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Public Utility District No. 1 of Douglas County

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April 29, 2004

Ms. Magalie Salas
Federal Energy Regulatory Commission
888 1st Street N. E.
Washington, D.C. 20426

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

Dear Ms. Salas:

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 2003 and those planned for 2004.

Very truly yours,

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

nvh

enclosures
c: (with report, but not appendices)

Mr. Ron Boyce
Mr. Brian Cates
Mr. Mark Eames
Mr. Mike Erho
Mr. Cary Feldmann
Mr. William Frymire
Mr. Ritchie Graves
Mr. Harry Hall
Mr. Stuart Hammond
Mr. James Hastreiter
Mr. Robert Heinith
Mr. Garfield Jeffers
Mr. Phil Mabini
Mr. Jerry Marco
Mr. Bryan Nordland
Ms. Kristine Petersen
Mr. Mark Quehrn
Mr. Bob Rose
Mr. Steve Saugee
Mr. Shaun Seaman
Mr. Nolan Shishido
Mr. Tim Weaver
Mr. Rod Woodin

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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, 1/ 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.

1/ 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

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).

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 2003 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 2004

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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 fourteenth annual report under the Agreement and will cover the period from January 1 to December 31, 2003.

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 2003 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 2003

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 2003 plan in December 2002 to the WCC for review. The District changed how the bypass operation was initiated from the years of monitoring juvenile fish runs with hydroacoustics verified with in-turbine fyke netting at Wells Dam, to a series of fixed dates. These dates were consistent with the ongoing negotiations with the Habitat Conservation Plan (HCP). The fixed start date selected was April 12. The fixed start date (April 12) was selected based upon an analysis of historical data and based upon the analysis of average passage to insure protection for 95.5 percent of the spring migrants. The end date of August 26 was selected to provide protection for 95 percent of the summer migrants (03-2[1]). The WCC approved the annual bypass system operation plan (03-2). Because of the fixed dates of operation, there would be no need for Bypass representatives in 2003 (Appendix A).

1.2 Habitat Conservation Plan

The Joint Fisheries Parties discussed the transition between the operations of the Coordinating Committee and the Habitat Conservation Plan process currently being negotiated. It was believed that the HCP would receive approval by the summer of 2003 (03-1). Dennis Rohr was acting interim chair of the HCP process. Chelan and Douglas PUDs were planning a pre-filing meeting with the F.E.R.C. set for February 19 prior to filing the HCP Agreements for F.E.R.C.'s approval (03-1).

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[1] 03-2 refers to the minutes of the Wells Coordinating Committee from the year 2003, the second meeting.

1.3 2003 Broodstock Protocol

Kirk Truscott with Washington Department of Fish and Wildlife (WDFW) presented a run forecast for the Methow Basin spring chinook of 1,781 adults comprised of 97 percent hatchery produced fish (03-1). Truscott was concerned that the low efficiency of the tributary traps would make implementation of the broodstock collection program difficult. Also, the lack of wild broodstock could pose genetic concerns for a full hatchery program (03-1). There was lack of agreement on how the program should proceed (03-2).

Steelhead broodstock are collected from the ladders at Wells Dam. The proposed broodstock document calls for a high proportion of wild brood, up to 30%. This would require some sorting of adults at the ladders, creating a situation where fish can become delayed in their upstream migration (03-3). The members of the Joint Fisheries Parties (JFP) were in concurrence with the action realizing that a delay would result. Following the meeting, NOAA Fisheries sent an e-mail (May 15) that concurred with the other fisheries parties that a delay of 1 – 2 days at Wells Dam is acceptable for brood collection activities (03-3; Appendix B).

1.4 Coordination of mid-Columbia and Canadian Juvenile Sockeye Research

Kim Hyatt with the Canadian Department of Fisheries and Oceans has been watching the over winter rearing conditions of sockeye in Osoyoos Lake. Information from hydroacoustics plus trawl surveys was used to project the spring outmigration. The estimated number of juvenile sockeye leaving Osoyoos Lake was 2.35 million in 2003 and 200 thousand in 2004. Dr. Hyatt requested 300 – 500 samples of juvenile sockeye from the mid-Columbia dams to help with this research (03-01).

1.5 Tributary Trap sub-Committee

Representatives of the JFP from both the Settlement Agreement and HCP forums met to discuss ways to improve trap efficiency for brood collection in tributaries (03-1). The JFP agreed to support the District's process of obtaining permits for installing these structures in the rivers (03-2). A tributary trap for the Chewuch River at Chewuch Dam, near the spring chinook acclimation pond fabricated and places in the fishway as an interim trapping measure (03-3). An alternate trap for the Twisp brood collection facility was also fabricated and was installed in late June (03-3). Bob Clubb with Douglas PUD emphasized that capital costs for the construction of new traps will only occur after the HCP has been approved by the F.E.R.C. (03-3).

1.6 Corps of Engineers Transportation Study

The Corps of Engineers scheduled a large scale transportation study in the lower Columbia River. To facilitate their research, large numbers of mid-Columbia hatchery fish were marked with PIT tags over several years. Yearling steelhead and chinook with PIT tags were released in

2003. Additional fish were marked for release in 2004. In addition to yearling chinook, sub-yearling chinook may be tagged for release in 2004 (03-2).

1.7 Flow Management Tool for Sockeye

Several years ago, the WCC approved the Canadian Fisheries Parties in the Okanagan Basin to develop a Flow Management Model designed to improve rearing conditions for sockeye salmon as a mitigative tool for the Wells Project. The model uses real time physical data (river flow and temperatures) and biological data (location of redds and stage of egg development) to predict how water releases from Lake Okanagan may impact sockeye and kokanee resources (03-3). In 2003, the model was developed and adjusted with field information in order to maximize benefits for fish, plus manage flood flows (03-2). The model contains a synthesis of many years of experience from fisheries and water management experts from the Okanogan area. The 2002-03 season was the first of three years of model development (03-3). To determine the success of the model, a retrospective analysis of 25 years of river flow and water release operations were compared to the operations recommended by the newly developed model. This information will be available early in 2004. A decision on how efficient the model has been in increasing production will be made after the 2004-05 evaluation (03-4).

1.8 Twisp Pond Screen Improvements

The District proposed improvements to the screens at the Twisp River Acclimation Ponds. The original design provides adequate screening under all but severe freshet conditions. During severe freshets the screens are not able to self clean. The proposed change would move the screen from a flat surface to a submerged slanted surface. Features such as sweeping flows across the screens and an air-burst system to lift and move debris are proposed. The design work has been developed in collaboration with engineers from the NOAA Fisheries and the Washington Department of Fish and Wildlife (03-5). It was recommended that the District contact the Department of Ecology to discuss placement of the screens closer to the ponds and that sweeping flows, required to self clean the screens, be included in the amount of water that could be diverted from the river (03-5). A meeting was held with Department of Ecology staff in December. Ecology said the concept would require amending the District's water certificate of six cubic feet of water per second for additional water requiresd for sweeping the screens. The District decided to go with the original option presented in October, for construction in the fall of 2004, because of the lengthy delay and difficulty in securing additional water rights.

1.9 Bull Trout Study

Pursuant to a January 10, 2000 request by the U.S. Fish and Wildlife Service to F.E.R.C. for bull trout consultation at Columbia River PUD projects, a bull trout monitoring program was initiated in 2001 and 2002 to understand the effect of large hydroelectric dams on the migratory behavior of bull trout in the mid-Columbia River. The study required collection of bull trout from the ladder at Wells and Rocky Reach dams and fitting these fish with radio transmitters. During the

first half of 2003, antennas for detecting these fish were in place in the Wells two fish ladders. Monitoring efforts continued in 2003 with efforts focused on monitoring project passage for passage of bull trout tagged with transmitters during the previous year (2002).

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Operation of the Juvenile Bypass

The Bypass was operated in accordance with HCP parameters. The spring bypass started on April 12 at 0000 hours and ran through June 13 at 2400 hours. Spring operations covered 63 days with a flow of 1.0 million-acre feet (MAF), or 6.5% of the total discharge. During spring bypass, there were 24 hours (2% of the hours) of forced spill. Summer bypass started on June 14 at 0000 hours and ran until August 26 at 2400 hours, for a total of 74 days. There was 1.1 MAF or 6.6% of the total discharge dedicated to summer bypass. During summer bypass, there were 57 hours (3.2% of the hours) of forced spill (Appendix C). In 2003, some of the federal projects suspended their summer spill program because of low river flows. Wells operated the bypass for summer passage as agreed to by the WCC.

2.2 Evaluation of the Adult PIT-Tag Detection System at Wells Dam

The District installed a Passive Integrated Transponder tag (PIT-tag) detection system in both adult fish ladders at Wells during the annual maintenance period the winter of 2001 – 2002. In 2003, this system was evaluated based upon an approved study plan. Of the 159 PIT tagged sockeye released in the ladder, 158 fish were detected in both coils and the other fish was detected in only one coil. The efficiency was 100 percent. In addition, there were approximately 1,500 PIT tagged fish from other studies that were detected in 2003 (03-1). There was no apparent delay in migration as a result of the detection weirs. As a side note, one percent of the survival study steelhead released in the spring of 2000 were detected by the system (03-1, Appendix D).

2.3 Steelhead Telemetry Study

In 2001, the mid-Columbia PUDs funded research to follow passage of steelhead adults from below Priest Rapids Dam through the mid-Columbia projects and into tributaries. The draft results were distributed to the WCC on March 6, 2003. The study showed near identical results to the telemetry study performed in 1999 in terms of passage time through the project (03-3). This was interesting as flows in the river for 1999 and 2001 were very different (Appendix E).

2.4 Dissolved Gas Monitoring

The volume of discharge in the Columbia River, April through August of 2003, was 93 percent of the twenty year average at Wells Dam. Monitoring of total dissolved gas showed a range of the 12-hour daily high values from 101 – 114 percent in the forebay and from 102 - 126 percent

in the tailrace. In 2003, emergency work on the switchyard at the dam reduced the generating capacity of the plant. A series of transformers that had been part of the original construction of the dam 40 years earlier needed to be replaced. When these transformers were being replaced, there were from two to four turbine units that could not generate power. There were three forced spill events that occurred due to the transformer replacement. An event on August 17 was large enough that the water quality standards were exceeded. A letter of explanation was sent to the Department of Ecology (Appendix F).

2.5 Spring Chinook Salmon Hatchery

The Methow Spring Chinook Supplementation Hatchery released 449,642 yearling fish in 2003. The releases were made up of 57,471 fish into the Twisp River, 130,887 into the Methow River and 261,284 into the Chewuch River. Total pounds of spring chinook released for this brood year was close to 30,000 pounds. All of these fish were marked with coded wire tags. In addition, approximately 30,000 yearlings were marked with PIT tags as part of the Corps of Engineers transportation study.

The 2002 brood year production on December 2003 was comprised of 493,521 fish at 28 fpp for the Methow Composite, Chewuch and Twisp population. These fish will be released in the spring of 2004 from acclimation ponds.

The 2003 broodstock were collected at the Methow Hatchery outfall, Fog Horn Dam trap, Chewuch Dam trap, Fulton Dam trap and Twisp trap. There were 254 adults that were retained for broodstock. The Fog Horn Dam trap has yet to collect any adult fish during the three years of operation. Fog Horn Dam is a poor fish barrier and is readily passed by migrating adult fish, thereby circumventing the trap. The Twisp trap was modified by moving the live box out from the bank. This significantly improved collection performance. Trapping on the Chewuch was conducted at the Fulton Dam plus a new location at, Chewuch Dam. Brood collection in the Chewuch only yielded adults at the Fulton Dam location. At spawning, adults are killed and gametes removed and held separately until the coded wire tag (CWT) could be removed from each parent and read. Hatchery staff planted 143,237 eyed eggs in the Mainstem Methow from the Weeman Bridge to the Fog Horn ditch diversion. Planted eggs were the product of non-listed crosses of Winthrop and Entiat National Fish Hatcheries, and unknown hatchery-origin fish. Approximately 188,282 fry were at the Methow Hatchery at the end of the calendar year.

Several evaluation reports associated with the operations at the Methow Hatchery were completed this year. They include spring chinook natural production reports for the years 2000, 2001 and 2002 (Appendices G, H, and I).

2.6 Bulltrout Telemetry Study

Forty bull trout were collected from the fishways at Wells, Rocky Reach and Rock Island dams and surgically fitted with radio transmitters in 2002. Monitoring for these fish was initiated in

2002 and continued through 2003. Monitors were placed around the fishways at four of the mid-Columbia dams (Wanapum, Rock Island, Rocky Reach and Wells dams), the forebay and tailrace of those dams and along the tributaries that fed this portion of the Columbia River. In addition, aerial flights and boat surveys were made monthly to help track bull trout. Mean ladder passage time at Wells Dam ranged from 5.04 to 7.7 hours (right to left ladders) and from the Wells forebay to the mouth of the Methow River was 5.8 days. Greater detail is shown in Appendix J.

(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 multiple adult collection sites; a central hatchery facility for incubation, early rearing, and adult holding; and three acclimation facilities for final rearing (Agreement IV). During 2003, hatchery personnel reared and released progeny from adults that returned in 2001 and reared progeny from adults that returned in 2002. They also collected broodstock and incubated eggs from 2003 broodyear returning adults.

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

3.2 Contract for Professional Services in Implementing the Settlement Agreement

During 2003, the District contracted with Mike Erho to serve as Studies Coordinator for the Wells Coordinating Committee. Mr. Erho also serves as coordinator 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.

3.3 Juvenile and Adult Fish Passage Operations at Wells Dam

During 2003, the juvenile bypass system operated as per conditions outlined in the Settlement Agreement (II, C, D and F). The Coordinating Committee recommended bypass operations based upon information collected during previous years of hydroacoustics and fyke net samples at Wells. The two adult ladders operated per criteria agreed to by the fisheries agencies and tribes.

3.4 Steelhead Production at Wells Hatchery

The Settlement Agreement specified that the District 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 show that 450,758 steelhead or 75,126 pounds were liberated in 2003. While slightly under the PUD obligation, the release was at the NOAA

Fisheries limit for the Section 10 Permit granted to Washington Department of Fish and Wildlife for liberating 450,000 steelhead.

3.5 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

(5) Chronology of Compliance for 2003

Items (3) and (4) above contain chronology of compliance in 2003. 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 N.

(6) Schedule of Activities for 2004

The following schedule of activities is planned for 2004:

April 1	Bypass barriers in place
April 1	Begin monitoring activities for TDG in the forebay and tailwater
April 12	Start of the spring juvenile bypass operation
May 1	Start collecting spring chinook broodstock at Methow Basin tributary traps
June	Presentation of the Okanogan Flow Management Model and retrospective analysis of the past 25 years of river operations
August 26	Completion of juvenile bypass operations
October	Production Plan annual review between the District, Agencies and Tribes
October 1	Begin construction of Twisp and Chewuch river broodstock trap modifications
On going	Planning sockeye mitigative strategies
On going	Planning for operations and protocols of the Methow Spring Chinook Facilities

(7) Minutes of Meetings

7.1 Minutes of the Wells Coordinating Committee for 2003

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 2003 are attached as Appendix N.

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Annual Bypass Operation Plan, Year 2003

Appendix B
Broodstock Collection Protocol, 2003

Appendix C
Summary of Bypass Operations at Wells Dam, 2003

Appendix D
Wells Dam Adult PIT-Tag Interrogation System Evaluation

Appendix E
Assessment of Adult Steelhead Migration through the mid-Columbia River using Radio-Telemetry Techniques, 2001 – 2002.

Appendix F
Letter to Department of Ecology in explanation of exceedance of Total Dissolved Gas water quality parameter on August 21, 2003.

Appendix G
Methow Basin Spring Chinook Natural Production Study Report for 2000

Appendix H
Methow Basin Spring Chinook Natural Production Study Report for 2001

Appendix I
Methow Basin Spring Chinook Natural Production Study Report for 2002

Appendix J
Movement of Bull Trout within the Mid-Columbia River and tributaries 2002 – 2003.

Appendix K
Annual Progress Report for Wells Hatchery Summer Steelhead; 2000 Brood Year.

Appendix L
Annual Progress Report for Wells Hatchery Summer Steelhead; 2001 Brood Year.

Appendix M
A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives

Appendix N

Minutes of the Wells Coordinating Committee for 2003

Appendix O

2003 Membership list of the Wells Coordinating Committee

Appendix P

The Long-Term Settlement Agreement for the Wells Hydroelectric Project

ANNUAL BYPASS OPERATION PLAN
YEAR 2003

APPENDIX A

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 2003 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 prior to the spring migration. This plan will be reviewed and approved by the Committee by March 1. This plan will also be available for the Habitat Conservation Plan Coordinating Committee for bypass operations in 2003 .

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). [HCP 4.3.1]

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 2003 above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	460	4/15
Methow (WDFW)	Spr. Chinook	435	4/15
OTID Elisford (CCT)	Spr. Chinook	100	4/15
Omak Creek (CCT)	Spr. Chinook	50	4/15
Carlton (WDFW)	Sum. Chinook	250	4/15
Similkameen (WDFW)	Sum. Chinook	30	4/15
Wells (WDFW)	Sum. Steelhead	450	4/20
Winthrop (USFWS)	Sum. Steelhead	120	5/01
Winthrop (USFWS)	Coho	245	4/25

Starting Dates and Ending Dates

The HCP provides for planng dates for the start and completion of bypass operation of April 10 through August 15. Previously, fyke netting and hydroacoustics provided the Wells Bypass Team information on the start of the juvenile migration as it reached Wells Dam. Starting in 2003, the bypass will be initiated based upon set dates of April 12 through August 26 at the recomondation of the HCP Coordinating Committee. These fixed dates were established from 21 years of hydroacoustic and 14 years of species composition information collected on juvenile run patterns at Wells Dam. The bypass operation is divided into a spring and summer period. The end of the spring period was set at June 13 at 2400 hours. The summer bypass stared on June 14 at 0000 hours.

The HCP coordinating committee will decide the start and end of bypass operation.

(01/09/03)

:\Data Files\bypass\bypass03

BROODSTOCK COLLECTION PROTOCOL
2003

APPENDIX B

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
Mid-Columbia Field Office
610 North Mission St. Suite C2 ∃ Wenatchee, WA 98801 ∃ (509) 664-1227 ∃ FAX (509) 662-6606

12 May 2003

To: Joint Fishery Parties / Mid-Columbia Coordinating Committee

From: Kirk Truscott

Subject: **DRAFT YEAR 2003 UPPER COLUMBIA RIVER SALMON AND STEELHEAD BROODSTOCK OBJECTIVES AND SITE-BASED BROODSTOCK COLLECTION PROTOCOLS**

The draft adult broodstock collection protocol for year 2003 is keyed on target numbers at various collection sites operated by WDFW that provide broodstock for Mid-Columbia PUD mitigation program facilities. Hatchery programs or facilities operated by other agencies or tribes are not addressed in the document with the exception of the Methow Basin spring chinook production and supplementation programs, and the Northwest Power Planning Council (NWPPC) Coho Reintroduction Program. This adult broodstock collection protocol is to be considered an interim and dynamic hatchery broodstock collection plan, which may be altered following joint fishery party (JFP) discussions. As such, there may be significant in-season changes in broodstock numbers, locations, or collection 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 2003 outlook for ESA-listed upper Columbia River spring chinook is substantially less than last years return. The TAC forecast for upper Columbia spring chinook is 25% of last years return at the mouth of the Columbia River. Upper Columbia summer chinook returns are expected to be approximately 68% of the 2002 return, while sockeye are expected to 44% of the 2002 return to the mouth of the Columbia River. The A-run steelhead component, which includes Upper Columbia stocks, is forecast to be 87% of the 2002 run to Bonneville Dam (Table 1).

The spring chinook collection protocols will target specific populations of fish in the Methow Basin through broodstock collections in tributary locations rather than collections at Wells Dam. Broodstock collection protocols for Wenatchee River spring chinook, Wenatchee River Basin summer chinook, Methow/Okanogan summer chinook, Wells stock steelhead and Wenatchee stock steelhead will target an increased proportion of wild origin fish for inclusion in the broodstock

Columbia River Mouth Fish Forecasts

			2002 Forecast	2002 Return	2003 Forecast
Spring chinook	Willamette		73,800	121,700	109,800
	Sandy		4,300		
	Cowlitz		3,100	3,700	4,900
	Kalama		1,600	2,800	3,600
	Lewis		2,000	2,000	2,300
	Upriver		333,700	294,900	145,400
	Wind		40,400		
	Drano Lake		18,500		
	Klickitat		1,600		
	Yakima		21,800	14,600	6,400
	Snake River	Total	149,800	132,700	72,500
	Snake River	Wild	44,900	60,200	25,000
	Upper Columbia	**Total**	51,000	53,100	13,200
	Upper Columbia	Wild	5,100	6,300	1,300
Summer chinook	Upriver		77,700	129,000	87,600
	Snake River	Total	17,000	27,900	19,300
	Snake River	Wild	6,600	4,500	7,700
Fall chinook [1]	LRH - Lower River	Hatch.	133,000	137,700	
	LRW - Lower River	Wild	18,300	18,300	
	BPH - Bonneville Pool	Hatch.	136,000	163,800	
	URB - Upriver Bright		273,800	285,400	
	MCB - Mid Col. Bright	Hatch.	91,800	101,900	
	BUB - Bonn. Upr. Br.	Hatch.	45,700	54,000	
	PUB - Pool Upr. Br.	Hatch.	46,100	47,900	
	LRB - L. River Brights	Wild	1,900	1,900	
	SAB - Select Area Br.	Hatch.	5,000	5,500	
	Total		*659,800*	*714,600*	
	Snake River	Wild	NA	NA	
Coho [1]	Early stock	Hatch.	112,700	250,000	
	Late stock	Hatch	58,900	150,000	

	Total		*171,600*	*400,000*	
Sockeye	Wenatchee		14,000	35,800	11,000
	Okanogan		27,200	13,800	11,000
	Snake River	Wild	26	57	80
	Total Upriver		*41,200*	*49,600*	*22,080*
Steelhead [2]	Upriver Skamania Index	Hatch.	11,300	15,300	12,100
(big/little index)		Wild	6,200	9,700	4,500
		Total	*17,400*	*25,000*	*16,600*
	Upriver A-run Index	Hatch.	264,700	235,800	209,000
		Wild	105,000	87,300	70,600
		Total	*369,700*	*323,100*	*279,600*
	Upriver B-run Index	Hatch.	39,000	97,600	53,200
		Wild	21,600	32,300	11,500
		Total	*60,600*	*129,900*	*64,700*
	Upriver combined	Hatch.	315,000	*348,700*	274,300
		Wild	132,800	*129,300*	86,600
		Total	*447,800*	*478,000*	*360,900*

Wenatchee Basin

The JFP agreed to manage the Chiwawa/Nason spring chinook stock as a composite in the Wenatchee Basin. Since 1993, an estimated 25% of all Chiwawa spring chinook recovered on the spawning grounds were found in Nason Creek. With this degree of straying, the current program appears to be augmenting the Nason Creek population, with an unknown impact to either population. To partially address the straying of Chiwawa River hatchery origin fish, trapping at Tumwater Dam will be the focus of the hatchery origin portion of the broodstock collection. Infusion of wild origin stock into the Chiwawa River supplementation program (Chiwawa River) is also an important element to the success of recovery of the Wenatchee River spring chinook ESU and will be an additional focus element in the broodstock collection for 2003.

White River spring chinook have been determined to be a genetically unique stock and shall be managed as a separate stock. If collection of spring chinook at Tumwater Dam is implemented, collection will be limited to hatchery origin only, thereby eliminating the potential to incorporate wild White River adults into the Chiwawa River hatchery supplementation program.
Nason Creek captive broodstock gametes may be incorporated into the Chiwawa/Nason adult supplementation program.

Progeny from the Nason Creek captive broodstock program at the Aquaseed facility in Rochester may be reared at Aquaseed and incorporated into the Chiwawa/Nason adult supplementation program as a component of the adult supplementation program. The progeny may be reared to pre-smolt stage at Aquaseed, then acclimated and released into Nason Creek.

Methow Basin

Consistent with the BAMP (1998), Biological Opinion for ESA section 10 Permit #1196, Permit # 1196 and the NWPPC Methow River Subbasin Summary, WDFW proposes to collect broodstock in a manner that reduces the Carson lineage within the supplementation production and consistent with the development of local tributary attributes. The collection protocol outlines tributary trapping on the Methow, Chewuch, and Twisp rivers and trapping at both the Winthrop NFH and Methow Fish Hatchery (FH).
In conjunction with the tributary trapping activities, Brood 2003 Twisp River captive broodstock gametes provided from adults held at the AquaSeed facility in Rochester WA. may be incorporated into the adult supplementation program. If the captive brood progeny in combination with the projected smolt production from the adult broodstock collection exceed 550,000 smolts, the broodstock collection will be reduced accordingly.

Distribution List:

Mike Erho, for distribution to Mid-Columbia Coordinating Committee
Kris Petersen, NMFS
WDFW

Bruce Sanford	Joe Foster	Rod Woodin	Ross Fuller	Chuck Johnson
Craig Busack	Bill Tweit	Jon Anderson	Heather Bartlett	
Cindy LeFleur	Rick Stilwater	Bob Jateff		
John Easterbrooks	Art Viola	Bob Rogers	Andrew Murdoch	Charlie Snow

Year 2003 Upper Columbia Broodstock Collection Targets by Species and Program

Spring Chinook

Wenatchee Basin

Consistent with broodstock collection during 2001 and 2002, the upper Columbia River spring chinook collection during 2003 will collect adults from the run-at-large, consistent with maintaining a 1:1 sex ratio, and at a minimum, 33% wild composition. Maintenance of a minimum 33% wild composition during broodstock in 2001 and 2002 provided spawning crosses dominated by HxW parental crosses (77% and 87%, respectively). Because of the reduced adult return expected in 2003, attaining full broodstock collection is unlikely. An estimated 95 – 111 spring chinook may be collected during brood collection efforts in 2003. Due to the minimal potential collection, maintaining a 1:1 sex ratio will be important to maximize the effective spawning population size.

In an effort to partially address the straying of Chiwawa River spring chinook to other tributaries in the Wenatchee Basin, hatchery origin adults will be collected, to the extent possible, at the Tumwater Dam facility, consistent with maintaining, at minimum, 33% wild origin in the broodstock, when combined with collection at the Chiwawa River weir. CWTs will be extracted and read prior to mating to prevent inclusion of Leavenworth or "out- of- basin" stock gametes into the listed stock. No Carson origin, or other "out- of –basin" spring chinook stock will be incorporated into the Chiwawa River adult supplementation program. Collection of the hatchery origin broodstock component at Tumwater Dam should reduce the potential number of Chiwawa River origin fish that may stray to other locations in the basin

Chiwawa River

Trapping Chiwawa spring chinook will follow a 4-days up and 3-days down trapping schedule, similar to the 2002. Trap efficiency is expected rage between 25% and 31%, similar to that observed during 2000, 2001 and 2002. Broodstock collection will be run-at-large with respect to migration timing and age-class. To maximize effective spawning population size, WDFW will attempt to maintain a 1:1 sex ratio within the broodstock. If required, the Chiwawa River weir collection will be utilized in conjunction with the collection at Tumwater Dam to provide the hatchery origin broodstock component. The number of hatchery origin fish retained will be determined by the trapping success at both Tumwater Dam and Chiwawa, and will be consistent with a minimum 33% wild origin broodstock component, and a maximum 33% extraction of the spring chinook population returning to the Chiwawa River. Spring chinook retained will be transferred to Eastbank Fish Hatchery (FH) for holding in well water. 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.

Tumwater Dam

In an effort to partially address the stray rate of Chiwawa River fish within the Wenatchee River Basin, the hatchery origin portion of the broodstock collection will target fish at Tumwater Dam. Collection at Tumwater Dam will focus on hatchery fish only, and will collect the initial 20 hatchery origin fish for the Chiwawa River adult supplementation program. After the initial 20 hatchery fish have been collected, additional hatchery fish will be collected at a rate consistent with wild origin collections at the Chiwawa River weir and a minimum 33% wild origin composition in the broodstock. If required, both Tumwater Dam and Chiwawa River weir collections will provide the hatchery proportion of the broodstock collection. All spring chinook retained at the Tumwater Dam trapping facility will be differentially tagged with elastomer tags prior to being transported to the Eastbank Fish Hatchery

Chiwawa spring chinook hatchery program and assumptions:

2002 Program assumptions:	
R.I. Settlement Program	672,000 yearling smolts
Broodstock required	379 Adults
Propagation survival	83% fertilization to release
Fecundity	4,400 eggs per female
Female to male ratio	1 to 1
Pre-spawn survival	97%
Wild/hatchery broodstock composition	33% / 67%
Wild ESA adults to Wenatchee Basin	426
Estimated wild proportion to Chiwawa	**61%**
Estimated wild to Chiwawa	**260**
Hatchery ESA to Wenatchee Basin	90
Estimated Proportion to Chiwawa	40%
Estimated Hatchery to Chiwawa	36
Chiwawa weir extraction rate	25%-31%
Projected wild broodstock collection	**65 - 81**
Projected hatchery origin collection (Chiwawa and Tumwater Dam)	**- -** 30 - 30
Total	**95 - 111-**

White River Brood Year 2003 smolt production associated with the White River Captive Broodstock Program will be separate from the 672,000 smolt production objective associated with the Chiwawa River adult supplementation program. White River Captive Brood adults will be spawned, eggs will be fertilize/incubated and juveniles reared to pre-smolt age at AquaSeed. Pre-smolts will be transferred to an acclimation/rearing facility on the White River for final rearing and release.

Methow Basin

Preliminary spring chinook run forecast to Wells Dam (1,781) exceeds the minimum escapement of 964 fish identified in ESA Section 10 Permit #1196, where adult fish may be trapped at Wells Dam. The projected return to the Methow Basin is expected to be approximately 97% hatchery origin, 87% of which are expected to return to or near the Winthrop NFH and the Methow Fish Hatchery. Of the hatchery fish returning to the Methow Fish Hatchery, greater than 65% are expected to be 1999 Methow Composite stock, that have 52% Winthrop-Carson ancestry. The remaining fish returning to the Methow Fish Hatchery are expected to be 1998 Methow Composite stock and 2000 Methow Composite stock, which have 17%-25% and 19.1%Winthrop-Carson ancestry, respectively. Wild origin fish returns to the Methow Basin are expected to be minimal (approximately 60 fish), primarily due to limited adult spawning escapement in 1999, poor emigration survival of the 1999 brood year and elimination (or near elimination) of the 1998 brood year adult spawning escapement due to 100% trapping effort at Wells Dam. Theoretically, the wild origin return in 2003 will be comprised of age-3 and age 4 wild origin fish associated with the 2000 and 1999 adult escapement to the Methow River Basin.

Due to the low expected escapement of wild chinook and likelihood of a hatchery return dominated by 1999 Methow Composite origin fish (52% Carson ancestry), WDFW has concerns regarding a broodstock collection that strictly targets a numerical broodstock collection objective without regard to broodstock origin, and the potential to overwhelm a limited tributary spawning escapement with a large hatchery program that may be predominately comprised of smolts that have 52% Carson ancestry.

Broodstock collection for the mainstem Methow River production component will be consistent with providing 1999 MetComp, 1998 MetComp, 2000 MetComp and wild origin parental outcrosses that provide up to 183,000 smolts, with no more than 50% of the production comprised of 1999 MetComp x 1999 MetComp origin. The fish for the mainstem program will be collected primarily at the Methow FH. The remaining Methow FH production (up to the program objective of 550,000 smolts) will be contingent upon successful collection of wild origin chinook and age-3 and age-5 hatchery chinook at the Methow FH outfall, Fulton Dam, Chewuch Dam, Twisp River, plus the Twisp captive brood. The production designated for the Chewuch River will include 1998 MetComp, 2000 MetComp and Wild origin parental outcrosses. The management of the Twisp stock remains stock specific and will be supported by the captive brood component currently at AquaSeed and any Twisp River wild and Twisp River hatchery origin fish that are collected in 2003 from any of the 5 collection locations (Winthrop NFH, Methow FH, Foghorn Dam, Fulton Dam and Chewuch Dam).

Critical to meeting program objectives for the 2003 BY (smolt production, reduction of Carson ancestry, preservation/enhancement of tributary populations and development of local tributary attributes), WDFW may collect up to 352 adult spring chinook for the 2003 brood. Trapping efforts will limit the proportion of age-4 hatchery origin fish in the broodstock (i.e. limit Carson ancestry). Initially, up to 51, age-4 hatchery origin fish may be retained (in combination from Chewuch and Methow FH outfall). Continued retention of age-4 chinook will be contingent upon collection of age-3 and age-5 hatchery fish, wild origin fish, cryopreserved milt at the Methow Fish Hatchery and available male component from the Twisp Captive Brood program (i.e. males not required for the captive brood program). In-situ stock separation of Methow Composite, Twisp, Carson-based Winthrop stock and stray fish via scales and CWTs during spawning operations will continue. Age determination will be accomplished via length frequency, while sex will be determined in mid-June. During June, the total number of males and females and the respective age composition of each sex will be determined, from that period forward, fish may be retained and released selectively (age and sex) consistent with reducing Carson ancestry within the Methow Composite stock, preserving and enhancing tributary populations and meeting production objectives at the Methow FH.

In an effort to reduce the overall Carson ancestry in the 2003 brood and to improve smolt production levels, MetComp 1998, MetComp 2000 males and wild males may be utilized twice as primary spawners. Additionally, Twisp anadromous and Twisp captive brood males may also be utilized twice as primary spawners. Because the number of wild, age-3 and age-5 fish available will influence the total broodstock collection of age-4 hatchery chinook retained and tributary trap efficiencies are unknown (due to unknown effects of proposed modifications), and the actual number of spawners associated with the Twisp River captive brood program are unknown, an estimated total broodstock collection is not provided, however, a maximum number of broodstock collected will not exceed 352 fish. The maximum broodstock collection of 352 fish accounts for 15% reduction expected due to ELISA culling, 5% pre-spawn mortality and maximum facility production of 550,000 smolts. The smolt production provided from the broodstock collected at the Methow FH (183,000 smolts) combined with a projected Twisp River Captive Brood smolt production of 40,000 – 176,000 smolts and 95,000 – 100,000 smolts as a result of Chewuch River broodstock collection activities provide an estimated smolt production for 2003 of 318,000- 459,000 smolts. To what degree we will meet the projected smolt production or the 550,000 smolt production objective for the Methow FH will be dependent upon overall run strength, trap efficiencies age/origin composition and success of the Twisp River captive brood program. If 1998 Winthrop x 1998 Winthrop or 1998 Winthrop x 1999 MetComp parental crosses are made, gametes/progeny will be released outside the Methow River Basin.

Methow FH spring chinook program assumptions:

Production Objective:	550,000 yearling smolts, @ 30g/fish
Propagation survival:	90% fertilization to release
Fecundity:	4,200 eggs/female
Sex ratio:	1: 1
Pre-spawn survival	95%
ELISA cull rate	15%
Max. broodstock required	352
Maximum smolt production expected for BY 2003	318,000-459,000

Winthrop NFH spring chinook program (BAMP):

Production Objective: 600,000 yearling smolts @ 30g/fish
Broodstock required: 362 (BAMP)

Methow River

Foghorn Dam Trap 7-days/week- Operated by USFWS personnel. No data exists regarding trapping efficiencies at this site. Only adipose present spring chinook and age-3 hatchery origin chinook will be retained at this site. All fish collected at this site will be held at the Methow FH.

Chewuch River

Fulton Dam Trap Until the 2001 season, the Fulton irrigation diversion dam on the Chewuch River had not been used since 1994. The trapping efficiency of the Fulton facility averaged 30% from 1992-1994, ranging from a low of 9.2 in 1992 to a high of 58.2% in 1993. Significant river flows in 1996 and 1997 disrupted the configuration of the dam, likely reducing the potential trapping efficiencies from those observed in 1992-1994. Maintenance work completed in the spring of 2001 was expected to return trapping efficiencies to approximately 60%. Unfortunately, the 2001 trapping efficiencies were approximately 3.5%, significantly less than anticipated. During the late winter/early spring of 2002, minor construction was again performed at the Fulton Dam site, seeking improvements to trapping efficiencies. Trapping efficiencies during the 2002 broodstock collection fell to just .3%, a clear indication that the modifications completed in 2001 and 2002 failed to return the trap to pre-1994 trapping efficiencies. Preliminary return forecast for the Chewuch includes 10 wild and 144 hatchery origin fish (age-4 and age-5). The possibility exists, that age-3 hatchery and wild origin chinook will be encountered in the Chewuch River and may provide additional broodstock. Due to variable SAR values

observed for the Methow FH program and highly variable age-3 component return within a brood year, no estimates of age-3 collections are provided. Up to 33% (51 fish) of the expected return to the Chewuch River may be retained for broodstock purposes (combined Fulton Dam and Chewuch Dam traps). Collections above the 51 fish will be consistent with in-season passage of chinook at Wells Dam and maintaining a minimum of 80 fish spawning escapement in the Chewuch River. Fish collected at the Fulton trap site will be held at the Methow FH.

Chewuch Dam Trap Due to the poor trapping efficiencies observed at the Fulton Dam Trap during 2001 and 2002, reduced adult returns and desire to incorporate tributary specific wild origin fish and 1998 Methow Composite and 2000 Methow Composite origin fish into the stock composition for BY 2003 Chewuch River smolt releases, an additional trap site has been identified. The trap site is located at the Chewuch Dam, approximately 8 Rm upstream from the confluence with the Methow River. The trap will consist of a temporary, removable picket weir that will impede passage across approximately 25% of the wetted perimeter of the Chewuch River during low flow periods (likely late June- end July 2003). A modified v-trap will be inserted into the existing fishway. The trap will be passively operated 24 hours/day. Because operations of this trap site is contingent upon reduced flows, broodstock collection may be skewed toward later migrating spring chinook, however, acquisition of the chinook returning to the Chewuch River is an important component of the 2003 smolt production, therefore the risk of a one-year interim trapping effort is appropriate. Because this is an alternative trap site and has no previous trapping record, no trap efficiency expectations are provided. Up to 33% (51 fish) of the expected return to the Chewuch River may be retained for broodstock purposes (combined Fulton Dam and Chewuch Dam traps). Collections above the 51 fish will be consistent with in-season passage of chinook at Wells Dam and maintaining a minimum of 80 fish spawning escapement in the Chewuch River. Fish collected at the Chewuch Dam trap site will be held at the Methow FH.

Twisp Weir A floating weir on the Twisp River provides for collection of Twisp stock spring chinook. Historically, trap efficiency is low at this facility, averaging 16% (range 10.4% – 23.7%) from 1992 through 1994. During the 2001 trapping season, the trap efficiency was just 6% and fell to just .2% in 2002. In an attempt to increase the trap efficiency for collection in 2003, a modified V-trap will be installed along the weir sill, adjacent to trap entrance. The efficacy of this modification is unknown, therefore no trap efficiency is provided for this trap. Expectations are that all Twisp origin spring chinook trapped at this site will be retained for the Twisp

program and held at the Methow FH. Trapping at the weir amy collect up to 31 fish, and will prioritize outcross with anadromous, and captive brood populations. Collections above the 31 fish will be consistent with in-season assessment of chinook passage at Wells Dam and maintaining a minimum of 80 fish spawning escapement in the Twisp River.

The Twisp weir poses several operating constraints, including stranding of steelhead and spring chinook on the weir pickets during upstream and downstream movement. Substantial steelhead spawning activity was observed during April 2002 and is expected to be present during the spring of 2003. The weir will be closely monitored, at the first indication of kelt migration difficulties or spring chinook fallback that cannot be adequately addressed operationally, the trapping will cease and the weir removed (pending appropriate flow conditions). Operation of this weir will include 24-hour on site monitoring throughout the trapping season.

Methow FH

Collection at the Methow Fish Hatchery outfall will be variable and dependent upon success of tributary collections. The collection will be selective and target age-3, age-5 chinook, and wild chinook and will limit the age-4 hatchery origin proportion within the broodstock consistent with mainstem Methow River production objectives (i.e. 183,000 smolts with no more than 50% age-4 x age-4 hatchery origin crosses).

Winthrop NFH

Trapping is expected to occur at the Winthrop NFH and will be consistent with collection protocols provided by the USFWS.

Wells Dam

No trapping of spring chinook will occur at Wells Dam because of the number of chinook expected to return past well dam exceeds the minimum escapement of 964 fish identified in ESA Section 10 Permit #1196, where adult fish may be trapped at Wells Dam. Additionally, previous years collections at Wells Dam have provided broodstock that include Winthrop, Entiat, Leavenworth, Dworshak and Lochsa River origin chinook. Trapping activities at Wells have also provided wild fish of unknown tributary origin, which were apportioned to tributaries utilizing elemental scaled analysis at approximately 60% precision, thereby mixing a portion of the wild fish of unknown origins together for release in the mainstem Methow River. Neither the inclusion of Carson origin fish, out-of-basin fish or an admixture of wild origins within the Methow River Basin smolt production furthers the overall genetic component of a composite population, nor do they address potentially unique stocks within the basin or promote the development of local tributary attributes, all of which are important components to aid in the recovery of the upper Columbia River ESU.

Twisp River Captive Brood:

The fish currently being held as captive broodstock at Aquaseed may be reared until maturity and the resultant gametes may be included in the Twisp program at Methow FH. We anticipate a range of 42,000-186,000 smolts from the Twisp captive brood program.

Summer Chinook

Wenatchee Basin

Wenatchee summer chinook 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%
Broodstock required	492

Trap **492**-wild origin, summer chinook at **Dryden Dam** and **Tumwater Dam.** Up to 25% of the total broodstock collection may occur at Tumwater Dam after 15 August. Collection will be proportional to return timing between 7 July and 12 September 2003. No selection for male or female will occur during collection with the exception of limiting the 3-year old component to 10% of the broodstock total. The 3-year old component will be limited to 10% of the broodstock collection to minimize the potential of reduced production as a result of a strong 3-year-old age class, as was the case in 2001.

Methow/Okanogan Basins

Beginning in 1997, the adult supplementation program for the Methow/Okanogan Basins has incorporated an increasing proportion of hatchery origin adults into the broodstock. Hatchery fish comprised an average 39% of the broodstock total from 1994-1996 and has increased to an average of 63.8% between 1997 and 2001. In addition to the increasing hatchery component observed in the broodstock collection since 1997, an increase in the proportion of "strays" has also been evident. Strays provided an average 0.6% of the total broodstock collected between 1994 and 1996. During the 1997-2001 period, the proportion of strays in the total broodstock collected, ranged from 0.8% to 21%. A consistent and increasing reliance on hatchery origin fish, with potentially high stray component, to support an adult supplementation program may eventually have negative consequences to the program. Consistent with broodstock collection in 2002, WDFW proposes to reduce both the hatchery and stray proportion in the broodstock

collection by reducing the hatchery contribution during 2003 to no more than 50% of the broodstock collection. Fish will continue to be collected throughout the summer chinook return past Wells Dam through 28 August 2003. The origin in the collection will be consistent with a minimum 1:1 ratio of hatchery and wild origin fish. The 2002 broodstock collection was achieved utilizing just 8 of 27 available trapping days; therefore, a full broodstock collection is likely in 2003

Collection in the manner proposed for 2003 will result in additional summer chinook being handled, consistent with that observed in 2002. While additional fish will be handled, the fish retained for broodstock will be limited to 556 adult summer chinook, consistent with the draft Biological Opinion for the artificial propagation in the Upper Columbia River Basin of non-listed anadromous fish stocks.

Methow/Okanogan 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%
Broodstock required	556

Trap **556**-mixed origin (minimum 1:1 ratio of hatchery and wild), summer chinook at **Wells Dam east ladder**. Collection will be proportional to return timing between 7 July and 28 August. The 3-year old component will be limited to 10% of the broodstock collection to minimize the potential of reduced production as a result of a strong 3-year-old age class, as was the case in 2001.

Columbia River Mainstem below Wells Dam

Wells Hatchery summer chinook programs and assumptions:

Wells program	320,000 yearling smolts
	484,000 sub yearlings
Lake Chelan program	100,000 green eggs
Rocky Reach program	200,000 yearling smolts
	450,000 accelerated sub yearling
	628,000 normal sub yearling
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%
Broodstock required	1,348

Collect up to 1,196 run-at-large summer chinook from the **volunteer ladder trap** at Wells Fish Hatchery outfall. (The 1,196 fish broodstock objective does not include

120,000 yearling smolt production for Grant PUD survival study in 2005. Existing mitigation obligations and facility/operational constraints at Wells Hatchery may preclude continued production of yearling summer chinook for Grant PUD survival studies. Successful discussions between affected parties need to be conducted to address facility and operational constraints prior to additional adult collections for Grant PUD survival studies.

Sockeye

Wenatchee Basin

Lake Wenatchee sockeye 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%
Broodstock required	260

Trap **260** wild sockeye proportional to run timing at **Tumwater Dam**. Due to unequal sex ratio in previous years, attempts should be made to collect an equal number of males and females.

Steelhead

Wenatchee Basin

Wenatchee summer steelhead 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%

Trap **208** mixed origin, steelhead at **Dryden and Tumwater dams**. Consistent with 2001 collection strategy, hatchery x hatchery parental cross, and unknown hatchery parental cross hatchery origin adults will be excluded from the broodstock collection. Hatchery steelhead parental origins will be determined through evaluation of VIE tags during collection. In the event our steelhead collections fall extremely behind schedule, as has been the case in some years due to trap inefficiency at Dryden, WDFW may capture some adult steelhead from the mainstem Wenatchee River by hook and line. Prior to hook and line collections the JFP will be notified. Hook and line collection is consistent with proposed

activities in WDFW=s ESA Section 10 Direct Take Permit Application (#1395) In addition to trapping and hook and line collection efforts, Tumwater Dam may be operated during February- early April period to supplement broodstock numbers if the fall trapping effort provides fewer than 208 adults.

Methow River Basin

Wells Hatchery summer steelhead programs and assumptions:

Methow/Okanogan Program	450,000 yearling smolts (230 adults)
WNFH transfer (Methow R)	125,000 eyed eggs for 100,000 smolts (55 adults)
Ringold transfer (Col. R.)	200,000 eyed HxH eggs for 180,000 smolts (88 adults)
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	97%

Trapping efforts will selectively retain **373-** steelhead at Wells Dam (East and West ladder collection), to attain a 30% wild origin component within the broodstock. Based on an estimated 8,000 steelhead returning to Wells Dam and a 10% wild origin component (approximate 10-year average), 800- wild origin steelhead are expected to return to Wells Dam. A 30% wild origin component within the broodstock (112 fish) would result in approximately 14% extraction of the wild origin component arriving at Wells Dam. Increasing the wild origin component within the broodstock to near 30% will provide opportunities to increase the HxW and WxW parental cross proportion of the BY 2004 production from what has occurred previously under random run-at-large collections. Increasing the number of HxW and WxW parental crosses within the Wells Program is consistent with management objectives described in WDFW's ESA Section 10 Permit 1395 Application and consistent with other upper Columbia River summer steelhead supplementation efforts (Wenatchee Basin). Collection will also be selective for adipose present hatchery origin steelhead (HxW parental crosses), consistent with production objectives. The East and West ladder traps at Wells Dam will be operated concurrently, three days per week, up to 16 hours per day. Trapping on the East ladder will be commensurate with summer chinook broodstocking efforts through 28 August and will continue through 29 October, concurrent with west ladder collections. All steelhead excluded from the broodstock will be directly passed upstream at the trapping site or captured, examined and released upstream from the trap site.

Adult return number/origin, age structure and sex ratio will be assessed in-season (Wells Dam and Priest Rapids Dam), and adjustments to the broodstock collection will be made consistent with the estimated return to Wells Dam, proportion of wild steelhead within the return to Wells Dam and production objectives. Adjustments to the broodstock collection objective may also occur in conjunction with FERC decisions resulting from the Wells HCP. If the FERC authorizes the Wells HCP prior to complete broodstock collection, and stipulate a reduction in DCPUD steelhead mitigation responsibility, the broodstock collection objective may be reduced accordingly.

Coho

Wenatchee and Methow Basin

The 2003 brood year production goals are 1 million smolts for release in the Wenatchee River Basin and 250,000 for the Methow River Basin. Coho returning to the Wenatchee River Basin may be collected at Dryden Dam or Tumwater Dam. In the Methow River, coho will be collected at the Winthrop National Fish Hatchery and possibly at Wells Dam.

Wenatchee River Basin Coho Program and assumptions:

Program	1,000,000 smolts
Propagation survival	60% fertilization to release
Fecundity	2,750 eggs per female
Female to male ratio	46:54
Pre-spawn survival	90%
Adults Required	1,464

Trap 1,464 run at large adult coho at Dryden Dam. If the weekly broodstock collection goal is not attained through trapping efforts at Dryden Dam, adult coho will concurrently be trapped at Tumwater Dam. To maximize genetic diversity, collection will provide a representative sample of returning coho from throughout the run. Based information collected in 2000 and 2001, the first coho are expected to arrive at Dryden Dam during the first week of September and to continue through the first week of December. The peak migration period may occur between mid-October and mid-November.

Between 9/1/03 and 11/14/03, broodstock collection at Dryden Dam will take place concurrently with WDFW steelhead broodstock collection and will be coordinated with Eastbank Fish Hatchery Complex personnel. The Yakama Nation will provide two people (fisheries biologist and/or fisheries technicians) each day during this time period to assist in the operation and collections at the Dryden Dam fish trapping facilities. Between 11/14/2003 and 12/8/2003, Yakama Nation personnel may operate the trapping facility independently of Eastbank Fish Hatchery personnel (if steelhead collections have been met), following a 5- days/week schedule.

During this time period, one biologist and 2-3 technicians will be present each day for collection of Broodstock at Dryden Dam. If steelhead collections are required during the 14 November-08 December period, Yakama personnel will notify WDFW personnel when steelhead appear in the trap and arrangements between staffs will made for WDFW to pick up and transfer the steelhead to Eastbank/Wells Hatchery. If steelhead collection is not required during the 14 November-08 December period, Yakama personnel will provide daily enumeration, and will examine for tags/marks and origin (hatchery/wild) all steelhead and chinook prior to releasing fish upstream from the trap site. Data collected during this period will be forwarded to WDFW weekly.

Coho trapping at Tumwater Dam will also occur for the purpose of a radio-tag evaluation and broodstock collection. Trapping efforts at Tumwater Dam will be coordinated with Eastbank Fish Hatchery personnel (if the facility is being concurrently used for steelhead collection) or may be operated independently by Yakima Nation personnel if steelhead and summer chinook broodstock collection efforts have ceased. Coho trapping operations, outside that required for steelhead or summer chinook broodstock collection periods at Tumwater Dam, may proceed 3 days/week, 16 hours/day between September 1 and December 8, 2003. Trapping will be either active or passive, depending upon the frequency of fish passage and will be consistent with trap holding constraints. In the absence of WDFW trapping activity, Yakama personnel will provide daily enumeration, and will examine for tags/marks and origin (hatchery/wild) all steelhead and chinook prior to releasing fish upstream from the trap site. Data collected during this period will be forwarded to WDFW weekly.

Methow Basin

Methow River Basin Coho Program and assumptions:

Program	250,000 smolts
Propagation survival	70% fertilization to release
Fecundity	2,750 eggs per female
Female to male ratio	29:71
Pre-spawn survival	90%
Adults Required	497

Collect a total of 497 adult coho (combined Winthrop NFH and Wells Dam collections). Collections at Wells Dam will be concurrent with West ladder steelhead collections.

Fall Chinook

Below Priest Rapids Dam

Priest Rapids Hatchery Program Assumptions:	
Production: Grant PUD Mitigation-	5,000,000
John Day Mitigation-	1,700,000
Propagation Survival	87%
Pre-Spawn Survival	88%
Fecundity	4,500
Female/Male Ratio	2:1
Broodstock Required	6,000

Collection of fall chinook broodstock at Priest Rapids Hatchery will generally begin in early September and continue through mid November. All fish retuning to the Priest Rapids Hatchery volunteer channel will be trapped and retained. Broodstock not required for production (primarily males) will be surplused.

Year 2002 Upper Columbia Broodstock Collections and Operations by Trapping Site

Wenatchee Basin

Dryden Dam- 7 July – 8 December 5 days/week

- **Summer chinook**

  Collect **492-** wild origin chinook between 07 July and 12 September 2003. Up to 25% of brood (123 fish) may be taken at Tumwater Dam after 15 August. The 3-year old component will be limited to 10% of the broodstock collection. Broodstock will be held and spawned at Eastbank FH. **The trap will passively collect summer chinook, 5 days/week and 24 hours/day, between 7 July and 12 September 2003.**

- **Steelhead**

  To reach total of 208 mixed origin steelhead (combined with Tumwater Dam or hook and line collections), **the trap will operated passively 5 days/week and 24 hours/day between 7 July and 12 November 2003.** Hatchery x hatchery and unknown hatchery origin adult fish will be excluded from the broodstock collection. Collection may also occur between 13 November and 8 December commensurate with coho broodstock collection activities. Broodstock will be held at Eastbank FH initially, and then transferred to Wells Hatchery for the duration of holding and spawning.

- **Coho**

  To reach a broodstock total of 1,464 coho (combined with Tumwater collections), the trap will operate passively **5-days/week and 24-hours/day between 1 September and 8 December 2003. Trapping between 1 September and 12 November will be concurrent with WDFW steelhead broodstock collections.** The Yakima Nation personnel may operate the Trap between 13 November and 3 December. If WDFW steelhead broodstock collection continues during this period, Yakama personnel will trap and retain steelhead and notify WDFW personnel of retained steelhead. WDFW personnel will coordinate with Yakama personnel to arrange for disposition of steelhead. If WDFW steelhead broodstock collection has ceased, Yakama personnel will provide daily enumerate, and will examine for tags/marks and identify origin (hatchery or wild) all steelhead and chinook trapped and passed upstream of the trap.

Tumwater Dam **1 June – 3 December**

- **Spring chinook**

  Adipose fin clipped spring chinook will be retained as part of the Chiwawa/Nason broodstock, consistent with a 33% wild broodstock composition when combined with fish collected at the Chiwawa River weir. These fish will be marked with an elastomer tag prior to transfer to Eastbank FH for holding and spawning. **The trap will actively/passively collect and retain adipose clipped spring chinook, 3 days/week, and may trap up to 16-hours per day between 1 June and 31 July 2003. Weekly evaluation of spring chinook passage at Tumwater Dam (via video) will determine if trapping will commence prior to 1 June.** If less than 20 salmon (aggregate of Tumwater Dam and Chiwawa River trapping), have been collected by 15 August, all spring chinook held in captivity will be returned to the point of collection for natural spawning.

- **Summer chinook**

  Up to 123 summer chinook may be taken after 15 August to augment the Dryden summer chinook collection as necessary. **The trap will actively collect summer chinook, 3- days/ week and 16- hours/day, between 15 August and 12 September 2002** as necessary to achieve **492** wild origin summer chinook (when combined with broodstock collection at Dryden Dam).

- **Sockeye**

  260 wild origin, run-at-large; target a 1:1 male/female ratio. Broodstock collection will commence after peak passage at Rock Island Dam, but no earlier than 15 July. **The trap will actively collect sockeye, 3- days/week and 16- hours/day, beginning no earlier than 15 July 2003.** Adult broodstock will be held and spawned at Lake Wenatchee Net Pens.

- **Steelhead**

  To reach a total of 208 mixed origin steelhead (when combined with Dryden Dam or hook and line collections), the **Tumwater Dam trap will collect steelhead, 3-days per week, 16- hours/day, between 15 July and 12 November 2003 as needed to meet the 208 fish collection objective.** Collection may also occur between 13 November and 03 December 2008, commensurate with coho trapping activities and from February-early April if a broodstock shortfall occurs. Broodstock will be held at Eastbank initially, and then transferred to Wells Hatchery for the duration of holding and spawning. Hatchery x hatchery and unknown hatchery origin adult fish will be excluded from the broodstock collection.

- **Coho**

To reach a broodstock total of 1,464 coho (combined with Dryden and Dam 5 collections), and for radio telemetry purposes, the trap may operate 3-days/week and up to 16-hours/day, between 1 September and 8 December 2003. Trapping between 1

September and 12 November will be concurrent with WDFW steelhead broodstock collections for steelhead and summer chinook (if the facility is being utilized for that purpose), otherwise, the Yakima Nation, independent of WDFW, will operate the trap. Regardless of the trap operators, the trap will operated no more than 3-days/week and up to 16-hours/day. Dependent upon the frequency of fish passage, the trap may be operated actively or passively during coho broodstock collection (i.e. consistent with holding capacity of the trap).

Chiwawa Weir **June 1 – September 13** **4 days/week**

- **Spring chinook**
  Retain up to 379 spring chinook (combined Chiwawa River/Tumwater Dam collections). Adult collection will maintain, at a minimum, 33% wild origin fish. Collection of hatchery origin fish will be dependent upon hatchery origin collection numbers at Tumwater Dam. If the sex ratio is skewed toward females, in-season adjustments will be made to reduce the total broodstock collection, consistent with the 672,000- smolt production objective. **The Chiwawa weir will trap 24-hours/day, 4 days up and 3 days down, between 1 June and 13 September 2003,** maintaining a consistent schedule to ensure unimpeded escapement upstream. **If Tumwater Dam videotape review indicates spring chinook passage at Tumwater Dam prior to 1 June, trapping at Chiwawa will commence within 48 hours**. Spring chinook retained will be transferred to Eastbank FH for holding in cool well water. In the event that hatchery origin fish are required to be released, to maintain the 1/3 wild proportion, they will be transported by tank truck to a release point located upstream from the weir and released.

Spring chinook target **not to exceed 379 mixed origin, fish from Chiwawa and Tumwater Dam**. If less than 20 salmon have been collected by 15 August (aggregate of Tumwater and Chiwawa River sites), trapping will be terminated and all spring chinook held in captivity will be returned to the point of collection 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.

Methow Basin

Foghorn Dam **1 May - 27July** **7-days/week**
Operate passively, 7-days/week, checked once daily.

- **Spring Chinook**
  Retain only adipose present and age-3 hatchery origin spring chinook.
  All fish collected at Foghorn Trap will be held at the Methow FH.

Fulton Dam **1 May - 27 July** **7 days/week**
Passive operation, 24-hours a day, checked minimum of twice daily.

- **Spring chinook**
  Retain up to 33% of spawning escapement, in aggregate with Chewuch Dam collections (approximately 51 fish). All fish will be held at the Methow FH.

Chewuch Dam **1 May- 27 July** **7 days/week**

- Spring chinook
  Retain up to 33% of spawning escapement in aggregate with Fulton Dam collections (approximately 51 fish). All fish will be held at the Methow FH.

Twisp Weir **1 May - 27 July** **7 days/week**
Passive operation 24-hours a day. 24-hour observation required.

- **Spring Chinook**
  Collect up to 33% of the projected return to the Twisp River (approximately 31 fish.)

Methow FH **1 May-27 July** **Variable Trapping**

- **Spring Chinook**
  Trap at the Methow FH outfall. Collection may provide up to 352 adult spring chinook (combined Twisp, Fulton, Chewuch Dam, Foghorn Dam and Methow FH collections). Trapping will be variable and dependent upon success of tributary collections, Twisp captive brood program and will consistent with Methow basin management objectives (reduced Carson origin in Methow Composite production, preserve and enhancement of Chewuch and Twisp River populations and full facility production).

Winthrop NFH-

- **Spring Chinook**

  Trap consistent with USFWS protocols

- **Coho**

  Trap 497 adult coho from the Winthrop NFH outfall (in combination with Wells Dam collections).

Columbia River

Wells Dam **7 July – 29 October**
East Ladder Active trapping 16-hours/day on a Monday-Wednesday schedule

- **Methow/Okanogan summer chinook**
  Selectively retain **556 summer chinook** between 7 July and 28 August for transfer to and holding/spawning at Eastbank FH. The trap will operate 3 days/week, 16-hours a day with the ladder open to passage at night between **7 July - 28 Aug. 2003.** Collection will maintain, at a minimum, **50% wild origin** fish in the broodstock. **The 3-year old component, will be limited to 10% of the broodstock total.**

- **Steelhead**
  Selectively retain wild origin steelhead and hatchery steelhead to meet weekly collection objectives (aggregate collection with west ladder). Trapping will be commensurate with summer chinook broodstock collection (7 July - 28 August). During post summer chinook broodstock collection (29 August – 29 October), trap concurrent with the west ladder schedule and coordinate with west ladder collections (daily) to achieve a 30% wild composition and meet the weekly collection objectives. Trapping will limit the collection to steelhead with an intact adipose fin. Steelhead trapped will be anesthetized and examined for tags/marks and dorsal fin condition to assess hatchery/wild origin. All fish released will be fully recovered from anesthesia prior to release.

Wells Dam

West Ladder **4 August - 29 Oct. 3 days/week**

Active trapping 16-hours/day on a Monday-Wednesday schedule

- **Steelhead**

  Selectively collect **373 mixed origin fish (aggregate collection with the east ladder)**, to attain a 30% wild origin component (112 fish) within the broodstock retained. **The trap will operate in an active mode 3 days/week (Monday-Wednesday), 16 hours/day, between 4 August and 29 October 2003.** 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.

- **Coho**

  Collect at Wells Dam on an as- need- basis to meet broodstock collection objective. Collection will be concurrent with steelhead collection at the West ladder trap.

Wells FH - 14 July – 28 August

- **Summer chinook**

  Collect **1,196 salmon, including jacks,** to satisfy Wells FH and Turtle Rock FH programs. The trap will operate continuously between 14 July and 28 August 2003, as required to achieve broodstock collection. The 3-year old component will be limited to 10% of the broodstock total. 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.

Priest Rapids Hatchery

- **Fall Chinook**

  Collect fall chinook returning to the Priest Rapids Hatchery volunteer collection site beginning early September and continuing through mid November. Target 6,000 adults for spawning purposes.

SUMMARY OF BYPASS OPERATIONS AT WELLS DAM, 2003

APPENDIX C

Memorandum

TO: Wells Coordinating Committee
FROM: Rick Klinge, Douglas PUD
DATE: August 29, 2003
SUBJECT: Summary of Bypass Operations at Wells Dam, 2003

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Flows in the Columbia River were below average for 2003. At Wells Dam, all ten units were ready and available during the most of the bypass operations. Replacement of breakers in the switchyard created times when only eight units were available. This season, the highest hourly discharge occurred on June 11 at 1600 hours with 225 kcfs.

The 2003 outmigration was from brood year 2001 for the spring migration and brood year 2002 for the summer migration. Spring chinook natural escapement was unusually large in 2001 with a natural escapement (Wells Count minus hatchery broodstock) of 9,997 fish. Sockeye escapement was the largest in recent time with 74,490 adults returning to Wells in 2001. Natural escapement of summer / fall chinook in 2002 was also extremely large with a combined escapement of 69,095 fish above Wells Dam.

The operation of the bypass in 2003 was set at the agreed HCP dates of staring on April 12 through August 26. In the past hydroacoustics and fyke netting have provide information on real time data of the fish migration. The fixed dates were established from 21 years of hydroacoustic and 14 years of species composition information collected on juvenile run patterns at Wells Dam. Generally the bypass operation is divided into a spring and summer period. The end of the spring period was set at June 13 at 2400 hours. The summer bypass stared on June 14 at 0000 hours.

The spring bypass operated for a total of 63 days and with a total discharge of 1.0 MAF, or 6.5% of total project discharge. During the spring bypass operation, there was forced spill during 24 hours or 2% of the time.

Summer bypass started on June 14 at 0000h and ran until August 26 at 2400h, for a total of 74 days. There was 1.1 MAF or 6.6% of the total discharge dedicated to summer bypass. During the summer operation, there were 57 hours (3.2%) that had forced spill.

C: Wells HCP Coordinating Committee

WELLS DAM ADULT PIT-TAG INTERROGATION SYSTEM EVALUATION

APPENDIX D

WELLS DAM
ADULT PIT-TAG INTERROGATION SYSTEM EVALUATION

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March 12, 2004

BACKGROUND

The Public Utility District of Douglas County (Douglas PUD) owns and operates the Wells Dam on the Mid-Columbia River (Figure 1). Presently, three important species of anadromous Pacific salmon (*Oncorhynchus spp.*) are found in the waters above the projects. They include, by numerical dominance, sockeye (*O. nerka*), chinook (*O. tshawytscha*) and steelhead (*O. mykiss*).

In 1997, NOAA Fisheries listed Upper Columbia River (UCR) steelhead as endangered under the Endangered Species Act (ESA). In 1998, UCR spring-run chinook were similarly listed as endangered under the ESA. The presence of ESA listed stocks at the Wells Project required NOAA Fisheries to conduct a Section 7 consultation on project operations that have the potential to affect the survival and long-term reproductive fitness of listed spring chinook and steelhead.

NOAA Fisheries initiated this Section 7 consultation in 1999 and concluded in 2000 with the preparation of a final Biological Opinion (BO) for the Wells Project (issued on June 18, 2000). Conservation Recommendation 11.3 in the Wells BO recommended that Douglas PUD develop and install an adult PIT-tag interrogation system in the fishways at Wells Dam.

Fortunately, portions of the Wells adult fish ladders were designed without the inclusion of overflow sections and instead each weir in the upper control section of the ladder contained two large submerged orifices. The lack of overflow sections and the presence of mid-weir passage orifices presented the District with a unique opportunity to interrogate 100% of the adult fish migrating through each control weir without having to substantially modify the existing fishway weir structures.

The 2002 Wells PIT interrogation system used a set of precisely wrapped PIT-tag coils surrounded by an internal and external waterproof shield

constructed of a rigid polycarbonate material. The dimensions of the coil can be found in Figures 2a and 2b. Each coil and associated shield was attached to the upstream face of an orifice (Figure 3). Each coil was designed to surround but not interfere with the function of the selected orifice. Each weir has two orifices and hence two coils. For 2002, each of the two fish ladders had two weirs equipped with PIT detection coils (Figure 4). A total of 8 coils were installed at Wells Dam during the winter of 2001-2002. In each of the two ladders, Pools 67 and 68 were selected as the most appropriate control weirs for the system to be installed.

METHODS

Following the installation of the prototype adult PIT-tag interrogation system, Douglas PUD consulted with the Wells Coordinating Committee (WCC) regarding ways to evaluate the detection efficiency of the newly installed interrogation system. The final study plan was approved by the WCC in May of 2002 and included four evaluation goals. Goals of the evaluation included:

1. Estimating the detection efficiencies for adult sockeye PIT-tagged at Wells Dam,
2. Estimating the detection efficiencies for run-of-river adult fish that were either PIT-tagged as juveniles or PIT-tagged as adults at Bonneville Dam,
3. Determining whether there were species specific differences in the detection efficiencies of the Wells adult PIT system,
4. And determining whether the adult PIT-tag interrogation system impeded or substantially altered adult fish passage through the upper fishway.

Study Design

Similar to adult PIT-tag evaluations conducted at Bonneville Dam in 2001 (Lady and Skalski, 2001), the 2002 Wells adult PIT-tag interrogation system evaluation utilized both on-site and run-of-river PIT-tagged adult fish. The following section outlines the statistical methodologies used to estimate detection efficiencies for PIT-tagged adult fish migrating through the fishways at Wells Dam.

Estimating Detection Efficiency

Mark-Recapture Model

All adult salmon and steelhead migrating through the adult fish ladders at Wells Dam were required, by design, to pass through PIT-tag interrogation coils located on control weirs 67 and 68. No overflow sections were present at these two weirs and as such, 100% of the upstream migrating fish are available to be sampled by the interrogation coils. As such, it was reasonably expected that detection probabilities are independent between weirs. The potential influence of fish behavior on the assumptions of independence was minimized by the physical layout of the detection system. The overall probability of detection (P) at a ladder can then be expressed as

$$P = 1 - (1 - p_{67})(1 - p_{68}) \qquad (1)$$

where

p_{67} = probability of detection at weir 67,

p_{68} = probability of detection at weir 68.

The detection histories of the adult PIT-tagged salmon at the two weirs can then be used to estimate the probabilities p_{67}, p_{68} and subsequently, the overall detection probability P.

Based on the Peterson/Lincoln single mark-recapture model, the detection probabilities at the individual weirs can be estimated as

$$p_{67} = \frac{m}{n_2} \tag{2}$$

and

$$p_{68} = \frac{m}{n_1} \tag{3}$$

where

n_1 = total number of PIT-tagged adult salmon detected at the first weir (i.e., 67);

n_2 = total number of PIT-tagged adult salmon detected at the second weir (i.e., 68);

m = number of PIT-tagged adult salmon detected at both weirs (i.e., 67 and 68).

Combining Equations (2-3) with Equation (1) yields an estimator for the overall detection probability of

$$\hat{P} = \frac{n_1 n_2 - (n_1 - m)(n_2 - m)}{n_1 n_2}. \tag{4}$$

The likelihood model that describes the detection histories at the two weirs can be written as

$$L(p_1, p_2 | n_{11}, n_{10}, n_{01}) =$$

$$\binom{r}{n_{11}, n_{10}, n_{01}} \left(\frac{p_1 p_2}{1-(1-p_1)(1-p_2)}\right)^{n_{11}} \left(\frac{p_1(1-p_2)}{1-(1-p_1)(1-p_2)}\right)^{n_{10}} \left(\frac{(1-p_1)p_2}{1-(1-p_1)(1-p_2)}\right)^{n_{01}} \tag{5}$$

or equivalently

$$\binom{r}{n_1, n_2, m} \left(\frac{p_1 p_2}{1-(1-p_1)(1-p_2)}\right)^{m} \left(\frac{p_1(1-p_2)}{1-(1-p_1)(1-p_2)}\right)^{n_1-m} \left(\frac{(1-p_1)p_2}{1-(1-p_1)(1-p_2)}\right)^{n_2-m}$$

where

n_{11} = number of PIT-tagged adults detected at both weirs 67 and 68,

n_{10} = number of PIT-tagged adults detected at weir 67 but not 68,

n_{01} = number of PIT-tagged adults detected at weir 68 but not 67,

$r = n_{11} + n_{10} + n_{01} = n_1 + n_2 - m$.

Likelihood model (5) was used to calculate the variance of $\hat{P}$ as well as to construct a profile likelihood confidence interval for P. Separate analyses were performed for each of the two fish ladders at Wells Dam. Separate analyses were also be performed for each species and each of the two sockeye mark groups (on-site and run-of-river).

Travel Time Between Weirs

The forth goal of the evaluation was to ensure that the placement of the adult PIT interrogation coils around the adult fish passage orifices did not impede the upstream migration of adult salmon and steelhead. For this evaluation, travel time between weir 67 and 68 was defined as the time from the first detection at the lower weir to the last detection at the upper weir. For adult fish that traversed the ladders multiple times, only the first event was used. First, the PIT-tag interrogation records collected from weirs 67 and 68 were compared and the travel times between coils calculated. Rates of travel were separately reported for both ladders, for each of the four species of fish and for both sockeye study groups (on-site and run-of-river). The results of this evaluation were compared with the average per-weir travel time for adult salmon and steelhead observed in the upper fishways at Wells Dam.

Delay

In order to provide in-season monitoring of the affects of the PIT-tag system on the run at large, daily inspections of the PIT-tag interrogation weirs were conducted by District staff. In particular, District staff was instructed to report any unusual observation of fish either stacking-up downstream of the PIT coils or jumping in the vicinity of the detection systems. In addition, fish counting personnel were also instructed to keep records of fish dropping back downstream through the video counting stations and to compare the 2002 downstream counts with downstream counts from years prior to the system being installed.

Qualitative Observations

Douglas PUD requested that Biomark Inc. provide a qualitative summary of observation collected during the 2002 PIT-tagged fish migration at Wells Dam. The adult PIT qualitative summary was not part of the formal evaluation of the Wells adult PIT-tag interrogation system, however because the information collected by the Wells system was of particular interest to many Columbia River fish managers, the qualitative summary has been attached to this report as Appendix A.

RESULTS

Detection Efficiency: On-Site Releases

The original PIT-tag evaluation system study plan outlined a goal of tagging a minimum of 400 fish at Wells Dam in an effort to ensure sufficient sample size for the evaluation. Fortunately, an unexpectedly large number of adult PIT-tagged run-of-river fish showed up at Wells Dam in 2002. Because a large portion of these additional PIT-tagged fish originated from mainstem survival studies at downstream hydroelectric projects, their arrival at Wells

Dam, in such large numbers, was not anticipated during the development of the study plan. The presence of these fish substantially increased the sample size for the PIT-tag system evaluation and subsequently reduced the need to continue tagging sockeye at the left bank ladder trap.

In total, one-hundred-eighty-nine (189) adult sockeye salmon were tagged and released back into the left bank ladder at Wells Dam. Because of the potential for fallback (fish "falling" further downstream after progressing past a detector), the detection history for the left bank was looked at for length of time from being anesthetized, tagged and released to detection at a weir, length of time between detections at consecutive weirs, and the order of detection at weirs.

Of the fish detected at both detection sites, most (98%) were detected at the lower weir within 2.4 hours after being tagged (0.10 days), with only three fish displaying a travel time of greater than 2.4 hours (2.7, 3.0, and 7.4 hours) to reach the first weir. Four fish were detected at the upper weir only (0.156, 0.723, 0.857, and 4.936 days after release), and one fish at the lower weir only (0.669 days after release). None of these fish were detected later at the right bank, and are assumed to have been traveling upstream without falling back. Twenty-four of the on-site tagged fish were detected in the right bank of Wells Dam, with all twenty-four of these fish being detected in the right bank ladder at least 24-hours after release in the left bank ladder.

Table 1: Numbers used in estimation of detection efficiency at Wells Dam.

Total adult fish (sockeye) tagged	189
Total detected at **first** weir, left bank	155
Total detected at **second** weir, left bank	158
Total detected at **both** weirs, left bank	154

The detection efficiency for on-site tagged sockeye passing through the left bank ladder was 0.9998 (Table 2) with a 95% confidence interval of (0.9990–1.0000).

Table 2: Numbers used in estimation of detection efficiency at Wells Dam.

Parameter	Estimate (standard error)	Profile likelihood 95% confidence interval
$\hat{p}_1$ at first weir	0.9747 (0.0125)	
$\hat{p}_2$ at second weir	0.9935 (0.0064)	
Overall $\hat{P}$	0.9998	(0.9990, 1.0000)

Detection Efficiency: Run-of-River Fish

The detection histories of run-of-river migrating adult salmon and steelhead, not part of the on-site tag-release study, are tabulated in Table 3. Each bank of weirs was looked at separately, with 734 unique fish detected in the left bank, and 581 in the right bank. Although the majority of these fish appear to enter an adult ladder only once, there were a number of "fallbacks and redetections" – instances where a fish was redetected days or even months later than the initial detection. These secondary and (more rarely) tertiary ladder detections were considered legitimate events and included in the analyses, increasing the total number of histories to 828 for the left bank and 632 for the right bank. As there were not enough detections to obtain detection probabilities for all combinations of species, run and rearing type, the histories were pooled for four species: chinook (spring and summer), steelhead, sockeye, and coho (Table 4). There were not enough detections for an estimate of detection probabilities for fall chinook.

Two assumptions were made in determining the detection history of each fish: 1) the fish detected was traversing the adult ladder in an upstream direction, and 2) fish continued upstream after being detected at the

downstream weir. These two assumptions were necessary to determine the "10" (detected downstream but not upstream) and the "01" (detected upstream, but not downstream) histories. The first assumption was very likely, as the probability of an adult fish entering an adult ladder at its upstream exit point was very small. The second assumption, while not as strong, was more conservative, and did not appear to affect the estimate of over-all probability of detection.

Table 3: Detection histories used in estimation of detection efficiency for each bank of Wells Dam, in-river adults. "11" indicated detection at both weirs, "10" detection at downstream weir only, "01" detection at upstream weir only. Species-Run-Type codes were PITAGIS designations.

	Left Bank Detection History			Right Bank Detection History		
Species-Run-Type	11	10	01	11	10	01
11H	11	0	0	17	0	0
11U	67	3	10	34	2	1
12H	498	5	44	284	15	6
Pooled Chinook	**576**	**8**	**54**	**335**	**17**	**7**
13H	--	--	--	1	0	0
13U	1	0	0	3	1	0
15H	7	0	0	9	0	0
15U	6	0	0	2	0	0
21U	2	0	0	3	0	0
23H	2	1	0	9	0	0
Pooled Coho	**4**	**1**	**0**	**12**	**0**	**0**
32H	124	3	15	210	8	3
32W	2	2	0	6	0	0
Pooled Steelhead	**126**	**5**	**15**	**216**	**8**	**3**
42U	3	0	0	4	0	0
45U	15	0	0	11	1	0
45W	7	0	0	1	1	0
Pooled Sockeye	**25**	**0**	**0**	**16**	**2**	**0**

The probability of detection for each of the four main anadromous fish stocks were separately estimated to ensure that subtle behavior differences (e.g. approach trajectories and swimming performance) between stocks did not appreciably alter the results of the evaluation. Probability of detection for each species of run-of-river fish was estimated using the same methodology as the on-site release study. A summary of the per species detection probabilities can be found in Table 4. The overall probability of detection for an adult PIT-tagged fish in each fish ladder (bank) was very high (left bank: 0.9959—1.0000; right bank: 0.9990—1.0000) and exceeded the preseason objective of 0.9800.

Table 4: Estimated detection efficiency at Wells Dam. Standard errors were not estimable when the probability of detection was 1.0.

Left Bank

	Detection Estimates (standard error) on pooled:			
Parameter	Chinook	Coho	Steelhead	Sockeye
$\hat{p}_1$ at first weir	0.9143 (0.0112)	1.0000 (0.4996)	0.8936 (0.0260)	1.0000 (NA)
$\hat{p}_2$ at second weir	0.9863 (0.0047)	0.8008 (0.1952)	0.9618 (0.0167)	1.0000 (NA)
Overall $\hat{P}$	**0.9988**	**1.0000**	**0.9959**	**1.0000**
profile likelihood 95% confidence interval on $\hat{P}$	(0.9977, 1.0000)	NA	(0.9899, 1.0000)	NA

Right Bank

	Detection Estimates (standard error) on pooled:			
Parameter	Chinook	Coho	Steelhead	Sockeye
$\hat{p}_1$ at first weir	0.9795 (0.0077)	1.0000 (NA)	0.9863 (0.0079)	1.0000 (NA)
$\hat{p}_2$ at second weir	0.9517 (0.0114)	1.0000 (NA)	0.9643 (0.0124)	0.8889 (0.0787)
Overall $\hat{P}$	**0.9990**	**1.0000**	**0.9995**	**1.0000**
profile likelihood 95% confidence interval for $\hat{P}$	(0.9978, 1.0000)	NA	(0.9984, 1.0000)	NA

Travel Time Between Weirs

Rates of travel between interrogation weirs were determined and were provided to help fisheries managers assess whether the design of the weirs in the adult ladders hampered adult fish passage. Figures 6 and 7 show the distribution of the travel times of adults detected at both downstream and upstream detection sites.

Table 5 lists the summary statistics by species for each bank of adult ladders. The majority of the adult fish (75%) for three species in the left bank and all four species in the right bank were estimated to have traversed through both weirs in less than 4 minutes. Seventy-five percent of the sockeye in the left bank traversed in 11.6 minutes or less. Travel time distributions were skewed by a small number of fish with very large travel times, creating large differences between median and mean travel times. While most instances of protracted travel time between detections were obviously separate travel events (i.e. greater than 2 days), there were a few fish that could not be automatically placed in this category.

Table 5: Summary statistics for the travel times (in minutes).

Left Bank	Chinook	Coho	Steelhead	In-River Sockeye	On-Site Sockeye
Number detected at both weirs	498	4	125	25	154
Minimum	0.150	0.667	0.017	0.333	0.317
1st quarter	0.600	0.917	0.350	1.583	3.050
Median	1.642	1.325	0.983	5.183	6.509
Mean	11.390	1.521	2.496	8.836	24.768
3rd quarter	2.867	1.929	2.050	11.567	17.525
Maximum	1,124.000	2.767	102.233	53.133	589.483

Right Bank	Chinook	Coho	Steelhead	In-River Sockeye
Number detected at both weirs	293	12	212	16
Minimum	0.167	0.167	0.050	0.283
1st quarter	0.517	0.363	0.433	0.571
Median	1.350	0.792	0.892	1.675
Mean	13.249	1.772	2.760	11.395
3rd quarter	3.300	2.279	2.292	3.696
Maximum	1,541.767	9.133	65.350	133.217

The rates of travel time observed during 2002 were comparable to the median rates of travel observed for radio-tagged chinook, sockeye and steelhead during ladder passage studies conducted at Wells. Table 6 contains median per weir fishway passage rates calculated from studies conducted by English et al. (2001), English et al. (1998) and Stuehrenberg, et al. (1995)

Table 6: Median per weir travel times (in minutes) for radio-tagged fish passing through the fishways of Wells Dam in 1993, 1997 and 1999.

Left Bank	Spring Chinook	Summer Chinook	Steelhead	Sockeye
Median	1.88	2.42	1.92	2.87
Right Bank	Spring Chinook	Summer Chinook	Steelhead	Sockeye
Median	1.97	2.33	1.94	1.34

Delay

In addition to monitoring the travel time for fish moving between weir 67 and 68, Douglas PUD personnel conducted daily inspections of the fishway pools immediately downstream of the PIT-tag coils. No discernable accumulation of fish downstream of the installation was apparent during any of the daily inspections. No jumping of fish in the immediate vicinity of the adult PIT-coil system was observed.

Personnel monitoring the video fish counting stations located one weir downstream of each PIT-tag interrogation system also did not observe a significant accumulation of fish in the counting station window pool or an increase in the number of fish falling back downstream of the adult fish counting windows in 2002 compared to observations collected prior to the installation of the adult PIT-tag interrogation system.

SUMMARY

The 2002 PIT-tag interrogation system was installed at Wells Dam to fulfill Conservation Recommendation 11.3 in the 2000 Wells BO. The 2002 system evaluation utilized 189 sockeye PIT-tagged on the east ladder of Wells Dam and was augmented by an unexpected large return of 1,315 unique run-of-river PIT-tagged adult salmon and steelhead. During the 2002 fish migration, the adult PIT-tag interrogation system detected 1,460 run-of-river passage events for run-of-river fish and 176 unique detections of adult sockeye tagged at Wells.

Because of the large samples sizes attained by the study, all four goals of the 2002 evaluation were achieved with a high level of resolution. The detection efficiency for on-site tagged sockeye passing through the left bank ladder was 0.9998 (Table 2) with a 95% confidence interval of (0.9990—1.0000). The overall detection probability for an adult PIT-tagged fish passing over Wells Dam was also correspondingly high (left bank: 0.9959—1.0000; right bank: 0.9990—1.0000). The probability of detection for an adult PIT-tagged chinook, coho, steelhead and sockeye in each fish ladder was also consistently high and ranged from 0.9977 - 1.0000 for chinook, 1.0000 for coho, 0.9899 - 1.0000 for steelhead and 1.0000 for sockeye.

The detection efficiencies for run-of-river fish, on-site tagged sockeye and for all four fish species evaluated (chinook, coho, steelhead and sockeye) were not significantly different from one another or between the ladders examined. In all cases, the detection efficiency estimates exceeded the preseason evaluation objective of 98%.

No evidence of increased fallback at the fish counting stations and no observed accumulations of fish downstream of the adult PIT systems were noted by project personnel or fish counting staff in 2002.

Median travel time between weirs on the left and right bank ladders ranged from 1.642 to 1.350 minutes for chinook, 1.325 to 0.792 minutes for coho, 0.983 to 0.892 minutes for steelhead, 5.183 to 1.675 minutes for run-of-river sockeye and 6.509 minutes for left bank tagged sockeye. The per weir travel time for PIT-tagged fish observed after the installation of the adult PIT-tag system were very similar to the per weir travel times observed during radio-telemetry studies conducted prior to the installation of the adult PIT-tag system, with one exception. Per weir travel times for left ladder detected sockeye were longer in 2002 than from sockeye detected in the right bank ladder and were longer than the per weir travel times observed during the 1997 radio-telemetry study. No explanation for the left bank ladder sockeye observations were available at the time of reporting.

Based upon the data collected and analyzed during the 2002 evaluation, and given the existing uses of the data being collected from the system, there does not appear to be a need to either modify or expand the existing adult PIT-interrogation system at Wells Dam. During the 2003 migration season, Douglas PUD staff will continue to monitor sockeye passage rates through the left bank ladder weirs through the use of passive monitoring tools (underwater video cameras and PIT-tag detections). Results will be reported to the Wells Coordinating Committee as soon as they become available.

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L. C. Stuehrenberg, G. A. Swan, L. K. Timme, P. A. Ocker, M. B. Eppard, R. N. Iwamoto, B. L. Iverson and B. P. Sandford. 1995. Migrational characteristics of adult spring, summer and fall chinook salmon passing through reservoirs and dams of the Mid-Columbia River.

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



Figure 2a. Plan View of an adult PIT-tag interrogation coil similar to the one installed on the orifices of fishway weirs 67 and 68 at Wells Dam, 2002.

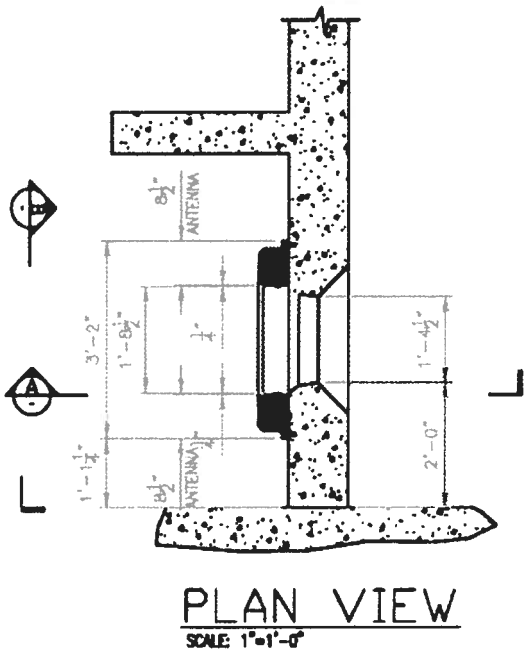


Figure 2b. Side View of an adult PIT interrogation coil similar to the one installed on the orifices of fishway weirs 67 and 68 at Wells Dam, 2002.

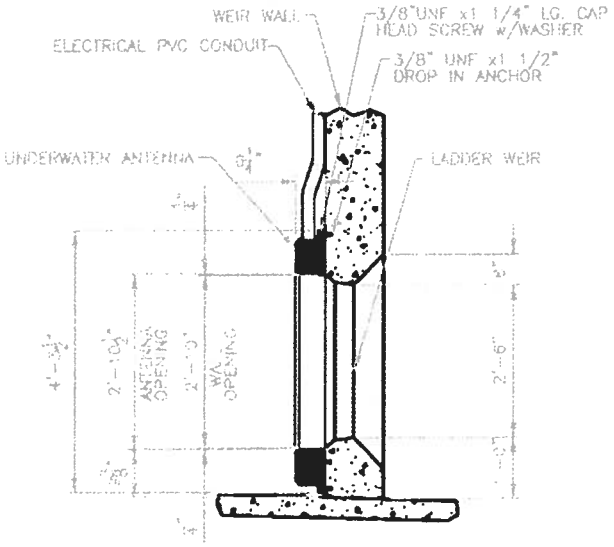


Figure 3. Upstream view of an adult PIT interrogation coil located on weir 67 on the east ladder of Wells Dam, 2002.

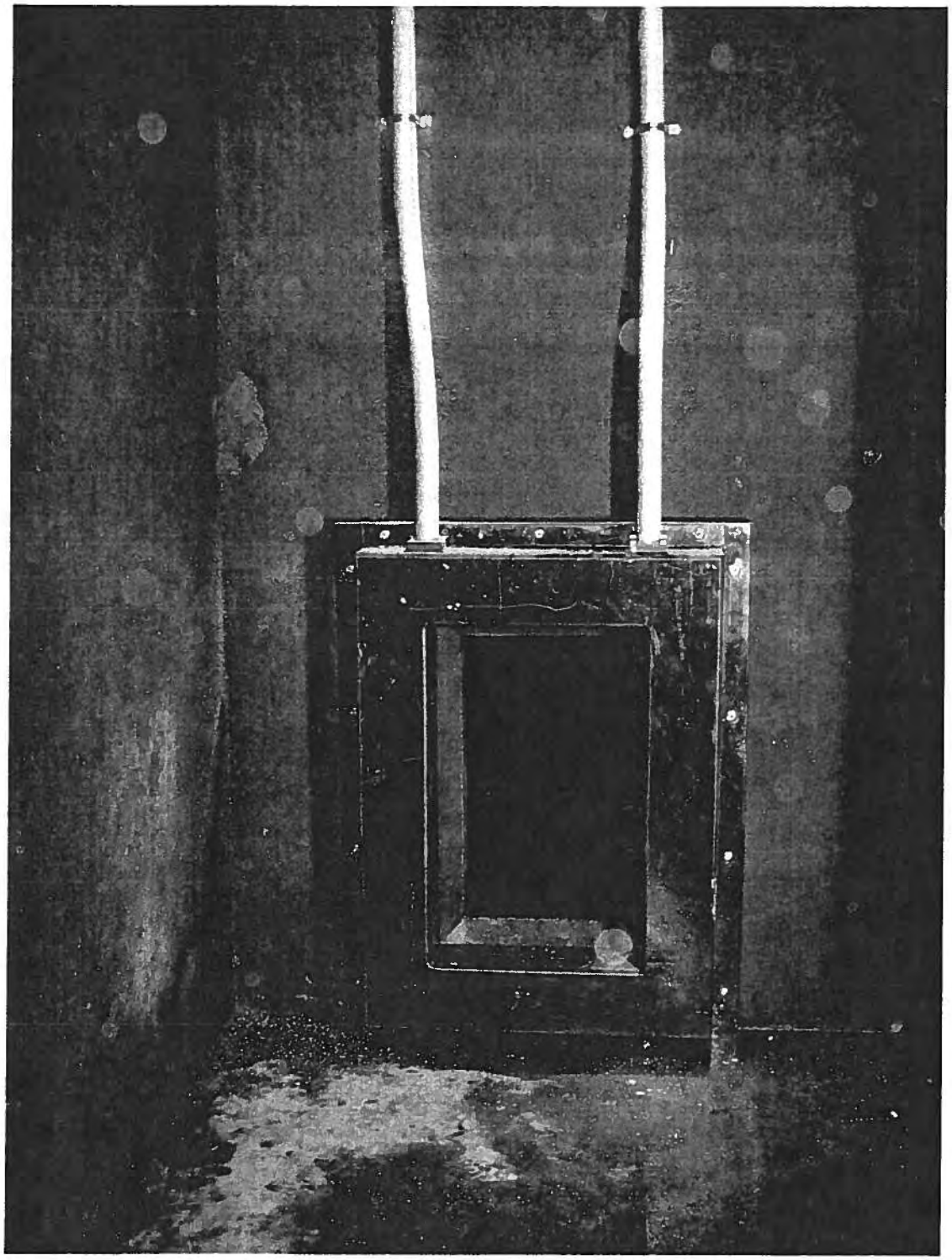


Figure 4. Side by side installation of two adult PIT-tag interrogation coils located on weir 67 of the east fish ladder at Wells Dam, 2002.

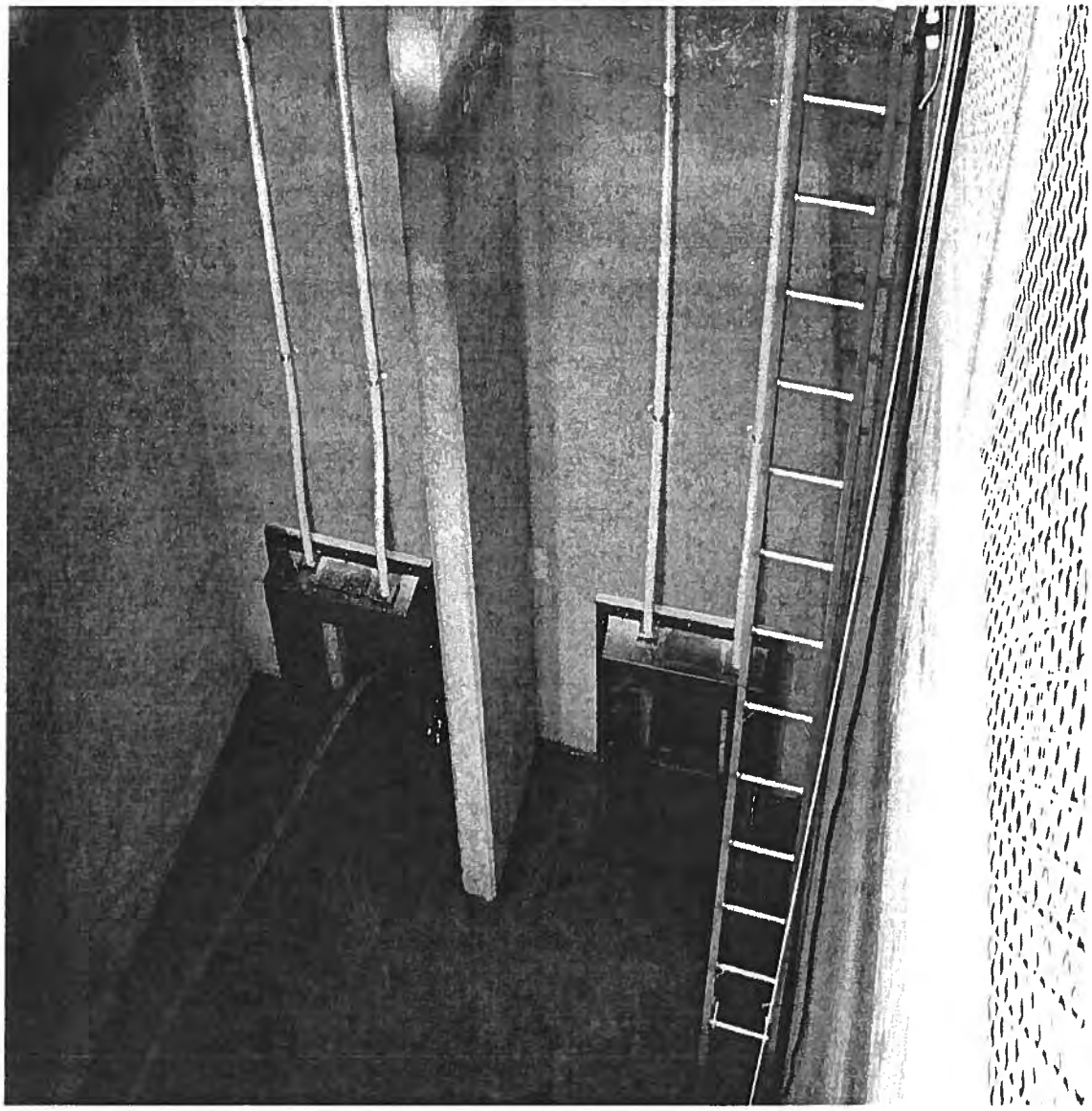


Figure 5. Proposed PIT-tagging technique for adult anadromous salmonids (adapted from: Biomark, Inc. 1999).

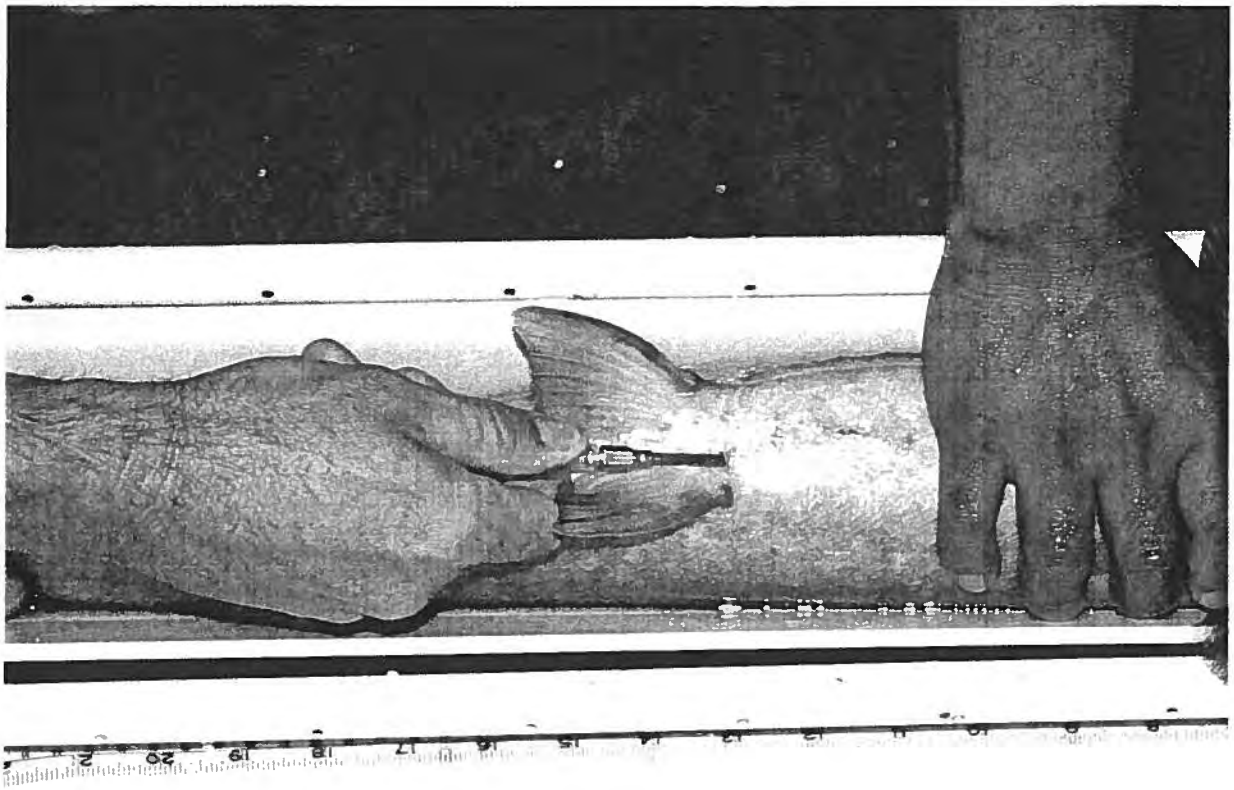


Figure 6. Travel time distributions through the left bank adult ladder at Wells Dam for each species. The x-axis is the total time from first to last detection, the y-axis is the percent of travel times that fall into that travel time range.

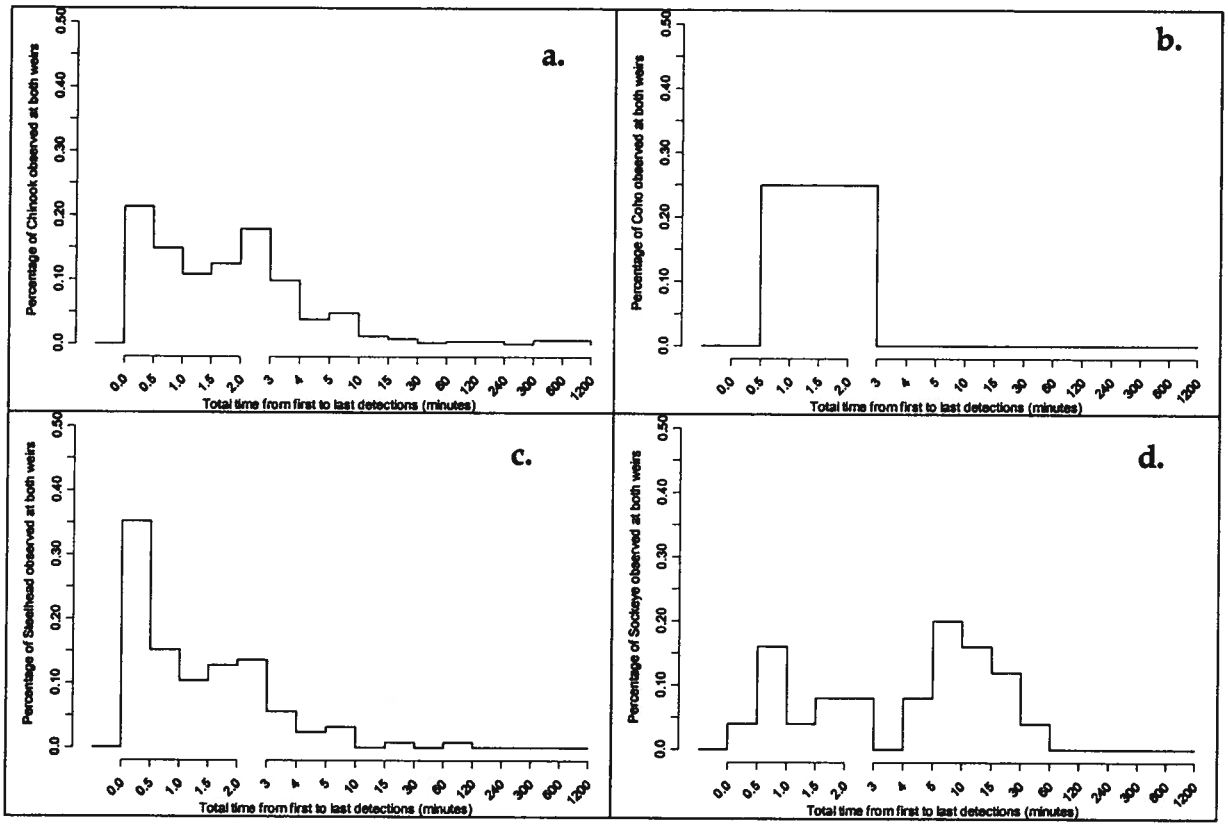
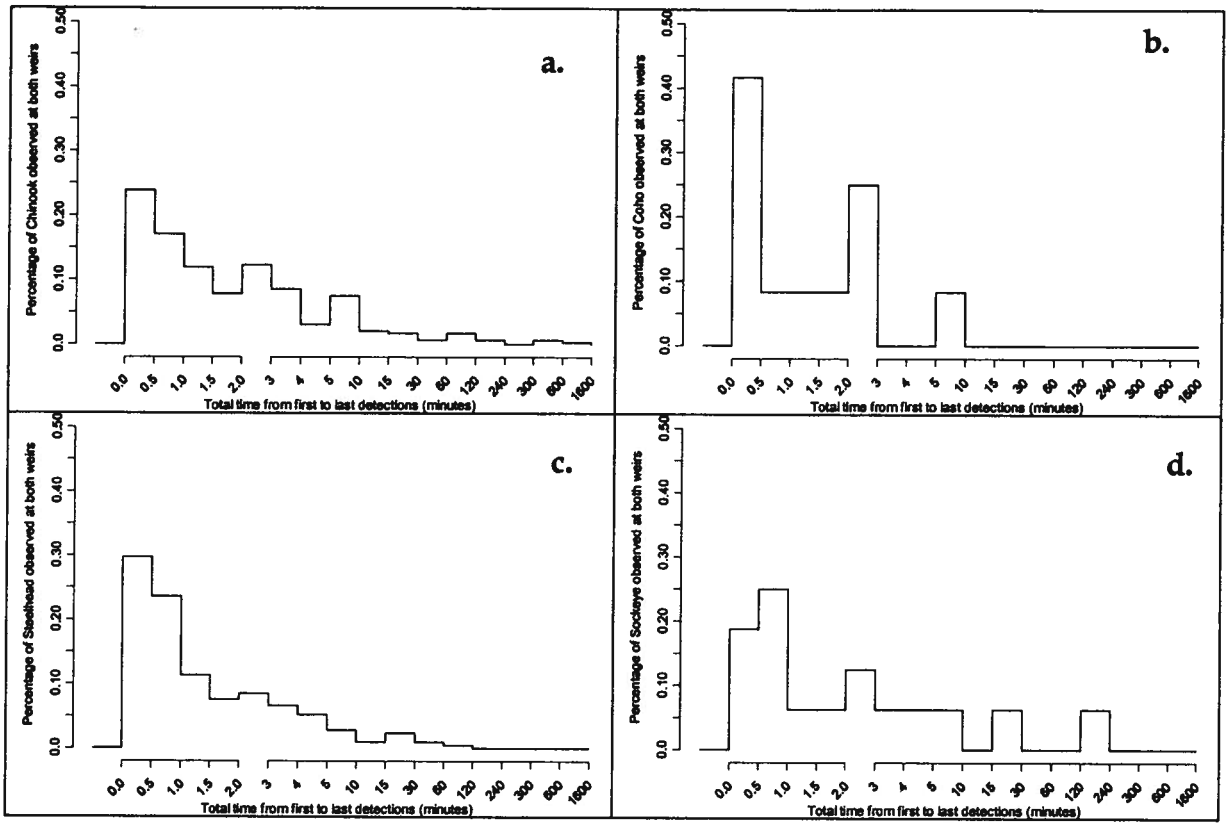


Figure 7. Travel time distributions through the right bank adult ladder at Wells Dam for each species. The x-axis is the total time from first to last detection, the y-axis is the percent of travel times that fall into that travel time range.



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APPENDIX A

EXPLORATION OF PIT TAG DATA COLLECTED FROM WELLS DAM ADULT LADDER ANTENNAS IN 2002

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April 2003

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Figure 3. Arrival date at McNary Dam and median travel time (days) from McNary Dam to Wells Dam for spring chinook salmon released above or below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group. 10

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Figure 5. Arrival date at McNary Dam and median travel time (days) from McNary Dam to Wells Dam for summer chinook salmon released above or below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group. 11

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Introduction

PIT tag antennas, at adult passage routes within the Columbia River Basin, provide for an efficient means to determine characteristics such as adult passage rates, travel times, migration history, site fidelity, and smolt-to-adult survival. Fisheries managers and scientists can use these data to evaluate and guide their respective anadromous fish programs. The resolution of the various passage characteristics will be increased as more dams in the basin are equipped with adult detection capability.

Beginning on 29 March 2002 complete coverage for adult PIT tag detection was available at both Wells Dam adult fish ladders. The purpose of this report is to analyze the records of adult salmonids detected at Wells Dam in 2002 to provide a general summary of the number of fish and species detected and summarize the various passage characteristics.

Methods

Data used for this investigation were obtained from PIT tag antennas at the Wells Dam left and right adult ladders from 21 March through 15 November 2002. Summary data are provided only for adult salmonids detected at Wells Dam during this time period. Our data summary does not describe the fate of all detected anadromous salmonids released above Wells Dam in 2000 or 2001 as this is beyond the scope of the current effort. The lack of adult detection capability at Wells Dam in 2001 prevents estimation of smolt-to-adult return rates for fish that may have returned in 2001 or 2002. All summary information was obtained through the Pacific States Marine Fisheries Commission PIT tag Information Systems. Travel times and rates are calculated for two groups of fish; fish tagged and released as juveniles above or at Wells Dam (coded as "Above") and fish tagged as juveniles and released below Wells Dam (coded as "Below"). Timing of arrival at McNary and Wells is provided only for fish that were later observed at Wells Dam (i.e., run-timing curves are not intended to represent the general population of adult migrants).

Species composition, abundance, migration rate and timing

Species of anadromous salmonids detected at Wells Dam in 2002 included chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*), sockeye salmon (*O. nerka*) and (Table 1). Hatchery summer chinook salmon (n=707) and steelhead (n=355) were most abundant (Table 1 and Figure 1).
Adult salmonids detected at Wells Dam include two general groups; those fish of known origin released at or above Wells Dam and fish of unknown origin that were collected, tagged, and released at a downstream project. Stock specific median travel times and sample size are reported separately for each group in

Table 2 and again in the run-timing curves for each stock. Fish released at or above Wells Dam are of known origin; however, stocks classified as being released below Wells Dam are generally of unknown origin. With the exception of summer chinook from the Turtle Rock facility, other stocks have been collected at the noted projects via gatewell dipping or bypass samples and have been incorporated into a variety of survival projects. There is the potential that these fish were originally released as unmarked juveniles above Wells Dam. Median travel time for spring and summer chinook from Bonneville Dam to McNary Dam was approximately 6 days (d) for all groups (Table 2). Travel time from McNary to Wells Dam for spring chinook released above Wells Dam (14.2 d) was slightly longer than for fish released, collected and tagged at The Dalles Dam (12.0 d). Travel time for summer chinook from McNary to Wells Dam (19.7 d) was approximately 4 to 5 d longer than that of spring chinook salmon. Summer chinook salmon released above Wells Dam exhibited slightly longer travel times from McNary Dam to Wells Dam than summer chinook salmon released at either Rocky Reach or Rock Island dam. Fall chinook from below Wells Dam had a median travel time from Bonneville to McNary Dam of 5 d and approximately 30 d from McNary Dam to Wells Dam (Table 2). Two of the five fall chinook salmon detected at Wells Dam were released from the Priest Rapids Hatchery. Median travel time of coho salmon through both reaches was longer than that of spring and summer chinook (Table 2). The prolonged travel time from Bonneville Dam to McNary Dam, for coho salmon released above Wells Dam, is the result of two of the five fish requiring greater than 27 d to transit the reach. Fallback was not apparent for either one of these fish. Steelhead released above Wells Dam required approximately 11 d to travel from Bonneville Dam to McNary Dam, slightly lower than that for tagged fish from below Wells Dam (km/d). Median travel time of steelhead from McNary Dam to Wells Dam fell within the range calculated for salmon. Travel rates (km/d) for steelhead were similar between the two reaches, unlike those reported for salmon which decreased in the upriver reach (Table 2).

Hatchery spring chinook salmon arrived at McNary Dam in two pulses, with the first pulse occurring in early May and the second pulse in late June and July (Figure 2). The first pulse consisted primarily of fish released above Wells Dam while the second pulse was made up largely of fish released below Wells Dam. The two pulses remained evident in arrival date at Wells Dam with the majority of early arriving fish being of known origin from above Wells Dam (Figure 3). Summer chinook salmon arrived at McNary Dam from mid June through late August with a peak in early July (Figure 4). Passage of PIT-tagged summer chinook at Wells Dam peaked in the third week of July (Figure 5). Summer chinook released above Wells Dam passed primarily in July and August with one fish arriving in October. Passage of fall chinook salmon, from below Wells Dam, occurred in August and September at McNary Dam and in September and October at Wells Dam (Figure 6 and Figure 7).

The two groups of coho salmon passed over McNary and Wells dam as two very distinct groups (Figure 8 and Figure 9). Coho released below Wells Dam were detected over a protracted period at McNary and Wells dams beginning in early April and extending until late July. Passage of coho salmon, released above Wells Dam, at McNary and Wells dams occurred much later and over a shorter period of time with the first detections at McNary Dam and Wells Dam occurring in early September and the last detection occurring in late October and early November.

Run-timing curves of steelhead passage at McNary Dam were similar between the two groups (Figure 10). Passage at McNary Dam started in July and extended until the end of September for both groups. Early passage, of fish released above Wells Dam, was evident in April at Wells Dam (Figure 11). In the July through November time period, the overlapping distributions of run-timing curves observed at McNary Dam persisted at Wells Dam.

Besides the fish tagged as adults at Wells Dam, none of the sockeye salmon passing over Wells Dam were tagged at sites above Wells Dam as juveniles. Passage of sockeye salmon at McNary Dam occurred in mid July while passage at Wells Dam occurred from early July through late August with peak passage occurring in mid July (Figure 12).

Species specific observations

Table 3 contains release site codes for fish detected at Wells Dam in 2002. Numbers of fish observed and the location and number of fish released are presented below by species in the following section.

Chinook salmon

The majority of adult chinook salmon detected at Wells Dam originated from hatcheries above Rocky Reach Dam (Turtle Rock, Wells, and Winthrop) (Table 4). Approximately 1% of the chinook released at Rock Island (331:26,350 released) and Rocky Reach (264:24,683 released) dams in 2000 were detected at Wells Dam in 2002. Chinook salmon that had been reared and released at the Dworshak (1:27,178 released), Entiat (4:59,955 released), and Leavenworth (2:approx. 270,000 released) National Fish hatcheries (NFH) were also observed in 2002. The one fish from Dworshak NFH was released in 2000; whereas, the fish from the Entiat NFH and Leavenworth NFH were released in 2002. In addition to the known origin fish, juvenile chinook salmon tagged at Rocky Reach, Rock Island, Wanapum, Priest Rapids, McNary, and The Dalles dams in 2000 returned to Wells Dam in 2002. One-hundred-six adult chinook salmon captured at Bonneville Dam in 2002 and marked with radio and PIT tags were detected at Wells Dam.

Coho salmon

Coho salmon were released from the Winthrop NFH in 2000 (8,937 released) and 2001 (8,000). The absence of adult detection capability in 2001 precluded determination of

the number of returning adults from the 2000 migration year, but coho salmon released above Wells Dam were observed at Bonneville Dam in 2001 and 2002. Eighty-five of the coho salmon released in 2000 were detected at the Bonneville Dam in 2001 and 23 of the coho salmon released in 2001 were detected at Bonneville Dam in 2002. Adults detected at Bonneville Dam did not necessarily translate into upriver detections as no adult coho salmon were detected at McNary Dam in 2001 and only 10 were detected at McNary Dam in 2002. Seventeen coho salmon were detected at Wells Dam in 2002. This total consisted of all 10 coho salmon detected at McNary Dam and seven coho salmon not detected at McNary Dam. Twelve (0.15%) of the coho salmon released from Winthrop in 2001 were detected at Wells Dam in 2002 (Table 5). The remaining 5 coho salmon were of unknown origin, and were captured and tagged at The Dalles Dam in 2001.

Steelhead

Steelhead released into the Wells Dam tailrace (23,917 released) and at the mouth of the Methow River (23,857 released) as part of the 2000 yearling summer steelhead survival study made up the majority of PIT tagged steelhead detected at Wells Dam in 2002. Approximately 0.7% of the fish from each release location were detected at Wells Dam in 2002. Twenty juvenile steelhead captured and tagged at Rocky Reach (13:3,947 released) and Rock Island (7:1,195 released) dams in 2000 were observed at Wells Dam in 2002. Three fish tagged and released at Lower Granite Dam in spring 2000 (approx. 90,000 released) and one fish tagged and released in 2001 (approx. 15,700 released) at Lower Granite Dam were detected at Wells Dam in 2002.

Sockeye salmon

In addition to the 176 adult sockeye salmon PIT tagged at Wells Dam in 2002, 43 fish PIT tagged as juveniles at Rock Island, Rocky Reach, and Bonneville dams in 2000 were also detected at Wells Dam in 2002 (Table 7). Approximately 700 juvenile sockeye salmon were released at each site.

Table 1. Composition of adult salmonids detected at Wells Dam from March 21 through November 15, 2002 based on species, run type, and rearing type.

Species	Run	Hatchery	Unknown	Wild	Total
Chinook	Spring	39	99		138
	Summer	650			650
	Fall	1	5		6
	Unknown	17	112	1	130
Coho	Spring		5		5
	Fall	12			12
Steelhead	Summer	355	16	9	380
	Fall		1		1
Sockeye	Summer		7	176	183
	Unknown		27	9	36

Table 2. Sample size (n), median travel time in days (Med), and rate (km/d) from Bonneville Dam to McNary Dam and from McNary Dam to Wells Dam for adult salmonids detected at Wells Dam from March 21 through November 15, 2002.

	Bonneville Dam to McNary Dam (236 km)						McNary Dam to Wells Dam (360 km)					
	Above			Below			Above			Below		
Stock	n	Med	Km/d	n	Med	Km/d	n	Med	Km/d	n	Med	Km/d
Spring Chinook	25	6.5	36.3	78 (a)	6.1	38.7	27	14.2	25.4	94	12.0	30.0
Summer Chinook	21	6.2	38.1	443 (b)	6.7	35.2	38	19.7	18.3	527	16.9	21.3
Fall Chinook	0	n/a	n/a	5 (c)	5.0	47.2	0	n/a	n/a	5	29.3	12.3
Coho	5	14.9	15.8	4 (d)	6.7	35.2	5	20.1	17.9	5	17.0	21.2
Steelhead	300	10.7	22.1	36 (e)	11.8	20.0	306	16.9	21.3	41	15.4	23.4
Sockeye	0	n/a	n/a	14 (f)	6.0	39.3	0	n/a	n/a	24	13.7	26.3

a: majority were collected, tagged, and released at The Dalles Dam
b: from Turtle Rock Pond, released at Rocky Reach and Rock Island dams
c: two of fish from Priest Rapids Hatchery, others collected, tagged and released at McNary and The Dalles dams
d: collected, tagged, and released at The Dalles Dam
e: majority were collected, tagged, and released at Rocky Reach and Rock Island dams
f: majority were collected, tagged, and released at Rocky Reach Dam

Table 3. Release site codes for fish detected at Wells Dam in 2002.

Release Site Code	Release Site
BO2BYP	Bonneville Dam PH2 - release into the facility bypass flume/pipe
BONAFF	Bonneville Dam Adult Facility
DWORNF	Dworshak National Fish Hatchery
COLR	Released into the Columbia River at the mouth of the Methow River
ENTH	Entiat National Fish Hatchery
LEAV	Leavenworth National Fish Hatchery
LGRRBR	Lower Granite Dam - barge transportation from facility
LGRRRR	Lower Granite Dam - return to river at facility
MCNGWL	McNary Dam - release into gatewell
OKANR	Okanagon River
PRDH	Priest Rapids Hatchery
RIS	Rock Island Dam
RRE	Rocky Reach Dam
TDAICE	The Dalles Dam - ice/trash sluiceway
TDASPF	The Dalles Dam - spillway forebay release (within 0.5 km of dam)
TDASPT	The Dalles Dam - spillway tailrace release (within 0.5 km of dam)
TDATRB	The Dalles Dam - release into turbine
UMAR	Umatilla River
WINT	Winthrop National Fish Hatchery
WANPL	Wanapum Dam - pool
WANTAL	Wanapum Dam - tailrace
PRDPL	Priest Rapids Dam - pool
PRDTAL	Priest Rapids Dam - tailrace

Table 4. Hatchery and release site for chinook salmon detected at Wells Dam from March 21 through November 15, 2002.

	Hatchery							
Release Site	Dworshak	Entiat	Leavenworth	Priest Rapid	Turtle Rock	Wells	Winthrop	Unknown
BONAFF								106
DWORNF	1							
ENTH		4						
LEAV			2					
MCNGWL								1
OKANR						8		
PRDH				1				
RIS					331			17
RRE					264			7
TDAICE								29
TDASPF								27
TDASPT								22
TDATRB								25
UMAR								1
WINT							31	
WANPL						11		
WANTAL						15		
PRDPL						12		
PRDTAL						9		

Table 5. Hatchery and release site for coho salmon detected at Wells Dam from March 21 through November 15, 2002.

	Hatchery	
Release Site	Cascade	Unknown
TDASPF		3
TDASPT		1
TDATRB		1
WINT	12	

Table 6. Hatchery and release site for steelhead detected at Wells Dam from March 21 through November 15, 2002.

	Hatchery	
Release Site	Wells	Unknown
BONAFF		19
LGRRBR		1
LGRRRR		3
RIS		13
RRE		7
WELTAL	172	
COLR	166	

Table 7. Hatchery and release site for sockeye salmon detected at Wells Dam from March 21 through November 15, 2002. Sockeye salmon were captured and tagged as adults in July 2002 and released into the Wells Dam tailrace (WELTAL) to determine detection efficiency of the Adult PIT-Tag interrogation.

	Hatchery
Release Site	Unknown
BO2BYP	7
RIS	8
RRE	28
WELTAL	176 (a)

a: tagged as adults and released into the Wells Dam tailrace; not used in run-timing calculations

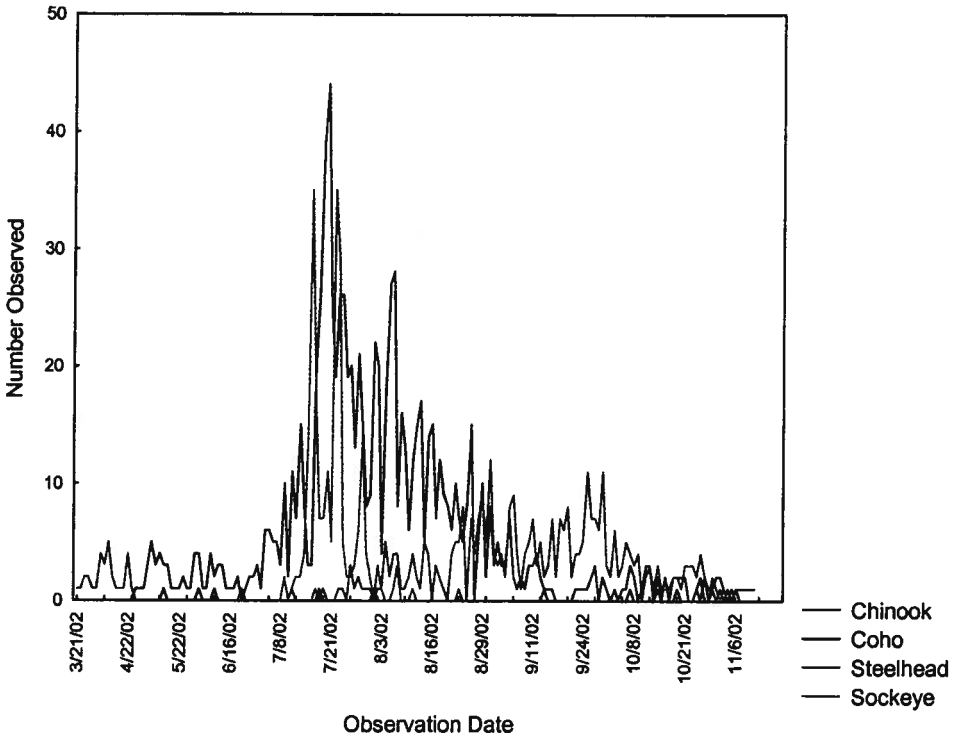


Figure 1. Timing of the arrival of adult PIT-tagged salmonids at Wells Dam from March 21 through November 15, 2002.

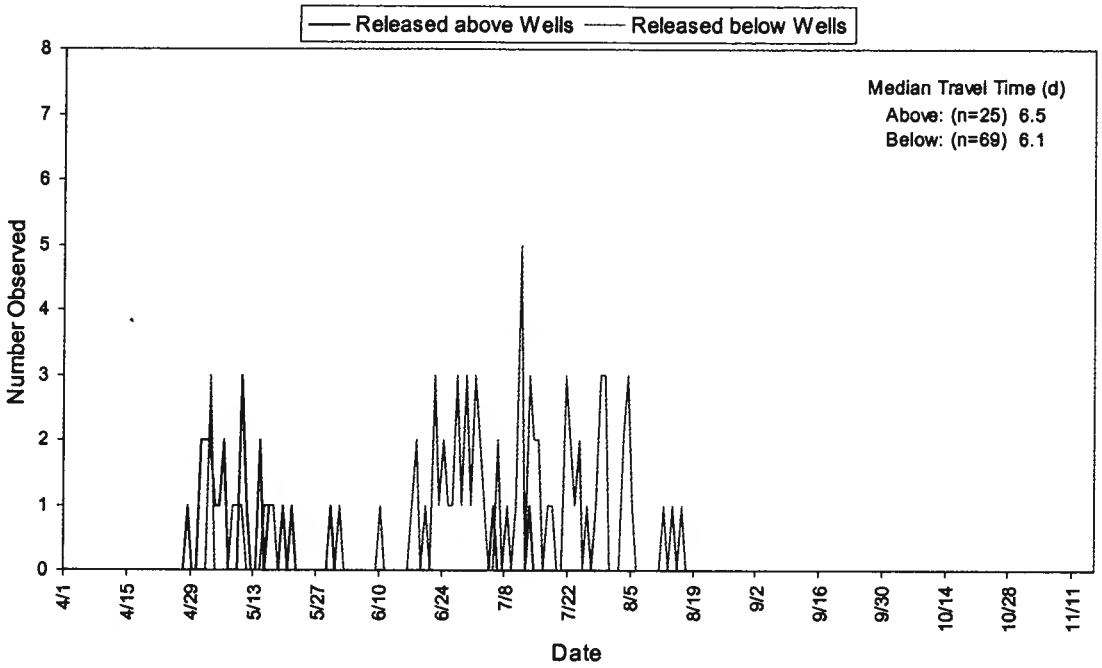
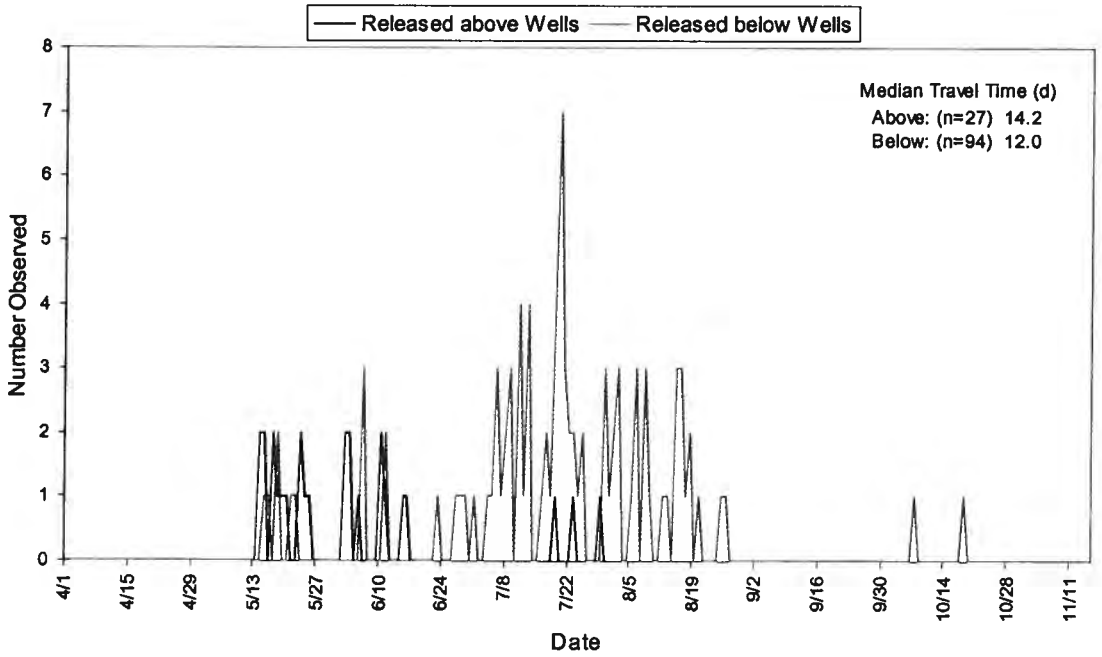


Figure 2. Arrival date at McNary Dam and median travel time (days) from Bonneville Dam to McNary Dam for PIT-tagged spring chinook salmon released above or below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group.



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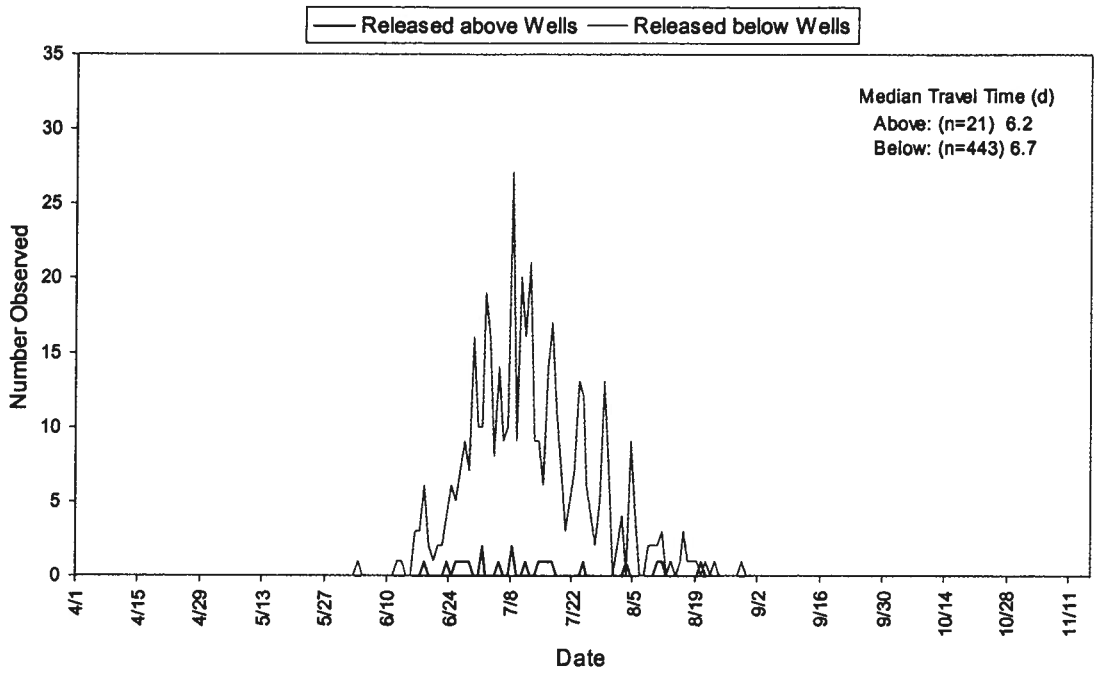


Figure 4. Arrival date at McNary Dam and median travel time (days) from Bonneville Dam to McNary Dam for PIT-tagged summer chinook salmon released above or below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group.

