24
29-Apr	105.3%	105.5%	106.0%	24	29-May	109.8%	110.9%	112.4%	24	29-Jun	110.4%	110.7%	111.0%	24	29-Jul	110.0%	110.6%	110.8%	24
30-Apr	105.8%	106.2%	106.8%	24	30-May	110.1%	110.6%	111.4%	24	30-Jun	110.3%	110.6%	110.9%	24	30-Jul	110.9%	111.8%	113.1%	24
					31-May	109.5%	110.0%	110.4%	24						31-Jul	110.6%	110.9%	111.3%	24
Avg	104.8%	105.1%	105.6%	22	Avg	108.7%	109.1%	109.5%	25	Avg	110.1%	110.6%	111.1%	24	Average	109.8%	110.3%	110.9%	24

Wells Dam 2000 Forebay

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr
1-Aug	109.5%	109.7%	110.0%	24	1-Sep	106.6%	106.9%	107.6%	24
2-Aug	109.6%	110.2%	110.5%	24	2-Sep	105.2%	105.4%	105.9%	24
3-Aug	110.3%	111.0%	112.0%	24	3-Sep	104.5%	104.7%	105.1%	23
4-Aug	110.2%	110.5%	111.0%	24	4-Sep	104.4%	104.8%	105.8%	24
5-Aug	110.2%	110.7%	111.1%	24	5-Sep	104.7%	105.0%	105.4%	23
6-Aug	110.5%	111.3%	111.7%	24	6-Sep	104.2%	104.5%	104.6%	24
7-Aug	110.1%	110.5%	110.9%	24	7-Sep	105.7%	107.0%	107.4%	24
8-Aug	110.0%	110.5%	110.8%	24	8-Sep	106.2%	106.9%	107.4%	23
9-Aug	110.4%	110.7%	111.2%	24	9-Sep	103.7%	103.9%	104.6%	24
10-Aug	109.2%	109.7%	110.0%	24	10-Sep	102.8%	103.0%	103.2%	23
11-Aug	108.1%	108.5%	109.1%	24	11-Sep	102.7%	103.3%	103.9%	23
12-Aug	107.5%	107.7%	108.3%	24	12-Sep	104.0%	104.7%	105.3%	24
13-Aug	107.6%	108.1%	109.2%	24	13-Sep	104.5%	105.3%	105.5%	24
14-Aug	107.4%	108.0%	108.8%	24	14-Sep	106.5%	107.5%	108.1%	24
15-Aug	107.7%	108.1%	108.7%	24	15-Sep	106.6%	107.0%	107.2%	24
16-Aug	107.6%	108.1%	108.5%	24					
17-Aug	108.3%	108.9%	109.6%	24					
18-Aug	107.7%	108.1%	109.0%	24					
19-Aug	106.4%	106.6%	106.7%	24					
20-Aug	106.1%	106.4%	106.9%	24					
21-Aug	106.3%	107.1%	107.6%	24					
22-Aug	107.1%	107.9%	108.7%	24					
23-Aug	108.2%	109.4%	110.6%	24					
24-Aug	109.0%	109.5%	110.1%	24					
25-Aug	109.5%	110.0%	110.3%	24					
26-Aug	108.5%	108.9%	109.4%	24					
27-Aug	107.5%	108.0%	108.7%	24					
28-Aug	106.6%	107.1%	107.4%	24					
29-Aug	106.7%	107.3%	107.8%	24					
30-Aug	106.6%	107.4%	107.7%	24					
31-Aug	108.2%	108.9%	109.4%	24					
Avg	108.3%	108.9%	109.4%	24	Avg	104.8%	105.3%	105.8%	24

Appendix A. TDG Sampling at Wells Dam, 2000.

Wells Dam 2000 Tailwater

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr
1-Apr	103.6%	104.0%	104.5%	20	1-May	108.6%	109.5%	113.4%	24	1-Jun	110.9%	111.7%	112.0%	24	1-Jul	110.1%	110.5%	110.9%	24
2-Apr	103.7%	104.0%	104.4%	21	2-May	109.5%	110.4%	115.5%	24	2-Jun	111.9%	112.5%	113.1%	24	2-Jul	109.5%	109.9%	110.1%	24
3-Apr	104.4%	104.9%	105.5%	21	3-May	109.0%	109.9%	112.5%	24	3-Jun	111.5%	111.8%	112.0%	24	3-Jul	109.6%	109.9%	110.1%	24
4-Apr	104.9%	105.1%	105.4%	19	4-May	108.5%	109.3%	112.7%	24	4-Jun	111.7%	112.7%	112.9%	24	4-Jul	109.3%	109.6%	109.9%	24
5-Apr	104.0%	104.3%	104.6%	22	5-May	108.3%	108.7%	110.6%	24	5-Jun	113.4%	113.9%	114.7%	24	5-Jul	110.1%	111.0%	111.3%	24
6-Apr	103.7%	103.8%	104.0%	17	6-May	107.6%	107.9%	108.1%	24	6-Jun	111.7%	112.1%	112.3%	23	6-Jul	110.8%	111.2%	112.0%	24
7-Apr	102.2%	102.2%	102.6%	13	7-May	107.7%	108.1%	108.3%	24	7-Jun	111.3%	112.0%	112.3%	24	7-Jul	110.1%	110.3%	110.3%	24
8-Apr	103.5%	104.0%	104.4%	21	8-May	108.6%	108.9%	109.2%	24	8-Jun	112.0%	112.4%	113.2%	24	8-Jul	110.4%	110.7%	111.3%	24
9-Apr	104.2%	104.6%	105.0%	20	9-May	109.2%	109.5%	110.4%	24	9-Jun	111.3%	111.8%	112.2%	24	9-Jul	109.5%	110.2%	110.6%	24
10-Apr	104.3%	104.8%	109.7%	23	10-May	109.4%	109.5%	109.6%	24	10-Jun	110.7%	111.2%	111.5%	24	10-Jul	109.8%	110.3%	110.7%	24
11-Apr	104.7%	104.9%	105.1%	21	11-May	108.9%	109.1%	109.3%	24	11-Jun	110.1%	110.6%	110.9%	24	11-Jul	110.0%	110.7%	111.3%	24
12-Apr	105.6%	106.5%	109.8%	22	12-May	108.6%	108.7%	109.4%	24	12-Jun	112.5%	113.8%	119.5%	24	12-Jul	110.7%	111.5%	111.8%	24
13-Apr	107.1%	107.6%	109.6%	19	13-May	109.3%	109.7%	110.0%	24	13-Jun	111.1%	113.1%	119.0%	24	13-Jul	111.3%	111.8%	112.3%	24
14-Apr	107.5%	107.8%	109.1%	23	14-May	110.8%	111.3%	111.5%	24	14-Jun	112.5%	114.7%	119.2%	24	14-Jul	110.0%	110.6%	111.2%	24
15-Apr	106.8%	107.1%	107.3%	24	15-May	111.3%	111.5%	111.9%	24	15-Jun	110.0%	110.6%	114.0%	24	15-Jul	109.1%	109.8%	110.4%	24
16-Apr	106.1%	106.6%	107.1%	24	16-May	112.1%	112.3%	112.5%	24	16-Jun	109.8%	110.5%	110.7%	24	16-Jul	109.8%	110.7%	111.4%	24
17-Apr	107.4%	108.3%	111.9%	23	17-May	111.5%	111.9%	112.2%	24	17-Jun	113.4%	115.0%	117.4%	24	17-Jul	111.0%	111.6%	112.1%	24
18-Apr	110.9%	113.1%	116.1%	22	18-May	110.8%	110.9%	111.0%	24	18-Jun	112.6%	113.5%	115.9%	24	18-Jul	110.8%	111.3%	111.6%	24
19-Apr	111.5%	113.3%	115.9%	24	19-May	110.8%	111.0%	111.3%	24	19-Jun	110.4%	110.8%	111.2%	24	19-Jul	111.4%	112.2%	112.4%	24
20-Apr	109.2%	111.3%	115.3%	24	20-May	111.1%	111.3%	111.6%	24	20-Jun	112.9%	114.5%	120.9%	24	20-Jul	112.0%	112.6%	113.1%	24
21-Apr	110.4%	112.7%	115.2%	24	21-May	111.1%	111.2%	111.6%	24	21-Jun	111.2%	111.8%	112.5%	24	21-Jul	112.2%	113.0%	113.4%	24
22-Apr	112.5%	116.5%	122.0%	24	22-May	111.8%	112.9%	117.2%	24	22-Jun	111.3%	111.6%	112.0%	24	22-Jul	112.0%	112.5%	113.3%	24
23-Apr	107.8%	108.5%	109.9%	24	23-May	111.8%	112.9%	117.2%	24	23-Jun	111.7%	112.3%	112.8%	24	23-Jul	110.8%	111.5%	112.1%	24
24-Apr	111.1%	113.3%	126.3%	24	24-May	110.5%	111.1%	112.7%	42	24-Jun	110.4%	110.8%	111.2%	24	24-Jul	110.9%	111.9%	112.3%	24
25-Apr	119.3%	125.4%	131.3%	24	25-May	111.1%	111.5%	111.8%	24	25-Jun	109.8%	110.7%	111.0%	24	25-Jul	112.4%	113.2%	113.7%	24
26-Apr	107.7%	109.2%	118.5%	24	26-May	111.5%	112.0%	112.4%	24	26-Jun	111.0%	112.1%	113.4%	23	26-Jul	111.6%	112.2%	112.6%	24
27-Apr	108.9%	110.6%	117.0%	24	27-May	111.6%	112.3%	112.6%	24	27-Jun	115.0%	117.8%	121.2%	24	27-Jul	111.0%	111.7%	111.9%	24
28-Apr	108.3%	109.5%	116.7%	24	28-May	111.6%	111.8%	112.0%	24	28-Jun	113.9%	115.6%	120.8%	24	28-Jul	111.1%	111.6%	112.0%	24
29-Apr	106.7%	106.9%	107.1%	24	29-May	110.3%	110.7%	111.5%	24	29-Jun	111.6%	112.0%	112.6%	24	29-Jul	111.2%	111.7%	112.0%	24
30-Apr	107.1%	107.4%	107.8%	24	30-May	110.7%	111.6%	112.0%	24	30-Jun	111.2%	111.6%	112.2%	24	30-Jul	111.8%	112.3%	112.9%	24
					31-May	111.3%	111.9%	112.3%	24						31-Jul	111.4%	111.8%	112.2%	24
Avg	107.2%	108.3%	111.0%	22	Avg	110.2%	110.6%	111.7%	25	Avg	111.6%	112.5%	114.2%	24	Avg	110.7%	111.3%	111.7%	24
																	109.6%		
																	113.2%		

Appendix A. TDG Sampling at Wells Dam, 2000.

Wells Dam 2000 Tailwater

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr
1-Aug	110.4%	110.6%	111.0%	24	1-Sep	108.3%	108.6%	109.0%	24
2-Aug	110.2%	111.2%	111.7%	24	2-Sep	105.8%	106.3%	107.4%	24
3-Aug	111.0%	111.9%	112.5%	24	3-Sep	104.8%	105.2%	105.7%	23
4-Aug	111.2%	111.9%	112.3%	24	4-Sep	104.4%	105.2%	105.8%	24
5-Aug	110.8%	111.4%	111.9%	24	5-Sep	105.1%	105.5%	105.9%	23
6-Aug	111.2%	112.3%	112.7%	24	6-Sep	104.5%	104.8%	105.0%	24
7-Aug	111.2%	112.0%	112.4%	24	7-Sep	105.7%	107.0%	107.7%	24
8-Aug	111.2%	112.0%	112.8%	24	8-Sep	106.2%	106.9%	107.4%	23
9-Aug	111.5%	112.0%	112.4%	24	9-Sep	103.7%	103.9%	104.6%	24
10-Aug	110.8%	111.1%	111.6%	24	10-Sep	102.8%	103.0%	103.2%	23
11-Aug	109.9%	110.3%	110.5%	24	11-Sep	102.7%	103.3%	103.9%	23
12-Aug	109.0%	109.4%	110.0%	24	12-Sep	104.0%	104.7%	105.3%	24
13-Aug	108.6%	109.4%	110.0%	24	13-Sep	104.2%	104.8%	105.1%	24
14-Aug	108.6%	109.4%	109.8%	24	14-Sep	106.0%	107.1%	107.7%	24
15-Aug	108.8%	109.5%	109.9%	24	15-Sep	106.3%	106.8%	107.2%	24
16-Aug	108.8%	109.6%	110.0%	24					
17-Aug	109.6%	110.5%	111.3%	24					
18-Aug	109.1%	109.6%	110.2%	24					
19-Aug	107.4%	107.8%	108.3%	24					
20-Aug	107.4%	108.1%	108.6%	24					
21-Aug	107.7%	108.4%	109.0%	24					
22-Aug	108.2%	108.8%	109.5%	24					
23-Aug	108.5%	109.3%	109.8%	24					
24-Aug	109.6%	110.6%	111.0%	24					
25-Aug	110.6%	111.2%	111.7%	24					
26-Aug	109.6%	110.3%	110.7%	24					
27-Aug	109.3%	109.8%	110.3%	24					
28-Aug	108.4%	108.6%	108.8%	24					
29-Aug	108.4%	109.2%	109.9%	24					
30-Aug	108.4%	109.1%	109.5%	24					
31-Aug	109.3%	109.8%	110.1%	24					
Avg	109.5%	110.2%	110.6%	24	Avg	105.0%	105.6%	106.1%	24

Appendix B. Daily average flows at Wells Dam, 2000.

all values in kcfs

Date	Total Q	Bypass	Spill Q	N2 Spill
1-Apr	79.4		0.0	0.0
2-Apr	78.2	0.0	0.0	0.0
3-Apr	118.0	0.0	0.0	0.0
4-Apr	105.0	0.0	0.0	0.0
5-Apr	95.4	0.0	0.0	0.0
6-Apr	101.5	0.0	0.6	0.0
7-Apr	122.8	0.0	1.6	0.0
8-Apr	115.8	0.0	1.7	0.0
9-Apr	124.4	0.0	2.9	0.0
10-Apr	133.6	0.0	1.7	0.0
11-Apr	137.2	0.0	1.7	0.0
12-Apr	135.0	6.5	2.0	0.0
13-Apr	137.1	8.7	0.7	0.0
14-Apr	131.2	9.4	0.0	0.0
15-Apr	104.5	7.8	0.0	0.0
16-Apr	125.4	8.0	0.0	0.0
17-Apr	159.1	9.6	4.5	0.0
18-Apr	162.7	10.0	16.4	0.0
19-Apr	186.1	10.0	28.5	0.0
20-Apr	168.7	10.0	13.3	0.0
21-Apr	178.5	10.4	11.9	0.0
22-Apr	207.1	10.4	28.4	0.0
23-Apr	182.9	10.4	4.1	0.0
24-Apr	213.0	10.4	31.0	0.0
25-Apr	209.3	10.0	61.3	0.0
26-Apr	171.9	10.0	6.5	0.0
27-Apr	187.8	10.0	12.9	0.0
28-Apr	175.1	10.0	2.0	0.0
29-Apr	163.3	10.0	0.0	0.0
30-Apr	165.7	10.0	0.0	0.0
Avg	145.9	6.3	7.8	0.0

Date	Total Q	Bypass	Spill Q	N2 Spill
1-May	173.9	9.2	7.7	0.0
2-May	172.6	9.6	1.2	0.0
3-May	168.7	10.0	3.5	0.0
4-May	173.0	10.0	3.6	0.0
5-May	165.2	10.0	0.0	0.0
6-May	140.9	9.4	0.0	0.0
7-May	154.0	10.0	0.0	0.0
8-May	170.5	10.0	0.0	0.0
9-May	169.3	10.0	0.0	0.0
10-May	176.8	10.0	0.0	0.0
11-May	160.4	10.0	0.0	0.0
12-May	168.1	10.0	0.0	0.0
13-May	155.6	10.0	0.0	0.0
14-May	137.9	9.3	0.0	0.0
15-May	168.8	10.0	0.0	0.0
16-May	152.9	10.0	0.0	0.0
17-May	158.5	10.0	0.0	0.0
18-May	163.6	10.0	0.0	0.0
19-May	156.0	10.0	0.0	0.0
20-May	139.4	9.4	0.0	0.0
21-May	135.0	8.6	1.6	0.0
22-May	165.5	10.0	6.7	0.0
23-May	148.9	8.6	0.3	0.0
24-May	141.8	8.6	0.0	0.0
25-May	121.7	8.3	0.0	0.0
26-May	119.5	8.2	0.0	0.0
27-May	103.2	7.5	0.0	0.0
28-May	97.6	6.7	0.0	0.0
29-May	101.3	7.0	0.0	0.0
30-May	153.1	8.8	0.0	0.0
31-May	128.0	8.7	0.0	0.0
Avg	149.7	9.3	0.8	0.0

Date	Total Q	Bypass	Spill Q	N2 Spill
1-Jun	109.6	8.4	0.0	0.0
2-Jun	112.4	7.8	0.0	0.0
3-Jun	120.4	8.6	0.0	0.0
4-Jun	118.9	8.3	0.0	0.0
5-Jun	137.0	8.5	0.0	0.0
6-Jun	124.9	8.4	0.0	0.0
7-Jun	118.0	7.8	0.0	0.0
8-Jun	101.5	7.3	0.0	0.0
9-Jun	97.0	6.8	0.0	0.0
10-Jun	93.9	6.1	0.0	0.0
11-Jun	112.9	6.8	0.0	0.0
12-Jun	136.4	8.6	0.0	0.0
13-Jun	133.8	8.5	0.0	0.0
14-Jun	129.3	8.2	0.0	0.0
15-Jun	113.2	7.7	0.0	0.0
16-Jun	99.8	6.1	0.0	0.0
17-Jun	103.9	6.3	0.0	0.0
18-Jun	98.0	6.5	0.0	0.0
19-Jun	126.6	7.7	2.4	0.0
20-Jun	133.9	8.8	5.1	0.0
21-Jun	134.3	8.2	0.0	0.0
22-Jun	134.6	9.0	0.4	0.0
23-Jun	120.5	7.7	0.0	0.0
24-Jun	109.7	7.8	0.0	0.0
25-Jun	104.0	7.3	0.0	0.0
26-Jun	141.3	8.4	3.3	0.0
27-Jun	174.8	9.7	20.3	0.0
28-Jun	141.8	9.1	4.5	0.0
29-Jun	139.5	8.7	0.0	0.0
30-Jun	107.9	7.3	0.0	0.0
Avg	121.0	7.9	1.2	0.0

Date	Total Q	Bypass	Spill Q	N2 Spill
1-Jul	88.2	6.5	0.0	0.0
2-Jul	74.6	5.3	0.0	0.0
3-Jul	112.7	7.7	0.0	0.0
4-Jul	93.8	6.9	0.0	0.0
5-Jul	136.3	8.4	0.0	0.0
6-Jul	155.1	9.2	0.0	0.0
7-Jul	167.4	9.6	0.0	0.0
8-Jul	129.1	8.9	0.0	0.0
9-Jul	86.8	6.4	0.0	0.0
10-Jul	129.7	8.4	0.0	0.0
11-Jul	127.6	8.0	0.0	0.0
12-Jul	136.9	8.6	0.0	0.0
13-Jul	127.6	8.7	0.0	0.0
14-Jul	135.3	8.5	0.0	0.0
15-Jul	104.9	8.0	0.0	0.0
16-Jul	88.3	7.5	0.0	0.0
17-Jul	120.9	8.2	0.3	0.0
18-Jul	133.7	8.3	0.0	0.0
19-Jul	134.6	8.1	0.0	0.0
20-Jul	134.6	8.1	0.0	0.0
21-Jul	119.3	7.6	0.0	0.0
22-Jul	89.8	6.4	0.0	0.0
23-Jul	84.9	6.3	0.0	0.0
24-Jul	123.6	7.4	0.0	0.0
25-Jul	124.7	7.7	0.0	0.0
26-Jul	125.7	7.3	0.0	0.0
27-Jul	112.0	6.8	0.0	0.0
28-Jul	121.5	7.7	0.0	0.0
29-Jul	105.5	7.6	0.3	0.0
30-Jul	115.7	7.4	0.0	0.0
31-Jul	136.1	8.1	0.0	0.0
Avg	118.6	7.7	0.0	0.0

Appendix B. Daily average flows at Wells Dam, 2000.

all values in kcfs

Date	Total Q	Bypass	Spill Q	N2 Spill	Date	Total Q	Bypass	Spill Q	N2 Spill
1-Aug	132.3	8.0	0.0	0.0	1-Sep	93.6	7.2	0.0	0.0
2-Aug	123.9	8.0	0.0	0.0	2-Sep	67.8	0.0	0.0	0.0
3-Aug	122.6	7.6	0.0	0.0	3-Sep	58.0	0.0	0.0	0.0
4-Aug	129.4	8.0	0.0	0.0	4-Sep	77.1	0.0	0.0	0.0
5-Aug	108.5	7.1	0.0	0.0	5-Sep	91.2	0.0	0.0	0.0
6-Aug	103.0	6.9	0.0	0.0	6-Sep	99.1	0.0	0.0	0.0
7-Aug	126.5	7.7	0.0	0.0	7-Sep	81.5	0.0	0.0	0.0
8-Aug	125.1	7.7	0.0	0.0	8-Sep	70.3	0.0	0.0	0.0
9-Aug	148.2	8.8	0.0	0.0	9-Sep	60.2	0.0	0.0	0.0
10-Aug	153.5	9.8	0.0	0.0	10-Sep	71.0	0.0	0.0	0.0
11-Aug	135.7	10.0	0.0	0.0	11-Sep	98.5	0.0	0.0	0.0
12-Aug	121.9	8.1	0.0	0.0	12-Sep	97.1	0.0	0.0	0.0
13-Aug	102.6	7.2	0.0	0.0	13-Sep	101.8	0.0	0.0	0.0
14-Aug	130.6	8.2	0.0	0.0	14-Sep	101.5	0.0	0.0	0.0
15-Aug	134.3	8.5	0.0	0.0	15-Sep	92.0	0.0	0.0	0.0
16-Aug	130.6	7.8	0.0	0.0	16-Sep				
17-Aug	125.5	8.2	0.0	0.0	17-Sep				
18-Aug	119.6	7.6	0.0	0.0	18-Sep				
19-Aug	51.9	3.5	0.0	0.0	19-Sep				
20-Aug	68.6	5.1	0.0	0.0	20-Sep				
21-Aug	85.4	5.9	0.0	0.0	21-Sep				
22-Aug	86.0	6.1	0.0	0.0	22-Sep				
23-Aug	72.9	6.5	0.0	0.0	23-Sep				
24-Aug	100.3	8.2	0.0	0.0	24-Sep				
25-Aug	89.7	8.3	0.0	0.0	25-Sep				
26-Aug	58.6	5.2	0.0	0.0	26-Sep				
27-Aug	75.3	5.8	0.0	0.0	27-Sep				
28-Aug	107.4	7.3	0.0	0.0	28-Sep				
29-Aug	103.4	7.0	0.0	0.0	29-Sep				
30-Aug	110.9	7.6	0.0	0.0	30-Sep				
31-Aug	98.2	7.4	0.0	0.0					
Avg	109.1	7.4	0.0	0.0	Avg	84.0	0.5	0.0	0.0

Appendix L

Survival Estimates for Radio-Tagged and PIT tagged Yearling Summer Steelhead Migrating through the Mid-Columbia River, 1999.

SURVIVAL ESTIMATES FOR RADIO-TAGGED AND PIT-TAGGED YEARLING SUMMER STEELHEAD MIGRATING THROUGH THE MID-COLUMBIA RIVER, 1999

by

Shane A. Bickford[1]
Dr. John Skalski[2]
Rich Townsend[2]
Dr. Russ Frith[3]
Richard Alexander[3]
Donn Park[4]
Scott McCutcheon[4]

[1] *Environmental and Regulatory Services*
Public Utility District No. 1 of Douglas County
East Wenatchee, Washington

[2] *School of Fisheries, University of Washington*
Seattle, Washington

[3] *LGL Limited*
Sidney, British Columbia

[4] *Biomark, Incorporated*
Boise, Idaho

Research Funded by:

Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, Washington 98802 - 4497

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EXECUTIVE SUMMARY

In the spring of 1999, the Public Utility District No. 1 of Douglas County conducted a side-by-side comparison of the behavior and survival of radio-tagged and PIT-tagged steelhead smolts. The primary goal of the study was to determine whether radio-tagged steelhead could be utilized to develop unbiased estimates of survival through the Wells Hydroelectric Project.

In order to accomplish the primary goal of the study, five replicate groups of radio-tagged and PIT-tagged steelhead were collected, tagged and released at Crazy Rapids on the Okanogan River. Care was taken to ensure that both collection and handling procedures were similar between the two tag groups. Specific objectives toward accomplishing the primary goal included 1) testing the assumptions of the single (SRR) release-recapture model for radio-tagged fish, 2) estimating capture and reach specific survival probabilities for radio-tagged and PIT-tagged steelhead, and 3) comparing travel time, arrival distributions, relative guidance efficiencies and reach survival estimates for radio-tagged and PIT-tagged steelhead smolts.

The behavior and survival comparison of radio-tagged and PIT-tagged steelhead was facilitated through the release of 296 radio-tagged and 10,035 PIT-tagged steelhead. The release site was located 42 km upstream of Wells Dam in the Okanogan River. Five side-by-side replicate releases of radio-tagged and PIT-tagged fish were completed in 1999. Each of the five replicate releases contained approximately 60 radio-tagged and approximately 2,000 PIT-tagged fish.

To minimize differences between tag groups, fish were collected and randomly assigned to either the radio-tag or PIT-tag study groups. Standardization between radio-tag and PIT-tag release groups was furthered by simultaneous tagging, recovery, transport and release. Water source and recovery times were also matched between the two tag groups. Differences between radio and PIT release groups included differences in tag size, tag implantation techniques and holding container size.

Recapture and passive interrogation of radio-tagged fish was facilitated via the installation of five multi-antenna receiver stations. Three aerial receiver zones were established upstream of Wells Dam. One zone covered the confluence of the Okanogan and Columbia rivers, the second covered the confluence of the Methow and Columbia rivers and the third zone covered the forebay of Wells Dam. Two additional aerial receiver zones were established downstream of Wells Dam. The first tailrace zone was located 5 km downstream of Wells Dam. The second tailrace zone was located 13 km downstream of Wells Dam near Beebe Bridge.

In addition to the five Douglas PUD aerial receiver zones, radio-tagged steelhead were also detected as they passed by underwater antenna systems deployed by Chelan PUD at Rocky Reach and Rock Island dams.

Recapture and passive interrogation of PIT-tagged fish took place at Rocky Reach, McNary, John Day and Bonneville dams. Additional study fish were interrogated at the Columbia River estuary by a boat towed PIT-tag trawl.

A comparison of the arrival dates of radio-tagged and PIT-tagged steelhead at the video-room at Rocky Reach Dam found the arrival distributions to be significantly different (P = 0.0012). A plot of arrival distributions suggested that fewer radio-tagged fish relative to PIT-tagged fish were detected at Rocky Reach after May 17, 1999.

Harmonic mean travel times from release to the Rocky Reach video counting station was 4.2408 days for radio-tagged fish and 3.9811 days for PIT-tagged fish. This represented a 6 hour difference in the travel time of radio-tagged and PIT-tagged fish. A statistical comparison of the harmonic mean travel times between the two tag groups concluded that the observed 6 hour differences between the mean travel time of the radio and PIT release groups was not significant (P = 0.3000).

A comparison of the relative guidance efficiency for radio-tagged fish through the Rocky Reach video-counting station provided an overall test of equal survival and guidance to that point in the river. Results of this test indicated that there was no statistically significant (P = 0.2266) difference detected between the radio and PIT release groups.

Estimates of survival for Okanogan released radio-tagged and PIT-tagged steelhead were based upon the single release-recapture model. Radio-tagged and PIT-tagged fish were interrogated at the video counting room at Rocky Reach. Fewer radio-tagged fish were interrogated at the video room than anticipated prior to the study. Hence, survival for radio-tagged fish could only be estimated from release to the forebay of Rocky Reach Dam rather than from release to the tailrace of the dam as originally planned.

Radio-tag survival from Crazy Rapids to the forebay of Rocky Reach Dam averaged 0.822 ($S\hat{E} = 0.075$*). PIT-tag survival from Crazy Rapids to the tailrace of Rocky Reach Dam averaged 0.878 (* $S\hat{E} = 0.017$*). Because PIT-tag survival estimates included survival through Rocky Reach Dam, only a qualitative reach survival comparison was possible for fish released in 1999. Radio-tag survival from release to the forebay of Rocky Reach was 5.6% lower and markedly less precise than the estimate of survival derived from PIT-tagged fish released in 1999. Radio-tag survival from Pateros to the tailrace of Wells Dam was a 3.4% less than the estimate of PIT-tagged fish survival through the same section of river.*

Differences in survival estimation techniques, tagging procedures, differences in fish behavior and differences in tag types, were thought to explain the majority of the differences observed between arrival distribution and survival between radio and PIT tagged steelhead smolts.

The radio-tag survival technique provides a considerable reduction in sample size over PIT-tag release-recapture techniques. However, a lack of demonstrated precision, substantially higher study costs and the potential for negative (modified fish behavior) and positive (invalid tag detections) bias still impedes the application of radio-tag mark-recapture technique at Wells Dam.

Consistent differences in survival and arrival distributions between radio-tagged and PIT-tagged steelhead were sufficiently large in 1999 to warrant further study of the radio-tag survival technique for steelhead. Similar side-by-side radio-PIT survival comparisons for yearling chinook, sockeye and subyearling chinook are recommended before radio-tag survival estimates can be utilized as unbiased project survival estimators at Wells Dam.

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1.0 INTRODUCTION

The development of the PIT-tag and the single release-recapture (SRR) and paired release-recapture (PRR) models have dramatically increased the precision of survival studies conducted at Columbia and Snake river hydroelectric projects. Precise project survival estimates through Snake River dams have been generated from release groups numbering fewer than 5,000 fish (Skalski et al., 1997). However, in order to develop similarly precise SRR and PRR survival estimates at Mid-Columbia River projects tens of thousands of PIT-tagged fish must be released.

In both cases sample size requirements are directly related to the rate of interrogation and detection of PIT-tagged fish. In the Mid-Columbia River, only Rocky Reach Dam contains an efficient PIT-tag detection facility. PIT-tagged fish are collected at Rock Island Dam, however the rate of collection in 1999 was insufficient for use in partitioning survival between mainstem projects. The three remaining PUD dams do not contain PIT-tag interrogation equipment. The lack of multiple and efficient PIT-tag detection facilities in the Mid-Columbia River makes the application of the SRR and PRR models more complicated and less precise relative to similar survival studies conducted in the Snake River system.

Recent Mid-Columbia River survival studies have utilized between 20,000 and 90,000 PIT-tagged animals in order to precisely estimate survival through individual hydroelectric projects (Bickford, et al., 1999a; Eppard et al., 1999; Stevenson et al., 1999; Bickford et al., 2000). This represents a considerable reduction in sample size compared to freeze-brand survival studies but still represents a substantial investment of fish and tags. The need to release tens of thousands of PIT-tagged fish for survival studies severely limits the application of the PIT-tag survival technique to certain species passing through particular sections of the Mid-Columbia River.

Toward the goal of reducing sample size requirements, while still maintaining high precision, researchers at the University of Washington performed a statistical evaluation of radio-tag release-recapture techniques specifically aimed at the development of project specific survival estimates (Skalski et al., 1999). Following recommendations outlined by the University of Washington, the Public Utility District No. 1 of Douglas County proposed a side-by-side comparison of radio-tag and PIT-tag release-recapture methodologies. To conduct this comparison, radio-tagged and PIT-tagged fish would be collected, tagged, held for recovery and transported simultaneously to a common release site in the Okanogan River.

The 1999 Wells radio-PIT comparison study was conducted to determine the feasibility of the radio-tag survival technique at Wells Dam. Toward accomplishment of the primary goal, radio-tagged steelhead survival would be estimated from release through six downstream recapture sites. PIT-tag survival would be estimated from release through three downstream recapture sites. Based upon data collected at a common recapture site, Rocky Reach Dam, the behavior (arrival distribution, harmonic mean travel times, relative guidance efficiency) and reach survival estimates (release to the tailrace of Rocky Reach) of the two tag groups would be compared.

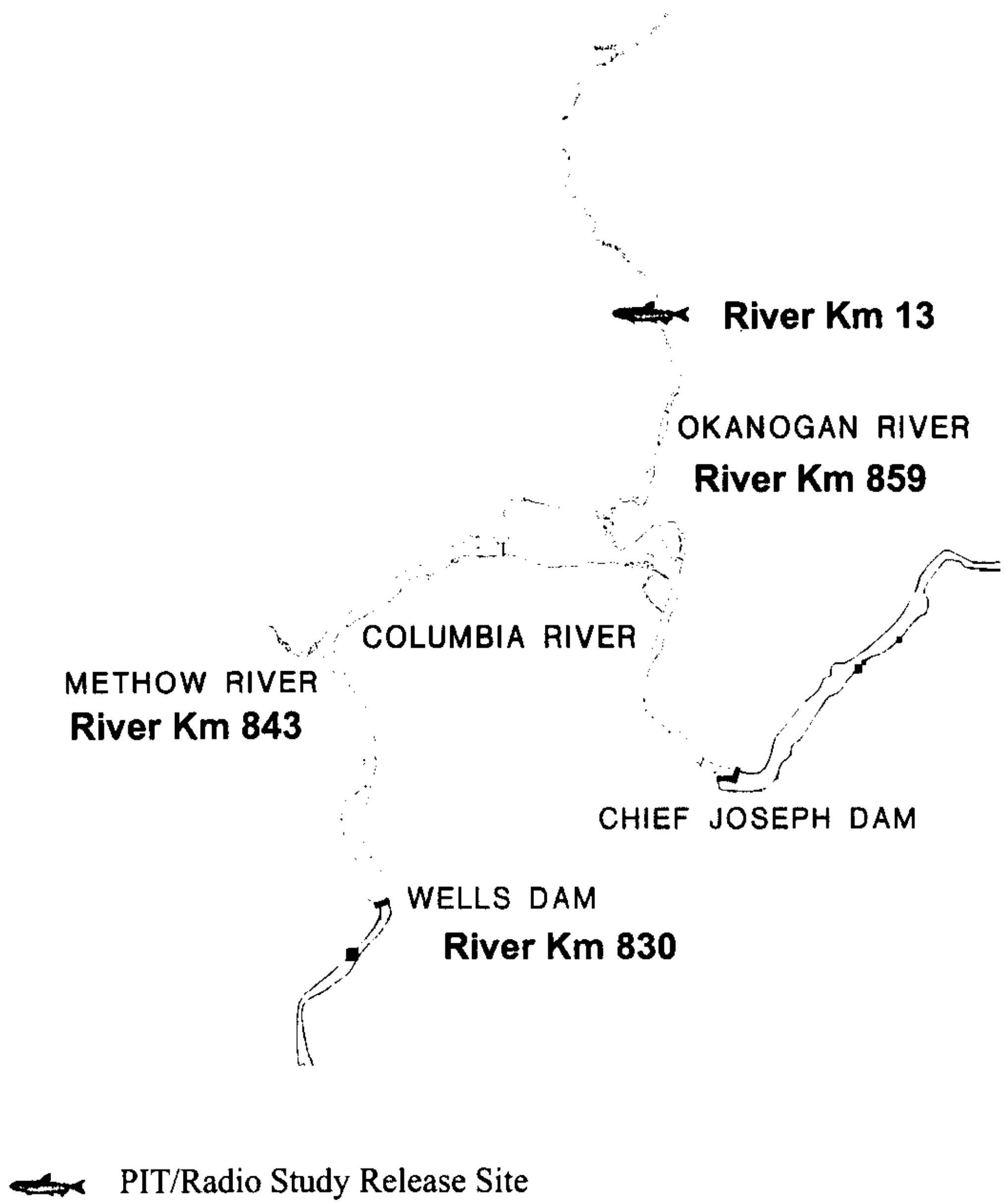
2.0 STUDY AREA

The Wells Hydrocombine generating facility is located at river km (R km) 830 on the Mid-Columbia River (Figure 1). The Wells Hydrocombine, unlike typical Columbia River hydroelectric projects, efficiently combines generation, spill and fish facilities into one structure. The Wells bypass system provides a safe, non-turbine passage route through the dam for over 92% of the spring and summer migrants (Johnsen et al., 1992; Skalski et al., 1996). Wells is the uppermost generating project on the Columbia River which anadromous chinook (*Oncorhynchus tshawytscha*); steelhead (*O. mykiss*) and sockeye salmon (*O. nerka*) migrate through.

The reservoir formed by Wells Dam is called Lake Pateros. The Methow River enters Lake Pateros at R km 843 near the town of Pateros. The Okanogan River enters Lake Pateros at R km 858.6. The radio-PIT comparison study simultaneously released both radio-tagged and PIT-tagged fish at Crazy Rapids located over 42 km upstream of Wells Dam at Okanogan R km 13.4 km (Figure 2).

Figure 1. Mainstem Columbia and Snake rivers depicting important hydroelectric projects.

Figure 2. Crazy Rapids radio-tag and PIT-tag release site.



3.0 METHODS AND MATERIALS

3.1 Fish Collection

The collection of yearling hatchery summer steelhead (study animals) took place at the Wells Fish Hatchery. Volitionally migrating steelhead smolts were allowed to exit Pond #2 via an overflow weir. Fish passing over the weir were washed downstream through an outfall pipe and were deposited into a large collection trap.

Two to three days prior to each tagging session, sufficient numbers of steelhead smolts were collected from the trap. A 20 cm Aqualite Harvester hydraulic fish pump (Magic Valley Harvest, Hagerman, Idaho) was used to pump steelhead from the live trap into a 2,000 L fiberglass transportation container. The transportation container was outfitted with a re-circulation pump and metered compressed oxygen. Once the fish were loaded into the transport container, they were transported less than 0.5 km to one of two concrete holding raceways. Transport times from the collection site to the holding raceways was less then 15 minutes per load.

Each concrete holding raceway contained a minimum of 70,000 L of single pass river water. Pond #2 and Raceway #1 and #2 all received a continuous supply of gravity fed river water from the Wells Hatchery water distribution system.

3.2 Tagging and Holding Procedures

On tagging days, small groups of untagged steelhead were crowded toward the pint-sized-pescalator (PRA Manufacturing, Nanaimo, British Columbia, Canada). The pescalator was comprised of a 30 cm diameter fiberglass pipe with an archimedies screw built into the center. As the pescalator rotated, it captured and transported water and fish up and out of the raceway. At the top of the pescalator, fish and water were deposited into a 10 cm transport pipe. The pescalator carefully delivered fish and small amounts of water directly into an anesthetic bath (tricaine methanesulfonate ~ MS-222). Once anesthetized, individual fish were sorted and assigned to a tag group. Fish less than 155 mm fork length (FL) and larger than 300 mm FL, and fish with obvious injuries were removed from the study. The remaining healthy steelhead smolts were tagged with either a radio-tag or a PIT-tag.

3.2.1 Radio-tags

3.2.1.1 Tag Characteristics

Digitally coded LOTEK model MFC-3GM (DSP compatible) radio-telemetry transmitters were utilized during the comparison study. Tag pulse was set at 2.5 bursts per second with an expected tag life of 22 days. Each tag weighed 1.8 g in air (1.0 g in water) and was 8.2 mm wide and 19 mm long. The tag antenna was 40 cm long. The antenna was covered with protective insulation. There were 100 radio-tag codes on each of three channels (15, 16 and 19; 149.60, 149.62, and 149.68 MHz). Each of the five release groups (60 fish per group) was divided evenly among the three available channels to minimize the risk of code collision and signal interference.

3.2.1.2 Implantation Procedures

Juvenile steelhead surgical implantation procedures were based on the methods outlined in Adams et al. (1998a) and Martinelli et al. (1998) supplemented by information from John Stevenson (BioAnalysts Inc., pers. comm.) and Theresa Martinelli (USGS, pers. comm.). In addition, taggers attended a training session at the USGS Laboratory in Cook, Washington conducted by Ms. Martinelli. Rainbow trout from the Wells Hatchery were used to refine tagging procedures and to test holding and transportation equipment. In total, 298 juvenile steelhead were radio-tagged over the coarse of the study. On each of the five tagging days, between 58 and 61 fish were radio-tagged. Fish were tagged on April 22, 26, and 30 and May 4 and 8, 1999. All fish were tagged three days after being collected from rearing pond # 2 at the Wells Fish Hatchery.

On tagging days, 60 to 65 juvenile steelhead were randomly collected from the pescalator and placed into a 198 L holding container. Individual fish were transferred from this holding container into a light anesthetic bath containing MS-222 (15mg/L). Individual fish were retained within the bath for approximately 3 minutes prior to being transferred into a stronger bath of MS-222 (100mg/L). Fish were held in the stronger anesthetic for approximately 3 minutes or until the fish lost equilibrium. Anesthetized fish were measured to the nearest millimeter (mm). Fish less than 155 mm FL and over 300 mm FL or fish with visible signs of disease or injury were culled and not used for radio tagging. Anesthetized fish were placed on a soft, grooved foam pad. The foam pad was soaked with Stress Coat (Aquarium Pharmaceuticals, Inc., Chalfont, Pennsylvania) to control scale loss and to maintain the exterior mucous coat during surgery. Fish were placed ventral side up in the foam groove and the gills were continuously flushed with anesthetic solution (MS-222, 20mg/L) delivered through a tube placed into the mouth of the fish. About 1 minute prior to completion of the surgery, the flow of the anesthetic solution was replaced with fresh oxygenated river water to start the recovery process. Surgical equipment was disinfected with a diluted germicidal solution.

To implant the transmitter into each fish, a 1 cm incision was made 3 mm away from and parallel to the mid-ventral line starting about 3 mm anterior to the pelvic girdle. The incision was only deep enough to penetrate the peritoneum (Adams et. al, 1998a). To provide an outlet for the antenna, a shielded-needle catheter was inserted through the incision, posterior to the pelvic girdle and viscera, to a point 5-10 mm off center from the mid-ventral line and slightly caudal to the origin of the pelvic fins (Adams et. al, 1998a). Pulling the catheter back onto the needle shaft exposed the point of the needle. Pressure was applied until both the needle and catheter pierced the skin of the fish. The needle was pulled back out of the incision, leaving the catheter in position to guide the antenna through the body wall of the fish.

The radio transmitter was implanted by first threading the antenna through the incision end of the catheter. Both the antenna and catheter were then gently pulled posterior while the transmitter was inserted into the body cavity. The position of the transmitter inside the fish was adjusted by gently pulling on the antenna until the transmitter was horizontal and directly under the incision. An antibiotic was pipetted (25 mg/L) into the incision to prevent infection. The incision was closed with three interrupted, absorbable sutures (5-0 braided Coated Vicryl and taper RB-1 needle, Ethicon Corp.) evenly spaced across the incision. The antenna was attached to the side of the fish with a single suture in the caudal peduncle about 5-6 mm posterior to the exit site. A small amount of tissue adhesive (Nexaband) was applied to the incision and exit site to secure the sutures in place. The surgical implantation procedure required that the fish be removed from the water throughout the procedure, and took an average of 5 minutes to complete (range: 3 min 21 s – 7 min 45 s). Columbia River water supplied from the hatchery served as the water source throughout the tagging operation. Immediately after surgery, tagged fish were placed into a freshwater recovery bucket (10 L) until the fish gained equilibrium and regular swimming and breathing movements were observed.

After recovering from the tagging procedure, fish were placed in 11 L Rubbermaid holding containers equipped with water supply, supplemental oxygen diffusers and a snap down lid. Four of the 11 L Rubbermaid containers were placed inside individual 151 L transportation totes supplied with flow through Columbia River water. In order to minimize disturbance stress, fish were checked only 3 times during the 36-hour recovery period. Check No. 1 occurred 1 hour following tagging, check No. 2 and No. 3 took place 24 and 36 hours after tagging. The final check took place immediately prior to release.

Dissolved oxygen (DO) levels were monitored with a Hanna (H1 9142) dissolved oxygen meter (mg/L) and the temperature was measured using a hand held thermometer (°C). The target range for optimal oxygen levels in the transportation containers was 9-12 mg/L and target water temperature within 2° C of ambient Columbia River water. Biomark Inc. monitored and recorded the DO and water temperatures in individual transportation totes every hour, 24-hours per day. Water flow and hoses were checked hourly to ensure adequate flow was maintained throughout the recovery period.

Important features of the transportation totes and holding containers included the following: the ability to hold only one fish (or two fish with a divider) per container to avoid tangling of the antenna; no sharp edges or rough surfaces within individual holding containers; and totes were required to be small enough that each transportation tote could be easily lifted and moved. In addition, totes and containers were fitted with individual water and oxygen supply systems and totes were made out of a dark opaque colored material to minimize visual disturbance. Release containers within totes were equipped with watertight lids and were immersed in water to prevent water loss during loading and transportation.

Within each of the release totes, three of the four release containers held one fish per container and the fourth container had a plastic mesh divider so that two smaller fish (< 184 mm) could be accommodated. Three of the containers were placed on the bottom of the tote and one was placed on a second level (supported by the lids of the bottom containers). In total, there were 12 release totes each containing 5 or less fish for a total of 60 or less radio-tagged juvenile steelhead. The totes were filled partially with water up to the level of the drainage holes of the smaller containers on the bottom row. This allowed water exchange during transport without loss of water. The one container on top had smaller holes drilled closer to the lid of the container to minimize water loss during the transportation phase of the study.

3.2.2 PIT-tags

PIT-tags were implanted into steelhead smolts with 12-gauge hypodermic syringes loaded with individual 12 mm Destron Fearing 400-kHz PIT-tags. Fish were tagged according to criteria described in Prentice et al. (1987). To prevent disease transmission, each hypodermic needle was soaked in ethyl alcohol and allowed to dry before being reloaded with a PIT-tag. Immediately following tagging, each unique tag code for each fish was entered into a database. In addition to the tag code, date of tag implantation, tag personnel identification code, fish size, water temperature and obvious abnormalities (disease, deformities and injuries) were recorded.

A 10 cm pipe half full of water was used to transfer the PIT-tagged fish into the 1,200 L release containers. Once inside the containers the fish were allowed to recover. During tagging and initial recovery, the release containers were supplied with a continuous flow of Columbia River water and when needed metered compressed oxygen. Water and dissolved oxygen levels were closely monitored throughout the entire 36-hour recovery period. Approximately 402 tagged steelhead were placed inside each release container. Loading densities were established to ensure that no release container contained more than 0.03 Kg of fish/L water.

Recovering tagged steelhead were provided with 100-150 L/minute (L/min) of river water per container. River water was supplied to each container through a 5 cm flexi-hose. Water temperature and dissolved oxygen levels inside each release container were closely monitored and recorded to ensure that the pre-release recovery history of each container was comparable within and between tagging groups and comparable to the radio-tag release groups.

3.3 Transportation and Release Procedures

Side-by-side transport and release of radio-tagged and PIT-tagged steelhead took place on April 24, 28 and May 2, 6 and 10. On each of the five release days, five PIT-tag release containers and 12 radio-tag transportation totes were transported to Crazy Rapids on the Okanogan River. Upon arrival at the release site the containers and totes were loaded onto the release barges.

Both tag groups were removed from the water supply lines at 0900 hours. After being disconnected from the water supply lines, metered compressed oxygen was immediately supplied to each release container. The transport vehicles departed the hatchery at 0915 hours and stopped in Brewster at 0930. Fish arrived at the Okanogan barge loading site at 1000 hours or 45 minutes after leaving Wells Hatchery. Both PIT and radio-tag study groups were released approximately 1 hour and 30 minutes after water supply lines at the Wells Hatchery were first disconnected. This time included a 45 minute transportation segment between the WFH and Crazy Rapids and a 30 minute loading and release segment. All five Okanogan side-by-side releases were initiated at 1030 hours.

3.3.1 Radio-tags

In order to minimize stress, radio-tagged fish were kept in the release totes throughout the loading, transport and unloading phases of the study. The radio-tagged steelhead were transported to the barge loading site using a 5 m U-Haul truck. The release totes were transferred from the hatchery recovery facility to the U-Haul truck by hand. Each of the release totes had a lid that was secured during transport to minimize water movement and fish agitation. During transportation, each of the smaller release containers within each transportation tote was supplied, when needed, with metered compressed oxygen. Individual oxygen supply lines were submerged within each release container.

Records of time, oxygen concentrations and water temperatures were recorded at the start of truck loading, prior to departing the hatchery, en-route to the release site, upon arrival at the release site, and once containers were loaded onto the barge prior to release. The temperature and oxygen concentrations of the Okanogan River were recorded at release.

Radio-tagged fish were released simultaneous with groups of PIT-tagged fish. Radio-tagged fish were released from holding containers by immersing the container into the Okanogan River.

3.3.2 PIT-tags

On each of the five release days, five PIT-tag release containers were loaded onto a 25,000 Kg capacity flatbed truck. During transportation, each of the release containers was continuously supplied with metered compressed oxygen. At the barge loading site, each PIT-tag release container was hoisted off the transport truck with a crane and loaded onto a barge floating in the Okanogan River. The PIT-tag barge was outfitted with a water supply system. Immediately after the PIT-tag release containers were loaded onto the barges, the metered compressed oxygen supply system was disconnected and the on-board water supply system turned on.

Dissolved oxygen and water temperatures for each release container were recorded before leaving the hatchery, half way to Crazy Rapids (Brewster) and upon arrival at the release site. Desired dissolved oxygen concentrations inside each container were manually adjusted to maintain between 9 and 12 mg O_2/L. Injured and moribund fish were removed and recorded before release. River water flow through each PIT-tag release container was estimated at 75-125 L/minute.

Barges carrying PIT- and radio-release containers arrived at the specified release location at the same time (Figure 2). Temperature, dissolved oxygen and fish status were recorded prior to final release. PIT-tagged fish were released directly into the Okanogan River though 20 cm x 15 cm eccentric reducers. Water to water transfers were maintained throughout the entire study.

3.4 Tag Interrogation

3.4.1 Radio-tag Detection

Lotek SRX_400 radio-telemetry receivers utilizing CODE_LOG version W16 data processing and storage program were utilized to interrogate radio-tagged steelhead smolts. Fixed-station receivers with corresponding antenna switchers or combiners were enclosed in locked weatherproof containers and powered by 12-volt (v), deep-cycle RV batteries. At locations where 110-v AC current was available, a 12-v AC/DC adapter was used to continuously trickle charge 12-v RV batteries. The use of a battery at these sites eliminated the possibility of lost data due to power failure. All receivers and power sources were monitored daily from April 24 to June 16, 1999. Additional information was collected at Rocky Reach and Rock Island dams from April 24 to June 30, 1999.

Fish presence was detected at important detection zones via the installation of multi-element (2, 3, 4 and 9-element) yagi antennas connected to SRX-400 radio-telemetry receivers. At times multiple yagi antennas were combined into one signal source for fish presence at selected sites above and below Wells Dam. Where necessary, radio signals had to be propagated along long distances (>100 ft) of coaxial cable. At these locations signal amplifiers were installed to maximize signal quality to each receiver.

Twelve receivers monitoring a total of 38 aerial yagi antennas were established at strategic locations; the Okanogan River mouth, Pateros, Wells Forebay, and at sites 5 and 13 km below Wells Dam. In addition, receivers and underwater antennas at Rocky Reach and Rock Island dams were also capable of detecting Douglas released radio tags.

3.4.2 PIT-tag Detection

PIT-tags were interrogated via Destron-Fearing 400 kHz PIT-tag reader systems installed in the fish bypass systems at Rocky Reach, Rock Island, McNary, John Day and Bonneville dams. PIT-tag interrogation data was archived to PTAGIS.

3.5 Estimating Smolt Survival

3.5.1. Radio-tags

3.5.1.1 Survival Estimation

The single release-recapture model (Cormack 1964; Jolly 1965; Seber 1965 Skalski et al. 1998) was used to analyze the radio-tag detections of smolts released at Crazy Rapids. The traditional model can be used to directly extract estimates of $\hat{S}_1$, $\hat{S}_2$, $\hat{S}_3$, $\hat{S}_4$, $\hat{S}_5$, and $\hat{S}_6$ (Figure 3). However, the traditional single release-recapture model cannot separate out the elements of the product $\lambda = S_7 \cdot p_7$ for the last reach (Figure 3).

Survival from release at Crazy Rapids to the forebay of Rocky Reach Dam was estimated by the product

$$\hat{S}_W = \hat{S}_1 \cdot \hat{S}_2 \cdot \hat{S}_3 \cdot \hat{S}_4 \cdot \hat{S}_5 \cdot \hat{S}_6 .$$

The delta method was used to estimate the variance associated with survival through this section of river.

The assumptions of the single release-recapture model are the following (Skalski et al. 1998):

A1. The test fish are representative of the population of inference.

A2. Test conditions are representative of the conditions of interest.

A3. The number of fish released is exactly known.

A4. Radio-tag codes are accurately recorded at the time of tagging and at all detection sites.

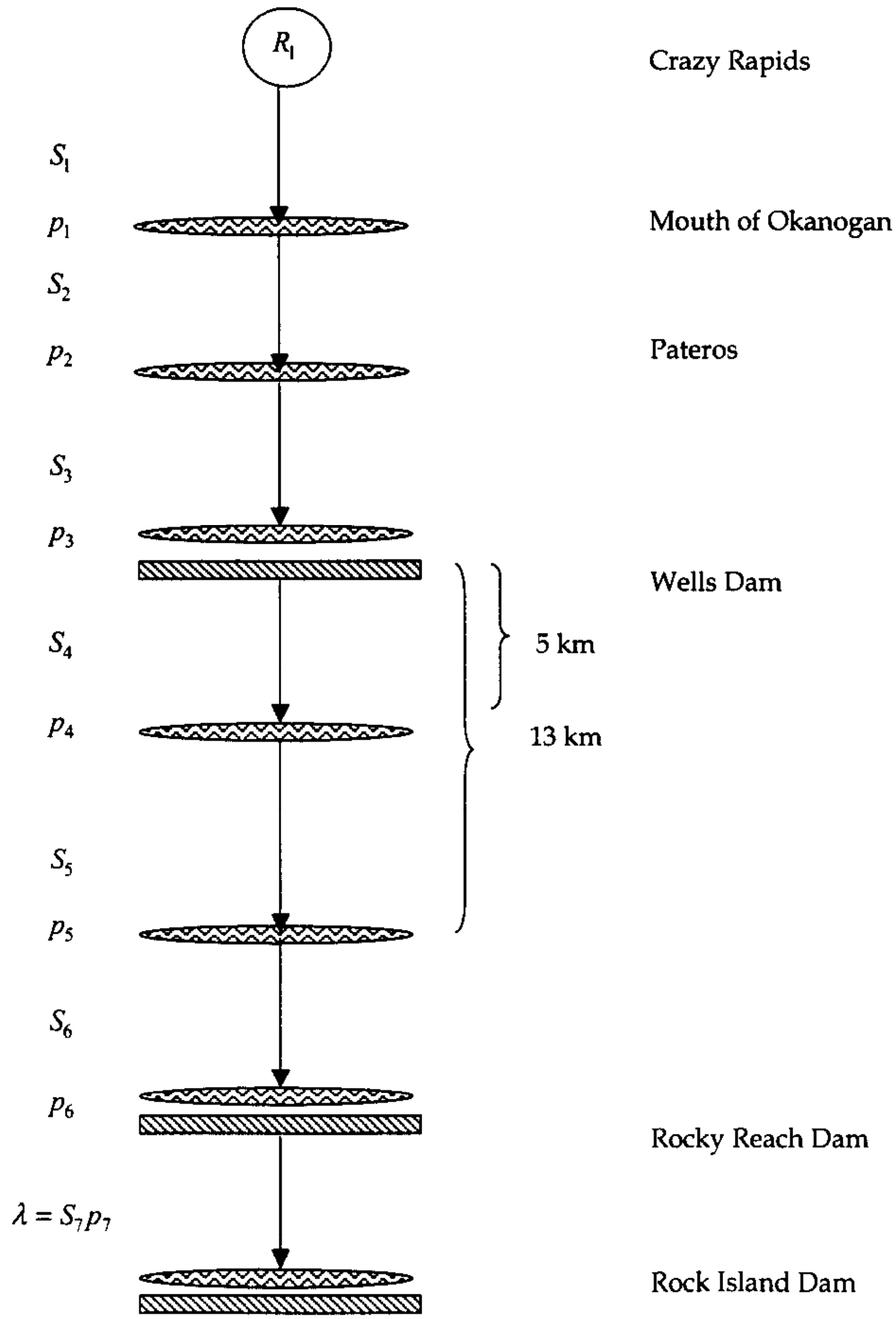
A5. For replicated studies, data from different releases are statistically independent.

A6. The fate of each individual fish is independent of the fates of all other fish.

A7. All fish in a release group have equal survival and detection probabilities.

A8. Prior detection history has no effect on subsequent survival and detection probabilities.

Figure 3. Schematic of the release location and radio-antenna detection arrays used in the 1999 Okanogan River radio-tag smolt survival study. Parameters estimated from the release-recapture data are indicated.



A 90% confidence interval for survival from release to the forebay and tailrace of Rocky Reach was calculated according to the formula:

$$\hat{S}_W \pm 1.645\sqrt{V\hat{a}r\left(\hat{S}_W \middle| S_W\right)}.$$

3.5.1.2 Tests of Assumptions

For the single release-recapture model to be valid, certain data patterns should be evident from the capture histories. A series of tests of assumptions were performed to determine the validity of the model (i.e., goodness-of-fit). The data from a single release can be summarized by an m-array matrix of the form below:

Release Site	Mouth of Okanogan (2)	Pateros (3)	Wells Forebay (4)	Wells Tailrace #1 (5)	Wells Tailrace #2 (6)	Rocky Reach Forebay (7)	Rock Island Forebay (8)
Initial (1)	m_{12}	m_{13}	m_{14}	m_{15}	m_{16}	m_{17}	m_{18}
Mouth of Okanogan (2)		m_{23}	m_{24}	m_{25}	m_{26}	m_{27}	m_{28}
Pateros (3)			m_{34}	m_{35}	m_{36}	m_{37}	m_{38}
Wells Forebay (4)				m_{45}	m_{46}	m_{47}	m_{48}
Wells Tailrace #1 (5)					m_{56}	m_{57}	m_{58}
Wells Tailrace #2 (6)						m_{67}	m_{68}
Rocky Reach Forebay							m_{78}

(7)

The values m_{ij} are the number of fish detected at site i that are detected for the first time downstream at site j.

Burham et al. (1987, pp. 71-74) presents a series of tests of assumptions called Test 2 that examine whether upstream detections affect downstream survival and/or detection. Contingency table tests were performed, as follows:

Test 2.2

m_{13}	m_{14}	m_{15}	m_{16}	m_{17}	m_{18}
m_{23}	m_{24}	m_{25}	m_{26}	m_{27}	m_{28}

Test 2.3

$m_{14}+m_{24}$	$m_{15}+m_{25}$	$m_{16}+m_{26}$	$m_{17}+m_{27}$	$m_{18}+m_{28}$
m_{34}	m_{35}	m_{36}	m_{37}	m_{38}

Test 2.4

$m_{15}+m_{25}+m_{35}$	$m_{16}+m_{26}+m_{36}$	$m_{17}+m_{27}+m_{37}$	$m_{18}+m_{28}+m_{38}$
m_{45}	m_{46}	m_{47}	m_{48}

Test 2.5

$m_{16}+m_{26}+m_{36}+m_{46}$	$m_{17}+m_{27}+m_{37}+m_{47}$	$m_{18}+m_{28}+m_{38}+m_{48}$
m_{56}	m_{57}	m_{58}

Overall significance of Test 2 was based on the sum of the chi-square statistics $\chi_5^2+\chi_4^2+\chi_3^2+\chi_2^2=\chi_{14}^2$. Detections at the Rocky Reach and Rock Island dams included only fish detected in the forebay. Tailrace detections that might include dead fish were not used in the analyses.

Burnham et al. (1987, pp. 74-77) also presents a series of tests of assumptions called Test 3 which also examine whether upstream capture histories affect downstream survival and/or capture. However, the seven detection sites resulted in 128 unique capture histories with only 296 radio-tagged fish released. The consequence is that the Burnham et al. (1987) Test 3 would produce contingency table analyses that would be too sparse (i.e., too small of cell counts) for valid analysis. As such, modifications were made. The first test was of the form:

Test 3.1′

		Detection History to Pateros	
		111	101
Below Pateros	Detected		
	Not Detected		

This contingency table evaluates whether detections at the mouth of the Okanogan River affect redetections below Pateros. The next test in the sequence produced a contingency table of the form:

Test 3.2′

		Detection History at Okanogan, Pateros, Wells Forebay	
		111	101
Below Wells Forebay	Detected		
	Not Detected		

This contingency table evaluates whether detections at Pateros affected detections below Wells Dam forebay. The last table was as follows:

Test 3.3′

		Detection History at Pateros, Wells Forebay, and 1st Tailrace Array	
		111	101
Below 1st Tailrace Array	Detected		
	Not Detected		

3.5.2 PIT-tags

3.5.2.1 Survival Estimation

The PIT-tagged steelheads released at Crazy Rapids on the Okanogan River were used to estimate reach survival using the single release-recapture (SRR) model. Smolts released in the Okanogan River had the potential of being detected at Rocky Reach, McNary, John Day, and Bonneville Dams (Figure 4). In addition, smolts detected by the NMFS experimental PIT-tag trawl were pooled with the Bonneville Dam detections.

Survival probabilities were estimated for each of the five replicate release groups. Mean survival from release to Rocky Reach was calculated as a weighted average of the five replicate estimates based on the formula

$$\hat{\bar{S}} = \frac{\sum_{i=1}^{5} W_i \hat{S}_i}{\sum_{i=1}^{5} W_i}$$

where the weights were calculated as

$$W_i = \frac{1}{\left(\frac{\hat{Var}\left(\hat{S}_i \middle| S_i\right)}{\hat{S}_i^2} \right)}.$$

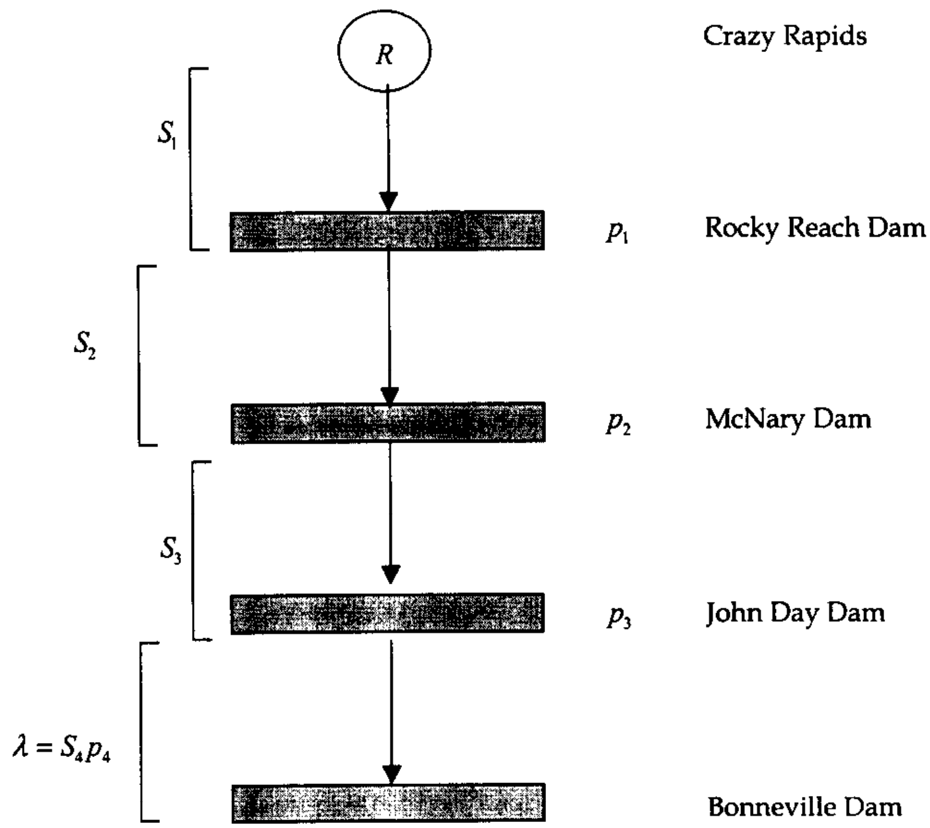
The variance of the weighted average was computed as

$$\hat{Var}\left(\hat{\bar{S}}\right) = \frac{\sum_{i=1}^{5} W_i \left(\hat{S}_i - \hat{\bar{S}}\right)^2}{(n-1)\sum_{i=1}^{5} W_i}.$$

An approximate $(1-\alpha)$ 100% confidence interval estimate was calculated as

$$\hat{\bar{S}} \pm 1.96\sqrt{\hat{Var}\left(\hat{\bar{S}}\right)}.$$

Figure 4. Schematic of release-recapture design used in the PIT-tag survival analysis and associated estimated parameters.



3.5.2.2 Tests of Assumptions

The data from a PIT-tagged single release can be summarized by an m-array matrix of the form below:

Release Sites	Rocky Reach (2)	McNary (3)	John Day (4)	Bonneville (5)
Initial (1)	m_{12}	m_{13}	m_{14}	m_{15}
Rocky Reach (2)		m_{23}	m_{24}	m_{25}
McNary (3)			m_{34}	m_{35}
John Day (4)				m_{45}

To test the validity of the SRR model, Burnham et al. (1987) Tests 2 and 3 were performed. Tests 2 assessed whether upstream detection histories affected downstream survival and/or detection. Contingency tables for Tests 2 were of the form:

Test 2.2

m_{13}	m_{14}	m_{15}
m_{23}	m_{24}	m_{25}

χ_2^2

Test 2.3

$m_{14} + m_{24}$	$m_{15} + m_{25}$
m_{34}	m_{35}

χ_1^2

The overall significance of Test 3 was based on the sum of chi-square statistics $\chi_2^2 + \chi_1^2 = \chi_3^2$.

The Burnham et al. (1987) Test 3 also examined whether upstream capture histories had an affect on downstream survival and/or capture. The possible effect of detection at Rocky Reach Dam on subsequent histories was tested using the contingency table below:

Test 3.1

Capture History at John Day and Bonneville Dams	Capture History to McNary Dam: 101	111
11		
10		
01		
00		

χ^2_3

To test whether detection at McNary Dam had an effect on subsequent downstream histories, the following contingency table was used:

Test 3.2

Capture History at Bonneville Dam	Capture History to John Day Dam: 1111	1101	1011	1001
0				
1				

χ^2_3

The overall significance of Test 3 was based on the sum of the chi-square statistics $\chi^2_3 + \chi^2_3 = \chi^2_6$.

Individual release groups were tested at an $\alpha = 0.10$ significance level. An experimental-wise error rate of $\alpha = 0.10$ was also used to assess the overall performance of the study by using a test-wise error rate of

$$1-(1-0.10)^5 = 0.0209.$$

3.6 Comparison of PIT-tagged and Radio-tagged smolts

3.6.1 Comparison of Arrival Distributions

The arrival distributions of the PIT- and radio-tagged releases from Crazy Rapids to Rocky Reach Dam were compared. To perform this analysis, the two groups of fish needed to be released concurrently. In addition, the PIT- and radio-tagged fish needed to be detected at the same location at Rocky Reach Dam. Hence, the PIT-tag detector at Rocky Reach Dam was also fitted with radio antenna equipment as well. The arrival distributions were compared using an R x C contingency table chi-square test of homogeneity of the form:

	PIT-tag	Radio-tag
Arrival Date		
	⋮	⋮

3.6.2 Comparison of Travel Times

For each tag type, mean travel time was computed using the harmonic mean $(\bar{t}_H)$ calculated as follows:

$$\bar{t}_H = \frac{1}{\frac{1}{n}\sum_{i=1}^{n}\frac{1}{t_i}} = \frac{n}{\sum_{i=1}^{n}\frac{1}{t_i}}$$

where

t_i = travel time from Wells tailrace to Rocky Reach Dam for the ith smolt recovered $(i = 1, \ldots, n)$.

The variance for the harmonic mean travel time was estimated by the formula

$$\hat{Var}(\bar{t}_H) = \frac{\left(\frac{s_{1/t}^2}{n}\right)}{\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{t_i}\right)^4}$$

and where

$$s_{1/t}^2 = \frac{\sum_{i=1}^{n}\left(\frac{1}{t_i} - \hat{u}_{1/t}\right)^2}{(n-1)},$$

$$\hat{u}_{1/t} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{t_i}.$$

Asymptotic (1- α) 100% confidence interval for harmonic mean travel time was computed as

$$\bar{t}_H \pm Z_{1-\frac{\alpha}{2}}\sqrt{\hat{Var}(\bar{t}_H)}$$

for both PIT- and radio-tagged smolts.

A statistical test of equal mean travel times for both tag types was performed using a Z-test of the form

$$Z = \frac{\bar{t}_{H-PIT} - \bar{t}_{H-RT}}{\sqrt{\hat{Var}(\bar{t}_{H-PIT}) + \hat{Var}(\bar{t}_{H-RT})}}.$$

3.6.3 Comparison of Relative Guidance Efficiency

The proportions of PIT-tagged and radio-tagged smolts collected by the Rocky Reach surface collector were compared using a 2 x 2 contingency table chi-square test of homogeneity of the form:

	PIT-tag	Radio-tag
r		
$R-r$		

where R is the release size and r, the number of smolts detected in the Rocky Reach bypass system. This test assesses whether the two tag groups had the same survival to and guidance efficiency into bypass No. 2 at Rocky Reach Dam.

3.6.4 Comparison of Reach Survival Estimates

The PIT-tag releases at Crazy Rapids had the capability of estimating steelhead smolt survival from release to the tailrace of Rocky Reach Dam. The radio-tag releases at Crazy Rapids also had the capability of providing a smolt survival estimate from release to the tailrace of Rocky Reach Dam. In addition, radio-tagged survival could also be estimated from release to the forebay of Rocky Reach Dam. The radio-PIT survival study comparison was designed to statistically compare reach survival between the two tag types over a common section of river. However, due to poor radio-tag detection rates at the video counting station and due to limitations in total radio-tag sample size, insufficient information was collected to precisely estimate radio-tag survival beyond the forebay of Rocky Reach. Hence the statistical survival comparison through the common river section had to be abandoned in favor of a more qualitative reach survival comparison.

Because the PIT-tag survival estimate included passage through Rocky Reach Dam, the survival estimate generated from the PIT-tag releases was expected to be less than or equal to the radiotelemetry survival estimate. Point estimates and confidence interval estimates were examined to assess reasonableness of this assertion and to provide insight into the comparability of the two tagging techniques.

4.0 RESULTS

4.1 Fish Collection

Steelhead collected from Pond #2 were not directly counted. Instead volumetric displacement was used to estimate the number of steelhead collected. The day before tagging, approximately 4,500 steelhead were crowded and fish pumped into a transport truck. The transport truck released the fish directly into two concrete raceways located proximal to the PIT-tagging facility. No steelhead mortalities were recorded during the collection and transportation process. The steelhead collected for the study were allowed to recovery in the pre-tagging raceways at least 48-hours before being tagged.

4.2 Tagging and Holding

The number of steelhead collected, handled, culled and tagged for the 1999 radio-PIT survival comparisons can be found in Table 1. In total, 74,669 steelhead were collected for tagging purposes. The majority of these fish (60,382) were utilized for the Wells Project PIT-tag survival study. In total 10,037 steelhead were PIT-tagged and 303 were radio-tagged for use in the radio-PIT comparison study.

Tagging and recovery of radio-tagged and PIT-tagged fish occurred simultaneously at the Wells Fish Hatchery. After being tagged, study fish were allowed to recovery for 36-hours before being transported and released.

Of the 10,037 steelhead smolts PIT-tagged for the radio-PIT comparison study, a total of 2 (0.020%) tagged steelhead died after being tagged (Table 1). Of the 303 steelhead smolts radio-tagged in 1999, one fish (0.33%) was sacrificed in order to recover a radio-tag that had failed prior to release and one (0.33%) fish died as a result of tag related injuries. In addition, five (1.65%) radio-tagged fish were sacrificed in order to recover tags that had become entangled with components of the release containers. All five tangled antennas were observed during the first release group. No shed PIT-tags were recovered from the Okanogan PIT-tag release groups. In total, 10,035 PIT-tagged and 296 radio-tagged steelhead were released at Crazy Rapids (Table 1).

Table 1A: PIT-tag release groups utilized for the 1999 Wells radio-PIT survival study.

Tagging Study	Release Site	Release No.	Tagged	Morts.	Sacrificed	Tags Shed	Total Released
PIT-tag	Okanogan	1	2,008	1			2,007
		2	2,005				2,005
		3	2,008	1			2,007
		4	2,008				2,008
		5	2,008				2,008
	Subtotal		10,037	2			10,035

Table 1B: Radio-tag release groups utilized for the 1999 Wells radio-PIT survival study.

Tagging Study	Release Site	Release No.	Tagged	Morts.	Sacrificed	Tags Tangle d	Total Released
Radio-tag	Tailrace	1	65		5	5	60
		2	60				60
		3	60				60
		4	60	1			59
		5	58		1		57
	Subtotal		303	1	6	5	296
PIT/Radio Comparison Study	**Both Studies**	**Grand Total**	**10,340**	**3**	**6**	**-**	**10,331**

4.3 Transportation and Release

Radio-tagged and PIT tagged steelhead were transported and released simultaneously at Crazy Rapids pump station on April 24, 28 and May 2, 6, and 10. On each of the five release days, five PIT-tag release containers and 12 radio-tag transport totes were transported to the barge loading site on time and within the parameters established in Section 3.3 (Transportation and Release Procedures).

Loading consistently required 15 minutes, transport time consistently ranged from 45 to 50 minutes and barge loading times remained consistent at 20 minutes between each of the five replicate releases.

Dissolved oxygen and water temperatures for each container were recorded periodically throughout the transportation process. Records of dissolved oxygen and temperature indicated similar trends between replicate release groups. Concentrations of dissolved oxygen varied between release containers and between tag groups but were maintained between 8.4 and 13.3 mg O_2/L for all groups. Average dissolved oxygen concentrations ranged from 10.4 to 10.8 mg O_2/L for all five release groups.

Water temperatures varied less than one degree during the transportation phase of the study. Columbia River water temperatures were within 2 $^{\circ}$C of Okanogan River water temperatures throughout the study. Okanogan River water temperatures ranged from 7.3 to 8.9°C.

All five steelhead releases were initiated at the Okanogan release site within 1 hour and 20 minutes after water supply lines at the WFH were disconnected. This included a 50 minute transportation interval and a 35-minute loading interval. As scheduled, the Okanogan releases were initiated at 1020 hours.

4.4 Interrogation Histories

4.4.1 Radio-tags

At the beginning of the study, the second Wells tailrace antenna array (approximately 13 km downstream) was not fully operational throughout the entire first release group. For this reason, detection histories and detection probabilities were expected to differ between release group 1 and releases 2-5. Table 2 provides detection histories at the mouth of the Okanogan, Wells forebay and second Wells tailrace station. As expected an overall chi-square test of homogeneity was rejected for the 5 radio-tag release groups $\left(P\left(\chi^2_{28} \geq 97.7003\right) < 0.0001\right)$. However, further analysis suggests releases 2-5 were homogeneous in detection histories $\left(P\left(\chi^2_{21} \geq 22.134\right) = 0.3918\right)$. Consequently, in subsequent analysis, release 1 and pooled releases 2-5 will be treated separately.

Table 3 presents the counts of radio-tagged smolt by capture history. Release 1 will only consider detections at the 5 km tailrace array and not at the 13 km tailrace array below Wells Dam. Releases 2-5 will include detection histories at both the 5 and 13 km tailrace arrays.

Table 2. Counts of radio-tagged steelhead smolts by detection history using the Wells forebay, Wells second tailrace antenna and Rocky Reach forebay arrays for each release group. Detection is noted by a "1" and a nondetection by a "0" at an antenna location.

Release	Detection History at Wells Forebay, 2nd Tailrace Arrays and Rocky Reach Forebay								
Date	111	110	101	100	011	010	001	000	Total
4/24/99	6	1	20	25	0	1	1	6	60
4/28/99	25	14	5	7	2	1	1	5	60
5/2/99	32	9	4	10	1	0	0	4	60
5/6/99	41	5	5	4	1	0	1	2	59
5/10/99	34	5	7	7	0	0	0	4	57

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Table 3. Counts of radio-tagged steelhead smolts by detection history. The first release group has histories for detections at Okanogan, Pateros, Wells forebay, Wells tailrace array #1, Rocky Reach, and Rock Island dams. The release groups 2-5 include the detection histories at the 2nd Wells tailrace release. Detection is noted by a "1" and a nondetection by a "0" at an antenna array location.

Release Group	History																Total
1	111111	011111	101111	001111	110111	010111	100111	000111	111011	011011	101011	001011	110011	010011	100011	000011	
	8		3						1		1						
	111101	011101	101101	001101	110101	010101	100101	000101	111001	011001	101001	001001	110001	010001	100001	000001	
	3						1										
	111110	011110	101110	001110	110110	010110	100110	000110	111010	011010	101010	001010	110010	010010	100010	000010	
	8	2	2					1									
	111100	011100	101100	001100	110100	010100	100100	000100	111000	011000	101000	001000	110000	010000	100000	000000	
	7	1	3	1	1				4	3	5		1		3	1	60
2-5	1111111	0111111	1011111	0011111	1101111	0101111	1001111	0001111	1110111	0110111	1010111	0010111	1100111	0100111	1000111	0000111	
	44		9		2				16		2						
	1111011	0111011	1011011	0011011	1101011	0101011	1001011	0001011	1110011	0110011	1010011	0010011	1100011	0100011	1000011	0000011	
	5		1						3		1						
	1111101	0111101	1011101	0011101	1101101	0101101	1001101	0001101	1110101	0110101	1010101	0010101	1100101	0100101	1000101	000010	
	5		4				1		5		2						
	1111001	0111001	1011001	0011001	1101001	0101001	1001001	0001001	1110001	0110001	1010001	0010001	1100001	0100001	1000001	0000001	
	1		2							1							
	1111110	0111110	1011110	0011110	1101110	0101110	1001110	0001110	1110110	0110110	1010110	0010110	1100110	0100110	1000110	0000110	
	41	2	5				2		10		3						
	1111010	0111010	1011010	0011010	1101010	0101010	1001010	0001010	1110010	0110010	1010010	0010010	1100010	0100010	1000010	0000010	
	6		2		1						3		1				
	1111100	0111100	1011100	0011100	1101100	0101100	1001100	0001100	1110100	0110100	1010100	0010100	1100100	0100100	1000100	0000100	
	8		5						2		2						
	1111000	0111000	1011000	0011000	1101000	0101000	1001000	0001000	1110000	0110000	1010000	0010000	1100000	0100000	1000000	0000000	
	1	1	5						9		8		3		9	3	236

4.4.2 PIT-tags

The release sizes for the five replicate Okanogan release groups varied from 2005 to 2008 fish. Table 4 has the detection histories at Rocky Reach, McNary, John Day, and Bonneville dams for each release group. Detections in the NMFS experimental PIT-tag trawl were pooled with Bonneville Dam detections for all of the analyses.

4.5 Estimating Smolt Survival

4.5.1 Radio-tags

4.5.1.1 Tests of Assumptions

Burnham Test 2 and modified Test 3 were performed for release 1 and pooled releases 2-5. Table 5 summarizes the results of the tests of assumptions for these two release groups. Neither release group rejected any of the Test 2's. Two of the 6 Tests 3's were rejected ($P < 0.10$). However, neither of the overall Test 3 results were significant ($P > 0.10$). Details of Tests 2 and 3 are found in Tables 6-7.

4.5.1.2 Survival Estimates

The Cormack-Jolly-Seber (CJS) model was used to estimate reach survival using the radiotelemetry detection histories in Table 3. The parameter estimates from the CJS model are reported in Table 8.

The survival of the radio-tagged hatchery steelhead from the release site in the Okanogan River to the forebay of Rocky Reach Dam was computed as a product of the survival estimates from the first six reaches reported in Table 8 (i.e., $\hat{S}_W = \hat{S}_1 \cdot \hat{S}_2 \cdot \hat{S}_3 \cdot \hat{S}_4 \cdot \hat{S}_5 \cdot \hat{S}_6$). For the first release group, Okanogan to Rocky Reach forebay survival was estimated to be $\hat{S} = 0.567$ (SE = 0.084). For releases 2-5, the survival from Okanogan to Rocky Reach forebay survival was estimated to be $\hat{S} = 0.844$ (SE = 0.037). Combining the results from the two analyses, a weighted average survival for the river reach from the Okanogan release site to the forebay of Rocky Reach Dam was $\hat{\bar{S}} = 0.822$ (SE = 0.075).

Table 4. Counts of PIT-tagged steelhead smolts by capture history for each Okanogan release group used in the 1999 radio-PIT survival study. A 1 denotes detected; 0, not detected; and 2, censored at Rocky Reach, McNary, John Day, and Bonneville tailraces. This history is based on PTAGIS files as of 13 July 1999.

Release	1111	0111	1011	0011	1101	0101	1001	0001	1110	0110	1010	0010	1100	0100	1000	0000	1200	0200	Total
112o1	4	15	26	61	13	34	44	118	14	40	52	164	21	95	247	1032	4	23	2007
116o2	8	12	15	52	11	40	42	118	10	41	61	170	24	122	245	998	6	30	2005
120o3	5	12	20	45	6	18	38	115	12	32	71	182	33	75	280	1022	14	27	2007
124o4	1	8	13	52	10	20	50	110	21	49	59	202	35	83	266	1028	0	1	2008
128o5	3	6	16	56	4	9	23	87	10	40	65	239	18	74	268	1088	2	0	2008

Table 5. Summary of P-values for Burnham et al. (1987) Tests 2 and 3 for release groups 1 and 2-5 for the radio-tag study from Crazy Rapids.

Test	Release Group	
	1	2-5
2.2	0.2426	0.4991
2.3	0.1681	0.3296
2.4	0.6916	0.3050
2.5	0.5659	0.5845
Overall 2	0.3870	0.5034
3.1′	0.6658	0.7842
3.2′	0.0766	0.0357
3.3′	0.1203	0.8170
Overall 3	0.1251	0.2087

Table 6. Details of Burnham et al. (1987) Tests 2.2-2.5 for release 1 and release groups 2-5.

Release	*Release site*	Pateros	Wells forebay	Tailrace 1	Tailrace 2	Rocky Reach	Rock Island		df	P-value
Test 2.2		*Recovery Site*								
1	Initial	6	1	1		0	0			
	Okanogan	33	14	1		0	0	2.8329	2	0.2426
2-5	Initial	4	0	0	0	0	0			
	Okanogan	163	54	3	0	0	0	1.3901	2	0.4991

Release	*Release site*	Wells forebay	Tailrace 1	Tailrace 2	Rocky Reach	Rock Island		df	P-value
Test 2.3		*Recovery Site*							
1	Above Pateros	15	2		0	0			
	Pateros	37	1		0	0	1.8998	1	0.1681
2-5	Above Pateros	54	3	0	0	0			
	Pateros	160	3	0	1	0	2.2195	2	0.3296

Release	*Release site*	Ant. 1 & 2	Ant. 3	Rocky Reach	Rock Island		df	P-value
Test 2.4		*Recovery Site*						
1	Above Wells Forebay	3		0	0			
	Wells Forebay	38		2	0	0.1573	1	0.6916
2-5	Above Wells Forebay	6	0	1	0			
	Wells Forebay	147	42	7	1	3.6244	3	0.3050

Release	*Release site*	Ant. 3	Rocky Reach	Rock Island		df	P-value
Test 2.5		*Recovery Site*					
1	Above Tailrace 1 & 2		2	0			
	Tailrace 1		24	4	0.3297	1	0.5659
2-5	Above Tailrace 1	42	8	1			
	Tailrace 1	128	15	3	1.0739	2	0.5845

Table 7. Details of modified Burnham et al. (1987) Tests 3.1′ - 3.3′ for release 1 and release groups 2-5.

Test 3.1′

Release	Capture History Downstream	Capture History to Pateros 101	111	χ^2_1	P-value
	Detected	6	32		
1	Not Detected	0	1	0.1866	0.6658
	Detected	4	160		
2-5	Not Detected	0	3	0.0750	0.7842

Test 3.2′

Release	Capture History Downstream	Capture History to Pateros 101	111	χ^2_1	P-value
	Detected	9	27		
1	Not Detected	5	4	3.1365	0.0766
	Detected	46	147		
2-5	Not Detected	8	9	4.4117	0.0357

Test 3.3′

Release	Capture History Downstream	Capture History to Pateros 101	111	χ^2_1	P-value
	Detected	0	21		
1	Not Detected	1	8	2.4138	0.1203
	Detected	3	112		
2-5	Not Detected	0	2	0.0535	0.8170

Table 8. Cormack-Jolly-Seber (CJS) estimates of survival and capture probabilities for radio-tagged release groups 1 and 2-5 in the 1999 radio-PIT survival study. The joint probability of survival from Rocky Reach to Rock Island and being captured at Rock Island Dam (λ) is reported in the last column. Standard errors are reported in parentheses.

Release	Survival						
	Release to Okanogan	Okanogan to Pateros	Pateros to Wells Forebay	Wells Forebay to 1st Tailrace Array	1st tailrace array to Rocky Reach Forebay		Release to Rocky Reach
1	0.992 (0.018)	0.949 (0.034)	0.990 (0.028)	0.786 (0.061)	0.774 (0.099)		0.567 (0.084)
	Release to Okanogan	Okanogan to Pateros	Pateros to Wells Forebay	Wells Forebay to 1st Tailrace	1st to 2nd Tailrace Array	2nd Tailrace Array to Rocky Reach Forebay	
2-5	0.988 (0.007)	0.965 (0.013)	0.985 (0.010)	0.932 (0.019)	0.969 (0.018)	0.996 (0.036)	0.844 (0.037)
						Weighted Average Survival	**0.822 (0.075)**

Release	Probability of Capture at						Combined Capture & Survival (λ)
	Okanogan	Pateros	Wells Forebay	Tailrace Array 1	Tailrace Array 2	Rocky Reach	
1	0.857 (0.047)	0.691 (0.062)	0.930 (0.039)	0.933 (0.046)	NA	0.765 (0.103)	0.500 (0.098)
2-5	0.982 (0.009)	0.742 (0.029)	0.966 (0.013)	0.741 (0.031)	0.850 (0.027)	0.798 (0.039)	0.522 (0.040)

4.5.2 PIT-tags

4.5.2.1 Tests of Assumptions

The individual Burnham et al. (1987) Tests 2.2 and 2.3 for each release are presented in Table 9 and the P-values of the tests summarized in Table 10. Only 1 of 10 Test 2's were significant at $\alpha = 0.10$ test-wise error rate. When examining the overall Test 2 results for each release and adjusting for an experimental-wise error rate of $\alpha_{EX} = 0.10$, none of the releases rejected the null hypothesis of model validity.

The individual Burnham et al. (1987) Tests 3.1 and 3.2 for each release are presented in Table 11 and the P-values of the tests summarized in Table 12. Again, only 1 of 10 Test 3's were significant at $\alpha = 0.10$, and none of the releases rejected the null hypothesis of model validity.

Hence, the tests of the SRR model assumptions for the Crazy Rapids releases suggest no apparent violations of assumptions and therefore, permit subsequent survival estimation.

4.5.2.2 Survival Estimates

The reach-specific survival estimates and associated capture probabilities (Figure 4) for each of the five Crazy Rapids PIT-tag releases are summarized in Table 13. The individual survival estimates from the release site to Rocky Reach tailrace ranged from 0.846 ($\hat{SE} = 0.039$) to 0.942 ($\hat{SE} = 0.056$) with a weighted average of $\hat{\bar{S}} = 0.878$ ($\hat{SE} = 0.017$). An approximate 90% CI for the survival from the release site at Crazy Rapids to Rocky Reach tailrace is CI $(0.850 < \mu_S < 0.906) = 0.90$.

Table 9. Burnham et al. (1987) Test 2 for individual release groups. Test 2.2 assesses whether detections at Rocky Reach had an effect on downstream survival and/or detections. Test 2.3 assesses whether detections at McNary had an effect on downstream survival and/or detections.

a. Test 2.2

Release		McNary	John Day	Bonneville	χ_2^2	P-value
112o1	Okanogan	184	225	118		
	Rocky Reach	52	78	44	1.5955	0.4503
116o2	Okanogan	215	222	118		
	Rocky Reach	53	76	42	3.3991	0.1828
120o3	Okanogan	137	227	115		
	Rocky Reach	56	91	38	0.9146	0.6330
124o4	Okanogan	160	254	110		
	Rocky Reach	67	72	50	6.1731	0.0457
128o5	Okanogan	129	295	87		
	Rocky Reach	35	81	23	0.0206	0.9898

b. Test 2.3

Release		John Day	Bonneville	χ_1^2	P-value
112o1	Okanogan + Rocky Reach	303	162		
	McNary	73	47	0.6010	0.4382
116o2	Okanogan + Rocky Reach	298	160		
	McNary	71	51	1.6783	0.1952
120o3	Okanogan + Rocky Reach	318	153		
	McNary	61	24	0.4192	0.5173
124o4	Okanogan + Rocky Reach	326	160		
	McNary	79	30	0.9585	0.3276
128o5	Okanogan + Rocky Reach	376	110		
	McNary	59	13	0.5217	0.4701

Table 10. Summary of Burnham et al. (1987) Test 2 results for the Okanogan releases.

Release	P-value		
	2.2	2.3	Overall
112o1	0.4503	0.4382	0.5326
116o2	0.1828	0.1952	0.1662
120o3	0.6330	0.5173	0.7211
124o4	0.0457	0.3276	0.0678
128o5	0.9898	0.4701	0.9095

Table 11. Burnham et al. (1987) Test 3 for individual release groups. Test 3.1 assesses whether capture histories at Rocky Reach had an effect on downstream detection histories at John Day and Bonneville dams. Test 3.2 assesses whether capture histories at Rocky Reach and McNary had an effect on downstream detection histories at Bonneville.

a. Test 3.1

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ_3^2	P-value
		101	111		
112o1	11	15	4		
	10	40	14		
	01	34	13		
	00	95	21	2.3958	0.4944
116o2	11	12	8		
	10	41	10		
	01	40	11		
	00	122	24	6.2854	0.0985
120o3	11	12	5		
	10	32	12		
	01	18	6		
	00	75	33	0.3784	0.9447
124o4	11	8	2		
	10	49	21		
	01	20	10		
	00	83	35	1.6846	0.6404
128o5	11	6	3		
	10	40	10		
	01	9	4		
	00	74	18	1.6858	0.6401

b. Test 3.2

Release	Capture History at Bonneville Dam	Capture History to John Day Dam				χ_3^2	P-value
		1111	1101	1011	1001		
112o1	0	14	52	40	164		
	1	4	26	15	61	1.4882	0.6850
116o2	0	10	61	41	170		
	1	8	15	12	52	5.0007	0.1717
120o3	0	12	71	32	182		
	1	5	20	12	45	1.8768	0.5984
124o4	0	21	59	49	202		
	1	1	13	8	52	4.2869	0.2321
128o5	0	10	65	40	239		
	1	3	16	6	56	1.2087	0.7509

Table 12. Summary of Burnham et al. (1987) Test 3 results for the Okanogran releases.

Release	P-value		
	3.1	3.2	Overall
112o1	0.4944	0.6850	0.6924
116o2	0.0985	0.1717	0.0799
120o3	0.9447	0.5984	0.8948
124o4	0.6404	0.2321	0.4264
128o5	0.6401	0.7509	0.8220

Table 13. Cormack-Jolly-Seber estimates of survival and capture probabilities for each of the Okanogan release groups used in the 1999 radio-PIT survival study. The joint probability of recovery from John Day to Bonneville and being captured at Bonneville Dam (λ) is reported in the last column. Standard errors are reported in parentheses.

Release	Survival			Probability of Capture at			Combined Capture and Survival (λ)
	Release to Rocky Reach	Rocky Reach to McNary	McNary to John Day	Rocky Reach	McNary	John Day	
112o1	0.866 (0.043)	0.677 (0.052)	0.971 (0.083)	0.245 (0.016)	0.223 (0.017)	0.337 (0.027)	0.282 (0.023)
116o2	0.906 (0.045)	0.721 (0.056)	0.992 (0.095)	0.232 (0.015)	0.232 (0.018)	0.292 (0.026)	0.236 (0.022)
120o3	0.846 (0.039)	0.768 (0.067)	0.948 (0.101)	0.282 (0.017)	0.180 (0.017)	0.317 (0.029)	0.216 (0.021)
124o4	0.856 (0.041)	0.721 (0.058)	1.166 (0.121)	0.265 (0.017)	0.184 (0.016)	0.280 (0.028)	0.183 (0.019)
128o5	0.942 (0.056)	0.673 (0.070)	0.862 (0.093)	0.216 (0.016)	0.130 (0.014)	0.397 (0.034)	0.186 (0.019)
Weighted Average	0.878 (0.017)						

4.6 Comparative Statistics

4.6.1 Comparison of Arrival Distributions

A chi-square test of homogeneity of arrival dates of radio-tagged and PIT-tagged steelhead smolts from Crazy Rapids to Rocky Reach Dam video-room found the arrival distributions to be significantly different [$P(\chi^2_{21} \geq 46.1605) = 0.0012$, Table 14]. A plot of arrival distribution (Figure 5) suggests fewer radio-tagged smolts were detected after 17 May than PIT-tagged smolt.

4.6.2 Comparison of Travel Times

The mean travel time for the radio-tagged steelhead smolts through the same reach of river was $\bar{t}_H$ = 4.2408 days ($\hat{SE}$ = 0.2463). The harmonic mean travel time for the PIT-tag steelhead smolts from Savage Rapids to Rocky Reach Dam was $\bar{t}_H$ = 3.9811 days ($\hat{SE}$ = 0.0462). The mean travel times for the radio-tagged and PIT-tagged steelhead smolts were not significantly different (P = 0.3000).

4.6.3 Comparison of Relative Guidance Efficiency

The fraction of PIT-tagged and radio-tagged smolts detected in the video room at Rocky Reach Dam provides an overall test of equal survival and guidance of the two types of tagged steelhead smolts (Table 15). Of the steelhead smolts released at Crazy Rapids, 44 (14.9%) radio-tagged and 1,765 (17.6%) PIT-tagged steelhead survived to Rocky Reach and were guided through the second entrance and gatewell collection system at Rocky Reach Dam. The guidance efficiency for these two groups of fish provides an overall test of equal survival and guidance of the two tag groups. No significant difference was detected between radio- and PIT-tag release groups $\left(P\left(\chi^2_1 > 1.4623\right) = 0.2266\right)$.