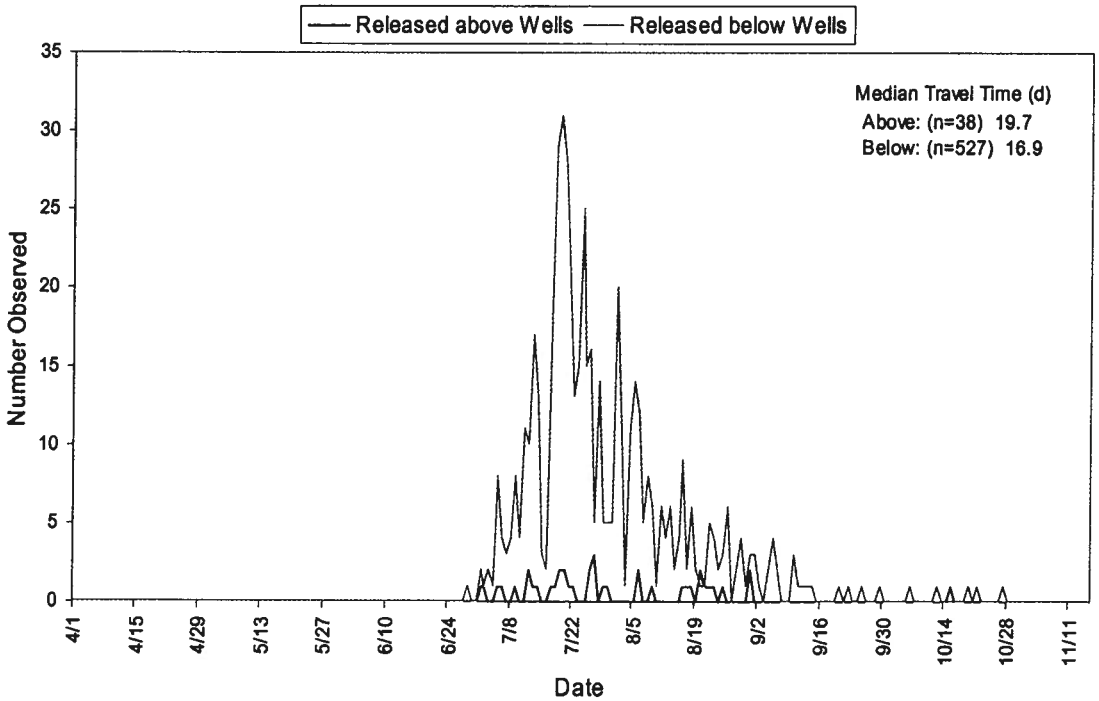


Figure 5. Arrival date at McNary Dam and median travel time (days) from McNary Dam to Wells Dam for PIT-tagged summer chinook salmon released above or below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group.

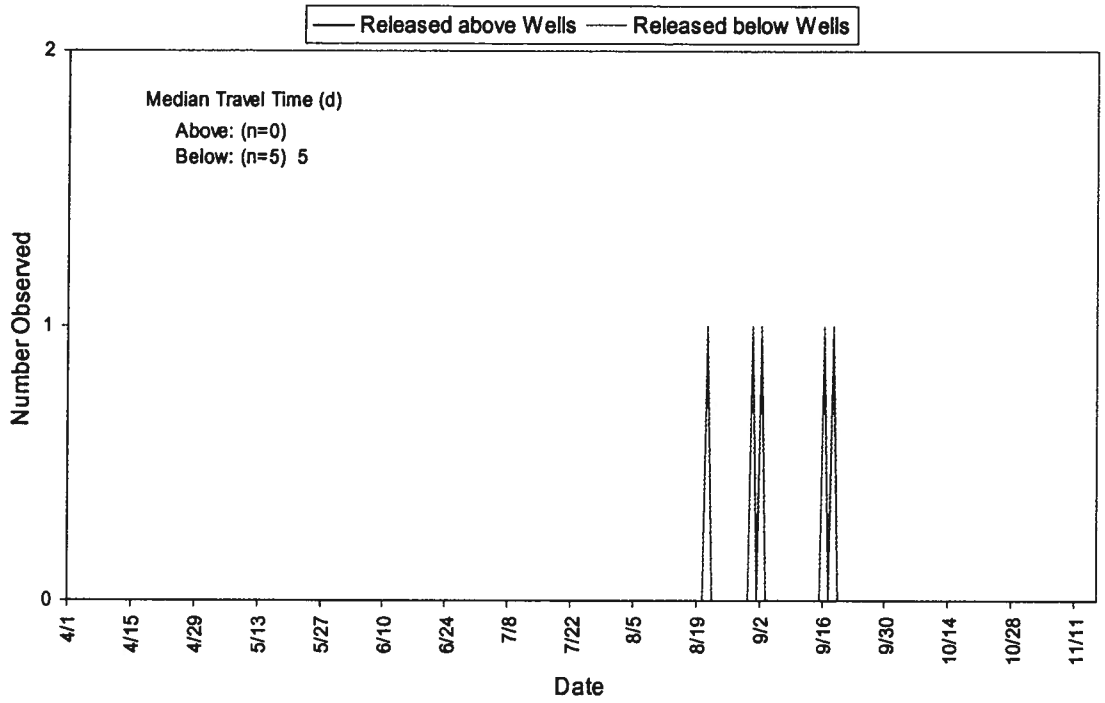


Figure 6. Arrival date at McNary Dam and median travel time (days) from Bonneville Dam to McNary Dam for PIT-tagged fall chinook salmon released below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group.

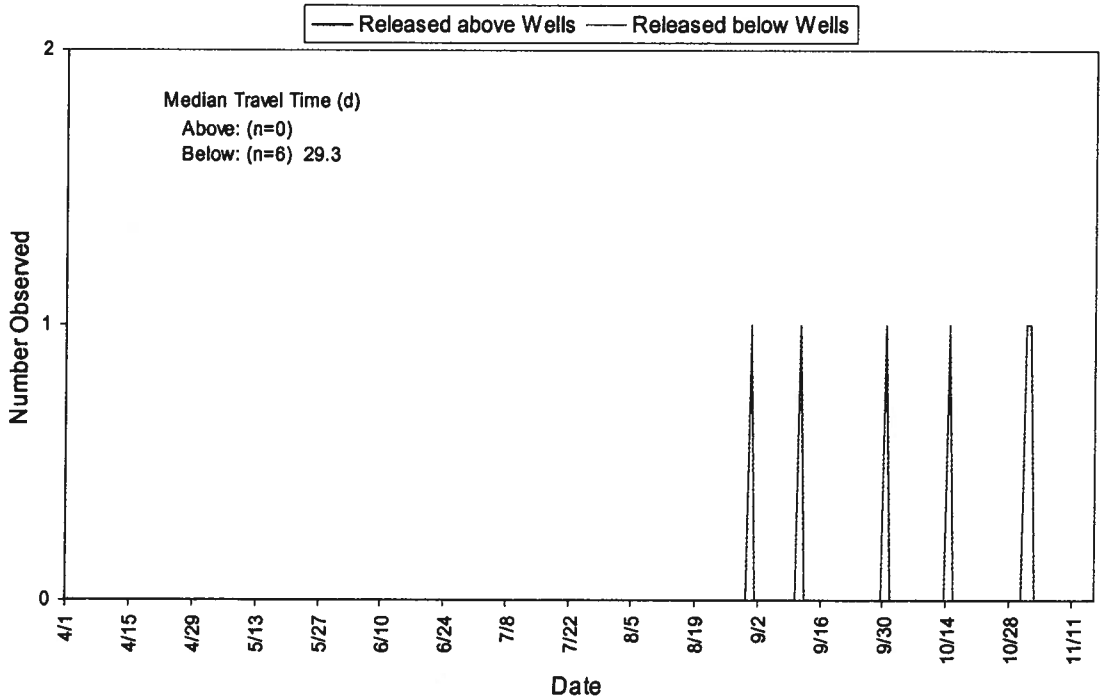


Figure 7. Arrival date at McNary Dam and median travel time (days) from McNary Dam to Wells Dam for PIT-tagged fall chinook salmon released below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group.

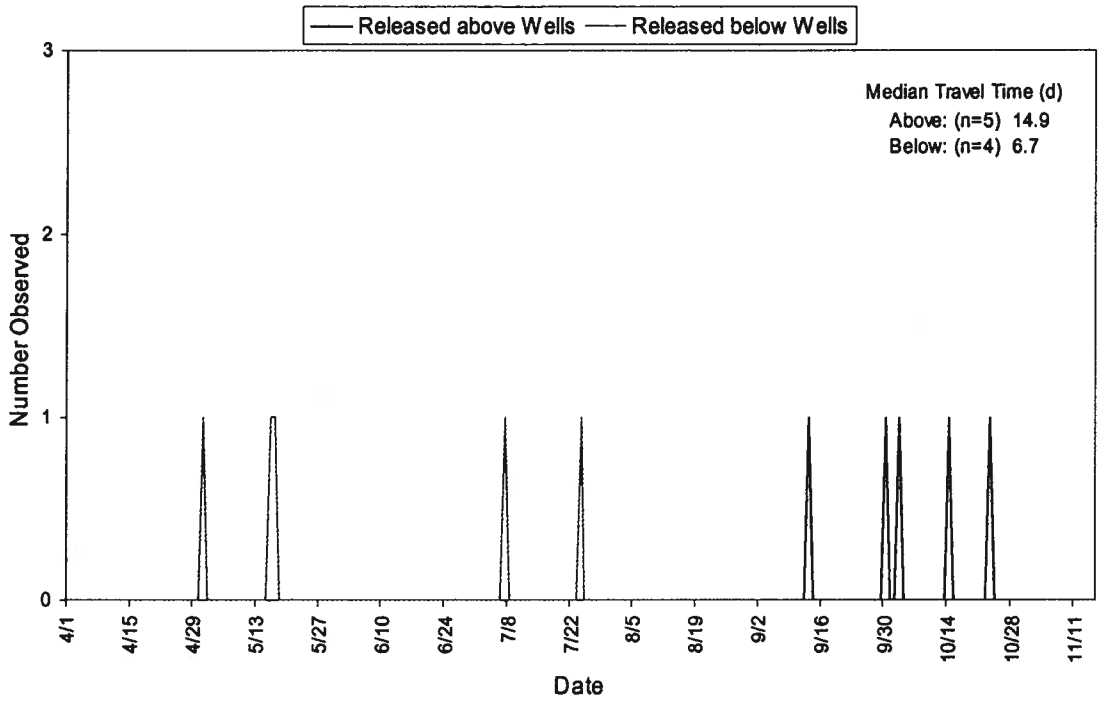


Figure 8. Arrival date at McNary Dam and median travel time (days) from Bonneville Dam to McNary Dam for PIT-tagged coho salmon released above or below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group.

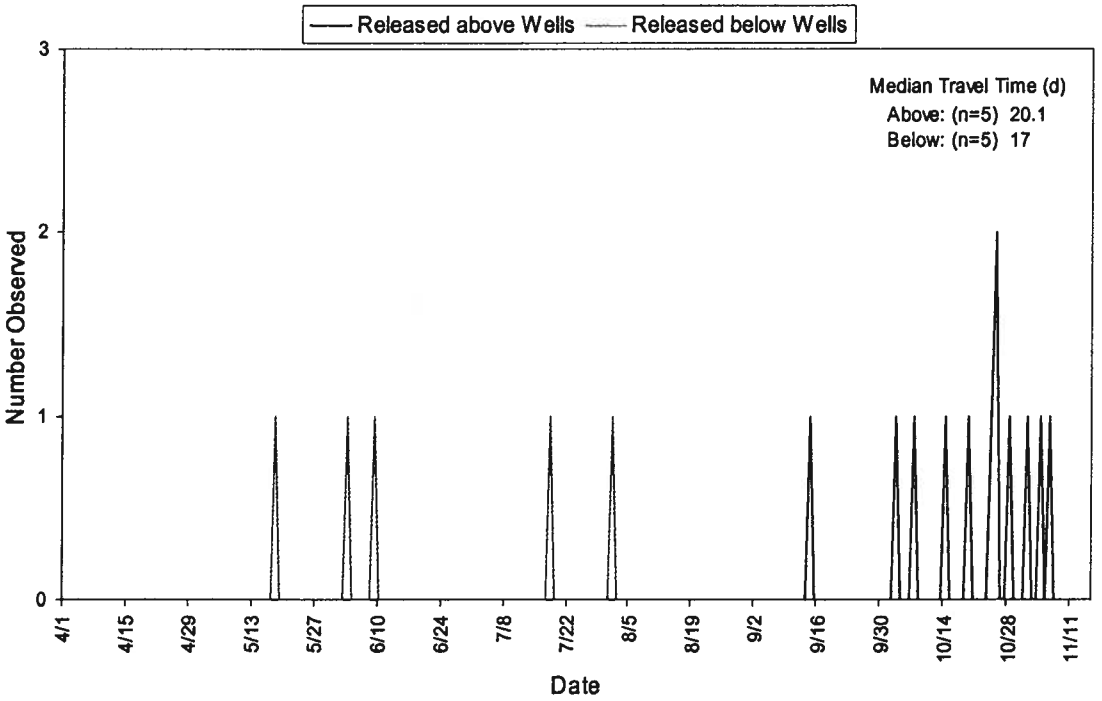
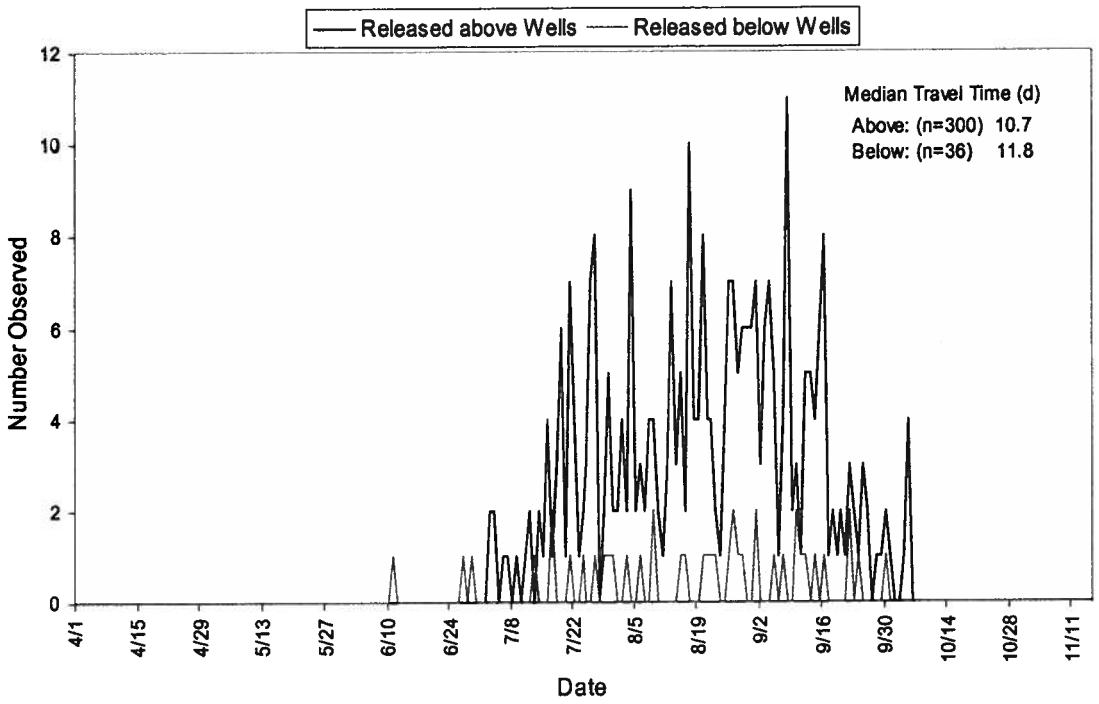


Figure 9. Arrival date at McNary Dam and median travel time (days) from McNary Dam to Wells Dam for PIT-tagged coho salmon released above or below Wells Dam and later detected as adults at the Wells Adult PIT detection system. Sample size (n) and median travel time (d) are presented for each group.



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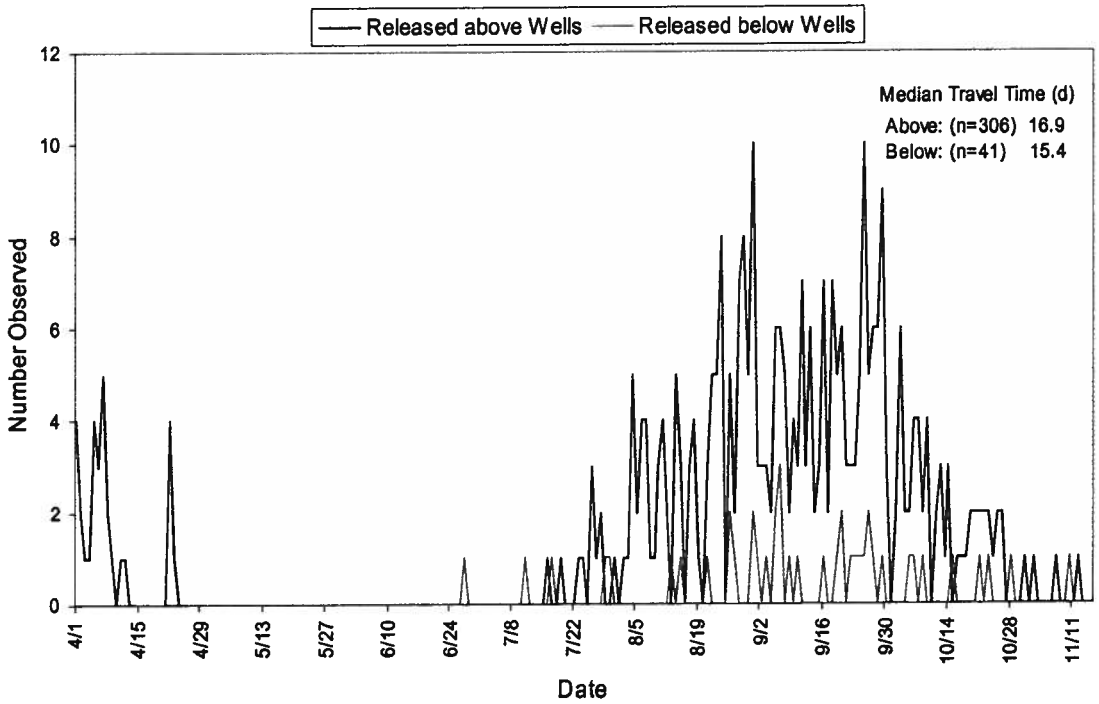

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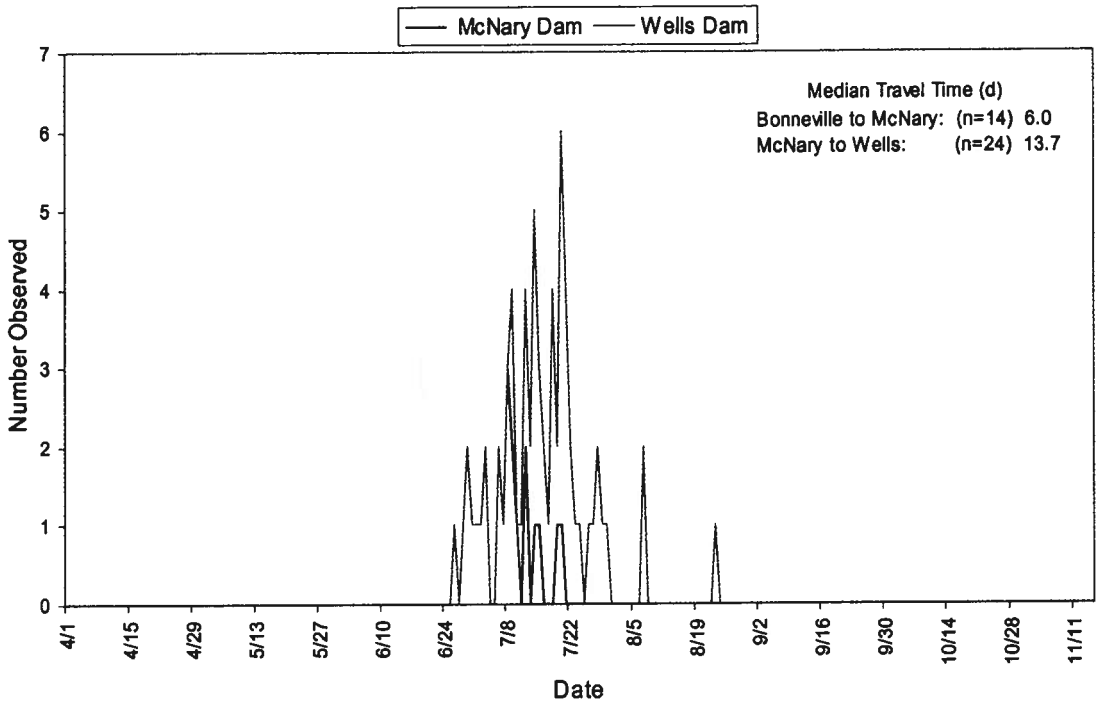

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ASSESSMENT OF ADULT STEELHEAD MIGRATION THROUGH THE MID-COLUMBIA RIVER USING RADIO TELEMETRY TECHNIQUES, 2001-2002

APPENDIX E

Assessment of Adult Steelhead Migration through the Mid-Columbia River using Radio-Telemetry Techniques, 2001-2002

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30 June 2003

Assessment of Adult Steelhead Migration through the Mid-Columbia River using Radio-Telemetry Techniques, 2001-2002

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30 June 2003

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ABSTRACT

Radio-telemetry technology was used to assess the upstream and downstream migration of adult steelhead past five dams on mid-Columbia River and to spawning locations. Radio tags were placed in 396 steelhead that were captured at Priest Rapids Dam between 17 July and 11 October 2001. Eighty one percent of the steelhead that were tagged were hatchery fish (possessing an adipose and/or a ventral clip). Washington Department of Fish and Wildlife (WDFW) staff bio-sampled 1779 steelhead that passed via the trap at the Priest Rapids left-bank fishway. Of the 1779 steelhead sampled, 1441 (81%) were hatchery steelhead. Fifty-eight percent of the fish that were tagged were recorded as females. All radio-tagged fish were released back into the Columbia River at a location 12.7 km downstream of Priest Rapids Dam (Vernita Bridge boat launch).

Detections of radio-tagged adult steelhead from fixed stations monitoring mainstem Columbia River locations (from the Hanford Reach to Wells Dam and all 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. Thirteen sets of aerial surveys were conducted to determine the spawning distribution and fates of the radio-tagged steelhead.

A total of 396 radio-tagged steelhead released and 366 (92%) were detected at Priest Rapids, 343 (87%) at Wanapum, 334 (84%) at Rock Island, 305 (77%) at Rocky Reach, and 274 (69%) at Wells. Of the 30 tagged fish that did not return to Priest Rapids Dam after release: 7 were removed by fishers prior to spawning; 5 were tracked to known spawning areas in the Snake River, Yakima River, and mid-Columbia between Savage Island and Coyote Rapids; 16 were last tracked between Coyote Rapids and Priest Rapids; and 2 were never tracked. Of the radio-tagged steelhead detected in the vicinity of Priest Rapids Dam, 96.9% were either tracked to known spawning areas or successfully passed and remained above Priest Rapids Dam. Comparable percentages for the other dams were 97.6% for Wanapum Dam, 96.6% for Rock Island Dam, 94.2% for Rocky Reach Dam, and 95.8% for Wells Dam. These are not survival estimates since it is not known the ultimate fate (i.e., the survival or mortality) of the fish that were radio-tagged.

The median migration rate between the dams (i.e. excluding dam passage rates) on the mid-Columbia River was: 33.2 km/d between Priest Rapids and Wanapum, 26.9 km/d between Wanapum and Rock Island, 39.6 km/d between Rock Island and Rocky Reach, and 39.3 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 1999 (33.7, 32.6, 36.7, 36.3 km/d, respectively). The median migration speed from the Priest Rapids tailrace to the Wells Dam fishway exits (i.e. including pool and dam migration rates) was 20.3 km/d which is similar to the estimation for the radio-tagged steelhead in the same area in 1999 (20.1 km/d). The median migration rates from the release site to the most upstream dam (Vernita Bridge to Wells exit) were similar for both the 2001 (10.94 d, 18.7 km/d) and 1999 studies (10.87 d, 18.3 km/d).

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The fallback rates for steelhead were similar for all dams. Approximately, 8% of the fish that passed a dam fell back (range 5%-12%). 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. The 18 involuntary fallbacks detected for all dams combined represented 1.2% of the unique dam passage events and most of these, (12 or 67%) were hatchery fish. On average, 3.5% of the unique fish passage events were classified as "voluntary" fallbacks (range 2.1-7.0% for the different dams) and 3.1% were classified as re-ascents (range 1.1%-5.9%). An examination of the fates for all fallbacks revealed that 77% 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 (80% for hatchery fish and 61% for "wild" fish). At Priest Rapids and Wanapum dams, the fallback route was determined for most of the fish that fell back. Since the spillways were not operated during the upstream migration period for steelhead, all fallbacks passed via the sluice or powerhouse. The sluiceways at these dams accounted for the vast majority of the fallbacks; 93% at Priest Rapids and 86% at Wanapum.

Median Project passage time for non-fallback steelhead at dams without ladder trapping activity were: 10.56 h for Wanapum Dam, 4.46 h for Rock Island Dam, and 16.56 h for Rocky Reach Dam. The median Project passage times for non-fallback steelhead at the two mid-Columbia dams with ladder trapping activity were: 13.60 h for Priest Rapids Dam and 19.46 h for Wells Dam. Entrance passage times represented 57-84% of the Project passage time for steelhead at Rocky Reach and Wells dams, and generally less than 50% of the Project passage time at the other dams. Fishway passage times were generally less than 35% of the total Project passage time and fairly consistent both within and between projects. Median Fishway passage times ranged from 1.17 h to 2.68 h over all projects.

At Priest Rapids, left-bank upper Fishway passage times for trapping intervals (7.5 h) were significantly different ($p=0.001$) than those for non-trapping intervals (2.1 h). The median Project passage time at Priest Rapids Dam was also significantly longer during trapping (22 h) than during non-trapping intervals (14 h). The Wells right-bank upper fishway showed no significant differences in fish passage time during trapping and non-trapping periods ($p=0.223$). Trapping had a substantial effect on the right-bank Project passage times at Wells Dam where trapping and non-trapping intervals were 58 h and 28 h, respectively. However, it should also be noted that the right-bank fishway had other problems in 2001. Fouling of the diffusion grates resulted in substantial reductions in gate opening widths and head differential which could have affected fishway passage times. The Wells left-bank ladder had very little trapping and no problems with diffusion gates and the median project passage time for steelhead was 16.3 h.

For fishways with junction pools, the median passage time after the last detection in an entrance zone was very short (0.02-2 min). The passage time for the counting stations ranged from 8 min for Rocky Reach and 26 min for the Rock Island fishways. The most frequently used fishway entrance at Rocky Reach was the trifurcation entrance.

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Of the 1535 unique detections at the fishway exits for all dams, 119 fallback and 45 re-ascents were detected. The overall fallback rate for the mid-Columbia dams was 7.8% and 37.8% of these fallback fish re-ascended the dam where they fell back. Of the 97 unique fish that fell back, 26 fell back at more than one dam. Only 1 of the 97 fallback fish was recovered by an angler in the Rocky Reach pool after the fish had fallen back through Wells Dam. As in 1999-2000, the fallback rates were slightly higher at Wanapum and Wells than at the other mid-Columbia dams and Wanapum and Priest Rapids had the highest rates of re-ascents.

Of the 396 steelhead tagged, 2 were never tracked and 23 (6%) were known to have been caught and removed prior to spawning. Of the remaining 371 steelhead available for spawning, 314 (84.4%) were tracked to known spawning areas prior to or during the spawning period, and 58 (15.6%) 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 58 steelhead assigned to a non-spawning area (i.e., mid-Columbia reaches from Coyote to Wells Dam), 22 (38%) 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 assigned to a tributary stock, 16% were tracked upstream of their spawning destination. Straying rates for Ringold, Wenatchee, Methow/Okanogan hatchery releases were estimated to be 23%, 19%, and 5%, respectively. Most of the strays detected were fish tracked to the Methow and Okanogan rivers. This was not surprising since some of the broodstock for the Ringold and Wenatchee hatchery releases came from fish collected at or above Wells Dam.

In general, the results from this study were very similar to those for the 1999-2000 adult steelhead tracking on the mid-Columbia River. The portion of the radio-tagged steelhead tracked upstream of Priest Rapids Dam or to known spawning areas was 92.7% compared to 91.6% for the 1999-2001 study. The median Project passage times estimated for each dam were similar between the two studies.

The monitoring of kelt migrations was more complete in 2002 because all adult tag codes could be readily tracked along the mainstem Columbia without the problems created in 2000 by the use of identical tag codes in the juvenile survival studies. Over all tributaries and mainstem areas, the kelting rate for 2002 was estimated to be between 56% to 73%. Kelting rates for fish tracked to tributaries were generally higher (65-75%) than those for fish last tracked in reaches along the mid-Columbia (26-68%). The kelting rates estimated for 2002 were generally higher and more reliable than those estimated for the 2000 downstream migration. Of the 170 tributary spawners that were tracked as kelts, 30 (18%) were detected at or below Coyote Rapids as they migrated downstream out of the survey area. The downstream tracking rate for kelts is not a survival estimate because some kelts could have passed undetected and some may have been removed by anglers.

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INTRODUCTION

Radio-telemetry techniques have been used in the Columbia River basin to study the migration of adult salmonids since 1975. Most of the early research efforts were concentrated on the lower Columbia with the work directed by the National Marine Fisheries Service, Northwest and Alaska Fisheries Center (Monan and Liscom 1975; Liscom et al.1977;1978; 1979). The first large scale radio-telemetry studies were initiated in the early 1990's with the primary focus being adult chinook and steelhead migrations through the lower Snake River dams (e.g. Bjornn et al. 1992; 1993; 1995; 2001a; 2001b). The early radio-telemetry studies on the mid-Columbia examined the upstream migration of sockeye in 1992 (Swan et al. 1994) and chinook in 1993 (Stuehrenberg et al. 1995). In 1995, the focus shifted to the lower Columbia with the annual release of 850-3000 radio-tagged fish from Bonneville Dam from 1996 through 1998 (Bjornn et al. 2000a; 2000b; 2000c; 2000d). A substantial portion of the radio-tagged chinook and sockeye released at Bonneville between 1996 and 1998 have migrated to the mid-Columbia, and these fish have formed the basis for adult passage studies for each of the mid-Columbia dams (Bjornn et al. 1997; Perry et al. 1998; English et al. 1998a; 1998b; 1999a; Alexander et al. 1998 and Nass et al. 2000). Adult steelhead tagged at Bonneville Dam have not provided much information for mid-Columbia dams because less than 3% of these fish migrate through the mid-Columbia. The first major radio-telemetry study of adult steelhead migration through the mid-Columbia was conducted in 1999-2000, when 395 fish were tagged and released near Priest Rapids Dam (English et al. 2001). The success of the 1999-2000 study, along with some outstanding questions regarding post-spawning behavior and year to year variation in migratory success, led to an agreement to repeat the study in 2001-2002. This report provides a summary of the 2001-2002 results in a format similar to that of the 1999-2000 report and provides detailed comparisons of the information collected from these two major studies of adult steelhead migration through the mid-Columbia basin.

Salmon bound for spawning grounds in the mid-Columbia basin must migrate up the Columbia River past nine hydro-electric dams. Fishways have been built on each dam below Chief Joseph Dam to facilitate the passage of salmon. The five mainstem dams with adult fish passage facilities are operated by three Public Utilities. Priest Rapids and Wanapum dams are managed by Public District No. 2 of Grant County (GCPUD). Rock Island and Rocky Reach dams are run by Public District No. 1 of Chelan County (CCPUD), and Wells Dam is operated by Public District No. 1 of Douglas County (DCPUD). The work reported here is a result of a coordinated effort by these three PUD's to assess adult steelhead passage through their projects. As in 1999, LGL Limited, of Sidney BC was contracted to manage the project, collect and analyze all the data and prepare a comprehensive report. The fish trapping and tagging operations at Priest Rapids Dam were the responsibility of a Washington Department of Fish and Wildlife (WDFW) with technical assistance from LGL staff. BioAnalysts Inc. were responsible for the deployment and maintenance of all fixed-stations for CCPUD as well as assisting with aerial surveys.

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Study Objectives

The objectives for the 2001-2002 study were similar to those for the 1999-2001 study. The following objectives are common at Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams:

1. determine total Project passage time for tagged steelhead;
2. determine tailrace, fishway entrances, and fishways passage rates at each project;
3. determine the portion of steelhead that fall back at each project;
4. compare fallback rates to operations at the projects;
5. determine the fate for all radio-tagged steelhead within the study area;
6. determine the passage times through the reservoirs;
7. determine the holding/spawning area for all radio-tagged steelhead;
8. assess the extent to which adult steelhead use tributaries in the study area; and
9. assess kelt timing as they migrate downstream through the projects in the study area.

Specific objectives for each dam or group of dams are:

Priest Rapids and Wanapum dams:

- determine the proportion of the fallback fish that fell back via the powerhouse, spillway or sluice;

Priest Rapids and Wells dams:

- 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;

Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams:

- determine the amount of time fish spend in the junction pools; and

Rock Island and Rocky Reach dams:

- determine the amount of time fish spend at the counting stations.

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Study Area

The study area for this project included the Columbia River from the confluence of the Yakima River (Rkm 539.3) to Chief Joseph Dam (Rkm 877.1), and the tributaries of the Yakima River, 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 Ice Harbour Dam (Rkm 537.7) 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 operates this dam.

METHODS

Study Design

A total of 399 adult summer steelhead were scheduled to be radio-tagged at Priest Rapids Dam over the main period of migration (July - October) to provide a tagging rate of approximately 5.3% on an estimated run of 7,480 fish (Table 1). Based on passage proportions from the 1999-2000 study where 395 tags were applied, the expected number of radio-tagged steelhead to pass each dam were 335 (85%) at Priest Rapids, 326 (83%) at Wanapum, 298 (75%) at Rock Island, 205 (52%) at Rocky Reach, and 162 (41%) at Wells (English et al. 2001). 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 actual movement histories in 2001-2002.

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 of each dam, and a network of underwater bared coax or dipole antennas were used at the entrances (including the collection channels) and exits of each fishway. Underwater dipole antennas were used at the sluiceway and turbine intakes, and bared coax antennas were deployed in each spillway to detect

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radio-tagged fish falling back over the dam via these alternative routes. Remote fixed station arrays were also maintained at Coyote Rapids to detect radio-tagged fish moving downstream of the release site. A single tributary monitoring site was located at Crab Creek to determine 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 (Wenatchee River), 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. Remote fixed station arrays were also maintained at the Methow River (two), Okanogan River (mouth), the Columbia River at Wolf Rock, Wells Hatchery broodstock collection pond, 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 21 July and 13 October, 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, 250 ml of MS-222 stock solution of 500g/2.5gal water used in 80 gal of water) 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 gastrically radio-tagged with Lotek MCFT-3A tags (16x51mm, 400d kill switch). Radio tags applied to summer steelhead in proportion to the run at Priest Rapids Dam, and were spread across four channels or frequencies (channels 4, 5, 7, and 8 on the 148 MHz band) with approximately 100 codes on each channel. A predetermined schedule applied tags on the different frequencies evenly over the run. Tagged steelhead were then placed in a sanctuary boot (a rubber inner tube filled with water) 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 8 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 were 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.

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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. Some underwater antennas at the dams were monitored with an SRX and the Lotek digital spectrum processors (model DSP 500).

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. The arrays were balanced by transmitting a signal of known strength through each antenna system. Signals were amplified or attenuated to provide similar signal strengths between antennas. A balanced telemetry array allows us to accurately determine fish location based on signal strength when the transmitter was detected by more than one antenna at any given time. Each receiver station and associated antennas were tested periodically throughout the monitoring period. Testing was normally conducted by moving a test tag through the zone monitored by each antenna, while a second observer monitored the detections displayed on the associated receiver. The routine data quality control procedures conducted during weekly downloading included:

1. Visual checking of the all antenna and receiver operation;
2. Battery testing for voltage levels;
3. Immediate analysis of all downloaded data using LGL's field software that provided information on data gaps, number of bad records, number of noise records, noise levels for each antenna and channel, tag detections for each antenna and channel, battery checks and the first and last records in the download file;
4. Within 48 hours of the downloading time, all data were processed through additional verification routines as the data was imported into the project database using LGL's Telemetry Manager software. These import routines check the receiver records against the list of known tags released, apply predefined filters to identify noise records, and provide immediate data summary displays that are used to identify deficiencies in the monitoring system; and
5. Summary results from these in-season analyses were immediately transmitted back to the field crews along with any problems identified.

The above visual checking, data verification and analysis procedures ensured that any deficiencies in the receiver and antenna monitoring systems were detected and corrected rapidly throughout the study period.

Telemetry Array - Fixed Stations

The movements and passage of radio-tagged steelhead were determined by combining detection data collected using underwater and aerial antenna arrays (stripped coax, dipoles, and Yagis) at Priest Rapids (Figure 2) and Wanapum dams (Figure 3). The arrays were designed to monitor movements of radio-tagged animals from the river into the fishway entrances, collection channels and through the exits, and also to detect downstream (fallback) movements through the

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spillway/sluiceway, and turbine entrances. Aerial antennas were used in the tailrace, at remote stations, and during mobile tracking. Underwater antennas were used in the fishways. A total of 22 telemetry receivers (9 at Priest Rapids Dam, 9 at Wanapum Dam, 1 at Crab Creek, 1 at Hanford Reach, and 2 mobile) were deployed for GCPUD (Appendix Report A1, Appendix Tables A1-A3). Additional detection data was made available from other on-going studies which supplied the equivalent of two more additional receivers.

The adult fishways at Rock Island and Rocky Reach dams, as well as two tributaries (the Wenatchee and Entiat rivers) were monitored (Figures 4 and 5). Within the tailrace areas at both dams, 6-element aerial Yagi antennas were used. Within the fishways at the projects, a combination of bared coax and dipole underwater antennas were used. At the tributary monitoring sites, 4-element Yagi aerial antennas were used at the three shore-based receiver stations, and bared coax underwater antennas were used at the Tumwater Dam fishway. A total of 23 fixed-station receiver stations (9 at Rock Island Dam, 9 at Rocky Reach Dam, 1 at Tumwater Dam, 1 at Monitor in the lower Wenatchee, 2 above Rocky Reach near Turtle Rock, and 1 near the mouth of the Entiat River) were deployed for CCPUD (Appendix Report A1, Appendix Table B1-B3).

Radio-tagged fish movements at Wells Dam (Figure 6) were detected using a combination of aerial and underwater antennas. The arrays were designed to monitor movements of radio-tagged animals from the river into the fishway entrances, collection channels and through the exits. In the tailrace, twin 3-element Yagi antennas mounted on 10 ft towers were located directly below the project, on both banks. Movements in the fishways were monitored using underwater dipole antennas mounted at the entrance, above the collection channel, below and above the fish traps, and at the exits. In addition, one site monitored the entrance to the Wells Hatchery channel, and one monitored the steelhead broodstock capture and holding pond. Aerial antenna arrays were located near the mouth of the Methow River, 18 km upstream on the Methow, the Okanogan at Monse, and the Columbia River at Wolf Rock (near Pateros). A total of 12 fixed-station receivers were deployed for DCPUD (Appendix Report A1, Appendix Tables C1-C3).

Mobile Tracking

Mobile tracks were conducted by fixed-wing aircraft, helicopter, and boat to determine the location of radio-tagged animals between fixed-station sites, and in holding/spawning areas of tributaries. Mobile zones were designated as sections of river between fixed-station sites, or natural reach breaks in the river. Three separate telemetry studies (steelhead, lamprey, and bull trout) coordinated to produce extensive coverage of the study area. The detection histories for many fish would have been far less complete, had it not been for the coordination. In addition, substantial cost savings and efficiencies of scale were achieved for each project.

Aerial tracking was conducted from a Cessna 182 fixed-wing plane with two 3-element Yagi antennas mounted to the strut of each wing. The aircraft flew along the river and its tributaries at speeds between 60 mph and 100 mph, and at heights between 300 ft and 500 ft above ground. 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 four SRX receivers each

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scanning a separate channel. The approximate position and identity of each fish were also recorded manually on data sheets as a backup to the electronic systems. Similarly, aerial tracking in the smaller tributaries of the Wenatchee, Enitat, and Methow were conducted from a Bell 2 helicopter with a single 3-element antenna mounted on the nose of the aircraft.

Tracking by boat was conducted between Coyote Rapids in the Hanford Reach to the tailrace of Rock Island Dam. This tracking effort was primarily conducted by GCPUD in support of a radio-telemetry study on adult lamprey. Two types of arrays were used depending on the objective. In general, twin three-element aerial antennas were mounted to a post and secured in the boat. Surveys would be conducted by transects running upstream and downstream in the river with the aerials pointed in opposite directions, and usually at each bank. In addition, a single dipole mount was fabricated for boat tracking to more accurately determine the location of holding animals. The aerials would be used to determine presence in an area; the dipoles were then used to determine a more accurate geographic fix. Tracking procedures were similar to that used on the aerial surveys.

Data Analysis

Analyses were conducted using Telemetry Manager, Ascent and other computer programs developed in Visual Foxpro by LGL Limited. 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 an exit.

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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 to the other mid-Columbia dams except there was no junction pool passage time as no such structure exists 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
4)	4 to 5	Upper fishway passage
5)	1 to 6	Project passage

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 past 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 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

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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.

Fishway Counts

The number of adult salmon and steelhead counted at each fishway monitoring station are available for Priest Rapids Dam (Appendix Table A4); Rock Island and Rocky Reach dams (Appendix Table B4); and Wells Dam (Appendix Table C4). These data are summarized and presented with the daily passage numbers for the radio-tagged fish in the Results section below.

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 0900 and 1700 hours from 17 July through 11 October 2001. Specific dates and times for each trapping day are provided in Appendix Table D1.

Trapping of salmon for broodstock was conducted in both fishways at Wells Dam, usually on Monday, Tuesday, and Wednesday between 0530 and 1900 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 21 May through 21 August, and the trap on the right-bank fishway was used to collect steelhead from 9 July through 15 November 2001. 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.

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 either trapping or non-trapping groups according to the time of first detection in the trap zone.

Upper Fishway passage times (below trap to exit) were assumed to be the most direct measure of the effect of trapping on fish passage. 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 non-trapping periods. A log transformation was applied to the data for use in a two sample t-test.

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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. These fish could also be classified as involuntary fallbacks that re-ascended, therefore, the total number of involuntary fallbacks would be the sum of the re-ascended fallbacks and the involuntary fallbacks that did not re-ascend.

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

Tags Applied

Radio tags were placed in 396 steelhead that were captured at Priest Rapids Dam between 15 July and 13 October 2001 (Table 1). Peak tagging periods were between 2 and 8 September when 16% of the tags were applied. A total of 81% (321) of the steelhead that were tagged were hatchery fish (possessing an adipose and/or a ventral clip). Fifty-eight percent of the fish that were tagged were recorded as females. Hatchery steelhead represented 81% of the 1779 steelhead bio-sampled by WDFW staff through trapping operations at the Priest Rapids left-bank fishway.

Tracking Effort

During this study, over 10,000,000 individual records of radio-tagged fish were obtained. Most of the tracking data were recorded 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. The results presented in this report were derived from more than 232,389 site hours of monitoring data obtained from the 54 fixed-station sites operated between 14 July and 29 December 2001 (Tables 2, 6 and 10). Fixed-stations near tributary mouths and at least one at each dam and one at Coyote Rapids were operated through late June 2002 to detect downstream migrating kelts. LGL Limited and BioAnalysts Inc. were responsible for the maintenance and

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downloading of fixed-station monitoring sites (details provided in Appendix 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). Interruptions in fishway operation were documented to facilitate analysis (Appendix Report A2).

Mobile Tracking

Mobile tracking provided detailed data on the holding and spawning destinations for most of the radio-tagged fish. Aerial surveys along the mainstem of the Columbia, Yakima, Wenatchee, Entiat, Methow, and Okanogan rivers were conducted on 24 occasions between 27 July 2001 and 2 July 2002 (Appendix Table F1). Overall, there were 36 fixed wing flights, 6 helicopter flights, and 24 boat surveys. This unusually high level of survey effort was the result of the coordination of three separate radio-telemetry studies. The number of surveys per mobile tracking zone ranged from 7 to 43 and depended on the objectives of the separate studies and logistical constraints associated with flying. The mobile survey strata are presented in Figure 7.

Priest Rapids Dam

Project Passage

Of the 396 radio-tagged steelhead released, 366 (92%) were detected at Priest Rapids Dam (Table 3). A total of 29,711 steelhead were counted using video monitors between 1 July to 15 November (Figure 8, Appendix Table A4). There were two peaks in the adult steelhead migration; the first in the week ending 11 August and the second in the week ending 22 September. Peak numbers of radio-tagged fish detected at Priest Rapids during their upstream migration occurred during the week ending 8 September. While the passage of radio-tagged fish was not a consistent portion of the unmarked fish, the entire run was represented by the radio-tagged individuals.

Of the 366 radio-tagged steelhead that were detected at Priest Rapids Dam, 343 (93.7%) unique radio-tagged steelhead were detected at the exits (Table 3). Of the 354 steelhead detected at the fishway entrances, 61% used the left-bank fishway and 39% used the right-bank fishway (Table 3). Of the 343 unique fish that passed the dam, 24 (7.0%) fell back below the dam (Table 4).

Fallback

The portion of the fallback fish that passed the dam using the left-bank fishway (58%) was slightly lower than the 61% for all fish that passed the dam. Hatchery fish were 79% of the fallback fish which was similar to the hatchery portion for those fish detected at the fishway exits (76%). Most of the fallbacks occurred between 6 September and 1 November when spillway flow was minimal to none (Figure 9). As observed in 1999, the frequency of fallback events was more related to the number of radio-tagged fish present than to spillway flow.

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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 past undetected by either the sluice or powerhouse, the fallback route for these fish, and the 7 fish not detected by a forebay antenna prior to fallback, was classified as unknown (Table 4). Of the remaining 14 fish with a known fallback route, 13 (93%) fell back via the sluiceway and 1 fellback (7%) via the powerhouse. Of the 13 fish that fell back via the sluice, 1 was classified as an involuntary fallback. In total, 11 (3.2%) of the radio-tagged steelhead that passed Priest Rapids Dam were classified as voluntary fallbacks. Eleven (46%) of the 24 fallbacks re-ascended and remained above the dam. Details on the ultimate fate of the fallback fish are provided later in the report.

Wanapum Dam

Project Passage

There were 343 (87% of release) radio-tagged steelhead detected at Wanapum Dam (Table 3). Reliable counts of the number of adult steelhead that passed Wanapum Dam each week in 2001 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 343 radio-tagged steelhead that were detected at Wanapum Dam, 338 (99%) unique radio-tagged steelhead were detected at exits. Sixty percent of the total number of fish passing through the fishway exits used the left-bank fishway and 40% used the right-bank fishway (Table 3). Of the 338 unique fish that passed the dam, 31 (9.2%) fell back below the dam (Table 5).

Fallback

The portion of the fallback fish that passed the dam using the left-bank fishway (58%) was slightly lower than the 60% portion for all fish that passed the dam. Of the fish that fell back, 90% were hatchery fish. Since 76% of the fish detected at the Wanapum fishway exits were hatchery fish, these fish had a greater tendency to fallback than "wild" fish. Most of the fallbacks occurred between 29 August and 8 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 3 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 7 fish not detected by a forebay antenna prior to fallback, were classified as unknown (Table 5). Of the remaining 21 fish with a known fallback route, 18 (86%) fell back via the sluice and 3 (14%) via the powerhouse. Of the 31 fish that fell back, 8 were classified as voluntary fallbacks, 20 re-ascended a fishway and 3 were classified as involuntary fallbacks. Two of the 3 involuntary fallbacks fell back via the sluice. Details on the ultimate fate of the fallback fish are provided later in the report.

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classified as involuntary fallbacks. These involuntary fallbacks represent 1.8% 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

The degree to which radio-tagged steelhead entered and exited individual entrance gates was assessed (Figure 12). The analysis shows that the net movement of steelhead is positive at all entrances, except the right powerhouse (downstream) entrance (RPE) and OG#2. The spillway entrance was not operational in 2001. The busiest entrance was the left powerhouse entrance (LPE) also referred to as the upstream entrance.

Wells Dam

Project Passage

Of the 396 radio-tagged steelhead released, 274 (69%) were detected at Wells Dam (Table 11). A total of 18,438 steelhead were counted using video monitors between 1 July to 15 November (Figure 13, Appendix Table C4). The pattern of steelhead migration upstream at Wells Dam was similar to those observed at the other dams. Peak upstream passage of radio-tagged fish occurred during the week ending 15 September, while the peak count of all steelhead was observed in the week ending 29 September.

Of the 274 radio-tagged steelhead that were detected, 2 were taken for broodstock. Of the remaining 272 fish, 252 (93%) unique radio-tagged steelhead were detected at the exits (Table 11). Twenty-six percent of the total number of fish passing through the fishway exits used the right-bank fishway and 74% used the left-bank fishway (Table 11). Of the 252 unique fish that passed Wells Dam, 30 steelhead (11.9%) fell back below the dam (Table 12).

Fallback

The portion of the fallback fish that passed the dam using the left-bank fishway (70%) was slightly lower than the 74% portion for all radio-tagged steelhead that passed the dam. Hatchery fish were 97% of the fallback fish. This was slightly higher than the hatchery portion of those fish that passed Wells Dam (91%). Most of the fallbacks occurred between 3 September and 11 October when spillway flow was minimal to none (Figure 14). Of the 30 fish that fell back, 17 were classified as voluntary fallbacks, 10 re-ascended a fishway and 3 were classified as involuntary fallbacks. Details on the ultimate fate of the fallback fish are provided later in the report.

In-river and Dam Travel Times

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 18.7 km/d (Table 13). The migration speed from the first detection in the Priest Rapids tailrace to the Wells Dam fishway exits was 20.3 km/d. The median migration speeds between the dams on the Columbia

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River were: 33.2 km/d between Priest Rapids and Wanapum, 26.9 km/d between Wanapum and Rock Island, 39.6 km/d between Rock Island and Rocky Reach, and 39.3 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: 1.2 km/d between Rock Island and the Columbia State Park monitoring station on the lower Wenatchee River, 2.6 km/d between Columbia State Park and Tumwater Dam, 1.7 km/d between Wells Dam and the lower Methow River, and 2.5 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 13.6 h at Priest Rapids, 10.6 h at Wanapum, 4.7 h at Rock Island, 16.5 h at Rocky Reach, and 19.5 h at Wells Dam (Table 14). However, it should be noted that the tailrace antennas at Rock Island, Rocky Reach, and Wells dams were mounted 300 m downstream, while at Priest Rapids and Wanapum dams tailrace antenna distances were approximately 1200 m. The tailrace monitoring sites were consistent with the sites used in previous studies at each project except Wells (moved in 2001).

Median Project passage times for fallback fish were also calculated, however, the much smaller sample sizes make these median times much less meaningful than those provided for the fish that did not fall back (Table 14). In general, median Project passage times for fallback fish last detected below a specific dam were longer than for those that did not fall back. For fallback fish last detected above a specific dam, the median Project passage times tended to be similar or less than those for fish that did not fall back. The only exceptions were for Rock Island and Rocky Reach dams where the samples sizes were very small (>5 fall back fish that re-ascended and remained above the dam).

Fishway Passage Times

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 the same for each bank (2.5 h), but the passage time through the tailrace and entrance zones were different. Fish using the left fishway found the entrance in 1.8 h compared to 4.2 h for the right bank. The median Entrance time for steelhead at the collection channel and main entrances of the left-bank fishway were 3.0 h and 3.3 h, respectively, compared to 0.6 h for the entrance zones of the right-bank fishway. The Entrance passage time accounted for 42% and 8% of the left and right cumulative median passage times, respectively. Overall, the left fishway median Project passage time (12.8) was shorter than for the right (15.1 h)

At Wanapum Dam, Fishway passage times were significantly shorter ($p<0.002$) for the right-bank fishway compared to the left, however, the difference between the median values was small (2.5 h versus 2.1 h; Tables 15 and 16). The shorter Fishway passage time for the right-bank fishway was offset by a substantially longer Tailrace passage time (4.7 versus 1.9 h) 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 the left-bank fishway. The median Entrance time for steelhead at the collection channel and main

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entrance of the left-bank were 3.8 h and 2.4 h, respectively, compared to 3.2 h for the entrance zone of the right-bank fishway. The Entrance passage time accounted for 41% and 32% of the left and right cumulative median passage times, respectively. Overall, the left fishway median Project passage time (9.5 h) was shorter than the right fishway (13.1 h).

At Rock Island Dam, median Fishway passage times were comparable for each fishway ranging between 1.2 h -2.1 h (Table 15). The shortest fishway passage was for the right-bank fishway, which accounted for 90% of the radio-tagged steelhead detected at the fishway exits at Rock Island Dam (Table 7). The median Entrance passage time of the center and right-bank fishway were shorter (0.2 h and 1.6 h) compared to the left-bank fishway (1.8 h). The Entrance passage time accounted for 46%, 6%, and 39% of the left, center, and right cumulative median passage times, respectively. Project passage time was similar for all three fishways; 4.4 h at the center, 4.5 h at the left-bank, and 4.8 h at the right-bank fishway.

At Rocky Reach Dam, Fishway passage times were similar for the different entrances (2.1 h -2.3 h), as were the tailrace times (1.1 h – 1.4 h). In contrast, longer median Entrance times were observed at the upstream powerhouse entrance (16.8 h) compared to the downstream (9.6 h) and trifurcation (10.6) entrances. The Entrance passage time accounted for 77% of the cumulative median passage time. Project passage times were shortest for those fish that entered the fishway via the downstream powerhouse entrance (13.8 h).

At Wells Dam, Fishway passage times for the left- and right-bank fishways were significantly different ($p<0.001$); however, the difference between the median values was small (2.1 h versus 2.5 h; Tables 15 and 16). Tailrace times also had a small difference (2.7 h – 3.1 h). In contrast, the median Entrance passage time for steelhead at the left-bank fishway was 6.9 h compared to 18.7 h for the right-bank fishway. The Entrance passage time accounted for 57% and 78% of the left and right cumulative median passage times, respectively. Unusually long Entrance passage times on the right bank are likely the result of flow and head differentials in the collection area. In 2001, build-up of aquatic vegetation on the diffusion grates in the collection area resulted in flow control problems and sub-optimal fishway operations (see Appendix Report A2). Disrupted patterns of flow likely sent confusing cues to migrating fish and caused milling in the collection area. Overall, the median Project passage time for steelhead passing via the left-bank fishway (16.3 h) were substantially shorter than those for the right-bank fishway (28.6 h). The left-bank fishway accounted for 75% of the radio-tagged steelhead that passed Wells Dam so the median Project passage time for all steelhead (19.5 h) was substantially less than that estimated for the right-bank fishway.

Effect of Trapping on Passage Times at Priest Rapids and Wells Dams

Upper Fishway passage times (first below trap to last at exit) were assumed to be the most direct measure of the effect of trapping on fish passage times. Median passage times were calculated for radio-tagged steelhead that were detected at the below trap zone, and subsequently exited the fishways during trapping and non-trapping intervals.

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At Priest Rapids Dam, trapping was conducted on the left-bank fishway. The left-bank trap operated on 26 d for a total of 206.4 h (9.3% of the total time between 17 July and 16 October - Appendix Table D1). Of the radio-tagged steelhead that passed via the left-bank fishway, 10% of the fish passed during the trapping intervals. Median upper fishway times for steelhead on the left-bank fishway were 7.5 h (n=16) for fish that passed during a trapping interval, and 2.1 h (n=149) for fish that passed during a non-trapping interval (Appendix Table E1). These values were significantly different (p=0.0001, Appendix Table E2). The effect of trapping on median Project passage times at Priest Rapids Dam was also substantial (22 h during trapping and 14 h during no trapping intervals).

At Wells Dam, active trapping was conducted on both fishways. The left-bank trap operated on 14 d for a total of 110.9 h, and the right-bank fishway trap operated on 49 d for a total of 441.2 h (Appendix Table D1). On the left-bank fishway, no radio-tagged steelhead were captured. On the right-bank fishway, broodstock collection activities resulted in 2 of the radio-tagged steelhead trapped and diverted to Wells Hatchery.

The median upper Fishway passage times for the right-bank fishway were 1.7 h (n=6) for radio-tagged steelhead that passed during a trapping interval and 1.3 h (n=61) for fish that passed during a non-trapping interval (Appendix Table E1). The right-bank upper Fishway passage times for the trapping and no trapping groups were not significantly different (p=0.223; Appendix Table E2). In addition, the upper fishway time represented a small portion of the total Project passage time for each fish. However, trapping appeared to have had a substantial effect on the Project passage times at Wells Dam as the median Project passage time during trapping intervals was 59 h (n=6) for the right-bank fishway compared to 29 h (n=63) during no trapping intervals (Figure 18). This compares to 35 h and 12 h for radio-tagged steelhead in 1999, respectively.

Junction Pool and Counting Station Passage Times

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 relatively fast at all four dams and ranged from 0.0003 h at Wanapum to 0.031 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; therefore, the majority 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 0.134 h at Rocky Reach to 0.429 h at Rock Island left-bank counting station.

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Comparison of Fallback Rates between Dams

Of the 1535 unique detections at the fishway exits for all dams, 119 fallback and 45 re-ascents were detected (Table 18). Therefore, the overall fallback rate for the mid-Columbia dams was 7.8% and and the re-ascension rate was 37.8%. As in 1999-2000, the fallback rates were slightly higher at Wanapum (9.2%) and Wells (11.9%) than at the other mid-Columbia dams, and Wanapum (61.3%) and Priest Rapids (37.5%) had the highest rates for re-ascension.

Fate of Radio-Tagged Steelhead

Prior to Kelting

The spawning destination or furthest upstream detection location prior to kelting was determined for every radio-tagged steelhead (Table 19). Of the 396 steelhead tagged, 2 were never tracked and 23 (6%) were known to have been caught and removed prior to spawning. Of these 23 steelhead tags recovered prior to spawning, 15 were reported from tributaries sites (7 from Snake River, 1 from Yakima River, 2 from Methow River, and 5 from Okanogan River) and 8 were reported from reaches along the mid-Columbia River (3 from below Priest Rapids, 1 from the Wanapum pool, 1 from the Rocky Reach pool and 3 from the Wells pool). Of the remaining 371 steelhead available for spawning, 313 (84.4%) were tracked to known spawning areas prior to or during the spawning period, and 58 (15.6%) 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 30 tagged fish that did not return to Priest Rapids Dam after release: 7 were removed by fishers prior to spawning; 5 were tracked to known spawning areas in the Snake River, Yakima River, and mid-Columbia between Savage Island and Coyote Rapids; 16 were last tracked between Coyote Rapids and Priest Rapids; and 2 were never tracked. The two tributary destinations with the largest numbers of radio-tagged steelhead were the Methow River, with 51% of the fish tracked to spawning tributaries, and the Okanogan River with 23% (Figure 19). Radio-tagged "wild" steelhead were tracked to each tributary, but the majority of these fish were tracked to the Wenatchee (37%) and Methow (35%) rivers (Figure 20).

The precise location of the radio-tagged steelhead within each tributary was obtained from 24 sets of aerial surveys conducted between 27 July 2001 and 2 July 2002. The mobile survey data provided valuable information on the movement of steelhead into and between spawning tributaries, and was critically important for assigning fish to a specific tributary stock. Most of the fixed wing aerial surveys covered the mainstem of the major tributaries (Yakima, Wenatchee, Entiat, Methow, and Okanogan rivers) and the mainstem of the mid-Columbia River between the confluence of the Yakima River and Chief Joseph Dam (Appendix Table F1). In addition, helicopter surveys were used to track steelhead in tributaries to the Methow, Entiat, and Wenatchee rivers, and boat surveys were conducted on the main-stem Columbia between Coyote Rapids and Rock Island Dam tailrace.

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Radio-tagged steelhead were detected in three of the four Methow tributaries surveyed (maximum per month = 31 in Twisp River, 19 in Chewack River and 1 in Gold Creek; Appendix Table F2). The Mad River was the only tributary of the Enitat surveyed, and 1 radio-tagged steelhead was detected. In the Wenatchee watershed, radio-tagged steelhead were tracked in all the tributaries surveyed (maximum per month = 1 in Mission, 5 in Peshastin, 1 in Chumstick, 2 in Icicle, 2 in Chiwaukum, 5 in Chiwawa River, 2 in Nason Creek,). Ten fish were detected in the Similkameen. The peak count on the Similkameen was recorded in March while the peak counts for all tributaries to the Methow and Wenatchee rivers were recorded in April (Appendix Table F2).

The furthest upstream location for each radio-tagged fish provided an indication of the spawning areas and distribution of hatchery and naturally produced steelhead for each tributary stock (Appendix Figures F1-F8). As with other aspects of these studies, the spatial distribution of the radio-tagged steelhead within each basin was remarkably similar in each study year. The furthest upstream detections of the radio-tagged steelhead were distributed throughout the accessible portions of each basin. The only exception was Chumstick Creek which accounted for 6% of the radio-tagged fish tracked to the Wenatchee Basin in 2000 and no steelhead were tracked to this tributary during the 6 helicopter surveys conducted from March to June 2002 (Appendix Table F1). Meaningful comparison of the spawning distributions for hatchery-produced (black circles) and naturally-produced steelhead (yellow circles) were limited to the Wenatchee and Methow basins because of the small number of naturally-produced steelhead tracked to the Entiat and Okanogan basins. Steelhead were tracked into the upper reaches of these basins, however, the lowest 40 km of the Wenatchee and Methow accounted for 30% and 50%, respectively, of the naturally produced steelhead tracked to these basins. These percentages were larger than those for any of the other reaches defined within these watersheds. These reaches also had the largest portion of the hatchery produced steelhead. Overall, the distribution of naturally-produced steelhead was similar to that of the hatchery-produced fish (Appendix Tables F3 and F5). Too few fish were tracked to the Entiat Basin to draw any meaningful conclusions (Appendix Table F4 and Figures F3 and F4). Within the Okanogan Basin, the reach between Monse and Riverside accounted for more of the radio-tagged steelhead than any other reach in each study year (Appendix Table F6 and Figures F7 and F8). Detailed maps showing the flight path and location of the fish detected on each survey are provided on a CD in Appendix Map G1. On these maps, 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 during that survey. The colored 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 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, 366 of the 396 radio-tagged steelhead released were detected at Priest Rapids Dam and 16 of these were removed prior to the spawning period. Of the 350 fish detected at Priest Rapids Dam, and available for spawning, 293 (83.7%) were tracked to known spawning areas and 46 were tracked to mid-Columbia reaches above Priest Rapids Dam. Therefore, 339 (96.9%) 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 (Table 19).

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Comparable percentages for the other dams were 97.6% for Wanapum Dam, 96.6% for Rock Island Dam, 94.2% for Rocky Reach Dam, and 95.8%% for Wells Dam. These are not survival estimates since it is not known 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 58 steelhead assigned to a non-spawning area (i.e., mid-Columbia reaches from Coyote to Wells Dam), 22 (38%) were classified as stationary because they were tracked near the same location from late November 2001 to early July 2002 (Figure 21). More radio tags were last tracked in the Coyote Rapids to Priest Rapids reach than any other mainstem reach. Mobile tracking data from 13 aerial surveys and 10 boat surveys through this reach indicated that 13 (48%) of 27 tags were stationary. Each of the stationary tags was tracked on every aerial survey that covered the Coyote to Priest Rapids reach from January-June 2002; therefore, these detections were indications of either dead fish, regurgitated tags, or tags removed and discarded by fishers. A detailed examination of the fixed-station and mobile tracking data revealed that the other 14 tags last detected between Coyote Rapids and Priest Rapids Dam were not stationary and were last detected at the lower end of our survey area prior to December 2001 (9 fish) or after mid-May 2002 (5 fish).

Comparison of the pre-kelt distribution for hatchery and "wild" steelhead indicated that the contribution of hatchery steelhead for each spawning area varied substantially from the overall 81% for all radio-tagged steelhead (Table 20). The tributaries with the highest proportion of hatchery fish were the Okanogan River (94%) and Methow River (89%). The stocks with the largest "wild" component were Yakima (80%), Wenatchee River below Tumwater Dam (46%), and the Entiat River (38%). Of the 92 steelhead tracked to a mainstem location on the mid-Columbia River, 72% were hatchery fish. Not surprisingly, the two mid-Columbia reaches with the highest hatchery portions were: 1) below Coyote Rapids (100%) adjacent to Ringold Hatchery; and 2) the Rocky Reach Pool (95%), with steelhead rearing facilities located at East Bank Hatchery, Chelan Falls Hatchery and Wells 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 (Tables 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 27 involuntary fallbacks detected for all dams combined represented 1.8% of the unique dam passage events and most of these, (21 or 78%) were hatchery fish (Table 23). On average, 2.9% of the unique fish passage events were classified as "voluntary" fallbacks (range 2.1-3.6% for the different dams) and 3.1% were classified as "re-ascents" (range 1.1%-5.9%; Tables 21-23). An examination of the fates for all fallbacks revealed that 68% 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 (71% for hatchery fish and 61% for "wild" fish; Table 23).

The information provided on the fate of fallback fish in Tables 21-23, includes fish that fell back at more than one dam and some fish fell back several times at one or more dams. Appendix Table G2 provides the detailed tracking histories for the radio-tagged steelhead that

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fellback multiple times at a single or several dams. This appendix provides the origin (Hatchery or "wild"), fallback sequence (abcde), last detection location and spawning fate (0= not tracked to a spawning area, 1= tracked to a spawning area) for each fish, some of which fellback as many as five times. Of the 27 fish with multiple fallback events, 18 (67%) were tracked to spawning areas. One fish (Tag # 406) migrated above Wells Dam before falling back five times on its way to the Snake River.

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, 18% 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. There were 29 fish (10%) tracked to multiple spawning areas, with 24 of these fish detected in both the Methow and Okanogan rivers prior to the spawning period (Table 24).

Kelting Rates

Estimates of the overall kelting rate ranged from 56% to 73% of the radio-tagged fish at large and detectable during the kelting period (Table 25). 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 at each of the mid-Columbia dams, and one site in the Hanford Reach. Fish were classified as "known" kelts if they were tracked moving downstream after the spawning period. 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 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". Assuming that all these fish kelted, the maximum kelting rate is the number of suspected kelts divided by the number available for kelting (Table 25). For example, of the 63 radio-tagged steelhead that were detected in the Okanogan River during the spawning period, 43 were not detected in this watershed after the spawning period. If all of these fish kelted, the maximum kelting rate for the Okanogan stocks would be 68%. This is substantially higher than the minimum kelting rate of 52% based on only those fish tracked moving downstream after the spawning period (Table 25).

The range in kelting rates, defined by the minimum and maximum estimates, was 65-75% for all tributary stocks combined (Table 25; Figure 23). Of the 170 tributary spawners that were tracked as kelts, 119 (70%) were tracked at locations along the mid-Columbia River and 30 (18%) were detected at or below Coyote Rapids as they migrated downstream out of the survey area (Table 26). These estimates were substantially more reliable than those from the 1999-2001 study when downstream detections were compromised by the release of duplicate tag codes in a smolt survival studies. The range in kelting rates for fish assigned to mid-Columbia mainstem reaches (26%-68%) was much broader because of the greater potential for not detecting tags in

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the pools where the water depths can exceed the detection range for the radio tags. Given the high detection efficiency of the fixed station receivers deployed adjacent to each dam, the minimum kelting rate provided in Table 25 are likely much closer to the "true" kelting rate for these mainstem fish than the maximum kelting rates. The confirmed observation of 20 mainstem fish that migrate downstream during the kelting period suggest that some fish may be spawning along the mid-Columbia or 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 undetected by monitoring stations at the mouth or each tributary. The aerial surveys could have failed to detect these fish in 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 (i.e., sharp peaks) 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 tend to 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 decline in the mainstem abundance on 16 November 2001, evident in Figures 27-29, was due to the assignment of fish to tributaries based on the aerial surveys conducted on that date. Most of these fish would have entered the tributaries prior to the aerial survey, but had not migrated past the fixed-station monitoring sites or had not been detected at those sites.

The reciprocal to the mainstem patterns is the accumulation, holding and kelting timing for each tributary (Figure 30). Radio-tagged steelhead begin accumulating in tributaries within a week of the first release and reach a plateau of approximately 230 fish in late October, although the residence period of the Entiat stock is shorter compared to the other tributaries. The number of fish in the tributaries remained constant from early November 2001 through mid-March 2002. The number of radio-tags in the tributaries declined steadily from mid-March through early May as the kelts exited the spawning tributaries which corresponded with water temperatures above 9 to 10 °C (Figure 31). The kelt migration timing varied by stock. The first significant downstream migration of kelts was indicated by the eight fish that exited the Okanogan drainage on 28 March after a rapid increase in water temperature from 2.6 to 8.7 °C. The migration out of the Okanogan continued through 23 May. Kelt migration out of the Methow River began with two fish passing by the river mouth receiver in late March when water temperature reached 10 °C but most of the 97 Methow kelts exited when temperatures were consistently above 10 °C

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between 11 April and 7 June; about two weeks later than the Okanogan kelts. The migration timing for Wenatchee kelts was similar to that for the Methow stock but the water temperature were rarely above 9 °C and the last Wenatchee kelt exited on 19 June, about two weeks after the last Methow kelt. The downstream migration timing for the Entiat kelts was more compressed with all fish exiting from 13 April to 8 May; however, only eight radio-tagged steelhead were assigned to the Entiat stock and this small number of fish may not represent the full migration period for that stock. The downstream migration period for radio-tagged steelhead kelts detected at the mid-Columbia dams ranged from early March to mid-June, with 95% of the kelts passing the Wells, Rocky Reach and Rock Island dams between 11 April and 31 May and 95% passing the Wanapum and Priest Rapids dams between 18 April and 4 June 2002 (Figure 32).

Straying Rates

Each of the radio-tagged adult steelhead was inspected for marks that indicate where that fish had been released as a juvenile. Where fish possessing an adipose fin (un-clipped) are generally accepted as representing wild origin progeny, adipose-clipped or alternative-fin-clipped fish designate hatchery origin progeny. However, steelhead may also possess an adipose fin, but be alternately marked (fin-clipped or tagged) to indicate hatchery origin. Fish of Wells Hatchery origin could have one of four marks; 1) Methow release with adipose present and a blank CWT in the left operculum; 2) Methow release with adipose present and a blank CWT in the right operculum; 3) adipose-clipped only fish released into the Methow or Okanogan rivers, or 4) adipose and right ventral clipped fish reared at Ringold Hatchery and released into the Hanford Reach. Of the 221 radio-tagged steelhead that originated from a Methow or Okanogan release, 20 were removed prior to spawning (Table 27). Of the remaining 201 fish available for spawning, 72% (145) returned to the Methow and Okanogan rivers, 5% (10) were classified as strays to the other rivers below Wells Dam, and 22% (44 fish) were last tracked on the mid-Columbia River. Of the 13 radio-tagged steelhead identified as fish reared and released from Ringold Hatchery, 5 returned to the Hanford Reach, 5 were last tracked on the mid-Columbia River between Coyote Rapids and Rocky Reach Dam and 3 fish were tracked in tributaries (one in each of the Snake, Methow and Okanogan rivers).

Additional adipose present hatchery releases included those with visual implant elastomer (VIE) tags placed in the adipose tissue posterior of the left eye. These fish were reared at the East Bank Hatchery (adjacent to the Rocky Reach Dam) or Chiwawa ponds and released into the Wenatchee River. Of the 32 radio-tagged steelhead with VIE tags, 66% (21 fish) returned to the Wenatchee River, 19% (6) were classified as strays to the Methow and Okanogan rivers, and 16% (5) were last tracked on the mid-Columbia River (Table 27).

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DISCUSSION

Radio-telemetry techniques have been used in the Columbia River basin to study the migration of adult salmonids since 1975. The introduction to this report provides some background on the focus of the studies conducted on the Snake and Columbia rivers. English et al. (2001) presented data and analysis on the 1999-2001 mid-Columbia steelhead study and compared those results with pre-1999 studies on the Columbia River and elsewhere. In this discussion, the results of the 2001-2002 study will be compared to those previously reported for 1999-2000.

Median, tailrace, entrance, and Fishway passage times were very similar between years for respective dams (Figures 15 to 17). A notable exception is at Wells Dam (Figure 17) where the median Entrance passage time in 2001 was substantially longer at the right-bank fishway (19 h) compared to 1999 (4 h). It should be noted that there were significant changes to entrance gate opening width, trapping operations and the size of the steelhead run between these two years. Problems with fouling of the diffusion grates in 2001 resulted in substantial reductions in gate opening widths and head differential. Gate opening widths were reduced from the normal width of 2.4 m (8 ft) to 1.2-1.8 m (4-6 ft) and head differential between inside and outside of the right-bank fishway entrance was reduced from 45 cm to 30 cm. These changes were implemented to prevent the diffusion grates from failing in the right-bank fishway. The number of hours of trapping on the right bank fishway was reduced from 912 h in 1999 to 441 h in 2001. The number of steelhead counted through the fishways at Wells Dam in 2001 was 18,438; more than five times the 1999 count of 3,455. Based on previous year's data, we would have expected that the reduction in trapping time would have facilitated fish passage. However, the negative effect of reduced gate opening and head differential more than offset the positive effect of less trapping time. The distribution of steelhead between the two fishways in 2001 suggests that the left-bank fishway was the preferred passage route; accounting for 68% of the total count. In 1999, steelhead passage was equally distributed between the two fishways (English et al. 2001).

Fallback rates as a proportion of total fish passing a respective dam were 2.5-3.7 percentage points lower in 2001 than in 1999 (Table 18), except for Wells Dam where the fallback rate was 5.1 percentage points higher in 2001. The higher fallback rate for Wells Dam could be attributed to large number of hatchery steelhead returning to the Wells facility and the operation of the hatchery channel. Of the 30 steelhead that fell back at Wells Dam, 29 were hatchery fish and 9 of these were reared at Well Hatchery. All of the 3 involuntary fallbacks at Wells Dam were hatchery fish and 7 of the fallback fish were detected in the vicinity of the hatchery channel for extended periods. If the hatchery channel had been opened, it is likely that these fish would have entered the channel instead of passing through the fishway and becoming a fallback. The portion of fallbacks that re-ascended was 7-19 percentage points higher in 2001 than 1999 for Priest Rapids, Wanapum and Rocky Reach and approximately 12 percentage points lower at Rock Island and Wells dams (Table 18). The involuntary fallback rates for the mid-Columbia dams in 2001 were all low (0.6-1.5%) and similar to those observed in 1999.

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The portion of the radio-tagged fish that migrated past each dam was greater in 2001 for all five dams (64% at Wells, 70% at Rocky Reach, 82% at Rock Island, 85% at Wanapum, and 87% at Priest Rapids) compared to that observed in 1999 (41%, 52%, 75%, 82% and 85%, respectively; Table 28).

The median migration rates for radio-tagged steelhead through reservoirs were similar between 2001 and 1999 (Table 29). For example, the median migration rates, from the release site to the most upstream dam (Vernita Bridge to Wells exit) were identical at 10.9 d. Site-to-site differences were most pronounced for mainstem-to-tributary routes (e.g., Rock Island to Wenatchee and Wells to Monse) and are likely attributable to longer holding times in the mainstem.

The portion of the radio-tagged fish tracked upstream of the release site or to known spawning areas is used as an indicator to evaluate radio-tag studies conducted on adult salmon and steelhead. In 2001, 92.7% of the radio-tagged steelhead released were tracked upstream of the dams they were detected at, or to known spawning areas, and is similar to the estimates for 1999 (91.6%; Table 29). In 1999 and 2001, the Methow River accumulated the most radio-tagged steelhead prior to kelting (22.8% and 35.9 %, respectively; Table 30). In contrast, the portion of the tagged-steelhead assigned to the Wenatchee River stock was lower in 2001 (9.9%) than in 1999 (20.8%). Another observed change in the Wenatchee stock was an increase in the proportion of hatchery fish in the upper portion of the river (76% in 2001 compared to 43% in 1999; Table 31).

Table 32 compares the portion of radio-tagged steelhead tracked as kelts for 2000 and 2002 spring downstream migrations. The monitoring of kelt migrations was more complete in 2002 because all adult tag codes could be readily tracked along the mainstem Columbia without the problems created in 2000 by the use of identical tag codes in the juvenile survival studies. The minimum kelting rates estimated for 2002 ranged from 52% to 100% for the different tributary stocks and were generally higher and more reliable than those estimated for 2000. The most significant improvement in kelt tracking was for the lower Wenatchee stock where the minimum kelting rate (65%) was substantially higher than the 13% estimate for 2000. The minimum estimate for the Methow stock (68%) was also higher in 2002 than that estimated for the 2000 migration (59%). The lower minimum kelting rate for the Okanogan stock (52%) was probably the result of unreported removals prior to the kelting period in 2002. Interestingly, minimum kelting rates for radio-tagged steelhead last tracked in Columbia mainstem reaches prior to spawning ranged between 23% and 56%. These fish are either finding places to spawn in the reservoirs or mouths of tributaries and migrating downstream as kelts, or returning downstream after an unsuccessful attempt to spawn. The maximum kelting rates estimated for 2002 were all similar to or higher than those estimated for 2000. Kelting rates could not be estimated for the Yakima or Snake river stocks in 2002 because no aerial surveys were conducted in these areas after the spawning period and there were no fixed stations maintained downstream of these stocks during the kelting period.

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SUMMARY

1. Of the 396 radio-tagged steelhead released, 366 (92%) were detected at Priest Rapids, 343 (87%) at Wanapum, 334 (84%) at Rock Island, 305 (77%) at Rocky Reach, and 274 (69%) at Wells.

2. Of the radio-tagged steelhead detected in the vicinity of Priest Rapids Dam, 96.9% were either tracked to known spawning areas or successfully passed and remained above Priest Rapids Dam. Comparable percentages for the other dams were 97.6% for Wanapum Dam, 96.6% for Rock Island Dam, 94.2% for Rocky Reach Dam, and 95.8% 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 broodstock trapping in the fishways were: 10.6 h (0.44 d) at Wanapum, 4.7 h (0.19 d) at Rock Island, and 16.5 h (0.69 d) at Rocky Reach.

4. The median Project passage times for the two mid-Columbia dams with ladder trapping activity were: 13.6 h (0.57 d) at Priest Rapids Dam and 19.5 h (0.81 d) at Wells Dam. The left-bank fishway trap was operated at Priest Rapids Dam for 206 h and the fishway traps at Wells Dam were operated for 552 h during the 2002 adult steelhead migration.

5. The median dam passage times, fallback rates and migration rates through reservoirs for adult steelhead in the 2001 study were similar to those observed in 1999.

6. Project passage times and migration times through the reservoirs in 2001 were similar to those observed for radio-tagged steelhead tracked on the mid-Columbia River in 1999.

7. The median migration rate from the Priest Rapids tailrace to the Wells Dam fishway exits was 20.3 km/d which was same as the median migrations speed for radio-tagged steelhead tracked in 1999 (20.1 km/d).

8. Entrance passage times represented the largest proportion of the cumulative passage time (sum of median Tailrace, Entrance, and Fishway passage times) for steelhead at Rocky Reach (72%-84%) and Wells dams (57%-78%), and were less than 50% of the cumulative passage time at the other dams.

9. The median Entrance passage time at Wells in 2001 was substantially longer at the right-bank fishway (19 h) compared to 1999 (4 h). Unusually long entrance times at Wells can be largely explained by sub-optimal fishway operations which were the result of flow control problems associated with debris build-up on the diffusion grates in the collection area.

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10. Fishway passage times were generally less than 35% of the total Project passage time and were fairly consistent both within and between projects. Median Fishway passage times ranged from 1.2 h to 2.7 h over all projects.

11. The fallback rates for steelhead were similar for all dams. Approximately 8% of the fish that passed a dam, fell back (range 5%-12%). The 18 involuntary fallbacks detected for all dams combined represented 1.2% of the unique dam passage events and most of these, 12 (67%) were hatchery fish. On average, 3.5% of the unique fish passage events were classified as "voluntary" fallbacks (range 2.1%-7.0% for the different dams) and 3.1% were classified as re-ascents (range 1.1%-5.9%).

12. Of the radio-tagged steelhead that fell back at a dam, 77% were either tracked to known spawning areas or successfully passed and remained above the fallback dam (80% for hatchery fish and 61% for "wild" fish).

13. At Priest Rapids, left-bank upper Fishway passage times were significantly different ($p=0.001$) for trapping and non-trapping intervals. At Wells Dam, right-bank upper fishway showed no significant differences in Upper Fishway passage time during trapping and non-trapping periods ($p=0.223$). However, Project passage time for trapping (58 h) and non-trapping (28 h) periods was substantial.

14. Of the 396 steelhead tagged, 2 were never tracked and 23 (6%) were known to have been caught and removed prior to spawning. Of the remaining 371 steelhead available for spawning, 314 (84.4%) were tracked to known spawning areas prior to or during the spawning period, and 58 (15.6%) 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 58 steelhead assigned to a non-spawning area (i.e., mid-Columbia reaches from Coyote to Wells Dam), 22 (38%) were classified as stationary and the others were either tracked as kelts or not detected during the last two aerial surveys.

15. The stocks with the largest "wild" component were Yakima (80%), Wenatchee River below Tumwater Dam (46%), and the Entiat River (38%). The tributaries with the highest proportion of hatchery fish were the Okanogan River (94%) and Methow River (89%).

16. Of the radio-tagged steelhead assigned to a tributary stock, 18% were tracked upstream of their spawning destination.

17. Estimates of the overall kelting rate ranged from 56% to 73% of the radio-tagged fish at large and detectable during the kelting period.

18. Of the 170 tributary spawners that were tracked as kelts, 30 (18%) were detected at or below Coyote Rapids as they migrated downstream out of the survey area.

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19. Straying rates for Ringold, Wenatchee, and Methow/Okanogan hatchery releases were estimated to be 23%, 19%, and 5%, respectively.

20. The portion of the radio-tagged fish that migrated past each dam was greater in 2001 for all five dams (64% at Wells, 70% at Rocky Reach, 82% at Rock Island, 85% at Wanapum, and 87% at Priest Rapids) compared to that observed in the 1999 study (41%, 52%, 75%, 82% and 85%, respectively).

21. Upstream/destination migration success (tracked upstream of dams or to known spawning area) for 2001 was 92.7% and was very similar to the 1999 estimate of 91.6%.

22. The minimum kelting rates estimated for tributary stocks in 2001-2002 (52%-100%) were generally higher and more reliable than those estimated for 1999-2000 (13%-75%).

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TABLES

Table 1. Estimated versus actual proportions of steelhead captured and radio-tagged at Priest Rapids left fish ladder, 15 July to 13 October 2001.

		Expected run and initial tagging targets							Actual run and revised tagging targets							
Week		Number tagged	Prop'n of tags	Total tagged	Number of fish	# if 10% capture	% of capt tagged	% of run tagged	Number tagged	Prop'n of tags	Total tagged	"Actual" run	# if 10% capture	# actually captured	% of capt tagged	% of run tagged
1	15 July - 21 July	5	0.013	5	94	9	53	5.3	5	0.013	5	1178	118	13	38	0.4
2	22 July - 28 July	13	0.033	18	244	24	53	5.3	13	0.033	18	1664	166	25	52	0.8
3	29 July - 4 Aug	19	0.048	37	356	36	53	5.3	19	0.048	37	1716	172	86	22	1.1
4	5 Aug - 11 Aug	36	0.090	73	675	67	53	5.3	37	0.093	74	3260	326	230	16	1.1
5	12 Aug - 18 Aug	40	0.100	113	750	75	53	5.3	40	0.100	114	2795	280	237	17	1.4
6	19 Aug - 25 Aug	44	0.110	157	825	82	53	5.3	44	0.110	158	1667	167	50	88	2.6
7	26 Aug - 1 Sep	48	0.120	205	900	90	53	5.3	33	0.083	191	1764	176	78	42	1.9
8	2 Sep - 8 Sep	48	0.120	253	900	90	53	5.3	62	0.155	253	2236	224	77	81	2.8
9	9 Sep - 15 Sep	48	0.120	301	900	90	53	5.3	47	0.118	300	3257	326	172	27	1.4
10	16 Sep - 22 Sep	38	0.095	339	712	71	53	5.3	37	0.093	337	3731	373	294	13	1.0
11	23 Sep - 29 Sep	32	0.080	371	600	60	53	5.3	32	0.080	369	2325	233	162	20	1.4
12	30 Sep - 6 Oct	20	0.050	391	375	37	53	5.3	20	0.050	389	1321	132	101	20	1.5
13	7 Oct - 13 Oct	8	0.020	399	150	15	53	5.3	7	0.018	396	598	60	39	18	1.2
Total		**399**	**1.000**		**7480**	**748**	**53**	**5.3**	**396**	**0.992**		**27512**	**2751**	**1564**	**35**	**1.4**

Table 2. Summary of fixed-station monitoring effort (in hours) for each week for all sites monitored in 2001 between the Snake River and Wanapum Dam forebay (see Appendix Table A2 for details).

Week Ending	Snake R. Ice Harb.	Yakima	Coyote Rapids	Priest Rapids Dam						Crab Creek	Wanapum Dam						Grant PUD Total	University of Idaho Total
				Tailrace	Fishway Entrances	Fishway Exits Left	Fishway Exits Right	Fishway Exits Total	Forebay		Tailrace	Fishway Entrances	Fishway Exits Left	Fishway Exits Right	Fishway Exits Total	Forebay		
14-Jul	0	0	0	116	83	0	15	15	336	0	0	0	0	0	0	188	753	0
21-Jul	0	0	0	336	503	106	167	273	335	0	266	243	131	129	260	168	2917	0
28-Jul	0	0	0	336	504	168	168	336	304	36	333	500	168	168	336	302	3659	0
04-Aug	0	0	105	335	504	168	168	336	168	168	336	504	168	168	336	336	3800	0
11-Aug	103	102	168	335	502	168	167	335	168	167	335	501	168	168	336	335	3853	205
18-Aug	168	168	168	335	504	168	167	335	297	32	334	500	168	168	336	335	3847	336
25-Aug	167	168	166	336	502	168	167	335	335	0	335	503	167	168	335	335	3852	335
01-Sep	167	168	168	336	504	168	168	336	336	135	334	503	168	168	336	335	3995	335
08-Sep	168	168	167	336	502	168	166	334	336	167	334	503	168	168	336	335	4020	336
15-Sep	168	168	168	336	503	168	168	336	336	167	334	504	168	168	336	334	4026	336
22-Sep	168	168	167	336	503	168	167	335	336	168	335	499	168	168	336	335	4021	336
29-Sep	168	168	168	336	503	165	167	332	336	167	335	501	168	167	335	334	4014	336
06-Oct	168	168	168	336	503	168	167	335	336	167	334	501	167	168	335	334	4019	336
13-Oct	143	168	168	336	503	168	167	335	228	167	335	500	168	168	336	335	3914	311
20-Oct	168	168	168	336	504	166	167	333	108	168	336	501	168	168	336	334	3793	336
27-Oct	145	168	168	336	504	168	167	335	168	167	336	502	168	168	336	334	3857	313
03-Nov	168	168	168	336	503	168	168	336	168	167	336	504	168	168	336	336	3862	336
10-Nov	168	168	168	336	503	167	167	334	168	168	334	501	168	167	335	335	3851	336
17-Nov	168	168	54	336	503	167	167	334	168	58	333	500	168	168	336	335	3627	336
24-Nov	167	166	0	336	503	167	167	334	168	0	332	500	168	168	336	335	3514	333
01-Dec	168	168	105	336	503	167	168	335	168	0	334	500	168	168	336	335	3623	336
08-Dec	168	168	133	335	502	167	168	335	168	0	333	257	140	168	308	335	3349	336
15-Dec	168	167	0	71	109	39	167	206	167	0	117	60	0	168	168	334	1606	335
22-Dec	168	168	0	0	0	0	168	168	168	0	0	0	0	168	168	334	1174	336
29-Dec	168	168	0	0	0	0	168	168	168	0	0	0	0	168	168	336	1176	336
Totals	**3244**	**3291**	**2745**	**7239**	**10757**	**3495**	**3863**	**7358**	**5806**	**2269**	**7071**	**10087**	**3461**	**3823**	**7284**	**7688**	**86237**	**6535**

Table 3. Numbers of steelhead radio-tagged and released near Vernita Bridge in 2001 that were detected at fixed stations between the Snake River and Wanapum Forebay.

Release Week Ending	Snake R. Ice Harb.	Yakima	Coyote Rapids	Vernita Bridge Release	Priest Rapids Dam At Dam	Tail	Fishway Entrances	Fishway Exits Left	Right	Total	Unique	Forebay	Crab Creek	Wanapum Dam At Dam	Tailrace	Fishway Entrances	Fishway Exits Left	Right	Total	Unique	Forebay
21-Jul	0	1	1	5	5	5	5	1	4	5	5	2	0	5	5	5	3	1	4	4	0
28-Jul	0	1	3	13	12	11	11	6	5	11	10	4	0	9	9	9	7	4	11	9	6
04-Aug	3	1	5	19	18	18	16	7	7	14	14	6	0	14	13	14	11	9	20	14	9
11-Aug	2	2	9	37	32	32	30	18	11	29	29	11	0	28	27	28	15	17	32	28	13
18-Aug	2	0	4	39	36	36	35	18	14	32	32	11	0	32	30	32	23	18	41	32	19
25-Aug	0	0	2	44	43	43	41	23	17	40	40	15	0	41	35	41	35	13	48	41	17
01-Sep	1	0	1	33	31	31	30	18	10	28	28	4	0	29	27	29	20	18	38	29	18
08-Sep	2	0	2	62	61	61	60	41	23	64	61	15	0	61	60	61	46	37	83	60	39
15-Sep	2	0	4	48	45	45	44	30	14	44	42	17	0	43	42	43	35	23	58	43	30
22-Sep	2	0	2	38	35	35	35	23	12	35	35	13	0	35	34	35	30	11	41	34	16
29-Sep	3	0	7	32	25	25	25	18	10	28	25	14	0	25	25	25	20	13	33	24	10
06-Oct	1	0	1	19	16	16	16	11	6	17	16	9	0	15	15	15	11	9	20	15	10
13-Oct	0	1	1	7	7	7	6	3	4	7	6	2	0	6	6	6	5	3	8	5	5
Totals	**18**	**6**	**42**	**396**	**366**	**365**	**354**	**217**	**137**	**354**	**343**	**123**	**0**	**343**	**328**	**343**	**261**	**176**	**437**	**338**	**192**

Table 4. Classification of radio-tagged steelhead that fell-back after passing Priest Rapids Dam, 2001-2002.

Week Ending	Unique Exits	Total Fallbacks by[a]					Voluntary Fallbacks by[b]					Involuntary Fallbacks by[c]					Reascended Fallbacks by[d]				
		SP	SL	PH	UK	Total	SP	SL	PH	UK	Total	SP	SL	PH	UK	Total	SP	SL	PH	UK	Total
21-Jul	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jul	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04-Aug	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Aug	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-Aug	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Aug	32	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
01-Sep	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-Sep	55	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
15-Sep	51	1	3	0	0	4	0	1	0	0	1	1	0	0	0	1	0	2	0	0	2
22-Sep	39	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
29-Sep	25	0	4	0	1	5	0	2	0	0	2	0	0	0	0	0	0	2	0	1	3
06-Oct	16	1	1	0	1	3	0	0	0	1	1	0	1	0	0	1	1	0	0	0	1
13-Oct	7	0	0	0	2	2	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
20-Oct	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Oct	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
03-Nov	0	0	1	1	0	2	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0
10-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01-Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-Dec	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Dec	0	0	2	0	0	2	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0
29-Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02-Feb	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09-Feb	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Total	**343**	**3**	**13**	**1**	**7**	**24**	**0**	**7**	**1**	**3**	**11**	**1**	**1**	**0**	**0**	**2**	**2**	**5**	**0**	**4**	**11**
Percent	**100.0%**	**0.9%**	**3.8%**	**0.3%**	**2.0%**	**7.0%**	**0.0%**	**2.0%**	**0.3%**	**0.9%**	**3.2%**	**0.3%**	**0.3%**	**0.0%**	**0.0%**	**0.6%**		**1.5%**	**0.0%**	**1.2%**	**3.2%**

[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

Table 5. Classification of radio-tagged steelhead that fell-back after passing Wanapum Dam, 2001-2002.

Week Ending	Unique Exits	Total Fallbacks by[a]					Voluntary Fallbacks by[b]					Involuntary Fallbacks by[c]					Reascended Fallbacks by[d]				
		SP	SL	PH	UK	Total	SP	SL	PH	UK	Total	SP	SL	PH	UK	Total	SP	SL	PH	UK	Total
21-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jul	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04-Aug	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Aug	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-Aug	32	0	2	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Aug	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	3
01-Sep	48	1	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-Sep	56	0	2	0	1	3	0	0	0	0	0	0	0	0	0	0	1	2	0	0	3
15-Sep	56	1	3	0	1	5	0	0	0	0	0	0	0	0	0	0	0	2	0	1	3
22-Sep	37	0	3	0	1	4	0	0	0	0	0	0	2	0	0	2	0	1	0	1	2
29-Sep	19	0	1	0	2	3	0	1	0	1	2	0	0	0	0	0	0	0	0	1	1
06-Oct	20	1	3	0	0	4	1	2	0	0	3	0	0	0	0	0	0	1	0	0	1
13-Oct	11	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
20-Oct	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Nov	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Nov	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0
01-Dec	0	0	0	2	0	2	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0
08-Dec	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**338**	**3**	**18**	**3**	**7**	**31**	**1**	**3**	**2**	**2**	**8**	**0**	**2**	**1**	**0**	**3**	**2**	**13**	**0**	**5**	**20**
Percent	**100.0%**	**0.9%**	**5.3%**	**0.9%**	**2.1%**	**9.2%**	**0.3%**	**0.9%**	**0.6%**	**0.6%**	**2.4%**	**0.0%**	**0.6%**	**0.3%**	**0.0%**	**0.9%**	**0.6%**	**3.8%**	**0.0%**	**1.5%**	**5.9%**

[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

Table 6. Summary of fixed-station monitoring effort (in hours) for each week for all sites monitored in 2001 between the Rock Island Dam and the Entiat River (see Appendix Table B1and B2 for details).

Week Ending	Rock Island Dam							Wenatchee River	Tumwater Dam	Rocky Reach Dam				Turtle Rock	Yacht Club	Entiat River	Chelan PUD Total
	Tailrace	Fishway Entrances	Junction Area	Fishway Exits						Tailrace	Entrance/ Transport Chan	Trifurication Pool	Fishway Exit				
				Left	Middle	Right	Total										
14-Jul	167	0	0	167	167	167	501	167	0	167	334	88	168	0	0	167	2260
21-Jul	168	245	60	167	167	167	501	167	55	167	371	167	167	35	33	168	2805
28-Jul	168	670	167	168	168	166	502	167	167	167	510	167	167	168	168	168	3858
04-Aug	167	666	167	166	166	167	499	167	167	167	633	168	166	168	168	168	3970
11-Aug	167	668	167	167	167	168	502	167	166	168	643	168	167	168	168	167	3988
18-Aug	168	670	168	167	166	167	500	167	167	168	638	168	167	168	168	166	3983
25-Aug	167	668	167	167	167	167	501	168	167	168	672	168	167	167	168	167	4016
01-Sep	167	669	167	167	167	167	501	168	167	168	587	168	167	168	168	167	3933
08-Sep	167	667	167	167	167	168	502	168	167	168	584	168	168	168	168	167	3931
15-Sep	168	667	168	168	167	168	503	168	167	168	672	168	168	168	168	167	4023
22-Sep	167	650	168	167	166	167	500	168	108	168	672	168	167	168	168	167	3939
29-Sep	168	671	168	167	167	168	502	168	61	168	671	168	167	168	168	168	3918
06-Oct	168	669	166	167	167	168	502	168	167	168	672	168	167	168	168	168	4021
13-Oct	168	668	167	167	168	167	502	168	167	168	668	167	168	168	168	168	4017
20-Oct	168	669	166	167	168	167	502	168	167	168	672	168	167	168	168	168	4021
27-Oct	168	670	167	167	167	168	502	168	168	168	668	167	167	168	168	167	4018
03-Nov	168	672	168	168	168	168	504	168	168	168	672	168	168	168	168	168	4032
10-Nov	167	629	166	168	167	167	502	168	167	168	663	165	166	97	168	168	3896
17-Nov	168	669	167	168	167	167	502	168	168	168	668	167	167	167	168	167	4016
24-Nov	168	666	167	168	168	167	503	168	167	168	668	167	167	168	168	168	4016
01-Dec	167	669	167	168	167	166	501	168	167	167	669	167	166	27	106	168	3810
08-Dec	168	669	167	167	167	167	501	168	168	167	669	167	167	0	0	167	3679
15-Dec	168	139	35	168	168	168	504	168	168	167	333	83	167	0	0	166	2602
22-Dec	168	0	0	168	168	150	486	168	168	168	0	0	168	0	0	168	1980
29-Dec	168	0	0	168	168	168	504	168	168	168	0	0	168	0	0	168	2016
Totals	**4191**	**13700**	**3437**	**4184**	**4180**	**4165**	**12529**	**4194**	**3737**	**4193**	**14009**	**3688**	**4179**	**3013**	**3163**	**4186**	**90748**

Table 7. Numbers of steelhead radio-tagged and released near Vernita Bridge in 2001 that were detected at fixed stations between the Rock Island Dam tailrace and the Entiat River.

Release Week Ending	Vernita Bridge Release	Rock Island Dam								Wenatchee River	Tumwater Dam	Rocky Reach Dam				Turtle Rock	Yacht Club	Entiat River
		At Dam	Tailrace	Fishway Entrances	Fishway Exits							At Dam	Tail	Fishway Entrances	Fishway Exit			
					Left	Middle	Right	Total	Unique									
21-Jul	5	4	4	4	1	1	2	4	4	0	0	4	4	4	4	2	3	0
28-Jul	13	9	9	9	3	2	8	13	9	0	0	9	9	9	7	1	5	0
04-Aug	19	14	14	14	3	5	14	22	14	3	3	13	13	13	8	1	3	1
11-Aug	37	28	28	28	5	7	26	38	28	5	4	26	26	26	20	8	15	0
18-Aug	39	31	31	31	2	5	28	35	31	3	0	31	31	31	26	10	17	0
25-Aug	44	41	40	41	10	11	35	56	39	7	4	36	36	35	33	15	23	0
01-Sep	33	29	29	29	13	12	23	48	28	2	1	29	29	29	27	10	14	0
08-Sep	62	60	60	60	12	13	58	83	59	8	6	52	51	52	49	23	31	0
15-Sep	48	42	40	42	3	4	37	44	38	2	0	37	37	37	36	19	24	0
22-Sep	38	33	33	33	9	11	30	50	33	1	1	32	30	32	32	12	22	0
29-Sep	32	23	23	23	7	6	23	36	23	4	2	19	19	18	17	7	9	0
06-Oct	19	15	15	15	4	5	11	20	15	2	0	13	13	13	13	9	10	1
13-Oct	7	5	5	5	0	1	4	5	5	1	0	4	4	4	4	2	4	0
Totals	**396**	**334**	**331**	**334**	**72**	**83**	**299**	**454**	**326**	**38**	**21**	**305**	**302**	**303**	**276**	**119**	**180**	**2**

Table 8. Classification of radio-tagged steelhead that fell back after passing Rock Island Dam, 2001-2002.

Week Ending	Unique Exits	Total Fallbacks	Voluntary Fallbacks[a]	Involuntary Fallbacks[b]	Reascended Fallbacks[c]
21-Jul	0	0	0	0	0
28-Jul	5	0	0	0	0
04-Aug	3	0	0	0	0
11-Aug	16	0	0	0	0
18-Aug	20	1	1	0	0
25-Aug	29	0	0	0	0
01-Sep	37	0	0	0	0
08-Sep	39	0	0	0	0
15-Sep	52	0	0	0	0
22-Sep	42	1	0	1	0
29-Sep	38	3	0	1	2
06-Oct	24	2	1	1	0
13-Oct	10	0	0	0	0
20-Oct	8	1	0	0	1
27-Oct	1	2	1	1	0
03-Nov	0	2	0	1	1
10-Nov	0	1	1	0	0
17-Nov	0	2	2	0	0
24-Nov	0	0	0	0	0
01-Dec	0	0	0	0	0
08-Dec	0	0	0	0	0
15-Dec	0	0	0	0	0
22-Dec	0	0	0	0	0
29-Dec	0	0	0	0	0
05-Jan	0	0	0	0	0
12-Jan	0	0	0	0	0
19-Jan	0	0	0	0	0
26-Jan	0	0	0	0	0
02-Feb	0	0	0	0	0
09-Feb	0	0	0	0	0
16-Feb	0	0	0	0	0
23-Feb	1	1	1	0	0
02-Mar	1	0	0	0	0
Total	**326**	**16**	**7**	**5**	**4**
Percent	**100.0%**	**4.9%**	**2.1%**	**1.5%**	**1.2%**

[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, 2001-2002.

Week Ending	Unique Exits	Total Fallbacks	Voluntary Fallbacks[a]	Involuntary Fallbacks[b]	Reascended Fallbacks[c]
21-Jul	0	0	0	0	0
28-Jul	4	0	0	0	0
04-Aug	2	0	0	0	0
11-Aug	11	0	0	0	0
18-Aug	10	0	0	0	0
25-Aug	21	0	0	0	0
01-Sep	27	0	0	0	0
08-Sep	32	1	0	0	1
15-Sep	53	0	0	0	0
22-Sep	40	3	0	1	2
29-Sep	37	0	0	0	0
06-Oct	19	3	3	0	0
13-Oct	11	0	0	0	0
20-Oct	7	3	3	0	0
27-Oct	0	2	2	0	0
03-Nov	0	0	0	0	0
10-Nov	0	1	0	1	0
17-Nov	0	0	0	0	0
24-Nov	0	2	1	1	0
01-Dec	1	0	0	0	0
08-Dec	0	1	1	0	0
15-Dec	0	0	0	0	0
22-Dec	1	1	0	1	0
29-Dec	0	0	0	0	0
05-Jan	0	1	0	1	0
Total	**276**	**18**	**10**	**5**	**3**
Percent	**100.0%**	**6.5%**	**3.6%**	**1.8%**	**1.1%**

[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 10. Summary of fixed-station monitoring effort (in hours) for each week for all sites monitored in 2001 between Wells Dam and the Okanogan River (see Appendix Table C1and C2 for details).

Week Ending	Tailrace	Wells Dam					Wolf's Rock	Methow River	Okanogan River	Douglas PUD Total
		Hatchery Cove	Fishway Entrances / Trap	Fishway Exits						
				Left	Right	Total				
14-Jul	336	167	335	167	167	334	0	334	167	2007
21-Jul	334	167	334	167	167	334	0	336	168	2007
28-Jul	336	167	335	166	167	333	0	191	167	1862
04-Aug	336	168	336	168	168	336	0	336	168	2016
11-Aug	333	166	332	166	166	332	0	334	166	1995
18-Aug	336	168	336	167	167	334	0	335	167	2010
25-Aug	336	168	336	168	167	335	0	334	167	2011
01-Sep	336	167	336	168	167	335	0	335	167	2011
08-Sep	335	167	336	167	167	334	0	335	168	2009
15-Sep	336	167	336	168	167	335	0	335	168	2012
22-Sep	336	167	336	168	167	335	0	334	167	2010
29-Sep	336	166	335	168	167	335	0	301	168	1976
06-Oct	335	167	336	167	167	334	81	225	167	1979
13-Oct	336	167	336	167	168	335	167	285	168	2129
20-Oct	335	167	334	167	167	334	166	336	168	2174
27-Oct	336	167	335	167	167	334	168	335	168	2177
03-Nov	336	168	336	168	168	336	168	336	167	2183
10-Nov	334	167	334	167	167	334	168	334	168	2173
17-Nov	335	167	334	167	167	334	168	336	168	2176
24-Nov	334	167	335	167	167	334	168	336	168	2176
01-Dec	336	166	334	167	167	334	168	336	167	2175
08-Dec	273	83	209	167	167	334	168	336	167	1904
15-Dec	167	0	0	87	168	255	168	336	168	1349
22-Dec	167	0	0	0	167	167	167	336	168	1172
29-Dec	168	0	0	0	168	168	168	336	168	1176
Totals	**7818**	**3591**	**7246**	**3766**	**4179**	**7945**	**2093**	**8043**	**4188**	**48869**

Table 11. Numbers of steelhead radio-tagged and released near Vernita Bridge in 2001 that were detected at fixed stations between the Wells Dam tailrace and Okanogan River.

Release Week Ending	Vernita Bridge Release	Wells Dam							Wolf's Rock	Methow River	Okanogan River	Mobile Tracking Douglas	Mobile Tracking Chelan	Mobile Tracking Grant
		At Dam	Tailrace	Fishway Entrances	Fishway Exits									
					Left	Right	Total	Unique						
21-Jul	5	4	4	4	2	2	4	4	1	1	1	3	1	1
28-Jul	13	7	7	7	6	2	8	7	4	4	2	7	2	7
04-Aug	19	8	8	8	6	2	8	8	1	5	3	8	6	5
11-Aug	37	20	20	18	10	7	17	17	4	9	3	16	10	15
18-Aug	39	27	27	27	22	5	27	27	10	17	7	27	5	7
25-Aug	44	32	32	31	25	5	30	29	8	13	8	25	18	7
01-Sep	33	26	26	26	24	1	25	25	6	11	8	23	6	5
08-Sep	62	51	51	51	43	8	51	50	7	28	14	48	15	2
15-Sep	48	37	37	36	19	11	30	30	7	18	6	30	17	26
22-Sep	38	31	30	31	18	11	29	29	15	17	8	29	8	13
29-Sep	32	16	16	14	6	7	13	13	10	7	3	12	14	8
06-Oct	19	12	12	12	7	4	11	11	10	5	0	10	7	11
13-Oct	7	3	3	3	1	1	2	2	1	1	1	2	4	2
Totals	**396**	**274**	**273**	**268**	**189**	**66**	**255**	**252**	**84**	**136**	**64**	**240**	**113**	**109**

Table 12. Classification of radio-tagged steelhead that fell back after passing Wells Dam, 2001-2002.

Week Ending	Unique Exits	Total Fallbacks	Voluntary Fallbacks[a]	Involuntary Fallbacks[b]	Reascended Fallbacks[c]
21-Jul	0	0	0	0	0
28-Jul	1	0	0	0	0
04-Aug	5	2	0	1	1
11-Aug	6	0	0	0	0
18-Aug	6	0	0	0	0
25-Aug	18	3	2	0	1
01-Sep	29	3	1	0	1
08-Sep	28	2	2	1	0
15-Sep	43	8	4	0	4
22-Sep	41	4	3	0	1
29-Sep	30	1	0	1	0
06-Oct	22	4	3	0	1
13-Oct	11	1	0	0	1
20-Oct	5	1	1	0	0
27-Oct	2	0	0	0	0
03-Nov	0	0	0	0	0
10-Nov	1	0	0	0	0
17-Nov	0	0	0	0	0
24-Nov	1	1	1	0	0
01-Dec	0	0	0	0	0
08-Dec	0	0	0	0	0
15-Dec	0	0	0	0	0
22-Dec	0	0	0	0	0
29-Dec	2	0	0	0	0
05-Jan	1	0	0	0	0
Total	**252**	**30**	**17**	**3**	**10**
Percent	**100.0%**	**11.9%**	**6.7%**	**1.2%**	**4.0%**

[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 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, Entiat, Methow, and Okanogan rivers, 2001.

From Location to Location (Site-Site) [a]	Upstream	Downstream
Median travel time (d)[b]		
Vernita - Coyote	-	30.9
Vernita - PR tailrace	1.1	-
PR exit - WA tailrace	0.9	1.2
WA exit - RI tailrace	2.2	3.3
RI exit - Lower Wenatchee	20.7	
Lower Wenatchee - TU tailrace	20.1	
TU tailrace - TU exit	0.2	
RI exit - RR tailrace	0.8	3.4
RR exit - Wells tailrace	1.7	12.1
Wells exit - Methow	9.8	
Wells exit - Monse	12.0	
Vernita-Wells exit	10.9	
PR tailrace-Wells exit	9.5	
Median speed of travel (km/d)		
Vernita - Coyote	-	0.3
Vernita - PR tailrace	11.8	-
PR exit - WA tailrace	33.2	24.3
WA exit - RI tailrace	26.9	18.0
RI exit - Lower Wenatchee	1.2	
Lower Wenatchee - TU tailrace	2.6	
TU tailrace - TU exit	3.2	
RI exit - RR tailrace	39.6	9.3
RR exit - Wells tailrace	39.3	5.5
Wells exit - Methow	1.7	
Wells exit - Monse	2.5	
Vernita-Wells exit	18.7	
PR tailrace-Wells exit	20.3	
Minimum speed of travel (km/d)		
Vernita - Coyote	-	0.1
Vernita - PR tailrace	0.3	
PR exit - WA tailrace	0.5	0.7
WA exit - RI tailrace	1.9	3.9
RI exit - Lower Wenatchee	0.2	
Lower Wenatchee - TU tailrace	0.8	
TU tailrace - TU exit	0.1	
RI exit - RR tailrace	0.4	0.3
RR exit - Wells tailrace	0.8	0.7
Wells exit - Methow	0.1	
Wells exit - Monse	0.3	
Vernita-Wells exit	2.0	
PR tailrace-Wells exit	1.9	

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, Entiat, Methow, and Okanogan rivers, 2001.

From Location to Location (Site-Site) [a]	Upstream	Downstream
Maximum speed of travel (km/d)		
Vernita - Coyote	-	6.9
Vernita - PR tailrace	49.7	
PR exit - WA tailrace	65.9	54.4
WA exit - RI tailrace	74.0	57.0
RI exit - Lower Wenatchee	18.9	
Lower Wenatchee - TU tailrace	10.1	
TU tailrace - TU exit	68.9	
RI exit - RR tailrace	75.2	96.0
RR exit - Wells tailrace	73.2	48.9
Wells exit - Methow	55.8	
Wells exit - Monse	37.6	
Vernita-Wells exit	41.0	
PR tailrace-Wells exit	42.4	
Sample Size [c]		
Vernita - Coyote	-	27
Vernita - PR tailrace	365	-
PR exit - WA tailrace	323	8
WA exit - RI tailrace	330	13
RI exit - Lower Wenatchee	36	
Lower Wenatchee - TU tailrace	21	
TU tailrace - TU exit	21	
RI exit - RR tailrace	298	13
RR exit - Wells tailrace	268	17
Wells exit - Methow	130	
Wells exit - Monse	64	
Vernita-Wells exit	245	
PR tailrace-Wells exit	252	

[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, 2001.

From Location to Location (Site-Site) [a]	Excluding Fallback	Fallback [b]	
		Last Below [b]	Last Above
Median travel time (h)			
PR tailrace - PR exit	13.6	19.9	11.7
WA tailrace - WA exit	10.6	14.4	9.0
RI tailrace - RI exit	4.7	8.9	5.8
RR tailrace - RR exit	16.5	29.7	95.1
WE tailrace - WE exit	19.5	18.3	11.6
Minimum Travel Time (h)			
PR tailrace - PR exit	2.6	4.6	6.3
WA tailrace - WA exit	2.8	3.7	3.3
RI tailrace - RI exit	1.4	2.5	3.1
RR tailrace - RR exit	3.1	6.3	7.0
WE tailrace - WE exit	2.3	2.9	7.6
Maximum Travel Time (h)			
PR tailrace - PR exit	1617.2	697.6	26.6
WA tailrace - WA exit	1502.6	1817.5	128.7
RI tailrace - RI exit	122.9	777.6	20.7
RR tailrace - RR exit	935.1	460.7	296.3
WE tailrace - WE exit	2249.1	1357.3	50.2
Sample Size [c]			
PR tailrace - PR exit	312.0	15.0	9.0
WA tailrace - WA exit	254.0	7.0	12.0
RI tailrace - RI exit	303.0	12.0	3.0
RR tailrace - RR exit	242.0	11.0	4.0
WE tailrace - WE exit	216.0	22.0	7.0

[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 past Priest Rapids, Wanapum, Rock Island, Rocky Reach and Wells dams on the mid-Columbia River, 2001.

	Median Passage Times (h)					Sample Size[3]			
	Tailrace[1]	Entrance	Fishway	Sum[2]	Total	Tailrace	Entrance	Fishway	Total
Priest Rapids Dam									
Left Fishway - Collection	1.7	3.0	2.4	7.1	12.2	122	123	123	122
Left Fishway - Main	1.8	3.3	2.6	7.7	15.5	83	83	83	83
Left Fishway (combined)	1.8	3.1	2.5	7.3	12.8	205	206	206	205
Right Fishway	4.1	0.6	2.5	7.2	15.2	131	131	131	131
Wanapum Dam									
Left Fishway - Collection	1.9	3.8	2.7	8.4	9.8	90	115	115	90
Left Fishway - Main	1.8	2.4	2.3	6.6	8.5	90	105	105	90
Left Fishway (combined)	1.9	3.0	2.5	7.4	9.5	180	220	220	180
Right Fishway	4.7	3.2	2.1	10.0	13.1	93	118	118	93
Rock Island Dam									
Left Fishway	0.7	1.8	1.4	3.9	4.5	19	19	19	20
Center Fishway	1.6	0.2	2.1	3.9	4.4	14	14	14	14
Right Fishway	1.2	1.5	1.2	3.9	4.8	282	289	289	284
Rocky Reach Dam									
Downstream Powerhouse	1.4	9.6	2.3	13.2	13.8	68	74	74	68
Upstream Powerhouse	1.1	16.8	2.1	20.0	25.0	51	54	54	51
Tirfurcation Entrance	1.2	10.6	2.3	14.0	16.3	136	145	145	137
Wells Dam									
Left Fishway	3.1	6.9	2.1	12.2	16.3	182	187	187	183
Right Fishway Stable Operations	2.6	16.3	2.5	21.5	27.4	45	45	45	46
Right Fishway Unstable Operations	3.1	24.5	2.5	30.1	29.3	16	17	17	16
Right Fishway (combined)	2.7	18.7	2.5	23.9	28.6	61	62	62	62

[1] Tailrace antennas at Rock Island, Rocky Reach, and Wells dams were mounted 300 m dowstream, compared to Priest Rapids and Wanapum dams where this distance was 1200 m.

[2] Sum of the median passage times for the tailrace, entrance and fishway intervals.

[3] Fish with second ascents or missing an arrival time at any particular site were excluded from this analysis

Table 16. Comparison of fishway passage times (h) for radio-tagged steelhead that migrated past Priest Rapids, Wanapum, Rock Island, Rocky Reach and Wells dams on the mid-Columbia River, 2001.

	Natural Log transformed (Ln)				
	PR	WA	RI	RR	WE
Fishway Passage					
Mean (h)					
Left Fishway	2.58	2.39	1.56		2.90
Right Fishway	2.69	2.80	1.71	2.96	3.45
Center Fishway			1.63		
Standard Deviation (h)					
Left Fishway	0.97	0.78	0.57		1.00
Right Fishway	0.99	1.24	0.75	1.08	1.11
Center Fishway			0.75		
Comparison (p-value)					
Left vs Right Fishway	0.325	0.002	0.269		0.001
Left vs Center Fishway			0.754		
Right vs Center Fishway			0.696		

Table 17. Comparison of junction pool and counting station passage times (h) for radio-tagged steelhead that migrated past Priest Rapids, Wanapum, Rock Island, and Rocky Reach dams on the mid-Columbia River, 2001.

	Dam	Fishway	Passage Times (h) Median	Mean	Min	Max	Sample Size
Junction Pool							
	Priest Rapids						
		Left Bank	0.051	0.344	0.0003	7.839	149
	Wanapum						
		Left Bank	0.0003	0.027	0.0003	0.434	120
	Rock Island						
		Right Bank	0.011	0.121	0.0003	1.063	107
	Rocky Reach						
		Right Bank	0.031	0.102	0.0058	1.914	190
Counting Station							
	Rock Island						
		Left Bank	0.429	0.727	0.1114	4.266	20
		Center	0.152	0.687	0.0433	6.619	15
		Right Bank	0.277	0.712	0.0003	8.117	291
	Rocky Reach						
		Right Bank	0.134	0.174	0.0086	2.000	275

Table 18. Steelhead fallback and re-ascending rates by dam for 1999 and 2001.

Dam	Unique[1] detections at exits	Unique fallbacks	Unique reascents	Percentages		Net Passage	
				Fallbacks	Reascents	No.	% of Exits
2001 Study							
Priest Rapids	343	24	11	7.0%	45.8%	330	96.2%
Wanapum	338	31	20	9.2%	64.5%	327	96.7%
Rock Island	326	16	4	4.9%	25.0%	314	96.3%
Rocky Reach	276	18	3	6.5%	16.7%	261	94.6%
Wells	252	30	10	11.9%	33.3%	232	92.1%
Total	1535	119	48	7.8%	40.3%	1464	95.4%
1999 Study							
Priest Rapids	335	34	9	10.1%	26.5%	310	92.5%
Wanapum	326	38	18	11.7%	47.4%	306	93.9%
Rock Island	298	22	8	7.4%	36.4%	284	95.3%
Rocky Reach	205	21	2	10.2%	9.5%	186	90.7%
Wells	162	11	5	6.8%	45.5%	156	96.3%
Total	1326	126	42	9.5%	33.3%	1242	93.7%
Difference							
Priest Rapids				-3.2%	19.4%		3.7%
Wanapum				-2.5%	17.1%		2.9%
Rock Island				-2.5%	-11.4%		1.0%
Rocky Reach				-3.7%	7.1%		3.8%
Wells				5.1%	-12.1%		-4.2%
Total				-1.7%	7.0%		1.7%

[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.

		Dam Detection Sites					
Location/Stock	Not Detected at Priest Rapids	Priest Rapids Dam	Wanapum Dam	Rock Island Dam	Rocky Reach Dam	Wells Dam	Totals
Number of tagged fish	30	366	343	334	306	274	396
Tags never tracked	2						2
Known removals prior to spawning							
Tributaries	5	10	8	7	7	7	15
Mid-Columbia River	2	6	5	5	4	4	8
Sub-total	7	16	13	12	11	11	23
Tributaries							
Snake River	3	8	4	2	1	1	11
Yakima River	1	4	1	1	1	1	5
Wenatchee River							
Below Tumwater Dam	0	26	26	26	15	6	26
Above Tumwater Dam	0	21	21	21	9	0	21
Entiat River	0	8	8	8	8	8	8
Wells Hatchery	0	17	17	17	17	17	17
Methow River	0	142	142	142	142	142	142
Okanogan River	0	64	64	64	64	64	64
Sub-Total	4	290	283	281	257	239	294
Mid-Columbia River							
Hanford Reach*							
Yakima R. - Coyote	1	5	3	2	2	0	6
Coyote - Priest Rapids[1]	16	11	2	1	1	0	27
Priest Rapids Pool	0	7	6	2	2	1	7
Wanapum Pool	0	9	8	8	5	2	9
Rock Island Pool	0	9	9	9	9	4	9
Rocky Reach Pool	0	6	6	6	6	4	6
Wells Pool	0	13	13	13	13	13	13
Sub-Total	17	60	47	41	38	24	77
Available for spawning	21	350	330	322	295	263	371
Spawning Areas (excluding removals)							
Tributaries	4	290	283	281	257	239	294
Mid-Columbia River	1	18	16	15	15	13	19
Sub-total	5	308	299	296	272	252	313
Percentages							
Spawning Areas	23.8%	88.0%	90.6%	91.9%	92.2%	95.8%	84.4%
Other Areas							
Below Dam	0.0%	3.1%	2.4%	3.4%	5.8%	4.2%	7.3%
Above Dam	0.0%	8.9%	7.0%	4.7%	2.0%	0.0%	8.4%
Above Dam or Spawning Areas	23.8%	96.9%	97.6%	96.6%	94.2%	95.8%	92.7%

* Fish last detected in the Hanford Reach include likely regirgitated tags and angler removals
Boxed areas are the mainstem areas between Coyote Rapids and the dam.

[1] Includes 9 fish last detected at Coyote Rapids prior to December 2001.

Table 20. Spawning destinations or furthest upstream detection of the hatchery and wild radio-tagged steelhead detected along the mid-Columbia River, prior to kelting.

Location/Stock	Radio-tagged Steelhead				
	Hatchery	Wild	Total	% Hatchery	% Wild
Total Tagged	321	75	396	81%	19%
Tags Never Tracked	2	0	2	100%	0%
Removals Prior to Spawning					
Tributaries (Wenatchee)	12	3	15	80%	20%
Mid-Columbia River	8	0	8	100%	0%
Sub-total	20	3	23	87%	13%
Tributary/Spawning Areas					
Snake River	9	2	11	82%	18%
Yakima River	1	4	5	20%	80%
Wenatchee River					
Below Tumwater Dam	14	12	26	54%	46%
Above Tumwater Dam	16	5	21	76%	24%
Entiat River	5	3	8	63%	38%
Wells Hatchery	17	0	17	100%	0%
Methow River	126	16	142	89%	11%
Okanogan River	60	4	64	94%	6%
Sub-Total	248	46	294	84%	16%
Mid-Columbia River					
Hanford Reach					
Yakima R. - Coyote	6	0	6	100%	0%
Coyote - Priest Rapids[1]	14	13	27	52%	48%
Priest Rapids Pool	6	1	7	86%	14%
Wanapum Pool	5	4	9	56%	44%
Rock Island Pool	4	5	9	44%	56%
Rocky Reach Pool	5	1	6	83%	17%
Wells Pool	11	2	13	85%	15%
Sub-Total	51	26	77	66%	34%
Percentages					
Tributary/Spawning Areas	77%	61%	74%		
Mid-Columbia River	16%	35%	19%		

[1] Includes 9 fish last detected at Coyote Rapids prior to December 2001.

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/Stock[1]	Hatchery	Wild	Total	Hatchery	Wild[2]	Total
Unique fish passed dam	259	84	343	256	82	338
Tributary/Spawning Areas						
Snake River	4	0	4	3	0	3
Yakima River	0	2	2	0	1	1
Wenatchee River						
Below Tumwater Dam	0	1	1	2	0	2
Above Tumwater Dam	0	0	0	2	0	2
Entiat River	0	0	0	0	0	0
Wells Hatchery	0	0	0	0	0	0
Methow River	5	0	5	10	0	10
Okanogan River	0	0	0	1	0	1
Sub-Total	9	3	12	18	1	19
Mid-Columbia River						
Hanford Reach						
Below Yakima R.	1	1	2	0	0	0
Yakima R. - Coyote	3	0	3	3	0	3
Coyote - Priest Rapids[1]	2	0	2	1	0	1
Priest Rapids Pool	2	1	3	2	1	3
Wanapum Pool	1	0	1	1	1	2
Rock Island Pool	1	0	1	1	0	1
Rocky Reach Pool	0	0	0	2	0	2
Wells Pool	0	0	0	0	0	0
Sub-Total	10	2	12	10	2	12
Total	19	5	24	28	3	31
Fallback Categories						
Voluntary	8	3	11	7	1	8
Involuntary	2	0	2	2	1	3
Rescended	9	2	11	19	1	20
Fallback Percentages						
Voluntary	3.1%	3.6%	3.2%	2.7%	1.2%	2.4%
Involuntary	0.8%	0.0%	0.6%	0.8%	1.2%	0.9%
Rescended	3.5%	2.4%	3.2%	7.4%	1.2%	5.9%
Total	7.3%	6.0%	7.0%	10.9%	3.7%	9.2%
% Above Dam or in Spawning Areas	89%	100%	92%	89%	67%	87%

[1] boxed numbers = involuntary fallbacks

[2]The single involuntary "wild" fallback at Wanapum Dam was tracked migrating downstream during the kelting period.

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/Stock[1]	Hatchery	Wild[2]	Total	Hatchery[3]	Wild[3]	Total
Unique fish passed dam	251	75	326	243	33	276
Tributary/Spawning Areas						
Snake River	1	0	1	1	0	1
Yakima River	0	1	1	0	1	1
Wenatchee River						
Below Tumwater Dam	1	0	1	4	0	4
Above Tumwater Dam	0	0	0	1	0	1
Entiat River	0	0	0	0	0	0
Wells Hatchery	0	0	0	0	0	0
Methow River	0	0	0	1	1	2
Okanogan River	0	0	0	1	0	1
Sub-Total	2	1	3	8	2	10
Mid-Columbia River						
Hanford Reach						
Below Yakima R.	0	0	0	0	0	0
Yakima R. - Coyote	2	0	2	0	0	0
Coyote - Priest Rapids	1	0	1	0	0	0
Priest Rapids Pool	1	1	2	1	0	1
Wanapum Pool	2	3	5	2	0	2
Rock Island Pool	2	0	2	3	2	5
Rocky Reach Pool	1	0	1	0	0	0
Wells Pool	0	0	0	0	0	0
Sub-Total	9	4	13	6	2	8
Total	11	5	16	14	4	18
Fallback Categories						
Voluntary	5	2	7	9	1	10
Involuntary	2	3	5	3	2	5
Rescended	4	0	4	2	1	3
Fallback Percentages						
Voluntary	2.0%	2.7%	2.1%	3.7%	3.0%	3.6%
Involuntary	0.8%	4.0%	1.5%	1.2%	6.1%	1.8%
Rescended	1.6%	0.0%	1.2%	0.8%	3.0%	1.1%
Total	4.4%	6.7%	4.9%	5.8%	12.1%	6.5%
% Above Dam or in Spawning Areas	64%	20%	50%	57%	50%	56%

[1] Boxed numbers = involuntary fallbacks

[2] One of the 3 involuntary "wild" fallbacks at Rock Island Dam was tracked migrating downstream during the kelting pe

[3] Two of involuntary fallbacks at Rocky Reach Dam (1 hatchery and 1 "wild") were tracked migrating downstream during the kelting period.

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/Stock[1]	Hatchery	Wild	Total	Hatchery	Wild	Total
Unique fish passed dam	229	23	252	1238	297	1535
Tributary/Spawning Areas						
Snake River	1	0	1	10	0	10
Yakima River	0	0	0	0	5	5
Wenatchee River						
Below Tumwater Dam	3	0	3	10	1	11
Above Tumwater Dam	0	0	0	3	0	3
Entiat River	1	1	2	1	1	2
Wells Hatchery	9	0	9	9	0	9
Methow River	8	0	8	24	1	25
Okanogan River	1	0	1	3	0	3
Sub-Total	23	1	24	60	8	68
Mid-Columbia River						
Hanford Reach						
Below Yakima R.	0	0	0	1	1	2
Yakima R. - Coyote	0	0	0	8	0	8
Coyote - Priest Rapids	0	0	0	4	0	4
Priest Rapids Pool	1	0	1	7	3	10
Wanapum Pool	1	0	1	7	4	11
Rock Island Pool	0	0	0	7	2	9
Rocky Reach Pool	3	0	3	6	0	6
Wells Pool	1	0	1	1	0	1
Sub-Total	6	0	6	41	10	51
Total	29	1	30	101	18	119
Fallback Categories						
Voluntary	16	1	17	45	8	53
Involuntary	3	0	3	12	6	18
Rescended	10	0	10	44	4	48
Fallback Percentages						
Voluntary	7.0%	4.3%	6.7%	3.6%	2.7%	3.5%
Involuntary	1.3%	0.0%	1.2%	1.0%	2.0%	1.2%
Rescended	4.4%	0.0%	4.0%	3.6%	1.3%	3.1%
Total	12.7%	4.3%	11.9%	8.2%	6.1%	7.8%
% Above Dam or in Spawning Areas	83%	100%	83%	80%	61%	77%

[1] Boxed numbers = involuntary fallbacks

Table 24 Detection of radio-tagged steelhead by stock in tributary spawning areas and along the mid-Columbia River, prior to kelting.

	Tributary/Spawning Area								
	Snake	Yakima	Wenatchee River		Entiat	Wells	Methow	Okanogan	
Location/Group	River	River	Lower	Upper	River	Hatchery	River	River	All
Fish assigned to spawning area	18	6	26	21	8	18	144	69	310
Tributary/Spawning Areas									
Snake River	18	0	0	0	0	0	0	0	18
Yakima River	0	6	0	0	0	0	0	0	6
Wenatchee River									
Below Tumwater Dam	0	0	26	21	1	0	2	0	50
Above Tumwater Dam	0	0	3	21	0	0	0	0	24
Entiat River	0	0	0	0	8	0	2	0	10
Wells Hatchery	0	0	0	0	1	18	0	0	19
Methow River	1	0	0	0	0	0	144	9	154
Okanogan River	0	0	1	0	0	0	15	69	85
Mid-Columbia River									
Hanford Reach									
Yakima R. - Coyote	0	0	0	0	0	0	0	0	0
Coyote - Priest Rapids	18	6	26	21	8	18	144	69	310
Priest Rapids Pool	4	2	26	21	8	18	144	69	292
Wanapum Pool	3	2	26	21	8	18	144	69	291
Rock Island Pool	1	1	26	20	8	18	144	69	287
Rocky Reach Pool	1	1	7	1	8	18	144	69	249
Wells Pool	1	0	3	0	5	9	144	69	231
Upstream of Spawning Location	18	6	7	1	5	9	15	0	61
Non-Destination Spawning Areas	1	0	3	0	1	0	15	9	29
Percentages									
Upstream of Spawning Area	100%	100%	27%	5%	63%	50%	10%	0%	20%
Other Spawning Areas	6%	0%	12%	0%	13%	0%	10%	13%	9%

Table 25 Recoveries of radio-tagged steelhead by location, distribution before and after kelting and kelting rates by stock.

Location/Stock	Distribution Before Kelting	Removals Prior to Kelting	Distribution After Removals	Distribution After Kelting	Suspected Kelts/ Removals	Known Kelts	Kelting Rate Min.	Kelting Rate Max.
Tributary/Spawning Areas								
Snake River *	18	7	11	0				
Yakima River *	6	1	5	0				
Wenatchee River								
Below Tumwater Dam	26	0	26	6	20	17	65%	77%
Above Tumwater Dam	21	0	21	5	16	15	71%	76%
Entiat River	8	0	8	0	8	8	100%	100%
Wells Hatchery	18	3	15	6	9	6	40%	60%
Methow River	144	2	142	34	108	97	68%	76%
Okanogan River	69	6	63	20	43	33	52%	68%
Sub-Total	310	19	291	71	204	176		
Mid-Columbia River								
Hanford Reach								
Below Yakim R. *	12	3	9	9	0	0		
Yakima R. - Coyote *	6	0	6	0	6	0		
Coyote - Priest Rapids	18	0	18	13	5	0	0%	28%
Priest Rapids Pool	7	0	7	0	7	2	29%	100%
Wanapum Pool	10	1	9	0	9	4	44%	100%
Rock Island Pool	9	0	9	2	7	5	56%	78%
Rocky Reach Pool	6	0	6	1	5	0	0%	83%
Wells Pool	16	3	13	3	10	3	23%	77%
Sub-Total	84	7	77	28	49	14		
Fish Never Tracked	2							
Total	396	26	368	99	253	190		
Stocks/areas with downstream monitoring sites								
Tributary/Spawning Areas	286	11	275	71	204	176	64%	74%
Mid-Columbia River	66	4	62	19	43	14	23%	69%
All Areas	352	15	337	90	247	190	56%	73%
% of Release		7%	93%	25%	64%	48%		

* No downstream monitoring station was present during kelting season

Table 26. Detection of radio-tagged steelhead kelts during their downstream migration through the mid-Columbia study area.

	Tributary/Spawning Area					
	Wenatchee River		Entiat	Methow	Okanogan	
Location/Group	Lower	Upper	River	River	River	All
Fish assigned to spawning area	26	21	8	144	69	268
Tributary Mouths	17	15	8	97	33	170
Mid-Columbia River						
Wells Pool				93	26	119
Rocky Reach Pool			7	87	24	118
Rock Island Pool	14	15	6	69	14	118
Wanapum Pool	11	15	4	59	12	101
Priest Rapids Pool	7	10	3	39	8	67
Coyote Rapids[1]	3	7	2	14	4	30
Percentages						
Tracked as kelts	65%	71%	100%	67%	48%	63%
Exited study area as kelts	18%	47%	25%	14%	12%	18%

Table 27. Spawning destinations or furthest upstream detection for radio-tagged steelhead originating from hatchery releases in the Wenatchee, Methow and Okanogan rivers.

	Juvenile Release Location				
Location/Stock	Ringold Hatch.	Wenatchee	Methow/Okanogan[1]	Snake[1]	Total
Number of radio-tagged fish	13	32	221	17	283
Removals Prior to Spawning					
Tributaries			12		12
Mid-Columbia River			8		8
Sub-total			20		20
Tributary/Spawning Areas					
Snake River	1	0	0	12	13
Yakima River	0	0	0		0
Wenatchee River					0
Below Tumwater Dam	0	9	4		13
Above Tumwater Dam	0	12	1		13
Entiat River	0	0	5		5
Wells Hatchery	0	0	18		18
Methow River	1	5	94		100
Okanogan River	1	1	51		53
Sub-Total	3	27	173	12	215
Mid-Columbia River					
Hanford Reach					
Below Yakima R.	0	0	0	5	5
Yakima R. - Coyote	5	0	1		6
Coyote - Priest Rapids	1	1	8		10
Priest Rapids Pool	0	1	2		3
Wanapum Pool	3	1	2		6
Rock Island Pool	1	1	2		4
Rocky Reach Pool	0	1	0		1
Wells Pool	0	0	13		13
Sub-Total	10	5	28	5	48
Fish available for spawning	13	32	201	17	246
Homing Summary					
Returned to release stream(s)/hatche	6	21	145	12	184
Returned to other stream (strays)	3	6	10	0	19
Removed at Wells Hatchery	0	0	18	0	18
Mid-Cloumbia Mainstem	4	5	28	5	42
Percentages					
Returned to release stream(s)/hatche	46%	66%	72%		75%
Returned to other streams (strays)	23%	19%	5%		8%
Removed at Wells Hatchery	0%	0%	9%		7%
Mid-Cloumbia Mainstem	31%	16%	14%		17%

[1] all fish with only an adipose clip were classified as Methow and Okanogan releases, except those fish last detected below in the Snake River or on the Columbia below the Yakima River .

Table 28. Comparison of radio-tagged steelhead distribution at the dams of mid-Columbia River in 1999/2000 and 2001/2002.

Location/Group	2001/2002		1999/2000		Difference	
	Number	Percent	Number	Percent	**Number**	**Percent**
Release						
Vernita Bridge						
	396	100.0%	395	100.0%	**1**	**0.0%**
Dams						
Priest Rapids						
All arrays	366	92.4%	353	89.4%	**13**	**3.1%**
Exits	343	86.6%	335	84.8%	**8**	**1.8%**
Wanapum						
All arrays	343	86.6%	328	83.0%	**15**	**3.6%**
Exits	338	85.4%	326	82.5%	**12**	**2.8%**
Rock Island						
All arrays	334	84.3%	309	78.2%	**25**	**6.1%**
Exits	326	82.3%	298	75.4%	**28**	**6.9%**
Rocky Reach						
All arrays	305	77.0%	229	58.0%	**76**	**19.0%**
Exits	276	69.7%	205	51.9%	**71**	**17.8%**
Wells						
All arrays	274	69.2%	195	49.4%	**79**	**19.8%**
Exits	252	63.6%	162	41.0%	**90**	**22.6%**

Table 29. Comparison of radio-tagged steelhead travel times in the main reaches of the mid-Columbia River in the 1999/2000 and 2001/2002.

From Location to Location (Site-Site) [a]	2001	1999	Difference
Median travel time (d) [b]			
Vernita - PR tailrace	1.1	1.1	0.0
PR exit - WA tailrace	0.9	0.9	0.0
WA exit - RI tailrace	2.2	1.8	0.4
RI exit - Lower Wenatchee	20.7	8.1	12.6
Lower Wenatchee - TU tailrace	20.1	11.5	8.6
TU tailrace - TU exit	0.2	0.0	0.2
RI exit - RR tailrace	0.8	0.9	-0.1
RR exit - Wells tailrace	1.7	1.8	-0.1
Wells exit - Methow	9.8	4.5	5.2
Wells exit - Monse	12.0	2.9	9.1
Vernita-Wells exit	10.9	10.9	0.1
PR tailrace-Wells exit	9.5	9.6	-0.1
Median speed of travel (km/d)			
Vernita - PR tailrace	11.8	11.9	-0.1
PR exit - WA tailrace	33.2	33.7	-0.5
WA exit - RI tailrace	26.9	32.9	-6.0
RI exit - Lower Wenatchee	1.2	3.0	-1.8
Lower Wenatchee - TU tailrace	2.6	4.5	-1.9
TU tailrace - TU exit	3.2	49.5	-46.3
RI exit - RR tailrace	39.6	36.7	2.9
RR exit - Wells tailrace	39.3	36.3	2.9
Wells exit - Methow	1.7	3.7	-2.0
Wells exit - Monse	2.5	10.3	-7.8
Vernita-Wells exit	18.7	18.8	-0.1
PR tailrace-Wells exit	20.3	20.1	0.2
Sample Size [c]			
Vernita - PR tailrace	365	341	24
PR exit - WA tailrace	323	299	24
WA exit - RI tailrace	330	280	50
RI exit - Lower Wenatchee	36	79	-43
Lower Wenatchee - TU tailrace	21	26	-5
TU tailrace - TU exit	21	5	16
RI exit - RR tailrace	298	208	90
RR exit - Wells tailrace	268	171	97
Wells exit - Methow	130	36	94
Wells exit - Monse	64	64	0
Vernita-Wells exit	245	162	83
PR tailrace-Wells exit	252	157	95

[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 30. Comparison of radio-tagged steelhead distribution at the tributaries and main reaches of the mid- Columbia River prior to kelting in 1999/2000 and 2001/2002.

	2001/2002 Study Totals		1999/2000 Study Totals		Difference	
Location/Stock	Number	Percent	Number	Percent	Number	Percent
Number of tagged fish	396	100.0%	395	100.0%	1	0.0%
Tags never tracked	2	0.5%	2	0.5%	0	0.0%
Known removals prior to spawning	0					
Tributaries	15	3.8%	3	0.8%	12	3.0%
Mid-Columbia River	8	2.0%	10	2.5%	-2	-0.5%
Sub-total	23	5.8%	13	3.3%	10	2.5%
Tributaries	0					
Snake River	11	2.8%	16	4.1%	-5	-1.3%
Yakima River	5	1.3%	6	1.5%	-1	-0.3%
Wenatchee River	0					
Below Tumwater Dam	26	6.6%	52	13.2%	-26	-6.6%
Above Tumwater Dam	21	5.3%	30	7.6%	-9	-2.3%
Entiat River	8	2.0%	8	2.0%	0	0.0%
Wells Hatchery	17	4.3%	18	4.6%	-1	-0.3%
Methow River	142	35.9%	90	22.8%	52	13.1%
Okanogan River	64	16.2%	50	12.7%	14	3.5%
Sub-Total	294	74.2%	270	68.4%	24	5.9%
Mid-Columbia River	0					
Hanford Reach	0					
Yakima R. - Coyote	6	1.5%	24	6.1%	-18	-4.6%
Coyote - Priest Rapids[1]	27	6.8%	32	8.1%	-5	-1.3%
Priest Rapids Pool	7	1.8%	9	2.3%	-2	-0.5%
Wanapum Pool	9	2.3%	13	3.3%	-4	-1.0%
Rock Island Pool	9	2.3%	10	2.5%	-1	-0.3%
Rocky Reach Pool	6	1.5%	8	2.0%	-2	-0.5%
Wells Pool	13	3.3%	14	3.5%	-1	-0.3%
Sub-Total	77	19.4%	110	27.8%	-33	-8.4%
Available for spawning	371	93.7%	380	96.2%	-9	-2.5%
Spawning Areas (excluding removals)						
Tributaries	294	74.2%	270	68.4%	24	5.9%
Mid-Columbia River	19	4.8%	38	9.6%	-19	-4.8%
Sub-total	313	79.0%	308	78.0%	5	1.1%
Percentages						
Spawning Areas	84.4%		81.1%			3.3%
Other Areas						
Below Dam	7.3%		8.4%			-1.1%
Above Dam	8.4%		10.5%			-2.2%
Above Dam or Spawning Areas	92.7%		91.6%			1.1%

[1] The 2001-2002 data for the Coyote-Priest Rapids stratum includes 9 fish last detected at Coyote Rapids prior to December 2001.

Table 31. Comparison of the proportion of hatchery origin radio-tagged steelhead in the tributaries and main reaches of the mid-Columbia River, prior to kelting in 1999/2000 and 2001/2002 .

	% Hatchery origin		
Location/Stock	2001 Study	1999 Study	**Difference**
Total Tagged	81%	75%	**6%**
Tags Never Tracked	100%	50%	**50%**
Removals Prior to Spawning			
Tributaries	80%	0%	**80%**
Mid-Columbia River	100%	90%	**10%**
Sub-total	87%	69%	**18%**
Tributary/Spawning Areas			
Snake River	82%	69%	**13%**
Yakima River	20%	17%	**3%**
Wenatchee River			
Below Tumwater Dam	54%	60%	**-6%**
Above Tumwater Dam	76%	43%	**33%**
Entiat River	63%	50%	**13%**
Wells Hatchery	100%	89%	**11%**
Methow River	89%	80%	**9%**
Okanogan River	94%	90%	**4%**
Sub-Total	84%	71%	**13%**
Mid-Columbia River			
Hanford Reach			
Yakima R. - Coyote	100%	92%	**8%**
Coyote - Priest Rapids [1]	52%	81%	**-29%**
Priest Rapids Pool	86%	89%	**-3%**
Wanapum Pool	56%	92%	**-37%**
Rock Island Pool	44%	80%	**-36%**
Rocky Reach Pool	83%	75%	**8%**
Wells Pool	85%	93%	**-8%**
Sub-Total	66%	86%	**-21%**

[1] Includes 9 fish last detected at Coyote Rapids prior to December 2001.

Table 32. Comparison of radio-tagged steelhead kelting rates in the 1999/2000 and 2001/2002 mid-Columbia studies[1].

	Kelting Rate					
	Minimum			Maximum		
Location/Stock	2001/2002	1999/2000	**Difference**	2001/2002	1999/2000	**Difference**
Tributary/Spawning Areas						
Wenatchee River						
Below Tumwater Dam	65%	13%	**52%**	77%	65%	**12%**
Above Tumwater Dam	71%	57%	**15%**	76%	80%	**-4%**
Entiat River	100%	75%	**25%**	100%	75%	**25%**
Wells Hatchery						
Methow River	68%	59%	**9%**	76%	74%	**2%**
Okanogan River	52%	56%	**-4%**	68%	68%	**0%**
Sub-Total	0%	0%	**0%**	0%	0%	**0%**
Mid-Columbia River						
Hanford Reach						
Coyote - Priest Rapids	0%	0%	**0%**	28%	69%	**-41%**
Priest Rapids Pool	29%	0%	**29%**	100%	56%	**44%**
Wanapum Pool	44%	15%	**29%**	100%	92%	**8%**
Rock Island Pool	56%	20%	**36%**	78%	80%	**-2%**
Rocky Reach Pool	0%	13%	**-13%**	83%	75%	**8%**
Wells Pool	23%	14%	**9%**	77%	79%	**-2%**
Sub-Total	0%	0%	**0%**	0%	0%	**0%**
Stocks/areas with downstream monitoring sites						
Tributary/Spawning Areas	64%	48%	**16%**	74%	72%	**2%**
Mid-Columbia River	23%	8%	**14%**	69%	74%	**-5%**
All Areas	56%	37%	**19%**	73%	72%	**1%**

[1] Excluding strata with no downstream monitoring sites to detect kelts

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FIGURES

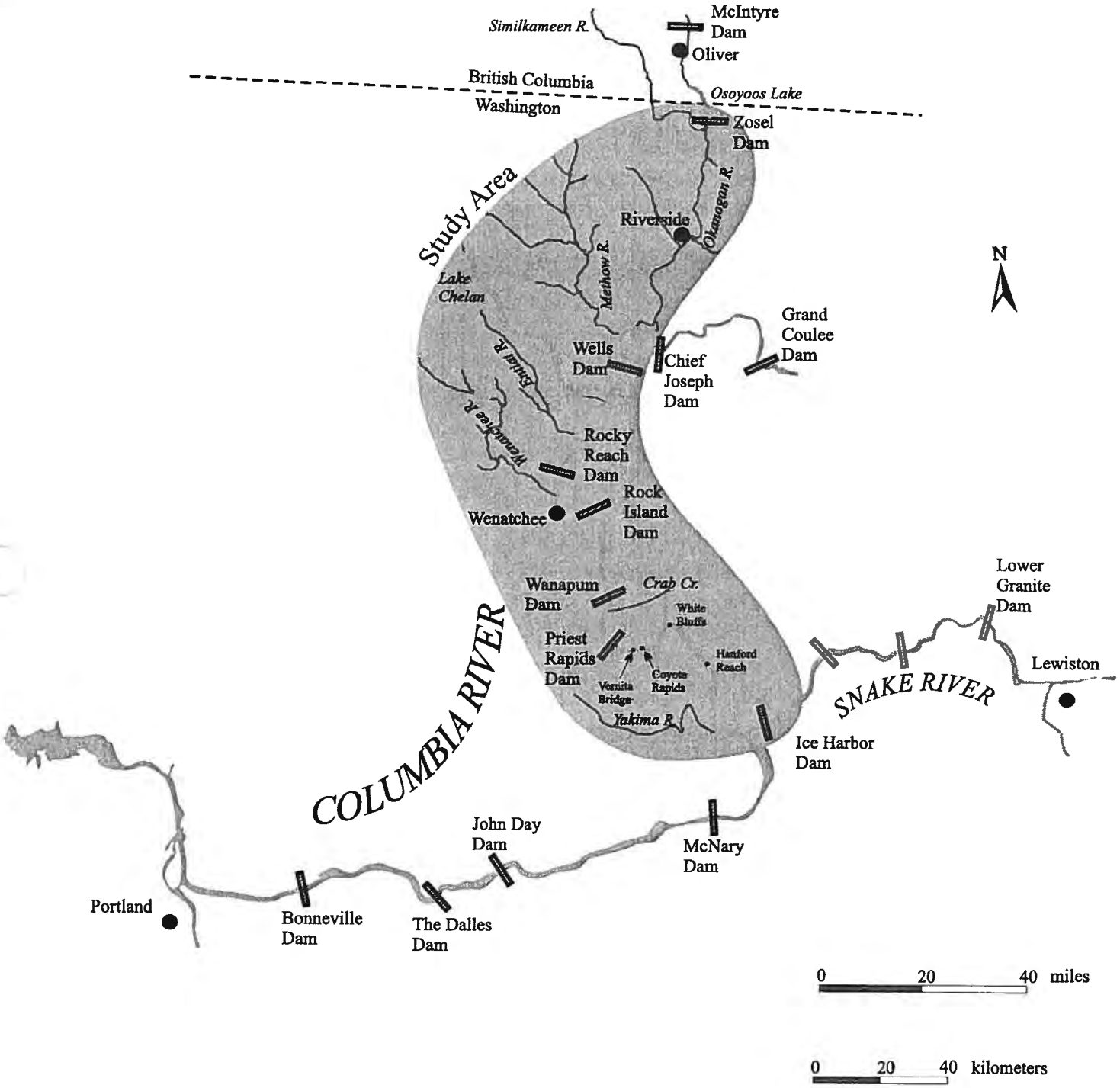

Figure 1. Study area and location of major dams and tributaries on the mid-Columbia River.

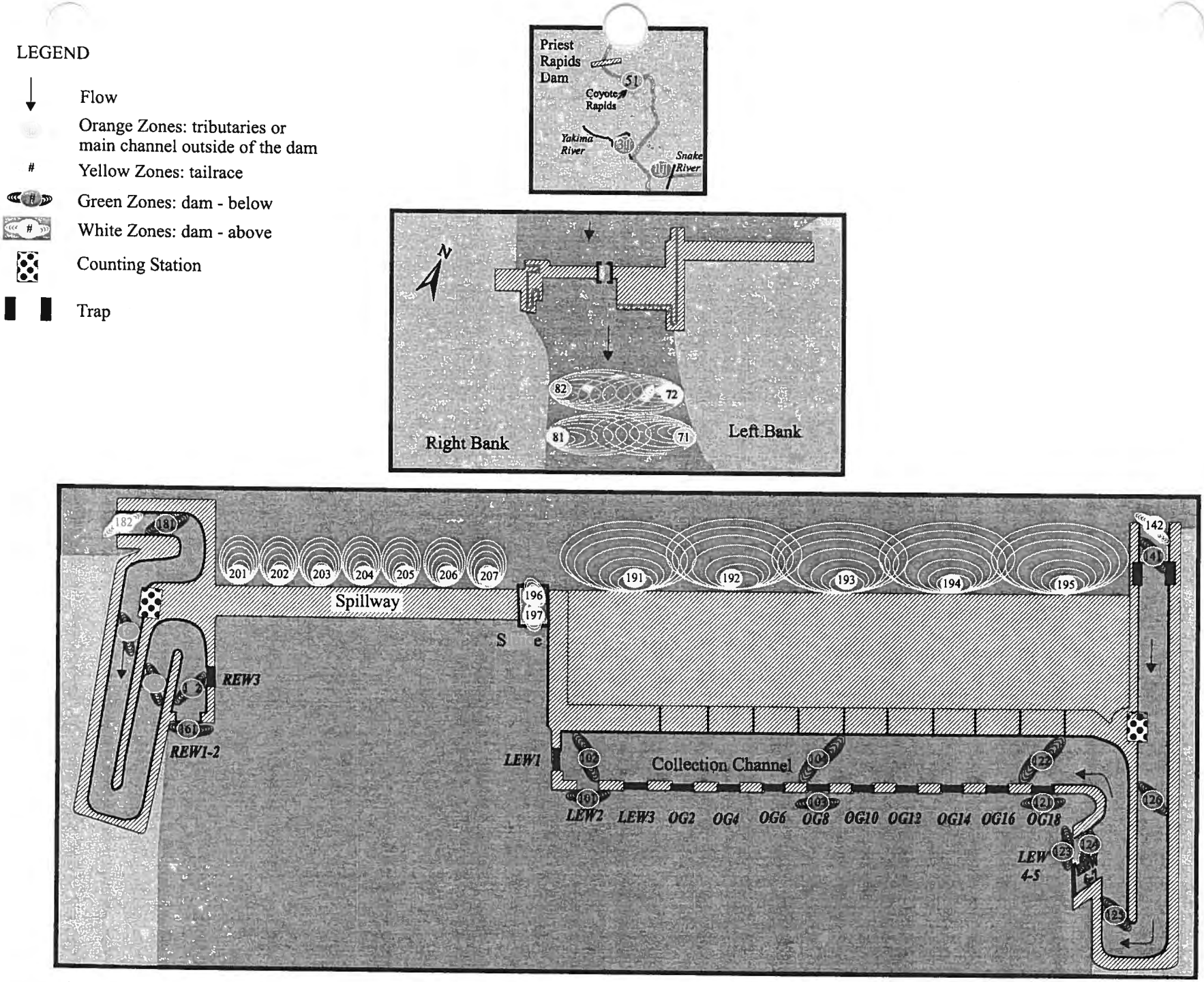

Figure 2. Fixed-station monitoring zones at Priest Rapids Dam and nearby area, 2001.

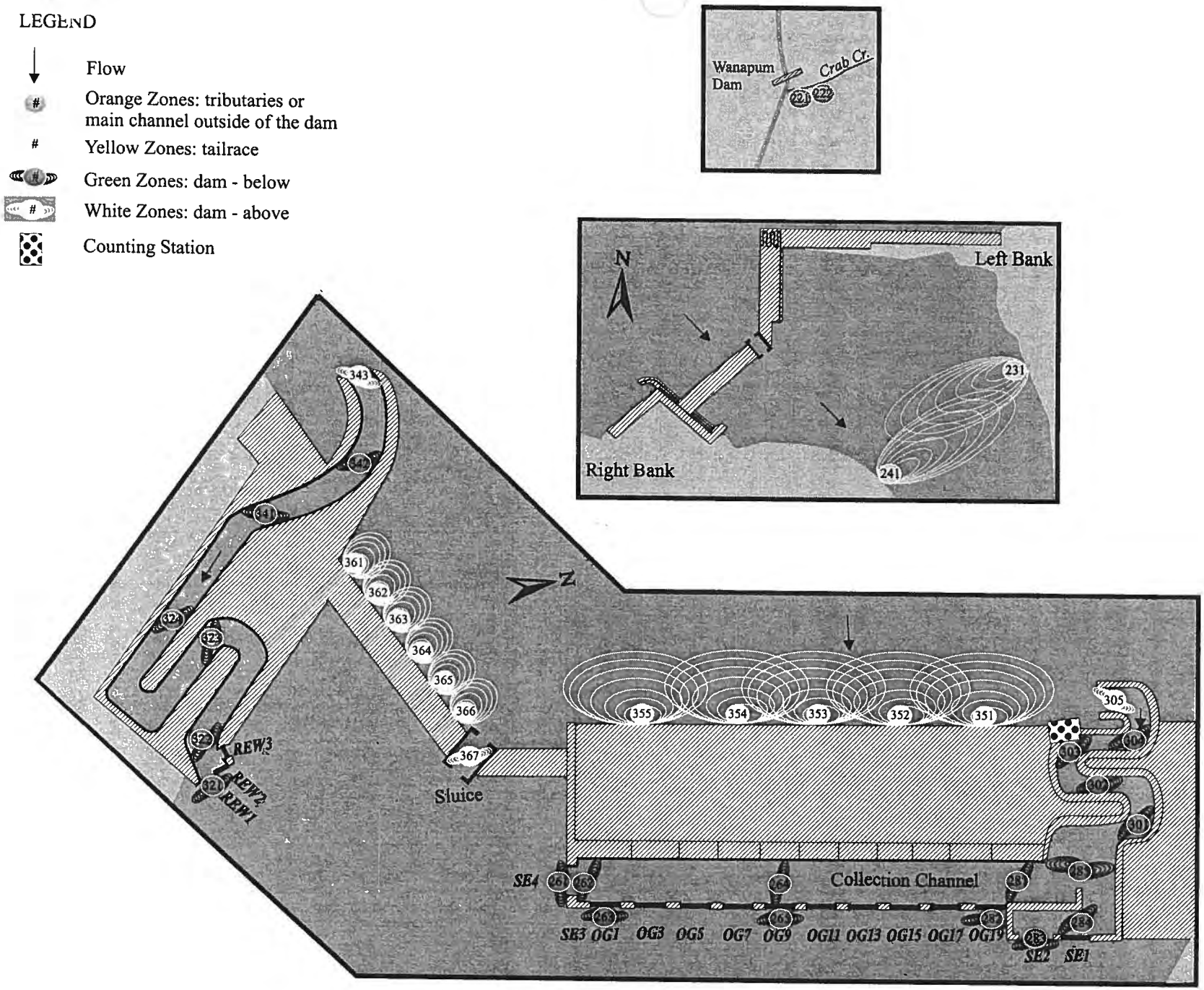

Figure 3. Fixed-station monitoring zones at Wanapum Dam and nearby area, 2001.

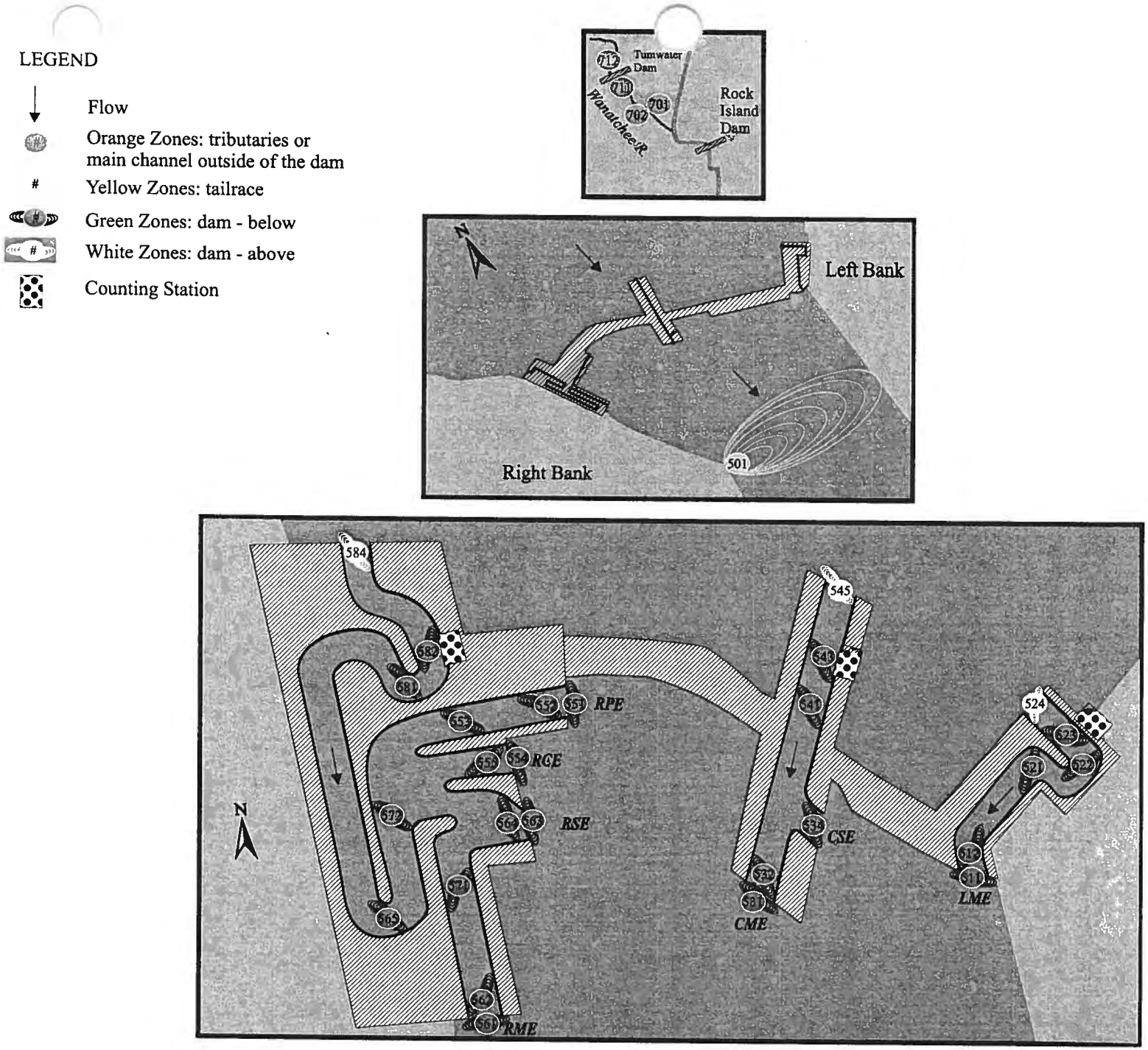

Figure 4. Fixed-station monitoring zones at Rock Island Dam and nearby area, 2001.

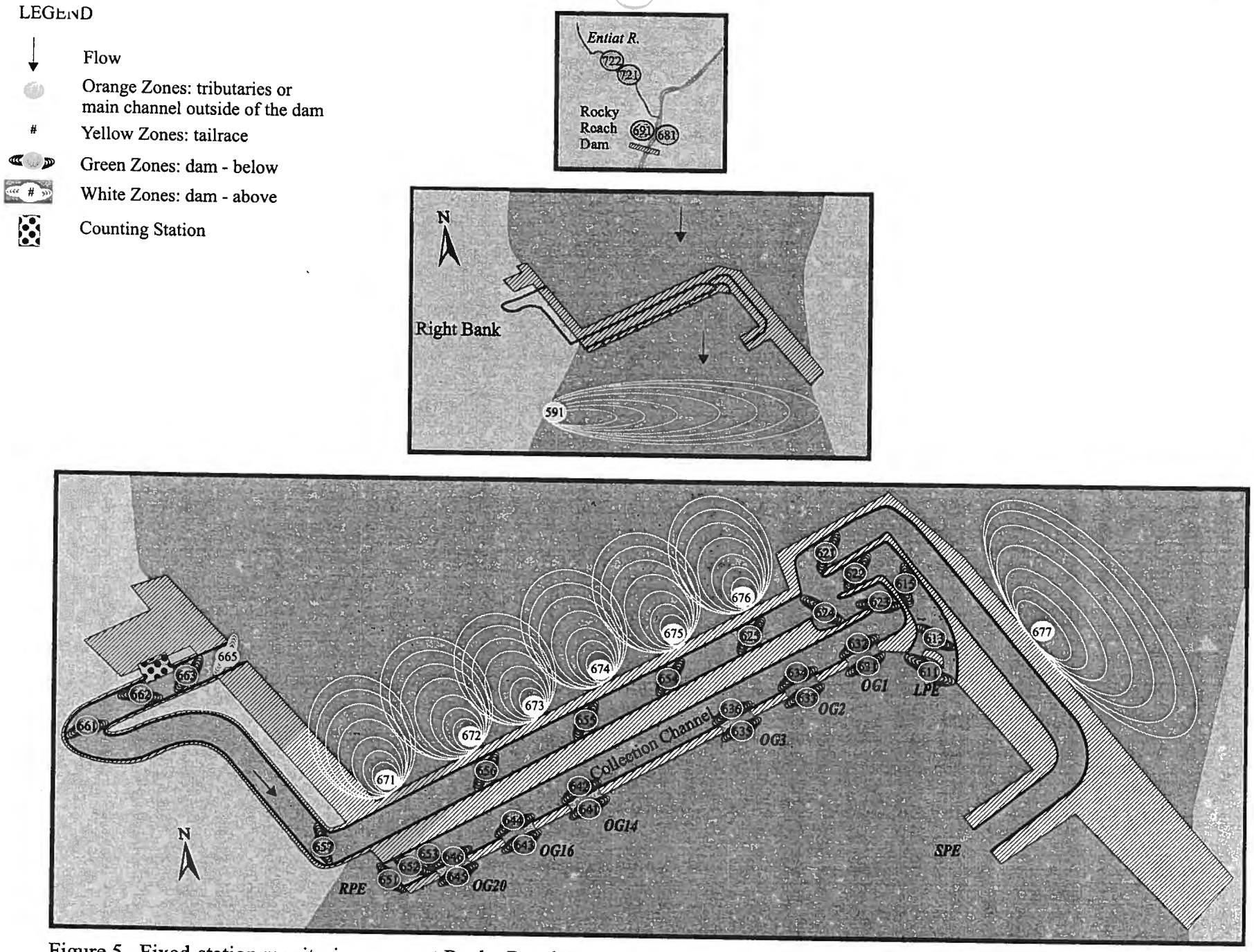

Figure 5. Fixed-station monitoring zones at Rocky Reach Dam and nearby area, 2001.

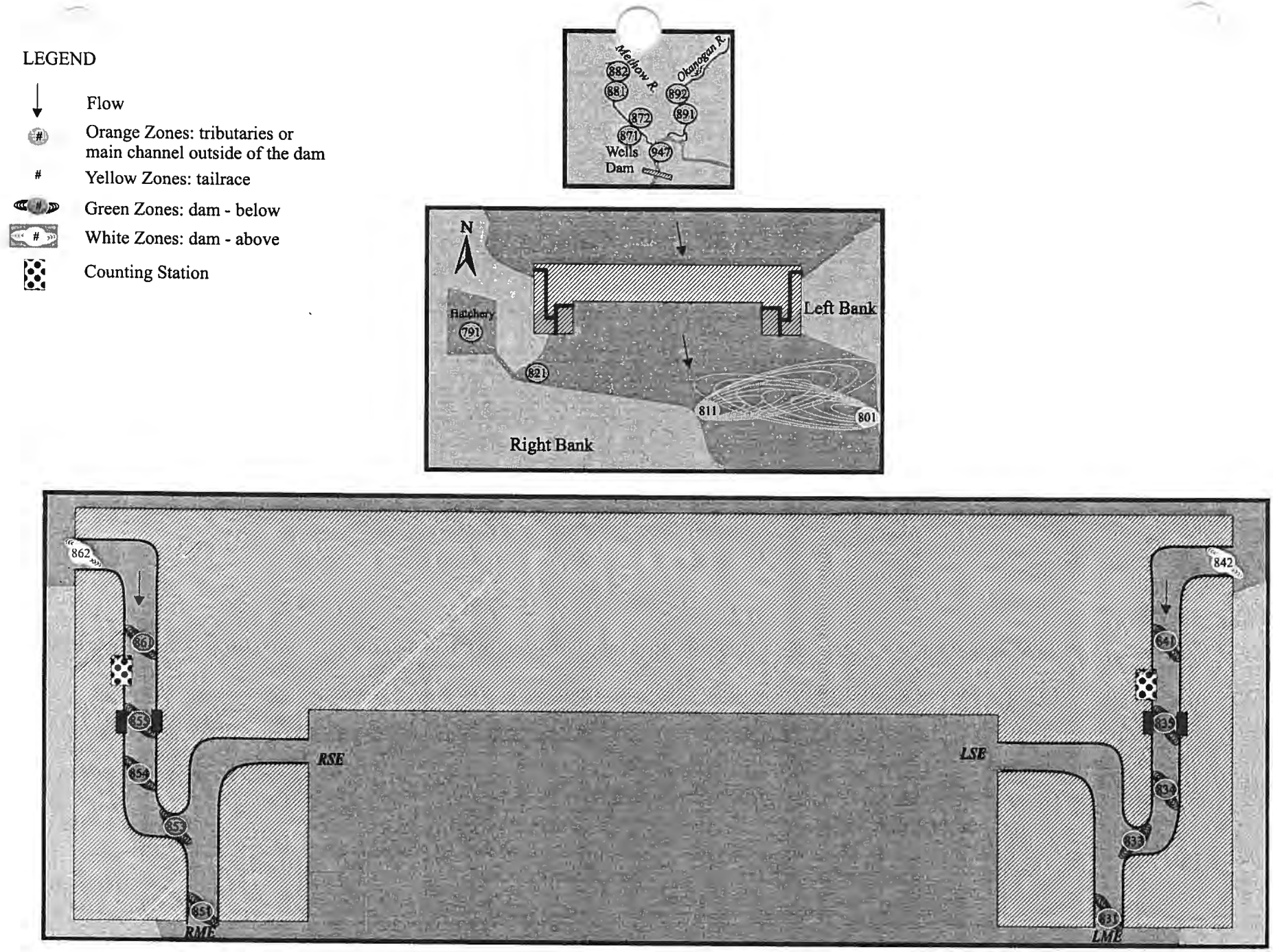

Figure 6. Fixed-station monitoring zones at Wells Dam and nearby area, 2001.

Zone	Description
8	Columbia Snake R. Mouth - Yakima R. Mouth
34	Yakima R. mouth - Benton City Bridge
35	Yakima R. Benton City Bridge - Prosser Dam
36	Yakima R. Prosser Dam - Granger
37	Yakima R. Granger - Yakima Dam
38	Yakima R. Yakima Dam - Rosa Dam
39	Yakima R. Rosa Dam - Elensburg
48	Columbia Yakima R. Mouth - White Bluffs
58	Columbia White Bluffs PR Tail
228	Columbia PR - WA
378	Columbia WA - Trinidad
379	Columbia Trinidad - RI
588	Columbia RI - Wenatchee R. Mouth
589	Columbia Wenatchee R. Mouth to RR
688	Columbia RR - Entiat R. Mouth
708	Wenatchee R. Mouth to Leavenworth
709	Wenatchee R. Icicle Creek
718	Wenatchee R. Leavenworth - Tumwater Dam
719	Wenatchee R. Tumwater Dam - Lake Wenatchee
728	Entiat River - Confluence to Mad River
729	Entiat - Mad River
738	Entiat - Mad River Confluence to Preston Falls
739	Entiat - Preston Falls to Headwater
748	Columbia Entiat R. Mouth - WE
868	Columbia WE - Pateros
878	Methow R. - Confluence to Libby Creek
879	Methow R. - Libby Creek
883	Methow R. - Libby Creek Confluence to Twisp R. Conflue
884	Methow R. - Twisp R. - Confluence to Buttermilk Cr.
885	Methow R. - Twisp R. - Buttermilk Confluence to Headw
886	Methow R. - Twisp R. - Buttermilk Cr.
887	Methow R. - Twisp R. Confluence to Headwater
888	Columbia Pateros - Chief Joseph
898	Okanogan R. Mouth - Monse
899	Okanogan R. Monse - Riverside
908	Okanogan R. Riverside - Zosel
919	Okanogan R. Similkameen

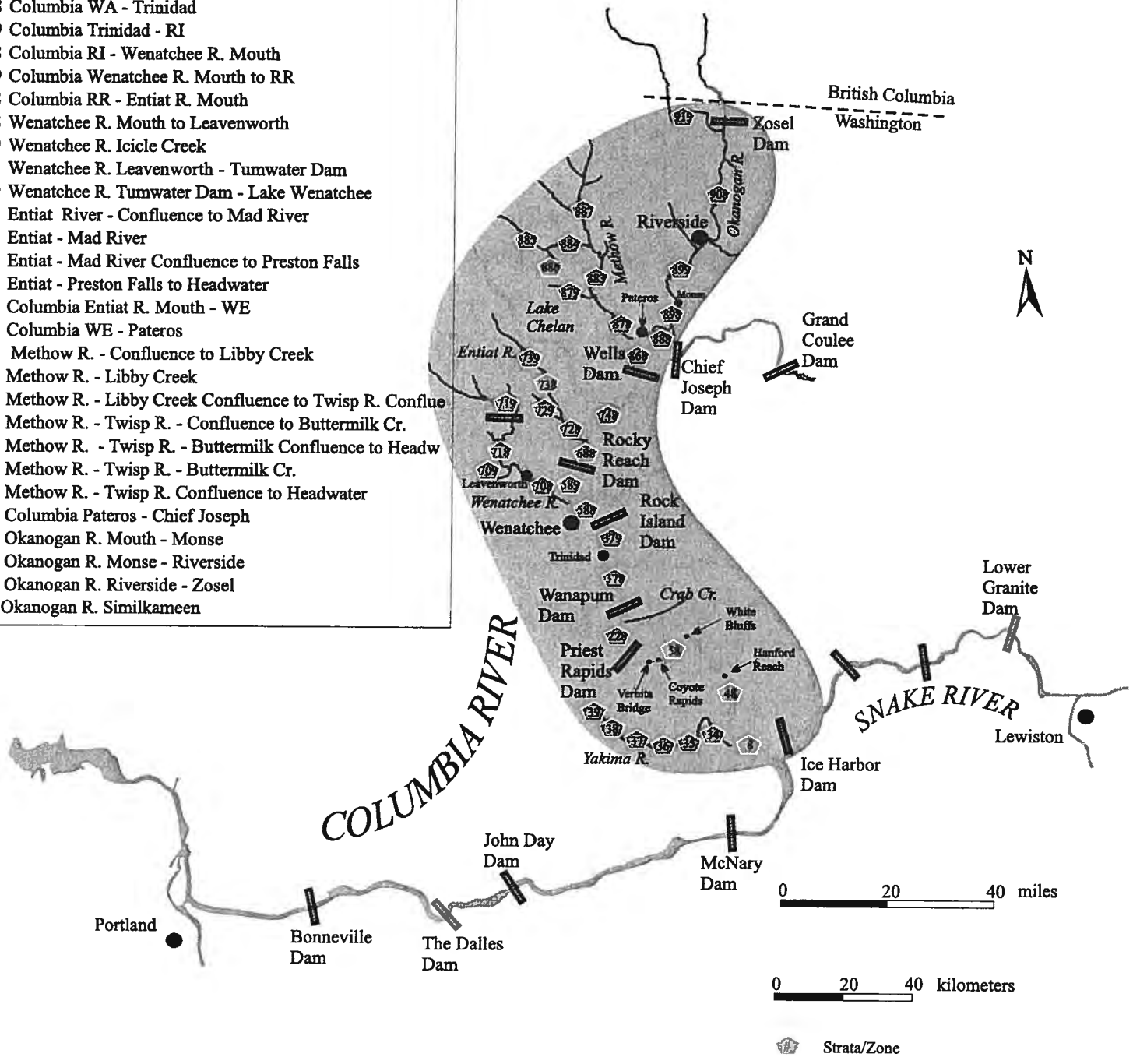

Figure 7. Mobile survey strata along the Columbia River and its tributaries, 2001 and 2002.

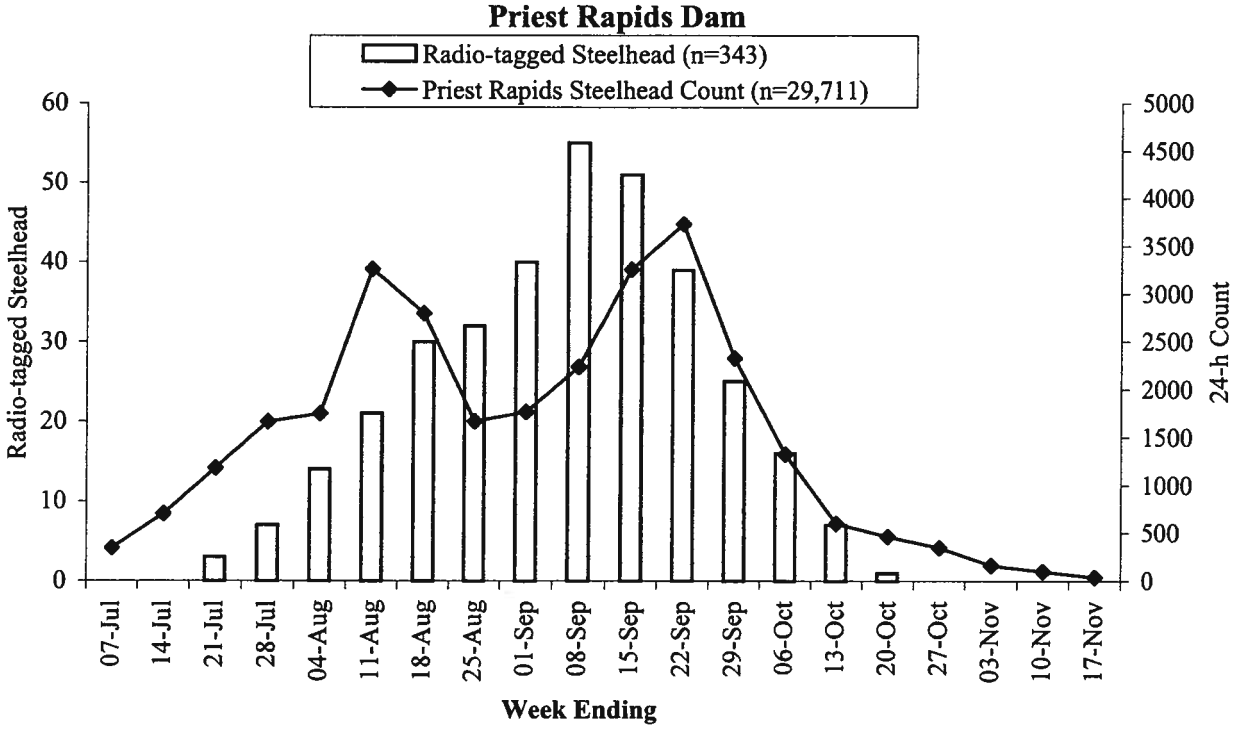

Figure 8. Comparison of the weekly counts of steelhead and radio-tagged steelhead that passe Rapids Dam in 2001.

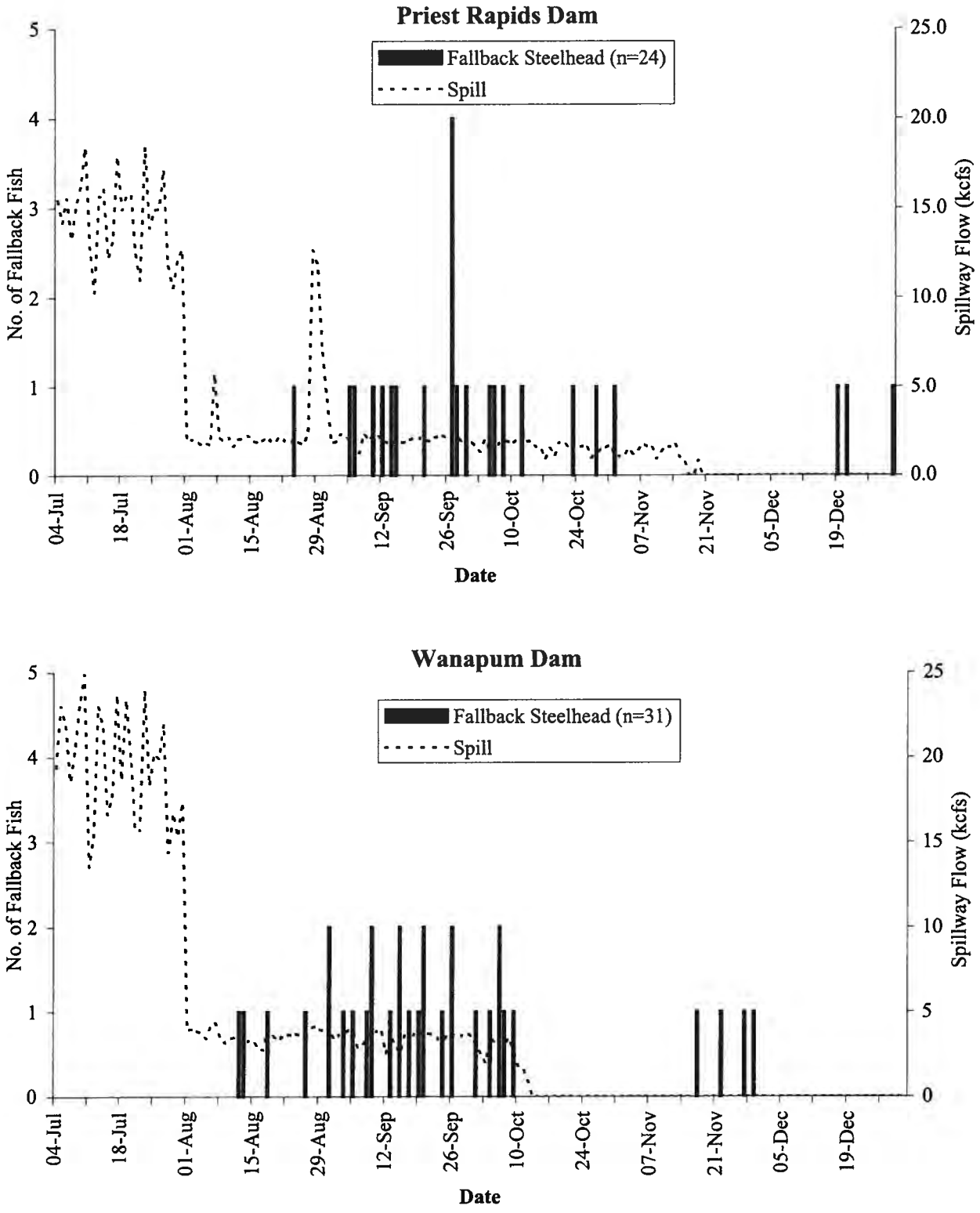

Figure 9. Comparison of spillway flows and the timing of steelhead fallback events at Priest Rapids and Wanapum dams in 2001.

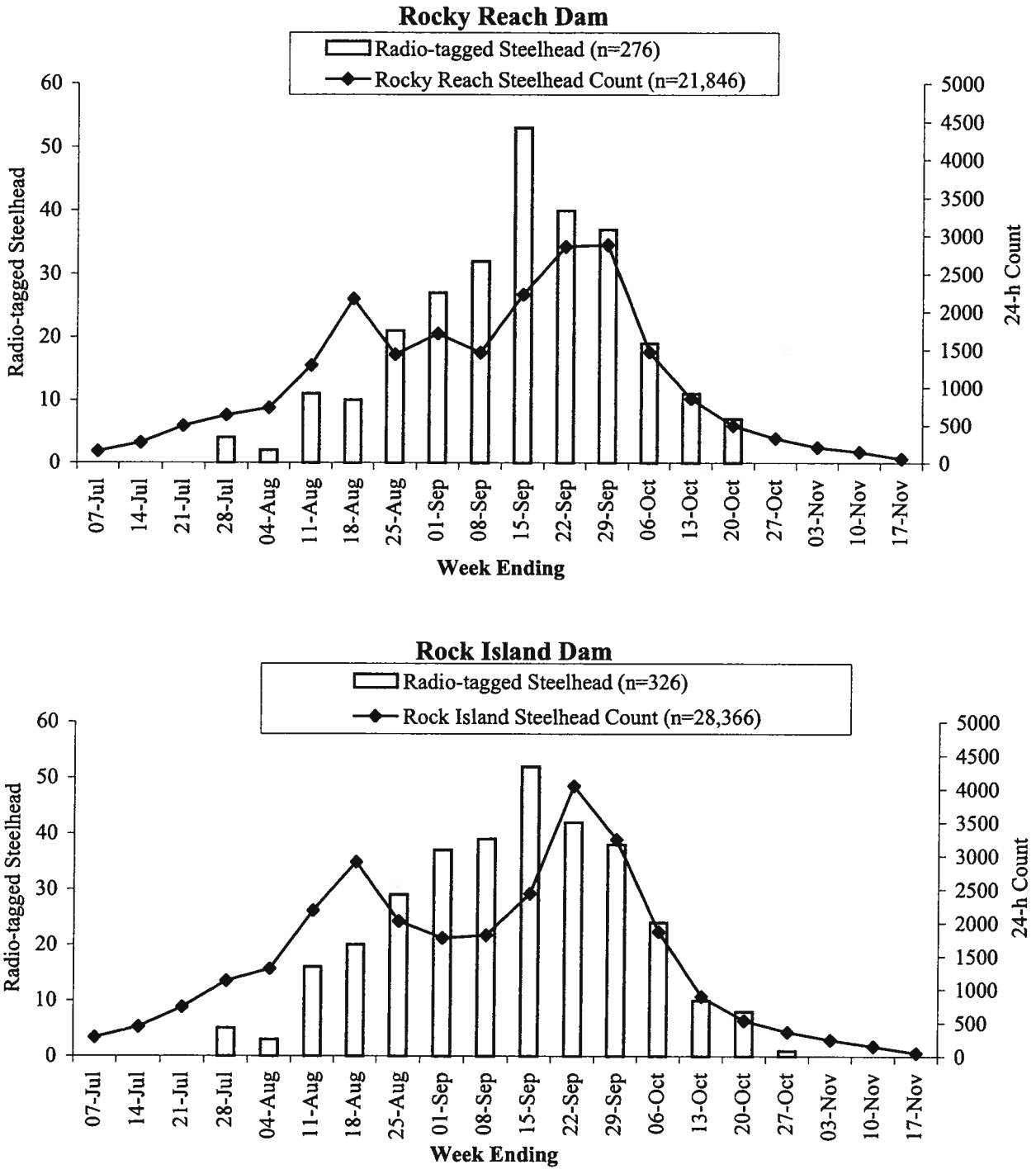

Figure 10. Comparison of the weekly counts of steelhead and radio-tagged steelhead that passed Rocky Reach and Rock Island dams in 2001.

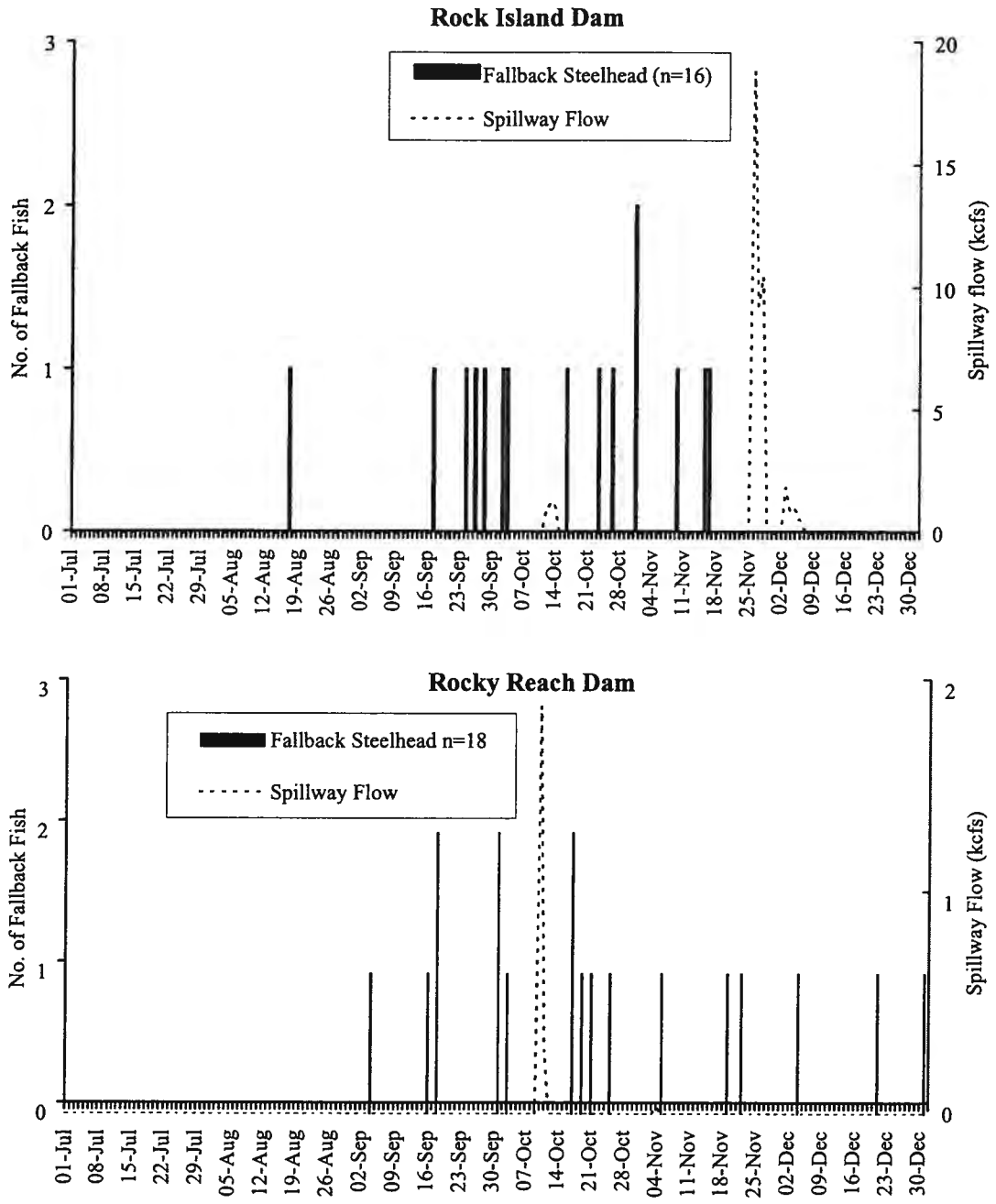

Figure 11. Comparison of spillway flows and the timing of steelhead fallback events at Rock Island and Rocky Reach dams in 2001.

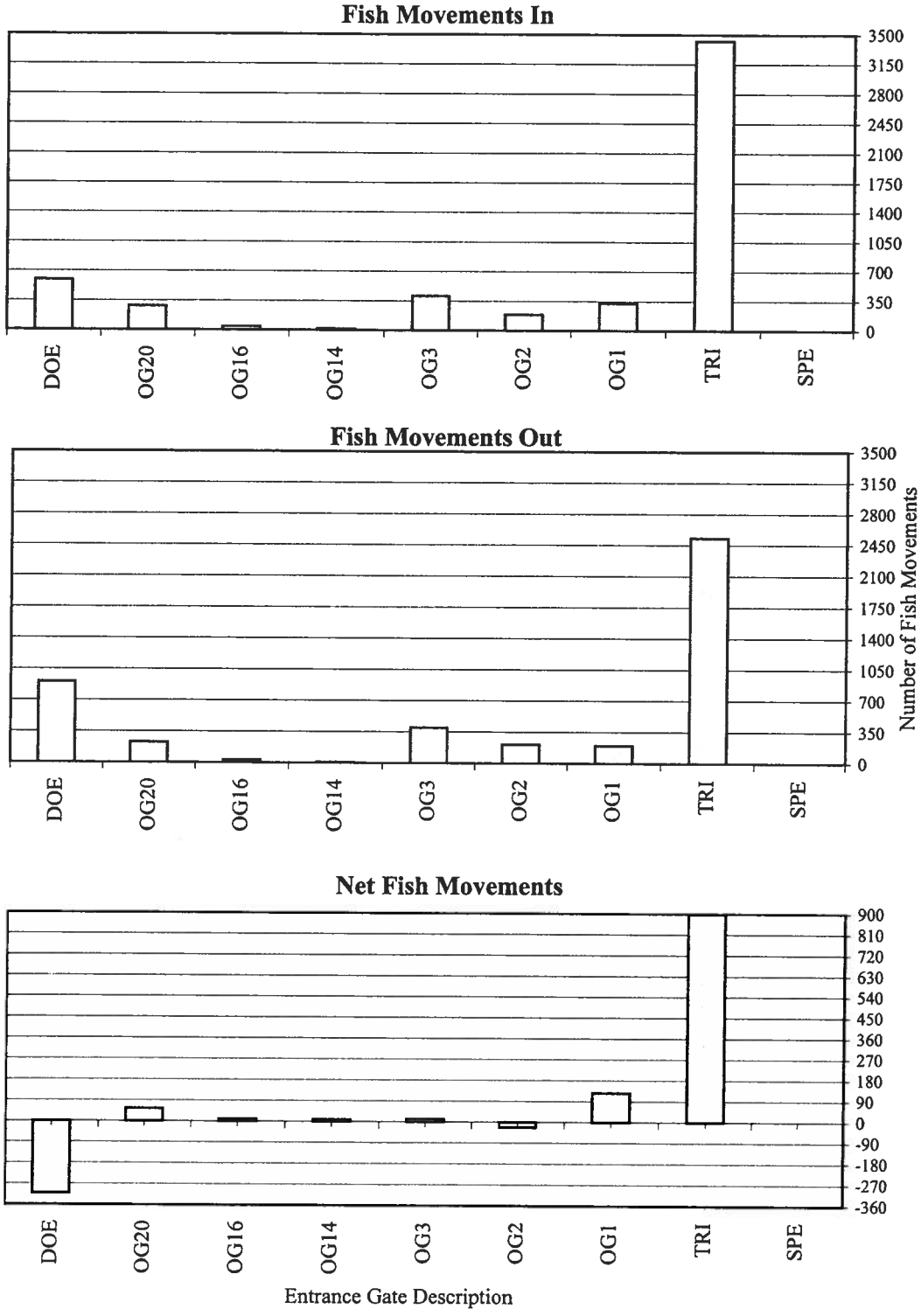

Figure 12. Movements of adult radio-tagged steelhead in and out of each entrance gate, and net movements, at Rocky Reach Dam, 2001.

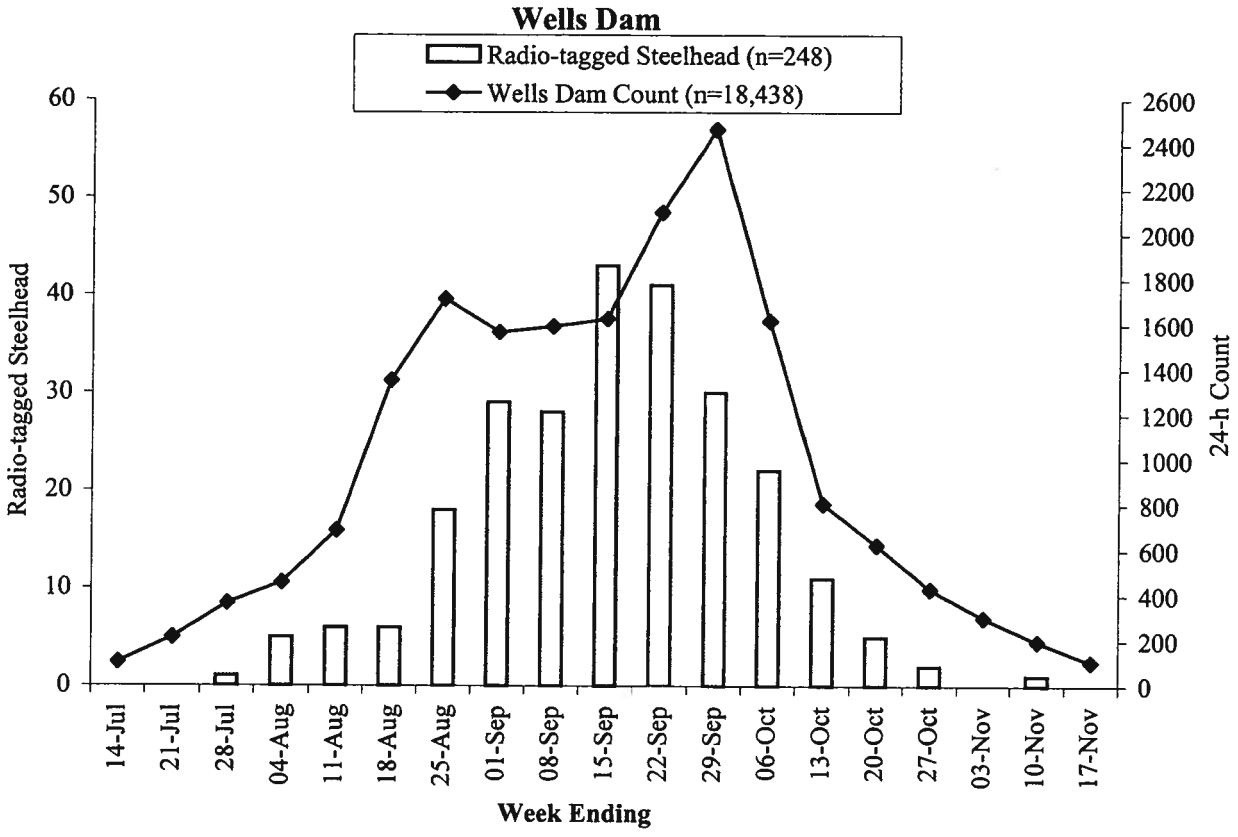

Figure 13. Comparison of the weekly counts of steelhead and radio-tagged steelhead that passed Wells Dam in 2001.

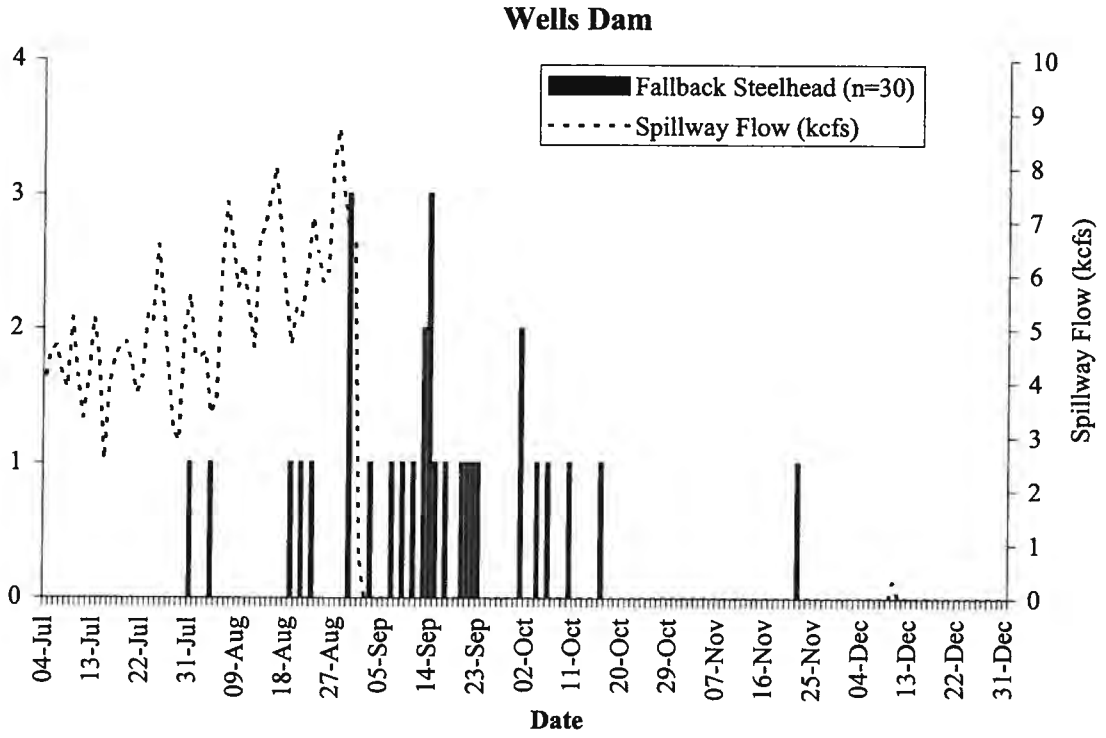

Figure 14. Comparison of spillway flow and the timing of steelhead fallback events at Wells Dam in 2001.

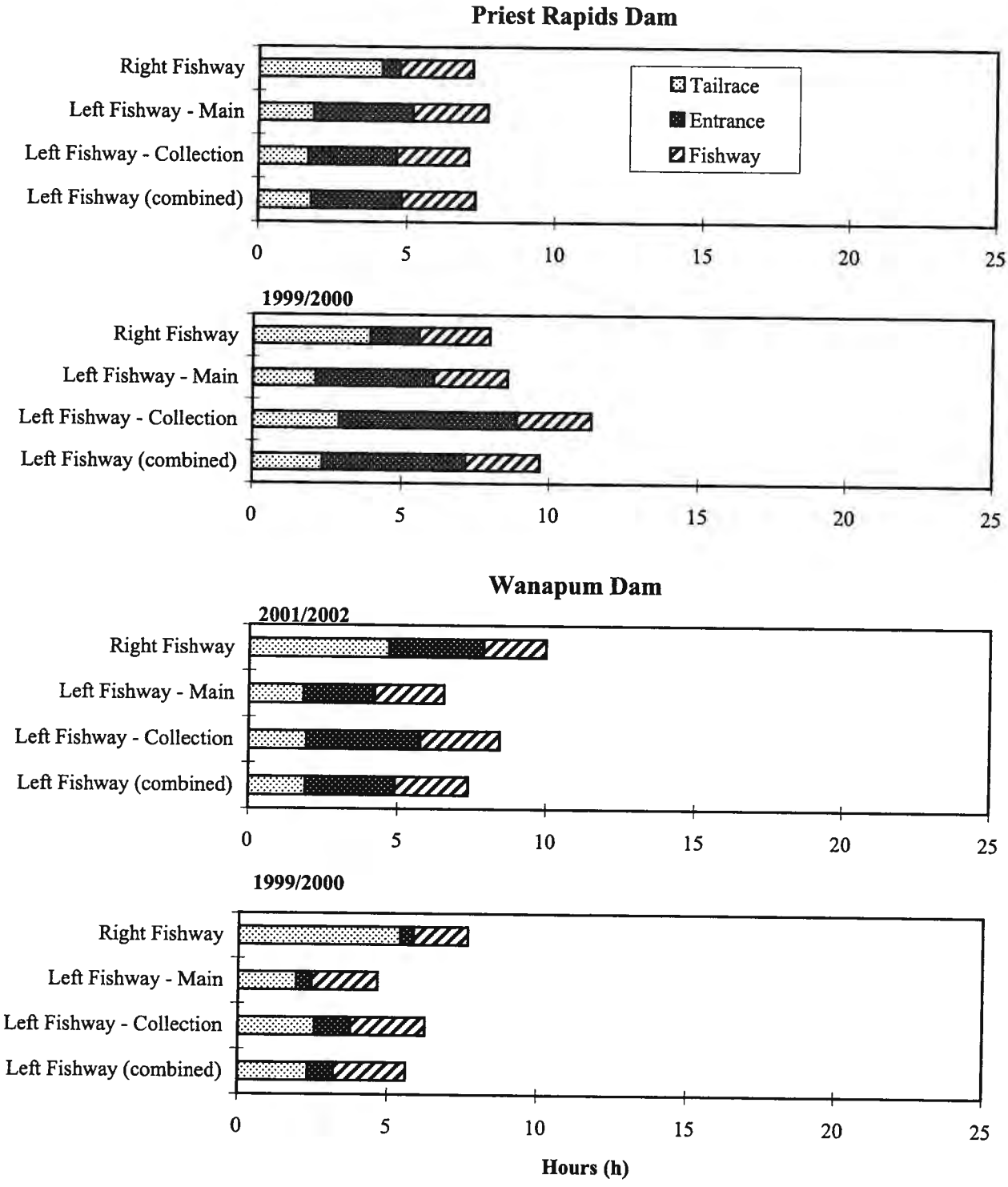

Figure 15. Comparison of median passage times (in hours) for steelhead that migrated past Priest Rapids and Wanapum dams in 2001 and 1999.

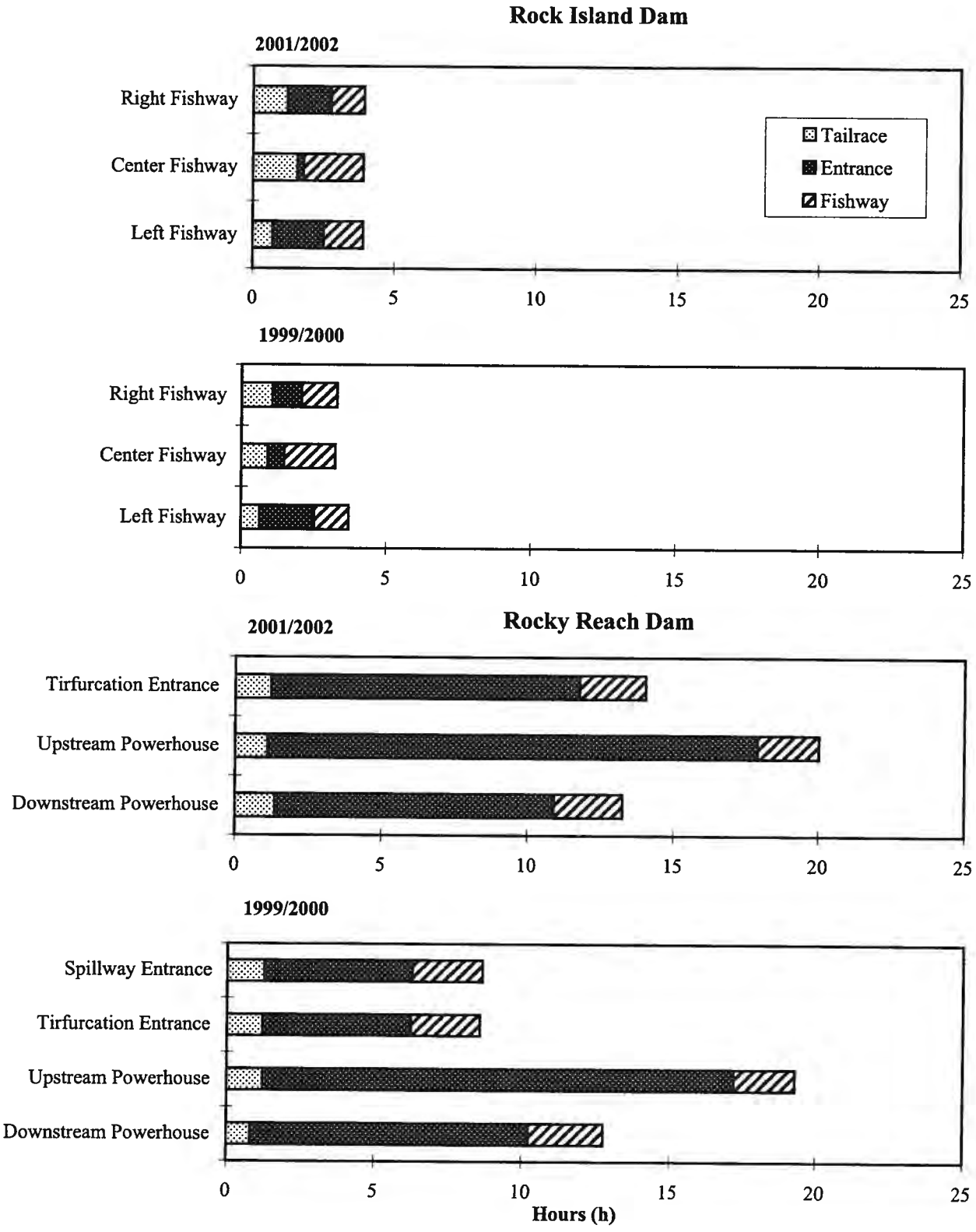

Figure 16. Comparison of median passage times (in hours) for steelhead that migrated past Rock Island and Rocky Reach dams in 2001 and 1999.

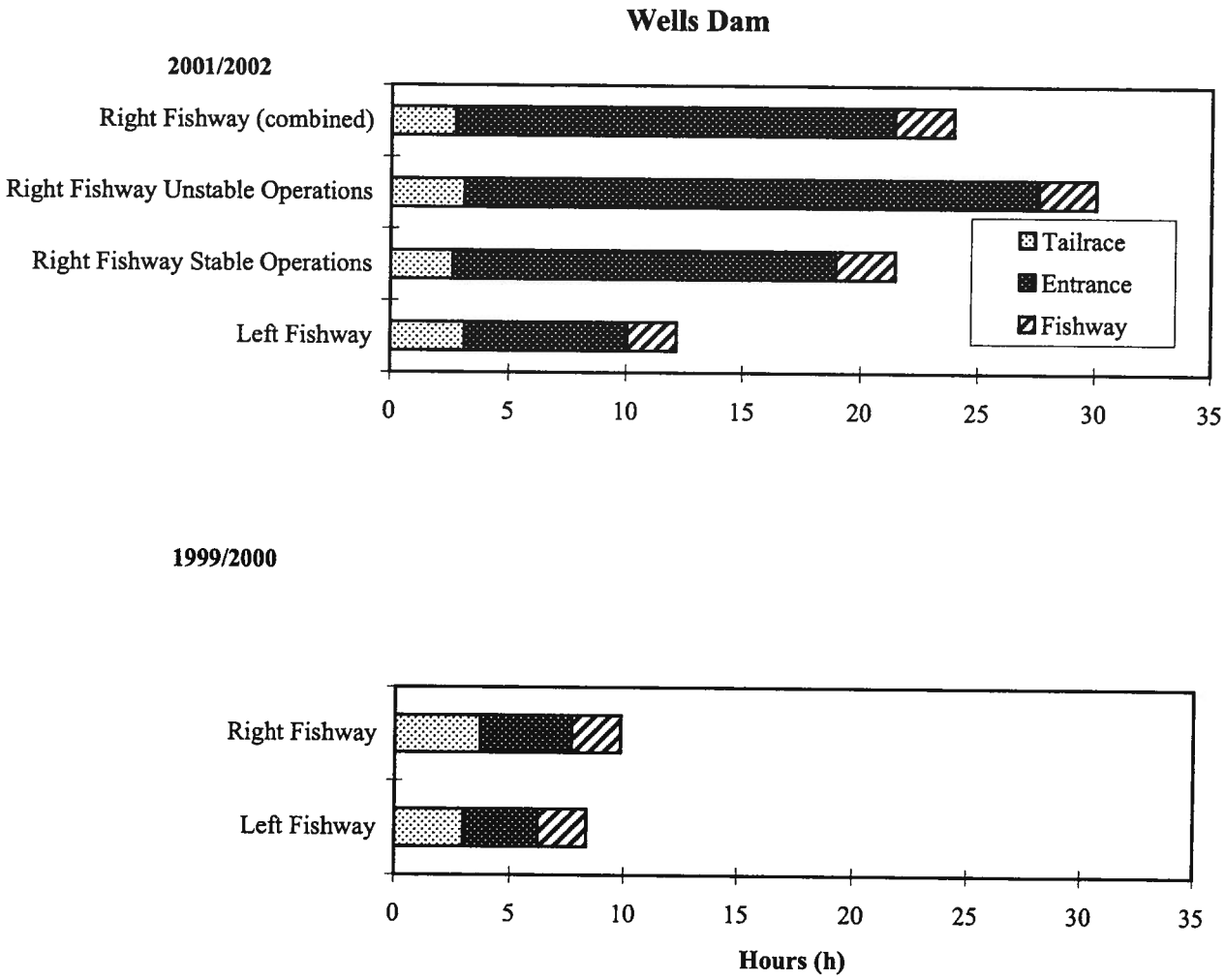

Figure 17. Comparison of median passage times (in hours) for steelhead that migrated past Wells Dam in 2001 and 1999.

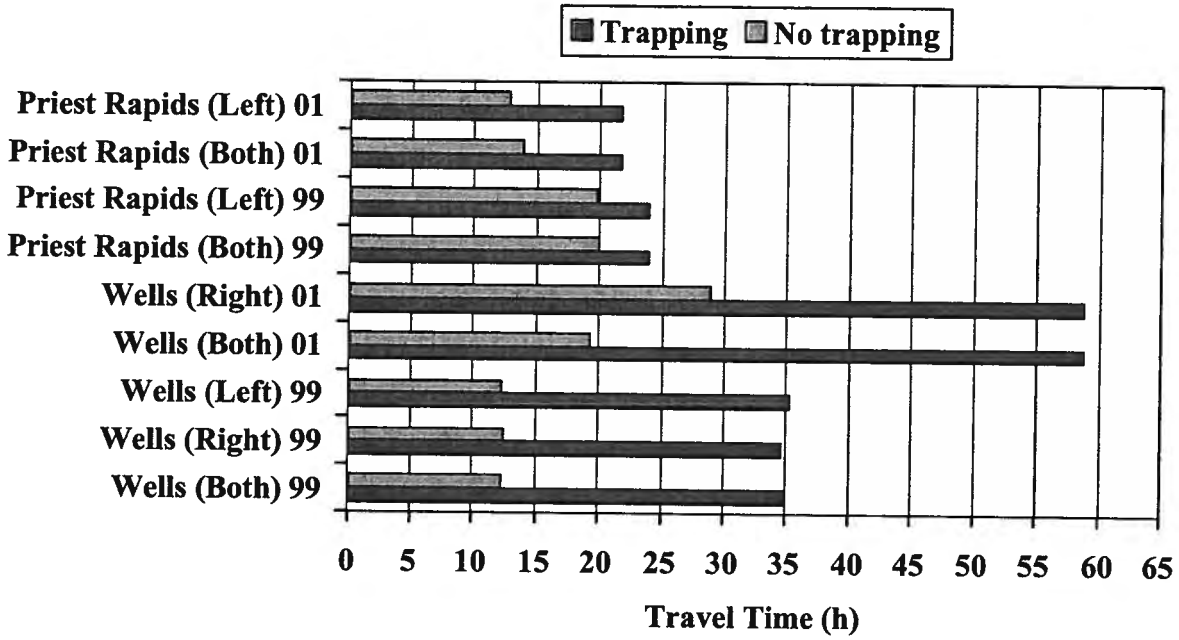

Figure 18. Comparison of median project passage times for trapping and no trapping intervals at Priest Rapids and Wells Dam, 1999 and 2001.

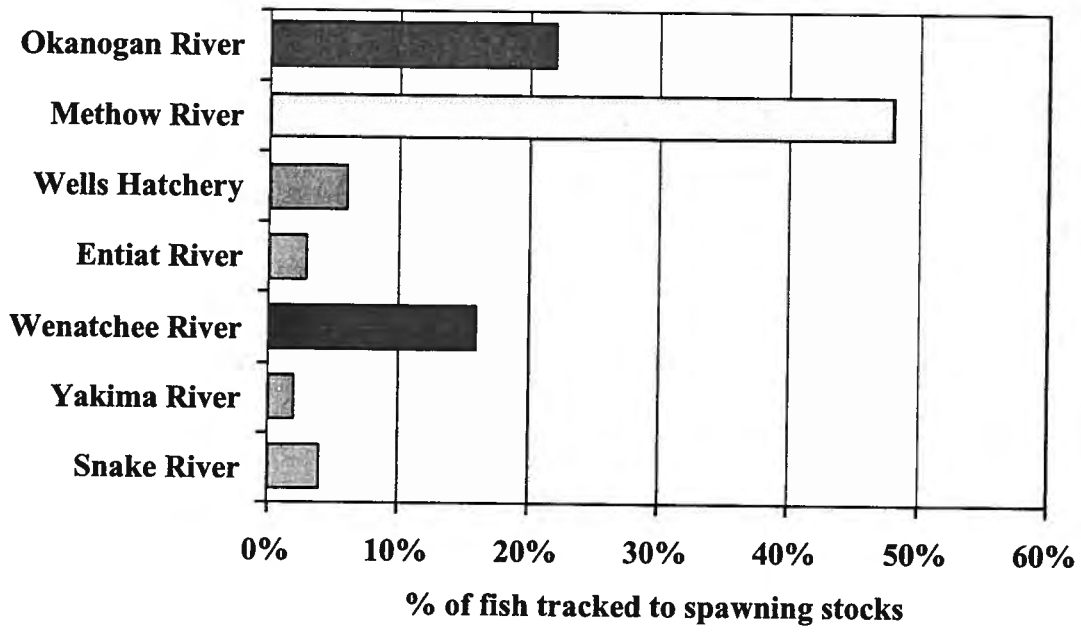

Figure 19. Distribution of hatchery and "wild" radio-tagged steelhead between the tributary spawning areas, 2001-2002.

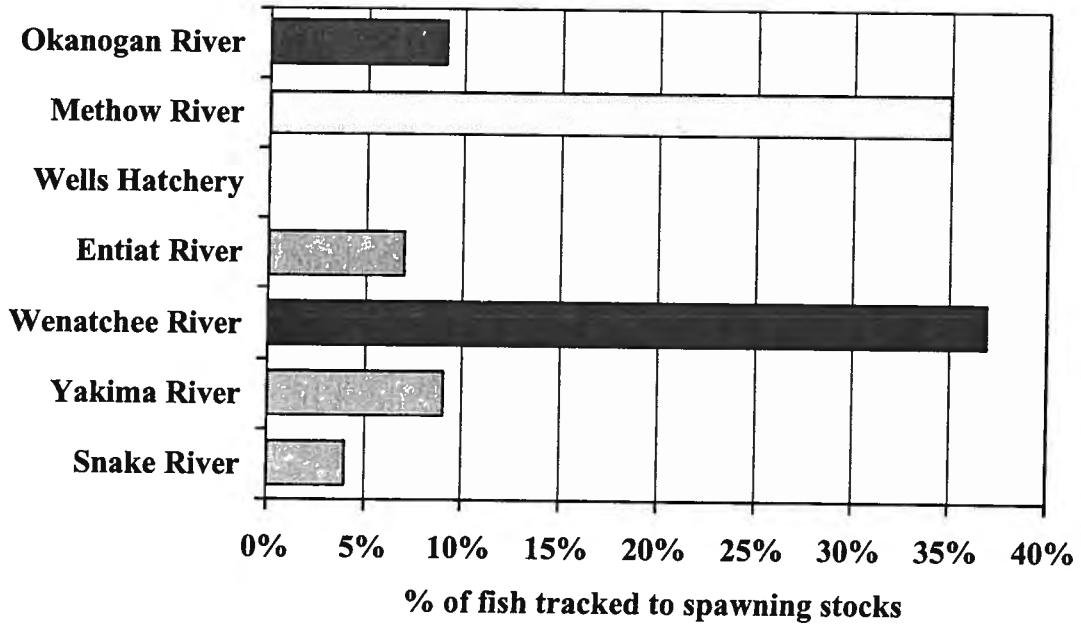

Figure 20. Distribution of "wild" radio-tagged steelhead between the tributary spawning areas, 2001-2002.

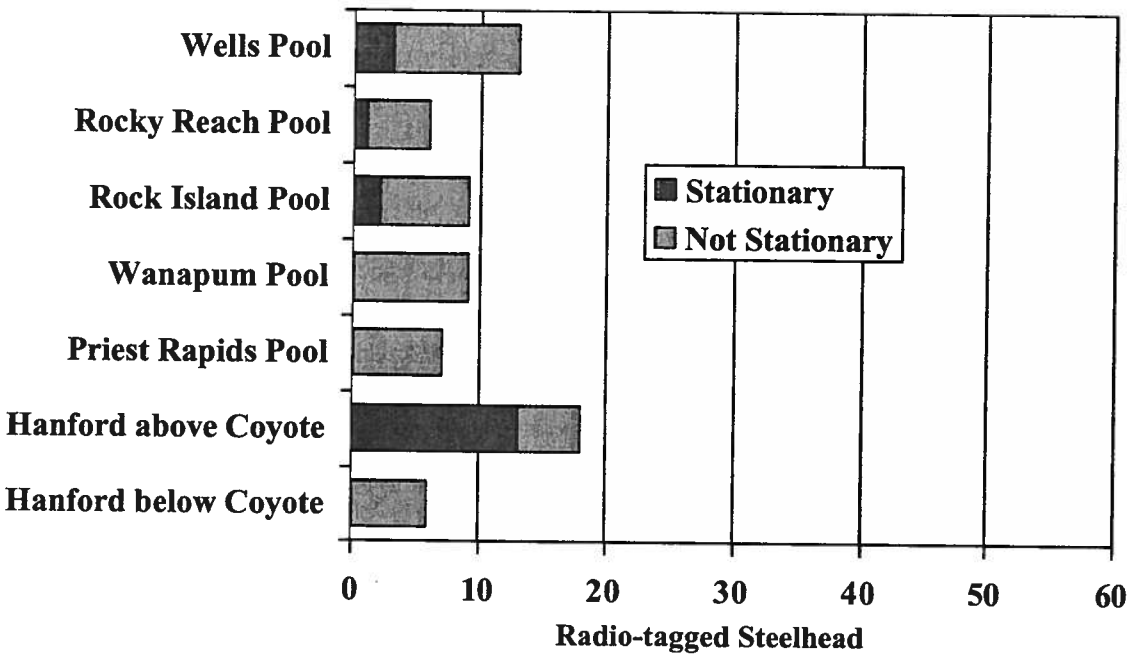

Figure 21. Distribution of stationary and non stationary steelhead radio-tags between the monitored reaches along the mid-Columbia River between the Yakima River and Chief Joseph Dam, 2001-2002.

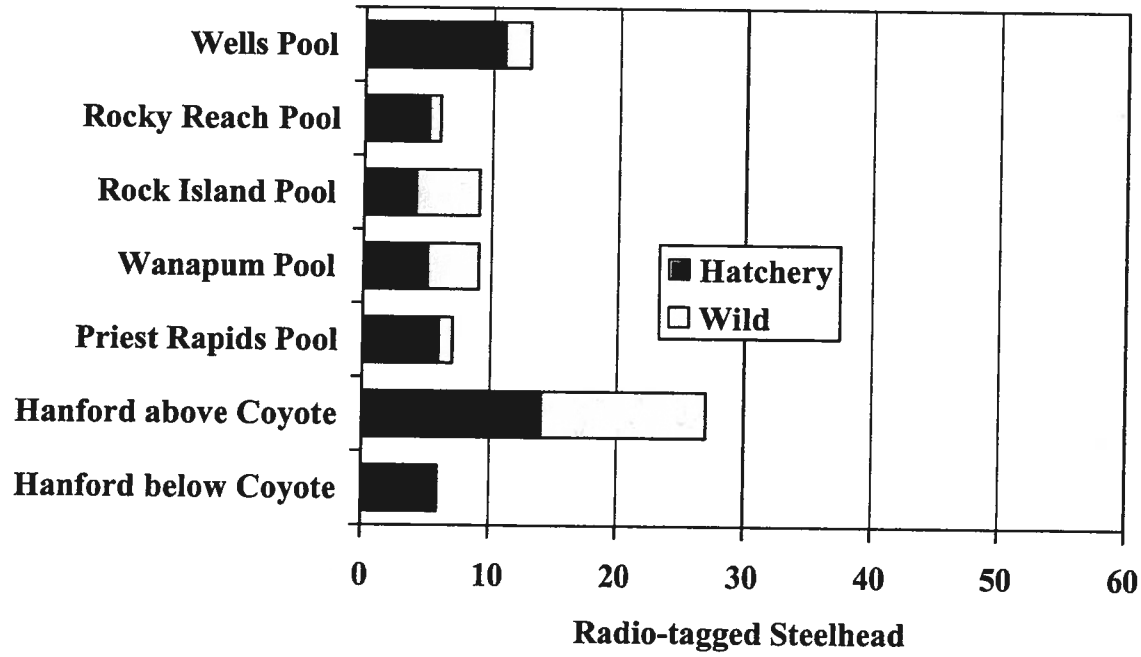

Figure 22. Distribution of the radio-tags applied to hatchery and "wild" steelhead between the monitored reaches along the mid-Columbia River between the Yakima River and Chief Joseph Dam, 2001-2002.

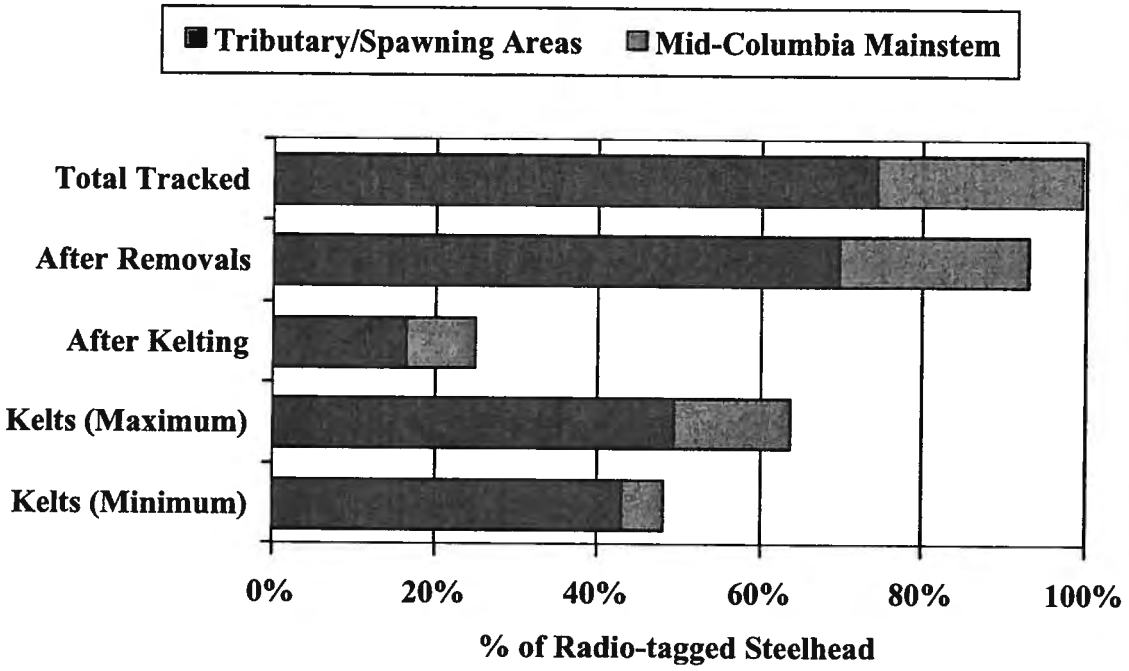

Figure 23. Estimated kelting rates for radio-tagged steelhead tracked to known spawning areas and reaches along the mid-Columbia River between Coyote Rapids and Wells Dam, 2001-2002.

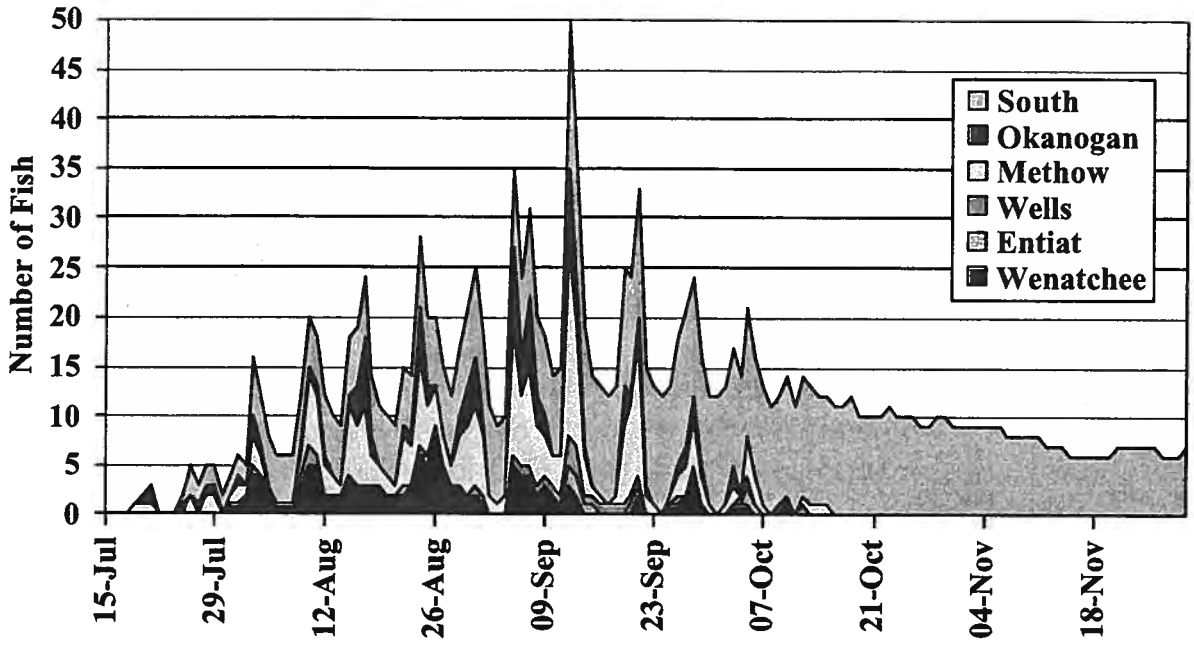

Figure 24. Upstream migration timing for radio-tagged steelhead of the different stocks on the mid-Columbia River between Coyote Rapids and Priest Rapids Dam, 2001.

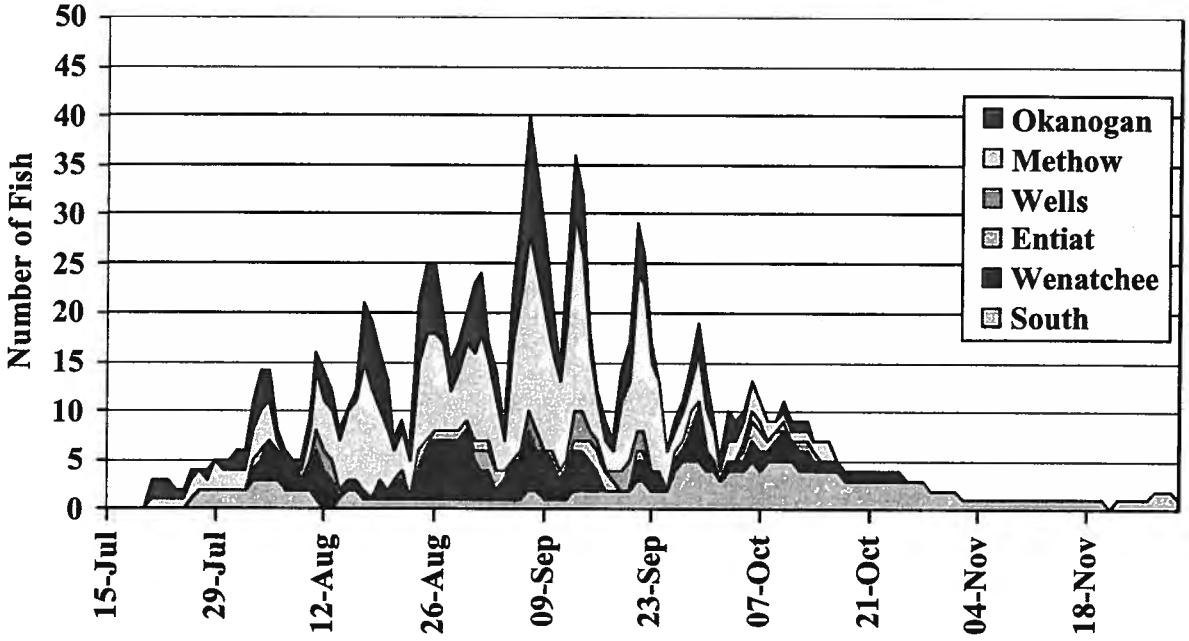

Figure 25. Upstream migration timing for radio-tagged steelhead of the different stocks on the mid-Columbia River between Priest Rapids and Wanapum dams, 2001.

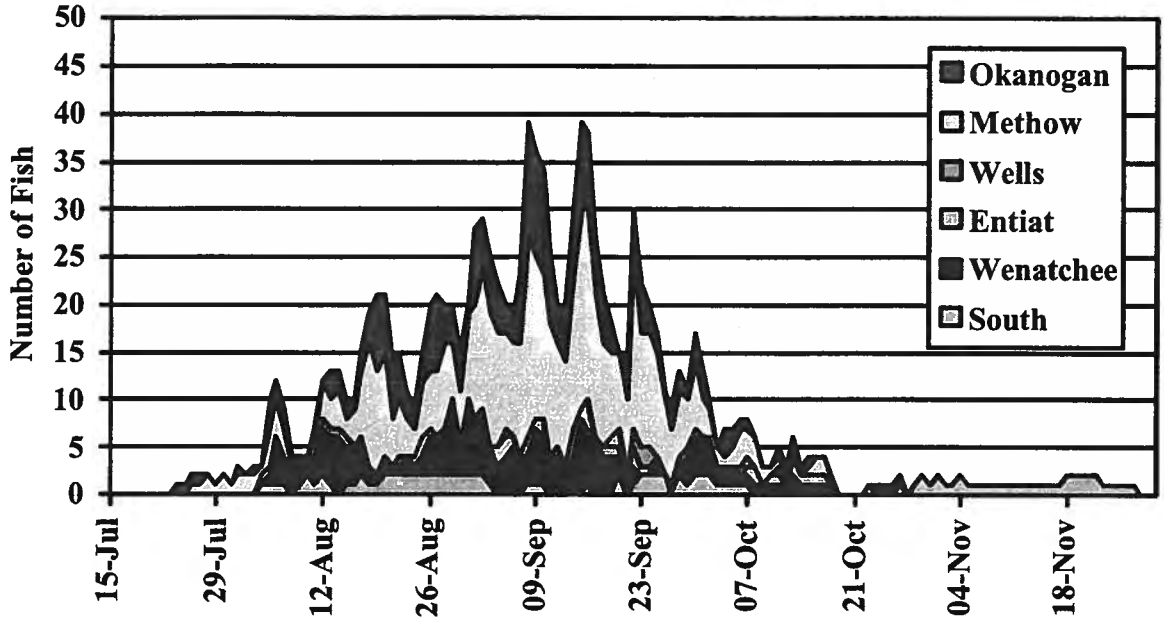

Figure 26. Upstream migration timing for radio-tagged steelhead of the different stocks on the mid-Columbia River between Wanapum and Rock Island dams, 2001.

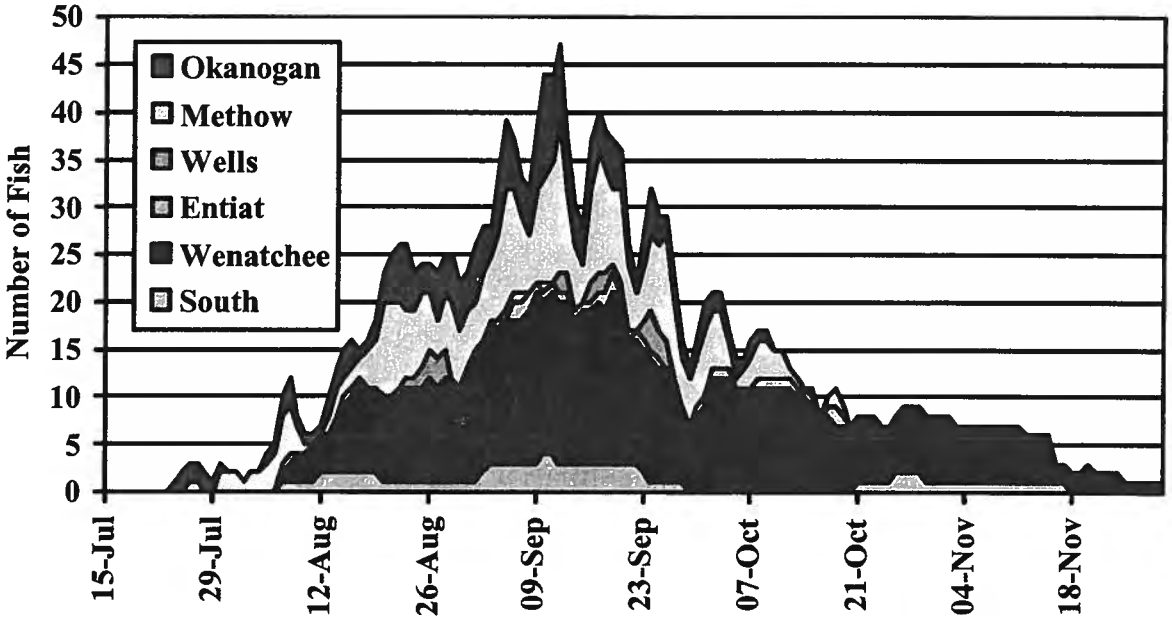

Figure 27. Upstream migration timing for radio-tagged steelhead of the different stocks on the mid-Columbia River between Rock Island and Rocky Reach dams, 2001.

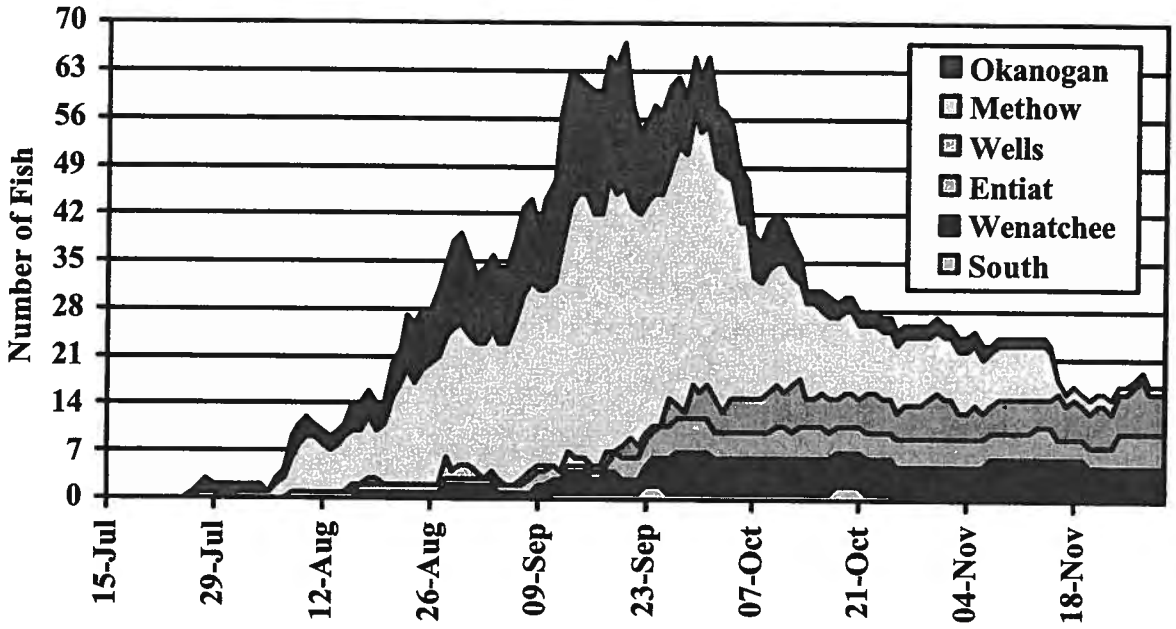

Figure 28. Upstream migration timing for radio-tagged steelhead of the different stocks on the mid-Columbia River between Rocky Reach and Wells dams, 2001.

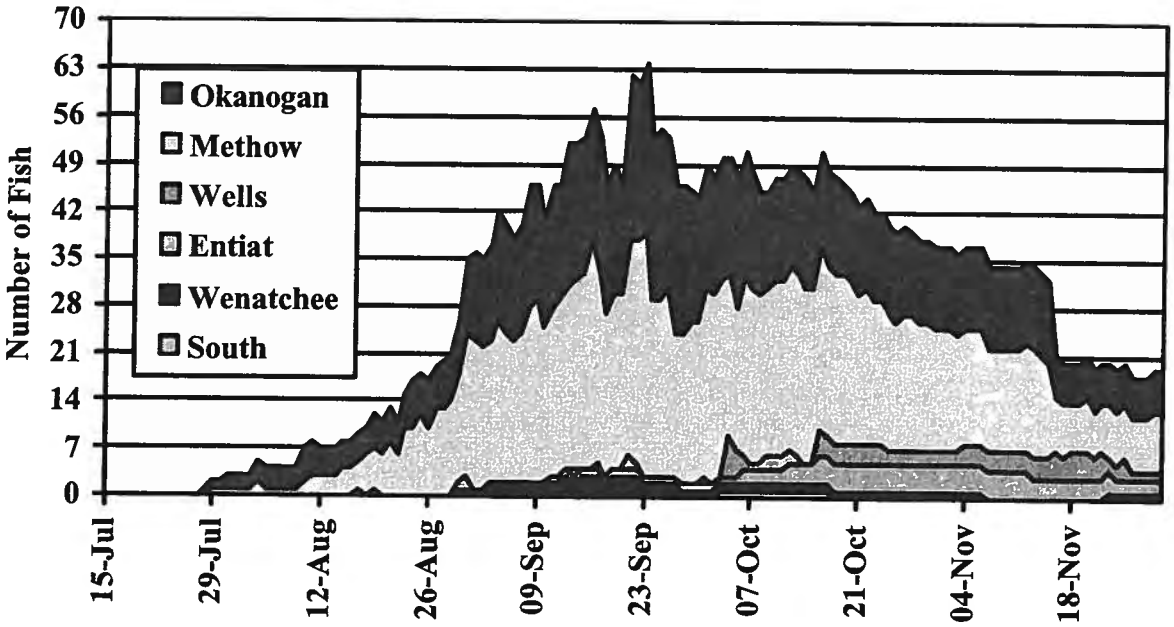

Figure 29. Upstream migration timing for radio-tagged steelhead of the different stocks on the mid-Columbia River above Wells Dam, 2001.

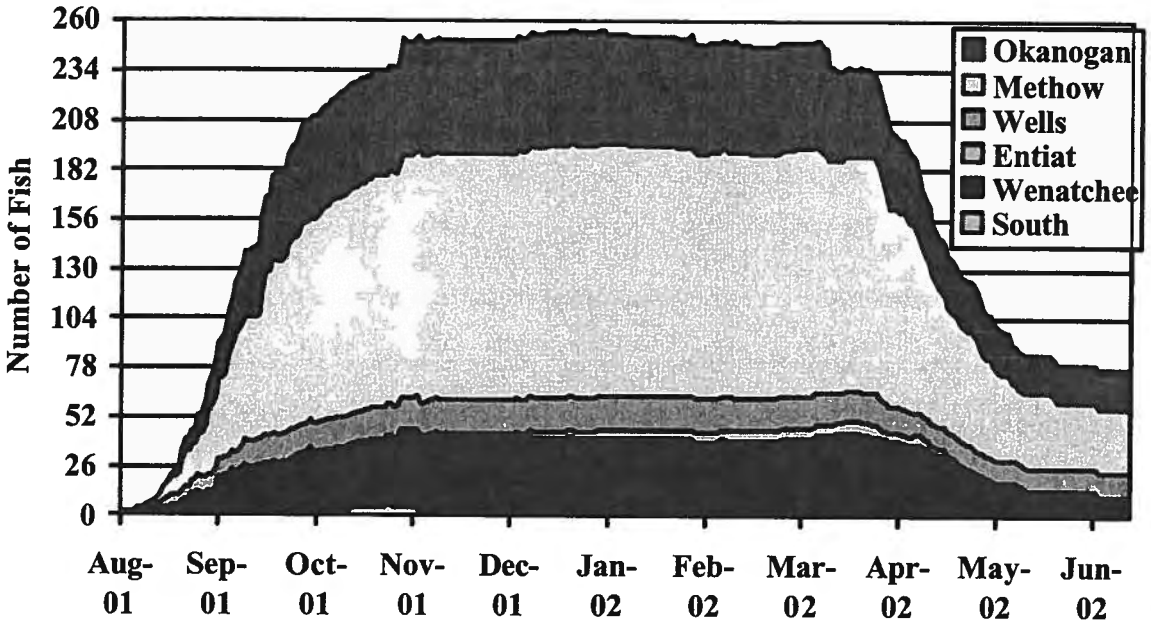

Figure 30. Immigration, emigration and accumulation of radio-tagged steelhead in known spawning areas from 1 August 2001 through 30 June 2002.

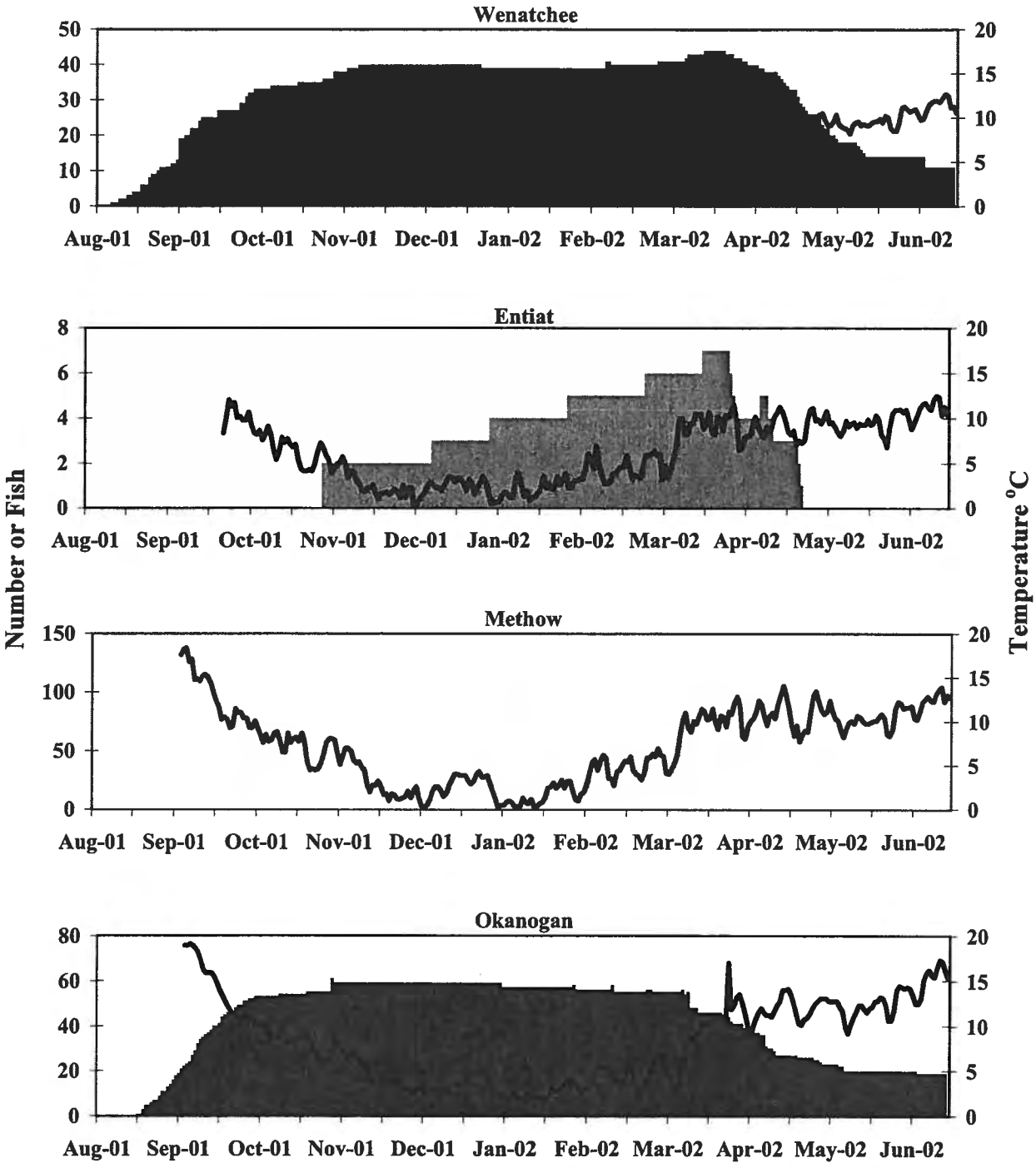

Figure 31. Number of radio-tagged steelhead in spawning areas and associated water temperatures for these tributaries to the mid-Columbia from August 2001 through June 2002.

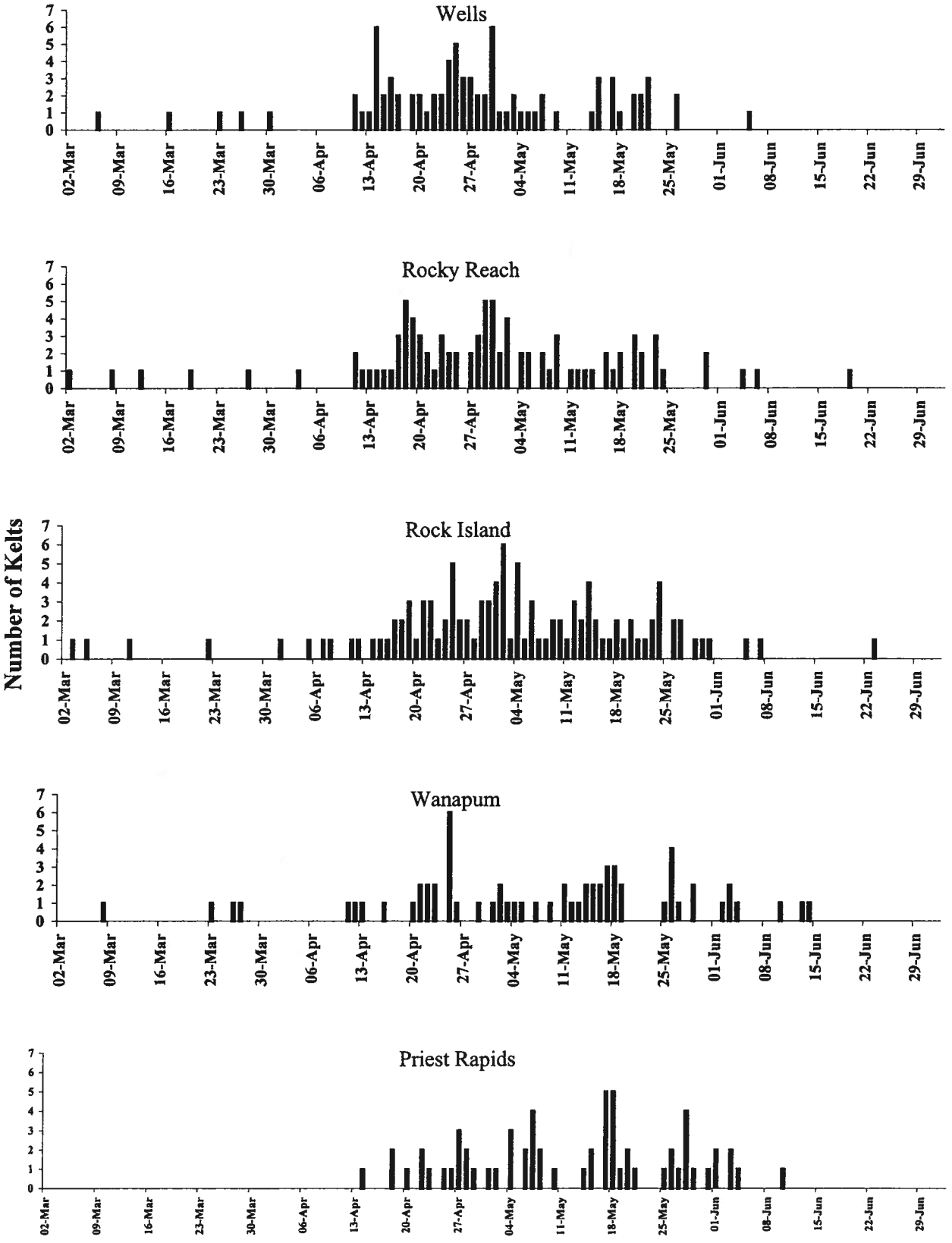

Figure 32. Numbers of radio-tagged steelhead kelts detected at each dam on mid-Columbia River during the downstream migration period from March through June 2002.

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APPENDICES

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APPENDIX REPORT A1 – DESCRIPTION OF TELEMETRY ARRAYS

Yakima River

The mouth of the Yakima River (zone 31) was monitored using a two antenna aerial array serviced by the University of Idaho.

Snake River

The mouth of the Snake River below Ice Harbour Dam (zone 11) was monitored using a two antenna aerial array serviced by the University of Idaho.

Hanford - Coyote Rapids

This site is located approximately 22.1 km downstream of Priest Rapids Dam on an island (Figure 2). A total six 3-element Yagi antennas mounted on two towers approximately 300 ft apart, and at an elevation of approximately 15 m off the surface of the water. All antennas were combined (zone 51) and were monitored with a single SRX receiver.

Priest Rapids Dam

Tailrace - The tailrace of Priest Rapids Dam was monitored with a total of eight 3-element aerial Yagi antennas mounted on four towers (2 antennas per tower). These antennas were located approximately 1.2 km downstream of the dam (Figure 2) with each tower representing its own detection zone (71, 72, 81, and 82). This setup was consistent with previous years of study in location, however, an additional tower was added 300 ft upstream of the original location on each bank to provide an "extended array" capable of tracking movements in the rapids. The pair of towers 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, all gates were closed. In addition to the OG 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. To examine entrance passage characteristics, dipole antennas were mounted on each exterior side of LEW2 (zone 101). Stripped coax antennas were deployed inside the collection channel to monitor the main entrance (zone 102), and the mid-point of the channel (OG#6-8, zone 104). In addition, a single stripped coax was deployed outside of OG#7 (zone 103) to monitor for movements along the outside face of the collection channel. Collectively, these antennas were monitored with two SRX 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 2). In addition to the collection channel, the bifurcation pool has two additional entrances that fish can enter the left-

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bank ladder (LEW4-5 and LEW6-7). Of these, only LEW4-5 was open during the study period. Coax antennas were deployed inside (zone 122) and outside of the upper collection channel at OG#18 (zone 121), dipoles were installed on the exterior side of LEW4-5 (zone 123), and coax antennas were deployed immediately inside the entrance of LEW4-5 (zone 124). As fish began their ascent of the left-bank ladder, they pass into the transport channel where two coax antennas were deployed at the first oriface wall (zone 125). This zone determines the time at which radio-tagged fish begin their ascent. Additional coax antennas were mounted below the counting station (zone 126). The antennas at this location were monitored by a single SRX system.

The left-bank fish ladder consists of a series of pools 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), two coax antennas below the adult trap (zone 141), and three antennas at the exit (zone 142) were deployed. The antennas at this location were monitored by a single SRX system.

Right-bank Fish Ladder - At the right-bank fish ladder, the ladder entrance, exit, and specific pools in between were monitored. The right fishway entrance 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 fishway entrance, two dipole antennas were deployed outside the entrance (zone 161), two coax antennas immediately inside of the ladder entrance (zone 162), and a coax antenna at the first oriface wall (zone 163). In addition, a dipole antenna was mounted below the counting station (zone 164). This array was monitored by a single SRX system. At the ladder exit, two coax antennas below the last diffusion grate (zone 181), and one coax antenna in each of the two upper weirs before the exit (zone 182) were deployed. These antennas were monitored by an SRX system.

Forebay - Dipole antennas in the gatewells of the powerhouse (zones 191-195), and coax antennas in each spillway (zones 201-207) were deployed to track movements in the forebay or downstream passage. In addition, dipole (zone 196) and coax antennas (zone 197) were deployed in the sluice. When these arrays were not operational, aerial antennas directed into the forebay were used. The spillway and powerhouse arrays were each monitored by a SRX or SRX/DSP system.

Crab Creek

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 tower at an elevation of approximately 15 m off the surface of the water. Antennas were pointed upstream and downstream (zone 221 and 222), and were monitored with a single SRX receiver.

Wanapum Dam

Tailrace - Fish in the tailrace of Wanapum Dam were monitored with a total of four 3-element aerial Yagi antennas. These antennas were located approximately 1.2 km downstream

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of the dam with two antennas on the left-bank (zone 231) and two antennas on the right-bank (zone 241, Figure 3). This setup was consistent with previous years of study. At both sites, the antennas were combined and 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 (Figure 3). The channel has a total of 20 OG that can either be opened or closed to permit entrance by adult salmonids migrating upriver. During the study period, all gates were closed. In addition to the OG, the transport channel has two entrances (defined as side entrance weirs; SE) located at the west end (SE3, SE4). Of those entrances, only SE4 was open during the study period. Dipole antennas were mounted on the outside of SE4 (zone 261), coax antennas were deployed on the inside of SE4 (zone 262), a single coax antenna was deployed on the outside of OG#20 (zone 263), and coax antennas were deployed inside (zone 264) and outside of OG#10 (zone 265). These antennas were monitored with a single SRX system.

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 was open during the study period. Coax antennas were placed on the inside (zone 281) and outside (zone 282) of OG#19 (upper collection channel), dipole antennas were mounted on the outside of SE2 (zone 283), coax antennas on the inside the entrance of SE1 (zone 284), and a single dipole was mounted in the bifurcation pool (zone 285). These antennas were monitored using a single SRX. In addition, antennas were placed at several locations throughout the fish ladder: two coax were deployed in pools above the lower fish ladder diffusion grates (zone 301), two coax were placed in the viewing window pool (zone 302), a single dipole was placed in the midway diffusion grate pool (zone 303), two coax antennas were placed below the count station (zone 304), and two coax antennas were deployed at the exit (zone 305). These antennas were monitored with a single SRX/DSP system.

Right-bank Fish Ladder - At the right-bank fish ladder, the ladder entrance, exit, and specific pools in between were monitored (Figure 3). The right fishway entrance has three entrances defined as right entrance weirs - REW1, REW2, and REW3. REW2 and 3 were closed for the duration of the study. At the right fishway entrance, two dipole antennas were deployed outside the entrance (zone 321), four coax antennas immediately inside of the ladder entrance (zone 322), and a coax antenna at the first oriface wall (zone 323). In addition, a coax antenna was mounted above the lower fish ladder diffusion grates (zone 324). This array was monitored by a single SRX system. Further up the ladder, coax antennas were deployed at the midway diffusion grate (zone 341), below the count station (zone 342), and one coax antenna in each of the two upper weirs before the exit (zone 343). These antennas were monitored by an SRX/DSP system.

Forebay - Dipole antennas in the gatewells of the powerhouse (zones 351-355), and in each spillway (zones 361-366) were deployed to track movements in the forebay or downstream passage. In addition, the sluice was monitored by dipole antennas mounted on each side of the

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spill plate. When these arrays were not operational, aerial antennas directed into the forebay were used. The spillway and powerhouse arrays were each monitored by an SRX/DSP system.

Wanapum Pool and Upstream

In April 2002, additional tower stations were deployed on the left and right-banks of the Columbia at Quilomeen Island (Figure 3) as part of another study. Two 3-element antennas were used on the right-bank, and four 3-element antennas were used on the left-bank (on Quilomeen Island pointing in both directions). At each site, all antennas were combined into one.

Rock Island Dam

Tailrace - Within the tailrace of Rock Island Dam, two 6-element Yagi aerial antennas were deployed in order to detect fish as they approached the project (Figure 4). These antennas were located on the right bank approximately 300 m below the dam (zone 501). 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. The antennas were combined together, effectively creating a single, large detection zone. Site selection was based on four factors: 1) consistency with previous studies assessing adult salmonid passage; 2) general proximity to the dam; 3) the amount of ambient electrical noise at the site; and 4) the width of the river channel. Based on empirical data, the site encountered acceptable levels of ambient electrical background noise, and allowed detection of tagged fish to a depth of approximately 6 m on the opposite shore.

Left-bank Ladder - At Rock Island Dam there are a total of three adult fishway ladders, the left bank ladder (eastern side of project), the center ladder (located between spillbays 14 and 16), and right bank ladder (west side of project; Figure 4). Within each of the ladders, underwater antenna systems were deployed to monitor the entrance and exits, as well as areas within the ladders that presented potential for passage delay (diffusers). The left bank ladder is located along the east shore near powerhouse 1. At the downstream portion of the ladder, a total of three antennas were deployed. The first antenna was located outside the ladder entrance, and detected fish as they approached the ladder (zone 511). The second antenna was located approximately 12 m inside of the entrance, and confirmed ladder entry and provided information on the length of time tagged fish spent immediately inside of the ladder entrance (zone 512). The third antenna was located at the upstream end of the transport channel, immediately below the first weir of the ladder (zone 513). This antenna was approximately 75 m inside of the ladder entrance, and provided information on whether there was any migrational delay associated with the transport channel.

At the upper end of the left ladder, a total of four antennas were deployed. The first antenna encountered by tagged fish moving upstream was located at the first bend in the ladder (zone 521). 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 522). This antenna provided information regarding migration rate between the diffuser weir and the ladder

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exit. The third and fourth antennas were located near the viewing window (zone 523), and immediately inside of the trash rack at the ladder exit (zone 524), respectively.

Center Ladder - Consistent with the left ladder, two underwater telemetry systems within the center ladder, one at the ladder entrance and the other at the exit were deployed (Figure 4). The center ladder at Rock Island Dam has a total of two entrances, the main entrance located at the end of the ladder, and a side entrance located on the west side of the transport channel approximately 15 m upstream of the main entrance (CME and CSE, respectively). Antennas were deployed both outside and inside of the main entrance (zones 531 and 532, respectively). For the side entrance, only one antenna located inside of the entrance was installed (zone 534). The outside antenna was not installed due to high flows and debris accumulation. 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 535). This antenna provided migrational timing of tagged fish to where they began to encounter the ladder weirs.

At the upstream end of the fishway, a total of five antennas were deployed. The first antenna encountered by fish as they moved upstream was located in a weir where a diffuser was installed (zone 541), and was approximately 50 m downstream of the ladder exit. This antenna provided information regarding migration rate 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 (zones 542 and 543, respectively). 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 544). This antenna, and the antenna located outside of the ladder exit (zone 545) provided information on the migration rate 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 551 and 552; RPE), center (zones 554 and 555; RCE), side (zones 563 and 564; RSE), and main entrance (zones 561 and 562; RME). All four entrances lead to the quadfurcation 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, each entrance (both outside and immediately inside of the entrance), the quadfurcation pool, as well as the lower ladder were monitored. At the powerhouse entrance, one antenna was installed outside the ladder entrance and a second antenna approximately 10 m inside the entrance within the transport channel. The third antenna was located at the upper end of the transport channel, approximately 10 m below the quadfurcation pool (zone 553). The middle entrance leads directly into the junction pool; therefore, the area immediately outside of the entrance, as well as approximately 5 m inside of the entrance was monitored. 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 quadfurcation pool. 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, both in and outside of the entrance were monitored. These antennas provided data on

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migration rate of fish moving through the entrances, as well as information regarding passage through the transport channel.

Since fish migrating up the ladder system from the quadfurcation pool had two possible routes of travel (either up the ladder or downstream through the transport channel leading to the main and side entrances), two antennas to assess the route selected were deployed. One antenna was deployed in each channel to determine which route fish took (zones 571 and 572). An additional antenna was located within the fish ladder, approximately 35 m upstream of the quadfurcation pool (zone 565). This antenna provided information on fish as they began their ascent of the fish ladder.

As with the other fishways at Rock Island Dam, the upper section of the right bank fish ladder was monitored. Within this area, a total of four antennas were deployed. The first antenna was located within the first weir downstream of the powerhouse roadway (zone 581). The second antenna was located in the fish viewing weir, immediately upstream of the roadway (zone 582). Based on migration rate between these antennas, it was possible to determine if fish were reluctant to pass underneath the roadway. The third antenna was located within the transport channel that leads from the last weir in the ladder system to the exit (zone 583), and the fourth antenna was located outside of the ladder trash rack (zone 584). These antennas provided data which allowed us to partition migrational timing through the transport channel, and total migration time of fish through the right ladder system, respectively.

Wenatchee River

Sampling efforts on the Wenatchee River consisted of two monitoring sites. One was located near the town of Monitor (rkm 8.7), and the other at Tumwater Dam (rkm 49.4). At the Monitor site (Figure 4), two 4-element aerial Yagi antennas were monitored separately (zones 711 and 712). As with other tributary aerial systems, one antenna was aimed downstream at a 40 degree angle to the shoreline, and the second aimed upstream at the same angle. Individual monitoring of these antennas allowed the position of the tagged fish to be determined relative to the site (i.e., downstream vs. upstream), and the direction of travel.

The second Wenatchee River site was located at Tumwater Dam. At this site, two 4-element aerial Yagi antennas were deployed, one below and one above the dam (zones 711 and 712), and each were monitored individually. Individual monitoring of these antennas allowed determination of whether the tagged fish was above or below the dam, as well as direction traveled.

Rocky Reach Dam

At Rocky Reach Dam, there is single fish ladder located on the right bank of the project (west side of the project). 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 systems used to monitor adult passage.

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Tailrace - Approximately 300 m downstream of the powerhouse, two 6-element aerial Yagi antennas located on the right bank were deployed (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 591), and were combined to provide a single detection area.

Spillway Entrance - The spillway ladder is located between spillbays 8 and 9, and extends into the tailrace of the project (Figure 5). At this site, due to high flows and turbulence, an antenna immediately outside of the entrance was not feasible (SPE). Alternatively, an underwater antenna approximately 3 m inside of the entrance, and a second antenna approximately 12 m upstream of the entrance antenna (zones 601 and 602, respectively) were installed. A third antenna was deployed approximately 35 m upstream of the second antenna, at the location where the entrance channel connects with the transport channel (zone 603). The spillway transport channel then runs along the base of the spillway, and eventually connects with the trifurcation pool. It should be noted however, that the spillway entrance was not operational during the time tagged fish were migrating.