Figure 5. Proportions of radio-tagged and PIT-tagged steelhead smolts that arrived at Rocky Reach Dam video room from releases in the Okanogan River.

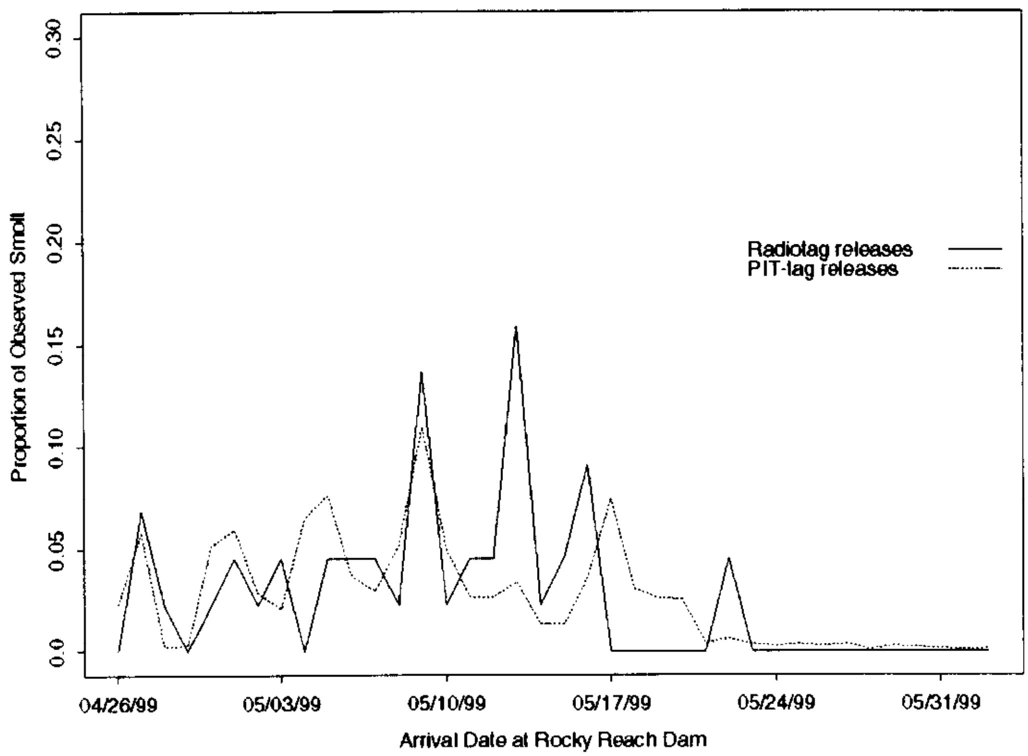

Table 14. Arrival counts at Rocky Reach video room for radio-tagged and PIT-tagged steelhead smolts released in the Okanogan River.

Date	PIT-tag	Radio-tag
04/26/99	41	0
04/27/99	102	3
04/28/99	4	1
04/29/99	5	0
04/30/99	91	1
05/01/99	105	2
05/02/99	51	1
05/03/99	37	2
05/04/99	114	0
05/05/99	134	2
05/06/99	65	2
05/07/99	52	2
05/08/99	91	1
05/09/99	193	6
05/10/99	88	1
05/11/99	47	2
05/12/99	47	2
05/13/99	60	7
05/14/99	23	1
05/15/99	23	2
05/16/99	64	4
05/17/99 - 06/02/99	328	2
Total	1765	44

Table 15. Comparison of relative guidance efficiency at Rocky Reach Dam between the pooled groups of radio-tagged and PIT-tagged steelhead smolts released into the Okanogan River.

Capture History Downstream	PIT-tag	Radio-tag	χ_1^2	P-value
r	1765	44		
$R-r$	8278	252	1.4623	0.2266

4.6.4 Comparison of Reach Survival Estimates

For radio-tagged fish, survival was estimated from the release at Crazy Rapids to detection in the forebay of Rocky Reach Dam. For PIT-tagged fish, survival was estimated from the release at Crazy Rapids to the tailrace of Rocky Reach. For this comparison, PIT-tag survival was expected to be less than or equal to radio-tag survival. Survival for radio-tagged fish from Crazy Rapids to the forebay of Rocky Reach averaged $\hat{\bar{S}} = 0.822$ ($\hat{SE} = 0.075$) with a 90% confidence interval of CI ($0.699 < S < 0.945$) = 0.90. Survival for PIT-tagged fish from Crazy Rapids to the tailrace of Rocky Reach Dam averaged $\hat{\bar{S}} = 0.878$ ($\hat{SE} = 0.017$) with a 90% confidence interval of CI ($0.850 < \mu_S < 0.906$) = 0.90. The overlapping 90% confidence interval for the survival estimates generated by the PIT-tag and radio-tag releases suggest no significant difference. However, the PIT-tag survival estimate that includes the additional mortality through Rocky Reach Dam is higher than the radio-tag estimate. This counterintuitive result raises some concerns regarding the comparability of the two tagging techniques. More information may be needed before resolving the issue of the most appropriate approach for estimating smolt survival.

Additional survival comparisons were possible from data collected in 1999. Survival from Pateros to the tailrace of Wells Dam was estimated based upon 15 replicate pairs of PIT-tagged steelhead. Survival from Pateros to the tailrace of Wells Dam, based upon the PRR model, averaged $\hat{\bar{S}} = 0.943$ ($\hat{SE} = 0.016$) (Bickford et al., 2000). In comparison, survival for radio-tagged fish from Pateros to a point 5 km downstream of Wells Dam averaged $\hat{S} = 0.904$ ($\hat{SE} = 0.042$). There was also no significant difference $\left(P(|Z| > 0.8677) = 0.3855\right)$ in survival between these estimates. But again, the PIT-tagged fish had a higher survival than radio-tagged steelhead smolts in this lower part of the study area.

5.0 DISCUSSION

5.1 Fish Collection

In total, 74,669 steelhead were collected for tagging purposes during the 1999 survival study. Of these fish, 10,340 fish were used in the radio-PIT comparison study. The remaining steelhead were utilized for a PIT-tag survival study conducted at the Wells Hydroelectric Project. Fish included in the comparison study were randomly tagged with either a PIT-tag or radio-tag.

The volitional collection and handling of hatchery steelhead in 1999 took place without measurable impact upon the study animals. The use of a 15 cm Aqualite harvester, a 2,000 L fish transportation container and short distances between collection and tagging locations helped maintain fish health at optimum levels throughout the collection phase of the study.

5.2 Tagging and Holding

The side-by-side radio-PIT comparison study utilized 303 radio-tagged steelhead and 10,037 PIT-tagged steelhead. Tagging and holding facilities were designed to minimize fish stress and to maximize fish survival to releases. Physiological information collected on PIT-tagged fish indicated that nominal stress was induced from the collection, handling and tagging procedures employed in 1999. Physiological samples collected 36-hours after tagging and immediately prior to release suggested that PIT-tagging stress was minimal and that the 36-hour recovery period was sufficient in duration to allow stress indices to return to resting levels (Bickford et al., 2000). In total, only 2 (0.019%) of the PIT-tagged and one (0.33%) of the radio-tagged steelhead died after being tagged. No shed PIT-tags were recovered from inside the release containers utilized for the comparison study. Six radio-tagged steelhead were removed from the study due to either antenna tangles (5) or radio-tag malfunction (1). The remaining 296 radio-tagged fish were released without incident.

5.3 Transportation and Release

Transportation techniques utilized for the comparison study were successful at safely moving large numbers of tagged fish to the release site within the temperature, dissolved oxygen, fish survival and time intervals established in Section 3.3. Transport intervals were consistent between the five replicate release groups. Travel time from the hatchery to the barge loading site averaged 50 minutes. Recovery and transport times remained comparable both within and between PIT and radio release groups. Loading, transportation and water quality (water temperature and dissolved oxygen concentrations) were also comparable within and between PIT and radio release groups. No meaningful differences were detected.

5.4 Interrogation

The Cormack-Jolly-Seber model was used to estimate capture and survival probabilities for the radio-tag and PIT-tag release groups. Overall, detection probabilities for both PIT-tagged and radio-tagged steelhead were higher than anticipated.

Detection probabilities for radio-tagged steelhead ranged from a low of 0.741 ($\hat{SE}$ = 0.029) at Pateros to a high of 0.982 ($\hat{SE}$ = 0.009) at the Okanogan River mouth. Capture probabilities averaged 0.966 ($\hat{SE}$ = 0.013) at the forebay of Wells Dam, 0.741 ($\hat{SE}$ = 0.031) at the 5 km tailrace array, 0.850 ($\hat{SE}$ = 0.027) at the 13 km tailrace array and 0.798 ($\hat{SE}$ = 0.039) at the underwater antenna array deployed in the forebay of Rocky Reach Dam. Fewer radio-tagged fish were detected at the video room at Rocky Reach Dam than anticipated.

Mean capture probabilities for the Okanogan PIT-tag release groups averaged 0.250 at Rocky Reach, 0.198 at McNary, and 0.358 at John Day dams. Capture probabilities at John Day were much higher than anticipated and were instrumental in the development of precise reach survival estimates for the Okanogan PIT release groups.

5.5 Comparative Statistics

5.5.1 Comparison of Arrival Distributions

A chi-square test of homogeneity of arrival dates of radio-tagged and PIT-tagged steelhead smolts from release to Rocky Reach Dam video-room found the arrival distributions to be significantly different. A small number of PIT-tagged fish arrived at Rocky Reach much later than the last radio-tag release group. However, the majority of the radio-tagged and PIT-tagged migrants migrated downstream together and likely experienced similar capture processes at Rocky Reach Dam.

5.5.2 Comparison of Travel Times

The mean travel time for the radio-tagged steelhead smolts through the same reach of river was $\bar{t}_H = 4.2408$ days ($\hat{SE} = 0.2463$). The harmonic mean travel time for the PIT-tagged steelhead smolts released from Crazy Rapids to Rocky Reach Dam was $\bar{t}_H =$ 3.9811 days ($\hat{SE} = 0.0462$). The mean travel times between tag groups were not statistically different. The observed difference translated into a 6.23 hour mean arrival difference between tag groups. PIT-tagged steelhead released for this study arrived first and displayed a more protracted migration past Rocky Reach relative to radio-tagged fish whose migrating was slightly slower and more truncated than that of the PIT-tagged fish.

5.5.3 Comparison of Relative Guidance Efficiency

Of the tagged steelhead smolts released at Crazy Rapids, 14.9% of the radio-tagged and 17.6% of the PIT-tagged steelhead survived to Rocky Reach Dam and were guided through the second surface collector and gatewell collection system at Rocky Reach Dam. The guidance efficiency of the two relative tag groups provided an overall test of equal survival and guidance. No statistical difference (P = 0.2266) was detected between the two tag types. Survival and guidance rates for PIT-tagged fish was higher than that for radio-tagged fish indicating a possible behavior and survival difference between tag groups.

5.5.4 Comparison of Reach Survival Estimates

Survival for radio-tagged fish from Crazy Rapids to the forebay of Rocky Reach averaged $\hat{\bar{S}} = 0.822$ ($\hat{SE} = 0.075$). The goal of the radio-tag portion of the comparison study was to estimate reach survival with a 90% confidence interval (CI) with error of less than 10%. The precision goal for radio-tag survival estimates was not achieved in 1999. Radio-tag survival was estimated at 0.822 with a 90% CI of 12.34%.

Conversely, survival for PIT-tagged steelhead from Crazy Rapids to the tailrace of Rocky Reach Dam averaged $\hat{\bar{S}} = 0.878$ ($\hat{SE} = 0.017$). The goal of the PIT-tag portion of the comparison study was to estimate reach survival with a 90% CI with error of less than 10%. The PIT-tag precision goal was met during the 1999 study. Okanogan PIT-tag survival was estimated at 0.878 with a 90% CI of 2.80% and a 95% CI with error of 3.33%.

The statistical comparison of reach survival estimates was degraded by a lack of statistical precision about the radio-tag survival estimate and by important differences in where radio-tagged and PIT-tagged fish were detected at Rocky Reach Dam. PIT-tagged steelhead were detected as they passed through surface collector pipe No. 2. Radio-tagged fish were also detected at this location but insufficient numbers were collected to provide a precise estimate of survival to the tailrace of Rocky Reach Dam. Subsequently, radio-tag detections on all underwater antennas in the forebay of Rocky Reach Dam were pooled for use in estimating reach survival from release to the forebay of Rocky Reach Dam. As a result, the radio-tag survival estimate did not contain mortality through Rocky Reach Dam. Accordingly, the radio-tag reach survival estimate was expected to be equal to or greater than the PIT-tag reach survival estimate.

Even though the PIT-tag survival estimate contained mortality through Rocky Reach Dam, the point estimate of survival was still 5.6% higher than the radio-tag survival estimate. However, it should be pointed out that the 90% confidence interval for the radio-tag survival estimate was large and overlapped considerably with that of the PIT-tag survival estimate.

An *ad hoc* survival comparison was also possible from data collected in 1999. Survival from Pateros to the tailrace of Wells Dam was estimated from 15 replicate release pairs of PIT-tagged steelhead. Survival from Pateros to the tailrace of Wells Dam, based upon the PRR model, averaged $\hat{\bar{S}} = 0.943$ ($\hat{SE} = 0.016$) (Bickford et al., 2000). In comparison, survival for radio-tagged fish migrating from Pateros to a point 5 km downstream of Wells Dam, based upon the SRR model, averaged $\hat{S} = 0.904$ ($\hat{SE} = 0.042$). There was a 3.4% difference in reach survival between the two tag groups. Again, the radio-tag estimate of survival was lower than the PIT-tag result. However, it should be noted that this second survival comparison included not only differences in tag type (radio-tag versus PIT-tag) but also includes differences in estimation techniques (SRR versus PRR).

6.0 SUMMARY OF FINDINGS

Arrival distributions were significantly different between radio and PIT release groups. Harmonic mean travel times and relative guidance efficiency rates to the video room at Rocky Reach Dam were not statistically different between the radio and PIT release groups. However, PIT-tagged fish arrived at Rocky Reach first and were detected at a higher relative rate compared to simultaneously released radio-tagged fish.

The radio-tag survival estimates were less precise than anticipated. The radio-tag survival estimates generated in 1999 were consistently lower than the estimates of survival for PIT-tagged steelhead. Radio-tag survival from release to detection in the forebay of Rocky Reach Dam was 5.6% less than PIT-tag survival from release to the tailrace of Rocky Reach Dam. Radio-tag survival from Pateros to the tailrace of Wells Dam was a 3.4% less than the estimate of PIT-tag through the same section of river. Differences in survival estimation techniques, tagging procedures, differences in fish behavior and differences in tag types, were thought to explain the majority of the differences observed between arrival distribution and survival between radio and PIT tagged steelhead smolts.

The radio-tag survival technique provides a considerable reduction in sample size over PIT-tag release-recapture techniques. However, a lack of demonstrated precision, substantially higher study costs and the potential for negative (fish behavior related) and positive (invalid tag detections) bias still impede the application of radio-tag mark-recapture technique at Wells Dam.

Differences in survival and arrival distributions between radio-tagged and PIT-tagged steelhead were sufficiently large in 1999 to warrant further study of the radio-tag survival technique for steelhead. Similar side-by-side radio-PIT survival comparisons for yearling steelhead are recommended before acceptance of the technique can occur. Similar side-by-sdie comparisons should also take place for yearling chinook, sockeye and subyearling chinook before radio-tag survival studies can be utilized as unbiased project survival estimators at Wells Dam.

The development of the nano radio-tag and the use of underwater antenna/receiver systems will likely improve upon the radio-tag mark-recapture technique utilized in 1999.

7.0 ACKNOWLEDGMENTS

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Appendix M

Project Survival Estimate for Yearling Summer Steelhead Migrating through the Wells Hydroelectric Facility, 2000.

PROJECT SURVIVAL ESTIMATES FOR YEARLING SUMMER STEELHEAD MIGRATING THROUGH THE WELLS HYDROELECTRIC FACILITY, 2000

by

Shane A. Bickford[1]
Dr. John Skalski[2]
Rich Townsend[2]
Scott McCutcheon[3]
Ryan Richmond[3]
Dr. Russ Frith[4]
Robert Fechhelm[4]

[1] *Environmental and Regulatory Services*
Public Utility District No. 1 of Douglas County
East Wenatchee, Washington

[2] *School of Aquatic and Fisheries Science*
University of Washington
Seattle, Washington

[3] *Biomark, Incorporated*
Boise, Idaho

[4] *LGL Limited*
Sidney, British Columbia

Research Funded by:

Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, Washington 98802 - 4497

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EXECUTIVE SUMMARY

In the spring of 2000, the Public Utility District No. 1 of Douglas County conducted a PIT-tag survival study at the Wells Hydroelectric Project. Yearling hatchery summer steelhead smolts were collected, PIT-tagged and released above and below the project on twelve different occasions. The primary goal of the study was to precisely estimate the survival of PIT-tagged steelhead migrating from the mouth of the Methow River to and through the tailrace of the Wells Hydroelectric Project. Specific objectives toward accomplishing the primary goal included 1) testing the assumptions of the single (SRR) and paired (PRR) release-recapture models, 2) estimating capture and reach specific survival probabilities and 3) developing component estimates of reach survival for steelhead passing from the mouth of the Methow River to the tailrace of the Wells Hydroelectric Project.

Steelhead smolt survival from the mouth of the Methow River to the tailrace of Wells Dam was assessed through the release of 23,857 steelhead at Pateros and 23,925 steelhead into the tailrace of Wells Dam. The Methow River release site was located 13 km upstream of Wells Dam at river km 843. The tailrace or control release site was located 300 meters downstream of Wells Dam at river km 829.6. Twelve replicate releases of steelhead were completed at both the Methow and tailrace release sites. Each replicate release at each release site contained approximately 2,000 yearling steelhead.

To minimize differences between replicate release groups, fish destined for release at the Methow and tailrace release sites were treated identically throughout the collection, tagging, recovery and transportation phases of the study. Toward this goal, the PIT-tagging crews were continually rotated between the Methow and tailrace release groups. Holding containers and tagging equipment were randomly assigned to release groups. Columbia River water was utilized throughout the collection, tagging, recovery and release phases of the study to provide consistent pre-release conditions between replicate release pairings. Water chemistry was monitored and recorded hourly to ensure consistency between the two release sites and within each of the twelve replicate release pairs.

Fish physiology for the Methow and tailrace release groups was monitored throughout the study. Six of the twelve Methow/tailrace release replicates were sampled to provide pre-release comparisons of fish physiology between replicate release pairs. Physiological data amassed included indices of steelhead handling stress (plasma cortisol and plasma glucose), morphology (length, weight and mesenteric fat), fish condition (fin erosion, descale, and injury rates), smoltification (ATPase and silvering) and fish health (organ tissue color, size and texture). In addition to sampling tagged fish, several control groups of untagged fish were also sampled. Information from the control groups was used to develop baseline indices of fish stress, fish condition and smoltification prior to the tagging procedure.

The information on fish physiology was used to detect subtle differences in fish handling (handling stress and fish condition) within and between the Methow and tailrace release groups. Physiological information was also used to detect differences in fish condition within and between replicate release pairs (smoltification, morphology and fish health). It was hypothesized that subtle differences in handling, stress, or fish condition might increase the variability and uncertainty surrounding reach survival estimates. In extreme cases, differences within a replicate might result in biased estimates of reach survival.

Overall, meaningful differences either within or between the six replicate release pairs sampled were lacking. Differences included a marked decline in fish condition, ATPase levels and fat indices over time. Overall, fish appeared to be healthy with little descaling, fin erosion or injuries noted.

The collection of short-term and long-term stress indices were informative and indicated that collection, handling, tagging and transportation techniques were not meaningfully different either within or between replicate release pairs sampled. In general, indices of short-term and long-term stress were moderate for PIT-tag sample groups. Stress indices for tagged fish were similar to literature values for fish exposed to short-term handling stress.

Recapture and passive interrogation of study fish took place at Rocky Reach, McNary, John Day and Bonneville dams. Additional study fish were detected at the Columbia River estuary by a boat towed PIT-tag trawl. The majority of the Methow and tailrace release replicates (Methow/tailrace) migrated downstream together. Similar to results from the 1999 steelhead survival study, the Methow/tailrace release pairings generally exhibited homogeneous arrival distributions at McNary, John Day and Bonneville dams. Chi-square tests indicated that arrival distributions at Rocky Reach were significantly different within all twelve replicate release pairs. However, visual inspection of the twelve arrival distributions at Rocky Reach Dam clearly demonstrated good mixing between the treatment and control release groups.

Detection and survival probabilities for the Methow/tailrace release pairings were not significantly different for the majority of the release pairings. Detection rates for Douglas PUD released steelhead smolts averaged 0.587 ($S\hat{E} = 0.009$), 0.155 ($S\hat{E} = 0.005$) and 0.149 ($S\hat{E} = 0.013$) at Rocky Reach, McNary and John Day dams, respectively.

Survival through Wells Dam was estimated based upon the relative survival of Methow and tailrace release groups. Survival from the Methow release site through to the tailrace of Wells Dam ranged from 0.865 to 1.022. To remain consistent with survival estimates from previous studies at Wells Dam and from studies conducted at other Snake and Columbia river dams, all reported point estimates of survival were based upon the weighted average of the replicate survival estimates. The weighted average survival for yearling steelhead passing from the mouth of the Methow River to 300 m downstream of Wells Dam was 0.946 ($S\hat{E} = 0.015$) (n = 12) during 2000. The survival estimate generated for steelhead in 2000 was the product of survival through the reservoir, forebay, dam and tailrace for ESA listed summer steelhead smolts. The 2000 Wells survival estimate was not significantly different (p = 0.9636) from the 1999 Wells steelhead survival estimate of 0.943 ($S\hat{E} = 0.016$) (n = 15).

Estimates of reach specific survival were derived from release sites to immediately downstream of Rocky Reach, McNary and John Day dams. Survival from the Rocky Reach tailrace to the McNary tailrace and from the McNary tailrace to the John Day tailrace were not significantly different ($p < 0.10$) between the paired Douglas PUD release groups. As a result, the independent estimates of reach survival were pooled. Average steelhead survival from the Rocky Reach tailrace to the McNary tailrace averaged (weighted) 0.656 ($S\hat{E} = 0.011$). Survival from the McNary tailrace to the John Day Dam tailrace averaged 1.017 ($S\hat{E} = 0.053$).

In addition to Douglas PUD tagged steelhead, the Fish Passage Center released three replicate release groups of PIT-tagged yearling spring chinook from the Winthrop National Fish Hatchery. Estimates of detection and survival from this group of fish provided an interesting contrast between spring chinook and summer steelhead survival during the 2000 outmigration.

Detection rates for year 2000 Winthrop spring chinook averaged 0.261 ($S\hat{E} = 0.028$), 0.206 ($S\hat{E} = 0.034$) and 0.063 ($S\hat{E} = 0.010$) at Rocky Reach, McNary and John Day dams. Estimated reach survival for Winthrop fish migrating from Winthrop to the tailrace of Rocky Reach Dam averaged 0.705 ($S\hat{E} = 0.040$). Estimated reach survival from the Rocky Reach tailrace to the McNary tailrace for Winthrop fish averaged 0.692 ($S\hat{E} = 0.088$). The 2000 reach survival estimate for Winthrop spring chinook was not significantly different from the reach survival estimates generated for Winthrop spring chinook released in 1998 and 1999 and from steelhead reach survival estimates generated in 1999 and 2000.

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1.0 INTRODUCTION

In the spring of 1998, the Public Utility District No. 1 of Douglas County conducted a pilot survival study at the Wells Hydroelectric Project. Results from the 1998 study indicated that the critical assumptions of the SRR and PRR models could be satisfied during PIT-tag survival studies at Wells Dam. Chinook survival through the Wells project was estimated based upon the relative survival of chinook released at Pateros and chinook released below Wells Dam. Estimated chinook survival from the mouth of the Methow River to the tailrace of Wells Dam averaged 99.7% ($\hat{SE}$ = 0.015) in 1998 (Bickford et al. 1999).

Estimated survival from the Rocky Reach tailrace to the McNary tailrace during 1998 averaged 0.659 ($\hat{SE}$ = 0.040) for yearling Wells summer chinook, 0.720 ($\hat{SE}$ =0.091) for yearling Winthrop spring chinook and 0.720 ($\hat{SE}$ = 0.084) for yearling Methow run-of-river chinook (Bickford et al., 1999). Estimated reach survival from Rocky Reach to McNary were not significantly different (p=0.5390) between Winthrop spring and Wells summer chinook. Likewise, estimated survival for Wells summer chinook and Methow run-of-river chinook were not significantly different (p=0.2040).

In the spring of 1999, Douglas County PUD conducted a second year of PIT-tag survival studies at Wells Dam. The 1999 survival study was designed to accurately estimate the survival of PIT-tagged steelhead smolts migrating through the Wells Hydroelectric Project. During the 1999 study, fifteen replicate pairs of ESA listed yearling summer steelhead were released. Estimated steelhead survival from the mouth of the Methow River to the tailrace of Wells Dam averaged 0.943 ($\hat{SE}$ = 0.016) (Bickford et al., 2000).

Estimated survival from the Rocky Reach tailrace to the McNary tailrace during 1999 averaged 0.686 ($\hat{SE}$ =0.010) for yearling Wells summer steelhead and 0.727 ($\hat{SE}$ =0.053) for yearling Winthrop spring chinook (Bickford et al., 2000a; Bickford et al., 2000b). Estimated reach survival from Rocky Reach to McNary were not significantly different (p > 0.10) between Winthrop spring chinook and the Okanogan, Pateros and Wells tailrace releases of PIT-tagged Wells summer steelhead.

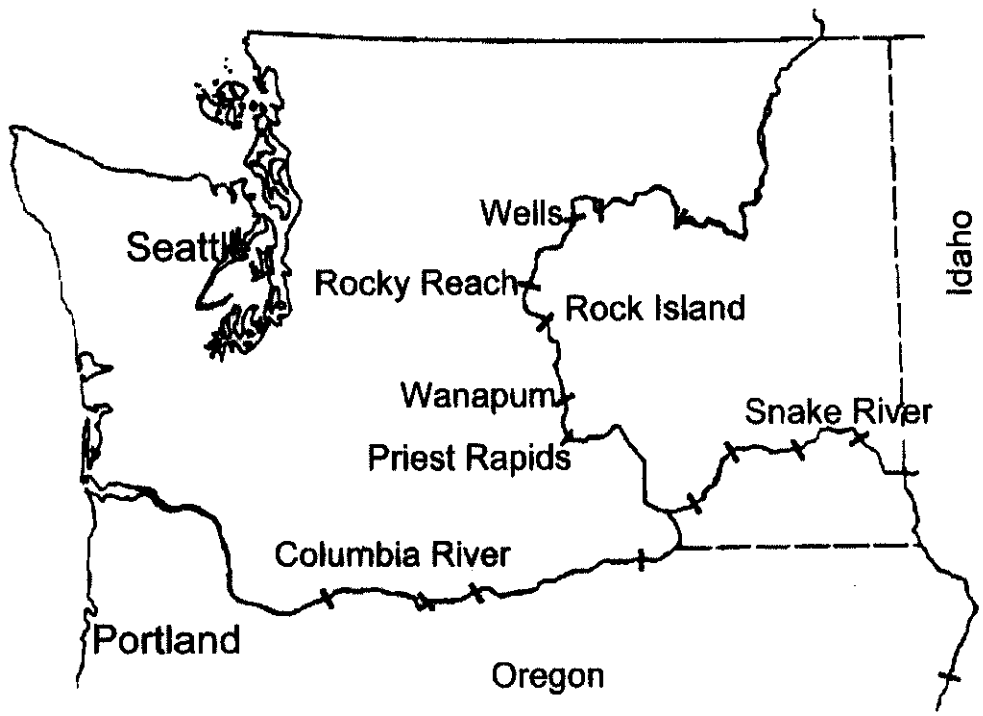
During the spring of 2000, Douglas PUD conducted a third year of PIT-tag survival studies. The 2000 survival study was designed to be similar to previous survival studies conducted at Wells Dam. Goals of the study included evaluating critical model assumptions, estimating reach specific survival rates, estimating precisely the survival for yearling summer steelhead migrating from the mouth of the Methow River through and to the tailrace of the Wells Hydroelectric Project, and rigorously comparing survival estimates from this study with survival estimates generated from other survival studies.

2.0 STUDY AREA

The Wells Hydrocombine generating facility is located at river km (R km) 830 on the upper Columbia River (Figure 1). The Wells Hydrocombine, unlike typical Columbia River hydroelectric projects, efficiently combines generation, spill and fish passage facilities into one structure. The generation facilities at Wells Dam contain ten Kaplan turbines capable of producing 840,000 kilowatts of electricity. Juvenile fish are bypassed away from turbines via a highly effective surface collection system. The Wells bypass system provides a safe, non-turbine passage route through the dam for over 92% of the spring and 96% of the summer migrants (Johnsen et al., 1992; Skalski et al., 1996). Wells is the uppermost generating project on the Columbia River which anadromous chinook (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*) and sockeye salmon (*O. nerka*) migrate through. Adult fish passage is provided by two fish ladders located at either end of the powerhouse.

The reservoir formed by Wells Dam is called Lake Pateros. The Methow River enters Lake Pateros at R km 843 (Figure 2). The Methow is the most important production area for Upper Columbia River salmon and steelhead upstream of Wells Dam. Both natural and hatchery produced steelhead smolts originate from this system. The Okanogan River enters Lake Pateros at R km 870. Steelhead smolts migrating out of the Okanogan River are mostly hatchery fish planted into this system each spring by staff from the Wells Fish Hatchery.

Figure 1. Mainstem Columbia and Snake rivers depicting important hydroelectric projects.



3.0 METHODS AND MATERIALS

3.1 Fish Collection

The collection of yearling hatchery summer steelhead (study animals) took place at the Wells Fish Hatchery. Steelhead smolts ready to migrate were allowed to volitionally exit Pond #4 via an overflow weir. Fish passing over the weir were washed downstream through an outfall pipe and deposited into a 23,000 L collection trap.

Two to three days prior to each tagging session, sufficient numbers of steelhead smolts were collected from the trap. Fish were pumped from the trap into a 2,000 L transportation container with a 20 cm Aqualite Harvester hydraulic fish pump (Magic Valley Harvest, Hagerman, Idaho). The transportation container was outfitted with a displacement meter, water re-circulation pump and metered compressed oxygen. The displacement meter ensured that the density of fish inside the transport container never exceeded 0.16 Kg fish/L. Once inside the transport container, the fish were transported less than 0.5 km to one of two concrete pre-tagging holding raceways. Transport time from the collection site to the holding raceways was less than 15 minutes per load.

The Wells pre-tagging raceways contained a minimum of 70,000 L of single pass river water. Rearing pond #4 and pre-tagging raceway #1 and #2 all received a continuous supply of gravity fed river water from the Wells Hatchery water distribution system.

3.2 Tagging and Holding Procedures

On tagging days, small groups of untagged steelhead, being held in either of the two pre-tagging raceways, were crowded toward a pint-sized-pescalator (PRA Manufacturing, Nanaimo, British Columbia, Canada). The pescalator was comprised of a 30 cm diameter fiberglass pipe with an Archimedies screw built into the center. As the pescalator rotated, it captured and transported water and fish up and out of the raceway. At the top of the pescalator, fish and water were deposited into a 10 cm transport pipe. The transport pipe delivered each fish directly into an anesthetic bath containing 40 ppm of Methanosulfonate-222 (MS-222). Once fish began to lose equilibrium, small groups of fish were dip netted into an 8 L container filled with a lighter (20-30 ppm) solution of MS-222.

Once anesthetized, diseased, mortally wounded and residual steelhead were removed from the study group. Remaining healthy steelhead smolts were tagged within the body cavity using 12-gauge hypodermic needles loaded with individual 12 mm Destron-Fearing 134.2-kHz ISO PIT-tags. Fish were tagged according to criteria described in Prentice et al. (1987) and Bickford et al. (1999, 2000a and 2000b). To prevent disease transmission, each hypodermic needle was soaked in ethyl alcohol for 10 minutes and allowed to dry before being reloaded with a PIT-tag. Needles were used only 11 times each to ensure sharpness and promote rapid healing of the tag incision.

Immediately following tagging, each unique tag code for each fish was entered into a database. In addition to the tag code, date of tag implantation, tag personnel identification code, fish length, water temperature and obvious abnormalities were recorded.

A 10 cm diameter pipe half full of water was used to transfer the tagged fish into 1,200 L release containers for recovery. During tagging and initial recovery, the release containers were supplied with a continuous flow of single pass river water in addition to metered compressed oxygen. Water and dissolved oxygen levels were closely monitored throughout the entire 36-hour recovery period. Between 400 and 412 tagged steelhead were placed inside each release container. Loading densities were established to ensure that no release container held more than 0.03 Kg of fish/liter water (Kg fish/L).

Containers with recovering tagged steelhead were supplied with 50-60 L/min of river water through a 5 cm flex-hose. Water temperature and dissolved oxygen levels inside each release container were closely monitored and recorded each hour to ensure that the pre-release recovery history of each container was similar within and between tagging groups. PIT-tag release groups were randomized at the time of tagging, release containers alternated between release groups and tagging personnel rotated between and among tagging groups.

3.3 Transportation and Release Procedures

Releases of PIT-tagged WFH steelhead took place at the Methow River and tailrace release sites on April 24, 26, 28, and 30 and May 2, 4, 6, 8, 10, 12, 14 and 16. On each of the twelve release days, five release containers were transported with a flatbed truck to each of the barge loading sites.

Pateros release groups were removed from the water supply lines at 0800 hours and transported to the barge loading site at the Methow River. In the afternoons, five tailrace release containers were removed from the water supply lines at 1300 hours and transported to the barge loading site in the Wells tailrace. Release times were staggered to allow Pateros fish additional time to arrive at Wells Dam prior to the release of tailrace fish.

After being disconnected from the river water supply lines, metered compressed oxygen was immediately supplied to each release container. To compensate for differences in travel distances between the Methow and tailrace barge loading sites, the transport vehicle destined for the tailrace site made purposeful excursions to ensure that the total travel times, stress and subsequent pre-release histories of the Methow and tailrace release groups were similar.

At the barge loading stations, the release containers were hoisted off the transport trucks and loaded onto barges for final release. Barges were outfitted with water supply lines. Immediately after the release containers were loaded onto the barges, the metered compressed oxygen supply system was disconnected and the on-board river water supply system was turned on. Dissolved oxygen and water temperatures for each container were recorded periodically throughout the transportation process. Desired dissolved oxygen concentrations inside each container were manually adjusted to maintain between 9 and 12 mg O_2/L. Injured and moribund fish were removed and recorded. River water flow through each container on the barge was estimated at 60-80 L/minute.

Barges carrying release containers were towed to their respective release locations (Figure 2). Temperature, dissolved oxygen, and fish activity levels were recorded prior to final release. Following the pre-release inspection for mortalities, the fish were released directly into the Columbia River though 20 x 15 cm eccentric reducers. Water to water transfers were maintained throughout the entire study. Fish were released at the Methow and tailrace release sites approximately 1 hour after water supply lines at the WFH were disconnected. The Methow releases were initiated at 0900 hours and the tailrace releases were initiated at 1400 hours.

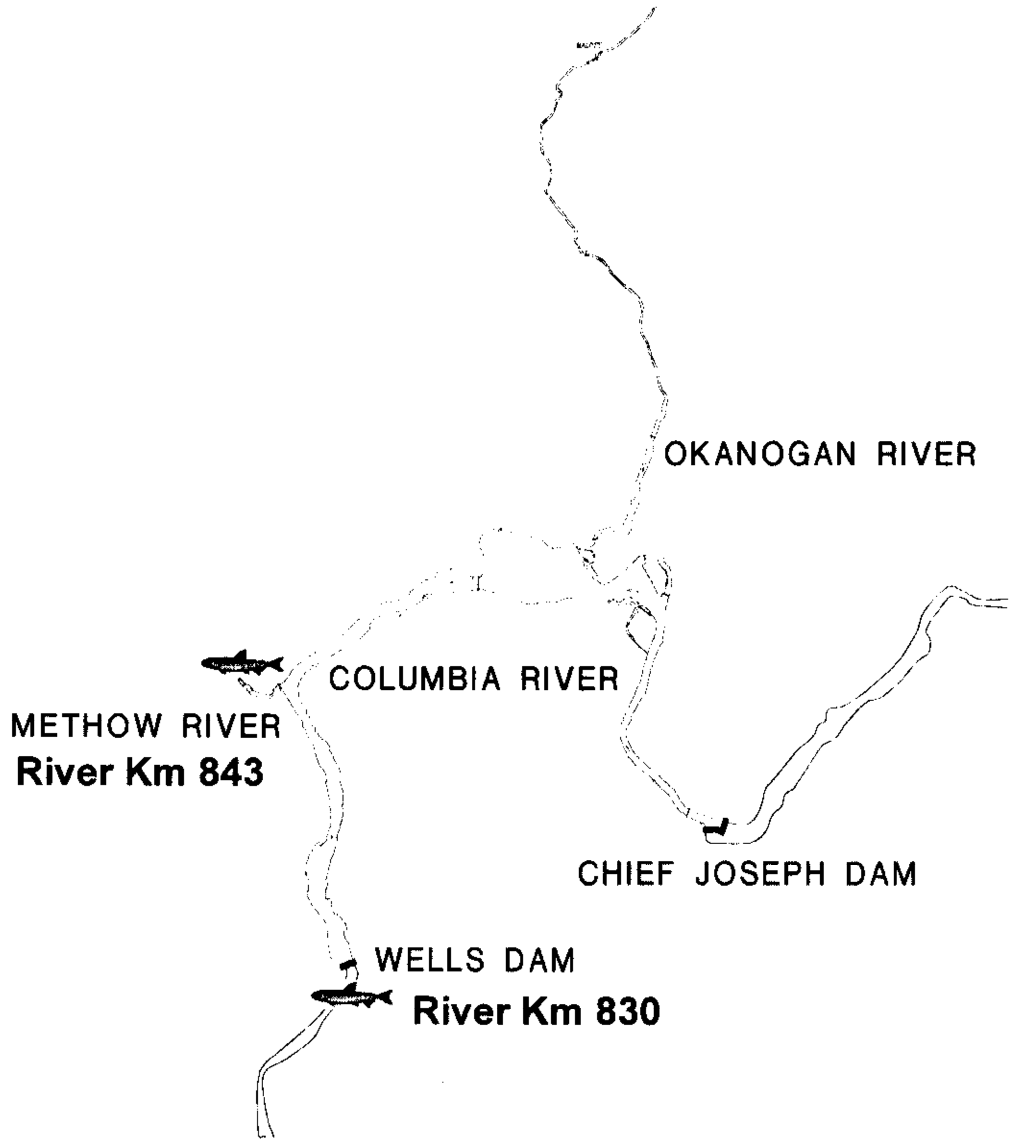
3.4 Physiological Monitoring

A sub-sample of at least 10 fish from the Pateros release group and at least 10 fish from the tailrace release group were collected on six of the twelve release days (April 24 and 28, May 2, 6, 10, and 14). These fish were used for the collection of important physiological information pertinent to the interpretation of survival estimates. Measures of smoltification (gill ATPase and smolt index), measures of stress (plasma cortisol and plasma glucose), morphological measures (length, weight) and indices of fish health (color and texture of internal organs, fin erosion, descale, infection) were collected. The physiological information collected was used to assess differences in stress, fish condition and fish health within and between replicate release pairs. In addition, comparisons were also made between replicate releases destined for the same release locations. Additional information collected from the post-mortem examination of steelhead included estimates of PIT-tag retention, observations of tag placement and tag implantation related injuries.

To provide a baseline level of fish stress, condition and health, a control group of 20 untagged steelhead was also sampled. Control fish were not anesthetized and tagged but were subjected to the same collection (fish pump), holding (raceway) and sampling conditions (lethal dose of anesthetic) as treatment (tagged) fish.

Collection of stress measures was particularly important for assessing the impact of stress experienced by fish during the tagging and recovery components of the study. In addition, stress levels within and between replicate release pairs were compared to indices of fish health, smolt status and fish condition. Statistical comparisons of physiological measures were accomplished with one-way ANOVA's followed by Tukey tests (Zar, 1984).

Figure 2. Release sites utilized during the 2000 Wells steelhead survival study.



PIT-Tag Release Sites

3.5 PIT-Tag Detection

PIT-tagged steelhead released during the 2000 survival study were detected at five downstream locations (Figure 3). The first of these sites was located in the surface collector bypass pipes at Rocky Reach Dam. At Rocky Reach Dam, the detection of 134.2 kHz PIT-tags was made possible by the installation of two 12 inch dual coil ISO PIT-tag detection systems and four single coil 24 inch ISO PIT-detection systems. Biomark, Inc. of Boise, Idaho installed this system through funding provided by the Public Utility District No. 1 of Douglas County and the Public Utility District No. 1 of Chelan County. Operation of the Rocky Reach juvenile bypass system was conducted by the Public Utility District No. 1 of Chelan County.

Recapture and detection of study fish also occurred at McNary, John Day and Bonneville dams. Additional detections took place at the Columbia River estuary-sampling site where NMFS operates a mid-water trawl equipped with a PIT-tag detection tunnel. The PTAGIS database managed by the Pacific States Marine Fisheries Commission was used to store and archive all the release and recapture information available for study fish. Operation of downstream fish passage facilities and PIT-tag detection facilities were funded by the United States Army Corps of Engineers and the Bonneville Power Administration. Faculty and staff at the Columbia Basin Research Unit, University of Washington conducted model testing, verified model assumptions and provided detection and reach survival probabilities.

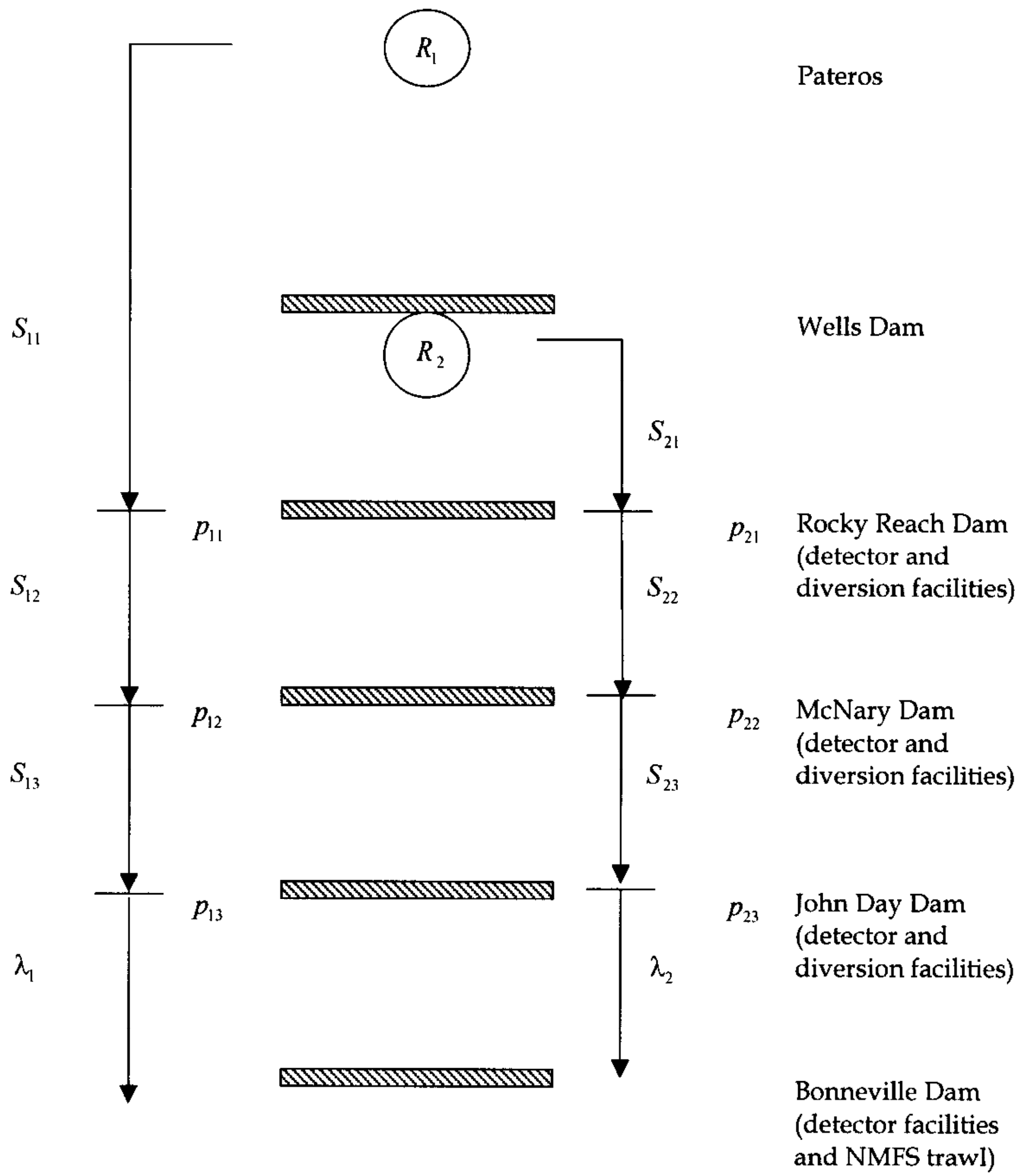
3.6 Release and Recapture Design for the Survival Study

Two release locations were used to estimate Wells project survival in the 2000 PIT-tag survival study (Figure 3). One release location was at the mouth of the Methow River near the town of Pateros, Washington (R_1). The second release location was in the tailrace of the Wells Dam approximately 300 m downstream of the project (R_2). Releases at these two sites were coordinated. The study consisted of 12 pairs of hatchery releases at the upstream(R_1) and downstream (R_2) sites. On a particular release day, approximately 2,000 hatchery fish were released at each of the upstream and downstream sites. The fish at the top of the pool (R_1) were released at 0900 hours with the tailrace group (R_2) released at 1400 hours. Release times were coordinated to facilitate mixing between the upstream and downstream release groups (i.e., 5 hours apart). The paired releases were conducted every other day for a total of approximately 48,000 hatchery yearling summer steelhead from Wells Fish Hatchery. The quantitative goal of these releases was to estimate mean smolt survival through the Wells project with a ±5% confidence interval around a point estimate calculated at the 95% confidence level.

3.7 Analysis of the PIT-Tagging Data

The single release-recapture model provided estimates of reach-specific survival and capture probabilities for all but the last recovery site (Figure 3) for each release group. Of primary interest is the smolt survival probability for the Wells Hydroelectric Project. Releases R_1 and R_2 of Figure 3 were used to estimate survival from Pateros to and through the Wells tailrace $\left(\hat{S}_W\right)$. Due to the current nature of salmon survival studies in the Mid Columbia Basin, analyses results that will be used as a basis for the following year's studies are required prior to the point of certainty that no further study fish will be detected. A date is determined that the additional detections will be so few as to not seriously affect survival estimates, and the analyses are based on that data. This year, all analyses contained within this report are based on the data obtained from the PTAGIS database on July 18, 2000.

Figure 3. Schematic of release and PIT-tag detection facilities used in the 2000 Wells Project Survival Study. Parameters that will be estimated from the release-recapture data are indicated.



Survival through the Wells project $\left(\hat{S}_W\right)$ was estimated from the results of the upstream and downstream releases (e.g., R_1 and R_2) by the expression:

Estimated Wells project survival:

$$\hat{S}_W = \frac{\hat{S}_{11}}{\hat{S}_{21}} \tag{1}$$

with associated variance estimate based on the Delta method (Seber 1982: pp. 7-9) of

$$\begin{aligned} V\hat{a}r\left(\hat{S}_W\right) &\doteq \left(\frac{\hat{S}_{11}}{\hat{S}_{21}}\right)^2 \left[\frac{Var\left(\hat{S}_{11}\right)}{\hat{S}_{11}^2} + \frac{Var\left(\hat{S}_{21}\right)}{\hat{S}_{21}^2}\right] \\ &\doteq \hat{S}_W^2 \left[\hat{C}V\left(\hat{S}_{11}\right)^2 + \hat{C}V\left(\hat{S}_{21}\right)^2\right] \end{aligned} \tag{2}$$

and where

$$\hat{C}V\left(\hat{\theta}\right) = \frac{\sqrt{Var\left(\hat{\theta}\right)}}{\hat{\theta}}.$$

Separate estimates of $\hat{S}_W$ were calculated for each of the 12 paired-releases.

A weighted average of the survival estimates from the replicate releases was calculated according to the formula

$$\hat{\bar{S}} = \frac{\sum_{i=1}^{k} W_i \hat{S}_i}{\sum W_i} \tag{3}$$

where k = number of replicate releases (e.g., 12);

$\hat{S}_i$ = survival estimates from the ith release pair ($i = 1, \ldots, k$);

$$W_i = \frac{1}{\left(\frac{V\hat{a}r\left(\hat{S}_i\right)}{\hat{S}_i^2}\right)} = \frac{1}{CV\left(\hat{S}_i\right)^2} \tag{4}$$

with variance

$$V\hat{a}r\left(\hat{\bar{S}}\right) = \frac{\sum_{i=1}^{k} W_i \left(\hat{S}_i - \hat{\bar{S}}\right)^2}{(k-1)\sum_{i=1}^{k} W_i}. \tag{5}$$

It was found that by weighting simply inversely proportional to $Var(\hat{S}_i)$, the weights were correlated with the point estimates [i.e., Equation (2)], resulting in downward bias in the average survival. By calculating the relative variance [Equation (4)], this correlation between the variance estimate and the point estimate is eliminated or reduced.

An asymptotic $(1-\alpha)$ 100% confidence interval for the weighted average of the survival estimates was computed according to the formula

$$\hat{\bar{S}} \pm Z_{1-\frac{\alpha}{2}} \sqrt{\hat{Var}(\hat{\bar{S}})}.$$

The paired release-recapture methods of Burnham et al. (1987) were used to find the most parsimonious models for estimating reach survival [Equations (1)]. A forward-sequential procedure was used in model selection based on likelihood-ratio tests of nested models. The most efficient estimates of reach survival were based on the statistical models for the paired-releases that properly shared all common parameters. The best models for characterizing the paired-releases were found using Program SURPH.1 (Smith et al. 1994).

Proportionate daily detection distributions (mixing) of the release groups (e.g., R_1 and R_2) of smolts is sufficient but not necessary for valid estimation of reach survival. For example, estimates of $\hat{S}_{11}$ and $\hat{S}_{12}$ can be derived independently without mixing of upstream and downstream smolts based on the assumptions of the single release-recapture model. The assumptions of the single release-recapture model are the following (Skalski et al. 1998):

A1. The test fish are representative of the population of inference.

A2. Test conditions are representative of the conditions of interest.

A3. The number of fish released is exactly known.

A4. PIT-tag codes are accurately recorded at the time of tagging and at all detection sites.

A5. For replicated studies, data from different releases are statistically independent.

A6. The fate of each individual fish is independent of the fates of all other fish.

A7. All fish in a release group have equal survival and detection probabilities.

A8. Prior detection history has no effect on subsequent survival and detection probabilities.

In order to estimate S_W, the survival S_{11} is assumed to be of the form:

$$S_{11} = S_W \cdot S_{21} \tag{6}$$

leading to the relationship

$$\frac{S_{11}}{S_{21}} = \frac{S_W \cdot S_{21}}{S_{21}} = S_W .$$

The equality (6) suggests two additional assumptions for valid estimation of Wells project survival. These are:

A9. Survival in the Wells project (S_W) is conditionally independent of survival in the Rocky Reach (S_{21}) project.

A10. Releases (R_1) and (R_2) experience the same survival probability in the Rocky Reach (S_{21}) project.

Assumption (A9) implies that there is no synergistic relationship between survival processes in the Wells and Rocky Reach projects. In other words, smolts that survived the Wells project are no more or less susceptible to mortality in the Rocky Reach project than smolts released in the tailrace of Wells. Assumption (A10) can be satisfied by mixing of the two release groups R_1 and R_2 but can also be satisfied if the survival process at Rocky Reach (S_{21}) is stable over the course of smolt passage by the two releases. A stable survival process might well be expected for one to a few days under similar flow and dam operations at Rocky Reach. Near constant survival rates at Lower Granite, Little Goose, and Lower Monumental projects over the majority of the outmigration have been reported by Skalski et al. (1997). Furthermore, unlike paired-release methods of the earlier Mid-Columbia survival studies in the 1980s, the assumption of equal capture probabilities is unnecessary for estimator (1) to be valid.

3.7.1 Tests of Model Assumptions

The assumptions of the single release-recapture model were tested for each PIT-tag release group. Model assumptions were also tested for each paired-release used in estimating reach survival.

Tests Within a Release for the Single Release-Recapture Model

For the single release-recapture model to be valid, certain data patterns should be evident from the capture histories. For each release group, a series of tests of assumptions were performed to determine the validity of the model (i.e., goodness-of-fit). The data from a single-release can be summarized by an m-array matrix of the form below where the m_{ij}'s are the number of smolts released at site i that are next detected at site j:

	Recovery Site			
Release Site	Rocky Reach (2)	McNary (3)	John Day (4)	Bonneville (5)
Initial (1)	m_{12}	m_{13}	m_{14}	m_{15}
Rocky Reach (2)		m_{23}	m_{24}	m_{25}
McNary (3)			m_{34}	m_{35}
John Day (4)				m_{45}

Burnham et al. (1987: p. 65, pp. 71-74) presents a series of tests of assumptions called Test 2 that examine whether upstream detections affect downstream survival and/or detection. For each release, two contingency table tests were performed, as follows:

Test 2.2

m_{13}	m_{14}	m_{15}
m_{23}	m_{24}	m_{25}

χ_2^2 (7)

Test 2.3

$m_{14}+m_{24}$	$m_{15}+m_{25}$
m_{34}	m_{35}

χ_1^2 (8)

Overall significance of Test 2 was based on the sum of the chi-square statistics $\chi_2^2+\chi_1^2=\chi_3^2$. Test-wise error rates were adjusted for the experimental-wise error rate of $\alpha_{EX}=0.10$ across the replicate releases.

Burnham et al. (1987: p. 65, pp.74-77) also present a series of tests of assumptions called Test 3 that also examine whether upstream capture histories affect downstream survival and/or capture. For each release, contingency tables were constructed of the form:

		Capture History to McNary Dam		
		101	111	
Capture History	11			
at John Day and	10			
Bonneville Dams	01			
	00			χ^2_3

(9)

Contingency table (9) tests whether capture at Rocky Reach Dam has a subsequent effect on capture histories at John Day and Bonneville dams. To test whether capture at Rocky Reach and/or McNary dams has a subsequent effect on the capture history at Bonneville Dam, a contingency table can be constructed of the form:

		Capture History at John Day Dam				
		1111	1101	1011	1001	
Capture History	1					
at Bonneville	0					χ^2_3

(10)

Contingency tables (9) and (10) are slight modifications from Burnham et al. (1987) to take into account more of the information from the individual capture histories. Overall significance of Test 3 was based on the sum of the chi-square statistics $\chi^2_3 + \chi^2_3 = \chi^2_6$. Test-wise error rates were adjusted for the experimental-wise error rate of $\alpha_{EX} = 0.10$ across the replicate releases.

Tests Between Releases Within a Paired-Release

At each downstream PIT-tag recapture site (i.e., Rocky Reach, McNary, John Day, Bonneville), a test of the assumption of mixing among the releases of smolts (e.g., R_1 and R_2) was conducted. A test of homogeneous recoveries over time was performed using a contingency table listing the daily downstream detections at each dam for each pair of releases:

		Release	
		R_1	R_2
	1		
Day of	2		
Detection	3		
	⋮	⋮	⋮
	D		

(11)

A contingency table of form (11) was calculated for each of the 12 Pateros/Wells paired releases. Each test was performed at $\alpha = 0.10$. Because of the multiple tests across release-pairs, Type I error rates were adjusted for an overall experimental-wise error rate of $\alpha_{EX} = 0.10$. A Type I error occurs when a hypothesis test falsely rejects the null when it is true. In this case, our null hypothesis is that there is no difference in downstream detections for a pair of releases. When $\alpha = 0.10$ for a specific test, we realize that if the null hypothesis is true, it will be erroneously rejected 10 percent of the time. When calculating a number of comparisons, though, the likelihood that a Type I error will occur increases. For 12 comparisons of the daily detection rates at McNary Dam, for example, the probability of at least one Type I error increases to 71.8%. To decrease this likelihood, the test-wise Type I error per comparison is reduced to $\alpha = 0.0087$, so that the experimental-wise error rate is $\alpha_{EX} = 0.10$. When the rejection of a hypothesis test does occur, this does not lead to rejecting the experiment, but indicates that this particular data set is inconsistent with the null hypothesis.

To test whether releases with a paired-release (e.g., R_1 and R_2) had similar downstream survival and capture histories for Rocky Reach Dam and below, likelihood ratio tests were performed to compare models with alternative downstream survival and capture scenarios. These tests were used to help determine the most parsimonious paired-release model for the estimation of S_W. Burnham et al. (1987: pp.128, Test 1.T2) suggests using a 2 x 2 contingency table test to determine where the capture and survival rates for the R_1 and R_2 releases were equal at and below Rocky Reach Dam (i.e., $p_{11} = p_{21}$, $S_{12} = S_{22}$, $p_{12} = p_{22}$, etc.), another indication of complete mixing. The 2 x 2 table of the form below was constructed for each paired-release:

Test 1.T2

	Release R_1	Release R_2
m_1	m_{11}	m_{21}
z_1	z_{12}	z_{22}

(12)

where m_{i2} was the number of smolts detected at Rocky Reach for the ith release group $(i = 1, 2)$ and z_{i2} was the number of smolts that were released that were not detected at Rocky Reach but were subsequently detected at McNary Dam or below.

Two additional Test 1's were also performed. A Test 1.T3 was performed of the form:

Test 1.T3

	Release R_1	Release R_2
m_1	m_{13}	m_{23}
z_1	z_{13}	z_{23}

(13)

where m_{i3} was the number of smolts detected at McNary Dam for the ith release group $(i = 1, 2)$ and z_{i3} was the number of smolts that were not detected at McNary but were subsequently detected at John Day Dam or below.

A Test 1.T4 was also performed of the form:

Test 1.T4

	Release	
	R_1	R_2
m_4	m_{14}	m_{24}
z_4	z_{14}	z_{24}

(14)

where m_{i4} was the number of smolts detected at John Day Dam for a release $i\ (i = 1,2)$ and z_{i4} was the number of smolts that were not detected at John Day Dam but were subsequently detected at Bonneville Dam.

While contingency tables (12-14) test for equality of overall recapture for releases R_1 and R_2, it does not provide the fine-grained test of equal site-specific capture and survival rates for both releases available using the likelihood-ratio tests. For this reason, inferences concerning downstream mixing will be largely based on the sequential use of likelihood-ratio tests.

Tests of Handling Effects at Rocky Reach and Rock Island Dams

Smolts passing through the bypass systems at Rocky Reach and Rock Island dams were collected and anesthetized for potential tagging as part of the Chelan PUD smolt survival studies. During the 2000 study, 3,400 PIT-tagged steelhead smolts released upstream of Rocky Reach, as part of the Douglas PUD smolt survival study, were intercepted and anesthetized a second time at Rocky Reach. At Rock Island, the number of smolts intercepted was 1,471. Chi-square contingency table tests were used to assess whether this second handling affected downstream detection and survival probabilities. For each dam (Rocky Reach and Rock Island), the downstream histories of "handled" fish and "detected, but not handled" fish at that dam were compared in a table the form of (Table 15). Both groups of fish traveled through the bypass systems, with the only difference being the collection and anesthetizing process.

		Handled fish	Detected, but not handled fish
Capture History	111		
at McNary, John Day	110		
and	101		
Bonneville Dams	100		
	011		
	010		
	001		
	000		

(15)

3.7.2 Modeling Paired-Tag Releases

For each pair of Pateros and tailrace release groups used to estimate survival through the Wells project, a model fitting routine was performed to identify the most appropriate and parsimonious likelihood model. Two approaches to model fitting were used for each release pair: (a) forward-step fitting routine and (b) test of overall fit of the selected model.

The forward-step fitting routine began with all detection, survival, and last reach probabilities unique. The forward sequential procedure was used to test whether (in order) $\underset{\sim}{p_1}$, $\underset{\sim}{S_2}$, $\underset{\sim}{p_2}$, $\underset{\sim}{S_3}$, $\underset{\sim}{p_3}$, and $\underset{\sim}{\lambda}$ were homogeneous between release groups from Pateros and the Wells tailrace. The forward-step fitting procedures kept survival probabilities S_{11} and S_{21} unique throughout all steps of the test (Figure 3). The selected model was then compared to the fully parameterized Cormack-Jolly-Seber (CJS) model to assess whether the selected model adequately described the capture data.

3.7.3 Smolt Survival Comparison

Using the estimates from 1999 and this year (2000), a comparison of mean survival was performed. The test of equal survival was based on an asymptotic Z-test of the form:

$$Z = \frac{\left|\hat{\bar{S}}_{1999} - \hat{\bar{S}}_{2000}\right|}{\sqrt{V\hat{a}r\left(\left(\hat{\bar{S}}_{1999}\right) + V\hat{a}r\left(\hat{\bar{S}}_{2000}\right)\right)}}$$

where

$\hat{\bar{S}}_{1999}$ = weighted average of Wells survival from the 1999 PIT-tag study, and

$\hat{\bar{S}}_{2000}$ = weighted average of Wells survival from the 2000 PIT-tag study.

The two-tailed test of equality of survival estimates was performed at $\alpha = 0.10$.

4.0 RESULTS

4.1 Fish Collection

Steelhead collected from the earthen rearing pond (Pond #4) were not directly counted. Instead volumetric displacement was used to estimate the number of steelhead collected and transported to the pre-tagging raceways. Two days before tagging, roughly 4,500 steelhead were crowded and fish pumped into the transport truck. The transport truck then released these fish directly into pre-tagging raceways located proximal to the PIT-tagging facility. No steelhead losses were recorded during the fish pumping and transportation process. The steelhead collected from Pond #4 were allowed to recover in the pre-tagging raceways at least 48-hours prior to being tagged.

4.2 Tagging and Holding

In total, 49,370 steelhead were collected for tagging purposes. Not all of the 49,370 hatchery steelhead collected for tagging were retained and tagged. In total, 1,103 excess steelhead were released directly into the Columbia River below Wells Dam. The majority of these fish were simply in excess of the number of fish needed for tagging. A smaller component of these fish were removed because they did not represent the population of steelhead expected to migrate through Wells Dam in 2000. Fish were removed from tagging when they expressed signs of disease, serious injury, precocity or grotesque growth abnormalities.

Steelhead smolts were the population of inference for the 2000 survival study at the Wells Hydroelectric Project. As such, precocious steelhead parr were excluded because they were not expected to migrate through the dam in 2000. Fish with serious injuries, growth abnormalities and external signs of disease were excluded because they were not expected to survive the tagging and handling procedures. The remaining 48,267 steelhead were tagged for use in the Wells project survival study.

Of the 48,267 steelhead smolts PIT-tagged for the Wells project survival study, a total of 14 (0.03%) tagged steelhead died after being tagged. Fish loss was evenly divided between the Pateros (7) and tailrace release groups (7) (Table 1). In addition to tagging related losses, an additional 126 (0.3%) tagged steelhead were sacrificed for physiological sampling. An additional 345 shed PIT-tags were recovered inside release containers utilized for the 2000 Wells project survival study. Shed tags were recovered in similar number from the Pateros (182 or 0.76%) and tailrace (175 or 0.73%) release groups. In total, 23,857 PIT-tagged steelhead were released at Pateros and 23,925 PIT-tagged steelhead were released into the Wells tailrace (Table 1).

4.3 Transportation and Release

Releases of PIT-tagged WFH steelhead took place at the Methow River and tailrace release sites on April 24, 26, 28 and 30 and May 2, 4, 6, 8, 10, 12, 14 and 16. On each of the twelve release days, five release containers were transported to each of the two barge loading sites on time and within the parameters established in Section 3.3 (Methods and Materials). Standardization of truck loading, transportation, and barge loading times were achieved both within and between replicate release groups. Loading required 10 minutes, transport time averaged 16 minutes and barge loading times required 10 minutes. As each container was loaded onto a barge, it was immediately connected to the barge water supply line. The maximum amount of time that any individual release container was not being supplied by river water did not exceed 30 minutes.

Dissolved oxygen and water temperatures for each container were recorded at pre-determined intervals throughout the transportation process. Records of dissolved oxygen and temperature indicated similar trends within and between replicate release sites. Concentrations of dissolved oxygen varied slightly between release containers but for the most part dissolved oxygen concentrations were consistently maintained between 9 and 12 mg O_2 / L throughout the transportation interval.

Water temperatures within a replicate pair varied less than one degree during the transportation phase of the study. Water temperatures in the Pateros and tailrace release containers were maintained within 0.5° C of Columbia River water temperatures at all times. Over the course of the study, Columbia River water temperatures climbed from an average of 8.2° C on the first release day to 11.3° C by the end of the study.

Table 1: Tag releases for the 2000 Wells steelhead survival study.

Tagging Study	Release Site	Release No.	Tagged	Morts.	Sacrificed	Tags shed	**Total Released**
Wells Dam	Pateros	1	2,017	2	11	6	1998
		2	2,003			12	1991
		3	2,019	1	10	18	1990
		4	2,008	2		14	1992
		5	2,016		10	14	1992
		6	2,001			13	1988
		7	2,011		10	8	1993
		8	2,001	1		17	1983
		9	2,011	1	12	23	1975
		10	2,002			10	1992
		11	2,015		10	26	1979
		12	2,005			21	1984
Wells Project	Pateros	Sub-total	24,109	7 (0.03%)	63 (0.26%)	182 (0.75%)	23,857

Table 1 (Continued).

Tagging Study	Release Site	Release No.	Tagged	Morts.	Sacrificed	Tags shed	**Total Released**
Wells Dam	Tailrace	1	2,015	1	11	10	1993
		2	2,008	1		13	1994
		3	2,019	1	10	10	1998
		4	2,008			8	2000
		5	2,016	1	11	13	1991
		6	2,045			33	2012
		7	2,011		11	12	1988
		8	2,001			8	1993
		9	2,011		10	12	1989
		10	2,000	2		9	1989
		11	2,013		10	14	1989
		12	2,011	1		21	1989
Wells Project	Tailrace	Sub-total	24,158	7 (0.03%)	63 (0.26%)	163 (0.67%)	23,925
Wells Project	**Survival Study**	**Grand Total**	**48,267**	**14** (0.03%)	**126** (0.26%)	**345** (0.71%)	**47,782**

4.4 Physiological Monitoring

Measures of smolt morphology, smolt readiness, indices of stress, fish condition and fish health were collected from six of the twelve PIT-tag release groups. These samples were collected from fish scheduled for release on April 24, 28 and May 2, 6, 10 and 14. Physiological samples of smolt status, fish health and stress levels were conducted to facilitate interpretation of variations in post-release behavior and survival within and between release groups of steelhead.

The mean fork length of PIT-tagged WFH steelhead sampled for physiological indices ranged from 198.7 to 207.7 mm (Table 2-A). A statistical analysis of mean fork length within and between replicate release pairings found no significant differences (one-way ANOVA, $p > 0.05$). This included comparisons between release locations, release days and control (untagged) versus treatment (tagged) fish. The mean weights of tagged steelhead ranged from 61.5 to 81.3 g. A statistical analysis of the differences between sample groups found no significant (one-way ANOVA, $p > 0.05$) differences between mean fish weights (Table 2-B). Mean condition factor ranged from 0.9605 to 0.8215 (Table 2-C). In general, fish condition declined during the course of the study. No significant differences ($p > 0.05$) in mean condition factor were detected within or between replicate release pairings.

Indices of fish health collected during the study included indices of smolt status, scale loss, fin condition, fat coverage of the mesenteries (fat index) and the color of the liver and bile duct. In general indices of fish health were typical of healthy fish. The mean smolt index for the tagged steelhead release groups ranged from 4.9 to 5.0. The smolt index remained consistently high throughout the six replicate release groups sampled. No trends in mean smolt indices were observed between replicates 1-12 (Table 2-D). Scale loss was nominal in all groups including the untagged physiological control group. Fin erosion was not observed to any measurable extent in any of the groups sampled. The mean fat index ranged from 2.6 to a maximum of 4.0. Mean fat indices decrease markedly during the May 14 sample. Fat coverage of the mesenteries (index) averaged 100% for sample groups released on April 28, May 2 and May 10. The lowest fat index recorded was collected from the May 14 Pateros release group. This release group had average fat coverage of the mesenteries of 70% with individual fish samples collected on that day ranging from 0% to 100% (Table 2-D). Color and size of internal organs was noted as normal for all groups sampled. In general, organ color and size was indicative of healthy pathogen free fish. The mean liver index varied only slightly over the course of the study with mean values ranging from 1.9 to 2.0. The mean bile index similarly remained high with values ranging from 2.7 to 3.0 (Table 2-D).

Blood plasma was collected for analysis of plasma glucose. Concentrations of glucose were utilized as an indicator of short and long-term stress. Plasma glucose concentrations ranged from 5.11 to 7.78 mMoles/L plasma (Table 3-A). A one-way ANOVA was used to determine whether there were significant differences within any of the 6 replicate release pairs sampled. The results indicated that the mean values for plasma glucose within replicate release pair 3 were significantly different ($p < 0.05$). In this pair, the Methow release group had higher indices of stress relative to the paired control release in the tailrace. Although the mean glucose values were significantly different, the differences were not sufficiently large enough to warrant concern regarding the resultant survival estimate for replicate 3. The remaining mean glucose values were not significantly ($p > 0.05$) different within individual replicate release pairs. In general, mean glucose concentrations for tagged fish declined slightly from the start to the end of the study.

As a secondary indicator of short-term handling stress, plasma cortisol concentrations were also collected from tagged and untagged steelhead. Concentrations of plasma cortisol during the 2000 study ranged from 112.45 to 329.46 ng cortisol/ml plasma for tagged steelhead (Table 3-B). The highest mean value was collected from Methow release replicate 7 and this value was significantly ($p < 0.05$) higher than all other sample means. The lowest mean cortisol value was collected from tailrace group 3. The sample mean for this one release group was nearly half that of the overall study sample mean. No significant differences ($p > 0.05$) were observed within replicate release pairings. No meaningful trends in mean cortisol values were observed over time.

Gill ATPase levels were measured to provide a quantitative comparison of smolt readiness. Values recorded for steelhead smolts ranged from 28.48 to 40.67 nmoles/mg protein/minute (Table 3-D). A comparison of mean ATPase values resulted in no significant differences ($p > 0.05$) within replicate release pairs used to estimate survival through Wells Dam. However, differences between individual release groups were significant. In general, gill ATPase values declined as the study progressed. The values observed in 2000 were similar to values observed in 1999 and comparable to values reported during past analyses conducted at the Wells Fish Hatchery.

Table 2. Lengths, Weights, Condition Factors and Health Indices for Wells Hatchery steelhead smolts, 2000.

A. Lengths.

Date	Sample Group	Release Group	Source	Release Site	Mean (mm)	S.D.	Min. (mm)	Max. (mm)	n
April 22	1	Control	Pre-tag	NA	199.6	18.7	172	240	12
April 22	2	Control	Pre-tag	NA	203.5	10.9	183	225	10
April 24	3	1	Tagged	Pateros	198.7	11.9	179	216	11
April 24	4	1	Tagged	tailrace	199.8	5.5	188	209	11
April 28	5	3	Tagged	Pateros	207.6	16.2	183	228	0
April 28	6	3	Tagged	tailrace	207.7	15.5	184	222	10
May 2	7	5	Tagged	Pateros	201.6	7.5	194	220	10
May 2	8	5	Tagged	tailrace	199.8	15.1	176	220	10
May 6	9	7	Tagged	Pateros	206.6	13.0	184	221	10
May 6	10	7	Tagged	tailrace	203.7	17.9	173	230	10
May 10	11	9	Tagged	Pateros	198.2	14.5	176	217	10
May 10	12	9	Tagged	tailrace	200.1	15.0	174	220	10
May 14	13	11	Tagged	Pateros	192.0	15.3	174	219	10
May 14	14	11	Tagged	tailrace	201.9	11.7	185	218	10

B. Weights.

Date	Sample Group	Release Group	Source	Release Site	Mean (mm)	S.D.	Min. (mm)	Max. (mm)	n
April 22	1	Control	Pre-tag	NA	75.31	22.8	45.0	131.6	12
April 22	2	Control	Pre-tag	NA	81.43	12.5	60.7	107.8	10
April 24	3	1	Tagged	Pateros	70.83	14.7	54.4	98.9	11
April 24	4	1	Tagged	tailrace	71.22	5.1	61.4	79.7	11
April 28	5	3	Tagged	Pateros	81.32	18.6	55.6	107.2	10
April 28	6	3	Tagged	tailrace	79.79	17.5	52.0	98.2	10
May 2	7	5	Tagged	Pateros	72.05	6.2	64.9	83.4	10
May 2	8	5	Tagged	tailrace	72.84	18.3	50.4	98.2	10
May 6	9	7	Tagged	Pateros	75.62	12.7	54.4	192.0	10
May 6	10	7	Tagged	tailrace	73.49	17.6	47.6	105.5	10
May 10	11	9	Tagged	Pateros	64.56	14.8	45.8	87.2	10
May 10	12	9	Tagged	tailrace	72.14	17.3	44.4	96.7	10
May 14	13	11	Tagged	Pateros	61.49	18.8	42.3	94.6	20
May 14	14	11	Tagged	tailrace	70.04	13.6	50.5	85.6	10

C. Condition Factor.

Date	Sample Group	Release Group	Source	Release Site	Mean (mm)	S.D.	Min. (mm)	Max. (mm)	n
April 22	1	Control	Pre-tag	NA	0.9235	0.0536	0.8359	1.0057	12
April 22	2	Control	Pre-tag	NA	0.9605	0.0347	0.8973	1.0147	10
April 24	3	1	Tagged	Pateros	0.8934	0.0786	0.7869	0.9994	11
April 24	4	1	Tagged	tailrace	0.8918	0.0273	0.8607	0.9353	11
April 28	5	3	Tagged	Pateros	0.8955	0.0505	0.8387	1.0113	10
April 28	6	3	Tagged	tailrace	0.8763	0.0310	0.8282	0.9222	10
May 2	7	5	Tagged	Pateros	0.8789	0.0407	0.7832	0.9237	10
May 2	8	5	Tagged	tailrace	0.8963	0.0476	0.8148	0.9881	10
May 6	9	7	Tagged	Pateros	0.8518	0.0477	0.7220	0.8910	10
May 6	10	7	Tagged	tailrace	0.8569	0.0348	0.8155	0.9193	10
May 10	11	9	Tagged	Pateros	0.8215	0.0915	0.5804	0.9179	10
May 10	12	9	Tagged	tailrace	0.8839	0.0407	0.8306	0.9581	10
May 14	13	11	Tagged	Pateros	0.8477	0.0580	0.7718	0.9789	10
May 14	14	11	Tagged	tailrace	0.8421	0.0728	0.7480	1.10138	10

D. Health indices.

Date	Sample Group	Release Group (Range)	Smolt Index (1-5)	Scale Index	Fin Index	Fat Index (1-4)	Liver Index	Bile Index	n
April 22	1	Control	5.0	0.083	0.083	3.5	2.0	2.7	12
April 22	2	Control	4.8	0.200	0.300	3.6	2.0	2.9	10
April 24	3	1	4.9	0.182	0.182	3.5	2.0	2.6	11
April 24	4	1	5.0	0.182	0.364	3.7	2.0	2.8	11
April 28	5	3	5.0	0.300	0.500	4.0	2.0	3.0	10
April 28	6	3	5.0	0.500	0.500	4.0	2.0	2.8	10
May 2	7	5	5.0	0.000	1.000	4.0	1.9	3.0	10
May 2	8	5	5.0	0.200	0.800	4.0	2.0	2.9	10
May 6	9	7	4.9	0.100	0.500	4.0	2.0	3.0	10
May 6	10	7	5.0	0.300	1.000	3.7	2.0	2.8	10
May 10	11	9	5.0	0.200	0.400	4.0	2.0	3.0	10
May 10	12	9	5.0	0.000	0.500	4.0	2.0	3.0	10
May 14	13	11	5.0	0.200	0.300	2.6	2.1	3.0	10
May 14	14	11	4.9	0.100	0.800	3.0	2.0	2.9	10

Table 3. Mean, standard error and sample size for physiological sampling of Wells Hatchery steelhead smolts, 2000.

A. Blood plasma glucose.

					Glucose (mMoles/L plasma)		
Date	Sample Group	Release Group	Source	Release Site	Mean (mm)	S.D.	n
April 22	1	Control	Pre-tag	NA	5.81	0.378	10
April 22	2	Control	Pre-tag	NA	5.90	0.276	10
April 24	3	1	Tagged	Pateros	6.62	0.411	10
April 24	4	1	Tagged	tailrace	7.27	0.562	10
April 28	5	3	Tagged	Pateros	7.78	0.368	10
April 28	6	3	Tagged	tailrace	5.66	0.234	10
May 2	7	5	Tagged	Pateros	5.90	0.399	10
May 2	8	5	Tagged	tailrace	6.86	0.274	10
May 6	9	7	Tagged	Pateros	7.03	0.452	9
May 6	10	7	Tagged	tailrace	6.19	0.324	10
May 10	11	9	Tagged	Pateros	5.74	0.460	10
May 10	12	9	Tagged	tailrace	5.11	0.644	10
May 14	13	11	Tagged	Pateros	5.86	0.334	10
May 14	14	11	Tagged	tailrace	6.37	0.449	10

B. Blood plasma cortisol.

					Cortisol (ng/ml plasma)		
Date	Sample Group	Release Group	Source	Release Site	Mean (mm)	S.D.	n
April 22	1	Control	Pre-tag	NA	222.57	16.217	10
April 22	2	Control	Pre-tag	NA	222.95	26.380	10
April 24	3	1	Tagged	Pateros	240.26	33.074	10
April 24	4	1	Tagged	tailrace	199.75	35.480	10
April 28	5	3	Tagged	Pateros	272.52	36.678	10
April 28	6	3	Tagged	tailrace	112.45	27.381	10
May 2	7	5	Tagged	Pateros	195.44	31.808	10
May 2	8	5	Tagged	tailrace	214.95	27.909	10
May 6	9	7	Tagged	Pateros	329.46	42.266	10
May 6	10	7	Tagged	tailrace	284.36	45.959	10
May 10	11	9	Tagged	Pateros	266.16	47.466	10
May 10	12	9	Tagged	tailrace	245.35	42.594	10
May 14	13	11	Tagged	Pateros	233.67	30.653	10
May 14	14	11	Tagged	tailrace	256.84	30.599	10

Table 3. (Continued).

C. Gill ATPase.

Date	Sample Group	Release Group	Source	Release Site	ATPase (nmoles/mg protein/min) Mean (mm)	S.D.	n
April 22	1	Control	Pre-tag	NA	32.83	3.083	10
April 22	2	Control	Pre-tag	NA	32.70	3.233	10
April 24	3	1	Tagged	Pateros	38.97	3.883	10
April 24	4	1	Tagged	tailrace	40.67	3.533	10
April 28	5	3	Tagged	Pateros	39.90	3.700	10
April 28	6	3	Tagged	tailrace	36.88	2.650	10
May 2	7	5	Tagged	Pateros	29.98	1.950	10
May 2	8	5	Tagged	tailrace	36.50	2.167	10
May 6	9	7	Tagged	Pateros	35.55	1.850	10
May 6	10	7	Tagged	tailrace	33.32	2.000	10
May 10	11	9	Tagged	Pateros	31.67	3.867	10
May 10	12	9	Tagged	tailrace	32.23	2.633	10
May 14	13	11	Tagged	Pateros	30.25	1.800	10
May 14	14	11	Tagged	tailrace	28.48	1.900	10

4.5 Estimates of Detection and Reach Survival Probabilities

Steelhead smolts released at Pateros and released into the Wells tailrace had the potential to be collected and passively interrogated at downstream PIT-tag detection facilities located at Rocky Reach, McNary, John Day, and Bonneville dams. A small number of additional fish were detected by the experimental PIT-tag trawl operated by the National Marine Fisheries Service and were pooled with the Bonneville Dam collections. Detection histories for barge-transported smolts were censored at the point of transportation. Release group specific detection histories are summarized in Table 4.

For simplicity, each tag group was given a two-part group identification code. The first part of the code denotes release locations (i.e., w = Wells tailrace, p = Pateros), and the second component, the sequential release number of the paired-release (i.e., 1, . . . , 12). For example, w03 denotes the third release from Wells tailrace. Subsequent analyses utilized all 12 replicate release pairs for estimating reach-specific survival and dam-specific detection probabilities.

Using the single-release model (Cormack 1964, Jolly 1965, Seber 1965), reach-specific survival was estimated for the following reaches:

1. Release location to the tailrace of Rocky Reach Dam (S_1).
2. Rocky Reach tailrace through to the tailrace of McNary Dam (S_2).
3. McNary tailrace through to the tailrace of John Day Dam (S_3).

Survival probabilities and associated standard errors for each group are reported in Table 5.

Table 4. Complete detection history for each release group. Counts of smolt by detection history for each release group used in the 2000 Wells steelhead survival study. The digit 1 denotes detected; 0, not detected; and 2, censored at Rocky Reach, McNary, John Day, and Bonneville dams. Detection histories reflect data downloaded from PTAGIS on July 18, 2000.

Release	1111	0111	1011	0011	1101	0101	1001	0001	1110	0110	1010	0010	1100	0100	1000	0000	1200	0200	Release Size
Pateros																			
p01	8	6	25	28	29	20	73	65	17	31	100	113	72	77	571	758	4	1	1998
p02	5	2	20	20	29	15	70	66	26	25	68	79	80	63	606	813	1	3	1991
p03	8	7	17	21	19	19	89	62	22	14	70	80	80	68	593	812	5	4	1990
p04	1	6	22	16	27	12	113	70	17	16	78	75	76	58	706	697	1	1	1992
p05	5	2	19	9	19	8	85	52	18	13	71	57	95	51	775	709	2	2	1992
p06	2	1	17	8	22	11	97	62	13	7	81	62	88	51	848	616	1	1	1988
p07	0	2	10	12	13	14	104	66	7	14	38	45	67	91	747	756	4	3	1993
p08	0	1	13	9	5	6	87	58	3	6	54	51	37	46	819	785	2	1	1983
p09	4	1	6	15	8	11	73	79	6	8	42	49	37	52	687	895	1	1	1975
p10	1	0	1	1	5	8	57	64	2	2	39	45	51	32	852	831	0	1	1992
p11	1	0	3	3	7	5	44	47	5	3	32	38	58	54	810	864	4	1	1979
p12	0	1	13	1	5	3	53	32	7	1	36	30	65	39	973	715	9	1	1984
Wells																			
w01	13	16	40	33	26	15	64	61	39	34	119	134	80	83	547	680	2	7	1993
w02	5	4	25	27	23	27	80	62	25	23	103	84	89	61	720	630	4	2	1994
w03	6	2	23	25	28	12	105	74	24	27	101	84	98	59	731	593	3	3	1998
w04	8	1	28	16	25	5	120	54	17	12	122	59	106	45	908	467	7	0	2000
w05	6	0	31	12	22	4	119	39	21	10	104	42	88	45	946	494	5	3	1991
w06	6	0	15	10	35	7	130	29	24	7	100	32	140	30	1103	338	5	1	2012
w07	0	2	15	12	21	12	107	51	17	5	55	44	108	50	942	546	1	0	1988
w08	1	0	7	5	10	5	142	39	5	3	70	35	51	11	1092	514	2	1	1993
w09	2	0	11	6	6	4	92	59	11	6	51	40	47	26	1009	619	0	0	1989
w10	0	1	6	2	8	4	76	52	6	4	50	31	53	38	931	724	1	2	1989
w11	1	0	3	5	4	6	57	52	6	7	46	37	59	49	909	733	3	4	1981
w12	0	0	1	2	9	10	83	29	7	4	44	28	79	41	1094	550	5	3	1989

Table 5. Cormack-Jolly-Seber (1964) estimates of survival and detection probabilities for each release group used in the 2000 Wells smolt survival study. The joint probability of recovery from John Day to Bonneville and being detected at Bonneville Dam (λ) is reported in the last column. Standard errors are reported in parentheses.

Release	Survival			Probability of Detection at			Combined detection and survival (λ)
	Release to Rocky Reach	Rocky Reach to McNary	McNary to John Day	Rocky Reach	McNary	John Day	
Pateros							
p01	0.918 (0.029)	0.661 (0.048)	1.030 (0.116)	0.490 (0.019)	0.219 (0.018)	0.264 (0.028)	0.204 (0.022)
p02	0.870 (0.029)	0.592 (0.045)	1.159 (0.155)	0.523 (0.021)	0.243 (0.021)	0.207 (0.027)	0.192 (0.025)
p03	0.856 (0.028)	0.674 (0.055)	0.957 (0.125)	0.530 (0.021)	0.214 (0.020)	0.219 (0.027)	0.222 (0.027)
p04	0.919 (0.028)	0.668 (0.059)	1.122 (0.164)	0.569 (0.020)	0.176 (0.018)	0.169 (0.023)	0.195 (0.026)
p05	0.884 (0.027)	0.662 (0.066)	0.949 (0.159)	0.618 (0.022)	0.184 (0.021)	0.176 (0.027)	0.180 (0.028)
p06	0.960 (0.029)	0.700 (0.076)	1.125 (0.218)	0.613 (0.021)	0.147 (0.018)	0.127 (0.022)	0.147 (0.026)
p07	1.002 (0.040)	0.681 (0.082)	0.872 (0.181)	0.496 (0.023)	0.158 (0.020)	0.109 (0.021)	0.188 (0.034)
p08	0.970 (0.042)	0.756 (0.146)	0.735 (0.190)	0.530 (0.026)	0.074 (0.015)	0.128 (0.025)	0.168 (0.032)
p09	0.971 (0.048)	0.527 (0.073)	0.983 (0.204)	0.450 (0.025)	0.128 (0.019)	0.132 (0.024)	0.198 (0.035)
p10	1.002 (0.052)	0.633 (0.134)	3.291 (1.966)	0.505 (0.028)	0.081 (0.018)	0.022 (0.013)	0.033 (0.019)
p11	0.965 (0.050)	0.626 (0.123)	1.122 (0.446)	0.505 (0.029)	0.115 (0.024)	0.064 (0.023)	0.082 (0.030)
p12	0.921 (0.038)	0.714 (0.155)	0.495 (0.152)	0.635 (0.028)	0.100 (0.023)	0.139 (0.033)	0.169 (0.040)
Weighted Average	0.925 (0.014)	0.652 (0.014)	1.027 (0.071)				
Mean				0.539 (0.017)	0.153 (0.016)	0.146 (0.019)	0.165 (0.016)
Wells							
w01	0.933 (0.026)	0.688 (0.042)	0.885 (0.077)	0.500 (0.018)	0.246 (0.018)	0.381 (0.030)	0.238 (0.021)
w02	0.980 (0.029)	0.603 (0.044)	1.046 (0.124)	0.550 (0.020)	0.223 (0.019)	0.241 (0.027)	0.206 (0.024)
w03	0.973 (0.026)	0.683 (0.052)	1.084 (0.139)	0.576 (0.019)	0.197 (0.018)	0.204 (0.024)	0.192 (0.023)
w04	0.968 (0.022)	0.781 (0.075)	0.848 (0.122)	0.693 (0.018)	0.150 (0.017)	0.206 (0.025)	0.202 (0.025)
w05	0.938 (0.022)	0.687 (0.068)	0.842 (0.125)	0.719 (0.019)	0.159 (0.018)	0.210 (0.027)	0.217 (0.027)
w06	0.972 (0.018)	0.640 (0.055)	1.165 (0.203)	0.797 (0.017)	0.204 (0.020)	0.134 (0.022)	0.160 (0.026)
w07	0.983 (0.028)	0.659 (0.072)	0.885 (0.165)	0.648 (0.021)	0.168 (0.020)	0.132 (0.023)	0.193 (0.032)
w08	0.930 (0.025)	0.624 (0.106)	1.756 (0.533)	0.744 (0.022)	0.077 (0.015)	0.062 (0.017)	0.103 (0.027)
w09	1.014 (0.039)	0.502 (0.078)	1.187 (0.296)	0.609 (0.026)	0.101 (0.018)	0.106 (0.023)	0.150 (0.032)
w10	0.950 (0.039)	0.631 (0.115)	1.391 (0.494)	0.599 (0.027)	0.098 (0.019)	0.060 (0.020)	0.090 (0.029)
w11	1.040 (0.049)	0.601 (0.109)	1.211 (0.428)	0.528 (0.027)	0.112 (0.021)	0.070 (0.023)	0.086 (0.027)
w12	1.006 (0.035)	0.546 (0.085)	3.540 (2.055)	0.661 (0.025)	0.145 (0.024)	0.022 (0.013)	0.035 (0.020)
Weighted Average	0.967 (0.008)	0.659 (0.018)	1.009 (0.081)				
Mean				0.635 (0.026)	0.157 (0.015)	0.152 (0.029)	0.165 (0.018)

The SRR model also provided capture probabilities (Table 5) for the following PIT-tag detector dams:

1. Rocky Reach Dam (p_1).
2. McNary Dam (p_2).
3. John Day Dam (p_3)

For the last reach between John Day and Bonneville Dams, only the joint product of survival and detection at Bonneville Dam (λ) could be estimated (Table 5).

In general, the capture probabilities in 2000 were substantially higher than those observed in 1998 and 1999 at Rocky Reach Dam. The mean capture probabilities in 2000 for steelhead were 0.587, 0.155, and 0.149 at Rocky Reach, McNary, and John Day dams, respectively.

4.6 Estimation of Survival Through the Wells Project

The analysis of Wells project survival consisted of three elements; (a) tests of assumptions, (b) model fitting, and (c) estimation of reach survival. These elements of the estimation of Wells project survival are provided below.

4.6.1 Tests of Assumptions

The Pateros and Wells tailrace releases of tagged Wells Fish Hatchery (WFH) steelhead were used to estimate survival through the Wells project. However, before reliable survival estimates can be derived, each PIT-tag release must fulfill various assumptions of the release-recapture models. Unlike Mid-Columbia paired and index survival studies of the 1980s, survival and capture probabilities can be independently estimated for each release group (Table 5). The ability to independently estimate parameters for each release of PIT-tagged steelhead allows for more robust estimation of project survival. Nevertheless, minimal model assumptions must be met and the best approach to estimating reach survival must be determined. The subsequent tests of assumptions assisted in the selection of the most appropriate approach for estimating reach survival.

Homogeneous Downstream Mixing of Release Groups

A convenient but not necessary condition for validly estimating reach survival is the downstream mixing of the Pateros and Wells tailrace releases within a paired release. One measure of mixing is the homogeneous arrival of smolts from the two releases at downstream detector dams (Appendix A). Table 6 summarizes the P-values for tests of homogeneous arrivals at Rocky Reach, McNary, John Day, and Bonneville dams. The release pairs generally had homogeneous arrival patterns at McNary, John Day, and Bonneville dams $(p > 0.10)$. Three of 36 chi-square tests (8.33%) at these dams were significant at $P \leq 0.10$. However, all 12 paired-release groups showed significant non-mixing $(P \leq 0.10)$ when they arrived at Rocky Reach Dam, the first downstream dam with PIT-tag detectors. Inspection of the arrival plots (Appendix A) nevertheless suggests good mixing, with both releases within pairs showing very similar modes of arrival at detector dams.

In order to use the simple Ricker (1958) relative recovery estimates for the Wells survival estimates, detection and survival rates at and below Rocky Reach Dam must be equal. Burnham et al. (1987) Tests 1.T2-1.T4 were used to test this assumption of the simple Ricker model. Table 7 summarizes the P-values associated with the tests of significance, while Appendix B provides details of the analysis. Eight of the 12 pairs showed significant differences in detection and survival probabilities to Rocky Reach Dam. Five of the 24 tests (20.83%) showed significant differences in detection or survival rates at McNary or John Day Dam.

Likelihood ratio tests will ultimately be used to determine the most appropriate description for the mixing of the individual releases within a paired-release.

Burnham et al. (1987) Test 2: Upstream Detections Do Not Affect Downstream Survival and/or Detection

To validate estimation of smolt survival using the SRR model, upstream detection history of alive fish should have no affect on downstream detection and survival probabilities of test fish. Test 2.2 tests whether the detections at Rocky Reach affected downstream capture histories at McNary, John Day, or Bonneville dams. Test 2.3 tests whether detections at Rocky Reach or McNary had no effect on downstream captures at John Day or Bonneville dams. Of the overall Test 2 results, 4 of the 24 release groups (16.7%) were significant at $\alpha = 0.10$ (Table 8). However, after adjustment for an experimental-wise error rare of $\alpha_{EX} = 0.10$ ($\alpha_{TW} = 0.0043$), only one of the Test 2 results was significant (i.e., release p07). In addition, details of the 2.2 and 2.3 tests showed no consistent pattern of violating model assumptions across release groups (Appendix B).

Burnham et al. (1987) Test 3: Upstream Detections Do Not Affect Downstream Survival and/or Detection

Another series of tests developed by Burnham et al. (1987) also tests whether upstream detection histories affect downstream detection or survival. Test 3.1 tests whether detection at Rocky Reach affects detection histories at John Day or Bonneville dams (Table 8). Test 3.2 tests whether detections at Rocky Reach and McNary affect detection histories at Bonneville Dam. Four of 48 Tests 3.1 and 3.2 were significant at $P \leq 0.10$ (8.33%). None of 48 individual tests were significant after adjustment for an experimental-wise error rate of $\alpha_{EX} = 0.10$ ($\alpha_{TW} = 0.0022$). Three of 24 (12.5%) overall Burnham Tests 3's were significant at $P \leq 0.10$. Details of the 3.1 and 3.2 tests can be found in Appendix B.

Tests of Handling Effects at Rocky Reach and Rock Island Dams

In 2000, smolts passing through the bypass systems at Rocky Reach and Rock Island dams were collected and anesthetized for potential tagging as part of the Chelan PUD smolt survival studies. During the 2000 study, 3,400 PIT-tagged steelhead smolts released upstream of Rocky Reach, as part of the Douglas PUD smolt survival study, were intercepted and anesthetized a second time at Rocky Reach. At Rock Island, the number of smolts intercepted was 1,471. Chi-square contingency table tests were used to assess whether this second handling affected downstream detection and survival probabilities (Table 8). During the 2000 survival study, four of 24 (16.77%) of the release groups showed significant differences $(P < 0.10)$ between handled and non-handled smolts at Rocky Reach Dam. Two of 24 (8.3%) of the release groups showed significant differences ($(P < 0.10)$ between handled and non-handled smolts at Rock Island Dam. After an adjustment to an experimental-wise error rate of $\alpha_{EX} = 0.10$ ($\alpha_{TW} = 0.0044$), none of the tests at either site were significant. For this reason, all smolts regardless of detection histories at Rocky Reach and Rock Island dams were included in the reach survival estimates.