Left Powerhouse Entrance – The left powerhouse entrance is situated where the powerhouse and spillway meet (Figure 5). At this site, two separate ladder entrances were available for migrating fish to enter. At each location, bared coax antennas were deployed inside, and dipole antennas were deployed outside of the entrance (zones 611, 612, 613 and 614). In addition, two bared coax antennas approximately 15 m upstream in the channel were deployed in order to determine whether or not there was any delay once the fish entered the ladder (zone 615).

Right Powerhouse Entrance -- The right powerhouse entrance is located at the downstream end of the collection channel, and consists of a single entry. At this location, a total of three underwater antennas were deployed. Consistent with other ladder entrances, antennas both outside and inside of the ladder entrance (zones 651 and 652) were deployed. A third antenna was located approximately 25 m upstream of the entrance at the location where the collection channel begins (zone 653). Fish that entered the right powerhouse entrance must travel through the entire collection channel before entering the trifurcation pool, and then through the transport channel that leads to the fish ladder (Figure 5).

Collection Channel Entrances – The collection channel extends the length of the powerhouse from the right powerhouse entrance to the trifurcation pool. Along the entire course of this channel, a series of 22 orifices (O.G. gates) provide access to the collection channel by migrating adults. Of the 22 orifices, all but six were closed. Antennas both inside and outside of the three open orifices (O.G. gates 1-3) at the upstream end of the powerhouse were deployed. These were assigned zone numbers 631 through 636. These antennas allowed us to detect fish as they approached and entered each orifice, as well as partition migration time through the collection channel. The three open orifices at the downstream end of the transportation channel were also monitored (O.G. gates 14, 16 and 20). These were assigned zone numbers 641 through 646.

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Trifurcation Pool – The trifurcation pool is located at the north end of the powerhouse, and is the structure where the spillway entrance, the left powerhouse entrance, and the collection channel meet (Figure 5). To assess potential migrational delay at this location, a series of underwater antennas were deployed. At the upstream end of each route that enters the trifurcation pool (i.e., spillway, left entrance and collection channel) antennas to assess migration rates through those routes, and to determine when tagged fish entered the trifurcation pool (zones 621-623) were installed. An underwater antenna was deployed upstream of the trifurcation pool within the transport channel, which leads to the ladder weirs (zones 624). A fifth antenna was installed within the transport channel upstream of a series of diffuser gates (approximately 20 m upstream of the trifurcation pool; zone 625).

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, a total of four antennas were deployed. The first antenna was located approximately halfway between the trifurcation pool and the end of the powerhouse (zone 654). The second antenna was located further upstream, approximately 2/3 the distance from the trifurcation pool to the fish ladder (zone 655). 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 656). 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 50 m upstream of the third antenna). This antenna provided additional information on fish as they began to ascend the fish ladder (zone 657).

Ladder Exit - At the exit of the fish ladder, antennas were deployed 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 661). The second and third antennas within this area were installed approximately halfway between the diffuser and the ladder exit in two adjacent weirs (zones 662 and 663), the fourth antenna within the last weir of the ladder (zone 664), and the fifth antenna outside of the ladder exit (zone 665). Collectively, these antennas provided us with information regarding the effects of the diffuser, as well as migration rate through the ladder system.

Turtle Rock/Wenatchee Yacht Club – These sites were located approximately 1 km above Rocky Reach Dam, and were designed to collect baseline data regarding migration rate from the dam to a site immediately upstream of the dam. On the southern end of Turtle Rock Island, two 6-element Yagi antennas were deployed, with one antenna aimed southeast to monitor the channel on the east side of the island, and the other antenna aimed to the west to monitor the main channel. The antennas were combined together, and designated as zone 681.

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On the west shore of the river, a single 6-element antenna located at the Wenatchee Yacht Club was deployed. This antenna was aimed toward the Turtle Rock site, and in combination with the Turtle Rock system, created a telemetry transect across the main channel of the river (zone 691).

Entiat River

On the Entiat River, a single telemetry site was installed at R.K. 4.8, which consisted of two 4-element aerial Yagi antennas (Figure 5). Antennas were aimed both upstream and downstream at 40 degree angles to the shoreline (zones 721 and 722), and were monitored individually as with other tributary sites to provide direction of travel and position relative to the telemetry system.

Wells Dam

Wells Tailrace – An antenna tower with two 3-element Yagis were deployed on each of the left (zone 801) and right-banks (zone 811) 100 m below Wells Dam (Figure 6). Antennas were pointed across and downstream, and each site was monitored with a single SRX.

Wells Hatchery Holding Pond – coax antennas were deployed into the sorting and holding sections of the adult steelhead brood pond (zone 791). This site used a single SRX.

Wells Hatchery Channel – coax antennas were deployed into two separate sections of the hatchery entrance channel (zone 821) to identify radio-tagged fish holding in this area. This site used a single SRX.

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 gate (zone 831 for left and zone 851 for right-bank fishway; Figure 6). The side gate entrances were closed for the duration of the study (RSE and LSE). 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 833 at left and zone 853 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 834 at left and zone 854 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 (zone 835 at left and zone 855 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 841 at left- and zone 861 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 842 at left- and 862 at right-bank fishway) in the pools adjacent to the exit (Figure 6). Both antennas were monitored using a single SRX/DSP.

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Columbia River at Wolf Rock

This aerial array was deployed on the right-bank of the river approximately 3 km downstream of the Methow River. Three 3-element antennas were mounted to a tree and monitored using a single SRX (zone 947).

Methow River - lower

This aerial array was deployed on the right-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 downstream and upstream (zone 871/872). The antennas were approximately 17 m off the surface of the water and monitored using a single SRX. This array had AC power.

Methow River - upper

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 downstream and upstream (zone 881/882). The antennas were approximately 7 m off the surface of the water and used a single SRX. This array had AC power.

Okanogan River - Monse

This aerial array was deployed on the left-bank of the river approximately 10 km upstream of the confluence with the Columbia (Figure 6). Twin 4-element Yagi antennas were mounted on a pole and pointed downstream and upstream (zone 891/892). The antennas were approximately 7 m off the surface of the water and used a single SRX. This array had AC power.

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APPENDIX REPORT A2 – DESCRIPTION OF EVENTS AFFECTING FISHWAY OPERATIONS AT MID-COLUMBIA DAMS IN 2001.

Priest Rapids Dam

-On 6 September, one of the oriface gates located at the base of the deneil trap wier became stuck in the closed position. Therefore, after trapping ended that day, only 1 oriface was available for upstream passage for approximately 24 hours.

-On 16 November, the sluice was closed for the winter.

-On 3 December, the left fishway was dewatered for maintenance.

-On 28 January, the right ladder was dewatered for maintenance.

Wanapum Dam

-On 12 October, the sluice was closed for the winter.

-On 3 December, the left fishway was dewatered for seasonal maintenance (approximately 4 weeks).

-On 24 January, the right fishway was dewatered for seasonal maintenance (approximately 4 weeks).

Rocky Reach Dam

-On 26 September, the AWS pumps to the fishway were shutdown for 11 hours for demobilization of the juvenile by-pass system. The fishway still had gravity flow.

Wells Dam

-On May 24, the right fishway was dewatered for maintenance between 0927-1005 hours, and the left fishway from 0837–0940.

-On 6 June, the right fishway was dewatered for maintenance between 1153-1246 hours, and the left fishway from 1101–1227.

-On 27 June, the right fishway was dewatered for maintenance between 1000-1030 hours, and the left fishway from 0900–0935.

-On 19 July, the right fishway was dewatered for maintenance between 1031-1100 hours, and the left fishway from 0924–0958.

-On 9 August, the right fishway was dewatered for maintenance between 1044-1217 hours, and the left fishway from 0833–1005.

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-On 29 August – Excerpt from email from Rick Klinge - The diffusion grate in the attraction chamber of the west ladder (right bank) has been partially plugged with aquatic weeds. Sensors on both sides of the diffusion grate show the head in the supply chamber and the attraction chamber. As the difference between these two points reached 2 feet, we contacted Bryan Nordlund, Bob Dach and left a message with Rod Woodin. The recommendation from NMFS was to do what-ever is necessary to maintain the integrity of the diffusion grates. On August 21 at 1136h, the attraction flow was reduced from 1.5 feet to 1.0 foot to reduce force against the grate. At 1400h, the entrance gate on the west ladder was pinched back from 8.0 feet to 6.0 feet. We continued to monitor the head in the supply chamber and attraction chamber through the week. On August 27, the differential again exceeded 2.0 feet. At this point, we reduced the entrance gate from 6.0 feet to 4.0 feet at 1400h. This seems to be helping as the differential now between the two points is at 1.3 feet. We are hoping to deploy a camera into the supply chamber in the next two days to determine our options. At this point, based upon video records, there does not seem to be an interruption in fish passage in the west ladder. We will watch this over the next few days.

-On 23 August, the right fishway was dewatered for maintenance between 0850-0924 hours, and the left fishway from 0943–1016.

-On 6 September, the right fishway was dewatered for maintenance between 1010-1035 hours, and the left fishway from 0911–1052.

-On 20 September, the right fishway was dewatered for maintenance between 1200-1230 hours, and the left fishway from 0837–0922.

-On 4 October, the right fishway was dewatered for maintenance between 0959-1021 hours, and the left fishway from 0831–0931.

-On 18 October, the right fishway was dewatered for maintenance between 0948-1010 hours, and the left fishway from 0856–0924.

-On 1 November, the right fishway was dewatered for maintenance between 1051-1117 hours, and the left fishway from 0937–1031.

-On 27 November, the right fishway was dewatered for maintenance. Rewatered later that day.

-On 10 December, the right fishway was dewatered for seasonal maintenance. Fishway was re-watered 28 January, 2002.

Table A1. Definition of fixed-station tracking zones for Priest Rapids and Wanapum dams, and zones along the Columbia River, Snake River, Yakima River, and Crab Creek.

River	Zone No.	Name	Antenna ID	Receiver	Antenna No.
Snake River					
	11	Ice Harbour Dam - Tailrace	2	1	1
Yakima River					
	31	Yakima River - Mouth	18,19	3	2
Columbia River					
Below Priest Rapids Tailrace					
	51	Coyote Rapids (22 km below Priest Rapids Dam).	34	5	1
Priest Rapids Dam					
	71	PR Left Tailrace - Downstream	50	7	1
	72	PR Left Tailrace - Upstream	51	7	1
	81	PR Right Tailrace - Downstream	81	8	1
	82	PR Right Tailrace - Upstream	82	8	1
	101	PR Left Collection Entrance Outside	90	10	1
	102	PR Left Collection Entrance Inside	91	10	1
	103	PR Midway Outside	92	10	1
	104	PR Midway Inside	93	10	1
	121	PR Upper Collection Channel Outside	74	12	1
	122	PR Upper Collection Channnel Inside	75	12	1
	123	PR Left Entrance Outside	76	12	1
	124	PR Left Entrance Inside	77	12	1
	125	PR Left First Wall	78	12	1
	126	PR Left Below Counting Station	79	12	1
	141	PR Left Above Diffusion Grate/Below Trap	106	14	1
	142	PR Left Exit	107	14	1
	161	PR Right Entrance Outside	122	16	1
	162	PR Right Enttrance Inside	123	16	1
	163	PR Right First Wall	124	16	1
	164	PR Right Below Counting Station	125	16	1
	181	PR Right Below Diffusion Grates	138	18	1
	182	PR Right Exit	139	18	1
	191	PR Pwr (U1-2) Forebay Dipole	146	19	1
	192	PR Pwr (U3-4) Forebay Dipole	147	19	1
	193	PR Pwr (U5-6) Forebay Dipole	148	19	1
	194	PR Pwr (U9-10) Forebay Dipole	149	19	1
	195	PR Pwr (U7-8) Forebay Dipole	150	19	1
	196	PR Sluice Dipole	151	19	1
	197	PR Sluice Coax	152	19	1
	201	PR Spillway Forebay Coax (G1-3)	154	20	1
	202	PR Spillway Forebay Coax (G4-6)	155	20	1
	203	PR Spillway Forebay Coax (G7-9)	156	20	1
	204	PR Spillway Forebay Coax (G10-12)	157	20	1
	205	PR Spillway Forebay Coax (G13-15)	158	20	1

Table A1. Definition of fixed-station tracking zones for Priest Rapids and Wanapum dams, and zones along the Columbia River, Snake River, Yakima River, and Crab Creek.

River	Zone No.	Name	Antenna ID	Receiver	Antenna No.
Columbia River					
Below Priest Rapids Tailrace - Cont'd					
	206	PR Spillway Forebay Coax (G16-18)	159	20	1
	207	PR Spillway Forebay Coax (G19-21)	160	20	1
Crab Creek					
	221	Crab Creek - Downstream	170	22	1
	222	Crab Creek - Upstream	171	22	1
Wanapum Dam					
	231	WA Left Tailrace	178,179	23	2
	241	WA Right Tailrace	186,187	24	2
	261	WA Left Collection Entrance Outside	218	26	1
	262	WA Left Collection Entrance Inside	219	26	1
	263	WA Lower Collection Channel Outside	220	26	1
	264	WA Midway Inside	221	26	1
	265	WA Midway Outside	222	26	1
	281	WA Upper Collection Channel Outside	202	28	1
	282	WA Upper Collection Channel Inside	203	28	1
	283	WA Left Entrance Inside	204	28	1
	284	WA Left Entrance Outside	205	28	1
	285	WA Left Lower Fishway	206	28	1
	301	Left Last Above Diffusion Grates	234	30	1
	302	Left at Viewing Window	235	30	1
	303	WA Left Above Midway Diffusion Grate	236	30	1
	304	WA Left Below Counting Station	237	30	1
	305	WA Left Exit	238	30	1
	321	WA Right Entrance Outside	250	32	1
	322	WA Right Entrance Inside	251	32	1
	323	WA Right First Wall	252	32	1
	324	WA Right Above Diffusion Grates	253	32	1
	341	WA Midway Diffusion Grate	266	34	1
	342	WA Right below Count Station	267	34	1
	343	WA Right Exit	343	34	1
	351	WA Pwr (U1-2) Forebay Dipole	274	35	1
	352	WA Pwr (U3-4) Forebay Dipole	275	35	1
	353	WA Pwr (U5-6) Forebay Dipole	276	35	1
	354	WA Pwr (U7-8) Forebay Dipole	277	35	1
	355	WA Pwr (U9-10) Forebay Dipole	278	35	1
	361	WA Spillway Forebay Dipole (G1-2)	282	36	1
	362	WA Spillway Forebay Dipole (G3-4)	283	36	1
	363	WA Spillway Forebay Dipole (G5-6)	284	36	1
	364	WA Spillway Forebay Dipole (G7-8)	285	36	1
	365	WA Spillway Forebay Dipole (G11-12)	286	36	1
	366	WA Spillway Forebay Dipole (G9-10)	287	36	1
	367	WA Sluice Dipole	288	36	1

Table A2. Details of fixed-station monitoring effort (in hours) for each week for all sites monitored in 2001 between Snake River and Wanapum Dam forebay.

					Receiver Numbers at Priest Rapids Dam										Receiver Numbers at Wanapum Dam								
Receiver No.		R1	R3	R5	R7	R8	R10	R12	R14	R16	R18	R19	R20	R22	R23	R24	R26	R28	R30	R32	R34	R35	R36
No. of Antenna		1	1	2	2	2	4	6	2	4	2	7	7	2	2	2	5	5	5	4	3	5	7
General Location		Ice Har. Snake R.	Yakima River	Coyote Rapids	Left Tail.	Right Tail.	Collect Chan	Left Entr.	Left Exit	Right Entrance	Right Exit	Sluice & Left Forebay	Right Forebay	Crab Crk	Left Tail.	Right Tail.	Collect Chan	Left Entrance	Left Exit	Right Entrance	Right Exit	Left Forebay	Sluice & Right Forebay
Week	**Week Ending**	**Number of Hours in Operation**																					
28	14-Jul	0	0	0	79	37	33	35	0	15	15	168	168	0	0	0	0	0	0	0	0	20	168
29	21-Jul	0	0	0	168	168	168	168	106	167	167	167	168	0	133	133	82	81	131	80	129	0	168
30	28-Jul	0	0	0	168	168	168	168	168	168	168	136	168	36	167	166	167	166	168	167	168	134	168
31	04-Aug	0	0	105	167	168	168	168	168	168	168	0	168	168	168	168	168	168	168	168	168	168	168
32	11-Aug	103	102	168	167	168	167	168	168	167	167	0	168	167	168	167	167	167	168	167	168	167	168
33	18-Aug	168	168	168	167	168	168	168	168	168	167	129	168	32	167	167	167	166	168	167	168	167	168
34	25-Aug	167	168	166	168	168	167	167	168	168	167	168	167	0	167	168	168	168	167	167	168	167	168
35	01-Sep	167	168	168	168	168	168	168	168	168	168	168	168	135	167	167	168	168	168	167	168	167	168
36	08-Sep	168	168	167	168	168	167	167	168	168	166	168	168	167	167	167	168	168	168	167	168	167	168
37	15-Sep	168	168	168	168	168	167	168	168	168	168	168	168	167	167	167	168	168	168	168	168	167	167
38	22-Sep	168	168	167	168	168	167	168	168	168	167	168	168	168	167	168	167	167	168	165	168	167	168
39	29-Sep	168	168	168	168	168	167	168	165	168	167	168	168	167	167	168	167	167	168	167	167	167	167
40	06-Oct	168	168	168	168	168	167	168	168	168	167	168	168	167	167	167	167	167	167	167	168	166	168
41	13-Oct	143	168	168	168	168	167	168	168	168	167	122	106	167	167	168	167	167	168	166	168	167	168
42	20-Oct	168	168	168	168	168	168	168	166	168	167	108	0	168	168	168	168	167	168	166	168	166	168
43	27-Oct	145	168	168	168	168	168	168	168	168	167	168	0	167	168	168	167	167	168	168	168	166	168
44	03-Nov	168	168	168	168	168	167	168	168	168	168	168	0	167	168	168	168	168	168	168	168	168	168
45	10-Nov	168	168	168	168	168	167	168	167	168	167	168	0	168	167	167	167	167	168	167	167	167	168
46	17-Nov	168	168	54	168	168	167	168	167	168	167	168	0	58	167	166	167	166	168	167	168	167	168
47	24-Nov	167	166	0	168	168	167	168	167	168	167	168	0	0	167	165	166	167	168	167	168	167	168
48	01-Dec	168	168	105	168	168	167	168	167	168	168	168	0	0	167	167	167	166	168	167	168	167	168
49	08-Dec	168	168	133	167	168	167	167	167	168	168	168	0	0	166	167	34	56	140	167	168	167	168
50	15-Dec	168	167	0	35	36	38	34	39	37	167	167	0	0	56	61	0	0	0	60	168	167	167
51	22-Dec	168	168	0	0	0	0	0	0	0	168	168	0	0	0	0	0	0	0	0	168	167	167
52	29-Dec	168	168	0	0	0	0	0	0	0	168	168	0	0	0	0	0	0	0	0	168	168	168
Total		**3412**	**3459**	**2745**	**3638**	**3601**	**3585**	**3594**	**3495**	**3578**	**4031**	**3685**	**2289**	**2269**	**3533**	**3538**	**3295**	**3312**	**3461**	**3480**	**3991**	**3828**	**4196**

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	Collection Channel Entrance	Exit
	Zone Numbers					
Priest Rapids Dam	71, 72, 81, and 82					
Left Fishway		123 and 124	122 and 125	104	101 and 102	142
Right Fishway		161 and 162	-	-	-	182
Wanapum Dam	231 and 241					
Left Fishway		283 and 284	281 and 285	264	261 and 262	305
Right Fishway		321 and 322	-	-		343

Table A4. Daily counts of chinook, coho, sockeye, and steelhead at Priest Rapids Dam, 2001.

Date (2001)	Chinook adult	Chinook jack	Coho adult	Coho jack	Sockeye	Steelhead
01-Jul	1425	57	0	0	6289	49
02-Jul	1058	31	1	0	6071	53
03-Jul	1213	41	0	0	5089	39
04-Jul	823	67	0	0	4349	46
05-Jul	1459	53	0	0	4734	72
06-Jul	739	37	0	0	2998	44
07-Jul	817	32	0	0	2758	42
08-Jul	1094	39	0	1	2272	79
09-Jul	1448	52	0	0	2780	83
10-Jul	1233	32	0	0	1960	90
11-Jul	2124	58	0	0	2670	99
12-Jul	1208	68	0	0	1865	85
13-Jul	1779	61	0	0	2110	158
14-Jul	1262	77	0	0	1231	109
15-Jul	1284	59	0	1	1051	105
16-Jul	1248	57	0	0	808	155
17-Jul	930	72	0	0	703	144
18-Jul	474	49	0	0	446	163
19-Jul	851	65	0	0	446	182
20-Jul	1184	59	0	0	549	217
21-Jul	1426	75	0	0	404	212
22-Jul	958	86	0	0	315	261
23-Jul	691	46	0	0	272	198
24-Jul	508	56	0	0	253	291
25-Jul	917	56	0	0	148	238
26-Jul	820	52	0	0	228	210
27-Jul	683	66	1	6	161	179
28-Jul	1401	75	5	4	261	287
29-Jul	1150	77	2	6	253	209
30-Jul	476	45	0	0	182	134
31-Jul	1245	77	0	0	248	195
01-Aug	807	36	0	0	277	227
02-Aug	534	39	0	0	164	351
03-Aug	820	56	0	0	145	309
04-Aug	678	52	0	0	149	322
05-Aug	556	77	0	0	79	360
06-Aug	1088	129	0	0	115	460
07-Aug	502	79	0	0	67	612
08-Aug	560	80	0	0	61	540
09-Aug	435	78	0	0	107	366
10-Aug	492	59	0	0	100	519
11-Aug	369	60	0	0	87	403
12-Aug	508	36	0	1	110	473
13-Aug	420	57	0	1	47	576
14-Aug	637	65	7	5	32	434
15-Aug	251	50	0	0	56	396
16-Aug	176	33	0	0	45	273
17-Aug	258	81	0	0	93	308
18-Aug	412	51	2	1	62	335

Table A4. Daily counts of chinook, coho, sockeye, and steelhead at Priest Rapids Dam, 2001.

Date (2001)	Chinook adult	Chinook jack	Coho adult	Coho jack	Sockeye	Steelhead
19-Aug	102	50	2	1	26	176
20-Aug	334	86	0	0	25	201
21-Aug	252	79	0	0	17	216
22-Aug	256	65	0	0	5	283
23-Aug	177	61	1	0	14	248
24-Aug	219	61	0	0	4	322
25-Aug	120	16	0	0	17	221
26-Aug	119	41	0	1	12	250
27-Aug	114	34	0	0	7	226
28-Aug	224	54	0	0	3	240
29-Aug	121	42	0	0	1	188
30-Aug	111	48	0	0	2	209
31-Aug	322	67	0	0	4	324
01-Sep	636	108	0	1	1	327
02-Sep	352	90	0	0	1	243
03-Sep	412	64	0	0	0	300
04-Sep	316	48	16	5	1	317
05-Sep	456	110	0	5	0	455
06-Sep	218	66	0	0	18	267
07-Sep	372	133	0	0	26	348
08-Sep	419	116	8	2	12	306
09-Sep	471	121	5	1	1	334
10-Sep	556	171	0	0	1	297
11-Sep	389	87	2	0	0	379
12-Sep	324	111	6	0	1	450
13-Sep	406	91	17	2	0	511
14-Sep	653	88	30	23	2	573
15-Sep	1126	127	70	49	1	713
16-Sep	978	187	11	25	0	609
17-Sep	1206	167	30	1	0	599
18-Sep	660	133	42	6	0	516
19-Sep	511	185	63	14	0	554
20-Sep	446	166	37	16	0	403
21-Sep	386	184	59	14	0	578
22-Sep	340	251	85	26	0	472
23-Sep	588	261	109	24	0	432
24-Sep	589	257	107	13	0	358
25-Sep	899	291	221	28	0	396
26-Sep	583	210	268	42	0	251
27-Sep	448	123	214	39	0	360
28-Sep	252	114	190	29	0	262
29-Sep	97	101	191	49	0	266
30-Sep	383	199	261	29	0	260
01-Oct	247	151	162	18	0	182
02-Oct	365	159	273	29	0	234
03-Oct	222	76	237	15	0	188
04-Oct	219	76	170	37	0	169
05-Oct	175	88	232	15	0	181
06-Oct	72	34	139	20	0	107

Table A4. Daily counts of chinook, coho, sockeye, and steelhead at Priest Rapids Dam, 2001.

Date (2001)	Chinook adult	Chinook jack	Coho adult	Coho jack	Sockeye	Steelhead
07-Oct	70	33	197	11	0	110
08-Oct	71	25	72	13	0	77
09-Oct	92	23	132	17	0	97
10-Oct	96	28	102	9	0	102
11-Oct	85	18	117	12	0	55
12-Oct	72	28	143	11	0	74
13-Oct	59	23	139	13	0	83
14-Oct	64	14	165	8	0	82
15-Oct	102	23	158	7	0	77
16-Oct	123	16	131	13	0	69
17-Oct	66	17	120	5	0	50
18-Oct	118	32	217	18	0	70
19-Oct	107	15	215	15	0	69
20-Oct	112	10	226	16	0	48
21-Oct	86	3	254	14	0	43
22-Oct	82	16	217	20	0	38
23-Oct	524	87	383	61	0	71
24-Oct	210	30	309	15	0	62
25-Oct	121	18	214	10	0	50
26-Oct	122	29	249	11	0	50
27-Oct	70	9	166	9	0	35
28-Oct	67	12	158	9	0	28
29-Oct	54	6	167	5	0	18
30-Oct	82	12	201	0	0	26
31-Oct	156	12	435	17	0	32
01-Nov	121	11	492	26	0	28
02-Nov	74	8	390	6	0	16
03-Nov	42	21	272	16	0	17
04-Nov	28	3	161	8	0	21
05-Nov	36	7	89	10	0	7
06-Nov	28	5	92	7	0	13
07-Nov	22	-1	71	6	0	12
08-Nov	24	3	97	2	0	15
09-Nov	8	2	65	1	0	21
10-Nov	8	0	73	4	0	12
11-Nov	11	2	62	5	0	7
12-Nov	13	0	41	1	0	9
13-Nov	11	1	23	2	0	8
14-Nov	5	1	25	0	0	9
15-Nov	6	2	19	1	0	7
Totals	**65922**	**9147**	**10135**	**1039**	**55902**	**29711**
Totals by fishway						
East	23479	4312	4146	373	22248	14969
West	42443	4835	5989	666	33654	14742

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					
	501	RI Tailrace -- West Shore - Upstream	394,395	50	2
	511	RI Left Ladder Entrance	402	51	1
	512	RI Left Ladder Entrance - Inside Entrance	403, 404	51	2
	521	RI Left Ladder Exit - First Corner	410	52	1
	522	RI Left Ladder Exit - Second Corner	411	52	1
	523	RI Left Ladder Exit - Last Pool	412	52	1
	524	RI Left Ladder Exit - Exit	413	52	1
	531	RI Center Ladder Entrance - Downstream Entrance	418	53	1
	532	RI Center Ladder Entrance - Inside Downstream Entrance	419	53	1
	534	RI Center Ladder Entrance - Inside Side Entrance	421, 422	53	2
	541	RI Center Ladder Exit - Diffusion Pool	426, 427	54	2
	543	RI Center Ladder Exit - Below Fish Viewing Pool	428, 429	54	2
	545	RI Center Ladder Exit - Exit	430	55	1
	551	RI Powerhouse II - East Entrance	434	55	1
	552	RI Powerhouse II - Inside East Entrance	435	55	1
	553	RI Powerhouse II - Upstream Transport Channel	436	55	1
	554	RI Powerhouse II - Middle Fishway Entrance	437	55	1
	555	RI Powerhouse II - Inside Middle Fishway Entrance	438	55	1
	561	RI Right Ladder Entrance - Downstream Entrance	442	56	1
	562	RI Right Ladder Entrance - Inside Downstream Entrance	443	56	1
	563	RI Right Ladder Entrance - Side Entrance	444	56	1
	564	RI Right Ladder Entrance - Inside Side Entrance	445	56	1
	565	RI Right Ladder Entrance - South Corner	446	56	1
	571	RI Quadfurication Area -- Upstream of West Entrance	450	57	1
	572	RI Quadfurication Area -- Begining o fFish Ladder	451	57	1
	581	RI Right Ladder Exit -- First Pool Down of Road	458	58	1
	582	RI Right Ladder Exit -- Fish Viewing Pool	459, 460	58	2
	584	RI Right Ladder Exit -- Exit	461	58	1
Columbia River					
Rocky Reach Dam					
	591	RR Tailrace -- West Shore - Upstream	466, 467	59	2
	611	RR Left Entrance - Outside West Entrance	482, 483	61	2
	613	RR Left Entrance - Inside West Entrance	484, 485	61	2
	615	RR Left Entrance - Midway to Trifurication Pool	486	61	1
	621	RR Trifurication - Spillway Channel	490	62	1
	622	RR Trifurication - Left Ladder	491	62	1
	623	RR Trifurication - Collection Channel	492	62	1
	624	RR Trifurication - Above Trifurication Pool	493	62	1
	625	RR Trifurication - Above Diffusers	494	62	1
	631	RR Collection Channel - Gate 1 Outside	498	63	1
	632	RR Collection Channel - Gate 1 Inside	499	63	1
	633	RR Collection Channel - Gate 2 Outside	500	63	1
	634	RR Collection Channel - Gate 2 Inside	501	63	1
	635	RR Collection Channel - Gate 3 Outside	502	63	1
	636	RR Collection Channel - Gate 3 Inside	503	63	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					
	641	RR Collection Channel - Gate 14 Outside	506	64	1
	642	RR Collection Channel - Gate 14 Inside	507	64	1
	643	RR Collection Channel - Gate 16 Outside	508	64	1
	644	RR Collection Channel - Gate 16 Inside	509	64	1
	645	RR Collection Channel - Gate 20 Outside	510	64	1
	646	RR Collection Channel - Gate 20 Inside	511	64	1
	651	RR Right Entrance	514	65	1
	652	RR Inside Right Entrance	515	65	1
	653	RR Beginning of Collection Channel	516	65	1
	654	RR Transport Channel - Spiral Staircase	517	65	1
	655	RR Tranport Channel - First Catwalk	518	65	1
	656	RR Fish Ladder - Second Catwalk	519	65	1
	657	RR Fish Ladder - Around Corner	520	65	1
	661	RR Fish Ladder Exit - Diffusion Pool	522	66	1
	662	RR Fish Ladder Exit - Second to Last Pool	523	66	1
	663	RR Fish Ladder Exit - Fish Viewing Pool - Below	524, 525	66	2
	665	RR Fish Ladder Exit - Exit	526	66	1
	671	RR Powerhouse and Spillway Primary - Unit 1	530	67	1
	672	RR Powerhouse and Spillway Primary - Unit 2 and 3	531	67	1
	673	RR Powerhouse and Spillway Primary - Unit 4 and 5	532	67	1
	674	RR Powerhouse and Spillway Primary - Unit 6 and 7	533	67	1
	675	RR Powerhouse and Spillway Primary - Unit 8 and 9	534	67	1
	676	RR Powerhouse and Spillway Primary - Unit 10 and 11	535	67	1
	677	RR Powerhouse and Spillway Primary - Spillway	536	67	1
Columbia River					
	681	Columbia River - South End of Turtle Rock	538, 539	68	2
	691	Columbia River - Yacht Club - West Shore	546, 547	69	2
Wentachee River					
	701	WEN Wenatchee River -- County Park - Downstream	554	70	1
	702	WEN Wetatchee River - County Park - Upstream	555	70	1
	711	WEN Wenatchee River -- Tumwater Dam - Downstream	562	71	1
	712	WEN Wenatchee River -- Tumwater Dam - Upstream	563	71	1
Entiat River					
	721	EN Entiat River -- South Shore - Downstream	570	72	1
	722	EN Entiat River -- South Shore - Upstream	571	72	1

Table B2. Details of fixed-station monitoring effort (in hours) for each week for all sites monitored in 2001 between the Rock Island tailrace and the Entiat River.

		Receiver Numbers at Rock Island Dam									Receiver Numbers at Rocky Reach Dam											
Receiver No.		R50	R51	R52	R53	R54	R55	R56	R57	R58	R59	R61	R62	R63	R64	R65	R66	R68	R69	R70	R71	R72
No. of Antennas		2	2	4	3	3	5	5	2	3	2	5	5	6	6	7	5	2	2	2	2	2
General Location		Tail.	Left Entr.	Left Exit	Center Entr.	Center Exit	Right Entr. Up	Right Entr. Down	Quad Area	Right Exit	Tail.	Left Ent.	Trifur Pool	Collect Chan	Collect Chan	West Entr. & Trans Char	Fishway Exit	Turtle Rock	Yacht Club	Wenatchee River County Park	Wenatchee River Tum Tail	Entiat River
Week	**Week Ending**	**Number of Hours in Operation**																				
28	14-Jul	167	0	167	0	167	0	0	0	167	167	168	88	0	0	166	168	0	0	167	0	167
29	21-Jul	168	63	167	62	167	60	60	60	167	167	168	167	37	0	166	167	35	33	167	55	168
30	28-Jul	168	168	168	168	168	167	167	167	166	167	168	167	167	7	168	167	168	168	167	167	168
31	04-Aug	167	166	166	166	166	167	167	167	167	167	167	168	168	130	168	166	168	168	167	167	168
32	11-Aug	167	168	167	166	167	167	167	167	168	168	168	168	168	168	139	167	168	168	167	166	167
33	18-Aug	168	168	167	167	166	167	168	168	167	168	168	168	168	168	134	167	168	168	167	167	166
34	25-Aug	167	167	167	167	167	167	167	167	167	168	168	168	168	168	168	167	167	168	168	167	167
35	01-Sep	167	167	167	168	167	167	167	167	167	168	168	168	168	83	168	167	168	168	168	167	167
36	08-Sep	167	167	167	166	167	167	167	167	168	168	168	168	168	80	168	168	168	168	168	167	167
37	15-Sep	168	167	168	167	167	167	166	168	168	168	168	168	168	168	168	168	168	168	168	167	167
38	22-Sep	167	167	167	147	166	168	168	168	167	168	168	168	168	168	168	167	168	168	168	108	167
39	29-Sep	168	168	167	168	167	167	168	168	168	168	168	168	168	167	168	167	168	168	168	61	168
40	06-Oct	168	167	167	168	167	167	167	166	168	168	168	168	168	168	168	167	168	168	168	167	168
41	13-Oct	168	167	167	168	168	167	166	167	167	168	167	167	167	167	167	168	168	168	168	167	168
42	20-Oct	168	167	167	168	168	167	167	166	167	168	168	168	168	168	168	167	168	168	168	167	168
43	27-Oct	168	167	167	168	167	167	168	167	168	168	167	167	167	167	167	167	168	168	168	168	167
44	03-Nov	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168
45	10-Nov	167	168	168	129	167	165	167	166	167	168	166	165	166	165	166	166	97	168	168	167	168
46	17-Nov	168	167	168	168	167	167	167	167	167	168	167	167	167	167	167	167	167	168	168	168	167
47	24-Nov	168	168	168	162	168	168	168	167	167	168	167	167	167	167	167	167	168	168	168	167	168
48	01-Dec	167	167	168	168	167	167	167	167	166	167	167	167	167	167	168	166	27	106	168	167	168
49	08-Dec	168	167	167	168	167	167	167	167	167	167	167	167	167	167	168	167	0	0	168	168	167
50	15-Dec	168	34	168	35	168	35	35	35	168	167	83	83	83	83	84	167	0	0	168	168	166
51	22-Dec	168	0	168	0	168	0	0	0	150	168	0	0	0	0	0	168	0	0	168	168	168
52	29-Dec	168	0	168	0	168	0	0	0	168	168	0	0	0	0	0	168	0	0	168	168	168
Total		**4191**	**3443**	**####**	**3382**	**4180**	**3436**	**3439**	**3437**	**4165**	**4193**	**####**	**3688**	**3471**	**3061**	**3707**	**4179**	**3013**	**3163**	**4194**	**3737**	**4186**

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		Junction Pool	Video Pool	Exit
		Outside	Inside			
	Zone Numbers					
Rock Island Dam	501					
Left Fishway		511	512		523	524
Centre Fishway						
Main Entrance		531	532		543	545
Side Entrance			534			
Right Fishway				553, 571, 572	582	584
East Entrance		551	552			
Middle Entrance		554	555			
Side Entrance		563	564			
West Entrance		561	562			
Rocky Reach Dam	591					
Fishway				621, 622, 623, 624, and 625	663	665
Trifurcation Entrance		611	613			
Upstream Powerhouse		651	652			
OG 1		631	632			
OG 2		633	634			
OG 3		635	636			
Downstream Powerhouse						
OG 14		641	642			
OG 16		643	644			
OG 20		645	646			
DOE		651	652			

Table B4. Daily counts of chinook, coho, sockeye, and steelhead at Rock Island and Rocky Reach dams, 2001.

Date (2001)	Rock Island Dam							Rocky Reach Dam						
	Chinook				Steelhead			Chinook				Steelhead		
	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total
01-Jul	1246	501	1	9456	14	19	33	783	167	0	4374	12	5	17
02-Jul	861	154	1	6625	9	11	20	776	162	5	4901	13	7	20
03-Jul	1240	454	5	7089	15	32	47	584	124	0	4820	8	9	17
04-Jul	1371	103	4	7025	12	25	37	731	64	0	4640	15	14	29
05-Jul	1201	304	5	7041	14	23	37	683	49	0	3620	14	9	23
06-Jul	1039	232	0	5962	20	23	43	693	56	0	3423	5	12	17
07-Jul	1461	206	0	5768	32	32	64	958	76	0	5138	19	10	29
08-Jul	894	210	0	4623	39	29	68	812	64	0	3126	25	13	38
09-Jul	830	270	0	3690	22	26	48	685	74	0	2474	22	16	38
10-Jul	1129	255	0	3679	26	23	49	620	83	0	2529	27	16	43
11-Jul	1057	454	0	2199	27	19	46	742	66	0	1652	18	8	26
12-Jul	1224	367	0	3246	25	25	50	901	77	0	1662	19	14	33
13-Jul	1460	441	0	2844	33	49	82	871	103	0	1627	19	10	29
14-Jul	1520	193	0	2260	41	53	94	1331	165	0	1974	30	30	60
15-Jul	1416	604	0	1689	47	42	89	1290	186	0	1508	43	29	72
16-Jul	923	314	0	1154	50	65	115	1284	140	0	1081	34	25	59
17-Jul	1155	289	0	1611	59	71	130	871	132	0	853	33	22	55
18-Jul	1103	316	0	855	55	84	139	1096	202	1	1163	48	45	93
19-Jul	1090	282	0	617	41	55	96	999	93	0	633	54	38	92
20-Jul	564	142	0	589	42	44	86	751	75	0	424	22	32	54
21-Jul	710	125	0	526	26	54	80	623	98	0	454	40	25	65
22-Jul	1209	296	0	614	59	81	140	521	64	1	404	38	25	63
23-Jul	825	223	0	378	61	80	141	1239	106	0	413	46	41	87
24-Jul	846	300	0	432	74	87	161	545	94	2	314	36	32	68
25-Jul	718	173	0	297	76	105	181	852	137	0	286	51	74	125
26-Jul	476	173	0	274	75	91	166	787	107	0	296	47	43	90
27-Jul	685	204	0	221	82	90	172	330	78	0	172	48	42	90
28-Jul	442	165	0	177	55	108	163	777	98	0	172	50	59	109
29-Jul	848	211	0	205	69	104	173	448	90	0	142	42	55	97
30-Jul	1156	466	0	247	101	104	205	672	79	0	144	43	52	95
31-Jul	881	174	0	186	47	102	149	1456	101	0	136	69	59	128

Table B4. Daily counts of chinook, coho, sockeye, and steelhead at Rock Island and Rocky Reach dams, 2001.

Date (2001)	Rock Island Dam							Rocky Reach Dam						
	Chinook				Steelhead			Chinook				Steelhead		
	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total
01-Aug	842	269	0	170	55	125	180	788	119	0	120	61	70	131
02-Aug	781	239	0	173	53	113	166	778	168	0	120	47	58	105
03-Aug	1014	337	0	148	82	134	216	579	112	0	91	43	47	90
04-Aug	508	215	0	96	73	143	216	1052	192	0	96	32	49	81
05-Aug	807	154	0	109	85	118	203	502	98	0	98	73	80	153
06-Aug	480	160	0	84	90	144	234	569	108	0	63	79	74	153
07-Aug	481	171	0	63	167	219	386	636	99	0	75	94	83	177
08-Aug	824	283	0	89	171	201	372	497	129	2	40	134	127	261
09-Aug	353	142	0	70	123	173	296	847	158	0	41	117	101	218
10-Aug	374	174	0	64	149	168	317	301	84	0	35	91	83	174
11-Aug	475	229	0	42	129	238	367	444	94	1	44	84	74	158
12-Aug	558	219	0	47	121	179	300	182	99	0	44	85	109	194
13-Aug	371	182	0	28	136	253	389	571	115	0	25	119	103	222
14-Aug	457	171	0	29	192	353	545	407	138	1	26	138	149	287
15-Aug	329	216	0	38	143	253	396	642	103	0	36	193	222	415
16-Aug	440	218	0	18	185	340	525	490	114	0	33	179	202	381
17-Aug	347	173	0	9	89	268	357	275	57	0	9	168	188	356
18-Aug	189	151	0	21	159	236	395	478	85	0	13	137	179	316
19-Aug	393	179	0	20	204	257	461	264	60	0	12	88	97	185
20-Aug	233	143	0	6	118	194	312	177	33	0	4	74	67	141
21-Aug	124	109	0	6	108	125	233	667	98	0	15	235	252	487
22-Aug	204	149	0	9	103	187	290	106	60	1	8	78	73	151
23-Aug	135	142	0	10	129	170	299	145	78	3	6	102	92	194
24-Aug	158	116	0	3	90	97	187	166	90	0	6	69	62	131
25-Aug	126	89	0	0	84	151	235	160	87	2	8	79	66	145
26-Aug	138	124	0	4	65	146	211	188	73	0	3	110	142	252
27-Aug	107	98	1	10	118	111	229	303	55	0	2	230	219	449
28-Aug	100	105	0	5	132	175	307	67	43	0	7	79	72	151
29-Aug	102	61	0	7	122	194	316	134	47	0	3	124	101	225
30-Aug	133	72	0	23	65	123	188	140	65	0	4	157	121	278
31-Aug	161	54	0	10	116	136	252	106	54	1	4	91	91	182

Table B4. Daily counts of chinook, coho, sockeye, and steelhead at Rock Island and Rocky Reach dams, 2001.

Date (2001)	Rock Island Dam							Rocky Reach Dam						
	Chinook				Steelhead			Chinook				Steelhead		
	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total
01-Sep	131	57	1	12	113	150	263	152	58	1	0	79	94	173
02-Sep	118	34	0	5	76	96	172	213	37	1	0	116	116	232
03-Sep	140	74	2	0	71	96	167	66	44	1	5	81	76	157
04-Sep	246	97	5	1	140	182	322	119	66	0	1	124	110	234
05-Sep	186	105	3	4	196	221	417	138	65	0	3	99	95	194
06-Sep	110	55	4	1	126	152	278	117	69	0	4	111	98	209
07-Sep	152	75	5	0	112	131	243	137	51	0	2	83	130	213
08-Sep	147	46	1	2	88	123	211	140	55	0	0	116	105	221
09-Sep	155	69	3	3	89	136	225	121	36	1	5	77	76	153
10-Sep	146	69	2	0	166	181	347	164	37	1	4	171	158	329
11-Sep	141	57	6	1	223	188	411	69	46	1	4	146	160	306
12-Sep	122	62	13	2	236	289	525	69	61	0	1	257	202	459
13-Sep	118	86	16	1	181	170	351	139	91	1	0	237	211	448
14-Sep	140	46	18	2	155	137	292	76	50	0	1	152	116	268
15-Sep	140	61	10	0	125	157	282	85	50	2	2	146	117	263
16-Sep	161	99	3	1	145	205	350	155	72	0	1	127	94	221
17-Sep	337	102	7	0	223	203	426	246	77	0	0	186	176	362
18-Sep	501	123	3	2	416	216	632	273	76	2	0	211	184	395
19-Sep	349	137	27	2	298	558	856	393	122	7	1	245	196	441
20-Sep	302	108	6	1	332	388	720	230	112	3	0	309	294	603
21-Sep	205	106	20	0	252	254	506	229	73	2	0	251	232	483
22-Sep	170	126	13	0	222	330	552	91	64	8	0	208	147	355
23-Sep	218	90	11	0	176	374	550	131	89	6	0	144	167	311
24-Sep	172	146	13	0	162	353	515	213	114	9	1	379	272	651
25-Sep	198	73	74	1	261	279	540	95	100	6	0	223	214	437
26-Sep	218	136	121	0	197	279	476	113	84	4	0	230	215	445
27-Sep	219	119	94	0	224	239	463	146	95	6	0	194	212	406
28-Sep	288	157	55	0	148	266	414	135	90	12	0	200	195	395
29-Sep	195	130	132	0	143	142	285	119	83	16	0	120	115	235
30-Sep	203	149	140	0	140	198	338	139	71	9	0	134	94	228
01-Oct	123	80	198	0	183	147	330	126	77	14	2	150	117	267

Table B4. Daily counts of chinook, coho, sockeye, and steelhead at Rock Island and Rocky Reach dams, 2001.

Date (2001)	Rock Island Dam							Rocky Reach Dam						
	Chinook				Steelhead			Chinook				Steelhead		
	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total
02-Oct	124	105	160	0	198	139	337	92	79	18	0	130	110	240
03-Oct	115	83	200	1	143	111	254	85	73	5	0	123	112	235
04-Oct	151	76	243	0	118	91	209	80	57	4	0	148	112	260
05-Oct	150	68	174	0	156	112	268	85	37	6	0	64	71	135
06-Oct	159	63	105	0	46	78	124	55	35	22	0	39	64	103
07-Oct	78	48	182	0	67	105	172	35	27	19	0	56	66	122
08-Oct	103	68	131	0	70	93	163	59	40	26	0	78	75	153
09-Oct	99	51	291	0	72	77	149	48	25	28	0	84	59	143
10-Oct	79	53	346	0	50	96	146	25	27	18	0	74	76	150
11-Oct	64	32	176	0	48	43	91	59	33	31	0	60	64	124
12-Oct	62	25	180	0	35	60	95	34	24	24	0	35	33	68
13-Oct	66	45	173	0	38	36	74	30	26	26	0	44	46	90
14-Oct	62	34	229	0	39	49	88	27	34	19	0	43	44	87
15-Oct	67	42	155	0	30	45	75	26	16	22	0	48	51	99
16-Oct	67	53	220	0	40	43	83	49	24	18	0	38	37	75
17-Oct	97	27	268	0	39	51	90	33	15	47	0	39	30	69
18-Oct	98	56	238	0	34	34	68	33	22	41	0	51	27	78
19-Oct	135	43	146	0	37	35	72	38	25	33	1	18	20	38
20-Oct	119	52	137	0	24	34	58	45	23	36	0	19	26	45
21-Oct	63	41	274	0	24	24	48	56	29	43	0	30	18	48
22-Oct	130	44	232	0	18	26	44	90	42	23	0	18	13	31
23-Oct	145	69	308	0	15	11	26	100	27	43	0	20	18	38
24-Oct	157	35	517	0	27	35	62	67	16	77	0	30	24	54
25-Oct	197	67	377	0	45	24	69	35	19	48	0	25	28	53
26-Oct	156	49	326	0	26	31	57	55	25	69	0	29	29	58
27-Oct	157	65	441	0	23	32	55	67	36	44	0	32	11	43
28-Oct	199	33	352	0	19	39	58	65	28	59	0	21	10	31
29-Oct	177	83	394	0	22	22	44	92	20	75	0	15	9	24
30-Oct	134	31	231	0	15	13	28	101	15	49	0	18	17	35
31-Oct	199	40	111	0	8	16	24	63	18	54	0	13	16	29
01-Nov	188	45	130	0	7	15	22	71	8	32	0	18	12	30

Table B4. Daily counts of chinook, coho, sockeye, and steelhead at Rock Island and Rocky Reach dams, 2001.

Date (2001)	Rock Island Dam							Rocky Reach Dam						
	Chinook				Steelhead			Chinook				Steelhead		
	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total	Adult	Jack	Coho	Sockeye	Clipped	Not Clipped	Total
02-Nov	262	34	262	0	19	23	42	31	5	33	0	13	13	26
03-Nov	196	48	237	0	18	8	26	35	1	61	0	19	10	29
04-Nov	172	27	221	0	15	30	45	42	6	62	0	15	17	32
05-Nov	133	31	259	0	11	7	18	21	2	35	0	14	13	27
06-Nov	129	3	220	0	12	19	31	22	5	58	0	19	18	37
07-Nov	59	7	185	0	6	13	19	29	2	32	0	4	3	7
08-Nov	54	5	158	0	6	3	9	25	5	28	0	9	12	21
09-Nov	32	2	99	0	6	5	11	21	2	27	0	5	11	16
10-Nov	26	3	100	0	5	13	18	16	2	19	0	3	5	8
11-Nov	41	11	79	0	6	7	13	15	2	16	0	3	4	7
12-Nov	25	0	63	0	4	11	15	8	0	13	0	3	4	7
13-Nov	41	6	70	0	3	11	14	5	1	15	0	9	7	16
14-Nov	36	5	28	0	1	8	9	4	0	18	0	10	17	27
Totals	**54378**	**18427**	**10451**	**83032**	**12268**	**16098**	**28366**	**45085**	**9298**	**1609**	**55684**	**11272**	**10574**	**21846**
Totals by fishway														
East	6262	3699	1209	12196	-	-	1205							
Centre	2948	1091	1051	5030	-	-	1553							
West	45168	13637	8191	65806	-	-	25608							

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					
	791	WE Hatchery	626	79	1
	801	WE Left Tailrace	634, 635	80	2
	811	WE Right Tailrace	642, 643	81	2
	821	WE Hatchery Channel	650	82	1
	831	WE Left Entrance - Main	658	83	1
	833	WE Left Fishway - Beginning	660	83	1
	834	WE Left Fishway - Below Trap	661	83	1
	835	WE Left Fishway - Trap	662	83	1
	841	WE Left Fishway - Above Trap	666	84	1
	842	WE Left Fishway Exit	667	84	1
	851	WE Right Entrance - Main	674	85	1
	853	WE Right Fishway - Beginning	676	85	1
	854	WE Right Fishway - Below Trap	677	85	1
	855	WE Right Fishway - Trap	678	85	1
	861	WE Right Fishway - Above Trap	682	86	1
	862	WE Right Fishway Exit	683	86	1
Methow River					
	871	Methow River - Lower - Mouth Downstream	690	87	1
	872	Methow River - Lower - Mouth Upstream	691	87	1
	881	Methow River - Upper - Downstream Ant.	698	88	1
	882	Methow River - Upper - Upstream Ant.	699	88	1
Okanogan River					
Okanogan River					
	891	Okanogan River - Mouth Downstream	706	89	1
	892	Okanogan River - Mouth Upstream	707	89	1
Columbia River					
	947	Columbia River - Lion Rock	746, 747	94	2

Table C2. Details of fixed-station monitoring effort (in hours) for each week for all sites monitored in 2001 between the Wells and Okanogan River.

		Receiver Numbers at Wells Dam										
Receiver No.		R80	R81	R82	R83	R84	R85	R86	R87	R88	R89	R94
No. of Antennas		2	2	1	4	2	4	2	2	2	2	2
General Location		Left Tailrace	Right Tailrace	Hatchery Cove	Left Entrance	Left Exit	Right Entrance	Right Exit	Methow River/Down	Methow River/Up	Okanogan River/Down	Wolf's Rock
Week	**Week Ending**	**Number of Hours in Operation**										
28	14-Jul	168	168	167	167	167	168	167	167	167	167	0
29	21-Jul	166	168	167	167	167	167	167	168	168	168	0
30	28-Jul	168	168	167	167	166	168	167	166	25	167	0
31	04-Aug	168	168	168	168	168	168	168	168	168	168	0
32	11-Aug	166	167	166	166	166	166	166	166	168	166	0
33	18-Aug	168	168	168	168	167	168	167	167	168	167	0
34	25-Aug	168	168	168	168	168	168	167	167	167	167	0
35	01-Sep	168	168	167	168	168	168	167	167	168	167	0
36	08-Sep	168	167	167	168	167	168	167	168	167	168	0
37	15-Sep	168	168	167	168	168	168	167	168	167	168	0
38	22-Sep	168	168	167	168	168	168	167	168	166	167	0
39	29-Sep	168	168	166	167	168	168	167	133	168	168	0
40	06-Oct	168	167	167	168	167	168	167	60	165	167	81
41	13-Oct	168	168	167	168	167	168	168	118	167	168	167
42	20-Oct	168	167	167	167	167	167	167	168	168	168	166
43	27-Oct	168	168	167	167	167	168	167	168	167	168	168
44	03-Nov	168	168	168	168	168	168	168	168	168	167	168
45	10-Nov	167	167	167	167	167	167	167	168	166	168	168
46	17-Nov	168	167	167	167	167	167	167	168	168	168	168
47	24-Nov	168	166	167	167	167	168	167	168	168	168	168
48	01-Dec	168	168	166	167	167	167	167	168	168	167	168
49	08-Dec	105	168	83	105	167	104	167	168	168	167	168
50	15-Dec	0	167	0	0	87	0	168	168	168	168	168
51	22-Dec	0	167	0	0	0	0	167	168	168	168	167
52	29-Dec	0	168	0	0	0	0	168	168	168	168	168
Total	**929250**	**3628**	**4190**	**3591**	**3621**	**3766**	**3625**	**4179**	**3999**	**4044**	**4188**	**2093**

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	801 and 811			
Left Fishway			834	842
Main Entrance		831		
Right Fishway			854	862
Main Entrance		851		

Table C4. Daily counts of chinook, sockeye, and steelhead at Wells Dam in 2001.

Date (2001)	Chinook		Sockeye	Steelhead		
	Adult	Jack		Hatchery	Wild	Total
01-Jul	520	37	2039	8	5	13
02-Jul	952	77	3818	9	4	13
03-Jul	465	56	3928	6	5	11
04-Jul	681	75	4721	10	6	16
05-Jul	978	72	6601	12	10	22
06-Jul	474	41	3957	8	3	11
07-Jul	507	40	5227	10	7	17
08-Jul	646	61	3785	8	4	12
09-Jul	338	34	4663	2	4	6
10-Jul	446	40	3629	8	7	15
11-Jul	334	29	2123	7		7
12-Jul	392	37	2525	15	12	27
13-Jul	539	56	2460	14	6	20
14-Jul	930	81	1868	12	6	18
15-Jul	979	104	1810	13	3	16
16-Jul	690	66	2238	16	7	23
17-Jul	510	48	1767	10	6	16
18-Jul	885	47	1371	16	6	22
19-Jul	366	45	1043	26	16	42
20-Jul	497	49	1276	15	9	24
21-Jul	1427	108	1199	36	36	72
22-Jul	628	127	823	33	25	58
23-Jul	423	77	755	10	12	22
24-Jul	919	108	571	12	12	24
25-Jul	598	66	504	10	18	28
26-Jul	459	51	548	62	26	88
27-Jul	1268	94	435	41	43	84
28-Jul	900	96	538	28	35	63
29-Jul	1176	158	324	30	23	53
30-Jul	689	71	414	11	18	29
31-Jul	304	112	216	54	21	75
01-Aug	1250	143	265	44	48	92
02-Aug	300	91	190	28	46	74
03-Aug	1068	177	199	27	15	42
04-Aug	751	108	228	43	51	94
05-Aug	303	81	159	32	40	72
06-Aug	1060	116	148	36	52	88
07-Aug	152	46	121	30	27	57
08-Aug	125	70	159	36	25	61
09-Aug	213	111	91	30	19	49
10-Aug	121	56	120	82	72	154
11-Aug	260	52	87	114	93	207
12-Aug	475	118	43	125	81	206
13-Aug	1110	179	67	45	48	93
14-Aug	159	84	26	39	27	66
15-Aug	103	40	40	68	52	120
16-Aug	275	56	38	123	124	247
17-Aug	509	100	34	196	145	341
18-Aug	505	170	38	167	113	280

Table C4. Daily counts of chinook, sockeye, and steelhead at Wells Dam in 2001.

Date (2001)	Chinook		Sockeye	Steelhead		
	Adult	Jack		Hatchery	Wild	Total
19-Aug	363	73	18	126	94	221
20-Aug	627	143	36	193	149	342
21-Aug	526	51	8	88	95	183
22-Aug	306	38	21	84	90	174
23-Aug	209	133	21	176	159	335
24-Aug	205	95	17	130	99	229
25-Aug	285	123	22	130	101	231
26-Aug	227	106	11	77	77	154
27-Aug	197	77	8	97	79	176
28-Aug	55	43	11	113	57	170
29-Aug	58	51	1	91	71	162
30-Aug	249	83	3	187	210	397
31-Aug	120	48	8	145	142	287
01-Sep	140	60	3	109	112	221
02-Sep	132	91	7	101	133	234
03-Sep	174	105	6	132	86	218
04-Sep	174	81	7	109	97	206
05-Sep	170	51	5	100	99	199
06-Sep	204	92	3	89	83	172
07-Sep	53	61	4	153	90	243
08-Sep	92	54	4	214	106	320
09-Sep	182	39	3	111	57	168
10-Sep	258	22	3	70	66	136
11-Sep	291	42	6	180	125	305
12-Sep	110	40	1	115	91	206
13-Sep	38	25	2	169	97	266
14-Sep	24	38	1	144	137	281
15-Sep	40	46	1	155	109	264
16-Sep	67	65	2	223	129	352
17-Sep	134	58	1	227	131	358
18-Sep	62	35		155	86	241
19-Sep	59	37		108	106	214
20-Sep	50	32	1	94	95	189
21-Sep	114	44		157	142	299
22-Sep	184	96	1	213	234	447
23-Sep	165	114		285	230	515
24-Sep	118	45		193	165	358
25-Sep	40	28	1	88	96	184
26-Sep	77	46		200	146	346
27-Sep	57	38		136	120	256
28-Sep	65	55		244	219	463
29-Sep	39	42		183	163	346
30-Sep	46	41		189	130	319
01-Oct	142	47		114	156	270
02-Oct	150	50		85	84	169
03-Oct	88	38		122	94	216
04-Oct	215	62		131	146	277
05-Oct	40	27		58	83	141
06-Oct	99	50		127	97	224

Table C4. Daily counts of chinook, sockeye, and steelhead at Wells Dam in 2001.

Date (2001)	Chinook		Sockeye	Steelhead		
	Adult	Jack		Hatchery	Wild	Total
07-Oct	83	37		79	106	185
08-Oct	50	23		28	42	70
09-Oct	51	12		49	49	98
10-Oct	104	35		85	30	115
11-Oct	78	3		33	39	72
12-Oct	84	9		90	73	163
13-Oct	61	24		55	48	103
14-Oct	107	15		59	51	110
15-Oct	111	23		36	31	67
16-Oct	100	28		46	49	95
17-Oct	64	20		38	43	81
18-Oct	78	13		60	29	89
19-Oct	101	28		72	39	111
20-Oct	102	18		34	36	70
21-Oct	138	29		44	27	71
22-Oct	141	26		44	18	62
23-Oct	120	15		42	30	72
24-Oct	68	7		23	27	50
25-Oct	62	27		41	20	61
26-Oct	55	24		19	29	48
27-Oct	67	36		30	36	66
28-Oct	71	29		21	28	49
29-Oct	57	17		42	41	83
30-Oct	25	11		26	17	43
31-Oct	30	11		23	4	27
01-Nov	34	3		17	14	31
02-Nov	31	7		12	10	22
03-Nov	26	4		24	23	47
04-Nov	38	3		12	18	30
05-Nov	23	11		14	19	33
06-Nov	11	15		11	8	19
07-Nov	33	6		23	19	42
08-Nov	65	1		11	13	24
09-Nov	45	1		10	13	23
10-Nov	23	1		15	11	26
11-Nov	21	4		13	5	18
12-Nov	13	1		18	12	30
13-Nov	9	1		19	3	22
14-Nov	12	3		15	3	18
15-Nov	16	3		16	2	18
Totals	**39587**	**7506**	**69476**	**10086**	**8351**	**18438**
Totals by Fishway						
East	9182	3434	37110	6660	5874	12534
West	30405	4072	32366	3426	2477	5903

Appendix Table D1. Trapping intervals at Wells and Priest Rapids dams in 2001.

Dam	Fishway	Start Date	Start Time	End Date	End Time	Duration (h)
Wells						
	Left Bank					
		21-May	11:11:00	21-May	18:59:00	7.8
		22-May	10:59:00	22-May	15:01:00	4.0
		23-May	10:59:00	23-May	19:01:00	8.0
		29-May	11:01:00	29-May	14:35:00	3.6
		09-Jul	05:19:00	09-Jul	14:51:00	9.5
		16-Jul	05:39:00	16-Jul	17:01:00	11.4
		17-Jul	05:23:00	17-Jul	16:55:00	11.5
		18-Jul	05:28:00	18-Jul	14:14:00	8.8
		23-Jul	05:37:00	23-Jul	16:30:00	10.9
		24-Jul	05:26:00	24-Jul	16:29:00	11.1
		08-Aug	05:28:00	08-Aug	16:23:00	10.9
		14-Aug	05:29:00	14-Aug	08:12:00	2.7
		20-Aug	05:41:00	20-Aug	15:06:00	9.4
		21-Aug	05:54:00	21-Aug	07:11:00	1.3
	Total					**110.9**
	Right Bank					
		09-Jul	05:33:00	09-Jul	14:51:00	9.3
		10-Jul	05:07:00	10-Jul	18:54:00	13.8
		16-Jul	05:28:00	16-Jul	16:12:00	10.7
		17-Jul	05:33:00	17-Jul	19:06:00	13.6
		18-Jul	05:22:00	18-Jul	16:31:00	11.2
		23-Jul	05:21:00	23-Jul	18:52:00	13.5
		24-Jul	05:35:00	24-Jul	19:04:00	13.5
		01-Aug	05:48:00	01-Aug	15:01:00	9.2
		06-Aug	05:27:00	06-Aug	18:01:00	12.6
		07-Aug	05:27:00	07-Aug	18:58:00	13.5
		08-Aug	05:43:00	08-Aug	18:52:00	13.2
		14-Aug	05:20:00	14-Aug	14:59:00	9.7
		15-Aug	05:29:00	15-Aug	14:58:00	9.5
		20-Aug	05:40:00	20-Aug	15:29:00	9.8
		21-Aug	05:45:00	21-Aug	14:05:00	8.3
		22-Aug	05:38:00	22-Aug	15:27:00	9.8
		27-Aug	05:32:00	27-Aug	14:59:00	9.5
		28-Aug	05:27:00	28-Aug	15:19:00	9.9
		29-Aug	05:40:00	29-Aug	14:44:00	9.1
		04-Sep	05:27:00	04-Sep	19:05:00	13.6
		05-Sep	05:23:00	05-Sep	19:01:00	13.6
		06-Sep	05:40:00	06-Sep	19:03:00	13.4
		10-Sep	05:39:00	10-Sep	18:58:00	13.3
		11-Sep	05:40:00	11-Sep	18:59:00	13.3
		12-Sep	05:40:00	12-Sep	08:31:00	2.9
		17-Sep	05:39:00	17-Sep	19:02:00	13.4

Appendix Table D1. Trapping intervals at Wells and Priest Rapids dams in 2001.

Dam	Fishway	Start Date	Start Time	End Date	End Time	Duration (h)
		18-Sep	05:11:00	18-Sep	19:57:00	14.8
		19-Sep	06:05:00	19-Sep	18:54:00	12.8
		24-Sep	09:45:00	24-Sep	14:32:00	4.8
		25-Sep	05:31:00	25-Sep	13:01:00	7.5
		26-Sep	05:36:00	26-Sep	13:50:00	8.2
		01-Oct	05:33:00	01-Oct	14:09:00	8.6
		02-Oct	05:35:00	02-Oct	14:31:00	8.9
		08-Oct	08:48:00	08-Oct	15:13:00	6.4
		09-Oct	08:31:00	09-Oct	14:07:00	5.6
		10-Oct	12:04:00	10-Oct	13:56:00	1.9
		15-Oct	07:55:00	15-Oct	14:57:00	7.0
		16-Oct	10:47:00	16-Oct	14:28:00	3.7
		18-Oct	08:11:00	18-Oct	14:15:00	6.1
		22-Oct	09:53:00	22-Oct	14:12:00	4.3
		23-Oct	10:32:00	23-Oct	13:40:00	3.1
		29-Oct	09:41:00	29-Oct	15:48:00	6.1
		30-Oct	10:43:00	30-Oct	14:19:00	3.6
		05-Nov	07:14:00	05-Nov	16:03:00	8.8
		06-Nov	07:23:00	06-Nov	14:25:00	7.0
		07-Nov	13:13:00	07-Nov	15:45:00	2.5
		13-Nov	10:54:00	13-Nov	15:45:00	4.9
		14-Nov	14:26:00	14-Nov	16:00:00	1.6
		15-Nov	06:01:00	15-Nov	15:59:00	10.0
	Total					**441.2**
	Wells Total					**552.1**
Priest Rapids						
	Left Bank					
		17-Jul	09:00:00	17-Jul	17:00:00	8.0
		19-Jul	09:00:00	19-Jul	17:00:00	8.0
		24-Jul	09:00:00	24-Jul	17:00:00	8.0
		26-Jul	09:00:00	26-Jul	17:00:00	8.0
		31-Jul	09:00:00	31-Jul	17:00:00	8.0
		02-Aug	08:50:00	02-Aug	17:00:00	8.2
		07-Aug	09:00:00	07-Aug	17:00:00	8.0
		09-Aug	09:00:00	09-Aug	17:00:00	8.0
		14-Aug	09:00:00	14-Aug	17:00:00	8.0
		16-Aug	09:00:00	16-Aug	17:00:00	8.0
		21-Aug	07:00:00	21-Aug	15:00:00	8.0
		23-Aug	07:00:00	23-Aug	15:00:00	8.0
		28-Aug	07:00:00	28-Aug	15:00:00	8.0
		30-Aug	07:00:00	30-Aug	15:00:00	8.0
		04-Sep	07:00:00	04-Sep	15:00:00	8.0
		06-Sep	07:00:00	06-Sep	17:00:00	10.0
		11-Sep	10:45:00	11-Sep	17:00:00	6.3
		18-Sep	09:40:00	18-Sep	17:40:00	8.0
		20-Sep	08:55:00	20-Sep	16:55:00	8.0
		25-Sep	09:05:00	25-Sep	17:05:00	8.0

Appendix Table D1. Trapping intervals at Wells and Priest Rapids dams in 2001.

Dam	Fishway	Start Date	Start Time	End Date	End Time	Duration (h)
		27-Sep	09:00:00	27-Sep	17:00:00	8.0
		02-Oct	09:09:00	02-Oct	15:09:00	6.0
		04-Oct	08:55:00	04-Oct	16:55:00	8.0
		09-Oct	09:10:00	09-Oct	17:10:00	8.0
		11-Oct	08:50:00	11-Oct	16:50:00	8.0
		16-Oct	09:00:00	16-Oct	17:00:00	8.0
	Total					**206.4**

Appendix Table E1. 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 2001.

Dam		Median Times (h)			Sample Size		
		Trapping	No trapping	Total	Trapping	No trapping	Total
Wells							
	Right-bank upper fishway	1.7	1.3	1.4	6	61	67
Priest Rapids							
	Left-bank upper fishway	7.5	2.1	2.1	16	149	165

Appendix Table E2. Statisics for t-tests of natural log transformed passage times of radio-tagged steelhead that passed Wells and Priest Rapids dams under trapping and non-trapping intervals, 2001.

Dam	Fishway	Segment	Trapping			No trapping			df	P
			Mean	SD	CV	Mean	SD	CV		
Wells										
	Right Bank	Upper Fishway	0.15	0.29	200%	0.31	0.27	90%	6	0.223
Priest Rapids										
	Left Bank	Upper Fishway	0.42	0.32	76%	0.85	0.32	37%	18	0.0001

Appendix Table F1. Mobile tracking survey dates and coverage, July 2001 - July 2002.

Date	Yakima R.	Hanford Yak R. to Coyote	Hanford Coyote to PR	Priest Rapids Pool	Wanapum Pool	Rock Island Pool	Wenatchee Below Tum	Wenatchee Above Tum	Rocky Reach Pool	Entiat R.	Wells Pool	Methow R.	Okan R.
Jul-27				A	A	A	A	A	A	A	A	A	
Aug-10			A	A	A	A	A	A	A	A	A	A	A
Aug-31				A	A	A	A	A	A	A	A	A	
Sep-12			B										
Sep-19		B	B										
Sep-21				A	A	A	A	A	A	A	A	A	
Sep-27			B										
Oct-04			B										
Oct-05			A/B	A	A	A	A	A	A	A	A	A	
Oct-12					A	A			A		A	A	A
Oct-16				A	A	A	A	A	A	A	A	A	
Oct-18											B		B
Oct-22			B										
Nov-01			B										
Nov-02				A	A	A	A	A	A	A	A	A	
Nov-16						A	A	A	A	A	A	A	A
Nov-21	A	A	A	A	A	A	A						
Dec-14			B										
Dec-20		B	B		B								
Dec-26				A	A	A	A	A	A	A	A	A	
Jan-08				A	A/B	A	A	A	A	A	A	A	
Jan-15					B								
Jan-21					B								
Jan-25				A	A	A	A	A	A	A			
Jan-30			B										
Feb-06					B								
Feb-07					B								
Feb-08				A	A	A	A	A	A	A	A	A	
Feb-13						A	A	A	A	A	A	A	A
Feb-14	A	A	A	A	A	A							
Feb-27						A	A	A	A	A	A	A	A
Feb-28	A	A	A	A	A	A							
Mar-01					B								
Mar-12						H	H	H	H	H	H	H	
Mar-13						A	A	A	A	A	A	A	A
Mar-14	A	A	A	A	A	A							
Mar-22					B								

Appendix Table F1. Mobile tracking survey dates and coverage, July 2001 - July 2002.

Date	Yakima R.	Hanford Yak R. to Coyote	Hanford Coyote to PR	Priest Rapids Pool	Wanapum Pool	Rock Island Pool	Wenatchee Below Tum	Wenatchee Above Tum	Rocky Reach Pool	Entiat R.	Wells Pool	Methow R.	Okan R.
Mar-26						H	H	H	H	H		H	
Mar-27						A	A		A	A	A	A	A
Mar-28		A	A	A	A	A	A	A					
Apr-08						H	H	H	H	H	H	H	
Apr-10	A	A	A	A	A	A						A	
Apr-11					A/B	A	A	A	A	A	A	A	A
Apr-12			B										
Apr-23						H	H	H	H	H	H	H	
Apr-24						A	A	A	A	A	A	A	A
Apr-25		A	A	A	A/B	A	A						
May-03				B									
May-07						H	H	H	H	H		H	
May-08						A	A	A	A	A	A	A	A
May-09		A	A	A	A	A	A						
May-16					B								
May-23						A	A	A	A	A	A	A	A
Jun-04						H	H	H	H	H		H	
Jun-05					A	A	A	A	A	A			
Jun-06						A			A		A	A	A
Jun-19		A	A	A	A	A	A	A	A	A	A		A
Jun-20					A	A			A		A	A	
Jul-01						A	A	A	A	A	A	A	A
Jul-02		A	A	A	A	A			A		A	A	A
No. surveys	5	12	23	23	34	43	35	30	35	30	30	32	17

A = fixed wing aerial, B = boat aerial, and H = helicopter aerial

Appendix Table F2. Number of unique radio-tagged steelhead detected in mobile surveys of the mid-Columbia River, 2001-2002 [1,2].

Zone	Description of Zone	Number of Distinct tags by month												
		Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02
8	Columbia River- Snake R. mouth to Yakima R. mouth	ns	ns	ns	ns	0	ns	ns	0	0	ns	ns	1	1
34	Yakima River mouth to Benton City Bridge	ns	ns	ns	ns	0	ns	1	0	0	0	ns	0	0
35	Yakima River- Benton City Bridge to Prosser Dam	ns	ns	ns	ns	0	ns	0	0	0	ns	ns	ns	ns
36	Yakima River- Prosser Dam to Granger	ns	ns	ns	ns	4	ns	0	1	0	ns	ns	ns	ns
37	Yakima River -Granger to Yakima Dam	ns	ns	ns	ns	0	ns	0	0	0	ns	ns	ns	ns
38	Yakima River- Yakima Dam to Rosa Dam	ns	ns	ns	ns	0	ns	ns	1	0	0	ns	ns	ns
39	Yakima River - Rosa Dam to Ellensburg	ns	ns	ns	ns	ns	ns	ns	0	0	0	ns	ns	ns
	Yakima River total	0	0	0	0	4	0	1	2	0	0	0	0	0
48	Yakima River mouth to White Bluffs	ns	ns	0	ns	4	0	3	3	1	2	3	2	3
58	Columbia River- White Bluffs to PR Dam tailrace	ns	6	49	37	21	15	18	17	19	20	16	14	13
228	Columbia River- Priest Rapids Dam to Wanapum Dam	2	1	11	4	0	0	1	6	3	7	10	8	8
378	Columbia River- Wanapum Dam to Trinidad	0	2	6	1	6	0	3	5	4	11	7	5	4
379	Columbia River- Trinidad to Rock Island Dam	0	3	0	3	0	1	3	6	1	5	10	3	3
588	Columbia River- RI Dam to Wenatchee River mouth	0	0	4	5	5	2	5	5	7	13	7	3	3
589	Columbia R.- Wenatchee R. mouth to Rocky Reach Dam	0	1	4	2	1	1	2	11	8	6	1	3	1
688	Columbia River- Rocky Reach Dam to Entiat R. mouth	0	0	0	6	2	2	4	8	3	4	10	7	3
703	Mission Creek	ns	ns	ns	ns	0	0	ns	ns	0	1	0	0	0
704	Peshastin Creek	ns	ns	ns	ns	ns	ns	ns	0	2	5	2	0	ns
708	Wenatchee River - Columbia River to Leavenworth	0	0	12	16	15	11	14	14	14	9	9	4	4
709	Icicle Creek	0	0	0	0	0	0	0	0	2	2	0	0	1
714	Chumstick Creek	ns	ns	ns	ns	ns	0	0	ns	0	0	0	0	ns
715	Chiwaukum Creek	ns	0	0	ns	0	ns	0	0	0	0	0	0	ns
716	Nason Creek	ns	0	ns	ns	0	0	0	0	0	2	0	0	ns
717	Chiwawa River	0	0	0	0	0	ns	0	0	1	5	3	0	0
718	Wenatchee River - Leavenworth to Tumwater Dam	0	1	2	6	4	3	4	4	6	8	6	4	1
719	Wenatchee River - Tumwater Dam to Lake Wenatchee	0	0	4	9	17	14	21	21	23	19	10	6	5
	Wenatchee River total	0	1	18	31	36	28	39	39	48	51	30	14	11

Appendix Table F2. Number of unique radio-tagged steelhead detected in mobile surveys of the mid-Columbia River, 2001-2002 [1,2].

Zone	Description of Zone	Number of Distinct tags by month												
		Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02
728	Entiat River to Mad River	0	0	0	2	2	2	3	4	6	4	1	0	0
729	Mad River	0	0	0	0	0	0	0	0	1	1	0	0	0
738	Entiat River- Mad River to Preston Falls	0	0	0	0	0	0	0	0	1	0	0	0	0
739	Entiat River - Preston Falls to Headwaters	0	0	ns	0	0	0	0	0	0	0	0	0	0
	Entiat River total	0	0	0	2	2	2	3	4	8	5	1	0	0
748	Columbia River- Entiat River mouth to Wells Dam	0	3	9	19	9	12	18	24	13	21	25	13	10
868	Columbia River - Wells Dam to Pateros	0	1	3	19	4	3	20	11	10	8	3	3	1
875	Gold Creek	0	0	ns	0	0	ns	0	0	0	1	1	1	ns
876	Chewachk River	ns	ns	0	0	0	ns	0	0	1	19	4	0	ns
877	Methow River- Winthrop to headwaters	0	0	0	0	0	0	0	0	5	17	6	4	3
878	Methow River - Columbia River to Libby Creek	0	0	18	77	109	0	88	120	100	36	28	21	17
879	Libby Creek	0	0	0	0	0	ns	0	ns	0	0	0	0	ns
883	Methow River- Libby Creek to Twisp River	0	1	1	2	4	1	14	12	48	29	9	7	8
884	Twisp River - Methow River to Buttermilk Creek	0	0	0	0	0	0	0	0	2	29	7	2	3
885	Twisp River - Buttermilk Creek to headwaters	0	0	0	0	0	0	0	0	0	2	1	0	0
886	Twisp River - Buttermilk Creek	0	0	0	0	0	0	0	0	ns	ns	ns	1	0
887	Methow River - Twisp to Winthrop	0	0	0	0	0	0	0	2	15	11	3	3	3
	Methow River total	0	1	19	79	113	1	102	134	171	144	59	39	34
888	Columbia River - Pateros to Chief Joseph Dam	0	13	23	27	1	5	21	30	24	20	6	6	4
898	Okanogan River - Columbia River to Monse	ns	0	ns	0	11	ns	3	4	3	5	2	2	2
899	Okanogan River - Monse to Riverside	ns	ns	ns	19	41	ns	35	38	31	12	12	11	10
908	Okanogan River - Riverside to Zosel	ns	ns	ns	1	12	ns	18	19	20	10	7	5	6
909	Okanogan River - Zosel to McDonald	ns	ns	ns	0	0	ns	ns	0	0	0	0	1	0
919	Similkameen River	ns	ns	ns	0	4	ns	ns	5	10	5	3	2	2
	Okanogan River total	0	0	0	20	68	0	56	66	64	32	24	21	20

[1] ns= no survey was conducted in that zone during that particular month

[2] A zero (0) value means a survey was conducted in the zone during that particular month but no radio-tagged steelhead were detected.

Appendix Table F3. Summary of the furthest upstream detections by reach for radio-tagged steelhead tracked in the Wenatchee River Basin during the spawning periods in 2000 and 2002.

	Study					
	1999/2000		2001/2002		Both Studies	
Portion of the river or tributary	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
Sample Size						
Mission Cr.	0	1	0	1	0	2
Peshastin Cr.	3	3	4	1	7	4
Wenatchee R. - Mouth to Leavenworth	12	12	5	3	17	15
Icicle Cr.	0	1	1	1	1	2
Chumstick Cr.	3	2	0	0	3	2
Chiwaukum Cr.	1	0	0	0	1	0
Nason Cr.	1	0	1	1	2	1
Chiwawa R.	3	1	1	4	4	5
Wenatchee R. Leavenworth to Tumwater	5	12	2	3	7	15
Wenatchee R. Tumwater to Lake Wenatchee	11	11	3	13	14	24
Total	**39**	**43**	**17**	**27**	**56**	**70**
Percent						
Mission Cr.	0%	2%	0%	4%	0%	3%
Peshastin Cr.	8%	7%	24%	4%	13%	6%
Wenatchee R. - Mouth to Leavenworth	31%	28%	29%	11%	30%	21%
Icicle Cr.	0%	2%	6%	4%	2%	3%
Chumstick Cr.	8%	5%	0%	0%	5%	3%
Chiwaukum Cr.	3%	0%	0%	0%	2%	0%
Nason Cr.	3%	0%	6%	4%	4%	1%
Chiwawa R.	8%	2%	6%	15%	7%	7%
Wenatchee R. Leavenworth to Tumwater	13%	28%	12%	11%	13%	21%
Wenatchee R. Tumwater to Lake Wenatchee	0%	2%	6%	4%	2%	3%
Total	72%	77%	88%	56%	77%	69%

Appendix Table F4. Summary of the furthest upstream detections by reach for radio-tagged steelhead tracked in the Entiat River Basin during the spawning periods in 2000 and 2002.

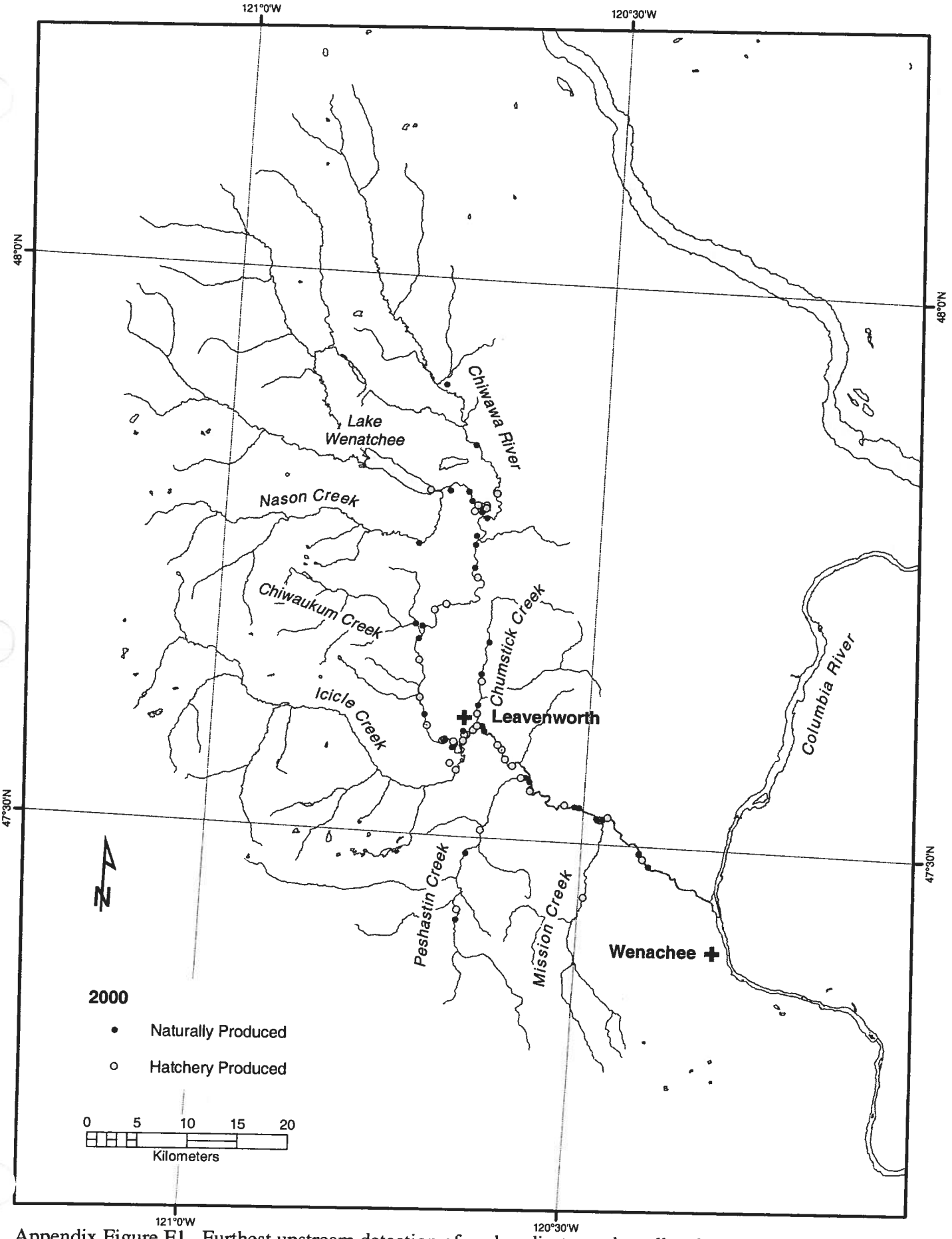
	Study					
	1999/2000		2001/2002		Both Studies	
Portion of the river or tributary	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
Sample Size						
Entiat R. Mouth to Mad R.	1	2	2	3	3	5
Entiat R. - Mad R. to Preston Falls	2	1	0	1	2	2
Mad River	0	1	1	0	1	1
Total	**3**	**4**	**3**	**4**	**6**	**8**
Percent						
Entiat R. Mouth to Mad R.	33%	50%	67%	75%	50%	63%
Entiat R. - Mad R. to Preston Falls	67%	25%	0%	25%	33%	25%
Mad River	0%	25%	33%	0%	17%	13%
Total	100%	100%	100%	100%	100%	100%

Appendix Table F5. Summary of the furthest upstream detections by reach for radio-tagged steelhead tracked in the Methow River Basin during the spawning periods in 2000 and 2002.

	Study					
	1999/2000		2001/2002		Both Studies	
Portion of the river or tributary	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
Sample Size						
Methow R. - mouth to Twisp	9	30	7	54	16	84
Methow R. - Twisp to Chewuck	3	9	0	8	3	17
Upper Methow R.	1	7	3	19	4	26
Twisp R.	1	8	3	25	4	33
Chewuck R.	3	15	2	18	5	33
Total	**17**	**69**	**15**	**124**	**32**	**193**
Percent						
Methow R. - mouth to Twisp	53%	43%	47%	44%	50%	44%
Methow R. - Twisp to Chewuck	18%	13%	0%	6%	9%	9%
Upper Methow R.	6%	10%	20%	15%	13%	13%
Twisp R.	6%	12%	20%	20%	13%	17%
Chewuck R.	18%	22%	13%	15%	16%	17%
Total	100%	100%	100%	100%	100%	100%

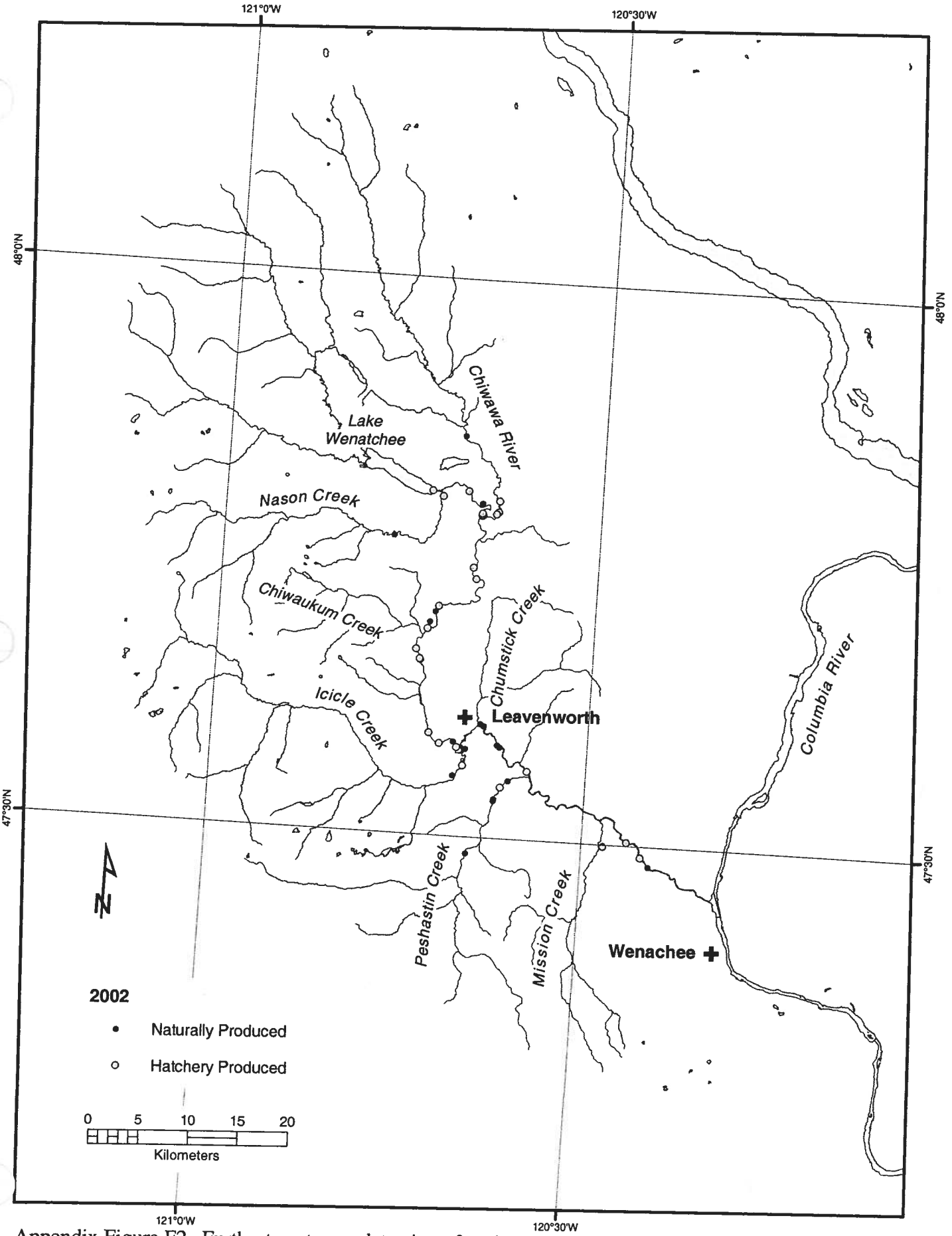
Appendix Table F6. Summary of the furthest upstream detections by reach for radio-tagged steelhead tracked in the Okanogan River Basin during the spawning periods in 2000 and 2002.

	Study					
	1999/2000		2001/2002		Both Studies	
Portion of the river or tributary	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
Sample Size						
Okanogan R. - mouth to Monse	1	1	0	3	1	4
Okanogan R. - Monse to Riverside	4	23	1	25	5	48
Okanogan R. - Riverside to Zosel	3	10	2	18	5	28
Okanogan R. - Zosel to McDonald	0	1	0	1	0	2
Similkameen R.	0	10	1	11	1	21
Total	**8**	**45**	**4**	**58**	**12**	**103**
Percent						
Okanogan R. - mouth to Monse	13%	2%	0%	5%	8%	4%
Okanogan R. - Monse to Riverside	50%	51%	25%	43%	42%	47%
Okanogan R. - Riverside to Zosel	38%	22%	50%	31%	42%	27%
Okanogan R. - Zosel to McDonald	0%	2%	0%	2%	0%	2%
Similkameen R.	0%	22%	25%	19%	8%	20%
Total	100%	100%	100%	100%	100%	100%



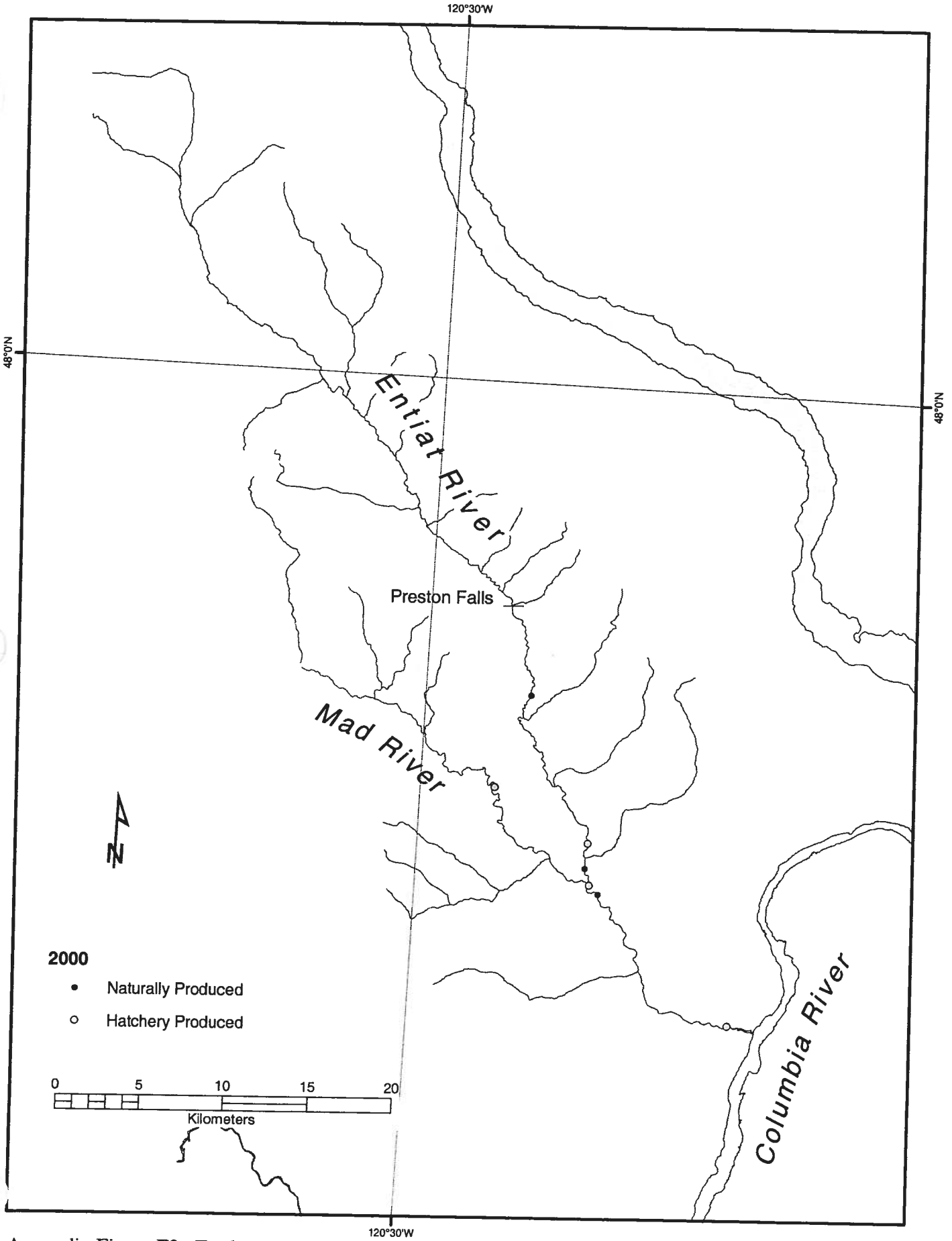
Appendix Figure F1. Furthest upstream detection of each radio-tagged steelhead tracked in the Wenatchee River Basin during the spawning period in 2000.

LGL Limited 2003.06.23 D:\Ea1477\BD_Wenatchee_Wenatchee_Fig_F1-2.mxd



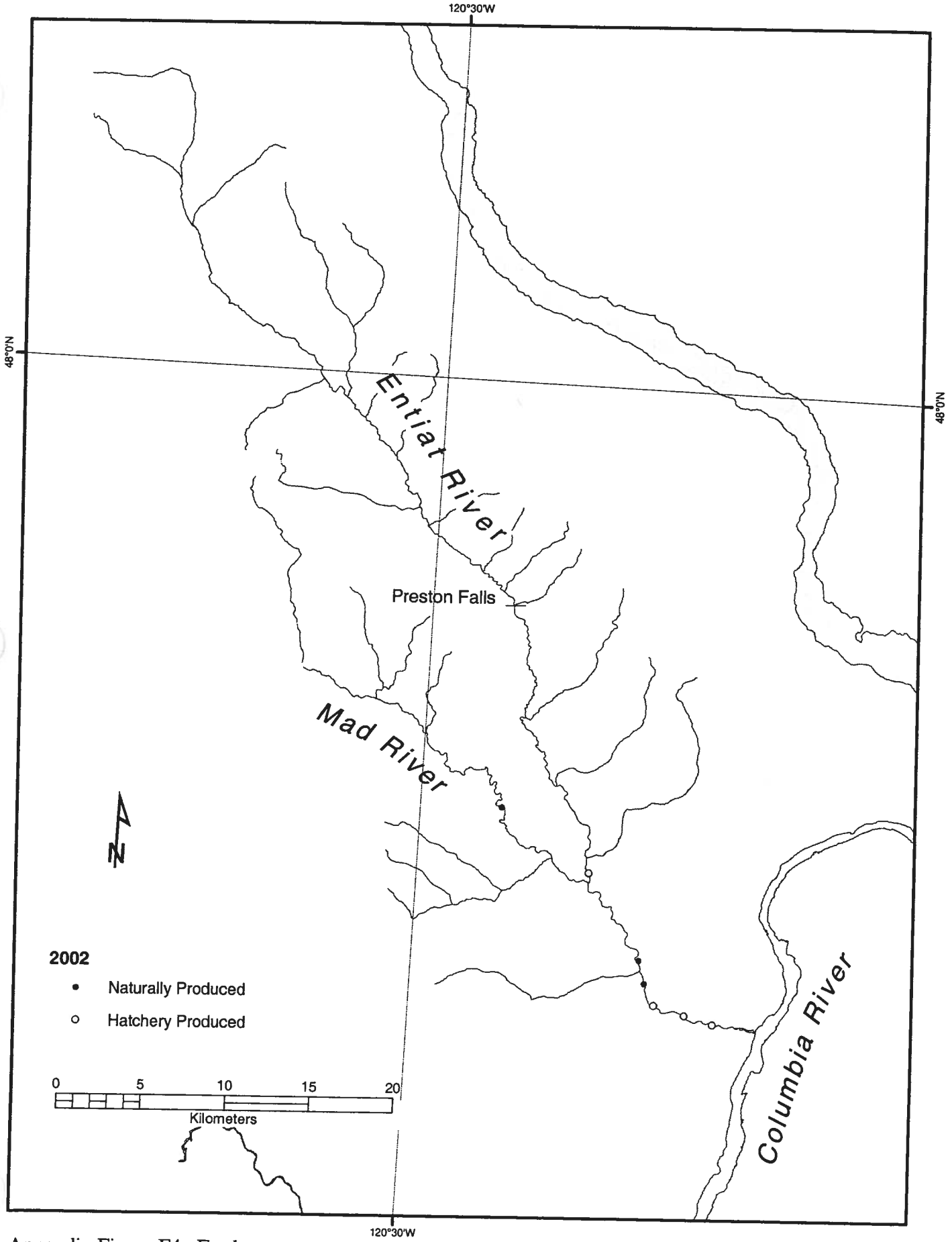
Appendix Figure F2. Furthest upstream detection of each radio-tagged steelhead tracked in the Wenatchee River Basin during the spawning period in 2002.

LGL Limited 2003.07.09 D:\Ea1477\BD_Wenatchee_Wenatchee_Fig_F1-2.mxd



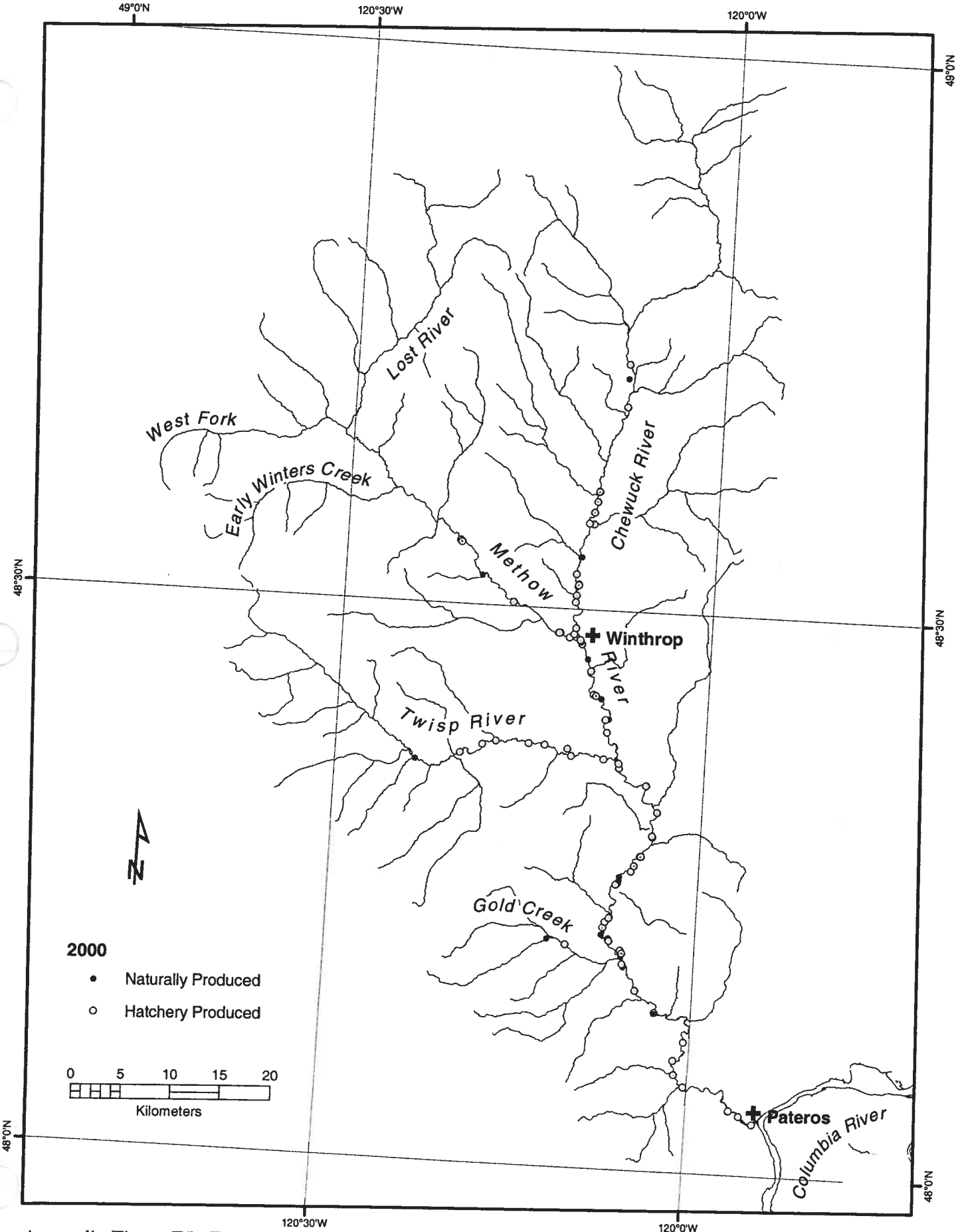
Appendix Figure F3. Furthest upstream detection of each radio-tagged steelhead tracked in the Entiat River Basin during the spawning period in 2000.

LGL Limited 2003.06.23 D:\Ea14477\BD_Entiat_Entiat_Fig_F3-4.mxd



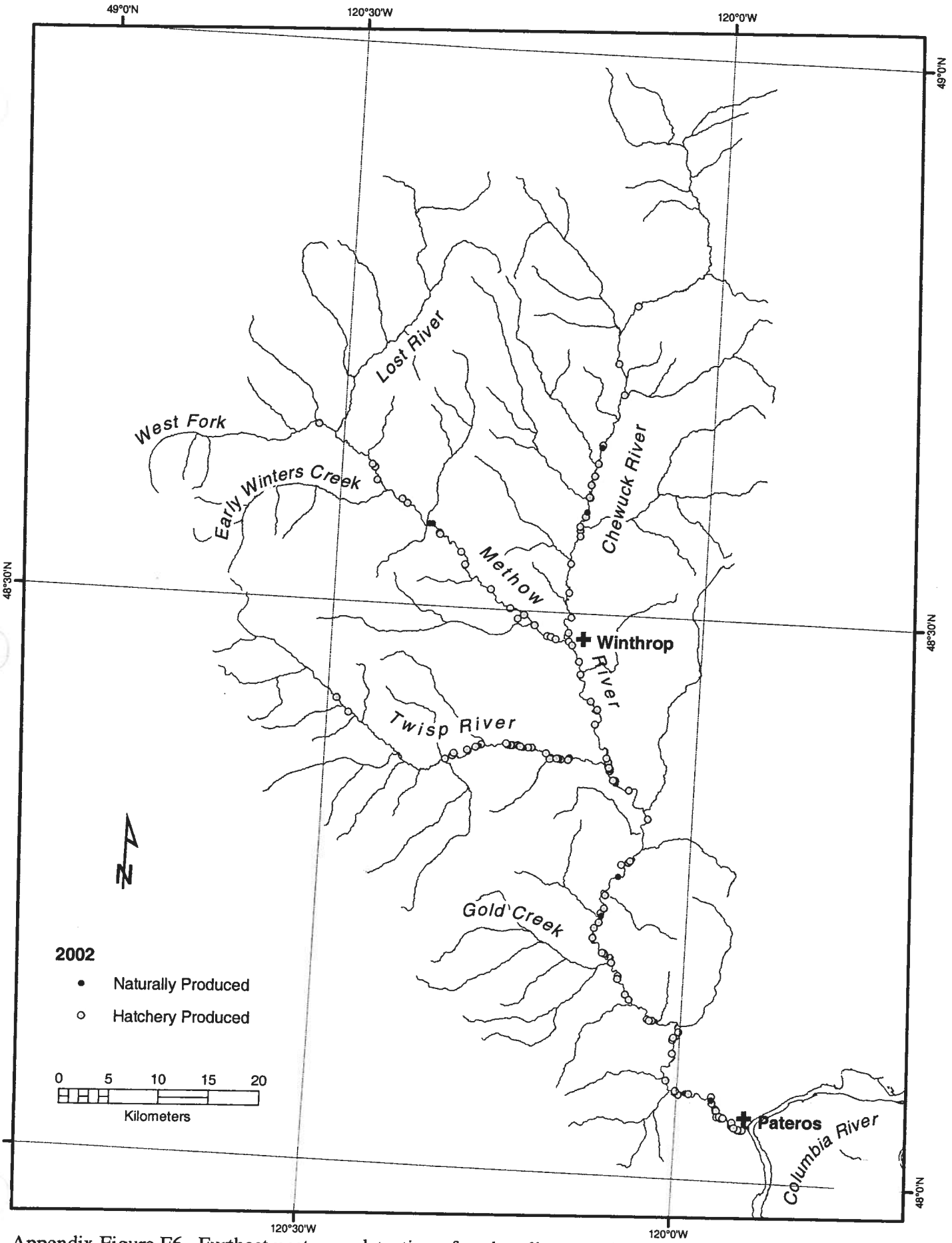
Appendix Figure F4. Furthest upstream detection of each radio-tagged steelhead tracked in the Entiat River Basin during the spawning period in 2002.

LGL Limited 2003.06.23 D:\Ea1477\BD_Entiat_Entiat_Fig_F3-4.mxd



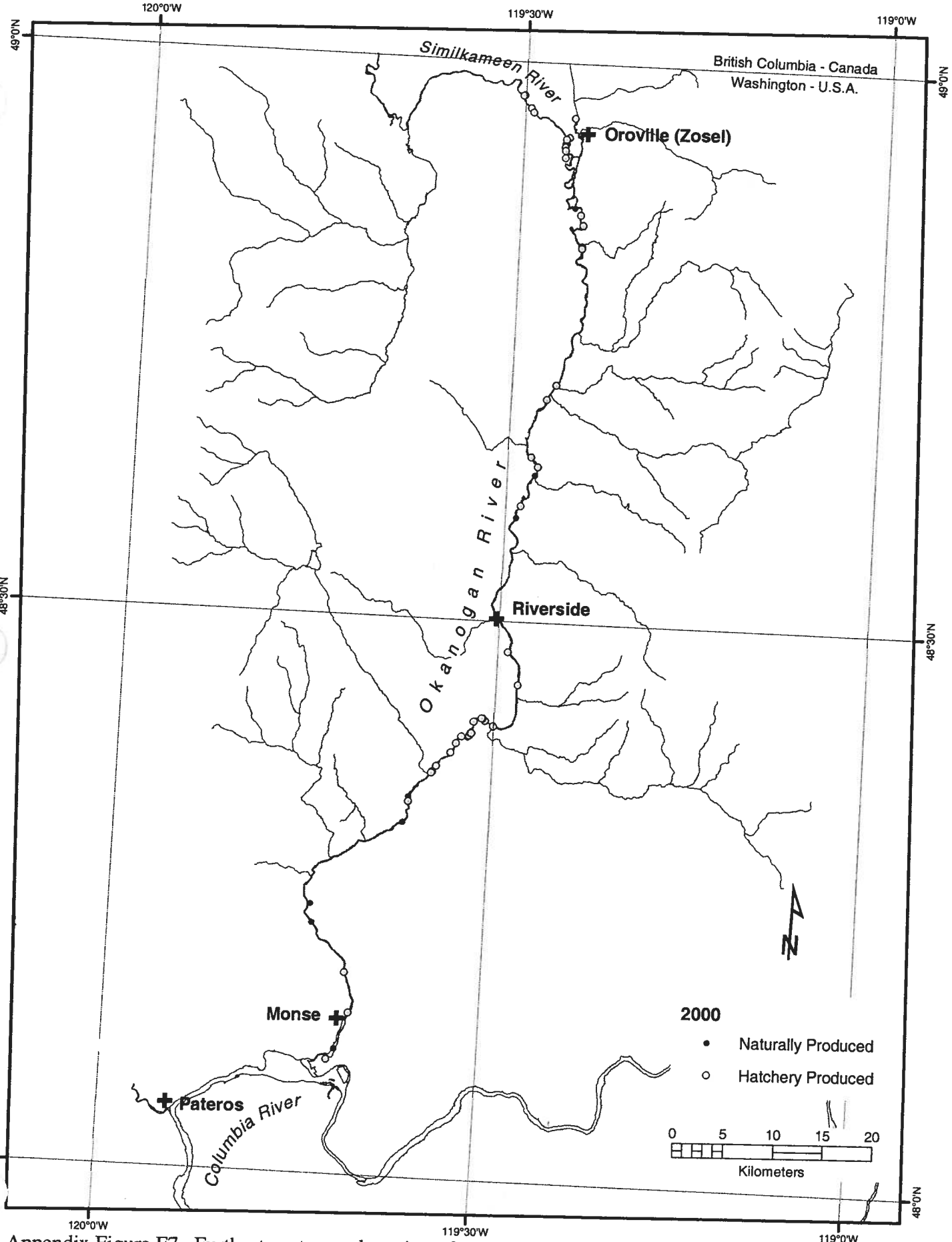
Appendix Figure F5. Furthest upstream detection of each radio-tagged steelhead tracked in the Methow River Basin during the spawning period in 2000.

LGL Limited 2003.06.23 D:\Ea1477\BD_Methow_Methow_Fig_F5-6.mxd



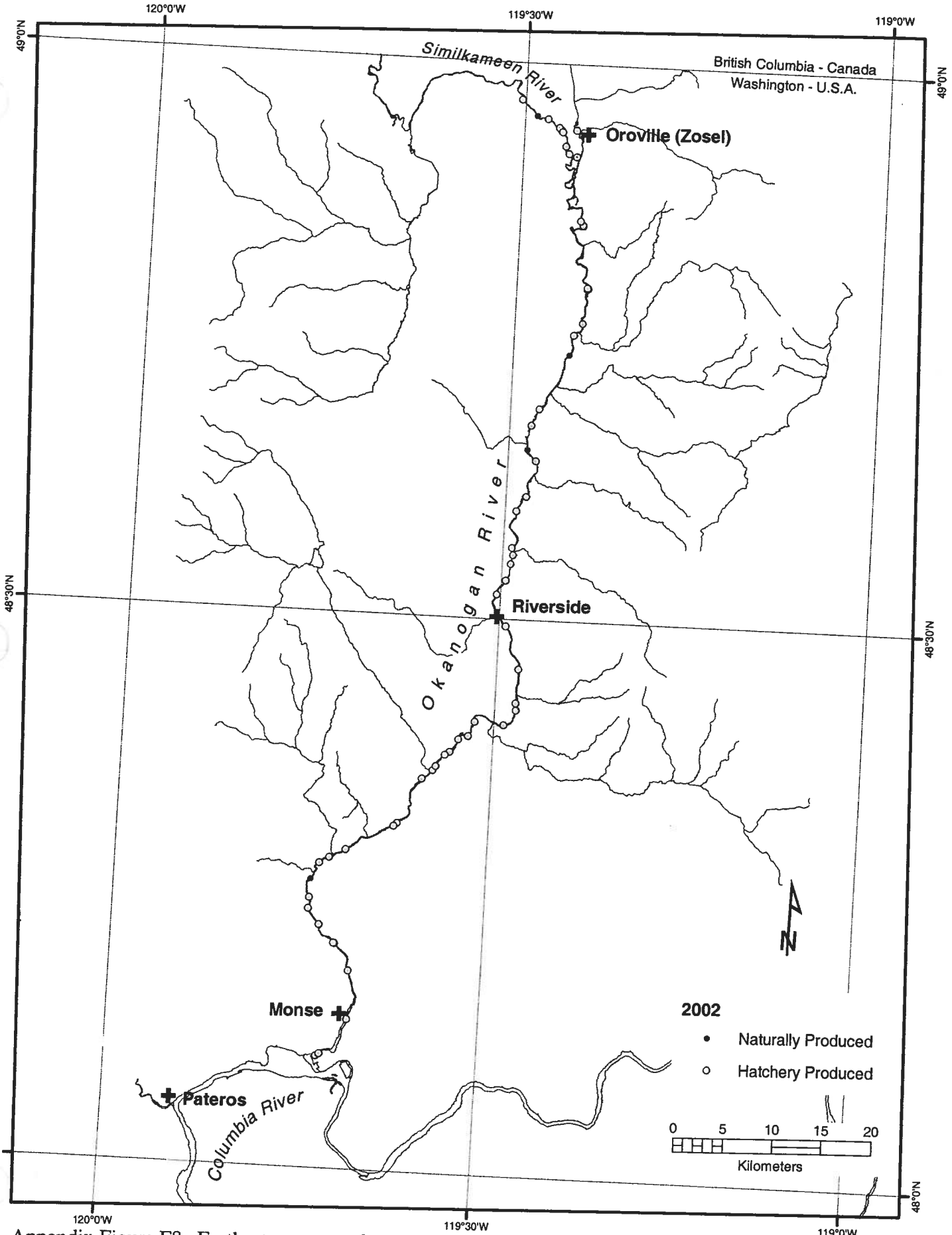
Appendix Figure F6. Furthest upstream detection of each radio-tagged steelhead tracked in the Methow River Basin during the spawning period in 2002.

LGL Limited 2003.06.23 D:\Ea1477\BD_Methow_Methow_Fig_F5-6.mxd



Appendix Figure F7. Furthest upstream detection of each radio-tagged steelhead tracked in the Okanogan River Basin during the spawning period in 2000.

LGL Limited 2003.06.23 D:\Ea1477\BD_Okanogan_Okanogan_Fig_F7-8.mxd



Appendix Figure F8. Furthest upstream detection of each radio-tagged steelhead tracked in the Okanogan River Basin during the spawning period in 2002.

LGL Limited 2003.06.23 D:\Ea1477\ED_Okanogan_Okanogan_Fig_F7-8.mxd

APPENDIX G - RESPONSE TO COMMENTS RECEIVED



environmental research associates

LGL Limited
environmental research associates
9768 Second St.,Sidney, BC Canada V8L 3Y8

9 June 2003

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

Thad Mosey
Public Utility District No. 1 of Chelan County
P.O. Box 1231, Wenatchee, Washington, 98807-1231

Stuart Hammond
Public Utility District No. 2 of Grant County
PO. Box 878, Ephrata, Washington, 98823

RE: Response to comments on the Assessment of Adult Steelhead Migration through the Mid-Columbia River Using Radio-Telemetry Techniques, 2000-2002 (7 February 2003)

Dear Shane, Thad and Stuart:

The only comments we have received on the draft report for the 2000-2001 adult steelhead telemetry study were those submitted by Ritchie Graves and Rod Woodin. The attached documents includes comments received from each of these reviewers along with our responses (in bold) for each comment. We have made all the associated changes to the report.

Yours truly,

Karl K. English
Vice-President, Western Operations

NOAA Fisheries' Comments on Douglas, Chelan, and Grant PUDs' Study: Draft B - Assessment of Adult Steelhead Migrations Through the Mid-Columbia River Using Radio-Telemetry Techniques, 2001-2002

Prepared by Ritchie Graves
March 13, 2003

This document constitutes my technical comments on those sections of the Mid-Columbia PUDs' study titled: Draft B - Assessment of Adult Steelhead Migrations through the Mid-Columbia River Using Radio-Telemetry Techniques, 2001-2002. If you have any questions regarding these comments, please contact me at 503-231-6891 or by e-mail at Ritchie.Graves@noaa.gov.

General Comments

1) The number of fish that successfully passing each dam and remain upstream of that dam (exit detections – fallbacks + re-ascending fish) should be presented in the results and discussion sections. For example, on page 11, it would appear that 330 fish ultimately passed Priest Rapids dam and continued their migration (343 total – 24 fallbacks + 11 re-ascends).

The number of fish that successfully passed each dam and remained upstream of that dam through the spawning period (net passage) has been added to Table 18 which previous included all the numbers required to calculate net passage.

2) Future studies should specifically include the Chelan River as a tributary. Steelhead are known to spawn in the lowermost stretch of this river. If this data is available from this study it should be included. By my count, about a dozen fish could have potentially spawned in this river (261 fish past RRE – 232 past Wells – 16 fish reared at Wells hatchery or detected in the vicinity of the hatchery).

Of the 9 fish last tracked in the Rocky Reach pool, 3 were last tracked in the vicinity of the Chelan River.

3) The summary (page 25 – 27) is very useful.

Specific Comments

Abstract

1) Pg ix. First paragraph indicates 53% of the sampled fish were recorded as female, text on page 10 indicates 58% were.

The percentage of females is 58% and has been corrected in the report.

2) Pg x. First paragraph indicates that about 8% of the adult steelhead that passed a dam fell back. There is no discussion of the route of passage through which these fish fell back. Route specific information should be summarized and included in the abstract.

The fallback route are only available for a portion of the fish that fell back at Priest Rapids and Wanapum dams. Most of these fish fell back via the sluice (93% at Priest Rapids and 86% at Wanapum).

3) Pg x. Third paragraph should provide the difference in the number of hours that produced the statistically significant result. The second sentence notes an 8 hour delay in Project passage as a result of trapping operations. Was this difference similarly a statistically significant one.

The upper fishway passage times for trapping intervals (7.5 h) and non-trapping intervals (2.1 h) at Priest Rapids were added to the abstract. The difference in the Project passage times between trapping and non-trapping intervals was also significant.

4) Pg xi. First and second paragraphs should summarize patterns among those fish falling back or harvested if any exist. If no patterns are apparent (i.e. few fish fell back more than once, all fish caught by anglers (?) were caught in reservoir X, etc.) this should be stated.

Of the 97 unique fish that fell back, 26 fell back at more than one dam and 1 of the 97 fallback fish was recovered by an angler in the Rocky Reach pool after the fish had fallen back through Wells Dam.

5) Pg xi. Information regarding straying patterns should be added after second paragraph, last sentence if any exist. If not, this should be stated.

Most of the strays detected were fish tracked to the Methow and Okanogan rivers. This was not surprising since some of the broodstock for the Ringold and Wenatchee hatchery releases came from fish collected at or above Wells Dam.

6) Pg xi. Breakdown of locations where kelt losses occurred should be summarized. This information should be presented with a caveat that this is not a true estimate of survival and why.

The downstream tracking rate for kelts is not a survival estimate because some kelts could have passed undetected and some may have been removed by anglers.

Results

7) Pg. 10. Third paragraph indicates 58% of fish were female, abstract shows 53% were female. **(corrected as above)**

8) Pg. 11-14. See General Comment 1.

9) Pg. 18. Second paragraph, numbers don't add correctly. 314 + 58 = 372, not 371.

The number 314 was an error. This should have been 313 as in Table 19.

Discussion

10) Pg. 24. Last paragraph is incorrect. While kelting rate estimates from telemetry studies are not available, keeling rate estimates are available in the Snake River basin as expansions of kelts observed in the Juvenile Bypass Facility at Lower Granite Dam. Allan Evans (CRITFC) estimated that in 2000 and 2001 (outmigrations), the kelting rate for wild Snake River steelhead was about 23% and 25% respectively. The majority of these fish are rated as being in "good" condition and the sex ratio is roughly 10:1 (female to male).

I discussed this comment with Ritchie and we could not identify any statements in the last paragraph on page 24 that were incorrect.

Summary

11) Pg. 25. I recommend adding a new bullet #2 summarizing the number of fish that successfully passed each project (i.e., were detected at the fishway exits once) and the proportion of these fish which stayed above the project (see General Comment 1).

Adding a new bullet with the summary information you requested would confuse the reader regarding comparisons between years. Therefore, we have provided the new bullet with a summary of the information from Table 18 below:

> **Of the radio-tagged steelhead detected at the upstream fishway exits for Priest Rapids Dam, 96.2% were last tracked above Priest Rapids Dam, prior to the kelting period. Comparable percentages for the other dams were 96.7% for Wanapum Dam, 96.3% for Rock Island Dam, 94.6% for Rocky Reach Dam, and 92.1% for Wells Dam.**

12) Pg. 26. Bullet #11, it is not clear to me how you are able to calculate average values based on a proportion of "unique dam passage events." It would seem logical that if 8% of the fish passing a dam fell back, that the sum of involuntary and voluntary fallbacks should also equal 8%. However, this does not seem to be the case. It would be of more use to indicate the number of total fallbacks (also indicate is any individuals fell back multiple times) and what proportion of fish passing each project this represented (reference to the new bullet recommended in my comment #11). With this context, the discussion of fallbacks (i.e., average proportion of fallbacks [voluntary and involuntary] and re-ascents) would make more intuitive sense.

The average fall back rate of approximately 8% (actually 7.8%) is the sum of involuntary fallbacks (1.2%), voluntary fallbacks (3.5%) and fish that re-ascended (3.1%), as indicated in Bullet #11.

Responses to comments from Rod Woodin – 6 May 2003

The following comments/questions regarding this report were provided through telephone conversations with Rod Woodin:

1. An appendix table should be added to the report showing the fate of those fish detected at each project that did not pass that project.

2. The three categories that define the fate of fallback fish (voluntary, involuntary and re-ascended) should clarify that the fish that re-ascended a project were also involuntary fallbacks.

3. The report should clarify that the information provided on the fate of fallback fish in Tables 21-23, includes fish that fell back at more than one dam and some fish fell back several times at one or more dams. An additional table is required to provide information on the fate and fallback locations for those fish that fell back at more than one dam and those that fellback several times at one or more dams.

4. Were any of the involuntary fallbacks tracked moving downstream during the kelting period?

5. The report should clarify that the tagging and release procedure could have affected the fallback rates estimated for Priest Rapids Dam. Five of the fish were tracked to spawning areas below Priest Rapids Dam were fish that never returned to Priest Rapids Dam after tagging and release near Vernita Bridge. These fish would likely have fallen back at Priest Rapids Dam if they had been permitted to pass the dam on their first attempt.

The above comments/questions have been addressed in the following manner:

1. A new table (Appendix Table G1), showing the fate of those fish detected at each project that did not pass that project, has been added to the report. The format for this table is similar to that used for Table 19. Of the 69 fish did not pass the last dam they encountered during their upstream migration, 64.6% were tracked to a spawning area. Wanapum and Rock Island dams had the fewest fish that did not pass (3 each). Rocky Reach Dam had the largest number of fish that did not pass. Of the 306 radio-tagged steelhead detected at Rocky Reach Dam, 25 (8.2%) did not pass. However, 18 (72.0%) of the fish that did not pass Rocky Reach were tracked to spawning areas below that dam.

2. We have added text to the section entitled "Classification of Fallback Fish" clarifying that the fish that re-ascended a project were also involuntary fallbacks.

3. We have added text to the appropriate paragraph in the section entitled "Fate of Radio-Tagged Steelhead" to clarify that the information provided on the fate of fallback fish in Tables 21-23, includes fish that fell back at more than one dam and some fish fell back several times at one or more dams. We have added a new table (Appendix Table G2) showing the origin (Hatchery or "wild"), fallback sequence (abcde...), last detection location and spawning fate (0= not tracked to a spawning area, 1= tracked to a spawning area) for each radio-tagged steelhead that fellback multiple times at a single or several dams. This new table reveals that some steelhead fellback as many as 5 times. Of the 27 fish with multiple fallback events, 18 (67%) were tracked to spawning areas. One fish (Tag # 406) migrated above Wells Dam before falling back 5 times on its way to the Snake River.

4. We have confirmed that three of the fish classified as involuntary fallbacks (1 at Wanapum, 1 at Rock Island and 2 at Rocky Reach) were tracked migrating downstream during the kelting period. This information has been added as a footnote to Tables 21 and 22.

5. The fact is we have no way of estimating the number of fish that would have fallen back at Priest Rapids if they had been permitted to pass the dam on their first attempt. Some of the fallback fish may not have fallen back if they had been permitted to pass the dam on their first attempt and some may have fallen back after their first attempt but did not fall back after their second ascent. The issue here is whether the fish detected at the exits of the Priest Rapid fishways are representative of the steelhead that passed Priest Rapids Dam. We do not know the effect of handling and tagging on fall back at any dam. We assume that the fish have fully recovered from any handling or tagging effects once they arrive back at the Priest Rapids project. The estimated fallback rates are correct, if the 343 radio-tagged steelhead that passed Priest Rapids Dam, including 17 fish that fell back to spawning areas below Priest Rapids, were representative of the steelhead that passed Priest Rapids in 2001. If the tagging location or release procedures make the radio-tagged steelhead not representative of the steelhead that passed Priest Rapids Dam, then all results for Priest Rapids Dam should be ignored. We have not found any evidence to suggest that the tagging location or release procedure used in 2001 or the 1999 adult steelhead study affected steelhead behavior to an extent that would make the radio-tagged fish not representative of the steelhead migrating through the study area during 1999-2000 or 2001-2002 study years.

Appendix Table G1. Spawning destinations or furthest upstream detection of the radio-tagged steelhead that have not passed the exits of each of the mid-Columbia dams, prior to kelting.

	Dam Detection Sites					
Location/Stock	Priest Rapids Dam	Wanapum Dam	Rock Island Dam	Rocky Reach Dam	Wells Dam	Totals
Number of tagged fish	18	3	3	25	20	69
Tags never tracked						
Known removals prior to spawning						
Tributaries	2	0	0	0	0	2
Mid-Columbia River	1	0	1	0	0	2
Sub-total	3	0	1	0	0	4
Tributaries						
Snake River	4	1	1	0	0	6
Yakima River	3	0	0	0	1	4
Wenatchee River						
Below Tumwater Dam	0	0	0	8	3	11
Above Tumwater Dam	0	0	0	8	0	8
Entiat River	0	0	0	0	4	4
Wells Hatchery	0	0	0	0	5	5
Methow River	0	0	0	0	0	0
Okanogan River	0	0	0	0	0	0
Sub-Total	7	1	1	16	13	38
Mid-Columbia River						
Hanford Reach*						
Yakima R. - Coyote	2	0	0	2	0	4
Coyote - Priest Rapids[1]	6	1	0	1	0	8
Priest Rapids Pool	0	1	0	1	0	2
Wanapum Pool	0	0	1	3	0	4
Rock Island Pool	0	0	0	2	4	6
Rocky Reach Pool	0	0	0	0	3	3
Wells Pool	0	0	0	0	0	0
Sub-Total	8	2	1	9	7	27
Available for spawning	15	3	2	25	20	65
Spawning Areas (excluding removals)						
Tributaries	7	1	1	16	13	38
Mid-Columbia River	2	0	0	2	0	4
Sub-total	9	1	1	18	13	42
Percentages						
Spawning Areas	60.0%	33.3%	50.0%	72.0%	65.0%	64.6%
Other Areas						
Below Dam	40.0%	66.7%	50.0%	28.0%	35.0%	35.4%
Above Dam	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Above Dam or Spawning Areas	60.0%	33.3%	50.0%	72.0%	65.0%	64.6%

* Fish last detected in the Hanford Reach include likely regirgitated tags and angler removals
Boxed areas are the mainstem areas between Coyote Rapids and the dam.

Appendix Table G2. Fallback sequence and fate for radio-tagged steelhead that fellback multiple times at one or more dams, prior to kelting.

				Multiple and Sequencial Fallback Events[1]						
Tag #	Channel	Code	Origin	Priest R.	Wanapum	Rock Is.	Rocky R.	Wells	Last Detection	Fate[2]
207	7	44	H			a		b	MOB Methow R. - from Methow R. Mouth to Libby Creek Mo	1
211	7	52	H	c	b	a			MOB Columbia Yakima R. Mouth - White Bluffs	1
225	8	79	W		a	b			MOB Columbia Trinidad - RI	0
237	4	105	H	d	c	ab			MOB Columbia Yakima R. Mouth - White Bluffs	1
258	5	43	H		a			b	MOB Columbia from Entiat R. Mouth to WE	1
267	7	63	W	d	c	b	a		MOB Yakima R. Prosser Dam - Granger	1
312	8	48	H	a	b				PRA Under Forbay Juvenile	1
318	5	62	H				ab		MOB Columbia RI - Wenatchee R. Mouth	0
324	8	74	H			c	b	a	MOB Columbia WA - Trinidad	0
342	4	108	H	c	b	a			MOB Columbia White Bluffs PR Tail	0
361	8	43	H		a			b	WA Pool 3	1
364	7	49	H				c	ab	MOB Columbia RI - Wenatchee R. Mouth	1
397	4	119	H		d	c	b	a	PRA Right below diffusion grates	0
406	5	37	H	e	d	c	b	a	SNA - Snake River - Ice Harbour Tailrace	1
430	5	71	H	a				b	MOB Methow R. - from Methow R. Mouth to Libby Creek Mo	1
436	8	99	H		a		b		RRH Tailrace -- West Shore - Upstream	1
475	5	80	H	b	a				SNA - Snake River - Ice Harbour Tailrace	1
478	4	86	H	a	b				MOB Columbia Yakima R. Mouth - White Bluffs	1
486	7	90	H		a		b		MOB Columbia Yakima R. Mouth - White Bluffs	1
536	4	104	H	a	b				SNA - Snake River - Ice Harbour Tailrace	1
548	4	129	H	a		b			MOB Columbia Wenatchee R. Mouth to RR	1
550	7	32	H	a		c	be	d	MOB Columbia WA - Trinidad	1
551	8	36	W	c	b	a			Hanford Juvenile	0
552	4	38	H	a	b				MOB Columbia PR - WA	0
381	4	87	W			ab			MOB Columbia Trinidad - RI	0
412	8	49	W	ab					MOB Columbia PR - WA	1
445	8	115	H					ab	WEL Left Tailrace	0
Not tracked to a spawning area										9
Tracked to a spawning area										18

[1] Fallback events registered only if the fallback occurred before 1 March 2002 (i.e. before kelting period).

[2] 0 - Not tracked to a spawning area
1 - Tracked to a spawning area

LETTER TO DEPARTMENT OF ECOLOGY IN EXPLANATION OF EXCEEDANCE OF TOTAL DISSOLVED GAS WATER QUALITY PARAMETER ON AUGUST 21, 2003

APPENDIX F

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

Chief Executive Officer/Manage
WILLIAM C. DOBBIN

Public Utility District No. 1 of Douglas County

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

August 21, 2003

Chris Maynard
Water Quality Program
Department of Ecology
PO Box 47600
Olympia, WA 98504-7600

Re: Notification of Water Quality Exceedance

Dear Chris,

Pursuant to the Wells Project Total Dissolved Gas Abatement Plan approved by the Department of Ecology on March 27, 2003, the District is required to notify the Department of Ecology when Total Dissolved Gas levels in the tailrace exceed 125 percent for a one hour average or 120 percent for an average of the twelve highest hourly readings in any one day or the 12 hour average level when the forebay station at the next dam downstream exceeds 115 percent level.

On August 15 and 16th, there was spill that caused the TDG values at the tailwater monitoring station to exceed the standards allowed in the Wells Gas Abatement Plan. The table below lists the 12 hour values for August 15 and 16th. There was an exceedance of the 12 hour value for August 15th, only.

Date	24 Hour Average	12 Hour Average	High value
August 15	117.0%	**126.0%**	137.9%
August 16	113.6%	118.8%	129.5%

There were several hours with an hourly average value that exceeded the 125 percent standard. The values that are reported to the Corps of Engineers in a real time fashion are values at the top of the hour. The letter from Ecology states that the "one hour average" can not exceed 125 percent. The "one hour average" has been determined by using the top of the hour data point, averaged with the three previous reads at 15 minute increments. Thus, a 1700h "one hour average" is based on the values at 1615, 1630, 1645 and 1700. These values are shown in the table below. The **BOLD** figures are in excess of 125 percent.

Wells Dam TDG Monitoring in 2003. Exceedance of Hourly Average of 125%.

Date	Hour	Top of Hour Read	**Hourly Average**
August 15	1600	130.9%	**125.4%**
August 15	1700	137.1%	**135.0%**
August 15	1800	137.6%	**138.0%**
August 15	1900	135.2%	**136.0%**
August 15	2000	133.3%	**134.0%**
August 15	2100	132.2%	**132.6%**
August 15	2200	131.1%	**131.7%**
August 15	2300	127.8%	**129.1%**
August 15	2400	124.5%	**125.6%**
August 16	1800	129.2%	123.8%
August 16	1900	123.8%	**127.0%**
August 16	2000	119.9%	120.8%

In addition, the forebay gas levels at the project immediately below Wells Dam, Rocky Reach, did exceed 115 percent TDG on August 18 and 19th.

Date	24 Hour Average	12 Hour Average	High Value
August 15	109.3%	109.9%	110.7%
August 16	109.5%	109.9%	110.2%
August 17	110.1%	112.0%	117.4%
August 18	118.9%	**120.8%**	122.3%
August 19	113.9%	**116.0%**	116.9%

Explanation of Spill Event

The high voltage bus arrangement at Wells Dam is configured so that four generators are on one section of bus (bus #1) and six generators are on another bus (bus #2). Each of these bus sections has a set of Potential Transformers (PT's). These PT's are original equipment and have been in service since the facility was first energized in 1967.

Recently, industry-wide records show that this particular type of PT has started to fail at an unacceptably high rate. The failures tend to be violent and often there is burning oil and broken porcelain flying around. Although the District has not experienced any failures of these devices, some of the devices have shown early warning signs that problems may be developing. The District was advised by

Gordon Struve, Senior Principal Engineer with Doble Engineering Company, that it would be prudent to replace these devices.

Replacement PT's were procured and the replacement for bus #2 was scheduled for August 11-13th, Monday through Wednesday. After in-house discussions, the replacement was changed to August 15-17th, Friday through Sunday, because the flows were expected to be lower and there would be less spill. The outage was scheduled to begin Friday morning at 6:00 am and go through Sunday until 6:00 pm.

During the replacement of the PT's, bus #2 and all of its generators had to be de-energized and the capacity of the plant was reduced to 4 units, or 328 MW. In preparation for the outage, the forebay level was reduced about 4 feet below normal to about 777'. This was done to create storage space in the forebay to help reduce the amount of spill required. However, the actual inflow to the Wells reservoir on Friday exceeded the forecast amount and a substantial amount of spill was required in order to keep forebay levels from exceeding project limits. Water was spilled on Friday from about 1:38 pm to 11:03 pm.

The PT replacement work was completed ahead of schedule and on Saturday, August 16th at about 3:25 pm switching was initiated to restore the plant to full capacity. Although the investigation is not complete, it appears that switching surges caused two surge arresters to fail that were protecting bus #1. This caused the loss of all ten generators at Wells Dam for about an hour. Again, spill was required to keep the forebay within project limits.

About an hour later, after removing clearances and doing the necessary switching, the operators were able to restore bus #2. They were then able to start generator units on bus #2 and the amount of spill for forebay level control was reduced. Spill was discontinued Saturday night at about midnight. The repairs affecting bus #1 were completed and the bus restored about 5:30 pm on Sunday, August 17th.

The forced spill conditions of August 15 and 16th should be considered a singular event related to the necessary replacement of unreliable equipment in the high voltage switchyard. Replacement of the original PT's and the faulty surge arresters should prevent recurrence of this condition.

The District took measures to minimize spill and the build of TDG in the Columbia River. The replacement of the potential transformers will provide greater reliability of the dam to generate power and thus minimize emergency spill events that potentially will create high dissolved gas conditions.

Please contact Rick Klinge at (509) 884-7191, if there are any questions concerning this matter.

Sincerely,

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

METHOW BASIN SPRING CHINOOK NATURAL PRODUCTION STUDY REPORT FOR 2000

APPENDIX G

Methow Basin Spring Chinook Natural Production Study Report For 2000

Prepared by

Joel Hubble
and
Eric Theiss

Fisheries Resource Management Program
Yakama Nation

Prepared for

Public Utility District No. 1 of Douglas County

East Wenatchee, WA

December 2003

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ABSTRACT

The estimated 2000 spring chinook run to Wells Dam was 2,587 (82% adults and 18% jacks). Of these 1,436 were taken for broodstock (89% adults and 11% jacks). The estimated spawner escapement was 826 fish after correction for Enitiat National Fish Hatchery (ENFH) "fallback" at Wells Dam.

A total of 368 spring chinook redds were located in the Methow Basin in 2000. The number of redds by major subbasin were as follows: Methow– 234 (64%), Lost– 2 (.06%), Early Winters- 0 (0%), Chewuch– 32 (9%) and Twisp– 99 (27%). The number of redds (71%) downstream of the Methow index (below Weeman Bridge) reach was the highest recorded since complete surveys were initiated in 1987.

The fish per redd ratio, after revised for ENFH "fallback at Wells Dam, was 2.2 and without revision 2.9.

A summary of the distribution of carcasses recovered in the Methow Basin is presented in Table 3. A total of 178 carcasses were recovered, of these 22 (12%) were of natural origin while the remaining 158 (78%) carcasses were of hatchery origin.

During the juvenile outmigrant monitoring period (October 5 – December 7) an estimated 1,414 spring chinook outmigrants passed the Halderman's Hole monitoring site. The 25%, 50% and 75% dates of cumulative passage for spring chinook were, respectively, October 15, October 27 and November 8. The mean spring chinook fork length was 102 mm (S.D. = 11.6). A total of 60 O. mykiss fish were captured during the monitoring period. Steelhead/ rainbow trout ranged in fork length from 72 to 301 mm, and had a mean fork length of 151 mm (S.D. = 49.6).

Future management considerations based on results of the 2000 spawner survey are as follows:

1. Future consideration needs to be made of relocating the Methow acclimation site further upstream nearer the traditional spawning reaches.
2. Indirectly related to the first issue, is the need to include in years when possible, a higher proportion of natural fish in the broodstock collection.
3. Given the low redd counts in the Lost River in recent years consideration should be given by technical and management makers to determining supplementation objectives for this population.

INTRODUCTION

The Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) is a compensation program directed towards the enhancement of the wild spring chinook (*O. tshawytscha*) stocks in the Methow Basin. The MBSCSP is the result of the Wells Settlement Agreement between the fishery agencies, tribes, Douglas PUD and the power purchasers of the Wells Project. The goal of this agreement is to compensate for unavoidable losses of juvenile anadromous fishes at Wells Dam. The stated purpose of the MBSCSP "...is to increase natural propagation of salmon in the Methow, Chewuch, and Twisp rivers in a manner that minimizes or eliminates ecological and genetic risks to the natural population.", through a monitored hatchery supplementation plan. The settlement agreement requires that the MBSCSP be operated according to procedures outlined by the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC, 1987). A specific outcome is that the MBSCSP "be capable of collecting, rearing, and releasing three potentially discrete stocks of salmon" (Methow, Chewuch and Twisp), which is part of the Phase I compensation requirements under the settlement agreement. Spring chinook spawner surveys in the Methow Basin are a monitoring and evaluation task, which is a component of the MBSCSP. Under Objective 2, Task 2.9 (Natural Production section) of the MBSCSP spawner surveys are conducted to evaluate various attributes (i.e., spawning behavior and geographic distribution) between natural and hatchery spawners. The entire monitoring and evaluation plan is presented in Appendix D of the MBSCSP document, which will provide the reader context for where spawner surveys mesh with other tasks of the evaluation program. Basin wide spring chinook spawning ground surveys have been conducted since 1987. In 1996 and 1998 no spawner surveys were conducted since nearly all spring chinook were collected at Wells Dam for broodstock.

STUDY AREA

The Methow River Basin is located in north-central Washington on the eastern slope of the Cascade Mountains (Figure 1). The Methow River and its tributaries lie in Okanogan County and drain an area of nearly 1,800 square miles. The headwaters of the Methow Basin are located near the Cascade Crest at a maximum elevation of 8,500 feet and drops to 781 feet where it joins the Columbia River (RM 524) at Pateros, WA. The upper portions of the Methow basin is mountainous, and dominated by sub-alpine and alpine forest at the upper elevations. Moving eastward from the Cascade Crest in association with a decrease in elevation the forests are dominated by ponderosa pine and steppe-brush in the lower most portion of the basin. Annual

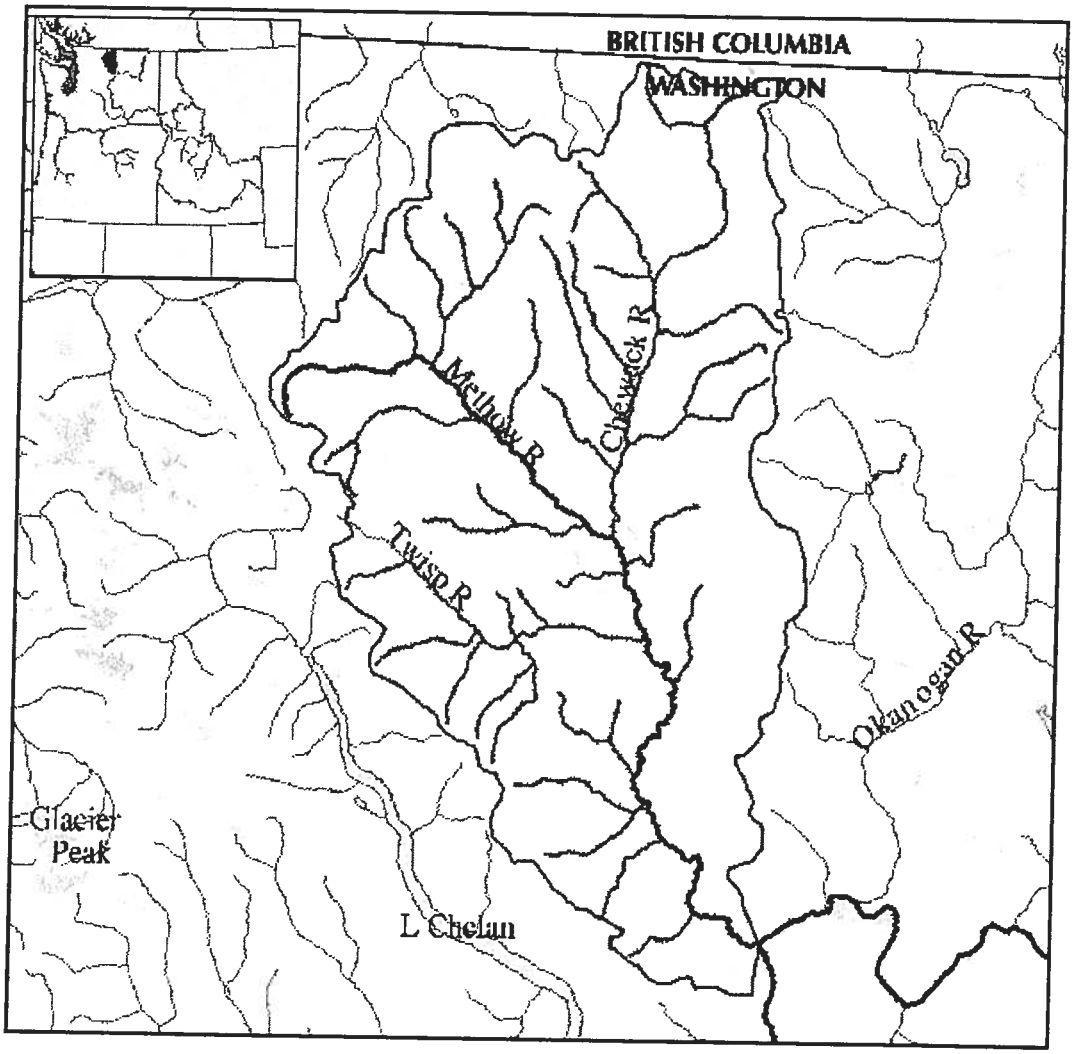

Figure 1. Map of the Methow Basin.

precipitation ranges from 80 inches at the Cascade Crest to 10 inches where the river enters the Columbia River (Richardson 1976). The majority of precipitation occurs from October through March, primarily in the form of snow. The summer months are dry with precipitation occurring in the form of brief thunderstorms. Stream flows in the Methow Basin are driven by the annual snow pack cycle of accumulation during the winter and the spring snowmelt. Generally peak river discharge occurs from mid May to mid June, with base flows occurring from late September through March, with a slight increase in the fall prior to snowfall due to fall rains.

The Methow Basin is characterized as rural with human developed concentrated in the towns of Mazama, Winthrop, Twisp and Methow. Individual homes are scattered throughout the lowlands and upland areas of the basin usually associated with acreage.

The lower Methow valley is a fertile agricultural area that experiences heavy irrigation demands. Water quality in the lower Methow Basin nonetheless remains high, with an AA rating from the Washington Department of Ecology. Spring chinook spawning in the Methow River extends from about Trout Creek (river mile 78) to about two miles downstream of the Chewuch River confluence (river mile 48).

The Chewuch River joins the Methow River at RM 50, at an elevation of 1,745 feet. These two rivers join in the city of Winthrop. The Chewuch basin covers 530 square miles and drains in a southern direction into the Methow River. The upper portion of the Chewuch River is located in the Pasayten Wilderness (above RM 32.4) and is heavily forested. Spring chinook spawn downstream from river mile 31.5, which is also used extensively for recreation and residential development.

The Twisp basin encompasses about 250 square miles of watershed and enters the Methow River at near RM 40. The elevation descends from 8,500 ft to 1,600 ft and drains in a southeast direction. The headwater and upslope areas lay within the Lake Chelan-Sawtooth Wilderness. Spring chinook spawning has extended upstream to South Creek (RM ~28).

METHODS AND MATERIALS

Spawning Escapement

As in previous years, natural escapement was derived by subtracting the various broodstock collections from the Wells Dam fish count. However, in 2000 during WDFW's broodstock collection at Wells Dam it was observed that several adipose present fish with a hatchery scale pattern were being collected. These fish were suspect as being of ENFH origin, as not 100% of the 2000 returning ENFH fish were CWT'ed. A total of 64 adults and 14 jacks of this type were subsequently marked with an opercle punch and released in the Wells Dam tailrace. Twenty-six of these were recaptured at ENFH, three were observed at Rocky Reach Dam, and seven were recaptured in WDFW's Wells Dam trap. The ENFH fish comprised 23% of the fish collected in WDFW's trap. Because of the high percent composition of these fish and the fact that fallback had occurred, an attempt was made to account for this in terms of the estimated natural escapement.

Initial calculations utilized directly the data derived from the opercle punch evaluation. This approach failed to result a reasonable natural escapement number. Failure of this approach is probably a result of not being able to fully account for the fate of all 78 opercle punched fish released, thus the estimated fallback rate (or upstream passage rate) was inaccurate. Additionally, marked and released ENFH fish may not have behaved in a similar fashion as unhandled ENFH fish.

Fallback of ENFH fish was indirectly accounted for by taking the difference between the percent composition of ENFH fish at Wells Dam (23%) and that observed on the spawning grounds (8%) from the carcass samples. This method assumes no pre-spawning mortality. The calculations for this method are presented in Appendix Table 1. It was estimated that 514 ENHF fish past Wells Dam, of these, 157 fish were estimated to comprise a portion of the natural escapement. There was an additional 32 fish recovered at the WNFH for a total of 189 fish. The difference, 325 fish, represents ENFH fallback fish, which were subtracted from the uncorrected natural escapement value of 1,151 fish. The revised natural escapement was 826 fish.

Spawning Surveys

Surveys were primarily conducted in the Methow, Lost, Chewuch and Twisp rivers, and in Early Winters Creek. The historical index reaches were normally surveyed weekly, while those reaches where nominal spawning occurs were normally surveyed bi-weekly. All spawning reaches where redds normally are located were surveyed at least once during or after the historic peak spawning period. The historic index reaches are the following:

- Methow: Weeman bridge to Mazama bridge (6.2 river miles)
- Lost: Lost River bridge to the Eureka Creek (4.2 river miles)
- Early Winters: Highway 20 bridge to Cedar Cr. (1.9 river miles)
- Chewuch: Falls Creek Campground to Camp Four bridge (6.8 river miles)

- Twisp: Buttermilk Creek bridge to the Mystery Creek bridge (10.1 river miles)

Regular surveys began August 1 and continued through September 28, with additional spot-checks conducted afterward. Appendix Tables 2, 3 and 4 present the complete week-by-week survey schedule and redd counts.

Raft or canoe surveys were conducted in the Methow River downstream from Lost River when flows were of sufficient depth, after which they were conducted on foot. All remaining rivers and tributaries were conducted on foot. To ensure survey consistency the same survey crew was normally assigned to the same spawning reach. However, for quality control purposes, a different crew occasionally surveyed another crew's survey reach. To avoid recounting or missing a previously counted redd, each redd was marked with surveyor's tape on the riverbank adjacent to the redd. Written on each posted tape were the consecutive redd number and survey date. A global positioning system unit (GPS) was also used to locate many of the redds, usually to an accuracy of 15 feet.

All live chinook were counted during each survey. Carcasses were recovered and checked for sex, tags, fin clips, and spawning success. Scales and DNA samples were collected when possible from each carcass, and fork length and post eye-to-hypural plate length was recorded. Heads from all adipose clipped carcasses were recovered and stored for later dissection and recording of the coded-wire-tag code. In addition, the river reach was recorded for each coded-wire-tagged carcass to evaluate the stock distribution of hatchery fish.

Juvenile Outmigration

An eight foot diameter rotary screw trap (EG Solutions, Corvallis, OR) was used to monitor juvenile spring chinook and steelhead/rainbow trout (*O. mykiss*) migration at RM 38.5 ("Halderman's Hole") on the Methow River from October 11 to December 7.

Three trap efficiency test releases of spring chinook were made during the course of the monitoring period. Unfortunately, only 25 fish were released in total, of which 17 fish were subsequently recaptured for a combined trap efficiency of 68 percent. However, because of the small sample size, daily spring chinook counts were expanded based upon the direct river flow entrainment method. This method assumes that fish entrainment is directly proportional to the percent stream discharge into the trap. This assumption is probably not completely accurate given the 68% fish entrainment value. Therefore, the daily passage estimates should be view more as a daily passage index. Daily spring chinook counts were divided by the daily rotary trap entrainment rate to estimate the number of daily outmigrants.

Flow approaching the trap was approximated using the combined daily flow data from the USGS Twisp River and Methow at Winthrop gauging stations. The flow (cfs) through the trap was calculated by multiplying the water velocity immediately in front of the cone by the exposed surface area (25 ft^2) of the cone opening. A linear regression was used to estimate mean daily discharge through the trap based upon the mean daily river discharge (Equation 1). The daily rotary trap

entrainment rate was defined as the ratio of mean daily discharge (cfs) through the trap divided by the estimated mean daily river discharge (cfs) (Equation 2). River discharge during the period of

trap operation ranged from 207 to 337 CFS (mean=268 CFS); while estimated discharge through the rotary trap ranged from 98 to 125 CFS (mean=112 CFS). The daily rotary trap entrainment rate ranged from 38% to 44% during the period of trap operation.

Estimated mean daily discharge through the trap = 0.27*Mean Daily River Discharge + 37 (Equation 1)

$$\text{Daily Rotary Trap Entrainment Rate} = \frac{\text{Estimated Mean Daily Discharge Through The Trap}}{\text{Mean Daily River Discharge}} \quad \text{(Equation 2)}$$

Estimated daily passage was calculated as follows:

$N(i)=n(i)/p(i);$

where $N(i)$ is the estimated daily passage, $n(i)$ is the daily catch, and $p(i)$ is the predicted daily rotary trap entrainment rate.

The cumulative estimated daily passage up to day j was calculated as follows:

$\text{summation } [AN(j)_{=1 \text{ to } j} N(i)];$

where $\text{summation } [AN(j)]$ is the cumulative estimated daily passage.

For purposes of data analysis, the sampling day ended when the trap was moved out of the flow in the morning, and a new sampling day began after the trap was redeployed to resume fishing. Therefore, fish collected from the livebox during the afternoon were pooled with fish collected through the night and up to the following morning check. Trap checks were normally performed at 0830, but additional checks were performed when debris load or fish abundance was elevated. For safety reasons, the trap was pulled to the bank with an electric winch when possible, then returned to the fishing position when the livebox was clean. Once the fish were removed from the livebox, they were anesthetized with MS-222, identified to genus or species, measured (fork length) to the nearest millimeter. After the fish were sampled they were allowed to recover in a bucket for a short period of time prior to release.

Periods when the trap was not fished (including repair times) were recorded. A linear regression was used to interpolate data for these periods. The linear regression was based on the daily fish counts for a 2-4 day period preceding and following the non-fished period.

RESULTS AND DISCUSSION

Spring Chinook Run Size

A summary of the Methow Basin spring chinook run size and spawner escapement for years 1967-2000 is presented in Table 1 and Figure 2. The estimated 2000 spring chinook run size to Wells Dam was 2,587 (2,130 or 82% adults; 457 or 18% jacks).

Broodstock Collection

A total of 1,436 fish (1,283 (89%) adults and 153 (11%) jacks) were taken for broodstock (Table 1). The broodstock collection was derived as follows: 338 spring chinook (296 adults, 42 jacks) were collected at Wells Dam and transferred to Methow Fish Hatchery (MFH); 156 chinook (133 adults, 23 jacks) volunteered to the MFH; and 942 chinook (854 adults, 88 jacks) volunteered to the WNFH.

The stock composition for each of the three broodstock collections is presented in Table 2. The Wells Dam collection was of natural origin- 2%, Methow Fish Hatchery (MFH) (all three subbasins)- 41%, WNFH- 44%, ENFH- 5%, Leavenworth National Fish Hatchery (LNFH)- 2%, Idaho origin- 1% and unknown- 17%. The MFH collection was comprised of MFH (all three subbasins)- 68%, Winthrop National Fish Hatchery (WNFH)- 23%, and unknown- 9%. The WNFH collection was comprised of MFH (all three subbasins)- 15%, WNFH- 75%, ENFH- 3%, and unknown- 6%.

Estimated Spawner Escapement

The derivation used to estimate the natural spawner escapement is presented in Appendix Table 1. Unlike in previous years, there was evidence based on WDFW's mark-recapture evaluation of adipose present hatchery fish at Wells Dam, that fallback of Enitiat National Fish Hatchery (ENFH) fish probably occurred, which resulted in over estimating the actual natural escapement. The estimated natural escapement is thus based upon the calculated number of ENFH fish that initially passed Wells Dam and subsequently fell back. In addition, the estimated spawner escapement value assumes no pre-spawning mortality. The estimated natural escapement to the Methow Basin was 826 fish.

Fish Per Redd Ratio

A total of 368 redds were counted for the entire Methow Basin. Based on the Wells Dam count without considering the fallback of ENFH fish, there were 2.9 fish per redd. However, taking into account fallback, the fish per redd ratio equals 2.2 fish per redd.

Table 1. Summary of spring chinook adults passing Wells Dam, number of broodstock collected at Winthrop National Fish Hatchery and Methow Valley Spring Chinook Hatchery, and estimate of natural spawners in the Methow Basin, 1967-2000.

Year	Wells Dam Counts				Hatchery Broodstock	Hatchery Broodstock	Natural Escapement
	Adults	Jacks	Total	Composition of Jacks	WNFH	MFH	(est.)
1967	541	616	1,157	53%	0	--	1,157
1968	4,086	845	4,931	17%	0	--	4,931
1969	3,048	551	3,599	15%	0	--	3,599
1970	2,092	578	2,670	22%	0	--	2,670
1971	2,535	633	3,168	20%	0	--	3,168
1972	3,368	248	3,616	7%	0	--	3,616
1973	2,505	507	3,012	17%	0	--	3,012
1974	3,199	221	3,420	6%	0	--	3,420
1975	2,096	129	2,225	6%	0	--	2,225
1976	1,510	1,249	2,759	45%	0	--	2,759
1977	3,976	235	4,211	6%	0	--	4,211
1978	3,532	83	3,615	2%	38	--	3,577
1979	971	132	1,103	12%	102	--	1,001
1980	941	241	1,182	20%	155	--	1,027
1971-1980 (avg)			2,831				2,801
1981	1,367	98	1,465	7%	399	--	1,066
1982	2,270	131	4,252	3%	601	--	3,651
1983	2,726	143	2,869	5%	755	--	2,114
1984	3,066	214	3,280	7%	510	--	2,770
1985	5,151	116	5,267	2%	1201	--	4,066
1986	2,896	65	2,961	2%	836	--	2,125
1987	2,272	74	2,346	3%	594	--	1,752
1988	2,844	96	2,940	3%	1327	--	1,613
1989	1,633	87	1,720	5%	195	--	1,525
1990	927	12	939	1%	121	--	818
1981-1990 (avg)			2,804			--	2,150
1991	682	100	782	13%	92	--	690
1992	1,596	27	1,623	2%	271	60	1,232
1993	2,422	22	2,444	1%	646	252	1,546
1994	243	15	258	6%	29	34	195
1995	72	41	113	36%	0	14	99
1996	388	73	461	16%	146	315	0
1997	972	32	1,004	3%	220	323	461
1998	416	14	430	3%	409	10	11
1999	360	289	649	45%	0	377	272
2000	2,130	457	2,587	18%	1,098	338	1,151/a
1991-2000 (avg)			1,035				501

/a If the ENFH fish fallback issue is taken into account the revised escapement value is 826 fish.

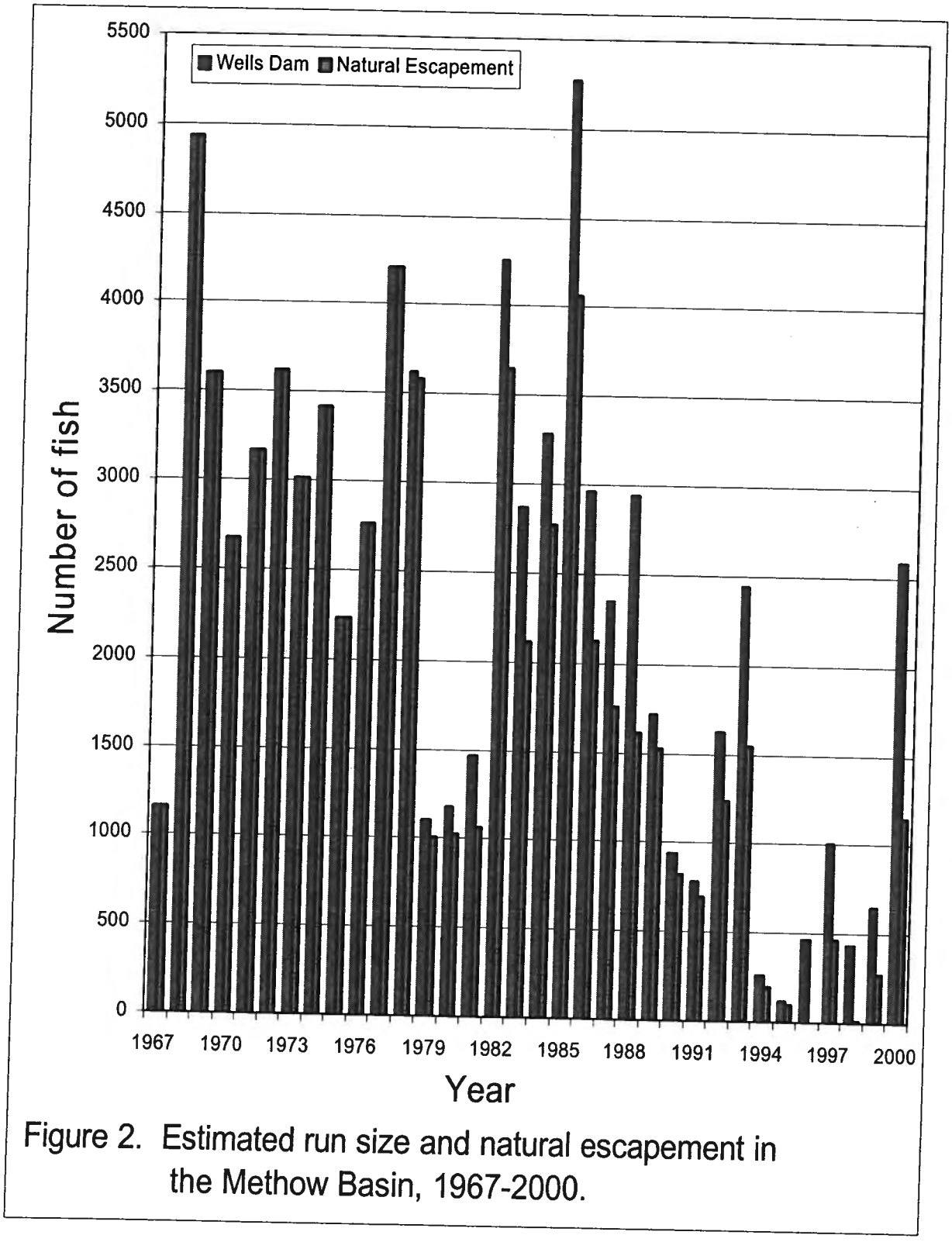

Figure 2. Estimated run size and natural escapement in the Methow Basin, 1967-2000.

Table 2. The number of 2000 brood spring chinook adults based on origin from Wells Dam, MFH and WNFH collection sites.

Stock	Wells Dam		Methow Outfall		WNFH	
	Adults	Percent	Adults	Percent	Adults	Percent
Methow Composit	96	29%	84	61%	124	14%
Twisp River	39	12%	9	7%	22	2%
Wild	7	2%	0	0%	0	0%
Carson (WNFH)	146	44%	32	23%	695	75%
ENFH	17 /a	5%	0	0%	32 /b	3%
LNFH	5	2%	0	0%	1	0%
Idaho	4	1%	0	0%	0	0%
Unknown	17	5%	12	9%	55	6%
Total	**331**	**100%**	**137**	**100%**	**929**	**100%**

/a 100% adipose clipped fish.

/b This number includes 28 adipose present fish with hatchery scale patterns.

Spawning Ground Surveys

A summary of past year's spring chinook redd counts by subbasin are presented in Appendix Table 6. The basin wide redd distribution for year 2000 is shown in Figure 3. There was 368 total redds counted in 2000. This compares to an annual mean of 40 redds for the period 1995-99, and an annual mean of 395 redds since complete surveys were initiated in 1987.

Methow

A total of 234 spring chinook redds were found in the Methow River, which comprised 63.6% of the basin total (Appendix Table 2). This includes two redds in Wolf Creek, five in the MFH outfall, 14 in the WNFH outfall (Spring Creek), and one in Foghorn ditch.

Presented in Table 3 is the number and percent of redds located above, within and below each index reach by subbasin. There were 23 (9.8%) redds located within the index reach (Mazama Bridge to Weeman Bridge). However, we estimate that all but one of these redds were lost during the fall and winter, when the river dewatered. The percentage of redds located above and below the index reach was 0.9% (2 redds) and 89.3% (209 redds), respectively.

The number of redds downstream of the Methow index reach was the highest recorded since complete surveys were initiated in 1987. The reach from Weeman Bridge to "Along-Highway 20" had the highest number of redds- 120, while the Foghorn-Chewuch confluence reach had the second most redds- 47, with most of these being deposited in the tail-out of the pool immediately downstream of Foghorn Dam. Seventy-one percent of the redds were deposited in these two reaches (51% in Weeman Bridge-"Along-Highway 20" and 20% in Foghorn-Chewuch confluence (Appendix Table 2).

September 11 was the peak week (44%) of spawning in the Methow River, while spawning extended from the week of August 28 through September 29.

The atypically high percentage (71%) of fish that spawned below the index reach appears to be the result of the run being composed of 85% in-basin hatchery origin fish (pers comm. Bob Jataff, WDFW, 2000). This is the most skewed run with respect to the wild to hatchery composition since the program was initiated. Foghorn Dam, which is situated just upstream of both hatcheries, was not determined to be an impediment to migrating adults, and thus not a factor contributing to the observed spawning distribution in the Methow. Most likely, the observed Methow spawning distribution is a consequence of returning hatchery adults not distributing to river reaches that are geographically distant from their initial acclimation site. Another factor is the availability of good spawning habitat in close proximity to both hatcheries. For example, ample spawning habitat exists near the Big Valley Ranch (RM 54.5) both in the mainstem and adjacent side channels, which is located within the Weeman Bridge-"Along-Highway 20" reach, where 51% of the redds in the Methow River were located. There were also redds located immediately below Foghorn Dam in close proximity to one another where adequate spawning habitat exists.

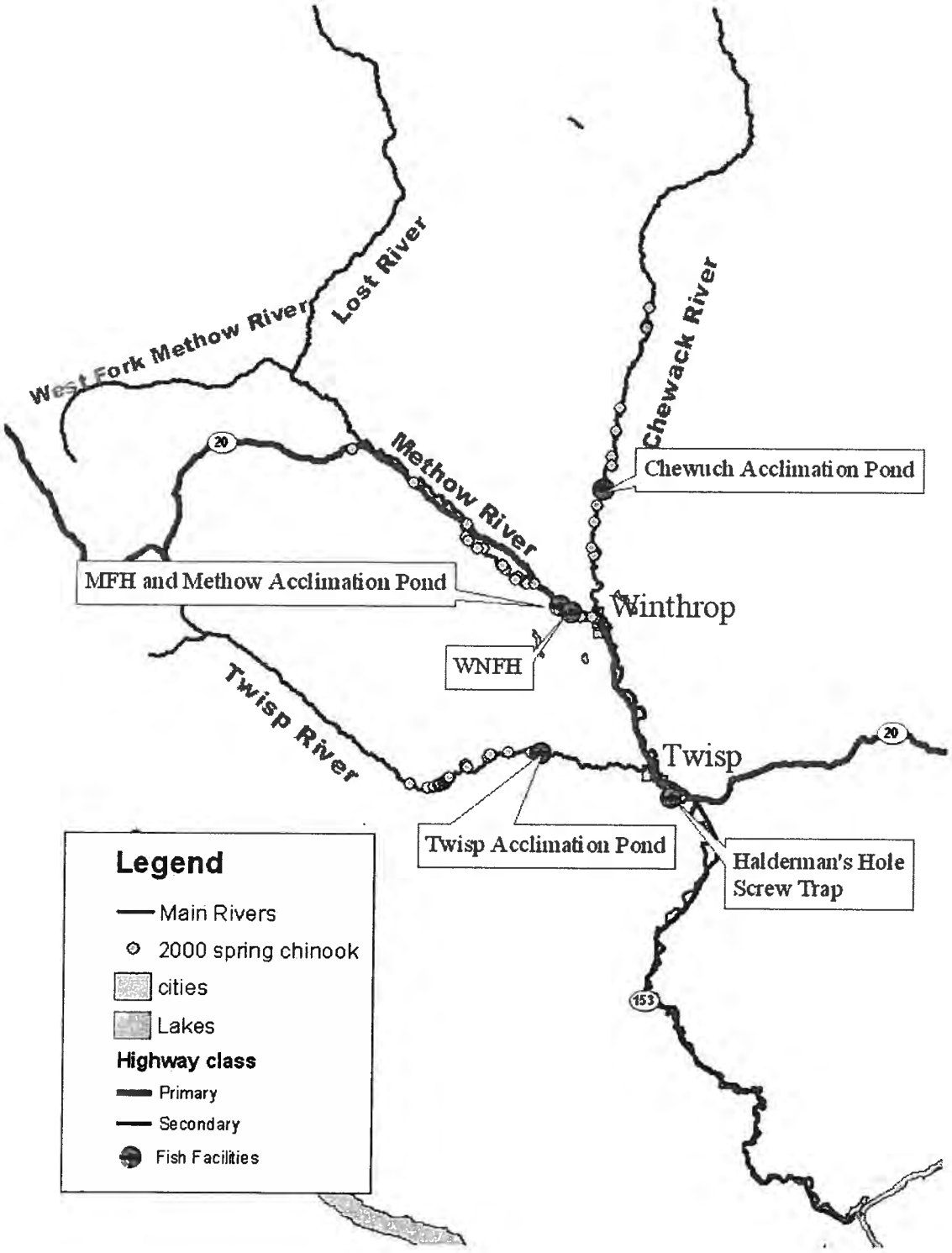

Figure 3. Spring Chinook spawning distribution and location of key sites in the Methow Basin.

Table 3. The number and percent of redds located above, within and below the index reaches in the Methow, Chewuch and Twisp basins, 1987-2000.

Year	Methow							Chewuch							Twisp						
	# of redds	% of redds	# of redds	% of redds	# of redds	% of redds	Total # of redds	# of redds	% of redds	# of redds	% of redds	# of redds	% of redds	Total # of redds	# of redds	% of redds	# of redds	% of redds	# of redds	% of redds	Total # of redds
1987	32	12.5%	75	29.3%	149	58.2%	256	38	19.9%	77	40.3%	76	39.8%	191	44	26.8%	79	48.2%	41	25.0%	164
1988	52	19.8%	82	31.3%	128	48.9%	262	51	25.2%	55	27.2%	96	47.5%	202	45	22.6%	111	55.8%	43	21.6%	199
1989	9	8.2%	60	54.5%	41	37.3%	110	22	13.8%	44	27.5%	94	58.8%	160	28	15.6%	100	55.9%	51	28.5%	179
1990	26	13.4%	80	41.2%	88	45.4%	194	34	21.5%	61	38.6%	63	39.9%	158	12	10.7%	77	68.8%	23	20.5%	112
1991	18	24.3%	31	41.9%	25	33.8%	74	17	18.7%	30	33.0%	44	48.4%	91	12	17.4%	40	58.0%	17	24.6%	69
1992	45	13.4%	90	26.8%	201	59.8%	336	38	20.5%	77	41.6%	70	37.8%	185	12	8.5%	73	51.8%	56	39.7%	141
1993	59	20.3%	92	31.7%	139	47.9%	290	23	27.7%	35	42.2%	25	30.1%	83	40	20.8%	108	56.3%	44	22.9%	192
1994	15	23.4%	8	12.5%	41	64.1%	64	5	18.5%	11	40.7%	11	40.7%	27	13	40.6%	13	40.6%	6	18.8%	32
1995	0	0.0%	7	77.8%	2	22.2%	9	2	100.0%	0	0.0%	0	0.0%	2	0	0.0%	2	50.0%	2	50.0%	4
1996 /	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0
1997	25	41.7%	4	6.7%	31	51.7%	60	2	3.6%	27	49.1%	26	47.3%	55	1	3.1%	12	37.5%	19	59.4%	32
1998 /	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0
1999	3	17.6%	2	11.8%	12	70.6%	17	0	0.0%	0	0.0%	6	100.0%	6	9	90.0%	1	10.0%	0	0.0%	10
2000	2	0.9%	23	9.8%	209	89.3%	234	1	3.1%	11	34.4%	20	62.5%	32	2	2.0%	63	63.6%	34	34.3%	99
Average	**26**	**17.8%**	**50**	**34.1%**	**97**	**57.2%**		**21**	**24.8%**	**39**	**34.1%**	**48**	**50.3%**		**20**	**23.5%**	**62**	**54.2%**	**31**	**31.4%**	

/a All fish were collected at Wells Dam for broodstock.

Lost River

Two redds were located near the confluence of the Lost and Methow rivers (Appendix Table 3). These were outside the index reach (Eureka Creek to Lost River Bridge). The Lost River accounted for 0.5% of the Methow Basin total redd count, which is well below the annual mean of 6.3% and the maximum of 11% recorded in 1989. Both redds were counted during the week of September 4.

No carcasses were found in the Lost, but two were found nearby in the Methow (Lost River Confluence-Gate Creek reach). Both were females; the first age four from WNFH, while the other was age five and wild.

Chewuch River

A total of 32 redds were deposited in the Chewuch River (Appendix Table 5), which comprised 8.7% of the Methow basin total. Eleven redds were located in the index reach (Camp-Four Bridge to Falls Creek Campground). This is comparable to the annual mean of 34.1% of the redds being located in the index reach (Table 3). One redd was located above and 20 redds below the index reach, respectively.

The peak spawn week (72%) in the Chewuch River occurred September 4, and spawning extended from the week of August 28 through September 26.

Twisp River

A total of 99 redds were located in the Twisp River (Appendix Table 4); with the majority of spawning occurred upstream of the Twisp acclimation pond (RM 5). Eighty-nine percent of the spawning occurred upstream to Little Bridge Creek. Sixty-three were redds deposited within the index reach (Mystery bridge to Buttermilk bridge), which is somewhat higher than the annual mean of 54.2% redds located within the index reach (Table 3). Two redds were located above the index reach, and 34 were located below the index reach.

Peak spawning (37%) in the Twisp River occurred the week of August 28, and spawning extended from the week of August 14 through September 18.

Other Tributaries

One redd was found near the diversion on Early Winters Creek. Surveys at the end of the season found no spring chinook redds in Lake, Twenty-Mile and Boulder creeks (Chewuch drainage), Gold Creek (Methow drainage), or Little Bridge Creek (Twisp drainage).

Carcass Distribution And Length Distribution

A total of 178 carcasses were recovered in the entire Methow Basin, of these 22 (12%) were of natural origin and 156 (78%) were of hatchery origin. A summary of CWT recoveries by hatchery release groups within specific reaches of the Methow, Chewuch and Twisp subbasins is presented in Figure 4.

Summary By Subbasin

Chewuch

Within the Chewuch 13 carcasses were recovered, of these, eight were of natural origin and five hatchery origin. Four CWTs were recovered from carcasses collected in the Chewuch with one CWT from each of the following releases:

Chewuch 97 (63/06/14)	1 fish
Methow 96 (63/01/30)	1 fish
Winthrop 96 (05/44/53)	1 fish
Enitiat 96 (05/37/07)	1 fish

One hatchery fish (adipose clipped) was recovered with no CWT present.

Methow

Within the Methow River 117 carcasses were recovered. The natural to hatchery origin composition was 11 and 106 fish, respectively. The composition of CWT recoveries was as follows:

Methow 96 (63/01/30)	43 fish
Methow 96 (63/63/15)	1 fish
Methow 97 (63/06/13)	2 fish
Chewuch 97 (63/06/14)	3 fish
Twisp 96 (63/61/14)	4 fish
Winthrop 96 (05/36/31)	6 fish
Winthrop 96 (05/38/56)	10 fish
Winthrop 96 (05/44/53)	8 fish
Winthrop 96 (05/46/11)	2 fish

Three CWTs were subsequently lost during dissection. There were seven adipose present carcasses without CWTs, but with a hatchery scale pattern that were most likely of ENFH origin (since this was only known adipose present without being CWT'ed returning to the mid-Columbia). Finally, 20 adipose clipped carcasses were recovered and were not able to be identified to stock origin.

Twisp

A total of 48 carcasses were recovered in the Twisp River, of these two were of natural origin and 46 of hatchery origin. Of the hatchery origin carcasses, six were most likely of ENFH origin (adipose present and without a CWT), 35 carcasses had a CWT and the remaining five no tag was present or recovered.

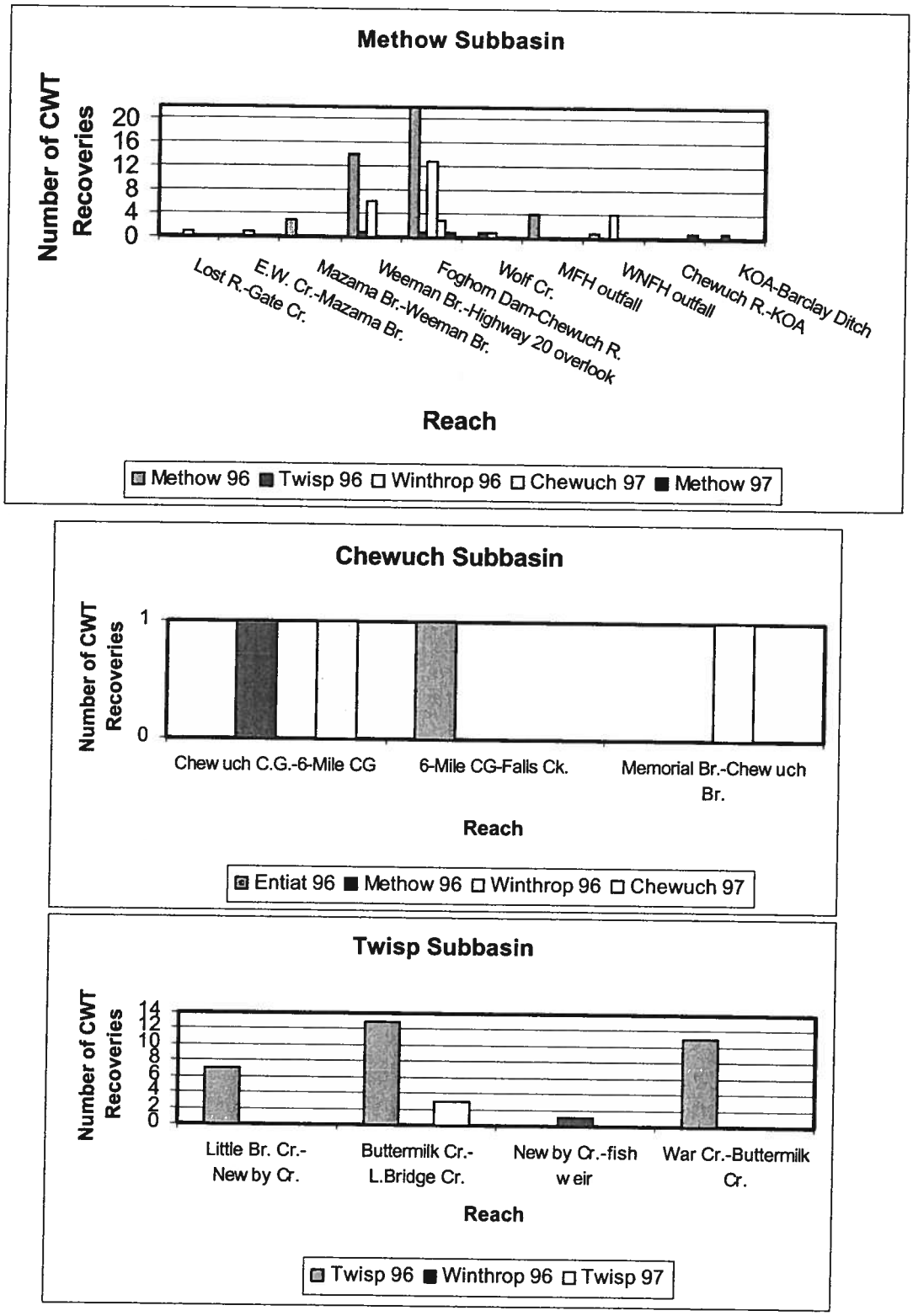

Figure 4. Summary of coded-wire-tag recoveries by release group within the Methow, Chewuch and Twisp subbasins in 2000.

The composition of CWT recoveries was as follows:

Twisp 96 (63/61/14)	26 fish
Twisp 96 (63/63/16)	5 fish
Twisp 97 (63/04/34)	3 fish
Winthrop 96 (05/36/31)	1 fish

Distribution By Release Group

The distribution of carcass recoveries by hatchery release group in the Methow, Chewuch and Twisp subbasins in presented in Figure 5. A total of 45 Methow-96 CWTs were successfully read from carcasses, of which 44 were recovered in the Methow River and one from the Chewuch River.

A total of 35 Twisp-96 CWTs were successfully read from recovered carcasses. Of these, 31 were recovered within the Twisp River and the other four were recovered in the Methow River.

A total of 28 Winthrop-96 carcasses were recovered and their CWT successfully read. Twenty-six of them were located in the Methow River and one each in the Chewuch and Twisp rivers.

Of the four Chewuch CWTs recovered and read, one was located in the Chewuch River while the remaining three were found in the Methow River.

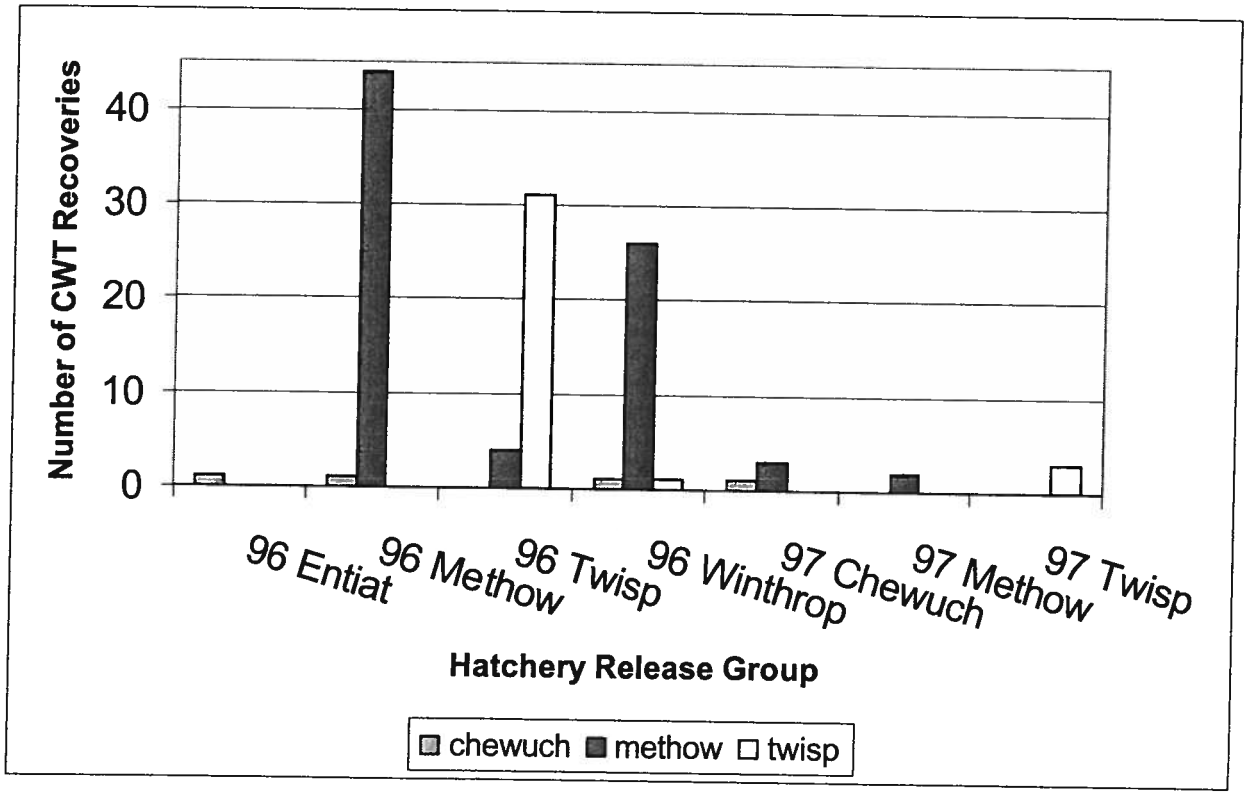

Figure 5. Summary of coded-wire-tag recoveries by release group throughout the Methow Basin in 2000.

One Entiat-96 CWT located in the Chewuch River successfully recovered and read.

Two Methow-97 CWTs were successfully recovered and read from carcasses in the Methow River, and three Twisp-97 CWTs were similarly recovered in the Twisp River.

Carcass Length Distribution

Figures 6-8 depict the fork length frequency of carcasses (not stock specific) recovered from the three subbasins. In the Methow the mean fork length of adults was 72 cm, and ranged from 52 cm to 104 cm. The mean fork length of adults in the Chewuch was 79 cm, with fish ranging from 56 cm to 93 cm. The mean fork length of adults in the Twisp was 72 cm, with a range of 53 cm to 84 cm.

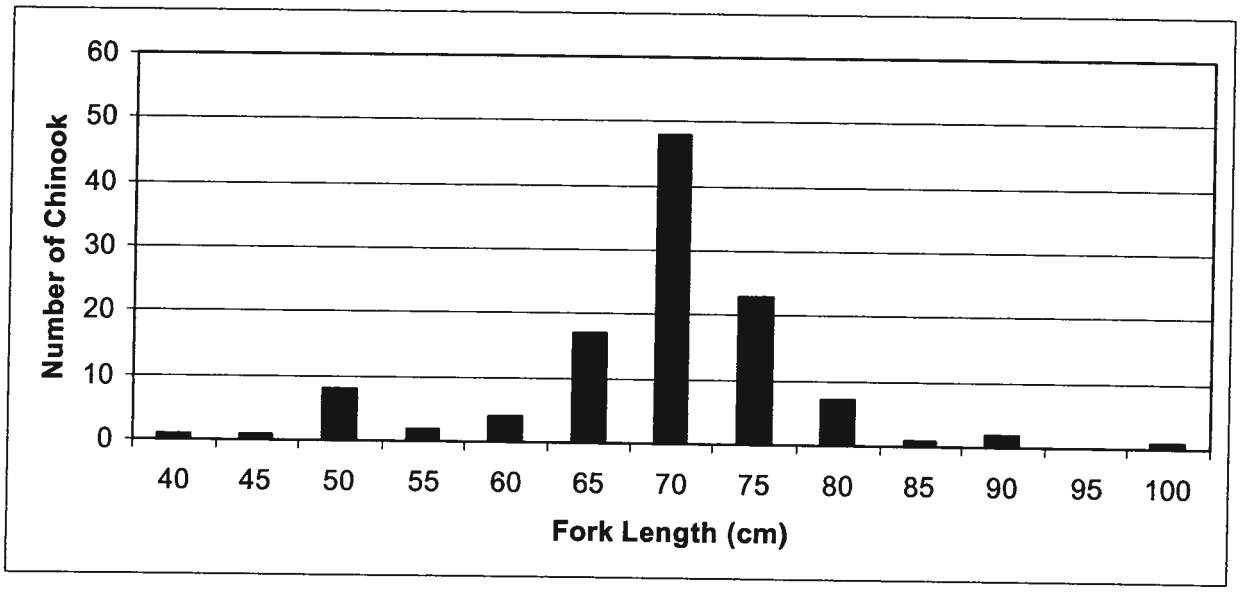

Figure 6. Fork length frequency of spring chinook carcasses collected from the Methow River in 2000.

Age Composition

A summary of the spring chinook age composition based on scales collected from carcasses in the Methow, Chewuch and Twisp subbasins is presented in Table 4.

A total of 123 hatchery scales were successfully read. Within the group of hatchery fish across all

Table 4. Summary of spring chinook age composition based on readable scales collected from carcasses in the Methow Basin, 2000.

River	Hatchery		Wild		
	Age-3	Age-4	Age-3	Age-4	Age-5
Methow	5	76	3	3	3
Chewuch	1	3	0	0	4
Twisp	3	35	0	1	1

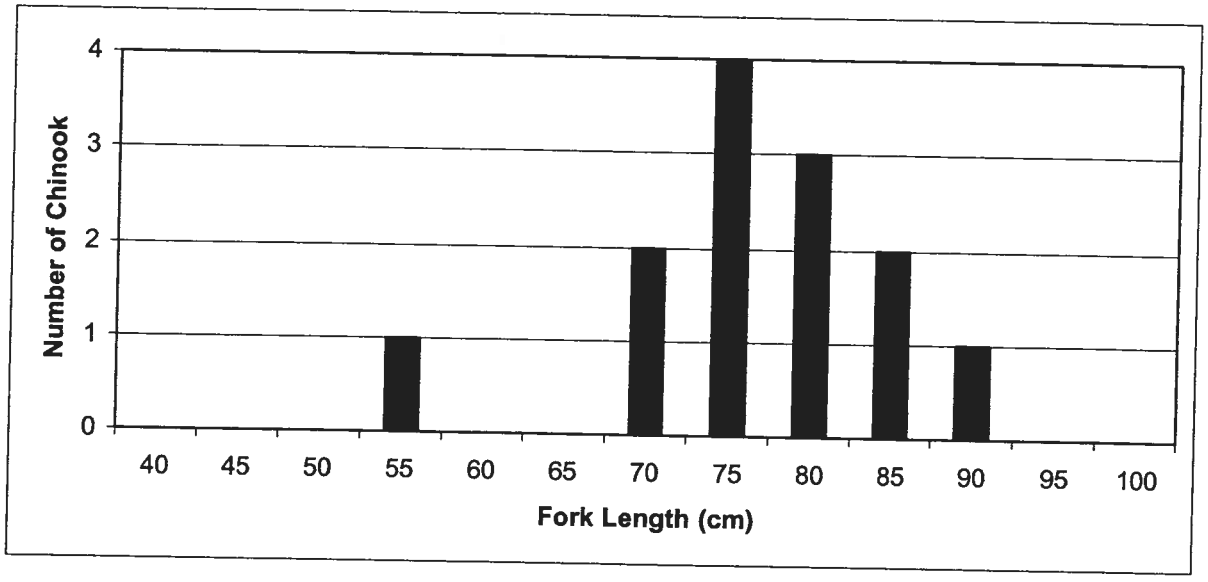

Figure 7. Fork length frequency of spring chinook carcasses collected from the Chewuch River in 2000.

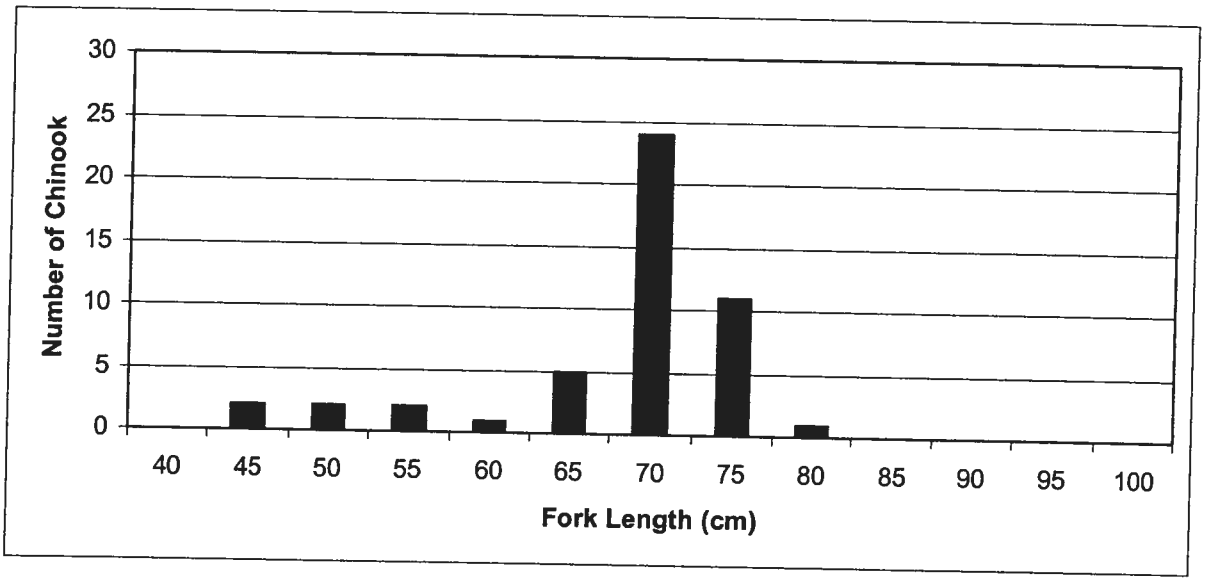

Figure 8. Fork length frequency of spring chinook carcasses collected from the Twisp River in 2000.

three subbasins all of the adults (age 4 or 5) were examined were age-4. Overall 7% of the hatchery fish in the Methow Basin were age-3 (jacks) and 93% age-4 adults. Wild fish age composition across the Methow Basin was 20% (N=3) age-3 (jacks), 27% (N= 4) age-4 and 53% (N= 8) age-5.

Juvenile Outmigration

Spring Chinook

Estimated daily spring chinook outmigrants are summarized in Appendix Table 7. During the monitoring period (October 5 – December 12) an estimated 1,414 spring chinook outmigrants passed the Halderman's Hole monitoring site. This estimate is based upon the direct percent river flow entrained by the rotary trap. The estimate is noticeably lower- 829 fish, if based upon the percent of spring chinook entrained into the trap from the three efficiency test releases (mean equaled 68%). The 25%, 50% and 75% dates of cumulative passage for spring chinook were, respectively, October 15, October 27 and November 8. There were three peak periods of outmigration, which occurred October 12 and 25 and November 21. In all cases there was no apparent association with either river flow or water temperature. River flow remained essentially constant throughout the monitoring period. Stream flow ranged from 207 cfs to 337 cfs, with a mean flow of 268 cfs and a standard deviation of 30.7. To be expected, water temperature declined throughout the monitoring period. In October the water temperature was 7° C or greater and ranged between 7 to 11° C; while water temperatures in November remained above freezing, ranging between 1 to 8° C. During the first week in December temperatures ranged between 3 to 5° C.

The mean spring chinook fork length was 102 mm (S.D. = 11.6) and ranged from 70 to 141 mm (Figure 9). With the exception of a few fish, all are considered to be of age-0.

Steelhead

A total of 60 *O. mykiss* fish were captured during the monitoring period. Since no efficiency test releases were made for *O. mykiss* only the absolute number of fish captured is reported. The numbers of outmigrating fish increased from October (25%) to November (53%), and into December, where 22% (13) of the fish were collected during the first week, after which monitoring ceased.

Steelhead/rainbow trout ranged in fork length from 72 to 301 mm (Figure 10), and had a mean fork length of 151 mm (S.D. = 49.6). The wide distribution in length indicates the presence of several year classes.

Other Species

Non-target fish species captured in the rotary trap are presented in Appendix Table 8. Mountian Whitefish (*Prosopium coulteri*) was the most common fish (104) collected, followed by dace (*Rhinichthys spp*)- 16, sculpins (*Cottus spp*)- 8, summer chinook (*O. tshawytscha*)- 5, 1 lamprey- 4, suckers (*Catostomus spp*)- 3, redside shiner (*Richardsonius balteatus*)-2, bulltrout (*Salvelinus Malma*)- 2, cutthroat trout (*O. Clarki*)- 2 and sockeye (*O. nerka*)-1.

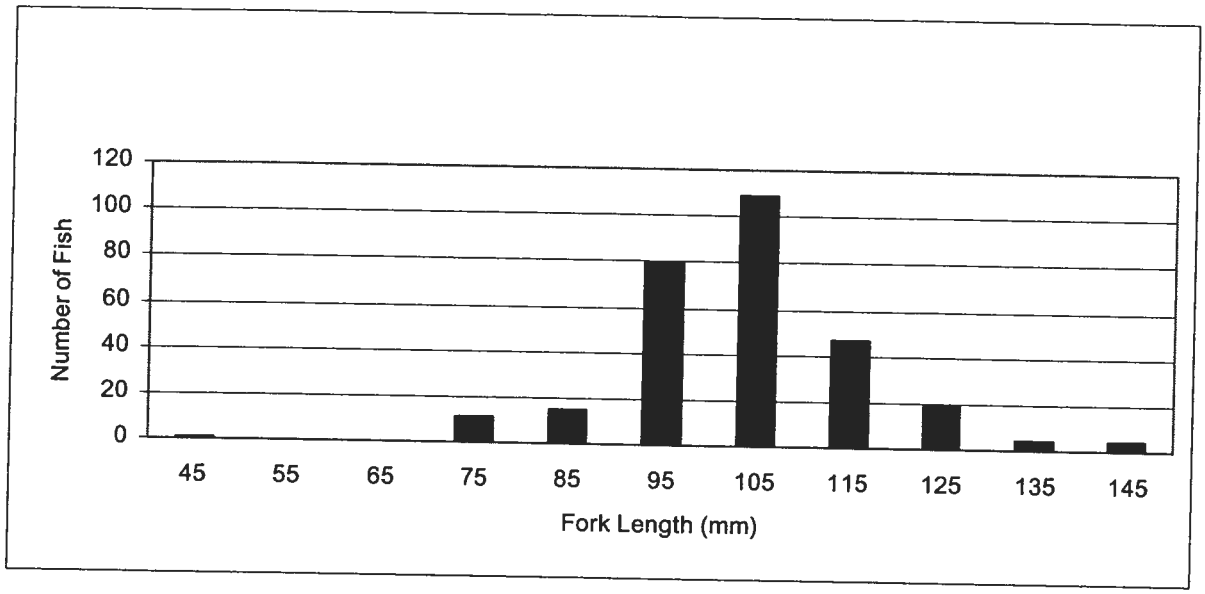

Figure 9. Fork length frequency of juvenile chinook captured in the rotary trap, fall 2000.

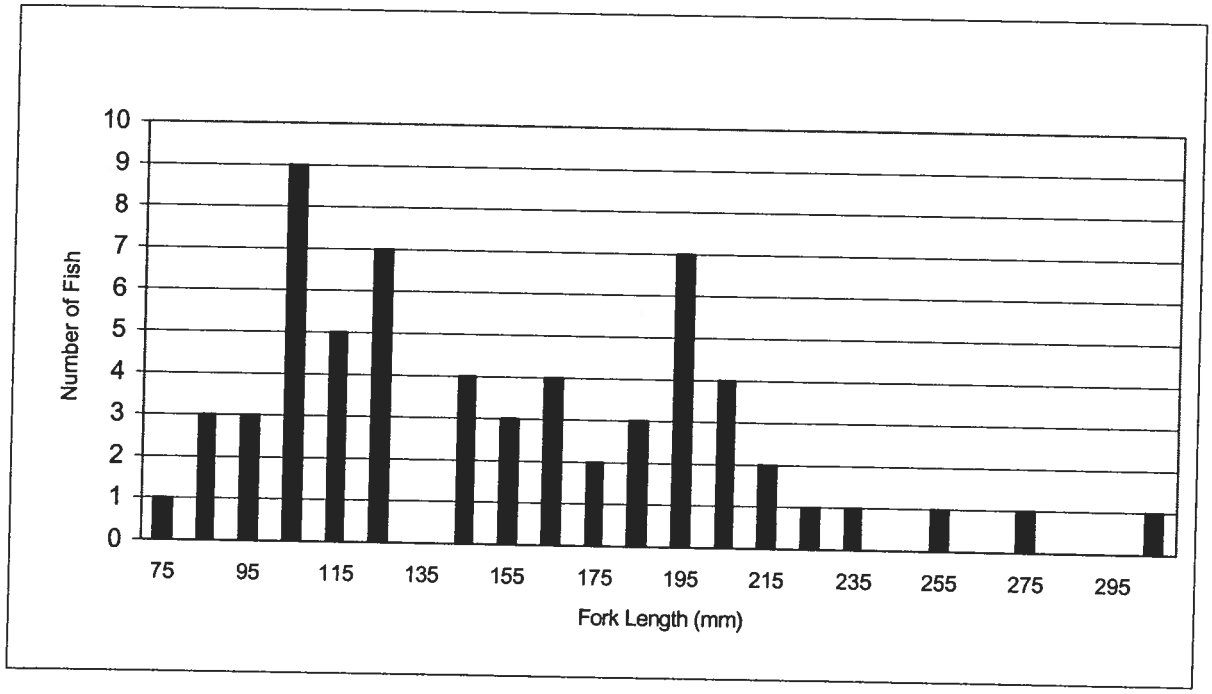

Figure 10. Fork length frequency of juvenile *O. mykiss* captured in the rotary trap, fall 2000.

Conclusions

Management Considerations

The uniqueness of the 2000 return being dominantly comprised of hatchery origin fish has raised two issues that will require future decision-making on both the technical and management levels. First, it's quite apparent, at least in the Methow River that the spawning distribution in 2000 shifted downstream, with the majority of fish spawning downstream to Weeman Bridge. Twenty percent of the redds were located between Foghorn Dam and the Chewuch River confluence. This may suggest that the supplementation objective of getting hatchery spawners to distribute throughout the Methow River in portion to the historic spawning distribution is not succeeding in the Methow. As previously stated in this document, it appears this is a function of both suitable spawning habitat near the two hatcheries and the acclimation and release of hatchery smolts from the MFH and WNFH. This phenomenon was not observed in either the Twisp or Chewuch rivers. It's believed that the lack of both quantity and quality of spawning habitat in the vicinity of each respective acclimation site force fish to migrate upstream into the index reaches, where most of the spawning historically occurs and where the most suitable spawning habitat exists. Future consideration needs to be made of relocating the Methow acclimation site further upstream nearer the traditional spawning reaches. Additionally, this needs to be considered for fish cultured at the WNFH.

Secondly, and indirectly related to the first issue, is the need to include in years when possible, a higher proportion of natural fish in the broodstock collection. The issue at hand is whether the MBSCSP is unwontedly moving incrementally towards a "concrete-to-concrete" type hatchery program especially in the Methow. For the Methow population the manner in which broodstock is collected needs to be revisited. Clearly, few if any natural spawners ever volunteer into the WNFH or the MFH broodstock holding ponds, thus the issue of tributary and/or Wells Dam broodstock collection needs to be further discussed. It's acknowledged that low run sizes in recent years have forced the Program to deviate somewhat from its original objectives.

Thirdly, given the low redd counts in the Lost River in recent years consideration should be given by technical and management makers to determining supplementation objectives for this population.

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APPENDICES

Appendix Table 1. Derivation of estimated natural escapement and fish per redd ratio.

Appendix Table 2. Methow subbasin survey schedule and redd counts, 2000.

Appendix Table 3. Lost River and Early Winters Creek survey schedules and redd counts, 2000.

Appendix Table 4. Chewuch subbasin survey schedule and redd counts, 2000.

Appendix Table 5. Twisp subbasin survey schedule and redd counts, 2000.

Appendix Table 6. Summary of Methow Basin Spring Chinook Redd Counts, 1987-2000.

Appendix Table 7. Daily juvenile chinook counts, adjustments for non-fishing time, and extrapolation for trapping efficiency for the rotary trap, fall 2000.

Appendix Table 8. Daily counts of non-chinook species captured from the rotary trap, Fall 2000.

Appendix Table 1. Derivation of estimated natural escapement and fish per redd ratio.

Part A. Total run, broodstock and escapement counts

	Adults	Jacks	Total
Count past Wells Dam	2130	457	2587
Collected at Wells Dam	296	42	338
Collected at MFH	133	23	156
Collected at WNFH	854	88	942
Estimated natural escapement	847	304	1151

Part B. Total carcass data

	Adults	Jacks	Total
adipose present hatchery fish released below Wells Dam	64	14	78
adipose present hatchery carcasses on spawning grounds	13	0	13
CWT'ed ENFH carcasses on spawning grounds	1	0	1
Total carcasses located in Methow basin	178	0	178

Part C. Total redds located in Methow basin

	Redds
Methow, Lost, Early Winters Creek, Chewuch and Twisp	368

Part D. Calculations to derive ENFH fallback & fish/redd

Number of ENFH fish collected at Wells Dam		95
Total number of fish collected Wells (338 fish + 78 fish)	÷	416
Estimated run composition (%) of ENFH		**23%**
Total number of fish past Wells Dam		2,249
Estimated run composition (%) of ENFH	x	23%
Estimated number of ENFH fish past Wells Dam		**514**
Total number of carcasses		178
Number of ENFH carcasses	÷	14
Percent of ENFH carcasses (spawning grounds)		**8%**
Estimated uncorrected spawner escapement		1,151
Percent of ENFH carcasses (spawning grounds)	x	8%
Estimated ENFH fish that spawned in Methow		**91**
Estimated number of ENFH fish past Wells Dam		514
Estimated number of ENFH fish comprising natural escapement (91 fish + 32 fish collected at WNFH)	-	123
Estimated fallback of ENFH fish		**391**
Estimated uncorrected spawner escapement		1151
Estimated fallback of ENFH fish	-	391
Estimated corrected spawner escapement		**760**
Estimated corrected spawner escapement		760
Total number of redds in the Methow basin	÷	368
Fish per Redd Ratio		**2.1**

Appendix Table 2. Methow subbasin survey schedule and redd counts, 2000.

River Section	Section number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9*	
		7/31	8/7	8/14	8/21	8/28	9/4	9/11	9/18	9/25	Total
Trout Cr. - Ballard cmp. gr.	--										0
Ballard cmp. gr. - Lost R.	1	0		0	0			0	0		0
Lost R. - Gate Cr.	2				0	0	0	0	0		0
Gate Cr. - Early Winters Cr.	3	0			0		0		0		0
Early Winters Cr. - Mazama Br.	4	0	0		0		2	0	0		2
Mazama Br. - Rd. barrier	**5**	**0**	**0**	**0**	**0**	**0**	**4**	**1**	**0**	**0**	**5**
Rd. barrier - Weeman Br.	**6**	**0**	**0**	**0**	**0**	**6**	**5**	**0**	**5**	**2**	**18**
Weeman Br. - Along Highway 20	7		0	0		16	31	69	4	0	120
Along Highway 20 - Wolf Cr.	8		0	0		0	3	0	0	0	3
Wolf Cr. - Foghorn Dam	9		0	0		0	6	3	5		14
Foghorn Dam - Chewuch Confluence	10		0	0		5	12	30	0		47
Chewuch Conf. - KOA Campground	11					0				3	3
											0
Wolf Creek						2			0		2
Methow Hatchery outfall						4		0		1	5
Spring Creek (Winthrop H. outfall)							7		1	6	14
Foghorn Ditch										1	1
		0	0	0	0	33	70	103	15	13	234

* Includes data from weeks after 9/25

Appendix Table 3. Lost River and Early Winters Creek survey schedules and redd counts, 2000.

River Section	Section number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	
Lost River		7/31	8/7	8/14	8/21	8/28	9/4	9/11	9/18	9/25	Total
Sunset Cr. - Eureka Cr.	1		0								0
Eureka Cr. - Lost R. Rd. Br.	**2**		**0**	**0**		**0**	**0**		**0**		**0**
Lost R. Rd. Br. - confluence	3	0	0	0	0	0	2	0			2
Early Winters Creek											0
Klipchuch cmp. gr. - Early Winters Br.	1										0
Early Winters Br. - Highway 20 Br.	2				0			0			0
Highway 20 Br. - diversion dam	3		0		0			0			0
Diversion dam - Highway 20 Br.	4		0			1			0		1
Highway 20 Br. - confluence	5					0			0		0
						0			0		0
		0	0	0	0	1	2	0	0	0	3

Appendix Table 4. Chewuch subbasin survey schedule and redd counts, 2000.

River Section	Section number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9 *	
		7/31	8/7	8/14	8/21	8/28	9/4	9/11	9/18	9/25	Total
falls - 30 mi. Br.	1				0						0
30 mi. Br. - road-side cmp.	2		0		0		0		0		0
Rd. side cmp. - Andrews Cr.	3		0		0		0	0	0		0
Andrews Cr. - Lake Cr.	4		0		0		0	0	0		0
Lake Cr. - Buck Cr.	5				0		0	0	0		0
Buck Cr. - camp 4	6	0	0	0	0	0	0	0	0	1	1
camp 4 - road-side cmp.	**7**		**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**2**
road-side cmp. - Chewuch cmp. gr.	**8**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**3**
Chewuch cmp. gr. - mile 6 cmp.	**9**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**		**4**
mile 6 cmp. - Falls Cr. cmp. gr.	**10**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**2**
Falls Cr. cmp. gr. - 8 mile ranch	11	0			0	0	3	0	0	1	4
8 mile ranch - Memorial Br.	12	0	0		0	0	7		0		7
Memorial Br. - Chewuch Br.	13	0	0		0	0	0		0	1	1
Chewuch Br. - halfway pt.	14	0		0		1	1		0	1	3
halfway pt. - confluence	15			0		0	4		0	1	5
		0	0	0	0	1	23	0	2	6	32

* Includes data from weeks after 9/25

Appendix Table 5. Twisp subbasin survey schedule and redd counts, 2000.

River Section	Section number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	
		7/31	8/7	8/14	8/21	8/28	9/4	9/11	9/18	9/25	Total
Rd. end cmp. gr. - up 2 mi.	1		0	0							0
Rd. end cmp. gr. - South Cr. Br.	2		0	0			2		0		2
South Cr. Br. - Popular Flats cmp. gr.	3	0	0	0			0		0		0
Popular Flats cmp. gr. - Mystery Br.	4	0		0			0		0		0
Mystery Br. - War Cr. Br.	**5**	**0**	**0**	**0**	**5**	**10**	**0**		**0**	**0**	**15**
War Cr. Br. - cabin	**6**	**0**	**0**	**1**	**7**	**17**	**0**		**5**	**0**	**30**
cabin - Buttermilk Br.	**7**	**0**	**0**	**0**	**8**	**6**			**4**	**0**	**18**
Buttermilk Br. - green Br.	8		0	1	0		1	0	3	0	5
green Br. - Little Br. Cr.	9			0	0		15	0	3	0	18
Little Cr. Br. - Newby Cr. Br.	10			0	0	1		0	3		4
Newby Cr. Br. - fish weir	11			0	0	3			1		4
fish weir - wooden Br.	12			0					2		2
wooden Br. - Poorman's Br.	13		0						1		1
Poorman's Br. - Twisp R. Br.	14		0						0		0
Twisp R. Br. - confluence	15		0	0				0	0		0
		0	0	2	20	37	18	0	22	0	99

Appendix Table 6. Summary of Methow Basin Spring Chinook Redd Counts, 1987-2000.

River	Survey Reach	Number of redds and corresponding percentages.					
		1987	1988	1989	1990	1991	1992
Lost River							
Index Reach	Eureka Ck-Lost R. Bridge	52	53	53	31	16	71
		92.9%	100.0%	93.0%	93.9%	100.0%	97.3%
Below Index Reach	Lost R. Br-Confluence	4	0	4	2	0	2
		7.1%	0.0%	7.0%	6.1%	0.0%	2.7%
	Annual Lost Total	56	53	57	33	16	73
	Annual Percent of Methow Basin	8.2%	7.2%	11.0%	6.6%	6.4%	9.9%
Early Winters Cr.							
	Klipchuck C.G.-Hwy Bridge	6	8	5	0	0	2
		42.9%	47.1%	45.5%	0.0%	0.0%	66.7%
	Highway Br.-Confluence	8	9	6	1	0	1
		57.1%	52.9%	54.5%	100.0%	0.0%	33.3%
	Annual Early Winters Total	14	17	11	1	0	3
	Annual Percent of Methow Basin	2.1%	2.3%	2.1%	0.2%	0.0%	0.4%
Methow River							
Above Index Reach	Lost R. Conf.-Mazama Bridge	32	52	9	26	18	45
		12.5%	19.8%	8.2%	13.4%	24.3%	13.4%
	Number of Redds Above The Index Reach	**32**	**52**	**9**	**26**	**18**	**45**
	Percent of Redds Above The Index Reach	**12.5%**	**19.8%**	**8.2%**	**13.4%**	**24.3%**	**13.4%**
Index Reach	Mazama Br.-Weeman Bridge	75	82	60	80	31	90
		29.3%	31.3%	54.5%	41.2%	41.9%	26.8%
Below Index Reach	Weeman Br.-Winthrop Bridge	131	121	37	74	21	173
		51.2%	46.2%	33.6%	38.1%	28.4%	51.5%
	Winthrop Bridge-Twisp Bridge	16	7	2	7	3	21
		6.3%	2.7%	1.8%	3.6%	4.1%	6.3%
	Twisp Bridge-Carlton Bridge	2		2	7	1	7
		0.8%	0.0%	1.8%	3.6%	1.4%	2.1%
	Number of Redds Below The Index Reach	**149**	**128**	**41**	**88**	**25**	**201**
	Percent of Redds Below The Index Reach	**58.2%**	**48.9%**	**37.3%**	**45.4%**	**33.8%**	**59.8%**
	Annual Methow Total	256	262	110	194	74	336
	Annual Percent of Methow Basin	37.6%	35.7%	21.3%	39.0%	29.6%	45.5%

Appendix Table 6 Cont'. Summary of Methow Basin Spring Chinook Redd Counts, 1987-2000.

River	Survey Reach	Number of redds and corresponding percentages.					
		1987	1988	1989	1990	1991	1992
Chewuch River							
Above Index Reach	30 Mile Bridge-Andrews Creek	17	25	1	16	6	12
		8.9%	12.4%	0.6%	10.1%	6.6%	6.5%
	Andrews Creek-Lake Creek	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Lake Creek-Camp-4 Bridge	21	26	21	18	11	26
		11.0%	12.9%	13.1%	11.4%	12.1%	14.1%
	Number of Redds Above The Index Reach	**38**	**51**	**22**	**34**	**17**	**38**
	Percent of Redds Above The Index Reach	**19.9%**	**25.2%**	**13.8%**	**21.5%**	**18.7%**	**20.5%**
Index Reach	Camp-4 Bridge-Falls Creek Campground	77	55	44	61	30	77
		40.3%	27.2%	27.5%	38.6%	33.0%	41.6%
Below Index Reach	Falls Creek Campground-Chewuch Bridge	54	63	52	42	16	61
		28.3%	31.2%	32.5%	26.6%	17.6%	33.0%
	Chewuch Bridge-Confluence	22	33	42	21	28	9
		11.5%	16.3%	26.3%	13.3%	30.8%	4.9%
	Number of Redds Below The Index Reach	**76**	**96**	**94**	**63**	**44**	**70**
	Percent of Redds Below The Index Reach	**39.8%**	**47.5%**	**58.8%**	**39.9%**	**48.4%**	**37.8%**
	Annual Chewuch Total	191	202	160	158	91	185
	Annual Percent of Methow Basin	28.0%	27.6%	30.9%	31.7%	36.4%	25.1%
Twisp River							
Above Index Reach	upstream-South Creek	5	3	0	0	0	0
		3.0%	1.5%	0.0%	0.0%	0.0%	0.0%
	South Creek-Mystery Bridge	39	42	28	12	12	12
		23.8%	21.1%	15.6%	10.7%	17.4%	8.5%
	Number of Redds Above The Index Reach	**44**	**45**	**28**	**12**	**12**	**12**
	Percent of Redds Above The Index Reach	**26.8%**	**22.6%**	**15.6%**	**10.7%**	**17.4%**	**8.5%**
Index Reach	Mystery Bridge-Buttermilk Bridge	79	111	100	77	40	73
		48.2%	55.8%	55.9%	68.8%	58.0%	51.8%
Below Index Reach	Buttermilk Bridge-Little Bridge \a	29	27	41	19	17	16
		17.7%	13.6%	22.9%	17.0%	24.6%	11.3%
	Little Bridge-Confluence \b	12	16	10	4	0	40
		7.3%	8.0%	5.6%	3.6%	0.0%	28.4%
	Number of Redds Below The Index Reach	**41**	**43**	**51**	**23**	**17**	**56**
	Percent of Redds Below The Index Reach	**25.0%**	**21.6%**	**28.5%**	**20.5%**	**24.6%**	**39.7%**
	Annual Twisp Total	164	199	179	112	69	141
	Annual Percent of Methow Basin	24.1%	27.1%	34.6%	22.5%	27.6%	19.1%
Annual Basin Total		681	733	517	498	250	738

\a in 1987 survey ended at Newby Cr.

\b in 1987 survey started at Newby Cr.

\c in 1996 & 1998 all fish were collected at Wells Dam for broodstock.

Appendix Table 6 Cont'. Summary of Methow Basin Spring Chinook Redd Counts, 1987-2000.

River	Number of redds and corresponding percentages.						
	1994	1995	1996 /c	1997	1998 /c	1999	2000
Lost River							
Index Reach	6	0	na	7	na	0	0
	100.0%	0.0%	na	0.0%	na	0.0%	0.0%
Below Index Reach	0	0	na	0	na	3	2
	0.0%	0.0%	na	0.0%	na	100.0%	100.0%
	6	0	na	7	na	3	2
	4.5%	0.0%	na	4.7%	na	8.3%	0.5%
Early Winters Cr.							
	4	0	na	0	na	0	0
	100.0%	0.0%	na	0.0%	na	0.0%	0.0%
	0	0	na	0	na	0	1
	0.0%	0.0%	na	0.0%	na	0.0%	100.0%
	4	0	na	0	na	0	1
	3.0%	0.0%	na	0.0%	na	0.0%	0.3%
Methow River							
Above Index Reach	15	0	na	25	na	3	2
	23.4%	0.0%	na	44.6%	na	17.6%	0.9%
	15	**0**	**na**	**25**	**na**	**3**	**2**
	23.4%	**0.0%**	**na**	**44.6%**	**na**	**17.6%**	**0.9%**
Index Reach	8	7	na	4	na	2	23
	12.5%	77.8%	na	7.1%	na	11.8%	9.8%
Below Index Reach	39	2	na	27	na	11	206
	60.9%	22.2%	na	48.2%	na	64.7%	88.0%
	2	0	na	0	na	1	3
	3.1%	0.0%	na	0.0%	na	5.9%	1.3%
	0	0	na	0	na	0	0
	0.0%	0.0%	na	0.0%	na	0.0%	0.0%
	41	**2**	**na**	**31**	**na**	**12**	**209**
	64.1%	**22.2%**	**na**	**48.2%**	**na**	**70.6%**	**89.3%**
	64	9	na	56	na	17	234
	48.1%	60.0%	na	37.3%	na	47.2%	63.6%

Appendix Table 6 Cont'. Summary of Methow Basin Spring Chinook Redd Counts, 1987-2000.

River	Number of redds and corresponding percentages.						
	1994	1995	1996 /c	1997	1998 /c	1999	2000
Chewuch River							
Above Index Reach	2	0	na	0	na	0	0
	7.4%	0.0%	na	0.0%	na	0.0%	0.0%
	0	0	na	0	na	0	0
	0.0%	0.0%	na	0.0%	na	0.0%	0.0%
	3	2	na	2	na	0	1
	11.1%	100.0%	na	3.6%	na	0.0%	3.1%
	5	**2**	**na**	**2**	**na**	**0**	**1**
	18.5%	**100.0%**	**na**	**3.6%**	**na**	**0.0%**	**3.1%**
Index Reach	11	0	na	27	na	0	11
	40.7%	0.0%	na	49.1%	na	0.0%	34.4%
Below Index Reach	1	0	na	22	na	5	12
	3.7%	0.0%	na	40.0%	na	83.3%	37.5%
	10	0	na	4	na	1	8
	37.0%	0.0%	na	7.3%	na	16.7%	25.0%
	11	**0**	**na**	**26**	**na**	**6**	**20**
	40.7%	**0.0%**	**na**	**47.3%**	**na**	**100.0%**	**62.5%**
	27	2	na	55	na	6	32
	20.3%	13.3%	na	36.7%	na	16.7%	8.7%
Twisp River							
Above Index Reach	0	0	na	1	na	0	2
	0.0%	0.0%	na	3.1%	na	0.0%	2.0%
	13	0	na	0	na	9	0
	40.6%	0.0%	na	0.0%	na	90.0%	0.0%
	13	**0**	**na**	**1**	**na**	**9**	**2**
	40.6%	**0.0%**	**na**	**3.1%**	**na**	**90.0%**	**2.0%**
Index Reach	13	2	na	12	na	1	63
	40.6%	50.0%	na	37.5%	na	10.0%	63.6%
Below Index Reach	6	0	na	12	na	0	23
	18.8%	0.0%	na	37.5%	na	0.0%	23.2%
	0	2	na	7	na	0	11
	0.0%	50.0%	na	21.9%	na	0.0%	11.1%
	6	**2**	**na**	**19**	**na**	**0**	**34**
	18.8%	**50.0%**	**na**	**59.4%**	**na**	**0.0%**	**34.3%**
	32	4	na	32	na	10	99
	24.1%	26.7%	na	21.3%	na	27.8%	26.9%
Annual Basin Total	133	15	na	150	na	36	368

\a in 1987 survey ended at Newby Cr.

\b in 1987 survey started at Newby Cr.

\c in 1996 & 1998 all fish were collected at Wells Dam for broodstock.

Appendix Table 7. Estimated daily spring chinook outmigrants for the rotary trap, Fall 2000.

Date	Hours trap fished per day	Chinook daily absolute fish count /a	Mean daily discharge (CFS)	Percent discharge into trap	Spring chinook extrapolation based on percent flow entrained	Temperature (Centigrade)	Spring chinook extrapolation based on mark-recapture efficiency
10/5/00	14:00	12	301	40%	30	10	18
10/6/00	0:00	13	298	40%	32	9	18
10/7/00	0:00	13	301	40%	33	10	19
10/8/00	0:00	14	297	40%	34	10	20
10/9/00	0:00	14	297	40%	36	10	21
10/10/00	0:00	15	297	40%	37	10	22
10/11/00	0:00	15	291	40%	39	12	23
10/12/00	0:25	16	288	40%	40	11	24
10/13/00	22:55	11	284	40%	27	11	16
10/14/00	9:30	10	282	40%	25	10	15
10/15/00	0:00	9	278	41%	22	8	13
10/16/00	0:00	8	279	41%	20	9	12
10/17/00	1:15	7	284	40%	17	11	10
10/18/00	23:10	3	284	40%	7	11	4
10/19/00	6:50	1	284	40%	2	8	1
10/20/00	8:30	2	288	40%	5	8	3
10/21/00	23:45	3	297	40%	8	8	4
10/22/00	0:00	11	294	40%	28	8	17
10/23/00	0:00	20	290	40%	49	8	29
10/24/00	0:40	28	290	40%	70	8	41
10/25/00	23:45	30	284	40%	74	8	44
10/26/00	0:00	17	284	40%	42	8	25
10/27/00	23:45	18	284	40%	45	8	26
10/28/00	0:00	18	312	39%	45	8	26
10/29/00	0:00	17	337	38%	45	8	25
10/30/00	0:00	17	310	39%	43	9	25
10/31/00	0:00	16	298	40%	41	8	24
11/1/00	0:00	16	294	40%	40	9	23
11/2/00	0:00	15	285	40%	38	7	23
11/3/00	21:20	15	284	40%	37	7	22
11/4/00	16:20	3	293	40%	8	8	4
11/5/00	0:00	4	293	40%	9	7	5
11/6/00	0:00	4	284	40%	11	7	6
11/7/00	23:50	5	277	41%	12	6	7
11/8/00	23:15	4	293	40%	10	5	6
11/9/00	23:25	5	295	40%	13	6	7
11/10/00	0:05	2	283	40%	5	6	3
11/11/00	22:15	3	266	41%	7	4	4
11/12/00	22:30	1	260	42%	2	4	1
11/13/00	22:30	1	264	41%	2	4	1
11/14/00	22:20	7	257	42%	17	-	10
11/15/00	20:45	8	237	43%	19	-	12
11/16/00	14:51	3	251	42%	7	4	4
11/17/00	23:07	4	244	43%	9	4	6
11/18/00	22:10	3	231	43%	7	4	4
11/19/00	7:35	10	230	44%	24	4	15
11/20/00	0:00	18	246	42%	42	5	26
11/21/00	17:15	25	234	43%	58	3	37
11/22/00	23:20	11	220	44%	25	1	16
11/23/00	0:10	5	236	43%	12	4	7
11/24/00	0:00	0	228	44%	16	3	0
11/25/00	0:30	1	229	44%	2	3	1
11/26/00	22:20	5	232	43%	12	3	7
11/27/00	0:25	5	227	44%	11	3	7
11/28/00	23:20	1	209	45%	2	1	1
11/29/00	1:15	3	245	43%	7	3	4
11/30/00	23:14	6	239	43%	14	5	9
12/1/00	23:20	4	233	43%	9	5	6
12/2/00	21:25	2	232	43%	5	5	3
12/3/00	23:55	0	227	44%	0	5	0
12/4/00	23:45	2	207	45%	4	3	3
12/5/00	17:10	4	229	44%	9	4	6
12/6/00	22:00	3	226	44%	7	4	4
12/7/00	21:30	3	222	44%	7	3	4
Fish totals		569			1,414		829

a/ Red highlighted numbers denote days where the daily fish count was interpolated due to the trap being operated less than 24 hours per day.

Appendix Table 8. Daily absolute counts of non-chinook species captured for the rotary trap, Fall 2000.

Date	Steelhead (<130 mm)	Steelhead (>=130 mm)	Mountain Whitefish	Dace	Bulltrout	Sculpin	Suckers	Summer Chinook	Sockeye	Cutthroat	Redside Shiner	Lamprey
10/5/01	1	2	4	3	0	0	0	0	0	0	0	0
10/6/01	0	0	0	0	0	0	0	0	0	0	0	0
10/7/01	0	0	0	0	0	0	0	0	0	0	0	0
10/8/01	0	0	0	0	0	0	0	0	0	0	0	0
10/9/01	0	0	0	0	0	0	0	0	0	0	0	0
10/10/01	0	0	0	0	0	0	0	0	0	0	0	0
10/11/01	0	0	0	0	0	0	0	0	0	0	0	0
10/12/01	1	1	0	2	1	0	0	1	0	0	0	0
10/13/01	0	2	2	2	0	0	0	0	0	0	0	0
10/14/01	0	0	0	0	0	0	0	0	0	0	0	0
10/15/01	0	0	0	0	0	0	0	0	0	0	0	0
10/16/01	0	0	0	0	0	0	0	0	0	0	0	0
10/17/01	2	2	17	0	0	1	0	1	1	0	0	0
10/18/01	2	1	3	0	0	0	0	0	0	0	0	0
10/19/01	0	0	0	0	0	0	0	0	0	0	0	0
10/20/01	0	0	0	0	0	0	0	0	0	0	0	0
10/21/01	0	1	0	0	0	0	0	0	0	0	0	0
10/22/01	0	0	0	0	0	0	0	0	0	0	0	0
10/23/01	0	0	0	0	0	0	0	0	0	0	0	0
10/24/01	3	2	7	0	0	0	0	0	0	0	0	0
10/25/01	3	3	3	2	0	0	1	2	0	0	0	0
10/26/01	2	5	1	0	0	0	1	1	0	1	1	0
10/27/01	1	1	6	0	0	0	0	0	0	0	0	0
10/28/01	0	0	0	0	0	0	0	0	0	0	0	0
10/29/01	0	0	0	0	0	0	0	0	0	0	0	0
10/30/01	0	0	0	0	0	0	0	0	0	0	0	0
10/31/01	0	0	0	0	0	0	0	0	0	0	0	0
11/1/01	0	0	0	0	0	0	0	0	0	0	0	0
11/2/01	0	0	0	0	0	0	0	0	0	0	0	0
11/3/01	0	3	6	0	0	0	0	0	0	0	0	0
11/4/01	1	0	0	0	0	0	0	0	0	0	0	0
11/5/01	0	0	0	0	0	0	0	0	0	0	0	0
11/6/01	0	0	0	0	0	0	0	0	0	0	0	0
11/7/01	0	0	3	1	0	0	1	0	0	0	0	0
11/8/01	0	0	1	0	0	0	0	0	0	0	0	0
11/9/01	0	0	0	0	0	0	0	0	0	0	0	0
11/10/01	0	0	1	1	0	0	0	0	0	0	0	0
11/11/01	0	0	6	0	0	0	0	0	0	0	0	0
11/12/01	1	0	3	0	0	0	0	0	0	0	0	0
11/13/01	0	1	0	0	0	0	0	0	0	0	1	0
11/14/01	0	0	0	0	0	0	0	0	0	0	0	0
11/15/01	1	1	0	1	0	0	0	0	0	0	0	0
11/16/01	0	1	0	0	0	0	0	0	0	0	0	0
11/17/01	0	0	0	0	0	1	0	0	0	0	0	0
11/18/01	0	0	1	1	0	0	0	0	0	0	0	0
11/19/01	0	0	0	0	0	0	0	0	0	0	0	0
11/20/01	0	0	0	0	0	0	0	0	0	0	0	0
11/21/01	1	2	3	0	0	0	0	0	0	0	0	1
11/22/01	1	0	2	0	0	0	0	0	0	0	0	0
11/23/01	5	2	3	0	0	0	0	0	0	0	0	0
11/24/01	0	0	0	0	0	0	0	0	0	0	0	0
11/25/01	0	1	6	1	0	0	0	0	0	0	0	0
11/26/01	1	0	6	0	0	0	0	0	0	0	0	0
11/27/01	0	0	1	1	0	0	0	0	0	0	0	1
11/28/01	0	1	1	0	0	0	0	0	0	0	0	0
11/29/01	0	0	4	0	0	0	0	0	0	0	0	0
11/30/01	0	0	1	0	0	2	0	0	0	0	0	1
12/1/01	0	0	0	0	1	0	0	0	0	0	0	0
12/2/01	2	0	0	0	0	0	0	0	0	0	0	0
12/3/01	0	0	0	1	0	1	0	0	0	0	0	0
12/4/01	0	0	0	0	0	2	0	0	0	0	0	0
12/5/01	0	0	0	0	0	1	0	0	0	0	0	1
12/6/01	0	1	13	0	0	0	0	0	0	0	0	0
12/7/01	0	0	0	0	0	0	0	0	0	1	0	0
Totals	28	33	104	16	2	8	3	5	1	2	2	4

METHOW BASIN SPRING CHINOOK NATURAL PRODUCTION STUDY REPORT FOR 2001

APPENDIX H

Methow Basin Spring Chinook Natural Production Study Report For 2001

Prepared by

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Fisheries Resource Management Program
Yakama Nation

Prepared for

Public Utility District No. 1 of Douglas County

East Wenatchee, WA

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INTRODUCTION

The Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) is a compensation program directed towards the enhancement of the wild spring chinook (*O. tshawytscha*) stocks in the Methow Basin. The MBSCSP is the result of the Wells Settlement Agreement between the fishery agencies, tribes, Douglas PUD and the power purchasers of the Wells Project. The goal of this agreement is to compensate for unavoidable losses of juvenile anadromous fishes at Wells Dam. The stated purpose of the MBSCSP "...is to increase natural propagation of salmon in the Methow, Chewuch, and Twisp rivers in a manner that minimizes or eliminates ecological and genetic risks to the natural population.", through a monitored hatchery supplementation plan. The settlement agreement requires that the MBSCSP be operated according to procedures outlined by the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC, 1987). A specific outcome is that the MBSCSP "be capable of collecting, rearing, and releasing three potentially discrete stocks of salmon"(Methow, Chewuch and Twisp), which is part of the Phase I compensation requirements under the settlement agreement.

Spring chinook spawner surveys in the Methow Basin are a monitoring and evaluation task, which is a component of the MBSCSP. Under Objective 2, Task 2.9 (Natural Production section) of the MBSCSP spawner surveys are conducted to evaluate various attributes (i.e., spawning behavior and geographic distribution) between natural and hatchery spawners. The entire monitoring and evaluation plan is presented in Appendix D of the MBSCSP document, which will provide the reader context for where spawner surveys mesh with other tasks of the evaluation program. Basin wide spring chinook spawning ground surveys have been conducted since 1987. In 1996 and 1998 no spawner surveys were conducted since nearly all spring chinook were collected at Wells Dam for broodstock.

STUDY AREA

The Methow River Basin is located in north-central Washington on the eastern slope of the Cascade Mountains (Figure 1). The Methow River and its tributaries lie in Okanogan County and drain an area of nearly 1,800 square miles. The headwaters of the Methow River are located near the Cascade Crest at an elevation of 6,000 feet and drops to 779 feet where it joins the Columbia River at Pateros, WA. The upper portion of the Methow River is heavily forested, predominantly with ponderosa pine. This area is used extensively for recreation and is experiencing a considerable amount of growth especially residential and commercial development. The lower Methow valley is a fertile agricultural area that experiences heavy irrigation demands. Water quality in the lower Methow Basin nonetheless remains high, with an AA rating from the Washington Department of Ecology. Spring chinook spawning in the Methow River extends from about Trout Creek (river mile 78) to about 2 miles downstream of the Chewuch River confluence (RM 48).

The Chewuch River joins the Methow River at RM 50, at an elevation of 1,745 feet. These two rivers join in the city of Winthrop. The Chewuch basin covers 530 square miles and drains in a southern direction into the Methow River. The upper portion of the Chewuch River is located in the Pasayten Wilderness (above RM 32.4) and is heavily forested. Spring chinook spawn downstream from river mile 31.5, which is also used extensively for recreation and residential development.

The Twisp basin encompasses about 250 square miles of watershed and enters the Methow River at near RM 40. The elevation descends from 8,500 ft to 1,600 ft and drains in a southeast direction. The headwater and upslope areas lay within the Lake Chelan-Sawtooth Wilderness. Spring chinook spawning has extended upstream to South Creek (RM ~28).

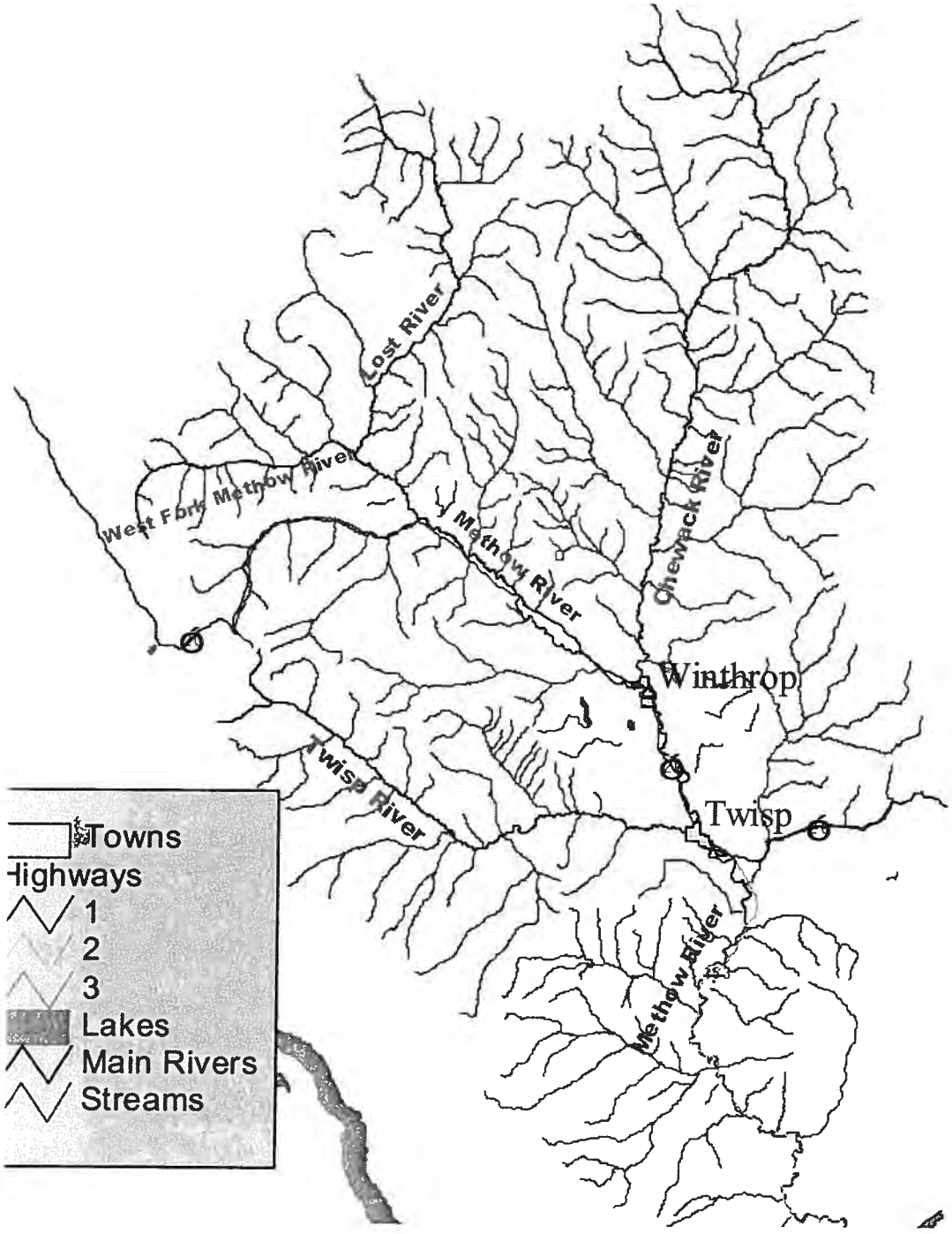

Figure 1. Map of the middle and upper Methow Basin.

METHODS AND MATERIALS

Spawning Surveys

Redd Surveys

Surveys were primarily conducted in the Methow, Lost, Chewuch and Twisp rivers, and in Early Winters Creek. The historical index reaches were normally surveyed weekly, while those reaches where nominal spawning occurs were normally surveyed bi-weekly. All spawning reaches where redds normally are located were surveyed at least once during or after the historic peak spawning period. The historic index reaches are the following:

- Methow: Weeman bridge to Mazama bridge (6.2 river miles)
- Lost: Lost River Bridge to the Eureka Creek (4.2 river miles)
- Early Winters: Highway 20 Bridge to Cedar Creek (1.9 river miles)
- Chewuch: Falls Creek Campground to Camp Four Bridge (6.8 river miles)
- Twisp: Buttermilk Creek Bridge to the Mystery Creek Bridge (10.1 river miles)

Regular surveys began August 1 and continued through September 28, with additional spot-checks conducted afterward. Appendix Tables 1 - 4 present the complete week-by-week survey schedule and redd counts.

Surveys were conducted in the upper Methow, Lost, Chewuch and Twisp rivers, and in Early Winters Creek. Raft or canoe surveys were conducted in the Methow River downstream from Mazama Bridge, according to river flows. To ensure survey consistency, the same survey crew was normally assigned to the same spawning reach. However, for quality control purposes a different crew occasionally surveyed another crew's survey reach. To avoid recounting or missing a previously counted redd, each redd was marked with surveyor's tape on the riverbank adjacent to the redd. Written on each posted tape were the consecutive redd number and survey date. A global positioning system unit (GPS) was also used to locate many of the redds, usually to an accuracy of 15 feet.

Carcasses were recovered and checked for sex, tags, fin clips, and spawning success. Scales and DNA samples were collected when possible from each carcass, and fork length and post eye-to-hypural plate length was recorded. The snouts was taken from carcasses with an adipose clip for later dissection and reading of the coded-wire-tag.

Juvenile Outmigration

The feasibility of operating an eight-foot diameter rotary trap (EG Solutions, Corvallis, OR) in the Methow River at RM 38.5 ("Halderman's hole") for the spring smolt outmigration (target species spring chinook) was conducted March 31 through May 1, 2001. The trap ceased operation the afternoon of April 13 and began again operation on April 17. This was to allow for passage of large numbers of MFH hatchery spring chinook smolt releases. The trap was not operated the period of April 21-26 because of both debris issues due to an increase in river discharge, which also coincided with the hatchery release of steelhead smolts upriver. The trap was redeployed on April

30, but was prematurely terminated on May 1 when an excessive number of hatchery steelhead mortalities occurred (exceeding NMFS' take level).

The daily flow pattern for the period the trap was in operation was based on the USGS gauge stations called, "Methow River at Winthrop" (#12448500) on the Methow, and the "Twisp River near Twisp "(#12448998) located at the Twisp River confluence. The actual discharge at the trap site was probably somewhat less depending on the amount of flow being diverted for irrigation upstream of the trap. River discharge began to increase significantly on April 25 from a mean based flow of approximately 240 cfs for the seven days preceding this date. River discharge peaked on April 28 at a mean daily flow of 564 cfs.

Trap calibration efficiency tests were not conducted during the period of trap operation.

Trap checks were normally performed in the morning. Fish were netted from the live box and anesthetized using MS-222 at a dosage of approximately 40 ppm. Data recorded from fish sampled included species identification, fork length, weights (subsampled), maturity (fry, parr or smolt) and external marks. Fish were allowed to recover and released downstream near the trap later that same morning.

RESULTS AND DISCUSSION

Spawning Ground Surveys

Introduction

Summary of the Methow Basin spring chinook run size and spawner escapement for years 1967-2001 is presented in Table 1 and Figure 2. The estimated 2001 spring chinook run size to Wells Dam was 10,871 (9,994 adults; 877 jacks).

Total broodstock collected by the Methow Fish Hatchery (MFH) was 874 fish (Table 1). No broodstock collection occurred at Winthrop National Fish Hatchery (WNFH) in 2001. The percent adults and jacks was 83.7% and 16.2%, respectively. Broodstock collection was derived as follows: 761 spring chinook (619 adults, 142 jacks) were collected at MFH; 48 fish were taken from the Twisp weir (34 wild and 14 hatchery); and 65 fish were collected at Fulton Dam on the Chewuch River (27 wild and 38 hatchery). The estimated spawner escaped derived by subtracting the Wells Dam count from fish taken for broodstock was 9,997 (Table 1).

In the Methow Basin 4,399 redds were counted; and were distributed as follows: Methow River- 2,828; Lost River- 72; Early Winters Creek- 17; Chewuch River- 1,105; and the Twisp River- 371 redds.

There was a mean of 2.3 fish per redd.

Methow

The 2,828 redds located in the Methow River comprised 64.3% of the basin total (Appendix Table 1). This included 22 redds located in the MFH outfall and 86 redds located in the WNFH outfall (Spring Creek). Unlike in recent years 21 redds were located between the Chewuch River confluence and the MVID East diversion dam.

An estimated 183 (6.5%) redds became naturally dewatered within the Methow River, most of which were located from the Lost River confluence (RM 73.0) to approximately RM 60.8 (near McKinney Mountain diversion).

There were 415 (14.7%) redds located within the index reach (Mazama Bridge to Weeman Bridge). The percentage of redds located above and below the index reach was 4.3% (18 redds) and 84.7% (2,395 redds), respectively (Table 2).

Since 1995 the majority of spawning has occurred downstream of Weeman Bridge (RM 59.8). For the period 1987-95 the average percent of total redds within the Methow river located below Weeman Bridge was 41.7%. For the period 1997-2001 redd counts below Weeman Bridge have

Table 1. Summary of spring chinook adults passing Wells Dam, number of broodstock collected at Winthrop National Fish Hatchery and Methow Fish Hatchery and estimate of natural spawners in the Methow Basin, 1967-2001.

Year	Wells Dam Counts				Hatchery Broodstock WNFH	Hatchery Broodstock MFH	Natural Escapement (est.)
	Adults	Jacks	Total	Composition of Jacks			
1967	541	616	1,157	53%	0	–	1,157
1968	4,086	845	4,931	17%	0	–	4,931
1969	3,048	551	3,599	15%	0	–	3,599
1970	2,092	578	2,670	22%	0	–	2,670
1971	2,535	633	3,168	20%	0	–	3,168
1967-71	**2,460**	**645**	**3,105**	**25%**	**0**	–	**3,105**
1972	3,368	248	3,616	7%	0	–	3,616
1973	2,505	507	3,012	17%	0	–	3,012
1974	3,199	221	3,420	6%	0	–	3,420
1975	2,096	129	2,225	6%	0	–	2,225
1976	1,510	1,249	2,759	45%	0	–	2,759
1972-71	**2,536**	**471**	**3,006**	**16%**	**0**	–	**3,006**
1977	3,976	235	4,211	6%	0	–	4,211
1978	3,532	83	3,615	2%	38	–	3,577
1979	971	132	1,103	12%	102	–	1,001
1980	941	241	1,182	20%	155	–	1,027
1981	1,367	98	1,465	7%	399	–	1,066
1977-81	**2,157**	**158**	**2,315**	**9%**	**139**	–	**2,176**
1982	2,270	131	4,252	3%	601	–	3,651
1983	2,726	143	2,869	5%	755	–	2,114
1984	3,066	214	3,280	7%	510	–	2,770
1985	5,151	116	5,267	2%	1201	–	4,066
1986	2,896	65	2,961	2%	836	–	2,125
1982-86	**3,222**	**134**	**3,726**	**4%**	**781**	–	**2,945**
1987	2,272	74	2,346	3%	594	–	1,752
1988	2,844	96	2,940	3%	1327	–	1,613
1989	1,633	87	1,720	5%	195	–	1,525
1990	927	12	939	1%	121	–	818
1991	682	100	782	13%	92	–	690
1987-91	**1,672**	**74**	**1,745**	**5%**	**466**	–	**1,280**
1992	1,596	27	1,623	2%	271	60	1,232
1993	2,422	22	2,444	1%	646	252	1,546
1994	243	15	258	6%	29	34	195
1995	72	41	113	36%	0	14	99
1996	388	73	461	16%	146	315	0
1992-96	**944**	**36**	**980**	**12%**	**218**		**614**
1997	972	32	1,004	3%	220	323	461
1998	416	14	430	3%	409	10	11
1999	360	289	649	45%	0	377	272
2000	2,130	457	2,587	18%	1,098	338	1,151/a
2001	9,994	877	10,871	8%	0	874	9,997
1997-2001	**2,774**	**334**	**3,108**	**15%**	**345**		**2,685**

/a If the ENFH fish fallback issue is taken into account the revised escapement value is 826 fish.

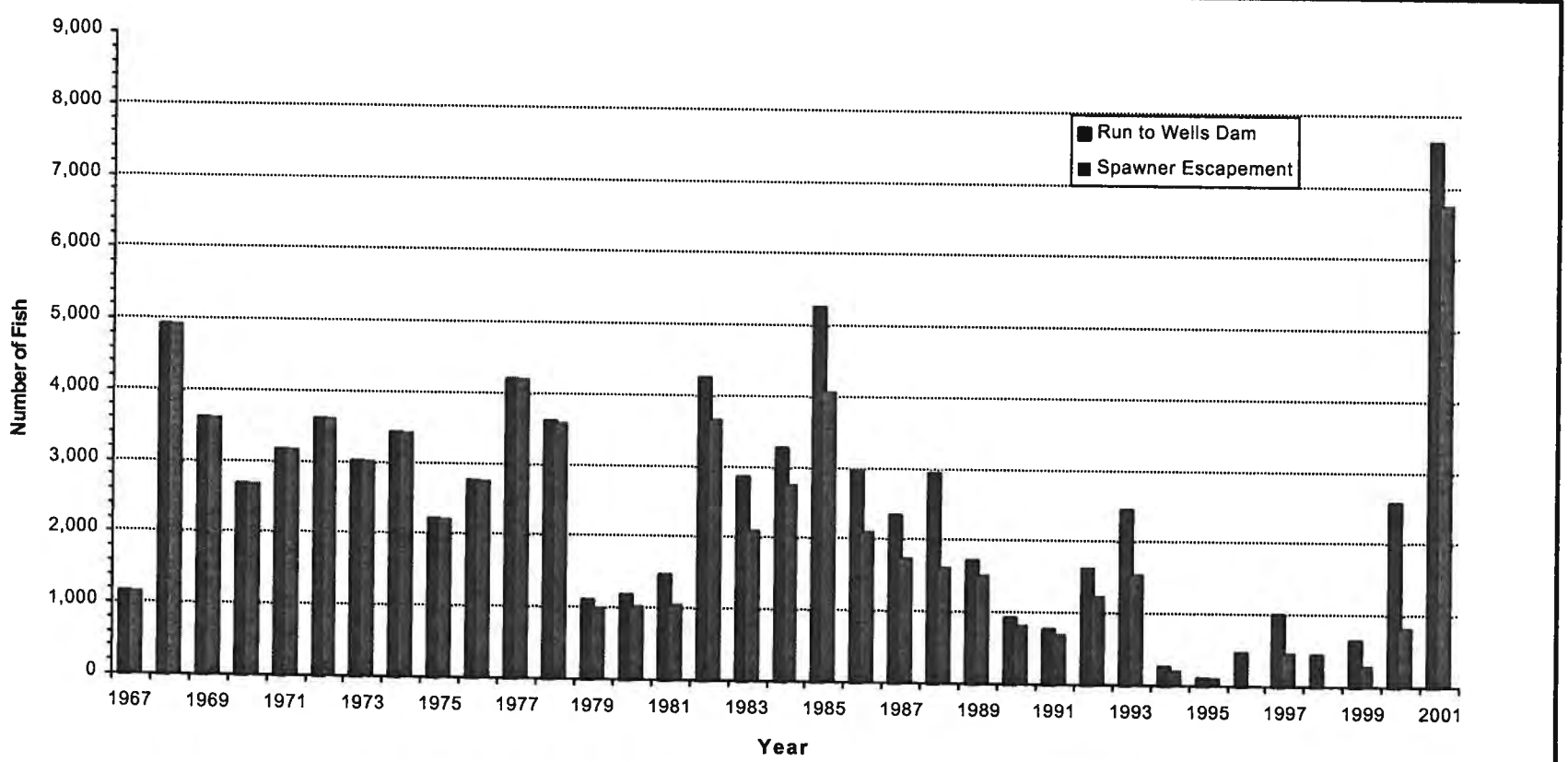

Figure 2. Estimated run size and natural escapement in the Methow Basin.

Table 2. The number and percent of redds located above, within and below the index reaches in the Methow, Chewuch and Twisp basins, 1987-2001.

	Methow River							Chewuch River							Twisp River						
	Above		Within		Below		Total	Above		Within		Below		Total	Above		Within		Below		Total
Year	No. of redds	% of redds					Total														
1987	32	12.5	75	29.3	149	58.2	256	38	19.9	77	40.3	76	39.8	191	44	26.8	79	48.2	41	25.0	164
1988	52	19.8	82	31.3	128	48.9	262	51	25.2	55	27.2	96	47.5	202	45	22.6	111	55.8	43	21.6	199
1989	9	8.2	60	54.5	41	37.3	110	22	13.8	44	27.5	94	58.8	160	28	15.6	100	55.9	51	28.5	179
1990	26	13.4	80	41..2	88	45.4	194	34	21.5	61	38.6	63	39.9	158	12	10.7	77	68.8	23	20.5	112
1991	18	24.3	31	41.9	25	33.8	74	17	18.7	30	33.0	44	48.4	91	12	17.4	40	58.0	17	24.6	69
1992	45	13.4	90	26.8	201	59.8	336	38	20.5	77	41.6	70	37.8	185	12	8.5	73	51.8	56	39.7	141
1993	59	20.3	92	31.7	139	47.9	290	23	27.7	35	42.2	25	30.1	83	40	20.8	108	56.3	44	22.9	192
1994	15	23.4	8	12.5	41	64.1	64	5	18.5	11	40.7	11	40.7	27	13	40.6	13	40.6	6	18.8	32
1995	0	0.0	7	77.8	2	22.2	9	2		0	0.0	0	0.0	2	0	0.0	2	50.0	2	50.0	4
1987 -95	**28**	**15.0**	**58**	**38.6**	**90**	**46.4**	**177**	**26**	**29.5**	**43**	**32.3**	**53**	**38.1**	**122**	**23**	**18.1**	**67**	**53.9**	**31**	**28.0**	**121**
1996	—																				
1997	25	41.7	4	6.7	31	51.7	60	2	3.6	27	49.1	26	47.3	55	1	3.1	12	37.5	19	59.4	32
1998	—																				
1999	3	17.6	2	11.8	12	70.6	17	0	0.0	0	0.0	6		6	9	90.0	1	10.0	0	0.0	10
2000	2	0.9	23	9.8	209	89.3	234	1	3.1	11	34.4	20	62.5	32		2.0	63	63.6	34	34.3	99
2001	18	0.6	415	14.7	2395	84.7	2828	39	3.5	243	22.0	823	74.5	1105	2	0.8	224	60.4	144	38.8	371
1996 -01	12	15.2	111	10.7	662	74.1	785	11	2.6	70	26.4	219	71.1	300	3	24.0	75	42.9	49	33.1	128
Avg.	**23**	**15.1**	**75**	**30.0**	**266**	**54.9**	**364**	**21**	**21.2**	**52**	**30.5**	**104**	**48.2**	**177**	**4**	**19.9**	**69**	**50.5**	**37**	**29.5**	**123**

comprised an average of 71.2% of the total. Correspondingly, the mean percent of redds located in the index reach has declined from 38.6% (1987-95) to 10.9% (1997-2001) of the total. This downstream shift in the redd distribution is most likely attributed to the present inability to acclimate the Methow smolts off-station from both hatcheries further upstream. Secondly, the necessity in 1996 and 1998 to collect 100% of the fish run because of the poor run size has resulted in the natural escapement being largely comprised of hatchery fish that were acclimated and released from the MHF and the WNFH.

The mean carcass fork length was 76 cm (range 41 to 108 cm) for all fish sampled (N=1,264) in the Methow River (Figure 3). The mean fork length for males and females was 79 cm and 75 cm respectively.

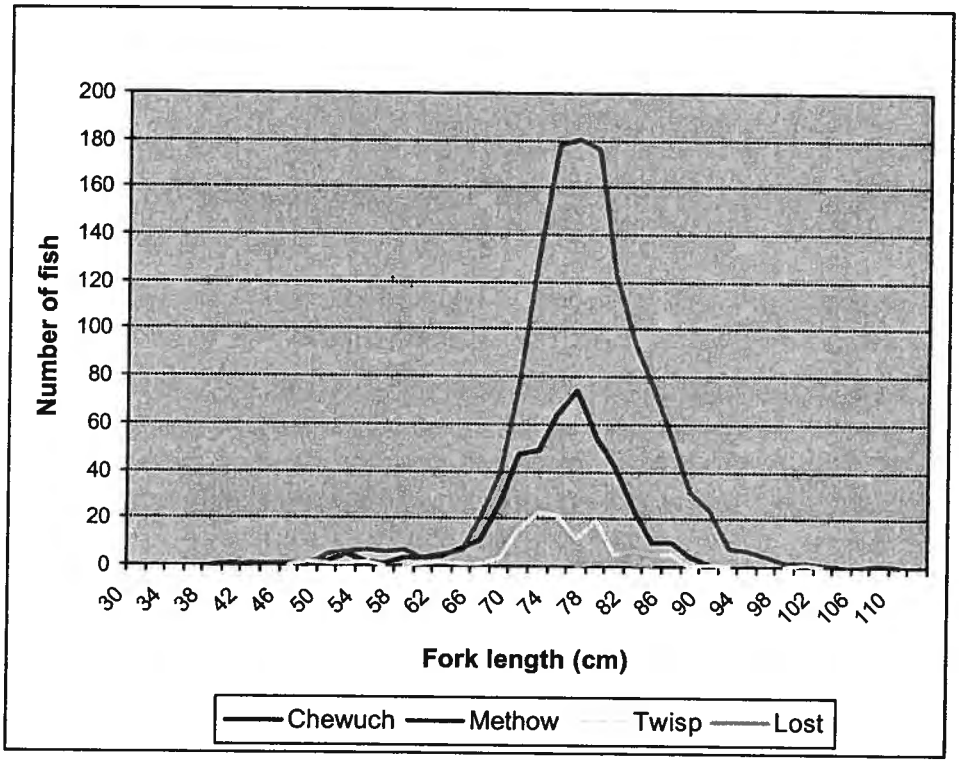

Figure 3. Fork length distribution of spring chinook carcasses by subbasin for the Methow Basin 2001.

Lost River

There were 72 redds located in the Lost River, which was the highest number recorded since 1992. The index reach (Eureka Creek to Lost River Bridge) had 56 (77.8%) redds with the remaining 16 (22.2%) redds located between the Lost River Bridge and the confluence. The Lost River accounted for 1.6% of the Methow Basin total redd count (Appendix Table 2).

Though the data is limited, it appears the number of spawners in the Lost River relative to the upper Methow River (Lost R. to Mazama Bridge) may increase as a function of decreasing mean

August/September discharge (Figure 4). This suggests that when low flows persist in the upper Methow spring chinook spawners seek out the Lost River where better flow conditions exist during the spawning period. The years considered for the evaluation were 1987-1990, 1992, 1993 and 2001, which all had basin wide redd counts in excess of 498 (Table 3). The mean August/ September flow (USGS #12447383 at Mazama) for these years combined was 56 cfs (range 15-141), which was lower than the overall August/September mean of 103 cfs for the period of record (1987-2001). Years (1991 and 1995-2000) with low basin wide redd counts (<498) were excluded from the analysis to minimize an error due to small redd sample sizes. Unfortunately some of the years (4 out of 8) excluded from the analysis due poor spawner escapement coincided with above normal seasonal flow for the period 1987-2001. The overall mean August/September flow was 145 cfs (range 18-360) for these years. The analysis would have been more robust if these years

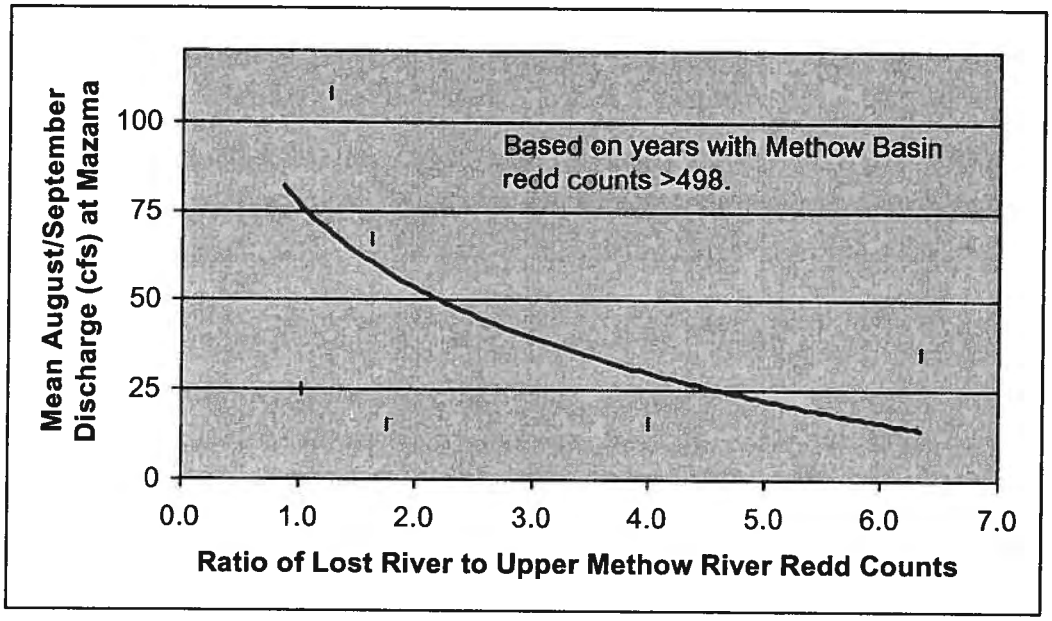

Figure 4. Relationship of upper Methow River discharge to the ratio of Lost River to upper Methow (Lost River to Mazama Bridge) spring chinook redd counts.

Table 3. Summary of Lost River to upper Methow River spring chinook redd counts in relation to Methow River discharge (at Mazama) for the period 1897-2001.

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Mean Aug/Sep flow (cfs) at Mazama	15	25	35	108	235	67	124	18	85	141	178	59	360	79	15
Lost River redd counts	56	53	57	33	16	73	51	6	0	—	7	—	3	2	72
Lost River to Mazama Bridge redd counts	32	52	9	26	18	45	59	15	0	—	25	—	3	2	18
Ratio of Lost R. to Lost R-Mazama Br. redd counts	1.8	1.0	6.3	1.3	0.9	1.6	0.9	0.4	0.0	—	0.3	—	1.0	1.0	4.0
Basin Redd Count	681	733	517	498	250	738	617	133	15	—	150	—	36	368	4399

could have been included as they in general represented years with above normal mean August/ September flows.

Six carcasses were found in the Lost River and the mean fork length was 79 cm (range 77-81 cm) (Figure 3).

Twisp River

The total redd count in the Twisp River was 371 redds. Within the index reach (Mystery Bridge to Buttermilk Bridge) 224 (60.4%) redds were found. Redds located above and below the index reach, respectively, were 3 (0.8%) and 144 (38.8%). Two dewatered redds were located in the Poplar Flats Campground area, which naturally dewaters a short distance (<0.25 rivermile).

This year was the lowest spawning contribution (8.4%) of the Twisp River to the overall Methow Basin spring chinook spawning population. Twisp River mean redd contribution is 26.1% for the period of 1987-2000. The low redd contribution is most likely attributed to the low percent of hatchery spawners comprising the Twisp River spawning population relative to the Methow and Chewuch populations.

The mean carcass fork length was 74 cm (range 51-99 cm) for all fish sampled (N=129) in the Twisp River (Figure 3). The mean fork length for male and female carcasses was 79 cm and 74 cm respectively.

Chewuch River

There was deposited in the Chewuch River 1,105 redds, which comprised 22.0% of the Methow Basin redd total. The index reach (Camp Four Bridge to Falls Creek Campground) had 243 (22.0%) redds; with 39 (3.5%) and 823 (74.5%) redds, respectively, located above and below the index reach.

The mean carcass fork length was 74 cm for all fish sampled (N=448) in the Chewuch River (Figure 3). The mean fork length for male and female carcasses was 73 cm and 75 cm respectively.

Other Tributaries

Seventeen redds were located in Early Winters Creek, and for the first time since the 1980's two redds were found in Gold Creek.

Carcass Distribution and Coded Wire Tag Recoveries

A summary of the coded wire tag (CWT) codes successfully recovered from spring chinook carcasses for each subbasin is presented in Table 4. For the entire Methow Basin 1,251 coded-wire-tags were successfully dissected and read. The majority of tags were recovered in the Methow

Table 4. Summary of coded-wire-tag recoveries from the spring chinook spawner surveys in the Methow Basin in 2001.