Table 6. Results (i.e., P-values) of chi-square tests of mixing for Pateros and Wells release groups based on arrival timing at Rocky Reach, McNary, John Day, and Bonneville dams.

Release Pair	P-value			
	Rocky Reach	McNary	John Day	Bonneville
p01 & w01	0.0017	0.2767	0.8423	0.6322
p02 & w02	< 0.0001	0.8183	0.5495	0.9230
p03 & w03	< 0.0001	0.6345	0.6766	0.5480
p04 & w04	< 0.0001	0.7322	0.0853	0.9916
p05 & w05	< 0.0001	0.1969	0.8549	0.8295
p06 & w06	< 0.0001	0.5779	0.5733	0.5362
p07 & w07	< 0.0001	0.2748	0.4184	0.1516
p08 & w08	< 0.0001	0.4310	0.3385	0.1562
p09 & w09	< 0.0001	0.8281	0.0362	0.9785
p10 & w10	< 0.0001	0.4934	0.6167	0.1611
p11 & w11	< 0.0001	0.5560	0.6648	0.0788
p12 & w12	< 0.0001	0.1203	0.9758	0.4009

Table 7. Results (i.e., P-values) of Burnham et al. (1987) Test 1.T2, 1.T3 and 1.T4 for equal detection and survival probabilities at downriver detection sites for the Pateros and Wells tailrace releases.

Release Group	P-value		
	Rocky Reach (1.T2)	McNary (1.T3)	John Day (1.T4)
p01 & w01	0.373	0.597	0.004
p02 & w02	0.267	0.373	0.392
p03 & w03	0.074	0.276	0.738
p04 & w04	< 0.001	0.949	0.120
p05 & w05	< 0.001	0.089	0.852
p06 & w06	< 0.001	0.021	0.889
p07 & w07	< 0.001	0.880	0.260
p08 & w08	< 0.001	0.115	0.068
p09 & w09	< 0.001	0.200	0.926
p10 & w10	0.057	0.648	0.862
p11 & w11	0.647	0.314	0.812
p12 & w12	0.774	0.756	0.079

Table 8. Results (i.e., P-values) of Burnham et al. (1987) Tests 2 and 3 for goodness-of-fit to the single release-recapture assumptions for the Pateros and Wells tailrace releases. Also included are the results (P-values) of tests for the effects of smolt handling at Rocky Reach and Rock Island dams.

Release	Burnham Tests						Handling Effects at	
	2.2	2.3	Overall 2	3.1	3.2	Overall 3	Rocky Reach	Rock Island
Pateros								
p01	0.530	0.068	0.203	0.114	0.474	0.207	0.159	0.283
p02	0.138	0.945	0.265	0.417	0.337	0.399	0.642	0.451
p03	0.056	0.848	0.122	0.810	0.507	0.771	0.960	0.879
p04	0.186	0.957	0.338	0.046	0.297	0.070	0.205	0.738
p05	0.395	0.531	0.522	0.771	0.598	0.809	0.930	0.716
p06	0.545	0.200	0.415	0.986	0.753	0.969	0.351	0.725
p07	0.001	0.377	0.002	0.471	0.501	0.558	0.928	0.720
p08	0.041	0.885	0.093	0.752	0.777	0.890	0.835	0.967
p09	0.637	0.480	0.706	0.413	0.162	0.238	0.017	0.544
p10	0.192	0.373	0.251	0.351	0.032	0.060	0.530	0.978
p11	0.452	0.998	0.662	0.712	0.829	0.894	0.187	0.987
p12	0.785	0.924	0.920	0.286	0.016	0.028	0.033	0.739
Wells								
w01	0.840	0.909	0.948	0.343	0.314	0.331	0.862	0.743
w02	0.847	0.097	0.380	0.401	0.601	0.569	0.067	0.806
w03	0.231	0.663	0.373	0.097	0.277	0.117	0.591	0.613
w04	0.452	0.957	0.661	0.120	0.295	0.145	0.778	0.344
w05	0.481	0.625	0.637	0.102	0.405	0.167	0.054	0.865
w06	0.062	0.744	0.129	0.608	0.226	0.403	0.622	0.916
w07	0.043	0.867	0.096	0.144	0.186	0.116	0.370	0.796
w08	0.038	0.962	0.088	0.366	0.816	0.662	0.819	0.040
w09	0.556	0.024	0.100	0.755	0.667	0.838	0.850	0.044
w10	0.776	0.683	0.879	0.626	0.597	0.726	0.575	0.723
w11	0.973	0.330	0.800	0.588	0.590	0.698	0.851	0.558
w12	0.082	0.876	0.170	0.300	0.680	0.561	0.251	0.924

4.6.2. Modeling the Paired-Releases

All model testing was conducted at a significance level of $\alpha = 0.10$. Results of the model selection procedures for each of the 12 paired Pateros-Wells tailrace releases is summarized in Table 9. In 2 of the 12 paired releases, model parameters were homogeneous beginning with the capture probabilities at Rocky Reach Dam (i.e., Model $M_{\underset{\sim}{S_1}}$, the most parsimonious model). Alternative models were selected for the 8 remaining replicate releases. The best model that described release-pairs 3, 4, 5, 6, 7, 8, 9, and 10 was Model $M_{\underset{\sim}{S_1},\underset{\sim}{p_1}}$ which allowed detection rates at Rocky Reach to vary between the treatment and control release groups. For release pairs 1 and 12, Model $M_{\underset{\sim}{S_1},\underset{\sim}{p_1},\underset{\sim}{S_2},\underset{\sim}{p_2},\underset{\sim}{S_3},\underset{\sim}{p_3}}$ was selected as the simplest model that was not significantly different from the Cormack-Jolly-Seber model.

4.6.3 Wells Project Survival Estimates

From the model selection process came the separate estimates of survival S_{11} and S_{21} for each release (Table 10) location to Rocky Reach Dam within a paired-release. The ratio of these separate estimates (Equation 1) provides the estimates of Wells project survival $\left(\hat{S}_W\right)$ from the mouth of the Methow River to Wells Dam tailrace (Table 11). The weighted average for survival from the 2000 study was $\hat{S}_W = 0.946$ (SE = 0.015) compared to a weighted average of $\hat{S}_W = 0.943$ (SE = 0.016) calculated from the 1999 investigations. A Z-test of the difference in the mean survival estimates for 2000 and 1999 was not significantly different at $P = 0.9636$.

Table 9. Forward-sequential model selection results for Pateros-Wells tailrace release pairs.

a. Release groups p01 & w01

Hypothesis	χ^2	Df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.1349	1	0.7134
$M_{\underset{\sim}{S_1}}$ vs. CJS	16.4499	6	0.0115
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.1240	1	0.7248
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	15.5743	5	0.0082
$p_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	1.4873	1	0.2226
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}}$ vs. CJS	11.3257	4	0.0231
$S_3 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	1.0852	1	0.2975
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}}$ vs. CJS	10.9868	3	0.0118
$p_3 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{\lambda}$	8.1047	1	0.0044
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}}$ vs. CJS	1.1748	1	0.2784

b. Release groups p02 & w02

Hypothesis	χ^2	Df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.8857	1	0.3466
$M_{\underset{\sim}{S_1}}$ vs. CJS	2.9435	6	0.8159

Table 9. (Continued)

c. Release groups p03 & w03

Hypothesis	χ^2	Df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$ [1]	2.6535	1	0.1033
$M_{\underset{\sim}{S_1}}$ vs. CJS	5.2953	6	0.5065
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.1368	1	0.7115
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	1.9363	5	0.8579

Note: Model fit to the data were indicated by a "~" when the parameters were treated as a vector (i.e. different between releases within a pair). The notation indicates which parameter was tested for homogeneity given (i.e. " | ") the specification of the other model parameters.

d. Release groups p04 & w04

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	22.2913	1	2.34e-6
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.9292	1	0.3351
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	3.7961	5	0.5791

[1] Though the P-value for this test is just above the 0.10 decision level set for this analysis, it was decided that due to earlier hypothesis testing (Tables 6 and 7) indicating that the detection rates at Rocky Reach were different for the two releases in the pairing and the P-value's proximity to the critical value, to investigate the next parameter.

Table 9. (Continued)

e. Release groups p05 & w05

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	12.1124	1	0.0005
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0732	1	0.7868
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	4.2561	5	0.5132

f. Release groups p06 & w06

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	55.6617	1	8.61e-14
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.5204	1	0.4707
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	7.3333	5	0.1970

g. Release groups p07 & w07

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	32.5448	1	1.16e-8
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0477	1	0.8271
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	2.1774	5	0.8241

Table 9. (Continued)

h. Release groups p08 & w08

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	42.5987	1	6.72e-11
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0202	1	0.8869
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	7.3378	5	0.1967

i. Release groups p09 & w09

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	19.1822	1	1.1 e-5
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0536	1	0.8169
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	5.2118	5	0.3906

j. Release groups p10 & w10

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	5.8849	1	0.0153
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.4829	1	0.4871
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	3.6299	5	0.6038

Table 9. (Continued)

k. Release groups p11 & w11

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.3430	1	0.5581
$M_{\underset{\sim}{S_1}}$ vs. CJS	1.9228	6	0.9267

l. Release groups p12 & w12

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.4628	1	0.4963
$M_{\underset{\sim}{S_1}}$ vs. CJS	15.1034	6	0.0195
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	1.0396	1	0.3079
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	14.9756	5	0.0105
$p_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	1.7256	1	0.1890
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}}$ vs. CJS	14.4830	4	0.0059
$S_3 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	12.2074	1	0.0005
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}}$ vs. CJS	12.4118	1	0.0004
$p_3 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{\lambda}$	9.1978	1	0.0024
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}}$ vs. CJS	0.4628	1	0.4963

Table 10. Estimates of survival, detection, and λ parameters for the best-fit paired-release models selected by stepwise-fitting procedures.

Population	Survival			Detection			Product of Capture/ Survival Below John Day
	to Rocky Reach	RR --> McNary	McN --> John Day	Rocky Reach	McNary	John Day	
p01	0.918 (0.029)	0.661 (0.048)	0.965 (0.089)	0.490 (0.019)	0.219 (0.018)	0.282 (0.023)	0.224 (0.015)
w01	0.933 (0.026)	0.688 (0.041)	0.921 (0.068)	0.500 (0.018)	0.246 (0.017)	0.366 (0.025)	
p02	0.858 (0.023)	0.614 (0.029)	1.000 (<0.001)	0.537 (0.014)	0.226 (0.013)	0.240 (0.013)	0.213 (0.012)
w02	0.992 (0.024)						
p03	0.854 (0.023)	0.684 (0.033)	1.000 (<0.001)	0.531 (0.011)	0.204 (0.012)	0.214 (0.012)	0.208 (0.012)
w03	0.975 (0.023)			0.575 (0.018)			
p04	0.918 (0.024)	0.720 (0.047)	0.977 (0.100)	0.569 (0.019)	0.163 (0.012)	0.187 (0.017)	0.198 (0.018)
w04	0.968 (0.020)			0.692 (0.018)			
p05	0.880 (0.024)	0.677 (0.047)	0.885 (0.092)	0.621 (0.020)	0.171 (0.013)	0.194 (0.019)	0.200 (0.019)
w05	0.941 (0.021)			0.717 (0.018)			
p06	0.947 (0.024)	0.694 (0.042)	1.000 (<0.001)	0.621 (0.019)	0.169 (0.012)	0.145 (0.011)	0.170 (0.012)
w06	0.977 (0.017)			0.793 (0.017)			
p07	0.990 (0.031)	0.670 (0.054)	0.879 (0.122)	0.502 (0.019)	0.163 (0.014)	0.120 (0.015)	0.191 (0.024)
w07	0.989 (0.026)			0.644 (0.020)			
p08	0.955 (0.035)	0.719 (0.071)	1.000 (<0.001)	0.539 (0.023)	0.072 (0.009)	0.097 (0.011)	0.144 (0.015)
w08	0.936 (0.025)			0.740 (0.021)			
p09	1.014 (0.044)	0.508 (0.052)	1.072 (0.171)	0.431 (0.022)	0.114 (0.031)	0.119 (0.017)	0.174 (0.024)
w09	0.992 (0.033)			0.623 (0.023)			
p10	0.968 (0.041)	0.749 (0.095)	1.000 (<0.001)	0.523 (0.025)	0.076 (0.011)	0.066 (0.009)	0.099 (0.013)
w10	0.973 (0.038)			0.584 (0.025)			
p11	0.946 (0.036)	0.614 (0.082)	1.165 (0.308)	0.517 (0.020)	0.114 (0.016)	0.067 (0.016)	0.084 (0.020)
w11	1.058 (0.039)						
p12	0.921 (0.038)	0.714 (0.155)	0.495 (0.152)	0.635 (0.028)	0.100 (0.029)	0.139 (0.033)	0.169 (0.040)
w12	1.006 (0.035)	0.546 (0.085)	3.540 (2.029)	0.661 (0.025)	0.145 (0.024)	0.022 (0.013)	0.035 (0.020)

Table 11. Replicate estimates of Wells Project survival ($\hat{S}_W$) from Pateros to Wells Dam tailrace based on the best parsimonious model selected for each paired-release using the stepwise-fitting procedure. Weighted average and standard error based on Equations (4 -6).

Release Groups	$(\hat{S}_W)$
p01/w01	0.984 (0.041)
p02/w02	0.865 (0.031)
p03/w03	0.876 (0.031)
p04/w04	0.948 (0.032)
p05/w05	0.935 (0.033)
p06/w06	0.969 (0.030)
p07/w07	1.001 (0.041)
p08/w08	1.020 (0.046)
p09/w09	1.022 (0.056)
p10/w10	0.995 (0.057)
p11/w11	0.894 (0.047)
p12/w12	0.916 (0.049)
Weighted Average	0.946 (0.015)

5.0 DISCUSSION

5.1 Fish Collection

In total, 49,560 steelhead were collected for tagging on twelve separate occasions during the 2000 survival study. The volitional collection and handling of hatchery steelhead in 2000 took place without measurable impact upon the study animals. The use of a 20 cm Aqualite harvester, a 2,000 L fish transportation container and short distances to move fish helped to maintain fish health at optimum levels throughout the collection phase of the study.

5.2 Tagging and Holding

Of the 49,560 steelhead collected at the Wells Fish Hatchery, 1,293 steelhead smolts were not tagged. The majority of these fish were in excess of the number of fish needed for the study. Exactly 607 (1.2%) of the total number of fish collected were not tagged because they displayed outward signs of disease, serious injury, residualism, precocity or grotesque growth abnormalities. The remaining 48,267 steelhead were tagged and randomly assigned to either the Pateros or the tailrace release groups.

In order to assess project related survival with the paired release-recapture technique it is important that the collection, tagging and pre-release conditions experienced by the study groups are closely matched. Two metrics used to compare handling effects are the number of mortalities and the number of shed tags collected from the treatment and control groups. During the holding phase of the study, pre-release mortality was closely matched with 7 Pateros and 7 tailrace mortalities observed. Rates of tag shed were also similar between the Pateros (0.76%) and tailrace (0.73%) release pairs.

Twelve replicate pairs of fish were successfully held and paired for use in estimating survival through Wells Dam. After accounting for mortality, tag shed and fish sacrificed for physiological assessment, the study goal of releasing a minimum of 20,000 steelhead at each of the two release locations was achieved with a total of 23,857 fish released at Pateros and 23,925 fish released into the Wells tailrace.

5.3 Transportation and Release

In order to isolate survival of the project from handling effects, it is important to minimize differences resulting from transportation and release techniques. Performance standards were established to ensure consistency within and between replicate release groups. Performance standards included loading and unloading times and techniques, travel times and road conditions and water quality parameters. Real-time monitoring and adjustment was used to ensure that the performance standards were achieved.

Transport times totaled less than one hour from tagging sites to release locations for all twelve release groups. Recovery and transport times remained constant within and between release groups. Transportation, loading and travel conditions (water temperature, travel time, dissolved oxygen concentrations and final fish condition) were closely matched between the Pateros and tailrace release pairs. The use of specially designed release containers, on-board oxygen supply systems and short distances to release sites helped to ensure that fish condition, upon arrival, was comparable for all twenty-four release groups. No changes to the loading, transportation or release are required for future PIT-tag survival studies utilizing the Methow and tailrace release sites.

5.4 Physiological Monitoring

Physiological monitoring provided a comparative index of fish health and stress between treatment and control release groups and provided a robust comparison of physiological indices between tagged and untagged fish. The collection of detailed physiological indices was used to verify that subtle differences in handling (stress) and fish condition did not interfere with the assessment of project survival at Wells Dam.

Variability <u>within</u> replicate release pairs (e.g. fish health, smolt condition and stress levels) had the potential to bias estimates of survival through Wells Dam. By measuring physiological parameters, a more accurate description of actual project effects could be developed. For example, large differences in fish health or fish handling within a replicate pair could result in biased project survival estimates.

Variability in fish health, condition and fish handling <u>between</u> replicate releases would not result in biased estimates of survival through the dam but could complicate the interpretation of the resultant survival estimates. For example, differences in fish health between replicate pairs might correlate with unrelated changes in river operation. Without measuring the physiological differences between replicate release groups, one could improperly conclude that river operations resulted in the observed fish survival response, when in fact fish health and morphology might be the overriding survival variable.

To address concerns related to the variability within and between release pairs, statistical comparisons of fish physiology and morphology were conducted. To provide this information, 126 tagged steelhead and 20 untagged steelhead were sacrificed and sampled prior to release.

In general, no significant differences were observed between tagged and untagged steelhead. This included indices of morphology, health, condition and stress. No relevant differences in health, condition and stress were observed within replicate release pairs sampled (Methow versus tailrace). Based on the 6 replicates (12 release groups) and two control groups studied, PIT-tagged Wells Hatchery steelhead smolts were approximate surrogates for untagged steelhead smolts migrating past Wells Dam in 2000. Significant differences in fish health, fish condition and smolt readiness were lacking within replicate pairs. Trends in estimated fish survival, over time, did not appear to be related to fish condition, fish health or fish handling indices.

The range of plasma glucose values observed during 2000 for PIT-tagged steelhead smolts were similar to literature values for chinook smolts following short-term handling stress and were only slightly higher than literature values for fish at rest (3.17 to 6.67 mMoles/L plasma) (Barton et al., 1986; Maule et al., 1988). The concentrations of glucose found in the blood of WFH steelhead smolts after capture, PIT-tagging and holding for 48-hours were similar to fish sampled prior to PIT-tagging and were similar to fish exposed to short-term handling during other studies (e.g. juvenile coho - Iwama et al., 1995; juvenile chinook - Barton et al., 1986). Typically, plasma glucose concentrations increase rapidly following a short-term stress. In the absence of additional stress plasma glucose concentrations are expected to return to resting values within 24-hours of the stress event (Iwama et al., 1995; Barton et al., 1986; Groot et al., 1995).

Plasma cortisol values in the 100 to 250 ng/ml plasma range are typical of fish, including steelhead smolts, exposed to short-term handling and transport stress. The majority of the samples collected during the 2000 survival study fell within this range of values. The highest reading measured during the survival study was 329 ng/ml plasma well short of the stress levels observed by researchers conducting laboratory experiments. Values as high as 500 ng/ml have been reported for steelhead smolts following severe confinement (Barton and Iwama, 1991). The concentrations of cortisol found in blood plasma samples collected from tagged and untagged steelhead smolts were similar to one another and contained no observable trend over time. In only a few cases were sample means from fish tagged during the 2000 survival study in excess of 250 ng/ml plasma.

Compared to literature values, gill ATPase values from all of the steelhead sampled in 2000 were low compared to values for smolts prepared for salt-water entry. Similar observations were made during the 1999 steelhead survival study (Bickford et al., 2000). Weitkamp and Loeppke (1983) reported values in the 387 to 602 nmoles/mg protein/minute range for Upper Columbia River steelhead smolts collected downstream of Wells Dam at Priest Rapids and McNary dams. It is common for the ATPase values from inland stocks of salmonids to be low at the start of migration. In contrast, ATPase values for coastal stocks that encounter saltwater shortly after migration typically exhibit much higher ATPase values at the onset of migration (Ewing et al., 1980).

5.5 Estimation of Detection and Reach Survival Probabilities

Mean detection probabilities for all 12 Douglas PUD release groups averaged 0.587 at Rocky Reach, 0.155 at McNary and 0.149 at John Day dams. Mean detection probabilities for Wells steelhead released in 1999 were 0.250, 0.198, and 0.358 at Rocky Reach, McNary, and John Days dams, respectively (Bickford et al., 2000a). Mean detection probabilities for yearling chinook in 1998 were 0.098, 0.111, and 0.118 at Rocky Reach, McNary, and John Day dams, respectively (Bickford et al., 1999). The doubling of steelhead detection rates at Rocky Reach between 1999 and 2000 stemmed from technical improvements in PIT-tag interrogation capabilities rather than differences in operation of the bypass facility.

Estimated reach survival from the mouth of the Methow River to the Rocky Reach tailrace averaged 0.907 ($\hat{S}E$ = 0.018) in 1999 and 0.925 ($\hat{S}E$ = 0.14) during 2000. Estimated reach survival from the tailrace of Wells Dam to the tailrace of Rocky Reach averaged 0.959 ($\hat{S}E$ = 0.010) in 1999 and 0.967 ($\hat{S}E$ =0.008) during 2000. Estimated survival for 1998 yearling chinook migrating from the Methow to the Rocky Reach tailrace and from the Wells tailrace to the Rocky Reach tailrace averaged 0.943 ($\hat{S}E$ = 0.073) and 0.952 ($\hat{S}E$ = 0.066), respectively.

Survival downstream of Rocky Reach, as expected, was homogeneous between the two Douglas PUD release groups (p = 0.3070). Consequently, replicate reach survival estimates were pooled to provide more precise estimates of survival through the downstream river reaches. Estimated survival from the Rocky Reach tailrace to the McNary tailrace was precise and averaged 0.656 ($\hat{S}E$ = 0.011) for Douglas PUD tagged steelhead in 2000 [CI ($0.634 \leq S \leq 0.678$) = 0.95].

The reach survival estimates from the Rocky Reach tailrace to the McNary tailrace in 2000 for Wells summer steelhead was not significantly different ($p > 0.10$) from the estimates of survival for 1999 summer steelhead (0.686, $\hat{S}E$ = 0.010), 2000 yearling spring chinook (0.692, $\hat{S}E$ = 0.088), 1999 yearling spring chinook (0.727, $\hat{S}E$ = 0.053), 1998 yearling spring chinook (0.720, $\hat{S}E$ = 0.091), 1998 yearling Methow run-of-river chinook (0.720, $\hat{S}E$ = 0.084), 1998 yearling summer chinook (0.659, $\hat{S}E$ = 0.040), 2000 yearling summer chinook (0.731, $\hat{S}E$ = 0.063) and 2000 yearling coho (0.715, $\hat{S}E$ = 0.123) (Appendix C).

5.6 Estimation of Survival through the Wells Project

Individual estimates of survival for replicate releases of summer steelhead smolts migrating from the mouth of the Methow River to and through the tailrace of Wells Dam ranged from 0.865 (SE = 0.031) to 1.022 (SE = 0.056). Project survival (pool and dam) for yearling steelhead in 2000 averaged 0.946 with a standard error (SE) of 0.015 and a 95% CI of ± 2.9%. Wells project survival (pool and dam) for yearling steelhead in 1999 averaged 0.943 with a standard error (SE) of 0.016 and a 95% CI of ± 3.1%. Project survival (pool and dam) for yearling chinook in 1998 averaged 0.997 with a standard error (SE) of 0.015 and a 95% CI of ± 2.9%.

6.0 SUMMARY OF FINDINGS

For the third year in a row, Douglas PUD has produced precise estimates of survival for juvenile fish migrating through the Wells Hydroelectric Project. During the 2000 survival study, summer steelhead smolts migrating from the mouth of the Methow River mixed adequately with smolts released in the tailrace of Wells Dam. The weighted average estimate of summer steelhead survival in 1999 was 0.943 and in 2000 was 0.946. Precision for the 2000 Wells survival study was also high with a 95% CI of +/- 2.9%.

7.0 ACKNOWLEDGMENTS

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Finally we thank the fish and wildlife staff at Chelan County PUD for providing PIT-tag interrogation data and for their careful operation of the fish bypass system at Rocky Reach Dam.

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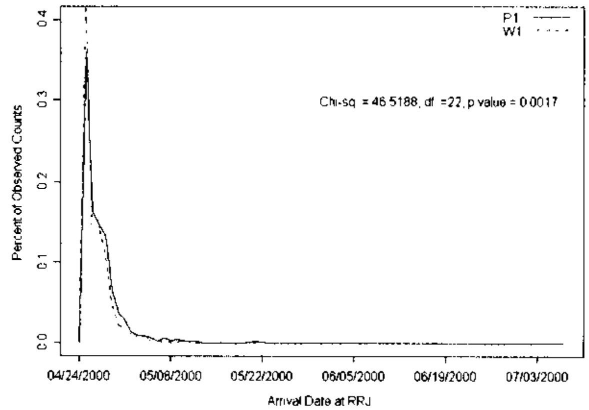
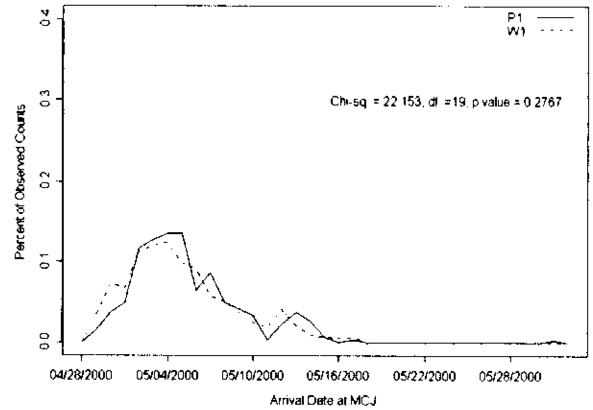
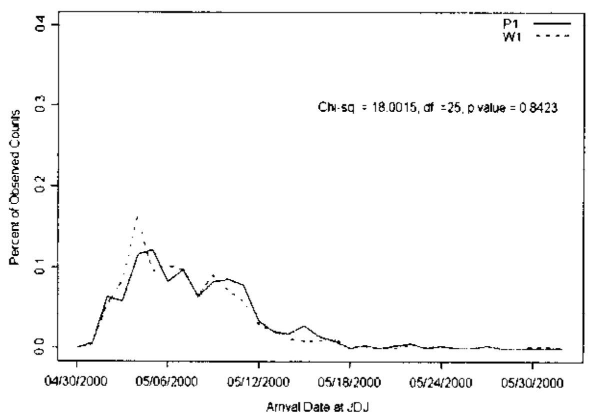
APPENDIX A

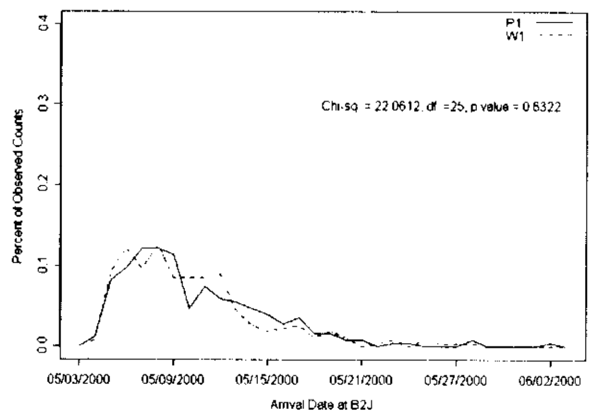
Graphics and chi-square tests of downstream detection trends for paired PIT-tag release groups.

Pair P01 and W01









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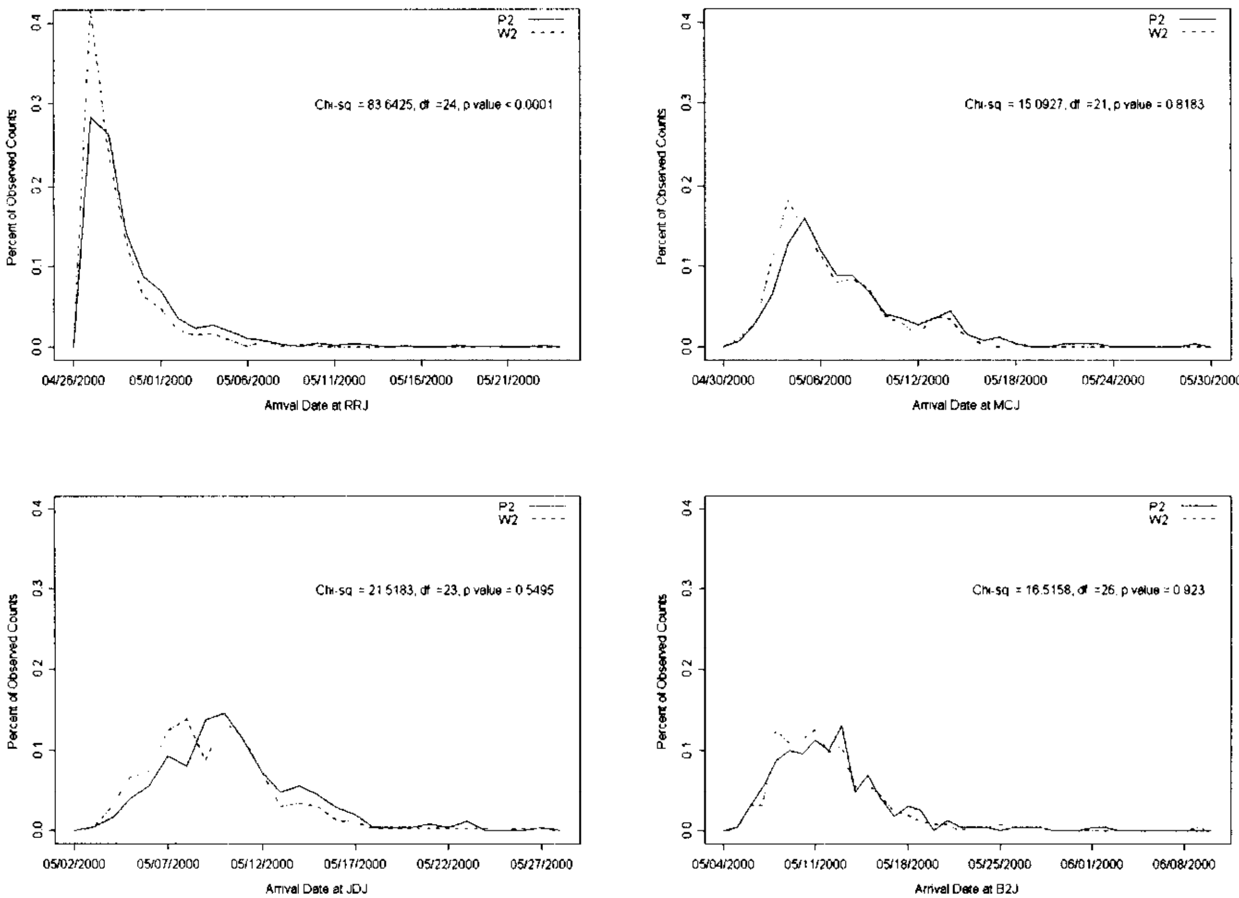

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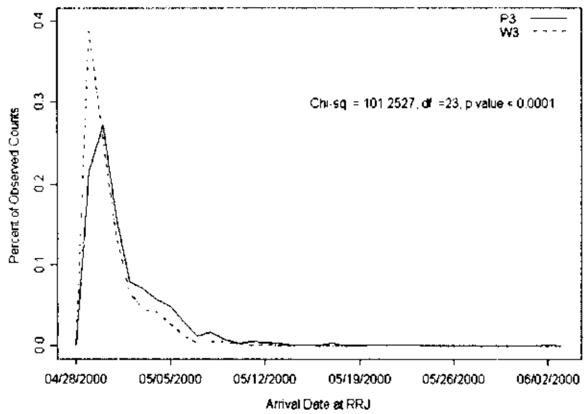

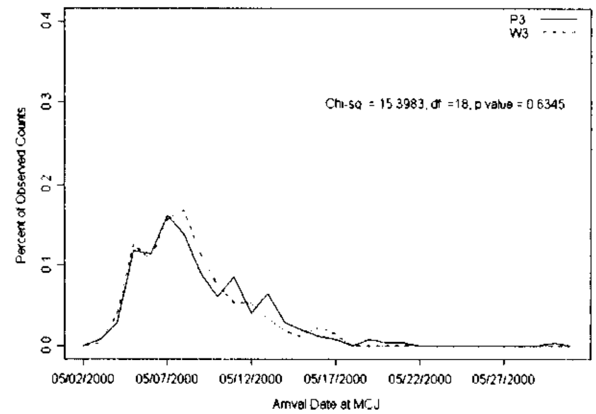

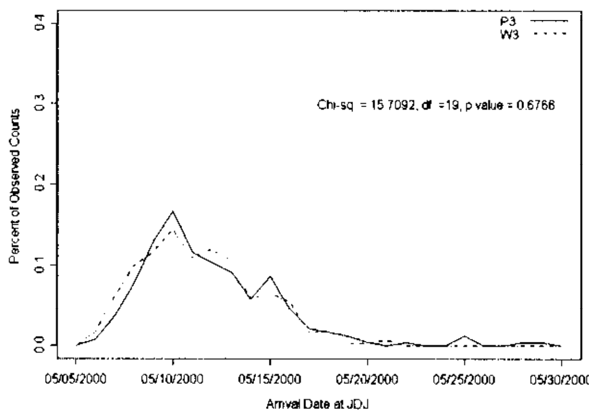

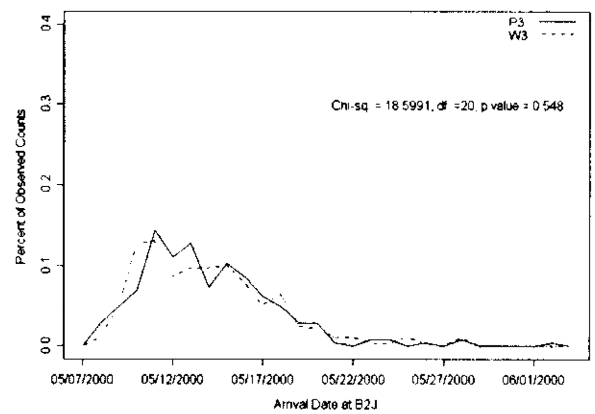

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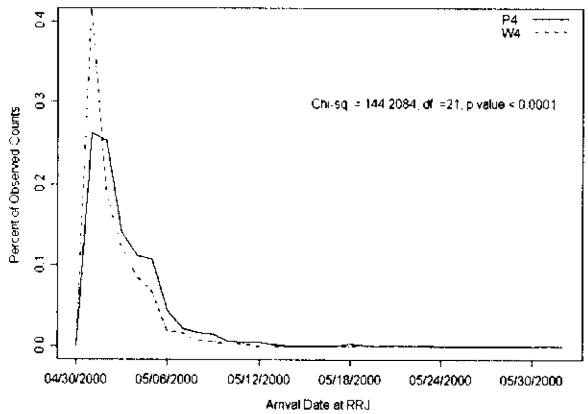

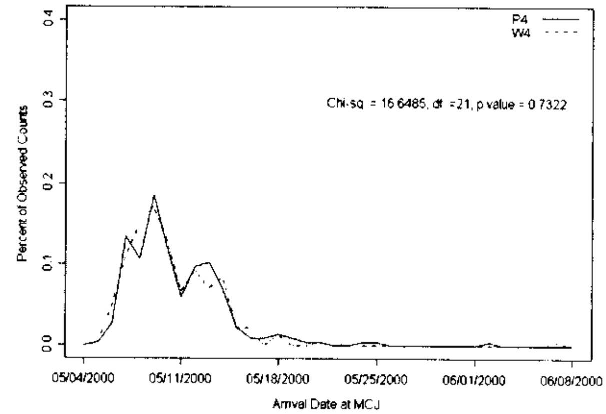

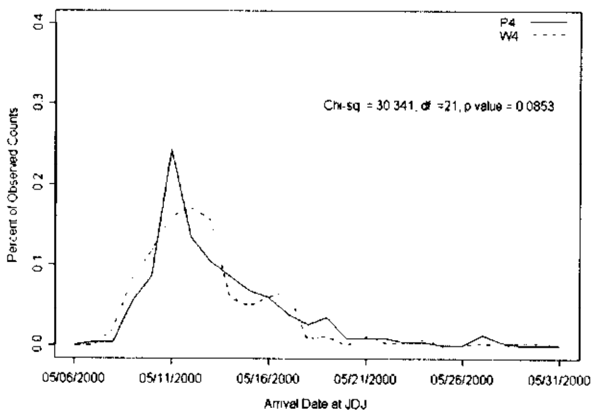

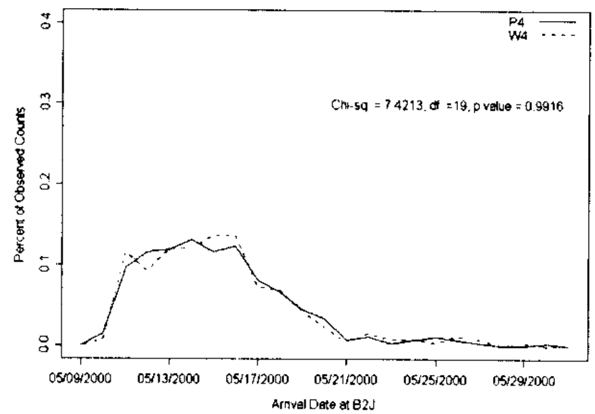

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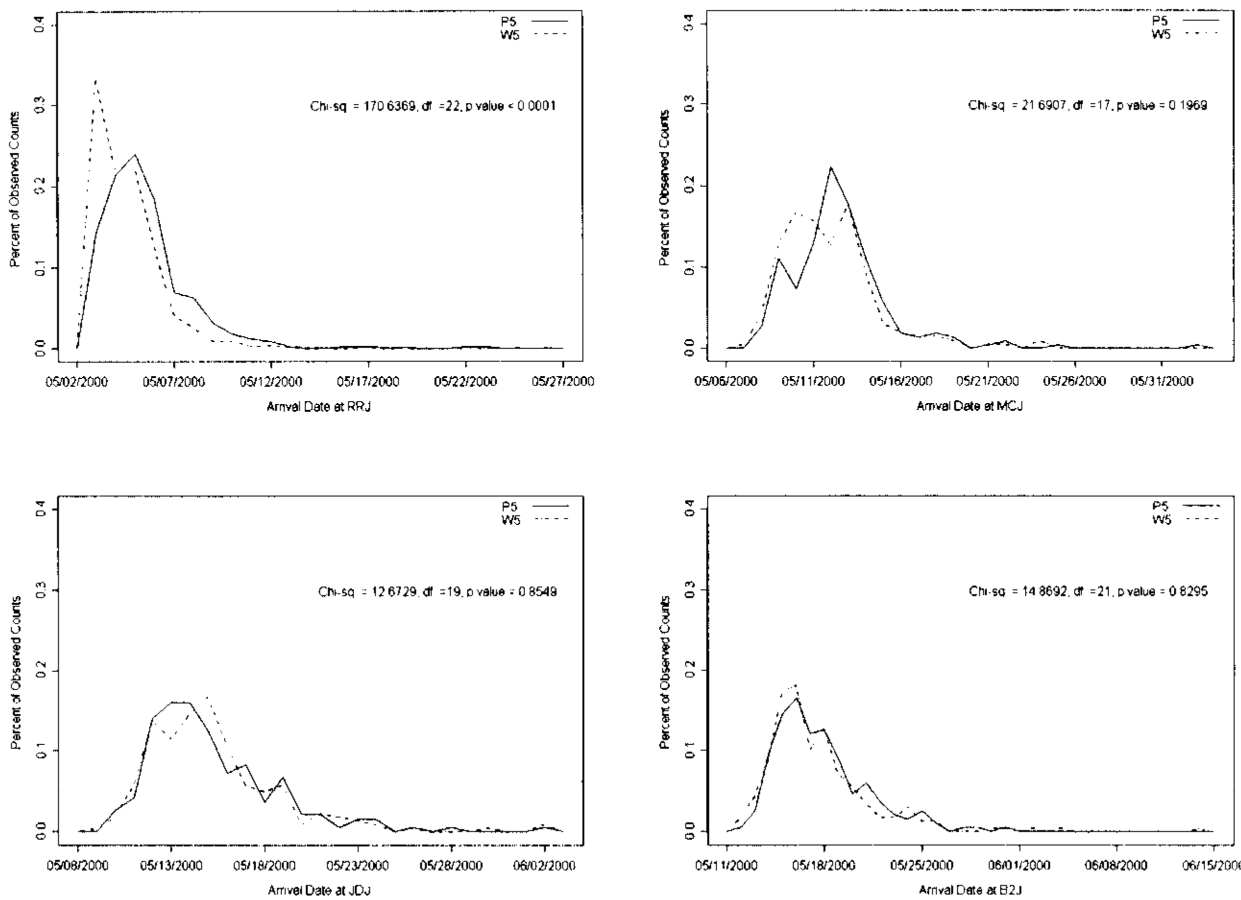

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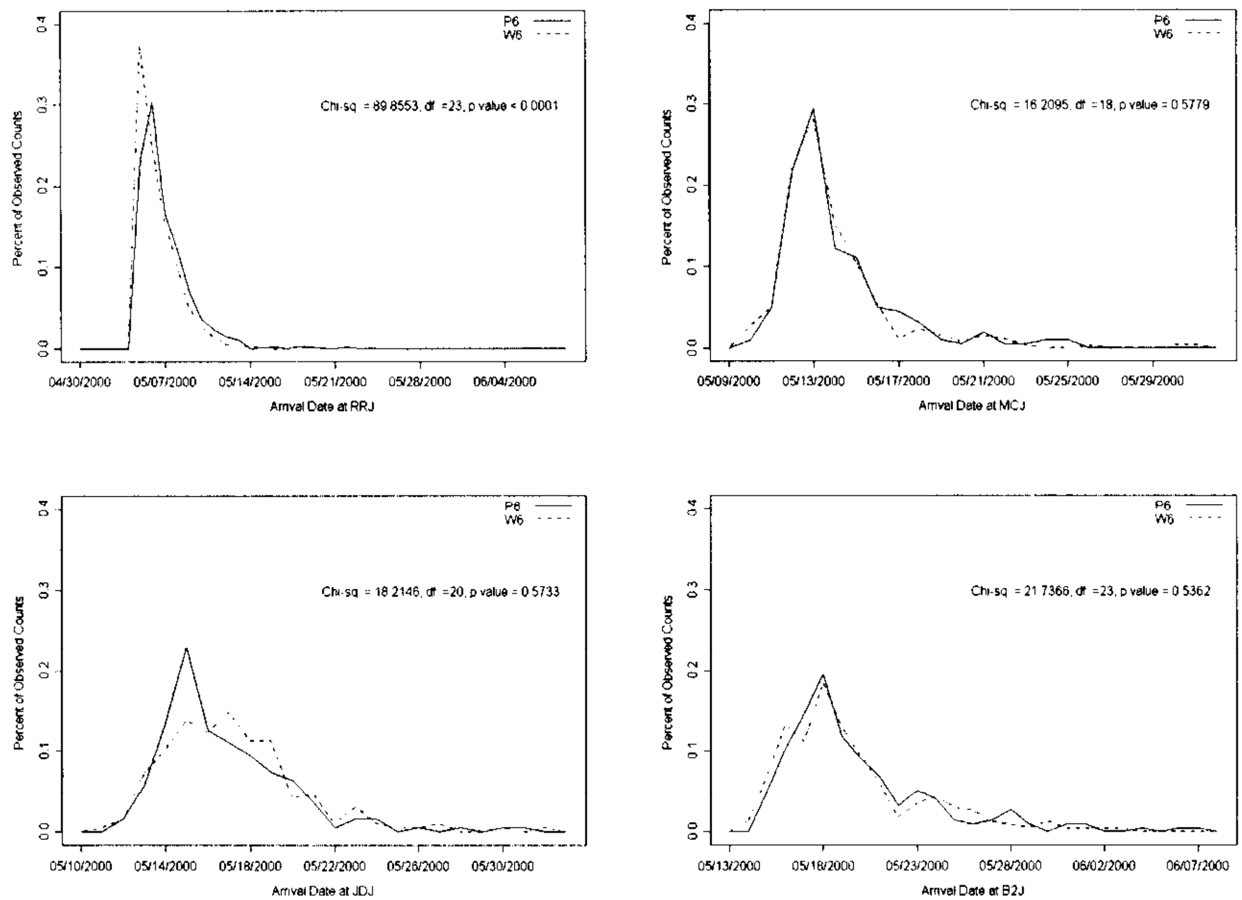

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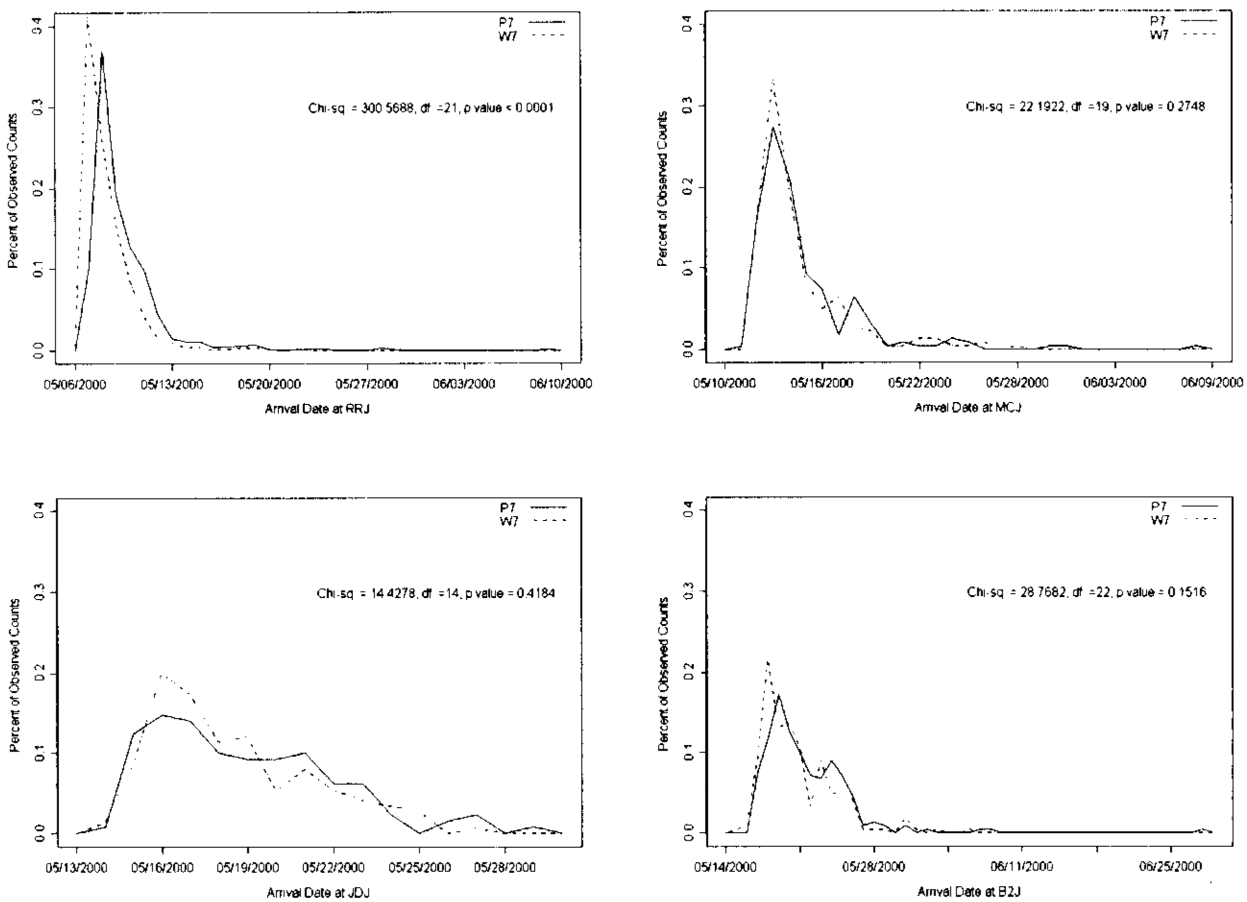

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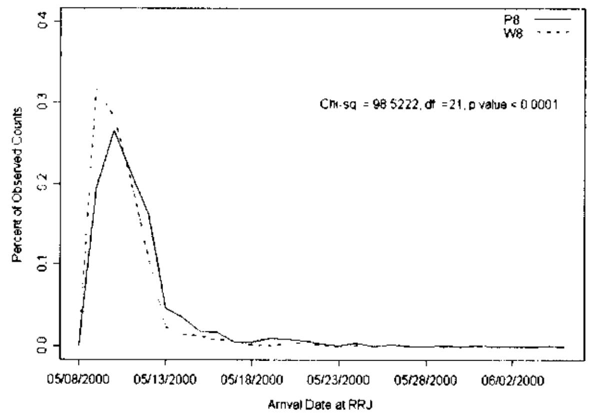

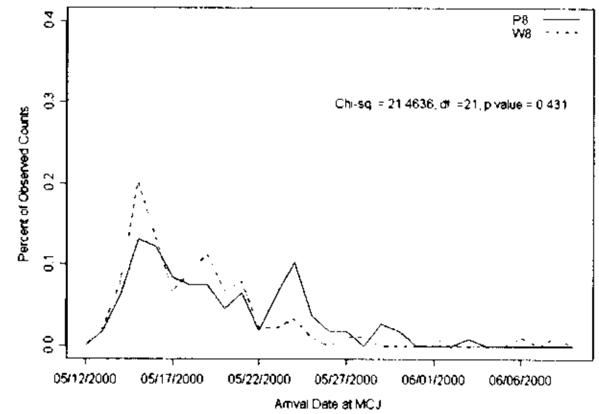

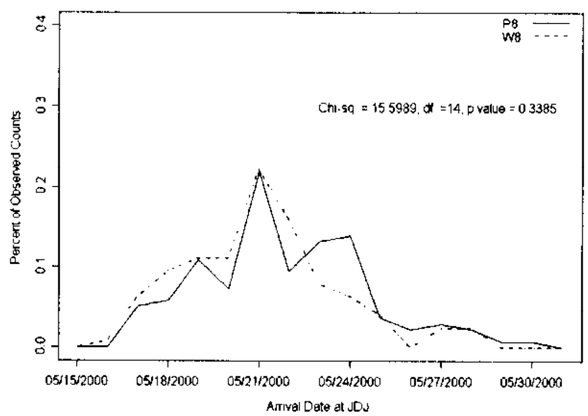

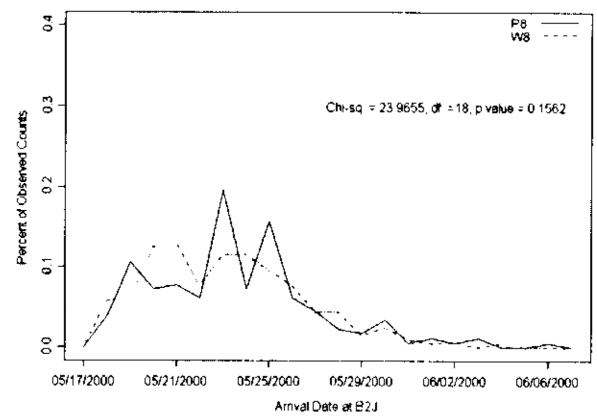

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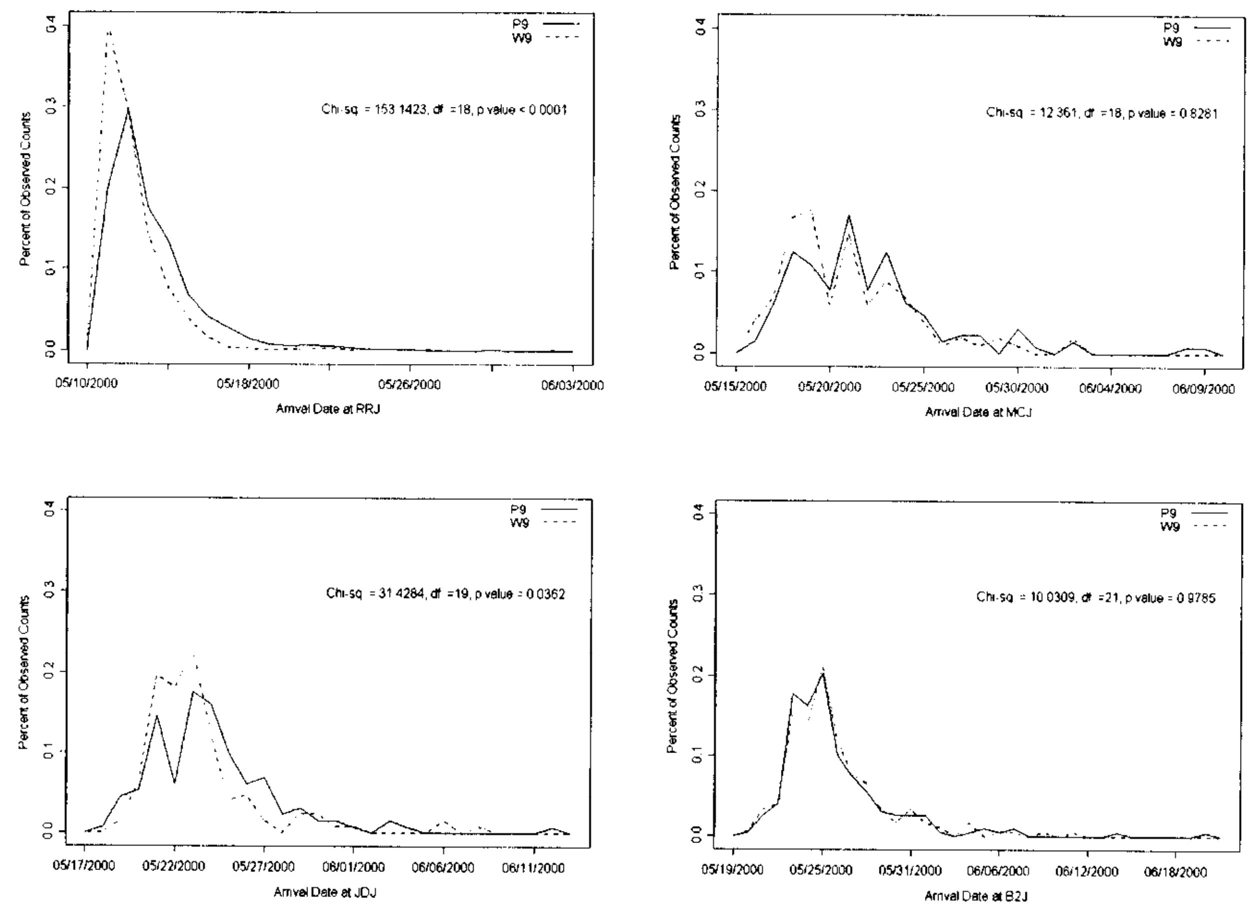

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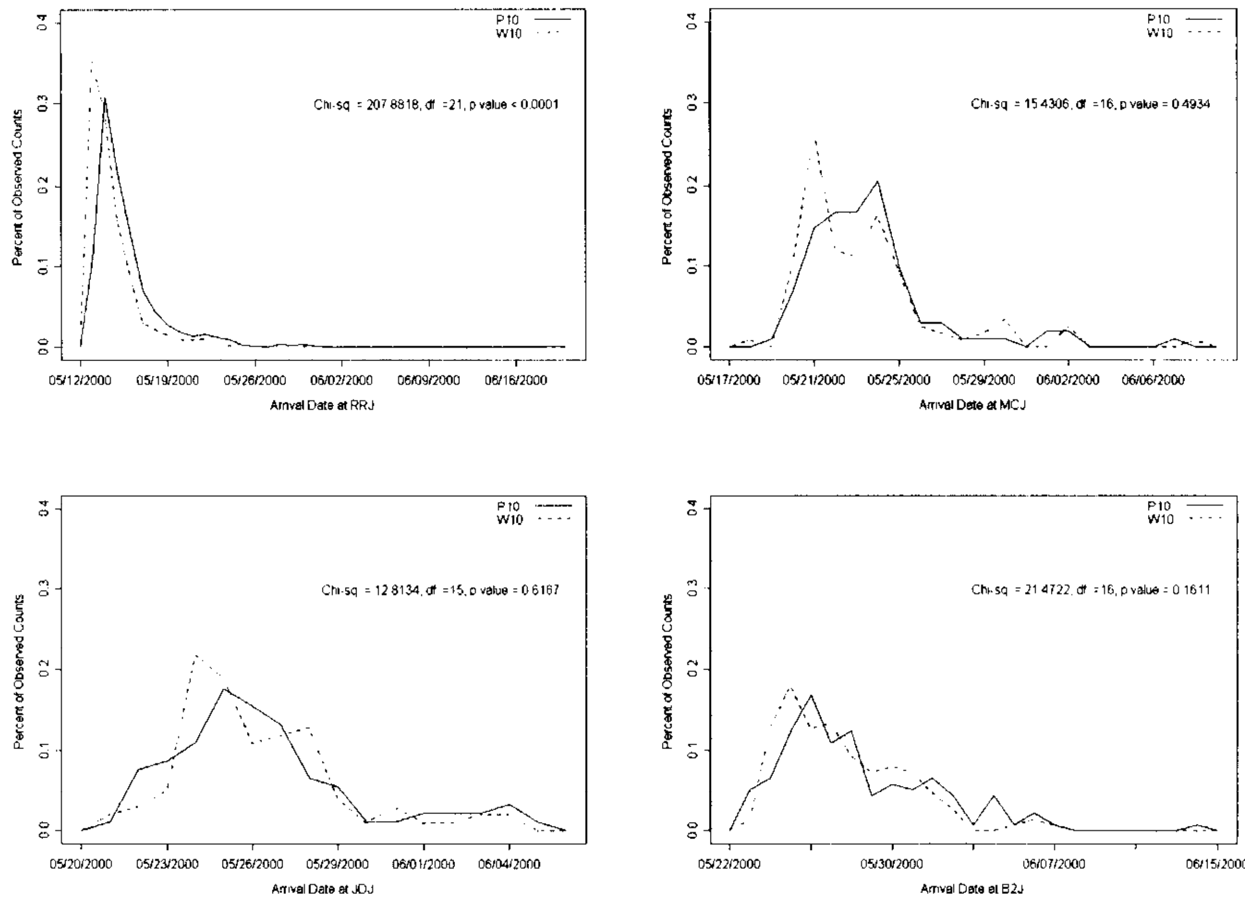

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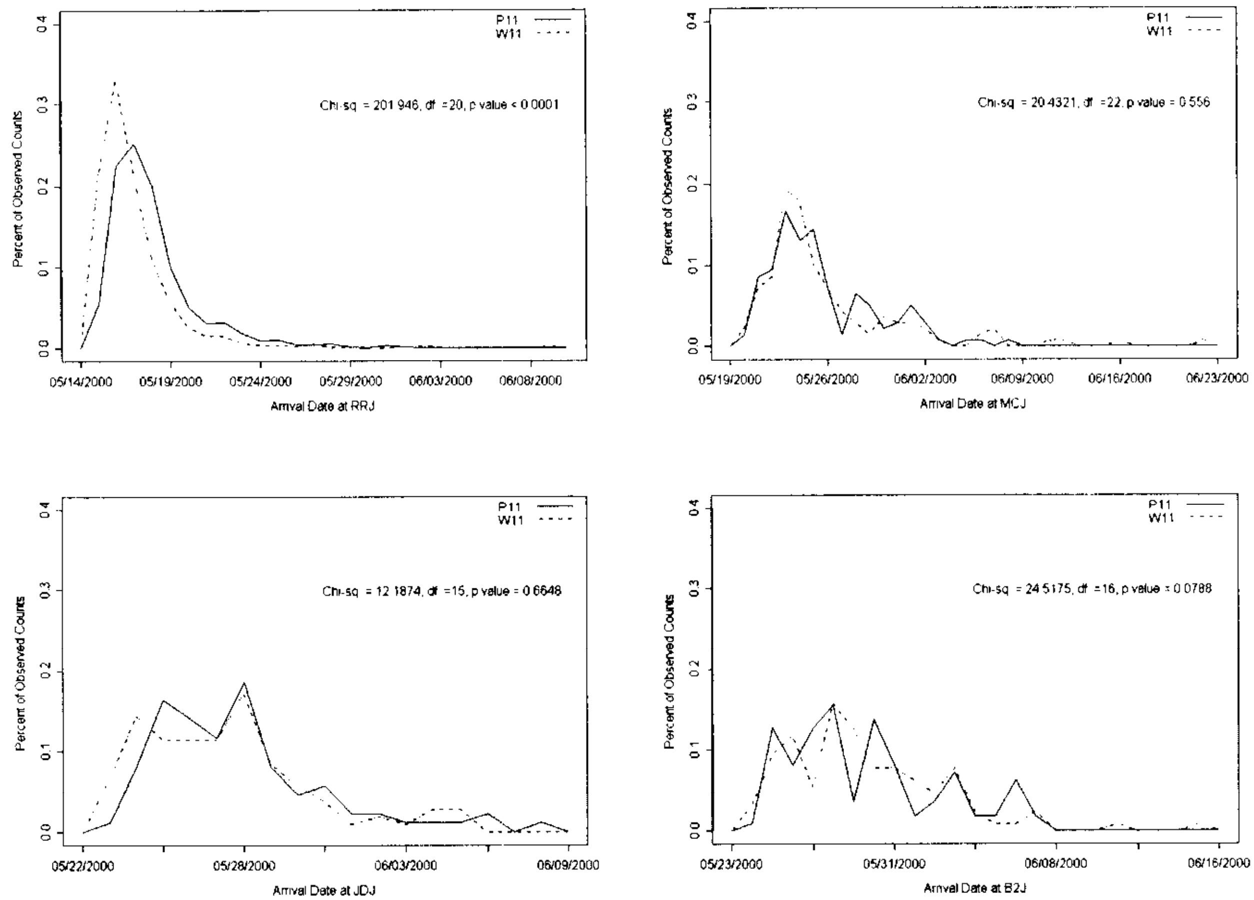

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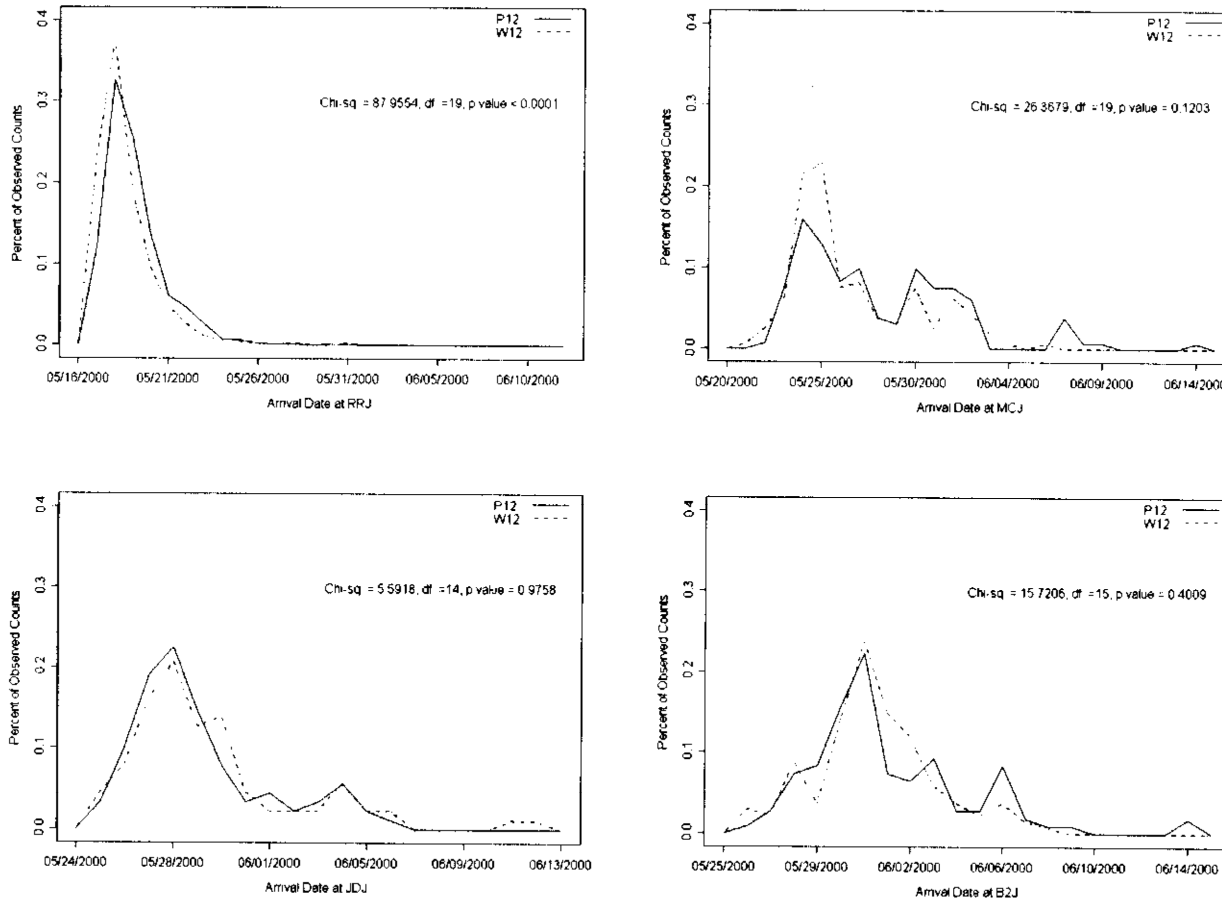


APPENDIX B

Chi-square tables for Burnham et al. (1987) Tests 1, 2, and 3. Chi-square tests for the effects of smolt handling at Rocky Reach and Rock Island dams.

Table B1. Burnham Test 1.T2 and 1.T3 for Pateros and Wells tailrace paired-releases. The m_i are the number of fish detected at that dam, z_i are the number of fish *not detected* at that dam, but detected downstream.

Release Group	Rocky Reach					McNary Dam				
	History	Release: Pateros	Release: Wells	χ_1^2	P-value	History	Release: Pateros	Release: Wells	χ_1^2	P-value
p01 & w01	$m_{.2}$	899	930			$m_{.3}$	265	315		
	$z_{.2}$	341	383	0.795	0.373	$z_{.3}$	404	451	0.279	0.597
p02 & w02	$m_{.2}$	905	1074			$m_{.3}$	249	263		
	$z_{.2}$	273	290	1.234	0.267	$z_{.3}$	323	381	0.794	0.373
p03 & w03	$m_{.2}$	903	1119			$m_{.3}$	246	262		
	$z_{.2}$	275	286	3.193	0.074	$z_{.3}$	339	412	1.185	0.276
p04 & w04	$m_{.2}$	1041	1341			$m_{.3}$	215	226		
	$z_{.2}$	254	192	26.030	< 0.001	$z_{.3}$	374	399	0.004	0.949
p05 & w05	$m_{.2}$	1089	1342			$m_{.3}$	215	204		
	$z_{.2}$	194	155	13.868	< 0.001	$z_{.3}$	293	347	2.886	0.089
p06 & w06	$m_{.2}$	1169	1558			$m_{.3}$	197	255		
	$z_{.2}$	203	116	48.929	< 0.001	$z_{.3}$	327	316	5.336	0.021
p07 & w07	$m_{.2}$	990	1266			$m_{.3}$	215	216		
	$z_{.2}$	247	176	29.591	< 0.001	$z_{.3}$	275	284	0.023	0.880
p08 & w08	$m_{.2}$	1020	1380			$m_{.3}$	107	89		
	$z_{.2}$	178	99	46.682	< 0.001	$z_{.3}$	272	298	2.488	0.115
p09 & w09	$m_{.2}$	864	1229			$m_{.3}$	129	102		
	$z_{.2}$	216	141	44.945	< 0.001	$z_{.3}$	264	259	1.639	0.200
p10 & w10	$m_{.2}$	1008	1131			$m_{.3}$	102	117		
	$z_{.2}$	153	134	3.636	0.057	$z_{.3}$	207	217	0.209	0.648
p11 & w11	$m_{.2}$	964	1088			$m_{.3}$	138	139		
	$z_{.2}$	151	160	0.209	0.647	$z_{.3}$	167	200	1.012	0.314
p12 & w12	$m_{.2}$	1161	1322			$m_{.3}$	131	158		
	$z_{.2}$	108	117	0.083	0.774	$z_{.3}$	165	187	0.097	0.756

Table B2. Burnham Test 1.T4 for Pateros and Wells tailrace paired-releases. The m_1 are the number of fish detected at John Day dam, z_1 are the number of fish *not detected* at that dam, but detected downstream.

Release Group		John Day			
		Release		χ^2_1	P-value
	History	Pateros	Wells		
p01 & w01	$m_{.4}$	328	428		
	$z_{.4}$	187	166	8.512	0.004
p02 & w02	$m_{.4}$	245	263		
	$z_{.4}$	323	381	0.732	0.392
p03 & w03	$m_{.4}$	239	292		
	$z_{.4}$	189	219	0.112	0.738
p04 & w04	$m_{.4}$	231	263		
	$z_{.4}$	222	204	2.411	0.120
p05 & w05	$m_{.4}$	194	226		
	$z_{.4}$	164	184	0.035	0.852
p06 & w06	$m_{.4}$	191	194		
	$z_{.4}$	192	201	0.019	0.889
p07 & w07	$m_{.4}$	128	150		
	$z_{.4}$	197	191	1.266	0.260
p08 & w08	$m_{.4}$	137	126		
	$z_{.4}$	156	196	3.341	0.068
p09 & w09	$m_{.4}$	131	127		
	$z_{.4}$	171	161	0.009	0.926
p10 & w10	$m_{.4}$	91	100		
	$z_{.4}$	134	140	0.030	0.862
p11 & w11	$m_{.4}$	85	105		
	$z_{.4}$	103	119	0.057	0.812
p12 & w12	$m_{.4}$	89	86		
	$z_{.4}$	93	131	3.088	0.079

Table B3. Burnham Test 2.2 for individual release groups. This procedure tests the assumption of whether detections at Rocky Reach affect downstream survival and/or detection.

Release		Test 2.2			χ^2_2	P-value
Pateros		Recovery Site				
	Release Site	McNary	John D.	Bonn.		
p01	Pateros	135	141	65		
	Rocky Reach	130	125	73	1.268	0.530
p02	Pateros	108	99	66		
	Rocky Reach	141	88	70	3.964	0.138
p03	Pateros	112	101	62		
	Rocky Reach	134	87	89	5.764	0.056
p04	Pateros	93	91	70		
	Rocky Reach	122	100	113	3.363	0.186
p05	Pateros	76	66	52		
	Rocky Reach	139	90	85	1.859	0.395
p06	Pateros	71	70	62		
	Rocky Reach	126	98	97	1.215	0.545
p07	Pateros	124	57	66		
	Rocky Reach	91	48	104	14.298	0.001
p08	Pateros	60	60	58		
	Rocky Reach	47	67	87	6.392	0.041
p09	Pateros	73	64	79		
	Rocky Reach	56	48	73	0.902	0.637
p10	Pateros	43	46	64		
	Rocky Reach	59	40	57	3.305	0.192
p11	Pateros	63	41	47		
	Rocky Reach	75	35	44	1.587	0.452
P12	Pateros	45	31	32		
	Rocky Reach	86	49	53	0.484	0.785

Table B3. (Continued)

Release		Test 2.2			χ^2_2	P-value
Wells		Recovery Site				
		McNary	John D.	Bonn.		
w01	Wells	155	167	61		
	Rocky Reach	160	159	64	0.348	0.840
w02	Wells	117	111	62		
	Rocky Reach	146	128	80	0.332	0.847
w03	Wells	103	109	74		
	Rocky Reach	159	124	105	2.935	0.231
w04	Wells	63	75	54		
	Rocky Reach	163	150	120	1.589	0.452
w05	Wells	62	54	39		
	Rocky Reach	142	135	119	1.463	0.481
w06	Wells	45	42	29		
	Rocky Reach	210	115	130	5.562	0.062
w07	Wells	69	56	51		
	Rocky Reach	147	70	107	6.315	0.043
w08	Wells	20	40	39		
	Rocky Reach	69	77	142	6.551	0.038
w09	Wells	36	46	59		
	Rocky Reach	66	62	92	1.173	0.556
w10	Wells	49	33	52		
	Rocky Reach	68	56	76	0.507	0.776
w11	Wells	66	42	52		
	Rocky Reach	73	49	57	0.056	0.973
w12	Wells	58	30	29		
	Rocky Reach	100	45	83	5.004	0.082

Table B4. Burnham Test 2.3 for individual release groups. This procedure tests the assumption of whether detections at McNary affect downstream survival and/or detection.

Release	Release Site	Test 2.3 Recovery Site: John Day	Test 2.3 Recovery Site: Bonn.	χ^2_1	P-value
Pateros					
p01	Pateros + Rocky Reach	266	138		
	McNary	62	49	3.334	0.068
p02	Pateros + Rocky Reach	187	136		
	McNary	58	44	0.005	0.945
p03	Pateros + Rocky Reach	188	151		
	McNary	51	38	0.037	0.848
p04	Pateros + Rocky Reach	191	183		
	McNary	40	39	0.003	0.957
p05	Pateros + Rocky Reach	156	137		
	McNary	38	27	0.392	0.531
p06	Pateros + Rocky Reach	168	159		
	McNary	23	33	1.639	0.200
p07	Pateros + Rocky Reach	105	170		
	McNary	23	27	0.780	0.377
p08	Pateros + Rocky Reach	127	145		
	McNary	10	11	0.021	0.885
p09	Pateros + Rocky Reach	112	152		
	McNary	19	19	0.498	0.480
p10	Pateros + Rocky Reach	86	121		
	McNary	5	13	0.794	0.373
p11	Pateros + Rocky Reach	76	91		
	McNary	9	12	< 0.001	0.998
p12	Pateros + Rocky Reach	80	85		
	McNary	9	8	0.009	0.924

Table B4. (Continued)

Release		Test 2.3		χ_1^2	P-value
Wells		John Day	Bonn.		
w01	Wells + Rocky Reach	326	125		
	McNary	102	41	0.013	0.909
w02	Wells + Rocky Reach	239	142		
	McNary	57	50	2.748	0.097
w03	Wells + Rocky Reach	233	179		
	McNary	59	40	0.190	0.663
w04	Wells + Rocky Reach	225	174		
	McNary	38	30	0.003	0.957
w05	Wells + Rocky Reach	189	158		
	McNary	37	26	0.238	0.625
w06	Wells + Rocky Reach	157	159		
	McNary	37	42	0.107	0.744
w07	Wells + Rocky Reach	126	158		
	McNary	24	33	0.028	0.867
w08	Wells + Rocky Reach	117	181		
	McNary	9	15	0.002	0.962
w09	Wells + Rocky Reach	108	151		
	McNary	19	10	5.075	0.024
w10	Wells + Rocky Reach	89	128		
	McNary	11	12	0.166	0.683
w11	Wells + Rocky Reach	91	109		
	McNary	14	10	0.949	0.330
w12	Wells + Rocky Reach	75	112		
	McNary	11	19	0.025	0.876

Table B5. Burnham et al. (1987) Test 3.1 for individual release groups. This procedure tests whether capture histories at Rocky Reach affect downstream detection histories at John Day and Bonneville.

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ_3^2	P-value
		101	111		
p01	11	6	8		
	10	31	17		
	01	20	29		
	00	77	72	5.9494	0.1141
p02	11	2	5		
	10	25	26		
	01	15	29		
	00	63	80	2.8388	0.4172
p03	11	7	8		
	10	14	22		
	01	19	19		
	00	68	80	0.9642	0.8099
p04	11	6	1		
	10	16	17		
	01	12	27		
	00	58	76	7.9886	0.0462
p05	11	2	5		
	10	13	18		
	01	8	19		
	00	51	95	1.1237	0.7714
p06	11	1	2		
	10	7	13		
	01	11	22		
	00	51	88	0.1479	0.9855
p07	11	2	0		
	10	14	7		
	01	14	13		
	00	91	67	2.5257	0.4707
p08	11	1	0		
	10	6	3		
	01	6	5		
	00	46	37	1.2040	0.7520
p09	11	1	4		
	10	8	6		
	01	11	8		
	00	52	37	2.8632	0.4132

Table B5. (Continued)

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ^2_3	P-value
		101	111		
p10	11	0	1		
	10	2	2		
	01	8	5		
	00	32	51	3.2730	0.3514
p11	11	0	1		
	10	3	5		
	01	5	7		
	00	54	58	1.3735	0.7118
p12	11	1	0		
	10	1	7		
	01	3	5		
	00	39	65	3.7812	0.2861
Wells					
w01	11	16	13		
	10	34	39		
	01	15	26		
	00	83	80	3.3360	0.3427
w02	11	4	5		
	10	23	25		
	01	27	23		
	00	61	89	2.9370	0.4014
w03	11	2	6		
	10	27	24		
	01	12	28		
	00	59	98	6.3166	0.0972
w04	11	1	8		
	10	12	17		
	01	5	25		
	00	45	106	5.8427	0.1195
w05	11	0	6		
	10	10	21		
	01	4	22		
	00	45	88	6.2096	0.1018

Table B5. (Continued)

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ^2_3	P-value
		101	111		
w06	11	0	6		
	10	7	24		
	01	7	35		
	00	30	140	1.8307	0.6083
w07	11	2	0		
	10	5	17		
	01	12	21		
	00	50	108	5.4081	0.1442
w08	11	0	1		
	10	3	5		
	01	5	10		
	00	11	51	3.1699	0.3662
w09	11	0	2		
	10	6	11		
	01	4	6		
	00	26	47	1.1912	0.7551
w10	11	1	0		
	10	4	6		
	01	4	8		
	00	38	53	1.7510	0.6257
w11	11	0	1		
	10	7	6		
	01	6	4		
	00	49	59	1.9251	0.5881
w12[2]	11	---	---		
	10	4	7		
	01	10	9		
	00	41	79	2.4088	0.2999

[2] There were no detections at both John Day and Bonneville Dams for release w12, so the chi-square test has 2 degrees of freedom.

Table B6. Burnham et al. (1987) Test 3.2 for individual release groups. This procedure tests whether capture histories at Rocky Reach and McNary affect downstream detection history at Bonneville.

Release	Capture History at John Day and Bonneville Dams	Capture History to John Day Dam				χ^2_3	P-value
		1111	1101	1011	1001		
p01	0	17	100	31	113		
	1	8	25	6	28	2.5057	0.4743
p02	0	26	68	25	79		
	1	5	20	2	20	3.3807	0.3366
p03	0	22	70	14	80		
	1	8	17	7	21	2.3276	0.5072
p04	0	17	78	16	75		
	1	1	22	6	16	3.6905	0.2969
p05	0	18	71	13	57		
	1	5	19	2	9	1.8772	0.5983
p06	0	13	81	7	62		
	1	2	17	1	8	1.2007	0.75287
p07	0	7	38	14	45		
	1	0	10	2	12	2.3608	0.5010
p08	0	3	54	6	51		
	1	0	13	1	9	1.1019	0.7766
p09	0	6	42	8	49		
	1	4	6	1	15	5.1321	0.1624
p10	0	2	39	2	45		
	1	1	1	0	1	8.8196	0.0318
p11	0	5	32	3	38		
	1	1	3	0	3	0.8846	0.8291
p12	0	7	36	1	30		
	1	0	13	1	1	10.3697	0.0157

Table B6. (Continued)

Release	Capture History at John Day and Bonneville Dams	Capture History to John Day Dam				χ_3^2	P-value
		1111	1101	1011	1001		
Wells							
w01	0	39	119	34	134		
	1	13	40	16	33	3.5557	0.3136
w02	0	25	103	23	84		
	1	5	25	4	27	1.8664	0.6006
w03	0	24	101	27	84		
	1	6	23	2	25	3.8598	0.2770
w04	0	17	122	12	59		
	1	8	28	1	16	3.7059	0.2950
w05	0	21	104	10	42		
	1	6	31	0	12	2.9129	0.4053
w06	0	24	100	7	32		
	1	6	15	0	10	4.3488	0.2262
w07	0	17	55	5	44		
	1	0	15	2	12	4.8121	0.1861
w08	0	5	70	3	35		
	1	1	7	0	5	0.9377	0.8163
w09	0	11	51	6	40		
	1	2	11	0	6	1.5673	0.6668
w10	0	6	50	4	31		
	1	0	6	1	2	1.8812	0.5974
w11	0	6	46	7	37		
	1	1	3	0	5	1.9184	0.5895
w12	0	7	44	4	28		
	1	0	1	0	2	1.5120	0.6795

Table B7. Counts of smolt by detection history for fish recaptured in the Rocky Reach sampling facility. Chi-square tests compare these counts with smolt counts for fish detected at Rocky Reach Dam, but not detected at the Rocky Reach sampling facility. Histories are for Release, Rocky Reach, McNary, John Day, and Bonneville Dams.

Release	11111	11110	11101	11100	11011	11010	11001	11000	11200	χ^2	df	p-value
Pateros												
p01	4	4	8	20	13	28	22	147	2	11.8346	8	0.1587
p02	1	5	6	10	1	15	9	92	0	6.0516	8	0.6415
p03	1	4	2	10	3	9	10	87	0	2.5442	8	0.9596
p04	0	1	2	8	3	9	18	114	1	10.9443	8	0.2049
p05	1	2	2	15	1	10	13	96	0	3.0700	8	0.9299
p06	0	1	3	1	1	8	5	48	0	8.9027	8	0.3506
p07	0	0	1	5	1	1	8	45	0	2.4908	7	0.9278
p08	0	0	1	3	0	6	11	102	0	3.5047	7	0.8347
p09	0	2	2	5	0	3	7	36	0	18.6757	8	0.0167
p10	1	0	1	8	0	6	8	136	0	6.0874	7	0.5296
p11	0	1	0	1	0	4	7	57	0	11.2710	8	0.1868
p12	0	1	1	0	0	0	1	22	0	15.2271	7	0.0332
Wells												
w01	4	13	7	21	14	35	14	145	1	3.9427	8	0.8623
w02	0	6	2	23	7	21	14	137	3	14.6192	8	0.0670
w03	1	5	3	9	1	9	9	78	1	6.5040	8	0.5910
w04	1	2	3	22	6	21	18	173	0	4.8116	8	0.7775
w05	0	7	8	14	1	22	26	211	2	15.2999	8	0.0536
w06	0	0	1	6	0	7	8	58	1	6.2231	7	0.6223
w07	0	0	1	6	2	1	9	87	0	7.5946	8	0.3697
w08	0	0	2	9	2	7	22	157	0	4.4088	8	0.8185
w09	0	1	0	3	1	4	6	45	0	3.3608	7	0.8497
w10	0	1	1	5	0	7	11	79	0	5.6983	7	0.5754
w11	0	0	1	10	0	6	11	129	0	4.0649	8	0.8512
w12	0	0	0	4	0	3	0	24	0	9.0245	7	0.2509

Table B8. Counts of smolt by detection history for fish recaptured at Rock Island Dam. Chi-square tests compare these counts with smolt counts for fish not recaptured at Rocky Island Dam but detected somewhere downriver[3]. Histories are for McNary, John Day, and Bonneville Dams.

Release	111	110	101	100	011	010	001	200	χ^2	df	p-value
Pateros											
p01	0	1	0	3	0	0	4	0	8.5918	7	0.2833
p02	0	0	0	3	1	0	4	0	6.7943	7	0.4506
p03	0	0	0	4	1	4	5	0	3.0657	7	0.8789
p04	0	0	0	0	1	3	3	0	4.3538	7	0.7382
p05	1	1	1	6	1	2	4	0	4.5418	7	0.7157
p06	0	0	0	3	0	0	2	0	4.4647	7	0.7250
p07	0	0	0	4	0	1	7	0	4.5070	7	0.7199
p08	0	0	0	3	0	2	4	0	1.8614	7	0.9671
p09	1	1	0	4	0	4	5	0	5.9650	7	0.5438
p10	0	0	0	4	0	2	5	0	1.6141	7	0.9781
p11	0	0	0	2	0	2	1	0	1.3569	7	0.9869
p12	0	0	0	6	1	1	2	0	4.3488	7	0.7388
Wells											
w01	0	0	0	3	0	2	2	0	4.3133	7	0.7431
w02	0	2	1	2	1	2	1	0	3.7654	7	0.8064
w03	0	0	1	4	2	1	3	0	5.3820	7	0.6134
w04	0	0	1	5	0	1	7	0	7.8742	7	0.3380
w05	0	0	1	5	1	2	5	0	3.2143	7	0.8645
w06	0	1	0	7	1	4	7	0	2.6437	7	0.9159
w07	0	0	2	3	0	2	3	0	3.8541	7	0.7964
w08	0	0	0	4	0	2	4	1	14.6738	7	0.0404
w09	0	2	2	1	1	2	5	0	12.9397	6	0.0440
w10	0	1	0	2	1	3	4	0	4.4833	7	0.7227
w11	0	1	1	2	0	1	2	0	5.8431	7	0.5582
w12	0	0	1	3	0	1	4	0	1.9521	6	0.9241

[3]It cannot be determined whether fish not detected at Rock Island Dam or below survived to Rock Island Dam; those fish and the fish not detected at Rock Island Dam or below are removed from the chi-square test of homogeneity

APPENDIX C

Between-year (1998 - 2000) and between-species comparisons of capture and survival processes through common reaches of the Mid-Columbia River.

Table C1. Summary of reach survival estimates from Rocky Reach tailrace to McNary Dam. Weighted averages reported for chinook salmon and steelhead for the years 1998-2000.

Species	Source	Year	$\hat{\bar{S}}$	$\hat{SE}\left(\hat{\bar{S}}\right)$	95% C.I.
Steelhead	Douglas Hatchery	1999	0.686	0.010	0.666 - 0.706
Steelhead	Douglas Hatchery	2000	0.656	0.011	0.634 - 0.678
Summer-Spring Mixed Chinook	Douglas run-of-river	1998	0.720	0.084	0.555 - 0.885
Summer Chinook	Douglas Hatchery	1998	0.659	0.040	0.581 - 0.737
Summer Chinook	Douglas Hatchery	2000	0.731	0.063	0.608 - 0.854
Spring Chinook	Winthrop Hatchery	1998	0.720	0.091	0.542 - 0.898
Spring Chinook	Winthrop Hatchery	1999	0.727	0.053	0.623 - 0.831
Spring Chinook	Winthrop Hatchery	2000	0.692	0.088	0.520 - 0.864
Coho	Winthrop Hatchery	2000	0.715	0.123	0.474 - 0.956

Table C2. Summary of detection probabilities for the 1998, 1999 and 2000 outmigrations.

Species	Year	Fish Origin	Detection Rates (SE)		
			Rocky Reach	McNary	John Day
Spring Chinook	1998	Winthrop Hatchery	0.128 (0.010)	0.126 (0.014)	0.089 (0.016)
Spring Chinook	1999	Winthrop Hatchery	0.172 (0.010)	0.306 (0.017)	0.210 (0.088)
Spring Chinook	2000	Winthrop Hatchery	0.261 (0.028)	0.206 (0.034)	0.063 (0.010)
Summer-Spring Mixed Chinook	1998	Run-of-River PT	0.126 (0.016)	0.135 (0.038)	0.128 (0.012)
Summer Chinook	1998	Douglas Hatchery PT, WT	0.085 (0.004)	0.110 (0.009)	0.095 (0.013)
Summer Chinook	2000	Douglas Hatchery OK	0.086 (0.016)	0.170 (0.049)	0.104 (0.055)
Summer Steelhead	1999	Douglas Hatchery OK, PT, WT	0.250 (0.009)	0.198 (0.005)	0.358 (0.013)
Summer Steelhead	2000	Douglas Hatchery PT, WT	0.587 (0.009)	0.155 (0.005)	0.149 (0.013)
Coho	2000	Winthrop Hatchery	0.543 (0.018)	0.118 (0.021)	0.104 (0.026)

APPENDIX D

Supplemental Figures D1, D3, D3, D4, D5, D6 and D7. Trends in mean fish length, weight, condition factor, fat index, ATPase, plasma cortisol and glucose.

Figure D1. Trends in mean fish length during the 2000 steelhead survival study.

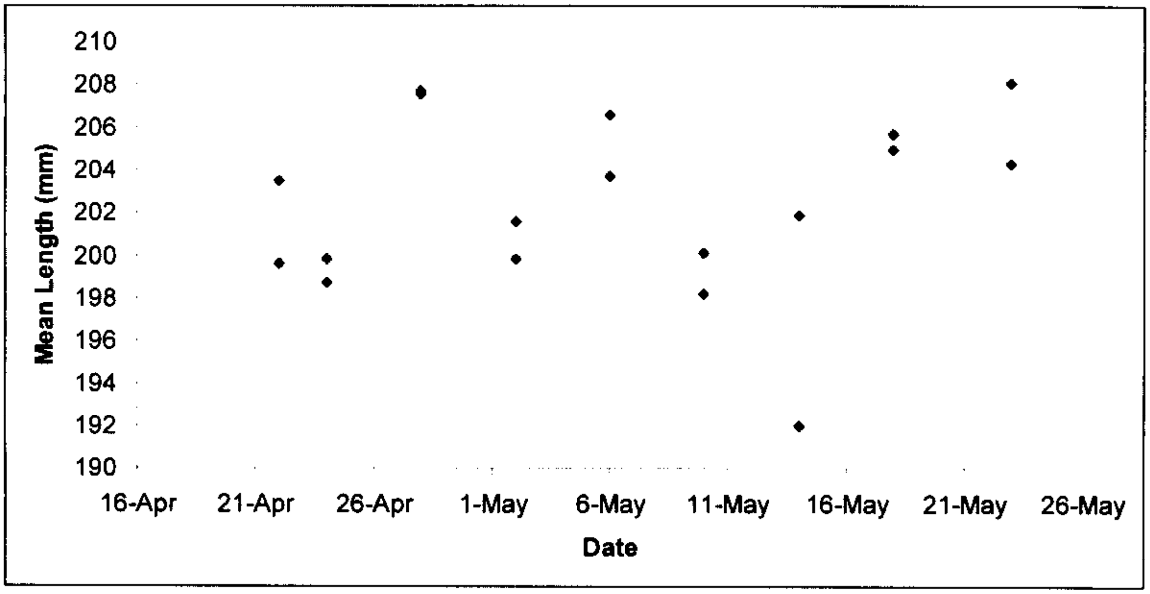


Figure D2. Trends in mean fish weight during the 2000 steelhead survival study.

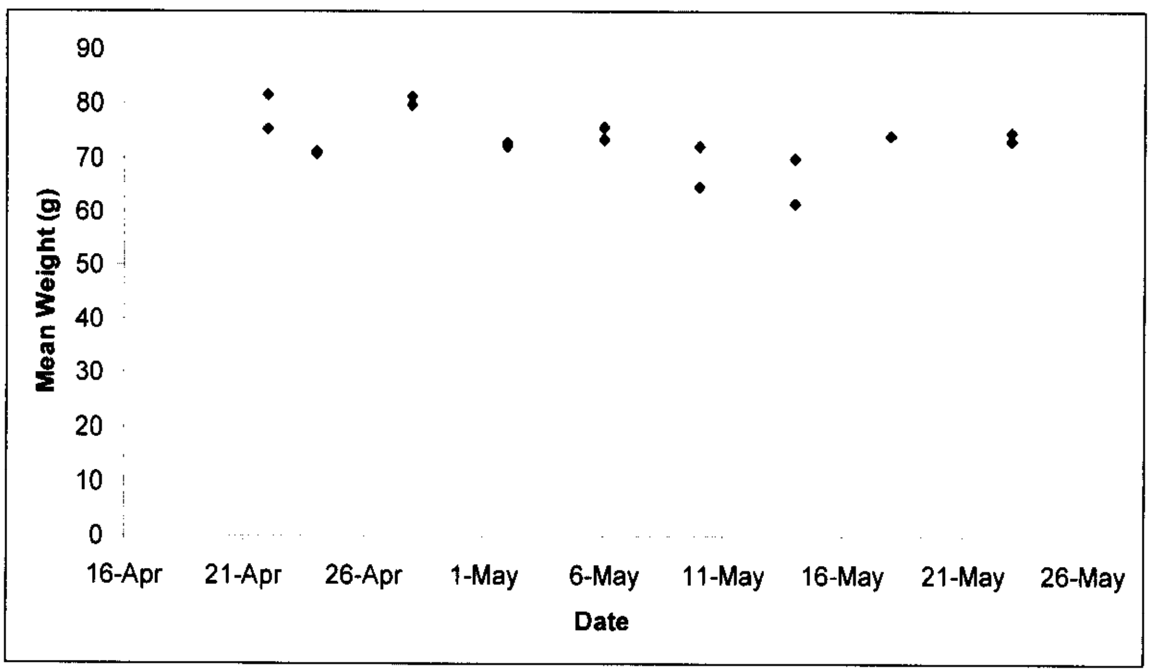


Figure D3. Trends in mean fish condition factor during the 2000 steelhead survival study.