Release Group	Coded Wire Tag Code	Chewuch	Lost	River Methow	Twisp	Total
96 Chewuch	630233	1	0	2	0	3
96 Entiat	053708	0	0	1	0	1
96 Methow	630130	0	0	10	0	10
96 Twisp	636114	0	0	1	1	2
96 Winthrop	053048	0	0	1	0	1
96 Winthrop	053631	0	0	2	0	1
96 Winthrop	053710	0	0	1	0	1
96 Winthrop	053856	0	0	5	0	5
96 Winthrop	054453	0	0	5	0	5
96 Winthrop	054611	0	0	3	0	3
96 Winthrop	054612	0	0	1	0	1
97 Chewuch	630614	149	0	101	2	252
97 Enitiat	054354	1	0	0	0	1
97 Enitiat	054353	0	0	1	0	
97 Methow	053210	0	0	1	0	1
97 Methow	054906	7	0	71	0	78
97 Methow	054907	6	0	74	0	80
97 Methow	630613	9	1	329	1	340
97 Twisp	630434	1	0	4	24	29
97 Winthrop	054348	0	0	1	0	1
97 Winthrop	054358	5	0	55	0	60
97 Winthrop	054359	3	0	32	0	35
97 Winthrop	054526	17	0	184	0	201
97 Winthrop	054948	7	0	81	0	88
97 Winthrop	630613	0	0	3	0	3
98 Methow Composite	054406	1	0	11	0	12
98 Methow Composite	631024	10	0	24	0	34
98 Spring Creek (f.chk.)	054363	0	0	1	0	1
Totals		217	1	1005	28	1251

(1,005 CWT's). The Chewuch, Twisp and Lost had CWT recoveries of 217, 28 and 1 respectively. Four CWT's were from out-of-basin fish with three from Entiat spring chinook and one from a Spring Creek fall chinook.

For the three major rivers (Methow, Chewuch and Twisp) 1,892 carcasses were found, of these 1,294 were located in the Methow; 461 in the Chewuch and 137 in the Twisp.

Methow

Of smolts released in the Methow subbasin (either from the WNFH or the MFH) 870 carcasses were subsequently recovered within the Methow River. The two most abundant smolt release groups recovered in the Methow River were the 97 Methow- 475 carcasses and the 97 Winthrop- 356 carcasses. These two release groups accounted for 95.5% of all Methow released CWT group recoveries. The majority (41.6%) of these carcasses were recovered in river section 7 (rm 59.6 to rm 54.0); followed by 24.3% in river section 10 (rm 51.5 to rm 49.8) and in river section 6 (rm 63.2 to 59.6) 12.3% (Figure 5 and Table 6). These three reaches accounted for 78.2% of all Methow River origin CWT'ed carcasses.

The distribution of Methow released smolts and their subsequent CWT carcass recoveries across all subbasins is presented in Figure 6. The majority (93.6%) of these fish were recovered in the Methow River indicating a strong homing fidelity. Six percent of these fish (56 carcasses) were found in the Chewuch River and 0.1% (1 carcass). None were recovered in the Lost River.

Four year old Methow released hatchery fish with a CWT comprised 96.9% (886 carcasses) of all adult carcasses while five year old age class comprised 3.1% (28 carcasses).

Chewuch

Carcasses recovered in the Chewuch River derived from Chewuch smolt releases totaled 160. The majority (42.5%) were recovered in river section 12 (rm 11.0 to 9.1) followed by river section 11 (rm 13.6 to rm 11.0) with 18.1% and river section 6 (rm 21.8 to 20.4) with 10.0% (Figure 7 and Table 6). These three reaches account for 70.6% of the CWT'ed carcass recoveries originating from Chewuch smolt releases.

The distribution of CWT'ed carcasses originating from Chewuch smolt releases was divided largely between the Methow and Chewuch rivers (Figure 8). The Chewuch accounted for 55.4% of these carcasses while 43.9% were recovered in the Methow. Two carcasses were found in the Twisp (0.7%) and none were recovered in the Lost River.

Excluding the jacks, Chewuch released age-4 CWT'ed carcasses comprised 98.8% compared to 1.2% for the age-5 CWT'ed carcasses.

Twisp

There was a total of 25 CWT carcasses originating from Twisp smolt releases recovered in the Twisp River (Figure 9 and Table 7). All but three of these were recovered in the index reach (Mystery Bridge to Buttermilk Bridge). Twelve carcasses were recovered in river section 7 (rm 15.8 to rm 12.1) and ten CWT carcasses in river section 9 (RM 11.0 to rm 8.2).

An additional six CWT'ed carcasses originating from the Twisp River were recovered in other

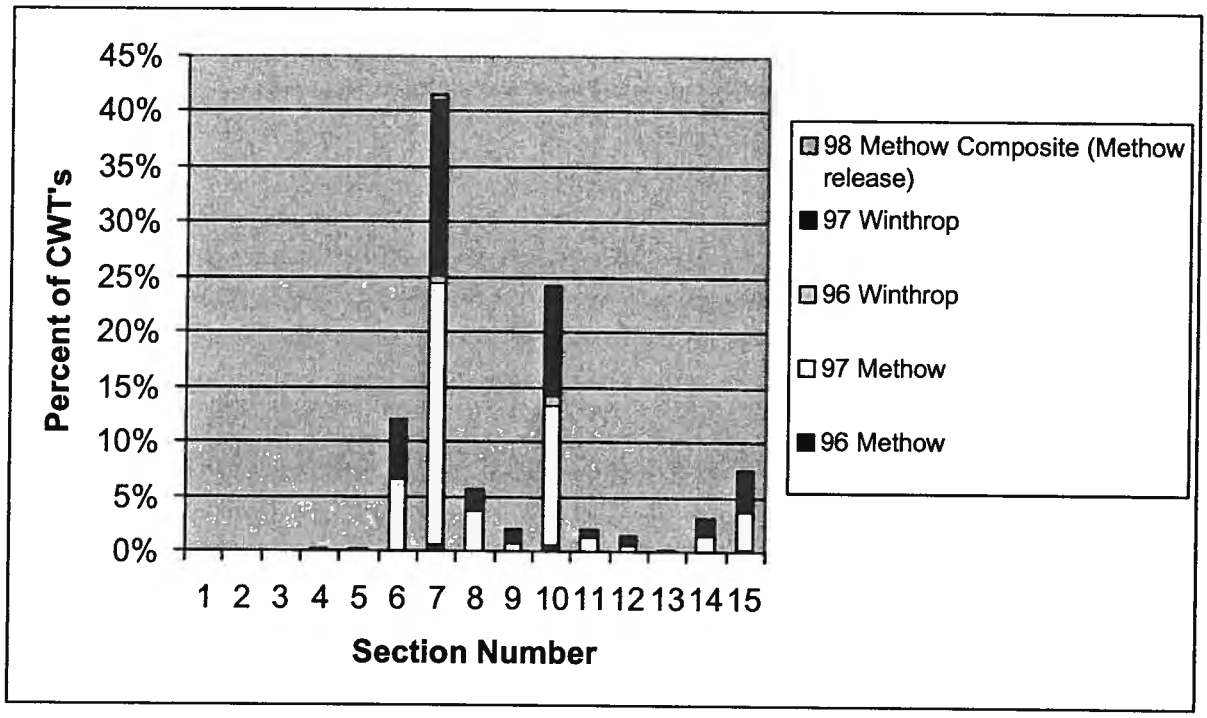

Figure 5. Distribution of coded-wire-tag recoveries from carcasses originating from smolts released from the WNFH and the MFH within the Methow River in 2001.

Table 5. Distribution of coded-wire-tags in the Methow River 2001.

Release Group	Above Index Reach	Index Reach	Below Index Reach	Below Winthrop Bridge (RM 49.8)	Total
96 Methow	0	0	9	1	10
96 Winthrop	0	1	14	3	18
96 Chewuch	0	0	2	0	2
96 Twisp	0	0	1	0	1
96 Entiat	0	0	1	0	1
97 Methow	1	58	358	58	475
97 Winthrop	0	47	252	57	356
97 Chewuch	1	6	82	12	101
97 Twisp	0	0	2	2	4
97 Enitiat	0	0	0	1	1
98 Methow Composite	0	5	20	10	35
98 Spring Creek	0	0	1	0	1
Total	2	117	742	144	1005

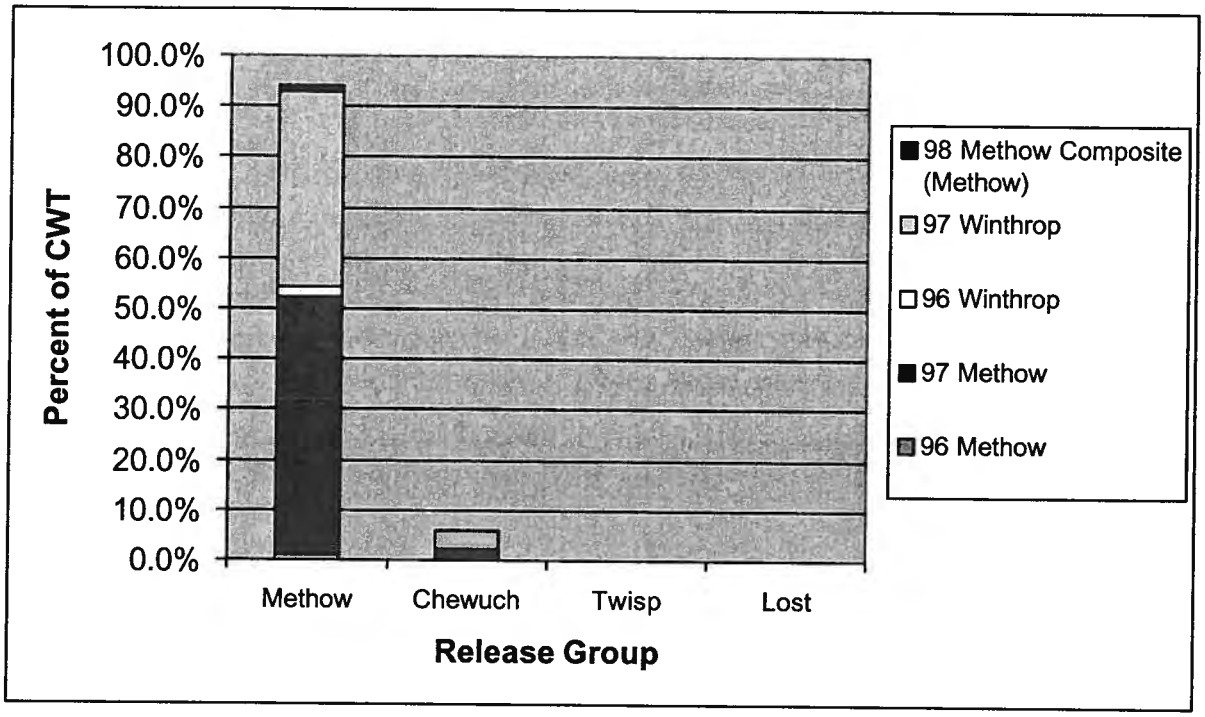

Figure 6. Distribution of coded-wire-tag recoveries from carcasses originating from smolts released from the WNFH and the MFH recovered in the Lost, Twisp, Chewuch

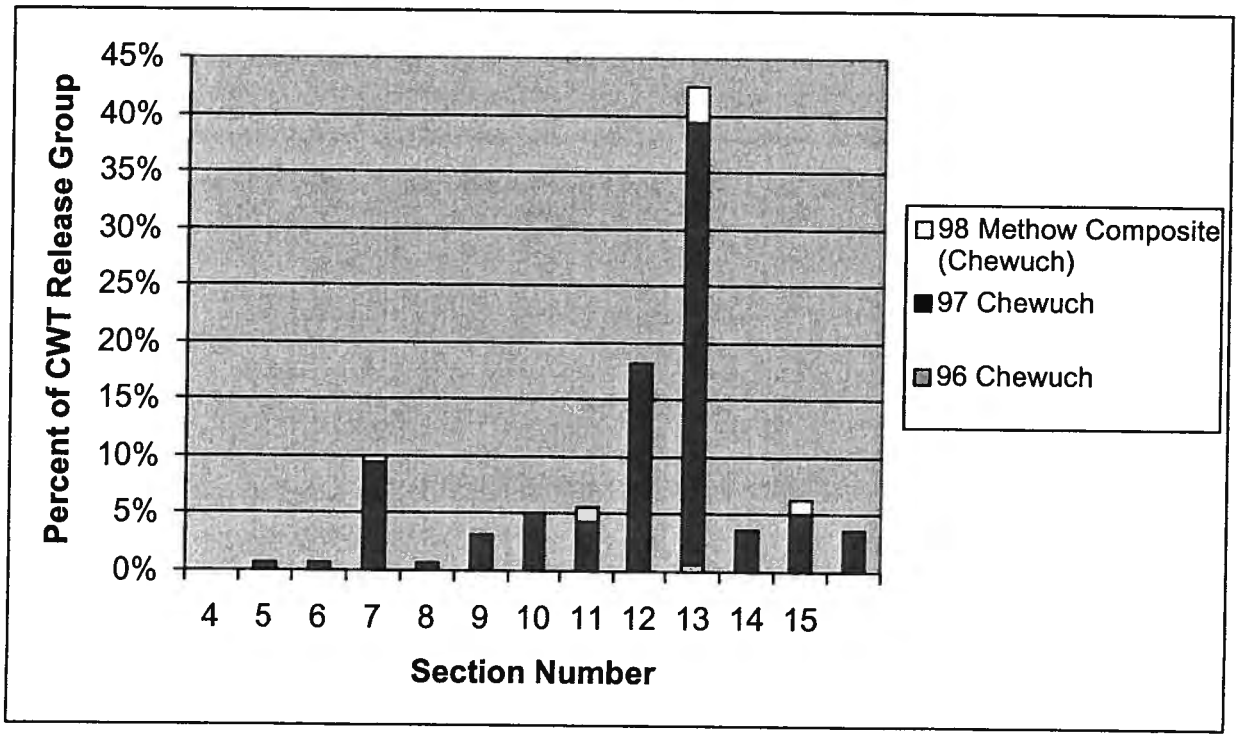

Figure 7. Distribution of coded-wire-tag recoveries from carcasses originating from smolts released from the Chewuch acclimation pond within the Chewuch River in 2001.

Table 6. Distribution of coded-wire-tags in the Chewuch River 2001.

Release Group	Above Index Reach	Index Reach	Below Index Reach	Total
96 Chewuch	0	0	1	1
97 Methow	3	2	17	22
97 Winthrop	0	7	25	32
97 Chewuch	17	21	111	149
97 Twisp	0	0	1	1
97 Enitiat	0	0	1	1
98 Methow Composite	1	2	8	11
Total	21	32	164	217

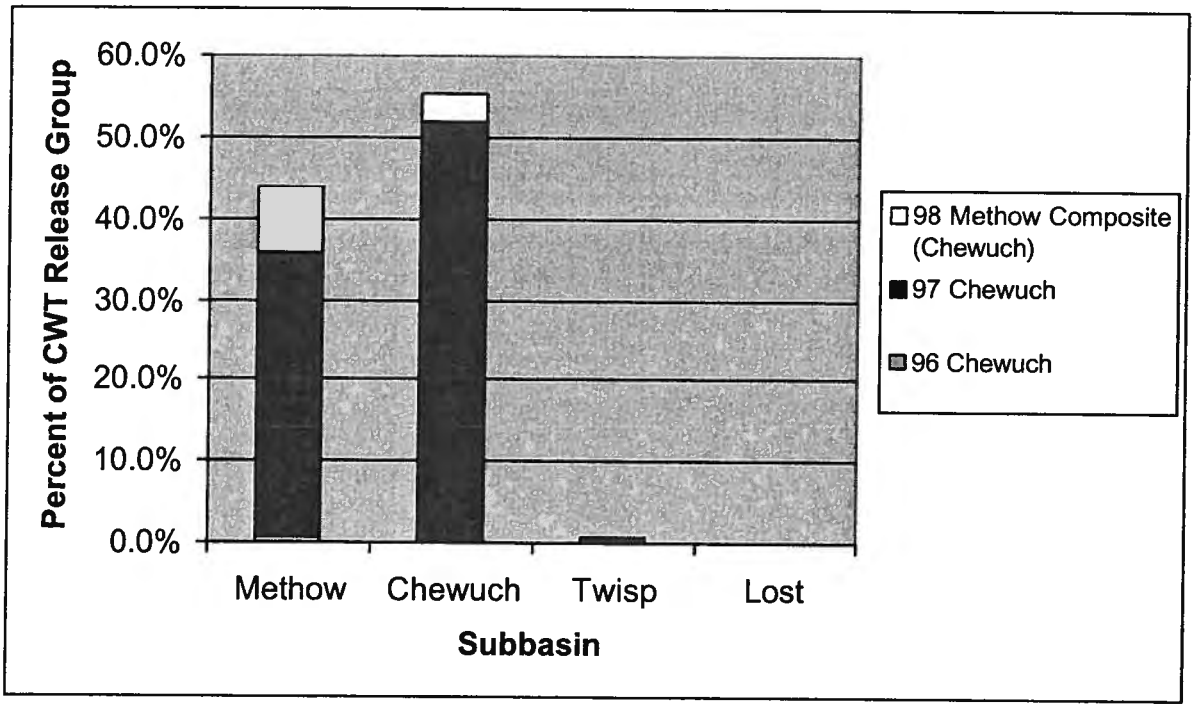

Figure 8. Distribution of coded-wire-tag recoveries from carcasses originating from smolts released from the Chewuch acclimation pond recovered in the Lost, Twisp, Chewuch and Methow rivers in 2001.

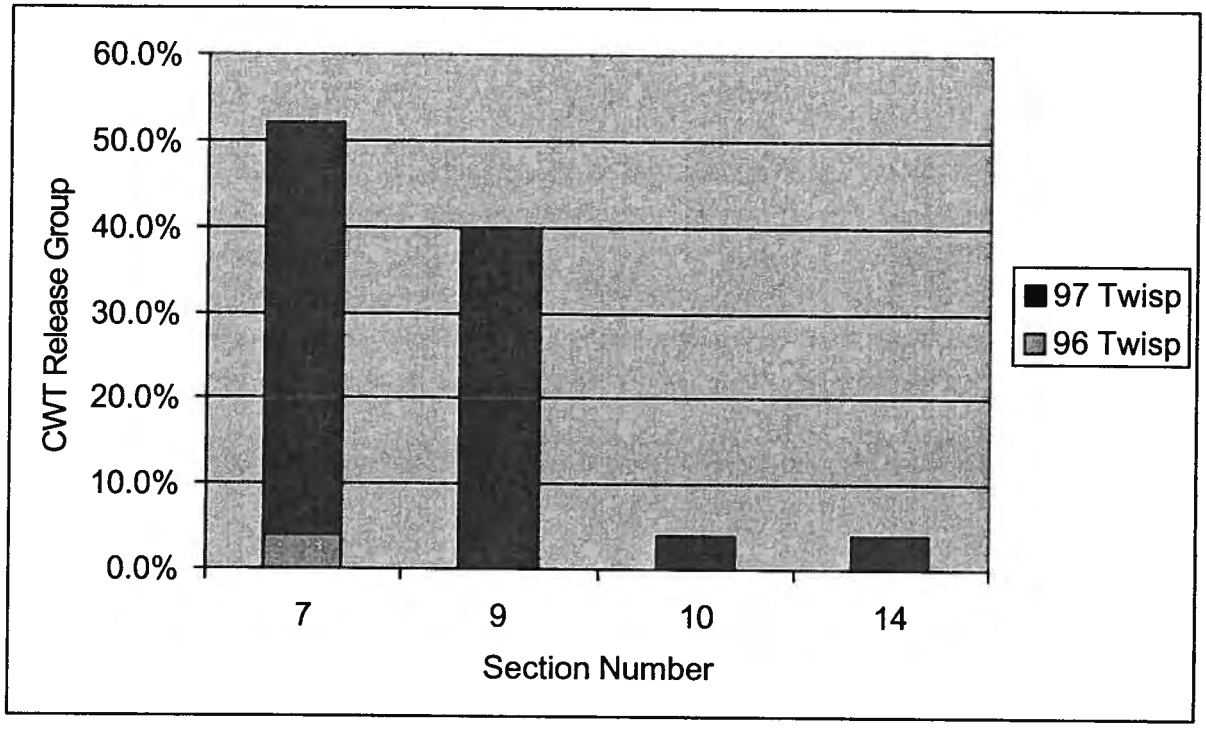

Figure 9. Distribution of coded-wire-tag recoveries from carcasses originating from smolts released from the Twisp acclimation pond within the Twisp River in 2001.

Table 7. Distribution of coded-wire-tags in the Twisp River 2001.

Release Group	Above Index Reach	Index Reach	Below Index Reach	Total
96 Twisp	0	1	0	1
97 Chewuch	0	2	0	2
97 Methow	0	1	0	1
97 Twisp	0	11	13	24
Total	0	15	13	28

Methow subbasins (Figure 10). Five were recovered in the Methow and one in the Chewuch.

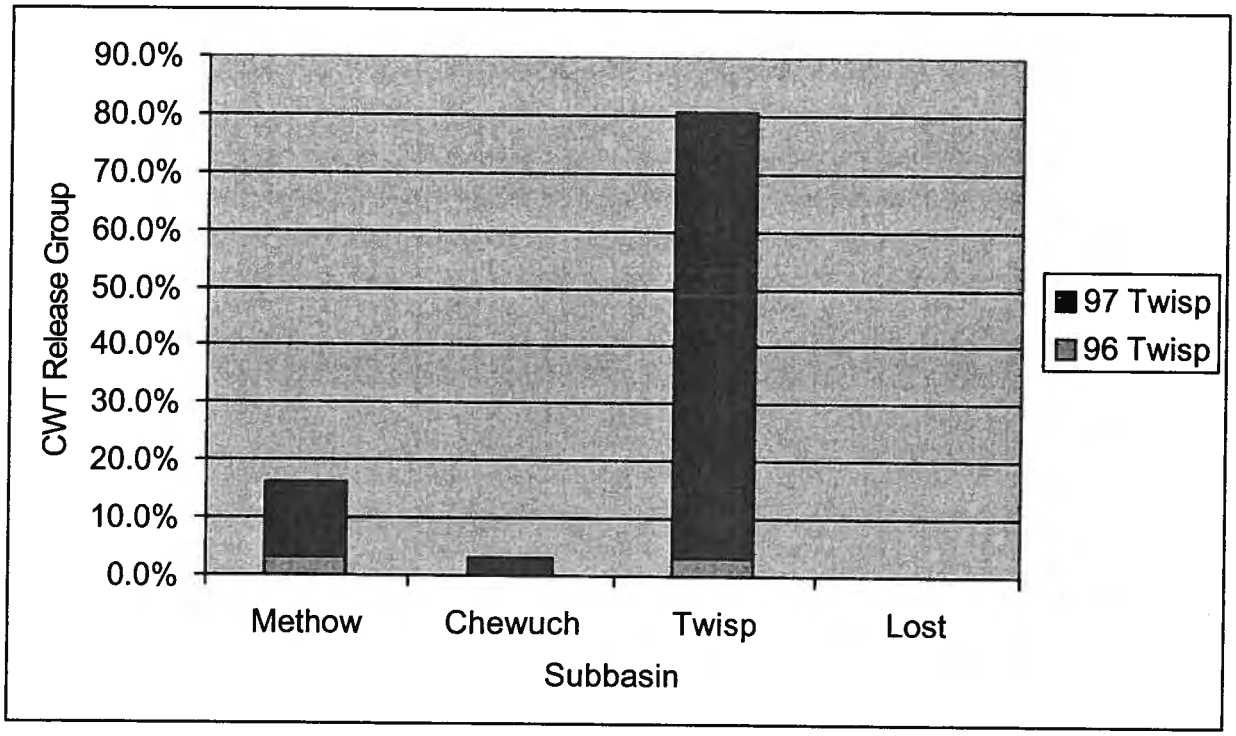

Figure 10. Distribution of coded-wire-tag recoveries from carcasses originating from smolts released from the Twisp acclimation pond recovered in the Lost, Twisp, Chewuch and

Juvenile Outmigration

A total of 1,899 fish were captured in the trap during its period of operation (Table 8). Most of the fish captured (865 or 45.5%) were young-of-the-year chinook, presumably summers. Their mean fork length was 49 mm (N= 365).

Approximately 439 wild spring chinook smolts were captured, which represented 23.1% of all fish species collected at the trap. Their average fork length was 113 mm (N= 274). Their mean fork length was higher than the mean fork length of 98 to 100 mm seen at the Chewuch trap for the years of 1993-96 (Hubble 1993, Hubble and Sexauer 1994, Hubble and Harper 1995). This difference could be a consequence increased growth rates for pre-smolts that over wintered in the mid-section of the Methow River and/or better growth rates for wild spring chinook produced from the Twisp and Methow subbasins, which are reflected in the smolt catch. It appears that the majority of smolts moved past the trap the first half of April. Smolt counts for the brief periods of operation after April 14 was low (0 to 4 fish daily). For reference, Hubble and Harper (1995) found the median dates of passage for wild spring chinook at the Chewuch River confluence in past years were- April 19 (1993), April 10 (1994), April 27 (1995) and April 8 (1996).

Table 8. Daily fish counts (unexpanded) captured at the Halderman hole rotary trap, spring 2001.

Date	Dace	Wild Chinook Fry	Wild Coho Fry	Wild Sockeye Fry	Hatchery Chinook Smolt	Hatchery Steelhead Smolt	Lamprey	Wild Steelhead Parr	Sculpin	Wild Chinook Smolt	Wild Coho Smolt	Wild Steelhead Smolt	Sucker	White-fish
Mar 31	55	5						1	1	19		4		1
Apr 1	17	80						1		64		18		
Apr 2	6	95						2	1	110		13		
Apr 3	27	85								57	1	9	1	
Apr 4		27		1			3			21		6	1	
Apr 5		25						1	1	17		2		
Apr 6		18		1						14				
Apr 7	13	9	3							11	1	5		
Apr 8		12								20		11		
Apr 9		14								30		8		
Apr 10		74					1		1	41		23		
Apr 11		114					2	13		7		7		
Apr 12		154	1					10		15				1
Apr 13		110								17		93		1
Apr 16		9												
Apr 18		5										1		
Apr 20		4												
Apr 27		8			1	12				5		1		
May 1		17	3		15	80		3		7	36	58		
Totals	113	865	7	2	16	92	6	31	4	455	38	259	2	3

Wild steelhead smolts accounted for 13.6% (N= 259) of the total fish captured. As seen with the wild spring chinook smolts the majority of steelhead appeared to outmigrate the first half of April. Their mean fork length was 174 mm (N=166) and fish ranged in size from 102 to 258 mm. Oncorhynchus mykiss under 100 mm in fork length were considered parr and were not classified as steelhead. There were 31 fish recorded in this category.

Seven wild coho fry were captured throughout the monitoring period. Their mean fork length was 41 mm. In addition, 38 wild coho smolts were captured with nearly all them being captured May 1 the last day of trap operation. There mean fork length was 137 (N= 38). These fish are the result of hatchery smolts that have been acclimated and released into the Methow Basin beginning in 1995 as part of the Yakama Nation's mid-Columbia coho feasibility reintroduction study.

Other species collected included:

- Sockeye fry- 3
- Hatchery spring chinook smolts- 32
- Hatchery steelhead smolts- 92
- Lamprey (spp unknown)- 6
- Dace- 118
- Sucker- 2
- Whitefish- 3

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Appendix Table 3. Twisp River survey schedule and redd counts, 2001.

Appendix Table 4. Lost River and Early Winters survey schedule and redd counts, 2001.

Appendix Table 1. Methow River survey schedule and redd counts, 2001.

River Section	Section Number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	**Total**
Trout Cr. - Ballard cmpgr.	—											
Ballard cmpgr. - Lost R.	1											
Lost R. - Gate Cr.	2		0		0		1					**1**
Gate Cr. - Early Winters Cr.	3		0		2							**2**
Early Winters Cr. - Mazama Br.	4			3			3	9		0		**15**
Mazama Br. - road barrier	5	0	0	0	0	4	3	1	0	0		**8**
road barrier- Weeman Br.	6	0	2	0	196	72	70	60	3	4		**407**
Weeman Br. - along highway 20	7	0	1	77	582	291	272	194	237	19	49	**1722**
along highway 20 - Wolf Cr.	8	0	0		24		27		52			**103**
Wolf Cr. - Foghorn Dam	9	0	0		98				89			**187**
Foghorn Dam - Chewuch confluence	10	1	1	16	40	146	22	28	0	0		**254**
Chewuch confluence - KOA Campground	11	0	0	0		0				4		**4**
KOA Camp Ground - Barkley Diversion	12	0	0			9				0		**9**
Barkley Diversion - MVID Diversion	13	0	0			8				0		**8**
MIVID Diversion - RV Park	14	0	0			0				0		**0**
RV Park - Twisp confluence	**15**		**0**							**0**		**0**
Twisp conflence - Halderman's hole	**16**				**0**							**0**
Halderman's hole - Carlton	**17**				**0**							**0**
Wolf Creek			**0**	**0**					**0**			**0**
Methow Hatchery outfall								**13**	**6**	**0**		**22**
WNFH Hatchery outfall (Spring Creek)								**86**		**0**		**86**
Total		**1**	**4**	**96**	**945**	**530**	**398**	**391**	**387**	**27**	**49**	**2828**

Appendix Table 2. Chewuch River survey schedule and redd counts, 2001.

River Section	Section Number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	**Total**
Falls to 30-Mile Bridge	1										
30-Mile Bridge to roadside cmp.	2				1	3					**4**
Roadside cmp. to Andrews Cr.	3										
Andrews Cr. to Lake Crr.	4	0		0		5		6		0	**11**
Lake Cr. to Buck Cr.	5	0		0		1		0		0	**1**
Buck Cr. to Camp 4 Bridge	6	0		0		16		4		3	**23**
Camp 4 Bridge to roadside cmpgr.	7	0	0	0	0	11		12	11	1	**35**
Roadside cmpgr. to Chewuch cmpfr.	8	0	0	0	3	4		50	1	0	**58**
Chewuch cmpgr. to mile 6 cmpgr.	9	3	0	0	2	6	16	50	1	2	**80**
Mile 6 cmpgr. to Falls Cr. Cmpgr.	10	0	0		0	19	3	45	3	0	**70**
Falls Cr. Cmpgr. to 8-Mile Ranch	11	0	0		10	70	8		157	0	**245**
8-Mile Ranch to Memorial Bridge	12	0	0		10		52	108	49	66	**285**
Memorial Bridge to Chewuch Bridge	13	0	0		0				13	0	**13**
Chewuch Bridge to halfway point	14		0		2		12		73	14	**101**
Halfway point to confluence	15		0		18		29		126	6	**179**
Total		**3**	**0**	**0**	**46**	**135**	**120**	**275**	**434**	**92**	**1105**

Appendix Table 3. Twisp River survey schedule and redd counts, 2001.

River Section	Section Number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	**Total**
2 miles above road end cmpgr. to road end cmpgr.	1										**0**
Road end cmpgr. to South Cr. Bridge	2		1								**1**
South Cr. Bridge to Poplar Flats cmpgr.	3		0								**0**
Poplar Flats cmpgr. to Mystery Bridge	4		0		2	0					**2**
Mystery Bridge to War Cr. Bridge	5	0	1	7	8	1	7	9	7	2	**42**
War Cr. Bridge to cabin	6	0	0	4	0	28		0	0	0	**32**
cabin to Buttermilk Bridge	7	0	0	23	19	68	36	0	4	0	**150**
Buttermilk Bridge to green bridge	8	0		1		4	8	0		0	**13**
Green bridge to Little Bridge Cr.	9	0	0	2		40	24	2		0	**68**
Little Bridge Cr. to Newby Cr.	10	0	0	0	0	1		9		0	**10**
Newby Cr. to fish weir	11	0	0			3		11		0	**14**
fish weir to wooden bridge	12	0		0	0	3		5		0	**8**
wooden bridge to Poorman's Bridge	13	0				0		13		0	**13**
Poorman's Bridge to Twisp R. Bridge	14	0		0		1		7			**8**
Twisp R. Bridge to confluence	15	0				10				0	**10**
Total		**0**	**2**	**37**	**27**	**159**	**75**	**56**	**11**	**2**	**371**

Appendix Table 4. Lost River and Early Winters Creek survey schedule and redd counts, 2001.

River Section	Section Number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Total
Lost River											
Sunset Cr. to Eureka Cr.	1										
Eureka Cr. to Lost River Rd. Bridge	2		2	0	0	0	2	15	15	20	2	**56**
Lost River Rd. Bridge to confluence	3			0		0				12	4	**16**
Early Winters Creek											
Klipchuch cmpgr. to Early Winters Bridge	1			0		0			0		0	**0**
Early Winters Bridge to Highway 20 Bridge	2			0		0			0		0	**0**
Highway 20 Bridge to diversion dam	3			0		0			8		0	**8**
diversion dam to Highway 20 Bridge	4			0		5			0	2	0	**7**
Highway 20 Bridge to confluence	5					0			2		0	**2**
Total			**2**	**0**	**0**	**5**	**2**	**15**	**25**	**34**	**6**	**89**

METHOW BASIN SPRING CHINOOK NATURAL PRODUCTION STUDY REPORT FOR 2002

APPENDIX I

Methow Basin Spring Chinook Natural Production Study Report For 2002

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December 2003

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ABSTRACT

The estimated 2002 spring chinook run size to Wells Dam was 7,633 (7,592 adults; 41 jacks) and the estimated spawner escapement was 6,596 fish.

There were 1,192 redds deposited in the Methow Basin in 2002 with subbasin redds counts as follows: Methow River- 721, Lost River- 54, Early Winters Creek- 6, Chewuch River- 301, Twisp River- 109 redds and Wolf Creek– 1 redd.

Subbasin redd counts within, above and below the index reach were as follows:

Methow:	above index- 6.2% (45 redds); index- 7.6% (55 redds); below- 86.1% (621 redds).
Chewuch:	above index– 4.3% (13 redds); index– 17.9% (54 redds); below– 77.7% (234 redds).
Twisp:	above index– 5.6% (6 redds); index– 80.4 (86 redds); below– 15.9% (17 redds).
Lost:	above index– 0.0% (0 redds); index– 74.1 (54 redds); below– 25.9% (14 redds).

The mean carcass fork length by subbasin and age class were the following:

Methow:	total: 78.1 cm (N= 499)	age-4: 76.5 cm (N= 425)	age-5: 88.5 cm (N= 64)
Chewuch:	total: 78.5 cm (N= 199)	age-4: 76.9 cm (N= 170)	age-5: 87.7 cm (N= 29)
Twisp:	total: 80.9 cm (N= 29)	age-4: 76.7 cm (N= 15)	age-5: 87.6 cm (N= 14)
Lost:	total: 78.7 cm (N= 15)	age-4: 76.1 cm (N= 13)	age-5: 95.5 cm (N= 2)

The age composition for returning adults on the spawning grounds was comprised of 86% 4-year olds and 14% 5-year olds. The age composition by subbasin was the following:

Methow:	age-4: 87.5% (N= 457)	age-5: 12.5% (N= 65)
Chewuch:	age-4: 85.7% (N= 174)	age-5: 14.3% (N= 29)
Twisp:	age-4: 53.3% (N= 16)	age-5: 46.7% (N= 13)
Lost:	age-4: 86.7% (N= 13)	age-5: 13.3% (N= 2)

A total of 914 carcasses were recovered in the Methow Basin (Methow– 634, Chewuch– 224, Twisp- 34, Lost- 17, Wolf Creek– 4 and Early Winters Creek– 1). Of the 914 carcasses recovered 695 coded-wire-tags were successfully dissected and read (Methow- 497, Chewuch– 174, Twisp– 8, Lost– 14, Early Winters– 1 and Wolf– 1). A summary of CWT recoveries by subbasin is presented in Tables 3a and 3b.

The Chewuch juvenile trap located on the Chewuch River (rm 0.1) was operated intermittently for the period of March 26 through May 3, and was not fished from April 15-30 to both allow for passage of the hatchery smolts and the need to redeploy the trap when the river discharge increased. An estimated 7,868 spring chinook smolts passed the trap during the period the trap was operated (March 26 - April 14 and May 1 - 3). The mean spring chinook fork length was 96 mm and ranged in size from 70 to 197 mm.

INTRODUCTION

The Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) (1995) is a compensation program directed towards the enhancement of the wild spring chinook (*O. tshawytscha*) stocks in the Methow Basin. The MBSCSP is the result of the Wells Settlement Agreement between the fishery agencies, tribes, Douglas PUD and the power purchasers of the Wells Project. The goal of this agreement is to protect, mitigate and compensate for unavoidable losses of juvenile anadromous fishes at Wells Dam. The stated purpose of the MBSCSP *"...is to increase natural propagation of salmon in the Methow, Chewuch, and Twisp rivers in a manner that minimizes or eliminates ecological and genetic risks to the natural population.*", through a monitored hatchery supplementation plan. The MBSCSP as part of the settlement agreement complies with the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC, 1987). A specific outcome is that the MBSCSP "*be capable of collecting, rearing, and releasing three potentially discrete stocks of salmon*" (Methow, Chewuch and Twisp), which is part of the Phase I compensation requirements under the settlement agreement.

Tasks reported on in the 2002 Methow Basin Spring Chinook Natural Production Study annual report address specific tasks under Objective 2 of the MBSCSP, which states *"Determine that actions taken under the MBSCSP conserve the genetic integrity and long-term fitness of naturally spawning populations of spring chinook salmon in the Methow Basin*". Spawning ground surveys addressed elements of Task 2.4 ("*Collect baseline stock profile data on Chewuch, Methow and Twisp populations of spring chinook salmon.*"), Task 2.9 ("*Determine if hatchery salmon are similar to natural salmon in spawning characteristics.*"), and Task 2.10 ("*Compare survival rates among various life stages for spring chinook salmon in a natural river environment. Quantify freshwater survival rates, parr production, and rearing densities of a selected population of spring chinook.*"). Juvenile outmigrant monitoring was aimed at addressing Task 2.11 ("*Characterize and quantify natural spring chinook salmon juvenile outmigration from a natural environment*"). Objective 1 (*Determine if Methow FH is capable of meeting the Phase 1 production requirements of the Agreement.*") and Objective 3 (*Determine if salmon released from Methow FH interact adversely with natural production in the Methow River Basin.*") relate primarily to aspects of the hatchery and fish culturing and are being evaluated by WDFW.

STUDY AREA

The Methow River Basin is located in north-central Washington on the eastern slope of the Cascade Mountains (Figure 1). The Methow River and its tributaries lie in Okanogan County and drain an area of nearly 1,800 square miles. The headwaters of the Methow Basin are located near the Cascade Crest at a maximum elevation of 8,500 feet and drops to 781 feet where it joins the Columbia River (RM 524) at Pateros, WA. The upper portions of the Methow basin is mountainous, and dominated by sub-alpine and alpine forest at the upper elevations. Moving eastward from the Cascade Crest in association with a decrease in elevation the forests are dominated by ponderosa pine and steppe-brush in the lower most portion of the basin. Annual precipitation ranges from 80 inches at the Cascade Crest to 10 inches where the river enters the Columbia River (Richardson 1976). The majority of precipitation occurs from October through March, primarily in the form of snow. The summer months are dry with precipitation occurring in the form of brief thunderstorms. Stream flows in the Methow Basin are driven by the annual snow pack cycle of accumulation during the winter and the spring snowmelt. Generally peak river discharge occurs from mid May to mid June, with base flows occurring from late September through March, with a slight increase in the fall prior to snowfall due to fall rains.

The Methow Basin is characterized as rural with human developed concentrated in the towns of Mazama, Winthrop, Twisp and Methow. Individual homes are scattered throughout the lowlands and upland areas of the basin usually associated with acreage.

The lower Methow valley is a fertile agricultural area that experiences heavy irrigation demands. Water quality in the lower Methow Basin nonetheless remains high, with an AA rating from the Washington Department of Ecology. Spring chinook spawning in the Methow River extends from about Trout Creek (river mile 78) to about two miles downstream of the Chewuch River confluence (river mile 48).

The Chewuch River joins the Methow River at RM 50, at an elevation of 1,745 feet. These two rivers join in the city of Winthrop. The Chewuch basin covers 530 square miles and drains in a southern direction into the Methow River. The upper portion of the Chewuch River is located in the Pasayten Wilderness (above RM 32.4) and is heavily forested. Spring chinook spawn downstream from river mile 31.5, which is also used extensively for recreation and residential development.

The Twisp basin encompasses about 250 square miles of watershed and enters the Methow River at near RM 40. The elevation descends from 8,500 ft to 1,600 ft and drains in a southeast direction. The headwater and upslope areas lay within the Lake Chelan-Sawtooth Wilderness. Spring chinook spawning has extended upstream to South Creek (RM ~28).

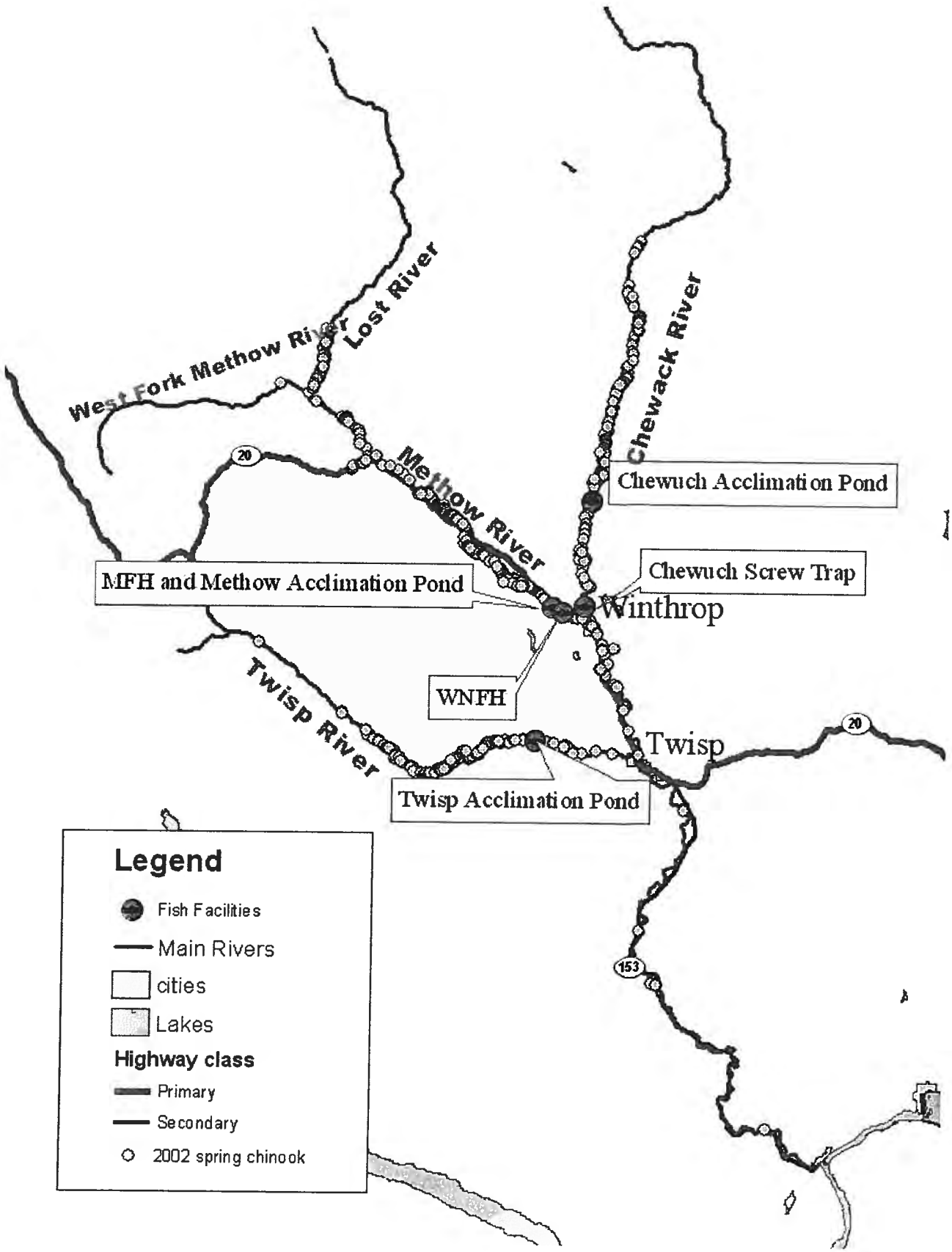

Figure 1. Spring Chinook spawning distribution and location of key sites in the Methow Basin.

METHODS AND MATERIALS

Spawning Surveys

Redd Surveys

Surveys were primarily conducted in the Methow, Lost, Chewuch and Twisp rivers, and in Early Winters Creek. The historical index reaches were normally surveyed weekly, while those reaches where nominal spawning occurs were normally surveyed bi-weekly. All spawning reaches where redds normally are located were surveyed at least once during or after the historic peak spawning period. The historic index reaches are the following:

- Methow: Weeman bridge to Mazama bridge (6.2 river miles)
- Lost: Lost River bridge to the Eureka Creek (4.2 river miles)
- Early Winters: Highway 20 bridge to Cedar Cr. (1.9 river miles)
- Chewuch: Falls Creek Campground to Camp Four bridge (6.8 river miles)
- Twisp: Buttermilk Creek bridge to the Mystery Creek bridge (10.1 river miles)

Regular surveys began August 1 and continued through September 28, with additional spot-checks conducted afterward. Appendix tables 1, 2 and 3 present the complete week-by-week survey schedule and redd counts.

Surveys were conducted in the upper Methow, Lost, Chewuch and Twisp rivers, and in Early Winters Creek. Raft or canoe surveys were conducted in the Methow River downstream from Mazama Bridge, according to river flows. To ensure survey consistency, the same survey crew was normally assigned to the same spawning reach. However, for quality control purposes a different crew occasionally surveyed another crew's survey reach. To avoid recounting or missing a previously counted redd, each redd was marked with surveyor's tape on the riverbank adjacent to the redd. Written on each posted tape were the consecutive redd number and survey date. A global positioning system unit (GPS) was also used to locate many of the redds, usually to an accuracy of 15 feet.

All live chinook were counted during each survey. Carcasses were recovered and checked for sex, tags, fin clips, and spawning success. Scales and DNA samples were collected when possible from each carcass, and fork length and post eye-to-hypural plate length was recorded.

Juvenile Outmigration

The Chewuch River (RM 0.1) five-foot diameter rotary trap (EG Solutions, Corvallis, OR) was operated in the Chewuch River between March 26, 2002 through May 3, 2002 to monitor the spring chinook smolt outmigration. The trap was not fished from April 15 through April 30 to allow for the passage of the spring chinook hatchery smolt releases from the Methow Fish Hatchery, Chewuch acclimation pond located at RM 7.8. During this same time period an increase in river discharge required pulling the trap initially for heavy debris and then to redeploy the trap at more suitable location within the existing site. Smolt trapping ceased May 3 due to the low spring chinook smolt daily counts when trapping resumed on May 1.

The daily mean river discharge was measured based on the discharge data provided by USGS at the Chewuch River at Winthrop gauge station located at Winthrop, WA on the Chewuch River (station '12448000).

Juvenile spring chinook catch efficiency for the Chewuch River rotary trap was calculated by releasing previously captured smolts; that were marked with an upper or lower caudal fin clip, 610 m upstream of the trap. Eleven releases were successfully conducted in April 2002 and release sizes ranged from 18 to 69 fish depending on the availability of fish each day. Each catch efficiency test release was completed within a 24 hour period, indicating that all the marked fish moved past the trap site the first evening after the fish were released. Fish for these efficiency tests were released at twilight and were held during the day in a separate live box located on the trap. Estimated trap efficiency was defined as the decimal fraction of marked fish recovered for each specific test release. The estimated trap efficiency for each test was plotted against river discharge to determine trap capture efficiency to river discharge. Since there was not a good linear regression fit of trap efficiency to discharge (r^2= 0.0025) the seasonal mean fish entrainment rate of 8.0% was used to expand daily spring chinook fish counts.

Trap checks were normally performed in the morning. Fish were netted from the live box and anesthetized using MS-222 at a dosage of approximately 40 ppm. Data recorded from fish sampled included species identification, fork length, weights (subsampled), maturity (fry, parr or smolt) and any external marks. Fish were also scanned for the presence of a coded wire tag to indicate their origin (hatchery or natural). Fish that were not used for efficiency releases were allowed to recover during the day in a separate live box and were released later that evening downstream of the trap.

RESULTS

Spawning Ground Surveys

Spring Chinook Run Size

A summary of the Methow Basin spring chinook run size and spawner escapement for years 1967-2002 is presented in Table 1 and Figure 2. The estimated 2002 spring chinook run size to Wells Dam was 7,633 (7,592 adults; 41 jacks).

Total broodstock collected by the Methow Fish Hatchery (MFH) was 996 fish (Table 1). As in 2001 no broodstock collection occurred in 2002 at Winthrop National Fish Hatchery. This was done to maximize the collection of Methow Composite type broodstock and to minimize the collection of WNFH Carson type broodstock. The estimated spawner escaped derived by subtracting the Wells Dam count from fish taken for broodstock was 6,637 (Table 1).

There was a total of 1192 redds deposited in the Methow Basin in 2002. Subbasin redds counts were the following- Methow River- 722, Lost River- 54, Early Winters Creek- 6, Chewuch River- 301 and the Twisp River- 109 redds. There were 84 dewatered redds found in the upper Methow River (Lost River to near Boulder Creek) and in the Twisp River two dewatered redds were found in the Popular Flats reach. Both reaches experience naturally induced dewatering except for above normal water years.

The estimated average number of fish per redd was atypically high at 5.6. Since 1987 the average fish per redd has been 3.3 with a range of 1.6 (1990; 498 redds and 818 spawners) to 8.5 (1999; 32 redds and 272 spawners). The other year with an atypical high fish per redd value, besides 1999 and 2002 occurred in 1995 (6.6 fish per redd). However, unlike in 2002 which had a high spawner escapement in both 1995 and 1999 spawner escapement was less than 300 fish.

Methow

The 722 redds located in the Methow River comprised 60.6% of the basin total (Appendix Table 1). This included 28 redds located in the MFH outfall and 35 redds located in the WNFH outfall (Spring Creek).

An estimated 84 redds became naturally dewatered within the Methow River, most of which were located from the Lost River confluence (river mile 73.0) to approximately river mile 60.8 (near McKinney Mountain diversion). This represented 11.6% of the total number of redds deposited in the Methow River.

There were 55 (7.6%) redds located within the index reach (Mazama Bridge to Weeman Bridge). The percentage of redds located above and below the index reach was 6.2% (45 redds) and 86.1% (621 redds), respectively (Figure 3). For the third consecutive year, the percent of redds located below the index reach (downstream of Weeman Bridge) exceeded 80%. In 2002 86.1% (N= 622) of the redds were located downstream of the index reach, which compares to the 1987-95 average of 41.7%. For each of these three return years (2000, 2001 and 2002) a portion of each run was comprised of fish produced from broodyear's 1996 and 1998 in which 100% of the run was spawned in the hatchery. The 2000 return was comprised of age 4 spawners from BY1996; the 2001 return was comprised of age 3 adults from BY1998 and age 5 adults from BY1996; while the 2002 spawners were comprised of age 4 adults from BY1998. Since all of these fish were released from either the MHF or the WNFH homing back to suitable spawning reaches below Weeman Bridge nearer to the hatcheries is not unexpected.

Table 1. Summary of spring chinook adults passing Wells Dam, number of broodstock collected at Winthrop National Fish Hatchery and Methow Fish Hatchery, and estimate of natural spawners in the Methow Basin, 1967-2002.

Year	Wells Dam Counts				Hatchery Broodstock	Hatchery Broodstock	Natural Escapement
	Adults	Jacks	Total	Composition of Jacks	WNFH	MFH	(est.)
1967	541	616	1,157	53%	0	--	1,157
1968	4,086	845	4,931	17%	0	--	4,931
1969	3,048	551	3,599	15%	0	--	3,599
1970	2,092	578	2,670	22%	0	--	2,670
1971	2,535	633	3,168	20%	0	--	3,168
1972	3,368	248	3,616	7%	0	--	3,616
1973	2,505	507	3,012	17%	0	--	3,012
1974	3,199	221	3,420	6%	0	--	3,420
1975	2,096	129	2,225	6%	0	--	2,225
1976	1,510	1,249	2,759	45%	0	--	2,759
1977	3,976	235	4,211	6%	0	--	4,211
1978	3,532	83	3,615	2%	38	--	3,577
1979	971	132	1,103	12%	102	--	1,001
1980	941	241	1,182	20%	155	--	1,027
1967-1980 (avg.)			**2,905**				**2,884**
1981	1,367	98	1,465	7%	399	--	1,066
1982	2,270	131	4,252	3%	601	--	3,651
1983	2,726	143	2,869	5%	755	--	2,114
1984	3,066	214	3,280	7%	510	--	2,770
1985	5,151	116	5,267	2%	1201	--	4,066
1986	2,896	65	2,961	2%	836	--	2,125
1987	2,272	74	2,346	3%	594	--	1,752
1988	2,844	96	2,940	3%	1327	--	1,613
1989	1,633	87	1,720	5%	195	--	1,525
1990	927	12	939	1%	121	--	818
1981-1990 (avg.)			**2,804**			**--**	**2,150**
1991	682	100	782	13%	92	--	690
1992	1,596	27	1,623	2%	271	60	1,232
1993	2,422	22	2,444	1%	646	252	1,546
1994	243	15	258	6%	29	34	195
1995	72	41	113	36%	0	14	99
1996	388	73	461	16%	146	315	0
1997	972	32	1,004	3%	220	323	461
1998	416	14	430	3%	409	10	11
1999	360	289	649	45%	0	377	272
2000	2,130	457	2,587	18%	1,098	338	1,019
1991-2000 (avg.)			**1,035**				**553**
2001	9,989	882	10,871	0.8%	0	874	9,997
2002	7,592	41	7,633	0.5%	0	996	6,637
2001-2002 (avg.)			**9,395**				**8,017**

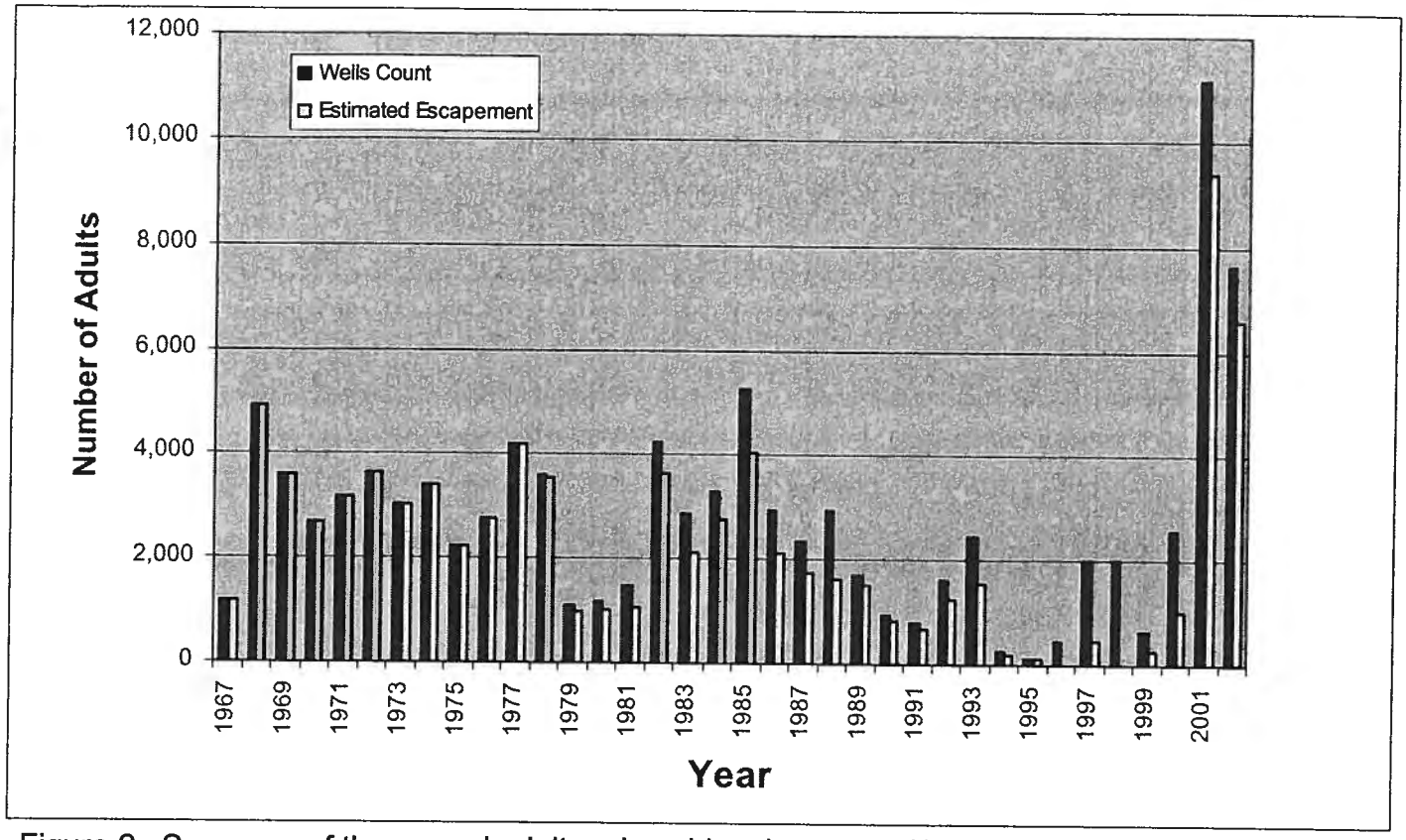

Figure 2. Summary of the annual adult spring chinook count at Wells Dam and the estimated spawner escapement to the Methow Basin, 2002.

The mean carcass fork length was 78.1 cm for all fish sampled (N = 499) in the Methow River (Figure 4). The mean fork length for 4 year-old and 5 year-old spawners was 76.5 cm (N = 425) and 88.5 cm (N = 64) respectively. For both age classes wild fish were somewhat larger than the hatchery fish (age-4: hatchery = 76.4 cm, wild = 81.7 cm; age-5: hatchery = 87.3 cm, wild = 95.1 cm).

Spawning commenced on August 7 and the last redds were located on September 25. The majority (78%) of spawning in the Methow River occurred between August 19 through September 5 (spawn weeks 4-6), while the median spawn date was about August 27 (Figure 5).

Lost River and Early Winters Creek

There were 54 redds located in the Lost River. The majority (40 redd and 74.1%) of the redds were deposited in the index reach (Eureka Creek to Lost River Bridge), while the remaining 14 (25.9%) redds located between the Lost River Bridge and the confluence. The Lost River accounted for 4.5% of the Methow Basin total redd count (Appendix Table 2). Six redds were deposited in Early Winters Creek, which accounted for 0.5% of the Methow Basin's total.

The mean fork length from carcasses recovered in the Lost River was 78.7 cm (N = 15) (Figure 4). The mean fork length of age-4 fish was 76.1 cm (N = 13) and 95.5 cm (N = 2) for age-5 fish.

Spawning occurred the earliest in the Lost River where 35 (62%) of the 54 redds were located on the August 21 survey. No further redds were found after the September 10 survey, where two redds were ɔcated (Figure 5).

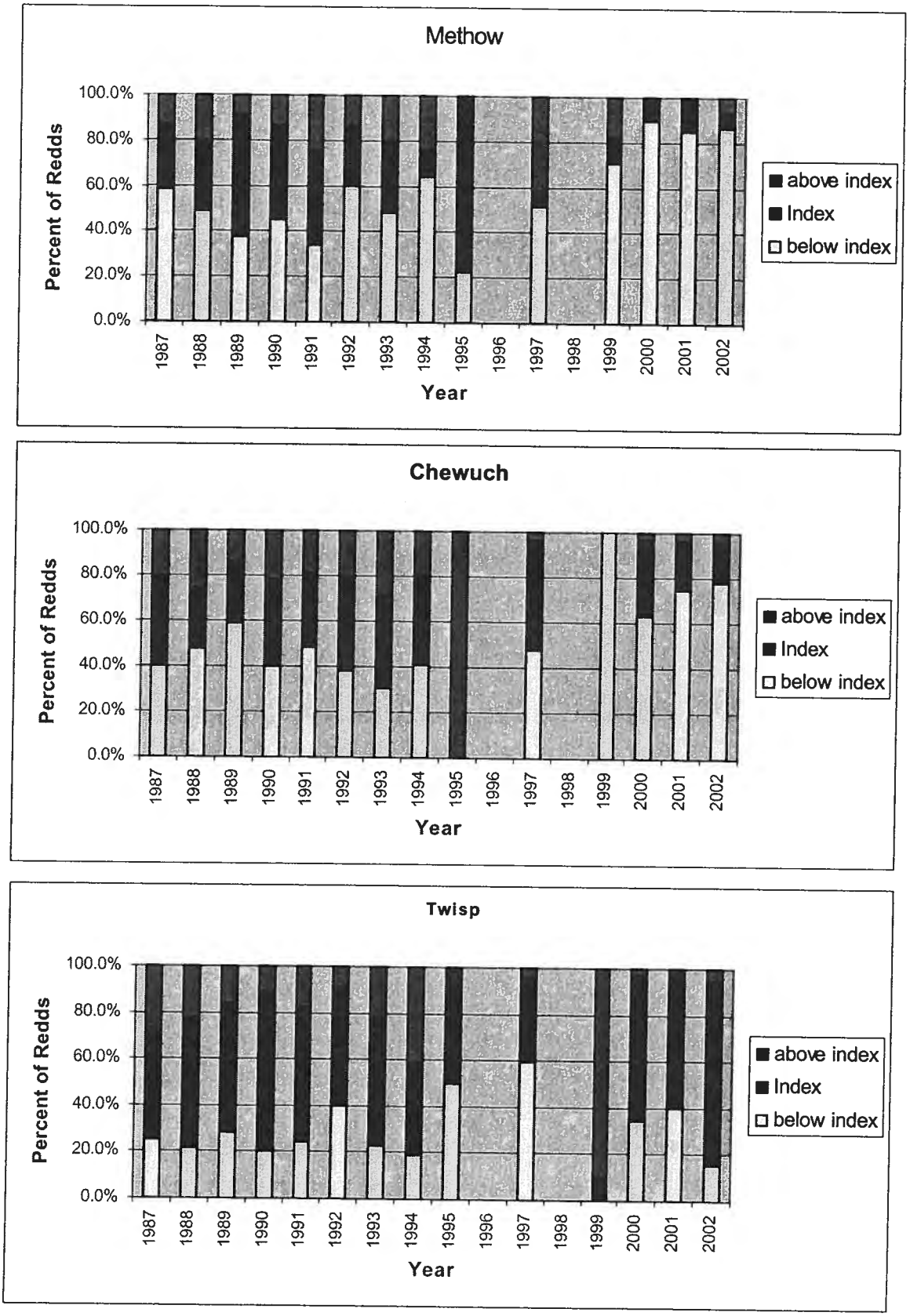

Figure 3. Summary of spring chinook redd counts within, above and below the Index reach for the Methow, Chewuch and Twisp rivers for 1987-2002.

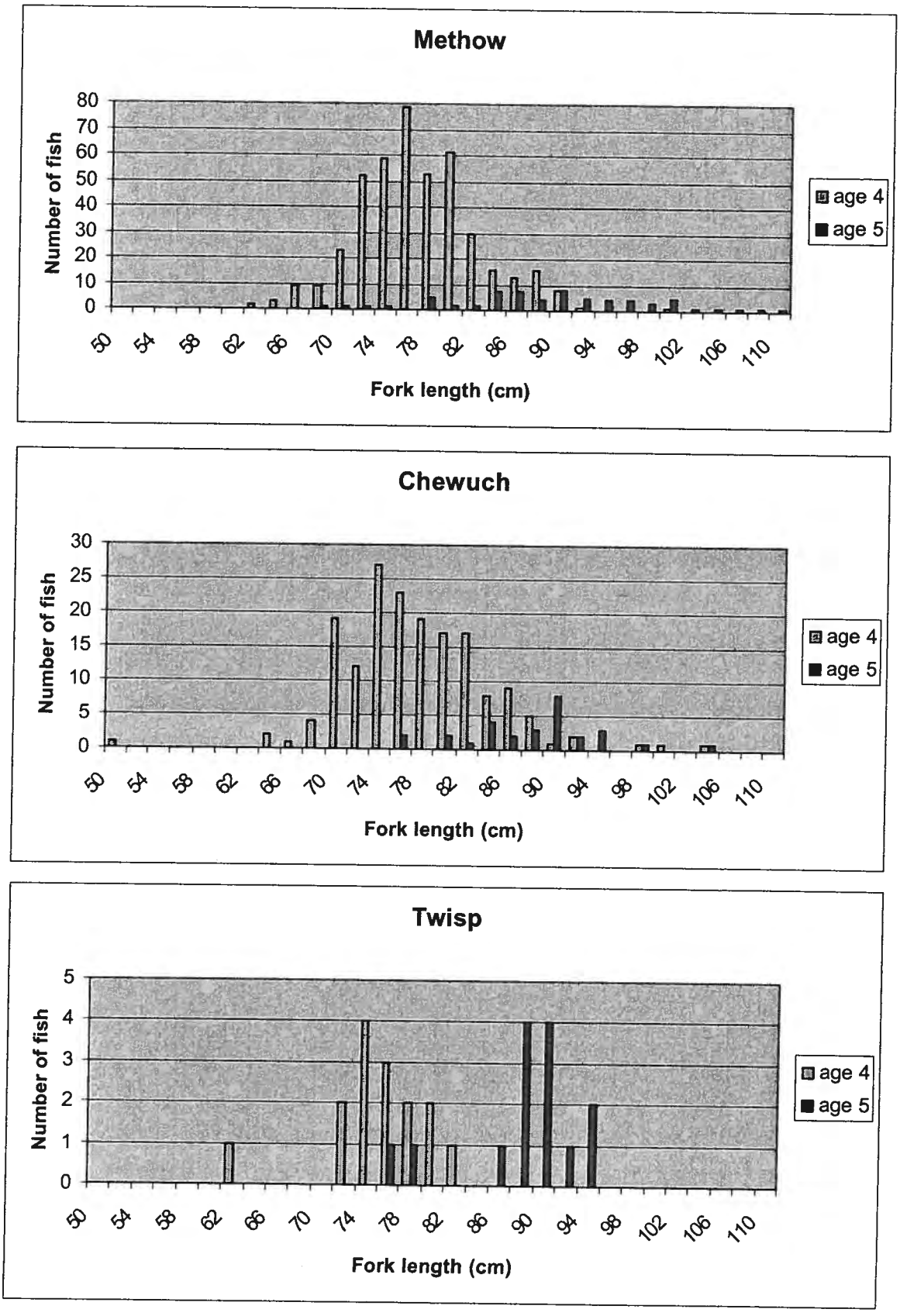

Figure 4. Fork length (cm) distribution of age-4 and age-5 adult spring chinook spawners for the Methow, Chewuch and Twisp rivers, 2002.

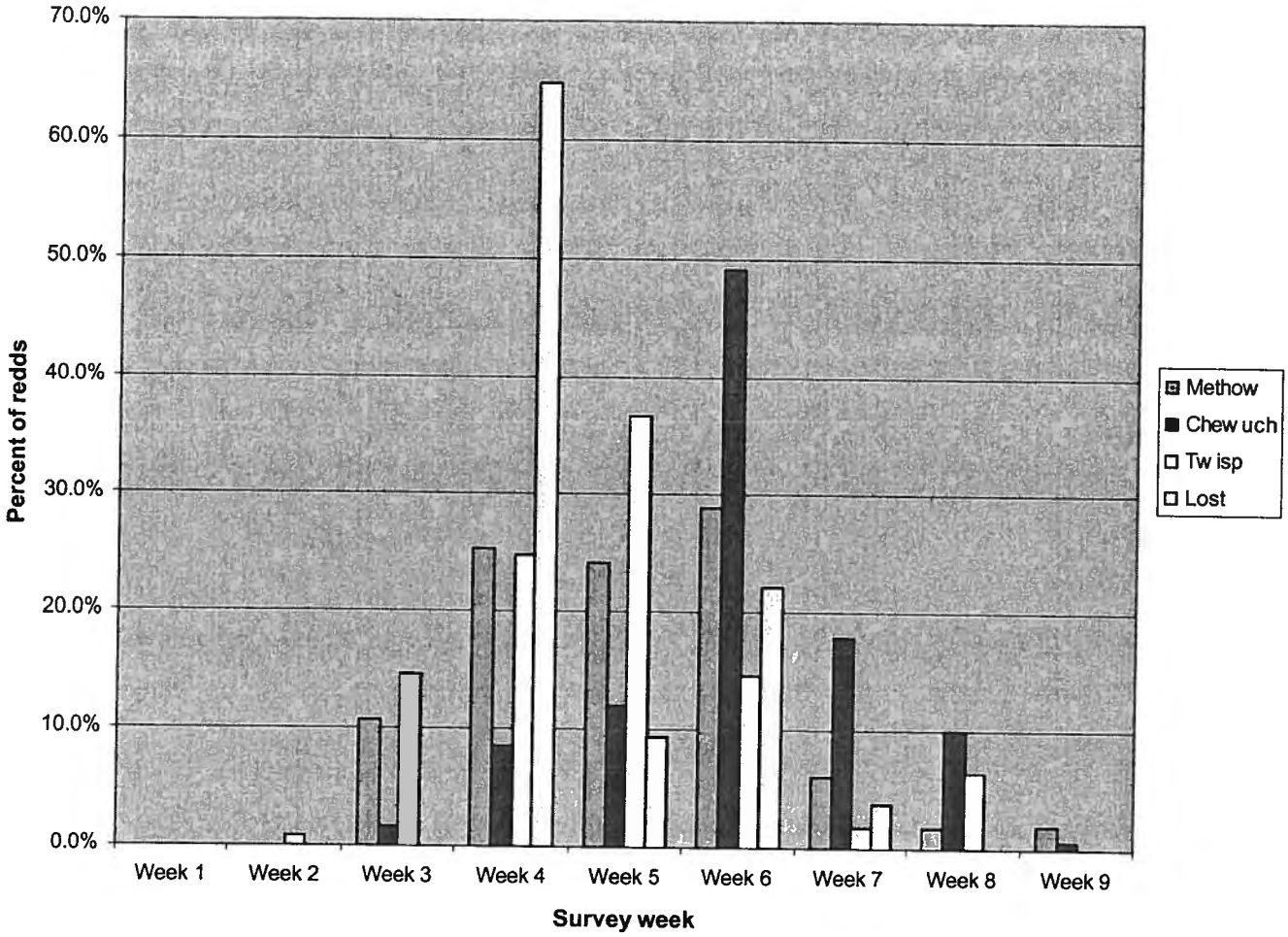

Figure 5. Summary of spring chinook spawn timing for the Methow, Chewuch and Twisp rivers, 2002 (week 1 = 7/28-8/3 and week 9 = 9/22-28).

Chewuch River

A total of 301 redds were deposited in the Chewuch River, which comprised 25.3% of the Methow Basin redd total. The index reach (Camp Four Bridge to Falls Creek Campground) had 54 (17.9%) redds. While there were 13 (4.3%) redds above and 234 (77.7%) redds below the index reach (Figure 3). Similar to the Methow River the percent of redds located in the lower Chewuch below the index reach has steadily increased for the past three years (2000-02) and has averaged 79% of the Chewuch River redd count. For comparison the average percent of redds located below the index reach for the years 1987-94 was 43%.

The mean carcass fork length was 78.5 cm for all fish sampled (N = 199) in the Chewuch River (Figure 4). The mean fork length between age-4's and age-5's was 76.9 cm (N = 170) and 87.7 cm (N = 29), respectively. As in the other subbasins the wild fish on average were larger than the hatchery fish for each age class (age-4: hatchery = 76.5 cm, wild = 84.0 cm; age-5: hatchery = 83.5 cm, wild = 90.2 cm).

The first and last redds were located on August 14 and September 24 respectively. The majority (79%) of spawning occurred between August 25 through September 14 (spawn weeks 5-7). The median spawn date occurred approximately September 7 (Figure 5).

Twisp River

The Twisp River had 109 redds, which accounted for 9.1% of the Methow Basin's total. Within the index reach (Mystery Bridge to Buttermilk Bridge) 86 (80.4%) redds were found (Figure 3). Redds located above and below the index reach, respectively, were 6 (5.6%) and 17 (15.9%). Two dewatered redds were located in the Poplar Flats Campground area, which naturally dewaters a short distance (<0.25 rivermile). Campground area, which naturally dewaters a short distance (<0.25 rivermile). Unlike the Methow and Chewuch rivers, the redd distribution within and below the index reach has remain fairly consistent in recent years to that observed prior to 1995. This observation is likely the result of less hatchery influence (in general lower hatchery smolt release numbers relative to wild production), and equally important the lack of quality spawning habitat downstream of the acclimation pond in comparison to the mainstem Methow River.

The Twisp River redd count comprised 9.1% of the total Methow Basin redd count, which is the second consecutive year the Twisp River has had the lowest redd contribution amongst the three major subbasins. As was the case in 2001 this is a consequence of lower numbers of hatchery smolts being released from the Twisp acclimation pond relative to the Methow and Chewuch subbasins.

The mean carcass fork length in the Twisp River was 80.9 cm (N = 29) (Figure 4). The mean fork length for 4 year-old and 5 year-old spawners was 76.7 cm (N = 15) and 87.6 cm (N = 14) respectively. As observed in the other subbasins the wild fish were larger than the hatchery fish within each respective age class (age-4: hatchery = 72.3 cm, wild = 76.2 cm; age-5: hatchery = 78.0 cm, wild = 88.3 cm).

Spawning began about August 7 and continued through September 16. The majority (62%) of spawning took place from August 19 through August 26 (spawn weeks 4 and 5), while the median spawn date was around August 24 (Figure 5).

Other Tributaries

No redds were found in either Gold or Wolf creeks in 2002. However, four carcasses were recovered in Wolf Creek three of which were females suggesting that spawning likely occurred.

Age Composition

Basin wide the age composition for returning adults on the spawning grounds (Table 2) was comprised 86% of 4-year olds (BY1999) and 14% of 5-year olds (BY1998). As is typical, most of the hatchery spawners were age- 4, and comprised from 87.5% in the Twisp River to 93.8% in the Chewuch. Wild spawners were comprised of at least 50% age-5 spawners in all subbasins. The approximate 50:50 split in the Twisp River between age 4 and age 5 spawners is a consequence of the low percent of hatchery fish (dominated by age-4 spawners) relative to the wild fish (dominated by age-5 spawners). Returning spawners to the Chewuch and Methow subbasins were the dominated by hatchery fish thus the overall age compositions to these two subbasins were comprised largely of 4 year old spawners.

Carcass Distribution and Coded Wire Tag Recoveries

Basin wide a total of 914 carcasses were recovered. The number of carcasses was as follows: Methow– 634, Chewuch– 224, Twisp- 34, Lost- 17, Wolf Creek– 4 and Early Winters Creek– 1.

A summary of the coded wire tag (CWT) codes successfully recovered from spring chinook carcasses for each subbasin is presented in Tables 3a and 3b. For the entire Methow Basin 694 coded-wire-tags were successfully dissected and read. The majority of tags were recovered in the Methow (496 CWTs). The Chewuch, Twisp and Lost rivers had CWT recoveries of 174, 8 and 14 respectively. While one coded wire tag each was found in Early Winters and Wolf creeks.

Table 2. Age composition summary of spawners collected off the spawning grounds by subbasin, 2002.

Subbasin	Hatchery		Wild		Total	
	Age 4	Age 5	Age 4	Age 5	Age 4	Age 5
Methow	89.0% (447)	11.0% (55)	50.0% (10)	50.0% (10)	87.5% (457)	12.5% (65)
Lost	92.9% (13)	7.1% (1)	0.0% (0)	100.0% (1)	86.7% (13)	13.3% (2)
Chewuch	93.8% (166)	6.2% (11)	30.8% (8)	69.2% (18)	85.7% (174)	14.3% (29)
Twisp	87.5% (7)	12.5% (1)	40.9% (9)	59.1% (13)	53.3% (16)	46.7% (13)

Methow

Of smolts released from the Methow subbasin (either from the WNFH or the MFH) 209 carcasses with successfully read CWTs were subsequently recovered within the Methow River. The three highest CWT groups recovered in the Methow River were Winthrop BY98– 113 (54.1%), Methow Composite WNFH BY98– 44 (21.5%) and Methow Composite MFH BY98– 28 (13.4%). These three release groups accounted for 89.0% of all CWTs recovered in the Methow River from smolts released from either the WNFH or the MFH (Figure 6). Most (63 tags or 30.1%) of the CWTs recovered in the Methow River were between Fog Horn Dam and the Chewuch River confluence. The two next reaches with the most CWT recoveries in the Methow River were in the outfall areas of the WNFH and the MFH (37 CWTs or 17.7%) and between the arkley ditch and the East Methow Valley Irrigation Diversion (28 CWTs or 13.4%). These three reaches accounted for 61.2% of all Methow River origin CWT'ed carcasses (Figure 6).

One coded wire tag from a Spring Creek Hatchery released fall chinook (BY1998) was found in the Methow River.

The distribution of Methow released smolts and their subsequent CWT carcass recoveries across all subbasins is presented in Figure 7. Most (209 or 88.9%) spawners were recovered in the Methow River, followed by 17 (7.2%) in the Chewuch River, 4 (1.7%) in the Twisp River and 5 (2.1%) in the Lost River.

Chewuch

Carcasses recovered in the Chewuch River derived from Chewuch smolt releases totaled 157. The majority (149 or 94.9%) were from the Methow Composite Chewuch BY98 release group, followed by the Chewuch BY97 with 8 (5.1%) CWT'ed carcasses. The reach from Eight-Mile Creek to Memorial Bridge had the most (57 or 36.3%) number of recovered CWT'ed carcasses. This was followed by river reach Falls Creek Campground to Eight-Mile Creek (31 or 19.7%) and river reach halfway point to the confluence (21 or 13.4%). These three reaches account for 69.4% of the CWT'ed carcass recoveries originating from Chewuch smolt releases (Figure 8).

The distribution of carcasses derived from Chewuch River smolt releases were most prominent (279 or 62.4%) in the Methow River, which was 1.8 times more than the number (157 or 35.1%) located in the Chewuch River. The remaining distribution of Chewuch derived carcasses in the other subbasins was as follows– visp: 1 (0.2%), Lost: 9 (2.0%), and one CWT (0.2%) each in Early Winters and Wolf creeks (Figure 9).

Table 3a. Summary of spring chinook carcass coded wire tag recoveries in the Methow and Chewuch subbasins from the 2002 spawner surveys[1].

Recovery Location		Coded-Wire-Tag Release Group								
River	Section No.	97 Chewuch	97 Met. Comp. WNFH	97 Met. Comp. Methow	97 Winthrop	98 Met. Comp. Chewuch	98 Met. Comp. WNFH	98 Twisp	98 Winthrop	Totals
Methow	1									
	2	0	0	0	1	5	1	0	2	**9**
	3	0	0	3	0	2	0	0	1	**6**
	4	0	0	0	0	4	0	0	1	**5**
	5	0	0	1	0	8	0	1	3	**13**
	6	0	1	3	0	27	1	1	2	**35**
	7	0	0	2	2	47	8	1	12	**72**
	8	0	0	0	1	6	0	0	1	**8**
	9	0	0	3	2	15	1	0	7	**28**
	10	2	1	11	6	89	13	3	32	**157**
	11	2	0	1	2	29	6	0	13	**53**
	12	0	0	4	2	28	8	1	14	**57**
	MFH outfall	0	0	0	3	10	0	0	8	**22**
	WNFH outfall	0	1	0	2	5	6	1	17	**31**
	Sub-basin Total	**4**	**3**	**28**	**21**	**275**	**44**	**8**	**113**	**496**
Chewuch	1	0	0	0	0	0	0	0	0	**0**
	2	0	0	0	0	0	0	0	0	**0**
	3	0	0	0	0	0	0	0	0	**0**
	4	0	0	0	0	0	0	0	0	**0**
	5	0	0	0	0	0	0	0	0	**0**
	6	0	0	0	0	5	0	0	1	**7**
	7	0	0	0	0	2	0	0	0	**2**
	8	0	0	0	0	5	0	0	0	**5**
	9	0	0	0	0	9	0	0	0	**9**
	10	1	0	0	1	10	1	0	4	**17**
	11	5	0	0	0	26	2	0	0	**33**
	12	0	0	0	1	57	0	0	4	**62**
	13	0	0	0	0	1	0	0	0	**1**
	14	1	0	0	0	13	1	0	1	**16**
	15	1	0	0	0	21	0	0	1	**23**
	Sub-basin Total	**8**	**0**	**0**	**2**	**149**	**4**	**0**	**11**	**174**

[1] This excludes the one Spring Creek Hatchery fall chinook CWT (BY1998) recovered in the Methow River.

Table 3b. Summary of Spring Chinook Carcass Coded Wire Tag Recoveries in the Twisp, Lost Early Winters and Wolf Subbasins From the 2002 Spawner Surveys.

Recovery Location		Coded-Wire-Tag Release Group								
River	Section No.	97 Chewuch	97 Met. Comp. WNFH	97 Met. Comp. Methow	97 Winthrop	98 Met. Comp. WNFH	98 Met. Comp. Chewuch	98 Twisp	98 Winthrop	Totals
Twisp	1	0	0	0	0	0	0	0	0	**0**
	2	0	0	0	0	0	0	0	0	**0**
	3	0	0	0	0	0	0	0	0	**0**
	4	0	0	0	0	0	0	0	0	**0**
	5	0	0	0	0	0	0	1	0	**1**
	6	0	0	0	0	0	0	0	0	**0**
	7	0	0	0	0	2	1	2	0	**5**
	8	0	0	0	0	0	0	0	0	**0**
	9	0	0	0	0	0	0	0	0	**0**
	10	0	0	0	0	0	0	0	0	**0**
	11	0	0	0	0	0	0	0	0	**0**
	12	0	0	0	0	0	0	0	2	**2**
	13	0	0	0	0	0	0	0	0	**0**
	14	0	0	0	0	0	0	0	0	**0**
	15	0	0	0	0	0	0	0	0	**0**
	Subbasin Total	**0**	**0**	**0**	**0**	**2**	**1**	**3**	**2**	**8**
Lost	2	0	0	0	0	0	4	0	1	**5**
	3	0	0	1	0	0	5	0	3	**9**
	Subbasin Total	**0**	**0**	**1**	**0**	**0**	**9**	**0**	**4**	**14**
Early Winters	1	0		0	0	0	1	0	0	**1**
	Subbasin Total	**0**		**0**	**0**	**0**	**1**	**0**	**0**	**1**
Wolf	1	0		0	0	0	1	0	0	**1**
	Subbasin Total	**0**		**0**	**0**	**0**	**1**	**0**	**0**	**1**

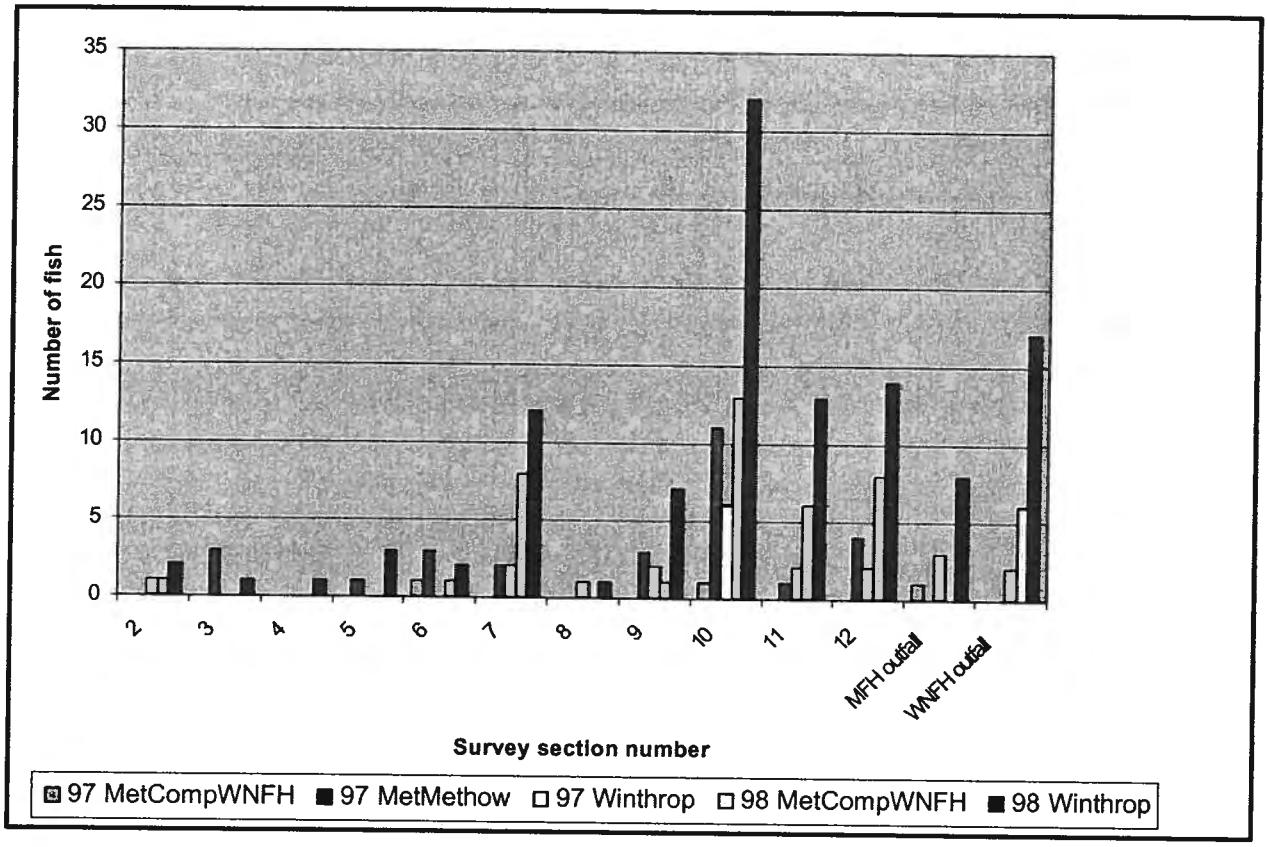

Figure 6. Distribution of coded wire tagged spring chinook carcass recoveries within the Methow River that originated from smolt releases in the Methow River, 2002.

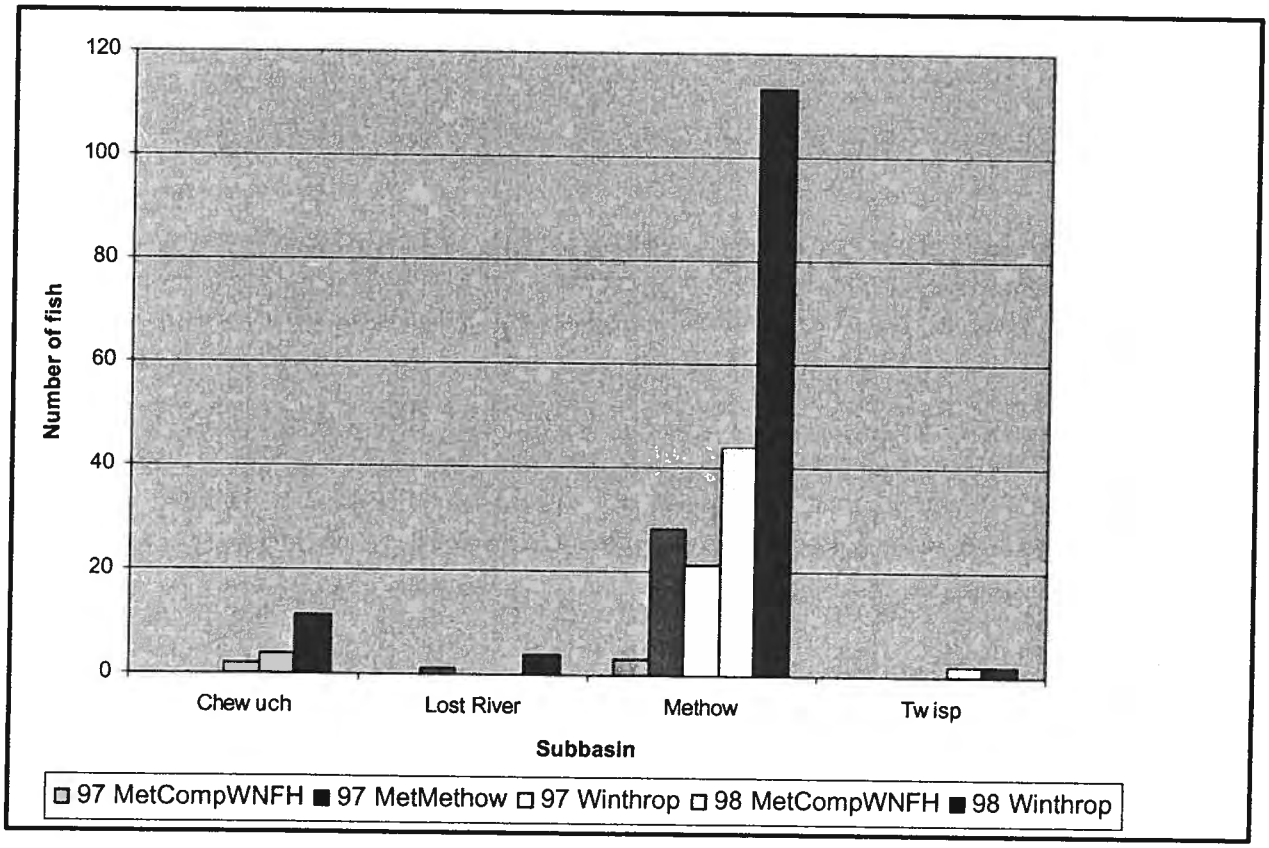

Figure 7. Distribution of coded wire tagged spring chinook carcass recoveries across all subbasins that originated from smolt releases in the Methow River, 2002.

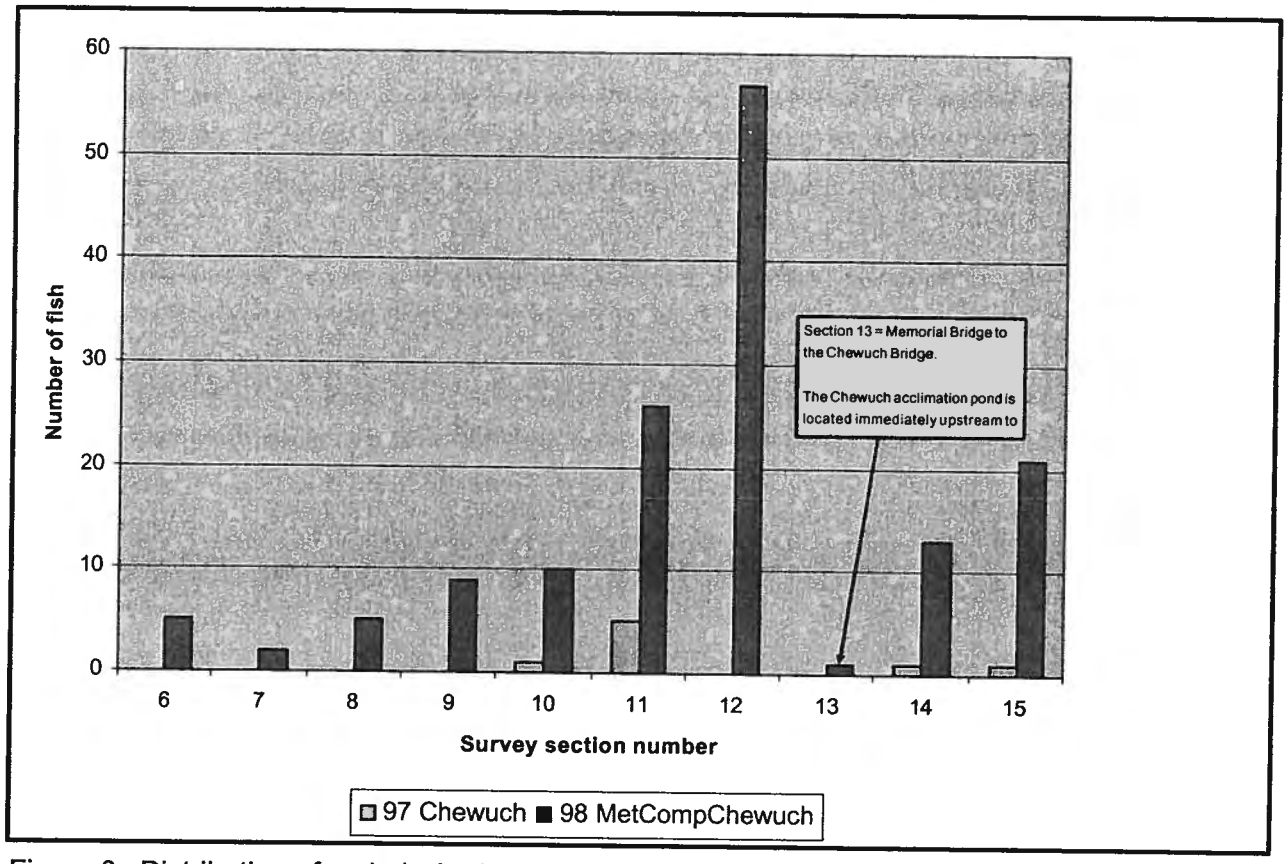

Figure 8. Distribution of coded wire tagged spring chinook carcass recoveries within the Chewuch River that originated from smolt releases in the Chewuch River, 2002.

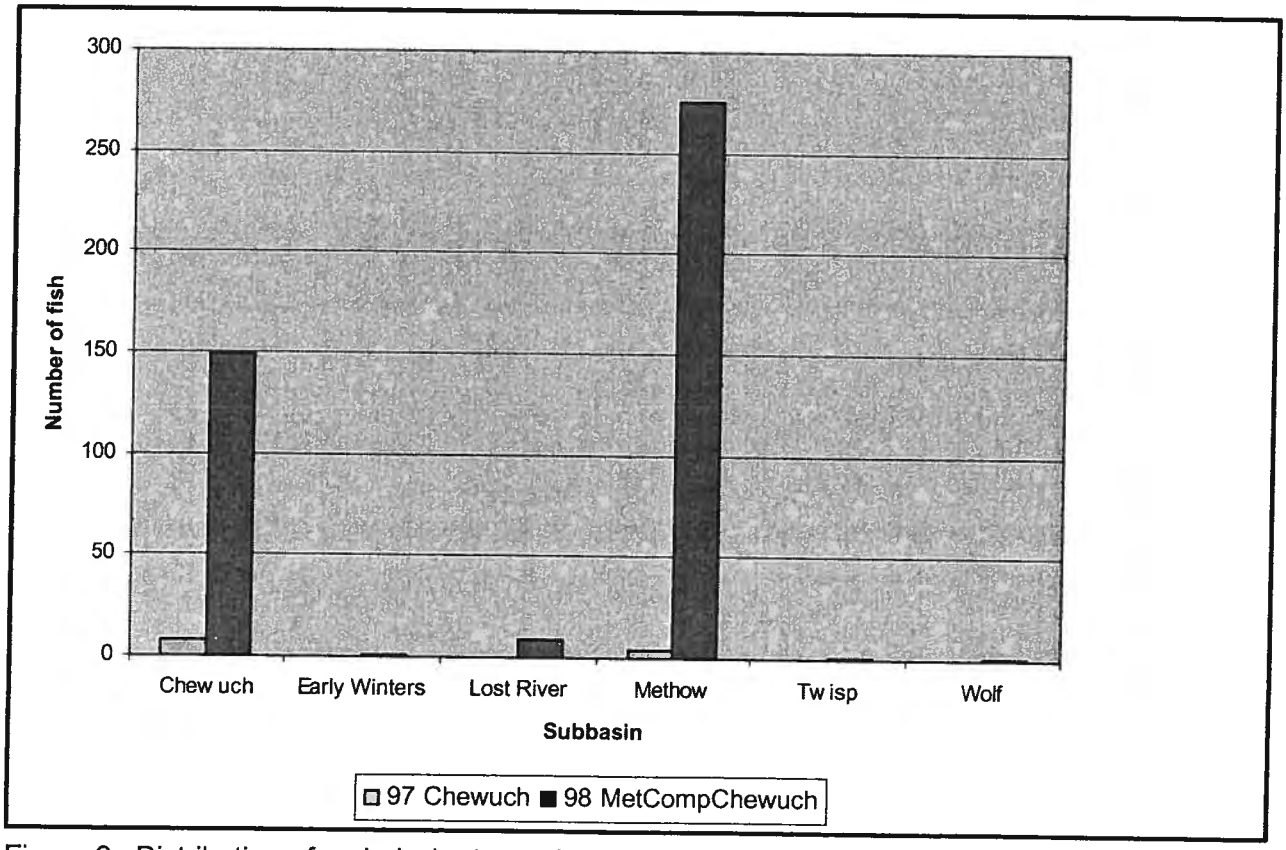

Figure 9. Distribution of coded wire tagged spring chinook carcass recoveries across all subbasins that originated from smolt releases in the Chewuch River, 2002.

Twisp

There was a total of three CWT carcasses originating from Twisp BY98 smolt release recovered in the Twisp River (Figure 10). Two of these were recovered between Mystery Creek Bridge to the War Creek Bridge and the other between Buttermilk Creek Bridge and the cabin (rm 12.1). An additional eight CWT'ed carcasses originating from the Twisp River acclimation release were recovered in the Methow River. (Figure 11).

Lost

A total of 14 CWT'ed carcasses were successfully identified in the Lost River. The majority (9 or 64.3%) were from the Methow Composite Chewuch BY98 smolt release (Figure 12). This was followed by four CWT'ed carcasses from the Winthrop BY98 smolt release and one from the Methow Composite Methow BY97 smolt release.

Wolf and Early Winters Creeks

In both Wolf and Early Winters creeks a single CWT'ed carcass both originating from the Chewuch River Methow Composite release (BY98) were recovered.

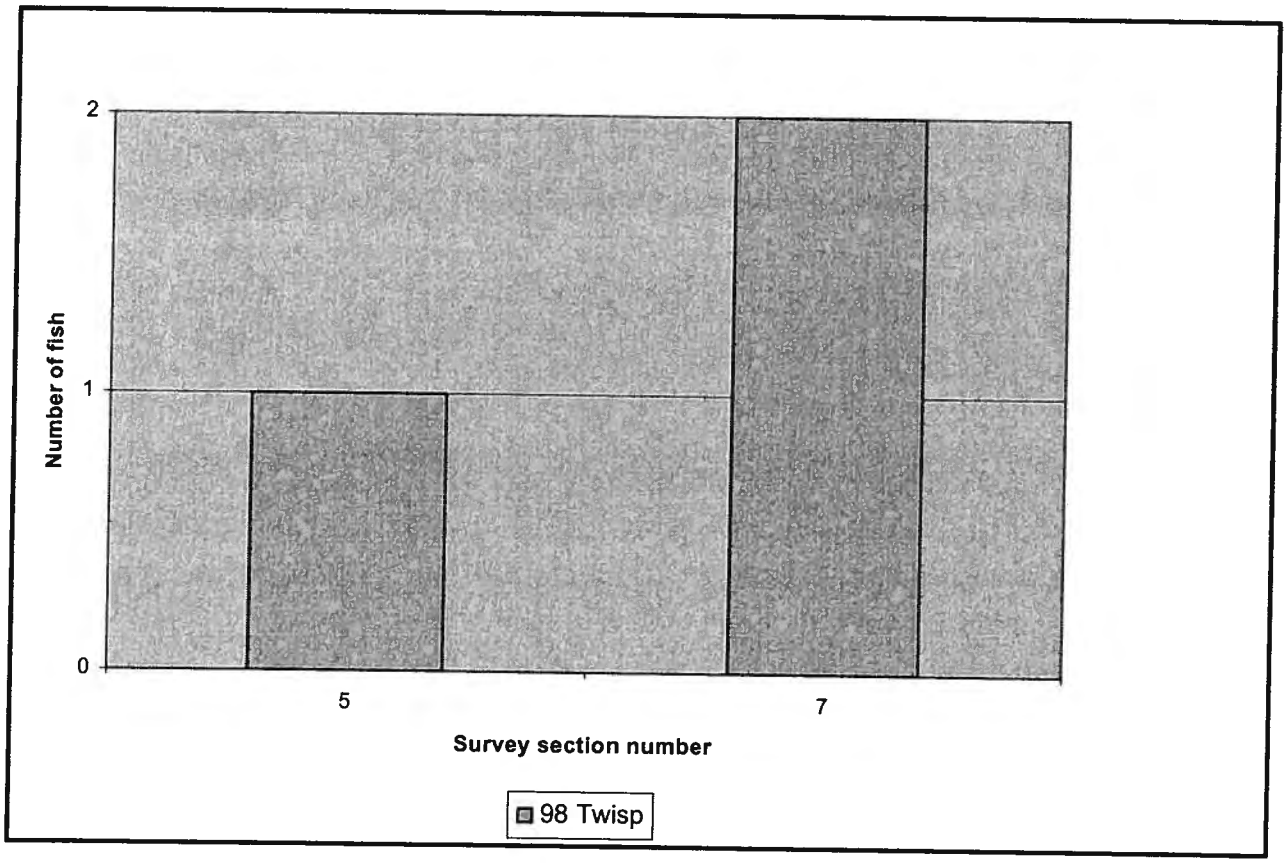

Figure 10. Distribution of coded wire tagged spring chinook carcass recoveries within the Twisp River that originated from smolt releases in the Twisp River, 2002.

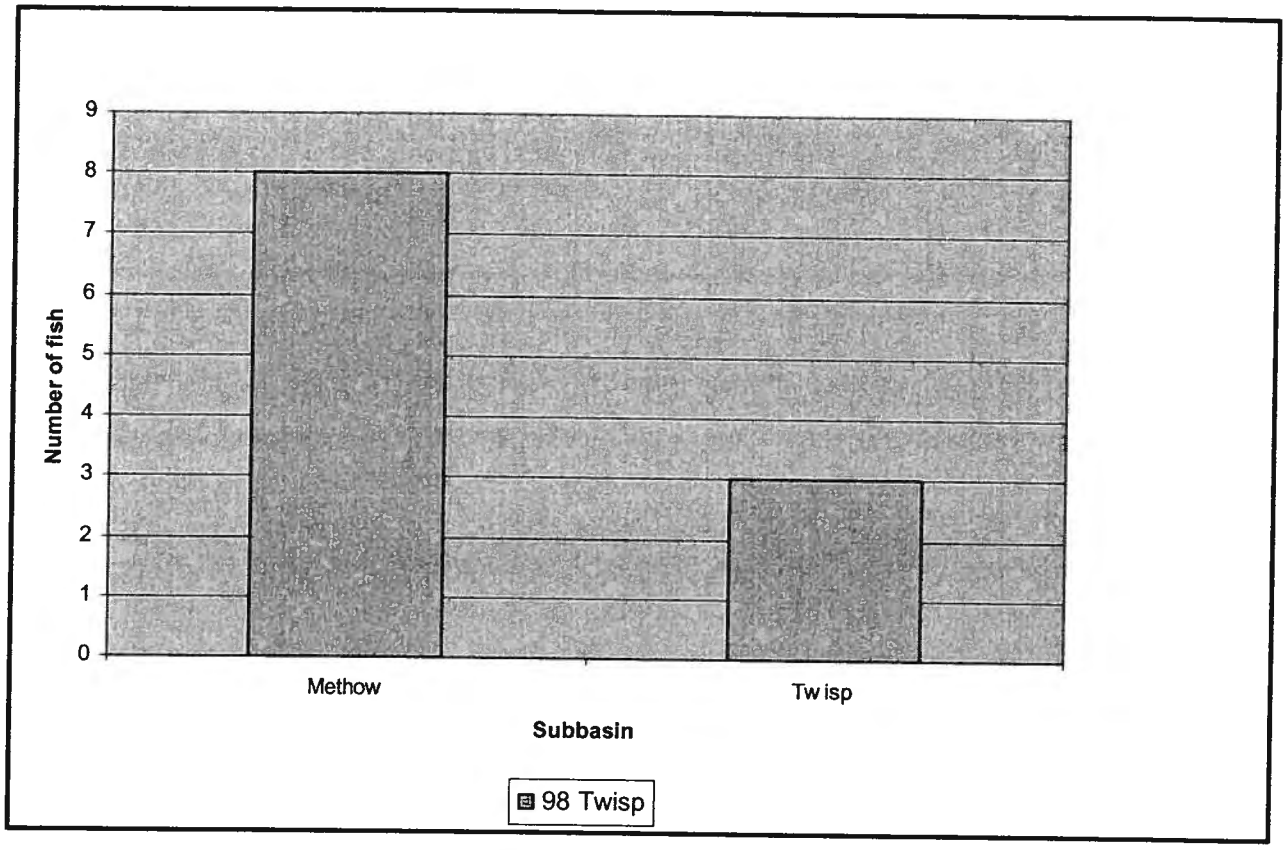

Figure 11. Distribution of coded wire tagged spring chinook carcass recoveries across all subbasins that originated from smolt releases in the Twisp River, 2002.

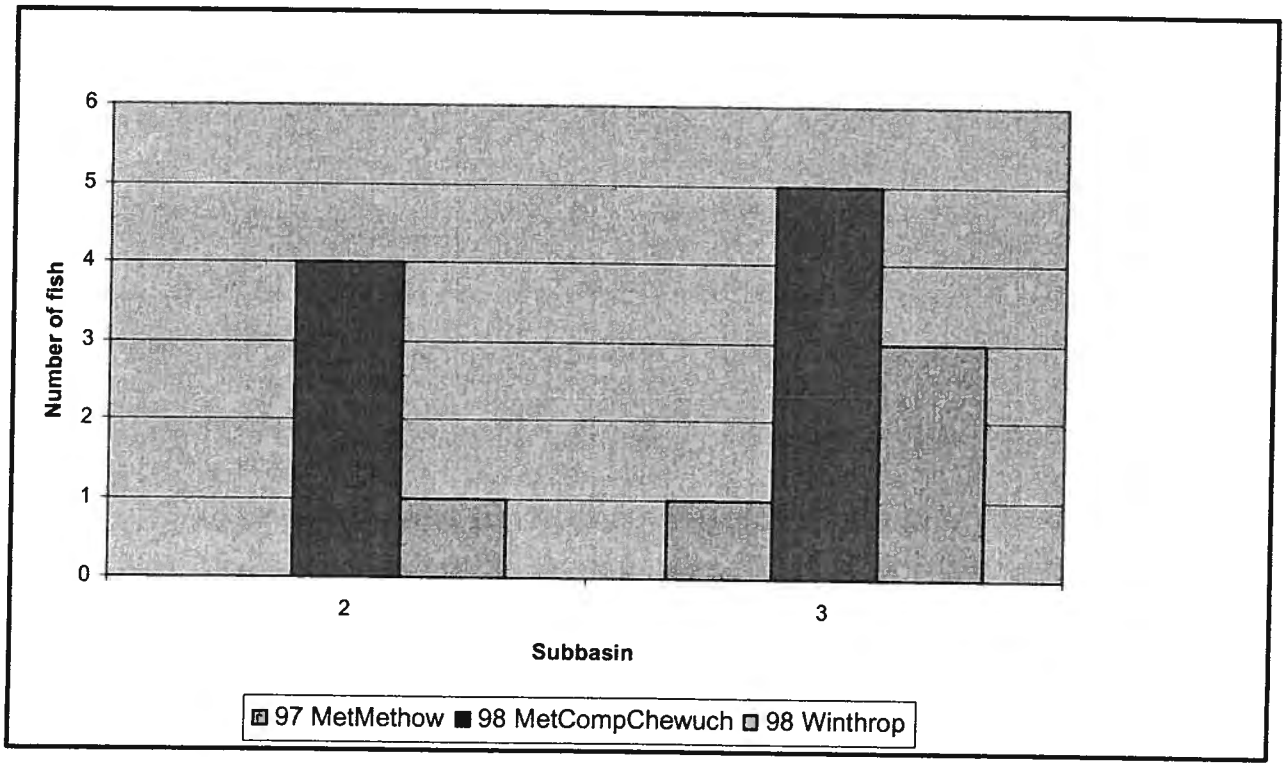

Figure 12. Distribution of coded wire tagged spring chinook carcass recoveries located in the Lost River from smolt releases that originated from the Methow and Chewuch rivers, 2002.

Juvenile Outmigration

A total of 633 spring chinook and 56 steelhead smolts were captured in the trap during its period of operation from March 26 through May 3, 2002 (Table 4). In addition a total of 990 young-of-the-year spring chinook were captured throughout the monitoring period. A complete estimate of spring chinook smolt outmigration was not possible due to the trap not fishing to allow for the passage of hatchery spring chinook smolt outmigrants and an increase in river discharge that required relocation of the trap. These two events occurred from April 15 - 30. For the period of March 26 through April 14 an estimated 7,868 spring chinook smolts passed the Chewuch trap located near the confluence of the Chewuch River.

The mean spring chinook fork length was 96 mm (N = 539) with a standard deviation of 8.6. Spring chinook ranged in size from 70 to 197 mm (Figure 13). The three fish equal to or greater than 145 mm suggest a smolt greater than age-1+. The mean fork length for steelhead/rainbow trout was 114 mm (N = 58) and the standard deviation was 35.5 (Figure 14). Fish ranged in fork length from 60 to 188 mm, which suggests a broad range in age classes and fish under 100 mm are likely steelhead or rainbow trout parr.

A summary of Chewuch trap efficiency test releases conducted in April 2002 are presented in Table 5. Eleven trap efficiency tests were successfully completed using wild spring chinook smolts during the month of April. River discharge ranged from approximately 78 to 168 cfs (based on measured discharge at the USGS gauge station #12448000 located at the Highway 20 bridge crossing in Winthrop, WA). The April 4 efficiency test was excluded from the final data set because it was significantly higher (30.7%) than the calculated efficiencies for the other ten test releases. The reason for this outlier value was not determined. There was no significant correlation ($r^2 = 0.0025$) between trap efficiency and river discharge. This most likely is related to the relatively narrow range (90 cfs) range in river discharge experienced during the period when wild smolts were available, coupled with the small number (an mean of 40 fish/release) of fish available per test release. Excluding the April 4 efficiency test, the overall mean trap efficiency was 8.0%, which was applied to expand the daily spring chinook catch totals since there was no flow specific correlation to trap entrainment efficiency.

Table 4. Summary of spring chinook and steelhead smolt counts at the Chewuch rotary trap located at RM 0.1 on the Chewuch River, 2002.

Date	Spring Chinook Daily Catch	Spring Chinook Estimated Passage	Steelhead Daily Catch	Discharge
3/26/02	1	13	1	62
3/27/02	16	200	2	63
3/28/02	7	88	0	63
3/29/02	19	238	1	6
3/30/02	27	338	1	67
3/31/02	32	400	1	72
4/1/02	38	475	2	79
4/2/02	69	863	0	77
4/3/02	68	850	2	78
4/4/02	52	650	3	81
4/5/02	27	338	2	87
4/6/02	33	413	1	95
4/7/03	44	550	1	105
4/8/02	67	838	7	111
4/9/02	25	313	4	115
4/10/02	37	463	5	118
4/11/02	25	313	2	128
4/12/02	18	225	5	141
4/13/02	14	175	2	168
4/14/02	10	125	3	265
4/15/02	not fished		not fished	304
4/16/02	not fished		not fished	281
4/17/02	not fished		not fished	261
4/18/02	not fished		not fished	244
4/19/02	not fished		not fished	235
4/20/02	not fished		not fished	239
4/21/02	not fished		not fished	249

Table 4 Cont.' Summary of spring chinook and steelhead smolt counts at the Halderman's Hole rotary trap located at RM 38.5 in the Methow River, 2002.

Date	Spring Chinook Daily Catch	Spring Chinook Estimated Passage	Steelhead Daily Catch	Discharge
4/22/02	not fished		not fished	271
4/23/02	not fished		not fished	279
4/24/02	not fished		not fished	267
4/25/02	not fished		not fished	266
4/26/02	not fished		not fished	264
4/27/02	not fished		not fished	260
4/28/02	not fished		not fished	255
4/29/02	not fished		not fished	273
4/30/02	not fished		not fished	336
5/1/02	3	38		448
5/2/02	0	0		575
5/3/02	1	13		626
Totals	633	7919	56	

Notes– Daily catches highlighted in red denote counts were interpolated using linear regression based on the daily counts three days before and after the period of non-fishing (March 30 through April 1). Days highlighted in blue for spring chinook estimated daily passage denote days where the mean daily discharge exceeded the river discharge that trap calibration catch efficiency tests were conducted.

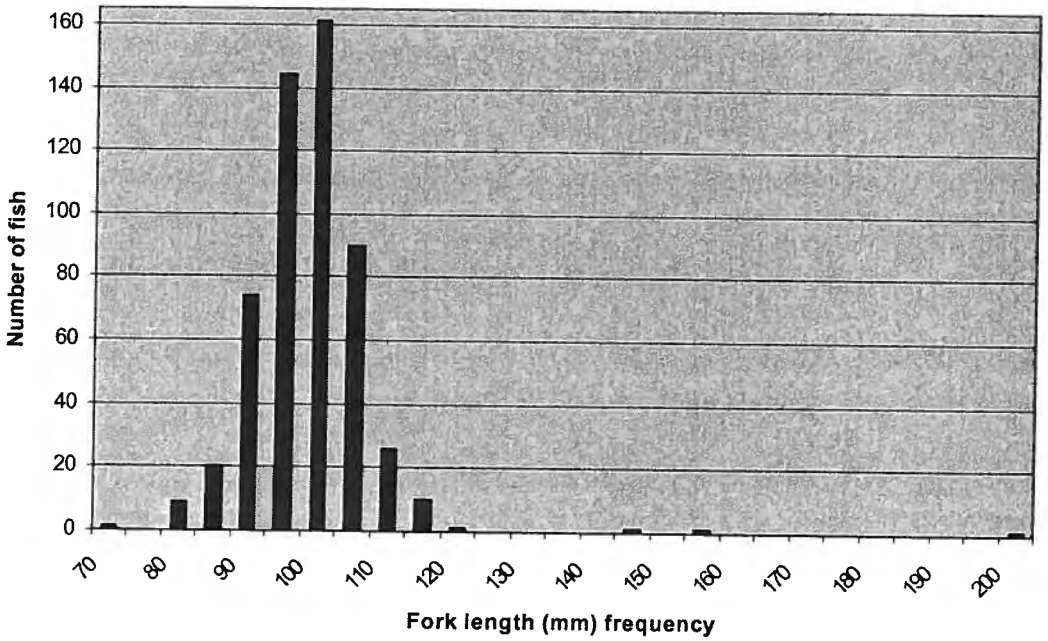

Figure 13. Spring chinook smolt fork length frequency from fish captured at the Chewuch River (RM 0.1) rotary trap on the Chewuch River, spring 2002.

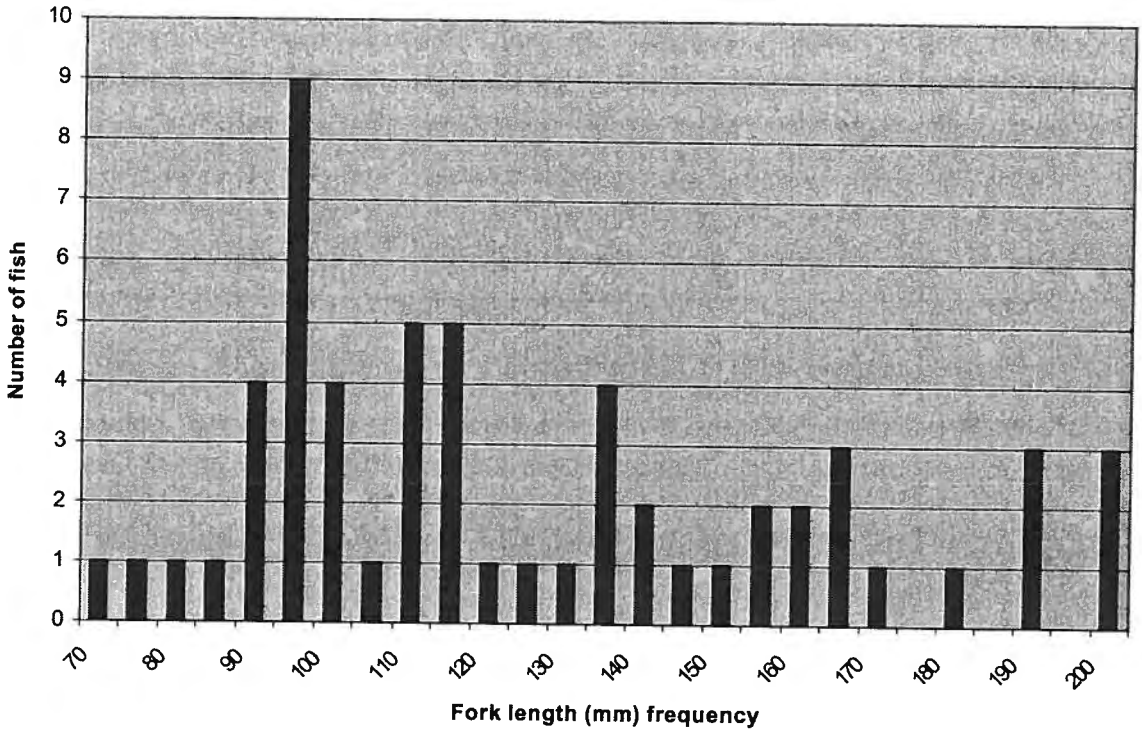

Figure 14. Steelhead/rainbow trout fork length frequency from fish captured at the Chewuch River (RM 0.1) rotary trap on the Chewuch River, spring 2002.

Table 5. Summary of trap efficiency test releases for the Chewuch River (RM 0.1) rotary trap on the Chewuch River, April 2002.

Release Date	Marked Fish Released	Marked Fish Recaptured	Trap Efficiency	Mean Daily Discharge
April 4	69	5	7.2%	78
April 3	68	6	8.8%	81
April 4	52	16	30.7%	87
April 5	26	3	11.5%	95
April 6	33	3	9.1%	105
April 7	44	2	4.5%	111
April 8	67	3	4.5%	115
April 9	25	3	12.0%	118
April 10	37	1	2.7%	128
April 11	25	2	8.0%	141
April 12	18	2	11.1%	168
Mean Efficiency (excluding the April 4 release)			8.0%	

CONCLUSIONS

Key Findings

1. Since 2000 the percent of redds below the Methow River spawner index reach (Mazama Bridge to Weeman Bridge) has exceeded 80%, which is an increase from the 1987-95 average of 41.7%.
2. Similar to the Methow, the percent of redds deposited in the Chewuch River has increased below the index reach (Camp 4 - Falls Creek campground) since 2000. The average for 2000 - 2002 is 79%, compared to 43% for the years 1987-94.
3. The spawning distribution in the Twisp River has remained fairly consistent since 1987.
4. The homing fidelity of Methow acclimated smolts was good with 88.9% (N= 209) of the returning adults spawning in the Methow River in 2002.
5. The homing fidelity of Chewuch acclimated smolts was fair with 62.4% (N= 279) of the returning adults spawning in the Methow River and 35.1% (N= 157) in the Chewuch in 2002. Of the Chewuch derived adults that spawned in the Methow, 59.1% spawned downstream to Foghorn Dam.
6. The homing fidelity of the Twisp acclimated smolts was poor with 27.3% (N= 3) of the returning adults spawning in the Twisp River and 72.7% (N= 8) in the Methow in 2002..
7. The highest CWT group recovered in the Lost River in 2002 was the Methow Composite Chewuch BY98 accounting for nine (64.3%) of the fourteen CWTs recovered.
8. It appears that the Lost River is being re-colonized by hatchery derived spawners in 2001 and 2002. Redd counts ranged from zero to seven annually from 1994 - 2000, and increased to 72 redds in 2001 and 54 redds in 2002. Seventeen carcasses were recovered in the Lost River in 2002, of which, 16 (94%) were of hatchery origin. In 2001 of the six carcasses recovered, five were of natural origin.

Management Considerations

1. Consideration should be given to the pros and cons of re-locating and/or adding an additional Methow spring chinook acclimation site further upstream of the MFH. Clearly, there is a benefit of reducing the number of redds located in the dewatered section of the upper Methow River. Additionally, there exists plenty of high quality spawning and rearing habitat downstream of the Weeman Bridge. At this time there is minimal overlap both spatially and temporally between spring and summer chinook spawners. Given the present spawning distribution represents a significant shift from what was observed historically, a open discussion by the fish managers should ensue as to any potential negative effects in the areas of ecological interactions and long-term fitness.
2. The shift in redd distribution observed since 2000 in the Chewuch should be viewed with some concern primarily because of the limited and of poorer quality spawning habitat that exists in the lower Chewuch River. Additionally, rearing habitat is generally of lower quality in the lower Chewuch River relative to further upstream.
3. Of the three acclimated smolt releases, the Chewuch release resulted in a significant number of spawners in 2002 straying primarily into the Methow River, and also into the Lost River. The CWT recovery rate in the Methow River was 43.9% in 2001 and 62.4% in 2002 for spawners that originated as Chewuch acclimated smolts. Reasons for this are not understood at this time, especially given that the acclimation protocols are similar for all three acclimation sites. A discussion amongst the fish managers and fish culturists is warranted to determine possible causes and corresponding solutions.

4. Though the stray rate of Twisp River derived hatchery spawners was high (72.7% N= 8) based on CWT recoveries in 2002, this should not necessarily be cause for alarm. The sample size of Twisp origin carcasses was low in 2002 at eleven CWTs recovered. This is not a large enough sample size to pass judgment on. In the two previous years (2001 and 2000) the homing fidelity of Twisp origin hatchery spawners has been high. In 2000 and 2001 the percent of CWTs in the Twisp relative to the Methow Basin was 89.5% (N= 34) and 80.6% (N= 25), respectively.
5. Historically the Lost River spring chinook population has been managed or treated as distinct population. From 1994 - 2000 a total of 18 redds were deposited in the Lost River, followed by an increase of 72 and 54 redds in 2001 and 2002, respectively. It appears that hatchery spawners are largely responsible for this increase in redd counts, opposed to naturally produced spawners. In 2002 94% (N= 16) of the carcasses were of hatchery origin, and of these, 64.3% (N= 9) were from the Methow Composite Chewuch BY98 smolt release group and the other five were from WNFH or MFH on-station acclimated smolt releases. In 2001 five of the six carcasses recovered were of natural origin, however, the parent brood years of 1996 (5-yr olds) and 1997 (4-yr olds) had a total of seven redds for these two years in the Lost River. Even if assumed that all seven redds were the result of Lost River spawners, the 72 redds observed in 2001 were largely the consequence of spawners produced outside of the Lost River. Further, it's likely these spawners were largely of hatchery origin given the size of the 2001 return (10,871 fish past Wells) relative to the parent brood years of 1996 and 1997 where the Methow Basin redd counts were assumed to be zero in 1996 (all adults were collected at Wells Dam this year) and 150 in 1997. Thus the majority of fish that returned to spawn in 2001 were most likely derived from acclimated smolts produced by the two hatcheries. For the future, fish managers need to consider from a biological/genetic and management perspective how best to manage the Lost River spring chinook population.

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APPENDIX TABLES 1-4

Appendix Table 1. Methow basin spring chinook weekly and river section redd counts, 2002.

Appendix Table 2. Chewuch basin spring chinook weekly and river section redd counts, 2002.

Appendix Table 3. Twisp basin spring chinook weekly and river section redd counts, 2002.

Appendix Table 4. Lost and Early Winters basins spring chinook weekly and river section redd counts, 2002.

Appendix Table 1. Methow basin spring chinook weekly and river section redd counts, 2002.

River Section	Section No.	Week 1 (7/28-8/3)	Week 2 (8/4-10)	Week 3 (8/11-17)	Week 4 (8/18-24)	Week 5 (8/25-31)	Week 6 (9/1-7)	Week 7 (9/8-14)	Week 8 (9/15-21)	Week 9 (9/22-28)	Total
Ballard Camp Ground - Lost R.	1	0	0	0	0	0	0	0	0	0	**0**
Lost R. - Gate Cr.	2	0	0	1	0	0	0	0	3	0	**4**
Gate Cr. - Early Winters Cr.	3	0	0	3	17	3	6	0	0	0	**29**
Early Winters Cr. - Mazama Br.	4	0	0	2	7	3	0	0	0	0	**12**
Mazama Br. - Rd. barrier	5	0	0	0	3	3	8	2	3	0	**19**
Rd. barrier - Weeman Br.	6	0	0	9	7	10	2	8	0	0	**36**
Weeman Br. - along Highway 20	7	0	0	21	81	93	100	11	0	0	**306**
along Highway 20 - Wolf Cr.	8	0	0	0	0	0	1	0	0	0	**1**
Wolf Cr. - Foghorn Dam	9	0	0	1	15	24	19	5	0	14	**78**
Foghorn Dam - Chewuch Confluence	10	0	8	15	32	20	20	15	6	0	**116**
Chewuch Confluence - Barkley Div.	11	0	0	20	0	8	5	2	1	0	**36**
Barkley Div. - Twisp confluence	12	0	0	0	0	9	6	0	0	0	**15**
Methow Hatchery outfall	—	0	0	1	0	0	42	0	0	0	**43**
Spring Creek (Winthrop H. outfall)	—	0	0	3	21	2	0	0	0	0	**26**
Methow River Totals		**0**	**8**	**76**	**183**	**175**	**209**	**43**	**13**	**14**	**721**
Wolf Creek	—	0	0	1	0	0	0	0	0	0	1
Gold Creek	—	0	0	0	0	0	0	0	0	0	0

Appendix Table 2. Chewuch basin spring chinook weekly and river section redd counts, 2002.

River Section	Section No.	Week 1 (7/28-8/3)	Week 2 (8/4-10)	Week 3 (8/11-17)	Week 4 (8/18-24)	Week 5 (8/25-31)	Week 6 (9/1-7)	Week 7 (9/8-14)	Week 8 (9/15-21)	Week 9 (9/22-28)	Total
Falls - 30 Mile Br.	1	0	0	0	0	0	0	0	0	0	**0**
30-Mile Br. - road-side campground	2	0	0	2	0	0	1	0	0	0	**3**
road-side campground - Andrews Cr.	3	0	0	0	0	0	0	0	0	0	**0**
Andrews Cr. - Lake Cr.	4	0	0	0	0	0	0	0	0	0	**0**
Lake Cr. - Buck Cr.	5	0	0	0	0	0	0	0	0	0	**0**
Buck Cr. - Camp 4 Br.	6	0	0	0	4	0	0	6	0	0	**10**
Camp 4 Br. - road-side campground	7	0	0	0	2	8	0	0	0	0	**10**
road-side campground - Chewuch campground	8	0	0	0	4	6	4	3	0	0	**17**
Chewuch campground - Mile-6 campground	9	0	0	1	4	5	0	12	0	0	**22**
Mile-6 campground - Falls Cr. campground	10	0	0	1	1	3	0	0	0	0	**5**
Falls Cr. campground - 8-Mile Ranch	11	0	0	0	0	0	32	0	0	0	**32**
8-Mile Ranch - Memorial Br.	12	0	0	1	11	0	38	33	30	0	**113**
Memorial Br. - Chewuch Br.	13	0	0	0	0	0	0	0	0	2	**2**
Chewuch Br. - halfway Pt.(rm 5)	14	0	0	0	0	4	43	0	0	0	**47**
Halfway Pt. (rm 5) - confluence	15	0	0	0	0	10	30	0	0	0	**40**
Basin Totals		**0**	**0**	**5**	**26**	**36**	**148**	**54**	**30**	**2**	**301**

Appendix Table 3. Twisp basin spring chinook weekly and river section redd counts, 2002.

River Section	Section No.	Week 1 (7/28-8/3)	Week 2 (8/4-10)	Week 3 (8/11-17)	Week 4 (8/18-24)	Week 5 (8/25-31)	Week 6 (9/1-7)	Week 7 (9/8-14)	Week 8 (9/15-21)	Week 9 (9/22-28)	Total
Road end campground - up 2 miles	1	0	0	0	0	0	0	0	0	0	**0**
Road end campground . - South Cr. Br.	2	0	0	0	0	0	0	0	0	0	**0**
South Cr. Br. - Popular Flats campground	3	0	0	0	0	0	0	0	0	0	**0**
Popular Flats campground - Mystery Br.	4	0	0	0	2	0	3	1	0	0	**6**
Mystery Br. - War Cr. Br.	5	0	0	1	9	2	1	1	0	0	**14**
War Cr. Br. - cabin	6	0	0	2	3	0	0	0	0	0	**5**
cabin - Buttermilk Br.	7	0	1	9	12	33	12	0	0	0	**67**
Buttermilk Br. - green Br.	8	0	0	1	0	0	0	0	0	0	**1**
green Br. - Little Br. Cr.	9	0	0	2	1	5	0	0	4	0	**12**
Little Cr. Br. - Newby Cr. Br.	10	0	0	0	0	0	0	0	0	0	**0**
Newby Cr. Br. - fish weir	11	0	0	0	0	0	0	0	0	0	**0**
fish weir - Wooden Br.	12	0	0	0	0	0	0	0	0	0	**0**
Wooden Br. - Poorman's Br.	13	0	0	0	0	0	0	0	0	0	**0**
Poorman's Br. - Twisp R. Br.	14	0	0	0	0	0	0	0	3	0	**3**
Twisp R. Br. - confluence	15	0	0	0	0	0	0	0	0	0	**1**
Basin Totals		**0**	**1**	**16**	**27**	**40**	**16**	**2**	**7**	**0**	**109**

Appendix Table 4. Lost and Early Winters basins spring chinook weekly and river section redd counts, 2002.