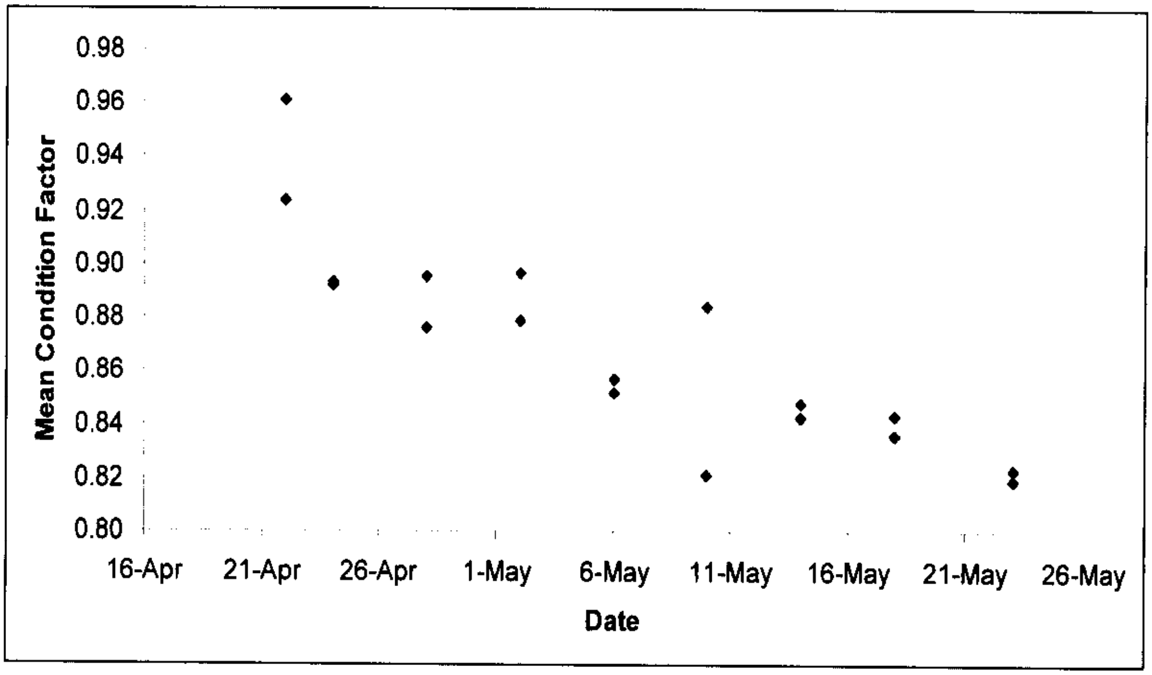


Figure D4. Trends in mean fish fat indices during the 2000 steelhead survival study.

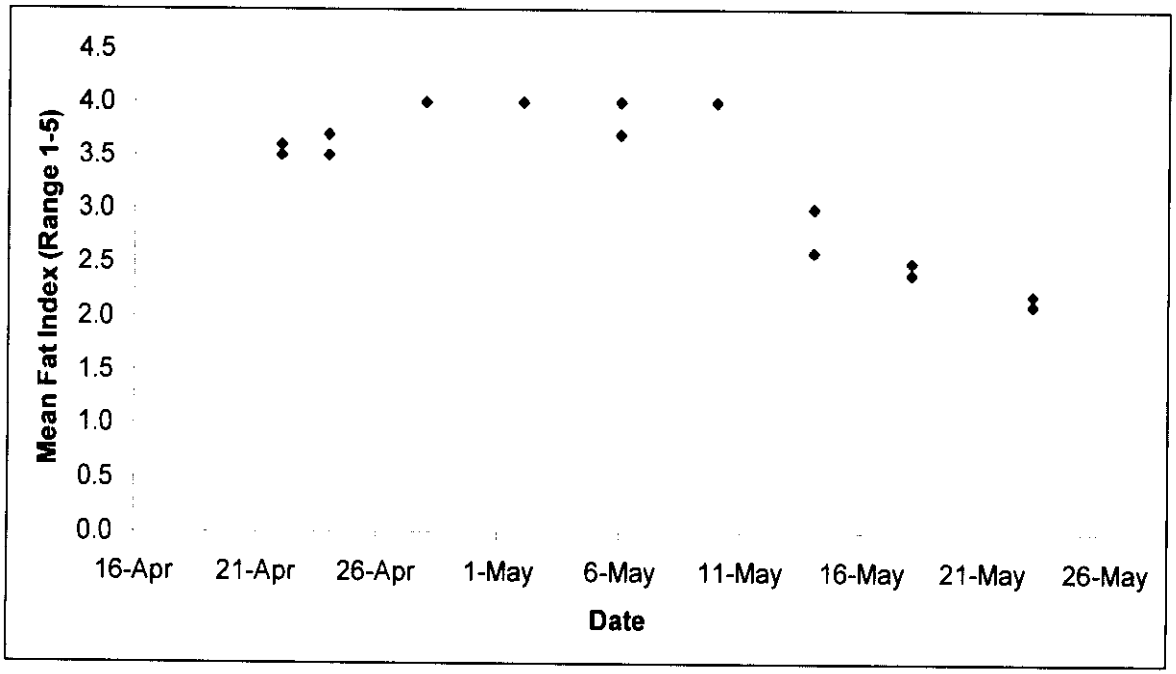


Figure D5. Trends in mean fish ATPase values during the 2000 steelhead survival study.

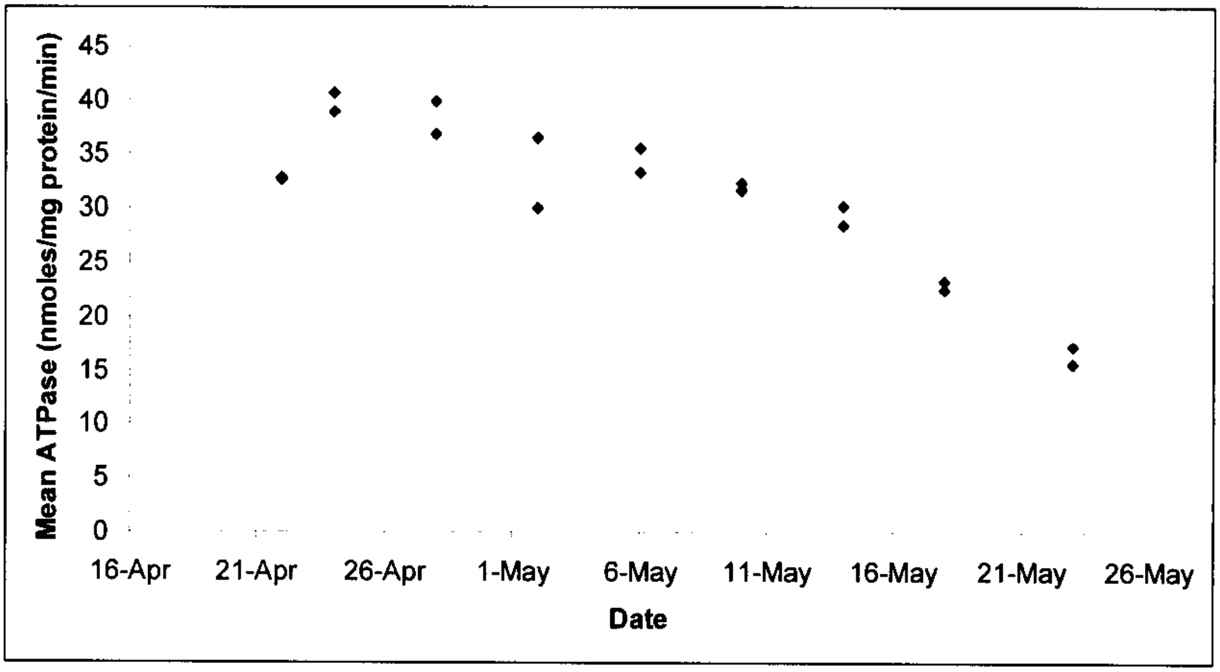


Figure D6. Trends in mean fish cortisol concentration during the 2000 steelhead survival study.

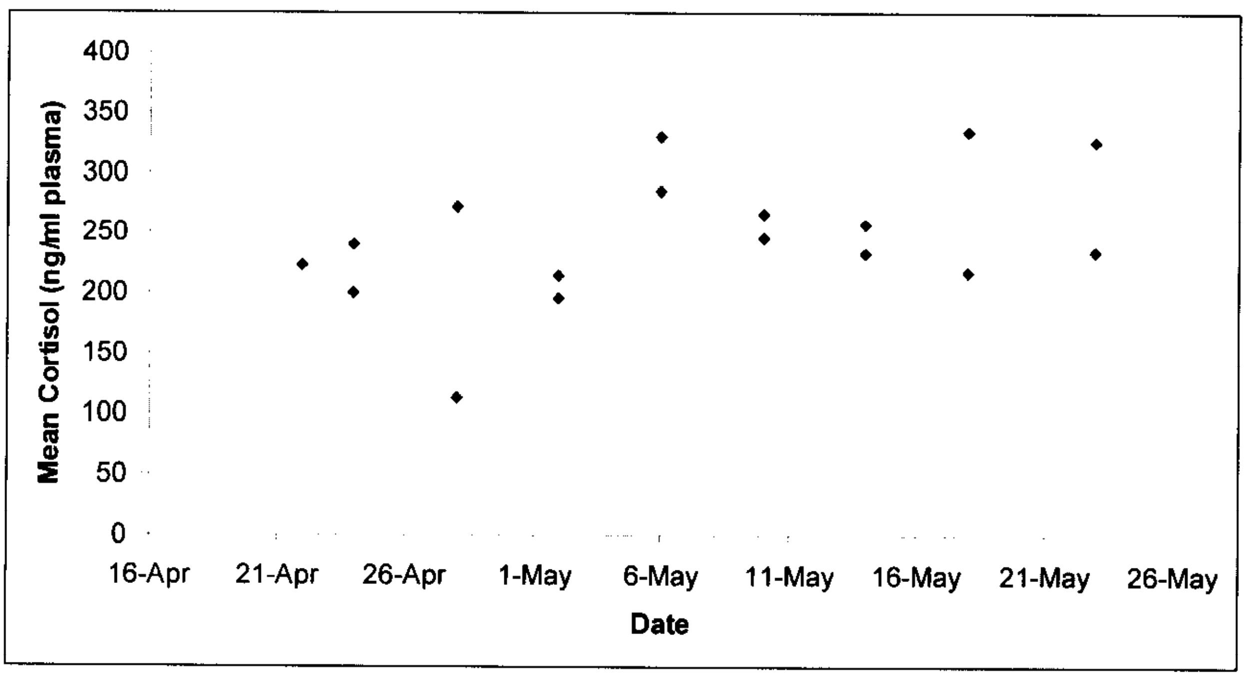
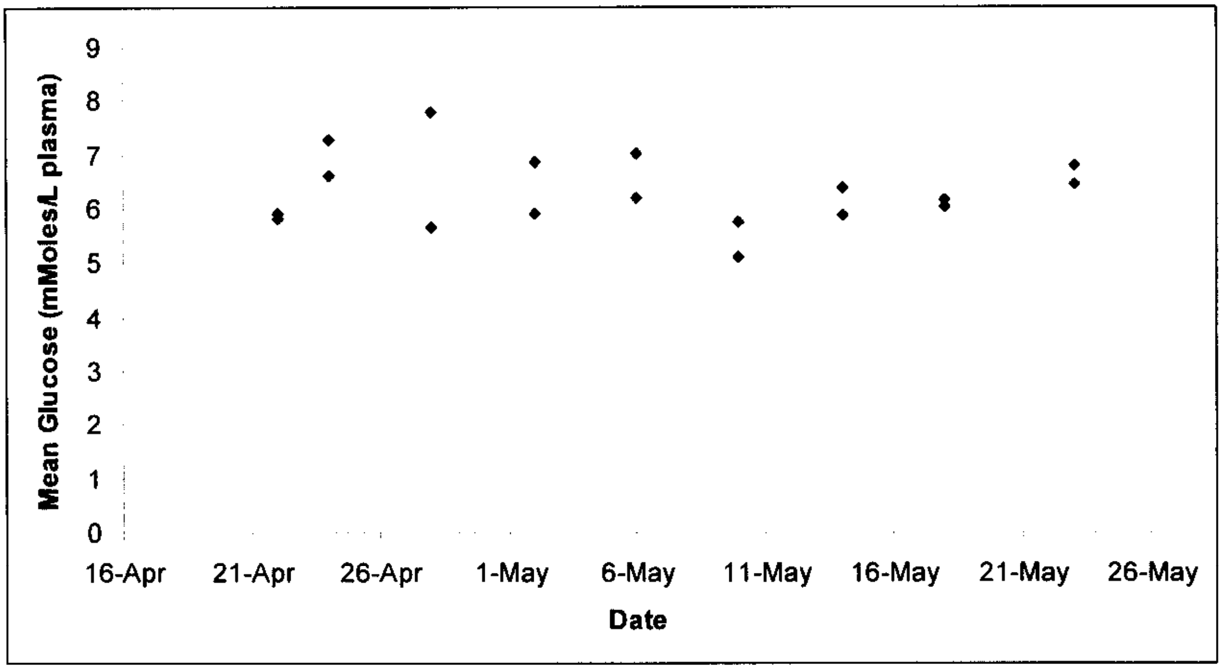


Figure D7. Trends in mean fish glucose values during the 2000 steelhead survival study.



APPENDIX E

Responses to comments received on the Draft report entitled: "Project survival estimates for yearling summer steelhead migrating through the Wells Hydroelectric Project, 2000."

RESPONSE TO COMMENTS FROM

BRYAN NORDLUND, BOB DACH AND STEVE SMITH, NMFS

The following pages contain NMFS's comments related to the 2000 Wells PIT-tag survival study. Each comment is followed by a response (bold text).

NMFS's Comments Follow:

Dear Mr. Bickford:

Thank you for the opportunity to review this report. In general, the document reflects the level of quality that we have come to expect from the Douglas County Public Utility District (PUD). We greatly appreciate your design and implementation efforts and the uncommon care that the researchers showed in handling endangered juvenile steelhead.

The majority of our comments are largely editorial in nature, although we do feel some additional effort should be taken to compare and contrast your results with similar information conducted from other studies, particularly the Chelan and Grant county evaluations, and other mainstem efforts on the lower Columbia River. The comparative information provided for the Winthrop fish, tagged by the Fish Passage Center, certainly helps to support your results but it would be interesting to note if fish released near the Wells Dam had the same downstream migration rate and survival (through common reaches) as fish released above the Lower Granite Dam, for example, or as fish released at the Priest Rapids Project (a comparison with information collected at The Dalles Dam would also help to ensure that cumulative effects were minimal). Through survival comparisons of test fish released at alternative locations we would hope to see similar survival trends through common downstream reaches. Inconsistent data may identify concerns with a particular reach or may indicate some level of cumulative effect currently not being addressed. In either case, the quality of the data and analysis provided in your report would lend itself to this type of comparison. A separate section in the report specifically addressing this issue would be very helpful.

Please also note the following specific comments:

1. Executive Summary (3rd paragraph from end): This is the first time reach survival estimates are noted. As discussed above, your weighted averages for survival from Rocky Reach to McNary (0.656) and from McNary to John Day (1.017) are almost opposite of those reported in the Chelan County PUD study - 1.032 and 0.696 for the same reaches respectively (Table 4-2, Skalski et al. November 9, 2000 Draft). Please discuss in the document possible explanations for this discrepancy. Only reporting comparative information that supports your data may have unintended effects on how your study results are viewed. Also, as you know, this type of evaluation does not specifically measure survival to a finite point (e.g., to the McNary tailrace) - some clarification of this terminology should be provided.

   The area of interest for this report was the Methow River to the Well's Dam tailrace. As such, it is more informative to compare Douglas PUD's fish with those of the Fish Passage Center released from the Winthrop National Fish Hatchery. A comparison of Chelan County PUD's study to this one for lower reaches has numerous confounding factors, different stock and species of fish, handling techniques, time of the year in the river, etc. While some of these also are true of the Winthrop fish, they were selected due to the common stretch of river they experienced with the Well's study.

2. Page 1, para. 4, line 5: Should "p<0.10" be "p>0.10" (talking about p value for non-significant result).

   This typographical error has been changed.

3. Page 1, para. 2, line 7: We suggest using "Estimated survival...averaged" in place of "Survival...averaged"

   The suggested change has been made.

4. Page 2, para. 3, last sentence: Sentence confusing. What does "this system" refer to? Is it not correct that smolts migrating out of the Okanogan River are already in the system? Why do they need to be planted?

   The majority of the steelhead migrating out of the Okanogan River Basin are hatchery fish. To clarify, the draft statement has been changed to, "Steelhead smolts migrating out of the Okanogan River are mostly hatchery fish planted into this system each spring by staff from the Wells Fish Hatchery."

5. Page 6, Section 3.3, para. 5, line 2: We suggest a more exact definition of what "fish status" was recorded immediately before release. Probably just a check for mortalities?

   The statement has been modified to clarify that fish status refers to fish activity and general appearance prior to release. The mortality check is also an important part of the pre-release inspection.

6. Page 7, Section 3.4: Where and when (at what point in the tagging/holding operation) were fish collected for physiological monitoring? The same information for untagged fish would be helpful (e.g., were untagged fish anesthetized?).

   Control fish were sampled as they exited the pescalator. In this way the control group of fish experienced identical collection, holding and sampling conditions relative to treatment groups of fish. The difference between treatment and control fish was isolated to the tagging and post-tagging recovery period. Section 3.4 has been modified to more accurately describe the sampling protocol.

7. Page 10, Section 3.6, last sentence: '...with a precision of ±5% and a 95% confidence interval' is somewhat confusing. Wouldn't '...with a ±5% confidence interval around the point estimate calculated at the 95% confidence level' be more accurate?

   The suggested change has been made.

8. Page 13, beginning of assumption section: We suggest defining "mixing." We suspect that what is meant is "proportionate daily detection distributions at downstream dams." This type of mixing is certainly desirable, and makes commonality of parameters more likely, but this

type of mixing is not sufficient to ensure that parameters will be common. Differences in the composition of the two groups, or differences in the way they were handled, for example, could lead to differences in parameters despite proportionality of detection distributions.

We agree. Proportionality in detection distributions between treatment and control releases does not directly translate into a lack of difference between parameters. Conversely, differences in parameters should not be inferred simply because proportionality in daily detection distributions was not attained between release groups. In the final report, "Mixing" has been defined as, "proportionate daily detection distributions." Because of these issues, downstream homogeneity of parameters are performed using likelihood ratio tests with R x C contingency tables used as supplemental information only.

9. Page 15, m-array: The authors need to explain exactly what m_{ij}'s are. See our comments on contingency tables for Tests 1.T below.

The following phrase has been added to the first paragraph found on page 15. "...of the form below where m_{ij}'s are the number of smolts released at site *i* that are next detected at site *j*:"

10. Page 17, para. 1: "the assumption...was conducted" should be "a test of the assumption...was conducted."

The suggested change has been made.

11. Page 17, table (11)--Not all readers will know what numbers go into the cells of the table.

Change "An R x C contingency table test of homogeneous recoveries over time was performed using a table of the form:" to "A test of homogeneous recoveries over time was performed using a contingency table listing the daily downstream detections at each dam for each pair of releases:"

12. Page 17: Some discussion of proper use of experiment-wise error rates would be helpful (see comment regarding results below). Test-wise error rates implied by experiment-wise level of 0.10 should be stated. Does rejection of a test at the *experiment*-wise level properly lead to rejection of the *experiment*, not just that one test?

Add after "overall experimental-wise error rate of $\alpha_{EX} = 0.10$." : "A Type I error occurs when a hypothesis test falsely rejects the null when it is true. In this case, our null hypothesis is that there is no difference in downstream detections for a pair of releases. When $\alpha = 0.10$ for a specific test, we realize that if the null hypothesis is true, it will be erroneously rejected 10 percent of the time. When calculating a number of comparisons, though, the likelihood that a Type I error will occur increases. For 12 comparisons of the daily detection rates at McNary Dam, for example, the probability of at least one Type I error increases to 71.8%. To decrease this likelihood, the test-wise Type I error per comparison is reduced to $\alpha = 0.0087$, so that the experimental-wise error rate is $\alpha_{EX} = 0.10$. When the rejection of a hypothesis test does occur, this does not lead to rejecting the experiment, but indicates that this particular data set is inconsistent with the null hypothesis."

13. Pages 18 and 19: In the tables for Tests 1.T, the notation m_{ij}, is different from that for the m-array on page 15 (e.g., m_{13} in the m-array is the number of fish detected for the first time at McNary Dam, while in Table 14 [Test 1.T4], m_{13} is the total number of fish detected at John Day Dam, regardless of previous history. This is very confusing. To be consistent with the notation in Burnham et al. (admittedly, not always a desirable goal!), the m-array notation would have an additional subscript to denote release group ("t" and "c" in Burnham et al.; see page 113) and the total number of fish from group i detected at John Day Dam would be m_{i4} (the "4" in the subscript is the reason the test is called "Test 1.T4").

Notation for m_{ij} changed in the report to be more consistent with Burnham.

14. Page 19: If the 1.T tests are worth mentioning, why omit 1.R tests?

See the reply to comment 15 below.

15. Page 19: It is suggested that Burnham et al. provided useful tests for "equality of overall recapture for releases R_1 and R_2," but that their suggested testing sequence is not as fine-grained as likelihood ratio tests used in this analysis. In reality, TEST 1 of Burnham et al. (adding the 1.R tests to 1.T presented here) is a series of contingency table tests with 1-to-1 correspondence to the likelihood ratio tests used for model selection in this analysis. For example, the five one-degree-of-freedom tests for the first pair of releases, reported in Table 9a, correspond to TESTs 1.R1, 1.T2, 1.R2, 1.T3, and 1.R3.

Though the hypotheses of the Burnham Test 1's correspond to the likelihood ratio tests (LRT), there is a subtle difference in execution. Burnham Test 1.T2 and the initial likelihood ratio test for each paired release both tested for similar detection rates at the first dam, Rocky Reach. The difference is that Burnham adds the assumption that all parameters downstream are assumed to be equal for the treatment and control releases (Burnham, et al. 1987:p. 66). The likelihood ratio tests do not make this initial assumption, as the collapsing of dimensions in the likelihood may mask potential effects that would only be discernable in the full model. Because of the flexibility and interpretation of LRT's, we recommend discontinuing the use of both Test 1.T's and 1.R's in the future, and rely solely on the likelihood ratio tests.

16. Page 21, Section 4.1, para. 1 line : The Methods section did not refer to an "earthen pond." Is this Pond #4?

Pond #4 is the same as the earthen rearing pond. The report has been modified to reflect the suggested change.

17. Page 21, Section 4.2: What proportion of the 1,103 were released because they were "excess" and what proportion for the other reasons? The first paragraph gives four criteria for exclusion of fish (signs of disease, serious injury, precocity, or grotesque growth abnormalities), and gives the reason for removal that "they did not represent the population of steelhead expected to migrate through Wells Dam in 2000." What is the source of the fish which the PIT-tagged sample is supposed to represent? If it is the other ponds at the hatchery, then surely those ponds have their share of diseased, injured, and precocious fish; some justification is needed for this claim of non-representativeness. The second paragraph gives reasonable justification for removing precocious parr and those with

serious injuries and growth abnormalities, but the fourth criterion–signs of disease is not mentioned.

Approximately 700 steelhead were released because they were in excess of tagging needs. Rational for excluding fish with external signs of disease, injury, precocity and growth abnormalities was added to the final report.

18. Page 23, Table 1: We suggest adding percentages to the sub- and grand total lines for morts, sacrificed, and tags shed.

The suggested change has been made.

19. Page 25, 2nd paragraph: You note that fish size ranged from 198.7 to 207.7 mm. These fish seem comparatively large when compared to other yearling steelhead (and yearling chinook as we tend to expect similar survival rates for these two species). Please provide a comparison to the size range of 'natural' outmigrants at the Wells Dam and discuss how differences may result in higher survival levels.

<u>Mean fork</u> lengths for fish <u>sampled</u> for physiological parameters ranged from 198.7 to 207.7 mm. The range in sizes for fish sampled however was much broader (172 to 240 mm). Fork lengths for the entire population of PIT-tagged steelhead ranged from 127 mm to over 250 mm during the 2000 survival study.

We are unaware of any project survival studies in the Mid-Columbia that have compared the survival of wild and hatchery steelhead.

20. Page 25, Section 4.4, para. 2, last 2 sentences: This seems to say that there was no difference in condition factor between tagged and untagged fish early in the study, but significant differences toward the end. This does not seem indicative of "general decline," but rather a decline that was specific to (or most pronounced for) tagged fish. If condition did decline during the course of the study, is this an expected event and how then would survival later in the season compare to survival earlier in the season? Clarification is needed.

Mean fish condition gradually declined over time for tagged fish (See Appendix D, Figure D3). The observed decline in condition factor was not significant within or between replicate release pairs sampled for physiology. The only significant difference in condition factor was

observed between the control group and fish sampled during the last two treatment sample groups.

The declining trend in fish condition followed the removal of roughly 120,000 fish from Pond #4. These fish were removed for release, by hatchery staff, into tributary streams upstream of Wells Dam. No other significant differences in condition factor were observed either within or between replicate pairs or between tagged and untagged steelhead.

21. Page 25, 3rd paragraph: Please describe the mean smolt and fat indices, particularly the possible range, when presenting the associated estimates (i.e., 4.9 to 5.0 on a scale of what?). Possible ranges of plasma cortisol concentrations and of gill ATPase should also be provided (pages 26 and 27 respectively).

    The range of possible values for mean smolt and mean fat indices has been added to Table 2. A discussion of relative plasma cortisol concentrations and gill ATPase levels can be found in the Discussion.

22. Page 26, para. 1: The lowered fat index for the May 14 group is dramatic. Is there an explanation?

    Typically, the more robust (fat) fish outmigrate from the hatchery ponds first followed in time by increasingly smaller and less robust fish. Roughly 10% of the hatchery population each year residualize within the hatchery rearing ponds. The later two release groups were drawn from the remaining 10-15% of the hatchery production.

23. Page 27, first full para: In our copy of the draft report, there is a passage that appears highlighted, perhaps flagged for later editing when data become available, as HSP70 data are missing from Table 3. If read as-is, the p value ("<0.05") in the highlighted passage appears to be incorrect, as it is referring to a non-significant result ("analysis...found no significant differences").

    Unfortunately, the laboratories at the University of British Columbia and University of Victoria have been, to date, unable to acquire critical enzymes for the processing of the HSP70 samples. As such, we have moved to finalize the report without these results.

24. Pages 28-31, Tables 2 and 3: Graphical presentation of at least some of this information would be useful; perhaps for those variables that showed a trend; condition factor, ATPase, glucose?

A graphical presentation of the trend in fish length, weight, condition factor, fat index, ATPase, plasma cortisol and glucose concentrations was added to the report. These graphs can be found in Appendix D, Page 92.

25. Table 2 gives length data for the sampled fish, but length was measured for all tagged fish. How do the samples compare to the groups as a whole?

Mean fish length was not significantly different between tagged and sampled and tagged and released groups of steelhead. However, the range in size for fish sampled versus fish tagged was different. See response to comment #19 (above).

26. Page 32, para. 1, line 6--"censured" should be "censored". Also, please discussed why the trawl recoveries were pooled with Bonneville. We are assuming that insufficient trawl recoveries were available to estimate the probability of detection at the Bonneville Dam.

Spelling correction has been made.

At the time the analysis was performed, only 473 fish had been detected by the trawl, across the 12 paired releases. Of those, 78 had been previously detected at Bonneville Dam, leaving 395 unique additional detections.

27. Page 32, bullets 1 - 3: If the PIT-tag detectors are located at the dams, are the reach survival estimates calculated for those fish specifically detected at a dam different from the reach survival estimates that include fish not specifically detected at that particular location but at some downstream location? It seems these two different groups could have different survival histories.

If this question is directed to the detections by the trawl and pooled with the Bonneville detections, those fish had to first survive through Bonneville to be detected by the trawl. Including those fish improves the information on survivals to Bonneville, but there is not enough information to extend survival and detection probabilities further downstream. In addition, pooling or not pooling trawl detections with the Bonneville detections has no effect on the estimate of Well's project survival.

28. Page 34, Table 5 and elsewhere-- Are estimates and analyses based on PIT-tag interrogation data up to a certain date, after which a few more detections would be expected to "trickle in?" If so, it should be mentioned in table captions and in the text.

Data for this analysis was downloaded on July 18, 2000, and is noted in the caption for Table 4 (Complete detection history for each release group), and the Methods Section 3.7 (page 10).

29. Page 36, para. 1, line 1: What is meant by "convenient?"

In this case, convenient refers to the most straightforward test.

30. Page 36, para. 1: Is there any way to improve the mixing at Rocky Reach Dam? Should the 5-hour difference between release times be adjusted? Is there an important fish behavior or project operation at Rocky Reach Dam that would cause non-mixed groups of fish arriving at the dam to become mixed below the dam?

The 5-hour release delay allows fish from both treatment and control groups to be collected, tagged and held for recovery at the same time and place. This cadence allows fish to be randomly assigned to treatment and control groups and reduces the potential of systematic sampling bias.

31. Page 38: The methods used to test handling effects should be given in the Methods section, including the nature of the statistical test employed. Tables B7 and B8 cannot be understood without an explanation of the methods and rationale for the test.

The suggested change has been incorporated into the final report.

32. Page 43: Section 4.6.2-- Table 9 seems to indicate that only 2 pairs (#2 and #11) had homogeneous parameters beginning with detection probability at Rocky Reach Dam. Release pair 12 appears to have the same model selected as release pair 1. The model for pairs 2 and 11 is identified as the "Ricker Model," but this is not quite accurate (see next comment).

Descriptions of final models have been corrected. "Ricker Model" has been changed to "most parsimonious model".

33. Page 49, Table 11: (This is not so much an editorial comment, but perhaps the seed for further discussion on methodology for paired-release studies such as this one. We are involved in similar studies and are consequently interested in such discussion): In attempting to replicate the analysis, we derived survival estimates that differed slightly from those in Table 11. Several explanations are possible: (1) the nature of PIT-tag analysis, where independent analyses rarely give precisely the same result;(2) slight differences in selected models; (3) PIT-tag data retrieved from PTAGIS in January 2001 vs. fall 2000. In any case, differences in survival estimates were small and not important.

However, there were two pairs for which the standard errors were substantially different, and these had an effect on the weighted average. The two pairs were 2 and 11, for which the "Ricker Model" was selected. Strictly speaking, the Ricker, or relative-recovery model, is a 2-parameter model: the Wells project survival estimate is derived from the ratio of the two recovery proportions. The model reported in Table 11 has 8 parameters (separate survival estimates for the two groups to Rocky Reach Dam, common detection probabilities at Rocky Reach, McNary, and John Day Dams, common survival probabilities to McNary and John Day Dams, and common survival/detection at Bonneville Dam). Consequently, the Wells Project survival probability is estimated with less precision than in the true relative-recovery model.

In the case of the 2000 Wells Project survival study, using the 2-parameter model for pairs 2 and 11 instead of the 8-parameter one reduces the weighted average estimate by about 1% (our result was 0.933). However, there are other models used for individual pairs in Table 11 that could have their parameter number reduced: for pairs 3 through 10 we really need only 5 parameters instead of 9, for instance. The general question is this: if our focus is on survival of the two groups in the first reach, should we use the model with the fewest parameters possible to increase the precision of each estimate?

We choose to use the full model, versus a collapsed model with less estimated parameters, for several reasons:

1. **The fuller model is consistent with the analytic approach given in Burnham et al.**
2. **The analysis strategy is consistent with the pre-project analysis plan (Skalski 2000). We consider it essential that the analysis follow the *a priori* analysis plan to remain objective and not be accused of finding an analysis to conform to the desired results. Different modeling approaches are guaranteed to produce slightly different results.**
3. **The analysis of the 2000 data is consistent with the prior analyses in 1998 and 1999.**
4. **The Ricker Model is the least robust to the violations of equal downstream parameters. The resulting variance estimate may be a poor characterization of the MSE (i.e. variance + bias^2). As such, the most biased estimates may also have the greatest weights under your proposed strategy.**

34. Page 54, 1st paragraph last sentence: How do you know that higher detection rates at Rocky Reach stemmed from technical improvements in PIT-tag interrogation capabilities rather than differences in operation of the bypass facility?

In 1999 we estimated a mean detection probability for Surface Collector No. 2 (SC2) of 0.250 ($\hat{SE}$ = 0.009). SC1 was not equipped with compatible PIT-tag detectors in 1999. In 2000 we estimated a mean detection probability of 0.587 ($\hat{SE}$ = 0.009) with both SC1 and SC2 covered by ISO PIT-tag detectors. Radio-tag and PIT-tag releases conducted by Chelan PUD in 1999 and 2000 indicated nearly equal detection probabilities between the two surface collectors.

35. Page 54 2nd paragraph: If survival from the Methow River to the Rocky Reach tailrace is 92.5% as reported, and survival from the Wells tailrace to the Rocky Reach tailrace is 96.7%, it seems survival from the Methow River to the Wells tailrace should be 95.7% as opposed to the 94.6% calculated in the report. Is this just a rounding error?

The ration of the weighted averages is 95.7% which is not the same as a weighted average of ratios. The weighted average of the ratios provides the same estimate as the reported survival estimate (94.65%) for fish traveling from the Methow River to the Wells tailrace.

Again, thank you for the opportunity to review this report. If you have any questions regarding these comments, please contact Bob Dach of my staff at (503) 736-4734.

Sincerely,

Bryan D. Nordlund, Chief
FERC and Water Diversions Branch

cc: MCCC

Appendix N

Assessment of Adult Steelhead Migration through the Mid-Columbia River using Radio-Telemetry Techniques, 1999 – 2000.

Assessment of Adult Steelhead Migration through the Mid-Columbia River using Radio-Telemetry Techniques, 1999-2000

by

Karl K. English, Cezary Sliwinski, Bryan Nass,[1] and John R. Stevenson[2]

prepared for

Public Utility District No. 2 of Grant County
P.O. Box 878, Ephrata, WA 98823

Public Utility District No. 1 of Chelan County
P.O. Box 1231, Wenatchee, WA 98807-1231

Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway, East Wenatchee, WA 98802-4497

5 January 2001

1 LGL Limited environmental research associates, 9768 Second Street, Sidney, BC V8L 3Y8

2 BioAnalysts Inc., 7981 168th Avenue N.E., Redmond, WA 98052

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ABSTRACT

Radio-tagged adult steelhead were monitored using radio-telemetry technology to assess passage over five mid-Columbia dams (Priest Rapids, Wanapum, Rock Island, Rocky Reach, Wells) and to spawning locations.

Detections of radio-tagged adult steelhead at fixed stations located in the Hanford Reach, at each dam and in major mid-Columbia tributaries were used to estimate passage times and fallback rates. Fifty-seven fixed-station receivers were deployed at strategic locations to detect and automatically record upstream movements of radio-tagged fish at or below dams and within tributaries. Eleven sets of aerial surveys were conducted to determine the spawning distribution and fates for the radio-tagged steelhead.

Of the 395 radio-tagged steelhead released near Vernita Bridge in 1999, 353 (89%) were detected at Priest Rapids, 328 (83%) at Wanapum, 309 (78%) at Rock Island, 229 (58%) at Rocky Reach, and 195 (49%) at Wells. Of the radio-tagged steelhead detected in the vicinity of Priest Rapids Dam, 94.4% were either tracked to known spawning areas or successfully passed and remained above Priest Rapids Dam. Comparable percentages for the other dams were: 95.3% for Wanapum Dam, 94.3% for Rock Island Dam, 93.3% for Rocky Reach Dam, and 93.2% for Wells Dam. These are not survival estimates since we do not know the ultimate fate (i.e., the survival or mortality) of the fish that were radio-tagged. Even data that shows that a tag is stationary is not conclusive since the fish could regurgitate their tags.

The median migration rate between the dams on the Columbia River was: 33.7 km/d between Priest Rapids and Wanapum, 32.6 km/d between Wanapum and Rock Island, 36.7 km/d between Rock Island and Rocky Reach, and 36.3 km/d between Rocky Reach and Wells Dam. Project passage times and migration times through the reservoirs were similar to those observed for radio-tagged steelhead tracked on the mid-Columbia River in 1997. The median migration speed from the Priest Rapids tailrace to the Wells Dam fishway exits was 20.1 km/d and this migration speed exceeded those estimated for radio-tagged steelhead tracked on the Skeena and Fraser rivers in British Columbia.

The fallback rates for steelhead were similar for all dams. Approximately, 10% of the fish that passed a dam fell back (range 7-12%). The 25 involuntary fallbacks detected for all dams combined represented 2% of the unique dam passage events and all of the involuntary fallbacks were hatchery fish. On average 5% of the unique fish passage events were classified as "voluntary" fallbacks (range 3-7% for the different dams) and 3% were classified as re-ascents (range 1-6%). An examination of the fates for all fallbacks revealed that 62% of the radio-tagged steelhead that fell back at a dam were either tracked to known spawning areas or successfully passed and remained above the fallback dam (57% for hatchery fish and 100% for "wild" fish). At Priest Rapids and Wanapum dams, the largest single fallback route was via the power house

(50%), followed by the sluice (35-42%) and the spillway (8-15%). Most of the fallbacks at each project occurred during non-spill periods.

Median Project passage time for non-fallback steelhead at dams without ladder trapping activity were 0.33 d for Wanapum Dam, 0.18 d for Rock Island Dam, and 0.53 d for Rocky Reach Dam, respectively. The median Project passage time for the two dams with ladder trapping activity were 0.84 d for Priest Rapids Dam and 0.69 for Wells Dam. Entrance passage times represented 50-85% for the project passage time for steelhead at Priest Rapids and Rocky Reach dams and generally less than 50% of the project passage time at the other dams. Fishway passage times were generally less than 30% of the total Project passage time and fairly consistent both within and between projects. Median Fishway passage times ranged from 1.2 h to 2.54 h over all projects.

At Priest Rapids and Wells dams, upper fishway passage times for steelhead that passed during a trapping interval were significantly longer than those for a no trapping interval. Upper fishway passage times at Wells Dam were 2-5 times longer for trapping intervals than for non-trapping intervals. Trapping also had a substantial effect on the project passage times at Wells Dam. The median Project passage times during trapping intervals were close to 35 h for both fishways compared to 12 h during no trapping intervals. The effect of trapping on project passage times at Priest Rapids Dam was much smaller (24 h during trapping and 20 h during no trapping intervals).

For fishways with junction pools, the median passage time for the junction pools, after the last detection in an entrance zone, was very short (0.017-0.081 h or 1-5 min.). The passage time for the counting stations ranged from 10 to 24 min. for the Rock Island fishways to less than a minute for the Rocky Reach fishway. The most frequently used fishway entrance at Rock Reach was the spillway entrance; however, the net movements through this entrance was negative. At Wells Dam, no significant differences were detected in the Project or Entrance passage times between periods when the side gates were open and periods when these gates were closed. Fishway passage times for the right-bank fishway were significantly different for the two gate configurations, but the difference was small (1.9 h vs 2.3 h).

Of the 395 steelhead tagged, 2 were never tracked and 13 (3.3%) were known to have been caught and removed prior to spawning. Of the remaining 380 steelhead available for spawning, 308 (81.1%) were tracked to known spawning areas prior to or during the spawning period, and 72 (18.8%) were not assigned to a known spawning area because they were last tracked on the mid-Columbia River between Coyote Rapids and Wells Dam prior to the kelting period. Of the 72 mainstem fish, 22 were classified as stationary and the others were either tracked as kelts or not detected during the last two aerial surveys.

Of the radio-tagged steelhead that fell back at a dam, 62% were either tracked to known spawning areas or successfully passed and remained above the fallback dam (57% for hatchery fish and 100% for "wild" fish).

Of the radio-tagged steelhead assigned to a tributary stock, 22% were tracked upstream of their spawning destination. Straying rates for Wenatchee, Entiat and Methow hatchery releases were estimated to be 15-18%.

Of the radio-tagged steelhead released below Priest Rapids Dam, 91.6% were tracked upstream of Priest Rapids Dam or in a known spawning area. This level of tracking and upstream migration success was higher than the four estimates for summer run steelhead returning to the Skeena River and comparable to the high rates observed for fall and winter/spring run steelhead returning to the Fraser and Bella Coola rivers in British Columbia.

Another comparison that can be made with other steelhead radio-telemetry studies is the portion tracked as kelts. Of the radio-tagged steelhead at large, 34% were tracked as kelts, and this value is similar to the minimum kelting rates for Skeena summer-run steelhead. The actual kelting rate for the mid-Columbia steelhead that spawned in 2000 is certainly higher than the minimum value of 34% and possibly as high as 69%. The maximum kelting rate for specific stocks ranged from 65% to 80%.

INTRODUCTION

Salmon bound for spawning grounds in the upper Columbia basin must migrate up the Columbia River passed nine hydro-electric dams. Fishways have been built on each dam below Chief Joseph Dam to facilitate the passage of salmon. This report presents the results of efforts to track radio-tagged steelhead along the Columbia River and its tributaries between Hanford Reach and Chief Joseph Dam from the beginning of July 1999 to the end of December 1999. The data required to assess the above objectives was acquired through the application of radio tags to summer steelhead captured at Priest Rapids Dam, and the subsequent tracking of radio-tagged fish as they approached and passed each dam. As part of a joint adult passage study being conducted by Public District No. 2 of Grant County (GCPUD), Public District No. 1 of Chelan County (CCPUD), and Public District No. 1 of Douglas County (DCPUD), 395 summer steelhead were radio-tagged and released back into the Columbia River. Summer-run steelhead typically arrive at Priest Rapids Dam the second week of July and the upstream migration continues into October (Larry Brown, Washington Department of Fish and Wildlife (WDFW), Wenatchee, WA, pers. comm).

The following objectives of the 1999 study were common at Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams:

1) to determine the total project passage time for all radio-tagged steelhead;
2) to determine the amount of time adult steelhead spend in the tailrace, fishway entrances, and fishways during their migration;
3) to compare the passage time estimates for the different fish ladders;
4) to determine the proportion of steelhead that fall back; and
5) to compare the fallback rates during spill operations to those during non-spill operations.

Additional common objectives were set for the whole study area:

6) to determine the passage times through the reservoirs;
7) to determine the holding/spawning area for all radio-tagged steelhead; and
8) to assess the extent to which adult steelhead use tributaries to the Columbia River.

Unique objectives (specific for a Public Utility District (PUD) or a dam were as follows:

at Priest Rapids and Wanapum dams:

9) to determine the proportion of the fallback fish that fell back via the spillway or sluice;

at Priest Rapids and Wells dams:

10) to compare the passage time estimates for fish that passed during trapping intervals and the passage times for fish that passed during periods when no trapping was conducted;

at Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams:

11) to determine the amount of time fish spend in the junction pools;

at Rock Island and Rocky Reach dams:

12) to determine the amount of time fish spend in the counting station;

at Rocky Reach:

13) to determine the number of radio-tagged steelhead that used each fishway entrance;

at Wells:

14) to observe and compare the project passage times for steelhead in regards to modified operations of fishway entrances.

Study Area

The study area for this project included the Columbia River from White Bluffs located at river kilometer (Rkm) 601.7 to Chief Joseph Dam at Rkm 877.1, and the tributaries of Crab Creek, Wenatchee River, Entiat River, Methow River, and the Okanogan River. Within this stretch of the Columbia lies Priest Rapids Dam (Rkm 638.9), Wanapum Dam (Rkm 669.0), Rock Island Dam (Rkm 729.5), Rocky Reach Dam (Rkm 762.2) and Wells Dam (Rkm 829.6; Figure 1). In addition, data collected at Hanford Reach (the Columbia River) and Ice Harbour Dam on the Snake River (Chris Peery, University of Idaho, Moscow, ID, pers. comm) were incorporated into the analysis to track radio-tagged fish which had left the primary study area.

Fishways have been built on each dam to facilitate the passage of salmon. There are two fishways at Priest Rapids Dam. The left-bank fishway has two entrances; a main entrance at the east end of the powerhouse, and a series of collection channel entrances along the downstream face of the powerhouse. The right-bank fishway has a single entrance and is adjacent to the spillway. There are two fishways at Wanapum Dam; the right-bank fishway adjacent to the spillway and the left-bank fishway located near the powerhouse. Priest and Wanapum dams are operated by GCPUD. At Rock Island Dam there are three fishways; the right-bank fishway consisting of four entrances, the center fishway that has two entrances, and the left-bank fishway with one entrance. There is one fishway at Rocky Reach that has four entrances, and a series of collection channel entrances along the downstream face of the Powerhouse. Rock Island and Rocky Reach dams are operated by CCPUD. There are two fishways at Wells Dam, the right- and left-bank fishway, each having two entrances. Douglas County Public Utility District (DCPUD) operates this dam.

METHODS

Study Design

A total of 400 adult summer steelhead were scheduled to be radio-tagged at Priest Rapids Dam over the historical period of migration (July - October) to provide a tagging rate of approximately 5.7% on an estimated run of 7,000 fish. Based on historical passage rates, the estimated number of radio-tagged steelhead to pass each dam were 335 at Priest Rapids, 326 at Wanapum, 298 at Rock Island, 205 at Rocky Reach, and 163 at Wells. Data from fixed station receivers and mobile tracking were used to monitor the movements and numbers of adult steelhead in the mid-Columbia River area and its tributaries. Passage times and indices were determined for each dam and holding and spawning locations were determined according to movement history within 1999.

The passage of radio-tagged fish detected at Priest Rapids and Wanapum dams was determined by combining detection data collected using antenna arrays in the tailrace, fishway entrances, and fishway exits. Aerial antennas were used to monitor the tailrace and forebay of each dam, and a network of underwater bared coax antennas were used at the entrances (including the collection channels) and exits of each fishway. Underwater dipole antennas were used in the forebay at each slouceway to detect radio-tagged fish falling back over the dam through this route. Remote fixed station arrays were also maintained at Coyote Rapids (island) to detect radio-tagged fish moving downstream of the release site, and at Crab Creek to monitor any use of this system.

At Rock Island and Rocky Reach dams the passage of radio-tagged fish was determined by combining detection data collected using antenna arrays in the tailrace, fishway entrances, and fishway exits. Aerial antennas were used to monitor the tailrace of each dam, and a network of underwater antennas were used at the entrances and exits of each fishway. Remote fixed station arrays were also maintained near the town of Monitor (Wenatchee River), Tumwater Dam, and Entiat River.

At Wells the passage of radio-tagged fish was determined by combining detection data collected using antenna arrays in the tailrace, fishway entrances, fishway trapping areas, and fishway exits. Unique tags detected at the dam were identified and classified according to their presence in the tailrace, fishway entrances, and fishway exits. For the gate configuration analysis, main gate and side gate configuration modifications were implemented in both fishways. Control and Treatment operations of the fishways were alternated over the study period. In-season, a complete trial was designated as one calender week or the period of time over which a minimum of five fish exited the dam. Changes in gate orientation were implemented at 0000 hours on Sundays by Wells Dam operators. The east and west ladders were operated simultaneously with respect to gate changes and trial periods. Trial periods were typically 1 or 2 wk in length; however, longer periods occurred to allow the necessary number of radio-tagged fish to pass the dam. Remote fixed station arrays were also maintained at the Methow River, Okanogan River (mouth), Okanogan River (Zosel Dam), and the Wells Hatchery channel.

Tag Application

Tagging operations were carried out at the left bank exit trap of Priest Rapids Dam in accordance with protocols established in the Section 10 permit held by WDFW. On Tuesday and Thursday of each week between the week ending July 17 and Oct 9, all fish were directed through the trap for sorting and sampling. Healthy adult steelhead were netted from the trap and placed in an anaesthetic tank (tricaine methane sulfonate, MS-222) for biological sampling. Steelhead were measured for length, checked for external marks, sexed, and sampled for scales. Steelhead were then transferred via a watered PVC pipe to a freshwater bin where they were radio-tagged with Lotek MCFT-3A tags (16x51mm, 400d). Radio tags applied to summer steelhead at Priest Rapids Dam were spread across seven channels or frequencies (channels 12-14, and 20-23; 149. MHz) with approximately 60 codes on each channel. Radio tags were applied approximately in proportion to the run passed Priest Rapids Dam. Tagged steelhead were then placed in a sanctuary boot and hoisted up a watered PVC pipe where they were subsequently released into a fish transport truck. Radio-tagged fish were held in a freshwater circulated tank equipped with oxygen until being transported and released back into the Columbia River at a location approximately 12.7 km downstream of Priest Rapids Dam (Vernita Bridge boat launch). A maximum of eight radio-tagged steelhead were held in the transport truck at any time and were held for no longer than 5 h. Water temperature and oxygen concentration was monitored regularly in the fishway, sampling bin, tagging bin, transport truck, and the Columbia River at the release site to ensure appropriate conditions for tagging, transport and release.

Tracking Equipment

Telemetry Receivers

The radio-tag receiver used during this study was the SRX_400 built by LOTEK Engineering Inc. of Newmarket, ON, with their CODE_LOG version W16 data processing and storage program. Underwater antennas at all dams were monitored with an SRX and the Lotek digital spectrum processors (model DSP 500). The aerial systems were monitored with the SRX and yagi antennas (3, 4, 6, or 9 element depending on location). Ten SRX units were deployed at each of Priest and Wanapum dams (including tailrace). Two SRX units were deployed at Grant County remote sites, and one receiver was used during tagging (a total of 24 SRX and 5 DSP). Nine SRX were deployed at Rock Island and 8 at Rocky Reach. Four SRX units were deployed at Chelan County remote sites (a total of 21 SRX and 11 DSP). Seven SRX units were deployed at Wells Dam/Hatchery and four units were used at Douglas County remote sites (a total of 11 SRX and 4 DSP). All receivers and DSP units were powered with 12-v RV batteries. Where AC power was available, the batteries were continually recharged with two amp battery chargers. At locations where AC power was not available, the telemetry systems were powered in one of two ways: 1) 75-w solar panels to continually recharge the 12-v batteries; or 2) 12-v batteries were used without a recharging system, and were simply replaced with a recharged battery whenever necessary.

Antennas

At Priest Rapids and Wanapum, underwater antennas (bared coax) were located at the right- and left-bank fishway entrance and exit, and left collection channel. Two dipole antennas were mounted in the sluiceway at each dam. Yagi antennas were used on the spillway and powerhouse forebay (3- or 4-element), and in the tailrace (6- or 9-element). The Coyote Rapids site used four 6-element antennas to cover the river channel on both sides of the island (upstream and downstream). The Crab Creek site used two 3-element antennas to point upstream and downstream.

During the 1999 radio-telemetry study, we monitored the adult fishways at Rock Island and Rocky Reach dams, as well as two tributaries (the Wenatchee and Entiat rivers) using various antenna configurations. Within the tailrace areas at both dams, we used 6-element aerial Yagi antennas. Within the fishways at the projects, we used a combination of bared coax and dipole underwater antennas. For the bared coax antennas, the outer insulation, the braided shielding, and the inner insulation were stripped away to expose the center strands of the coax. The amount of material stripped away was equal to one wavelength under water, which is equal to approximately 9". We applied shrink wrap to the last 11" of the antenna. The dipole antennas used at the projects were developed by Grant Systems Engineering of Newmarket, ON. These antennas were used to improve detection range, as well as to withstand areas of high turbulence.

For a detailed description of the dipole antennas, see Stevenson et al. 1997. At the tributary monitoring sites, we used 4-element Yagi aerial antennas at the three shore-based receiver stations, and bared coax underwater antennas at the Tumwater Dam fishway. The following section provides a detailed description of how each monitoring site was configured.

Fish movements below Wells Dam were detected using twin 9-element Yagi antennas stationed 1.2 km below the project. Movements in the Wells fishways were monitored using underwater dipole antennas. DSP units were used at fishway locations in combination with the SRX_400 and an antenna switcher. Non-DSP receiver sites used normal frequency scanning modes for monitoring. One site monitored radio-tagged fish that entered or exited the tailrace, five sites monitored left and right ladder entrances, below trap, trap, above trap and exits, and one site monitored the entrance channel at Wells Hatchery. The Wells Hatchery channel site was moved from the entrance of the volunteer trap, to the mouth of the channel to monitor steelhead holding in the hatchery cove. Remote station sites all used twin 4-element antennas to point upstream and downstream.

System Tuning

At all sites, both aerial and underwater antenna systems were tuned so that each antenna within a specified or adjacent zone provided comparable signal strengths for tagged fish at a given depth and distance relative to one another. This was accomplished by transmitting a signal of known strength through each antenna system and amplifying and attenuating accordingly. By doing so, this allowed us to accurately determine fish location based on signal strength when the transmitter was detected by more than one antenna at any given time.

System Configuration

<u>Coyote Rapids Site</u>

This site was located approximately 22.1 km downstream of Priest Rapids Dam on an island (Figure 2). Four 6-element Yagi antennas were mounted on a tower at an elevation of approximately 8 m, a total of approximately 15 m off the surface of the water (zone 1). Antennas were pointed upstream and downstream, and were monitored with a single SRX receiver.

<u>Priest Rapids Dam</u>

<u>Tailrace</u> - We monitored the tailrace of Priest Rapids Dam with a total of four 9-element aerial Yagi antennas (zones 2 and 3). The four tailrace antennas were located approximately approximately 1.2 km downstream of the dam (two antennas on the left bank and antennas and two antennas on the right bank (Figure 2). This setup was consistent with previous years of

study. At both sites, each antenna was monitored individually, with one pointing downstream and the other upstream. The antennas at each site were monitored with a single SRX system.

Collection Channel - The adult collection channel at Priest Rapids Dam is located on the downstream side of the powerhouse, and extends the full length of that structure. The channel has a total of 18 orifice gates (OG) that can either be opened or closed to permit entrance by adult salmonids migrating upriver (Figure 2). During the study period, even numbered gates (i.e., 2, 4, 6, 8, 10, 12, 14, 16, and 18; zone 4) were opened to allow adult passage, all other gates were closed. In addition to the orifice gates, the transport channel has three entrances (defined as left entrance weirs; LEW) located at the west end to permit entrance of adult fish (LEW1, LEW2 and LEW3). Of those entrances, only LEW2 was open during the study period. Stripped coax antennas were deployed to monitor the main entrance, the channel between opened orifice gates, and several points within the collection channel. Collectively, these antennas were monitored with two SRX/DSP systems.

Bifurcation Pool and Left Bank Ladder - As fish enter the collection channel, they travel toward the east shore along the powerhouse, and ultimately enter the bifurcation pool (zones 5 and 7) which is the beginning of the left-bank transport channel and fish ladder (Figure 2). In addition to the collection channel, the bifurcation pool has two additional entrances that fish can enter the left-bank ladder (LEW4-5 and LEW6-7). Of these, only LEW4-5 were open during the study period. Our objective at this location was to identify the passage route through the left-bank ladder. To accomplish this objective, we deployed underwater antennas (zone 6) immediately inside the entrance of LEW4-5, and within the bifurcation pool approximately 15 m above the entrance. The placement of the second antenna allowed us to monitor fish as they entered from either the collection channel or from LEW4-5.

As fish began their ascent of the left-bank ladder, they passed through the bifurcation pool and entered the left-bank ladder transport channel. This channel travels south for approximately 100 m before making a 180 degree turn and traveling north (Figure 2). Within this channel we deployed two underwater antennas to assess migrational time through this area and to determine the time at which radio-tagged fish began their ascent. The first antenna was located at the entrance of the transport channel, and the second approximately 30 m upstream of the bifurcation pool. The antennas at this location were monitored by a single SRX/DSP system.

The left-bank fish ladder consists of a series of pools separated by weirs which allow fish passage through either submerged orifices or over the top of the weir. Near the top of the ladder, this configuration changes to weirs which permit only submerged passage. To assess passage time through the section at the top of the ladder (as well as through the entire fishway), we deployed two underwater antennas below the adult trap (zone 8), and three antennas at the exit (zone 9; at different depths and then combined). The antennas at this location were monitored by a single SRX/DSP system.

Right-bank Fish Ladder - At the right-bank fish ladder, we monitored both the ladder entrance and exit. The right-bank fishway entrance (RFE) has three entrances defined as right entrance weirs - REW1, REW2, and REW3 (Figure 2). REW3 was closed during the duration of the study. At the right-bank fishway entrance, we deployed three underwater antennas, two immediately inside of the ladder entrance (zone 10), and a third approximately 75 m above the entrance (upstream of the first bend in the ladder, zone 11). At the ladder exit, we deployed three underwater antennas at the exit (zone 12), and one in each of the two upper weirs before the fish exits the ladder. At both sites, the antennas were monitored by an SRX/DSP system.

Forebay - Aerial antennas were deployed in front of the powerhouse and spillway to track movements in the forebay (Figure 2). Antennas (3-element yagi) were spaced one every turbine unit on the powerhouse, and one every two spillbays on the spillway (zones 13, 14, and 15). The spillway and powerhouse arrays were each monitored by an SRX system.

Crab Creek Site

This site was located approximately 8 km downstream of Wanapum Dam and 3 km upstream of the confluence with the Columbia (Figure 3). Two 3-element Yagi antennas were mounted on a tripod at an elevation of approximately 5 m (a total of approximately 15 m off the surface of the water). Antennas were pointed upstream and downstream (zone 16 and 17), and were monitored with a single SRX receiver.

Wanapum Dam

Tailrace - We monitored the tailrace of Wanapum Dam with a total of four 6-element aerial Yagi antennas. The four tailrace antennas were located approximately 1.2 km downstream of the dam (two antennas on the left bank (zone 100) and antennas and two antennas on the right bank (zone 101), Figure 3. This setup was consistent with previous years of study. At both sites, each antenna was monitored individually, with one pointing downstream and the other upstream. The antennas at each site were monitored with a single SRX system.

Collection Channel - The adult collection channel at Wanapum Dam is located on the downstream side of the powerhouse, and extends the full length of that structure. The channel has a total of 20 orifice gates that can either be opened or closed to permit entrance by adult salmonids migrating upriver (Figure 3). During the study period, odd numbered gates (i.e., 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19) were opened to allow adult passage, all other gates were closed. In addition to the orifice gates, the transport channel has two entrances (defined as side entrance weirs; SE) located at the west end to permit entrance of adult fish (SE3, SE4). Of those entrances, only SE4 was open during the study period. Stripped coax antennas were deployed to monitor the main entrance, the channel between opened orifice gates, and several points within the collection channel (zone 102). Collectively, these antennas were monitored with two SRX/DSP systems.

Bifurcation Pool and Left Bank Ladder - As fish enter the collection channel, they travel toward the east shore along the powerhouse, and ultimately enter the bifurcation pool which is the beginning of the left-bank transport channel and fish ladder (Figure 3). In addition to the collection channel, the bifurcation pool has two additional entrances that fish can enter the left-bank ladder (SE1 and SE2). Of these, only SE2 were open during the study period. Our objective at this location was to identify the passage route through the left-bank ladder. To accomplish this objective, we deployed underwater antennas immediately inside the entrance of SE1 (zone 103), and within the bifurcation pool approximately 15 m above the entrance (zone 104). The placement of the second antenna allowed us to monitor fish as they entered from either the collection channel or from SE2. In addition, two underwater antennas were deployed at the exit (at different depths; zone 105). The antennas in the bifurcation pool were monitored by one of the SRX/DSP systems used for the collection channel. The exit was monitored with a single SRX/DSP system.

Right-bank Fish Ladder - At the right-bank fish ladder, we monitored both the ladder entrance and exit. The right-bank fishway has three entrances defined as right entrance weirs (REW1, REW2, and REW3 (Figure 3). REW2 and 3 were closed during the duration of the study. At the right-bank fishway entrance, we deployed a total of three underwater antennas, two immediately inside of the ladder entrance zone (106), and a third at the second corner of the ladder (zone 107, directly across from the entrance). At the ladder exit, we deployed three underwater antennas at the exit, and one in each of the two upper weirs before the fish exits the ladder (zone 108). At both sites, the antennas were monitored by an SRX/DSP system.

Forebay - Aerial antennas were deployed along the front of the powerhouse and spillway to track movements in the forebay (zones 109, 110, and 111). Antennas (3-element yagi) were spaced one every turbine unit on the powerhouse, and one every spillway on the spillway (Figure 3). The spillway and powerhouse arrays were each monitored by an SRX system.

Rock Island Dam

Tailrace - Within the tailrace of Rock Island, we deployed two 6-element Yagi aerial antennas in order to detect fish as they approached the project (Figure 4). These antennas were located on the west shore approximately 300 m below the dam (zone 200). To improve coverage at this site, one antenna was aimed upstream at a 40-degree angle to the shoreline, and the second antenna was aimed downstream, also at a 40-degree angle to the shoreline. Site selection was determined by two factors: 1) the width of the river; and 2) the amount of electrical noise at the site. Based on empirical and mathematical data, the site encountered acceptable levels of electrical background noise, and allowed detection of tagged fish on the opposite shore at a depth of approximately 6 m.

Left-bank Ladder - At Rock Island Dam there are a total of three adult fishway ladders, the left (left bank, eastern side of project), center (spillway), and right (right bank, western side of project) ladders (Figure 4). In each of the ladders, we deployed antenna systems to monitor the entrance and exits, as well as the areas that presented potential for passage delay. The left-bank fishway is located along the east shore, near powerhouse 1. At the downstream end of the left ladder, we deployed a total of three antennas. The first antenna was located outside the entrance (LME) of the ladder (zone 201), and detected fish that were approaching the ladder entrance. The second antenna was located approximately 12 m inside of the entrance (zone 202), and provided information on whether fish that entered the ladder held immediately inside of the entrance for any length of time. The third antenna was located at the upstream end of the transport channel leading to the fish ladder (zone 203), immediately below the first weir of the ladder. This antenna was approximately 75 m inside of the ladder entrance and provided information on whether there was any migrational delay associated with the lower ladder.

At the upper end of the left ladder, we deployed a total of four antennas. The first antenna moving upstream was located at the first bend fish encountered as they moved through the ladder system (zone 204; Figure 4). Within this weir, a diffuser provided additional flow to the ladder. The placement of an antenna at this site provided information on the effects of that diffuser. A second antenna was located approximately halfway between the diffuser weir and the ladder exit (zone 205). This antenna provided information regarding migration rate between the diffuser weir and the ladder exit. The third and fourth antennas were located near the viewing window (zone 206), and immediately inside of the trash rack at the ladder exit, respectively.

Center Ladder - As with the left ladder, we deployed two systems within the center (spillway) fishway, one at the ladder entrance, and the other at the exit (Figure 4). The center fishway at Rock Island has a total of two ladder entrances, the main and side entrances (CME and CSE). The side entrance is located on the west side of the transport channel approximately 15 m upstream of the main entrance. Antennas were deployed both inside and outside of the main ladder entrance (zones 207 and 208). The side entrance had only one antenna located on the inside (zone 210). The outside antenna was not installed due to debris accumulating at this location. Inside antennas were located approximately 5 m upstream of each entrance. The fifth antenna monitoring the lower portion of the center ladder was located immediately below the first weir of the fish ladder, approximately 50 m upstream of the main entrance (zone 211). This antenna provided migrational timing of fish to the point they began to encounter the ladder weirs.

At the upstream end of the fishway, we deployed a total of five antennas. The first antenna encountered by fish as they moved upstream was located in a weir where a diffuser was installed. This antenna provided information regarding behavior of fish as they encountered the diffuser. The second and third antennas were deployed in weirs approximately halfway between the diffuser and the ladder exit. These antennas provided information on passage time of fish between the diffuser and the exit. A fourth antenna was deployed within the last weir of the ladder, which was located at the fish viewing facility (zone 212). This antenna, in combination with the antenna outside of the ladder exit (zone 213), provided information on behavior of fish as they exited the ladder system.

Right-bank Ladder - The right ladder at Rock Island Dam, located on the western side of the project, has a total of four ladder entrances; the powerhouse (zones 214 and 215 at RPE), center (zones 217 and 218 at RCE), side (zones 219 and 220 at RSE), and main entrance (zones 221 and 222 at RME). All four entrances lead to the junction pool, which is the area immediately below the adult fishway (Figure 4). To enumerate passage through each of the four entrances, as well as migrational timing through the system, we monitored each entrance (both outside and immediately inside of the entrance), the junction pool, as well as the lower ladder. At the powerhouse entrance, we installed one antenna outside the ladder entrance and a second antenna approximately 10 m inside the entrance (zone 216) within the transport channel. The third antenna was located at the upper end of the transport channel, approximately 10 m below the junction pool. The middle entrance leads directly into the junction pool; therefore, we monitored the area immediately outside of the entrance, as well as approximately 5 m inside of the entrance. The main ladder entrance is located near the west shore, and is the furthest downstream of all of the right ladder entrances. Fish that entered at this site travelled through a transport channel approximately 50 m in length, at which point it connects to the junction pool (zone 225). Approximately 20 m from the main entrance, a side entrance provides an opportunity for adult salmonids to enter the transport channel. For both the main and side entrances, we monitored both in and outside of the entrance. These antennas provided data on behavior of fish moving through the entrances, as well as information regarding passage through the transport channel.

Since fish leaving the junction pool and travelling toward the fish ladder had two possible routes of travel (either up the ladder or downstream through the transport channel leading to the main and side entrances), we deployed two antennas to assess their behavior. One antenna was deployed in each channel to determine which route fish took (zone 224 and 225). An additional antenna was located within the fish ladder, approximately 35 m upstream of the junction pool (zone 223). This antenna provided information on fish as they began their ascent of the fish ladder.

As with the other fishways at Rock Island Dam, we monitored the ladder exit of the right fish ladder. Within this area, we deployed a total of four antennas. The first antenna was located within the first weir downstream of the powerhouse roadway. The location of this antenna provided information on whether fish were reluctant to pass underneath the roadway or not (zone 226). The second antenna was located in the fish viewing weir, immediately upstream of the roadway, and provided migrational timing from one side of the roadway to the other. The third antenna was located within the transport channel that leads from the last weir in the ladder system to the exit (zone 227). This antenna provided data which allowed us to partition migrational timing through the transport channel. The fourth antenna was located outside of the ladder trash rack, and provided total migration time of fish through the right ladder system (zone 228).

Wenatchee River

Sampling efforts on the Wenatchee River consisted of two monitoring sites, the Monitor site (City of Monitor, located at Kenneth Blacks property, Rkm 8.7), and Tumwater Dam (Rkm 49.4). At the Monitor site (Figure 4), two 4-element aerial Yagi antennas were combined together and later separated into two antennas (zone 229 and 240). As with other aerial antennas systems, one antenna was aimed downstream at a 40 degree angle to the shoreline and the second aimed upstream at the same angle. The second Wenatchee River site was located at Tumwater Dam. At this site, two 4-element Yagi aerial antennas were deployed, one below and one above the dam (zone 230 and 234). In addition to the aerial antennas, we deployed two underwater antennas within the adult fishway; one antenna was located a few meters inside the entrance, and the second was located upstream near the exit, immediately below the adult fish handling facilities (zone 231 and 232). Collectively, these four antennas provided information regarding fish behavior below the project, as well as through the fish ladder.

Rocky Reach Dam

At Rocky Reach Dam, there is single fish ladder located on the west side of the project (right bank looking downstream). However, there are a total of 10 entrances through which adult steelhead can enter the adult fishway and ultimately pass through the system (Figure 5). The following is a detailed description of Rocky Reach adult bypass system, and the telemetry system used to monitor adult passage.

Tailrace - Approximately 300 m downstream of the powerhouse, we deployed two 6-element aerial Yagi antennas (Figure 5). As with other aerial antennas used within the study area, one antenna was pointed downstream at an angle of 40 degrees to the shoreline, and the second was pointed upstream at the same angle (zone 300).

Spillway Entrance - The spillway ladder is located between spillways 8 and 9, and extends into the tailrace of the project (Figure 5). At this site, due to high flows and turbulence, we were unable to deploy an antenna immediately outside of the entrance (SPE). Alternatively, we installed an antenna approximately 3 m inside of the entrance, and a second antenna approximately 12 m upstream of the entrance antenna (zone 301 and 302). A third antenna was deployed approximately 35 m upstream of the second antenna, at the point where the entrance channel connects with the transport channel (zone 303). The spillway transport channel then runs along the base of the spillway, and eventually connects with the trifurcation pool.

Trifurcation Pool Entrance - The entrance for the trifurcation pool is situated where the powerhouse and spillway meet (Figure 5). At this site, two separate ladder entrances were available for migrating fish to enter (TRI). At each entrance, we deployed bared coax antennas inside the entrance and dipole antennas on the outside (zone 304 and 305). In addition, we deployed two bared coax antennas approximately 15 m upstream in the channel in order to determine whether or not there was any delay once the fish entered the ladder (zone 306). At the trifurcation pool, the transport channels for the upstream, downstream, and spillway entrances meet (Figure 5). We also deployed antennas within each transport channel downstream of the trifurcation pool (zone 307 to 309). These antennas provided information regarding travel time between the entrance of the ladders to the point where fish entered the trifurcation pool. Also, since each transport channel was monitored, we could determine whether fish that entered the trifurcation pool subsequently descended any of the channels. Two additional antennas were installed upstream of the trifurcation pool to determine whether or not there was delay once the fish entered the trifurcation pool. One antenna was deployed at the upstream edge of the trifurcation pool, and a second approximately 20 m upstream of the first antenna within the transport channel leading to the fish ladder (zone 310).

Upstream Entrance - Along the entire course of the collection channel, there are a series of 22 orifices that provide access for migrating adults to the transport channel from the tailrace (Figure 5). Of the 22 orifices, all but six were closed. We deployed antennas both inside and outside of the three open orifices (OG 1-3) at the upstream end of the powerhouse. These were assigned zone numbers 312 to 317. These antennas allowed us to detect fish as they approached and entered each orifice, as well as partition migration time through the transport channel.

Downstream Entrance - Three open orifices (OG14, 16, 20) at the downstream end of the collection channel were monitored. These were assigned zone numbers 318 to 323. At the downstream ladder entrance (DOE), we deployed two additional underwater antennas. One was located outside of the downstream ladder entrance, and the second approximately 25 m inside the entrance (zone 324 and 325). Fish that entered the downstream ladder entrance must travel through the entire collection channel before entering the transport channel that leads to the fish ladder.

Transport Channel - From the trifurcation pool, the transport channel runs along the base of the powerhouse to the southwest end of the project (Figure 5). Within this area, we deployed a total of four antennas. The first antenna was located approximately halfway between the trifurcation pool and the end of the powerhouse (zone 311). The second antenna was located further upstream, approximately 2/3 the distance from the trifurcation pool to the fish ladder (zone 327). Approximately 15 m below the second antenna, there are a series of diffusion gates that provide additional flow into the transport channel. The deployment of the antenna upstream of these diffusion gates allowed us to evaluate the effects of these gates. A third antenna was installed with the goal of monitoring the area immediately below the first exposed weir of the fish ladder, to determine whether fish held in this area prior to ascending the ladder (zone 328). Within the upper end of the transport channel, the fish ladder weirs extend to an area immediately upstream of the diffusion gates. At normal tailrace water elevations, the lower weirs are submerged. Because the "first" exposed weir of the fish ladder is a function of fluctuating water levels at the tailrace, during high water levels the third antenna would be well below the first exposed weir, and during low water levels it would be at the second or third exposed weir. Therefore, at times it was difficult to assess the behavior of fish as they approached the fish ladder. The fourth antenna was deployed further upstream within the fish ladder (approximately 40-50 m upstream of the third antenna). This antenna provided additional information on fish as they began to ascend the fish ladder (zone 329).

Ladder Exit - At the exit of the fish ladder, we deployed antennas at five locations (Figure 5). The first antenna was located approximately 80 m downstream of the ladder exit immediately below the weir where a diffuser is located (zone 330). The second and third antennas within this area were installed approximately halfway between the diffuser and the ladder exit in two adjacent weirs (zone 331), the fourth antenna within the last weir of the ladder (zone 332), and the fifth antenna outside of the ladder exit (zone 333). Collectively, these antennas provided us with information regarding the effects of the diffuser, as well as migrational time through the ladder system.

Entiat River

On the Entiat River, we installed a single monitoring site at Rkm 4.8. This site consisted of two 4-element aerial Yagi antennas combined together for approximately half the study then changed to two individual antennas (Figure 5) . Antennas were aimed both upstream and downstream at 40 degree angles to the shoreline (zone 334 and 335).

Wells Dam

Tailrace - This site was located approximately 1.2 km downstream of Wells Dam at the US Geological Survey (USGS) gauging station tower on the right bank (Figure 6). Two 9-element Yagi antennas were mounted on the railing of the tower at an elevation of approximately 17 m from the base (a total of approximately 25 m off the surface of the water). Antennas were pointed upstream and downstream, and were monitored with a single SRX receiver (zone 400).

Left and Right Entrance/Collection Channel/Below Trap/Trap - This array used dipole antennas mounted at strategic locations to monitor movements in the lower half of the fishway. Three dipoles were mounted at different depths on the inside of the main (zone 403 for left- and zone 410 for right-bank fishway; LME and RME respectively) and side gate entrances (zone 404 for left- and zone 411 for right-bank fishway; LSE and RSE respectively), Figure 6. The fish ladder consists of a series of pools separated by weirs which allow fish passage through either submerged orifices or over the top of the weir. Near the top of the ladder, this configuration changes to weirs which permit only submerged passage. Two dipoles were mounted on the downstream side of two adjacent weirs (zone 405 at left- and zone 412 at right-bank fishway) at the base of the fishway where the elevation begins to increase. Two more dipoles were mounted on the downstream side of two adjacent weirs (zone 406 at left- and zone 413 at right-bank fishway) in the pools below the adult trap. A single dipole was mounted at mid-water level in the middle of the trap on a pole (zone 407 at left- and zone 414 at right-bank fishway). All antennas on the left and right banks were monitored using a respective SRX/DSP.

Left and Right Above Trap/Exit - This array used dipole antennas mounted at strategic locations to monitor movements in the upper half of the fishway. Two dipoles were mounted on the downstream side of two adjacent weirs (zone 408 at left- and zone 415 at right-bank fishway) in the pools above the adult trap, and two dipoles were mounted on the downstream side of two adjacent weirs (zone 409 at left- and 416 at right-bank fishway) in the pools adjacent to the exit (Figure 6). Both antennas were monitored using a single SRX/DSP.

Methow River Site 1 - This aerial array was deployed on the left bank of the river approximately 3 km upstream of the confluence with the Columbia (Figure 6). Twin 4-element yagi antennas were mounted on a 2 m tripod and pointed upstream and downstream (zone 417). The antennas were approximately 17 m off the surface of the water and used a single SRX. This array was eventually moved to Site 2 to make use of available AC power.

Methow River Site 2 - This aerial array was deployed on the right bank of the river approximately 3 km upstream of the confluence with the Columbia . Twin 4-element yagi antennas were mounted on a 2 m tripod and pointed upstream and downstream (zone 417). The antennas were approximately 5 m off the surface of the water and used a single SRX. This array had AC power.

Methow River Site 3 - This aerial array was deployed on the left bank of the river approximately 18 km upstream of the confluence with the Columbia (Figure 6). Twin 4-element yagi antennas were mounted on a 2 m tripod and pointed upstream and downstream (zone 420). The antennas were approximately 7 m off the surface of the water and used a single SRX. This array had AC power.

Okanogan River Site 1 - This aerial array was deployed on the left bank of the river approximately 3 km upstream of the confluence with the Columbia (Figure 6). Twin 4-element yagi antennas were mounted in a tree and pointed upstream and downstream (zone 418). The antennas were approximately 7 m off the surface of the water and used a single SRX.

Okanogan River Site 2 (Zosel Dam) - This aerial array was deployed at Zosel Dam approximately 42 km upstream of the confluence with the Columbia (Figure 6). One 4-element yagi antenna was mounted on a mast on the forebay and pointed upstream, and one 4-element was mounted on a mast on the tailrace side and pointed downstream (zone 419). The antennas were approximately 7 m off the surface of the water and used a single SRX.

Mobile Surveys

Mobile tracks were conducted by vehicle, and by fixed-wing aircraft to monitor movements of radio-tagged fish between fixed-station sites (Figure 7), at holding areas in tributaries, or to identify spawning locations for tagged fish.

Tracking from a Vehicle or on Foot

Tracking by a vehicle was conducted opportunistically during downloading of fixed-station receivers using one receiver and a 2-element Yagi antenna hand held or mounted to the side of a passenger van.

Aerial Surveys

Aerial tracking was conducted from a Cessna 182 fixed-wing plane with 2-element Yagi antennas mounted to the skid of each wing. The aircraft flew along the river and its tributaries at speeds between 60 and 100 mph, and at heights between 300 and 500 ft above ground. The entire study area could be covered in 3 d of flying at 5 h per flight. The location and identities of each fish were determined and stored in real time by a Global Positioning System (GPS) with a built-in data logger and three SRX receivers. The clocks in each receiver were synchronized with GPS time prior to each flight. The approximate position and identity of each fish were also recorded manually on data sheets as a backup to the electronic systems. During all surveys, the receivers were operated to scan all the channels, but the scan was set to offset the channels at any one time. In addition, receivers were set to scan in different directions so that the probability of passing a fish without recording it was reduced. Tracking by air was the primary method of identifying spawning/holding locations of radio-tagged fish on the Wenatchee, Entiat, Methow and Okanogan rivers.

Data Analysis

Analyses were conducted using *Telemetry Manager*, *Ascent* and other computer programs developed in Visual Foxpro by LGL. The operational files constructed using *Telemetry Manager* provided the primary data set on which specific queries were conducted. More specifically, benchmark times for each radio-tagged summer steelhead were determined to calculate times of passage between telemetry stations. Antennas or groups of antennas were defined in the program as "zones" by which residence and travel information could be derived. The fate of the radio-tagged fish detected at each dam was determined by combining detection data collected from stationary receiver sites. Upstream migration rates between monitored locations were derived at each dam for individual fish.

Definition of Passage Time Intervals

The amount of time fish were present in the tailrace, fishway entrances, and fishways was determined through the strategic deployment of receivers and antennas. Dates and times of detection were used to calculate respective time intervals.

At Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams, benchmark times included:

1) First detection in the tailrace;
2) First detection at the fishway entrance of passage;
3) Last detection at the fishway entrance of passage;
4) First detection at the junction pool;
5) Last detection at the junction pool; and
6) Last detection at the fishway exit of passage.

From the benchmark times, median travel times and respective coefficients of variation (CV) were calculated for each of the following passage segments:

Segment	Time	Group
1)	1 to 2	Tailrace
2)	2 to 3	Entrance passage
3)	4 to 5	Junction pool passage
4)	3 to 6	Fishway passage
5)	1 to 6	Project passage

At Wells Dam the benchmark times were identical with the other dams except that there was not any for junction pool since such structure does not exist at this dam:

1) First detection in the tailrace;
2) First detection at the fishway entrance of passage;
3) Last detection at the fishway entrance of passage;
4) Last detection at the below trap site of passage; and
5) Last detection at the fishway exit of passage.

From the benchmark times, median travel times and respective coefficients of variation (CV) were calculated for each of the following passage segments:

Segment	Time	Group
1)	1 to 2	Tailrace
2)	2 to 3	Entrance passage
3)	3 to 5	Fishway passage
5)	4 to 5	Upper fishway passage
6)	1 to 6	Project passage

In addition to the benchmark times used to calculate passage times, the entrance gate of first detection for an ascent was also determined for Wells Dam. For this analysis, all fish that passed Wells Dam were classified according to the first detection at a main or side gate entrance in the sequence of detections that completed the ascent and exit of a fishway.

The bench mark times and resulting travel times for each radio-tagged fish were determined by working backwards through a sequence of detections. The fishway of ultimate passage and the respective passage time was determined by identifying a sequence of detections in the ascent of a fishway, starting with a detection in a fishway exit zone.

In the case of a radio-tagged steelhead that fell back passed the dam and re-ascended a fishway, a second record of ascent would be determined. A fallback, for the purpose of analysis, was defined as a tag that was detected at a fishway exit and subsequently detected at the tailrace or a fishway entrance. When recorded, second ascents were excluded from the passage analysis.

Zone Definition and Analysis

Passage rates for each radio-tagged fish were determined from telemetry data collected from the numerous fixed-station antenna locations. In order to differentiate detection locations and streamline analyses, individual antennas were grouped into logical "zones" that defined pivotal areas of interest, such as individual fishway entrances and exits. Definition of the various fishway entrance, fishway, and exit zones are provided in (Appendix Table A3, B3, and C3). Although the *Telemetry Manager* software provided access to detection information by individual antenna, analysis by zone (typically groups of antennas) provided direct answers to the majority of the analytical queries.

Wells Dam - Entrance Gate Configuration and Passage Times

Public District No. 1 of Douglas County (DCPUD) identified an opportunity to potentially reduce passage times at Wells Dam by modifying gate operational procedures. More specifically, better passage conditions may be accomplished by closing the side gate entrance to the fishway. The 2000 radio-telemetry study was designed to assess the impacts of these changes on the time it takes summer steelhead to pass Wells Dam.

The primary goal of the study was to determine if the travel times of summer steelhead entering the fishway are affected by ladder operation that can include open (Control) or closed (Treatment) side gate entrances. The null hypothesis tested was that the radio-tagged fish had the same entrance passage time (first to last detection in the entrance zone of the passage fishway) under the alternative gate configurations. Note that under this hypothesis the experimental unit is a radio-tagged fish that is classified as either a Control or Treatment based on detection times and when the side gates were open or closed (English et al. 1998). Travel times were also examined for two other passage segments: 1) Project passage and 2) Fishway passage. Only radio-tagged fish detected at the start and end location of a passage segment could be included in the analysis of the travel times for that passage segment.

Radio-tagged fish were classified into Control and Treatment groups for the gate configuration study if the first and last detections in the entrance zone of the passage fishway were within a single Control or Treatment interval. The gates were opened and closed sequentially four times (blocks) over the period of summer steelhead migration (i.e., interspersion of the treatment). The distribution of the data was examined by probability plots which lead to the use of a logarithmic transform to achieve more homogeneous variance and normal distributions. The statistic used to test for significant differences in passage times was a two sample t-test (assuming unequal variances). Various combinations of Control and Treatment median Entrance times were compared for each fishway, and Control and Treatment median Project, Fishway, and Entrance times were compared for the fishways combined. Median Project, Fishway, and Entrance times of the east and west fishways were compared against each other.

Priest Rapids Dam and Wells Dam - Trapping Intervals and Fishway Passage Times

Trapping at the left bank fishway at Priest Rapids Dam was conducted by WDFW staff on Tuesdays and Thursdays between 9:00 and 17:00 from 13 July through 14 October 1999. Specific dates and times for each trapping day are provided in Appendix E1. The primary reason for trapping activities at Priest Rapids was to obtain biological samples for chinook and steelhead and provide the steelhead required for this study.

Trapping of salmon for broodstock was conducted in both fishway at Wells Dam, usually on Monday, Tuesday, and Wednesday between 0600 and 2200 hours. Trapping was conducted irregularly on other days to meet broodstock targets, and daily total trapping time varied as well. The trap on the left-bank fishway was used for collecting summer chinook and sockeye from 12 July through 25 August, and the trap on the right-bank fishway was used to collecting steelhead from 12 July through 17 November 1999. Actual active trapping times for Wells Dam

(Appendix Table E1) were determined using trap gate position data derived from an electronic sensor in the fishway. An open or closed gate was determined by analysing video imagery collected in the fish counting chute where a light sensor indicated the position of the trap gate. Times at which the gate position changed were recorded by DCPUD staff. These times were incorporated into LGL's *Ascent* software analysis program where radio-tag detection times were compared with gate position to classify a fish into a trapping or no trapping interval.

The passage times for radio-tagged steelhead that passed the trap during the times when the trap was operating were compared to the passage times for radio-tagged steelhead that passed the trap during the times when the trap was not operating. A radio-tagged fish was classified into the trapping or no trapping group according to the time of first detection in the below trap zone.

Travel times were examined for upper fishway passage. Similar to the Wells gate configuration analysis, only radio-tagged summer steelhead detected at the start and end location of a passage segment could be included in the analysis of the travel times for that passage segment. All fish that met the above criteria, regardless of the gate configuration, were included in the tests for significant difference in the passage times for trapping and no trapping periods. A log transformation was applied to the data for use in a two sample t-test.

Classification of Fallback Fish

Each fallback fish was classified into one of three categories (voluntary, involuntary, and re-ascended) based on its tracking history after the fallback event. A fish was classified as a "voluntary" fallback if it was later tracked to a tributary or a reach below, but not adjacent to, the fallback dam. Involuntary fallbacks where those fish last tracked to the reach immediately below the fallback dam. Fish that ascended the dam after the fallback event were classified as "re-ascended" fallbacks.

In addition to the above categories, fallbacks at Priest Rapids and Wanapum dams were classified according to the location of the fallback event. The forebay antenna deployed at each dam was used to identify the last detection location in the forebay prior to the fallback detection in the tailrace or fishway entrance. The three potential fallback locations were the spillway, sluiceway and powerhouse at each project. The fallback location was unknown if the only forebay detection was at a fishway exit or the last forebay detection was not a potential fallback route (i.e., the last forebay detection was on a spillway antenna during a non-spill period).

RESULTS AND DISCUSSION

Tags Applied

Vernita Bridge

Radio tags were placed in 395 steelhead that were captured at Priest Rapids Dam between 1 July and 16 October 1999 (Table 1). Peak tagging periods were between 22 August and 4 September when 24% of the tags were applied. A total of 75% (298) of the steelhead that were tagged were hatchery fish (possessing an adipose and/or a ventral clip). Hatchery steelhead represented 83% of the 825 steelhead sampled by WDFW staff through trapping operations at the Priest Rapids left-bank fishway. Fifty-three percent of the fish that were tagged were recorded as females.

Tracking Effort

During this study we obtained over 7,000,000 individual records of radio-tagged fish. Most of the tracking data were obtained by fixed-station receivers. Tracking data were condensed to records of fish arrival and departure dates from the fixed-station receivers, and to unique locations for each day that each fish was detected using mobile tracking methods.

Fixed-station Tracking

Tracking by fixed-station receivers provided the most continuous coverage of fish movements than mobile tracking. The results presented in this report were derived from more then 195,224 site hours of monitoring data obtained from the 56 fixed-station sites operated between 4 July and 31 December 1999 (Tables 2, 6, and 10). LGL Limited and BioAnalysts Inc. were responsible for the maintenance and downloading of fixed-station monitoring sites (details provided in Tables A2, B2, and C2) and the coverage at each site was continuous during the complete upstream migration of adult steelhead (beginning July through late December).

Mobile Tracking

Boat surveys in September and October 2000 were used to identify the precise location of tags in the reach between Coyote Rapids and Priest Rapids Dam. Mobile tracking provided detailed data on the holding and spawning destinations for most of the radio-tagged fish. Aerial surveys along the main stem of the Columbia, Wenatchee, Entiat, Methow, and Okanogan rivers were conducted on eleven occasions between 25 October 1999 and 16 June 2000 (Appendix Table F1). The mobile survey strata are presented in Figure 7.

Priest Rapids Dam

Project Passage

Of the 395 radio tags applied to steelhead at Vernita Bridge, 353 (89%) were detected at Priest Rapids Dam (Table 3). A total of 8,162 steelhead were counted using video monitors between 4 July to 15 November (Figure 8, Appendix Table A4). Peak passage upstream of the dam occurred during the week ending 4 September. The passage timing of the tagged and untagged steelhead at Priest Rapids Dam indicates that weekly tagging at Vernita Bridge was roughly proportional to the total number of steelhead that passed the release site each week.

Of the 353 radio-tagged steelhead that were detected at Priest Rapids Dam, 335 (95%) unique radio-tagged steelhead were detected at the upstream end of the fishways (exits); 74% used the left-bank fishway and 26% used the right-bank fishway. Of the 335 fish, 34 (10%) fell back below the dam (Table 4).

Fallback

The portion of the fallback fish that passed the dam using the left-bank fishway (83%) was slightly higher than the 74% for all fish that passed the dam. Similarly, hatchery fish were 87% of the fallback fish which was higher than the hatchery portion at release (75%). Most of the fallbacks occurred between 29 August and 17 November when spillway flow was minimal to none (Figure 9). The frequency of fallback events was more related to the number of radio-tagged fish present than to spillway flow.

There were three fallback events where a tag was last detected by a forebay spillway antenna during a no spill period. Since these radio-tagged steelhead could have passed undetected by either the sluice or powerhouse, the fallback route for these fish, and the 3 fish not detected by a forebay antenna prior to fallback, was classified as unknown (Table 4). Of the remaining 28 fish with a known fallback route, 12 (43%) fell back via the sluiceway, 11 (39%) via the powerhouse, and 5 (18%) via the spillway.

Of the 12 fish that fell back via the sluice, only 1 was classified as an involuntary fallback. In contrast, 4 of 5 (80%) of the spillway fallbacks and 5 of 11 (45%) of the powerhouse fallbacks were classified as involuntary fallbacks at Priest Rapids Dam. In total, 12 (3.9%) of the radio-tagged steelhead that passed Priest Rapids Dam were classified as involuntary fallbacks. Details on the ultimate fate of the fallback fish are provided later in the report.

Wanapum Dam

Project Passage

There were 328 (83%) radio-tagged steelhead detected at Wanapum Dam (see Table 3). Reliable counts of the number of adult steelhead that passed Wanapum Dam each week in 1999 are not available. The only available counts are considered to be an index of unknown accuracy and, therefore, will not be included in this report. Of the 328 radio-tagged steelhead that were detected at Wanapum Dam, 326 (99%) unique radio-tagged steelhead were detected at the upstream end of the fishways (exits); 79% used the left-bank fishway and 21% used the right-bank fishway. Of the 326 fish, 38 (11.6%) fell back below the dam (Table 5).

Fallback

The portion of the fallback fish that passed the dam using the left bank fishway (84%) was slightly higher than the 79% for all fish that passed the dam. Hatchery fish were 86% of the fallback fish which was similar to that observed at Priest Rapids and higher than the hatchery portion at release (75%). Most of the fallbacks occurred between 27 August and 1 October when spillway flow was minimal to none (Figure 9). As observed for Priest Rapids, the frequency of fallback events was more related to the number of radio-tagged fish present than to spillway flow.

At Wanapum Dam, there were 8 fallback events where a tag was last detected by a forebay spillway antenna during a no spill period. As at Priest Rapids, the fallback route for these fish and the 3 fish not detected by a forebay antenna prior to fallback, was classified as unknown (Table 5). Of the remaining 27 fish with a known fallback route, 14 (52%) fell back via the powerhouse, 8 (30%) via the sluice, and 5 (18%) via the spillway.

Of the 38 fish that fell back, 18 were classified as voluntary fallbacks, 18 re-ascended a fishway and 2 were classified as involuntary fallbacks. Both of these involuntary fallbacks (0.6% of the radio-tagged steelhead that passed Wanapum Dam) fell back via the powerhouse. Details on the ultimate fate of the fallback fish are provided later in the report.

Rock Island Dam

Project Passage

Of the 395 radio tags applied to steelhead at Vernita Bridge, 309 (78%) were detected at Rock Island Dam (Table 7). A total of 6,271 steelhead were counted using video monitors between 4 July to 14 November (Figure 10, Appendix Table B4). Peak passage upstream of the dam occurred during the week ending 4 September.

Of the 309 radio-tagged steelhead that were detected at Rock Island Dam, 298 (96%) unique radio-tagged steelhead were detected at the upstream end of the fishways (exits); 73% used the right-bank fishway, 14% used the middle fishway, and 13% used the left-bank fishway. Of the 298 fish, 22 (7.4%) fell back below the dam (Table 8).

Fallback

The portions of the fallback fish that passed the dam using each fishway were: 59% right, 23% center and 18% left. Hatchery fish were 86% of the fallback fish which was similar to that observed at Priest Rapids and Wanapum dams. Most of the fallbacks occurred between 18 September and 14 November when spillway flow was minimal to none (Figure 11). Of the 22 fish that fell back, 9 were classified as voluntary fallbacks, 8 reascended a fishway and 5 were classified as involuntary fallbacks. These involuntary fallbacks represent 1.7% of the radio-tagged steelhead that passed Rock Island Dam. Details on the ultimate fate of the fallback fish are provided later in the report.

Rocky Reach Dam

Project Passage

There were 229 (58%) radio-tagged steelhead detected at Rocky Reach Dam (see Table 7). A total of 4,712 steelhead were counted using video monitors between 4 July to 14 November (Figure 10, Appendix Table B4). Peak passage upstream of the dam occurred during the week ending 4 September.

Of the 229 radio-tagged steelhead that were detected at Rocky Reach Dam, 205 (90%) unique radio-tagged steelhead were detected at the upstream end of the fishways (exits). Of the 205 fish, 21 (10.2%) fell back below the dam (Table 9).

Fallback

Hatchery fish were 95% of the fallback fish which was higher than that observed at Priest Rapids, Wanapum and Rock Island dams (86-87%). Most of the fallbacks occurred between 29 August and 24 October when spillway flow was minimal to none (Figure 11). Of the 21 fish that fell back, 14 were classified as voluntary fallbacks, 5 re-ascended a fishway and 2 were classified as involuntary fallbacks. These involuntary fallbacks represent 1.0% of the radio-tagged steelhead that passed Rocky Reach Dam. Details on the ultimate fate of the fallback fish are provided later in the report.

Fishway Entrances

We examined the degree to which radio-tagged steelhead entered and exited individual entrance gates (Figure 12). The analysis shows that the net movement of steelhead is positive (movements in through entrance gates) at all entrances, but the spillway. The spillway entrance recorded more movement in and out than any other entrance. The next busiest entrance was the upstream entrance (UPE).

Wells Dam

Project Passage

Of the 395 radio tags applied to steelhead at Vernita Bridge, 195 (49%) were detected at Wells Dam (Table 11). A total of 3,455 steelhead were counted using video monitors between 4 July to 15 November (Figure 13, Appendix Table C4). Peak passage upstream of the dam occurred during the week ending 4 September.

Of the 195 radio-tagged steelhead that were detected, 18 were taken for broodstock and 3 were transported and released above Wells Dam. Of the remaining 174 fish, 162 (93%) unique radio-tagged steelhead were detected at the upstream end of the fishways (exits); 52% used the right-bank fishway and 48% used the left-bank fishway. Of the 162 fish, 11 (6.8%) fell back below the dam (Table 12).

Fallback

The portion of the fallback fish that passed the dam using the left-bank fishway (76%) was slightly higher than the 52% for all radio-tagged steelhead that passed the dam. Hatchery fish were 94% of the fallblack fish. This percent was similar to that observed at Rocky Reach Dam but higher than that observed at Priest Rapids, Wanapum and Rock Island dams. Most of the fallbacks occurred between 30 September and 22 November when spillway flow was minimal to none (Figure 14). Of the 11 fish that fell back, 6 were classified as voluntary fallbacks, 4 re-ascended a fishway and 1 was classified as involuntary fallbacks. Details on the ultimate fate of the fallback fish are provided later in the report.

First Detection by Entrance Gate

Antennas monitoring the four fishway entrances were located inside each entrance. Therefore, the first detection of each fish at each fishway indicates the first entrance found and used by each radio-tagged fish. The data from Control intervals, when both gates were open, provide an indication of the relative importance of the main gate and side gates for each fishway. Of the 67 first detections of steelhead at fishway entrances during the Control intervals (including some fish that did not pass the project), slightly more than half of them (52%) occurred at the side gate (57% for the left- and 47% for the right-bank fishway, Appendix Table D1). The portion was similar (50%) when we limited the Control sample to only those fish that passed the dam (n=52) (Appendix Table D2).

Upstream Migration Speeds between Hanford Reach and Zosel Dam

The median migration time from the Vernita Bridge release site to the fishway exits at Wells Dam was 10.9 d which translates into a median migration speed of 18.8 km/d (Table 13). The migration speed from the first detection in the Priest Rapids tailrace to the Wells Dam fishway exits was 20.1 km/d. The median migration speeds between the dams on the Columbia River were: 33.7 km/d between Priest Rapids and Wanapum, 32.6 km/d between Wanapum and Rock Island, 36.7 km/d between Rock Island and Rocky Reach, and 36.3 km/d between Rocky Reach and Wells Dam. In contrast, the median migration speeds between the mainstem and tributaries sites and within tributaries were slower: 3.0 km/d between Rock Island and the Columbia State Park monitoring station on the lower Wenatchee River, 4.5 km/d between Columbia State Park and Tumwater Dam, 3.7 km/d between Wells Dam and the lower Methow River, and 10.3 km/d between Wells Dam and Monse at the Okanogan River.

The median project passage time (first detection at the tailrace to last detection at the exit) for radio-tagged steelhead, excluding fallbacks, was 20.16 h at Priest Rapids, 7.92 h at Wanapum, 4.32 h at Rock Island, 12.72 h at Rocky Reach, and 16.56 h at Wells Dam (Table 14). However, it should be noted that the tailrace antennas at Rock Island and Rocky Reach dams were mounted 300 meters downstream, while at Priest Rapids, Wanapum, and Wells dams those distances were extended to about 1200 meters.

The median project passage time for fallback fish last detected below a specific dam ranged from 0.23 d at Rock Island Dam to 0.98 d at Priest Rapids Dam. Similarly, the median project passage time for fallback fish last detected above a specific dam ranged from 0.19 d at Rock Island Dam to 0.76 d at Rock Reach Dam.

Comparison of Fishway Passage Times Between the Dams

Estimates of the median passage times through all five dams are provided in Table 15 and Table 16 and illustrated in Figures 15, 16, and, 17. At Priest Rapids Dam the time intervals spent migrating through the fishway were similar for each bank, but the passage time through the fishway entrance zones were different. The median travel times for steelhead at the collection channel and main entrances of the left-bank fishway were 6.01 h and 3.98 h, respectively, compared to 1.66 h for the entrance zones of the right-bank fishway. More than 75% of the steelhead migrating passed Priest Rapids Dam choose the left-bank fishway.

At Wanapum Dam overall, the Project passage time was similar regardless of the entrance used (Table 15). The Entrance and Fishway passage times were lower for the right-bank fishway. The Fishway passage time for the left and right-bank fishways were significantly different ($p<0.001$); however, the difference between the median values was small (1.83 d versus 2.42 d; Tables 15 and 16). These shorter Entrance and Fishway passages times for the right-bank fishway were offset by substantially longer Tailrace passage times for fish that passed via this fishway. Further investigation revealed that the longer time intervals were due to some fish that did not pass via the first fishway they encountered (left bank); therefore, the tailrace time for these fish would include time spent in the entrance zones at left-bank fishway. The median travel times for steelhead at the collection channel and main entrances of the left-bank fishway were 1.20 h and 0.52 h, respectively, compared to 0.45 h for the entrance zones of the right-bank fishway. The lower entrance times at right-bank ladders for both dams could be due to the simpler channel configuration. The left-bank entrances have more complex structure and there is a presence of diffuser flows which tend to obscure flows from the fishway (Stuehrenberg at al. 1995). As at Priest Rapids, most of the steelhead migrating passed Wanapum Dam choose the left-bank fishway (79%).

At Rock Island Dam, median Project passage time was longest for the left-bank fishway (9.46 h); however, only 13% of the radio-tagged steelhead that passed Rock Island Dam used the left-bank fishway. The median passage times through the entrances of center and right-bank fishway were slightly lower, 0.58h and 1.02h, compared to 1.89 h at the left-bank fishway. While the median Fishway passage times appear similar for each fishway (1.20-1.77h), statistical comparison of the various fishways reveal a significant difference between the passage times for the right and center fishway ($p=0.04$). Passage times were shortest for the right-bank fishway and this fishway accounted for 73% of the radio-tagged steelhead that passed Rock Island Dam.

At Rocky Reach Dam, the Project passage time was shortest for those fish that entered the fishway via the trifurcation pool entrance (9.92 h). The median Entrance passage times were shortest at the trifurcation pool and spillway entrances, 5.04h and 5.03h, respectively. Longer median times were observed at the upstream and downstream entrances to the collection channel 16.01h and 9.44, respectively. Further details regarding the use of each entrance have been provided above (Figure 12).

At Wells Dam, the Project passage time was similar for each fishway. Time intervals spent migrating through the fishway were similar for each fishway, but the Entrance passage times were slightly different. The median Entrance passage time for steelhead at the left-bank fishway was 3.25 h, compared to 4.01 h for the right-bank fishway. The number of steelhead that passed through either the left- or right-bank fishway was similar, 77 and 79, respectively.

Effect of Trapping on Passage Times at Priest Rapids and Wells Dams

Upper fishway passage times were assumed to be the most direct measure of an effect of trapping on fish passage times and were calculated for radio-tagged steelhead that were detected at the below trap zone and subsequently exited the fishways during trapping and no trapping intervals (Appendix Table D5).

At Priest Rapids Dam trapping was conducted on left-bank fishway. The left-bank trap operated on 25 days for a total of 195.8 h (Appendix Table E1). The collection activities resulted in 395 trapped steelhead that were later radio-tagged and released at Vernita Bridge. Trapping activities did not affect the passage of radio-tagged fish during trapping intervals, but did appear to increase the time required for fish to pass through the upper fishway. The trap was operated for 8.6% of the total time between 13 July and 14 October and accounted for 9% of the radio-tagged steelhead the passed via the left-bank fishway. Median upper fishway times for steelhead on the left-bank fishway were 5.0 h (n=18; CV=89%) for fish that passed during a trapping interval and 2.5 h (n=182; CV=111) for fish that passed during a no trapping interval. These values were significantly different (p=0.007).

At Wells Dam, trapping was conducted on both fishways. The left-bank trap operated on 21 d for a total of 336 h, and the right-bank fishway trap operated on 57 d for a total of 912 h (Appendix Table E1). On the left-bank fishway, none of the radio-tagged steelhead have been captured since chinook was the targeted species for broodstock purposes. On the right-bank fishway, broodstock collection activities resulted in 21 trapped radio-tagged steelhead. Out of these, 3 were released back into the forebay of the dam.

Median upper fishway passage time for steelhead on the left-bank fishway was 5.6 h (n=6; CV=96%) for fish that passed during a trapping interval and 2.0 h (n=71; CV=137%) for fish that passed during a no trapping interval. These values were not significantly different (p=0.054). The right-bank median upper fishway passage times for the trapping and no trapping groups were significantly different (p=0.0012). The median upper fishway passage times were 10.7 h (n=14; CV=124%) for fish that passed during a trapping interval and 2.0 h (n=40; CV=176%) for fish that passed during a non trapping interval. Upper fishway passage times at Wells Dam were 2-5 times longer for trapping intervals than for non-trapping intervals.

Trapping also had a substantial effect on the project passage times at Wells Dam. The median project passage times during trapping intervals were close to 35 h for both fishways compared to 12 h during no trapping intervals (Figure 18). The effect of trapping on project passage times at Priest Rapids Dam was much smaller (24 h during trapping and 20 h during no trapping intervals).

Effect of Entrance Gate Configuration on Passage Times at Wells Dam

The time period during which Control and Treatment operations were implemented was between 1 July and 30 November and included eight separate trials on each fishway (Appendix Table D3). Of the total radio-tagged fish observed at fishway exits on their first ascent (152), 52 (34%) and 89 (59%) were assigned to the Control and Treatment periods, respectively. An additional 11 (7%) of the total observed could not be assigned to a specific gate configuration trial

In previous studies, Entrance times were used to evaluate the effect of gate configuration on fish passage times because Entrance times tended to be a significant portion of the total Project passage time and they could be related directly to a gate configuration. Radio-tagged steelhead whose first and last Entrance times were not in the same gate configuration period were excluded from statistical analysis. Using the remaining observations, no significant differences were detected in the Entrance passage times between gate configurations for either fishway at Wells Dam (left bank: p=0.828; right bank: p=0.252).

The median Entrance passage times were short for each fishway and the variability between fish was large. The median Entrance passage time on the left-bank fishway was 3.2 h (mean= 1.08 and CV=169% for log transformed data) for the Control group and 2.5 h (mean= 1.83, CV=203%) for the treatment group. Median Entrance passage time on the right-bank fishway was 1.3 h (mean= 0.03, CV=6874%) for the Control group and 5.2 h (mean= 0.75, CV=300%) for the Treatment group. The very large CV's estimated for the Entrance passage times on the right-bank fishway were the result of the wide range of passage times observed. Some fish passed through the entrance zone in less than a minute while others took more than 35 h.

Given the above observations, the Project or Fishway passage times might provide a better indication of the affect of the gate configuration on the passage interval. Appendix Table D6 provides the comparable mean, standard deviation, CV and t-test probability statistics for the Project and Fishway passage times. The variability associated with Project and Fishway passage times (see CV statistics) was substantially smaller than that associated with Entrance passage times. No significant differences were detected in Project passage times between the control and treatment gate configurations for either fishway (left bank: p=0.662; right bank: p=0.181). Fishway passage times were not significantly different for the left-bank fishway (p=0.698), but were significantly different for the right-bank fishway (p=0.013). However, the median Fishway passage times were relatively short and the difference between the median control and treatment times for the right-bank fishway was small (1.9 h vs 2.3 h).

Comparison of Junction Pool and Counting Station Times Between the Dams

Statistics of the passage times through the junction pools at Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams are provided in Table 17. The median passage times were fast at all four dams ranging from 0.017 h at Wanapum to 0.081 h at Rocky Reach Dam. It should be noted that the junction pool passage time is the time between the first and last detection at the junction pool after the last detection at an entrance zone antenna. Given the close proximity of entrance zone and junction pool antenna, it is likely that most fish holding in this area would be intermittently detected on entrance zone antenna such that most of their holding time would be assigned to an entrance zone.

The median passage times through the counting stations of Rock Island and Rocky Reach dams ranged from 0.004 h at Rocky Reach to 0.407 h at Rock Island right-bank counting station.

Fate of Radio-Tagged Steelhead

<u>Prior to Kelting</u>

The spawning destination or furthest upstream detection location prior to kelting was determined for every radio-tagged steelhead (Table 19). Of the 395 steelhead tagged, 2 were never tracked and 13 (3.3%) were known to have been caught and removed prior to spawning. Of the remaining 380 steelhead available for spawning, 308 (81.1%) were tracked to known spawning areas prior to or during the spawning period, and 72 (18.8%) were not assigned to a known spawning area because they were last tracked on the mid-Columbia River between Coyote Rapids and Wells Dam prior to the kelting period. The two tributary destinations with the largest numbers of radio-tagged steelhead were the Methow River (33 % of the fish tracked to spawning tributaries) and the Wenatchee River (31%) (Figure 19). Radio-tagged "wild" steelhead were tracked to each tributary, but the majority of these fish were tracked to the Wenatchee (51%) and Methow (23%) rivers (Figure 20).

The precise location of the radio-tagged steelhead within each tributary was obtained from 11 sets of aerial surveys conducted between 25 October 1999 and 16 June 2000. Detailed maps showing the flight path and location of the fish detected on each survey are provided on a CD in Appendix F. The black circles on the maps indicate the GPS location of the aircraft at the point in time when the maximum power signal was recorded for that tag code on the SRX400 receiver. The yellow circles on the maps indicate the last known position of a fish tracked on a previous aerial survey, but not tracked on the survey associated with that map. The mobile survey data provided valuable information on the movement of fish into and between spawning tributaries, and was critically important for assigning fish to a specific tributary stock. Most of the aerial surveys covered the mainstem of the major tributaries (Wenatchee, Entiat, Methow, and Okanogan rivers) and the mainstem of the mid-Columbia River between Savage Island and

Chief Joseph Dam (Appendix Table F1). The mainstem Yakima River to Ellensburg was surveyed on two separate occasions and the mainstem Columbia below Rocky Reach Dam was not surveyed during May 2000 because of the large number of radio tags released on juvenile chinook and steelhead during the smolt survival studies conducted by the Chelan and Grant PUD's. In addition to the mainstem, fixed wing surveys, helicopters were used track steelhead in tributaries to the Methow and Wenatchee rivers (Appendix Table F2). Of the 8 tributaries to the Methow surveyed, radio-tagged steelhead were detected in 3 (8 in Chewack River, 6 in Twisp River and 1 in Gold Creek). In the Wenatchee watershed, radio-tagged steelhead were tracked in 6 of the 12 tributaries surveyed (Appendix Table F2). The maximum number observed in these streams was: 6 in Peshastin Creek, 4 in Mission Creek, 4 in Chumstick Creek, 3 in Chiwawa River, 2 in Nason Creek and 1 in Chiwaukum Creek.

The assignment of spawning areas and furthest upstream detection prior to kelting were also used to summarize the fates for those fish detected at each dam (Table 19). For example, 353 of the 395 radio-tagged steelhead released were detected at Priest Rapids Dam and 13 of these were removed prior to the spawning period. Of the 340 fish detected at Priest Rapids Dam and available for spawning, 281 (82.6%) were tracked to known spawning areas and 40 were tracked to mid-Columbia reaches above Priest Rapids Dam. Therefore, 321 (94.4%) of the radio-tagged steelhead detected in the vicinity of Priest Rapids Dam were either tracked to known spawning areas or successfully passed and remained above Priest Rapids Dam. Comparable percentages for the other dams were 95.3% for Wanapum Dam, 94.3% for Rock Island Dam, 93.3% for Rocky Reach Dam, and 93.2% for Wells Dam (Table 19). These are not survival estimates since we do not know the ultimate fate (i.e., the survival or mortality) of the fish that were radio-tagged. Even data that shows that a tag is stationary is not conclusive since the fish could regurgitate their tags.

Of the 72 steelhead not assigned to a known spawning area, 19 (26%) were classified as stationary because they were tracked near the same location from late November 1999 to late June 2000. The distribution of the stationary and not stationary radio-tags among the mid-Columbia reaches is provided in Figure 21. More radio tags were last tracked in the Coyote Rapids to Priest Rapids reach than any other mainstem reach (32 tags). Mobile tracking data from 8 aerial surveys through this reach indicated that 10 of the 32 tags were stationary and the other 22 tags were not detected after mid-February 2000. Each of these 10 stationary tags was tracked on every aerial survey that covered the Coyote to Priest Rapids reach. The 22 tags classified as not stationary probably migrated downstream and out of the survey area, or were removed by fishermen. Sport fishermen are permitted to harvest steelhead in the vicinity of Ringold Hatchery and several of the fish last tracked near the Ringold Hatchery migrated downstream from the Coyote to Priest Rapids reach in March 2000 just prior to the steelhead spawning period.

Comparison of the pre-kelt distribution for hatchery and "wild" steelhead indicated that the ratio of hatchery to "wild" steelhead for each spawning area varied substantially from the overall 75:25 ratio for the 395 radio-tagged steelhead (Table 20). The stocks with the largest "wild" component were Yakima (83%), Wenatchee River above Tumwater Dam (57%), and the Entiat River (50%). The tributaries with the highest proportion of hatchery fish were the Okanogan River (90%) and Methow River (80%). Of the 120 steelhead tracked to a mainstem location on the mid-Columbia River, 87% were hatchery fish. Not surprisingly, the two mid-Columbia reaches with the highest hatchery portions were: 1) the Wells Pool (93%), with steelhead hatcheries located at Wells Dam and the Methow and Okanogan rivers; and 2) below Coyote Rapids (92%) adjacent to Ringold Hatchery (Table 20, Figure 22).

Additional summaries of steelhead fates prior to kelting were prepared for each group of hatchery and "wild" steelhead that fell back at each dam (Table 21-23). The boxed numbers in each of these tables indicated those fish that fell back and were last tracked below the dam where the fallback occurred. As indicated earlier, these fish were classified as "involuntary" fallbacks. The 25 involuntary fallbacks detected for all dams combined represented 2% of the unique dam passage events and all of these were hatchery fish. On average 5% of the unique fish passage events were classified as "voluntary" fallbacks (range 3-7% for the different dams) and 3% were classified as reascents (range 1-6%). An examination of the fates for all fallbacks revealed that 62% of the radio-tagged steelhead that fell back at a dam were either tracked to known spawning areas or successfully passed and remained above the fallback dam (57% for hatchery fish and 100% for "wild" fish).

Detailed examination of the fish assigned to each spawning area revealed that almost every stock had some individuals that were tracked upstream of the spawning destination. In total, 22% of the radio-tagged steelhead assigned to a tributary stock were tracked upstream of their spawning destination (Table 24). The only stock groups not tracked upstream of their destination were those with no potential for upstream detection (Wells Hatchery and Okanogan River stocks). The Wells Hatchery fish were removed during broodstock collections and not permitted to migrate further upstream, and no areas were surveyed upstream of the Okanogan River. One wandering steelhead was tracked passed each of the five mid-Columbia dams during it's upstream migration to the Okanogan River where it remained from 16 November 1999 until 24 February 2000. Then, this same fish migrated downstream through all five mid-Columbia dams during the no spill period between 27 February and mid- March 2000, and then upstream passed three Snake River dams to be recovered at the Lower Granite trap on 30 March 2000. This was just one of the 37 fish (14%) tracked to multiple spawning areas with 22 of these fish migrating into the Okanogan River prior to entering the Methow River to spawn (Table 24).

Kelting Rates

Estimates of the overall kelting rate ranged from 34% to 69% of the radio-tagged fish at large during the kelting period (Table 25). The wide range in kelting rates was primarily due to the uncertainties created by the release of juvenile steelhead and chinook with identical radio-tag codes to those of the adult steelhead (Skalski et al. 2000; English et al. 2000). The kelting rates were estimated for each tributary stock and mainstem reach using the data collected through extensive mobile tracking surveys and fixed-station arrays setup for juvenile radio-telemetry survival studies at the four mid-Columbia dams below Wells Dam. Fish were classified as "known" kelts if they were tracked moving downstream after the spawning period and there was no overlap with the radio tags applied to juvenile fish. The minimum kelting rates were estimated by dividing the "known" kelts by the number of radio-tagged fish at large after removals, for a specific stock or reach. The lower Wenatchee River stock had the lowest portion of known kelts because there were no monitoring stations downstream of the Wenatchee River where kelts could be detected before entering the juvenile survival study area.

The difference between the number of fish available for kelting (i.e., distribution after removals) and the fish tracked at the end of the study (i.e., distribution after kelting) was the "suspected kelts/removals". If we assume that all these fish kelted, the maximum kelting rates equals the number of suspected kelts divided by the number available for kelting after removals (Figure 23).

The range in kelting rates, defined by the minimum and maximum kelt estimates, was very large for mid-Columbia mainstem reaches (6-67%) (Table 25). The suspected kelts/removals for these mid-Columbia reaches are probably overestimated since some radio tags could be in waters too deep for detection during the final aerial surveys. However, the confirmed observation that several of the fish tracked to these mid-Columbia reaches did migrate downstream during the kelting period suggest that some fish may have entered the spawning areas undetected. These fish could have spawned in the portion of the major tributaries below the fixed-station monitoring sites or passed these fixed-station sites undetected. The aerial surveys could have failed to detect these fish in a tributary if they were holding in water greater than 20 m deep or if they migrated into and out of a tributary between the aerial surveys.

Run Timing by Stock and Location

The numbers of radio-tagged steelhead from each spawning area detected each day during the upstream migration period from 15 July through 30 November provide an indication of the upstream migration timing for each steelhead stock (Figures 24 - 29). The run-timing pattern below Priest Rapids Dam shows the rapid movement of all upstream stocks after release while the fish destined for spawning areas south of the study area (i.e., Ringold, Yakima and Snake River) resided for long periods in the Coyote to Priest Rapids reach (Figure 24). The migration pattern through the Priest Rapids pool was also quick for up-river steelhead stocks and most of the "South" stocks detected upstream of Priest Rapids Dam had returned downstream before the end of November (Figure 25). Above Wanapum Dam the peaks from the tagging days were still evident throughout most of the season and a few of the South stocks were detected until late November (Figure 26). The migration pattern changed substantially above Rock Island as Wenatchee stocks hold along the mainstem Columbia for extended periods prior to entering the Wenatchee River (Figure 27). A similar pattern of mainstem holding was observed for the stocks migrating through the Rocky Reach and Wells pools to up-river tributaries (Figures 28 and 29). The major decline in the mainstem abundance on 22 October 1999, evident in Figures 27-29, was due to the assignment of fish to tributaries based on the aerial surveys conducted on that date. Some of these fish may have entered the tributaries earlier, but had not migrated passed the fixed-station monitoring sites or had not been detected at those sites.

The reciprocal to the mainstem patterns was the accumulation, holding and kelting for each tributary (Figure 30). Steelhead began accumulating in tributaries within a week of the first release and reached a plateau of roughly 225 radio-tagged steelhead in late November. The number of fish in the tributaries remained constant from early December 1999 through early February 2000. Tributary numbers peaked in March just prior to the suspected spawning period and declined steadily from early April through early May as the kelts exited the spawning tributaries. Figure 30 only includes the known kelts and, therefore, does not reflect the true number of kelts from all stock. It is likely that many of the kelts from the lower Wenatchee stock were not detected because they were missed by the receiver monitoring the lower Wenatchee and tags detected on the mid-Columbia during May could not be confidently separated from the detections of juvenile fish tagged with the same codes.

The last run timing figure shows the accumulation of radio-tagged steelhead in the Hanford reach below Coyote Rapids (Figure 31). While significant numbers of South stocks were tracked in the Coyote to Priest Rapids reach from late September to late November, the number detected below Coyote Rapids remained low until early February. The number of South stocks detected increased rapidly between early February and mid-March and reach a maximum of 22 fish in early April. Most of the fish detected below Coyote Rapids were detected in the vicinity of Ringold Hatchery. Since there were no monitoring stations below Ringold, the detection pattern in Figure 31 represents the cumulative number of fish detected in this reach.

Straying Rates

Each of the radio-tagged adult steelhead was inspected for marks that indicate where that fish had been released as a juvenile. Presents of a blank wire cheek tag indicated that the fish was reared at the Wells Hatchery and released into the Methow River. Of the 33 radio-tagged steelhead that originated from these Methow releases, 70% returned to the Methow River, 15% were classified as strays to the Okanogan River, 9% were intercepted at during broodstock collections for Wells Hatchery, and 6% (2 fish) were last tracked on the mid-Columbia River (Table 26).

Visual implant elastomer (VIE) tags in the adipose tissue posterior of the left eye identified fish that were reared at the East Bank Hatchery adjacent to the Rocky Reach Dam and Chiwawa ponds. Most of the VIE tagged steelhead were released in the Wenatchee River but some were released into the Entiat River and along the mainstem of the Columbia. River. Of the 47 radio-tagged steelhead with VIE tags, 1 was recovered at the East Bank Hatchery adjacent to Rocky Reach Dam and 1 was removed from the Wells pool. Of the remainder, 56% returned to the Wenatchee and Entiat rivers, 18% were classified as strays to the Methow and Okanogan rivers, 7% were intercepted at during broodstock collections for Wells Hatchery, and 20% were last tracked on the mid-Columbia River (Table 26).

DISCUSSION

Few direct comparisons can be made between the results of the 1999 adult steelhead telemetry study and the results from other Columbia River studies. Studies that involved the radio tagging and subsequent tracking of adult salmonids on the mid-Columbia River have been conducted on several occasions. The first major adult salmon radio-telemetry study conducted on the mid-Columbia River in 1992 focused on sockeye (Swan et al. 1994). In 1993, substantial numbers of chinook salmon from spring, summer, and fall run-timing groups were radio-tagged at three dams (John Day, Priest Rapids, and Rocky Reach) and tracked throughout the mid-Columbia basin (Stuehrenberg et al. 1995). In 1996, spring and summer chinook (radio-tagged at Bonneville Dam) were monitored at Priest Rapids and Wanapum dams to evaluate different orifice gate configurations (Bjornn et al. 1997); however, the 1996 radio-tag releases were not monitored at Rock Island, Rocky Reach, or Wells dams. In 1997, adult sockeye, chinook and steelhead were tagged at Bonneville Dam and tracked as they passed Priest Rapids and Wanapum dam (Perry et al. 1998), Rocky Reach and Rock Island dams (English et al. 1998) and Wells Dam (Alexander et al. 1998). In 1998, spring and summer chinook tagged at Bonneville Dam were once again tracked at Priest Rapids and Wanapum dams (English et al. 1999) and at Wells Dam (Nass et al. 2000). Consequently, there are no comparable studies of where adult steelhead were radio-tagged and tracked throughout the mid-Columbia basin. However, some information from mid-Columbia tracking of the adult steelhead tagged at Bonneville Dam in 1997 is provided in English et al. (1998) and Alexander et al. (1998).

In 1997, 975 steelhead were tagged at Bonneville Dam between 14 June and 11 October. However, most of these fish were destined for the Snake River and only 25 (2.6%) were tracked at Rock Island Dam, 20 (2.0%) at Rocky Reach Dam and 19 (1.95%) at Wells Dam (English et al. 1998). The median Project passage times for those fish that passed each dam were 0.17 d at Rock Island (n=16), 1.08 d at Rocky Reach (n=15) and 0.40 d at Wells (n=16). These estimates based on very small sample sizes were remarkably similar to those estimated in this study from many more fish: 0.18 d at Rock Island (n=252), 0.53 d at Rocky Reach (n=178) and 0.69 d at Wells (n=140) (Table 14).

There were other observations that were consistent between the 1997 and 1999 steelhead data. Of the 31 steelhead detected at or above Rock Island Dam, 19 (61%) were detected at Wells Dam in 1997 compared to 63% (195 of 309) in 1999. Travel times between the dams were very similar in each year. Travel times between Rock Island and Rocky Reach dams were 0.95 d and 0.88 d; and travel times between Rocky Reach and Wells dams were 1.78 d and 1.82 d, for 1997 and 1999, respectively.

The 1999 travel times translate into median migration speeds of 36 km/d (0.4-67.9) for the Rock Island and Rocky Reach pools, which are similar to median migration speeds estimated for the Priest Rapids and Wanapum pools; 33 km/d (0.6-72.6). These migration speeds were much faster than the median migration speeds estimated for radio-tagged steelhead tracked on two large unregulated rivers in British Columbia. The median migration speed for radio-tagged steelhead tracked on a 86 km section of the Skeena River was 17.8 km/d (2.5-26.1) in 1994 (Koski et al. 1995) and 12.7 km/d (1.1-28.0) in 1995 (Alexander et al 1996). A comparable estimate for 45 radio-tagged steelhead tracked on the lower Fraser River in 1996 was 8.5 km/d (1.1-28.0) (Nelson et al. 1998). While Columbia River steelhead would not experience river currents as fast as those on the Skeena and Fraser rivers, it is interesting to note that the median migration speed for the 192 km between the Priest Rapids tailrace and the Wells Dam exits was 20.1 km/d (2.6-39.8). These Columbia River steelhead were able to sustain migration speeds exceeding those estimated for steelhead and chinook through similar reaches on the Skeena and Fraser rivers while migrating passed the five mid-Columbia dams (Figure 32). The only stock we have detected migrating upstream faster than mid-Columbia steelhead was summer run Skeena coho; 22.1 km/d (8.3-27.7)(Koski et al. 1995).

In 1999, the fixed-station monitoring sites deployed at each dam provided a complete record of fish passage for each radio-tagged steelhead that encountered each facility. These complete tracking histories and number of steelhead tracked at each location have resulted in reliable and comparable estimates of the Tailrace, Entrance and Fishway passage times for each of the five study area dams. Tailrace passage times were longest (1.9-5.4 h) at Priest Rapids, Wanapum and Wells where the tailrace zone extended to 1200 m below the dam compared to 0.6 h for Rock Island and 1.2 h Rocky Reach dams where tailrace monitoring sites were located 300 m below the dam. Entrance passage times represented 50-85% of the project passage time for steelhead at Priest Rapids and Rocky Reach dams and generally less than 50% of the project passage time at the other dams. Fishway passage times were shortest for Rock Island Dam (1.2-1.8 h) and the right bank fishway at Wanapum Dam (1.8 h). The passage times for all other fishways were remarkably similar (range 2.1-2.5 h).

A statistic used to evaluate radio-tag studies conducted on adult salmon and steelhead is the portion of the radio-tagged fish tracked upstream of the release site or in spawning areas. In this study, 91.6% of the radio-tagged steelhead released below Priest Rapids Dam were tracked upstream of Priest Rapids Dam or in a known spawning area. This level of tracking and upstream migration success was considerably better than the four estimates for summer run steelhead returning to the Skeena River (Koski et al. 1995; Alexander et al. 1996) and comparable to the high rates observed for fall and winter/spring run steelhead returning to the Fraser and Bella Coola rivers in British Columbia (Figure 33) (Nelson et al. 1998; English et al. 1998). Cooler water temperatures during the tagging periods for fall, winter and spring steelhead studies are believed to reduce the effect of handing stress on the radio-tagged steelhead and improve post-release survival for these run timing groups.

Another comparison that can be made with other steelhead studies is the portion tracked as kelts. In each case, a radio-tagged steelhead was classified as a kelt if it was tracked moving downstream after the spawning period. The portion tracked as kelts was the number of kelts divided by the number of radio-tagged steelhead available for kelting (i.e., the tracked tags less removals). In this study, 34% of the available steelhead were tracked as kelts, and this compares favourably with the minimum kelting rates for Skeena summer-run steelhead (Figure 34). The actual kelting rate for the mid-Columbia steelhead that spawned in 2000 is certainly higher than the minimum value of 34% and possibly as high as 69% (Table 25). Maximum kelting rates for specific stock ranged from 65% to 80%. The high kelting rates for winter/spring run steelhead from studies on the Fraser and Bella Coola rivers are likely due to the fact that most of these fish are in freshwater for only 1-2 months compared to 8-11 months for summer run steelhead.

Summary

1. Of the 395 radio-tagged steelhead released near Vernita Bridge in 1999, 353 (89%) were detected at Priest Rapids, 328 (83%) at Wanapum, 309 (78%) at Rock Island, 229 (58%) at Rocky Reach, and 205 (52%) at Wells.

2. Of the radio-tagged steelhead detected in the vicinity of Priest Rapids Dam, 94.4% were either tracked to known spawning areas or successfully passed and remained above Priest Rapids Dam. Comparable percentages for the other dams were: 95.3% for Wanapum Dam, 94.3% for Rock Island Dam, 93.3% for Rocky Reach Dam, and 93.2% for Wells Dam.

3. The median Project passage times for the radio-tagged steelhead detected by the tailrace and fishway exit monitoring stations at the three mid-Columbia dams without ladder trapping activity were: 0.33 d at Wanapum, 0.18 at Rock Island, and 0.53 at Rocky Reach.

4. The median Project passage times for the two mid-Columbia dams with ladder trapping activity were: 0.84 d at Priest Rapids and 0.69 d at Wells. Total trapping time in the fishways at Priest Rapids Dam was 195 h compared to 1584 h in the fishways at Wells Dam.

5. Project passage times and migration times through the reservoirs were similar to those observed for radio-tagged steelhead tracked on the mid-Columbia River in 1997.

6. The median migration rates from the Priest Rapids tailrace to the Wells Dam fishway exits was 20.1 km/d which exceeded the median migrations speeds for radio-tagged steelhead tracked on the Skeena and Fraser rivers in British Columbia.

7. Entrance passage times represented 50-85% of the project passage time for steelhead at Priest Rapids and Rocky Reach dams and generally less than 50% of the project passage time at the other dams.

8. Fishway passage times were generally less than 30% of the total Project passage time and fairly consistent both within and between projects. Median Fishway passage times ranged from 1.2 h to 2.54 h over all projects.

9. The fallback rates for steelhead were similar for all dams. Approximately, 10% of the fish that passed a dam fell back (range 7-12%). The 25 involuntary fallbacks detected for all dams combined represented 2% of the unique dam passage events and all of these were hatchery fish. On average 5% of the unique fish passage events were classified as "voluntary" fallbacks (range 3-7% for the different dams) and 3% were classified as re-ascents (range 1-6%).

10. Of the radio-tagged steelhead that fell back at a dam, 62% were either tracked to known spawning areas or successfully passed and remained above the fallback dam (57% for hatchery fish and 100% for "wild" fish).

11. At Priest Rapids and Wanapum dams, the largest single fallback route was via the power house (50%), followed by the sluice (35-42%) and the spillway (8-15%).

12. The median passage time for the junction pools, after the last detection in an entrance zone, was very short (0.017-0.081 h or 1-5 min.).

13. The passage time for the counting stations ranged from 10 to 24 min. for the Rock Island fishways to less than a minute for the Rocky Reach fishway.

14. The most frequently used fishway entrance at Rock Reach was the spillway entrance; however, the net movements through this entrance were negative.

15. At Wells Dam, no significant differences were detected in the Project or Entrance passage times between periods when the side gates were open and periods when these gates were closed. Fishway passage times for the right-bank fishway were significantly different for the two gate configurations, but the difference was small (1.9 h vs 2.3 h).

16. Upper fishway passage times at Wells Dam were 2-5 times longer for trapping intervals than for no trapping intervals. Trapping also had a substantial effect on the project passage times at Wells Dam

17. Of the 395 steelhead tagged, 2 were never tracked and 13 (3.3%) were known to have been caught and removed prior to spawning. Of the remaining 380 steelhead available for spawning, 308 (81.1%) were tracked to known spawning areas prior to or during the spawning period, and 72 (18.8%) were not assigned to a known spawning area because they were last tracked on the mid-Columbia River between Coyote Rapids and Wells Dam prior to the kelting period. Of the 72 mainstem fish, 22 were classified as stationary and the others were either tracked as kelts or not detected during the last two aerial surveys.

18. The stocks with the largest "wild" component were: Yakima (83%), Wenatchee River above Tumwater Dam (57%) and the Entiat River (50%). The tributaries with the high proportion for hatchery fish were the Okanogan River (90%) and Methow River (80%).

19. Of the radio-tagged steelhead assigned to a tributary stock, 22% were tracked upstream of their spawning destination.

20. Estimates of the overall kelting rate range from 34% to 69% of the radio-tagged fish at large during the kelting period.

21. Straying rates for Wenatchee, Entiat and Methow hatchery releases were estimated to be 15-18%.

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TABLES

FIGURES

APPENDICES

TABLES

Table 1. Expected versus actual steelhead returns, steelhead captured and steelhead radio-tagged at Priest Rapids left fish ladder, 11 July to 16 October 1999.

		Expected run and initial tagging targets						Actual run and steelhead tagged						
	Week Ending	Tagging Target	Prop'n of Tags	Priest Rapids Count	Number if 10% Captured	% of Captured Tagged	% of Run Tagged	Number Tagged	Prop'n of Tags	Priest Rapids Count	Number if 10% Captured	Number Actually Captured	% of Captured Tagged	% of Run Tagged
	17-Jul	4	0.010	70	7	57%	5.7%	2	0.005	95	10	5	40%	2%
	24-Jul	12	0.030	210	21	57%	5.7%	5	0.013	131	13	6	83%	4%
	31-Jul	20	0.050	350	35	57%	5.7%	15	0.038	278	28	22	68%	5%
	07-Aug	32	0.080	560	56	57%	5.7%	40	0.100	406	41	59	68%	10%
	14-Aug	36	0.090	630	63	57%	5.7%	28	0.070	523	52	35	80%	5%
	21-Aug	40	0.100	700	70	57%	5.7%	37	0.093	806	81	56	66%	5%
	28-Aug	44	0.110	770	77	57%	5.7%	48	0.120	1027	103	103	47%	5%
	04-Sep	48	0.120	840	84	57%	5.7%	48	0.120	1137	114	158	30%	4%
	11-Sep	48	0.120	840	84	57%	5.7%	39	0.098	936	94	70	56%	4%
	18-Sep	44	0.110	770	77	57%	5.7%	44	0.110	1000	100	149	30%	4%
	25-Sep	36	0.090	630	63	57%	5.7%	43	0.108	795	80	94	46%	5%
	02-Oct	24	0.060	420	42	57%	5.7%	26	0.065	364	36	29	90%	7%
	09-Oct	10	0.025	175	18	57%	5.7%	16	0.040	252	25	37	43%	6%
	16-Oct	2	0.005	35	4	57%	5.7%	4	0.010	203	20			2%
Totals	**1 Jul - 16 Oct**	**400**	**1.000**	**7000**	**700**	**57%**	**5.7%**	**395**	**0.9875**	**7953**	**795**	**823**	**48%**	**5%**

Table 2. Summary of fixed-station monitoring effort (in hours) for each week for all sites monitored in 1999 between the Hanford Reach and Wanapum Dam forebay (see Appendix Table A2 for details).

			Priest Rapids Dam							Wanapum Dam						Grant
				Fishway	Fishway Exits				Crab		Fishway	Fishway Exits				PUD
Week Ending	Hanford Reach	Coyote Rapids	Tailrace	Entrances	Left	Right	Total	Forebay	Creek	Tailrace	Entrances	Left	Right	Total	Forebay	Total
17-Jul	24	155	255	371	125	128	253	337	105	235	293	157	146	303	303	3190
24-Jul	0	168	334	501	168	167	335	357	168	174	326	166	167	333	336	3700
31-Jul	0	168	330	501	168	125	293	441	131	335	197	167	139	306	334	3635
07-Aug	0	168	332	503	168	167	335	501	168	335	334	167	167	334	289	3968
14-Aug	0	168	333	503	168	166	334	501	166	335	334	167	167	334	333	4009
21-Aug	0	168	332	503	168	167	335	501	167	302	334	167	167	334	336	3981
28-Aug	0	168	336	504	168	167	335	500	167	299	334	168	167	335	335	3983
04-Sep	0	168	336	503	167	167	334	503	168	336	335	167	167	334	335	4020
11-Sep	37	167	336	502	167	167	334	503	168	336	334	168	168	336	336	4059
18-Sep	168	167	336	503	168	167	335	504	167	336	334	167	167	334	336	4189
25-Sep	168	168	336	503	168	167	335	503	168	336	335	168	167	335	336	4193
02-Oct	168	168	336	502	168	167	335	503	168	335	334	168	167	335	336	4190
09-Oct	168	168	336	501	168	167	335	503	167	336	335	168	167	335	336	4190
16-Oct	168	168	336	501	168	168	336	502	167	335	331	168	167	335	336	4186
23-Oct	168	168	336	501	168	167	335	503	167	336	335	167	167	334	335	4187
30-Oct	114	168	336	500	168	166	334	503	168	335	335	167	166	333	336	4129
06-Nov	0	168	336	501	167	166	333	502	166	336	295	167	167	334	335	3973
13-Nov	0	168	336	478	168	167	335	501	168	335	274	167	167	334	336	3934
20-Nov	0	167	336	504	167	168	335	388	168	336	335	168	168	336	336	3912
27-Nov	0	168	167	255	168	168	336	83	110	126	125	167	167	334	118	2492
04-Dec	0	166	0	0	168	168	336	0	0	0	0	168	168	336	0	1510
11-Dec	0	168	0	0	168	168	336	0	0	0	0	168	168	336	0	1512
18-Dec	0	167	0	0	62	166	228	0	0	0	0	38	164	202	0	1027
25-Dec	0	168	0	0	0	168	168	0	0	0	0	0	168	168	0	840
Totals	**1183**	**4013**	**6451**	**9640**	**3711**	**3929**	**7640**	**9139**	**3192**	**6169**	**6189**	**3710**	**3960**	**7670**	**6413**	**83009**

Table 3. Numbers of steelhead radio-tagged and released near Vernita Bridge in 1999 that were detected at fixed stations between the Hanford Reach and Wanapum Dam forebay.

Release			Vernita	Priest Rapids Dam									Wanapum Dam							
Week	Hanford	Coyote	Bridge	At		Fishway	Fishway Exits					Crab	At		Fishway	Fishway Exits				
Ending	Reach	Rapids	Release	Dam	Tailrace	Entrances	Left	Right	Total	Unique	Forebay	Creek	Dam	Tailrace	Entrances	Left	Right	Total	Unique	Forebay
17-Jul	0	0	2	2	2	2	1	0	1	1	0	0	2	2	2	1	0	1	1	2
24-Jul	0	0	5	5	4	5	2	3	5	5	1	0	5	4	5	5	0	5	5	1
31-Jul	0	2	15	15	15	15	8	4	12	12	2	0	13	13	13	12	3	15	13	9
07-Aug	0	5	40	36	35	35	24	10	34	33	8	0	33	33	30	24	11	35	33	21
14-Aug	1	5	28	27	27	27	17	10	27	27	7	0	27	27	25	23	6	29	27	13
21-Aug	1	4	37	33	33	33	25	6	31	31	5	0	30	29	26	22	8	30	30	15
28-Aug	5	10	48	40	38	40	27	13	40	40	13	0	38	37	37	26	13	39	38	20
04-Sep	2	4	48	47	46	46	38	9	47	46	11	0	45	44	41	37	8	45	45	25
11-Sep	2	7	39	34	31	34	28	6	34	33	19	0	32	31	29	30	5	35	32	21
18-Sep	4	10	44	39	38	38	27	10	37	35	19	0	34	33	30	33	4	37	34	19
25-Sep	0	7	43	38	35	38	28	8	36	36	12	0	34	33	31	29	8	37	33	21
02-Oct	3	7	26	20	20	20	16	4	20	19	8	0	18	18	18	14	7	21	18	9
09-Oct	0	2	16	14	14	13	12	4	16	14	4	1	14	14	12	13	1	14	14	9
16-Oct	0	1	4	3	3	3	2	1	3	3	1	0	3	3	3	3	0	3	3	3
Totals	**18**	**64**	**395**	**353**	**341**	**349**	**255**	**88**	**343**	**335**	**110**	**1**	**328**	**321**	**302**	**272**	**74**	**346**	**326**	**188**

Table 4. Classification of radio-tagged steelhead that fell-back after passing Priest Rapids Dam, 1999-2000.

Week	Unique	Total Fallbacks by[a]					Voluntary Fallbacks by[b]					Involuntary Fallbacks by[c]					Reascended Fallbacks by[d]				
Ending	Exits	SP	SL	PH	UK	Total	SP	SL	PH	UK	Total	SP	SL	PH	UK	Total	SP	SL	PH	UK	Total
31-Jul	14																				
07-Aug	25																				
14-Aug	22		2			2												2			2
21-Aug	32																				
28-Aug	41				1	1									1	1					
04-Sep	42			1		1										0			1		1
11-Sep	43		1	1	1	3			1		1					0		1		1	2
18-Sep	41		1	1	1	3			1		1					0		1		1	2
25-Sep	35		1	1		2		1			1			1		1					
02-Oct	17		2		2	4		1			1				2	2		1			1
09-Oct	13				1	1									1	1					
16-Oct	10		3	1	1	5		2			2			1	1	2		1			1
23-Oct																0					
30-Oct			1			1		1			1					0					
06-Nov		2	1	1		4	1	1	1		3	1				1					
13-Nov				1		1								1		1					
20-Nov				1		1			1		1					0					
27-Nov				2		2			1		1			1		1					
04-Dec																0					
11-Dec																0					
18-Dec																0					
25-Dec																0					
05-Feb				1		1								1		1					
04-Mar					1	1				1	1					0					
11-Mar					1	1									1	1					
Total	**335**	**2**	**12**	**11**	**9**	**34**	**1**	**6**	**5**	**1**	**13**	**1**	**0**	**5**	**6**	**12**		**6**	**1**	**2**	**9**
Percent	**100.0%**	**0.6%**	**3.6%**	**3.3%**	**2.7%**	**10.1%**	**0.3%**	**1.8%**	**1.5%**	**0.3%**	**3.9%**	**0.3%**	**0.0%**	**1.5%**	**1.8%**	**3.6%**		**1.8%**	**0.3%**	**0.6%**	**2.7%**

[a] SP=Spillway; SL=Slouce; PH=Powerhouse; UK=Unknown

[b] Voluntary Fallbacks = fallback fish last tracked to tributaries or reaches below, but not adjacent to, the fallback dam

[c] Involuntary Fallbacks = fallback fish last tracked to reaches immediately below the fallback dam

[d] Reascended Fallbacks = fallback fish last tracked to locations above the fallback dam

07-Aug	16	1			1	2															
14-Aug	20	1	1			2											1	1			2
21-Aug	23	1				1											1				1
28-Aug	42		1			1												1			1
04-Sep	42			2	1	3				1	1								2		2
11-Sep	43				2	2				1	1									1	1
18-Sep	34		3	1	3	7		2	1	1	4							1		2	3
25-Sep	35		1	1	4	6		1	1	3	2									4	4
02-Oct	24	1	1	3		5		1	3		4						1				1
09-Oct	17		1			1		1			1										
16-Oct	10																				
23-Oct	3			1	1	2								1		1				1	1
30-Oct				1		1			1		1										
06-Nov																					
13-Nov				2		2			2		2										
20-Nov																					
27-Nov				3		3			2		2			1		1					
04-Dec																					
11-Dec																					
18-Dec																					
25-Dec																					
Total	**326**	**4**	**8**	**14**	**12**	**38**	**0**	**5**	**10**	**6**	**18**			**2**		**2**	**4**	**3**	**2**	**9**	**18**
Percent	**100.0%**	**1.2%**	**2.5%**	**4.3%**	**3.7%**	**11.7%**	**0.0%**	**1.5%**	**3.1%**	**1.8%**	**5.5%**	**0.0%**	**0.0%**	**0.6%**	**0.0%**	**0.6%**	**1.2%**	**0.9%**	**0.6%**	**2.8%**	**5.5%**

[a] SP=Spillway; SL=Slouce; PH=Powerhouse; UK=Unknown

[b] Voluntary Fallbacks = fallback fish last tracked to tributaries or reaches below, but not adjacent to, the fallback dam

[c] Involuntary Fallbacks = fallback fish last tracked to reaches immediately below the fallback dam

[d] Reascended Fallbacks = fallback fish last tracked to locations above the fallback dam

Totals	3035	12111	3028	3607	3401	3807	10815	3687	7572	3034	[illegible]	[illegible]

Table 7. Numbers of steelhead radio-tagged and released near Vernita Bridge in 1999 that were detected at fixed stations between the Rock Island Dam tailrace and the Entiat River.

Release	Vernita	Rock Island Dam								Wenatchee	Tumwater	Rocky Reach Dam				Entiat
Week	Bridge	At		Fishway	Fishway Exits							At		Fishway	Fishway	
Ending	Release	Dam	Tailrace	Entrances	Left	Middle	Right	Total	Unique	River	Dam	Dam	Tailrace	Entrances	Exit	River
17-Jul	2	2	2	2	2	0	0	2	2	0	0	2	2	2	2	0
24-Jul	5	5	3	5	1	0	5	6	5	3	1	2	2	2	2	0
31-Jul	15	13	11	13	2	3	9	14	13	4	1	9	9	9	9	1
07-Aug	40	33	25	33	6	6	27	39	30	11	7	20	18	20	20	0
14-Aug	28	25	21	25	9	4	18	31	25	9	4	16	16	16	15	0
21-Aug	37	30	29	30	5	3	26	34	29	7	3	25	25	24	24	0
28-Aug	48	37	36	37	2	4	34	40	36	7	4	31	30	30	29	0
04-Sep	48	45	42	45	5	7	41	53	43	13	6	35	35	35	26	2
11-Sep	39	28	27	28	3	4	22	29	25	6	1	23	21	22	20	0
18-Sep	44	29	28	29	5	8	25	38	29	8	0	21	20	20	19	0
25-Sep	43	31	29	31	4	8	27	39	31	8	1	20	20	20	17	0
02-Oct	26	16	16	16	1	2	13	16	15	2	0	14	14	14	14	0
09-Oct	16	12	11	12	2	2	10	14	12	4	0	8	8	6	5	1
16-Oct	4	3	3	3	0	0	3	3	3	1	0	3	3	3	3	0
Totals	**395**	**309**	**283**	**309**	**47**	**51**	**260**	**358**	**298**	**83**	**28**	**229**	**223**	**223**	**205**	**4**

Table 8. Classification of radio-tagged steelhead that fell back after passing Rock Island Dam, 1999-2000.

Week Ending	Unique Exits	Total Fallbacks	Voluntary Fallbacks[a]	Involuntary Fallbacks[b]	Reascended Fallbacks[c]
31-Jul	9				
07-Aug	11	1	1		
14-Aug	26	1			1
21-Aug	19	2	2		
28-Aug	31	1			1
04-Sep	45				
11-Sep	33	2			2
18-Sep	30	1			1
25-Sep	32	2			2
02-Oct	34	1	1		
09-Oct	10				
16-Oct	10	2	1	1	
23-Oct	8	2	1	1	
30-Oct		2	1	1	
06-Nov		1		1	
13-Nov		2	2		
20-Nov		1			1
27-Nov		1		1	
04-Dec					
11-Dec					
18-Dec					
25-Dec					
Total	**298**	**22**	**9**	**5**	**8**
Percent	**100.0%**	**7.4%**	**3.0%**	**1.7%**	**2.7%**

[a] Voluntary Fallbacks = fallback fish last tracked to tributaries or reaches below, but not adjacent to, the fallback dam

[b] Involuntary Fallbacks = fallback fish last tracked to reaches immediately below the fallback dam

[c] Reascended Fallbacks = fallback fish last tracked to locations above the fallback dam

Table 9. Classification of radio-tagged steelhead that fell back after passing Rocky Reach Dam, 1999-2000.

Week Ending	Unique Exits	Total Fallbacks	Voluntary Fallbacks[a]	Involuntary Fallbacks[b]	Reascended Fallbacks[c]
31-Jul	3	1			1
07-Aug	7				
14-Aug	14				
21-Aug	10	1	1		
28-Aug	27	1		1	
04-Sep	32	5	3	1	1
11-Sep	19				
18-Sep	19	1		1	
25-Sep	24	4	2	2	
02-Oct	23	2	2		
09-Oct	12				
16-Oct	5				
23-Oct	4	2	2		
30-Oct	4	1	1		
06-Nov					
13-Nov	1				
20-Nov		2	2		
27-Nov	1	1	1		
04-Dec					
11-Dec					
18-Dec					
25-Dec					
Total	**205**	**21**	**14**	**5**	**2**
Percent	**100.0%**	**10.2%**	**6.8%**	**2.4%**	**1.0%**

[a] Voluntary Fallbacks = fallback fish last tracked to tributaries or reaches below, but not adjacent to, the fallback dam

[b] Involuntary Fallbacks = fallback fish last tracked to reaches immediately below the fallback dam

[c] Reascended Fallbacks = fallback fish last tracked to locations above the fallback dam

Table 10. Summary of fixed-station monitoring effort (in hours) for each week for all sites monitored in 1999 between the Wells Dam and Zosel Dam (see Appendix Table C1and C2 for details)

Week Ending	Wells Dam Tailrace	Wells Dam Fishway Entrances / Trap	Wells Dam Fishway Exits Left	Wells Dam Fishway Exits Right	Wells Dam Fishway Exits Total	Methow River	Okanogan River Monse	Okanogan River Zosel Dam	Douglas PUD Total
17-Jul	24	48	24	24	48	48	24	24	264
24-Jul	57	214	36	34	70	0	0	0	411
31-Jul	167	336	168	168	336	34	0	0	1209
07-Aug	166	334	165	165	330	168	158	0	1486
14-Aug	167	334	167	167	334	168	168	0	1505
21-Aug	168	335	165	167	332	167	167	0	1501
28-Aug	168	336	166	167	333	168	167	80	1585
04-Sep	168	335	167	168	335	147	167	167	1654
11-Sep	168	236	117	120	237	94	167	167	1306
18-Sep	168	331	167	167	334	96	167	167	1597
25-Sep	168	336	165	167	332	168	168	167	1671
02-Oct	168	327	167	168	335	168	167	166	1666
09-Oct	168	252	168	168	336	168	168	167	1595
16-Oct	167	333	167	167	334	168	168	167	1671
23-Oct	166	335	167	168	335	168	168	168	1675
30-Oct	167	334	167	167	334	168	167	166	1670
06-Nov	168	334	106	167	273	168	168	168	1552
13-Nov	165	334	166	166	332	168	167	166	1664
20-Nov	168	336	168	168	336	168	168	158	1670
27-Nov	35	76	166	166	332	179	168	0	1122
04-Dec	0	0	168	168	336	332	168	0	1172
11-Dec	0	0	168	168	336	336	168	0	1176
18-Dec	0	0	37	167	204	335	167	0	910
25-Dec	0	0	0	167	167	335	167	0	836
Totals	**2961**	**5836**	**3322**	**3689**	**7011**	**4119**	**3532**	**2098**	**32568**

Table 11. Numbers of steelhead radio-tagged and released near Vernita Bridge in 1999 that were detected at fixed stations between the Wells Dam tailrace and Zosel Dam.

Release	Vernita	Wells Dam							Methow	Okanogan River		Mobile	Mobile	Mobile
Week	Bridge	At		Fishway	Fishway Exits						Zosel	Tracking	Tracking	Tracking
Ending	Release	Dam	Tailrace	Entrances	Left	Right	Total	Unique	River	Monse	Dam	Douglas	Chelan	Grant
17-Jul	2	1	1	1	1	0	1	1	0	0	0	0	2	0
24-Jul	5	2	2	2	1	0	1	1	0	0	0	1	3	0
31-Jul	15	7	7	6	0	2	2	2	1	0	0	2	6	0
07-Aug	40	18	18	18	9	8	17	17	5	5	1	14	11	8
14-Aug	28	14	14	14	10	4	14	14	5	4	0	12	11	1
21-Aug	37	19	19	19	7	9	16	16	9	5	0	17	10	4
28-Aug	48	28	28	27	8	16	24	24	7	10	0	22	8	6
04-Sep	48	31	31	25	10	9	19	18	1	12	0	26	15	1
11-Sep	39	21	21	20	6	14	20	20	2	10	0	18	6	6
18-Sep	44	18	18	17	11	6	17	17	5	8	0	16	12	5
25-Sep	43	16	15	14	8	6	14	14	2	7	0	14	15	10
02-Oct	26	14	14	13	5	8	13	13	2	7	0	13	3	5
09-Oct	16	4	4	4	2	2	4	4	0	2	0	4	8	2
16-Oct	4	2	2	2	1	0	1	1	1	0	0	1	2	2
Totals	**395**	**195**	**194**	**182**	**79**	**84**	**163**	**162**	**40**	**70**	**1**	**160**	**112**	**50**

Ta[illegible]e 1[illegible] Clas[illegible]atio[illegible] radi[illegible]ged [illegible]lhea[illegible] [illegible]t fel[illegible]k a[illegible] passi[illegible] Well[illegible]m, 1[illegible]200[illegible]

Week Ending	Unique Exits	Total Fallbacks	Voluntary Fallbacks[a]	Involuntary Fallbacks[b]	Reascended Fallbacks[c]
31-Jul	2				
07-Aug	1				
14-Aug	5				
21-Aug	9				
28-Aug	18				
04-Sep	25	1			1
11-Sep	15				
18-Sep	20	1	1		
25-Sep	23				
02-Oct	16	1			1
09-Oct	13	2			2
16-Oct	6				
23-Oct	5				
30-Oct	1				
06-Nov					
13-Nov	1	2	2		
20-Nov	2	3	2		1
27-Nov		1		1	
04-Dec					
11-Dec					
18-Dec					
25-Dec					
Total	**162**	**11**	**5**	**1**	**5**
Percent	**100.0%**	**6.8%**	**3.1%**	**0.6%**	**3.1%**

[a] Voluntary Fallbacks = fallback fish last tracked to tributaries or reaches below, but not adjacent to, the fallback dam

[b] Involuntary Fallbacks = fallback fish last tracked to reaches immediately below the fallback dam

[c] Reascended Fallbacks = fallback fish last tracked to locations above the fallback dam

Table 13. Median travel time (d) and rate of travel (km/d) for radio-tagged steelhead that migrated between fixed-station receivers on the Columbia, Wentachee, and Entiat rivers, 1999.

From Location to Location (Site-Site)[a]	Upstream	Downstream
RI exit - RR tailrace	67.9	2.6
RR exit - Wells tailrace	63.9	10.6
Wells exit - Methow	46.2	0.2
Wells exit - Monse	51.4	1.1
Vernita-Wells exit	37.8	-
PR tailrace - Wells exit	39.8	-
Sample Size[c]		
Vernita - Coyote	-	64
Vernita - PR tailrace	341	0
PR exit - WA tailrace	299	19
WA exit - RI tailrace	280	2
RI exit - Lower Wenatchee	79	2
Lower Wenatchee - TU tailrace	26	1
TU tailrace - TU exit	5	23
RI exit - RR tailrace	208	7
RR exit - Wells tailrace	171	10
Wells exit - Methow	36	1
Wells exit - Monse	64	3
Vernita-Wells exit	162	-
PR tailrace - Wells exit	157	-

[a] Sites are: PR = Priest Rapids Dam, WA = Wanapum Dam, RI = Rock Island Dam, RR = Rocky Reach Dam, TU = Tumwater Dam

[b] Travel time is the time from last detection at first site to first detection at second site .

[c] Sample sizes exclude fish that were missing an arrival time at any particular site.

Table 14. Median project passage times (h) for radio-tagged steelhead that passed dams on mid-Columbia River, 1999.

From Location to Location (Site-Site) [a]	Excluding Fallback	Fallback [b] Last Below [b]	Fallback [b] Last Above
Median travel time (h)			
PR tailrace - PR exit	20.26	23.52	16.24
WA tailrace - WA exit	7.96	9.33	11.79
RI tailrace - RI exit	4.23	5.52	4.45
RR tailrace - RR exit	12.61	13.25	18.17
WE tailrace - WE exit	16.65	10.31	15.57
Minimum Travel Time (h)			
PR tailrace - PR exit	2.72	3.99	6.26
WA tailrace - WA exit	1.79	3.31	2.80
RI tailrace - RI exit	1.26	2.03	2.67
RR tailrace - RR exit	3.03	3.73	5.65
WE tailrace - WE exit	2.81	4.08	7.02
Maximum Travel Time (h)			
PR tailrace - PR exit	493.44	603.90	67.40
WA tailrace - WA exit	67.93	22.21	37.14
RI tailrace - RI exit	29.42	54.09	20.09
RR tailrace - RR exit	1657.65	1415.97	30.69
WE tailrace - WE exit	1611.81	37.30	21.53
Sample Size [c]			
PR tailrace - PR exit	293	20	9
WA tailrace - WA exit	282	19	16
RI tailrace - RI exit	252	12	5
RR tailrace - RR exit	178	18	2
WE tailrace - WE exit	140	11	5

[a] Sites are: PR = Priest Rapids Dam, WA = Wanapum Dam, RI = Rock Island Dam, RR = Rocky Reach Dam, TU = Tumwater Dam, WE Wells Dam

[b] Fallback are fish that were detected below a dam after being detected above the dam. Fallback fish are dam specific. A fish that only fell back at one dam would not be classified as a fallback at the other dams.

[c] Sample sizes exclude fish that were missing an arrival time at any particular site.

Table 15. Median passage times (h) for radio-tagged steelhead that migrated passed Priest Rapids, Wanapum, Rock Island, Rocky Reach and Wells dams on the mid-Columbia River, 1999.

	Median Passage Times (h)					Sample Size[3]			
	Tailrace[1]	Entrance	Fishway	Sum[2]	Total	Tailrace	Entrance	Fishway	Total
Priest Rapids Dam									
Left Fishway - Collection	2.89	6.01	2.52	11.42	22.59	132	139	139	134
Left Fishway - Main	2.11	3.98	2.50	8.58	18.59	107	112	112	107
Left Fishway (combined)	2.34	4.83	2.52	9.68	20.48	239	251	251	242
Right Fishway	3.92	1.66	2.40	7.98	20.65	79	82	82	80
Wanapum Dam									
Left Fishway - Collection	2.56	1.20	2.48	6.25	9.78	153	150	150	157
Left Fishway - Main	1.94	0.52	2.21	4.67	5.95	75	78	78	75
Left Fishway (combined)	2.35	0.85	2.42	5.62	8.55	228	228	228	232
Right Fishway	5.39	0.45	1.83	7.67	8.60	61	60	60	61
Rock Island Dam									
Left Fishway	0.63	1.89	1.20	3.73	10.74	18	17	17	22
Center Fishway	0.90	0.58	1.77	3.25	6.50	20	18	18	25
Right Fishway	1.06	1.02	1.24	3.31	4.36	215	242	242	222
Rocky Reach Dam									
Downstream Powerhouse	0.79	9.44	2.54	12.76	20.92	83	85	85	85
Upstream Powerhouse	1.21	16.01	2.08	19.30	16.99	36	41	41	37
Tirfurcation Entrance	1.20	5.04	2.34	8.57	9.92	46	47	47	46
Spillway Entrance	1.23	5.03	2.38	8.65	16.21	30	32	32	30
Wells Dam									
Left Fishway	2.97	3.25	2.14	8.36	12.84	77	77	77	77
Right Fishway	3.67	4.01	2.17	9.85	16.74	74	72	72	79

[1] Tailrace antennas at Rock Island and Rocky Reach dams were mounted 300 m dowstream, compared to Priest Rapids, Wanapum, and Wells dams where this distance was extended to 1200 m.

[2] Sum of the median passage times for the tailrace, entrance and fishway intervals.

[3] Fish with second ascents were excluded from this analysis

Table 16. Comparison of fishway passage times (h) for radio-tagged steelhead that migrated passed Priest Rapids, Wanapum, Rock Island, Rocky Reach and Wells dams on the mid-Columbia River, 1999.

	Log transformed				
	PR	WA	RI	RR	WE
Fishway Passage					
Mean (h)					
Left Fishway	1.26	1.15	0.99		0.91
Right Fishway	1.03	0.67	0.37	1.56	1.05
Center Fishway			0.69		
Standard Deviation (h)					
Left Fishway	0.93	0.91	1.70		0.56
Right Fishway	0.97	0.36	1.12	1.76	0.94
Center Fishway			0.54		
Comparison (p-value)					
Left vs Right Fishway	0.069	<0.001	0.161		0.289
Left vs Center Fishway			0.499		
Right vs Center Fishway			0.038		

Table 17. Comparison of junction pool and counting station passage times (h) for radio-tagged steelhead that migrated passed Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams on the mid-Columbia River, 1999.

			Passage Times (h)				Sample
	Dam	Fishway	Median	Mean	Min	Max	Size
Junction Pool							
	Priest Rapids						
		Left Bank	0.041	0.322	0.010	13.356	201
	Wanapum						
		Left Bank	0.017	0.022	0.008	0.057	22
	Rock Island						
		Right Bank	0.024	0.063	0.002	0.674	171
	Rocky Reach						
		Right Bank	0.081	0.291	0.009	9.376	183
Counting Station							
	Rock Island						
		Left Bank	0.167	1.001	0.018	6.386	21
		Center	0.177	0.248	0.056	0.763	23
		Right Bank	0.407	0.843	0.011	13.088	254
	Rocky Reach						
		Right Bank	0.004	0.386	0.0003	59.828	204

Table 18. Comparison of fallback and re-ascending rates by dam, 1999.

Dam	Unique[1] detections at exits	Unique fallbacks	Unique reascents	Percentages	
				Fallbacks	Reascents
Priest Rapids	335	30	9	9.0%	30.0%
Wanapum	326	37	18	11.3%	48.6%
Rock Island	298	22	6	7.4%	27.3%
Rocky Reach	205	21	2	10.2%	9.5%
Wells	162	17	5	10.5%	29.4%
Total	1326	127	40	9.6%	31.5%

[1] Only includes each fish once for each dam, therefore, multiple fallbacks or multiple reascents only count as one event.

Table 19. Spawning destinations or furthest upstream detection of the radio-tagged steelhead detected at each of the Mid-Columbia Dams, prior to kelting.

	Detection Site					
Location/Group	Priest Rapids Dam	Wanapum Dam	Rock Island Dam	Rocky Reach Dam	Wells Dam	Totals for all tags
Tags detected at each dam	353	328	309	229	195	395
Tags never tracked						2
Removals prior to spawning						
Tributaries (Wenatchee)	3	3	3	0	0	3
Mid-Columbia River	10	7	7	5	4	10
Sub-total	13	10	10	5	4	13
Tributaries						
Snake River	6	3	1	1	1	16
Yakima River	4	2	0	0	0	6
Wenatchee River						
Below Tumwater Dam	52	52	52	16	3	52
Above Tumwater Dam	30	30	30	4	0	30
Entiat River	8	8	8	7	2	8
Wells Hatchery	18	18	18	18	18	18
Methow River	90	90	90	90	90	90
Okanogan River	50	50	50	50	50	50
Sub-Total	258	253	249	186	164	270
Mid-Columbia River						
Hanford Reach						
Savage Is. - Coyote	9	6	2	1	0	24
Coyote - Priest Rapids	19	10	7	3	1	32
Prist Rapids Pool	9	5	2	1	1	9
Wanapum Pool	13	13	8	5	5	13
Rock Island Pool	10	9	9	6	3	10
Rocky Reach Pool	8	8	8	8	3	8
Wells Pool	14	14	14	14	14	14
Sub-Total	82	65	50	38	27	110
Fish available for spawning	340	318	299	224	191	380
Spawning Areas (excluding removals)						
Tributaries	258	253	249	186	164	270
Mid-Columbia River	23	20	16	15	14	38
Sub-total	281	273	265	201	178	308
Percentages						
Spawning Areas	82.6%	85.8%	88.6%	89.7%	93.2%	81.1%
Other Areas						
Below Dam	5.6%	4.7%	5.7%	6.7%	6.8%	8.4%
Above Dam	11.8%	9.4%	5.7%	3.6%	0.0%	10.5%
Above Dam or Spawning Areas	94.4%	95.3%	94.3%	93.3%	93.2%	91.6%

Boxed areas are the mainstem areas between Coyote Rapids and the dam.

Table 20. Spawning destinations or furthest upstream detection of the hatchery and wild radio-tagged steelhead detected at each of the Mid-Columbia Dams, prior to kelting.

	Radio-tagged Steelhead				
Location/Group	Hatchery	Wild	Total	% Hatchery	% Wild
Total Tagged	298	97	395	75%	25%
Tags Never Tracked	1	1	2	50%	50%
Removals Prior to Spawning					
Tributaries (Wenatchee)	0	3	3	0%	100%
Mid-Columbia River	9	1	10	90%	10%
Sub-total	9	4	13	69%	31%
Tributary/Spawning Areas					
Snake River	11	5	16	69%	31%
Yakima River	1	5	6	17%	83%
Wenatchee River					
Below Tumwater Dam	31	21	52	60%	40%
Above Tumwater Dam	13	17	30	43%	57%
Entiat River	4	4	8	50%	50%
Wells Hatchery	16	2	18	89%	11%
Methow River	72	18	90	80%	20%
Okanogan River	45	5	50	90%	10%
Sub-Total	193	77	270	71%	29%
Mid-Columbia River					
Hanford Reach					
Savage Is. - Coyote	22	2	24	92%	8%
Coyote - Priest Rapids	26	6	32	81%	19%
Prist Rapids Pool	8	1	9	89%	11%
Wanapum Pool	12	1	13	92%	8%
Rock Island Pool	8	2	10	80%	20%
Rocky Reach Pool	6	2	8	75%	25%
Wells Pool	13	1	14	93%	7%
Sub-Total	95	15	110	86%	14%
Percentages					
Tributary/Spawning Areas	65%	79%	68%		
Mid-Columbia River	32%	15%	28%		

Table 21. Spawning destinations or furthest upstream detection of the radio-tagged steelhead that fell back at Priest Rapids and Wanapum dams, prior to kelting.

	Fallback Site					
	Priest Rapids Dam			Wanapum Dam		
Location/Group	Hatchery	Wild	Total	Hatchery	Wild	Total
Unique fish passed dam	251	84	335	244	82	326
Tributary/Spawning Areas						
Snake River	1	1	2	1	1	2
Yakima River	0	1	1	0	1	1
Wenatchee River						
Below Tumwater Dam	2	1	3	1	1	2
Above Tumwater Dam	0	0	0	2	0	2
Entiat River	0	0	0	1	0	1
Wells Hatchery	0	0	0	1	1	2
Methow River	3	0	3	5	0	5
Okanogan River	2	0	2	4	0	4
Sub-Total	8	3	11	15	4	19
Mid-Columbia River						
Hanford Reach						
Savage Is. - Coyote	9	1	10	5	1	6
Coyote - Priest Rapids	12	0	12	9	0	9
Prist Rapids Pool	0	0	0	2	0	2
Wanapum Pool	0	0	0	0	0	0
Rock Island Pool	0	0	0	0	0	0
Rocky Reach Pool	1	0	1	0	0	0
Wells Pool	0	0	0	2	0	2
Sub-Total	22	1	23	18	1	19
Total	30	4	34	33	5	38
Fallback Categories						
Voluntary	10	3	13	15	3	18
Involuntary	12	0	12	2	0	2
Rescended	8	1	9	16	2	18
Fallback Percentages						
Voluntary	4.0%	3.6%	3.9%	6.1%	3.7%	5.5%
Involuntary	4.8%	0.0%	3.6%	0.8%	0.0%	0.6%
Rescended	3.2%	1.2%	2.7%	6.6%	2.4%	5.5%
Total	12.0%	4.8%	10.1%	13.5%	6.1%	11.7%
% Above Dam or in Spawning Areas	60%	100%	65%	67%	100%	71%

Table 22. Spawning destinations or furthest upstream detection of the radio-tagged steelhead that fell back at Rock Island and Rocky Reach dams, prior to kelting.

	Fallback Site					
	Rock Island Dam			Rocky Reach Dam		
Location/Group	Hatchery	Wild	Total	Hatchery	Wild	Total
Unique fish passed dam	223	75	298	172	33	205
Tributary/Spawning Areas						
Snake River	0	0	0	0	0	0
Yakima River	0	0	0	0	0	0
Wenatchee River						
Below Tumwater Dam	0	0	0	6	0	6
Above Tumwater Dam	0	1	1	1	1	2
Entiat River	0	0	0	0	0	0
Wells Hatchery	1	0	1	0	0	0
Methow River	0	1	1	1	0	1
Okanogan River	2	0	2	1	0	1
Sub-Total	3	2	5	9	1	10
Mid-Columbia River						
Hanford Reach						
Savage Is. - Coyote	2	0	2	1	0	1
Coyote - Priest Rapids	6	0	6	3	0	3
Prist Rapids Pool	1	0	1	0	0	0
Wanapum Pool	5	0	5	2	0	2
Rock Island Pool	1	1	2	5	0	5
Rocky Reach Pool	0	0	0	0	0	0
Wells Pool	1	0	1	0	0	0
Sub-Total	16	1	17	11	0	11
Total	19	3	22	20	1	21
Fallback Categories						
Voluntary	9	0	9	13	1	14
Involuntary	5	0	5	5	0	5
Rescended	5	3	8	2	0	2
Fallback Percentages						
Voluntary	4.0%	0.0%	3.0%	7.6%	3.0%	6.8%
Involuntary	2.2%	0.0%	1.7%	2.9%	0.0%	2.4%
Rescended	2.2%	4.0%	2.7%	1.2%	0.0%	1.0%
Total	8.5%	4.0%	7.4%	11.6%	3.0%	10.2%
% Above Dam or in Spawning Areas	37%	100%	45%	50%	100%	52%

Table 23. Spawning destinations or furthest upstream detection of the radio-tagged steelhead that fell back at Wells Dam and totals for all Mid-Columbia dams, prior to kelting.

	Fallback Site					
	Wells Dam			Totals for All Dams		
Location/Group	Hatchery	Wild	Total	Hatchery	Wild	Total
Unique fish passed dam	139	23	162	1029	297	1326
Tributary/Spawning Areas						
Snake River	0	0	0	2	2	4
Yakima River	0	0	0	0	2	2
Wenatchee River						
Below Tumwater Dam	2	0	2	11	2	13
Above Tumwater Dam	0	0	0	3	2	5
Entiat River	2	0	2	3	0	3
Wells Hatchery	0	0	0	2	1	3
Methow River	2	0	2	11	1	12
Okanogan River	1	1	2	10	1	11
Sub-Total	7	1	8	42	11	53
Mid-Columbia River						
Hanford Reach						
Savage Is. - Coyote	0	0	0	17	2	19
Coyote - Priest Rapids	0	0	0	30	0	30
Prist Rapids Pool	0	0	0	3	0	3
Wanapum Pool	1	0	1	8	0	8
Rock Island Pool	1	0	1	7	1	8
Rocky Reach Pool	1	0	1	2	0	2
Wells Pool	0	0	0	3	0	3
Sub-Total	3	0	3	70	3	73
Total	10	1	11	112	14	126
Fallback Categories						
Voluntary	6	0	6	53	7	60
Involuntary	1	0	1	25	0	25
Rescended	3	1	4	34	7	41
Fallback Percentages						
Voluntary	4.3%	0.0%	3.7%	5.2%	2.4%	4.5%
Involuntary	0.7%	0.0%	0.6%	2.4%	0.0%	1.9%
Rescended	2.2%	4.3%	2.5%	3.3%	2.4%	3.1%
Total	7.2%	4.3%	6.8%	10.9%	4.7%	9.5%
% Above Dam or in Spawning Areas	70%	100%	73%	57%	100%	62%

Table 24. Detection of radio-tagged steelhead by stock in tributary spawning areas and along the Mid-Columbia River, prior to kelting.

Location/Group	Snake River	Yakima River	Wenatchee River Lower	Wenatchee River Upper	Entiat River	Wells Hatchery	Methow River	Okanogan River	All
	Tributary/Spawning Area								
Fish assigned to spawning area	16	6	55	30	8	18	90	50	273
Tributary/Spawning Areas									
Snake River	16								16
Yakima River		6							6
Wenatchee River									
Below Tumwater Dam			55	30	1				86
Above Tumwater Dam			4	30					34
Entiat River					8				8
Wells Hatchery						18			18
Methow River			1				90	6	97
Okanogan River	1		1		1		22	50	75
Mid-Columbia River									
Hanford Reach									
Savage Is. - Coyote	12								12
Coyote - Priest Rapids	16	6	55	30	8	18	90	50	273
Prist Rapids Pool	3	2	55	30	8	18	90	50	256
Wanapum Pool	3	2	55	30	8	18	90	50	256
Rock Island Pool	1		55	30	8	18	90	50	252
Rocky Reach Pool	1		10	3	7	18	90	50	179
Wells Pool	1		3		2		84	48	138
Upstream of Spawning Location	16	6	10	3	2	0	22	0	59
Non-Destination Spawning Areas	1		6		2	0	22	6	37
Percentages									
Upstream of Spawning Area	100%	100%	18%	10%	25%	0%	24%	0%	22%
Other Spawning Areas	6%	0%	11%	0%	25%	0%	24%	12%	14%

Table 25. Recoveries of radio-tagged steelhead by location, distribution before and after kelting and kelting rates by stock.

Location/Group	Distribution Below Kelting	Known Removals	Distribution After Removals	Distribution After Kelting	Suspected Kelts/ Removals	Known Kelts	Kelting Rate Min.	Kelting Rate Max.
Tributary/Spawning Areas								
Snake River	16	13	3	3	0	0	0%	0%
Yakima River	6	0	6	5	1	1	17%	17%
Wenatchee River								
Below Tumwater Dam	55	3	52	18	34	7	13%	65%
Above Tumwater Dam	30	0	30	6	24	17	57%	80%
Entiat River	8	0	8	2	6	6	75%	75%
Wells Hatchery	18	18	0	0	0	0		
Methow River	90	0	90	23	67	53	59%	74%
Okanogan River	50	0	50	16	34	28	56%	68%
Sub-Total	273	34	239	73	166	112	47%	69%
Mid-Columbia River								
Hanford Reach								
Savage Is. - Coyote	26	2	24	14	10	0	0%	42%
Coyote - Priest Rapids	33	1	32	10	22	0	0%	69%
Prist Rapids Pool	9	0	9	4	5	0	0%	56%
Wanapum Pool	13	0	13	1	12	2	15%	92%
Rock Island Pool	13	3	10	2	8	2	20%	80%
Rocky Reach Pool	8	0	8	2	6	1	13%	75%
Wells Pool	18	4	14	3	11	2	14%	79%
Sub-Total	120	10	110	36	74	7	6%	67%
Fish Never Tracked	2							
Total	395	44	349	109	240	119	34%	69%
% of Release		11%	88%	28%	61%	30%		

Table 26. Spawning destinations or furthest upstream detection for radio-tagged steelhead originating from hatchery releases in the Wenatchee and Methow rivers.

	Juvenile Release Location		
Location/Group	Wenatchee/Entiat [1]	Methow	Total
Number of radio-tagged fish	47	33	80
Removals Prior to Spawning			
Tributaries (Wenatchee)			
Mid-Columbia River	2		2
Sub-total	2	0	2
Tributary/Spawning Areas			
Snake River			
Yakima River			
Wenatchee River			
Below Tumwater Dam	17		17
Above Tumwater Dam	6		6
Entiat River	2		2
Wells Hatchery	3	3	6
Methow River	7	23	30
Okanogan River	1	5	6
Sub-Total	36	31	67
Mid-Columbia River			
Hanford Reach			
Savage Is. - Coyote	1		1
Coyote - Priest Rapids		1	1
Prist Rapids Pool			0
Wanapum Pool	3	1	4
Rock Island Pool			0
Rocky Reach Pool	2		2
Wells Pool	3		3
Sub-Total	9	2	11
Fish available for spawning	45	33	78
Homing Summary			
Returned to release stream	25	23	48
Returned to other stream (strays)	8	5	13
Removed at Wells Hatchery	3	3	6
Mid-Cloumbia Mainstem	9	2	11
Percentages			
Returned to release stream(s)	56%	70%	62%
Returned to other streams (strays)	18%	15%	17%
Removed at Wells Hatchery	7%	9%	8%
Mid-Cloumbia Mainstem	20%	6%	14%

[1] Most of the fish with VIE tags were released in the Wenatchee and Entiat rivers but some were released into the Mid-Columbia.

FIGURES

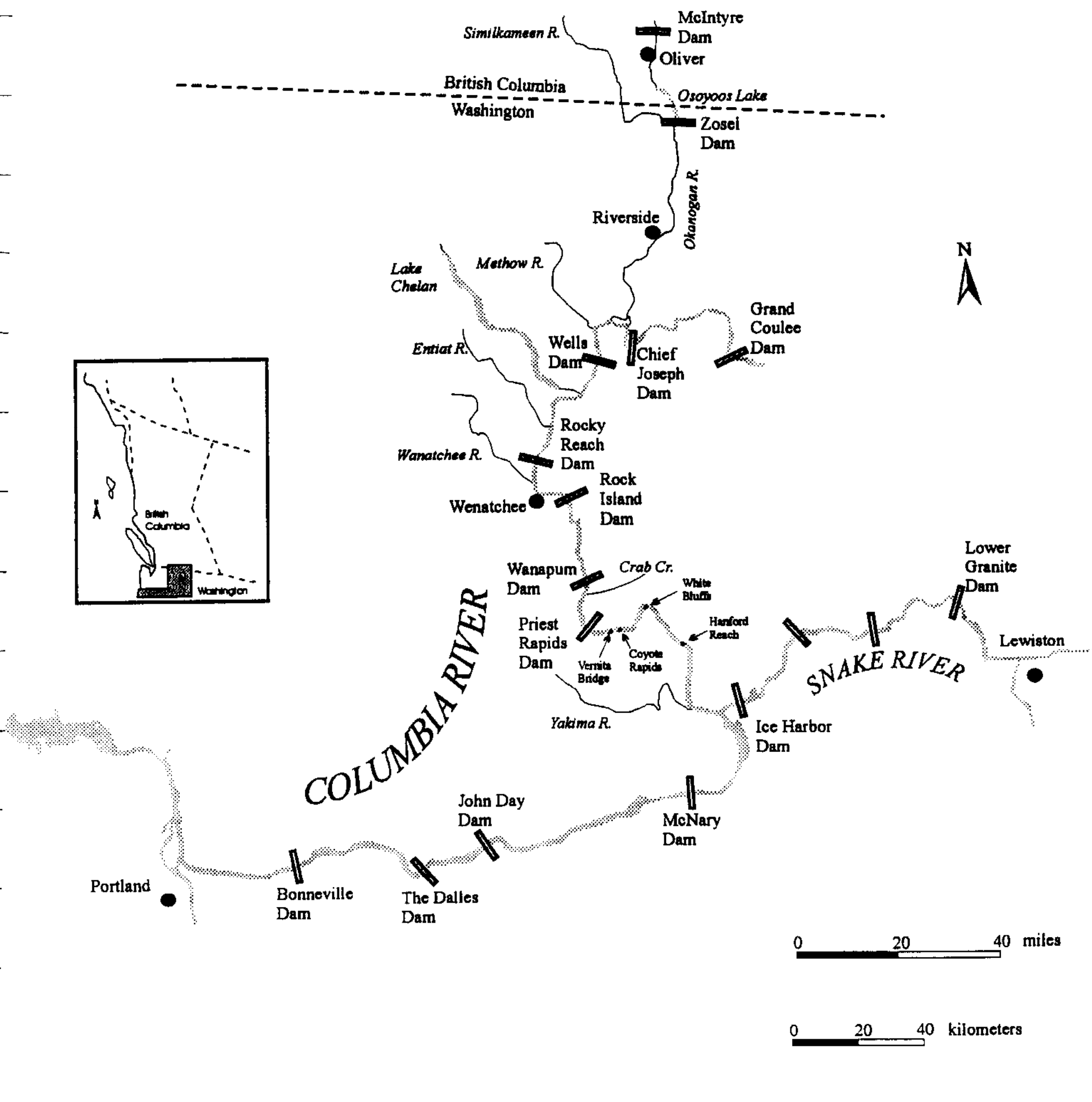

Figure 1. Study area and location of major dams and tributaries on the mid-Columbia River.

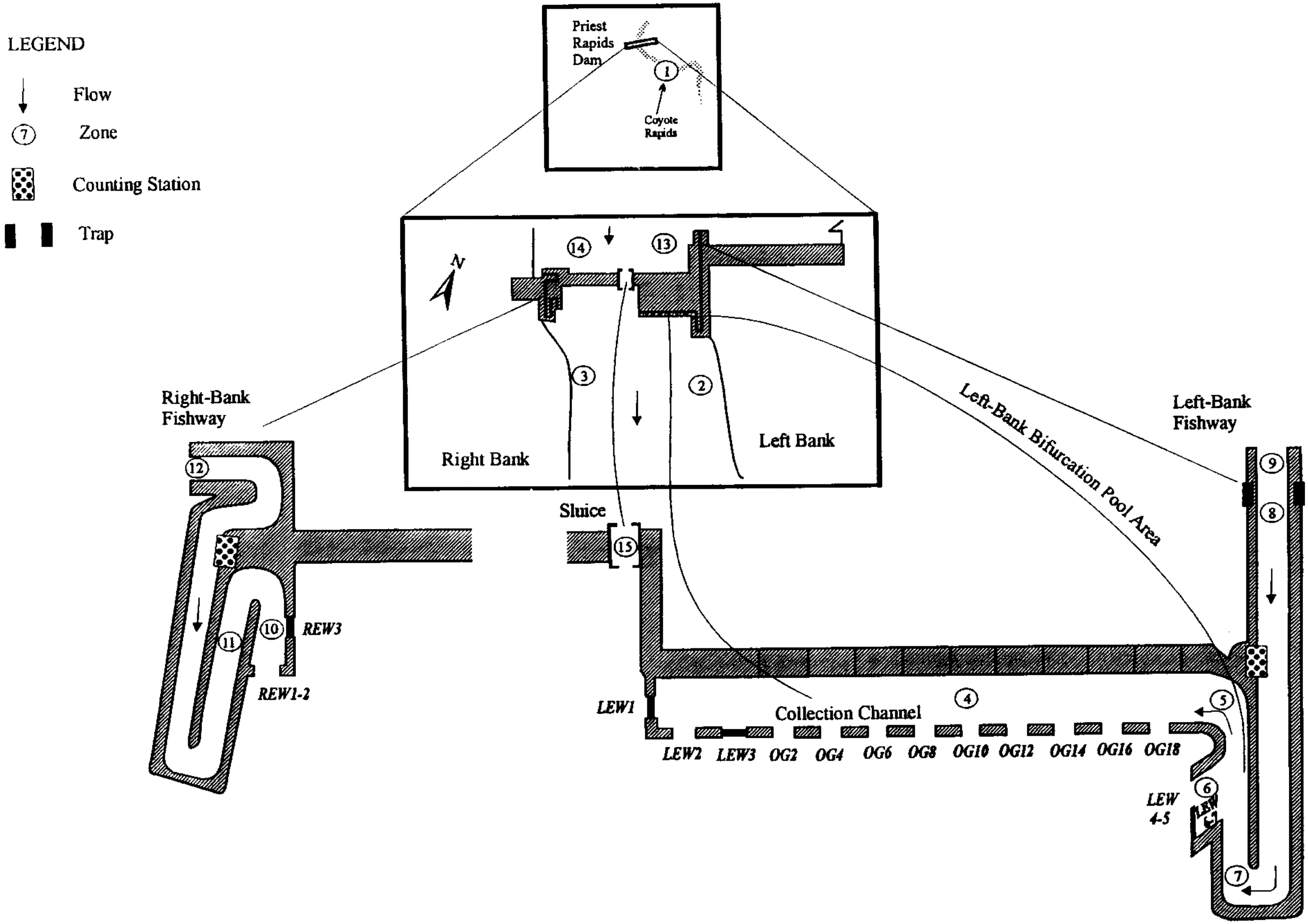

Figure 2. Fixed-station monitoring zones at Priest Rapids Dam and nearby area, 1999.

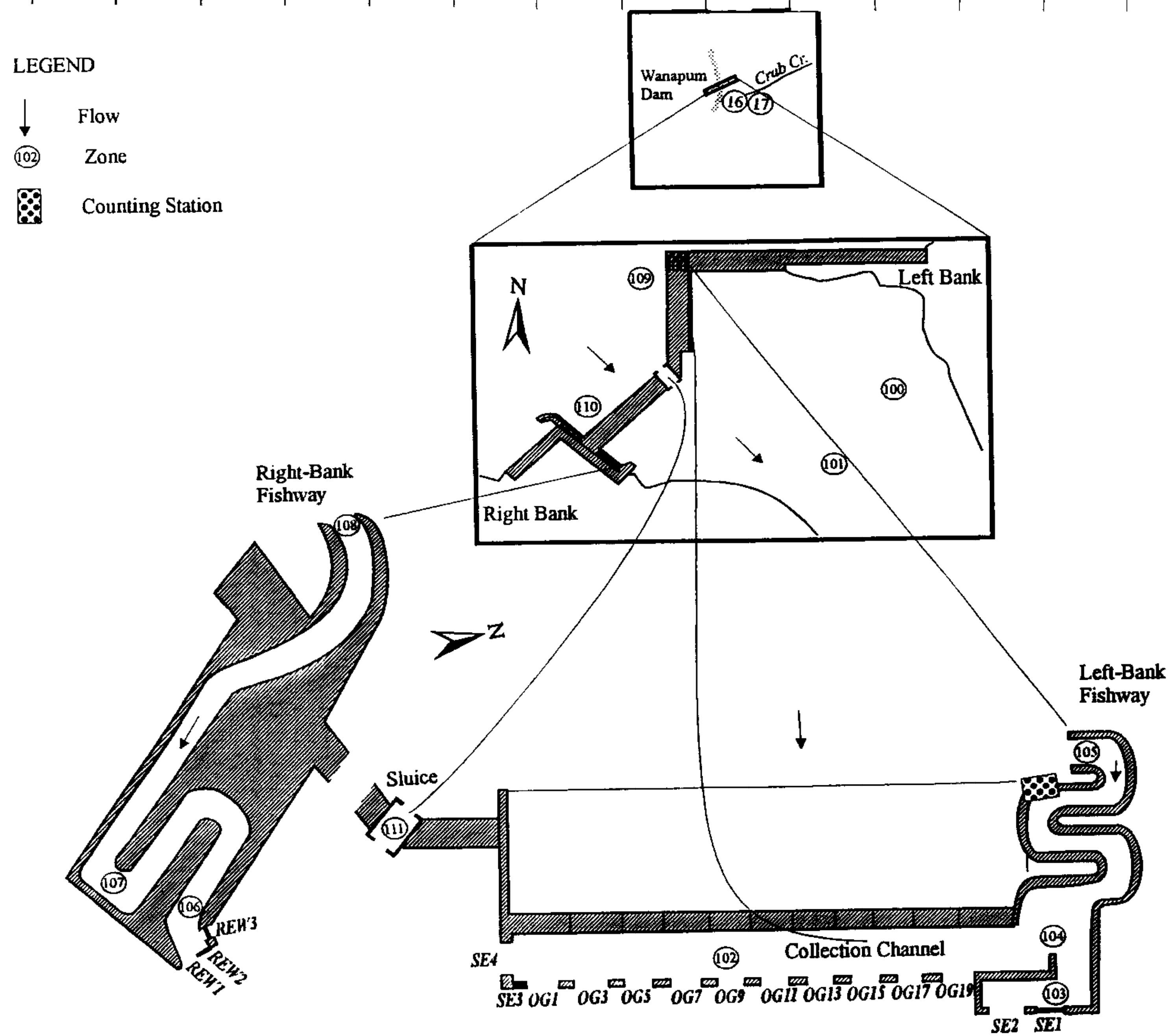

Figure 3. Fixed-station monitoring zones at Wanapum Dam and nearby area, 1999.

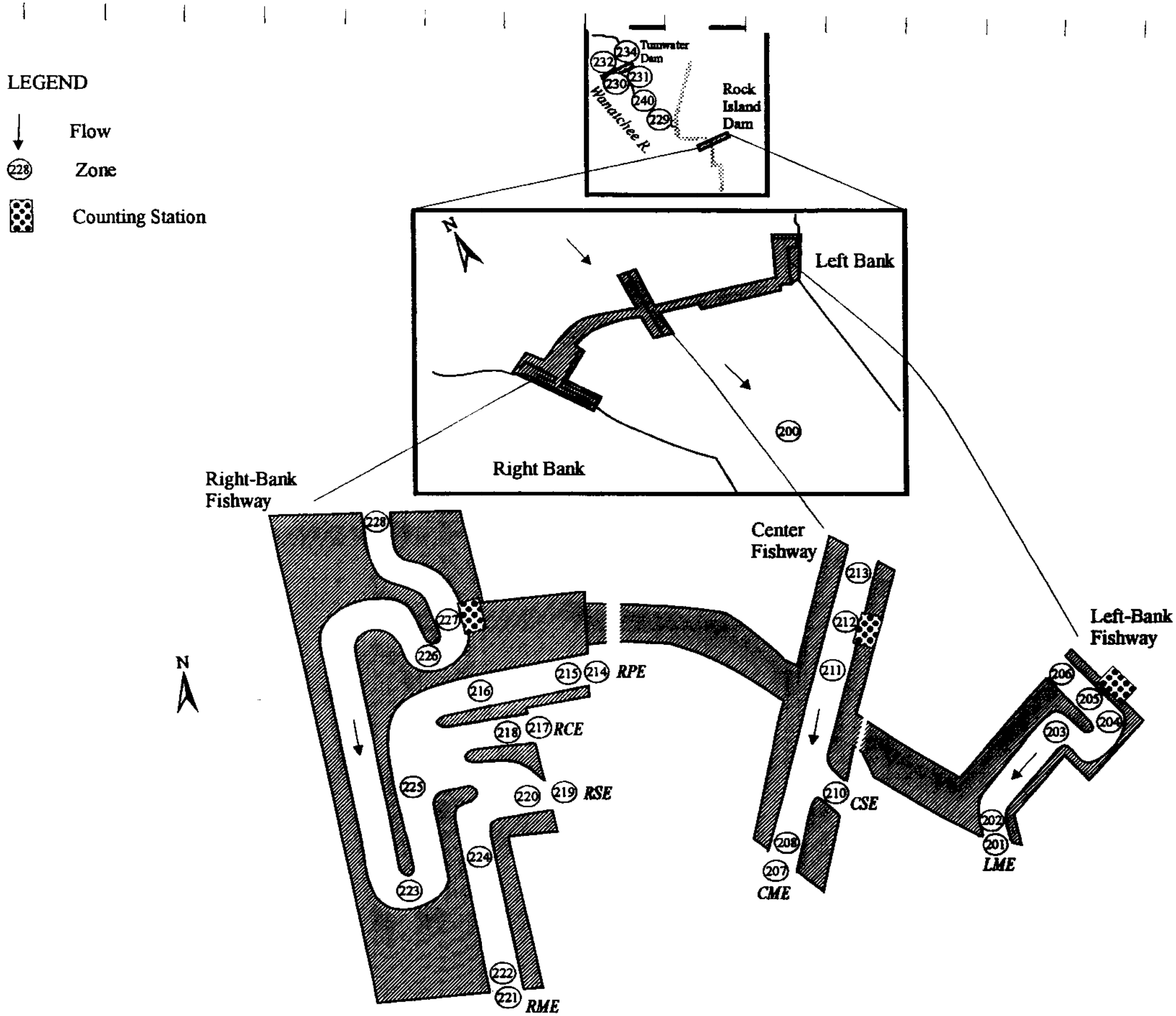

Figure 4. Fixed-station monitoring zones at Rock Island Dam and nearby area, 1999.