River Section	Section No.	Week 1 (7/28-8/3)	Week 2 (8/4-10)	Week 3 (8/11-17)	Week 4 (8/18-24)	Week 5 (8/25-31)	Week 6 (9/1-7)	Week 7 (9/8-14)	Week 8 (9/15-21)	Week 9 (9/22-28)	Total
Lost River										0	
Sunset Cr. - Eureka Cr.	1	0	0	0	0	0	0	0	0	0	**0**
Eureka Cr. - Lost R. Road Br.	2	0	0	0	24	2	12	2	0	0	**40**
Lost R. Road. Br. - confluence	3	0	0	0	11	3	0	0	0	0	**14**
Lost River Totals		**0**	**0**	**0**	**35**	**5**	**12**	**2**	**0**	**0**	**54**
Early Winters Creek											
Klipchuch campground. - Early Winters Br.	1	0	0	0	0	0	0	0	0	0	**0**
Early Winters Br. - Highway 20 Br.	2	0	0	0	0	0	0	0	0	0	**0**
Highway 20 Br. - diversion dam	3	0	0	0	0	0	0	0	0	0	**0**
diversion dam - Highway 20 Br.	4	0	0	0	3	0	3	0	0	0	**6**
Highway 20 Br. - confluence	5	0	0	0	0	0	0	0	0	0	**0**
Early Winters Creek Totals		**0**	**0**	**0**	**3**	**0**	**3**	**0**	**0**	**0**	**6**

MOVEMENT OF BULL TROUT WITHIN THE MID-COLUMBIA RIVER AND TRIBUTARIES 2002-2003

APPENDIX J

MOVEMENT OF BULL TROUT WITHIN THE MID-COLUMBIA RIVER AND TRIBUTARIES, 2002-2003

Draft

ROCKY REACH HYDROELECTRIC PROJECT
FERC Project No. 2145

July 9, 2003

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SECTION 1: INTRODUCTION

On June 10, 1998, the U.S. Fish and Wildlife Service (Service) listed bull trout (*Salvelinus confluentus*) 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)). The Service identified habitat degradation, fragmentation and alterations associated with dewatering, road construction and maintenance, mining, and grazing; blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment into diversion channels; and introduced non-native species as major factors 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). The Service believes many populations are now isolated and disjunct.

In a letter to the Federal Energy Regulatory Commission (FERC), the Service requested consultation under Section 7 of the ESA regarding the effects of hydroelectric project operations on bull trout in the Columbia River (letter from M. Miller, USFWS, to M. Robinson, FERC, dated January 10, 2000). The request for consultation was based on observations of bull trout in the study area. 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 Chelan, Douglas, and Grant PUDs (Mid-Columbia PUDs), the Mid-Columbia PUDs initiated an evaluation of the status of bull trout in the project area. Currently, little is known about the life-history characteristics (e.g., movements, distribution, habitat use, etc.) of bull trout in the mid-Columbia River. Therefore, in order to assess the operational effects of hydroelectric projects on adult bull trout within the mid-Columbia, we radio-tagged forty adult bull trout collected at three Mid-Columbia River dams. We tracked these fish to describe their movements and migration patterns within the mid-Columbia Basin.

Our specific objectives were to: (1) describe the movements and migration patterns of adult bull trout in the mid-Columbia system and (2) assess the effects of hydroelectric operations on the movement and migration patterns of adult bull trout in the mid-Columbia River. Results presented here represent the second year of a multi-year study. Therefore, any conclusions drawn from this work at this time are tentative. We will complete a final report with additional data and analyses after the final year of study. This report is simply an interim progress report.

SECTION 2: PROJECT AREA

The primary geographical area of interest was the mainstem Columbia River from Priest Rapids Dam to Chief Joseph Dam (Figure 1). It is within this area that we assessed the effects of Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams on the movement and migration patterns of adult bull trout. At these dams, we placed fixed-site radio telemetry systems to monitor the movements of radio-tagged bull trout. The study area also included the four major tributaries to the mid-Columbia River, Wenatchee, Entiat, Methow, and Okanogan systems. Both fixed-site telemetry systems and mobile telemetry surveys were used to monitor the movement of radio-tagged bull trout within these systems.

Columbia River flows passing through the mid-Columbia River projects during the period May through October, 2002, are shown in Figure 2, Figure 3, and Figure 4. Discharge at the mid-Columbia River projects was a combination of turbine generation and spill from May to end of August. Thereafter, only minimal spill levels occurred at Priest and Wanapum dams. Migration of bull trout upstream through each of the projects was provided by a fishway ladder system. These ladders systems consist of one or more main entrances located in the tailrace of each project. Some projects also include orifice gates (O.G. gates) that are used to provide additional entrances to the collection channels of the main ladder system (i.e. Priest Rapids, Wanapum, and Rocky Reach Dams). Migration downstream past mid-Columbia River projects likely occurs through powerhouse or spillway passage routes and could include juvenile collection facilities.

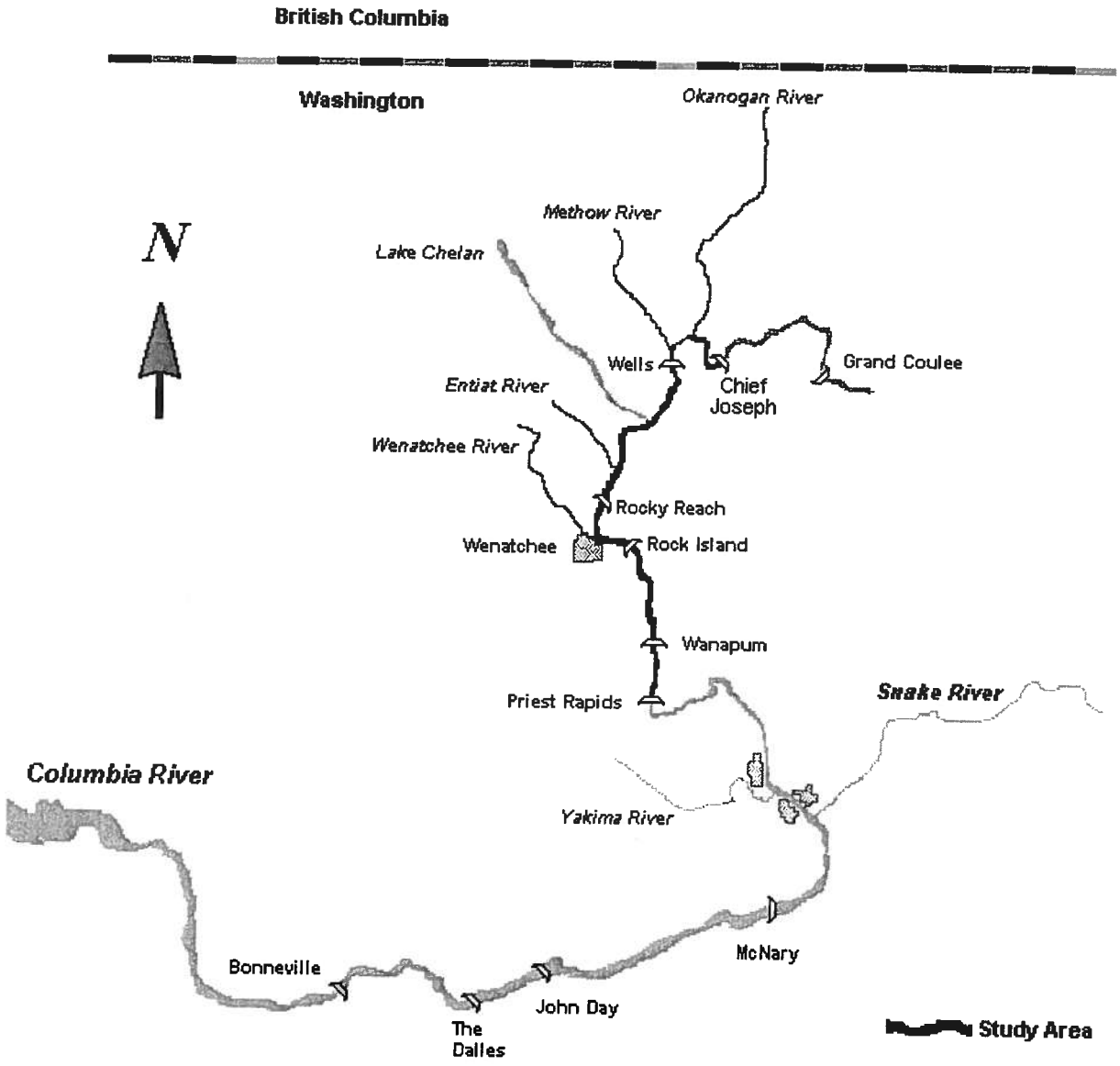

Figure 1: Study area for assessing migration patterns of bull trout in the mid-Columbia River. Fixed radiotelemetry sites monitored the movement of bull trout near Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams. Fixed sites placed in the Wenatchee, Entiat, Methow, and Okanogan rivers monitored time of entry and exodus of bull trout in large tributaries of the mid-Columbia River.

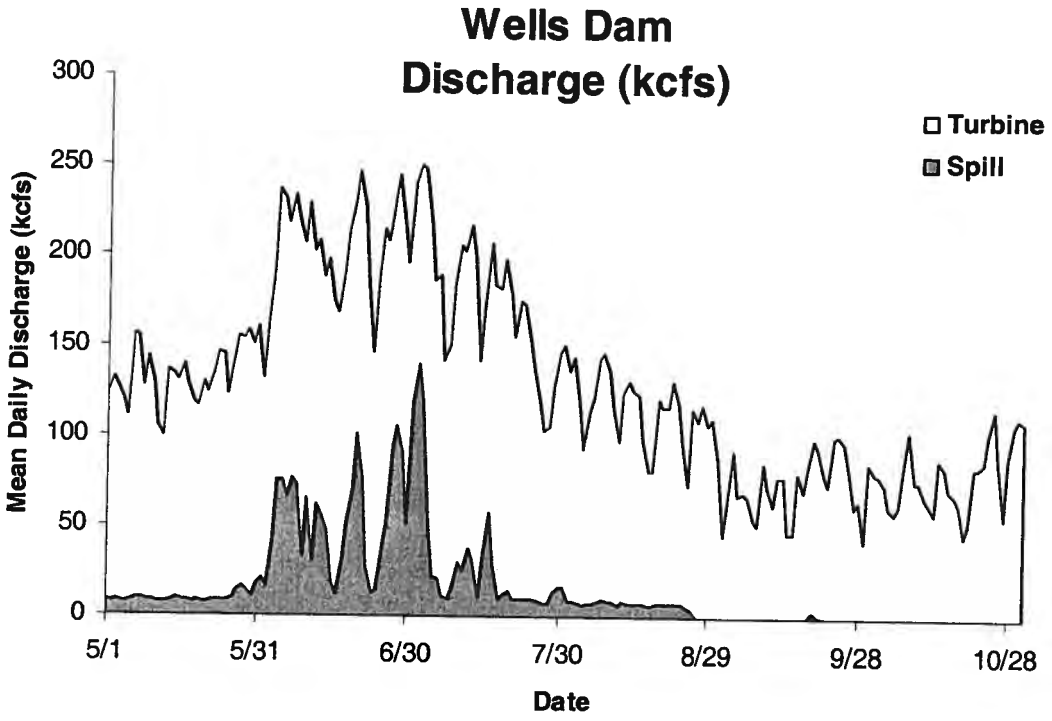

Figure 2: Columbia River flows passing through Wells Dam during the period May through October, 2002.

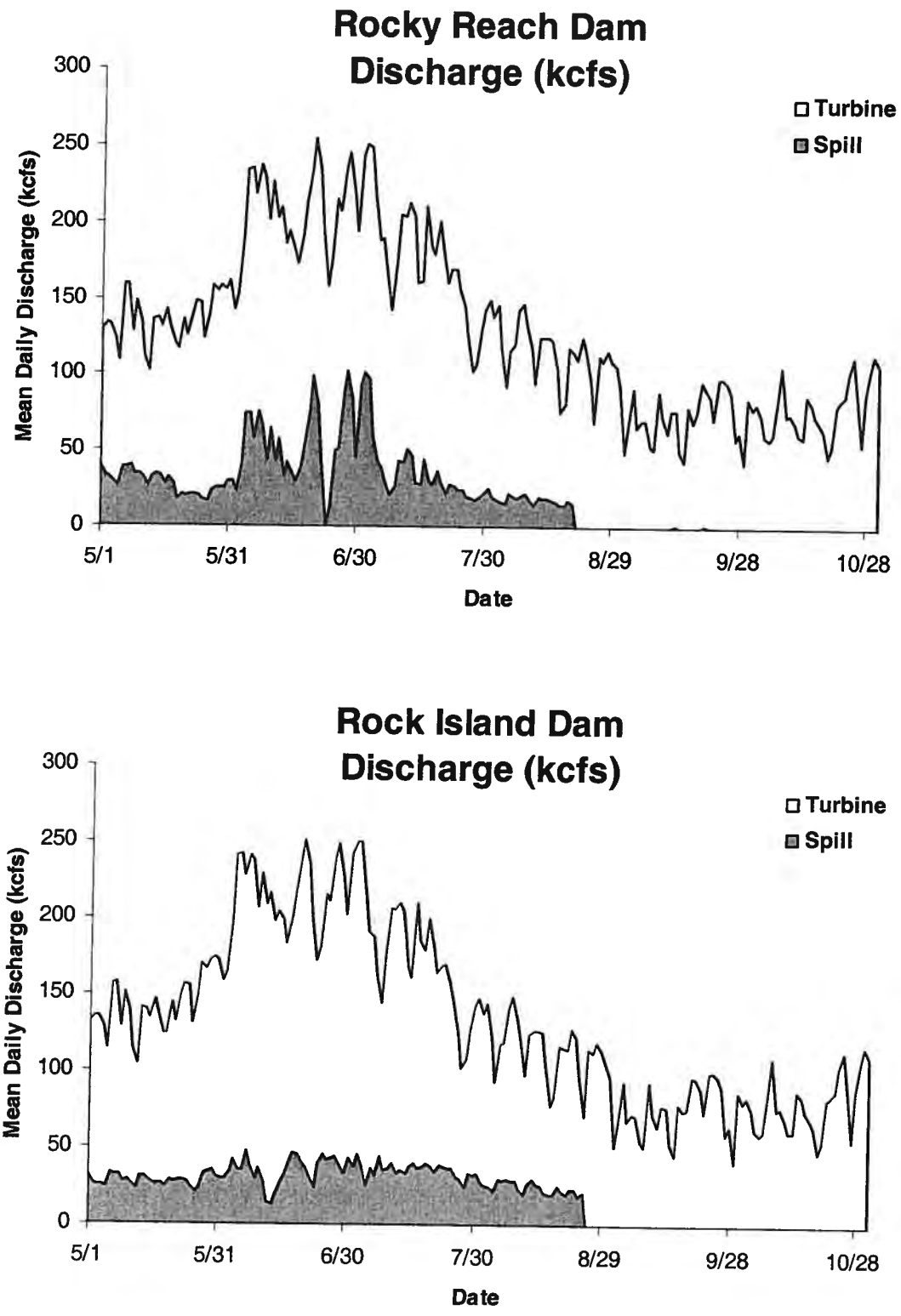

Figure 3: Columbia River flows passing through Rocky Reach and Rock Island dams during the period May through October, 2002.

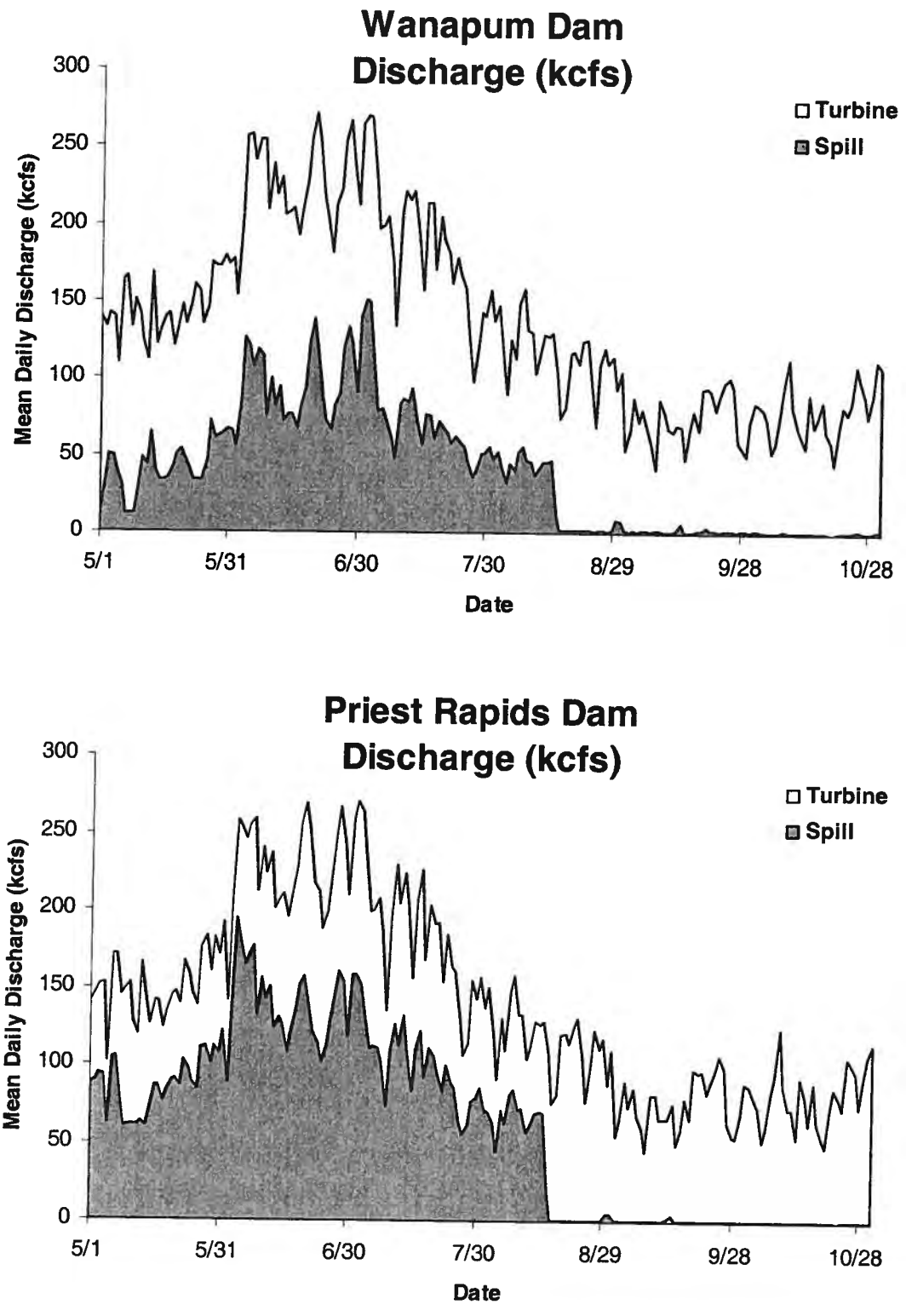

Figure 4: Columbia River flows passing through Wanapum and Priest Rapids dams during the period May through October, 2002.

SECTION 3: METHODS

This study relied on radio tags to monitor the movements and migration patterns of adult bull trout in the mid-Columbia River. Below we describe the number of fish tagged, tagging procedures, and monitoring systems.

3.1 Number of Bull Trout Tagged

To assess the movements and migration patterns of adult bull trout, we originally proposed to tag a total of 40 bull trout in the mid-Columbia River. This number was based on discussions with the Service and represented approximately 20% of all bull trout counted at the dams in previous years. The number of trout collected and tagged at each dam was based on the proportion of fish that migrated past those dams in 2000. Typically, the greatest numbers of bull trout are observed during the months of May and June at Rock Island, Rocky Reach, and Wells dams (Figure 5, Figure 6, and Figure 7). More bull trout are observed at Rocky Reach Dam than at either Rock Island or Wells dams. Based on this information, we originally intended to collect and tag 10 adult bull trout at Rock Island Dam, 20 at Rocky Reach Dam, and 10 at Wells Dam during mid-May to late-June 2002. We did not attempt to tag at Priest or Wanapum dams because so few bull trout have been observed at these projects that the capture and tagging of bull trout was considered unlikely.

To avoid a temporal bias in our sampling program, we collected bull trout throughout the migration period (20 May to 27 June) at Rocky Reach Dam by establishing weekly tagging targets. These weekly targets were based on the proportion of fish observed at Rocky Reach Dam during the 2000 and 2001 bull trout migration periods (Table 1; Figure 5 and Figure 6). That is, we captured bull trout throughout the passage period, but collected and tagged a greater number during the period of peak passage.

In order to describe the passage distribution, we compiled numbers of bull trout passing Rocky Reach Dam during each week of the 2000 and 2001 migrations. We then calculated the proportion of the total run that passed the project during each week. We estimated the numbers of bull trout captured and tagged at the dam during each week of the 2002 sampling period from the product of the weekly proportions and total sample size (i.e., 20 fish at Rocky Reach) (Table 1; Figure 5 and Figure 6). At most, five fish were to be collected and tagged during a given sampling week (Table 1; Figure 6). Because of the desire to maintain the predetermined tagging schedule, it was decided that if the weekly tagging quotas were not met at the project, the deficit would be carried into the following week.

Diel passage data for adult bull trout at Rocky Reach and Rock Island dams indicated that most bull trout passed the projects between 0800-2300 hours (Figure 8 and Figure 9). Since the upstream release of radio-tagged fish at Rocky Reach Dam required logistical support from Chelan PUD, we decided to operate the traps between 0800-1700 hours.

We established no weekly tagging goals for collecting bull trout at Rock Island or Wells dams. At Rock Island, this was due to the difficulty in meeting tagging quotas in 2001 near the end of the tagging period. Therefore, it was decided to collect and tag all fish as they passed the project. At Wells Dam, we reduced the overall trap operation time to minimize potential harassment to

migrating chinook salmon and steelhead. At Wells Dam collection and tagging began on 21 May and continued through 19 June with the trap operating typically Tuesday through Thursday between 0900-1400 hours (Figure 10).

Table 1: Weekly adult bull trout tagging schedule for Rocky Reach Dams, 2002. The tagging schedule was based on the proportion observed (counted) during the same period during the 2000 and 2001 migrations.

Week	Beginning	2000 and 2001 Average	Tag
1	13-May	30.5	4
2	20-May	41.5	5
3	27-May	32.5	4
4	03-June	18.0	2
5	10-June	14.5	2
6	17-June	11.5	2
7	24-June	10.0	1
	Totals	**158.5**	**20**

3.2 Trapping Facilities

3.2.1 Rocky Reach and Rock Island Dams

The trapping facilities at Rocky Reach and Rock Island dams are integrated with the existing fish-viewing structures within the ladders (Figure 11 and Figure 12). Essentially, the fish-viewing guide wall extends upstream to the exit weir, and a pneumatically-activated gate is integrated within the guide wall.

On the other side of the pneumatic gate is a collection area, which contains a removable capture vessel. As a bull trout entered the viewing area, a technician activated the pneumatic gate, which blocked passage into the forebay and diverted the bull trout into the collection area. Using an underwater camera, the technician could observe the bull trout enter the collection area, at which time the gate would be closed, trapping the bull trout. Non-target species and small bull trout (<40 cm) were allowed to exit the ladder by simply not activating the pneumatic gate. After a bull trout was contained within the collection area, either an electric or hand-operated winch raised the collection vessel from the collection area up to the work-surface platform. As the vessel emerged from the water, we placed a wooden cover on top of the vessel to reduce stress to the fish and eliminate the possibility of the fish jumping out of the vessel.

We then transferred the captured bull trout from the collection vessel to the surgical facility. To facilitate transport and reduce handling stress, we sedated bull trout with MS-222 (at a concentration of 80 mg/L) while they were contained in the collection vessel (see Surgical Techniques for detailed description of sedation). At Rocky Reach Dam, the collection vessel was moved laterally along an I-beam monorail, which placed it near the surgical facility located under the roadway of the ladder.

We then transferred the fish by hand to the surgical table for processing. At Rock Island Dam, the surgical facility was located within a trailer approximately 10 m from the collection area. There, we transferred fish in a rubber bladder filled with anesthetic water to the surgical facility.

3.2.2 Wells Dam

Bull trout at Wells Dam were trapped at the brood-stock collection facility located within the left bank ladder. The brood-stock collection facility is located at pool 40, approximately half way up the fish ladder. The trap is operated by placing a barrier fence across the entire width of pool 40. When the trap is in operation, all fish ascending the left bank ladder are blocked by the barrier fence and are forced to ascend the off-ladder trap via a steep pass denil which leads to an upwell enclosure. Once inside the upwell enclosure, fish are attracted down a sorting chute by jets of water, introduced into the upwell enclosure, located near the top of the sorting chute. As the fish slide down the sorting chute, they are identified and either diverted into the holding tank or allowed to pass upstream of the trap. When a bull trout was observed in the chute, a technician activated a pneumatic gate, and the fish is diverted into a 600-gallon holding tank. Non-target species and small bull trout (<40 cm) were shunted back to the ladder upstream of the trapping barrier. The fish ladder supplied the holding tank with freshwater at a rate of 30 to 40 gal/hr to maintain adequate dissolved oxygen and temperature levels. At the time of tagging, bull trout were netted from the holding vessel and transferred to an anesthetic vessel containing an 80 mg/l solution of MS-222. Once anesthetized, we transferred the fish to a mobile surgical station for further processing.

3.3 Tagging Procedures

3.3.1 Description of Radio Tags

We implanted adult bull trout with digitally-encoded transmitters developed by Lotek Engineering. The transmitter, model MCFT-3A, was 16 mm in diameter, 46 mm long, and weighed 6.2 grams in water and 16.0 grams in air. With a 5.0-second burst rate, the estimated life of the transmitter was 761 days.

Winter (1983) identified a criterion of 2% for the ratio of transmitter to body weight (in air) as being acceptable. For transmitters used in this study, that criterion would allow the tagging of trout equal to or greater than 800 grams. However, more recent information suggests that a radio transmitter that is as much as 5-10% of the fish's body weight will not adversely affect fish behavior (Adams et al. 1998). Using the criterion of 5% would allow the tagging of fish as small as 320 grams, and 10% would allow the tagging of fish as small as 160 grams. Taking a conservative approach, we decided to only tag fish with a fork length greater than 40 cm (~650 grams). Based on this strategy, at most, the transmitter would amount to 2.5% of the fish's body weight.

3.3.2 Surgical Techniques

Our surgical procedures followed methods described in Summerfelt and Smith (1990), with some modifications based on consultation with the Service. We anesthetized bull trout in a pre-operative solution of tricaine methanesulfonate (MS 222) at a concentration of 80 mg/l. Service biologists found that 80 mg/l of MS 222 for initial induction, followed by a concentration of 40 mg/l during surgery was adequate to maintain anesthesia during implantation of transmitters in bull trout (J. De La Vergne, USFWS, personal communication). Before preparation of the pre-operative solution of MS-222, the water was sampled for pH. If the solution was acidic (pH<7.0), it was buffered with

sodium bicarbonate to maintain a pH of 7, thereby reducing physiological stress associated with anesthesia (Wedemeyer 1970). After sedation, the fish was weighed, measured and a genetic sample was taken from the upper lobe of the caudal fin. In addition, we removed scales for age analysis from all bull trout collected at Rock Island, Rocky Reach and Wells dams. Scale analysis was performed by the Washington Department of Fish and Wildlife. Genetic samples were preserved and provided to the Service. Genetic characterization was not a task of this study; therefore, genetic results are not presented in this report.

After fully sedated, we placed the fish on a V-shaped cradle in preparation for surgery. From the time when the fish was placed onto the surgical cradle until surgery was completed, a surgical assistant flushed the gills of the fish with a 40-mg/l solution of MS-222 using a large bulb-type syringe. During this process gill activity was monitored, and if necessary, either freshwater or a stronger solution of MS-222 (80 mg/l) was used to maintain the desired level of anesthesia. Before surgery, we sterilized all surgical instruments and the radio-transmitter in 100% ethyl alcohol and rinsed them with a 3% solution of sodium chloride to prevent irritation at the incision site.

Before making the incision, we swabbed the tissue with iodine to decrease the likelihood of post-operative infection. An incision about 2-cm long was made lateral to the linea alba and about 2 cm anterior of the pelvic girdle through the musculature of the fish. We then inserted a 16-gauge cannula sheathed within a Teflon tube (to protect internal organs) into the body cavity of the fish. The cannula was positioned at an angle 45 degrees to the medial line of the fish, and distill to the posterior end of the incision. Once the cannula was inserted into the fish, the Teflon sheath was removed and the transmitter antenna was inserted into the cannula. We then removed the cannula and inserted the transmitter into the body cavity of the fish. The body cavity was closed with 3 to 4 internally-knotted absorbable sutures and swabbed with iodine. Veterinary tissue glue was applied to both the incision and the exit site of the transmitter antenna.

After surgery, we transferred the fish to a 49-liter cooler that was supplied with river water. We held the fish until equilibrium was achieved (typically 10 to 15 minutes). The same vessel was used for post-operative recovery, transport, and release. During the handling procedure, start and completion times were recorded for surgery, recovery, transport, and release. In addition, the water temperature within the recovery/transport vessel was monitored before transport and release.

3.4 Transport and Release

We followed the same general transport procedures at release sites near Rock Island and Wells dams. Typically, after the fish had recovered, we loaded the transport vessel, which contained the fish and was supplied with air delivered through an air stone, into a truck and transported the fish quickly to the release site. At the release site, we removed the air stone and transported the vessel into the river. We recorded the water temperature within the vessel and also in the river. The vessel was then gently rolled onto its side and the lid was opened allowing the fish to swim free of the vessel. The swimming behavior of the fish was observed and any abnormalities were noted.

The transport procedures described above differed slightly for fish tagged and released at Rocky Reach Dam. Because the surgical station was located under a roadway within the fish ladder, it was not possible to carry the holding vessel to the upper deck for transport to the release site. For fish released into the tailrace of Rocky Reach Dam, we loaded the vessel into a boat and transported the

vessel to the boat dock located about 50 m upstream from the dam on the right bank. A truck then transported the vessel from the dock to the release site downstream from the dam. For fish released upstream from the project, the vessel was loaded into a boat and transported directly to the release site. We released fish according to the procedures described above.

At the request of the Service, at each of the three dams we released half the fish downstream from the dam and half upstream. The purpose of this release strategy was to increase the sample size of fish ascending the ladder systems at each of the projects where fish were collected and tagged. For fish released upstream from the dam, we released them as close as possible to the dam, but outside the influence of the forebay. Figure 13, Figure 14 and Figure 15 show specific release locations.

3.5 Fish Monitoring Systems

3.5.1 Fixed Telemetry

We used multiple-telemetry techniques to assess the movement of tagged bull trout within the study area. At Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams, we deployed a combination of aerial and underwater antennas. The primary purpose for these systems was to document the presence of bull trout at each project, specific to either the forebay or tailrace. In addition to these systems, a number of additional telemetry systems were deployed to address specific questions posed by Chelan and Douglas PUDs. At Rock Island, Rocky Reach, and Wells dams, we installed additional systems to identify tagged bull trout that could enter, ascend, and exit specific gates and fish ladders. At these projects, all possible access points to the adult fish ladders and the exits were monitored individually, allowing the route of passage to be determined as well as the ability to establish the exact time of entrance and exit from the ladder system. English et al. (1998, 2001) provided a detailed description of the telemetry systems at each of the dams and within the tributaries.

To assess movement within tributaries, we used both fixed-telemetry sites and aerial surveys within the Wenatchee, Entiat, Methow, and Okanogan rivers (see English et al. 1998, 2001). In the Wenatchee River basin, we deployed a single fixed-telemetry site located at the Wenatchee River County Park (R.K. 12.5). In the Entiat River basin, we deployed a single system located at R.K. 4.8. In the Methow basin, we established two telemetry sites, one at R.K. 2.4 and the other at R.K. 17.5. In the Okanogan basin, we installed a single system at R.K. 9.0. At each of these locations, two 3- or 4-element Yagi antennas were deployed and monitored separately, with one antenna aimed downstream and the other upstream. This allowed us to assess the presence and direction of travel of bull trout at each site.

3.5.2 Aerial Surveys

We conducted aerial surveys typically on a monthly basis from April 2002 to the end of March 2003. In addition to the mainstem Columbia River from Priest Rapids Dam to Chief Joseph Dam, we conducted aerial surveys in the Wenatchee, Entiat and Methow river systems. Because only one bull trout was detected at the fixed-telemetry site on the Okanogan River (and later entered the Methow River), no surveys of that basin were conducted. In the other basins, aerial surveys covered the mainstems to natural barriers or to points of safe access for fixed-wing aircraft. In addition, where possible, aerial surveys were conducted in smaller tributaries where bull trout presence was likely.

3.5.3 Boat Surveys

In 2001, boat surveys were used to assess general habitat use by tagged bull trout in the mainstem Columbia River. During that period, we conducted bi-weekly boat surveys in Rock Island and Rocky Reach reservoirs. However, for the 2002 study period, that task was not repeated. Instead, boat surveys were only used to locate tagged fish that had not been detected for some time. As such, only two boat surveys were conducted within the Rock Island and Rocky Reach reservoirs. During those surveys, the methods described in Stevenson et al. (2002) were employed.

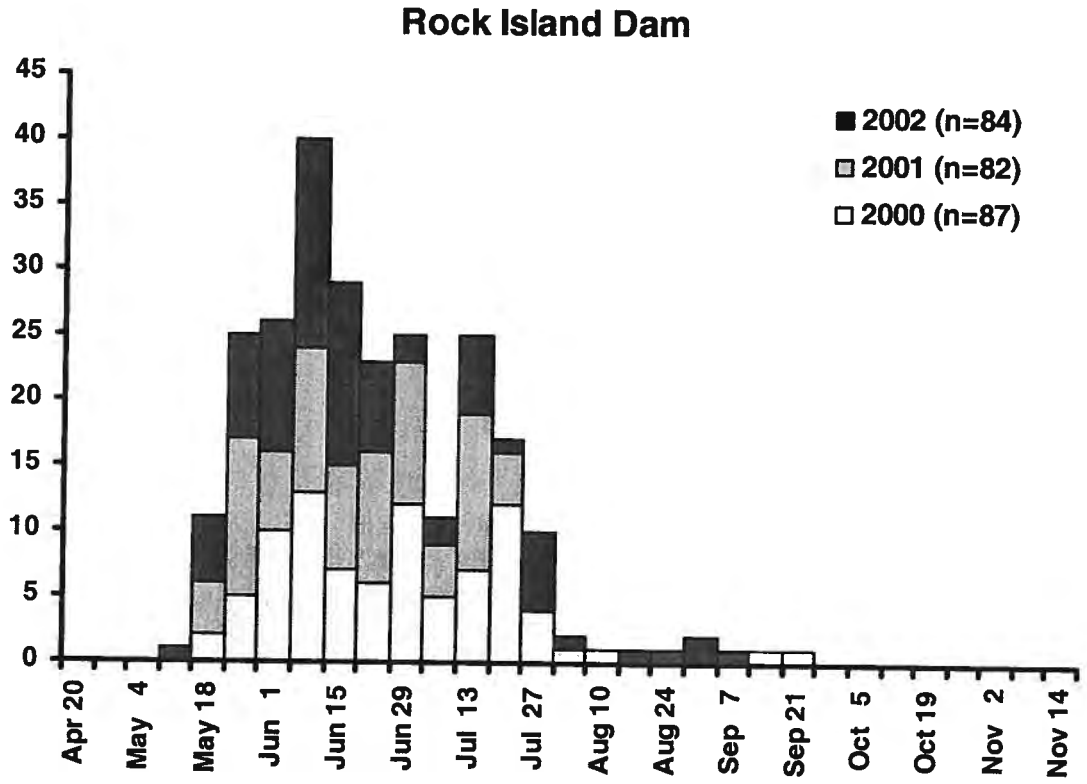

Figure 5: Passage distribution plotted by week for bull trout passing Rock Island Dam from 2000-2003.

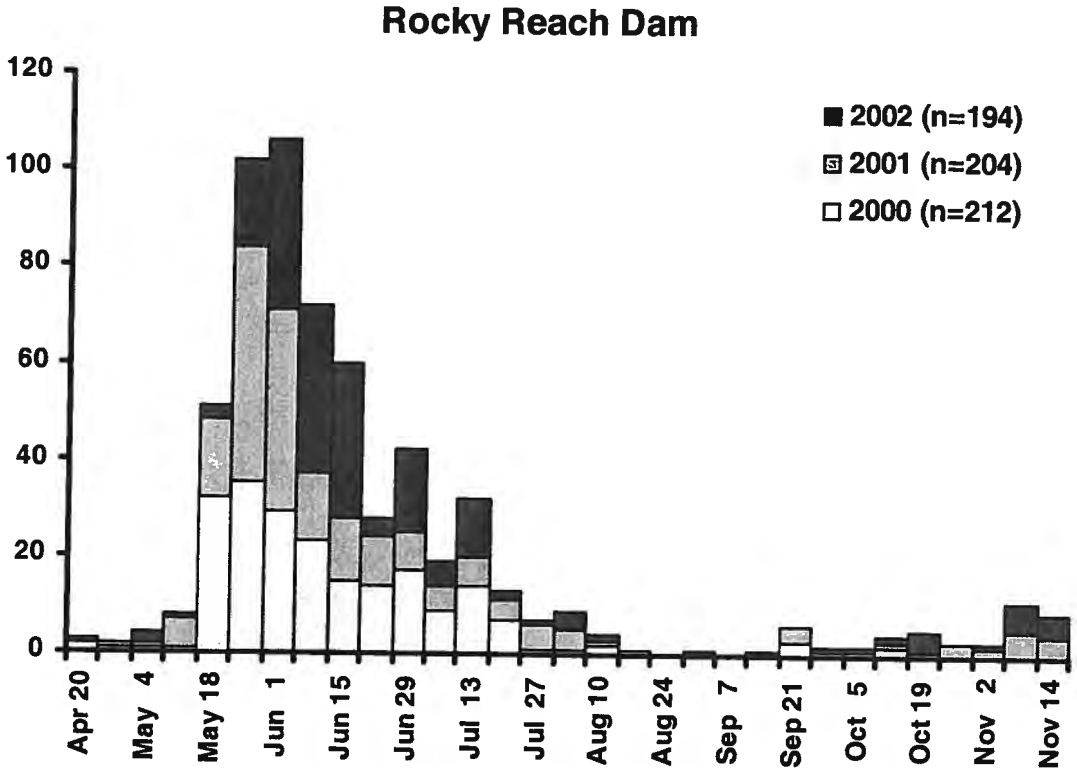

Figure 6: Passage distribution plotted by week for bull trout at Rocky Reach Dam from 2000-2003.

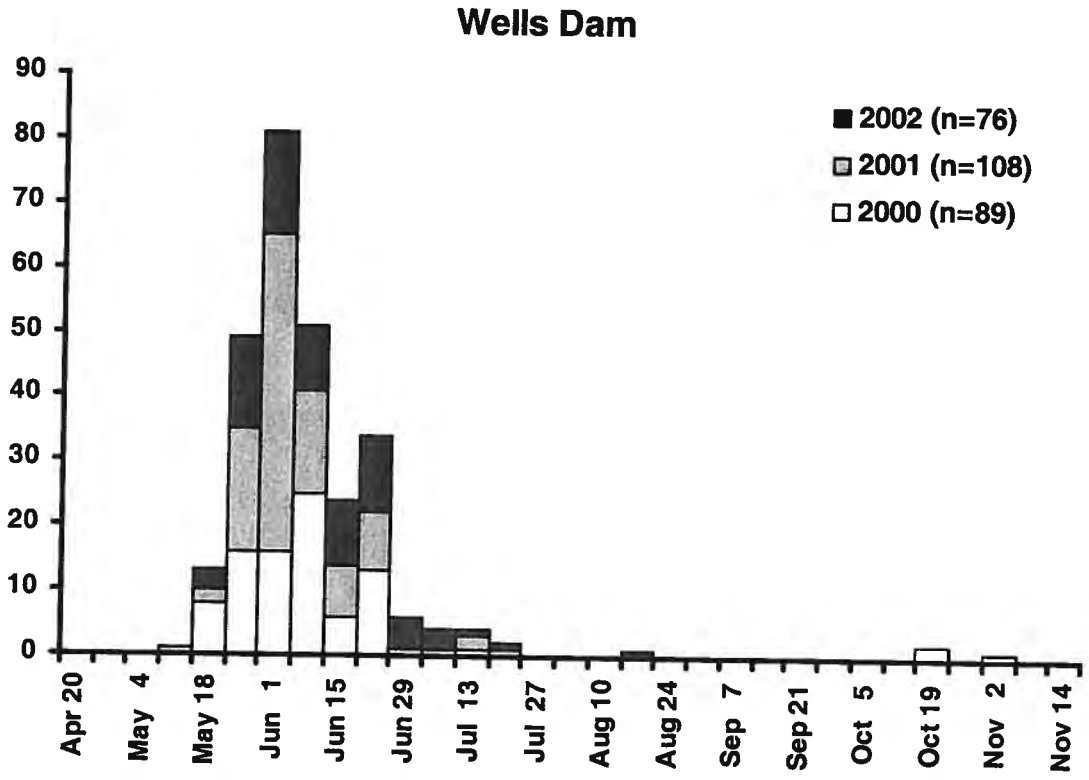

Figure 7: Passage distribution plotted by week for bull trout at Wells Dam from 2000-2003.

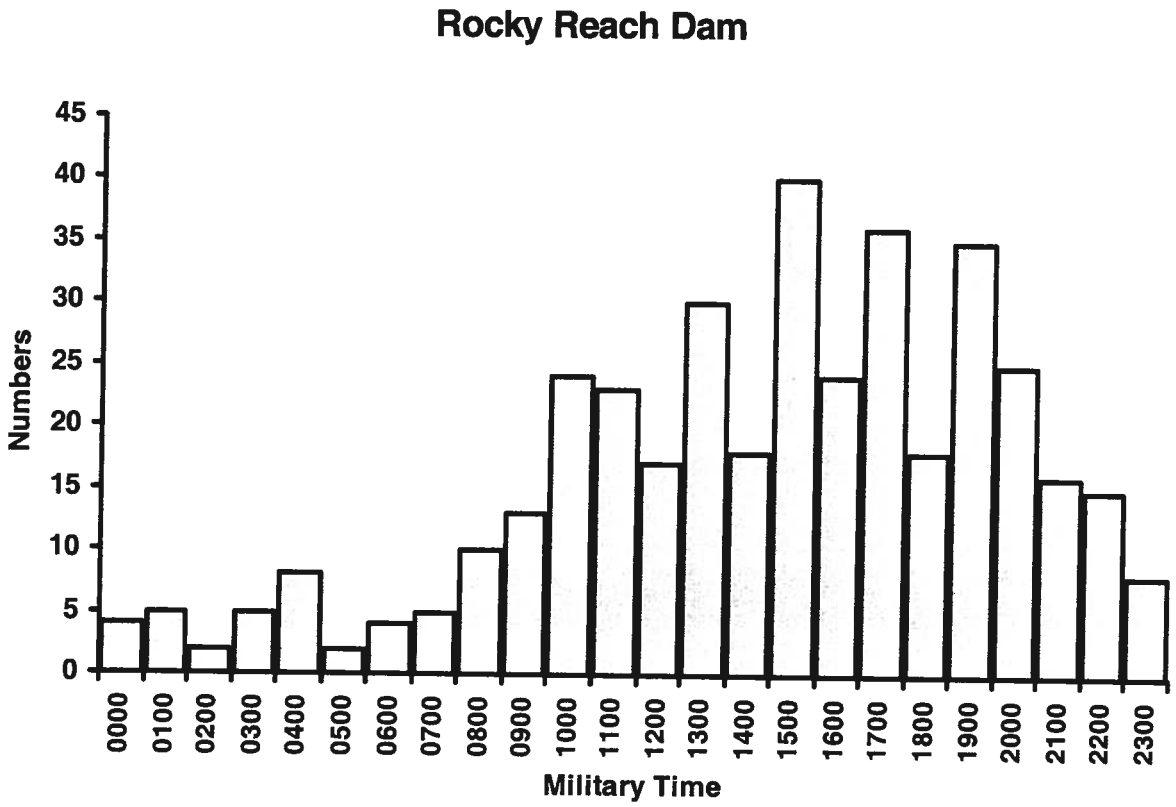

Figure 8: Time of passage for bull trout counted at Rocky Reach Dam ladder from 15 April to 31 November 2000 and 2001.

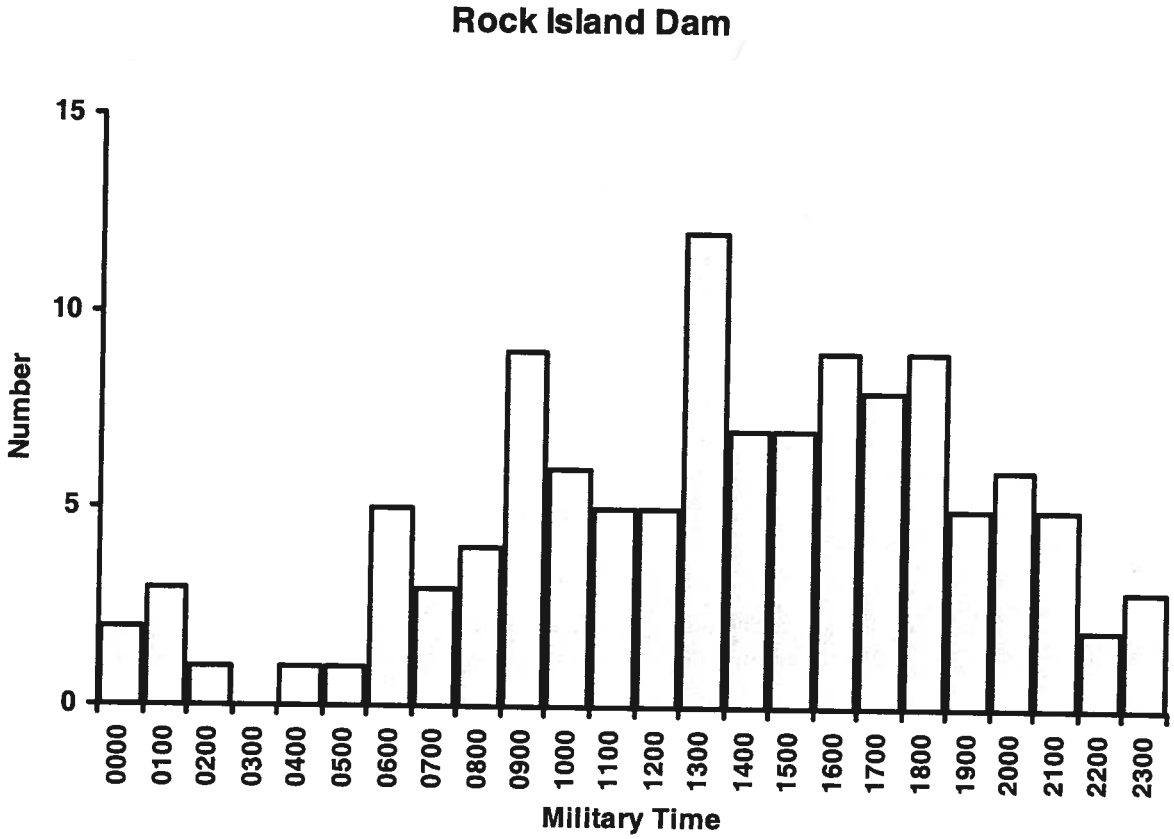

Figure 9: Time of passage for bull trout counted at Rock Island Dam ladders from 15 April to 31 November 2000 and 2001.

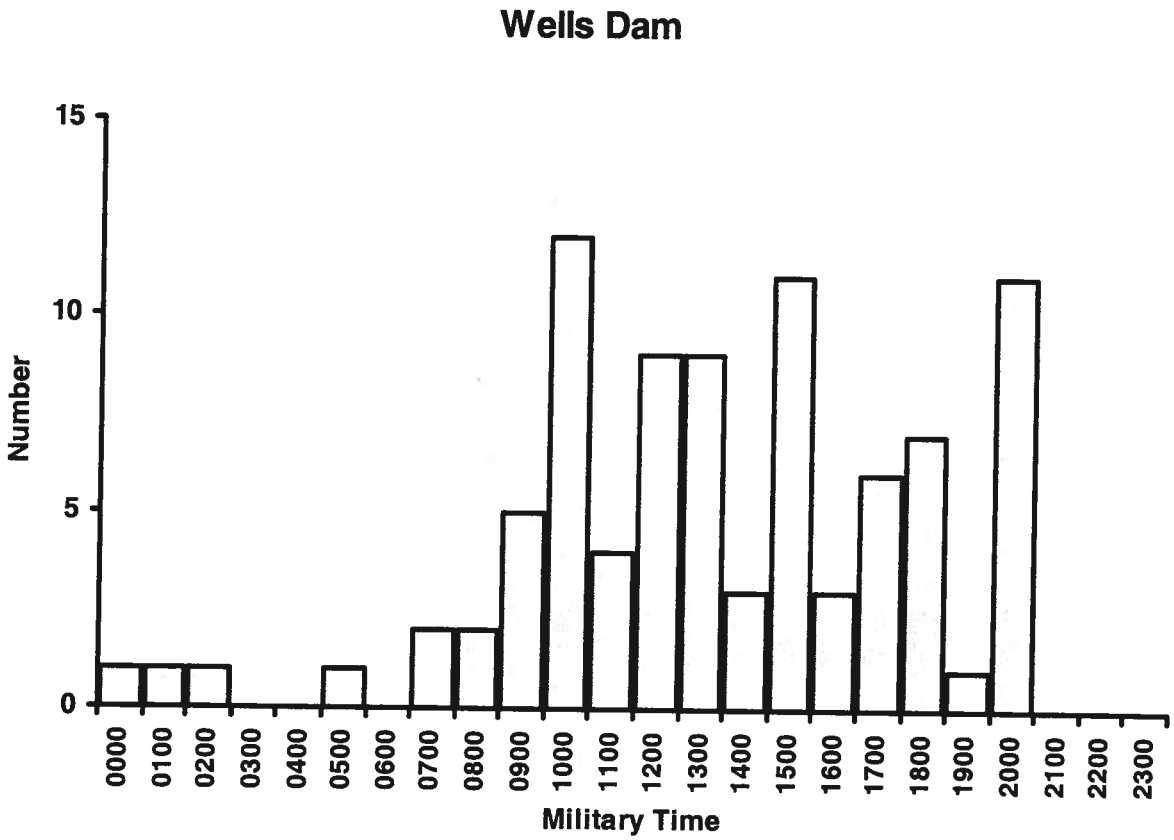

Figure 10: Time of passage for bull trout counted at Wells Dam ladders from 15 April to 31 November 2000.

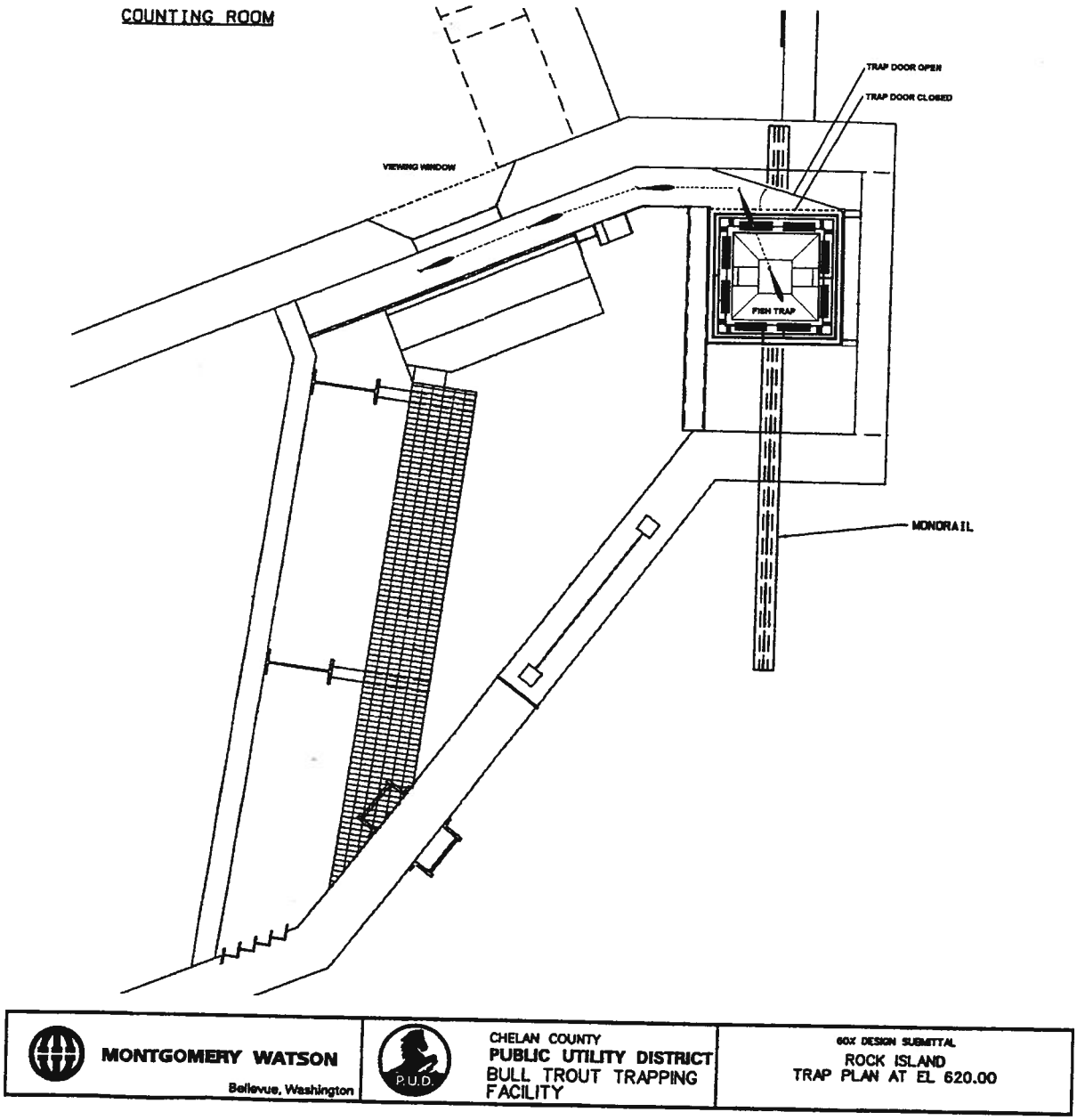

Figure 11: Plan view of Rock Island Dam fish trap showing movement of bull trout past the viewing window and the pneumatic gate open for entry into fish trap.

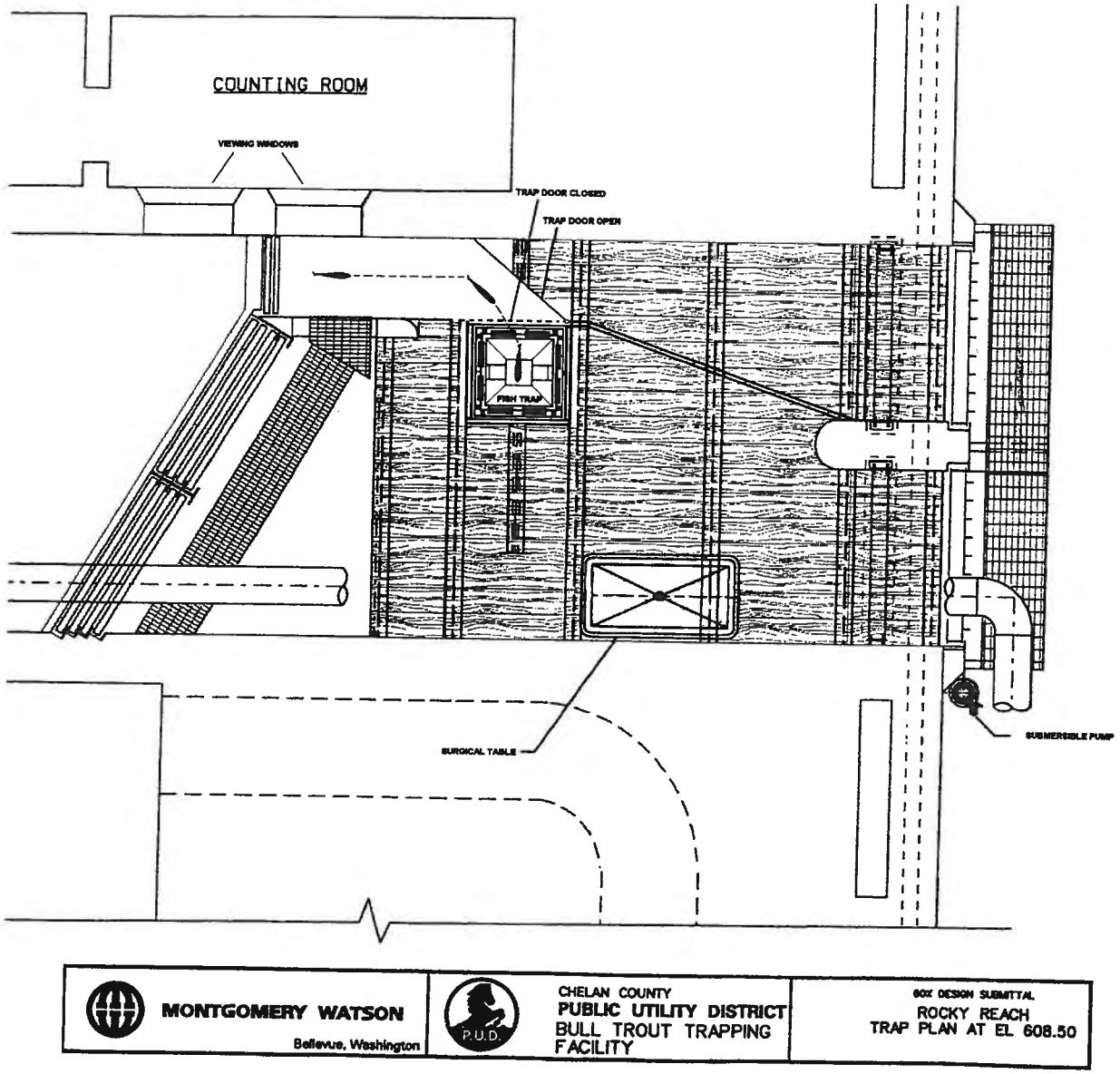

Figure 12: Plan view of Rocky Reach Dam trap showing movement of bull trout past the viewing window and the pneumatic gate open for entry into fish trap.

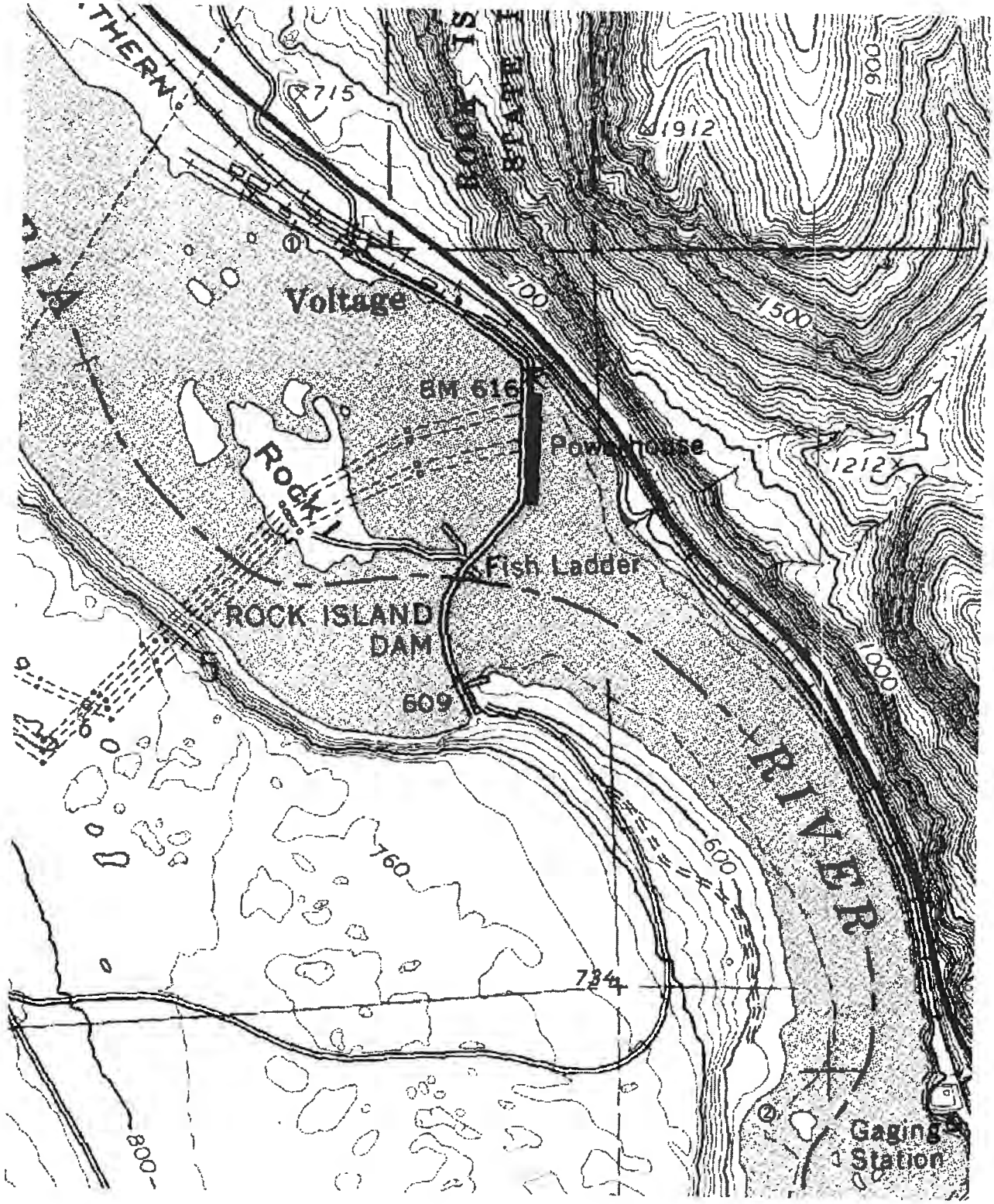

Figure 13: Bull trout release locations upstream (1) and downstream (2) of Rock Island Dam.

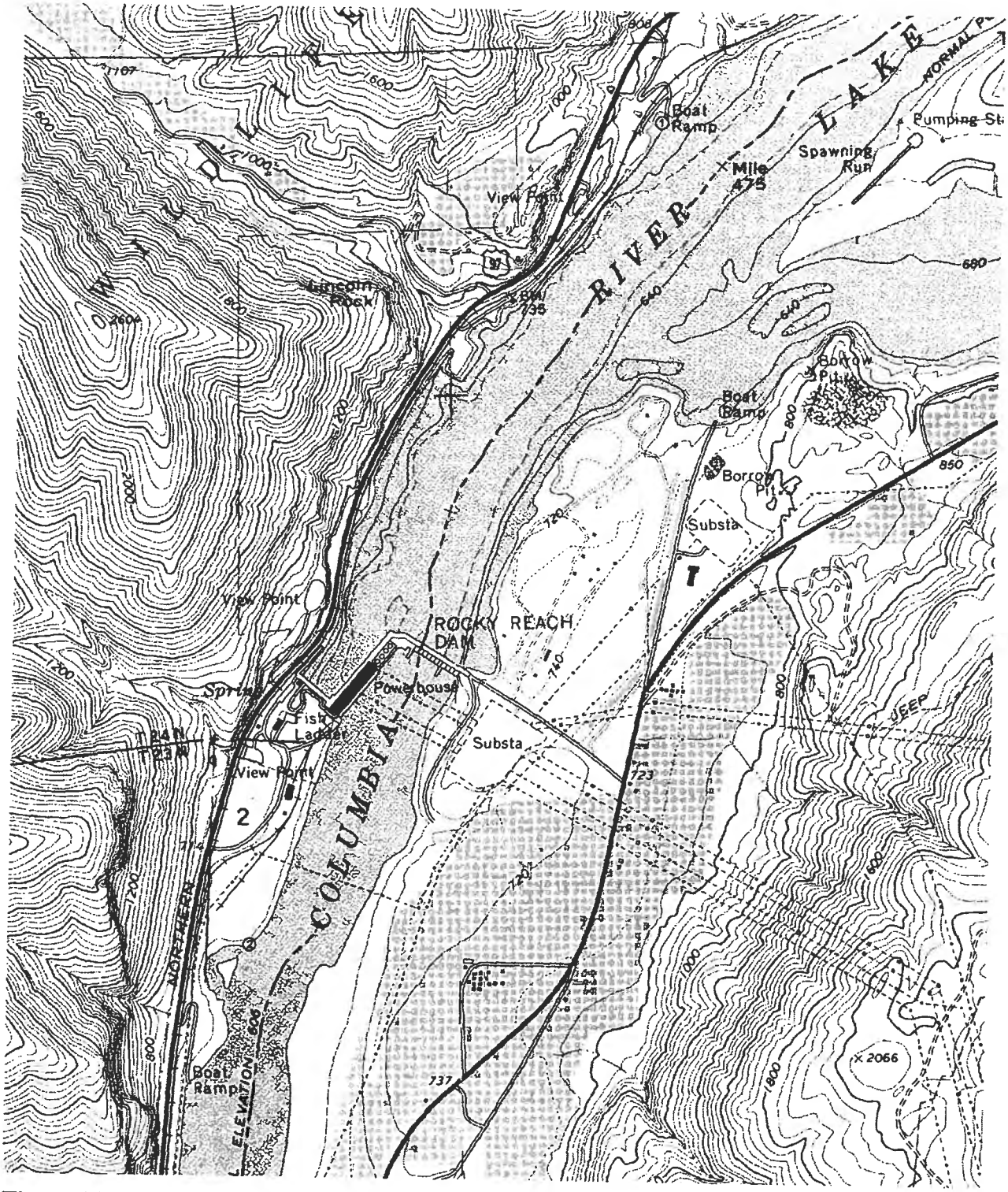

Figure 14: Bull trout release locations upstream (1) and downstream (2) of Rocky Reach Dam.

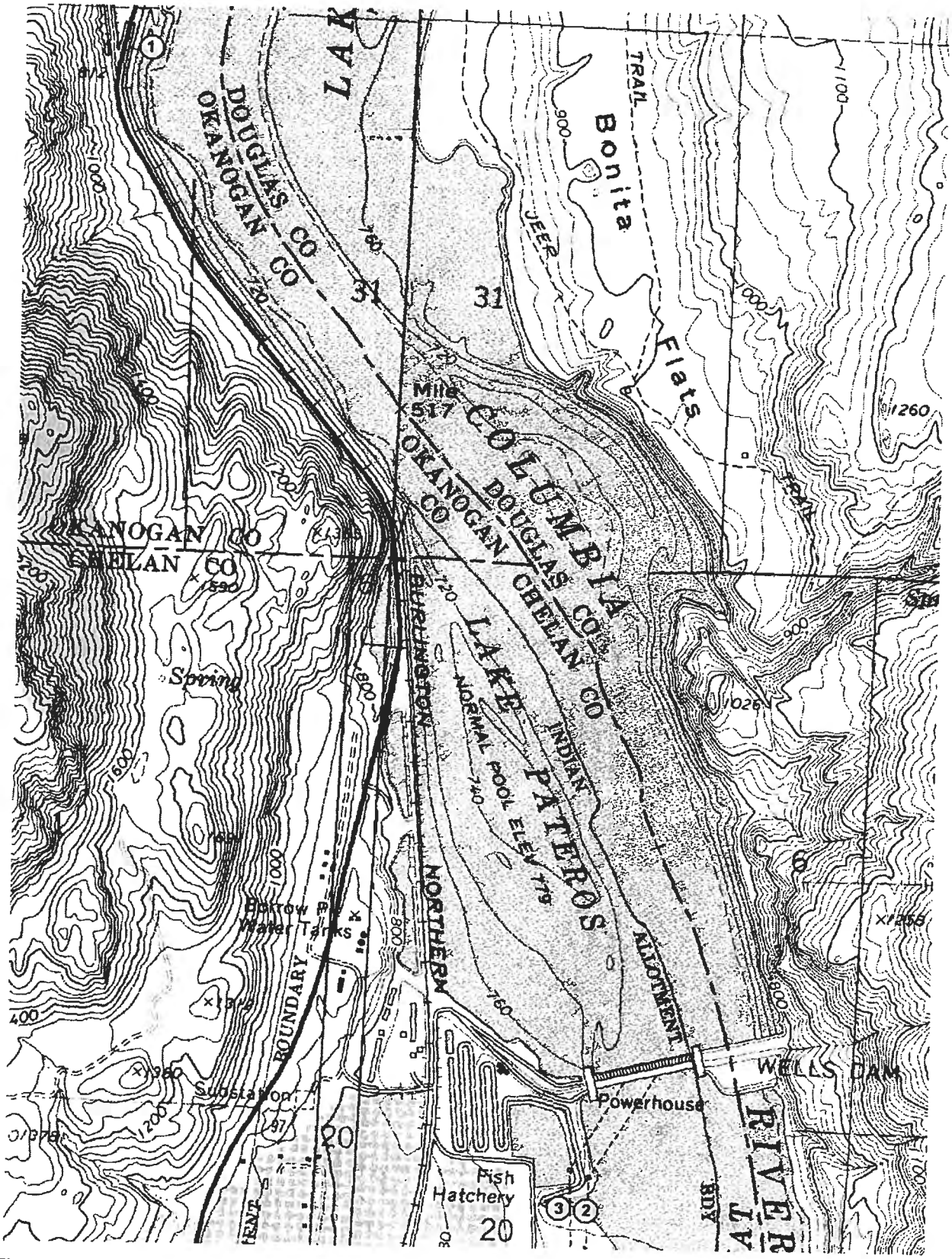

Figure 15: Bull trout release locations upstream (1) and downstream (2) of Wells Dam. Location of hatchery outfall (3) is also identified on the map.

SECTION 4: RESULTS AND DISCUSSION

Following our sampling protocol, we tagged and released a total of 40 adult bull trout in the mid-Columbia River (Table 2). We fell short of our tagging goal of 10 fish at Rock Island and 10 at Wells dams, and exceeded our goal of 20 fish at Rocky Reach Dam. At Rock Island, we captured and tagged a total of eight bull trout, with half released upstream and half downstream from the dam. In an effort to capture and tag a total of 40 adult trout, we extended the sampling period at Rocky Reach Dam once the tagging goal of 20 fish was met. There we captured and tagged 23 adult bull trout. We released 11 upstream and 12 downstream from the dam. At Wells Dam, we collected and tagged 9 adult bull trout by 12 June, releasing five upstream and four downstream from the dam.

The mean length and weight of fish tagged in 2002 tend to increase upstream with the smallest fish collected at Rock Island Dam to the largest fish captured at Wells Dam (Table 2). For bull trout tagged at Rock Island Dam, the mean length and weight were 49.6 cm and 1,325 g, respectively. For bull trout tagged at Rocky Reach Dam, the respective mean length and weight were 55.1 cm and 1,967 g. Finally, for bull trout tagged at Wells Dam, the mean length and weight were 57.3 cm and 2,183 g, respectively. Overall, the 40 bull trout averaged 54.5 cm fork length and 1,888 g. In 2001, fish size also tended to increase upstream but with a much less noticeable difference between Rock Island and Rocky Reach dams (Stevenson et al. 2002).

Age analysis of fish collected in 2002 was determined for two components of total age and assessed for spawning check marks. For example, an age-5 fish was categorized as a 3/2 fish which meant that the fish reared in a cold water environment such as a tributary for 3 years, migrated downstream, and spent 2 years in a relatively warmer water environment such as the mainstem Columbia River. In 2002 age could be determined for 36 of 40 individuals. Four fish could not be aged due to scale regeneration. Of these 36 fish, 12 were age-4 (two were classified as 4/0, and ten as 3/1), 19 were 5 years of age (seven were classified as 4/1, and twelve as 3/2), 3 were 6 years of age (two were classified as 4/2, and one as 3/3), and 2 were 7 years of age (both were classified as 4/3). Of the 36 fish where scales could be read, 5 had previously spawned on one or more occasion (Table 2). In 2001, only total age was determined for 10 bull trout captured at Wells Dam. Of these fish, two were age-5 fish, six were age-6 fish and scale regeneration precluded the aging of the remaining two fish.

For the 40 bull trout captured and tagged at the three collection locations, the mean surgical, recovery, and transport times were 4.7, 11.7, and 11.8 minutes, respectively. The surgical times at the three dams were similar, with the mean times varying by only 0.7 minutes. However, recovery and transport times for the different release sites varied somewhat. The mean recovery time varied between projects by 2.2 minutes, and was likely due to the time necessary to prepare the tagging facility for the next tagging event (this task was completed while the tagged fish recovered). For the transport times, variability was due to road conditions and distance traveled to the various release sites, and varied a total of 4.7 minutes. Nevertheless, the mean overall time from start to finish (surgery, recovery, transport, and release) among tagging locations varied by only 8.3 minutes, with the Rock Island upstream releases requiring only 22.3 minutes and the Rocky Reach downstream releases requiring 30.6 minutes.

Water temperatures within the transport vessel changed little from the time of recovery to the time of release in the river. On only two occasions did the water temperature increase during the time the fish were held in the vessel. On both occasions the temperature increased 0.5°C, however, the increase in temperature during transport probably benefited the fish. That is, for these two fish, the temperature at the release site was higher than the water temperature at the collection site. The increase within the transport vessel served to acclimate fish to the higher temperature of the release location (in both cases, the temperature within the transport vessel at the time of release was the same as at the release site).

Differences in temperatures between the collection site and release site were more common. For fish tagged and released at Rock Island and Rocky Reach dams (n = 31), differences in temperatures between the collection and release sites occurred on ten occasions (Table 2), but the difference in temperature never varied by more than 1°C. At Wells Dam, temperatures at the collection and release sites differed during the release of seven of nine trout, four of which were less than 1.0 °C. For the downstream releases, three trout experienced temperature differences of 1.0 °C. For trout released upstream of Wells Dam, temperature differences ranged from 0.5 and 3.0°C. While these temperature differences did not appear to affect survival or behavior of the fish exposed to them, it is possible that behavior immediately after release could have been affected. However, we observed no abnormal behavior immediately after release.

Table 2: Description of the 40 adult bull trout tagged at Rock Island, Rocky Reach, and Wells dams from 20 May to 27 June 2002. An "s" after the age indicates previous spawning.

Collection		Transmitter		Fish Metrics			Elapsed Time (m)			Water Temp. (°C)			
Date	Time	Chan.	Code	Length	Weight	Age	Surgery	Recovery	Transport	Begin	End	Rel.	Location
Rock Island Dam													
20-May	1555	14	97	53.0	1,700	3/1(s)	6	11	7	11.0	11.0	12.0	Up
23-May	1321	14	90	49.5	1,250	3/2	6	13	11	12.0	12.0	11.5	Down
04-Jun	0845	14	110	60.0	2,400	4/1	5	8	8	12.5	12.5	13.0	Up
04-Jun	1622	14	105	52.0	1,350	3/1	4	10	10	13.0	13.0	13.0	Down
07-Jun	1019	14	109	50.0	1,400	3/1	5	11	7	12.5	12.5	13.0	Up
07-Jun	1640	14	113	43.0	800	4/1	4	10	11	12.5	12.5	12.5	Down
12-Jun	0928	14	119	42.5	700	R	4	10	7	13.0	13.0	14.0	Up
12-Jun	1256	14	115	46.6	1,000	3/1	5	11	11	13.5	13.5	13.0	Down
			Mean:	**49.6**	**1,325**	---	**5**	**10**	**10**				
			Minimum:	**42.5**	**700**	---	**4**	**8**	**8**				
			Maximum:	**60.0**	**2,400**	---	**6**	**13**	**11**				
Rocky Reach Dam													
20-May	1445	14	88	65.5	3,200	R	6	14	10	11.0	11.0	11.0	Up
21-May	1737	14	89	63.0	2,950	3/2	6	20	11	11.0	11.0	11.0	Down
23-May	1413	14	92	50.5	1,950	3/2	5	16	11	11.0	11.0	11.0	Up
29-May	0858	14	95	57.0	2,100	3/2	6	13	14	12.0	12.0	12.0	Down
30-May	1057	14	98	57.0	1,950	3/2	4	14	10	12.0	12.0	12.0	Up
30-May	1409	14	104	56.0	2,000	3/2	6	13	12	12.0	12.0	12.0	Down
03-Jun	1310	14	108	62.0	2,350	4/1	5	6	13	12.0	12.0	12.0	Up
03-Jun	1416	14	101	55.3	1,950	R	5	6	13	12.0	12.0	12.0	Down
04-Jun	1212	14	100	52.5	1,700	3/2	4	7	11	12.5	12.5	12.5	Up
04-Jun	1427	14	111	56.5	2,200	R	5	17	13	12.0	125	12.5	Down
06-Jun	1017	14	103	61.4	3,300	4/3(s)	5	11	14	12.0	12.0	12.0	Up
06-Jun	1533	14	106	58.5	2,500	3/2(s)	3	16	14	12.0	12.0	12.0	Down
07-Jun	1413	14	121	48.1	1,350	3/1	5	18	11	12.5	12.5	12.5	Up
10-Jun	1200	14	114	54.0	1,700	3/2	4	14	11	12.0	12.0	12.5	Down
10-Jun	1656	14	116	60.8	2,850	4/1	6	17	11	12.0	12.0	12.0	Up
11-Jun	1406	14	118	46.0	950	3/1	4	11	12	12.5	12.5	13.0	Down
12-Jun	1337	14	122	59.7	2,100	3/2	5	10	13	13.0	13.0	13.0	Up
18-Jun	1040	14	126	60.4	2,300	3/3(s)	6	10	13	13.5	13.5	13.5	Down
21-Jun	1136	14	123	57.5	1,750	3/1	4	11	12	14.0	14.0	14.0	Up
24-Jun	1400	14	124	57.0	1,800	3/2	4	13	11	14.5	15.0	15.0	Up
26-Jun	0824	14	125	46.0	1,000	3/1	4	14	12	15.0	15.0	15.0	Down
27-Jun	1226	14	127	41.5	650	4/0	4	14	14	15.0	15.0	15.0	Down
27-Jun	1755	14	120	40.4	650	4/0	4	12	11	15.0	15.0	15.0	Down
			Mean:	**55.1**	**1,967**	---	**4**	**12**	**12**				
			Minimum:	**40.4**	**650**	---	**4**	**10**	**11**				
			Maximum:	**65.5**	**3,300**	---	**6**	**14**	**14**				
Wells Dam													
23-May	1530	14	91	69.9	4,250	4/3(s)	5	12	21	10.5	10.5	10.5	Up
28-May	1510	14	93	54.5	1,800	4/2	4	9	13	11.5	11.5	12.5	Down
03-Jun	0915	14	107	60.5	2,300	4/1	4	19	12	13.0	13.0	15.0	Up
03-Jun	1425	14	94	51.0	1,400	3/1	4	4	12	13.0	13.0	15.0	Up
03-Jun	1650	14	96	56.0	1,850	4/2	4	7	11	12.0	12.0	13.0	Down
04-Jun	0912	14	102	63.5	2,900	4/1	4	9	11	13.0	13.0	13.0	Down
04-Jun	1325	14	99	46.5	1,150	3/1	3	6	18	13.0	13.0	16.0	Up
11-Jun	1325	14	112	62.1	2,600	3/2	6	10	11	13.0	13.0	14.0	Down
12-Jun	1535	14	117	52.0	1,400	4/1	4	11	14	14.0	14.0	14.5	Up
			Mean:	**57.3**	**2,183**	---	**4**	**8**	**12**				
			Minimum:	**46.5**	**1,150**	---	**3**	**4**	**11**				
			Maximum:	**69.9**	**4,250**	---	**6**	**11**	**13**				

4.1 Mortalities

We captured and tagged a total of 40 adult bull trout, none of which died during the period from capture to release. All 40 fish appeared to be healthy and exhibited normal behavior upon release. Indeed, most had migrated to a tributary stream or moved several kilometers from a release area. During the monitoring phase of the study, however, a total of six transmitters were recovered within the study area. Only one carcass was recovered with a transmitter. However, it should be noted that recovery of a transmitter without a carcass does not necessarily indicate that the fish perished. During the capture and tagging phase of the study, a bull trout was collected at Rocky Reach Dam that had scarring consistent with a transmitter being extruded through the musculature where the transmitter antenna exited the fish. For this fish, the incision and suture scars were readily apparent, as well as an "asterisk" shaped scar where the antenna exited the body. It appears that this fish was captured and tagged the previous year by USFWS or as part of this study, lost the transmitter, and survived. Therefore, it is possible that some of the fish where the transmitters were recovered survived the loss of the transmitters. The fate and detailed detection histories of each of these fish are presented in Miller et al. (2002), and therefore, will not be presented here. However, the following discussion is a brief summary of the fish where the transmitter was recovered.

Four of the six fish were captured and tagged at Wells Dam, with two released upstream of the project, and two released downstream from the project. All four of these fish migrated into the Methow basin, and the transmitters were recovered in the Twisp River. For one of these fish, the carcass and transmitter was recovered together. The carcass was found frozen in an area where there was little water within the stream channel. For another fish, the transmitter was found on shore above the wetted channel. For all of these fish, the distance traveled from the release site ranged between 98 and 116 km, and all were recovered in the Twisp River upstream from a stream section that became dewatered during the period of residency.

One transmitter was found in the upper Entiat River onshore under a boulder, and had obvious cut marks on the transmitter antenna. Fish and Wildlife Service personnel who recovered the transmitter indicated that the transmitter appeared to be in a mink den, and the marks on the antenna were the result of predation or scavenging. This fish was released downstream at Rocky Reach Dam, and had traveled a total of 55 km.

The sixth fish was released at Rock Island Dam, and did not exhibit a similar migratory behavior as other tagged fish. That is, it did not enter any of the Columbia River tributaries for any length of time. Instead, it moved upstream and was detected at Wells Dam prior to moving downstream, where the transmitter was recovered below Rock Island Dam. The transmitter was located onshore above the high water mark under debris. Overall, this fish appears to have traveled a total of 322 km prior to the transmitter being recovered.

We suspect that three other fish may have perished, two are currently located approximately 100 m upstream of Box Canyon in the Mad River, and one is in the Twisp River. We suspect that these fish have died in these tributary streams since they have been detected in the same location over an extended period of time. An effort will be made in the future to locate these fish to see if they have moved from these locations since last fall.

4.2 Migration Rate and Downstream Migration

Because of the extensive deployment of telemetry systems at each mainstem dam and near the mouths of major tributaries, we were able to document the length of time each fish spent within various areas at the dams, the elapsed time between dams, the time required to travel from a dam to the next upstream tributary, and whether bull trout migrated downstream past any of the projects within the study area. For some of the fish tagged in 2001, the transmitters were still active as they migrated upstream in 2002. Therefore, these fish have also been included in this analysis. It should be noted that the number of fish used to estimate the following residence times does not always total the number of fish passing the dam of interest, or the reach of river upstream from the project due to incomplete detection histories. For example, if a fish is not detected by the tailrace antenna array, the tailrace and overall dam passage time cannot be estimated. For clarity, we defined the following terms.

- Tailrace residence is the elapsed time between the first detection by the tailrace array and the first detection upon final entrance into the ladder system.
- Fishway residence is the elapsed time between the first detection upon final entrance into the ladder system to the last detection at that ladder exit.
- Elapsed time at the dam is the sum of the tailrace and fishway times.
- Elapsed time between dams is the time from last detection at a ladder exit to the time of first detection within the tailrace of the next upstream dam.
- Elapsed time from a dam to an upstream tributary is the time from last detection at the ladder exit to the time of entry into an upstream tributary.

For all estimates, we only included fish that were actively migrating upstream. For example, fish that were detected by the tailrace and ladder systems, but migrated downstream and entered a tributary were not used to calculate tailrace residence time. Downstream migration past a given project was assessed as the detection of a fish downstream from the dam after the fish had recently exited the ladder system.

4.2.1 Rock Island Dam

At Rock Island Dam, we captured and tagged eight adult bull trout. We released half downstream, and the other half upstream from the dam. All four of the fish released downstream from the project migrated upstream, with one fish passing the project through the left bank ladder, and three through the right bank ladder. In addition, one fish tagged in 2001 (tag 14-7) passed Rock Island Dam through the right bank ladder. For these five fish, the median tailrace residence was 5.66 days and varied from 0.43-16.43 days (Table 3). The median residence time through the right bank and left bank fishway was 0.85 days and 0.18 days, respectively. Passage through the right and left bank fishway varied from 0.18 to .97 days. The median elapsed time at the dam for all five fish was 5.90 days and varied from 1.21-17.35 days (Table 3). In 2001, the median elapsed time at the dam was 2.28 days, less than half of what was observed for fish in 2002 (Table 4).

The migration time for bull trout from Rock Island Dam to Rocky Reach Dam or to an upstream tributary was assessed for eight fish tagged and released at Rock Island Dam in 2002, plus one fish tagged in 2001. Of these nine bull trout, seven migrated upstream and were detected in the tailrace of Rocky Reach Dam and the other two fish migrated directly into the Wenatchee River. The median time between projects was 2.78 days and ranged from 1.14-5.46 days (Table 3). The median

elapsed time between detection at Rock Island Dam and the Wenatchee River was 5.99 days and ranged 4.56-7.41 days (Table 3). In 2001, the median migration rate for four fish from Rock Island to Rocky Reach Dam was 1.33 days, and from Rock Island Dam to the Wenatchee River for a single fish was 1.39 days (Table 4).

In 2002, the median elapsed time past Rock Island Dam, and through the reservoir to Rocky Reach Dam or to the Wenatchee River increased for bull trout relative to what was observed in 2001 (Table 4). The increased passage time at Rock Island Dam and through the reservoir did not appear to affect bull trout tagged and released at Rock Island Dam in 2002. All but one fish survived and ultimately migrated upstream to enter a tributary stream. Similar to 2001, one fish died in 2002 shortly after release. After migrating upstream, it migrated back downstream past Rock Island Dam where its tag was recovered.

4.2.2 Rocky Reach Dam

To assess the movement and behavior of bull trout at Rocky Reach Dam, we tagged and released 11 bull trout upstream and 12 downstream of the project in 2002. In our analysis of residence and passage times at the project, we also include fish tagged at Rock Island Dam and bull trout tagged in 2001 that passed the project during the 2002 study period. In sum, 21 tagged bull trout passed Rocky Reach Dam which included eight released in Rocky Reach tailrace, one released in Rocky Reach forebay, six from Rock Island Dam and six fish tagged in 2001. However, we also include two fish tagged in 2001 that ascended the fishway more than once. One of those fish ascended the ladder system three times and migrated back downstream twice while the other fish ascended the ladder system twice and migrated back downstream only once. Therefore, there were a total of 24 passage events that occurred at Rocky Reach Dam in 2002. Unfortunately, during the upstream passage of one bull trout (released downstream from Rocky Reach Dam) the ladder exit receiver did not record the exit time. This reduces the number of passage events to 23.

Fish passage through the ladder system at Rocky Reach Dam was accessible through a number of entrances or gates. Possible entrances included the right bank entrance, six O.G. gates, the left bank entrance, and the spillway entrance. The entrance location used by fish that passed Rocky Reach Dam included 5 tagged fish that entered the spillway entrance, 9 entered the left ladder entrance, 6 through one of the six O.G. gates, and 4 through the right ladder entrance. In 2001, most of the fish (7 of 9) ascended the ladder system through the left entrance and the other two passed the project through the right entrance. In 2002, the median tailrace residence time was 4.44 days and ranged from 0.60-16.25 days (Table 3). The median fishway residence time was 0.28 days and ranged 0.13-6.15 days. The median elapsed time at the dam was 4.86 days and varied from 1.11-16.50 days (Table 3). In contrast during the 2001 migration, the median time at the dam was 3.79 days, and the median tailrace time was 1.28 days (Table 4). However, the median fishway time in 2001 was greater at 1.92 days. Therefore, fish spent more time in the tailrace of Rocky Reach in 2002 compared to 2001 (Table 4).

Closer inspection of the data revealed that the amount of time spent in the tailrace is considerably different for fish actively migrating upstream. That is, fish that were tagged at Rock Island and migrated past Rocky Reach Dam versus fish collected at Rocky Reach Dam that were released back into the tailrace. For the eleven fish that were actively migrating upstream the median time spent in the tailrace was 2.97 days compared to 7.67 days for the eight fish that were tagged and then

released downstream at Rocky Reach Dam. However, the median ladder times for these two groups of fish were similar. For active migrants, the median ladder passage time was 0.28 days, and for fish released in the tailrace, the median passage time was 0.23 days. A re-analysis of the 2001 data revealed a similar trend. During that study period, the median tailrace time for active migrants was 0.85 days compared to 1.79 days for the fish collected and tagged at Rocky Reach and released downstream from the project. It therefore appears that releases downstream from the project increased tailrace residence time.

Migration downstream past Rocky Reach Dam included three fish that had ascended the ladder system and contributed to five voluntary or involuntary downstream passage events. The first downstream migration occurred when fish (14-124), released upstream of Rocky Reach Dam, was detected 15 hours later in the tailrace of the project. This fish re-ascended the ladder and entered the Entiat River, where it resided for five days. The following day this fish moved back downstream a second time and was detected in the tailrace of Rocky Reach Dam over the course of three days. This fish was last detected in the Rocky Reach tailrace and has not been detected for the remainder of the study period. The third downstream movement past Rocky Reach Dam was observed for a fish tagged during the 2001 study period. Fish 14-32 passed downstream of Rocky Reach Dam twice over an 18-day period. After ascending the ladder system the first time, this fish moved back downstream through the powerhouse (unit 6 or 7), and began re-ascending the ladder within three hours. Over the course of four days, this fish moved upstream through the ladder system. The bull trout moved downstream past Rocky Reach Dam again eleven days later (passage route unknown). This fish re-ascended the ladder over a one day period, entered the Entiat River briefly, and was later detected in the tailrace of Wells Dam seven months later. The last downstream migration past Rocky Reach Dam was observed for a bull trout tagged during the 2001 study period (fish 14-37). After initially ascending the Rocky Reach ladder, this fish moved back downstream through the project approximately one day later (passage route unknown). The fish spent about four days in the tailrace prior to re-ascending the ladder over a six hour period. This fish was subsequently detected in the Entiat River 15 days later, which was the last contact with this fish.

The migration time for bull trout from Rocky Reach Dam to Wells Dam or to an upstream tributary was assessed for 31 bull trout. The 31 tagged fish included eight released into the tailrace of Rocky Reach, one fish released into the forebay, six fish tagged at Rock Island, six fish from the 2001, and ten fish released into the forebay of Rocky Reach. We could not estimate a migration time one fish (14-97) that entered the Entiat River because there was no detection at the Rocky Reach ladder exit. The median travel time for 23 bull trout from Rocky Reach to the Entiat River was 11.34 days and ranged 3.51-26.98 days (Table 3). For the seven fish that traveled to Wells Dam the median elapsed time between projects was 2.03 days and varied from 1.09-3.71 days (Table 3). Similar to other migrations, travel times to either the Entiat River or Wells Dam was greater in 2002 compared to 2001. In 2001, the median time between Rocky Reach Dam and the Entiat River was 7.20 days, and from Rocky Reach to Wells Dam, the median migration time was 1.69 days (Table 4).

4.2.3 Wells Dam

We tagged and released 9 adult bull trout at Wells Dam to assess migration behavior. All four of the fish released into the tailrace re-ascended the ladder. In sum, a total of 11 tagged fish passed through Wells Dam, which included five fish from Rocky Reach, four released into the tailrace of Wells

Dam, and two fish from the 2001 tagging period. In addition, one fish migrated back downstream of Wells Dam and re-ascended the ladder. Therefore, there were a total of 12 passage events at Wells Dam, with two bull trout ascending the right bank ladder, and 10 at the left ladder. However, during the course of the study the DSP unit monitoring the left bank ladder entrance malfunctioned when the majority of the fish passed the project. Therefore, of the 10 passage events through the left bank ladder, only one fish was detected at the entrance. The absence of detection at this ladder entrance does not affect overall dam passage time, but precludes estimates of tailrace and ladder residence times.

For the 3 passage events at Wells Dam where the tailrace residence time could be calculated, the median tailrace residence time was 7.84 days and ranged from 1.64-18.35 days (Table 3). For fish passing the right bank ladder, the median fishway residence time was 0.21 days and varied from 0.20-0.23 days. The passage time for a single fish that ascended left bank ladder was 0.32 days. The overall elapsed time at the dam for the 12 passage events was 7.60 days and ranged 1.83-24.87 days (Table 3). Relative to 2001, the 2002 median tailrace residence time was greater. In 2001 the median tailrace time was 1.53 days compared to 7.84 days in 2002. However, the median passage times were less within the ladders, as well as for the overall dam passage time (Table 4).

Due to the lack of entrance times for all but one fish that ascended the left bank ladder, it is not possible to compare tailrace times for active migrants versus fish released into the tailrace of Wells Dam. However, it is possible to assess elapsed time at the dam for the two groups of fish. For seven fish that were active migrants (fish released at downstream projects), the median elapsed time at the dam was 3.56 days compared to 20.09 days for the fish released downstream of Wells Dam. A re-analysis of the 2001 data also reveals a similar trend. In 2001, a total of eight fish were detected by the tailrace array, as well as a ladder entrance. Four of those fish were active migrants, and four were released downstream from the project. For the active migrants, the median tailrace time was 1.04 days compared to3.64 days for fish released downstream from the project. As with Rocky Reach Dam, it appears that releasing bull trout immediately downstream from the project increases tailrace residence time, thereby exaggerating the actual tailrace residence and elapsed time at the dam. This is likely due to a recovery period following release that may increase upstream migration indices.

For the 16 tagged bull trout upstream of Wells Dam, 11 migrated into the Methow River and were detected by the fixed-telemetry stations there, providing an estimate of migration time between Wells Dam and the Methow River. For those fish, the median travel time between the dam and the Methow River was 2.78 days and ranged 0.33-16.42 days (Table 3). This estimate does not include 5 of 16 fish that either passed Wells Dam or were released upstream of the project. Two of those fish were tagged during the 2001 study period (14-20; and 14-21). Both entered the Methow River and were detected during aerial surveys, but were not detected at the fixed-telemetry sites. Another fish, also tagged in 2001 (14-9) was not detected after exiting the Wells left bank ladder. It is likely that the transmitter expired shortly after this fish passed Wells Dam. At the time of last detection, this transmitter was nearly 400 days old, which exceeds the expected 360 day tag life. The fourth fish (14-108), first entered the Okanogan River and had a travel time between Wells Dam and the Okanogan River site at 3.37 days. This fish eventually migrated into the Methow River where it resided. The fifth fish (14-99) was released upstream of Wells Dam and moved back downstream through the project. This fish migrated further downstream and briefly entered the Wenatchee River.

The migration time between Wells Dam and the Methow River was greater in 2002 (2.78 days) than what was observed in 2001. During the 2001 study period, the median migration rate between Wells Dam and the Methow River was 0.40 days (Table 4).

As previously mentioned, two bull trout migrated downstream past Wells Dam. The first fish (14-100), was released upstream of Rocky Reach Dam. After migrating upstream to Wells Dam this fish initially ascended the right bank ladder and then moved back downstream past the project within a nine hour period. The fish then re-ascended the left bank ladder and exited the ladder system within four days. This fish eventually entered the Methow River, where it was last detected in February, 2003. The second fish (14-99) was released upstream of Wells Dam and approximately five hours later was detected in the tailrace of the project. The fish migrated downstream, passed Rocky Reach Dam and entered the Wenatchee River for 19 days. This fish after exiting the Wenatchee River traveled back upstream to the tailrace of Rocky Reach Dam and then moved back downstream past Rock Island Dam. The fish then moved back upstream through the Rock Island ladder system and re-entered Wenatchee River where it resided for over three months.

Table 3: Summary of migration time (days) for adult radio-tagged bull trout that traveled between fixed station telemetry sites. Fixed station telemetry sites were located at the tailrace and ladder exits at Rock Island, Rocky Reach, and Wells dams and within tributaries. Migration time was only assessed for actively migrating fish.

Location[1]	N	Mean	Median	Minimum	Maximum
Rock Island Dam					
Tailrace (A-B)	5	6.93	5.66	0.43	16.43
Left Fish Ladder (B-C)	1	0.18	0.18	0.18	0.18
Right Fish Ladder (B-C)	4	0.73	0.85	0.25	0.97
Elapsed Time at Dam (A-C)	5	7.55	5.90	1.21	17.35
Dam to Wenatchee River (C-D)	2	5.99	5.99	4.56	7.41
Dam to Rocky Reach Tailrace	7	2.70	2.78	1.14	5.46
Rocky Reach Dam					
Tailrace (A-B)	22	5.82	4.44	0.60	16.25
Fish Ladder (B-C)	23	0.59	0.28	0.13	6.15
Elapsed Time at Dam (A-C)	21	6.51	4.86	1.11	16.50
Dam to Entiat River (C-D)	23	12.26	11.34	3.51	26.98
Dam to Wells Tailrace	7	2.28	2.03	1.09	3.71
Wells Dam					
Tailrace (A-B)	3	9.27	7.84	1.64	18.35
Left Fish Ladder (B-C)	1	0.32	0.32	0.32	0.32
Right Fish Ladder (B-C)	2	0.21	0.21	0.20	0.23
Elapsed Time at Dam (A-C)	12	9.89	7.60	1.83	24.87
Dam to Methow River (C-D)	11	5.83	2.78	0.33	16.42

[1]Locations are defined as:

A First detection by tailrace system (300 meters downstream).
B First detection inside either ladder entrance.
C Last detection at either ladder exit.
D First detection at tributary site.

Table 4: Summary of migration time in 2002 and 2001 (days) for adult radio-tagged bull trout that traveled between fixed station telemetry sites. Fixed station telemetry sites were located at the tailrace and ladder exits at Rock Island, Rocky Reach, and Wells dams and within tributaries. Migration time was only assessed for actively migrating fish.

	2002		2001	
Location[1]	**N**	**Median**	**N**	**Median**
	Rock Island Dam			
Tailrace (A-B)	5	5.66	---	---
Left Fish Ladder (B-C)	1	0.18	---	---
Right Fish Ladder (B-C)	4	0.85	---	---
Elapsed Time at Dam (A-C)	5	5.90	3	2.28
Dam to Wenatchee River (C-D)	2	5.99	1	1.39
Dam to Rocky Reach Tailrace	7	2.78	4	1.33
	Rocky Reach Dam			
Tailrace (A-B)	22	4.44	9	1.28
Fish Ladder (B-C)	23	0.28	9	1.92
Elapsed Time at Dam (A-C)	21	4.86	9	3.79
Dam to Entiat River (C-D)	23	11.34	13	7.20
Dam to Wells Tailrace	7	2.03	6	1.69
	Wells Dam			
Tailrace (A-B)	3	7.84	10	1.53
Left Fish Ladder (B-C)	1	0.32	1	11.63
Right Fish Ladder (B-C)	2	0.21	7	5.45
Elapsed Time at Dam (A-C)	12	7.60	8	8.87
Dam to Methow River (C-D)	11	2.78	13	0.40

[1]Locations are defined as:

A First detection by tailrace system (300 meters downstream).
B First detection inside either ladder entrance.
C Last detection at either ladder exit.
D First detection at tributary site.

4.3 Tributary Selection and Residence

All but three adult bull trout tagged in 2002 selected a major tributary for fall or fall-winter residence (Table 5). Major tributaries selected include the Wenatchee, Entiat, and Methow river systems. In our analysis we summarize the residence times and locations selected by 39 bull trout that entered a major tributary. The summary includes 37 fish tagged in 2002 and two fish tagged in 2001 (Table 5). A total of eight fish tagged in 2001 were detected during upstream migrations and some entered into the various tributaries. However, the transmitters for only two of these fish functioned long enough to establish entrance and exodus from a tributary. The three remaining fish tagged in 2002 resided within various sections of the mainstem Columbia River and did not select a major tributary for fall or fall-winter residence.

One fish (14-110) tagged in 2002 that did not select a tributary is presumed to have died. The transmitter was discovered downstream from Rock Island Dam. This fish was released upstream from Rock Island Dam, migrated upstream to Wells Dam and made brief forays into the Wenatchee and Entiat rivers. The fish migrated back downstream past Rock Island Dam where its tag was recovered on 22 August, 2003. Another fish (14-124) has only been detected occasionally, but appears to have resided between the Wenatchee River confluence and Rocky Reach Dam. The third fish (14-127), has been residing between the Wenatchee River confluence and the Entiat River confluence.

The tributaries selected by each fish released at Rock Island, Rocky Reach, and Wells dams are presented in Figure 16, Figure 17, and Figure 18. These figures represent major tributaries selected, not specific locations within the major tributaries. Appendix A provides the locations where fish were detected during each aerial survey. Entrance times of fish within the tributaries are based on the first detection at the fixed-sites within each tributary. All fish that entered tributaries were detected at the fixed site. However, some fish were not detected at the fixed-sites during their exit. Therefore, we used aerial surveys to determine exit times for these fish.

4.3.1 Wenatchee River

Bull trout that selected the Wenatchee River system originated from fish tagged at all three projects. Of the 39 bull trout that selected a major tributary in the mid-Columbia River, six (15.4%) moved into the Wenatchee River basin (Table 5). Two bull trout were tagged and released downstream of Rock Island (Figure 16). Three were tagged at Rocky Reach Dam and released downstream from the project (Figure 17). The sixth fish was tagged and released upstream of Wells Dam (Figure 18). This fish migrated downstream past two projects to enter the Wenatchee River.

Bull trout that entered the Wenatchee River remained within the mainstem and did not move into other tributaries of the Wenatchee River system. We used aerial surveys to describe the location of all six fish in the Wenatchee River. One resided near the town of Monitor, another near the town of Dryden, and two near the town of Leavenworth. Two others resided near the confluence of the Chiwawa River.

Bull trout that selected the Wenatchee Basin entered and exited the system at different times. Two entered the Wenatchee River by the end of June, three by mid-July, and the sixth fish at the beginning of August, 2002 (Table 5). The median date of entry for the six fish was 3 July, 2002. The time of egress also varied. Four of the six fish that resided within the Wenatchee River exited the system by the first week of November, 2002. The other two fish exited in mid-December and mid-January (Table 5). The median date of exodus for the six fish that resided in the Wenatchee River was 6 November, 2002. For the six bull trout that left the Wenatchee River, four resided in the Columbia River between Rock Island Dam and the Wenatchee River confluence. Another was detected throughout the Rock Island Pool, and the sixth fish resided downstream from Rock Island Dam.

During the 2001 study period, 6 of 11 (55%) adult bull trout released downstream from Rocky Reach dam selected the Wenatchee Basin. During the 2002 study period, 3 of 12 (25%) adult bull trout released downstream from Rocky Reach dam selected the Wenatchee Basin. This pattern of downstream migration was only observed in 1 of 16 (6%) bull trout released into the tailrace of Rock Island or Wells dams for 2001 and 2002 combined. That fish was released into the Wells tailrace and migrated downstream to the Entiat River. This pattern of downstream migration is uncommon for upstream releases at the three projects. In the two years of collection and tagging, a total of 39 fish were released upstream from the project where the were captured. Of those, only one (2.6%) selected a tributary downstream from the release location. That fish was released upstream of Wells Dam and ultimately resided within the Wenatchee River. For the Wenatchee River, this raised the question of whether tributary selection by some fish is an artifact of release location. While this pattern was not observed to the same degree in 2002 as the previous year, it does indicate that release location at Rocky Reach Dam may influence tributary selection.

4.3.2 Entiat River

Bull trout that selected the Entiat River originated from fish tagged at Rock Island and Rocky Reach dams (Table 5). During the 2002 study period, 21 of 39 (53.9%) adult bull trout moved into the Entiat River. Five tagged fish from Rock Island Dam entered the Entiat River with two released downstream from the project and three upstream (Figure 16). The other 16 fish were tagged at Rocky Reach Dam, with half released downstream from the project, and the other half upstream (Figure 17). None of the fish tagged at Wells Dam resided within the Entiat Basin (Table 5).

All fish in the Entiat system resided in either the Mad River (eleven fish) or the mainstem Entiat River (ten fish). Those in the Mad River selected locations upstream from the Pine Flat Campground (Appendix A). Of the ten fish that resided in the mainstem Entiat River, two were located downstream of the Mad River confluence, one between the Mad River confluence and Preston Falls, and seven upstream of Preston Falls (Appendix A).

All tagged bull trout that entered the Entiat River basin did so relatively quickly after being released. Bull trout entered the Entiat River from 6 June to13 July with more than half of the fish entering the system by the end of June (Table 5). The median date of entry into the Entiat Basin was 21 June, 2002. The time of egress varied between fish in the Entiat River and those in the Mad River with median exit times of 4 September and 23 October, respectively. All tagged fish that left the Entiat River did so by 9 October. The last date of exit was 17 December for fish that left the Mad River.

Of the 21 tagged fish that entered the Entiat Basin, 15 exited the system by 17 December. For six that remained in the Entiat basin, one died (14-95), two others are suspected to have died (14-122 and 14-123), and three others had not left the system by the end of March 2003. All three of these fish were in the Mad River.

All 15 bull trout that left the Entiat Basin moved downstream into the Columbia River to reside in Rocky Reach, Rock Island and Wanapum reservoirs. Ten tagged fish moved downstream from the Entiat River and resided within the Rocky Reach pool with seven located between Rocky Reach Dam and the Entiat River confluence and three are located between the Entiat River confluence and Wells Dam. Four bull trout moved downstream past Rocky Reach Dam and resided between the confluence of the Wenatchee River and Rocky Reach Dam. Finally, one bull trout migrated downstream past Rocky Reach and Rock Island dams and resided in the tailrace of Rock Island Dam.

4.3.3 Methow River

Bull trout that selected the Methow River originated from fish tagged at Rocky Reach and Wells dams (Table 5). During the 2002 study period, 12 of 39 (30.8%) adult bull trout moved into the Methow River. Four bull trout were tagged at Rocky Reach Dam with one released downstream and three released upstream from the project (Figure 17). The remaining eight bull trout migrated from Wells Dam with half released downstream of the project and the other half upstream (Figure 18). None of the fish tagged at Rock Island Dam moved into the Methow River (Table 5).

Bull trout in the Methow system selected two primary areas, the mainstem Methow River and the Twisp River (Appendix A). Of the 12 fish that resided within the Methow basin, nine were located within the Twisp River upstream of Buttermilk Creek. For the other three fish that entered the Methow basin, their last date of detection was on 1 July. Therefore, it is difficult to say with any certainty where they ultimately took up residence. Of these fish, one was last detected upstream of the town of Winthrop, and likely remained upstream of this location throughout the study period. The other two fish (also last detected on 1 July), were located between the Methow River confluence and Libby Creek. It is quite possible that these fish either migrated further upstream in the Methow River past town of Winthrop, into the Twisp River, or some other tributary between aerial surveys, and that the locations that they resided were not surveyed during subsequent aerial surveys. This scenario would explain why their last date of detection was on 1 July.

All bull trout entered the Methow River basin in June 2002 and have resided there throughout the study period. Bull trout entered the Methow basin between 3 June and 27 June with a median entry date of 22 June. Radio-transmitters from four of the12 fish that entered the Methow Basin were recovered and it is assumed that these fish died (see Section 4.1). Four of the remaining eight fish in the system were last detected on 18 March, 2003 during an aerial survey. None of these fish were detected within the mainstem Columbia, nor were they detected at the fixed-telemetry sites on the lower river. It is therefore assumed that these fish were still within the Methow basin at the conclusion of the study on 31 March, 2003. For the remaining four fish in the Methow Basin, their last detections for the study period were within the Methow Basin. Three were detected in the mainstem Methow River on 1 July, 2002, and one in the Twisp River on 19 February. Due to the lack of telemetry detections after those dates anywhere within the study area, it is likely that those fish reside in areas that were not surveyed during aerial flights, and remained within the Methow

basin after the study period concluded on 31 March, 2003. Therefore, for the 12 fish that entered the Methow Basin, no dates of egress from that system exist.

Table 5: Tributaries selected by adult bull trout tagged at Rock Island, Rocky Reach and Wells dams and the dates they entered and left those tributaries, 2002. Table includes two fish tagged at Rocky Reach Dam in 2001.

Tagging Information			Tributary Residence			
Release	Code	Date	Entrance	Exit	Subbasin	Location
			Rock Island Dam			
Down	105	04-Jun-02	27-Jun-02	17-Dec-02	Wenatchee	Mainstem Wenatchee River
Down	113	07-Jun-02	22-Jun-02	06-Nov-02	Wenatchee	Mainstem Wenatchee River
Down	90	23-May-02	01-Jul-02	04-Sep-02	Entiat	Mainstem Entiat River
Down	115	12-Jun-02	01-Jul-02	04-Sep-02	Entiat	Mainstem Entiat River
Up	110[2]	04-Jun-02	---	---	Columbia River	---
Up	97	20-May-02	19-Jun-02	31-Mar-03	Entiat	Mad River
Up	119	12-Jun-02	29-Jun-02	31-Mar-03	Entiat	Mad River
Up	109	07-Jun-02	20-Jun-02	17-Dec-02	Entiat	Mad River
			Rocky Reach Dam			
Down	127	27-Jun-02	---	---	Columbia River	---
Down	104	30-May-02	01-Jul-02	09-Oct-02	Wenatchee	Mainstem Wenatchee River
Down	125	26-Jun-02	06-Jul-02	06-Nov-02	Wenatchee	Mainstem Wenatchee River
Down	126	18-Jun-02	14-Jul-02	14-Jan-03	Wenatchee	Mainstem Wenatchee River
Down	101	03-Jun-02	25-Jun-02	06-Nov-02	Entiat	Mad River
Down	106	06-Jun-02	27-Jun-02	09-Oct-02	Entiat	Mainstem Entiat River
Down	111	04-Jun-02	18-Jun-02	06-Nov-02	Entiat	Mad River
Down	118	11-Jun-02	01-Jul-02	09-Oct-02	Entiat	Mainstem Entiat River
Down	114	10-Jun-02	01-Jul-02	09-Oct-02	Entiat	Mad River
Down	120	27-Jun-02	13-Jul-02	09-Oct-02	Entiat	Mad River
Down	95[2]	29-May-02	09-Jun-02	06-Nov-02	Entiat	Mainstem Entiat River
Down	89	21-May-02	09-Jun-02	31-Mar-03	Methow	Twisp River
Down	46	18-Jun-01	04-Jul-02	01-Aug-02	Entiat	Mainstem Entiat River
Up	124	24-Jun-02	---	---	Columbia River	---
Up	103	06-Jun-02	21-Jun-02	09-Oct-02	Entiat	Mainstem Entiat River
Up	121	07-Jun-02	20-Jun-02	06-Nov-02	Entiat	Mad River
Up	88	20-May-02	06-Jun-02	31-Mar-03	Entiat	Mad River
Up	92	23-May-02	19-Jun-02	04-Sep-02	Entiat	Mad River
Up	122	12-Jun-02	20-Jun-02	31-Mar-03	Entiat	Mainstem Entiat River
Up	123	21-Jun-02	01-Jul-02	31-Mar-03	Entiat	Mainstem Entiat River
Up	98	30-May-02	12-Jun-02	09-Oct-02	Entiat	Mad River
Up	116	10-Jun-02	24-Jun-02	31-Mar-03	Methow	Twisp River
Up	100[3]	04-Jun-02	27-Jun-02	---	Methow	Twisp River
Up	108	03-Jun-02	23-Jun-02	31-Mar-03	Methow	Twisp River
Up	7	04-Jun-01	11-Jun-02	04-Aug-02	Entiat	Mainstem Entiat River
			Wells Dam			
Down	112[3]	11-Jun-02	19-Jun-02	---	Methow	Mainstem Methow River
Down	93[2]	28-May-02	24-Jun-02	---	Methow	Twisp River
Down	96[2]	03-Jun-02	22-Jun-02	---	Methow	Twisp River
Down	102	04-Jun-02	26-Jun-02	31-Mar-03	Methow	Twisp River
Up	99	04-Jun-02	01-Aug-02	06-Nov-02	Wenatchee	Mainstem Wenatchee River
Up	91[3]	23-May-02	03-Jun-02	---	Methow	Mainstem Methow River
Up	94[3]	03-Jun-02	20-Jun-02	---	Methow	Mainstem Methow River
Up	107[2]	03-Jun-02	09-Jun-02	---	Methow	Twisp River
Up	117[2]	12-Jun-02	21-Jun-02	---	Methow	Twisp River

[1] Exit dates of 31 March, 2003 indicate those fish were in the tributaries at the end of the study period.
[2] Fish presumed to have died.
[3] No exit date for these fish. It is likely that they were in the basin specified as of 31 March, 2003.

4.4 Mainstem Habitat Use

During the 2001 study period we utilized boat surveys to describe the general habitat used by tagged adult bull trout as they moved through Rock Island and Rocky Reach reservoirs. For that study, we conducted bi-weekly boat surveys during the period June 2001 to March 2002. For this year of research, this task was not repeated. Instead, we conducted only two boat surveys with the purpose of locating fish that hadn't been detected for some time.

Consistent however with the prior year of research, we described the extent that radio-tagged bull trout used the Wells Hatchery outfall and the mainstem Columbia River downstream from Rock Island Dam. The purpose of this work was to determine if bull trout used the Wells Hatchery outfall as temperature refugia, and to assess the extent that bull trout used Wanapum and Priest Rapids reservoirs. The following sections summarize our findings.

4.4.1 Wells Hatchery Outfall

To assess the extent that bull trout used the Wells Hatchery outfall, we deployed an underwater telemetry system within the outfall channel downstream from the ladder system. Of the 15 tagged bull trout that were in the vicinity of Wells Dam, 10 were tagged in 2002 and five were tagged in 2001. The hatchery outfall was visited by 8 of 15 (53.3%) bull trout (**Error! Reference source not found.**). Of those that entered the outfall, three were tagged at Rocky Reach and five were tagged at Wells Dam. The proportion of tagged fish that entered the outfall in 2001 was 92% (Stevenson et al. 2002).

Four of the five fish tagged at Wells Dam that entered the outfall were released downstream from the dam. Thus, their detection in the outfall was not surprising given that they were released about 20 m downstream from the underwater telemetry system. However, all of these fish were detected multiple times, with one detected on 24 separate occasions (**Error! Reference source not found.**). On average, fish were detected 9.4 times at the hatchery outfall with a total of 10.2 minutes per visit. The total elapsed time for fish detected at the outfall averaged 6.0 days, with a range of several minutes to 15.5 days. Total elapsed time is defined as the period of time between the first detection and the last detection for the first and last visits, respectively

Bull trout were more likely to use the outfall during daylight hours than at night. Of the 75 detections for the 8 tagged bull trout that occurred in the outfall, 56 occurred during periods of daylight (0500-2100 hours), with an average of 3.5 detections per daylight hour. During periods of darkness, we observed on average 2.4 detections per hour (n=19) (Figure 19).

Possible explanations for the high occurrence of adult bull trout in the hatchery outflow include use of the area as a temperature refuge, opportunistic feeding opportunities, or simple exploratory behavior. With regard to the outflow providing bull trout with a temperature refuge, the hatchery operates September through May primarily on well water that is a constant 11.1°C (there is some use of Columbia River water at this facility). After May, the mainstem Columbia River is the primary water source for the hatchery (supplemented with about 4 cfs of well water).

During the period when bull trout were being released downstream of Wells Dam, the water temperature was recorded at the time bull trout were being released. The release location was approximately 20 meters below the last weir of the hatchery outfall. During the period of 3 June to 12 June, the water temperatures ranged between 13.0 and 16.0°C. It should be noted that the temperature was recorded within a few feet of the shore, and at a depth of approximately 2 feet. Therefore, it is likely that the temperature mid-channel was lower. Water temperatures recorded within the mainstem Columbia (recorded at Wells Dam) during the time period when bull trout were detected in the hatchery outfall (3 June to 20 June) ranged between 10.1 and 13.3°C. From these data it appears that Columbia River temperatures were less than within the hatchery outfall, or at least comparable. These temperatures are within the thermal optima for adult bull trout (EPA 2001). Therefore, it does not appear that bull trout utilize the hatchery outfall as a temperature refuge.

It is possible that the bull trout frequented the outfall in search of prey. Typical operation at the hatchery is to volitionally release yearling chinook smolts between 15 and 30 April. These smolts migrate downstream through the ladder system and then enter the Columbia River. Although hatchery releases occurred before we detected bull trout in the outflow, large number of smolts were routinely observed during the period when the bull trout frequented the outflow (Shane Bickford, DPUD, personal communication). Given that bull trout feed opportunistically (Goetz 1989), it is likely that the tagged bull trout were taking advantage of the large concentration of juvenile salmonids within the outfall and ladder system.

Table 6: Number of visits and length of time that eight bull trout were detected within the Wells Hatchery outfall. The mean, minimum, maximum and total times are in hours and the elapsed time is in days. The elapsed time is defined as the period of time between the first and last detections at this location.

Release Location	Code	Number of Visits	Time				
			Mean	Min	Max	Total	Elapsed
Rocky Reach Dam							
Up	100	9	0:06:41	0:00:18	0:32:41	1:00:08	4.16
Up	108	5	0:01:15	0:00:19	0:02:15	0:06:14	4.65
Up	116	7	0:03:08	0:00:15	0:16:59	0:21:59	2.87
Wells Dam							
Down	93	24	0:16:06	0:00:16	1:04:05	6:26:13	15.50
Down	96	17	0:05:19	0:00:16	1:12:57	1:30:24	14.60
Down	102	3	0:01:51	0:01:35	0:02:03	0:05:32	0.08
Down	112	4	0:04:32	0:00:19	0:07:43	0:18:08	4.74
Up	99	6	0:03:47	0:00:22	0:08:45	0:22:40	1.26

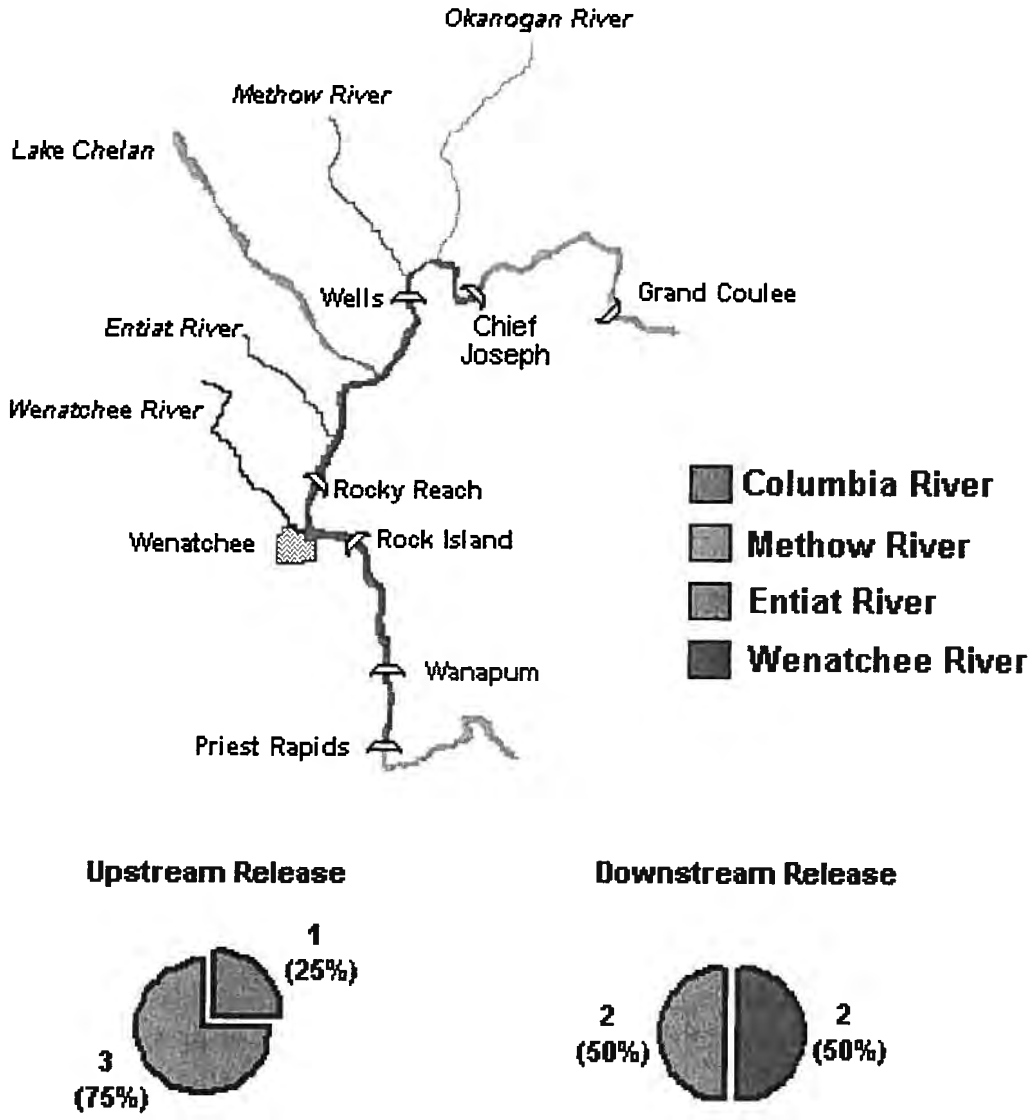

Figure 16: Mid-Columbia River tributaries selected by bull trout after they were released upstream and downstream from Rock Island Dam, 2002. Final destination for radio-tagged bull trout within each tributary is noted in Table 5.

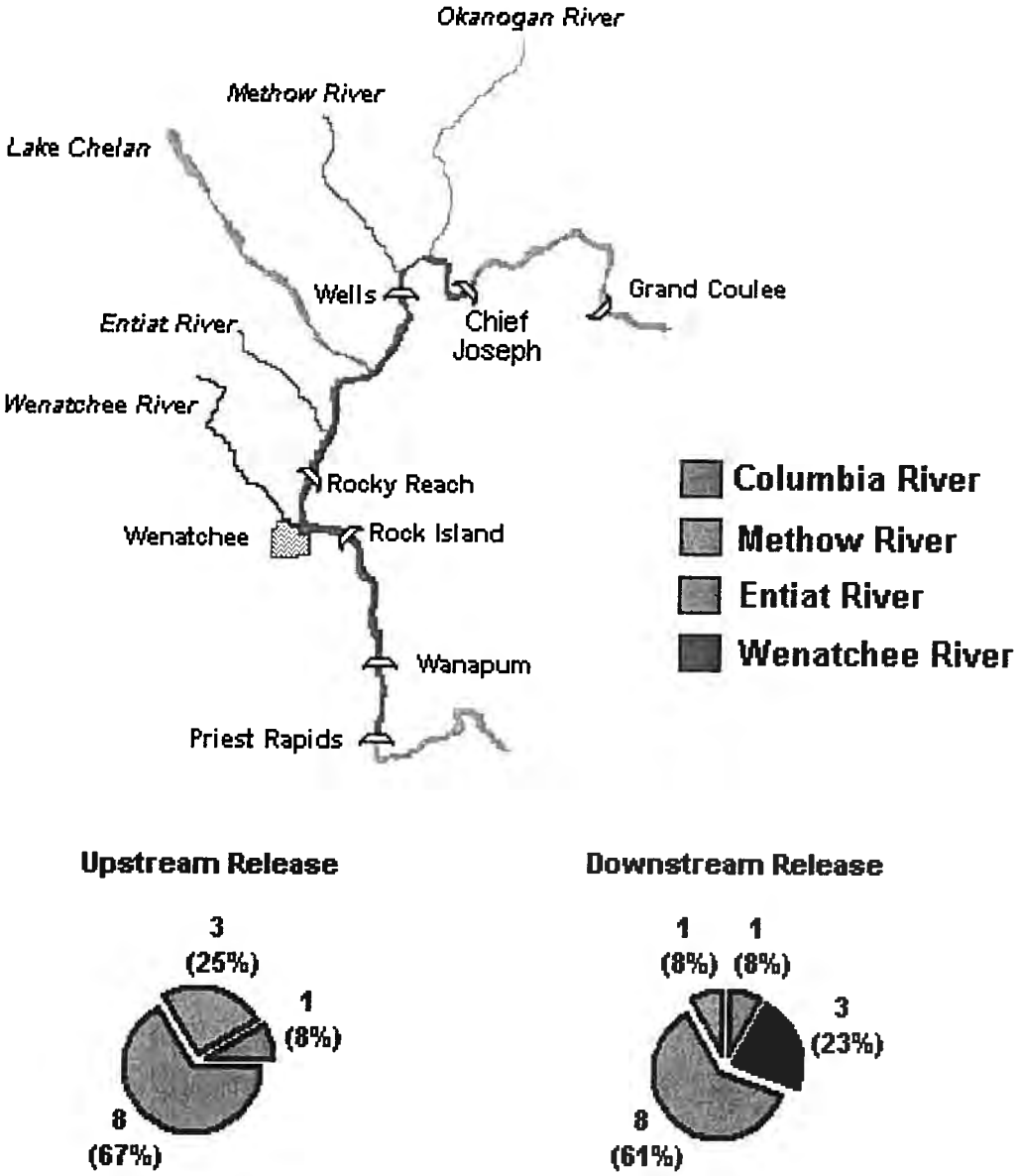

Figure 17: Mid-Columbia River tributaries selected by bull trout after they were released upstream and downstream from Rocky Reach Dam, 2002. Final destination for radio-tagged bull trout within each tributary is noted in Table 5.

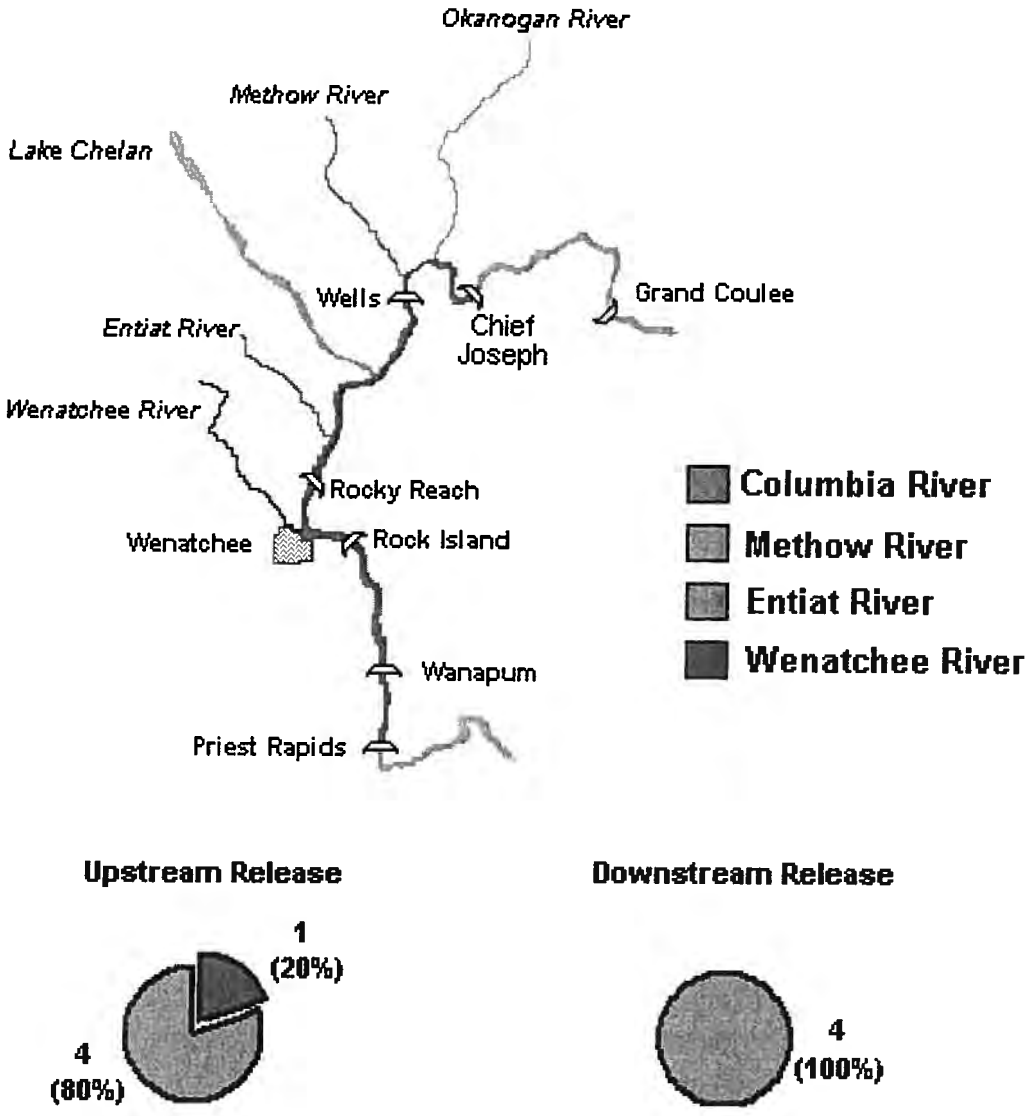

Figure 18: Mid-Columbia River tributaries selected by bull trout after they were released upstream and downstream from Wells Dam, 2001. Final destination for radio-tagged bull trout within each tributary is noted in Table 5.