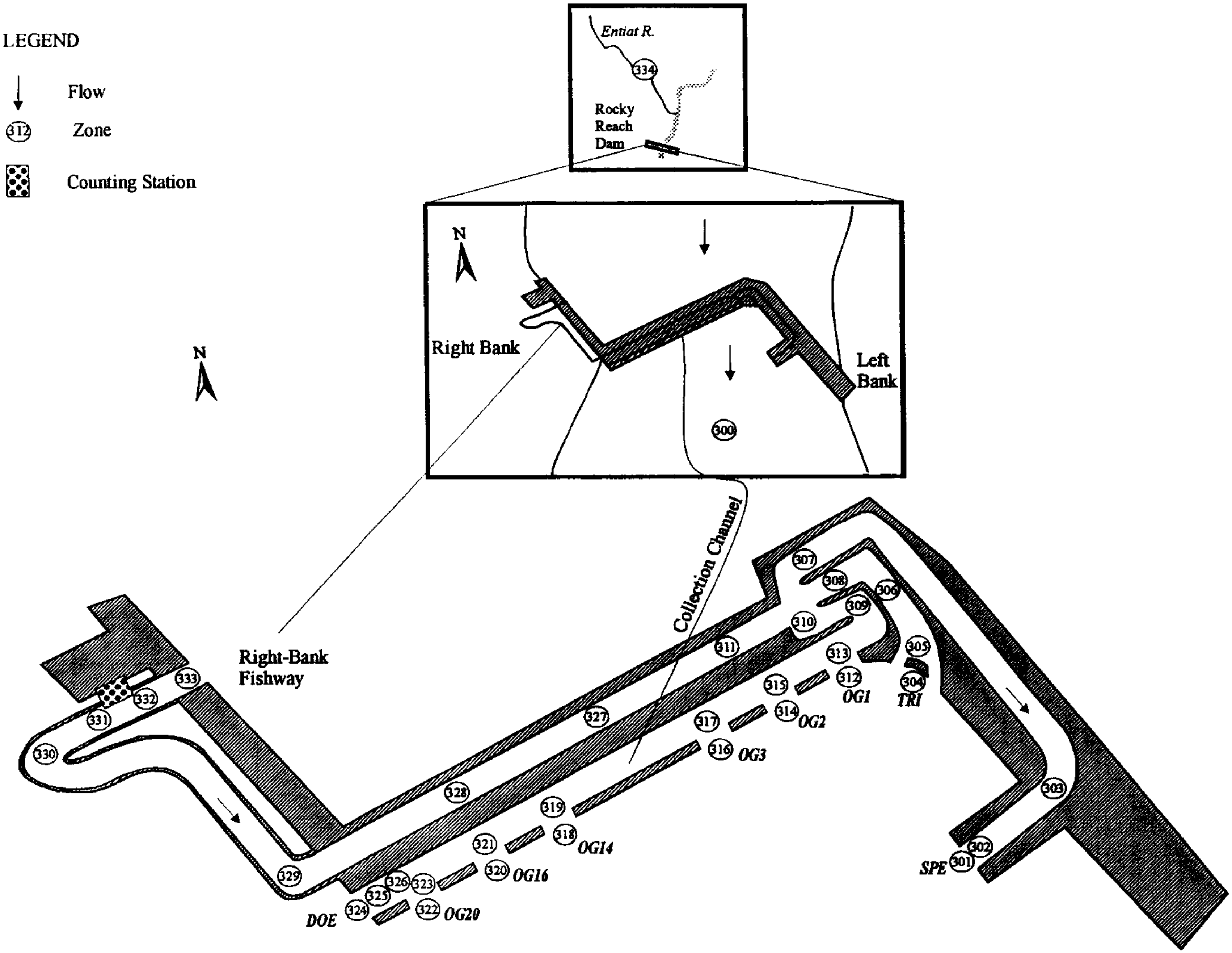

Figure 5. Fixed-station monitoring zones at Rocky Reach Dam and nearby area, 1999.

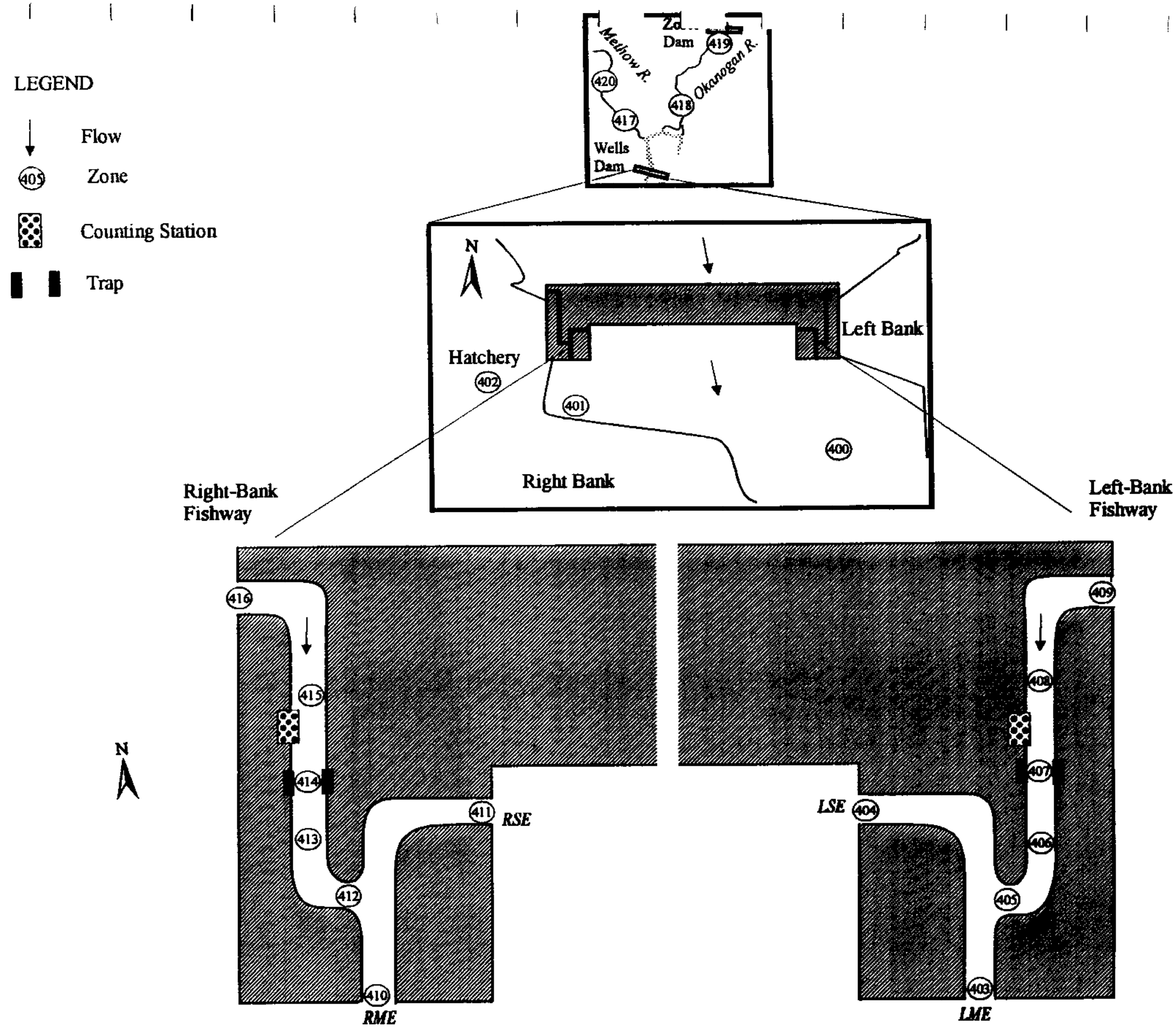

Figure 6. Fixed-station monitoring zones at Wells Dam and nearby area, 1999.

Zone	Description
20	From Priest Rapids Dam to White Bluffs
50	From Priest Rapids Dam to Wanapum Dam
150	From Wanapum Dam to Trinidad
250	From Trinidad to Rock Island Dam
251	From Rock Island Dam to Mouth of Wenatchee R.
252	From Mouth of Wenatchee R. to Leavenworth
254	From Leavenworth to Tumwater Dam
256	From Mouth of Wenatchee R. to Rock Reach Dam
350	From Rocky Reach Dam to Mouth of Entiat R.
351	Entiat River
352	From Mouth of Entiat R. to Wells Dam
450	From Wells to Pateros
451	From Pateros to Chief Joseph
452	Methow River
453	From Mouth of Okanogan R. to Monse
454	From Monse to Riverside
455	From Riverside to Zosel Dam

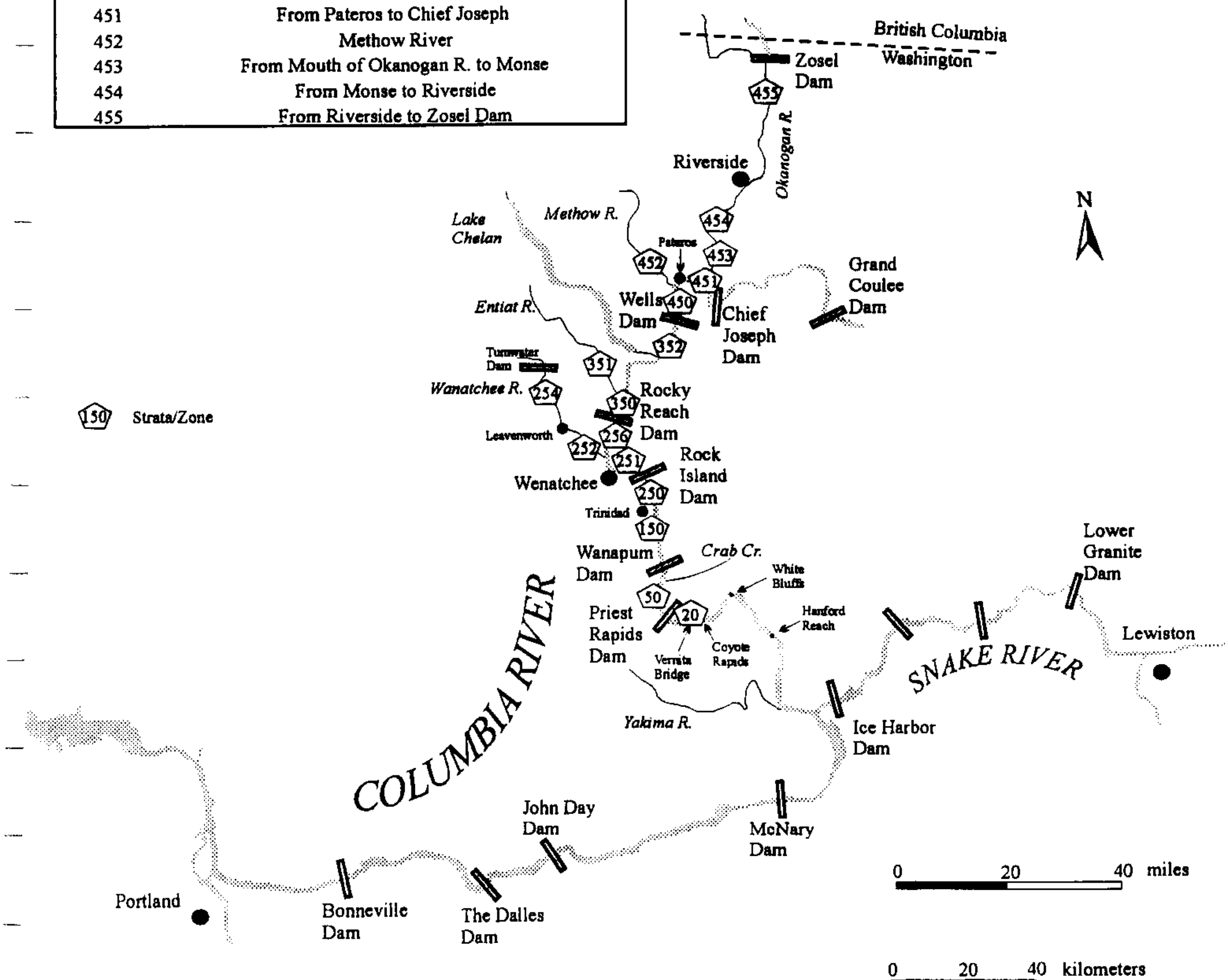

Figure 7. Mobile survey strata along the Columbia River and its tributaries, 1999.

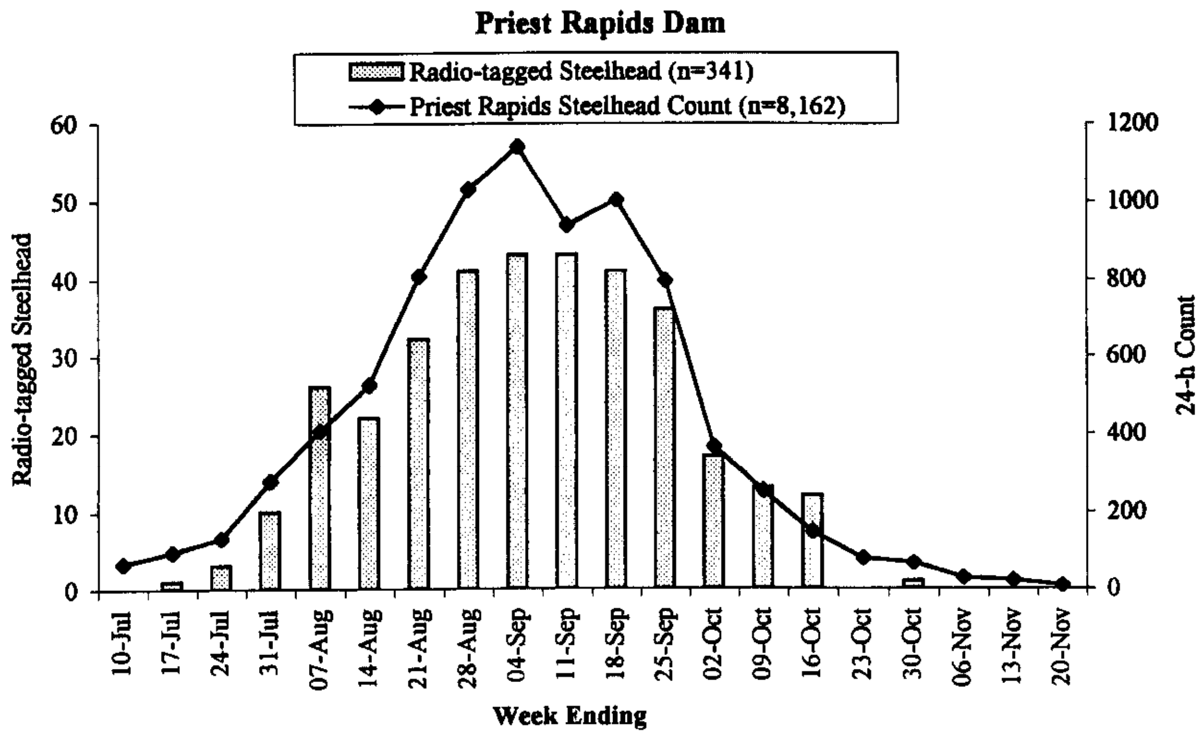

Figure 8. Comparison of the weekly counts of steelhead and radio-tagged steelhead that passed Priest Rapids Dam in 1999.

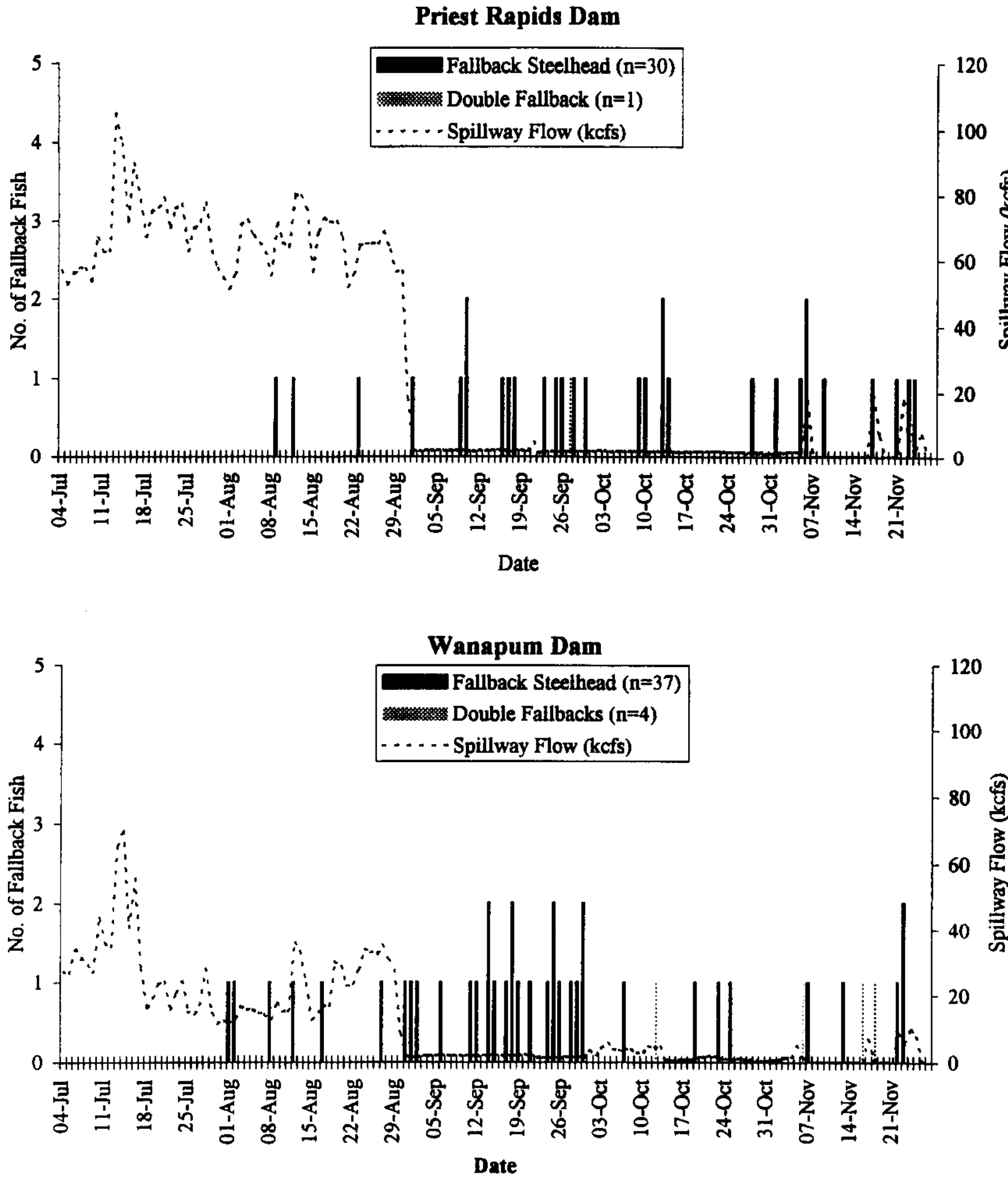

Figure 9. Comparison of spillway flows and the timing of steelhead fallback events at Priest Rapids and Wanapum dams in 1999.

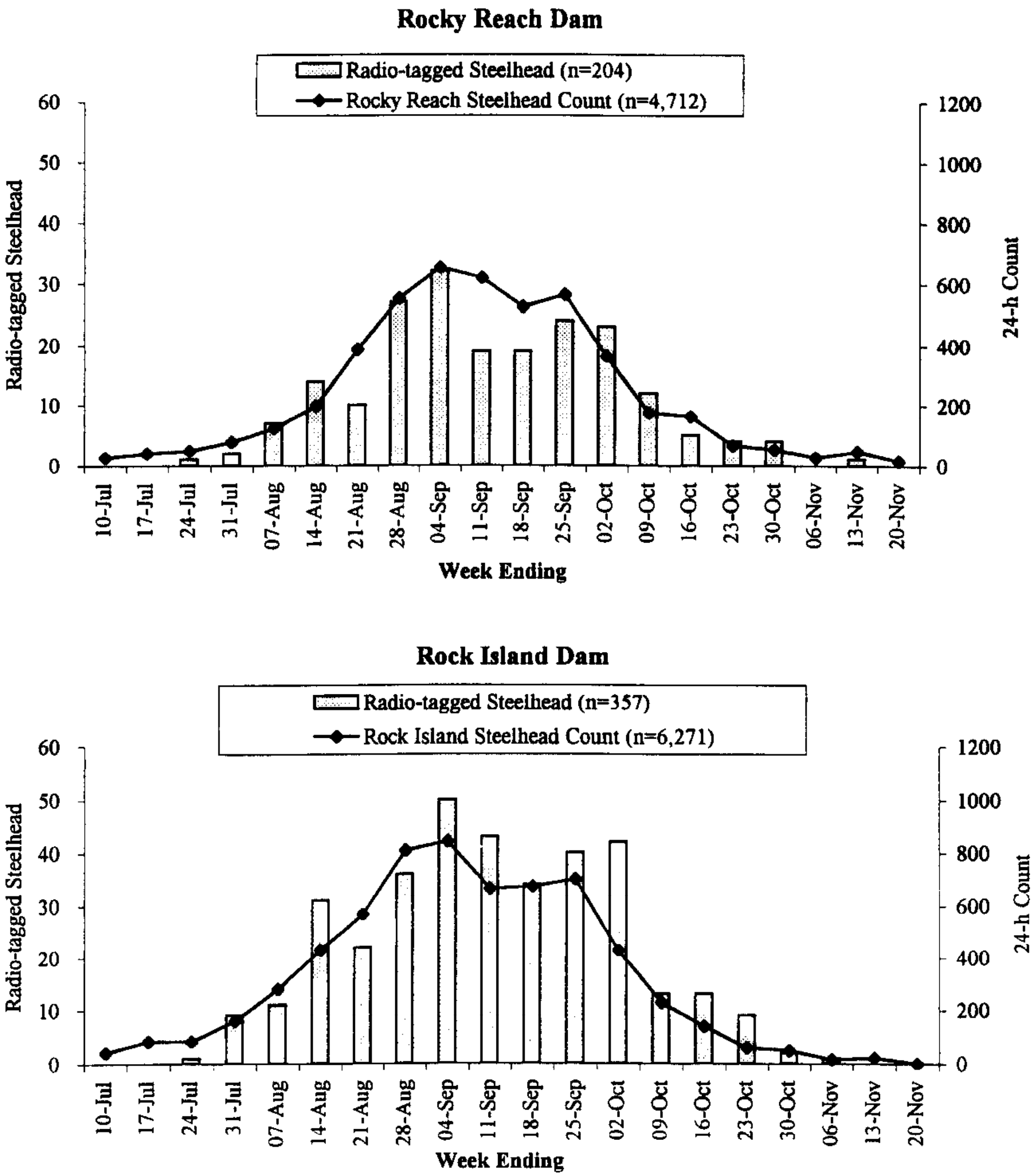

Figure 10. Comparison of the weekly counts of steelhead and radio-tagged steelhead that passed Rocky Reach and Rock Island dams in 1999.

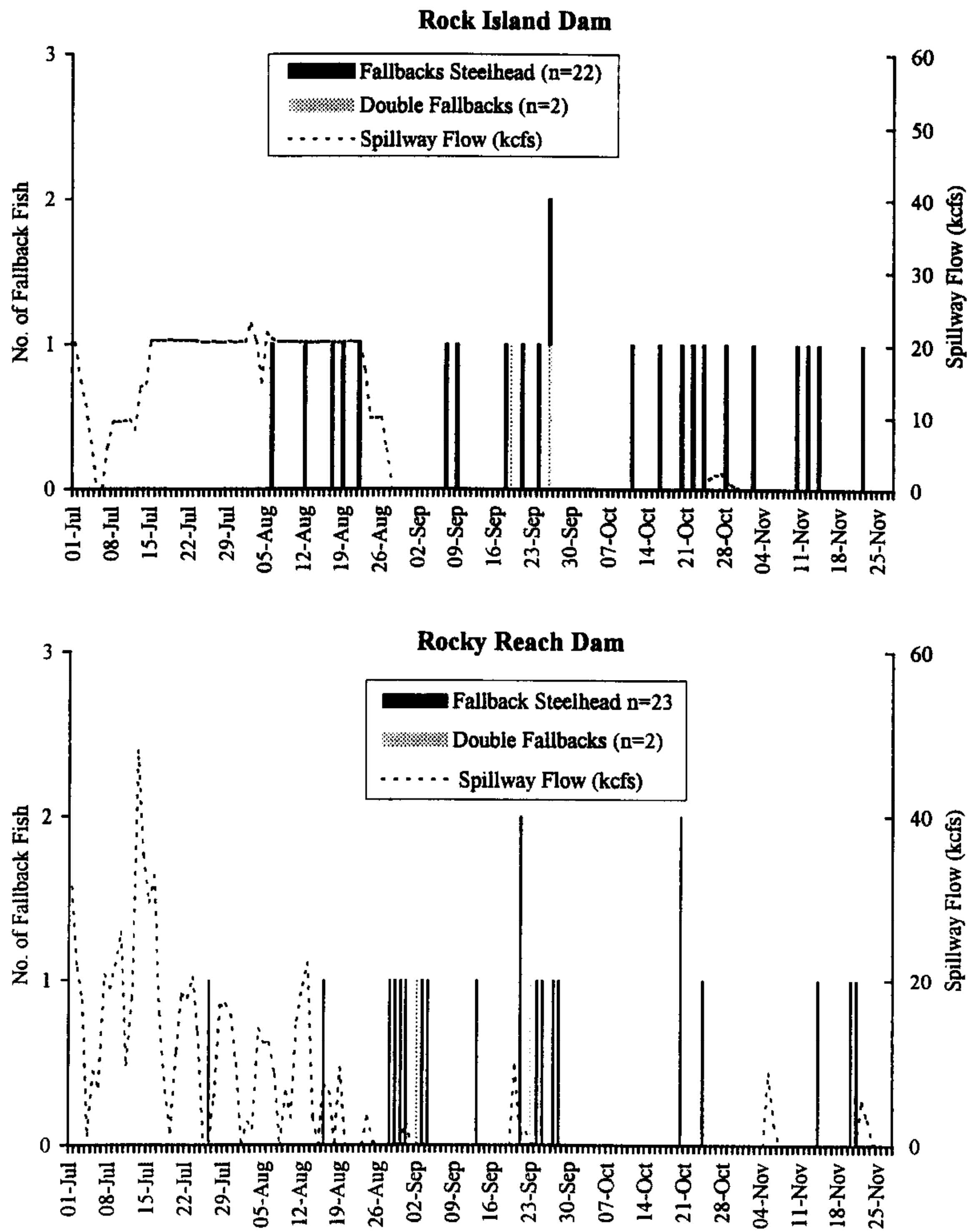

Figure 11. Comparison of spillway flows and the timing of steelhead fallback events at Rock Island and Rocky Reach dams in 1999.

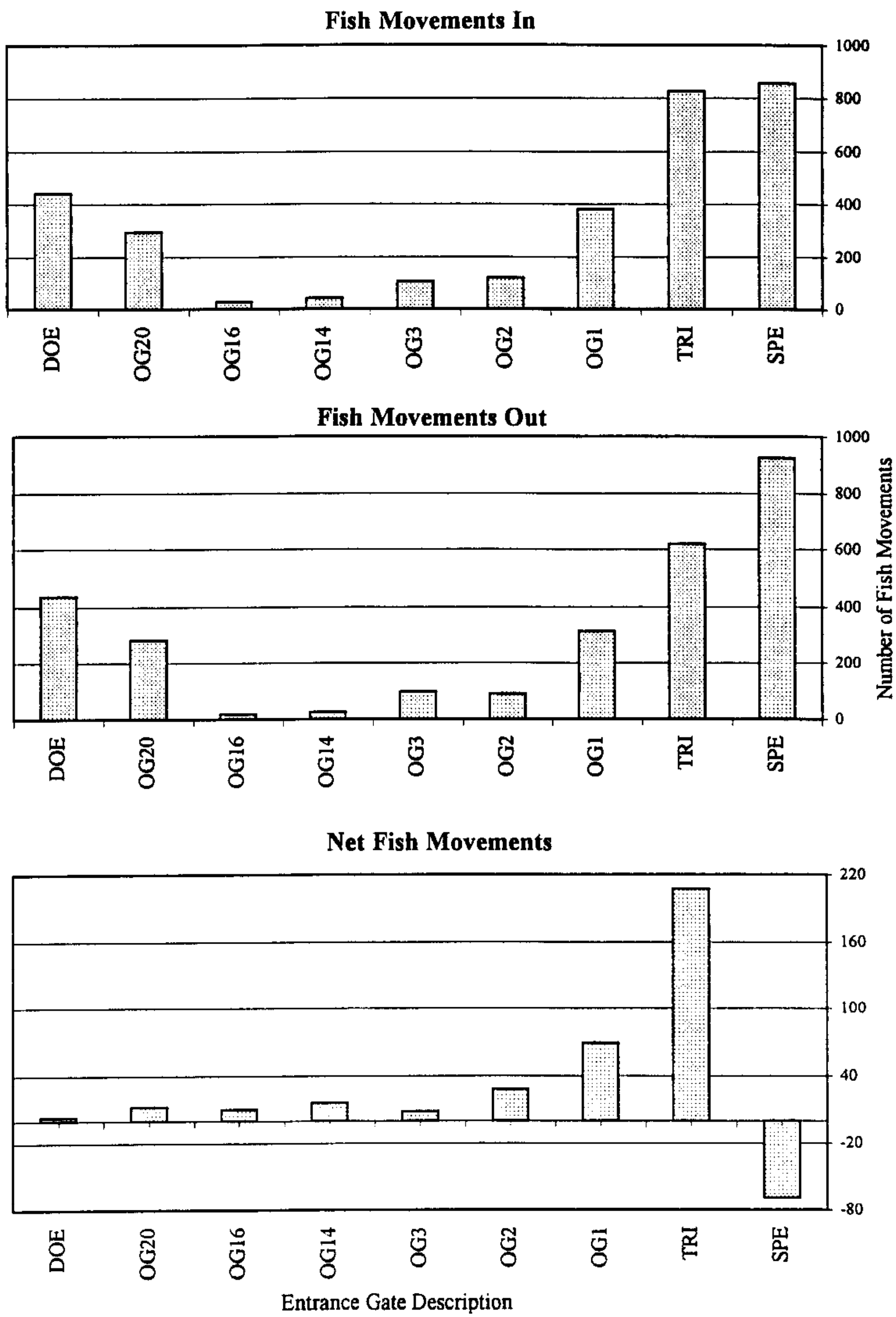

Figure 12. Movements of adult radio-tagged steelhead in and out of each entrance gate, and net movements, at Rocky Reach Dam, 1999.

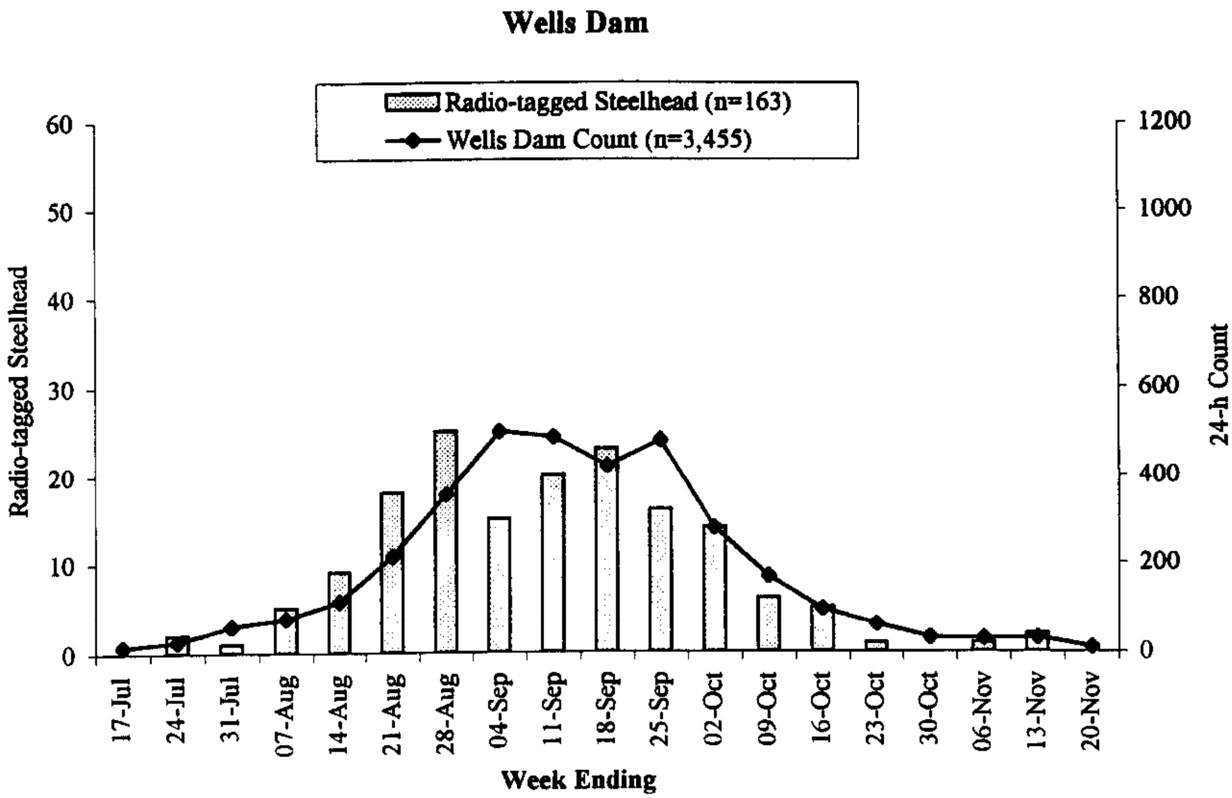

Figure 13. Comparison of the weekly counts of steelhead and radio-tagged steelhead that passed Wells Dam in 1999.

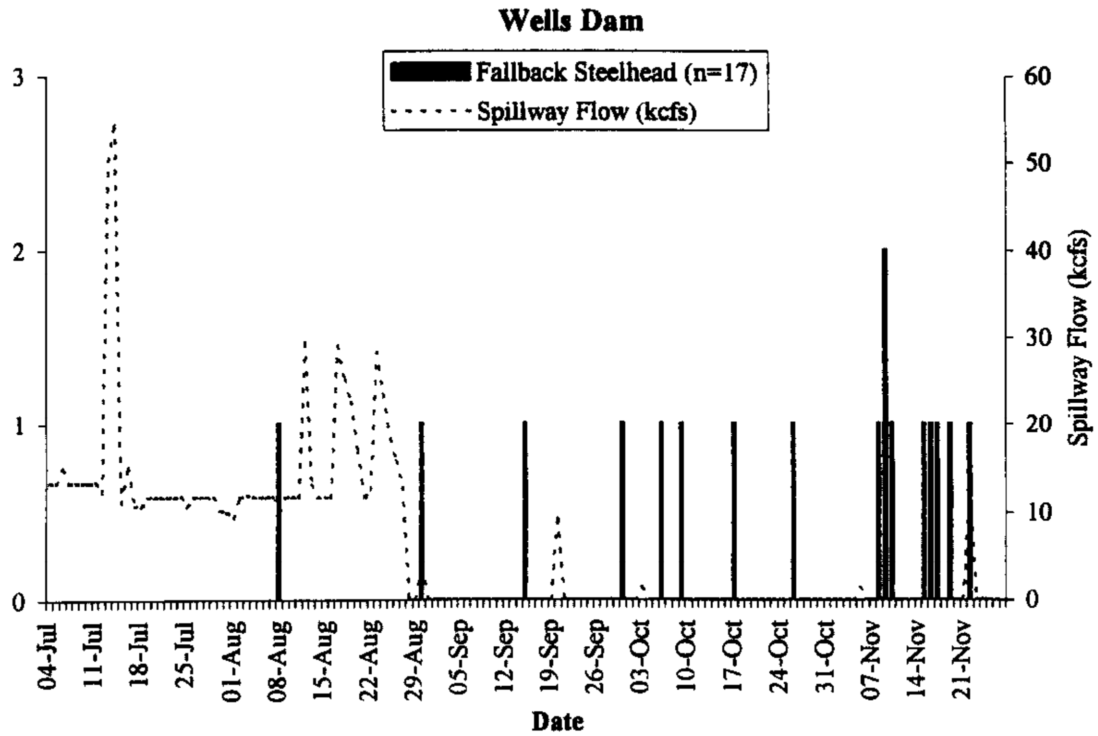

Figure 14. Comparison of spillway flow and the timing of steelhead fallback events at Wells Dam in 1999.

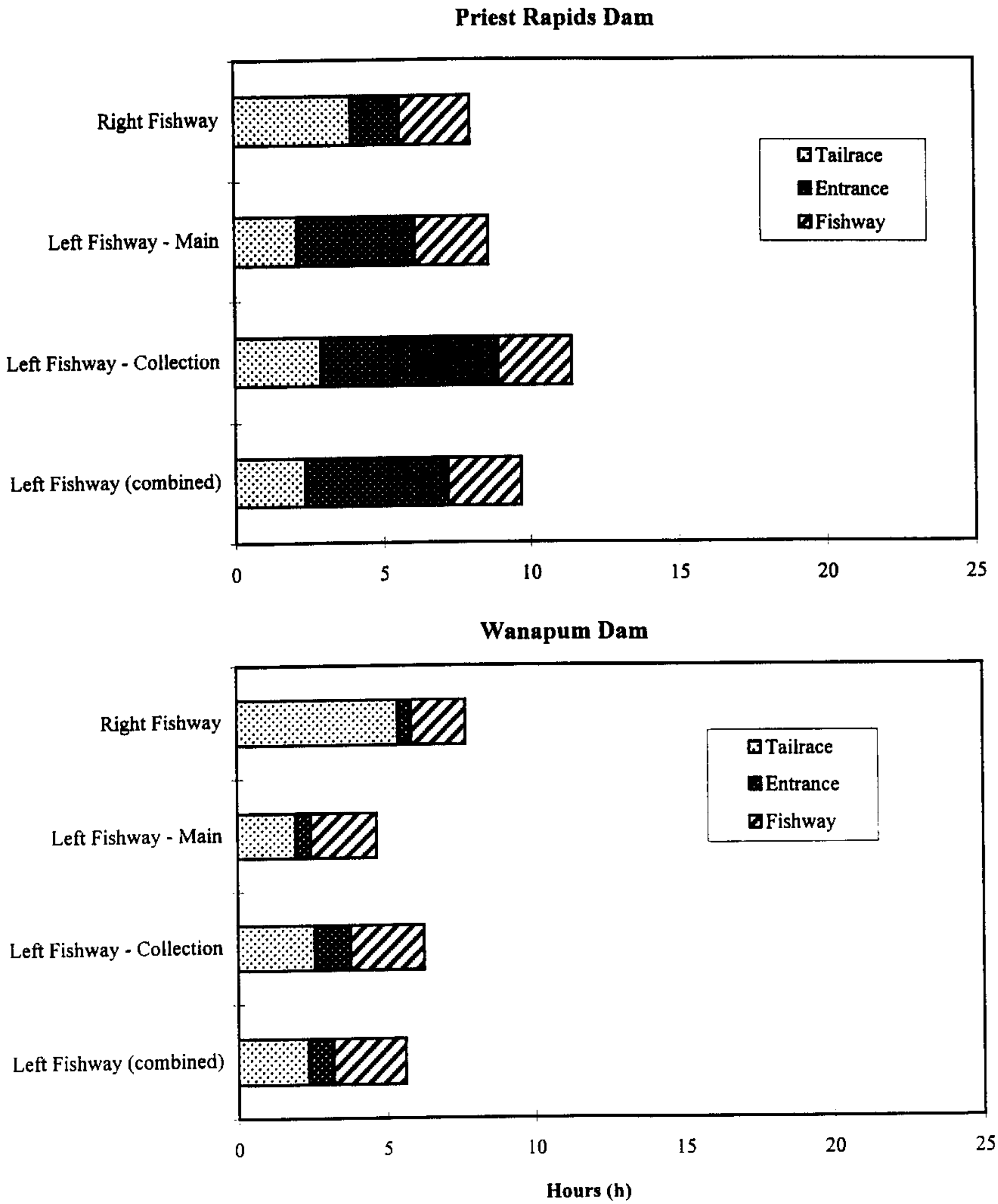

Figure 15. Comparison of median passage times (in hours) for steelhead that migrated passed Priest Rapids and Wanapum dams, 1999.

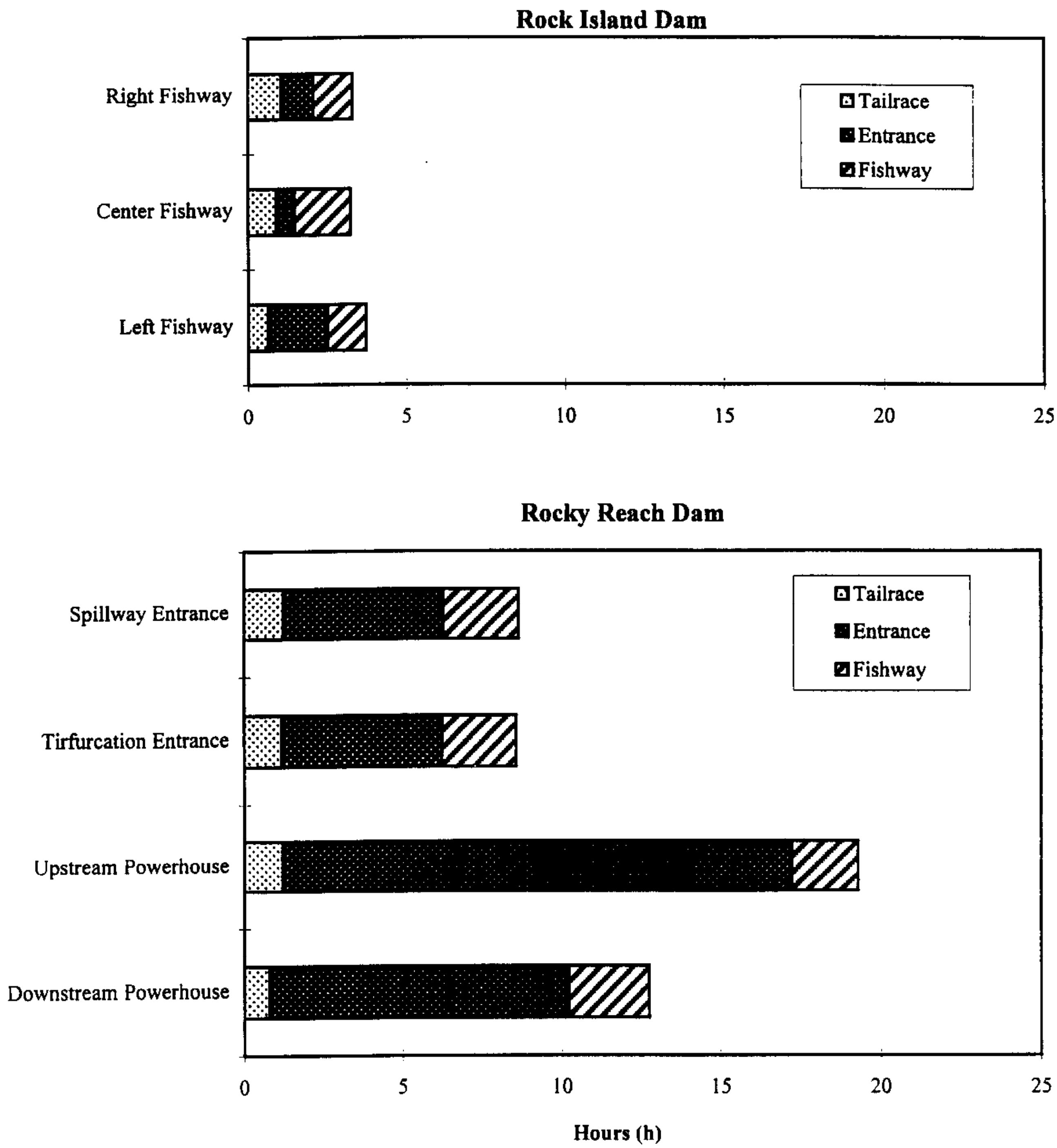

Figure 16. Comparison of median passage times (in hours) for steelhead that migrated passed Rock Island and Rocky Reach dams, 1999.

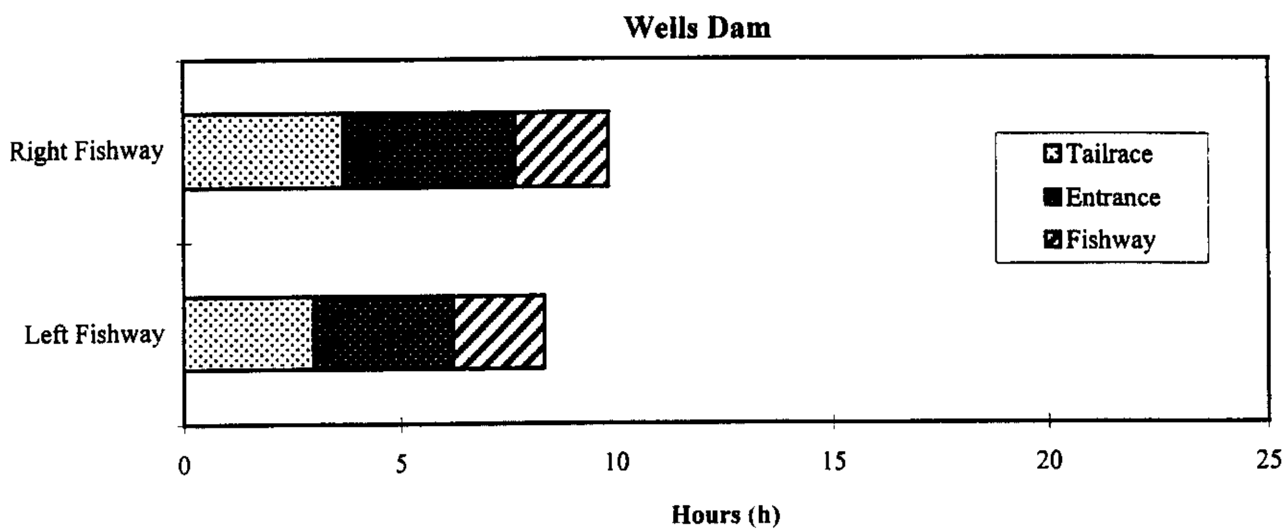

Figure 17. Comparison of median passage times (in hours) for steelhead that migrated passed Wells Dam, 1999.

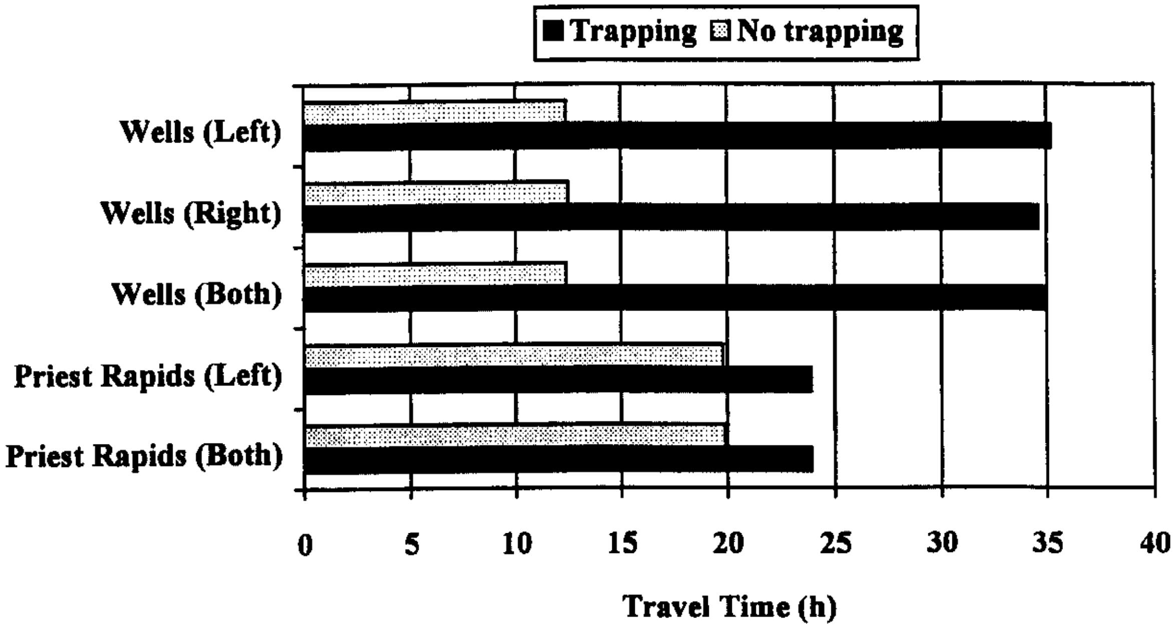

Figure 18. Comparison of median project passage times for trapping and no trapping intervals at Priest Rapids and Wells dams, 1999.

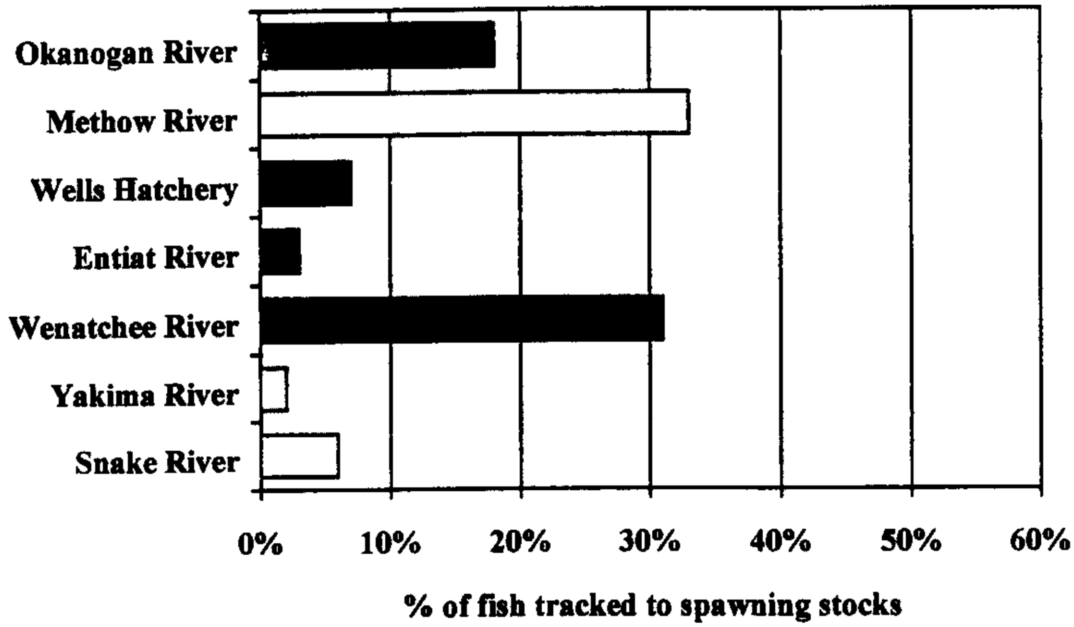

Figure 19. Distribution of radio-tagged steelhead between the tributary spawning areas, 1999-2000.

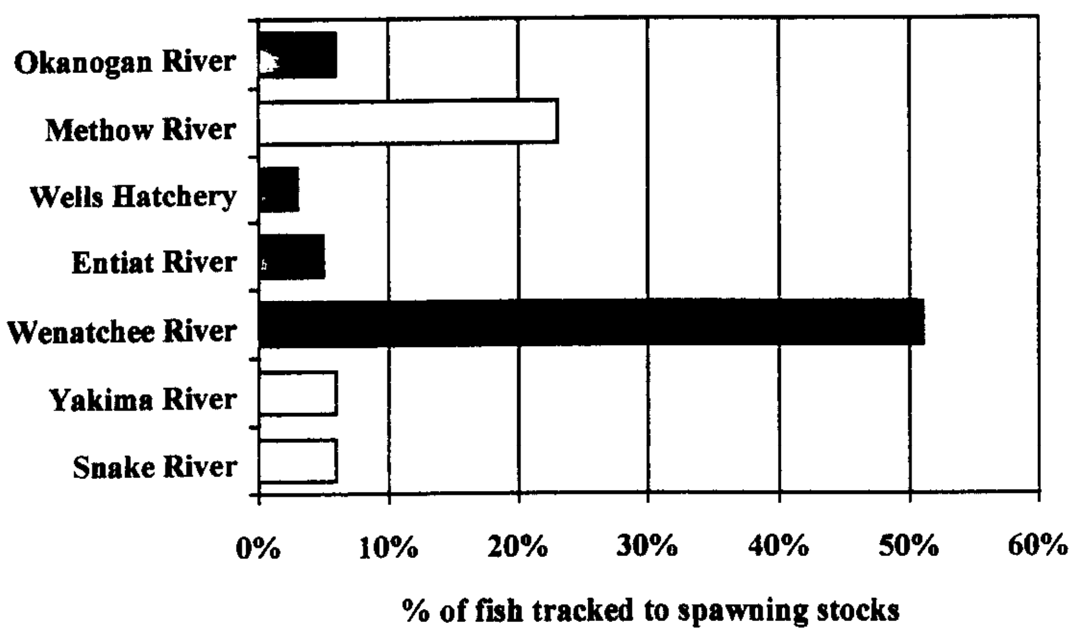

Figure 20. Distribution of "wild" radio-tagged steelhead between the tributary spawning areas, 1999-2000.

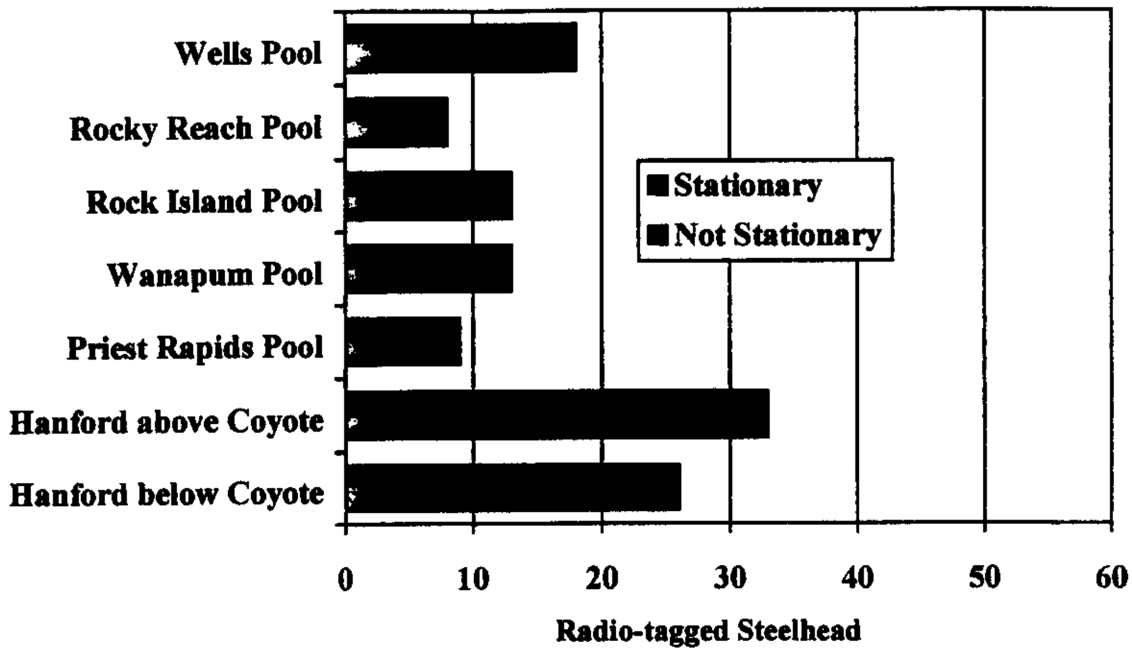

Figure 21. Distribution of stationary and not stationary steelhead radio-tags between the monitored reaches along the Mid-Columbia River between the Yakima River and Chief Joseph Dam, 1999-2000.

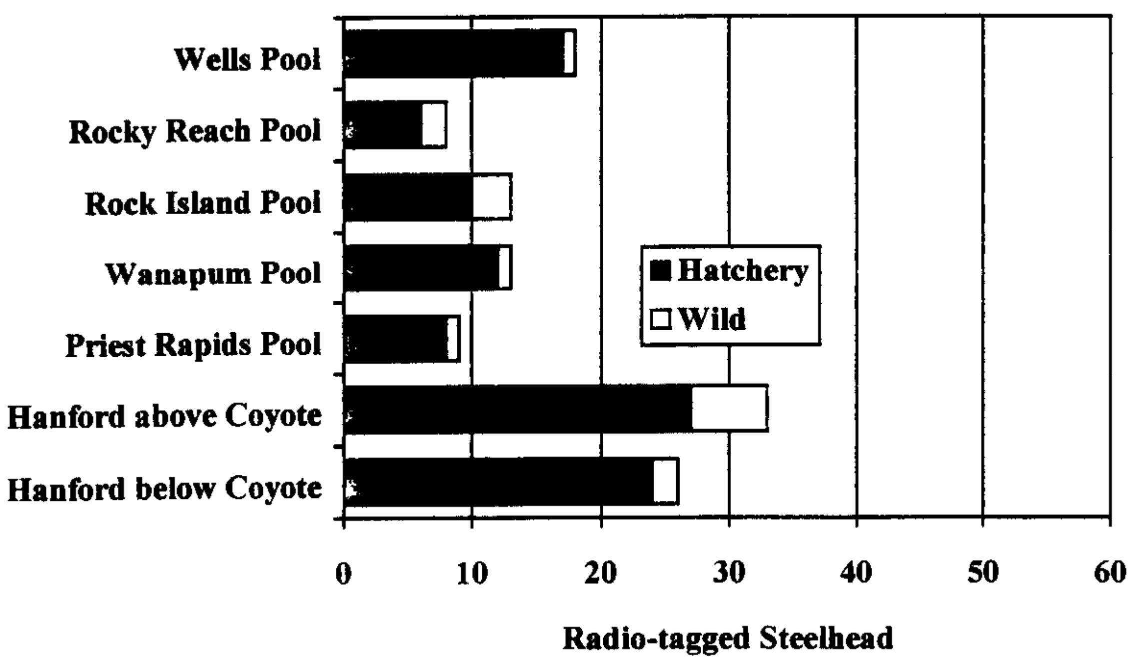

Figure 22. Distribution of the radio tags applied to hatchery and "wild" steelhead between the monitored reaches along the Mid-Columbia River between the Yakima River and Chief Joseph Dam, 1999-2000.

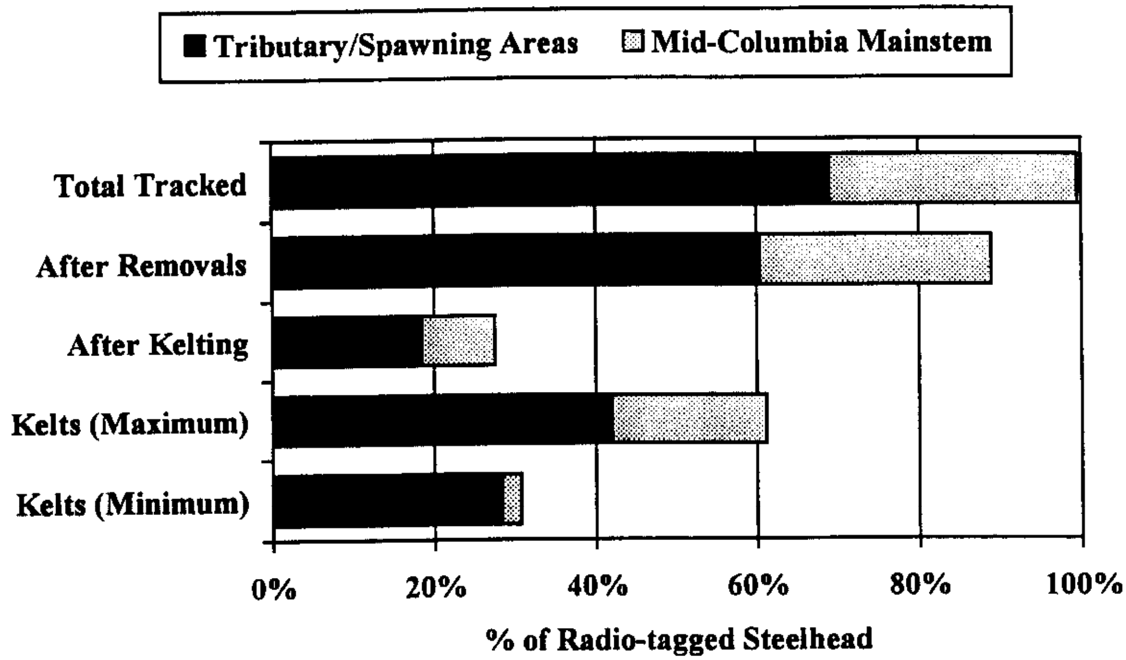

Figure 23. Estimated kelting rates for radio-tagged steelhead tracked to known spawning areas and reaches along the Mid-Columbia River between Coyote Rapids and Wells Dam, 1999-2000.

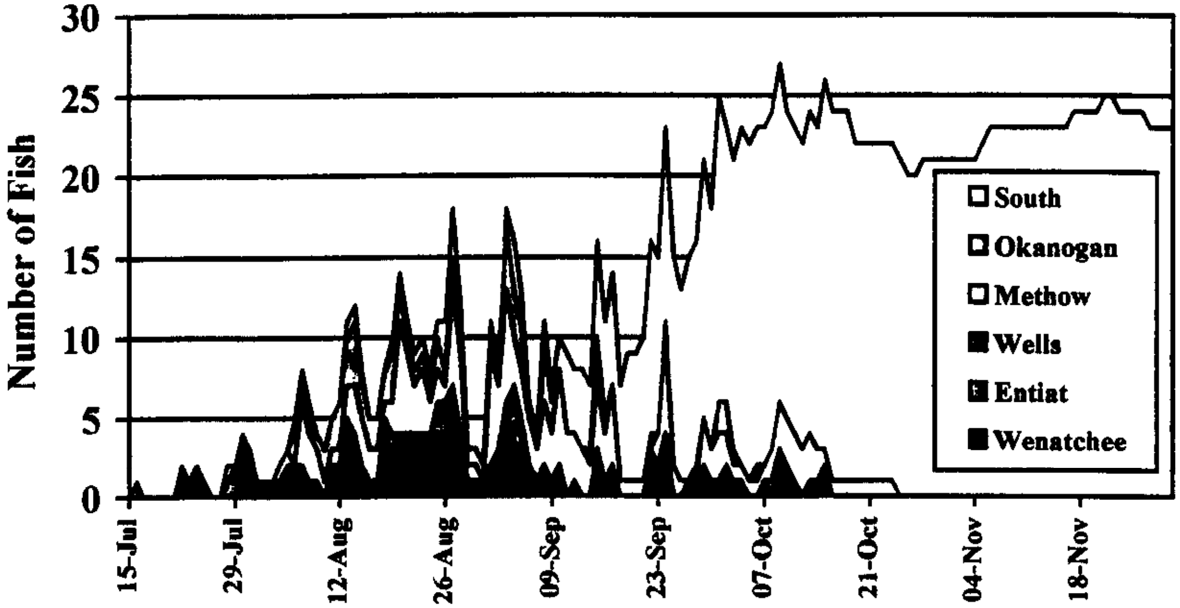

Figure 24. Upstream migration timing for radio-tagged steelhead of the different stocks on the Mid-Columbia River between Coyote Rapids and Priest Rapids Dam, 1999.

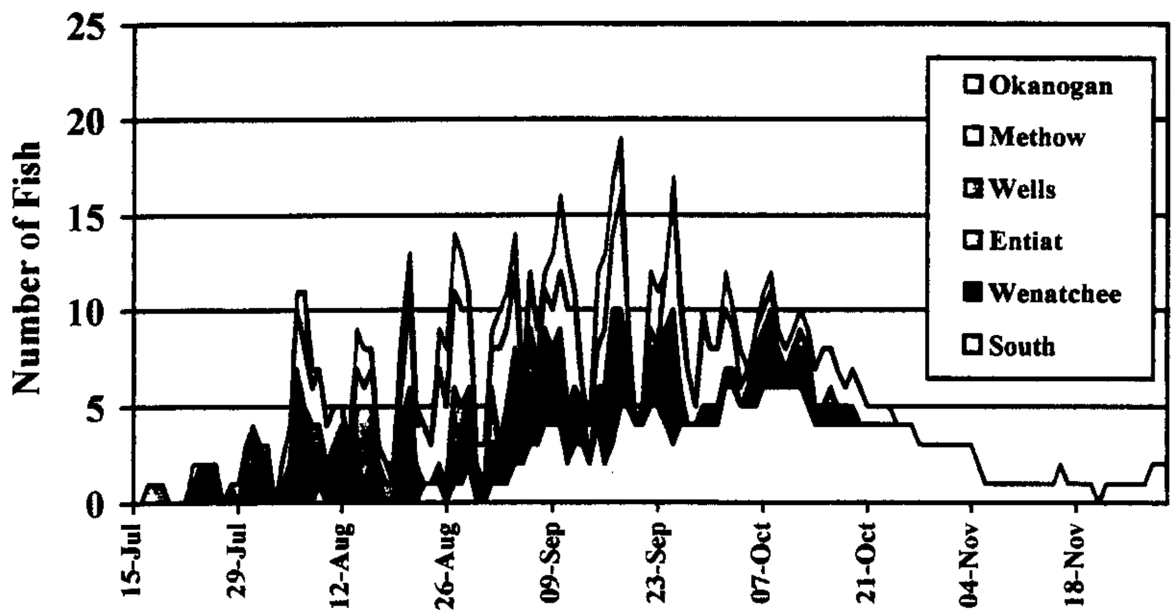

Figure 25. Upstream migration timing for radio-tagged steelhead of the different stocks on the Mid-Columbia River between Priest Rapids and Wanapum dams, 1999.

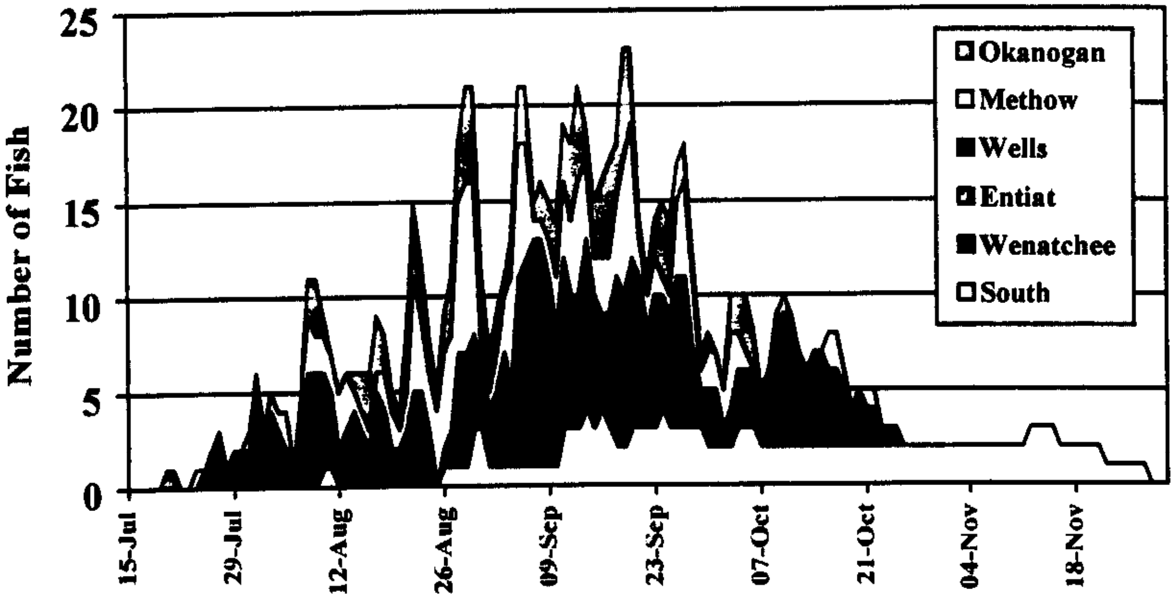

Figure 26. Upstream migration timing for radio-tagged steelhead of the different stocks on the Mid-Columbia River between Wanapum and Rock Island dams, 1999.

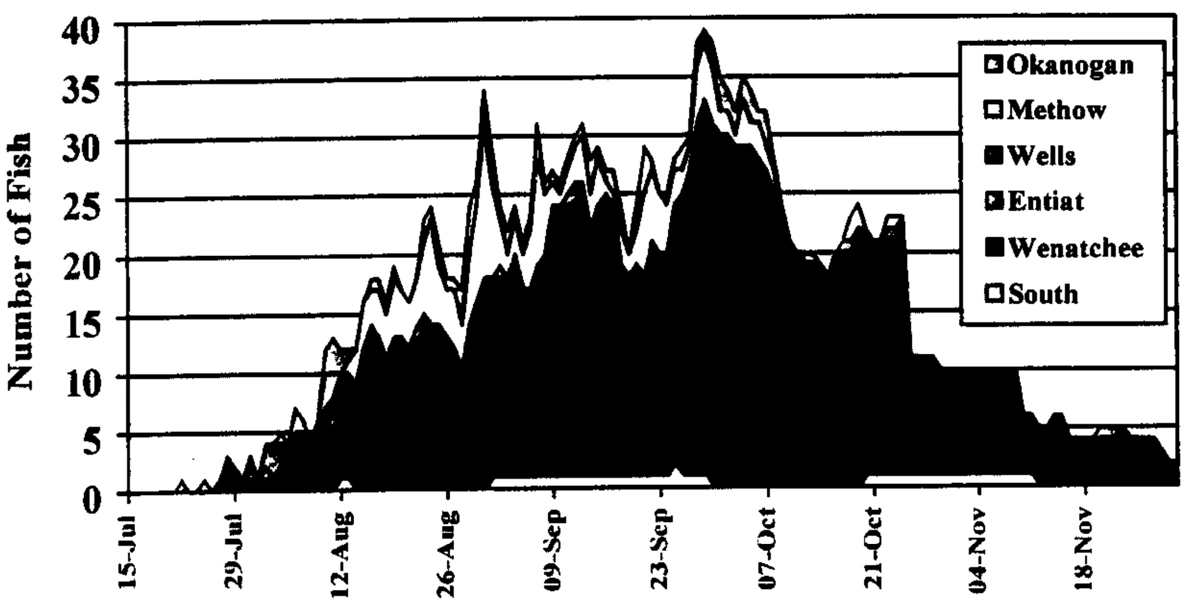

Figure 27. Upstream migration timing for radio-tagged steelhead of the different stocks on the Mid-Columbia River between Rock Island and Rocky Reach dams, 1999.

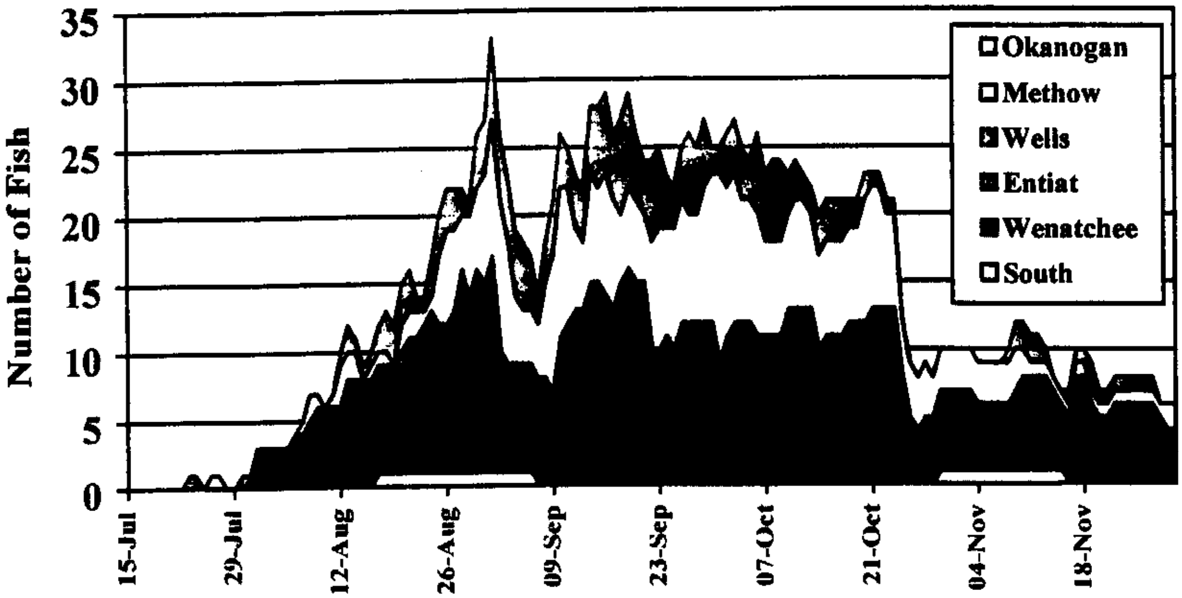

Figure 28. Upstream migration timing for radio-tagged steelhead of the different stocks on the Mid-Columbia River between Rocky Reach and Wells dams, 1999.

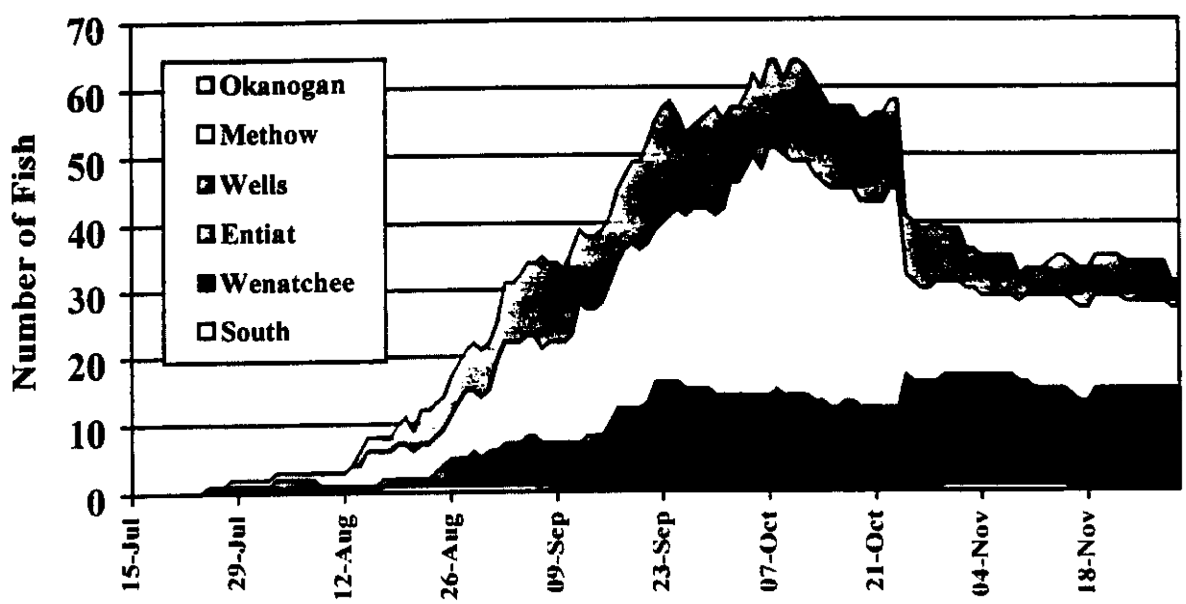

Figure 29. Upstream migration timing for radio-tagged steelhead of the different stocks on the Mid-Columbia River above Wells Dam, 1999.

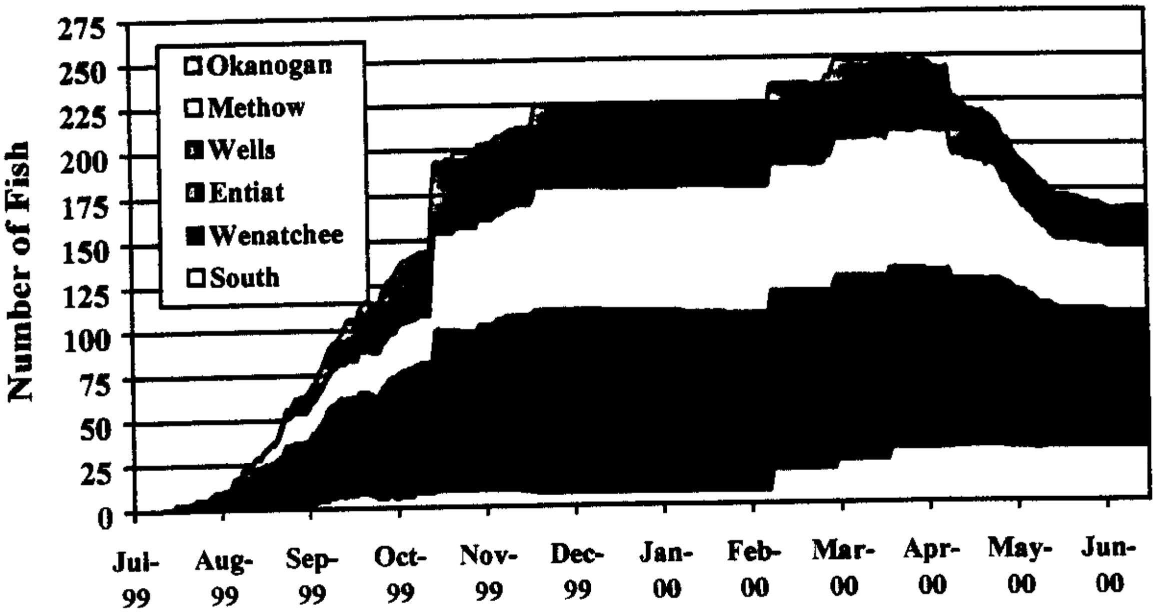

Figure 30. Immigration, emigration and accumulation of radio-tagged steelhead in known spawning areas from 15 July 1999 through 22 June 2000.

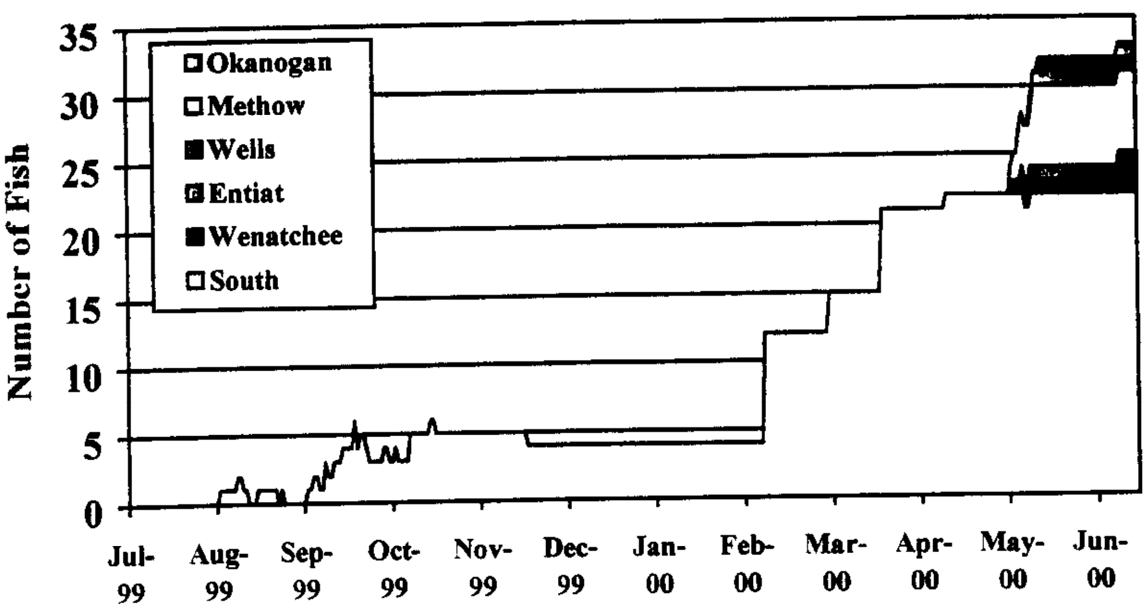

Figure 31. Accumulation of radio-tagged steelhead in the Hanford Reach below Coyote Rapids from 15 July 1999 through 22 June 2000.

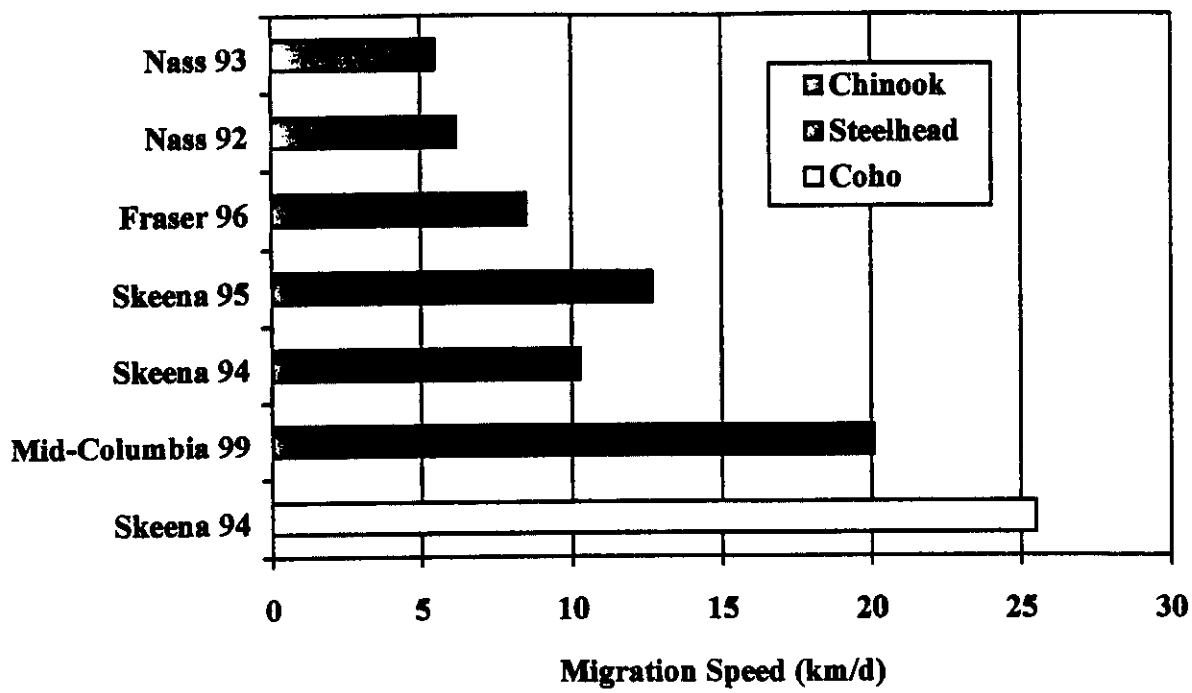

Figure 32. Comparison of upstream migration speeds for radio-tagged steelhead through the Mid-Columbia River in 1999 with migration speeds for radio-tagged steelhead, chinook and coho tracked through the middle reaches of the Fraser, Skeena and Nass rivers in British Columbia.

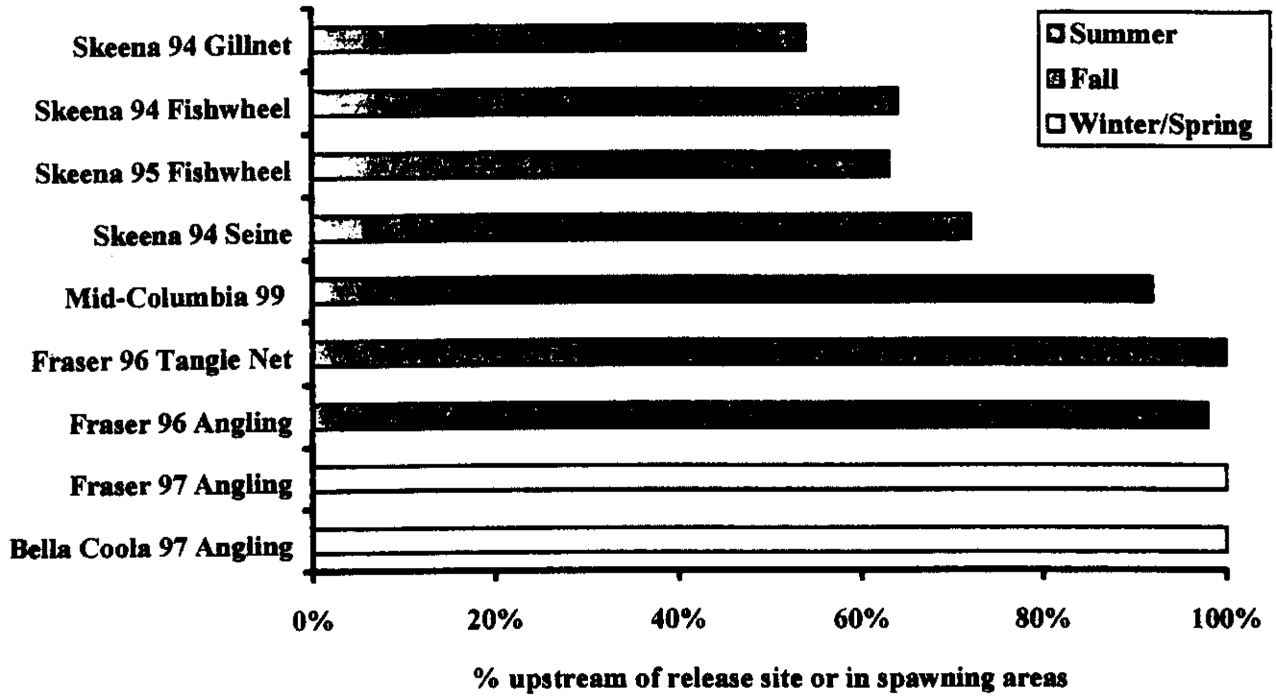

Figure 33. Comparison of percent of the radio-tagged steelhead tracked upstream of the release site or in spawning areas for different river systems, run timing groups and capture methods.

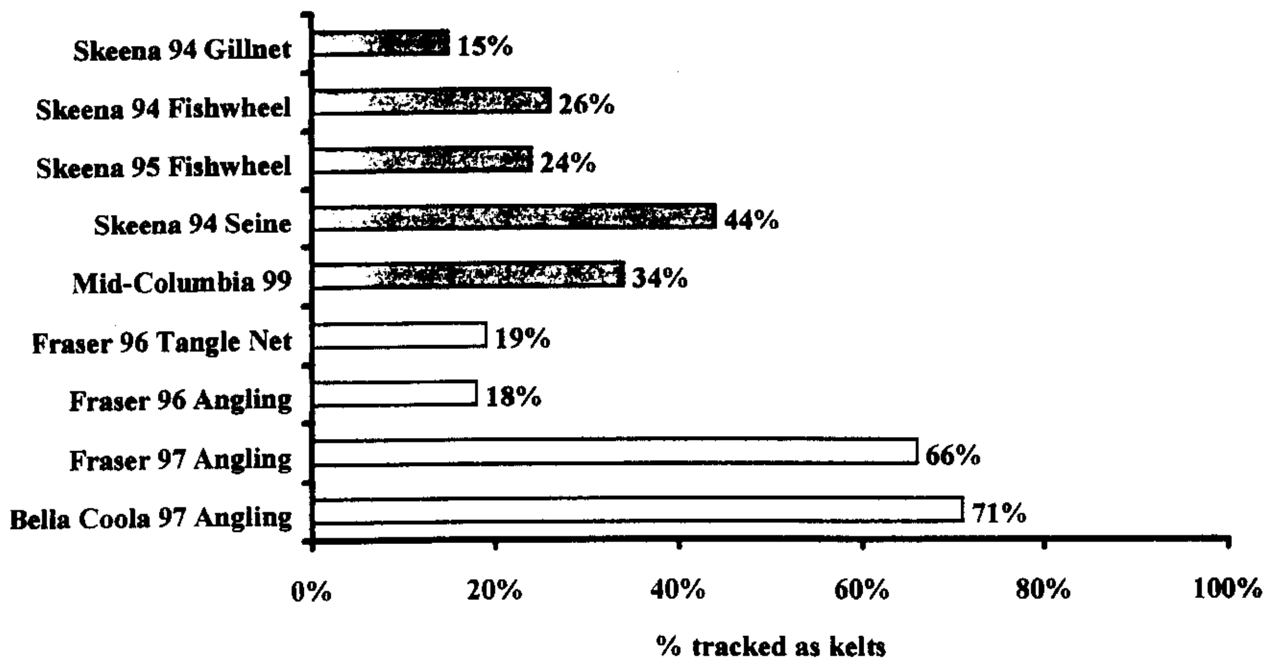

Figure 34. Comparison of percent of the radio-tagged steelhead tracked as kelts for different river systems, run timing groups and capture methods.

APPENDICES

Table A1. Definition of fixed-station tracking zones for Priest Rapids and Wanapum dams and zones along the Columbia River, Snake River, and Crab Creek.

River	Zone No.	Name	Antenna ID	Receiver	Antenna No.
Snake River					
	501	Ice Harbour Dam	801	41	1
Columbia River					
Below Priest Rapids Tailrace					
	500	Hanford Reach	800	40	1
	1	Coyote Rapids (22 km below Priest Rapids Dam).	1, 2	1	2
Priest Rapids Dam					
	2	PR Left Tailrace	8, 9	2	2
	3	PR Right Tailrace	15, 16	3	2
	5	PR Collection Channel Up	22	4	1
	6	PR Left entrance	23	4	1
	7	PR Left Fishway	24	4	1
	4	PR Collection Channel	29, 30, 31	5	3
	8	PR Below Trap	36	6	1
	9	PR Left Exit	37	6	1
	10	PR Right Entrance	43	7	1
	11	PR Right Fishway	44	7	1
	12	PR Right Exit	50, 51	8	2
	13	PR Left Forebay	57, 58	9	2
	15	PR Sluice	64, 65	10	2
	14	PR Right Forebay	71, 72	11	2
Crab Creek					
	16	Crab Creek - downstream	78	12	1
	17	Crab Creek - upstream	79	12	1
Wanapum Dam					
	100	WA Left Tailrace	85, 86	15	2
	101	WA Right Tailrace	92, 93	16	2
	103	WA Left Entrance - Lower & Up	99, 100	17	2
	104	WA Bifurcation Pool	101	17	1
	102	WA Collection Channel	106, 107, 10	18	3
	105	WA Left Exit	113	19	1
	106	WA Right Entrance	120	20	1
	107	WA Right Fishway	121	20	1
	108	WA Right Exit	127	21	1
	109	WA Left Forebay	134, 135	22	2
	111	WA Sluice	141, 142	23	2
	110	WA Right Forebay	148, 149	24	2

Table A2. Details of fixed-station monitoring effort (in hours) for each week for all sites monitored in 1999 between Hanford Reach and Wanapum Dam forebay.

					Receiver Numbers at Priest Rapids Dam													Receiver Numbers at Wanapum Dam							
Receiver No.		R40	R41	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24
No. of Antenna		1	1	2	2	2	3	3	2	2	2	2	2	2	2	2	2	3	3	1	2	1	2	2	2
General Location		Han. Reach	Ice Har.	Coyote Rapids	Left Tailrace	Right Tailrace	Left Entranc	Collect Chan	Left Exit	Right Entrance	Right Exit	Left Forebay	Sluice	Right Forebay	Crab Crk	Left Tailrac	Right Tailrace	Left Entrance	Collect Chan	Left Exit	Right Entrance	Right Exit	Left Forebay	Sluice	Right Forebay
Week	Week Ending	Number of Hours in Operation																							
28	17-Jul	24	24	155	129	126	127	133	125	111	128	126	127	84	105	150	85	148	147	157	145	146	157	103	146
29	24-Jul	0	0	168	168	166	167	166	168	168	167	167	168	22	168	167	7	167	67	166	159	167	168	168	168
30	31-Jul	0	0	168	165	165	166	167	168	168	125	167	168	106	131	167	168	166	86	167	31	139	168	134	166
31	07-Aug	0	0	168	168	164	168	167	168	168	167	168	167	166	168	167	168	168	168	167	166	167	168	153	121
32	14-Aug	0	0	168	168	165	168	167	168	168	166	167	167	167	166	167	168	167	167	167	167	167	166	167	167
33	21-Aug	0	0	168	168	164	168	168	168	167	167	167	167	167	167	134	168	167	167	167	167	167	168	166	168
34	28-Aug	0	0	168	168	168	168	168	168	168	167	167	167	166	167	132	167	167	168	168	167	167	168	167	167
35	04-Sep	0	0	168	168	168	168	168	167	167	167	168	168	167	168	168	168	168	167	167	167	167	168	167	167
36	11-Sep	37	106	167	168	168	167	168	167	167	167	168	167	168	168	168	168	167	167	168	167	168	168	167	168
37	18-Sep	168	168	167	168	168	168	168	168	167	167	168	168	168	167	168	168	167	168	167	167	167	168	168	168
38	25-Sep	168	168	168	168	168	168	167	168	168	167	168	168	167	168	168	168	168	167	168	167	167	168	168	168
39	02-Oct	168	62	168	168	168	167	168	168	167	167	168	168	167	168	168	167	167	166	168	167	167	168	167	168
40	09-Oct	168	127	168	168	168	167	167	168	167	167	168	167	168	167	168	168	168	167	168	167	167	168	168	168
41	16-Oct	168	168	168	168	168	167	167	168	167	168	167	167	168	167	168	167	164	167	168	167	167	168	167	168
42	23-Oct	168	168	168	168	168	167	167	168	167	167	168	167	168	167	168	168	168	167	167	167	167	168	167	167
43	30-Oct	114	109	168	168	168	167	166	168	167	166	168	167	168	168	167	168	168	167	167	167	166	168	167	168
44	06-Nov	0	0	168	168	168	167	167	167	167	166	167	167	168	166	168	168	128	167	167	167	167	167	150	168
45	13-Nov	0	0	168	168	168	167	144	168	167	167	168	166	167	168	168	167	107	167	167	167	167	168	167	168
46	20-Nov	0	0	167	168	168	168	168	167	168	168	168	132	88	168	168	168	167	168	168	168	168	168	168	168
47	27-Nov	0	0	168	82	85	85	83	168	87	168	83	0	0	110	63	63	62	62	167	63	167	60	57	58
48	04-Dec	0	0	166	0	0	0	0	168	0	168	0	0	0	0	0	0	0	0	168	0	168	0	0	0
49	11-Dec	0	0	168	0	0	0	0	168	0	168	0	0	0	0	0	0	0	0	168	0	168	0	0	0
50	18-Dec	0	0	167	0	0	0	0	62	0	166	0	0	0	0	0	0	0	0	38	0	164	0	0	0
51	25-Dec	0	0	168	0	0	0	0	0	0	168	0	0	0	0	0	0	0	0	0	0	168	0	0	0
Total		**1183**	**1100**	**4013**	**3232**	**3219**	**3225**	**3204**	**3711**	**3211**	**3929**	**3226**	**3103**	**2810**	**3192**	**3162**	**3007**	**3119**	**3037**	**3710**	**3070**	**3960**	**3238**	**3106**	**3175**

Table A3. Definition of tailrace, entrance, junction pool, collection channel, and exit zones used to calculate travel times for fish that passed Priest Rapids and Wanapum dams.

	Tailrace	Entrance	Junction Pool	Collection Channel	Exit
	Zone Numbers				
Priest Rapids Dam	2 and 3				
Left Fishway		6	5 and 7	4	9
Right Fishway		10	-	-	12
Wanapum Dam	100 and 101				
Left Fishway		103	104	102	105
Right Fishway		106	-	-	108

Table A4. Daily counts of chinook, coho, sockeye, and steelhead at Priest Rapids Dam, 1999.

Date (1999)	Chinook adult	Chinook jack	Coho adult	Coho jack	Sockeye	Steelhead
04-Jul	510	22	0	0	426	12
05-Jul	258	1	0	0	438	2
06-Jul	653	8	0	0	675	9
07-Jul	892	8	0	0	682	13
08-Jul	350	11	0	0	512	13
09-Jul	463	5	0	0	765	9
10-Jul	619	14	0	0	705	8
11-Jul	432	0	0	0	776	4
12-Jul	715	17	0	0	944	30
13-Jul	574	2	0	0	729	8
14-Jul	432	9	0	0	589	20
15-Jul	390	5	0	0	689	10
16-Jul	730	2	0	0	693	15
17-Jul	613	9	0	0	545	8
18-Jul	228	13	0	0	335	9
19-Jul	496	12	0	0	700	23
20-Jul	812	14	0	0	655	16
21-Jul	510	5	1	0	496	20
22-Jul	1016	25	0	0	376	17
23-Jul	639	5	0	0	388	18
24-Jul	616	22	0	0	278	28
25-Jul	564	18	0	0	286	46
26-Jul	218	6	0	0	126	29
27-Jul	330	9	1	0	172	39
28-Jul	357	14	1	0	136	30
29-Jul	518	8	0	0	207	41
30-Jul	307	9	0	0	128	44
31-Jul	429	3	0	0	134	49
01-Aug	356	9	1	0	118	51
02-Aug	218	5	0	0	72	43
03-Aug	633	14	0	0	78	49
04-Aug	211	14	0	0	78	48
05-Aug	565	24	1	4	97	65
06-Aug	185	16	12	0	70	90
07-Aug	125	10	4	0	45	60
08-Aug	180	3	7	0	34	56
09-Aug	160	4	6	0	36	59
10-Aug	289	6	2	0	48	63
11-Aug	185	4	1	0	13	58
12-Aug	177	6	0	0	21	89
13-Aug	198	3	1	0	9	93
14-Aug	270	8	0	0	2	106
15-Aug	116	5	0	0	12	105
16-Aug	146	5	0	0	12	113
17-Aug	104	0	0	0	3	92
18-Aug	88	4	2	0	1	73
19-Aug	154	6	0	0	5	83
20-Aug	325	4	0	0	1	166
21-Aug	318	6	0	0	8	174
22-Aug	283	3	0	0	9	114

Table A4. Daily counts of chinook, coho, sockeye, and steelhead at Priest Rapids Dam, 1999.

Date (1999)	Chinook adult	Chinook jack	Coho adult	Coho jack	Sockeye	Steelhead
23-Aug	56	1	1	0	0	91
24-Aug	562	6	1	0	2	233
25-Aug	296	7	0	0	1	143
26-Aug	630	7	0	0	0	162
27-Aug	379	3	1	0	1	149
28-Aug	427	10	0	0	1	135
29-Aug	1332	22	0	0	1	190
30-Aug	1560	18	0	0	0	207
31-Aug	911	17	0	0	7	201
01-Sep	299	1	0	0	5	125
02-Sep	935	25	1	0	2	117
03-Sep	1179	23	1	0	5	167
04-Sep	798	23	0	0	1	130
05-Sep	803	22	0	0	6	150
06-Sep	1036	27	0	0	0	160
07-Sep	516	23	0	0	1	105
08-Sep	638	11	0	0	0	108
09-Sep	1074	16	0	0	0	133
10-Sep	1401	10	0	0	0	172
11-Sep	744	20	0	0	0	108
12-Sep	1705	25	0	0	0	107
13-Sep	530	17	0	0	0	103
14-Sep	1080	27	0	0	0	147
15-Sep	279	23	0	0	0	113
16-Sep	955	26	0	0	0	164
17-Sep	875	24	0	0	0	237
18-Sep	276	20	0	0	0	129
19-Sep	440	37	0	0	0	124
20-Sep	668	31	0	0	0	107
21-Sep	550	40	0	0	0	73
22-Sep	240	32	0	0	0	88
23-Sep	270	46	0	0	0	174
24-Sep	155	41	0	0	0	121
25-Sep	309	38	0	0	0	108
26-Sep	99	24	0	0	0	61
27-Sep	77	18	0	0	0	59
28-Sep	160	30	1	0	0	37
29-Sep	84	14	0	0	0	55
30-Sep	69	31	0	0	0	61
01-Oct	64	17	1	0	0	42
02-Oct	94	11	0	0	0	49
03-Oct	123	20	0	0	0	45
04-Oct	138	11	0	0	0	37
05-Oct	139	16	2	0	0	58
06-Oct	27	15	0	0	0	27
07-Oct	54	7	0	0	0	25
08-Oct	83	4	0	0	0	35
09-Oct	80	19	0	0	0	25
10-Oct	46	12	0	0	0	20
11-Oct	57	18	0	0	0	38

Table A4. Daily counts of chinook, coho, sockeye, and steelhead at Priest Rapids Dam, 1999.

Date (1999)	Chinook adult	Chinook jack	Coho adult	Coho jack	Sockeye	Steelhead
12-Oct	36	16	0	0	0	17
13-Oct	87	7	1	0	0	25
14-Oct	121	13	0	0	0	9
15-Oct	52	5	0	0	0	24
16-Oct	33	5	0	0	0	13
17-Oct	33	9	0	0	0	11
18-Oct	110	8	1	0	0	13
19-Oct	74	5	0	0	0	7
20-Oct	46	2	0	0	0	3
21-Oct	49	8	0	0	0	24
22-Oct	75	7	0	0	0	11
23-Oct	72	11	0	0	0	8
24-Oct	347	15	0	0	0	7
25-Oct	110	6	0	0	0	16
26-Oct	268	5	0	0	0	17
27-Oct	110	9	0	0	0	7
28-Oct	162	2	0	0	0	5
29-Oct	77	4	0	0	0	5
30-Oct	42	3	0	0	0	8
31-Oct	88	3	0	0	0	2
01-Nov	52	1	0	0	0	7
02-Nov	77	1	0	0	0	2
03-Nov	54	3	0	0	0	6
04-Nov	80	1	0	0	0	3
05-Nov	45	4	0	0	0	1
06-Nov	38	1	0	0	0	7
07-Nov	18	2	0	0	0	2
08-Nov	11	1	0	0	0	1
09-Nov	20	2	0	0	0	3
10-Nov	13	0	0	0	0	6
11-Nov	14	0	0	0	0	5
12-Nov	2	0	0	0	0	4
13-Nov	7	0	0	0	0	0
14-Nov	6	1	0	0	0	6
15-Nov	7	0	0	0	0	2
Totals	**47695**	**1581**	**51**	**4**	**14390**	**8162**
Totals by fishway						
East	32872	1118	34	4	12404	6513
West	14823	463	17	0	1986	1649

Table B1. Definition of fixed-station tracking zones for Rock Island and Rocky Reach dams and zones along the Wenatchee, Columbia, and Entiat rivers.

River	Zone No.	Name	Antenna ID	Receiver	Antenna No.
Columbia River					
Rock Island Dam					
	200	RI Tailrace -- Right Shore	156, 157	60	2
	201	RI Left Fishway - Entrance Out	162	61	1
	202	RI Left Fishway - Entrance In & Corner	163, 164	61	2
	203	RI Left Fishway Exit - First Corner	169	62	1
	204	RI Left Fishway Exit - Second Corner	170	62	1
	205	RI Left Fishway Exit - Video Pool	171	62	1
	206	RI Left Fishway Exit - Exit	172	62	1
	207	RI Center Fishway Down En Out	176	63	1
	208	RI Center Fishway - Downstream Ent In	177	63	1
	209	RI Center Fishway - Side Ent (Not Installed)	178	63	1
	210	RI Center Fishway - Side Ent In & Start of Ladder	179, 180	63	2
	211	RI Center Fishway Ex - Dif Pool & 4 Pools above Dif	183, 184	64	2
	212	RI Center Fishway - Down of Tras - before Vid P & VP	185, 186	64	2
	213	RI Center Fishway Exit - Exit	187	64	1
	214	RI Right Fishway - East Entrance Out	190	65	1
	215	RI Right Fishway - East Entrance In	191	65	1
	216	RI Right Fishway - Up Tran Cha	192	65	1
	217	RI Right Fishway - Middle En Out	193	65	1
	218	RI Right Fishway - Middle Ent In	194	65	1
	221	RI Right Fishway - West Entrance Out	197	66	1
	222	RI Right Fishway - West Entrance In	198	66	1
	219	RI Right Fishway - Side Entrance Out	199	66	1
	220	RI Right Fishway - Side Entrance In	200	66	1
	223	RI Right Fishway - South Corner	201	66	1
	224	RI Quadfurication Area -- Trans. Channel	204	67	1
	225	RI Quadfurication Area -- Begining of Ladder	205	67	1
	226	RI Right Fishway Exit -- First Pool Down of Road	211	68	1
	227	RI Right Fishway Exit -- above Video	212, 213	68	2
	228	RI Right Fishway Exit -- Exit	214	68	1
Columbia River					
Rocky Reach Dam					
	300	RR Tailrace -- Right Shore	219, 220	69	2
	301	RR Spillway Entrance - Out	225	70	1
	302	RR Spillway Entrance - In	226	70	1
	303	RR Spillway Entrance - Before Tran Cha	227	70	1
	304	RR Left Entrance - West Entrance Out	232. 234	71	2
	305	RR Left Entrance - West Entrance In	233, 235	71	2
	306	RR Left Entrance - Near Diffusion Gates	236	71	1
	307	RR Trifurication Pool - Spillway Channel	239	72	1
	308	RR Trifurication Pool - Left Fishway	240	72	1
	309	RR Trifurication Pool - Coll Channel	241	72	1
	310	RR Trifurication Pool - Above Tri-pool	242	72	1
	311	RR Trifurication Pool - End of Diffusers	243	72	1

Table B1. Definition of fixed-station tracking zones for Rock Island and Rocky Reach dams and zones along the Wenatchee, Columbia, and Entiat rivers.

River	Zone No.	Name	Antenna ID	Receiver	Antenna No.
Columbia River					
Rocky Reach Dam - Cont'd					
	312	RR Collection Channel - Gate 1 Outside	246	73	1
	313	RR Collection Channel - Gate 1 Inside	247	73	1
	314	RR Collection Channel - Gate 2 Outside	248	73	1
	315	RR Collection Channel - Gate 2 Inside	249	73	1
	316	RR Collection Channel - Gate 3 Outside	250	73	1
	317	RR Collection Channel - Gate 3 Inside	251	73	1
	318	RR Collection Channel - Gate 14 Outside	318	74	1
	319	RR Collection Channel - Gate 14 Inside	319	74	1
	320	RR Collection Channel - Gate 16 Outside	255	74	1
	321	RR Collection Channel - Gate 16 Inside	256	74	1
	322	RR Collection Channel - Gate 20 Outside	257	74	1
	323	RR Collection Channel - Gate 20 Inside	258	74	1
	324	RR Right Fishway - Out	260	75	1
	325	RR Right Fishway Entrance - In	261	75	1
	326	RR Collection Channel - Beginning of Cha	262	75	1
	327	RR Transport Channel - Spiral Staircase	263	75	1
	328	RR Transport Channel - Beg of Fishway Grade	264	75	1
	329	RR Fishway - Before And After Bend	265, 266	75	2
	330	RR Fishway Exit - Below Diffusion Pool	267	76	1
	331	RR Fishway Exit - Below Video	268	76	1
	332	RR Fishway Exit - at Video	269, 270	76	2
	333	RR Fishway Exit -- Exit	271	76	1
Wentachee River					
	229	WEN Wenatchee River -- County Park - Downstream	274	77	1
	240	WEN Wetatchee River - County Park - Upstream	275	77	1
	230	WEN Wenatchee River -- Tumwater Dam - Looking Downstream	281	78	1
	234	WEN Wenatchee River -- Tumwater Dam - Looking Upstream	282	78	1
	231	WEN Wenatchee River -- Tumwater Dam - Inside Entrance	288	79	1
	232	WEN Wenatchee River -- Tumwater Dam - Top Ladder	289	79	1
Entiat River					
	334	EN Entiat River -- Downstream	295	80	1
	335	EN Entiat River - Upstream	296	80	2

Table B2. Details of fixed-station monitoring effort (in hours) for each week for all sites monitored in 1999 between the Rock Island tailrace and the Entiat River.

		Receiver Numbers at Rock Island Dam									Receiver Numbers at Rocky Reach Dam								Wenatchee River			
Receiver No.		R60	R61	R62	R63	R64	R65	R66	R67	R68	R69	R70	R71	R72	R73	R74	R75	R76	R77	R78	R79	R80
No. of Antennas		2	3	4	5	5	5	5	2	4	2	3	5	5	6	6	7	5	2	2	2	2
General Location		Right Tailrac	Left Entrance	Left Exit	Center Fishway	Cente Exit	Right Fishway	Right Fishway	Quad Area	Right Exit	Right Tailrac	Spillway Entrance	Left Entrance	Trifur Pool	ollect Chan	Collect Chan	Trans Channel	Fishway Exit	County Park	Tum Tail	Tum Tai	Entiat River
Week	Week Ending	Number of Hours in Operation																				
28	17-Jul	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
29	24-Jul	107	111	110	110	110	108	108	108	108	105	105	105	104	105	105	39	106	83	86	86	81
30	31-Jul	167	167	166	167	166	167	166	167	167	167	168	167	167	168	167	167	168	168	167	167	167
31	07-Aug	167	167	166	167	168	167	167	165	166	167	167	168	167	167	167	167	166	167	167	167	167
32	14-Aug	168	167	167	167	167	167	167	167	167	167	166	146	166	167	167	167	168	167	166	166	167
33	21-Aug	168	167	167	166	167	167	167	166	167	167	168	168	168	168	168	168	167	167	166	166	167
34	28-Aug	168	168	168	168	167	168	167	167	167	168	168	167	168	168	168	168	167	167	167	167	167
35	04-Sep	168	167	168	167	167	167	167	167	166	168	167	168	168	168	41	168	167	167	167	167	167
36	11-Sep	167	167	167	167	166	168	168	168	167	167	167	166	168	168	128	168	167	167	166	166	166
37	18-Sep	168	167	167	167	167	168	168	168	168	168	167	167	167	167	168	168	158	167	167	167	167
38	25-Sep	167	167	167	167	167	167	167	167	166	168	167	167	168	168	168	168	168	167	167	167	166
39	02-Oct	167	168	167	167	166	168	168	168	167	168	168	167	168	168	168	168	168	168	167	167	167
40	09-Oct	167	167	167	166	167	167	167	167	168	168	168	167	168	168	168	168	168	168	167	167	168
41	16-Oct	167	167	167	167	167	167	166	167	168	168	167	167	168	166	167	168	168	168	168	168	168
42	23-Oct	167	167	168	167	167	168	168	168	167	167	168	167	167	167	168	167	168	168	167	167	167
43	30-Oct	168	167	167	167	167	167	166	167	167	166	168	167	168	168	168	168	168	168	167	167	168
44	06-Nov	168	167	167	167	168	167	167	167	167	166	167	167	167	168	168	167	168	168	168	168	167
45	13-Nov	168	167	167	166	167	157	166	166	167	167	167	167	167	167	168	167	168	168	168	167	167
46	20-Nov	166	167	167	167	167	167	167	167	167	167	167	167	167	168	168	168	168	168	168	167	167
47	27-Nov	58	56	167	57	166	57	57	57	167	61	62	61	61	62	62	62	167	168	168	168	167
48	04-Dec	0	0	136	0	59	0	0	0	168	0	0	0	0	0	0	0	168	130	168	168	167
49	11-Dec	0	0	106	0	0	0	0	0	167	0	0	0	0	0	0	0	156	156	168	167	167
50	18-Dec	0	0	167	0	37	0	0	0	167	0	0	0	0	0	0	0	168	133	168	167	167
51	25-Dec	0	0	57	0	167	0	0	0	167	0	0	0	0	0	0	0	168	145	168	166	167
Total		3035	3032	3607	3028	3401	3023	3028	3028	3807	3034	3036	3010	3036	3040	2876	2975	3797	3687	3789	3783	3780

Table B3. Definition of tailrace, entrance, junction pool, collection channel, video pool, and exit zones used to calculate travel times for fish that passed Rock Island and Rocky Reach dams.

	Tailrace	Entrance Outside	Entrance Inside	Junction Pool	Video Pool	Exit
	Zone Numbers					
Rock Island Dam	200					
Left Fishway		201	202		205	206
Centre Fishway						
Main Entrance		207	208		212	213
Side Entrance			210			
Right Fishway				216, 224, 225	227	228
East Entrance		214	215			
Middle Entrance		217	218			
Side Entrance		219	220			
West Entrance		221	222			
Rocky Reach Dam	300					
Fishway				307, 308, 309, 310, 311	332	333
Spillway Entrance		301	302			
Trifurcation Entrance		304	305			
Upstream Powerhouse		324	325			
OG 1		312	313			
OG 2		314	315			
OG 3		316	317			
Downstream Powerhouse						
OG 14		318	319			
OG 16		320	321			
OG 18		322	323			
DOE		324	325			

Table B4. Daily counts of steelhead at Rocky Reach and Rock Island dams, 1999.

Date (1999)	Rocky Reach Steelhead	Rock Island Steelhead
04-Jul	2	5
05-Jul	1	2
06-Jul	6	4
07-Jul	5	7
08-Jul	4	1
09-Jul	3	9
10-Jul	5	13
11-Jul	4	12
12-Jul	4	10
13-Jul	6	10
14-Jul	7	11
15-Jul	9	9
16-Jul	4	15
17-Jul	6	16
18-Jul	9	7
19-Jul	7	11
20-Jul	10	7
21-Jul	4	11
22-Jul	2	12
23-Jul	5	19
24-Jul	12	16
25-Jul	6	24
26-Jul	8	17
27-Jul	8	24
28-Jul	16	25
29-Jul	10	23
30-Jul	16	22
31-Jul	14	26
01-Aug	19	33
02-Aug	18	42
03-Aug	10	39
04-Aug	9	44
05-Aug	6	32
06-Aug	39	37
07-Aug	22	52
08-Aug	30	46
09-Aug	13	64
10-Aug	19	68
11-Aug	21	83
12-Aug	28	50
13-Aug	42	51
14-Aug	43	67
15-Aug	31	70
16-Aug	26	70
17-Aug	46	108
18-Aug	50	82
19-Aug	50	82
20-Aug	95	84
21-Aug	88	73
22-Aug	48	86
23-Aug	60	126
24-Aug	86	115
25-Aug	79	108
26-Aug	90	93
27-Aug	90	139

Table B4. Daily counts of steelhead at Rocky Reach and Rock Island dams, 1999.

Date (1999)	Rocky Reach Steelhead	Rock Island Steelhead
28-Aug	98	141
29-Aug	79	115
30-Aug	133	107
31-Aug	50	122
01-Sep	89	150
02-Sep	121	95
03-Sep	101	110
04-Sep	78	144
05-Sep	104	82
06-Sep	70	99
07-Sep	81	142
08-Sep	90	90
09-Sep	109	103
10-Sep	87	93
11-Sep	76	54
12-Sep	61	78
13-Sep	48	94
14-Sep	89	117
15-Sep	77	95
16-Sep	81	107
17-Sep	85	80
18-Sep	83	100
19-Sep	88	95
20-Sep	54	119
21-Sep	100	125
22-Sep	107	119
23-Sep	86	93
24-Sep	61	71
25-Sep	68	77
26-Sep	66	70
27-Sep	48	109
28-Sep	72	52
29-Sep	42	61
30-Sep	39	76
01-Oct	52	33
02-Oct	45	27
03-Oct	20	10
04-Oct	22	50
05-Oct	27	43
06-Oct	30	53
07-Oct	19	28
08-Oct	18	29
09-Oct	39	16
10-Oct	60	32
11-Oct	22	24
12-Oct	18	32
13-Oct	21	10
14-Oct	23	16
15-Oct	6	12
16-Oct	12	13
17-Oct	17	11
18-Oct	14	6
19-Oct	12	7
20-Oct	8	9
21-Oct	6	9

Table B4. Daily counts of steelhead at Rocky Reach and Rock Island dams, 1999.

Date (1999)	Rocky Reach Steelhead	Rock Island Steelhead
22-Oct	6	3
23-Oct	3	14
24-Oct	4	9
25-Oct	9	11
26-Oct	12	6
27-Oct	3	12
28-Oct	9	3
29-Oct	7	5
30-Oct	8	3
31-Oct	5	4
01-Nov	6	3
02-Nov	2	6
03-Nov	5	0
04-Nov	4	0
05-Nov	3	2
06-Nov	1	1
07-Nov	0	5
08-Nov	0	0
09-Nov	3	5
10-Nov	3	1
11-Nov	11	4
12-Nov	12	5
13-Nov	18	2
14-Nov	15	0
Totals	**4712**	**6271**
Totals by fishway		
East		500
Centre		563
West		5208

Table C1. Definition of fixed-station tracking zones for Wells Dam and zones along the Methow, Columbia and Okanogan rivers.

River	Zone No.	Name	Antenna ID	Receiver	Antenna No.
Columbia River					
Wells Dam					
	400	WE Tailrace	501, 502	30	2
	403	WE Left Entrance Main	508	31	1
	404	WE Left Entrance Side	509	31	1
	405	WE Left Fishway	510	31	1
	406	WE LF Below Trap	511	31	1
	407	WE LF Trap	512	31	1
	409	WE Left Exit	515	32	1
	408	WE LF Above Trap	516	32	1
	410	WE Right Entrance Main	522	33	1
	411	WE Right Entrance Side	523	33	1
	412	WE Right Fishway	524	33	1
	413	WE RF Below Trap	525	33	1
	414	WE RF Trap	526	33	1
	416	WE Right Exit	529	34	1
	415	WE RF Above Trap	530	34	1
	401	WE Wells Hatchery Cove	536	35	1
	402	WE Wells Hatchery Channe	543	36	1
Methow River					
	417	Methow River	550, 551	37	2
	420	Methow River	803	44	1
Okanogan River					
Okanogan River					
	418	Okanogan River	557, 558	38	2
Zosel Dam					
	419	Zosel	564, 565	39	2

Table C2. Details of fixed-station monitoring effort (in hours) for each week for all sites monitored in 1999 between the Wells and Zosel dams.

		Receiver Numbers at Wells Dam									
Receiver No.		R30	R31	R32	R33	R34	R35	R37	R44	R38	R39
No. of Antennas		2	5	2	4	2	1	2	1	2	2
General Location		Tailrace	Left Entrance	Left Exit	Right Entrance	Right Exit	Hatchery Cove	Methow River	Methow River	Okanogan Monse	Zosel Dam
Week	Week Ending	Number of Hours in Operation									
28	17-Jul	24	24	24	24	24	24	24	24	24	24
29	24-Jul	57	154	36	60	34	56	0	0	0	0
30	31-Jul	167	168	168	168	168	167	34	0	0	0
31	07-Aug	166	166	165	168	165	166	168	0	158	0
32	14-Aug	167	166	167	168	167	167	168	0	168	0
33	21-Aug	168	168	165	167	167	167	167	0	167	0
34	28-Aug	168	168	166	168	167	167	168	0	167	80
35	04-Sep	168	167	167	168	168	167	147	0	167	167
36	11-Sep	168	118	117	118	120	167	94	0	167	167
37	18-Sep	168	168	167	163	167	168	96	0	167	167
38	25-Sep	168	168	165	168	167	167	168	0	168	167
39	02-Oct	168	168	167	159	168	167	168	0	167	166
40	09-Oct	168	168	168	84	168	168	168	0	168	167
41	16-Oct	167	167	167	166	167	168	168	0	168	167
42	23-Oct	166	167	167	168	168	168	168	0	168	168
43	30-Oct	167	167	167	167	167	168	168	0	167	166
44	06-Nov	168	167	106	167	167	168	168	0	168	168
45	13-Nov	165	167	166	167	166	168	168	0	167	166
46	20-Nov	168	168	168	168	168	168	168	0	168	158
47	27-Nov	35	37	166	39	166	39	168	11	168	0
48	04-Dec	0	0	168	0	168	0	165	167	168	0
49	11-Dec	0	0	168	0	168	0	168	168	168	0
50	18-Dec	0	0	37	0	167	0	168	167	167	0
51	25-Dec	0	0	0	0	167	0	168	167	167	0
Total		**2961**	**3011**	**3322**	**2825**	**3689**	**2965**	**3415**	**704**	**3532**	**2098**

Table C3. Definition of tailrace, entrance, below trap, and exit zones used to calculate travel times for fish that passed Wells Dam.

	Tailrace	Entrance	Below Trap	Exit
	Zone Numbers			
Wells Dam	400			
Left Fishway			406	409
Main Entrance		403		
Side Entrance		404		
Right Fishway			413	416
Main Entrance		410		
Side Entrance		411		

Table C4. Daily counts of chinook, coho, sockeye, and steelhead at Wells Dam in 1999.

Date (1999)	Chinook Adult	Chinook Jack	Coho	Sockeye	Steelhead Hatchery	Steelhead Wild	Steelhead Total
04-Jul	50	2		40			
05-Jul	15	1		34			
06-Jul	19	7		33			
07-Jul	99	2		66			
08-Jul	91			115			
09-Jul	139	3		178	3		3
10-Jul	91			171	2		2
11-Jul	44	4		85		1	1
12-Jul	70			167			
13-Jul	179	7		203	1		1
14-Jul	127	5		359	2		2
15-Jul	26	1		158	3		3
16-Jul	51			180	5		5
17-Jul	158	5		295	2		2
18-Jul	211	5		639	6		6
19-Jul	55	3		460	3		3
20-Jul	41	5		535	3		3
21-Jul	151	8		748	5		5
22-Jul	304	12		694	3		3
23-Jul	264	4		493	5		5
24-Jul	172	6		677	1		1
25-Jul	340	14		736	4	1	5
26-Jul	38	4		334	6		6
27-Jul	302	6		532	8		8
28-Jul	231	9		533	7		7
29-Jul	275	9		458	5	2	7
30-Jul	194	5		471	11	2	13
31-Jul	196	4		378	10	2	12
01-Aug	74	3		281	11	3	14
02-Aug	74	5		185	7	3	10
03-Aug	210	9		206	9	3	12
04-Aug	273	8		145	6	1	7
05-Aug	236	5		194	16	1	17
06-Aug	29	2		126	7	1	8
07-Aug	45			113	6	1	7
08-Aug	210	15		159	13		13
09-Aug	113	2		138	6	1	7
10-Aug	175	9		136	8	1	9
11-Aug	65	7		95	22	1	23
12-Aug	72	3		72	17	6	23
13-Aug	74	7		67	17	3	20
14-Aug	88	24		37	15	4	19
15-Aug	211	18		60	31	3	34
16-Aug	167	7		63	13	2	15
17-Aug	143	6		67	18	5	23
18-Aug	86	8		58	12		12
19-Aug	101	19		42	39	6	45
20-Aug	39	6		24	44	7	51
21-Aug	105	6		26	34	2	36
22-Aug	132	11		36	57	11	68
23-Aug	52	8		27	21	3	24

Table C4. Daily counts of chinook, coho, sockeye, and steelhead at Wells Dam in 1999.

Date	Chinook		Coho	Sockeye	Steelhead		
(1999)	Adult	Jack			Hatchery	Wild	Total
24-Aug	143	13		27	48	4	52
25-Aug	145	8		21	24	2	26
26-Aug	82	24		7	23	7	30
27-Aug	69	16		13	77	3	80
28-Aug	141	34		3	63	13	76
29-Aug	103	48		4	57	17	74
30-Aug	15	52		2	23	5	28
31-Aug	50	35		2	28	12	40
01-Sep	40	17		5	65	4	69
02-Sep	59	9		3	88	11	99
03-Sep	34	7		4	75	5	80
04-Sep	70	42		1	102	8	110
05-Sep	106	15		6	82	4	86
06-Sep	134	6		5	48	3	51
07-Sep	81	5		3	48	8	56
08-Sep	41	8		8	33	6	39
09-Sep	49	16		4	64	3	67
10-Sep	15	9			76	13	89
11-Sep	17	23		1	95	3	98
12-Sep	53	21		1	62	23	85
13-Sep	11	7		1	22	6	28
14-Sep	7				24	4	28
15-Sep	6	4		2	50	8	58
16-Sep	15	11		1	64	12	76
17-Sep	13	9			46	3	49
18-Sep	7	10			85	10	95
19-Sep	31	8		1	57	13	70
20-Sep	54	7			27	17	44
21-Sep	10	6			31	12	43
22-Sep	9	11			56	3	59
23-Sep	15	8			55	7	62
24-Sep	17	9			66	32	98
25-Sep	19	9			79	25	104
26-Sep	12	8			50	5	55
27-Sep	20	5			30	10	40
28-Sep	38	12			34	3	37
29-Sep	21	12			20	4	24
30-Sep	22	15			37	5	42
01-Oct	33	17			24	5	29
02-Oct	40	15			37	14	51
03-Oct	29	10			18	3	21
04-Oct	5	7		1	14	9	23
05-Oct	8	5			19	8	27
06-Oct	11	2			21	1	22
07-Oct	53	7	2	1	28	1	29
08-Oct	55	4	2		14	4	18
09-Oct	50	6	15		24	4	28
10-Oct	9	4	3		18	1	19
11-Oct	1	1			5		5
12-Oct	5	7	3		3		3
13-Oct	11	6	6		12	4	16

Table C4. Daily counts of chinook, coho, sockeye, and steelhead at Wells Dam in 1999.

Date (1999)	Chinook Adult	Chinook Jack	Coho	Sockeye	Steelhead Hatchery	Steelhead Wild	Steelhead Total
14-Oct	16	7	15	1	14	8	22
15-Oct	13	5	7		11	2	13
16-Oct	5	6	7		16	1	17
17-Oct	18	3	13		7	4	11
18-Oct	12	4	6	1	7	2	9
19-Oct	5	4	13		3	2	5
20-Oct	16	5	2		3	1	4
21-Oct	20	5			7	1	8
22-Oct	39	5	4		6	1	7
23-Oct	20	5	10		11	7	18
24-Oct	19	1	5		1	2	3
25-Oct	6	1	3		4	2	6
26-Oct	3		1		1	1	2
27-Oct	2		10		2		2
28-Oct	40	1	13		4		4
29-Oct	10	2	9		8	3	11
30-Oct	2	1	4		2	2	4
31-Oct	25	2	19		9		9
01-Nov	11		6		4	1	5
02-Nov					4	1	5
03-Nov	1	1	2		1		1
04-Nov	11	2	3		2	1	3
05-Nov	5	1	1		1	2	3
06-Nov	30		1		2	2	4
07-Nov	4		1			4	4
08-Nov					2		2
09-Nov	1				1		1
10-Nov	19	1	3		4		4
11-Nov	36	5	4		1	8	9
12-Nov	14	4	5		2	2	4
13-Nov	8				6	1	7
14-Nov	4		2		7	1	8
15-Nov	3		1			2	2
Totals	**9209**	**1040**	**201**	**12258**	**2928**	**527**	**3455**

Totals by Fishway	Chinook Adult	Chinook Jack	Coho	Sockeye	Steelhead Hatchery	Steelhead Wild	Steelhead Total
East	5530	425	101	6392	1390	313	1703
West	3679	615	100	5866	1538	214	1752

Appendix Table D1. Entrance gate of first detection by fishway for radio-tagged steelh Wells Dam in 1999.

Fishway/Group		No. of Radio-tagged Fish [a] Main Gate	Side Gate	Percentage Main Gate
Left-bank fishway				
	Control	15	20	43%
	Treatment	39	21	65%
	Total	**54**	**41**	**57%**
Right-bank fishway				
	Control	17	15	53%
	Treatment	42	13	76%
	Total	**59**	**28**	**68%**
Left- and right-bank fishways				
	Control	32	35	48%
	Treatment	81	34	70%
	Total	**113**	**69**	**62%**

[a] Control and Treatment groups based the gate configuration at the time of first detection at an entrance

Appendix Table D2. Entrance gate of first detection by fishway for radio-tagged steelhead passed Wells Dam in 1999.

Origin/Group		Number of Radio-tagged Fish		Percentage	
		Main Gate	Side Gate	Main Gate	Side Gate
Steelhead that passed Wells Dam[a]					
Left fishway					
	Control	16	17	48%	52%
	Treatment	26	15	63%	37%
	Excluded	2	2	50%	50%
	Total	**44**	**34**	**56%**	**44%**
Right fishway					
	Control	10	9	53%	47%
	Treatment	42	6	88%	13%
	Excluded	6	1	86%	14%
	Total	**58**	**16**	**78%**	**22%**
Both fishways					
	Control	26	26	50%	50%
	Treatment	68	21	76%	24%
	Excluded	8	3	73%	27%
	Total	**102**	**50**	**67%**	**33%**

[a] for fish that had entrance times on their first ascent. Second ascents were excluded.

Appendix Table D3. Number of radio-tagged steelhead that passed Wells Dam, by gate configuration, 1 July - 30 November 1999.

Group[a]		Start		End		Duration	Left Fishway	Right Fishway	Grand
		Date	Time	Date	Time	(d)	Number of Passses	Number of Passses	Total
Control (side gate open)									
	Contol 1	23-Aug	0:00	29-Aug	23:59	7.0	7	8	15
	Control 2	06-Sep	0:00	12-Sep	23:59	7.0	8	2	10
	Control 3	27-Sep	0:00	10-Oct	23:59	14.0	18	8	26
	Control 4	01-Nov	0:00	30-Nov	23:59	30.0	0	1	1
	Total					**58.0**	**33**	**19**	**52**
Treatment (side gate closed)									
	Treatment 1	01-Jul	0:00	22-Aug	23:59	53.0	13	7	20
	Treatment 2	30-Aug	0:00	05-Sep	23:59	7.0	9	17	26
	Treatment 3	13-Sep	0:00	26-Sep	23:59	14.0	15	20	35
	Treatment 4	11-Oct	0:00	31-Oct	23:59	21.0	4	4	8
	Total					**95.0**	**41**	**48**	**89**
Unassigned							**4**	**7**	**11**
Grand Total							**78**	**74**	**152**

[a] second ascents were excluded from the analysis

Appendix Table D4. Median passage times (h) and sample sizes for radio-tagged steelhead that passed Wells Dam entrance zones during different gate configurations in 1999.

	Medain Times (h)				Sample Size[a]			
	Control	Treatment	Excluded	Total	Control	Treatment	Excluded	Total
Left Fishway								
Project	11.5	13.1	25.9	12.8	32	41	4	77
Fishway	2.2	2.0	2.4	2.1	33	41	3	77
Entrance	3.2	2.5	22.0	3.3	33	41	3	77
Right Fishway								
Project	9.9	16.9	47.4	16.7	19	48	7	74
Fishway	1.9	2.3	14.2	2.2	19	48	5	72
Entrance	1.3	5.2	27.9	4.0	19	48	5	72
Both Fishways								
Project	10.6	16.5	45.5	15.7	51	89	11	151
Fishway	2.1	2.2	4.0	2.1	52	89	8	149
Entrance	2.5	3.4	26.2	3.5	52	89	8	149

[a] second ascents were excluded from the analysis

Appendix Table D5. Median passage times (h) and sample sizes for radio-tagged steelhead that passed Wells Dam and Priest Rapids trap zones during trapping and non-trapping periods in 1999.

Dam	Median Times (h)			Sample Size		
	Trapping	No trapping	Total	Trapping	No trapping	Total
Wells						
Left-bank upper fishway	5.6	2.0	2.1	6	71	77
Right-bank upper fishway	10.7	2.0	2.1	14	40	54
Both upper fishways	5.8	2.0	2.1	20	111	131
Priest Rapids						
Left-bank upper fishway	5.0	2.5	2.5	18	182	200

Appendix Table D6. Statisics for t-tests of natural log transformed passage times of radio-tagged steelhead that passed Wells Dam under control and treatment trials and steelhead that passed Wells and Priest Rapids dams under trapping and non-trapping intervals, 1999.

			Variable 1			Variable 2				
Dam	Fishway	Segment	Mean	SD	CV	Mean	SD	CV	df	P
Wells			Control			Treatment				
	Left Bank									
		Project	2.57	0.92	36%	2.66	0.86	32%	65	0.662
		Fishway	0.88	0.48	55%	0.93	0.62	67%	72	0.698
		Entrance	1.08	1.83	169%	0.98	2.00	203%	71	0.828
	Right Bank									
		Project	2.41	0.82	34%	2.71	0.79	29%	32	0.181
		Fishway	0.65	0.23	35%	1.10	0.95	86%	61	0.013
		Entrance	0.03	2.27	6874%	0.75	2.24	300%	33	0.252
	Left + Right									
		Project	2.51	0.88	35%	2.69	0.82	30%	98	0.238
		Fishway	0.80	0.49	61%	1.02	0.82	80%	139	0.043
		Entrance	0.70	2.05	293%	0.86	2.13	248%	110	0.661
			Left Fishway			Right Fishway				
	Left vs. Right									
		Project	2.66	0.88	33%	2.79	1.10	39%	140	0.425
		Fishway	0.91	0.56	62%	1.05	0.94	90%	114	0.289
		Entrance	1.11	1.92	173%	0.83	2.48	300%	134	0.435
			Trapping			No Trapping				
	Left Bank	Upper Fishway	1.66	0.82	50%	0.81	0.50	61%	5	0.054
	Right Bank	Upper Fishway	2.04	1.27	62%	0.65	0.40	61%	14	0.001
	Left + Right	Upper Fishway	1.93	1.15	60%	0.75	0.47	62%	20	0.000
Priest Rapids										
	Left Bank	Upper Fishway	0.47	0.31	65%	0.73	0.35	47%	20	0.006

Appendix Table E1. Trapping intervals at Wells and Priest Rapids dams in 1999.

Dam	Fishway	Start Date	Start Time	End Date	End Time	Duration (h)
Wells						
	Left Bank					
		12-Jul	6:00	12-Jul	22:00	16.0
		13-Jul	6:00	13-Jul	22:00	16.0
		14-Jul	6:00	14-Jul	22:00	16.0
		19-Jul	6:00	19-Jul	22:00	16.0
		20-Jul	6:00	20-Jul	22:00	16.0
		21-Jul	6:00	21-Jul	22:00	16.0
		26-Jul	6:00	26-Jul	22:00	16.0
		27-Jul	6:00	27-Jul	22:00	16.0
		28-Jul	6:00	28-Jul	22:00	16.0
		2-Aug	6:00	2-Aug	22:00	16.0
		3-Aug	6:00	3-Aug	22:00	16.0
		4-Aug	6:00	4-Aug	22:00	16.0
		9-Aug	6:00	9-Aug	22:00	16.0
		10-Aug	6:00	10-Aug	22:00	16.0
		11-Aug	6:00	11-Aug	22:00	16.0
		16-Aug	6:00	16-Aug	22:00	16.0
		17-Aug	6:00	17-Aug	22:00	16.0
		18-Aug	6:00	18-Aug	22:00	16.0
		23-Aug	6:00	23-Aug	22:00	16.0
		24-Aug	6:00	24-Aug	22:00	16.0
		25-Aug	6:00	25-Aug	22:00	16.0
	Total					**336.0**
	Right Bank					
		12-Jul	6:00	12-Jul	22:00	16.0
		13-Jul	6:00	13-Jul	22:00	16.0
		14-Jul	6:00	14-Jul	22:00	16.0
		19-Jul	6:00	19-Jul	22:00	16.0
		20-Jul	6:00	20-Jul	22:00	16.0
		21-Jul	6:00	21-Jul	22:00	16.0
		26-Jul	6:00	26-Jul	22:00	16.0
		27-Jul	6:00	27-Jul	22:00	16.0
		28-Jul	6:00	28-Jul	22:00	16.0
		2-Aug	6:00	2-Aug	22:00	16.0
		3-Aug	6:00	3-Aug	22:00	16.0
		4-Aug	6:00	4-Aug	22:00	16.0
		9-Aug	6:00	9-Aug	22:00	16.0
		10-Aug	6:00	10-Aug	22:00	16.0

Appendix Table E1. Trapping intervals at Wells and Priest Rapids dams in 1999.

Dam	Fishway	Start Date	Start Time	End Date	End Time	Duration (h)
		11-Aug	6:00	11-Aug	22:00	16.0
		16-Aug	6:00	16-Aug	22:00	16.0
		17-Aug	6:00	17-Aug	22:00	16.0
		18-Aug	6:00	18-Aug	22:00	16.0
		23-Aug	6:00	23-Aug	22:00	16.0
		24-Aug	6:00	24-Aug	22:00	16.0
		25-Aug	6:00	25-Aug	22:00	16.0
		30-Aug	6:00	30-Aug	22:00	16.0
		31-Aug	6:00	31-Aug	22:00	16.0
		1-Sep	6:00	1-Sep	22:00	16.0
		6-Sep	6:00	6-Sep	22:00	16.0
		7-Sep	6:00	7-Sep	22:00	16.0
		8-Sep	6:00	8-Sep	22:00	16.0
		13-Sep	6:00	13-Sep	22:00	16.0
		14-Sep	6:00	14-Sep	22:00	16.0
		15-Sep	6:00	15-Sep	22:00	16.0
		20-Sep	6:00	20-Sep	22:00	16.0
		21-Sep	6:00	21-Sep	22:00	16.0
		22-Sep	6:00	22-Sep	22:00	16.0
		27-Sep	6:00	27-Sep	22:00	16.0
		28-Sep	6:00	28-Sep	22:00	16.0
		29-Sep	6:00	29-Sep	22:00	16.0
		4-Oct	6:00	4-Oct	22:00	16.0
		5-Oct	6:00	5-Oct	22:00	16.0
		6-Oct	6:00	6-Oct	22:00	16.0
		11-Oct	6:00	11-Oct	22:00	16.0
		12-Oct	6:00	12-Oct	22:00	16.0
		13-Oct	6:00	13-Oct	22:00	16.0
		18-Oct	6:00	18-Oct	22:00	16.0
		19-Oct	6:00	19-Oct	22:00	16.0
		20-Oct	6:00	20-Oct	22:00	16.0
		25-Oct	6:00	25-Oct	22:00	16.0
		26-Oct	6:00	26-Oct	22:00	16.0
		27-Oct	6:00	27-Oct	22:00	16.0
		1-Nov	6:00	1-Nov	22:00	16.0
		2-Nov	6:00	2-Nov	22:00	16.0
		3-Nov	6:00	3-Nov	22:00	16.0
		8-Nov	6:00	8-Nov	22:00	16.0
		9-Nov	6:00	9-Nov	22:00	16.0
		10-Nov	6:00	10-Nov	22:00	16.0
		15-Nov	6:00	15-Nov	22:00	16.0
		16-Nov	6:00	16-Nov	22:00	16.0
		17-Nov	6:00	17-Nov	22:00	16.0
	Total					**912.0**
	Wells Total					**1248.0**

Appendix Table E1. Trapping intervals at Wells and Priest Rapids dams in 1999.

Dam	Fishway	Start		End		Duration
		Date	Time	Date	Time	(h)
Priest Rapids						
	Left Bank					
		13-Jul	10:45	13-Jul	18:30	7.8
		15-Jul	9:00	15-Jul	17:00	8.0
		20-Jul	9:00	20-Jul	17:00	8.0
		27-Jul	9:00	27-Jul	17:00	8.0
		29-Jul	9:00	29-Jul	17:00	8.0
		3-Aug	9:00	3-Aug	17:00	8.0
		5-Aug	9:12	5-Aug	17:12	8.0
		10-Aug	9:00	10-Aug	17:00	8.0
		12-Aug	9:00	12-Aug	17:00	8.0
		17-Aug	9:00	17-Aug	17:00	8.0
		19-Aug	9:00	19-Aug	17:00	8.0
		31-Aug	9:00	31-Aug	17:00	8.0
		2-Sep	9:00	2-Sep	15:00	6.0
		7-Sep	9:00	7-Sep	16:00	7.0
		9-Sep	9:00	9-Sep	16:00	7.0
		14-Sep	9:00	14-Sep	17:00	8.0
		16-Sep	9:00	16-Sep	17:00	8.0
		21-Sep	9:00	21-Sep	17:00	8.0
		23-Sep	9:00	23-Sep	17:00	8.0
		28-Sep	9:00	28-Sep	17:00	8.0
		30-Sep	9:00	30-Sep	17:00	8.0
		5-Oct	9:00	5-Oct	17:00	8.0
		7-Oct	9:00	7-Oct	17:00	8.0
		12-Oct	9:00	12-Oct	17:00	8.0
		14-Oct	9:00	14-Oct	17:00	8.0
	Total					**195.8**

Appendix Table F1. Aerial survey dates and coverage (H= helicopter, F= fixed-wing aircraft).

		Survey Dates										
	Year	1999	1999	2000	2000	2000	2001	2000	2000	2001	2000	2000
	Month	Oct	Nov	Jan	Feb	Mar	Mar	Apr	May	May	Jun	Jun
Survey Location	Days	25,26	28,29	17,18	16-18	6-10	27-30	17-19	2-4	18,19	1,2	15,16
Tributary/Spawning Areas												
Snake River												
Yakima River					F	F						
Wenatchee River												
Below Tumwater Dam		F	F	F	F	H/F	H/F	H/F	H/F	H	H	F
Above Tumwater Dam		F	F	F	F	H/F	H/F	H/F	H/F	H	H	F
Entiat River		F	F	F	F	F	F	F	H/F	H/F	H	F
Wells Hatchery												
Methow River		F	F	F	F	H/F	H/F	H/F	H/F	H/F	H	F
Okanogan River		F	F	F	F	F	F	F	F	F	F	F
Mid-Columbia River												
Hanford Reach												
Savage Is. - Coyote			F*	F*	F	F	F	F			F	F
Coyote - Priest Rapids			F	F	F	F	F	F			F	F
Prist Rapids Pool			F	F	F	F	F	F			F	F
Wanapum Pool			F	F	F	F	F	F			F	F
Rock Island Pool		F	F	F	F	F	F	F			F	F
Rocky Reach Pool		F	F	F	F	F	F	F	F	F	F	F
Wells Pool		F	F	F	F	F	F	F	F	F	F	F

* Partial survey - Savage Island to White Bluffs section not surveyed

Appendix Table F2. Number of radio-tagged steelhead detected in tributaries to the Methow and Wenatchee rivers during aerial surveys, 1999-2000.

	Survey dates										
Year	1999	1999	2000	2000	2000	2000	2000	2000	2000	2000	2000
Month	Oct	Nov	Jan	Feb	Mar	Mar	Apr	May	May	Jun	Jun
Tributary / Days	25,26	28,29	17,18	16-18	6-10	27-30	17-19	2-4	18,19	1,2	15,16
Methow River											
Gold Creek	-	-	-	-	0	0	1	1	1	0	-
Libby Creek	-	-	-	-	0	-	-	0	0	-	-
Beaver Creek	-	-	-	-	-	0	0	0	-	-	-
Twisp River	-	-	-	-	0	4	6	2	2	2	1
Chewack River	-	-	-	-	1	8	8	7	1	1	1
Lake Creek	-	-	-	-	-	-	-	0	-	-	-
Wolf Creek	-	-	-	-	0	-	0	-	-	-	-
Early Winters Creek	-	-	-	-	-	-	-	0	-	-	-
Methow R Tributaries	**-**	**-**	**-**	**-**	**1**	**12**	**15**	**10**	**4**	**3**	**2**
Wenatchee River											
Mission Creek	-	-	-	-	1	-	4	1	0	0	-
Peshastin Creek	-	-	-	-	0	1	6	4	4	3	-
Chumstick Creek	-	-	-	-	0	1	4	1	0	0	0
Chiwaukum Creek	-	-	-	-	0	-	-	1	-	-	-
Chiwawa River	-	-	-	-	0	0	2	2	3	-	-
Chickamin Creek	-	-	-	-	0	-	-	0	-	-	-
Rock Creek	-	-	-	-	0	-	-	-	-	-	-
Phelps Creek	-	-	-	-	0	-	-	-	-	-	-
Nason Creek	-	-	-	-	0	0	2	0	0	-	-
White River	-	-	-	-	0	0	0	0	0	-	-
Napeequa Creek	-	-	-	-	0	-	-	0	0	-	-
Little Wenatchee River	-	-	-	-	0	0	0	0	0	-	-
Wenatchee R Tributaries	**-**	**-**	**-**	**-**	**1**	**2**	**18**	**9**	**7**	**3**	**0**

Appendix O

2000 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program.

2000 Public Utility District No. 1 of Douglas County
Northern Pikeminnow Removal and Research Program

Prepared For

Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, WA 98802-4497

Prepared by
Tyson Jerald

Columbia Research
426 E. Woodin Ave.
Chelan, WA 98816
(509) 679-0384

Final Review Draft
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Abstract

Northern Pikeminnow removal efforts took place from May 18, 2000 to September 30, 2000. Anglers used hook and line and long line removal techniques to capture northern pikeminnow from 1 mile below Wells Dam upstream to the boat restricted zone (BRZ) of Chief Joseph Dam. Anglers utilized hook and line removal methods exclusively on the lower 14-mile stretch of the Okanogan River. A total of 24 anglers participated in the 19 week removal program.

Anglers captured a total of 11,646 northern pikeminnow over 10" in fork length and 692 northern pikeminnow under 10" in fork length. These fish (12,338 pikeminnow total) were captured during 4485.75 hours of angling effort translating into an overall catch per unit effort or fish per hour (CPUE) value of 2.75. A majority of the fish were captured in the immediate 1 mile tailrace below Wells Dam (9044 fish during 2929 angling hours, CPUE = 3.09). Anglers caught 3271 northern pikeminnow in the Wells reservoir between Wells Dam and Chief Joseph tailrace. These captures took place during 1536.75 hours of angling effort resulting in a CPUE value of 2.13. Effort within the Okanogan River consisted of 20 angling hours during which time 23 pikeminnow were captured (CPUE = 1.15).

Long line captures accounted for a majority of the overall catch (73% or 9034 northern pikeminnow). A total of 5902 pikeminnow were captured on the long line gear within Wells Dam tailrace during 1937 hours resulting in a CPUE value of 3.05 for that location. Wells reservoir long lining effort consisted of 1434.75 hours of effort to capture 3132 pikeminnow (CPUE = 2.18).

Hook and line captures accounted for 27% of the total catch. A total of 3304 pikeminnow were captured using this gear type. These fish were captured during 1114 hours of angling effort translating into an overall hook and line CPUE of 2.97. Anglers fished for 992 hours within the immediate 1 mile tailrace of Wells Dam capturing 3142 pikeminnow (CPUE =3.17). Hook and line effort within Wells reservoir consisted of 102 hours of angling effort (139 pikeminnow captured, CPUE = 1.36).

A total of 865 non-target fish were captured and released representing 7% of the overall catch. This catch consisted of 8 separate species. Sucker sp. were by far the most frequently encountered (596 fish or 69% of the non-target catch). Hook and line incidental catch consisted of sucker sp. (47 fish), burbot (32 fish), columbia river chub (pikeminnow x peamouth hybrid = 26 fish), peamouth (20 fish), sculpin sp. (2 fish), whitefish (2 fish), and walleye (1 fish). Although sturgeon were incidentally hooked during the removal efforts (estimated at about 10 fish), none of these fish were counted as the lines were immediately cut when these fish were hooked. Long line incidental catch consisted of bridgelip suckers (549 fish), sculpin (87 fish), burbot (52 fish), columbia river chub (19 fish), whitefish (11 fish), peamouth (9 fish), walleye (5 fish), and chiselmouth (3 fish). All incidentally collected fish were released in a live healthy state. No anadromous salmonids were encountered during the 2000 removal efforts.

From gonad analysis it was determined that pikeminnow spawning efforts peaked in July during the week of 7/9/00, at which time 94% of the sub-sampled pikeminnow were classified ripe. A 63% majority of the dissected stomachs were empty. The remaining stomachs contained prey items identified as crayfish (16%), smolt (9%), unidentified fish (5%), unidentified plant (5%), and unidentified insect (2%).

Scale and opercle analysis indicated that pikeminnow recruitment into the current Wells tailrace fishery began at age 6.4 (scale analysis) and age 5.9 (opercle analysis). The fish exhibited relatively high growth rates when compared with other regional northern pikeminnow populations.

Introduction

With a dramatic decline in the abundance of salmonid stocks (Oncorhynchus spp.) in the Columbia River, there has been a trend throughout the ecosystem to provide for the enhancement of these fish stocks. Over each of the past six years, Douglas Public Utility District (Douglas PUD or District) has funded projects focusing on the research and removal of the predacious northern pikeminnow (Ptychochelius oregonensis) on juvenile salmonids near Wells Dam, Washington. Wells Dam, located at river mile 515 on the Columbia River is owned and operated by DCPUD. The District is mandated by the Federal Energy Regulatory Committee to enhance and protect fish and wildlife resources impacted by the construction of Wells hydroelectric project.

Pikeminnow research and removal has been recognized as an important part of restoring salmonid stocks within the Columbia River ecosystem (Vigg et al. 1990, Matthews et al. 1991). Northern pikeminnow removal and research was initiated on the lower Columbia River during the summer of 1990. A total of 17,334 pikeminnow were captured in the test fisheries (Vigg, 1990). In 1991 a total of 39,817 fish were removed from eight US Army Corps of Engineer dams on the lower main stems of the Columbia and Snake Rivers (Beaty et al. 1991). Shortly thereafter, mid-Columbia Public Utilities began to investigate the possibilities of initiating similar pikeminnow research and removal activities. In 1993 Douglas County PUD jointly funded a juvenile salmonid predation study in the mid-Columbia region with Chelan County PUD and Grant County PUD (Burley et al. 1994). This study focused on identifying areas of northern pikeminnow abundance and areas of high predation on out-migrating juvenile salmonids within the mid-Columbia region. Density index values of pikeminnow in the mid-Columbia reservoirs were as high as many reservoirs of the lower-Columbia. The immediate tailrace of Wells Dam and the outfall of Wells Hatchery were determined to be sites where large concentrations of pikeminnow could be found relative to the reservoir and forebay areas surrounding Wells Dam.

Douglas PUD initiated a northern pikeminnow test fishery in 1995. The goals of this pilot project were to assess the effectiveness of several gear types for removing pikeminnow, estimate the population of pikeminnow and removing pikeminnow from the tailrace of Wells Dam (Bickford and Klinge, 1996). During the summer of 1995 anglers captured 1198 pikeminnow, most of which were caught using hook and line removal techniques. Population estimates for the Wells tailrace were estimated at fewer than 10,761 fish. A similar removal program was undertaken in 1996 with goals of increasing effort and removing as many pikeminnow as possible from the Wells tailrace (Bickford, 1997). Unfortunately, difficult fishing conditions related to high river flows and velocity hampered removal efforts at Wells Dam. Commercial long line gear was also utilized, and although the lines did not capture a large amount of pikeminnow, CPUE levels were high when this gear was tested. Low catch rates in 1996 prompted biologists at Douglas PUD to switch into a northern pikeminnow research phase in 1997. That year, northern pikeminnow were radio tagged throughout the Wells reservoir and tailrace. Northern Pikeminnow migration patterns, spawning locations, and preferred habitats were identified throughout Wells reservoir and from the Wells tailrace 11 miles downstream to

Chelan Falls (Bickford and Skillstead, 2000).

During 1998 in an effort to increase catch levels, Douglas PUD entered into a contract with Columbia Research for the research and removal of northern pikeminnow. The Columbia Research removal strategy focused on an incentive based fishery with a crew of experienced anglers paid on a per-fish basis (anglers hired directly by Douglas PUD in 1995 and 1996 had been paid by the hour). During 1998 and 1999, anglers participating in the fishery captured 7,347 and 10,382 pikeminnow respectively. Prompted by the success of the 1998 and 1999 control efforts, Douglas PUD once again entered into a competitive bidding process for the removal of pikeminnow. For the third year in a row, Columbia Research provided Douglas PUD with the lowest price per fish for the 2000 pikeminnow removal project.

Materials and Methods

Angling efforts were initiated on May 18, 2000 and were completed on September 30, 2000. Removal efforts were conducted weekly throughout this time period. Weekly summaries were furnished to the District during the project to provide biologists with progress and success rates. Anglers participating in the fishery were paid a $5.00 bounty for each captured pikeminnow over 10" in length, and a $.25 bounty for pikeminnow under 10" in length. Anglers turned in their catch on a daily basis at the Wells Dam boat launch or at the Columbia Research field office in Chelan, Washington. Anglers were responsible for presenting daily data sheets specifying times fished to the nearest ¼ hour, locations fished, number of fish caught per location, long line set times, incidental catch, and tackle/baits used.

The 2000 project took place within the immediate 1 mile tailrace area of Wells Dam, Wells reservoir to the boat restricted zone (BRZ) of Chief Joseph Dam, and the lower 13 miles of the Okanogan River. A scientific collection permit was obtained through Washington Department of Fish and Wildlife allowing anglers to fish in the mouth of the Wells Hatchery Outlet and the BRZ of Wells Dam. Captured northern pikeminnow were divided into three primary catch locations. Pikeminnow captured from Wells Dam to 1 mile downstream were designated "Wells tailrace". Fish captured from the Wells forebay to Chief Joseph Dam were designated "Wells reservoir". Captures in the Okanogan River were designated catch location "Okanogan". Weekly and seasonal CPUE rates were calculated by location and by removal technique (sport fishing vs. long line).

Both sport fishing and long line removal techniques were utilized for pikeminnow capture. Sport fishermen used a variety of baits and tackle. Baits consisted of salmonid smolt mortalities, crayfish, worms, crickets, and chicken livers. Smolt mortalities were salvaged from Little Goose Dam, Lower Granite Dam, and McNary Dam juvenile bypass facilities. Personnel at the Wells Fish Hatchery also provided smolt mortalities. Columbia Research in turn provided the fresh smolts to the anglers. Otherwise, anglers purchased or collected the majority of their own baits. Fishing effort was applied specifically by boat in all locations. A small amount of effort took place from docks located along the banks near the Methow – Columbia River confluence area.

Long line use was only authorized in the main stem Columbia due to concerns over incidental steelhead catch in the Okanogan and Methow rivers. Long lines used in 2000 were approximately 250' in length with each ground line having from 40 to 70 gabions. Leader and hooks were then tied to each gabion. Leaders consisted of 10 pound monofilament test approximately 2 feet in length. Long lines were baited with smolt mortalities, crayfish, crickets, worms and chicken livers. Long line gear was typically checked once daily. This allowed anglers to release all non-target fish back into the river unharmed. Long line effort for the purpose of calculating CPUE was determined by total hours spent to pull, check, reset lines as well as preparation time (tying hooks, assembling lines, etc.).

Biological Data was collected on the weekly catch. Sub-sample data consisted of fork length, weight, sex, stomach contents, and gonad maturity. Northern pikeminnow fork lengths were measured to the nearest millimeter. An Ohaus 5000 electronic scale was used to weigh fish to the nearest 2 grams. Pikeminnow were sexed and identified as male, female or unidentified. Stomach contents were then visually identified. Gonad maturity was characterized by a range of values (0 - 4), corresponding to the following criteria:

0 - Unidentified	Gonads could not be distinguished between male and female.
1 - Immature	Gonads thin and streamlined, sex may be difficult to determine.
2 - Developing	Eggs and milt do not flow easily with pressure, but sex is easily determined. Eggs are small and gray in color.
3 - Ripe	Females contain orange-colored eggs. Eggs and milt flow freely with gentle pressure.
4 - Spent	Gonad size reduced. Some eggs or sperm may still be present.

Lengths, weights, scales and opercles were collected from 40 northern pikeminnow collected from within the immediate Wells Dam tailrace. These scales were to analyzed and compared to other regional samples in an effort to determine recruitment into the current pikeminnow fishery and relative growth to other pikeminnow populations. 40 scale samples were also collected from Wanapum reservoir. The fish were collected in August and frozen until October, at which time fish were de-thawed. Fork lengths were recorded to the nearest millimeter and weights were recorded to the nearest gram using an Ohaus 5000 electronic scale. Scales were removed posterior to the dorsal fin and opercles from the left side of each pikeminnow. Scales and opercle were placed in 2" scale envelopes and transferred to Central Washington University aquatics lab for analysis. Within the lab, samples were hand washed and dried for examination. Five to ten scales were chosen at random without prior knowledge of the fish's length. The samples were then analyzed using a standard library microfiche reader. Annuli rings were agreed upon by two technicians and then penciled onto the microfiche reader along with the focus and total length distances. Distances between the marks were then recorded to the nearest millimeter.

Data analysis was performed using the Quattro database. Hand written annulus measurements were transferred to the database for post sample analysis. Back calculations were performed within the database using the Dahl-Lee formula. These back calculations were then averaged by year class to provide a comprehensive growth rate table. Recruitment within each fishery was determined by averaging back calculated ages of individual pikeminnow reaching 254 mm (10 inches) in fork length. To compare fitness or health parameters within the two populations, Fulton-type condition factors were computed for each population using length and weight data.

Average yearly growth rates of pikeminnow within Wells tailrace and Wells reach were compared with similar scale analysis projects from the Pacific Northwest region (Wydoski and Whitney, 1979). These comparisons were analyzed to determine general relationships or differences in growth rates between the separate populations.

A two-sample t-test was performed on age estimates from opercle and scale samples to identify significant differences between aging methods. An additional t-test was performed to determine the direction of difference between scale and opercle readings (e.g. did scale or opercle readings provide significantly higher estimates). A two-sample t-test was also performed on condition factors between the two populations. This test was administered in an attempt to distinguish any existing differences between the health indices (fitness) of the two populations.

Results

A total of 12,338 northern pikeminnow were captured during 4485.75hours of angling effort translating into an overall CPUE of 2.75 fish per angling hour. The majority of the fish (11,646) were over 10" in fork length and 692 fish were less than 10". Twenty anglers participated in removal efforts

The majority of pikeminnow (9044) were caught within the Wells tailrace and a total of 3271 pikeminnow were captured within Wells reservoir. Low catch values were logged within the Okanogan River (23 fish). In regards to CPUE, the highest values were also obtained in the Wells tailrace. Anglers logged 2929 hours of effort within the Wells tailrace area to capture the 9044 pikeminnow (CPUE = 3.09). A total of 1536.75 hours of effort were logged in Wells reservoir to capture the 3271 pikeminnow translating into a CPUE value of 2.13. Anglers participated in 20 hours of effort fishing the Okanogan River to capture 23 pikeminnow (CPUE = 1.15).

The highest weekly catch levels occurred during the first six weeks of the removal program. During this time a total of 4958 pikeminnow were captured or 40% of the total yearly catch. Catch values were relatively consistent after week 6 (Beginning of July) until the end of the project. Weekly CPUE values remained relatively consistent throughout the removal efforts fluctuating around 2.5 to 3.0. The peak bi-weekly CPUE value of 3.45 was obtained during the first week (5/18/00) of the removal efforts and the low weekly CPUE value of 1.85 was recorded during the week of 7/23/00.

The majority of pikeminnow were captured on the long line gear (73% or 9034 pikeminnow). Overall focus of the 2000 fishery switched from focusing on a hook and line angling strategy to the more labor-intensive long line strategy. Long line efforts were initiated during week 1 within Wells Reservoir and produced similar catch levels and CPUE values of hook and line efforts within Wells tailrace. Historically, hook and line effort within Wells tailrace was the primary spring fishing method during the peak spring fishing periods. However, with recent advancements in the long line gear it was possible to capture pikeminnow within the vast expanses of the Wells Reservoir system. Unfortunately, after mid-July, catch and CPUE values on the long line gear within Wells reservoir significantly decreased and as a result, the main long line operation was moved to the more productive Wells tailrace. By mid-August, effort for the entire program consisted solely of 1 long line crew operating specifically within the Wells tailrace area.

May and June marked the highest catch rates of pikeminnow on hook and line gear. Hook and line anglers captured a total of 3304 (27%) of the total catch. The west bank, east bank, and Wells hatchery outlet in the immediate tailrace area were the most productive hook and line fishing locations. During this time period pikeminnow were concentrated in the immediate Wells tailrace and easily accessible to the sport anglers. The most productive baits used by anglers were smolt, crickets and crayfish. These baits alone accounted for over 90% of pikeminnow captures. Angler participation decreased in mid-July as pikeminnow became more difficult to catch. Only the most experienced fishermen were participating in the removal fishery by the first of August. A majority of these individuals possessed extensive experience in both sport fishing and long line removal techniques, enabling the crew to maintain adequate catch levels.

Angling attempts at fishing the Wells reservoir and Okanogan River locations met with limited success. The only productive angling location within the Wells reservoir area was the mouth of the Methow River near Pateros, Washington. Individual anglers who had extensive angling experience in that area captured 193 pikeminnow during 120 hours of angling effort (CPUE = 1.61).

A majority (63%) of dissected pikeminnow stomachs were empty. The main prey items identified in pikeminnow gut analysis consisted of crayfish (16%), smolt (9%), unidentified fish (5%), unidentified plant (5%), and unidentified insect (2%).

Gonad analysis indicated 2000 northern pikeminnow spawning efforts peaked in July. The peak spawn period occurred during the week of July 9, at which time 94% of the sub-sampled fish were classified as ripe.

Incidental catch consisted of 8 separate species with a total of 865 non-target fish captured. Gear types appeared to be selective for northern pikeminnow as incidental fish captures only accounted for 7% of the overall catch. Sucker sp. (*Catostomus columbianus* and *Catastomus machrocheilus*), sculpin (*cottus* sp.), burbot (*lota lota*), and columbia river chub (peamouth x pikeminnow hybrid) were most frequently encountered bycatch. Peamouth (*Mylocheilus caurinus*), whitefish (*Prosopium williamsoni*), walleye (*Stizostedion vitreum*), and chiselmouth (*Acrocheilus alutaceus*) were encountered to a lesser extent. An estimated 10 white sturgeon (*Acipenser transmontanus*) were incidentally hooked during the removal efforts, however, these fish were not included as incidental catch as the lines were immediately cut when these fish were hooked.

Hook and line incidental catch consisted of sucker sp. (47 fish), burbot (32 fish), columbia river chub (pikeminnow x peamouth hybrid = 26 fish), peamouth (20 fish), sculpin sp. (2 fish), whitefish (2 fish), and walleye (1 fish). Long line incidental catch consisted of bridgelip suckers (549 fish), sculpin (87 fish), burbot (52 fish), columbia river chub (19 fish), whitefish (11 fish), peamouth (9 fish), walleye (5 fish), and chiselmouth (3 fish). All incidentals were released in a live-healthy state. No anadromous salmonids were encountered during the 2000 removal efforts.

A total of 39 Wells opercles were measured, as one of the 40 sampled fish opercles contained no visible annulus increments. Thirty-eight scales were verified as two of the samples contained re-generated scales and were not able to be accurately counted. All Wanapum opercles were verified and recorded. Thirty-nine Wanapum scales were measured with 1 of the sampled fish containing all re-generated scales.

Both opercle and scale analysis indicated that pikeminnow within Priest Rapids reservoir were larger at age (*N)* than pikeminnow within Wells dam tailrace (Table 1). Scale and opercle analysis indicated a higher average size within all age classes for the Priest Rapids pikeminnow.

Table 1 Northern Pikeminnow Scale and Opercle Back Calculation

(Data other than Wanapum and Wells supplied by Wydoski and Whitney, 1979)

	Age											
Location	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Flathead Lk, MT	30	53	81	112	145	175	203	234	262	287		
Alva Lk, MT	53	84	117	150	183	213	241	267	292	312		
Seely Lake, MT	56	89	127	165	201	234	262	290	320	353		
Idaho Lakes	81	152	211	267	305	348	378	406	434	470		
Lake Washington	64	152	229	281	316	347	368	387	409	425		
Wells Reach	74	118	157	183	213	245	271	287	309			
Wanapum Reach	99	142	177	209	235	254	280	295	330	351	370	396
Average	65	113	157	195	228	259	286	309	337	366		
Range:												
Smallest	30	53	81	112	145	175	203	234	262	287		
Largest	99	152	229	281	316	348	378	406	434	470		
Northern Pikeminnow Average Total Length via Opercle Analysis												
Wells Reach	68	119	160	190	216	252	267	286	302	271	283	295
Wanapum Reach	134	165	195	217	242	274	289	315	324	355	364	379

Results showed recruitment into the current fishery was quickest within the Wanapum reach area. Pikeminnow were determined to enter into the Wanapum reach fishery (length 254 mm) at age 5.4 (scales) and 5.0 (opercle). It was indicated that pikeminnow recruitment into the current Wells tailrace fishery began at age 6.4 (scale analysis) and age 5.9 (opercle analysis).

Wells and Wanapum fish exhibited relatively high growth rates when compared with regional northern pikeminnow populations (Table 1). Wanapum reach fish were larger at age class (*N*) than all other populations analyzed to date. Wells fish were larger overall than 4 of the 5 other regionally analyzed pikeminnow populations.

Fulton-type condition factor analysis was very similar between the two studied populations. Wells tailrace fish were computed to have an average condition factor of 1.10. The Wanapum reach condition factor was computed at 1.09. A two-sample t-test indicated no significant difference between the condition factor for the two populations studied ($P > 0.72$).

A two-sample t-test indicated that aging differences between the opercle analysis and the scale analysis were significant ($P < 0.00$). An additional test to determine the directional difference between methods provided a significantly higher estimate within age of opercles when compared to scale analysis ($P<0.00$).

Discussion

Since Douglas County PUD initiated the pikeminnow removal program in 1995, a total of 31,578 pikeminnow have been removed from the study area. This represents a significant decrease in predation on juvenile salmonids within Wells tailrace and reservoir locations.

The year 2000 northern pikeminnow fishery produced the highest yearly catch total since pikeminnow removal efforts were initiated within Wells tailrace and Wells reservoir in 1995. This can be attributed, in large part, to the efficacy of the long line capture techniques. Long line angling again proved to be highly effective compared to hook-and-line angling. Frequently, long lines were spread over 5 km of river, allowing anglers to quickly identify where the greatest densities of fish were located. The long line gear allowed anglers to target areas within the reservoir that would have otherwise been ignored due to low overall CPUE. Long lines were capable of being fished in relatively productive waters that were not fully exploited during previous removal efforts (e.g. very remote areas within Wells reservoir and depths of up to 35 m). The long line fishery also provided comprehensive biological data from the entire population of northern pikeminnow from both Wells tailrace and Wells reservoir.

Initially, concerns of high incidental catch and mortality due to a non-specific long line fishery hampered acquisition of a Scientific Collection Permit for this type of fishery on the Columbia River. To the contrary, Columbia Research's long line methods have proven to be highly selective for northern pikeminnow and only slightly increased the total percentage of non-target species encountered. Long lines allow for the selective harvesting of northern pikeminnow from all depths, currents, substrates, and seasons.

Although long line efforts within the Wells reservoir were productive in early spring, overall catch rates and CPUE levels were significantly lower when compared to the Wells tailrace area, especially from mid-August to the completion of the project. The largest problem encountered in reservoir long lining resulted from the, "fishing out" of productive locations after one or two long line sets (long lines placed in tailrace areas could often be fished for four or five days before the location was fished out).

Another factor contributing to increased catch levels was the strategy of paying anglers on an incentive per-fish basis (anglers were paid on an hourly basis in 1995 and 1996). This trend has been consistent since the beginning of the per-fish payment strategy in 1997. We recommend the continuation of the incentive fishery removal program during future pikeminnow removal programs. Anglers paid by the number of fish caught had the flexibility to fish the most productive hours of the day and had greater incentive to catch fish. A majority of anglers over the previous two years focused their fishing efforts on the highly productive early morning and late evening fishing periods.

Hook and line anglers continued to observe a trend (also observed in 1998 and 1999) of relatively poor catch rates when utilizing hook and line gear within Wells reservoir and the Okanogan. River. Anglers fishing these locations typically experience CPUE rates near 1 fish per hour, with the exception of angling effort near the mouth of the Methow River where catch rates were relatively high in the spring of 2000. It is probable that pikeminnow congregate near the location during the early spring, feeding on the smolt outmigration emanating from the Methow River.

Several noteworthy observations were made during the long line effort this season. Long line anglers noticed fishing was more productive during the fuller moon cycles, benefiting the nighttime fishermen. Another phenomenon noticed was that fishing was poorer when the barometric pressure was declining, however when the pressure was constant, fishing was successful. When air pressure increased, catch also increased. Anglers also noticed that in early spring (windy and stormy weather) and late fall, fish congregate in deeper waters. During the summer months (and when the weather is favorable during the spring and fall) northern pikeminnow moved en mass to shallower water to feed.

Seasonal trends were observed during the 2000 removal activities that were similar to those observed in 1998 and 1999. Pikeminnow research has determined that these fish congregate in tailrace areas and hatchery outfalls during times of peak smolt outmigration (Bickford et al. 1996; Burley et al. 1994; Li et al. 1987). These trends have been witnessed for the last three years during the months of May and June when anglers experienced high catch rates within the Wells tailrace area. Anglers have also reported high catch rates near the mouth of the Wells Hatchery outfall during smolt releases. It has been shown, during radio tagging experiments conducted by Douglas PUD, that pikeminnow migrate in mid summer to spawn in mass at particular locations throughout the Wells and Rocky Reach reservoirs. (Bickford and Skillingstad, 2000). The removal of gravid pikeminnow from these known spawning sites during 1998, 1999 and 2000 has greatly increased the effectiveness of the pikeminnow exploitation efforts.

Wells tailrace scale and operculum analysis indicated that these fish grow slower than the Wanapum fish. There are several environmental factors, which probably influenced rapid growth rates of pikeminnow within the Wanapum reach. Wanapum reach is located approximately 208 km downriver from Wells tailrace and ultimately receives more nutrient load from tributary streams. This nutrient load will ultimately influence juvenile pikeminnow growth rates in response to increased insect and other increased forage availability. The Wenatchee and Entiat river tributaries which lie below Wells tailrace and above Wanapum dam are corridors for large number of wild and hatchery origin juvenile salmonids. These juvenile smolts constitute the main prey items for larger piscivorous pikeminnow in the spring and as such provide increased forage base opportunities for the Wanapum reach pikeminnow population.

Higher catch rates of pikeminnow have been recorded within the Wanapum reach over the past 3 years when compared to the Wells tailrace fishery (Jerald, 1999). This is an indicator that a larger population of pikeminnow exists within the Wanapum reach area. The Wanapum population is likely large due to the availability of preferred habitat and larger populations of prey. These factors ultimately influence growth rates and results in pikeminnow being recruited into the Wanapum fishery at an earlier age.

Both Wells and Wanapum pikeminnow populations exhibited relatively high growth rates when compared with other regional pikeminnow populations. This is evidence that prime habitat and ample forage conditions within the Columbia River ecosystem promote rapid pikeminnow growth. It has been suggested and widely accepted (Li et al. 1987) that dam construction on the Columbia River has promoted pikeminnow population growth due to the expansion of optimum habitats. The once free flowing river segmentation has increased pikeminnow rearing habitat within the reservoirs and provides pikeminnow with concentrated smolt prey sources in the tailraces of hydroelectric projects.

Condition factors were similar between the Wells and Wanapum populations. The two-sample t-test indicated no significant difference, an indicator that both pikeminnow populations were similar in health or fitness.

The two-sample t-test showed significant differences between pikeminnow scale and opercle analysis. This difference could have been attributed to a variety of factors. Scale readings were probably biased towards smaller fish, as scale annulus were often difficult to discern, especially on the larger pikeminnow sampled. Opercles were probably biased towards larger year classes as a result of deposits being counted, which were not true annulus. Overall technicians had a hard time finding rings on scales and discerning between rings on opercles. The bias towards larger estimates of opercle age was verified by an additional t-test indicating higher age estimates during the opercle analysis.

Data from this study has provided valuable information in regards to growth rates of pikeminnow populations within the mid-Columbia River ecosystem. The data indicates that pikeminnow within the project area are growing faster than several other regional populations of pikeminnow and are recruiting to a piscivorous size at a much earlier age. In future years, regional biologists will be interested in identifying decreased or increased pikeminnow growth in relation to the pikeminnow fisheries. This research will provide base-line growth measurements and allow for the comparison of present and future pikeminnow growth data.

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Appendix P

Recommended Ladder Operating Criteria Wells Dam 2000

Recommended Ladder Operating Criteria
Wells Dam 2000

Summary of Radio-telemetry Studies 1992-1999
and
Recommendations for Future Ladder Operations

Proposed: June 15, 2000
Approved: June 29, 2000

Shane A. Bickford

Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, Washington 98802-4497

FINAL

June 15, 2000

SUMMARY

Passage investigation conducted in 1992, 1993, 1997, 1998 and 1999 have demonstrated very rapid passage rates for migrating sockeye, steelhead and chinook through the tailrace and upper fishways at Wells Dam. Median total project passage (1.2 km below dam to fishway exits) for sockeye and steelhead have been 20.6 hours and 12.2 hours, respectively. Median project passage times have been 26, 33 and 31 hours for spring, summer and fall chinook, respectively. Brood stock collection activities significantly increases (more than double) the median project passage times for spring and summer runs of chinook.

Efforts to reduce passage times for chinook without increasing sockeye and steelhead passage times and without altering brood stock collection activities were studied in 1997, 1998 and 1999. Experiments conducted in 1997 and 1998 indicate that closing the side gates reduced total project passage times by greater than 50%. Closing the side gates to improve chinook passage also resulted in no significant change in the ladder passage times for sockeye and steelhead.

Based upon this information, Douglas PUD proposes to close the side ladder entrances and widening the main ladder entrance from a 6-foot to an 8-foot opening. The collection gallery to tailrace differential will remain unchanged at 1-½ feet.

BACKGROUND

The passage times for radio-tagged adult sockeye and adult chinook salmon at Wells Dam were monitored by the National Marine Fisheries Service (NMFS) in 1992 and 1993, respectively (Swan et al., 1994; Stuehrenberg et al., 1995). The results and recommendations from these two studies were coupled with observations made during additional ladder passage studies conducted during 1997, 1998 and 1999 (Alexander et al., 1998; English et al., 1999; Nass et al., 2000; English et al., 2000 (Draft)). Several observations remained consistent between these studies; including the preference of all species of fish to utilize the main gate as the primary route of passage over the dam, a net negative passage efficiency for fish passing through the side entrances and migrational delays resulting from brood stock collection activities.

The 1992 radio-telemetry study tagged 96 sockeye salmon trapped in the ladder at Rocky Reach Dam. Swan (1994) determined that radio tagged sockeye spent a median of 2.4 hours finding the ladders after arriving in the tailrace at Wells. Sockeye then spent a median of 4.8 and 7.2 hours moving through the actual right and left bank ladders, respectively.

Swan (1994) was the first researcher to document the preference of sockeye to use the main ladder entrances instead of the side ladder entrances. He also was the first to observe that more fish fall out the side entrance than utilize the side entrance as a route of passage over the dam.

The 1993 NMFS chinook radio-telemetry study conducted by Stuehrenberg et al. (1995) also noted that for spring and summer chinook, operation of the side ladder entrance gate produced a net negative passage result. Effectively more chinook dropped out of the side gate than entered the ladder through the side gate. Adult chinook on average spent over 82% of their total project passage time at Wells Dam milling inside the collection gallery looking for the base of the ladder. Stuehrenberg (1995) recommended that diffusion flow within the collection gallery could be reduced so that the diffusion flow no longer obscured the fishway flow. Closing the side entrance was also recommended as a way to increase ladder passage efficiencies.

Brood stock collection activities in the ladders and the close proximity of the dam to the Wells Fish Hatchery were also noted as contributing to the total project passage times for summer chinook at Wells Dam.

Based upon the observations and recommendations put forth by NMFS in the 1992 and 1993 reports, Douglas PUD tested the hypothesis that ladder passage times for chinook could be improved by closing the side ladder entrances.

Goals of the 1997, 1998 and 1999 ladder passage studies included collecting ladder passage times during alternating side gate operations (open and closed) and collecting additional passage behavior information for chinook, sockeye and steelhead.

The 1997 telemetry study determined that 100% of the radio-tagged spring chinook, 83% of the summer chinook and 95% of the sockeye utilized the main gate as their ultimate passage route over Wells Dam. Consequently, very few fish utilized the side gate even when it was open for passage.

Differences in total project passage times were not significant ($p < 0.05$) between treatment and control side gate operations for sockeye (1997) (treatment: side gate closed and control: side gate open four feet). However, total project passage times for summer chinook were dramatically reduced (1997 & 1998) when the side gates were closed (English et al., 1999; Nass et al., 2000).

In 1997, median project passage times for summer chinook dropped from 52.5 hours to 20.6 hours when the side entrances were closed. In 1998, median total project passage times for summer chinook dropped from 38.5 hours to 19.0 hours when the side entrances were closed. Further analysis indicated that migration rates through the collection gallery were dramatically reduced with the side entrances closed. Migration times for chinook through the upper fishways and tailrace however remained unchanged.

Radio-tagged steelhead have been monitored at Wells Dam for two years (1997 and 1999) (Alexander et al., 1998; English et al., 1999; English et al., 2000 (Draft)). Median total project passage times for summer steelhead were 9.6 hours and 15.7 hours in 1997 and 1999, respectively. These studies also indicated that closing the side entrances did not affected negatively effect steelhead ladder passage times.

In summary, the 1997 and 1998 passage studies confirmed Stuehrenberg's (1995) theory that closing the side entrances at Wells Dam reduces chinook travel times through Wells Dam. The 1997 and 1999 telemetry studies determined that closing the side entrances did not interfere with brood collection activities and did not significantly increase sockeye and summer steelhead passage times.

PROPOSAL

Based upon telemetry studies conducted at Wells Dam, the District proposes to close the side entrances to the fish ladders in an effort to further reduce total project passage times for adult spring and summer chinook. In concert with this change, the District will increase the main entrance opening from 6 feet to 8 feet. The fishway differential will remain at 1-1/2 feet. Results from the 1992 sockeye, 1993 chinook, 1997 sockeye and chinook, 1998 summer chinook and 1999 summer steelhead ladder passage studies all support this change in ladder operations.

Figure 1: Simplified Wells west ladder fishway. Diagram includes average summertime fishway flows at specific points of interest.

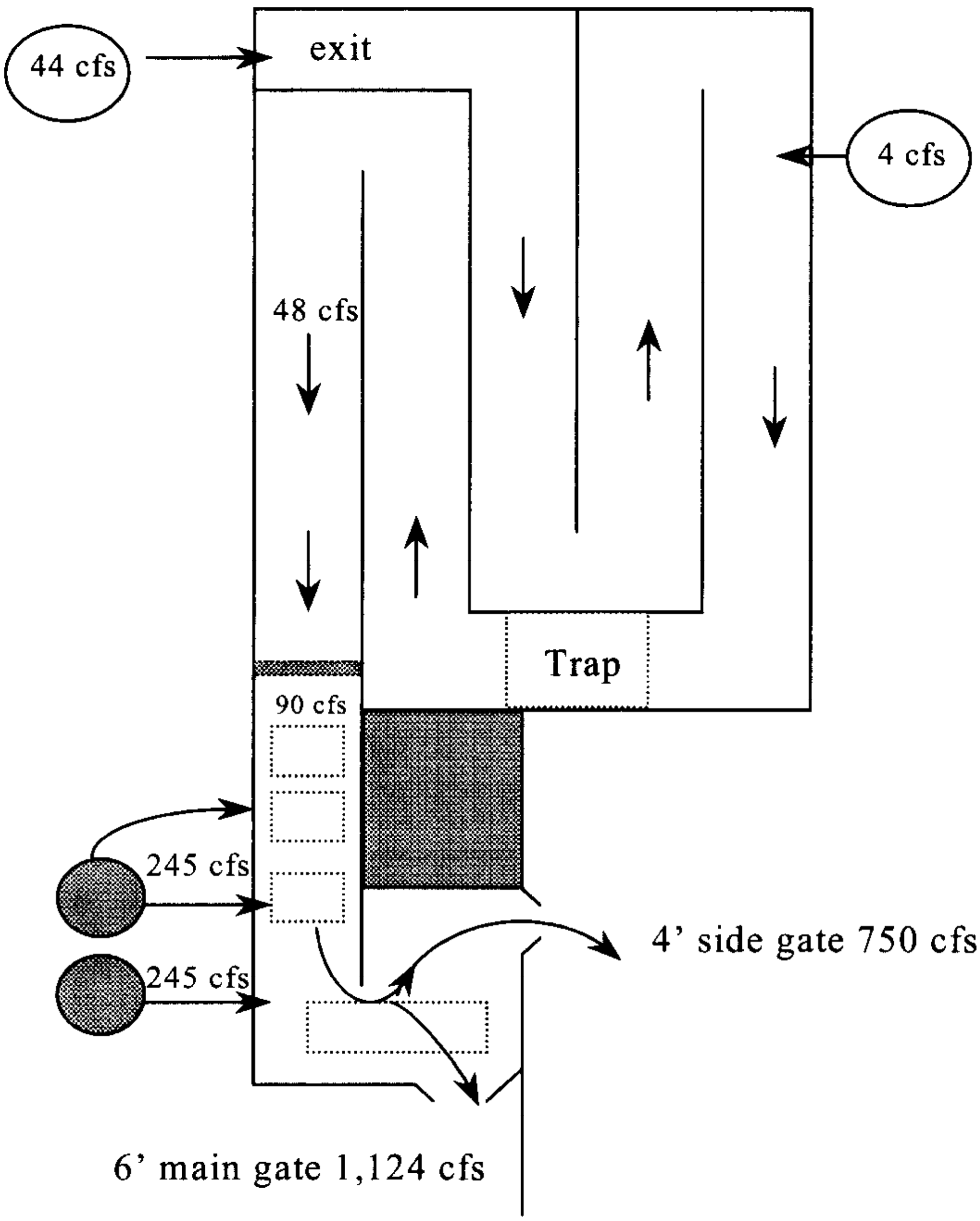
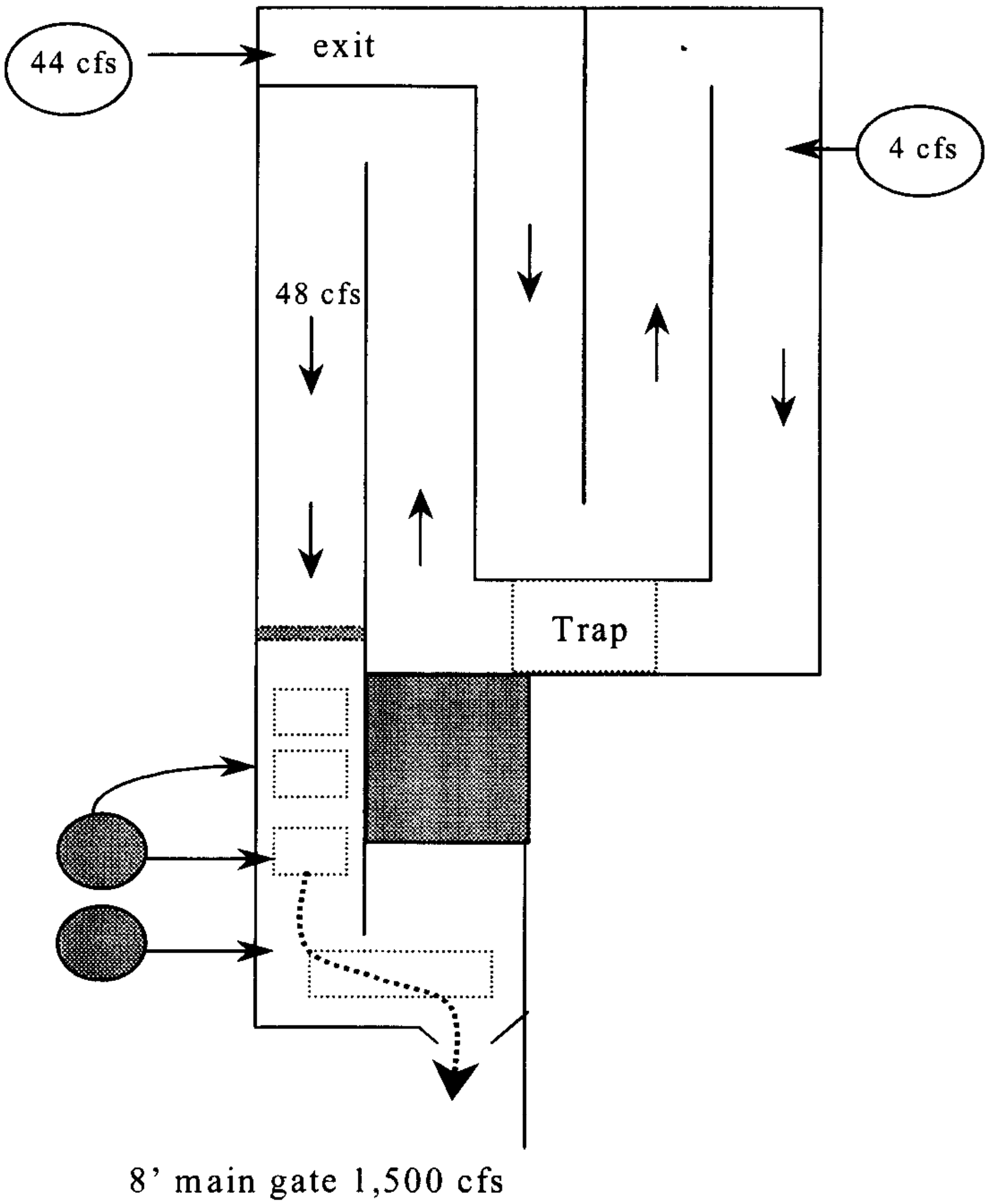


Figure 2: Simplified Wells west ladder fishway. Diagram includes average fishway flows after closing the side entrance.



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Appendix Q

Minutes of the Wells Coordinating Committee for 1999

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
JANUARY 27, 2000

Agreements Reached:
1. No decisions reached at this meeting

I. WELLS DAM

A. Wells 2001 Juvenile Survival Study

Bickford reviewed the proposed 2001 juvenile survival study for Wells Dam which was distributed for review. He explained the proposed study plan and gave Douglas PUD's reasoning for the study design presented. He explained that the information generated would be used in a weighted assessment of survival for Methow and Okanogan River fish. He described the development of the number of releases and the number of fish for each release.

Bickford explained that Douglas PUD's reasoning for beginning discussion of the 2001 study at this time was due to the complexity of the study and the extensive preparation that must be done to add the Okanogan component to the study. A major concern in adding the Okanogan River portion of the study relates to the poor water quality in the Okanogan River system. This factor effects the holding provisions that must be made for each release group prior to release. He said it will be necessary to make extensive preparations to provide acclimation in the Okanogan prior to release. Bickford said that Douglas PUD would be looking for approval early on to give them confidence to go ahead with the preparations necessary to conduct the study in 2001.

Brown raised the issue of whether yearling summer chinook are appropriate surrogates for spring chinook. Bickford said their assessment of this matter indicates that there is little difference in survival between yearling summer and yearling spring chinook. In 1998, he said their assessment of survival from Rocky Reach to McNary was approximately 65% for summer chinook and 70% for spring chinook. In response to Klinge's question, Brown said his concern is related to the size difference between yearling summer and spring chinook. Woodin suggested that Bickford consider releasing one or two groups of spring chinook to go along with the summer chinook to assess comparative survival. Bickford said they have talked about surrogacy studies for other species by collecting fish from hatcheries or screw traps and releasing from those locations.

Brown said the issue of surrogacy may be an important factor as the survival study efforts proceed. He said any effort to address this concern would be appreciated. Bickford said they have talked about this matter in-house. They will look at the numbers of fish and releases necessary to develop reliable information.

Heinith asked Bickford what Douglas PUD's intentions are regarding conduct of survival studies into the future. He said from a tribal perspective, they want to see studies covering a variety of environmental conditions. He asked how Douglas PUD views this issue. Bickford said their hope was to have as many studies on as many species as possible before 2003 to assess progress toward No Net Impact. There was considerable discussion concerning high and low flow conditions and the uncertainty within the time frame necessary to allow a survival study to proceed in a given year.

Bickford asked for comments or suggestions on the 2001 survival study proposal prior to the next meeting.

B. Report on Discussions with Canadian Parties on Okanogan Sockeye

Klinge went over the items that had been distributed to the committee in early January. He said the Canadian parties will be meeting in Penticton on February 8-9 to consider the Phase II report and whether they were comfortable with going ahead with recommendations included in the Phase II report. They will be making recommendations to the Wells Committee following the February meeting. Klinge said there may be something for the Wells Committee to consider as early as the next Wells Coordinating Committee meeting. Klinge went on to say he has reason to believe that the Department of Fisheries and Oceans is very supportive of a spawning channel with the favored location in the vicinity of McIntyre Dam.

Woodin asked if there was some interest in Canada to an adult trap and haul operation. Klinge said this option was evaluated in the "strawman" prepared by Bickford which was distributed with the Phase II report. He said the potential benefits are only there during low run years. The problem would be how to know when to transport. One approach might be to transport a certain number each year. On low run years this would result in most of the run being transported.

Heinith asked if Douglas's position would be that they have the responsibility to build the spawning channel and someone else might have O&M responsibility? Klinge said they would expect to construct a channel, if that option is selected, and the matter of O&M is something that would have to be determined.

Klinge said he would appreciate having the Wells Coordinating Committee review the mechanism set forth in Bickford's "strawman", for changing from the current hatchery operation to something such as a channel program, and provide feed-back. Woodin said he appreciated the work Douglas PUD has done to keep this effort moving forward but he would like to remind everyone that the current effort is only one part of the "big picture". He would hope that the compensation responsibilities of Chelan and Grant PUD's also be kept in mind as plans go forward.

Concern was expressed about the potential for a successful channel operation being an excuse for water managers to further compromise natural production by the management decisions they make.

II. INFORMATIONAL ITEMS

A. Adult Telemetry Study 2000

Heinith reported that there will be a major adult telemetry study conducted in the lower Columbia River in 2000. He said it would be good if there could be some effort to take advantage of these tagged fish in when the reach the mid-Columbia. He suggested that the PUD's consider what might be done to collect data in the mid-Columbia. Nordlund said Dach had asked him to point out this opportunity and to see what could be done to take advantage of these fish. A suggestion was made that maybe an effort could be made to locate the presence of radio tags on the spawning grounds. It was pointed out that with the survival studies being planned for 2000 the available equipment would likely be fully utilized.

B. Preliminary Run Forecast and Broodstock Collection Protocol

Brown distributed a preliminary run forecast for spring chinook, summer chinook, sockeye and steelhead. Indications are that the spring chinook run will be the largest in a number of years with 23,595 to 28,613 destined for the "upper"-Columbia. Approximately 4,500 of these are expected to be of wild origin. The summer chinook run above Priest Rapids is expected to total 25,700 fish. The sockeye run is expected to total 5,500 to 10,430 in the Wenatchee system and 25,500 in the Okanogan system. The steelhead run is expected to total 11,053 to 12,626 above Priest Rapids.

Brown provided estimates for the distribution of spring chinook spawners in the mid-Columbia. He said that he wanted to get the information out early even though the numbers might change as the season progresses. He said unlike some recent years this years adult escapement is expected to be quite good. He will distribute a proposed brood stock collection protocol prior to the next meeting.

C. 2000 Steelhead Adult Telemetry Study

Bickford reported that, as a result of the discussion at the last coordinating committee meeting and Brown's suggestion, both the December and January flights were made. He said the tributary monitors are still in the Methow and Okanogan Rivers. The monitors are loading up with data due to fish milling into and out of the tributaries.

D. February Meeting Date

The committee agreed to meet on Friday, February 25 in Wenatchee. Heinith said he probably would not be able to attend but would like to participate in the discussion on selected agenda items by speaker phone.

The next meeting of the Wells Coordinating Committee will be February 25 in Wenatchee.

ATTENDANCE LIST

Name	Representing	e-mail address
Jerry Marco	Colville Confederated Tribes	cctfish@mail.wsu.edu
Bob Heinith	Columbia River Intertribal Fisheries Commission	heib@critfc.com
Bryan Nordlund	National Marine Fisheries Service	bryan.nordlund@noaa.gov
Larry Brown	Washington Department of Fisheries and Wildlife	brownlgb@dfw.wa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Paul Ward	Yakama Indian Nation	ward@yakama.com
Brian Cates	U.S. Fish and Wildlife Service	brian_cates@fws.gov
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Mike Erho	The Committee	merho@televar.com

WELLS 2000-02

WELLS COORDINATING COMMITTEE MEETING SUMMARY FEBRARY 25, 2000

Agreements Reached:
1. The committee agreed to support the survival study concept, previously proposed by Douglas PUD, for the 2001 survival study.

I. WELLS DAM

A. Okanagan Sockeye Update

Klinge reviewed the information distributed to the committee on February 22 regarding the Okanagan Basin Technical Work Group letter to Douglas PUD detailing their position on sockeye measures in Canada. He reported on the meeting he had attended in Penticton, B.C. where the Canadian position on sockeye measures were discussed. He reviewed the various measures included in the package of measures developed by the Okanagan Basin TWG. Adult trap and haul, improved water management, habitat improvement, and a spawning channel were measures favored by the OBTWG. Klinge pointed out a listing of measures suggested for funding in 2000. These are primarily measures to investigate feasibility of developing the suite of measures being considered. The one implementation measure suggested for funding in 2000 was construction of two Newberry Riffles.

Klinge said the Canadian suggestions were discussed with the Douglas PUD Commissioners and received a very favorable response. The commission was encouraged by the fact that the Canadian parties were unified in their response. Clubb addes that the Canadian parties were not proposing that Douglas PUD have the sole responsibility for the measures being suggested. They said they would support the measure or measures Douglas PUD and the Wells Coordinating Committee selected for meeting Douglas PUD sockeye mitigation responsibility. Feldman asked, if a spawning channel were selected, would it include potential capacity for Chelan or Grant PUD mitigation. Klinge said they are still waiting to hear from the Wells Coordinating Committee on the "straw-man" proposal distributed to the committee on January 5.

Marco asked, if the water management problems were resolved, would a spawning channel be necessary. Bickford responded that he had looked at egg to fry survival for sockeye populations along the west coast and the highest survival he had found in the literature was about 12%. Egg to fry survival at some spawning channels was as high as 85%. He said survival improvement is where the spawning channel advantage lies.

Klinge said Douglas PUD was ready to move ahead in implementing the measures identified by the OBTWG for 2000 funding if the Wells Coordinating Committee is in favor of proceeding in this direction. Klinge said Douglas PUD is willing to fund the Cassimer Bar Hatchery Program through release of the 1999 brood year fingerlings this fall. He went on to say that they are unwilling to fund the collection of brood stock in 2000 for continuation of the Cassimer Bar Program beyond release of the 1999 brood year fish. Klinge said there appears to be a change in how Canadian parties are viewing the channelized portion of the Okanagan River in Canada. They are interested in restoring the habitat function of that area.

Marco said he had been given a heads-up by Klinge that the Douglas proposal was coming. He said he has talked to the Colville Tribal folks and they are not supportive of the Douglas PUD proposal. They feel that any sockeye mitigation proposal needs to include a hatchery component. They are in favor of a mid-Columbia wide, comprehensive sockeye package that includes all the measures discussed and recognizes that the sockeye mitigation responsibility goes beyond a Douglas PUD program. Klinge said if Douglas PUD were to try to implement all the measures suggested by the OBTWG and the Cassimer Bar Hatchery program, it would effectively double the costs associated with Douglas PUD's sockeye mitigation program. Douglas PUD feels the Canadian OBTWG proposal represents the best opportunity for biological success. Marco said the Colville Tribes cannot support the OBTWG proposal at the expense of the Cassimer Bar Hatchery Program.

Woodin said he is encouraged that Douglas PUD is looking favorably on the OBTWG proposal but he said it needs to be viewed in a comprehensive program which includes evaluation. There was considerable discussion concerning how a spawning channel program might be evaluated.

Klinge asked if the committee was supportive of Douglas PUD proceeding with the proposed action. Woodin said he sees benefits in the OBTWG proposal but is less than 100% sure that it is going to be the way to meet mid-Columbia sockeye mitigation. It was suggested that a meeting be held between the OBTWG and the Wells Coordinating Committee to explore additional options for sockeye measures in Canada including such things as hatchery production, egg boxes, etc in a comprehensive sockeye mitigation program.

Cates said he didn't see anything wrong with the OBTWG measures being pursued. He said this may be a reasonable sockeye mitigation program for one of the five mid-Columbia dams. Woodin suggested that the current Cassimer Bar Hatchery Program may be a good way to address two of the limiting factors identified for Okanagan sockeye, i.e. adult losses and summer rearing conditions.

Klinge said he would contact Elmer Fast, chairman of the OBTWG, to set up a meeting between the TWG and the Wells Coordinating Committee, and from his perspective, the sooner the better. March 29 or 30 were suggest dates for such a meeting.

Woodin said he would like to have more information on the spawning channel concept such as projected production, potential maximum capacity, etc. Bickford pointed out that the "straw-man" he developed, included a formula that could be used, with various input parameters, to project channel production. In terms of potential capacity, the proposed actions for 2000 will include an assessment of the site identified as the most favorable for spawning channel development.

B. Wells 2001 Juvenile Steelhead Survival Study

Bickford reviewed the details of the proposed 2001 juvenile survival study. He described the primary and secondary objectives and the number of fish to be tagged and the number of replicates and release sites. Bickford distributed comparative survival estimates from Snake River studies for steelhead and yearling chinook. He pointed out the similarity of the estimates for the two species and the tight confidence limits. He also showed comparative survival estimates for summer chinook yearlings and steelhead from Wells Hatchery and spring chinook from Winthrop Hatchery for the river reach from Rocky Reach Dam to McNary Dam. Bickford said additional comparison of species survival for that reach will be available from Wells studies in 2000 and 2001 and tag releases from Winthrop Hatchery in those years. Bickford pointed out the species comparative survival data that will be available following completion of the 2001 studies that can be used to address the species surrogacy issue raised at previous coordinating committee meetings.

A question was raised concerning the 2001 study and whether it was necessary to use Okanogan raised fish for that study. Bickford explained the difficulties associated with trying to use fish from the Similkameen Ponds in this study due to problems trying to operate a screw trap in the Okanagan River environment to collect those fish following release.

Bickford said he understands the committee is supportive of the concept of a 2001 study that includes releases at three sites, Okanogan River, Pateros, and Wells tailrace. He said it is important to determine committee support, at this time, so that certain elements of the 2001 study can be tested in 2000, such as on-site acclimation in the Okanogan River, early tagging of fish, etc. The committee agreed to support the survival study concept previously proposed by Douglas PUD for the 2001 survival study.

There was discussion of why Bickford had previously discussed the weighting of survival study results by Methow River and Okanogan River segments rather than just using survival estimates developed for fish from the two rivers. Bickford said he was not opposed to using Methow survival estimates for fish coming out of the Methow and Okanogan River survival estimates for fish leaving the Okanogan River.

III. INFORMATIONAL ITEMS

A. QAR Discussion

Bill Hevlin, NMFS, Portland, joined the meeting by speaker phone and asked to update the committee on the ongoing mid-Columbia QAR analysis of actions in the proposed actions on steelhead and spring chinook. He said a report of preliminary findings is scheduled to be out for review this spring. Marco asked if the intent was to use the QAR information for the Biological Opinion due out in 2000. Hevlin said that was the intent. Marco asked if there wasn't a time problem in getting the QAR information out in time to be used for the DEIS which is due out in June. Hevlin said the DEIS may be delayed. Woodin asked since the HCP conditions were being modeled in the QAR process, how were the Grant PUD projects being treated in the QAR analysis.

Peven said they were having a problem with information for QAR Analytical Committee meetings were was generally not available until the day of the meeting. This left little time for review. Hevlin said he would see that information is distributed to Analytical Committee members several days ahead of their meetings in the future.

Hevlin said he would like to have Tom Cooney and Mike Ford at the March Mid-Columbia Coordinating Committee meeting to update the committee on QAR progress. Hammond said it might be a better idea to have the coordinating committee members attend a QAR meeting to be updated since Grant PUD's QAR representative is the one who should be at such a meeting. Hevlin said they will be having a QAR Guidance Committee meeting on March 8 where Grant PUD's representative will be present. Hevlin said he would like to see a broader number of people updated on QAR activities and information and that is why he was asking for time at the next coordinating committee meeting for Cooney and Ford to present information.

The committee agreed to add a QAR presentation to the March Mid-Columbia Coordinating Committee meeting agenda.

B. Adult Steelhead Telemetry Study Update

Bickford reported that another aerial survey was conducted last week. He said maps showing the location of the tagged fish detected were available for any committee members who wants to see them. The smaller tributaries have not been surveyed to date since those surveys are difficult with fixed-wing aircraft. Since helicopter surveys are very expensive, Bickford said he would like to hold off on those until closer to the spawning season. Brown said it might be worth considering a helicopter survey in March. Bickford replied he would like to hold off on the helicopter surveys until there is some evidence that fish are beginning to move. He expects to be able to get in about three helicopter surveys, if things go right this spring.

Bickford said Nordlund had asked to have the question of a steelhead telemetry study in 2000 brought up at this coordinating committee meeting. He said Nordlund expressed the belief that there was a commitment to do three years of adult steelhead studies in the mid-Columbia. Dach said it wasn't necessary to do three *consecutive* years of telemetry studies. Bickford stated that the PUD's wanted to evaluate the results of the current adult steelhead telemetry study before committing to additional years study

Woodin said it might be worthwhile to consider monitoring radio-tagged steelhead at Priest Rapids in 2000 to provide additional information for planning purposes and to evaluate OG gate closures. Hammond agreed that this would be a worthwhile effort. There was discussion of the expected number of tagged fish that could be expected in the mid-Columbia from the radio tagging that will be done for the Corps of Engineers at Bonneville Dam in 2000. Based on observations in the past, about 3% of the steelhead tagged at Bonneville would be expected to show-up in the mid-Columbia and about 15% of the spring chinook.

C. Brood Stock Protocol Proposal

The discussion of brood stock collection protocols for 2000 was tabled until the March Mid-Columbia Coordinating Committee meeting.

The next meeting of the Mid-Columbia Coordinating Committee will be March 22, 2000 at Sea/Tac.

ATTENDANCE LIST

Name	Representing	e-mail address
Jerry Marco	Colville Confederated Tribes	cctfish@mail.wsu.edu
Bob Dach	National Marine Fisheries Service	bob.dach@noaa.gov
Bill Hevlin	National Marine Fisheries Service [by phone]	bill.hevlin@noaa.gov
Larry Brown	Washington Department of Fisheries and Wildlife	brownlgb@dfw.wa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Brian Cates	U.S. Fish and Wildlife Service	brian_cates@fws.gov
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Bob Clubb	Douglas County Public Utility District	bclubb@dcpud.org
Steve Hays	Chelan County Public Utility District	steveh@chelanpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Lee Bernheisel	Okanogan Wilderness League	owl@methow.com
Mike Erho	The Committee	merho@televar.com

WELLS 2000-03

WELLS COORDINATING COMMITTEE MEETING SUMMARY MARCH 22, 2000

Agreements Reached:

1.

I. INFORMATIONAL ITEMS

A. Mid-Columbia QAR Analysis

Tom Cooney and Mike Ford gave brief reports on the status of the QAR process. They provided a synopsis of findings to date for upper Columbia spring chinook and steelhead and said a draft report would be available for review in early April.

B. Priest Rapids Ladder Adult Trap

Dach reported that National Marine Fisheries Service and Grant PUD had held discussions concerning the Priest Rapids ladder trap. He said it is his opinion that Chelan and Douglas PUD's would probably want to be involved in design discussions since each PUD would have responsibilities related to adult survival evaluations in the future. He pointed out that cost sharing of new adult trapping facilities would seem to be advantageous.

C. Brood Stock Protocol

Brown reviewed the 2nd draft of the 2000 brood stock protocol. He said NMFS had requested that changes be made in the protocol for broodstock collection at Wells Dam. They would like to see an attempt made to pre-screen for adipose present hatchery fish. Brown said, logistically, this would be very difficult at the Wells Dam ladder trap. Brown said they are proposing to continue with the protocol shown and identify adipose present hatchery fish at the Methow Hatchery at the time of inoculation. The adipose present fish would be identified prior to and returned to the Columbia River below Wells Dam before they have been inoculated. It is assumed that these fish would be from Entiat Hatchery releases. Brown said he was open to additional comments and suggestions.

Heinith said the Umatilla and Yakama Tribes have requested that their names be removed from the 1998 Biological Assessment and Management Plan which is referenced in the draft broodstock protocol. Brown responded that the tribes were involved in the development of that plan and the issue of whether or not their names were removed from that document would have to be resolved at a higher level.

D. 2000 Adult Steelhead Telemetry Study

Heinith asked about his previous request for monitoring in the mid-Columbia for fish tagged at Bonneville Dam for the Corps of Engineers study. It was pointed out that Bickford had presented information at a previous meeting which showed the number of those fish that would be expected to show up in the mid-Columbia. Dach said it appeared to him that the only project that would have enough fish to make it worthwhile would be Priest Rapids. Hammond said he wanted to make it clear that they would not be monitoring for adult radio tags until their juvenile studies were completed. This would preclude them from monitoring for spring chinook but it is possible that they could monitor at Priest Rapids and/or Wanapum for summer chinook and steelhead. Hammond said he wasn't prepared to make a commitment, at this time, but there is a good possibility that such an effort would fit in with their scheduled activities in 2000.

Dach raised a question regarding the potential for two additional fly-over surveys for radio tagged steelhead, which had been discussed at a Grant PUD technical work group meeting. Bickford said this had already been covered.

E. Spill Representatives for Wanapum and Bypass Representatives for Wells Dam.

Dach will be the agency spill representative for Priest Rapids and Wanapum with Tom Lorz or Bob Rose representing the tribes. For the Wells Juvenile Bypass, Cates will be the agency representative and Marco will represent the tribes.

F. Mid-Columbia Coordinating Committee Meeting Summaries Review Schedule

The chair asked for clarification from the members concerning their perspective on the time necessary for review of draft meeting summaries prior to finalization. This issue was raised as a result of the desire of committee members present at an earlier meeting to have the meeting summaries finalized prior to the following meeting and the difficulty this presented to Heinith who represents the Umatilla Tribe and, at times, the Yakama Tribe. The committee agreed that it would be appropriate to have draft meeting summaries sent out for review promptly following the meeting with final comments received at the following meeting, after which the summary would be finalized and distributed.

II. WELLS DAM

A. Juvenile Monitoring at Wells Dam

Klinge said they have been monitoring hydroacoustically at Wells Dam and had fyke netted on March 13 and will fyke net again this evening. No fish have been observed, to date.

B. Okanogan Sockeye

Klinge reviewed previous committee discussion concerning the Canadian position regarding sockeye measures in Canada that could receive the support of the parties to the Okanagan Basin Work Group. Klinge said he has set up a meeting, at the committee's direction, with the Canadian parties. This meeting will be April 5 in Vancouver, B.C.

Klinge said he was hopeful that there would be some response to the Douglas PUD straw-man regarding how a hatchery-based compensation program could be converted to a spawning channel, and habitat based obligation. He said this could be discussed at the meeting. He said a tentative agenda had been developed by the OBWG parties and distributed to coordinating committee members.

Klinge suggested that following the meeting on April 5, a conference call could be set up to discuss the results of that meeting. The committee agreed to meet by conference call on April 13. Klinge will make the arrangements and notify the committee of the time and number to call to participate. Klinge said he was hopeful that a decision could be made, at that time, whether to proceed with the measures identified by the OBWG or terminate those efforts.

Dach said that he views the matter as being in the U.S. Fish and Wildlife Service area of responsibility and he was relying on Cates to carry-the-ball for the federal agencies. He said Dennis Carlson is the NMFS person (in Olympia) who he has been feeding information to. In the meantime, he is comfortable with the FWS playing the lead. Klinge emphasized that Douglas PUD is ready to move forward to begin implementing biologically sound sockeye measures in British Columbia. He said there are issues within the WCC that need to be resolved, such as the level of mitigation responsibility.

Feldmann asked how long it would take to see measures actually implemented in B.C. Klinge said the Ministry of Environment has assured him that that they will partner with Douglas PUD on measures they have identified so that work can move forward expeditiously.

The next meeting of the Wells Coordinating Committee will be held on April 5 in Vancouver, B.C.

Name	Representing	e-mail address
Bob Dach	National Marine Fisheries Service	bob.dach@noaa.gov
Bryan Nordlund	National Marine Fisheries Service	bryan.nordlund@noaa.gov
Michael Ford	National Marine Fisheries Service	mike.ford@noaa.gov
Tom Cooney	National Marine Fisheries Service	tom.cooney@noaa.gov
Larry Brown	Washington Department of Fisheries and Wildlife	brownlgb@dfw.wa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Brian Cates	U.S. Fish and Wildlife Service	brian_cates@fws.gov
Bob Heinith	Columbia River Intertribal Fisheries Commission	heib@critfc.org
Jerry Marco	Colville Confederated Tribes	cctfish@mail.wsu.edu
Paul Ward	Yakama Nation	ward@yakama.com
Bob Rose	Yakama Nation	brose@yakama.com
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Mike Erho	The Committee	merho@televar.com

WELLS COORDINATING COMMITTEE
CONFERENCE CALL SUMMARY
April 19, 2000

Agreements Reached:

1. The Wells Coordinating Committee agreed to support Douglas PUD's involvement in the proposed measures for assessing Okanagan sockeye enhancement options in Canada in 2000.

I. OKANAGAN SOCKEYE

Klinge reviewed the Wells Coordinating Committee/Okanagan Basin Technical Working Group joint meeting in Vancouver on April 5. The OBWG, at that time, reaffirmed their commitment to their stated "Ecosystem Approach". The OBTWG members reviewed the options developed in their proposed plan and the elements of their proposed year-one action plan. Various members of the OBTWG reviewed the thinking behind each of the options listed in the proposed plan and the benefits they see in following this approach. Klinge said the members of the OBTWG emphasized the significance of the consensus that had been developed among the representatives of the province, federal government, and the tribes regarding the options shown in the proposed sockeye plan. They said that the level of cooperation that had been developed and the momentum generated in development of this proposed plan was very important and should not be lost.

Marco said he had inquired at the meeting as to whether the various options that were included in the proposed plan had been prioritized. The answer he had received was that OBTWG considered the options as a package and they had not attempted to prioritize them. They considered this a package of tools that could be used to address Okanagan eco-system concerns. Marco said that he was encouraged by the OBTWG position regarding artificial propagation which he understood to be that consideration of artificial propagation was "not off the table" and might have a place in the measures that could be considered in the future.

Heinith asked Klinge if habitat protection had been discussed in the context of the options presented. Klinge responded that habitat protection per se wasn't one of the options listed but the restoration options indicates that they are interested in habitat protection.

Klinge described the Canadian parties position regarding the spawning channel option which they view as an extension of the natural environment, i.e. spawning habitat. They feel a channel would allow an increase in the "natural" egg to fry survival. Klinge said the spawning channel was considered the king-pin of the Okanagan sockeye program. Klinge went on to point out that the seven measures listed for a year-one action program were primarily information collection measures which would yield information which could be used to guide the decision on direction to pursue for meeting Douglas PUD's sockeye mitigation responsibilities after year-one.

Klinge read the statement that had been sent to the Wells Coordinating Committee members on April 7 as a suggested statement of support of the Wells Committee for implementing the year-one proposal and the eventual transfer of Wells mitigation responsibility from Cassimer Bar Hatchery to a spawning channel. Klinge pointed out that Douglas PUD's intention was to switch to a spawning channel mitigation program if the information developed in 2000 showed that a channel capable of meeting mitigation responsibilities could be constructed.

Ward asked Klinge for clarification on the current level of sockeye mitigation responsibility. Klinge explained that the program was to produce 8,000 pounds of production, during the evaluation phase, which would utilize production of approximately 200,000 fish at 25 fish per pound with the use of the Cassimer Bar Hatchery and net pens in Osoyoos Lake. The program has not regularly produced 200,000 fish for various reasons. Marco said they view the hatchery as being capable of producing approximately 100,000 fish.

Marco asked Klinge what the Douglas PUD position would be if a spawning channel were built and subsequently found to be unable to produce the required mitigation requirement. Klinge said it was hard for him to imagine a spawning channel being built and operated by the Canadian parties not being able to achieve the required level of production given the Canadian success with sockeye spawning channels. However, if the unexpected happened, they would have to evaluate the situation at that time and decide a course of action to meet mitigation responsibilities.

Heinith asked Klinge if consideration had been given to addressing, what probably was the most serious sockeye "bottleneck", getting adequate numbers of adults to the spawning grounds. Klinge said one of the provisions in the options listed was to investigate adult sockeye trap and haul. He said the Douglas PUD intent was to work with the Canadian parties on this assessment, if the year-one plan is supported by the Wells Coordinating Committee.

Woodin said that, conceptually, he is supportive of what Douglas PUD is attempting to do. He said he supported the first part of the statement of support distributed by Klinge for consideration by the Wells Coordinating Committee. However, he said he could not support making a pre-judgement on replacing the Cassimer Bar Hatchery operation with a spawning channel until the information developed through the year-one assessments was evaluated and a course of action determined. He said there was also a need to determine how the Douglas PUD sockeye mitigation responsibility might be transferred from a hatchery-based responsibility to a spawning channel-based responsibility. Klinge said this was what Douglas PUD had tried to do with the "straw-fish" document that was distributed to the committee early this year. Woodin said they had looked at some possible alternative language to that document but had not finalized anything, as yet. Woodin said another concern he had was that continuing to evaluate an alternative sockeye program would be necessary to see that the expected results were being realized. Klinge said they were in agreement that evaluation of an alternative sockeye program would be needed. He said the Canadian parties have their own evaluation requirements and it should be possible to cooperate in producing the information needed to assess an alternative sockeye program. Woodin said that it is critical that the information produced in the year-one program be available to aid in the decision making process by the end of the current year. A suggestion was made that Klinge, Woodin, and Marco work on acceptable alternative language for the support statement that had been distributed by Klinge. These individuals will attempt to produce alternative language for a statement of support to be considered by the Wells Committee at the next meeting.

Woodin asked Klinge to clarify the Douglas PUD position regarding when they would expect to transfer their mitigation responsibility from Cassimer Bar to a possible spawning channel in Canada. Klinge said if everything fell in place there is a possibility that a channel could be ready to receive fish by the fall of 2001. In that case, they would not support taking adults for the Cassimer Bar Hatchery in 2001. Klinge said he wanted to make it clear that Douglas PUD has no intention of supporting sockeye programs in multiple locations. He said they expect that the information collected in 2000 would show the feasibility of spawning channel construction that would have a high probability of success. When the channel was constructed and available for spawners, they would expect their mitigation responsibility to transfer from Cassimer Bar Hatchery to the spawning channel. If they did not expect the channel construction to be completed in time to receive adult sockeye in 2001, it is possible that adults could be collected for the Cassimer Bar Hatchery in 2001. Woodin said he felt more comfortable with that position than making the decision, at this time, that adults would no longer be collected for Cassimer Bar Hatchery after the 2000 broodyear. Rose said he didn't see why anyone would object to pursuing the year-one program for generating information which would be used in making a final decision on the direction of the Wells sockeye mitigation program in the future, as long as all of the potentially viable options were left on the table when that decision was being considered.

The committee agreed that a decision on the long-term direction of the Wells sockeye mitigation program could be made at the end of 2000 when the information developed under the year-one program was available. The agency and tribal members of the committee were supportive of Douglas PUD working with the Okanagan Basin Technical Working Group to implement the measures identified for year-one as long as the issue of the future of the Cassimer Bar Hatchery was left on the table until the information on the year-one assessments was available for review. Douglas PUD representatives agreed to take the agency/tribal position to their board of commissioners for their consideration. The PUD made it clear that they would not support a hatchery and a spawning channel and stressed their goal is to pursue a biologically viable sockeye mitigation program in the future. Their expectation is that the information developed in 2000 will point to the spawning channel as being the most promising means of meeting Wells sockeye mitigation responsibilities.

The next Wells Coordinating Committee meeting will be held in Wenatchee in early May and will include tours of mid-Columbia projects and activities.

PARTICIPANT LIST

Name	Representing	-mail address
od Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Bob Heinith	Columbia River Intertribal Fisheries Commission	heib@critfc.org
Jerry Marco	Colville Confederated Tribes	cctfish@mail.wsu.edu
Paul Ward	Yakama Nation	ward@yakama.com
Bob Rose	Yakama Nation	brose@yakama.com
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Bob Clubb	Douglas County Public Utility District	bclubb@dcpud.org
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Mike Erho	The Committee	merho@televar.com

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WELLS COORDINATING COMMITTEE MEETING SUMMARY MAY 2-3, 2000

Agreements Reached:

1. **The committee agreed to send out the final summary of the March 21 Wells Coordinating Committee meeting.**

I. JOINT ITEMS

A. March 21, 2000 Meeting Summary

The committee, at the March 21 meeting, agreed to finalize future meeting summaries at the following coordinating committee meeting. The chairman reported that comments received following distribution of the draft summary of the March 21 meeting, had been incorporated into a final summary and that summary was available for distribution. The committee approved the draft summary of the March 21 meeting and agreed to have the final summary distributed to the administrative law judge and the usual mailing list.

B. Adult Steelhead Telemetry Study Update

It was reported that the aerial surveys would be continuing through June as originally planned. Maps were shown which displayed the location of radio tagged steelhead detected during the aerial surveys in February, March, and April. It was pointed out that there were some problems at the hydro projects where juvenile telemetry studies were going on due to an overlap of tag frequencies on juvenile and adult tags being used. Chelan PUD has asked the contractor (LGL) to make weekly aerial surveys to try to separate the adult radio tags from the juvenile tags.

Marco asked if it would be possible to include Salmon Creek and Omak Creek in the aerial surveys since adult passage facilities are now in place that would allow steelhead access into those streams. Bickford indicated that those watersheds could be added to the surveys and pointed out that this was one of the advantages of the aerial surveys in that large areas could be covered in a relatively short period of time.

C. Spring Chinook Broodstock Collection Protocol

Brown explained that a issue had recently surfaced regarding the protocol for spring chinook broodstock collection at Wells Dam. He said there was a conflict between the conditions attached to the WDF&W Section 10 Permit for spring chinook broodstock collection and the Biological Opinion issued for Wells Dam operation. In one case the broodstock protocol allows passive collection 24 hours per day, three days per week. In the case of the Wells Dam BO, the brood stock collection protocol requires active collection 16 hours per day, three days per week with the ladder open for passage for the other 8 hours per day for the three collection days per week. Brown reported that the personnel operating the trapping facilities had experienced difficulty in the past operating the gate that diverts fish through the trapping area when closed and allows unrestricted passage when open. Bickford said that improvements to those gates were currently being made which should alleviate that problem. Brown said that this should help the situation and make it possible to operate in a way that doesn't violate the Wells Dam BO.

Brown also reported that they are planning to check all adipose present fish trapped to determine whether these are naturally produced fish or unmarked Entiat Hatchery fish. Through scale pattern analysis they expect to be able to identify Entiat Hatchery fish which will be returned to the river below Wells Dam or, if transport equipment is available, to transport those fish to the Entiat River.

The committee noted the large return of spring chinook being counted at Bonneville Dam in 2000. The count at Bonneville Dam through April 28 was in excess of 109,000 fish with roughly a month of spring chinook passage remaining. This is over three times the 10 year average count at Bonneville and, with an excellent jack count, prospects are bright for the 2001 run.

D. Communication of Adult Counts and Total Dissolved Gas Measurements to the C. of E.

Woodin reported that the Corps of Engineers data base does not include up-to-date information on adult fish counts and TDG measurements from the mid-Columbia. Chelan, Grant, and Douglas PUD representatives said they would look into the matter and make sure that information would get into the Corps data base as had been done in previous years.

Dach asked the PUD's to check the criteria being used to separate adult spring chinook from jack spring chinook in the counting process. He pointed out that no jacks had been counted in the mid-Columbia yet this year in the data he has seen. There was agreement the jack criteria would be checked at each of the dams to assure that the proper criteria were being used.

E. The Relationship Between the Mid-Columbia Coordinating Committee Process and Re-licensing Processes

Hammond explained how Grant PUD's re-licensing process was set up. He said they had come to the conclusion that the coordinating committee process would not be able to accommodate the public involvement required in their re-licensing effort. Hammond drew attention to the "Road Map to Re-Licensing" prepared by Grant PUD dated February 28, 2000. Hays said Chelan PUD had also come to the realization that there were requirements in their re-licensing efforts that could not be addressed through the Mid-Columbia Process. He went on to say that they are unwilling to bog down the Mid-Columbia Coordinating Committee process with the requirements of re-licensing. Hays said Chelan PUD has set up a Web Page where they will have anadromous fish activities displayed to give the re-licensing stakeholders an opportunity to become familiar with the on-going activities of the coordinating committee. Hays said he would be Chelan PUD's go-between to link their Mid-Columbia and re-licensing processes.

Woodin said he though it would be desirable for Grant and Chelan PUD's to prepare historical records of activities conducted under the auspices of the mid-Columbia Coordinating Committee over the past 20 years to bring re-licensing stakeholders up-to-date on what has gone on in the mid-Columbia in the past in terms of anadromous fish activities.

Heinith said that from a tribal perspective, there are a lot of unresolved issues insofar as the Mid-Columbia process is concerned and now the re-licensing efforts are heating up. He said he feels it is necessary for the Joint Fisheries Parties to sit down with Chelan and Grant PUD's to try to close the gap between activities under the Settlement Agreement and the individual re-licensing processes. Hammond said this is what Grant PUD had been attempting to do with the solution groups they have set up under their re-licensing process. These groups have been meeting since last year. There was discussion concerning how unresolved MCCC issues could be addressed for re-licensing purposes.

Maynard said he liked the idea of Hays being Chelan PUD's go-between linking the mid-Columbia and re-licensing processes. He said he attends Grant PUD's Water Quality Solution Group and would welcome efforts to provide coordination between the two processes.

Cates encouraged Hays to schedule a meeting as soon as possible with adequate notice to allow people time to prepare. Brett Swift asked for clarification on how the anadromous fish working group and the Mid-Columbia Coordinating Committee could be linked. Hays explained that an anadromous fish working group would be set up under the natural resources section of their re-licensing process and would be the forum that the re-licensing stakeholders would have to bring anadromous fish issues to the table. Gloria Smith asked how she could be involved in the anadromous fish area since she isn't a member of the MCCC and the HCP process isn't actually up and running in it's final form, as yet. Woodin said he feels it is important that the newer members of the re-licensing process have the opportunity to become familiar with what has gone on under the MCCC process in the past.

Heinith said that the big issue from the tribes perspective, in relation to future Chelan PUD re-licensing discussions, is whether or not Chelan PUD is willing to consider an evaluation of higher spill levels at Rocky Reach.

II. WELLS DAM

A. Okanagan Sockeye

Clubb said Douglas PUD is interested in knowing if the committee supports their efforts to work with the Canadian parties to investigate proposed

sockeye enhancement measures in Canada. He pointed out that Heinith had raised questions concerning the decision the committee made during April 13 and April 18 conference calls. Heinith said he had participated on the conference call on April 13 when the committee agreed that it was a good idea to proceed with the Canadian studies. He said that during the second conference call the committee considered language that would reflect the committee's support for continuing with the Canadian initiative. It was language regarding the pursuit of a "single option" that he had some concern with. Clubb said the Douglas PUD position is that they are unwilling to implement more than one option at a time. Rose raised a question concerning Douglas PUD's position if, at the end of the 2000 studies, the spawning channel option was determined to be inadequate to meet mitigation goals. Bickford pointed out that the intent of the language was to reflect the position that a single mitigation program would be evaluated and if found to be inadequate, attempts would be made to make that program adequate to meet mitigation goals. If it was then determined that those efforts were unsuccessful, other options would be explored for meeting Douglas PUD's obligations. Heinith said he would like to see the option of hatchery production kept on the table when options for future Wells sockeye mitigation are discussed. There was considerable discussion concerning the wording of the support statement developed during the April 18 conference call and the "single option" language. It was clear that Douglas PUD is unwilling to consider support for both the existing Cassimer Bar

Hatchery and a spawning channel in Canada. Clubb assured the committee that Douglas PUD intended to meet their sockeye mitigation responsibilities in the most biologically sound, cost effective manner possible. The committee members representing the Joint Fisheries Parties expressed their support for the progress Douglas PUD is making with the Okanagan Basin Technical Working Group to investigate sockeye enhancement measures in Canada. They, however, made it very clear that they want to leave all the options open for consideration when the information from the 2000 investigations is available. The committee recognized that there was work to be done prior to that decision to consider how the Douglas PUD responsibility for sockeye mitigation might be applied to a spawning channel program. The committee agreed that further discussion must take place prior to the end of 2000 when the information from the Canadian studies becomes available.

There was considerable discussion concerning information that will be available in early 2001 from the studies which were included in the proposed action plan presented to the committee by the Canadian parties. Included in the 2000 investigations are Newberry Riffles, dike setbacks, spawning channel siting, production estimates, and groundwater availability, Okanagan River water management improvements, and Cassimer Bar Hatchery evaluation.

Woodin said when the decision on Wells sockeye mitigation is being considered, it would be a good time for Chelan and Grant PUD's to become involved in the Okanagan sockeye discussions. Peven said they are supportive of Douglas PUD's efforts. Woodin again remarked that Chelan and Grant PUD's need to be more active in Okanagan sockeye issues since they will be included in the HCP requirements and Grant PUD's relicensing process. Rose pointed out that Douglas PUD doesn't have to look at Okanagan sockeye mitigation as just their responsibility. He said the other PUD's will also have Okanagan sockeye obligations.

B. Wells Juvenile Steelhead Survival Study

Bickford reviewed the study design of the Wells juvenile steelhead survival study and reported that they are approximately one third of the way through the study. He said study fish are taking about five days to pass from the release point at Pateros to McNary Dam and seven days to reach John Day Dam. Bickford said it appears there will be enough fish available to have all 15 replicate tag releases. He reminded the committee that the study design called for a minimum of 10 replicates and there was agreement to increase the number of replicates up to 15 if fish were available.

Dach asked Bickford if he could address the report of 10% loss of steelhead from the 1999 study to tern predation at Rice Island on the lower Columbia. Bickford said it was his understanding that those losses were about 10 to 12%.

The committee selected June 21 for the next Wells Coordinating Committee meeting which will be held at Sea/Tac.

ATTENDANCE LIST

Name	Representing	e-mail address
Bob Dach	National Marine Fisheries Service	bob.dach@noaa.gov
Larry Brown	Washington Department of Fisheries and Wildlife	brownlgb@dfw.wa.gov
Chris Maynard	Washington Department of Ecology	cmay461@ecy.wa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Brian Cates	U.S. Fish and Wildlife Service	brian_cates@fws.gov
Bob Heinith	Columbia River Intertribal Fisheries Commission	heib@critfc.org
Carl Merkle	Umatilla Tribes	carlmerkle@ctuir.com
Ken Johnson	Columbia River Intertribal Fisheries Commission	johk@critfc.org
Jerry Marco	Colville Confederated Tribes	cctfish@mail.wsu.edu
Bob Rose	Yakama Nation	brose@yakama.com
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Steve Hays	Chelan County Public Utility District	steveh@chelanpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Robert McDonald	Chelan County Public Utility District	robertmc@chelanpud.org
Thaddeus Mosey	Chelan County Public Utility District	thadm@chelanpud.org
Bob Clubb	Douglas County Public Utility District	rclubb@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Sarah Merkel	Chelan County	sarah.merkel@co.chelan.wa.us
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Gloria Smith	Department of the Interior	gloria_smith@ios.doi.gov
Keith Hatch	Bureau of Indian Affairs	keithhatch@bia.gov
Lee Bernheisel	Okanogan Wilderness League	owl@methow.com
Susan Crampton	Private Biologist	scrampt@methow.com
Brett Swift	American Rivers	bswift@amrivers.org
Mike Erho	The Committee	merho@televar.com

MID-COLUMBIA COORDINATING COMMITTEE CONFERENCE CALL SUMMARY June 19, 2000

Agreements Reached:
1. The committee agreed to support continued trapping of spring chinook broodstock on the west and east bank ladder traps at Wells Dam, three days per week for 16 hours per day, through the official end of the spring chinook run on June 28 and to passively trap on the west bank ladder trap through July 5.

The purpose of this conference call was to discuss the status of spring chinook broodstock collection at Wells Dam and to develop a strategy for Methow Basin spring chinook broodstock collection for the remainder of the 2000 brood year. A notice was sent to the members of the coordinating committee, by e-mail on June giving the date and time for the conference call and the number to call to participate.

Klinge reviewed the status of Methow River spring chinook passage at Wells Dam through the week of June 11-17. A total of 1834 adults and 380 jacks have passed the dam not including the fish trapped for broodstock. Trapping at the east bank ladder trap began this morning (June 19). Dompier asked for clarification concerning trapping at the east bank ladder trap. He said he thought that was an issue that was to be discussed on this conference call and it appears the decision has already been made. Woodin explained that the possibility of trapping on the east bank ladder had been discussed during a conference call on June____. Dompier asked Dach if either the Wells Dam or Washington Department of Fisheries and Wildlife Biological Opinions needed to be modified to accommodate the expansion of broodstock collection to the east bank ladder trap. Dach said they had reviewed this matter and made the decision that the change was consistent with provisions of those B.O.'s.

Dompier asked when the spring chinook run at Wells Dam will officially end. Klinge said the cut-off date for fish counting purposes is June 28. Brown said trapping will continue until July 5. Dompier asked for an explanation regarding how spring chinook would be separated from summer chinook after June 28. Woodin explained that the hatchery personnel had demonstrated a high degree of accuracy in the past in separating spring and summer chinook based on morphological characteristics. Any summer fish trapped and held at the Methow Hatchery would be returned to the lower Methow River prior to their spawning period.

Dompier asked if WDF&W had made any projections on the number of spring run fish that would likely arrive at Wells Dam between now and the end of the spring run. Brown said their earlier projections appear to be about 25% high concerning the spring chinook run passing Priest Rapids Dam and this probably extends throughout the mid-Columbia area. Given the recent passage at Wells Dam it is obvious the peak of the run is past and only a limited number of additional fish would likely be collected during the remaining trapping period.

Dompier asked Woodin if WDF&W had an official position, as a result of the discussion last week, concerning what would happen to the fish currently being held at the Winthrop Hatchery that would not be used for broodstock for the Methow or Winthrop Hatcheries. Woodin said he believes the decision had been made to move those fish to the Okanogan Basin streams. Dompier said the tribes wanted all fish not used for broodstock at the two Methow Basin hatcheries to be placed in the environment to allow them to spawn naturally. He stated that, in the tribes opinion, the habitat the fish are released to should include streams in the Methow Basin as well as in the Okanogan.

There was further discussion concerning whether trapping operations at Wells Dam should include use of the east ladder trap. Woodin explained that WDF&W's reason for beginning trapping on the east bank ladder was to try to catch-up with where they expected to be, at this point in time, in collection of broodstock for the two Methow Basin hatcheries. He said that even though they began trapping at the east ladder trap today that decision could be reversed if the committee was comfortable with fewer fish than were necessary for meeting program goals at those facilities.

The committee discussed the issue of Carson stock spring chinook to the Methow Basin composite stock. This had been discussed during a June 16 conference call between the tribes, WDF&W, and NMFS. There was some disagreement as to the understandings growing out of those discussions. Dompier was of the opinion that there was some agreement that Carson stock contributed about 40% to the composite stock. Woodin said the 40% referred to what was projected to be the Carson stock contribution to the 2000 Methow basin spring chinook broodyear. This issue was not resolved. Woodin said there would be a lot of discussion before a final decision concerning the disposition of the Carson stock adults and gametes.

Rose said it was his understanding that the purpose of the discussion today was to determine whether or not broodstock collection at Wells Dam should be expanded to include trapping at the east ladder trap. He said it appears this decision had already been made. Rose projected what additional fish might be trapped between now and July 5 and said this would still fall way short of the 640 fish needed for the two hatcheries to meet program objectives. Woodin said with the numbers of fish currently passing Wells Dam it is doubtful that they will collect more than about 350 of the 640 fish goal. Woodin said that his agency, WDF&W, on the basis of earlier discussions believed that it was necessary to trap at the both ladder traps to try to get as close as possible to the 640 fish goal. He went on to say that if people are unhappy with that decision, the east ladder trap could be closed. Dompier said he recognized what WDF&W was trying to accomplish by expanding the trapping operation to the east ladder trap. He said he supported that objective. He said they are most concerned about the disposition of the fish currently being held that will not be used for hatchery broodstock. He said if these fish are going to just be killed, additional trapping will only add to that number. He said another option is to just put the excess fish back into the Methow River at the hatchery. Rose said the Yakama Tribe was also concerned about the extended trapping schedule and the potential effect on the summer chinook run. Brown explained that the protocol was set up to result in an 18% trapping rate. Due to the ratio of east ladder passage to west ladder passage being different than the projected ratio used in setting the collection protocol they were seeing about a 14 % trapping rate. Brown suggested that trapping at both the west and east ladder traps be continued through the official end of the spring chinook run, June 28, with passive trapping on the west ladder trap only between through July 5. Trapping would continue for three days per week, 16 hours per day. Dompier observed that this would amount to an additional week of trapping. Rose said that from a Yakama perspective, they are willing to go along with Brown's suggested protocol. He said he wanted to point out that they are still concerned about the future disposition of the spring chinook being held at the Winthrop Hatchery and will be pursuing satisfactory resolution of that issue.

The committee agreed to support the expansion of trapping at Wells Dam to the east ladder trap through the end of the spring chinook run (June 28) with an additional week (three days) trapping on the west ladder trap only through July 5.

PARTICIPANT LIST

Name	Representing
Chris Petersen	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Rod Woodin	Washington Department of Fisheries and Wildlife
Bob Dach	National Marine Fisheries Service
Vince Tranquilli	National Marine Fisheries Service
Bob Rose	Yakama Indian Nation
Eric Theiss	Yakama Indian Nation
Doug Dompier	Columbia River Intertribal Fisheries Commission
Bob Clubb	Douglas County Public Utility District
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Mike Erho	The Committee

WELLS 2000-8

WELLS COORDINATING COMMITTEE MEETING SUMMARY JUNE 29, 2000

Agreements Reached:

1. **The committee agreed to support collection of marked spring chinook broodstock at Tumwater Dam during sockeye broodstock collection activities.**
2. **The committee agreed to August 9 for the next Mid-Columbia Coordinating Committee meeting which will be held in Portland, Oregon.**
3. **The committee agreed to the immediate implementation of adult passage operation changes proposed by Douglas PUD and to discuss follow-up evaluation of the changes in 2001**

I. JOINT ITEMS

A. Mid-Columbia, Rock Island, and Wells Coordinating Committees

Woodin asked for clarification regarding the separation of the summaries of the Mid-Columbia Coordinating Committee meeting summaries into Rock Island Coordinating Committee summaries and Mid-Columbia Coordinating Committee summaries. There was discussion of the three separate coordinating committees which involve, basically, the same people operating under the provisions of three separate settlement agreements. These agreements are: The Mid-Columbia Settlement Agreement which now involves the Rocky Reach Project, and the Priest Rapids Project (including both Priest Rapids and Wanapum Dams), the Rock Island Settlement Agreement, and the Wells Settlement Agreement. Technically, each agreement establishes a coordinating committee to provide a forum for technical coordination of activities conducted under each agreement. For convenience, these three committees have generally met concurrently. It was pointed out that several years ago a decision was made to combine the summaries of the Rock Island and Mid-Columbia Coordinating Committees into one summary. Subsequently, it was found that there were reasons why it would be better to separate the Rock Island meeting summary from the Mid-Columbia meeting summary. Therefore, beginning with the January 2000 meeting, there will be three separate meeting summaries prepared for each joint coordinating committee meeting.

Additionally, Chelan PUD is now involved with Rocky Reach relicensing activities and has established a web page to post relicensing information. They have requested that agendas for coordinating committee meetings be separated so that Rocky Reach specific agenda items can be posted on their relicensing web page. They have also requested that Rocky Reach agenda items be generally discussed at the end of the joint meetings so that interested relicensing stakeholders can be invited to those discussions without having to sit through discussion of agenda items pertaining to Wells, Priest Rapids, Wanapum, or Rock Island Dams.

While these changes may seem somewhat awkward, the committee recognized that there were good reasons to institute the changes.

B. Avian Predation

Woodin informed the committee of recent interest in having studies conducted on breeding colonies of avian predators and the movement of these predators in the Columbia Basin. The WDF&W will be looking into the potential for operations to control or relocate populations of these predators on juvenile salmon and steelhead. The individual who will be responsible for avian predation studies for WDF&W is Chris Thompson. He has already met with Paul Fielder and Todd West from Chelan PUD to discuss the WDF&W plans. Hammond asked Woodin if Thompson would also be meeting with Grant and Douglas PUD biologists. Woodin said that he expected Thompson would also want to meet with Grant and Douglas PUD people. Hammond said the U.S. Department of Agriculture had done some avian predator work on Goose Island, upstream of Priest Rapids Dam, including marking young birds to study their movement and distribution. Woodin offered to have Thompson present information to the committees at a future meeting of the committees. The committees felt that it would be good to have Thompson discuss his plans at a future meeting. Woodin said he would have Thompson coordinate that effort.

C. Report on 2000 Juvenile Survival Studies in the Mid-Columbia

Updates on the juvenile survival studies conducted by Douglas, Chelan, and Grant PUD's this spring were given by each PUD. These reports are each included under the appropriate meeting summary for each coordinating committee.

D. Test Fish Needs for 2001 Survival Studies

Woodin said there have been allocations of chinook yearlings for survival studies at Wells and Rocky Reach/Rock Island for 2001. He said if there are known needs for study fish in 2002 those needs need to be expressed and plans made for how those needs might be accommodated. He said WDF&W has always been sensitive to the issue of reduced study fish contribution to harvest, etc. and that sensitivity is increasing. Woodin said he is appreciative of the work Bickford has been doing on the physiological effect of tagging, holding, handling, etc of tagged fish. Woodin recommended a special meeting, or allocation of adequate time at a coordinating committee meeting, to talk about the issue of fish availability and study fish needs. The committees felt this would be a good idea.

E. Spring Chinook Broodstock Collection and Run Update

Brown distributed a revised summary of the spring chinook in-season projections. He reported that the Priest Rapids spring chinook run total in the projections he had previously presented were taken from the Fish Passage Center database. He said the revised information is taken from the Grant PUD fish counting database and shows a somewhat higher total run.

Brown reviewed the current status of broodstock collection at Wells Dam, Methow Hatchery, and Winthrop Hatchery. He reported that 291 adults and 42 jacks had been collected at the ladder traps at Wells Dam. In addition, seventy-one adults and 14 jacks had been collected and released back in to the river below Wells Dam after analysis of the scale pattern showed they were unmarked hatchery fish, most likely from the Entiat Hatchery. Seven of these fish were subsequently recaptured and then re-released below the dam.

At Methow Hatchery, 158 fish were collected, 145 of which were transferred to the Winthrop Hatchery for holding. There were five mortalities at Methow Hatchery. At Winthrop

Hatchery, 719 fish have been collected, a large proportion of which are Carson stock spring chinook. Brown reported that fish are still being collected at both hatcheries.

As a result of a conference call and coordination meetings which had taken place earlier in June, it had been agreed that "passive" trapping would take place at the Wells west ladder trap until July 5. Because of the large number of summer chinook and sockeye currently passing Wells Dam, the committee agreed that it would not be a good idea to continue to trap spring chinook in July. In addition it was felt that the number of spring chinook available for collection at Wells was too low to make it practical to continue collection at that site, particularly in consideration of the number of spring chinook currently being held at the hatcheries.

On the Wenatchee River, Brown said they have only recently been able to keep the Chiwawa weir in the trapping position since flows are now dropping. They have not, as yet, seen any spring chinook at the weir. Brown said he would recommend staying with the original protocol for weir operation.

Woodin said it may be worth considering collection of spring chinook at Tumwater Dam in conjunction with sockeye broodstock collection. He said there would not be additional trapping effort since they currently handle spring chinook at that site incidental to the sockeye trapping. He said marked and coded-wire-tagged spring chinook could be retained during the sockeye trapping operation and this would add to the spring chinook broodstock. Woodin said he was not advocating this policy, at this time, merely raising the possibility for committee consideration. Brown said they have encountered spring chinook in the past during sockeye broodstock collection at Tumwater and he said he feels this represents a viable option. Tranquilli asked if the "incidental take" matter is covered under the sockeye collection permit. Brown said he believes this would be covered under that permit. Cates inquired about the 1999 operation at the Chiwawa weir which had been suspended during the season due to bull trout concerns. Brown said this had been last year because several bull trout had been killed on the weir and also because few spring chinook were being collected at that time. He said their Section Seven Permit requires 24 hour surveillance whenever bull trout encountered. If any bull trout are killed they have to suspend operations. He said he feels the problem encountered with bull trout mortalities on the weir was due to the release location for fish collected in the trapped which were released immediately above the weir. They have changed the release location to some distance upstream and he feels there should be now re-occurrence of the problem in the future.

The committee agreed to support WDF&W in informal consultation with NMFS in pursuing the option of collecting spring chinook at Tumwater Dam during the sockeye broodstock collection operations.

Woodin reported on discussion of the potential of following a Wenatchee River composite stock spring chinook broodstock program involving collection of broodstock at Tumwater Dam and pursuit of a separate White River broodstock. He said his director would like to pursue this option in 2000 but their discussions with NMFS indicates that NMFS would not be able to move in that tight a time-frame.

Cates reported they have seen 1900 spring chinook at the Entiat Hatchery and 3914 at Leavenworth Hatchery. He said the tribal fishery on the Icicle River was very successful but the sport fishery has been somewhat disappointing so far this year.

F. Next Mid-Columbia Coordinating Committee Meeting

The committee agreed to August 9 for the next Mid-Columbia Coordinating Committee which will be in Portland, Oregon.

II. WELLS DAM

A. 2000 Steelhead Juvenile Survival Study

Bickford gave an update on the Wells Juvenile Steelhead Survival Study. He said the study has four goals. These are to: determine recovery rates at the various recovery sites, look at release numbers and replicates (i.e. 40,000 for 10 replicates/60,000 for 15 replicates), develop precise survival estimates, and make species survival comparisons. Bickford said the survival estimates and species comparisons are in progress.

Bickford reported that the recovery percentages at the downstream recovery sites was higher than expected, especially at Rocky Reach. The expected recovery rate at Rocky Reach was 30% and the actual recovery rate was over 60%. For McNary, John Day, and Bonneville the expected rates were 15% and the actual rates were 20%, 15%, and 15% respectively.

The study design specified 10 replicates with up to five additional replicates, depending upon fish availability. The total number of PIT tagged steelhead juveniles released was 51,822 fish in thirteen replicates. Bickford explained that they only released 13 of the 15 replicates tagged. This was because of the discovery of a tag shedding problem associated with deteriorating fish quality during the holding period for replicates 11 through 13. A decision was made to use replicates 14 and 15 to evaluate the tag shed problem rather than releasing those fish as part of the study. Bickford said it appeared that the emaciated condition of the fish tagged during the last several replicates and the low fat levels appeared to result in a higher rate of tag shedding after replicate 10.

Physiological monitoring during the course of tagging and release showed fish length didn't change but the weight of the fish decreased over time. It was later determined that the fish used during the later replicates had not been fed for over 40 days. It was stated that it is a common hatchery practice to stop feeding when fish are being released from rearing ponds to encourage egress. Physiological monitoring also determined that smolt status and fat cover decreased for fish used in the replicates 11 through 13.

Bickford said he thought preliminary estimates of survival would be available for the next WCC meeting on August 9.

B. Wells 2001 Survival Study

Bickford reviewed the study design for the Wells 2000 survival study approved by the committee at the February 2000 Wells Coordinating Committee meeting. There will be three release sites, Okanogan River, Methow River, and Wells tailrace. Release numbers will total 100-120,000 yearling summer chinook. The fish will be tagged beginning March 1 with releases beginning in mid-April. There will be 10 replicates. Bickford said that sample sizes will be refined based upon the detection rates observed during the Chelan PUD 2000 chinook study.

Bickford reported on feasibility tests conducted following the completion of the 2000 Wells study that will guide study planning. He said pescalator tests showed that tagged fish could be loaded at a rate adequate to meet replicate needs with a tag detection rate of nearly 100%. The physiological samples collected from yearling summer chinook transported and acclimated in the Okanogan River are being analyzed. Detection rates, travel times, and survival estimates for chinook released in the Okanogan River in 2000 will be completed by late August 2000.

C. Wells Ladder Operating Criteria

Bickford reviewed the NMFS 1992 and 1993 telemetry studies of Wells adult passage facilities. He reviewed the recommendations contained within these reports including the NMFS recommendation to study fish passage at Wells Dam with the side entrance gates closed and the downstream entrances opened to a full width of eight feet. Studies aimed at evaluating the effect of side gate closure were conducted in 1997, 1998, and 1999. Results showed similar total project passage time, for adult steelhead and sockeye, with the side entrances closed and the downstream entrances open eight feet as when the side entrances were open. However, Bickford pointed out that sockeye and steelhead already had shown rapid project passage time. Bickford said they had found that chinook passage was dramatically improved when the side entrances were closed. When the side gates were closed, summer chinook project passage times at Wells Dam were cut in half in 1997 and 1998. He said the NMFS had concurred that the side entrance gates be closed and the downstream entrances be opened to a full width of eight feet to facilitate more efficient fish passage. Larry Basham from the Fish Passage Center has already agreed to the operations proposed by Douglas PUD submitted to the committee last week.

Woodin asked if the changes proposed could be monitored using the fish radio-tagged at Bonneville. Bickford said there would be too few of those fish arriving at Wells Dam to permit a valid evaluation. There was further discussion concerning the effects of the proposed change on ladder and entrance pool hydraulics. Bickford said that changing the downstream entrance gate openings from 6 to 8 feet and closing the side entrances results in a 300 cfs reduction in attraction flow. Woodin said he would go along with the proposed change although he was uncomfortable with having no evaluation. He said he would like discussion of a follow-up evaluation of the changes in 2001. The committee agreed to implement the changes in adult passage operations proposed by Douglas PUD immediately and to discuss a follow-up evaluation of the changes in 2001.

D. Wells Juvenile Bypass Operations

Klinge presented information on the Wells Hydroacoustic Index and initiation of bypass operation. There was good correlation between the index and bypass operation. Woodin asked if the in-season information on percentage of salmonids was based on historical data or in-season fyke netting. Klinge explained that historical data on fyke netting had been analyzed by Bickford and was distributed to the WCC in 1997. At that time it was determined that there was little yearly variation in species composition. He said they are using this historical analysis for the percentage of salmonids during the juvenile passage season.

E. Wells Dam Total Dissolved Gas Monitoring

Klinge distributed TDG data for Wells Dam and pointed out that the levels have generally been below 115% at the tailrace monitoring site. He pointed out that the power system has been operated in such a way, during the last several days, that it has caused involuntary spill at the mid-Columbia projects during off-peak hours. This has resulted in some higher TDG levels following periods of inadvertent spill.

D. Okanogan Sockeye

Klinge provided an update on progress toward contracting with Canadian parties for work which the committee agreed to in the Okanagan Basin in British Columbia. Klinge reviewed the sockeye discussions which had taken place leading up to identification of the types of measures which Canadian parties would support. He said there are six projects included in the current initiative. These are:

1) Spawning channel pre-engineering
2) Review of Osoyoos Lake water releases
3) Potential re-watering of Okanagan River oxbows
4) Newberry riffle construction potential
5) Limiting factors analysis on Okanagan sockeye
6) Streambank re-vegetation

Tranquilli asked Klinge how these activities relate to the Cassimer Bar Hatchery operation. Klinge replied that it is Douglas PUD's hope that the efforts in British Columbia would eventually replace the Cassimer Bar operation. Woodin asked if we are still on track to have reports on those activities available by the first of the year. Klinge said he had been assured by the Canadian parties that preliminary reports would be available by the first of the year.

Klinge distributed a 2000 sockeye broodstock protocol from Marco. The protocol calls for collection of 140 adult sockeye for the Cassimer Bar operation. Woodin observed that there had been close coordination between the collection of sockeye broodstock and summer chinook for Wells Hatchery broodstock in the past and he anticipates that this would be the case in 2000. He suggested that Marco review the timing of broodstock collection given the early timing of the 2000 sockeye run.

The next meeting of the Wells Coordinating Committee will be August 9 in Portland.

ATTENDANCE LIST

Name	Representing	e-mail address
Bryan Nordlund	National Marine Fisheries Service	bryan.nordlund@noaa.gov
Vince Tranquilli	National Marine Fisheries Service	vince.tranquilli@noaa.gov
Larry Brown	Washington Department of Fisheries and Wildlife	brownlgb@dfw.wa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Brian Cates	U.S. Fish and Wildlife Service	brian_cates@fws.gov
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Robert McDonald	Chelan County Public Utility District	robertm@chelanpud.org
Thaddeus Mosey	Chelan County Public Utility District	thadm@chelanpud.org.
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Lee Bernheisel	Okanogan Wilderness League	owl@methow.com
Mike Erho	The Committee	merho@televar.com

WELLS COORDINATING COMMITTEE
CONFERENCE CALL SUMMARY
July 11, 2000

Agreements Reached:
1. The Wells Coordinating Committee agreed to support the CRITFC proposal to sample sockeye at Wells Dam for scale analysis with a sample size of 250 to 300 fish.

I. Conference Call Purpose

The purpose of the conference call was to consider a request by Jeff Fryer, Columbia River Intertribal Fish Commission, to sample sockeye salmon, collected in the east ladder trap at Wells Dam, for scale analysis.

II. Discussion

Klinge said he initiated this conference call based on a request received from Jeff Fryer, CRITFC, to sample sockeye salmon at the east ladder trap at Wells Dam for scale analysis. He said he feels it is important for the coordinating committee to review any proposed activity that requires handling fish whether that proposal is from the state, federal government, tribes, or PUD. He briefly reviewed the request which proposed sampling 400-500 fish beginning on July 10. He asked Fryer to review his proposal for the committee.

Fryer reviewed the history of sockeye sampling at Wells Dam which began in the late 1980's. He said in recent years he had not done any sampling at Wells Dam due to low run size and shifts in budget priorities. He said with the unexpectedly large run size in 2000 he would like to sample fish at Wells and Tumwater Dams to compare with previous scale work. In the last few years they have been getting scales from spawned out carcasses from Cassimer Bar and Eastbank Hatcheries but these have not been satisfactory for the type of analysis they are working on. Fryer said that while he would like to obtain scales from 400-500 fish, he feels that since he is starting late he would be doing good to sample 300 fish. He said he is planning to take scales from fish collected for Cassimer Bar Hatchery broodstock (140) and take scales from an additional 110 to 160 fish. He said he would coordinate that effort with WDF&W's broodstock collection schedule to minimize operation of the east ladder trap. He said he had worked with the Cassimer Bar Hatchery personnel yesterday (July 10) and collected scales from the 70 fish collected for broodstock. He said he planned to collect scales from the 120 fish which will be collected for broodstock next week and then plan to take as many as 110 to 160 over the following two weeks. He said he would only be collecting scales one day per week.

Marco asked if starting sampling late would tend to skew the data. Fryer said that it would and he would not be able to use it for determination of age composition of the run. Bickford asked Fryer how good the data would be since he had missed the peak of the run. Fryer said there would still be data that would be usable for his purposes even though the age composition analysis would not be usable.

The committee discussed concerns regarding the time necessary to allow recovery after handling. Recovery time from 10 minutes to 60 minutes were considered. Fryer said the recovery time they had been using at Bonneville appeared to be adequate to keep fish from falling back against the screens. He said using a recovery time as long as 60 minutes would not allow enough time during the day to sample the number of fish he was looking for. The recovery tank available at the east ladder trap is too small to accommodate more than about 5 or 6 fish at a time.

Klinge asked Fryer if he could live with a sample size of 250 fish. Fryer said he would always like to be able to sample more fish but that he felt 250 would give him enough to make it worthwhile. Several committee members expressed a desire to see the sample size adequate to allow meaningful information to be collected. Marco said he would support a sample size of 250-300 fish and Cates said he could support that number. Cates also said he felt it was important to be vigilant to assure adequate recovery time after handling.

With the assurance their would be adequate recovery time, the committee agreed to support sockeye scale sampling at Wells Dam east ladder trap with a sample size of 250 to 300 fish.

PARTICPANT LIST

Name	Representing
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Jerry Marco	Colville Confederated Tribes
Jeff Fryer	Columbia River Intertribal Fish Commission
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE MEETING SUMMARY
August 9, 2000

Agreements Reached:

1. **The committee agreed to hold the next meeting of the Mid-Columbia Coordinating Committee on September 12 at Sea/Tac.**

I. JOINT ITEMS

A. Review of the Summary of the June 29, 2000 Mid-Columbia, Rock Island, and Wells Coordinating Committee Meetings

The chairman reported that the comments received on the draft summaries of the June 29, 2000 Mid-Columbia, Rock Island, and Wells Coordinating Committee meetings had been incorporated into the summaries, with the exception of comments from Bickford and Nordlund. They had commented on the same portion of the Wells Coordinating Committee meeting summary and these were combined and sent to them for review. When they are satisfied with the way their comments were combined then the Wells committee meeting summary will also be ready to finalize. The committee agreed to have the meeting summaries finalized and distributed to the appropriate parties.

B. Next Meeting Time and Location

The committee agreed to hold the next coordinating committee meetings on September 12 at Sea/Tac.

C. Report on Avian Predation Studies and Possible Tern Study in the Mid-Columbia

Chris Thompson, WDF&W, and Ken Collis, RTR Consultants, reported on their work on avian predation and their interest in extending that work to the mid-Columbia. Thompson distributed an outline summarizing information on avian predation on juvenile salmonids and proposed work that they are seeking funding for which would extend their investigations to avian predation assessment in the mid-Columbia. Thompson said preliminary surveys indicate a minimum of 1% to 2% of the tagged fish released in the mid-Columbia were taken by the relatively small tern colony in the Potholes Reservoir. He pointed out that these birds fly approximately 45 miles between the Columbia River and the site of the colony. Thompson said that other activities in the Columbia Basin can effect tern numbers in the mid-Columbia, i.e. relocation activities at Rice and Sand Islands.

Thompson said they are looking to the Mid-Columbia Coordinating Committee to determine areas of emphasis and study priorities. He said the proposed work could be done sequentially or from year-to-year based on information collected the previous year.

Woodin pointed out that gulls are the species targeted for hazing efforts at the mid-Columbia dams. Thompson said that cormorants and terns feed exclusively on fish and feed throughout the Columbia system, not just at the dams as gulls appear to do. Collis remarked that studies in the McNary pool area indicated gulls are less of a problem than terns and cormorants insofar as salmonid predation is concerned.

Thompson said they are presenting the opportunity for the mid-Columbia PUDs to fund studies of avian predation on juvenile salmonids in the mid-Columbia. If there is interest, they will prepare a full fledged proposal for consideration. Rose said that another source of funding for this work, the Washington State Salmon Recovery Board, may also be available on a cost sharing basis. Tranquilli observed that there are several basic research questions that should be addressed. Woodin also pointed out that there is a window of opportunity, with all the survival studies going on, to assess avian predation on juvenile salmonids. Recovery of the tags from these studies will aid in determining areas of predation, etc.

Dach said that relicensing activities represent a potential source of funding for avian predation studies. He also suggested that the PUDs might consider these potential studies as an extension of the ongoing gull harassment efforts in the mid-Columbia.

There was discussion of how avian studies might fit into the overall scheme of mid-Columbia studies. It was pointed out that there has been recent information that has come out that begins to put into perspective the magnitude of avian predation in the mid-Columbia. Bickford reported that minimal juvenile fish tag recovery effort at the tern colony in Potholes Reservoir recovered over one percent of the steelhead PIT tags released for the Wells survival study. Bickford went on to say that approximately 12 percent of the PIT tags released for the Wells juvenile steelhead survival study in 1999 were recovered on Rice Island in the Columbia River Estuary.

Thompson explained that it could be very important for future management to have background information which describes the extent of this predation. Rose reiterated the potential for alternative funding that could provide up to 85% matching funds for this study.

The PUDs will get together to consider the possibility of joint funding for expansion of avian predation studies into the mid-Columbia.

D. Cumulative Juvenile Survival Studies

Dach said he wanted to raise a question concerning potential assessment of survival through the mid-Columbia. He said that once Douglas PUD completes their survival studies there won't be an assessment of cumulative survival through the system. He said individual project survival assessment may indicate each project is meeting the survival standard but the cumulative survival may show something different. Dach said his purpose in bringing this matter up is to alert everyone that there is a cumulative effect that needs to be addressed.

E. Bulltrout Study

Peven reported that BioAnalysts received the contract to tag bulltrout at Wells, Rocky Reach, and Rock Island. He said there will be one trap installed at Rocky Reach ladder, and either one, two, or three traps at Rock Island. It was pointed out that all five mid-Columbia projects are involved in the bulltrout study as part of the ESA concerns for bulltrout. However, Chelan PUD is spearheading the effort due to Rocky Reach relicensing activities. Peven said they would also monitor bulltrout at Wanapum and Priest Rapids but fish would not be tagged at those projects.

II. WELLS DAM

A. Okanagan Sockeye Studies

Klinge reviewed the six studies previously considered by the committee for exploring possible sockeye enhancement actions in British Columbia. Klinge said two contracts with the Department of Fisheries and Oceans were signed and they were moving ahead with those studies. The two contracts with the British Columbia Ministry of Environment and Parks have been signed but construction on one of those, the Riffle Habitat Restoration(Newberry Riffle) has been delayed until 2001. The two contracts with the Canadian Columbia River Intertribal Fisheries Commission have not been sign yet but Klinge thought they would soon be finalized.

Klinge said that several of these studies will develop preliminary information that will lead to implementation whether Douglas PUD funding is available or not. The Okanagan system is generating a lot of interest in Canada regarding fisheries resources. Klinge said the landowner at the preferred spawning channel site will be developing a golf course across the road and is leaning toward retaining the property for a complementary project to the golf course. DFO is looking at other potential sites for a spawning channel.

Tranquilli asked Klinge why Douglas PUD was looking for a substitute for the Cassimer Bar Hatchery, either in the short or long term. Klinge explained that they were interested in developing a biologically sound program to meet Douglas PUD's sockeye compensation responsibilities. They feel the best opportunity to contribute to the sockeye resource would be to develop a program in British Columbia.

Woodin reported that 260 sockeye were collected at Tumwater Dam on July 19-20 for the Lake Wenatchee program. In addition sampling was conducted at Tumwater from July 19 to 27 and 50 adult sockeye were radio tagged and released. Forty-nine of these were subsequently recorded passing the highway bridge at the outlet of Lake Wenatchee. Travel time from Tumwater Dam to the highway bridge averaged 5.7 days. Woodin said they would continue to monitor the location and final destination of the tagged fish.

B. Wells Dam Fishway Inspection Program

Dach asked why the problem experienced wit sockeye and jack chinook mortality wasn't detected by the regular fishway inspection procedures at Wells Dam. Klinge explained that the inspection program routinely looks at a number of parameters that are intended to assure proper operation of the adult fish passage facilities. Klinge explained the problem that developed a couple weeks ago which resulting in mortality to 92 sockeye and 9 jack chinook. These fish ended up in a box which would normally be used anesthetize fish diverted from the ladder for tagging or examination. A mechanic was adjusting a diversion "paddle", at the request of the Wells Hatchery crew, and left the paddle in a position that directed fish passing through the trap into the empty anesthetic tank. Klinge said that as a result of this mishap procedures have been developed between the PUD and the WDF&W hatchery crew to eliminate the possibility of a reoccurrence.

Dach asked if the operators at Wells Dam have regular inspection forms that they fill out when they inspect the adult fish passage facilities. He said he assumed that there would be two walk-throughs per day where such things as entrance openings, differentials, trash rack status, etc. would be recorded as well as turbine operations to show how often they were operating outside of the criteria for operating within 1% of peak efficiency. Klinge said he would check to see what is being done and what kind of paper record there might be. He will report back to the committee at the next meeting. Dach said if this is not being done, Douglas PUD should consider this a request to implement such a program. Woodin said that he would also request that the ladder traps be placed on the list of facilities to be inspected and included on such a report following the regular trapping period.

The next meeting of the Wells Coordinating Committee will be September 12 at Sea/Tac.

ATTENDANCE LIST

Name	Representing	e-mail address
Bryan Nordlund	National Marine Fisheries Service	bryan.nordlund@noaa.gov
Bob Dach	National Marine Fisheries Service	robert.dach@nooa.gov
Vince Tranquilli	National Marine Fisheries Service	vince.tranquilli@noaa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Chris Thompson	Washington Department of Fisheries and Wildlife	thompcwt@dfw.wa.gov
Brian Cates	U.S. Fish and Wildlife Service	brian_cates@fws.gov
Jerry Marco	Colville Confederated Tribes	cctfish@mail.wsu.edu
Bob Rose	Yakama Nation	brose@yakama.com
Bob Heinith	Columbia River Intertribal Fish Commission	heib@critfc.org
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Thaddeus Mosey	Chelan County Public Utility District	thadm@chelanpud.org.
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Ken Collis	RTR Consultants	kcollis@bendcable.org
Mike Erho	The Committee	merho@televar.com

WELLS COORDINATING COMMITTEE MEETING SUMMARY SEPTEMBER 12, 2000

Agreements Reached:

1. **The committee authorized distribution of the final summary of the August 9 Mid-Columbia Coordinating Committee meeting.**
2. **The committee agreed to hold the next coordinating committee meeting on October 17 at Sea/Tac and the following meeting November 7 in Portland.**

I. JOINT ITEMS

A. Approval of the August 9, 2000 Mid-Columbia Coordinating Committee Meeting Summary

The chair reported that comments were received from Peven, Dach, and Nordlund on the draft summary and these have been incorporated into the final. The committee agreed to have the final meeting summary distributed.

B. Avian Predation Study Considerations

Peven reviewed a field investigation conducted last week on the tern rookery in Potholes Reservoir where a few more PIT tags were recovered. Chelan PUD is interested in additional tag recoveries and is planning to use a helicopter, prior to hunting season, to get to the rookery island so that a NMFS flat plate scanner can be used to recovery tags. He said the three mid-Columbia PUD's are interested in funding additional work for 2001 in cooperation with Chris Thompson, WDF&W. Thompson will develop a proposal for Salmon Recovery Board funding and the PUD's will wait to see how that turns out before determining how they might be involved in those efforts.

Todd West, Chelan PUD, presented slides showing their activities at Rock Island examining food habits of avian predators and discussed their methods and procedures. He said the work would continue in 2001.

C. Adult Telemetry Study - 2001

Bickford said Douglas PUD had been approached, by NMFS, to conduct an adult telemetry study in 2001. He said that he was concerned that if a decision on what is to be studied is not made soon, juvenile study needs in 2001 may preclude an adult study. Dach said that NMFS is interested in an adult passage and survival study for either spring chinook or steelhead as little information exists for either of these species and would like to see fish of known origin collected to facilitate development of adult survival methodologies. It was determined that adult steelhead would be preferred given potential interactions with the juvenile studies if spring chinook were used. There was considerable discussion of how known origin steelhead might be identified and tagged so that their destination would be known. Bickford said that since steelhead are the species of interest rather than spring chinook, there is more time to develop the experimental design for an adult study and there would be less overlap with juvenile work at that time of the year. Woodin stressed the importance of pre-planning to avoid problems with duplicate tag frequencies as was experienced in 1999. The PUDs will develop a study proposal for consideration by the committee at the October or November meeting. Hammond suggested having Karl English, LGL, make a presentation at the October meeting.

Dach asked if the PUDs were familiar with the work Bjornn and Stuehrenburg are moving toward in terms of adult survival studies working with known origin fish. Bickford said he had been in contact with Stuehrenburg. Dach requested that efforts be closely coordinated with Bjornn and Stuehrenburg.

D. Survival Study Workshop

Peven proposed a survival study workshop similar to the one held in October 1999. He said he would like to have committee feedback on the idea. It was suggested that the workshop might be held in mid- to late November. Dach asked to have a presentation on possible methodology for adult survival studies. He said he would see if NMFS personnel could address this issue. The committee discussed the subjects that might be covered in a survival workshop and determined that the three major topics would be presentation of juvenile survival study results, plans for future juvenile survival studies, and the potential for adult survival studies. The committee selected November 28 as a tentative date for the Survival Study Workshop.

E. Spring Chinook Captive Brood Program

Woodin reported on discussions between WDF&W and Grant PUD regarding the direction of the spring chinook captive brood program. He said it looks like there is a good chance there will be a significant change in the captive brood program. Woodin said that in the Wenatchee River Basin they are considering use of the Nason Creek and Chiwawa as a composite stock. He said they will continue to manage the White River as a distinct stock. They will attempt to develop DNA screening of fish for identification of White River stock at Tumwater Dam. Nordlund asked how much time it would take for DNA turn around. Woodin replied that it would take about two weeks. Peven said Chelan PUD would like to be involved in the discussions between WDF&W, NMFS, and the tribes regarding Wenatchee River spring chinook.

Woodin said that in the Methow Basin they would continue to manage the Twisp River as a separate stock but would not be collecting eggs this year. He informed the committee that there were two Twisp stock females from the 1996 brood at the AquaSeed facilities at Rochester which will be spawned and their eggs combined with other Twisp fish at the Methow Hatchery.

Dach asked how the changes in the spring chinook captive brood program would effect the existing Chelan and Douglas PUD programs. Woodin explained that Douglas PUD currently supports the adult based Methow composite stock and Twisp stock programs. He said that with the proposed changes in the captive brood program, there would be increased probability of those programs meeting production objectives by feeding captive brood eggs into the anadromous programs. Woodin said that he also wanted to give Chelan and Douglas PUDs a "heads-up" on the WDF&W request for their hatchery people to review existing hatchery facilities for the potential for expansion of programs in a way that would make sense. Dach said he would like to point out that there appears to be a unified position within the fisheries community regarding direction for the future for Methow and Wenatchee Basins spring chinook management. The focus now is to determine the best way to accomplish these objectives.

F. Distribution of Spring Chinook Carcasses from USF&WS Hatcheries

Cates informed the committee of the distribution of spring chinook carcasses from Leavenworth, Entiat, and Winthrop Hatcheries to the natural production areas above those hatcheries to return nutrients to the watersheds. He said the necessary permits had been obtained from the Washington Department of Ecology.

G. Next Meeting of the Mid-Columbia, Rock Island, and Wells Coordinating Committees

The committees agreed to set the next meeting for October 17 at Sea/Tac. The committees also decided to meet on November 7 in Portland.

II. WELLS DAM

A. 2000 Juvenile Steelhead Survival Study - Results

Bickford gave a PowerPoint presentation on the 2000 Wells juvenile steelhead survival study. He reviewed the objectives of the study and provided a summary of the physiological sampling that was conducted throughout the study. He gave a summary of the detection rates at Rocky Reach, McNary, John Day, and Bonneville Dams. Bickford provided survival estimates for steelhead smolts from the Methow release site to 300 m below Wells Dam and compared the 1999 and 2000 survival estimates. Bickford also reported on spring chinook smolts tagged by the Fish Passage Center and released from the Winthrop Hatchery and gave survival estimates for those fish from Winthrop Hatchery to Rocky Reach tailrace. He also compared reach survival estimates for steelhead smolts, yearling hatchery summer chinook, run-of-river yearling chinook, and yearling Winthrop Hatchery spring chinook from Rocky Reach tailrace to McNary tailrace.

Bickford said the draft report on the 2000 study is, for all practical purposes, complete and he is just waiting for one piece of fish physiology information to add. He said that information was not critical and he could finalize the draft report without it.

Dach asked the committee if there was any reason to consider doing additional yearling chinook or steelhead survival studies at the Wells Project. He said he would rather see effort go into sub-yearling chinook or sockeye studies. Woodin remarked that if the 2001 chinook study, previously approved by the committee, likely would not contribute meaningful data there may be reason to re-direct that effort to sub-yearling chinook or sockeye. The committee discussed potential alternative study design for a 2000 survival study. Bickford said he would discuss the matter in-house and if that response is favorable, he would prepare an alternative study proposal which will be circulated immediately to the committee for review. A conference call will follow to consider committee approval of the alternate study direction. The conference call will be September 26 at 3 PM.

Woodin said he would like to see what level of mortality would be necessary from Okanogan to Pateros that would cause the overall mortality to be less than the HCP survival objective. Bickford said that with the current distribution of migrants originating from the Okanogan and Methow basins and the current average survival from Pateros to the Wells tailrace, incremental mortality in the neighborhood of 25% from the Okanogan to Pateros would be necessary to lower overall mortality to the HCP survival goal.

B. Surface Water Coordination at the Methow and Winthrop Hatcheries
(Julie Collins, USFWS, joined the meeting by telecom for this discussion item)

Klinge reviewed the operation of the Methow and Winthrop Hatcheries which both use surface water from the Foghorn Irrigation Ditch which diverts Methow River water at the Foghorn Dam (a rock structure). He said Foghorn Dam has degraded over the years and the river channel has moved away from the diversion structure. This has been a problem in the past and a major problem is expected in 2001 when both the Methow and Winthrop Hatcheries will be at full production and the maximum amount of surface water withdrawal, allowed under their water rights, will be required. Woodin asked if it would be possible to pump water into the ditch when the diversion capability is diminished. Klinge pointed out that the Methow Hatchery has a water right for 18 cfs and Julie Collins said the Winthrop Hatchery has a water right for 50 cfs. These are in addition to the water needs of the Foghorn Irrigation District needs. She said the problem usually occurs during winter low water, however, this year they are already experiencing problems this year because of extremely low flows in the Methow River. It was pointed out that the USFWS had applied for a permit, on two occasions, to rehabilitate Foghorn Dam so that there would be a reliable surface water supply for the two hatcheries. The permit process has been abandoned by USFWS since NMFS said ESA concerns would make it unlikely that a permit could be issued without additional information being submitted on the effects of the withdrawal on spring chinook and bulltrout. Julie said the letter from NMFS, detailing information needs for permit consideration, will be made available to the committee. Dach said the NMFS request for more information should not be considered a rejection of the permit. He recommended that the additional information be compiled and submitted to the NMFS for consideration. There is a process that needs to be followed and a request for additional information is not uncommon in that process. Klinge offered to work with Collins to compile the information requested so that the permit process can get back on track.

A question was raised concerning the construction window for work on Foghorn Dam. Klinge said he felt the window was too short and said he would like to see a winter work window which would allow construction this year if the permit can be secured in time. Klinge said he will pursue that possibility.

ATTENDANCE LIST

Name	Representing	e-mail address
Bryan Nordlund	National Marine Fisheries Service	bryan.nordlund@noaa.gov
Bob Dach	National Marine Fisheries Service	robert.dach@noaa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Brian Cates	U.S. Fish and Wildlife Service	brian_cates@fws.gov
Julie Collins	U.S. Fish and Wildlife Service (by telecom)	
Jerry Marco	Colville Confederated Tribes	cctfish@mail.wsu.edu
Bob Rose	Yakama Nation	brose@yakama.com
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Robert McDonald	Chelan County Public Utility District	robertmc@chelanpud.org.
Todd West	Chelan County Public Utility District	toddw@chelanpud.org
Cary Feldmann	Puget Sound Energy	cfeldm@puget.com
Mike Erho	The Committee	merho@televar.com

WELLS COORDINATING COMMITTEE MEETING SUMMARY
October 17, 2000

1. **The committee authorized distribution of the final summary of the September 12, 2000 Mid-Columbia Coordinating Committee meeting.**
2. **The committee agree to hold the next Rock Island Coordinating Committee meeting on November 29 at Sea/Tac.**

I. JOINT ITEMS

A. Approval of the September 12, 2000 Mid-Columbia Coordinating Committee Meeting Summary

The chair reported that the comments were received from Dach, Peven, Bickford, and Hammond. These comments were incorporated into the final drafts of the meeting summaries. The committee authorized the distribution of the final summaries.

B. The Date for the Next Mid-Columbia Coordinating Committee Meeting

The committee had previously agreed to meet on November 7 in Portland. It was pointed out that a Survival Study Workshop would be held on November 28 at Sea/Tac and it might be more expedient for the committee to meet at Sea/Tac the day after the workshop. The committee agreed to change the date and place for the next Mid-Columbia, Rock Island, and Wells Coordinating Committees to November 29 at Sea/Tac.

II. WELLS DAM

A. Wells 2001 Survival Study

Bickford reviewed the discussion which took place at the September, Wells Coordinating Committee meeting concerning possible Wells survival studies in 2001 and also reviewed the conference call which subsequently took place. During the meeting, Dach had stated that he didn't think it was necessary to do additional a yearling chinook survival studies at the Wells Project as previously approved by the committee. Alternative studies were discussed and a conference call was set for the next week to have further discussion on what kind of study might be considered in 2001. One of the studies considered was a sockeye surrogacy study which would assess sockeye survival through the mid-Columbia from Rocky Reach to McNary. It was pointed out that the study design wouldn't provide project specific survival but would compare sockeye survival, through the reach studied, with hatchery yearling chinook, steelhead, coho, and run-of-river yearling chinook. Following the conference call, Bickford prepared a decision tree and tolerance criteria, at Woodin's request, which were distributed to the committee. The decision tree showed how the results of the sockeye study could be used to address the sockeye surrogacy issue and to estimate Wells Project sockeye survival. Bickford said what Douglas PUD was proposing was to see if it was necessary to do an additional project survival study, at the Wells Project, before moving ahead into Phase III of the HCP. Bickford asked if the committee was comfortable going ahead without specifically estimating survival of yearling chinook and steelhead from the Okanogan River to Pateros or Wells tailrace. Dach said he was satisfied with the yearling chinook and steelhead survival information previously developed for the Wells Project. Heinith said what he was struggling with was the fact that the survival estimates for Wells don't include a low flow year. Bickford responded by pointing out that in 1998, during three of the replicate releases, outflow from Chief Joseph Dam was zero. Bickford said that it appeared to him that Heinith was opposed to the sockeye study which Douglas PUD had proposed so they are left with the option to either do the study previously approved by the committee or do no study at all. It was pointed out that Heinith was not in attendance at the September coordinating committee meeting when Bickford presented the review of reach survival estimates for hatchery steelhead, spring chinook, summer chinook, and coho and run-of-the-river yearling chinook over a three year period. It was this information that the committee reviewed that caused the question to be raised as to whether or not it was necessary to conduct an additional Wells Project yearling chinook or steelhead study. Bickford said what Douglas PUD would need to have in consideration of doing a sockeye reach survival study, was recognition that the HCP survival goal, for yearling chinook and steelhead, had been met and for those stocks and the Wells Project could move ahead to HCP Phase III. Woodin said he felt comfortable with the position that no additional yearling chinook or steelhead studies of Wells Project survival are necessary. Bickford said Douglas PUD needs to know right away if there is a need to have a yearling chinook or steelhead study as was originally agreed to. Heinith said his position, at this time, is that there is no need to do a yearling chinook or steelhead survival study in 2001 since it is unlikely that 2001 will be a low flow year. Dach summarized the JFP position which, simply stated, is that no yearling chinook or steelhead study is required for 2001. Information developed to date, is sufficient as far as NMFS is concerned, to meet the Phase I juvenile dam passage survival standard of the HCP for yearling chinook salmon and steelhead, and seems to satisfy the Wells Settlement Agreement. It was his thought that additional testing, under a low flow year or for the reach between Brewster and Pateros, could be conducted sometime in the future during Phase III, if necessary. Given the lack of information currently in hand for sockeye and sub-yearling chinook salmon, he felt it more important at this time to focus on these species.

B. Okanagan Sockeye

Klinge said he had spent October 16 with the Canadian parties in British Columbia. One of the things they asked Klinge was, will the Wells Coordinating Committee be ready to move forward with a British Columbia based sockeye program in 2001. Klinge said Heinith had raised a CRITFC concern about a B.C. based sockeye program because of potential U.S./Canada Treaty implications. Klinge urged the committee to recognize that the Canadian parties will be expecting that the committee will be ready to move ahead early in 2001 if a Canadian-based program is selected as a reasonable program to meet Douglas PUD's sockeye mitigation obligations.

C. Methow River Hatchery Water Supply Coordination

Klinge reported on efforts to move ahead with the preparation of applications for permits which were necessary to do work at Foghorn Dam which would allow adequate surface water supply for the Methow and Winthrop Hatcheries. He said he was working with the Fish and Wildlife Service to prepare the permit applications for the work which was needed. The committee encouraged Klinge to move ahead with the necessary preparations for the permits to allow the work to be done.

The next meeting of the Wells Coordinating Committee will be November 29 at Sea/Tac.

ATTENDANCE LIST

Name	Representing	e-mail address
Bob Dach	National Marine Fisheries Service	robert.dach@nooa.gov
Rod Woodin	Washington Department of Fisheries and Wildlife	woodirm@dfw.wa.gov
Stuart Hammond	Grant County Public Utility District	shammon@gcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Bob Heinith	Columbia River Intertribal Fish Commission	heib@critfc.org
Mike Erho	The Committee	merho@televar.com

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
December 11, 2000

Agreements Reached:
1.

I. JOINT ITEMS

A. Approval of the October 17 Mid-Columbia Coordinating Committee Meeting

The committee approved the draft summary of the October 17, 2000 Mid-Columbia Coordinating Committee meeting as per the suggested modifications received. It was understood that the chairman would discuss changes suggested by Dach and Bickford and resolve differences prior to finalization of the summary.

B. Establishment of Schedule for the Next Mid-Columbia Coordinating Committee Meetings

The committee selected the following dates for the January and February coordinating committee meetings and the January Rock Island/Rocky Reach Technical Work Group Meeting:

- January 22 - Rock Island/Rocky Reach Technical Work Group Meeting at ENSR
- January 23 - Mid-Columbia Coordinating Committee Meeting at Sea/Tac
- February 13 - Mid-Columbia Coordinating Committee Meeting at Sea/Tac

C. Adult Steelhead Telemetry Study

Karl English gave a PowerPoint presentation on the adult steelhead telemetry study conducted in 2000. All five of the mid-Columbia dams were studied. He said the primary objectives were to establish fish passage time and rate of fallback. English described the study area including release site, five dams, three major spawning areas, and four minor spawning areas. Fish were trapped at Priest Rapids left bank ladder trap and transported to an area just upstream of Vernita Bridge for release. The maximum tagging rate was 24 fish per day. The fish were held one to three hours, following tagging, before release.

English reported that the median passage time from detection in the tailrace of a dam to passage into the forebay was four to twenty hours. Median passage times at the various projects were as follows:

- Wells and Rocky Reach - 12 hours
- Rock Island - 4 hours
- Wanapum - 8 hours
- Priest Rapids - 20 hours

In response to a question, English said information on the range of passage times at each project will be detailed in the report.

English reported on the effect of broodstock trapping on median passage time at Wells Dam and Priest Rapids Dam. Median passage time was 12.5 hours during non-trapping periods and 35 hours during trapping at Wells and 20 hours during non-trapping periods and 24 hours during trapping periods at Priest Rapids.

Migration speed in kilometers per day through the various mainstem mid-Columbia reaches were shown. English said that, steelhead moved more rapidly through the mid-Columbia than steelhead in the Fraser and Skeena Rivers or chinook adults in the Nass River in British Columbia. Woodin asked what the range of migration speed was in the mid-Columbia and Skeena Rivers. English said that information would also be in the report. Heinith asked what the size range was for the steelhead tagged. English said 60 to 85 cm.

The rate of fall-back ranged from 6.5% to 11.5% at the five mid-Columbia projects. English described the fall-back classifications and said the voluntary fall-back rate was 3 to 6.5%, involuntary fall-back was >1 to 3.5%, and the fall-backs that re-ascended ranged from 1 to 5.5%.

English said that of the fish detected at each dam, 82 to 92% showed up on the spawning grounds. The percentage of fish last detected at sites below each dam ranged from 4.5 to 5.5%. This included the Rocky Reach pool, Rock Island pool, Wanapum pool, Priest Rapids pool, and the Hanford Reach. Of 353 fish detected at Priest Rapids Dam, 13 did not pass over the dam.

English reported that 100% of the radio-tagged steelhead were tracked. After rewards for tagged fish caught were given about 90% of the tagged fish remained. English said that the juvenile migration telemetry study timing made it impossible to precisely track adult steelhead and kelt migration information.

English summarized the presentation with the following observations:

- Eighty-one percent of the fish tagged were tracked onto the spawning areas.
- There was eleven percent known tag removal.
- Twelve percent of the fish tagged were destined for downstream stocks(Hanford Reach, Yakima River, and Snake River.
- Thirty-one percent of the total tagged were Wenatchee River fish.
- Fifty-two percent of the total were Methow/Okanogan River fish.
- The Methow/Okanogan group had a high kelt rate (56 - 75%).

English provided the following recommendations for consideration in future adult telemetry studies:

- Use a similar study design to the one used in 2000.
- Make sure there is no duplication in tag codes with other studies going on.
    - Tag duplication was the largest single headache in 2000.
    - Some juvenile detections were lost and some adult kelt data was compromised, especially in the Wenatchee River.

Heinith asked if they had actually observed radio-tagged fish spawning successfully on the spawning grounds. English said yes, but for steelhead he could not say the fish had actually spawned before moving downstream as kelts.

English said the report will go to the PUD's today and the report should be ready for the committee sometime in January.

D. Adult Steelhead Telemetry Study in 2001

Heinith said he would like to see some information from the spawning grounds. It was pointed out how difficult that would be due to the timing of the hydrograph. Heinith also said he would like to see better information on kelting. Dach said it was difficult for NMFS to do much with one year of data. He went on to explain that in the lower Columbia and Snake Rivers, three to five years of study have been done. Dach said the 1999-2000 study appeared to be a well executed study which produced very useful data and it is his opinion that this study should be repeated. He said it is the NMFS position that a data set for the mid-Columbia needs to be developed similar to that for the lower Columbia and Snake Rivers. Peven said the PUD's will caucus over lunch and come back with a joint position regarding the potential for an adult study in 2001. Woodin said he would strongly urge the PUD's to consider an adult steelhead study in 2001 to provide some between years comparisons.

Following lunch Hammond said he wasn't in a position to speak for Grant PUD at this time. Any new studies must go through their long-term settlement group and be considered in that long-term settlement context. Heinith asked what the "drop-dead" date for planning purposes was for a 2001 study. There was discussion concerning what would need to be done to conduct an adult telemetry study in 2001. Hammond said there are technical and policy questions associated with the proposed study. Dach remarked that if there isn't some resolution in a reasonable time, NMFS will send a letter to the PUD's strongly recommending that an adult telemetry study be conducted in 2001. The committee agreed that this matter should be discussed further at the January coordinating committee meeting.

II. WELLS DAM

A. Okanagan Sockeye

Klinge reported that he had met with the Canadian Joint Fisheries Parties last week and they told him that most of the information being collected on the six studies being funded by Douglas PUD will be received soon and this information will be sent to the committee along with a revised "strawfish" proposal for moving forward. Klinge reviewed the work being done in Canada and said the Canadian parties haven't seen the results of the studies but will receive the information at the same time as the Wells Coordinating Committee. He reported that there has been some progress with the land owner of the property which has been identified as the prime spawning channel site. Douglas PUD could make an offer on the property early next year.

Heinith asked if there was any indication of what kinds of funding might be available from Canadian sources. Klinge said there was more interest being generated in Canada but little in the way of funding for sockeye enhancement on the Okanagan.

Marco asked if there was anything new insofar as McIntyre Dam removal is concerned. Klinge said he was told that the dam would probably be taken out within 10 years. This would open up additional spawning habitat but wouldn't do anything for rearing since Vaseaux Lake is a shallow lake with little habitat for sockeye.

Heinith asked if anything was happening in the way of water management. Klinge said this was one of the studies being funded by Douglas PUD. The Canadians will probably pursue water management changes irregardless of where Douglas PUD goes with the current initiative.

B. Bull Trout Trapping at Wells Dam

Klinge mentioned that it looks like spring chinook brood stock collection will take place in the tributaries rather than at Wells Dam in 2001. Chris Peterson, WDFJ&W, has requested that the Wells Dam east fish ladder trap be made available for bull trout trapping in the spring of 2001. Bickford said they would be proposing to trap up to six days at the Wells east ladder during the peak of the bull trout migration for collecting ten bull trout. If ten fish aren't collected in the six days of they would collect bull trout in the hatchery volunteer trap. In response to a question from Dach, Bickford said they would operate the trap no more than 16 hours per day. Dach asked if they might consider only eight hours per day for more days. Bickford, Dach, and Miller will coordinate the effort necessary to meet the needs of the bull trout study.

The next meeting of the Wells Coordinating Committee will be January 22 at Sea/Tac.

ATTENDANCE LIST

Name	Representing	e-mail address
Jerry Marco	Colville Tribes	cctfish@mail.wsu.edu
Bryan Nordlund	National Marine Fisheries Service	Bryan.Nordlund@ noaa.gov
Chuck Peven	Chelan County Public Utility District	chuckp@chelanpud.org
Bob Dach	National Marine Fisheries Service	robert.doch@noaa.org
Shane Bickford	Douglas County Public Utility District	sbickford@dcpud.org
Rick Klinge	Douglas County Public Utility District	rklinge@dcpud.org
Mark Miller	U.S. Fish and Wildlife Service	mark_miller@fws.org
Rod Woodin	Washington Depart. of Fisheries and Wildlife	woodrimw@dfw.gov

Appendix R

2000 Membership list of the Wells Coordinating Committee

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2000 Membership list of the Wells Coordinating Committee

Ron Boyce
Oregon Department of Fish and Wildlife

Brian Cates
U.S. Fish and Wildlife Service

Bob Dach
National Marine Fisheries Service

Mike Erho
Wells Coordinating Committee Chairman

Cary Feldmann
Power Purchasers

Bob Heinith
Umatilla Tribes

Rick Klinge
Douglas County P.U.D.

Jerry Marco
Colville Confederated Tribes

Bob Rose
Yakama Nation

Rod Woodin
Washington Department of Fish and Wildlife