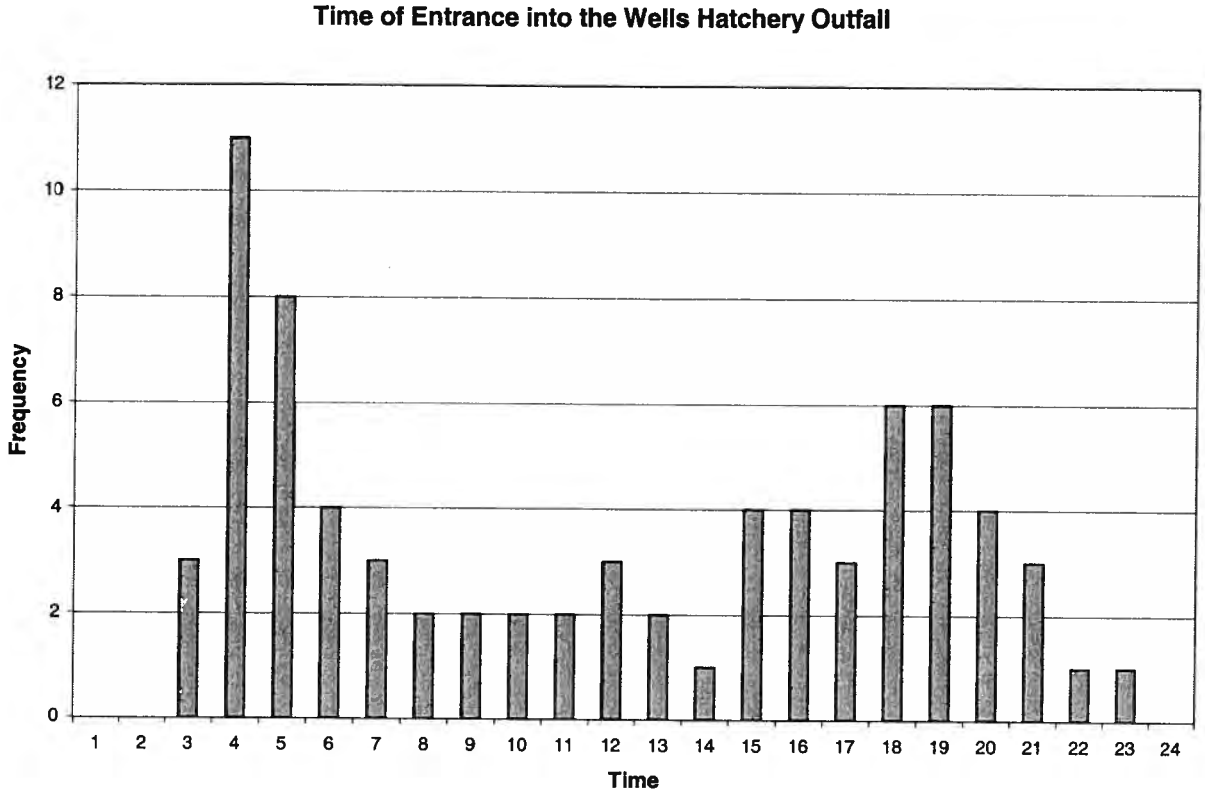

Figure 19: Diel pattern for eight radio-tagged bull trout detected at the Wells hatchery outfall. There were 75 visits to the hatchery outfall, but most (56) occurred between 0500-2100 hrs.

4.4.2 Wanapum and Priest Rapids Reservoirs

During the study (through 31 March, 2003) no tagged bull trout passed through Wanapum or Priest Rapids dams. However, subsequent to the conclusion of the study period, one fish (14-105) did migrated downstream and pass both Wanapum and Priest Rapids dams on 26 May, 2003 and 28 May, 2003, respectively. Because this fish did not migrated downstream of Rock Island Dam until after the completion of the 2002-2003 study, a detailed discussion will not be provided here. Rather, information for this fish will be provided in a supplemental report that is being prepared for Grant County PUD.

We detected a total of eight bull trout that moved downstream of Rock Island Dam after they left tributaries. This includes four fish that were tagged in 2001 and four that were tagged in 2002. The extent of movement observed for bull trout that migrated downstream of Rock Island Dam is based primarily on detection histories generated from fixed-site telemetry data collected at Priest Rapids, Wanapum, and Rock Island dams. Telemetry data collected at Rocky Reach and Wells dams, as well as the tributary sites have been integrated to aid in the removal of false records from the database generated by ambient background noise at the projects. In addition to the telemetry data collected at the fixed-sites, a total of 21 mobile boat surveys were conducted in the Wanapum reservoir, 21 within the Priest Rapids reservoir, and nine downstream of Priest Rapids Dam during the period of 1 April, 2002 and 31 March, 2003. Furthermore, a total of 15 aerial surveys were conducted for the reach of river between Priest Rapids and Rock Island dams.

Collectively, the eight radio-tagged bull trout that migrated downstream of Rock Island Dam after tributary residence represents 10.1% of the tagged population. That percentage is derived from 39 fish tagged in 2001 and 40 fish in 2002. The fixed-site telemetry data indicated that none of these fish were detected at either Wanapum or Priest Rapids dams. Therefore, the primary location of residence for these fish was within the Wanapum reservoir. The following is a summary of the detection history for each of the eight fish detected downstream of Rock Island Dam for the period of 1 April, 2002 to 31 March, 2003.

Code 6 Bull Trout – This fish was trapped and tagged at Rocky Reach Dam, released upstream of the project on 29 May 2001, and was 56.9-cm long (FL) and weighed 2,000 g. After release, this trout migrated upstream and entered the Entiat River on 10 June 2001, where it resided until 17 October 2001, much of the time near Silver Falls. After migration out of the Entiat River, this trout resided within the Columbia River between Rocky Reach Dam and the Entiat River confluence until it passed Rocky Reach Dam on 14 November 2001. During the period of 14 November 2001 to 17 April 2002, this fish was detected within the Rock Island reservoir and Rocky Reach tailrace by both fixed-telemetry sites and mobile surveys. On 3 June 2002, this fish was detected by the aerial array in the tailrace of Rock Island Dam over a seven hour period (Figure 20). This was the last contact with this fish.

Code 7 Bull Trout – This fish was trapped and tagged at Rocky Reach Dam, released upstream of the project on 4 June 2001, and was 48.5-cm long (FL) and weighed 1,150 g. After release, the fish was detected within the Rocky Reach forebay for about 1 day and then was detected at the Entiat River fixed-site (RK 4.8) on 8 June 2001. The fish migrated upstream and resided within the Entiat River upstream of Preston Falls. On 11 November 2001, this fish was again detected by the fixed-site on the lower Entiat River as it exited the tributary. The first detection in the tailrace of Rock

Island Dam was on 18 November 2001, at which time it migrated downstream of Rock Island Dam to a point about 11 km upstream of Wanapum Dam. The fish remained within this area for about 2 months (28 February to 25 April 2002; (Figure 20). The fish then began an upstream migration and was last detected at the Rock Island and Rocky Reach ladder exits on 20 May and 25 May, respectively, and re-entered the Entiat River on 11 June where it resided between the Mad River confluence and Preston falls until it exited the Entiat River on 4 August. This fish was last detected on 10 October 2002 between the Wenatchee River confluence and Rocky Reach Dam.

Code 15 Bull Trout – This trout was collected and tagged at Rocky Reach Dam and was released into the tailrace of the project. The fish was released on 25 May 2001 and was 56.1-cm long and weighed 1,950 g. After release, this fish spent about 4 days in the tailrace and ladder system at Rocky Reach Dam. After exiting the ladder, it was detected on 6 June 2001 at the Entiat River fixed-telemetry site. From there it migrated upstream and resided upstream of Preston Falls in the Entiat River. During its migration downstream, it was detected in the lower Entiat River again by the fixed-telemetry site on 2 November 2001. On 10 November 2001, the bull trout was detected at Rocky Reach Dam where it resided in the mainstem Columbia River between Rock Island and Rocky Reach dams until 27 March 2002, when it was first detected in the tailrace of Rock Island Dam. This fish was located during four separate aerial surveys within the Rock Island tailrace and by the fixed-telemetry site at that location until 6 August 2002 (Figure 20). This fish was detected on multiple occasions in the tailrace of Wells Dam during the period of 16 December, 2002 to 27 February, 2003. Subsequent to detections at that location, this fish was detected in the tailrace of Rocky Reach Dam on 17 March, 2003.

Code 36 Bull Trout – This bull trout was collected and tagged at Rock Island Dam on 13 June 2001 and was released upstream of the project. It was 59.7-cm long and weighed 1,750 g. After release, this fish migrated upstream to Rocky Reach Dam, where it spent about 3 months within the area between the Wenatchee River confluence and the tailrace of Rocky Reach Dam. On 21 September 2001, this fish was detected within the lower 3 to 4 km of the Wenatchee River, where it was detected during aerial surveys over the course of about 1.5 months. After exiting the Wenatchee River, it was first detected at Rock Island Dam on 1 December 2001 and later in the Rock Island tailrace during the period of 18-24 December 2001 (Figure 20). After exiting the Rock Island ladder, the fish again resided within the Rock Island reservoir until it ascended and exited the Rocky Reach ladder on 2 July, 2002. This fish was last detected at Wells Dam on 6 July 2002.

Code 99 Bull Trout – This bull trout was collected and tagged at Wells Dam on 4 June 2002 and was released upstream of the project. It was 46.5-cm long and weighed 1,150 g. Five hours after release, this fish was detected in the tailrace of Wells Dam, where it was detected over an eight day period. This trout then migrated downstream, and was detected in the tailrace of Rocky Reach Dam on 20 June 2002. The fish then migrated into the Wenatchee River, where it resided for 19 days between the Wenatchee River confluence and the town of Leavenworth. After migration out of the Wenatchee River, it was detected in the tailrace of Rocky Reach Dam for a period of one day beginning 11 July 2002, and was subsequently detected in the tailrace of Rock Island Dam on 13 July 2002 until 29 July 2002 (Figure 20). After ascending the Rock Island center fish ladder, this trout was detected in the Wenatchee River, where it resided until 6 November, 2002. After migrating out of the Wenatchee River, this fish resided between Rock Island Dam and the Wenatchee River confluence where it was last detected on 19 February, 2003.

Code 101 Bull Trout – This bull trout was collected and tagged at Rocky Reach Dam on 3 June, 2002 and was released downstream from the project. It was 55.3 cm in length, and weighed 1,950 g. After release, this fish ascended the Rocky Reach fish ladder, and exited the system on 15 June, 2002. Ten days later the fish was detected at the Entiat River fixed-telemetry site, and eventually migrated upstream and resided within the Mad River. The fish exited the Entiat basin on 6 November, 2002, and was detected in the tailraces of Rocky Reach and Rock Island dams on15 January, 2003 and 16 January, 2003, respectively. This fish was later detected approximately 2 miles upstream of Tarpiscan Creek on 18 March, 2003 during an aerial survey, and later (28 March, 2003) approximately 1 mile upstream of Tarpiscan Creek near the right bank during a boat survey conducted by Grant County PUD.

Code 110 Bull Trout – This bull trout was collected and tagged at Rock Island Dam on 4 June 2002, and is the only fish that has been detected below Rock Island Dam that is known to have expired (see Section 4.1). The fish was released upstream of the project, and was 60.0-cm long and weighed 2,400 g. After release, this fish was detected over a two day period in the tailrace of Rocky Reach Dam beginning 6 June 2002. Subsequently, this fish migrated downstream and entered the Wenatchee River on 11 June 2002, where it resided until 10 July, at one point between the town of Leavenworth and Tumwater Dam. After leaving the Wenatchee River, this trout was detected once again in the tailrace of Rocky Reach Dam beginning 10 July 2002 for a 3 day period, and after ascending the fish ladder, was detected in the tailrace of Wells Dam on 14 July 2002 for one day. After migrating downstream, the fish entered the Entiat River on 18 July, and remained for two days at the fixed-telemetry site (R.K. 4.8). On 20 July this fish was detected in the tailrace of Rocky Reach Dam, and on 21 July in the tailrace of Rock Island Dam. The next contact with this fish was between the period of 1 August and 22 August, at which time the transmitter was recovered (Figure 20).

Code 113 Bull Trout – This trout was captured and tagged at Rock Island Dam, and released downstream from the project on 7 June, 2002. The fish was 43.0 cm in length, and weighed 800 g. After release, the fish ascended the left bank ladder, and exited the system on 14 June, 2002. Eight days later, this fish was detected at the fixed-telemetry site on the Wenatchee River, and subsequently resided within the Wenatchee basin through 6 November, 2002, much of that time near the confluence of the Chiwawa River. After leaving the Wenatchee basin, this fish was detected in the tailrace of Rock Island Dam on 19 February, 2003, and near Sunland Bar on 28 March, 2003.

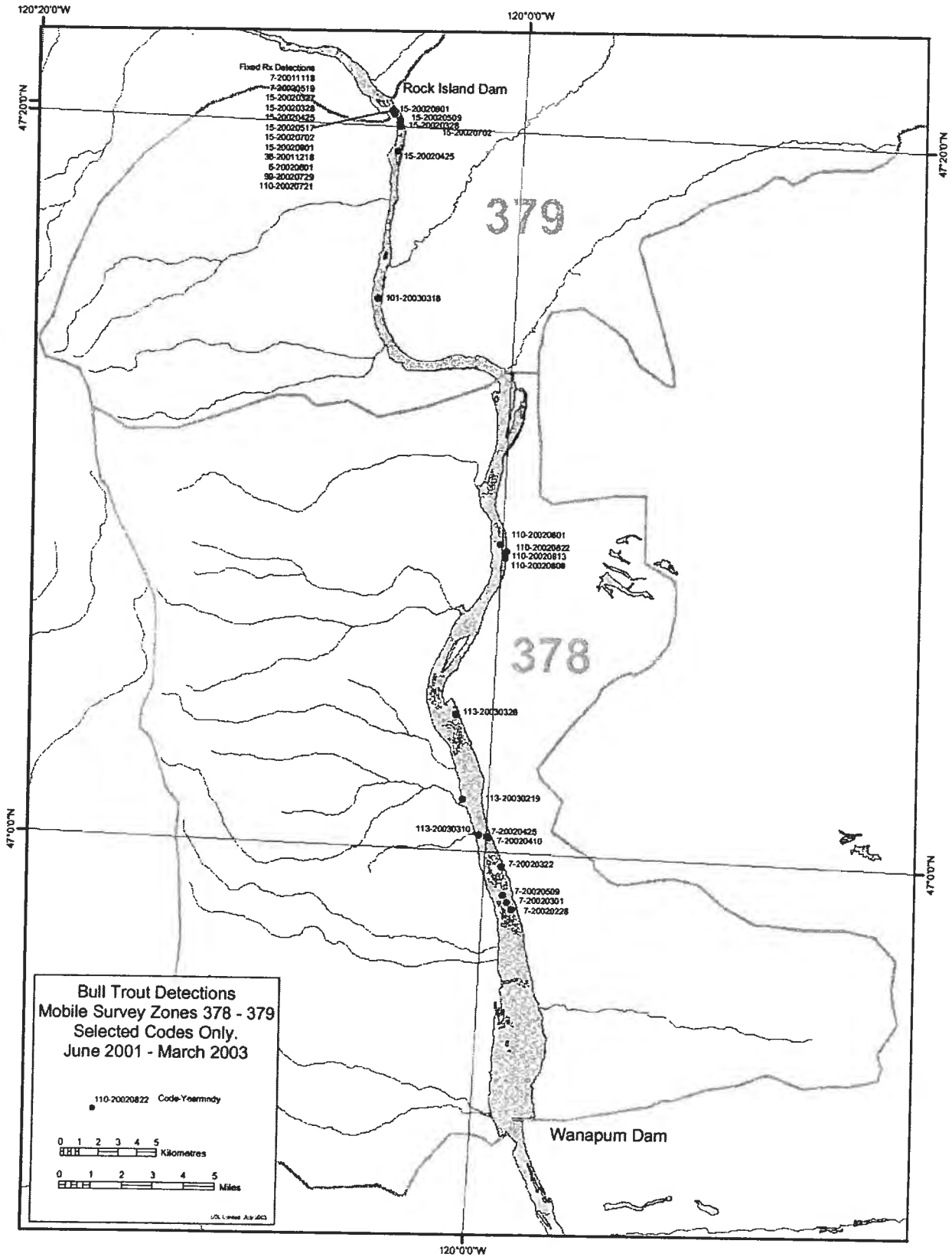

Figure 20: Map of bull trout detected downstream from Rock Island Dam.

SECTION 5: CONCLUSIONS

Based on the results from the 2002-2003 study, we offer the following tentative conclusions.

1. We successfully tagged 40 adult bull trout with radio tags in 2002. Of those, it appears that six may have died. However, there is no evidence that these deaths were the result of hydroelectric operations.
2. Based on data collected in 2002-2003, operations of hydroelectric facilities on the mid-Columbia River did not negatively affect the survival of adult bull trout. That is, no adult bull trout were killed during upstream or downstream passage through the mid-Columbia dams.
3. Although hydroelectric operations did not appear to affect the survival of adult bull trout, the presence of dams may have slowed migration times. On average, it took bull trout longer to pass dams than it did for them to move through reservoirs (i.e., from project to project).
4. The overall dam passage time is considerably greater for fish released into the tailrace of a given project relative to fish actively migrating upstream (i.e., released at a downstream project). The release location of future studies assessing passage rates at dams should be made upstream of the project, or far enough downstream to allow adequate recovery following tagging.
5. At Rocky Reach Dam, the location where tagged fish are released appears to influence tributary selection. Of the tagged fish released below the project in 2001, 54% entered the Wenatchee River. In 2002, this behavior was observed to a lesser degree, however, 20% of the fish released downstream entered the Wenatchee River.
6. There were four downstream passage events observed at Rocky Reach Dam and two at Wells Dam that occurred shortly after the fish were released or had ascended the ladder.
7. Bull trout entered tributaries shortly after release. They selected the Wenatchee, Entiat, and Methow systems. No bull trout selected the Okanogan system although one bull trout moved into the Okanogan it left shortly thereafter and moved into the Methow system. Most entered mainstem tributaries by end of June.
8. Over half (53%) of the bull trout detected within the Wells Dam tailrace entered the hatchery outfall. Because there was little difference in temperature between the outfall and the mainstem Columbia River, it is unlikely that bull trout used the outfall as a temperature refuge. Instead, they may have used the outfall to increase feeding opportunities.
9. Of the 79 bull trout tagged in 2001 and 2002, eight (10.1%) moved downstream of Rock Island Dam after an extended stay in tributaries. At the conclusion of the study period, no tagged bull trout passed Wanapum or Priest Rapids dams.

SECTION 6: ACKNOWLEDGMENTS

Chelan, Douglas, and Grant County PUDs funded this study. We thank Scott Kreiter (Chelan PUD), Shane Bickford (Douglas PUD), and Tom Dresser (Grant PUD) for providing valuable assistance in the development and implementation of this study. We especially thank Scott for assuming the role as project coordinator. We thank the Chelan PUD fishway attendants for their assistance in transporting tagged fish, and Thad Mosey for his help in securing equipment. Charlie Snow, Washington Department of Fish and Wildlife, coordinated the collection of bull trout at Wells Dam. We appreciate the Douglas PUD operators, who assisted with trapping and tagging activities at Wells Dam, and the Grant PUD fisheries technicians who conducted mobile surveys within Wanapum pool. We thank Karl English, Bryan Nass, and Cezary Sliwinski of LGL limited for processing telemetry data and LGL field personnel for their assistance in data collection at Priest Rapids, Wanapum, and Wells dams. Finally, we thank Jeff Reeves, Connor Giorgi, and Don Truscott of BioAnalysts for their dedication in trapping and monitoring of bull trout.

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APPENDIX A: BULL TROUT DETECTION MAPS

Available Upon Request

ANNUAL PROGRESS REPORT FOR WELLS HATCHERY SUMMER STEELHEAD; 2000 BROOD YEAR

APPENDIX K

Annual Progress Report For Wells Hatchery Summer Steelhead

2000 Brood Year

Prepared for
Public Utility District No. 1 of Douglas County

By

Charlie Snow

January 2003

Washington Department of Fish and Wildlife
600 Capitol Way N.
Olympia WA 98501-1091

ABSTRACT

Trapping of upper Columbia River summer steelhead for Wells Hatchery broodstock began on 12 July and finished on 15 November 1999. Wells Hatchery collected 351 steelhead from the west ladder and 41 steelhead from the east ladder of Wells Dam. Wild adults represented 11.2 % of the broodstock collected. Eight female and three male steelhead died prior to spawning (2.8%). The hatchery spawned 158 males with 202 females between 15 December 1999 and 22 March 2000, to produce an estimated 1,148,999 eggs. One additional female and one male were not viable at spawning. On 22 March 2000, the hatchery crew returned 14 male and 3 female steelhead to the Columbia River above Wells Dam. A total of 408,699 eyed eggs were transferred to other facilities, with an estimated 683,613 fertilized eggs retained at the hatchery for Wells programs.

Wells Hatchery released approximately 326,270 H x W smolts in the Methow River and its tributaries, representing 85.9% of the program release goal. The hatchery released an estimated 228,770 H x H smolts in the Okanogan River and its tributaries, representing 228.8% of the program release goal. All the steelhead releases were accomplished between 16 April and 22 May 2001. Unfertilized egg to fry survival was 83.6% for the Wells program eggs, and fry to smolt survival was 89.2%, and 90.5% for the H x W and H x H juveniles, respectively. Unfertilized egg to smolt survival was 81.2% for the Wells program steelhead.

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ACKNOWLEDGMENTS

This project was funded by the Public Utility District Number One of Douglas County, Washington. Their financial and technical assistance was much appreciated. The assistance of the Wells Hatchery crew, specifically Jerry Moore, Gary Osborne, Ace Trump, Stewart Mitchell, Dennis Schott, and Able Gonzales, was crucial to the data gathering effort necessary for this report. Heather Bartlett assisted with much of the sampling of the adult steelhead covered in this report. I thank John Sneva for providing the scale and age analysis, and Bob Rogers for his assistance with the fish health monitoring. Andrew Murdoch, Mike Tonseth, and Michael Humling provided constructive criticism of earlier drafts of this report.

INTRODUCTION

Hatchery production of summer steelhead in the Columbia River above Priest Rapids Dam was sporadic until the late 1960's, when Chelan and Wells hatcheries began operation. Wells and Chelan hatchery productions are part of the Wells Dam and Rocky Reach Dam mitigation agreements, respectively.

Collection of summer steelhead for hatchery production above Priest Rapids Dam occurred at both Priest Rapids and Wells Dams until 1982 (Mullen et al. 1992). The adult steelhead were held and spawned at Wells Hatchery, and the progeny were released into the upper Columbia River and it's tributaries. Thereafter, Wells Dam became the primary collection site for adult steelhead used for hatchery production above Wells Dam. In August 1997, the National Marine Fisheries Service (NMFS) listed the populations in the Upper Columbia Summer Steelhead Evolutionary Significant Unit, to include all populations upstream from the mouth of the Yakima River, as endangered under provisions of the Endangered Species Act of 1973. Hatchery steelhead were included in the listing and deemed critical to the recovery effort. However, it was noted that a major threat to the genetic integrity of wild fish comes from past and present hatchery practices.

This report covers all hatchery activities relating to the trapping, spawning, rearing, and release of the 2000 brood Wells summer steelhead.

BROODSTOCK COLLECTION

The adult collection goal for the 2000 brood of summer steelhead was 396 fish collected from the run at large migrating upstream of Wells Dam. Trapping of 2000 brood summer steelhead began on 12 July and finished on 15 November 2000. Peak collection occurred during the week of 11 September 1999 (Figure 1). The hatchery retained 392 fish during the collection period (98.9% of goal). An additional 54 hatchery and 6 wild steelhead were examined for marks and released above Wells Dam during the trapping period. Thirty seven hatchery and four wild steelhead were retained for broodstock from the east ladder of Wells Dam. Forty four of the total fish retained were wild origin fish (11.2%). The adult steelhead were held in well water in a covered pond until spawning. Formalin treatments to control fungus began on 4 December 1999 and continued approximately every other day for 1 h at a ratio of 1:6,000. The last formalin treatment was conducted on 18 March 2000.

Scale and otolith samples were used to verify age and origin information from the broodstock. Two hundred twenty five of the 363 readable scales collected from the broodstock were 1-ocean fish (61.9%). An additional 137 steelhead were 2-ocean fish (37.7%), and one 3-ocean fish was identified (0.2%). Hatchery origin steelhead were identified by an adipose fin-clip ($N = 333$). Of the adipose clipped fish, two right-green elastomer, 12 left side blank-wire cheek tag, and 16 right side blank-wire cheek tag marks were observed. One unmarked hatchery origin fish was also identified via scales. Seventeen natural origin male and 24 natural origin female steelhead were identified at

spawning. Male fish were typically larger than females at the same age, and the difference increased as ocean age increased (Table 1). Fewer than 1% of the hatchery origin fish spent more than one winter in fresh water. Greater than 80% of the natural origin steelhead in the broodstock spent more than one winter in fresh water (Table 2).

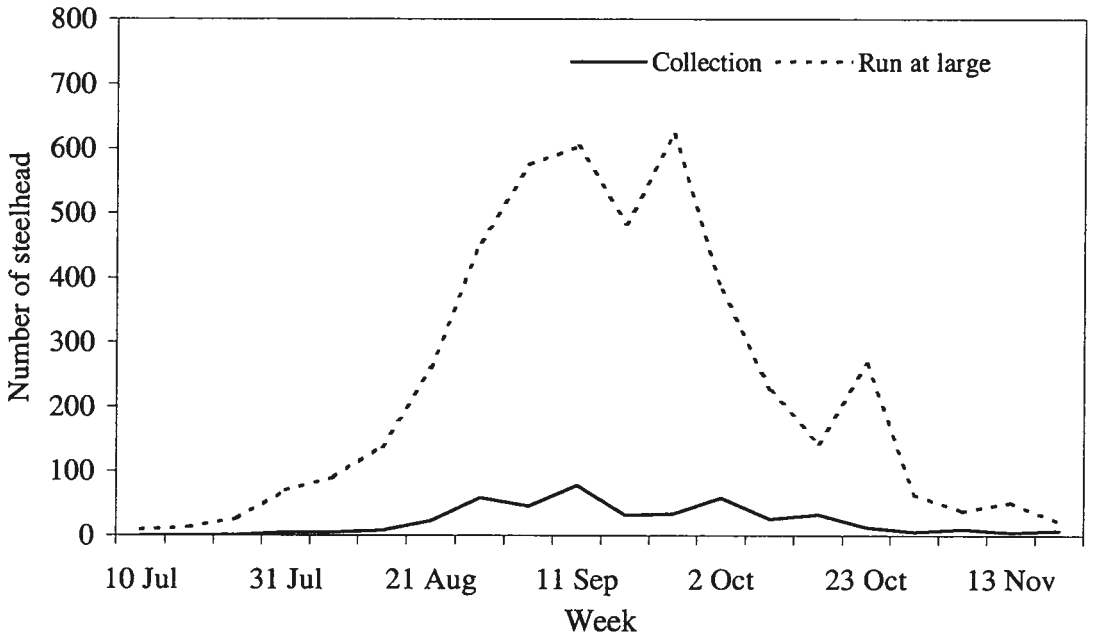

Figure 1. Collection of 2000 brood summer steelhead from Wells Dam.

Table 1. Mean fork length (cm) by sex, age, and origin of 2000 brood Wells summer steelhead determined by scale analysis.

Origin	Mean fork length (cm) by age and origin								
	1.1	1.2	1.3	2.1	2.2	3.1	3.2	R.1	R.2
					Males				
Hatchery	63.4	77.6		63.0				62.5	81.0
(*N*, SD)	(108, 2.9)	(27, 5.0)		(1, --)				(4, 3.8)	(1, --)
Wild	59.5			63.0	81.3	66.0	60.0		
(*N*, SD)	(2, 2.1)			(9, 3.3)	(3, 0.58)	(2, 0)	(1, --)		
					Females				
Hatchery	61.3	73.8	81					61.5	70.5
(*N*, SD)	(85, 2.4)	(96, 3.5)	(1, --)					(2, 2.1)	(2, 4.9)
Wild	62.0	99.0		62.7	74.5	61.0	75.0		74.5
(*N*, SD)	(1, --)	(1, --)		(11, 2.6)	(7, 3.3)	(1, --)	(1, --)		(2, 2.1)

Table 2. Comparison of fresh water (1.X, 2.X) and salt water (X.1, X.2) ages of Wells Hatchery 1997 through 2000 summer steelhead broodstocks based on scale and otolith analysis.

Origin		Brood year			
		1997	1998	1999	2000
Hatchery	*N*	295	419	356	324
	1.X	99.3%	1	99.4%	99.6%
	2.X or more	0.67%	0.0%	0.56%	0.3%
Wild	*N*	21	11	25	39
	1.X	9.5%	36.3%	12.0%	10.2%
	2.X or more	90.4%	63.6%	88.0%	89.7%
Hatchery	*N*	313	435	372	333
	X.1	76.3%	46.2%	50.8%	61.5%
	X.2 or more	23.6%	53.7%	49.1%	38.4%
Wild	*N*	21	12	27	41
	X.1	52.3%	75.0%	37.0%	63.4%
	X.2 or more	47.6%	25.0%	62.9%	36.5%

SPAWNING

Spawning began at the hatchery on 15 December 1999 and was completed on 22 March 2000 (Table 3). Three male and eight female steelhead died prior to spawning (2.8%). The peak of spawning was during the month of January 2000 ($N = 150$).

Spawn timing of the 2000 brood hatchery origin steelhead was significantly earlier when compared to wild steelhead within the broodstock ($P < 0.001$, Figure 2). A similar spawn timing disparity was observed in the 1999 brood (Snow 2002). Wild and hatchery broodstock were held together in a covered pond that provided minimal natural daylight. The fish were held in well water with an average temperature of 11.1EC. Columbia River water averaged 4.6EC between January and April 2000 when spawning occurred at the hatchery. The reduced natural light (i.e. shorter days) during the holding period should have delayed spawning, but warmer well water temperatures at the hatchery may have negated any effect.

To facilitate hatchery x wild genetic crosses at the hatchery, pituitaries from previously spawned steelhead were used as an intramuscular injection to accelerate the maturation of wild fish. Pituitary injections were applied to all wild fish on 2 and 23 February 2000. Wild male steelhead were used more than once as primary fertilizers to increase the total number of eggs produced from H x W crosses.

Wells Hatchery spawned 158 males with 202 females. One female steelhead was spawned but did not produce viable eggs. The adjusted egg collection was 1,148,999

eggs. Mean (SD) fecundity of the 2000 brood females ($N = 60$) was 5,453 (1,551). The mean fecundity of 2-salt females ($N = 32$, 5,922) was significantly greater ($P < 0.05$) than the mean fecundity of 1-salt females ($N = 28$, 4,917). The male to female spawn ratio was 0.78:1. Spawning was completed on 22 March 2000 and the hatchery crew returned the remaining surplus steelhead (13 male and 1 female hatchery steelhead, and 1 male and 2 female wild steelhead) to the Columbia River above Wells Dam.

All lethal spawned steelhead were kidney/spleen sampled for Infectious Hematopoietic and Pancreatic viruses. Ovarian fluid was also collected from 60 females for additional viral monitoring. No viral pathogens were detected in the 2000 brood.

Table 3. Spawning summary of 2000 brood Wells summer steelhead.

Spawning date	Females spawned	Estimated number of eggs[a]		
		H x H	H x W	Total
15-Dec-99	4	21,600		21,600
22-Dec	7	37,800		37,800
29-Dec	7	2,700	10,800	13,500
05-Jan-00	17	91,800		91,800
12-Jan	27	145,800		145,800
19-Jan	21	113,400		113,400
26-Jan	17	37,800	54,000	91,800
02-Feb	16	70,233	16,200	86,400
09-Feb	15		81,000	81,000
16-Feb	19		102,600	102,600
23-Feb	11	54,000	5,400	59,400
01-Mar	17		91,800	91,800
08-Mar	9	43,200	5,400	48,600
15-Mar	8	37,800	5,400	43,200
22-Mar	7	21,600	16,200	37,800
Total	202	677,733	388,800	1,066,500

[a] Actual egg collection is calculated at the eyed stage.

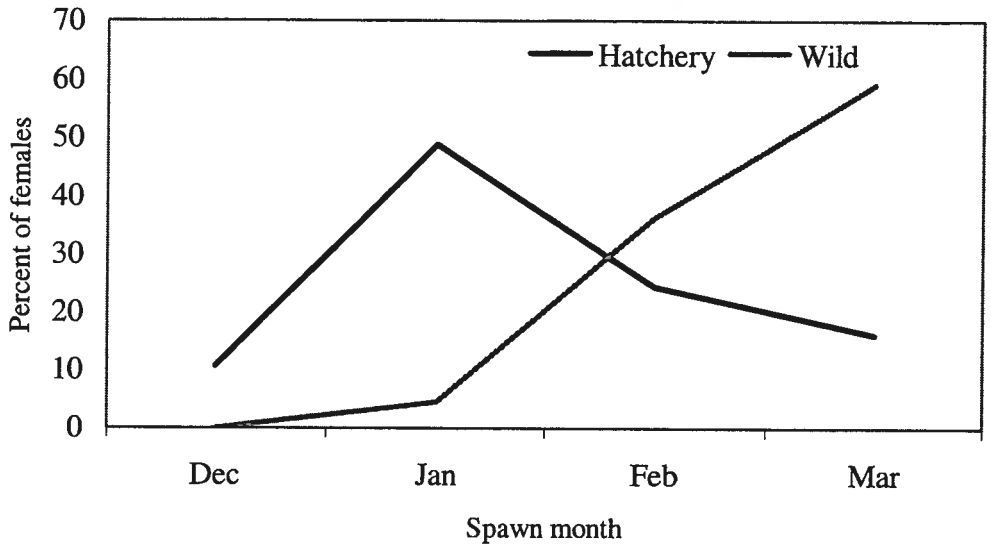

Figure 2. Percent of 2000 brood female steelhead spawned by origin and month.

JUVENILE REARING

Eggs were incubated on well water at a density of a single female per tray. After the eggs reached the eyed stage, those designated for other programs were transferred out, and the remaining eyed eggs were incubated at a density of 7,500 eggs per tray. Approximately 293,699 eyed eggs from the earliest H x H spawners were transferred to Lyons Ferry Hatchery between 10 and 20 April 2000. An additional 115,000 eggs from H x H spawners were transferred to the Winthrop National Fish Hatchery between 1 and 8 February 2000. The estimated unfertilized egg to fry survival was 83.6%.

Fry were moved from incubation trays to troughs inside the hatchery after blastopore closure. The juvenile steelhead were transferred to outside rearing ponds when they reached a mean weight of approximately 0.50 g per fish. The H x W and H x H fish were reared in outside raceways prior to tagging for 221, and 99 days, respectively.

The H x W juveniles experienced 22,001 mortalities during rearing at Wells Hatchery (6.1%). The H x H juveniles experienced 25,798 mortalities during rearing at Wells Hatchery (10.2%). Mortalities were primarily attributed to marking activities and juvenile transfers within the hatchery. No major fish health problems were encountered during the rearing of the H x W or H x H juveniles (Table 4).

Table 4. Fish health examinations conducted on the 2000 brood Wells steelhead during rearing at Wells Hatchery.

Date	Diagnosis	Recommendations/observations	
07 Apr 00	Healthy	No recommendation	Small fat deposits started.
11 May 00	Healthy	No recommendation	Gills and fins in good condition.
30 May 00	Healthy	No recommendation	Low level loss to air bladder fungus.
07 Jul 00	Healthy	No recommendation	Gills and fins in very good condition.
07 Aug 00	Healthy	No recommendation	Some dorsal fins nipped.
31 Jan 01	Healthy	No recommendation	Fat levels at 1+ to 2.
28 Feb 01	Healthy	No recommendation	Gills good, fat levels 1 to 1+.
27 Mar 01	OK	Fat levels at 1 to 1+, release as planned.	

Juvenile Marking

The 2000 brood steelhead were marked differently based on their parental origin. Hatchery x Wild progeny were freeze-branded with an "F" in position 2 (rotated clockwise 90°) when they were approximately 20 FPP. Progeny of H x H crosses were adipose fin-clipped only. Juvenile steelhead were marked at different times depending on the type of mark they were given, and the size requirements for the mark (Table 5).

Table 5. Juvenile tagging summary of 2000 brood Wells Hatchery steelhead.

Genetic cross	Date(s)	Mark	*N*	Rate (%)	FPP
H x H	8/7 to 8/14/00	Ad-clip	217,725	- -	90
H x W	11/7 to 11/27/00	RA-F-2 brand	350,100	92.2	20

Smolt Release

Organosomatic indexing (OSI) was conducted on both populations at Wells Hatchery prior to release (Table 6). The Normality indexes were 100% for the H x H fish and 90% for the H x W population, indicating that the sampled fish appeared healthy overall (Goede 1993; Goede and Barton 1990).

Table 6. Results of OSI sampling conducted on 2000 brood Wells Hatchery summer steelhead prior to release in 2001.

Program	*N*	Indices		Male : female ratio	Hematocrit (%)	Leucocrit (%)	Plasma protein
		Normality	Feeding				
H x H	20	100	100	1.5:1	47.8	1.14	6.93
H x W	20	90	100	0.42:1	48.3	0.68	6.94

In addition to OSI sampling, periodic smolt condition assessment, and pre-release length and weight sampling was also preformed. At release, the 2000 brood averaged 178.6 mm, and 172.9 mm for the H x W, and H x H groups, respectively (Table 7). No significant difference in pre-release fork lengths was observed between the two populations ($P > 0.05$). The H x W juvenile releases occurred from 16 April to 22 May 2001. The H x H releases occurred from 16 April to 9 May 2001 (Table 8). Fry to smolt

survival for the 2000 brood juveniles was 89.2%, and 90.5% for the H x W and H x H fish, respectively.

Table 7. Results of pre-release sampling conducted on the 2000 brood Wells summer steelhead.

Stock	Date	*N*	Fork length (CV)	Weight (SD)	Condition factor	FPP
H x H	4/2/2001	100	172.9 (12.9)	59.8 (21)	1.15	7.54
H x W	4/2/2001	100	178.6 (11.7)	66.8 (22)	1.17	6.7

Table 8. Wells Hatchery 2000 brood steelhead releases.

Stock	Mark	Release		
		N	Location	Date(s)
H x W	RA"F"-2 FBrand	109,950	Twisp River	4/16 to 5/22/01
H x W	RA"F"-2 FBrand	99,490	Chewuch River	4/16 to 5/22/01
H x W	RA"F"-2 FBrand	116,830	Methow River	4/16 to 5/22/01
Methow Basin total		326,270		
H x H	Ad-clip	82,415	Similkameen River	4/16 to 5/9/01
H x H	Ad-clip	112,605	Okanogan River	4/23 to 5/9/01
H x H	Ad-clip	13,800	Salmon Creek	4/18/01
H x H	Ad-clip	19,950	Omak Creek	4/30 to 5/1/01
Okanogan Basin total		228,770		
Grand total		555,040		

MONITORING AND EVALUATION

Smolt Condition Assessment

Smolt condition was assessed through visual external examination and assigning a numeric value to each sampled fish based on four different stages of development. Numeric values were designated for fish assessed as smolts = 1, transitional fish = 2, parr = 3, and residual fish = 4. The numeric values from sampled fish were averaged for each sample date to detect changes in smolt condition of the entire population over time. Each of the two earthen ponds were sampled eight times during the release period from Wells Hatchery (Figures 3 and 4). Both earthen pond populations exhibited the strongest signs of smoltification on the 4 May sample date.

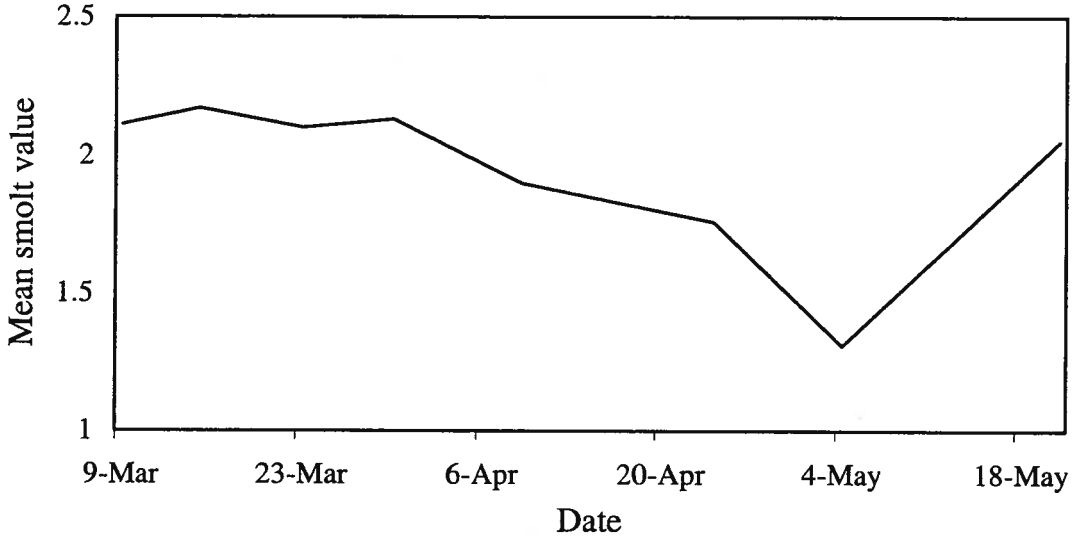

Figure 3. Mean smolt condition assessment value by date for the 2000 brood Wells Hatchery H x W summer steelhead.

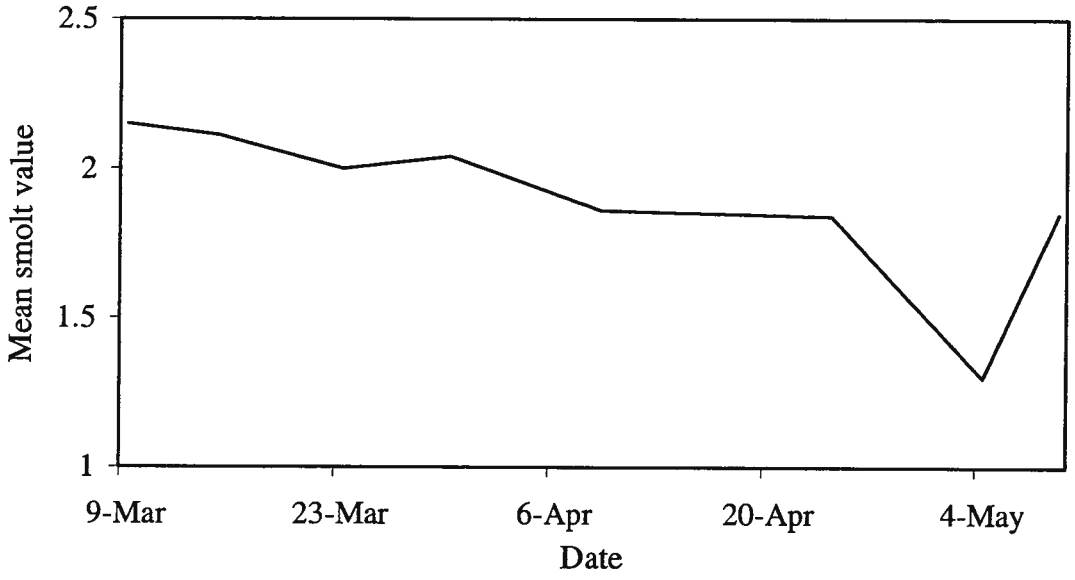

Figure 4. Mean smolt condition assessment value by date for the 2000 brood Wells Hatchery H x H summer steelhead.

Residualism

The number of potential non-migrant fish released from Wells Hatchery was estimated through visual assessment. After each holding pond was seined and all remaining fish were forced into the traps, samples were taken from the H x H (N = 105) and H x W fish (N = 107) to determine the percent of each population that appeared to be non-migrants

(e.g., parr and residual fish). An estimated 3,432 H x H and 7,073 H x W non-migrants were released from the 2000 brood (Table 9).

Table 9. Estimation of non-migrant fish within forced releases and total populations.

Date	Stock	Forced release group		Entire population		
		N	Non-migrants (%)	Migrants (%)	Non-migrants (%)	
5/9/01	H x H	12,000	28.6	227,770 (98.5)	3,432	1.50
5/21/03	H x W	14,175	49.9	326,270 (97.9)	7,073	2.17

2000 BROOD SUMMARY

Pre-spawn survival of the 2000 brood was greater than the standard set in the spawning protocols. Fertilized egg to ponding survival (egg to fry) was below the Integrated Hatchery Operations Team standards set for egg to fry survival (IHOT 1995). Ponding to release survival (fry to smolt) of the H x W population was also below the set standard (Table 10).

The collection of 392 adult steelhead for the 2000 brood of Wells summer steelhead provided enough eggs for the hatchery to exceed the production goal of 480,000 smolts by approximately 75,040 fish (15.6%). The excess was due primarily to the low pre-spawn mortality rate of 2.8%, and the low male to female ratio of 0.84:1 within the broodstock. Despite the production excess, the 2000 releases of steelhead smolts into the Upper Columbia ESU were below the ESU production cap of 1.16 million hatchery produced steelhead.

Table 10. Survival standard (%) and level achieved for the 2000 brood Wells Hatchery summer steelhead.

Stage	Standard	Survival achieved		
		Overall	H x W	H x H
Pre-spawn	95.0	97.2	- -	- -
Unfertilized egg to fry	90.0	83.6	- -	- -
Fry to smolt	90.0	- -	89.2	90.5

RECOMMENDATIONS

The Wells Hatchery steelhead program attempts to maximize the influence of wild steelhead genes within the broodstock by maximizing the H x W crosses of the spawning adults. Maximizing these parings is made difficult because of the small percentage of wild fish within the broodstock, and because hatchery fish mature earlier than wild fish within the hatchery environment. Wild fish are often injected with pituitary hormone to accelerate their maturity in order to facilitate H x W crosses. Ideally, spawning at the hatchery should mimic the timing of naturally spawning fish.

Wells steelhead are intended to supplement the number of steelhead returning to the Methow and Okanogan Rivers to assist in the recovery of this ESA listed species. It is important that hatchery produced fish be able to spawn successfully in the natural environment in order to realize the benefits of the supplementation effort. If the difference in maturation timing is present on the spawning grounds, it is worth questioning whether there is also a difference in viability between hatchery and wild origin steelhead when they are spawning naturally.

Reisenbichler and McIntyre (1977) found that hatchery steelhead on the Deschutes River were genetically different from wild fish, and when they interbreed with wild fish may produce fewer smolts than could be produced from a pairing of two wild fish. This early finding is supported by more recent work from Kostow et. al. (2003) and McLean et. al. (2003) which both reported significant differences in the reproductive success of naturally spawning hatchery and wild steelhead. The reproductive success of Wells steelhead could be investigated within the controlled environment of the unused spawning channel at Wells Hatchery. The ability of Wells-stock steelhead to contribute significantly to the production of wild fish is a key tenet of the supplementation program, and a key uncertainty. Investigating the reproductive ability of Wells steelhead may provide crucial information, and focus the hatchery program on more effective recovery efforts.

Adult steelhead are held in a covered building that reduces their exposure to natural light. This is intended to delay the spawn timing of the broodstock to more closely mimic the timing of naturally spawning steelhead. In addition, eggs from the earliest spawn days are transferred to other hatcheries in an attempt to avoid further spawn timing divergence from the continual propagation of early spawning fish. It is apparent that reduced exposure to the natural light cycle and early egg transfers have not been enough to significantly delay the spawn timing of the hatchery fish. Holding the steelhead in colder water, in addition to the reduced natural light, may delay the maturity of the hatchery fish enough to avoid the use of pituitary hormone injections. Colder holding water temperatures have been shown to delay spawn timing in hatchery origin rainbow trout (Morrison and Smith 1986).

Wild fish typically represent less than 10% of the total steelhead collected for broodstock. This prevents the hatchery from pairing wild fish with wild fish because the number of W x W crosses that could be achieved would be relatively small, and consequently, the number of H x H crosses would be much greater. It is unlikely that W x W crosses will become feasible at the hatchery until the proportion of wild fish within the broodstock increases substantially.

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ANNUAL PROGRESS REPORT FOR WELLS HATCHERY SUMMER STEELHEAD; 2001 BROOD YEAR

APPENDIX L

Annual Progress Report For Wells Hatchery Summer Steelhead

2001 Brood Year

Prepared for
Public Utility District No. 1 of Douglas County

By

Charlie Snow

January 2003

Washington Department of Fish and Wildlife
600 Capitol Way N.
Olympia WA 98501-1091

ABSTRACT

Trapping of upper Columbia River summer steelhead for Wells Hatchery broodstock began on 17 July and finished on 15 November 2000. Wells Hatchery collected 385 steelhead from the west ladder and 13 steelhead from the east ladder of Wells Dam. Wild adults represented 8.0 % of the broodstock collected. Eight female and four male steelhead died prior to spawning (3.0%). The hatchery spawned 161 male and 173 female steelhead between 20 December 2000 and 28 March 2001 to produce an estimated 987,634 eggs. Three additional females were spawned but the eggs were not viable. On 28 March 2001, the hatchery crew returned 42 male and 7 female surplus steelhead to the Methow River at approximately 50 rkm. A total of 455,900 eyed eggs were transferred to other facilities, with an estimated 492,668 fertilized eggs retained at the hatchery for Wells programs.

Wells Hatchery released approximately 264,110 H x W smolts in the Methow River and its tributaries, 94.3% of the program release goal. The hatchery released an estimated 126,855 H x H smolts in the Okanogan River and its tributaries, 63.4% of the program release goal. All the steelhead releases were accomplished between 29 April and 23 May 2002. The unfertilized egg to fry survival was 82.5% for the H x W progeny, and 84.5% for the H x H progeny. Fry to smolt survival was 95.9%, and 94.3% for the H x W and H x H juveniles, respectively. Unfertilized egg to smolt survival was 79.3% for the Wells program steelhead.

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This project was funded by the Public Utility District Number One of Douglas County, Washington. Their financial and technical assistance was much appreciated. The assistance of the Wells Hatchery crew, specifically Jerry Moore, Gary Osborne, Ace Trump, Stewart Mitchell, Dennis Schott, and Able Gonzales, was crucial to the data gathering effort necessary for this report. Heather Bartlett assisted with much of the sampling of the adult steelhead covered in this report. I thank John Sneva for providing the scale and age analysis, and Bob Rogers for his assistance with the fish health monitoring. Andrew Murdoch, Mike Tonseth, and Michael Humling provided constructive criticism of earlier drafts of this report.

INTRODUCTION

Hatchery production of summer steelhead in the Columbia River above Priest Rapids Dam was sporadic until the late 1960's, when Chelan and Wells hatcheries began operation. Wells and Chelan hatchery productions are part of the Wells Dam and Rocky Reach Dam mitigation agreements, respectively.

Collection of summer steelhead for hatchery production above Priest Rapids Dam occurred at both Priest Rapids and Wells Dams until 1982 (Mullen et al. 1992). The adult steelhead were held and spawned at Wells Hatchery, and the progeny were released into the upper Columbia River and it's tributaries. Thereafter, Wells Dam became the primary collection site for adult steelhead used for hatchery production above Wells Dam. In August 1997, the National Marine Fisheries Service (NMFS) listed the populations in the Upper Columbia Summer Steelhead Evolutionary Significant Unit, to include all populations upstream from the mouth of the Yakima River, as endangered under provisions of the Endangered Species Act of 1973. Hatchery steelhead were included in the listing and deemed critical to the recovery effort. However, it was noted that a major threat to the genetic integrity of wild fish comes from past and present hatchery practices.

This report covers all hatchery activities relating to the trapping, spawning, rearing, and release of the 2001 brood Wells summer steelhead.

BROODSTOCK COLLECTION

The adult collection goal for the 2001 brood of summer steelhead was 395 fish collected from the run at large attempting to pass Wells Dam. Trapping of 2001 brood summer steelhead began on 17 July and finished on 15 November 2001. Peak collection occurred during the week of 7 September 2000 (Figure 1). The hatchery retained 398 fish during the collection period (100.7% of goal). An additional 81 hatchery and 32 wild steelhead were examined for marks and released above Wells Dam during the trapping period. Nine hatchery and four wild steelhead were retained for broodstock from the east ladder of Wells Dam. Thirty two fish retained for broodstock were wild origin fish (8.0%). The adult steelhead were held in well water in a covered pond until spawning. Formalin treatments to control fungus began on 27 November 2000 and continued approximately every other day for 1 h at a concentration of 1:7,500 through 25 March 2001.

Scale and otolith samples were used to verify age and origin information from the broodstock. Two hundred seven of the 345 readable scales collected from the broodstock were 1-ocean fish (60.0%). An additional 138 steelhead were 2-ocean fish (40.0%). Hatchery origin steelhead were identified by an adipose fin-clip ($N = 269$), blank wire cheek tags ($N = 46$), or fin erosion indicative of hatchery rearing ($N = 8$). Of the adipose fin-clipped fish retained for broodstock, thirty were also cheek tagged; one had an orange-left elastomer tag; and one a green-left elastomer tag. Cheek tagged fish were part of an experiment to determine the relative survival of H x H and H x W steelhead. Elastomer tagged fish were strays from the Wenatchee steelhead program.

Male fish were typically greater in length than females of the same age, and the difference increased as ocean age increased (Table 1). None of the hatchery origin fish collected for broodstock spent more than one winter in fresh water. Greater than 90% of the natural origin steelhead in the broodstock spent more than one winter in fresh water (Table 2).

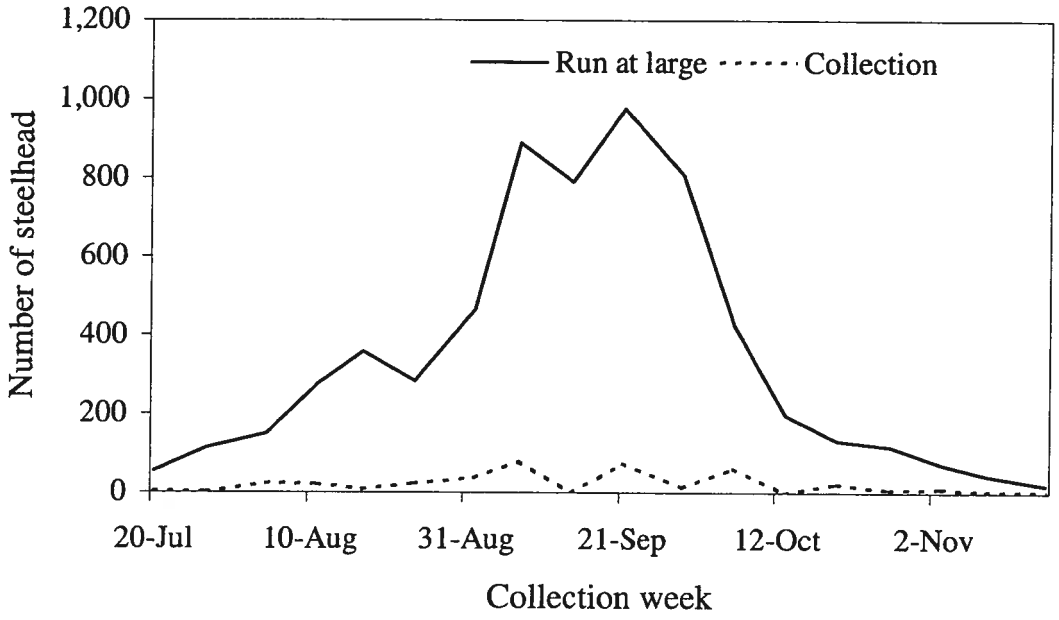

Figure 1. Collection of 2001 brood summer steelhead from Wells Dam.

Table 1. Mean fork length (cm) by sex, age, and origin of 2001 brood Wells summer steelhead determined by scale analysis.

Origin	Age 1.1	1.2	2.1	2.2
		Males		
Hatchery	61.3	76		
(*N*, SD)	(119, 3)	(27, 5)		
Wild	62		60.1	82.5
(*N*, SD)	(1, 0)		(13, 3)	(2, 4)
		Females		
Hatchery	60.3	72.9		
(*N*, SD)	(65, 2)	(105, 3)		
Wild			59.4	73
(*N*, SD)			(7, 3)	(3, 2)

Table 2. Comparison of fresh water (1.X, 2.X) and salt water (X.1, X.2) ages of Wells Hatchery 1997 through 2001 summer steelhead broodstocks based on scale and otolith analysis.

Origin		Brood year				
		1997	1998	1999	2000	2001
Hatchery	*N*	295	419	356	324	319
	1.X	99.3%	100%	99.4%	99.6%	100%
	2.X or more	0.67%	0.0%	0.56%	0.3%	0.0%
Wild	*N*	21	11	25	39	26
	1.X	9.5%	36.3%	12.0%	10.2%	3.8%
	2.X or more	90.4%	63.6%	88.0%	89.7%	96.1%
Hatchery	*N*	313	435	372	333	322
	X.1	76.3%	46.2%	50.8%	61.5%	58.3%
	X.2 or more	23.6%	53.7%	49.1%	38.4%	41.6%
Wild	*N*	21	12	27	41	26
	X.1	52.3%	75.0%	37.0%	63.4%	80.7%
	X.2 or more	47.6%	25.0%	62.9%	36.5%	19.2%

SPAWNING

Spawning began at the hatchery on 20 December 2000 and was completed on 28 March 2001 (Table 3). Eight hatchery origin male steelhead, three hatchery origin female steelhead, and one wild female steelhead died prior to spawning (3.0%). The peak in spawning occurred during the month of February 2001 ($N = 126$).

Spawn timing of the 2001 brood hatchery origin steelhead was significantly earlier when compared to wild steelhead within the broodstock ($P < 0.01$, Figure 2). A similar spawn timing disparity was observed in the 1999 and 2000 broods (Snow 2002; 2004). Wild and hatchery broodstock were held together in a covered pond that provided minimal natural daylight. The fish were held in well water with an average temperature of 11.1EC. Columbia River water averaged 6.1EC between January and April 2001 when spawning occurred at the hatchery. Since steelhead are spring spawners, reduced natural light during the holding period should delay their spawn timing, but the warmer well water at the hatchery may negate that effect.

Due to the difference in spawning timing of the hatchery and wild components, pituitary glands from previously spawned steelhead were emulsified and used as an intramuscular injection to accelerate the maturation of wild fish. Pituitary injections were applied to all wild fish on 14 February 2001. On 14 March 2001 all wild fish and 15 hatchery females were given pituitary injections. During spawning wild males were used more than once as primary fertilizers to increase the total number of eggs produced from H x W crosses.

Wells Hatchery spawned 161 male and 173 female steelhead. Three additional female steelhead were spawned, but did not produce viable eggs. The adjusted egg collection was 987,634 eggs. Mean (SD) fecundity of the 2001 brood females ($N = 169$) was 5,639 (1,722). The mean fecundity of 2-salt females ($N = 97$; 6,627) was significantly greater ($P < 0.001$) than the mean fecundity of 1-salt females ($N = 71$; 4,315). The male to female spawn ratio was 0.9:1. On 28 March 2001, the hatchery crew returned 39 hatchery origin and three wild male steelhead, and four hatchery origin and three wild female steelhead to the Methow River between the towns of Twisp and Carlton.

Kidney and spleen samples were collected from all lethal spawned steelhead to detect Infectious Hematopoietic and Pancreatic viruses. Ovarian fluid was also collected from 60 females for additional viral monitoring. No viral pathogens were detected in the 2001 brood.

Table 3. Spawning summary of 2001 brood Wells summer steelhead.

Spawn date	Females spawned	Estimated number of eggs [a]		
		H x H	H x W	Total
20-Dec-00	8	50,500		50,508
27-Dec	10	32,200	21,400	53,610
03-Jan-01	4	26,500		26,504
10-Jan	12	53,800	20,100	73,912
17-Jan	20	72,400	35,400	107,820
24-Jan	20	10,734		110,754
31-Jan	8	54,300		54,308
07-Feb	10	46,700		46,710
14-Feb	25	64,800	67,200	132,025
21-Feb	18	67,600	36,600	104,218
28-Feb	13	31,800	45,000	76,813
07-Mar	8	24,900	11,600	36,508
14-Mar	4	21,500	2,550	24,054
21-Mar	10		51,700	51,710
28-Mar	6		38,550	38,556
Total	176	657,734	330,100	988,010

[a] Actual egg collection is calculated at the eyed stage.

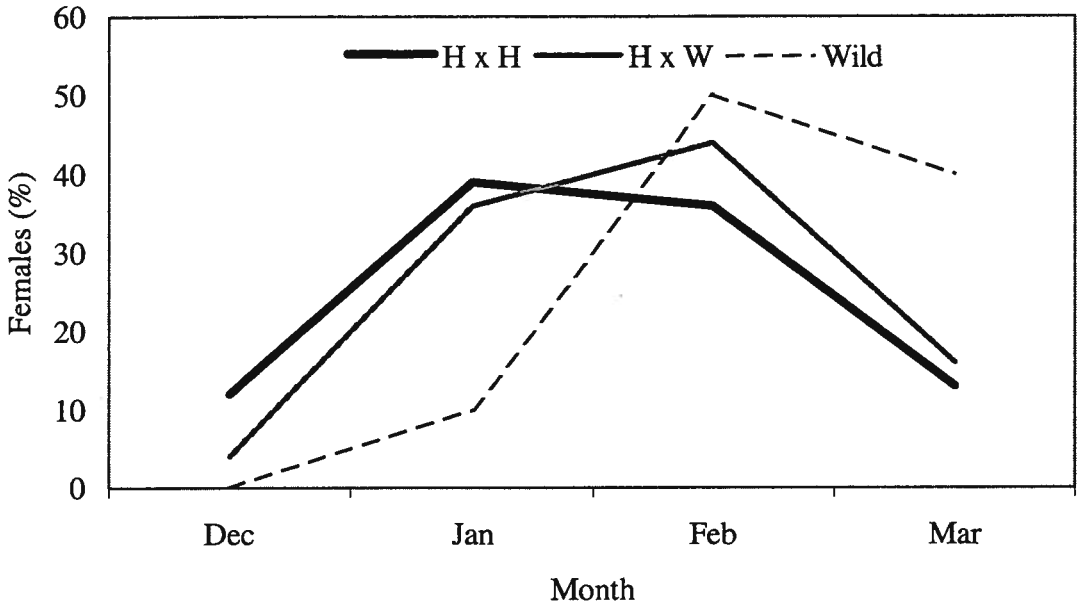

Figure 2. Percent of 2001 brood female steelhead spawned by origin and month.

JUVENILE REARING

Eggs were incubated on well water at a density of a single female per tray. After the eggs reached the eyed stage, those designated for other programs were transferred, and the remaining eyed eggs were incubated at a density of 7,500 eggs per tray. Approximately 305,600 eyed eggs from the earliest H x H spawners were transferred to Klickitat Hatchery. An additional 150,300 eggs from H x H spawners were transferred to the Winthrop National Fish Hatchery. Estimated unfertilized egg to fry survival was 82.5% for the H x W progeny and 84.5% for the H x H progeny.

Fry were moved from incubation trays to troughs inside the hatchery after blastopore closure. The juvenile steelhead were transferred to outside rearing ponds when they reached a mean weight of approximately 0.50 g per fish. The H x W and H x H fish were reared in outside raceways prior to tagging for 212 and 122 days, respectively.

The H x W juveniles experienced 11,148 mortalities during rearing at Wells Hatchery (4.0%). The H x H juveniles experienced 7,655 mortalities during rearing at Wells Hatchery (5.7%). Mortalities were primarily attributed to marking activities and juvenile transfers within the hatchery. No major fish health problems were encountered during the rearing of the H x W or H x H juveniles (Table 4).

Table 4. Fish health examinations conducted on the 2001 brood Wells steelhead during rearing at Wells Hatchery.

Date	Diagnosis	Recommendations/observations	
27-Apr-01	Healthy	No recommendation	Gills good, no evidence of fungus.
20-Jun-01	Healthy	No recommendation	Fat levels at 1-.
30-Jul-01	Healthy	No recommendation	Fat levels at 1+.
29-Oct-01	Healthy	No recommendation	Some eroded caudals, gills good.
5-Dec-01	Healthy	No recommendation	Gills good, light Ich noted on skin.
27-Feb-02	Healthy	No recommendation	Gills good, fat levels at 1+.

Juvenile Marking

The 2001 brood steelhead were marked differently based on their parental origin. Hatchery x Wild progeny were marked with yellow elastomer in the adipose tissue anterior to the left eye (LYE) when they were approximately 20 FPP. Progeny of H x H crosses were adipose fin-clipped only. Juvenile steelhead were marked at different times depending on the type of mark they were given, and the size requirements for the mark (Table 5).

Table 5. Juvenile tagging summary of 2001 brood Wells Hatchery steelhead.

Genetic cross	Dates	Mark	*N*	Rate (%)	FPP
H x H	9/7 to 9/10/01	Ad-clip	118,890	96.8	34
H x W	11/13 to 11/30/01	LYE	279,473	94.1	20

Smolt Release

Organosomatic indexing (OSI) was conducted on both populations at Wells Hatchery prior to release (Table 6). The Normality indexes were 95% for the H x H fish and 91% for the H x W population, indicating that the sampled fish appeared healthy overall (Goede and Barton 1990; Goede 1993).

Table 6. Results of OSI sampling conducted on 2001 brood Wells Hatchery summer steelhead prior to release in 2001 ($N = 20$ per sample).

Program	Indices		Male : Female	Hematocrit	Leucocrit	Plasma
	Normality	Feeding	ratio	(%)	(%)	protein
H x H	95	100	1:1	51.4	0.75	6.33
H x W	91	100	1.2:1	48.7	0.6	6.11

In addition to OSI sampling, periodic smolt condition assessment, and pre-release length and weight sampling was also preformed. At release, the 2001 brood averaged 181.8 mm, and 194.7 mm for the H x W, and H x H groups, respectively (Table 7). The H x H population had a significantly greater fork length at release than the H x W population ($P < 0.001$). The H x W and H x H juvenile releases occurred between 29 April and 23 May

2002 (Table 8). Fry to smolt survival for the 2001 brood juveniles was 95.9%, and 94.3% for the H x W and H x H fish, respectively.

Table 7. Results of pre-release sampling conducted on the 2001 brood Wells summer steelhead.

Stock	Date	*N*	Fork length (mm)	Weight	Condition factor	FPP	CV
H x H	4/10/2002	80	194.7	87.3	1.18	5.1	7.9
H x W	4/11/2002	100	181.8	72.9	1.21	6.2	14.8

Table 8. Wells Hatchery 2001 brood steelhead releases.

Stock	*N*	Location	Date(s)
H x W	84,475	Twisp River	4/29/02 to 5/23/02
H x W	85,615	Chewuch River	4/29/02 to 5/23/02
H x W	94,020	Methow River	4/29/02 to 5/23/02
Total	264,110		
H x H	58,090	Okanogan River	4/29/02 to 5/23/02
H x H	39,545	Similkameen River	5/02/02 to 5/16/02
H x H	20,520	Omak Creek	5/07/02 to 5/09/02
H x H	8,700	Salmon Creek	5/8/02
Total	126,855		
Grand total	390,965		

MONITORING AND EVALUATION

Smolt Condition Assessment

Smolt condition was assessed through visual external examination and assigning a numeric value to each sampled fish based on four different stages of development. Numeric values were designated for fish assessed as smolts = 1, transitional fish = 2, parr = 3, and residual fish = 4. The numeric values from sampled fish were averaged for each sample date to detect changes in smolt condition of the entire population over time. Each of the two earthen ponds were sampled seven times during the release period from Wells Hatchery (Figure 3). The H x W population exhibited the strongest signs of smoltification on the 14 May 2002 sample date. The H x H population exhibited the strongest signs of smoltification on the 21 May 2002 sample date.

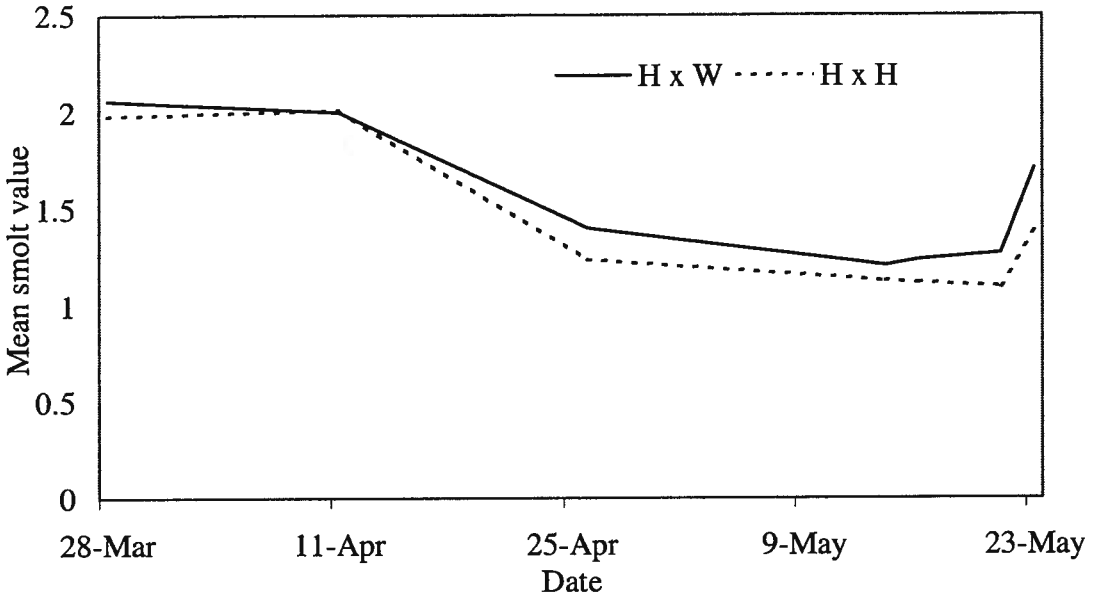

Figure 3. Mean smolt condition assessment value by date for the 2001 brood Wells Hatchery summer steelhead.

Residualism

The number of potential non-migrant fish released from Wells Hatchery was estimated through visual assessment. After each holding pond was seined and all remaining fish were forced into the traps, samples were taken from the H x H ($N = 212$) and H x W fish ($N = 400$) to determine the percent of each population that appeared to be non-migrants (e.g., parr and residual fish). An estimated 992 H x H and 4,909 H x W non-migrants were planted from the 2001 brood (Table 9).

Table 9. Estimation of non-migrant fish within forced releases and total populations.

Date	Stock	Forced release group		Entire population	
		N	Non-migrants (%)	Migrants (%)	Non-migrants (%)
5/23/02	H x H	12,400	27.5	126,855 (99.2)	992 (0.8)
5/23/02	H x W	17,850	8.0	264110 (98.1)	4,909 (1.9)

2001 BROOD SUMMARY

Pre-spawn survival of the 2001 brood was greater than the standard set in the spawning protocols. Fertilized egg to ponding survival (egg to fry) of the H x W and H x H progeny was below the Integrated Hatchery Operations Team standards set for egg to fry survival (IHOT 1995). Ponding to release survival (fry to smolt) was above the set standard for both populations (Table 10).

Wells Hatchery did not meet release goals specified for the 2001 brood steelhead. The collection of 398 adult steelhead would likely have provided adequate gametes for

program requirements if females had not been released ($N = 7$), and if egg shipments had not exceeded requirements by 40%. The adult collection in 2000 represented an extraction rate of 5.95% of the steelhead returning to Wells Dam.

Table 10. Survival standard (%) and level achieved for the 2001 brood Wells Hatchery summer steelhead.

Stage	Standard	Survival achieved (%)		
		Overall	H x W	H x H
Pre-spawn	95	96.9		
Unfertilized egg to fry	90		82.5	84.5
Fry to smolt	90		95.9	94.3

RECOMMENDATIONS

The Wells Hatchery steelhead program attempts to maximize the influence of wild steelhead genes within the broodstock by favoring H x W crosses of the spawning adults. Maximizing these parings is made difficult because of the small percentage of wild fish within the broodstock, and because hatchery fish mature earlier than wild fish within the hatchery environment. Wild fish are often injected with pituitary hormone to accelerate their maturity in order to facilitate H x W crosses. Ideally, spawning at the hatchery should mimic, as best as can be achieved, the timing of naturally spawning fish.

Wells steelhead are intended to supplement the number of steelhead returning to the Methow and Okanogan Rivers to assist in the recovery of this ESA listed species. It is important that hatchery produced fish be able to spawn successfully in the natural environment in order to realize the benefits of the supplementation effort. If the difference in maturation timing is present on the spawning grounds, it is worth questioning whether there is also a difference in viability between hatchery and wild origin steelhead when they are spawning naturally.

Reisenbichler and McIntyre (1977) found that hatchery steelhead on the Deschutes River were genetically different from wild fish, and when they interbreed with wild fish may produce fewer smolts than could be produced from a pairing of two wild fish. This early finding is supported by more recent work from Kostow et. al. (2003) and McLean et. al. (2003) which both reported significant differences in the reproductive success of naturally spawning hatchery and wild steelhead. The reproductive success of Wells steelhead could be investigated within the controlled environment of the unused spawning channel at Wells Hatchery. The ability of Wells-stock steelhead to contribute significantly to the production of wild fish is a key tenet of the supplementation program, and a key uncertainty. Investigating the reproductive ability of Wells steelhead may provide crucial information, and focus the hatchery program on more effective recovery efforts.

The adult steelhead are held in a covered building that reduces their exposure to natural light. This is intended to delay the spawn timing of the broodstock to more closely

mimic the timing of naturally spawning steelhead. In addition, eggs from the earliest spawn days are transferred to other hatcheries in an attempt to avoid further spawn timing divergence from the continual propagation of early spawning fish. It is apparent that reduced exposure to the natural light cycle and early egg transfers have not been enough to significantly delay the spawn timing of the hatchery fish. Holding the steelhead in colder water, in addition to the reduced natural light, may delay the maturity of the hatchery fish enough to avoid the use of pituitary hormone injections. Colder holding water temperatures have been shown to delay spawn timing in hatchery origin rainbow trout (Morrison and Smith 1986).

Wild fish typically represent less than 10% of the total steelhead collected for broodstock. This prevents the hatchery from pairing wild fish with wild fish because the number of W x W crosses that could be achieved would be relatively small, and consequently, the number of H x H crosses would be much greater. It is unlikely that W x W crosses will become feasible at the hatchery until the proportion of wild fish within the broodstock increases substantially.

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A HABITAT BASED EVALUATION OF OKANAGAN SOCKEYE SALMON ESCAPEMENT OBJECTIVES

APPENDIX M

Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 99/191

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A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives

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[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

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Abstract

Information from both historic and recent assessment activities has been assembled in this report to determine the current status of Okanagan sockeye. Subsets of the information are then used to: (i) evaluate the utility of historic escapement data, (ii) identify factors that may limit stock production within the Okanagan Basin and (iii) identify escapement objectives that are consistent with what is known about spawning and rearing habitat limitations in the Okanagan River and Osoyoos Lake.

Okanagan sockeye stock production is not large (average return of 56,147 sockeye per annum; range 1,666-199,832) compared to that found in other areas on the B.C. coast, but is very important locally to meet ceremonial and subsistence needs of First Nations people of the U.S. and Canadian portions of the Columbia and Okanagan River basins. Returns, averaging 18,148 adult sockeye per year in the current decade, are the lowest for any decade within the 45 year period of record for the stock. In addition, spawner abundance has declined to match record lows in 3 of the past 5 years and has stimulated expressions of concern by fisheries personnel and resource stakeholders about future prospects for long term persistence of Okanagan sockeye.

Analysis of spawning habitat capacity in terms of quantity and quality of gravel available for redds and egg incubation indicated that the Upper Okanagan River could accommodate several times the number of spawners that currently return annually. Similarly, analysis of rearing habitat in Osoyoos Lake based on both its nutrient status (total phosphorus load) and limits placed on sockeye use by changes in seasonal water quality parameters (temperature and oxygen levels) suggests that Osoyoos Lake has ample capacity to support good growth and survival of fry from no fewer than 58,730 spawners (as enumerated at Wells Dam). Analysis for possible associations between annual variations in spawner abundance and subsequent production variations of both smolt numbers and biomass also supports conclusions that neither spawning habitat in the Okanagan River or rearing habitat in Osoyoos Lake currently limit Okanagan sockeye population levels.

Recommendations supported by the paper are that: (1) minimum escapement objectives for Okanagan sockeye be set at 58,730 adults (in Wells Dam count units) or 29,365 adults as peak visual counts on the spawning grounds, (2) biological consequences of smolt size management of Osoyoos Lake sockeye be explored as a requisite to refining escapement objectives that might be adopted if Okanagan sockeye stock rebuilding is successful in future years, (3) annual sampling for size and age composition of Okanagan sockeye smolts be completed whenever feasible to facilitate future analysis of smolt-to-adult survival trends and smolt size management options in Osoyoos Lake, (4) annual sampling for age, size and sex composition of sockeye in catch and escapement be completed whenever feasible to facilitate future analysis of stock and recruit relations and to follow smolt-to-adult survival trends, (5) retrieval and review of source documentation pertaining to SEDS estimates of Okanagan sockeye escapement plus entry of supplemental comments describing methods used to generate escapement

estimates be completed, (6) annual summary estimates of Okanagan sockeye escapement from Wells Dam counts be incorporated into SEDS as a formal alternative to relatively imprecise spawning ground counts and finally (7) given that neither spawning gravel capacity or lake rearing capacity appear to set the principal limits on Okanagan sockeye population size at current stock levels, additional effort should be expended by the Okanagan Basin Fisheries Working Group to determine the reasons for recent stock declines in the absence of any targeted exploitation of Okanagan sockeye.

Résumé

Des renseignements tirés d'évaluations récentes et historiques ont été réunis dans le présent rapport dans le but de déterminer l'état actuel du saumon rouge de l'Okanagan. Des sous-ensembles de données ont ensuite été utilisés pour : i) évaluer l'utilité des données historiques sur les échappées, ii) déterminer les facteurs pouvant limiter la production du stock dans le bassin de l'Okanagan et iii) identifier des objectifs d'échappée conformes aux connaissances sur les limites des habitats de frai et de croissance de la rivière Okanagan et du lac Osoyoos.

La production du stock de saumon rouge de l'Okanagan est peu importante (remontée moyenne de 56 147 par an ; étendue de 1 666-199 832) si on la compare à celle des autres stocks de la côte de la C.-B., mais elle est très importante localement car elle satisfait aux besoins rituels et alimentaires des Premières nations habitant les parties américaines et canadiennes des bassins du fleuve Columbia et de la rivière Okanagan. Les remontées annuelles moyennes de la présente décennie, de 18 148 adultes, sont les plus faibles de toute décennie de la période de 45 ans pour laquelle nous disposons de données. L'abondance des géniteurs a décliné pour atteindre des records minimum pendant trois des cinq dernières années et a donné lieu à des inquiétudes de la part des pêcheurs et des intervenants quant au maintien à long terme du saumon rouge de l'Okanagan.

L'analyse de la capacité de l'habitat en ce qui a trait à la quantité et la qualité du gravier pour la construction des nids et l'incubation des œufs a montré que le cours supérieur de l'Okanagan pouvait accommoder plusieurs fois le nombre actuel de géniteurs qui y reviennent à chaque année. De même, l'analyse de l'habitat de croissance du lac Osoyoos, fondée sur les teneurs en matières nutritives (charge totale de phosphore) et les limites de l'utilisation par le saumon rouge découlant des variations saisonnières des paramètres de la qualité de l'eau (température et teneurs en oxygène), porte à croire que ce lac peut facilement permettre une bonne croissance et une bonne survie des alevins produits par au moins 58 730 géniteurs (tel que dénombrés au barrage Wells). Une analyse portant sur des relations possibles entre les variations annuelles de l'abondance des géniteurs et les variations ultérieures de la production de saumoneaux (nombre et biomasse) appuie aussi les conclusions selon lesquelles ni l'habitat de frai de la rivière Okanagan ni l'habitat de croissance du lac Osoyoos ne limitent actuellement la population de saumon rouge de l'Okanagan.

Les recommandations suivantes sont formulées dans le document : 1) d'objectifs minimum des échappées établis à 58 730 adultes (unités de dénombrement du barrage Wells) ou à 29 365 adultes par dénombrement visuel maximum sur frayères ; 2) examen des conséquences biologiques de la gestion de la taille des saumoneaux dans le lac Osoyoos à titre de condition préalable d'une définition plus fine des objectifs des échappées qui pourraient être adoptés si le stock de saumon rouge de l'Okanagan se rétablissait au cours des prochaines années ; 3) réalisation, chaque fois que cela est possible, d'un échantillonnage annuel des saumoneaux du stock de l'Okanagan fondé sur la taille et l'âge afin de faciliter toute analyse future des tendances de la survie de saumoneau à adulte et des options de gestion de la taille des saumoneaux dans le lac Osoyoos ; 4) réalisation, chaque fois que cela est possible, d'un échantillonnage annuel fondé sur l'âge, la taille et le sexe des saumons rouges capturés et des échappées afin de faciliter toute analyse future des relations stock-recrutement et des tendances de survie de saumoneau à adulte ; 5) obtention et examen de documents de base sur les estimations du système de données sur la remonte des salmonidés (SDRS) des échappées de saumon rouge de l'Okanagan et ajout de remarques supplémentaires décrivant les méthodes utilisées pour générer les estimations ; 6) incorporation au SDRS des estimations résumées annuelles des échappées du saumon rouge de l'Okanagan obtenues par dénombrement au barrage Wells en remplacement formel des dénombrements relativement imprécis réalisés sur les frayères et 7) étant donné que ni la capacité du gravier des frayères ni celle de l'habitat de croissance du lac ne semblent être les principales limites à la taille de la population de saumon rouge de l'Okanagan aux valeurs actuelles, des efforts supplémentaires devraient être consentis par le groupe de travail des pêches du bassin de l'Okanagan afin de déterminer les raisons du récent déclin du stock en l'absence de toute exploitation visant directement le saumon rouge de l'Okanagan.

1.0 Introduction

At the turn of the century, more than a dozen anadromous populations of sockeye salmon (*Oncorhynchus nerka*) inhabited at least eight distinct river basins in the Columbia River system (Fryer 1995, Allen and Meekin 1980). Over the past century, dams, overfishing, and other habitat degradation have reduced the number to two, viable, populations of sockeye salmon that return to the Wenatchee River in Washington State and the Upper Okanagan River in the southern interior of British Columbia (Figure 1).

Adult sockeye salmon bound for their spawning grounds in the Okanagan River must migrate past ten hydroelectric or flood control dams (9 on the Columbia River mainstem plus one on the Okanagan River) equipped with fishways. Wells Dam is the last major dam that Okanagan sockeye must pass to reach the Okanagan River. Wells Dam is located at 829.6 km on the Columbia River and lies approximately 30 km downstream of the confluence of the Okanagan River (Figure 1). Zosel Dam is located at 117 km on the Okanagan River, just south of the Canada-U.S. border. The primary spawning areas for sockeye lie approximately 42 km upstream of Zosel Dam near the town of Oliver. Most of the Okanagan River is directly accessible from Highway 97 and side roads, which run parallel to the river. Osoyoos Lake lies within the drainage course of the Okanagan River and serves as the nursery lake for juvenile sockeye.

Okanagan sockeye typically arrive at Wells Dam the last week of June or the first week of July and migration past the dam continues into August. Sockeye migrate from the Columbia mainstem into the Okanagan River and then to Osoyoos Lake in the interval between July and early September as long as temperatures in the Okanagan River remain below 21 degrees Celsius. However migration may be impeded by as much as three weeks in some years by high, summer water temperatures in the Okanagan River (Major and Mighell 1966, Allen and Meekin 1980, Mullan 1986, Chapman et al. 1995 and Alexander et al. 1998). Once past Zosel Dam, sockeye hold in Osoyoos Lake until late September after which they move into portions of the Okanagan River above Osoyoos Lake to spawn (Figure 2). Spawning begins in early October and continues through to early November.

Okanagan sockeye stock production is not large compared to that found in other areas on the B.C. coast, but is very important locally to meet ceremonial and subsistence needs of First Nations people of the U.S. and Canadian portions of the Columbia and Okanagan River basins. Two native fisheries occur upstream of Wells Dam. The Colville Confederated Tribes have a ceremonial and subsistence fishery located at Chief Joseph Dam and in the U. S. portion of the Okanagan River (Figure 1.), and the Okanagan First Nation has a ceremonial and subsistence fishery on the Upper Okanagan River.

2.0 Report Objectives

This report has been assembled in response to requests from the Okanagan First Nation and Canada's Department of Fisheries and Oceans (CDFO) to review historic escapement objectives and to advise on current needs for management, rehabilitation and

enhancement activities. We have assembled results from both historic and recent assessment activities to determine the current status of Okanagan sockeye. Specifically, we have attempted to assemble information on catch, escapement, harvest rate, juvenile production, biological traits of juveniles and adults of Okanagan sockeye between 1953 and 1998. The information assembled in this report is then used to: (i) evaluate the utility of historic escapement data, (ii) identify factors that may limit stock production within the Okanagan Basin and (iii) identify escapement objectives that are consistent with what is known about spawning and rearing habitat limitations in the Okanagan River and Osoyoos Lake.

3.0 Data Sources and Methods

3.1 Summary Catch and Escapement Records

Historic abundance trends and current status of Okanagan sockeye have featured prominently in several major reviews of Columbia Basin sockeye carried out by U. S. agencies (Mullan 1986, Chapman et al. 1995, Fryer 1995, Gustafson et al. 1997). Tabulations of summary catch and escapement information on Okanagan sockeye as presented by Chapman et al. (1995) are based on a systematic review of both published and unpublished source materials and are adopted for use in this paper, with some exceptions (see sections below), as "best" values.

3.2 Escapement Records

One to several, annual estimates of escapement based on different survey methods have been generated for Okanagan sockeye since approximately 1945. Currently, the abundance of adults returning to spawn in the Canadian portion of the Okanagan River are estimated at Wells Dam just downstream of the confluence of the Columbia and Okanagan rivers, at Zosel Dam south of Osoyoos Lake, and on the spawning grounds.

3.3 Escapement Estimates at Wells Dam

Wells Dam became operational in 1967 at which time annual enumeration of Okanagan adult sockeye passage rates through its fishways began. Annual counts have been tabulated by Chapman et al. (1995) and are also available from the Columbia River Fish Passage Center at "http://www.fpc.org/adlthist/weladult.htm".

Salmonids passing through fish ladders in all mainstem Columbia River dams are counted by experienced personnel stationed in front of viewing windows. Fish are counted for 50 minutes out of each hour over 16 hours per day during the seasonal periods when migration of particular salmon species occurs (e.g. sockeye pass Wells Dam primarily from mid-June to late August, Columbia River Fish Passage Center; Hatch and Schwartzberg 1991). Escapement estimates are multiplied by 1.2 to account for the 10 minutes per hour during which passage is not recorded. However, escapement estimates are not adjusted to correct for a small proportion of fish that may migrate at night (Hatch et al. 1992) or for double counts due to fallback where fish drop back over the dam after successfully ascending fishways and then ascend for a second time (Gibson

et al. 1979). As part of their contract with the U. S. Army Corps of engineers, the Washington Department of Wildlife is required to provide counts that are accurate to within 5 % (Fryer 1995). Although it is possible that this accuracy level is exceeded, it is likely safe to assume that counting procedures used at Wells Dam produce a highly reliable annual estimate of escapement passing Wells.

3.4 Spawning Ground Escapement Estimates (SGE's)

Surveys to sample and enumerate sockeye spawning in the Okanagan River have been executed by several generations of fisheries personnel working on behalf of both government (*i.e. CDFO, Canada Department of the Environment, U.S. Fish and Wildlife Service*) and non government groups (*e.g. private sector consultants, Douglas County Public Utility Division, Chelan Public Utility Division, Okanagan First Nation, Columbia River Intertribal Fish Commission etc.*). Consequently, differences in annual SGE's may reflect either real differences in annual abundance of spawners or alternately variations in field survey methods, level of effort, or analyses used to convert raw observations into summary estimates.

The data and procedures used to generate SGE's over the full period of record for Okanagan sockeye exhibit a rich but variable history of documentation in the form of CDFO Stream Inspection Logs (SIL's), CDFO-BC16 summary forms, Environment Canada Okanagan Basin Study Reports, U.S. Fish and Wildlife Service Science Reports, and Consultant reports (see bibliographies in major reviews of Columbia River sockeye stocks by: Allen and Meekin 1980, Mullan 1986, Fryer 1995, Chapman et al. 1995, Gustafson et al. 1997). In the present report estimates of annual escapement based on visual enumeration during spawning ground surveys were summarized from CDFO's regional Salmon Escapement Database System (SEDS; Serbic 1991), from CDFO Stream Inspection Log (SIL) forms maintained in the Kamloops or Salmon Arm offices of CDFO (Barry Rosenberger, CDFO, Kamloops, pers. comm.) and from summary tables provided in a major review of the status of Mid-Columbia sockeye salmon stocks by Chapman et al. (1995).

Authors of several PSARC Working Papers have noted that reliable interpretation of the significance of apparent trends in SEDS summary estimates is often difficult given inconsistencies in both field survey and analytical methods that may occur over decades of escapement survey work. Further, difficulties encountered in resolving the utility of historic SEDS estimates are often complicated by the absence from SEDS electronic files of qualifying comments (from entries in diaries, BC16 or SIL forms) from data suppliers about year-to-year variations in procedures used to generate annual estimates. Types of information required to qualify SEDS estimates include: (i) dates on which surveys were completed, (ii) the survey method in use, (iii) supplemental observations to confirm the temporal position of a survey relative to peak time of spawning, (iv) records of raw counts on which summary estimates are based, (v) degree of completeness of spawning area spatial coverage provided by a given survey, (vi) changes between surveys in methods or procedures for obtaining raw counts or for estimating total escapement.

In our experience, retrieval of sufficient information of the type identified above can facilitate reconstruction of poorly qualified summary escapement estimates into relatively constant precision time series that may be interpreted more confidently than the escapement time series currently available from the SEDS database. Although sufficient time was not available to complete a systematic review of all of the documentation pertaining to SGE's noted above, we have:

(i) interviewed CDFO personnel (B. Rosenberger, CDFO Kamloops Office, Feb.10, 1999) regarding methods applied to execute Okanagan River sockeye escapement surveys,

(ii) performed a reconnaissance of the spawning ground survey area to obtain first hand information regarding viewing conditions that may influence spawner enumerations in the Okanagan River, and

(iii) reviewed a wide range of source materials (e.g. Stream Inspection Logs; paper BC16's; Washington State Department of Fisheries Progress Reports; Consultant reports) to provide insights into the likely influence of variations in assessment methods, results and documentation on the utility of annual escapement estimates derived from spawning ground surveys.

Specific elements of field surveys will be presented in the results and discussion section below. However, a general description of the survey approach used for annual SGE's of sockeye is presented here.

The major spawning area for Okanagan sockeye exists in a 2.4 km stretch of natural river channel that begins immediately downstream of McIntyre Dam at the outlet of Vaseaux Lake (Figure 2). The Okanagan River was channelized from about 1.4 km above the city of Oliver, B. C., downstream to Osoyoos Lake as part of a flood control project completed in 1957. Some sockeye spawning occurs in the channelized section of the river, in which water flow is influenced by 13 engineered, vertical-drop, structures (VDS1 - VDS13, Figure1), and a minor component of the population has been observed to spawn in Osoyoos Lake in some years (Meekin 1969). In a typical year, sockeye escapement enumeration involved the completion of one to several seasonal surveys (Allen and Meekin 1980; B. Rosenberger, CDFO, Kamloops, pers. comm., Feb. 10, 1999) during which visual counts were made either while floating the river in a rubber raft (generally sections from McIntyre Dam to VDS13) or from access points that permitted streamside inspection on foot (sections from VDS13 to Osoyoos Lake). Individual fish were counted if possible or when very abundant were estimated by 10's. Abundance data were recorded as peak live plus dead (PLD) counts and the peak count from multiple surveys, was used as the basis for the annual index of spawner abundance.

3.5 Other Sources of Spawner Abundance Information

Supplementary programs have been conducted to assess Okanagan sockeye escapements past Wells Dam or in the Okanagan River at various times. Supplementary studies (*e.g. mark recapture programs, Zosel Dam fishway counts, radiotagging studies*) of adult sockeye have been completed in recent years by fisheries personnel associated with the Douglas County Public Utility District No. 1 in Wenatchee, Washington (Alexander et

al. 1998, Anonymous 1996, Swan et al. 1994, Hagen and Grette 1994, Hansen 1993, Hatch et al. 1993, Allen and Meekin 1980). However, as noted in an escapement cross calibration study conducted by Tschaplinski and Hyatt (1991), large differences in the magnitude of annual escapement estimates may occur as an inadvertent outcome of undocumented changes in annual assessment techniques. Thus, data from these supplementary surveys are identified and presented for comparison with longer time series estimates only where appropriate. All escapement values used in the current report are summarized in several tables (Tables 1-16) that document the origins of the data. Source documentation (e.g. paper "B.C.16's" forms, DFO - Stream Inspection Log forms and other unpublished reports) has been retrieved and examined in several instances to facilitate interpretation of poorly qualified summary estimates contained in summary tables of escapement estimates tabulated by other authors.

3.6 Biological Samples

Sampling for biological traits of sockeye in catches and escapements of Okanagan sockeye has not been routinely completed each year. Documentation of procedures for acquisition and processing of some of these samples is summarized by Allen and Meekin (1980) or Chapman et. al. (1995). Although information is known to be available for samples obtained from native food fisheries on the Columbia or Okanagan rivers in additional years (Columbia River Inter-Tribal Fish Commission, Portland, Oregon), most summary information requested was not available for inclusion in this report. It is important to retrieve this information in future. However, the absence of annual age-at-return information from both catch and escapement samples, precludes assessment of brood year specific production variations or stock and recruit analyses for Okanagan sockeye at present.

3.7 Juvenile Abundance Trends and Biological Traits

3.7.1 McNary Dam Smolt Indices

The relative abundance of sockeye salmon smolts migrating downstream in the Columbia Basin is assessed at the gatewells of each of several dams (e.g. Priest Rapids, McNary etc...). Index observations of annual variations in Okanagan smolt abundance considered in the present paper are completed annually at McNary Dam according to methods described by Fryer (1995) as follows. At McNary Dam (Figure 1), a portion of all downstream migrating smolts are diverted by screens from the upper portion of the water column into gatewells as water moves downwards towards the turbines. These smolts are then diverted into a bypass system where they are sent to the tailrace or collected for transportation via barge or truck to a point downstream of Bonneville Dam. An index of smolt abundance (Fish Passage Index or FPI) is made by counting the number of smolts using this system. Smolt indices are calculated as:

$$(FPI)_i = y_i/p_i$$

where y_i is the count of sockeye juveniles in the bypass system for day i, and p_i is the proportion of the flow passing through the turbines in day i (Pereira and Neeley 1990). Further details regarding the calculation of FPI and associated variances are available in Appendix 1. of Fryer (1995). Fryer notes that studies to estimate the efficiency of the smolt interception system to allow expansion of index numbers into total abundance estimates have not been completed for migrant sockeye. However, a series of studies focused on subyearling chinook have been completed (referenced in Raymond 1988) and suggest that cumulative FPI's for smolts will provide accurate estimates of annual variations in total smolt abundance.

McNary Dam is located far enough downstream on the Columbia River that annual assessments of sockeye smolt numbers and biological traits must also include procedures to separate smolts originating from the Okanagan system from those that compose the Wenatchee Lake sockeye stock. Details of the procedure used as the basis for this separation may be found in publications by Fryer (1994, 1995). The separation technique employs both smolt run timing differences (Wenatchee smolts generally pass McNary Dam prior to May 18 while the bulk of Okanagan sockeye smolts do not pass McNary Dam until after May 18th in any given year, Fryer 1995, Peven 1987) and scale pattern differences (Okanagan sockeye typically exhibit significantly higher circulus counts to the first annulus than do Wenatchee sockeye).

3.7.2 Acoustic and Trawl Surveys of Nerkid Abundance in Osoyoos Lake

Surveys to determine underyearling nerkid abundance (juvenile sockeye and kokanee), biological traits of underyearlings and general conditions in Osoyoos Lake that may influence sockeye production variations, have been completed in each of 1997 and 1998 (Rankin et al. 1998, Rankin et al. 1999). Sockeye smolts originating from lake rearing in these years are sampled at Rocky Reach Dam (Chuck Peven, Chelan Public Utility Division, pers. comm.). Sampling procedures vary depending on the nature of the sampling task assigned e.g. (i) execution of acoustic and trawl surveys in Osoyoos Lake to estimate distribution, abundance and biological traits of juvenile sockeye rearing there or (ii) sampling at the Rocky Reach Dam (Figure 1) bypass trap to obtain seasonal samples of Okanagan sockeye smolts migrating through the Columbia mainstem.

Detailed descriptions of standard procedures employed to survey sockeye nursery lakes have been fully documented in several published reports (Hyatt et. al. 1984, Hyatt and Stockner 1985, Gjernes et. al. 1986, Rutherford et al. 1986 and Hyatt et. al. 1989). Summary estimates and documentation at source (e.g. acoustics survey trip reports, trawl survey logs) are assembled and archived after each field survey and managed as electronic and paper records that constitute the Juvenile Sockeye Index Datasets (JSIDS) database maintained by Salmon Index Methods Unit personnel (K. Hyatt, P. Rankin) located at DFO's Pacific Biological Station in Nanaimo.

4.0 Results and Discussion

4.1 Adult Abundance Trends

Total returns of Okanagan sockeye have fluctuated greatly during the period of record (1953-1998) from an apparent high of over 200,000 fish in1967 to fewer than 5000 sockeye in each of 1963, 1994, 1995 and 1998 (Figure 3, Appendix Table 1). Precipitous declines in Okanagan sockeye returns in the early to mid 1960's coincided with the construction of five mainstem dams on the Columbia River (Chapman et al. 1995) which created severe passage problems for the fish. Completion of fishways and improvement in their operation facilitated stock recovery to levels that supported commercial and subsistence fisheries during the late 1960's to mid-1970's. However, for the past 26 years (1973-1998) returns of Okanagan sockeye have apparently been too low to support any significant harvest except in the 5 year interval between 1984 and 1988. Exploration of possible causes for alternating episodes of either high or low returns after the completion of the Columbia Dams in 1967 are beyond the scope of the present paper but have been considered in detail by others (i.e. Mullan 1986, Fryer 1995, Chapman et al. 1995).

4.2 Escapement Estimates at Wells Dam

Adult sockeye escapement estimates at Wells Dam reflect a pattern of annual variation that is similar, although not identical to changes in total returns (Figure 3). Variations in the numbers of adult sockeye passing Wells have fluctuated from a high of 113,000 potential spawners in 1967 to lows of fewer than 5000 potential spawners annually from 1961-1963 and again in each of 1994, 1995 and 1998. The 1985 -1998 decline in sockeye escapement following the 1984 peak count at Wells is no steeper than that observed during the 16 year interval following a similar escapement peak at Wells in 1967-68. However, in 3 of the past 5 years Okanagan sockeye escapements have been as low or lower than those estimated to have passed Wells during some of the worst years of returns (1960-65) associated with dam construction and passage difficulties.

Uncertainties regarding comparisons between depressed returns in the 1990's and those in the 1960's are related to the fact that Wells Dam fishway counts were not initiated until its completion in 1967. Prior to this, peak counts from escapement surveys of Okanagan River spawning areas have been expanded by a factor of two (Table 1) to roughly calibrate them to Wells passage equivalents (see results below). Some authors have suggested the expansion factor applied to the pre-Wells escapement estimates (1953-1966) should be closer to five (Mullan 1986, Gangmark and Fulton 1952), in which case the low escapement values from actual counts observed at Wells in recent years would take on even greater significance.

Given the absence of any significant catch, total returns of Okanagan sockeye in three of the past five years are among the lowest during the entire period of record (Figure 3) and have led to expressions of concern by fisheries personnel and resource stakeholders about future prospects for long term persistence of Okanagan sockeye.

4.3 Okanagan River Spawning Ground Escapement Estimates

Summary values from SEDS indicate that fall estimates of spawner abundance follow a similar pattern of annual variation to that observed earlier in the season at Wells Dam (Figure 4). However, fall abundance estimates from SEDS are much lower averaging only 43.08 % of the potential spawners enumerated at the Wells Dam (Table 2). Further, although covariation between SEDS and Wells annual estimates is significant ($p<0.01$, Figure 5a), the relation is highly variable with SEDS estimates spanning a multiyear range from 7.5 % to 107 % of Wells counts in 1979 and 1996 respectively.

Several authors have previously noted the discrepancies that exist between escapement estimates based on Wells Dam counts and those based on visual surveys of adult sockeye on the spawning grounds in the Upper Okanagan River (Gangmark and Fulton 1952, Allen and Meekin 1980, Chapman et al. 1995 and Peters et al. 1998). These differences have been variably attributed to: (i) inflated counts at Wells dam, especially in years of large volumes of spill during adult sockeye passage, causing an increase in the fallback rate and double enumeration of a proportion of adult migrants (Swan et al. 1994), (ii) inefficiencies of the spawning ground surveys due to the inability to make accurate counts given variable survey techniques, effort level and climatic limits on visual counting efficiency (Allen and Meekin 1980) and (iii) pre-spawning mortality, which may be a significant factor in the Okanagan Basin.

Chapman et al. (1995) summarized a considerable body of information regarding the magnitude and frequency of prespawning mortality of Okanagan sockeye. This author concluded that prespawning losses from all sources are likely to exceed 25 % in most years and much higher levels in some years when Okanagan River and Osoyoos Lake temperatures are high (> 21 degrees Celsius). Given the certainty and variable magnitude of prespawning mortality events, SEDS estimates have generally been considered to more closely represent annual variations in the number of sockeye that successfully survive to spawn in the Okanagan River each year (B. Rosenberger, CDFO Kamloops, pers. comm. March, 1999).

Application of unqualified SEDS estimates in analyses that require multiyear observations of relatively constant precision is of questionable utility. Consequently, we assembled and reviewed survey documentation from data suppliers to provide insights into the likely influence of variations in assessment methods, results and documentation on the utility of annual escapement estimates derived from spawning ground surveys.

4.4 Origins of Okanagan Sockeye SEDS Estimates

4.4.1 General Survey Procedures

Allen and Meekin (1980) note that extensive surveys of sockeye spawning in the Okanagan River were conducted between 1947 and 1974 by personnel of the U. S. Fish and Wildlife Service (1947-1964) or the Washington Department of Fisheries (1964-1974). Documents on file in the Kamloops Office of Canada's Department of Fisheries

and Oceans indicate that CDFO personnel also conducted surveys in many of these same years and were the only source of most survey observations after 1974. Although the agencies and personnel conducting spawning ground surveys have changed over time, examination of CDFO-Stream Inspection Log forms, CDFO-BC16 entries and reports from a variety of sources indicate that throughout the period of record survey procedures were remarkably consistent involving: (i) visual counts of sockeye by rafting the upper river (McIntyre to VDS13), (ii) annual coverage of the upper river "index section" (McIntyre to VDS13) where the majority of sockeye spawn and (iii) visual counting on foot from streamside access points in the lower sections of the river whenever these were surveyed.

Raw counts of both living and dead sockeye were initially recorded by stream section for each seasonal survey. Start and stop points for stream sections were consistently defined by the location of 13 vertical drop structures (locations 1-13 in Figure 2) installed as permanent hydraulic control devices in 1954. Raw count data were summed among sections by survey date and the annual escapement estimate was then derived from "peak counts" selected from seasonal totals available from one to several survey dates per year.

4.4.2 Survey Effort and Timing

Examination of field notes from approximately 20 years of stream inspection logs (SIL's) generated by personnel from either CDFO or the U. S. Fish and Wildlife Service and summarized here (Tables 3 and 4), indicates that one to several seasonal surveys were executed each year to determine sockeye abundance on the spawning grounds. Peak abundance levels could be readily distinguished in years of multiple surveys (9 of 20 years) but in more than half of the years we examined, observations from single survey dates served as the only source of spawning ground numbers and were likely treated as the equivalents of peak counts from multiple survey years. The magnitude of bias in annual spawner abundance estimates based on single seasonal surveys that do not coincide with peak seasonal abundance may be approximated through reference to spawner abundance distributions from years of multiple surveys (Figure 6). These indicate that if single visual surveys had been completed during 1971-1974 and had missed the peak of spawner abundance by one week the resultant low bias would have ranged from as little as 3 % to as much as 65 % (mean 43 %).

Failure to time surveys to coincide with peak abundance of spawners in the Okanagan River has the potential to contribute considerably to the low bias of spawning ground versus Wells Dam escapement estimates noted above. This problem may have been especially severe due to reductions in fisheries patrol staff in 1986 after which Okanagan stream inspections consist of single-trip, surveys in 10 of 11 years (Table 3). Historic knowledge of the temporal distribution of peak spawning activity and year specific communication with local informants are employed by CDFO field staff in attempts to minimize this source of bias (B. Rosenberger pers. comm.). However, examination of additional information suggests these efforts have not always been successful.

Previous work (summarized in Chapman et al. 1995) suggests that on average, peak spawning activity takes place in mid-October. However, the range of peak spawning time spans an interval from the end of Sept. to as late as Oct. 23rd. (Figure 7), depending on annual variations in local climate (e.g. water temp., river flow etc...). Examination of CDFO survey dates (from Table 3) relative to this general timing information suggests that either surveys have been consistently biased to occur after the peak of spawning has passed or that the timing of peak spawning activity for Okanagan sockeye has shifted to a later date in the most recent decade (Figure 7). A clue to which of these alternatives is most likely may be extracted from information on the relative abundance of carcasses versus live fish for a given survey (Tables 3 and 4).

In years where the survey date of peak spawner abundance may be identified with certainty, carcass counts always represent less than 5 % of the total count for that date (Table 4). By contrast, sockeye carcasses constitute between 9.2 and 27.7 % of live plus dead survey counts that occur approximately one week after the occurrence of peak abundance (Table 4). Applying the criterion that surveys in which more than 10 % of the counts are composed of carcasses may be classified as being a week or more late, suggests that CDFO surveys occurred after the peak date of sockeye abundance in each of 1991, 1992 and 1997. If this were true, we might expect that surveys from these years would exhibit a greater degree of low bias relative to Wells Dam counts than surveys from years in which carcasses were present but as less than 3 % of the total suggesting the count was closer to the date of peak abundance. Although carcass counts were not recorded in all cases (Table 3), the available evidence suggests that survey years in which carcasses made up more than 10 % of the total do produce annual abundance estimates exhibiting a greater degree of bias relative to Wells counts than years when escapement estimates were based on single surveys in which carcasses made up less than 3 % of the total (Table 5). Thus, in 3 of 9 years in which carcass counts were available, surveys appear to have occurred after the peak of sockeye abundance which is approximately the proportion one would expect (as per Figure 7) given that most, recent year CDFO surveys were routinely scheduled to occur after Oct. 17th.

4.4.3 Survey Effort and Spatial Coverage

Observations assembled from 10 years of CDFO, stream inspection logs (Table 6) indicate that spawner enumeration surveys typically provided coverage of all sections of the river between McIntyre Dam and Osoyoos Lake (Figure 8). However, it is also clear that this was not invariably the case and that during some undetermined portion of years making up the period of record between 1953-1998, surveys covered only an "index section" of river between McIntyre Dam and VDS13. Observations of spawner distribution from years involving coverage of all sections of the river indicate that on average more than 90 % (range 63-98 %) of spawning sockeye were observed in the 2.4 km unchannelized "index" portion of the Okanagan River (Table 6). By contrast, only 9.3 % (range 0-27 %) of adult sockeye observed appeared to utilize the channelized portions of the river extending from VDS13 downstream to Osoyoos Lake (Figure 8). Thus, although survey effort may have varied with respect to spatial coverage in some years, it appears that the bias introduced into annual estimates by variable spatial

coverage would have been small as long as counts in the index area between McIntyre and VDS13 were completed.

The level of certainty associated with the use of index section counts (either alone or combined with other counts) as a reliable annual abundance indicator has been called into question on the basis of 1997 assessments of sockeye spawner distribution based on two independent survey approaches. The first approach involved CDFO personnel who completed a routine survey for sockeye abundance by raft and streamside reconnaissance on Oct. 22, 1997. The second approach involved careful tracking by LGL Ltd. to determine the furthest point of upstream penetration of 219 sockeye that had been radio-tagged at either Bonneville or Wells Dam and which had subsequently entered the Lower Okanagan River (Alexander et al. 1998). Alexander et al. reasoned that the terminal distribution of radiotagged sockeye should approximate the distribution of spawning sites used by them. Comparison of results from these sources (Table 7) indicates that patterns of spawning site distribution differ depending on survey approach. Specifically, the radiotagging study results indicate much greater use (51 % of adult sockeye) of spawning habitat downstream of the upper river index section than suggested by CDFO visual counts (5 % of adult sockeye, DFO-SIL versus Rtags pooled results in Table 7).

Differences in sockeye distributions revealed by visual versus radiotag results suggest that the abundance of spawning sockeye was grossly underestimated by visual surveys in 1997 and possibly in other years. However, interpretation of these results is complicated by several factors including the potential influence of: (i) radiotag implantation on sockeye behaviour, (ii) climate events on sockeye distribution and (iii) climate conditions on visual survey efficiency. First, because very few sockeye containing radiotags were observed directly in the river during spawning it is not certain whether all or even most of these fish actually spawned in 1997. Second, 1997 was the coolest and wettest summer and fall experienced in the past 25 years with the result that high discharge levels occurred frequently in the Okanagan River during the spring and fall such that layers of silt that normally cover gravel in downstream sections of the river were scoured clear (B. Rosenberger pers. comm.) and may have attracted a larger proportion of spawners than would normally occupy these areas. Finally, higher than average discharge levels in the river during the visual count survey may have reduced counting efficiency greatly and especially in the areas of turbulent water immediately blow vertical drop structures favoured as holding locations by sockeye.

Further investigation is required to clarify the significance of these results. However, if radiotagging results obtained during 1997 do turn out to be representative of the true distribution of spawning areas, then low visual detection efficiencies on adult sockeye in river segments from VDS13 to Osoyoos Lake (rather than prespawning mortality) could account for a large proportion of the low bias in visual enumerations of sockeye on the spawning grounds relative to earlier season counts at the Wells Dam (Figure 4). This is not to say that annual counts of spawners in the index section from McIntyre Dam to VDS13 should be rejected as an indicator of sockeye abundance on the spawning grounds. Both radiotagging results and multiyear visual surveys confirm that the majority of sockeye prefer to spawn in the river section from McIntyre Dam to VDS13. Visual estimates of spawners in this section would be ineffective as an annual index of spawner

abundance only if the proportion of the total run using this segment changed dramatically from year to year relative to lower river segments. This does not appear likely as visual enumerations indicate the proportion of spawners utilizing the index section (McIntyre to VDS13) versus other river segments (VDS13 to Osoyoos Lake) remains reasonably constant (Table 6) despite multiyear changes in peak abundance from fewer than 2000 sockeye to more than 34000 sockeye. Although it is conceivable that as many as 3000 spawners might be overlooked in lower river sections in high water years such as 1997, it is inconceivable that this would be the case in years of better viewing conditions when lower river sections would have to contain 20000 to 35000 sockeye (1984, 1985, 1988, Table 6; 1971 as per Allen & Meekin, 1980) to account for 50 % of the annual total.

4.4.4 Analysis and Reporting of Survey Results to SEDS

Summary estimates of annual escapement by salmon species, by stream and by run are archived in CDFO's regional SEDS database. Raw survey observations extracted from field diaries and SIL's are summarized on "BC16" forms (or their equivalent) and forwarded to CDFO Stock Assessment Data Systems personnel for verification and entry. Because verification activities have not routinely extended to confirmation of annual survey methods or analytical approaches used to convert raw observations into annual summary estimates of spawner abundance, it is advisable to check SEDS estimates against source data before attempting to apply them to resolve questions about habitat capacity or biological production trends as a basis for setting annual escapement objectives.

Comparison of SEDS summary estimates with records of peak counts of spawning sockeye from SIL's (Table 2) indicates the two are closely associated (Figure 9) but by no means identical. In general, SEDS entries involve inflation of peak SIL counts by an average factor of 1.65 (range 0.42 - 7.14). Although the basis for each year's expansion is not well documented, raw numbers are commonly inflated as attempts to account for survey years when either the peak period of abundance was missed, spawning habitat coverage was incomplete or visibility on the grounds was poor (B. Rosenberger, pers. comm.). In addition, some SEDS entries which are lower than peak field counts (Figure 9), are simply wrong (e.g. 1969 and 1970 SEDS estimates, Table 2.) due to either entries from incomplete survey information or transcription errors. Expansions of raw observations from SIL's of Okanagan sockeye are not restricted to only SEDS summaries. In their systematic review of data sources for Mid-Columbia sockeye populations Chapman et al. (1995) summarized what they referred to as peak spawning ground counts of sockeye for the interval 1945-1993 (their Table 2). However, comparison of their peak counts against original survey counts suggests that even their peak counts represent a mixture of unexpanded and expanded estimates (Table 8).

Given the results presented above, it is likely that annual counts of sockeye escapement past Wells Dam maintain a higher level of both accuracy and precision than annual estimates obtained through visual surveys on the spawning grounds. However, it is impossible to discount the view that, in spite of many sources of uncertainty, spawning ground counts may still serve as a useful index of annual variations in the number of sockeye that actually survive to deposit their eggs in the Upper Okanagan River.

Consequently, analyses to determine associations between spawner abundance and either spawning ground habitat utilization or production at subsequent life history stages should consider both Wells and Okanagan River escapement estimates. We suggest the value of the latter could be improved considerably through systematic assembly and analysis of raw counts from SIL's to provide a more reliable set of multiyear escapement estimates than currently contained in SEDS but have not been allotted the time to complete this task here.

4.5 Associations Between Annual Variations in Adult and Juvenile Sockeye Life History Stages

Annual changes in brood year abundance of adult sockeye spawners are positively associated with annual changes in relative abundance of Okanagan sockeye smolts monitored at the McNary Dam bypass (Figure 10). Brood year abundance at Wells provides a statistically superior prediction of smolt abundance at McNary ($r^2 = 0.45$, $p < .05$) by comparison to SEDS estimates ($r^2 = 0.24$, $p > .05$) although both data sets show the same trend. Thus, there is no evidence of any decline in smolt production per spawner across an escapement range from 2000 to approximately 80,000 spawners at Wells or from less than 1000 to approximately 38,000 spawners on the grounds in the Okanagan River (Table 9).

We were able to find only 12 years of samples taken at scattered intervals between 1957 and 1991 to characterize sockeye smolt size-at-age (Table 10). However, these observations do suggest that growth and size achieved by juvenile sockeye rearing in Osoyoos Lake are density dependent such that sizes attained at low fry abundance (as indexed by brood year escapements) are significantly larger than sizes attained at high abundance. In this case as well, indices of brood year escapement in the Okanagan River and at Wells Dam provide evidence of similar trends (Figure 11), but only the relationship between smolt size and brood year adult abundance at Wells Dam achieves statistical significance ($r^2 = 0.496$, $p < .01$).

The average size of sockeye smolts produced in Osoyoos Lake is consistently among the largest observed for the species throughout its geographic range (Mullan 1984, Chapman et al. 1995, Fryer 1995). This has been interpreted as evidence that Osoyoos Lake is one of the most productive sockeye nursery lakes in North America. However, virtually all previous comparisons of Osoyoos Lake smolt size relative to smolts from other populations have failed to take into account the potentially confounding influence of between-population, density differences on size-at-age. We wished to compare Osoyoos lake smolt size and abundance observations in a less biased way with the size-at-age of juvenile sockeye from other populations. Consequently, we have attempted to calibrate abundance measures of Osoyoos brood year escapement to fall fry abundance estimates measured in acoustic and trawl survey (ATS) units commonly employed by us for surveys of juvenile sockeye abundance in British Columbia lakes (Hyatt et al. 1984, Hyatt and Stockner 1985).

Acoustic and trawl surveys of juvenile sockeye (and kokanee) abundance in Osoyoos Lake have been completed on eight occasions in four separate calendar years (Table 11). The number of juveniles produced in ATS units per spawner varies greatly between 13 and 152. Given the limited number of years of observations, we have used the mean of all observations at 70 fry per spawner to provide a first approximation for an Osoyoos Lake smolt size to sockeye fry abundance relationship (Figure 12a). At this point in our survey work, there is still some uncertainty about what proportion of the juvenile "nerkids" in Osoyoos Lake are sockeye as opposed to kokanee underyearlings. However, our implicit assumption that the kokanee component is small is supported by observations that: (i) kokanee spawners for the years in question were not abundant enough to be explicitly included in annual spawning ground counts, (ii) a 7 fold decline in brood year sockeye escapements between 1997 and 1998 was accompanied by a 10 fold decline in total abundance of juvenile "nerkids" estimated via ATS work (Hyatt et al. unpublished survey observations) suggesting that the juvenile "nerkid" population is likely composed almost entirely of sockeye and (iii) significant associations exhibited among sockeye smolts indexed after departure from Osoyoos Lake, smolt size achieved through rearing in Osoyoos Lake and spawner abundance would all likely be undetectable given a large or variable contribution of juvenile kokanee to lacustrine nerkid populations. In addition, four years of mark and recapture estimates of Okanagan sockeye smolt abundance passing Priest Rapids Dam between 1984 and 1988 provide a second independent set of observations which suggest a mean value of 101 smolts per spawner (Table 12). The latter observations suggest that if there is a bias in our conversion from brood year escapement to ATS units of abundance in Osoyoos Lake it will likely lean towards underestimating sockeye fry abundance (and the productivity of Osoyoos Lake relative to other nursery lakes).

The smolt size to fall fry abundance relationship for the Sproat Lake sockeye population located on Vancouver Island is also presented for comparative purposes. These observations indicate that at equivalent rearing densities in both Sproat and Osoyoos lakes, juvenile sockeye rearing in Osoyoos Lake attain an average of more than twice the weight of Sproat sockeye by the end of a single year of lake residence (Figure 12a). This feat is even more remarkable in light of results from our ATS work on Osoyoos Lake during 1997 and 1998 which indicates that seasonal temperature and oxygen conditions in two of three basins of Osoyoos Lake preclude rearing there by juvenile sockeye for the majority of the growing season between June and November (Rankin et al. 1998, Rankin et al. 1999). Accordingly, we have also provided a version of the fry abundance and smolt size relationship to reflect the observation that virtually all Osoyoos Lake sockeye production is dependent on rearing habitat in the North Basin of the lake (Figure 12 b). The product of sockeye abundance and mean weight observations provides a simple, meaningful index of the relative capacities of Osoyoos and Sproat lakes (Tables 10 and 13) to support sockeye smolt production within the context of annual variations in fry recruitment. Average smolt production from Osoyoos Lake amounts to 14.5 kg per ha (range 10.2-21.1 , Table 10) versus 7.59 kg per ha (range 4.8-13.4, Table 13) at Sproat Lake.

4.6 Okanagan Sockeye Escapement Objectives

Significant numbers of Okanagan adult sockeye return after 1 or 2 years at sea (Chapman et al. 1995). Catches and escapements are known to exhibit very different age compositions but are not routinely sampled for age-at-return thus precluding credible assessment of production variations associated with specific brood years. Given the absence of brood year specific adult recruitment information, it has not been possible to complete a reliable stock-recruit analysis for Okanagan sockeye to define a potential escapement optimum to date. However, observations assembled in this paper may be employed to define escapement objectives for Okanagan sockeye in terms of either: (i) spawning habitat use by adults or (ii) associations between spawner abundance and juvenile sockeye recruitment as an alternative to more traditional analyses focused on recruitment of adults.

4.6.1 Spawning Habitat Capacity and Escapement Objectives

The Fisheries Service of Canada's Department of the Environment in collaboration with the Washington Department of Fisheries completed a detailed study and analysis of both the quantity and quality of gravel available for sockeye spawning in the unchannelized, index section of the Okanagan River immediately below Vaseaux Dam (Anonymous 1973). Surveys, including 26 channel cross sections and water surface profiles, were carried out at discharges of 540 cfs, 380 cfs and 210 cfs. At discharges of 540 cfs and 380 cfs areas of spawning gravel falling within the water depth and velocity parameters of 8-18 inches and 0.8 to 2.5 feet per second, and consisting of 1.5-4 inch diameter gravel,
were calculated. "Good" spawning gravel was designated as satisfying all three of the above parameters while "medium" spawning gravel satisfied only two. Interpolations from field data were also used to predict the area of spawning gravel available at discharges of 250 cfs, 125 cfs and 90 cfs in order to create spawning area versus discharge relationships restricted to either high quality (i.e. "good") areas alone or including both high and medium quality areas (Figure 13).

Calculations of habitat capacity for adult sockeye (Anonymous 1973, Appendix 2) suggested that high quality spawning areas could support approximately 38,900 spawners at discharges of 380 cfs. An extremely conservative approach was taken in the formulation of these calculations as they assumed that: (i) no spawning would take place in medium quality areas of gravel once high quality areas were fully occupied, (ii) each female sockeye would require 4.18 square meters (i.e. 5 sq. yd) of gravel. Amazingly, choice of the latter value was based on a wholly circular argument that use of a lower value would have produced spawning ground capacity estimates that were "in excess of recorded escapements" even given the artificial restriction of spawners to only high quality areas. Allen and Meekin (1980) suggested on the basis of their field observations that the index spawning area in the Upper Okanagan River was 80 % saturated given a peak abundance of 14,968 females in 1971. Following calculations in Anonymous (1973) that 108, 860 square meters of good spawning gravel are available at river flows

of 325 cfs, this equates to an estimated requirement of 7.14 square meters of gravel for each female spawner (Table 14).

Several recent studies relate actual measures of fry output to spawning gravel requirements for female sockeye in various locations (Table 15). Results from these studies indicate, without exception, that previous calculations of Okanagan spawning ground capacity are biased low. Consequently, we have calculated new estimates based on: (i) the minimum as well as the mean number of females recent studies suggest a square meter of gravel will accommodate (i.e. 0.56 females.m^{-2} and 1.48 females.m^{-2}) plus (ii) continued adherence to the conservative assumption that spawning will only take place in the 108,860 m^2 of high quality habitat present in the Upper Okanagan "index section" at a river flow of 325 cfs (Anonymous 1973). These new estimates (Table 16) suggest that the Okanagan index area alone will have a minimum capacity to accommodate 67000 spawners (as SEDS units) and a mean capacity for approximately 179,000 spawners. These estimates are far in excess of observed escapements in all but a few years (Figure 14). Consequently, we suggest that the lower value of 67,000 spawners in SEDS units be set as the minimum escapement level required to "challenge" available spawning habitat in the Okanagan River (i.e. 135, 471 spawners if estimates were made as escapement past Wells Dam, Table 16, reference line a. in Figure 14).

4.6.2 Lake Rearing Capacity and Escapement Objectives

Both Mullan (1984) and Chapman et al. (1995) review a wealth of information to suggest that Osoyoos Lake is one of the most productive lakes occupied by juvenile sockeye throughout their geographic range. Rather than repeat their arguments here, we have attempted to place annual sockeye production from Osoyoos Lake into a broader context based on a known relationship between total phosphorus concentration and fish biomass maintained in a diverse suite of north temperate zone lakes. A large body of research supports the general view that phosphorus is an essential nutrient that commonly limits gross production in lakes from lower trophic levels on up through top consumers such as fish (Figure 15). More than two decades of research (Stockner and McIsaac 1996) also confirms that production levels of both primary producers and consumers such as sockeye are extremely low in the ultraoligotrophic sockeye nursery lakes of British Columbia. Production across trophic levels in these lakes is frequently controlled by the availability of limiting nutrients such as phosphorus, or less commonly, nitrogen (Stockner and Hyatt 1984, Hyatt and Stockner 1985, Johannes and Hyatt 1999).

Comparison of nutrient concentrations maintained throughout the growing season in Sproat and Great Central lakes (where the latter has received annual additions of inorganic fertilizers to stimulate nutrient limited production) with annual sockeye production estimates confirms the expectation that maintenance of extremely low seasonal mean nutrient levels is associated with levels of mean annual fish production that are among the lowest known for any set of north temperate zone lakes (Figure 15). By contrast, the North Basin of Osoyoos Lake maintains average seasonal phosphorus concentrations of 22 ug per liter (Mullan 1986, Pratt et al. 1991) which are an order of magnitude higher than the levels observed in Sproat or Great Central lakes (Hyatt and Stockner 1985, Johannes and Hyatt 1999). Thus, although not surprising, it is

encouraging that average annual production levels estimated here for sockeye rearing in the North Basin of Osoyoos Lake (Table 10) correspond reasonably well with the level anticipated by the larger phosphorus to fish production datasets (Figure 15).

There have been several previous attempts to determine quantitative limits on the productive capacity of Osoyoos Lake to support juvenile sockeye and then to convert this into estimates of adult escapement levels required to match these limits. Pinsent et al. (1974), used plankton abundance to estimate that the lake could carry the progeny of 107,479 sockeye females. Pratt et al (1991) used the volume of the euphotic zone (Koenings and Burkett 1978) to determine that the lake could support 4 million sockeye smolts. Both of these approaches are based on an assumption that the entire volume of the lake is available as accessible habitat throughout the growing season. Extremes of high epilimnial temperature (>20 degrees Celsius) and low hypolimnial oxygen (<5 ug per liter) restrict Osoyoos sockeye to mid depths of the North basin of the lake for most of the growing season (Rankin et al. 1999). Consequently the approaches used by both Pinsent et al. (1974) and Pratt et al. (1991) are considered unreliable (Bull 1999).

Estimates of the capacity of Osoyoos Lake to support annual production of juvenile sockeye, as developed in the current paper, implicitly account for seasonal fluctuations in the environmental variables noted above. Thus, use of these values should provide a more reliable means of estimating adult escapement levels that will provide sufficient fry recruitment to fully utilize the average productive capacity of Osoyoos Lake. However, conversions from average yearly, levels of juvenile sockeye production (expressed as kg per ha) to adult escapement requirements involve one additional complication. This is related to the observation that the size of yearling smolts produced in Osoyoos Lake varies non-lineally with increases in fry rearing density (Figures 11 and 12). Consequently, relatively small changes in assumptions about what constitutes a desirable smolt size have major effects on determinations of desirable levels of both fry recruitment and adult escapement to be maintained in Osoyoos Lake.

The current average size of age 1.0 sockeye smolts exiting Osoyoos Lake is in excess of 100 mm (9.5 g). If 100 mm is chosen as the minimum size of smolt required to ensure "adequate" survival during the rigors of riverine migration, then escapement requirements may be specified from Figure 6b as Ln Escapement at Wells = (321.81 - 100)/20.20 which yields an escapement requirement of 58,730 sockeye at Wells (reference line c in Figure 14) or approximately 29,365 as peak count units in the Upper Okanagan index area. Limiting Okanagan sockeye escapement levels to maintain production of 100 mm smolts from Osoyoos Lake represents a highly conservative position. Yearling sockeye smolts produced in Wenatchee Lake average only 86 mm (6.2 g) in length. Further, observations reported in Fryer (1995) indicate no significant difference exists between Wenatchee and Okanagan sockeye smolt-to-adult survival rates. If the "threshold" size for Osoyoos Lake sockeye smolts is reduced to 86 mm, similar to those in Wenatchee Lake, then Okanagan sockeye escapement requirements increase to 117,453 spawners passing the Wells Dam (reference level b in Figure 14) or 58,727 sockeye as peak counts in the Upper Okanagan River.

Estimates of habitat based escapement objectives identified above provide a range of defensible values from as few as 58, 730 to as many as 135,471 spawners passing Wells Dam. Each of these values involves different assumptions about relationships between habitat capacity and subsequent levels of stock production that may be achieved. Further refinements to these objectives will be possible as additional information is gathered on associations between changes in terminal escapement, lacustrine fry recruitment and smolt size. However, the more pertinent observations at present may be that: (i) annual escapement levels have rarely exceeded even the most conservative escapement reference level of 58,730 identified here (reference level c in Figure 14.) and (ii) current escapement levels have trended downwards to alarmingly low levels in three of the past five years in the absence of any significant exploitation pressures on returning adults. A more in-depth examination of the causes for this recent decline would appear advisable.

5.0 Summary and Conclusions

Summary estimates of annual escapement have been assembled by various agencies to provide indications of annual abundance changes of Okanagan sockeye salmon over more than a 40 year period of record. Although the Regional Salmon Escapement Data System (SEDS) contains one version of these summary estimates, it is apparent from inspection of various years of source documentation on which SEDS estimates are based, that assessment methods and effort levels have changed at various times such that summary estimates in SEDS may be alternately biased high or low by varying degrees throughout the period of record.

Analysis presented above suggests that alternate estimates of sockeye enumerated passing the Wells Dam provide a more reliable index of annual changes in escapement of Okanagan sockeye than the current summary estimates in SEDS and should be considered for inclusion there.

Summary estimates of escapement currently contained in SEDS are largely devoid of accompanying commentaries concerning changes in assessment methods or effort levels applied annually to generate estimates. Resolution of the utility of historic estimates is more difficult than need be given the absence from SEDS electronic files of qualifying comments that correspond to CDFO-BC16 and Stream Inspection Log comment entries. Completion of information capture and transfer to the regional database (SEDS) from both summary forms (i.e. paper copies of the "B.C. 16's") and source records (e.g. "stream log" information periodically recorded in association with individual inspections) should be encouraged to improve the general utility of all entries, for stock assessment as well as other purposes.

We recommend the implementation of systematic retrieval and review of SEDS source documentation for key stocks that are likely to become a focus for future PSARC work. Specific information missing from SEDS that should be incorporated from paper copies of the "B.C.16's" or other source records wherever possible includes: (i) dates on which surveys for a given species were completed, (ii) the survey method in use, (iii) supplemental observations to confirm the temporal position of a survey relative to peak time of spawning, (iv) records of raw counts on which summary estimates are based, (v)

degree of completeness of spawning area spatial coverage provided by each survey, (vi) changes between surveys in methods or procedures for obtaining raw counts or for estimating total escapement.

Development and application of standard techniques combined with documentation of procedures and observations-at-source to estimate juvenile abundance trends for Okanagan sockeye rearing in Osoyoos Lake (Rankin et al. 1998, 1999) have produced information of considerable utility to habitat based approaches to defining Okanagan sockeye escapement objectives by verifying that:

(i) growth and annual production variations for juvenile sockeye in Osoyoos Lake are density dependent,

(ii) most juvenile sockeye production is restricted to the North Basin of Osoyoos Lake,

(iii) unutilized potential to support production of additional sockeye exists in Osoyoos Lake given current fry recruitment and adult escapement levels,

(iv) defensible escapement objective may be provided on the basis of the relation between adult stock and size dependent recruitment variations of smolts.

We also recommend that the biological consequences of smolt size management for Osoyoos Lake sockeye be explored as a requisite to refining escapement objectives that might be adopted if Okanagan sockeye stock rebuilding is successful in future years. Generation of data sets to facilitate this will require more systematic retrieval of annual biosamples of smolts rather than the sporadic sampling that has apparently produced only 12 estimates of smolt size during the past 40 years.

Continued efforts to improve the documentation and reliability of escapement assessment methods applied to spawners in the Okanagan River is encouraged to resolve the issue of the extent to which differences in spawning ground versus Wells Dam estimates of sockeye are due to methodological or biological factors (e.g. prespawning mortality).

Examination of classical stock and adult recruit relationships was not possible for Okanagan sockeye stocks due to the general absence of annual estimates of the age composition of adult sockeye in food fishery catches and especially in escapement. The inability to assign stock specific returns to brood year of origin also precludes routine determination of annual smolt-to-adult survival rates for Okanagan sockeye. Because the latter information will be essential to the long term management of the stocks and lakes to determine combinations of smolt numbers and size that will optimize production, we recommend that annual sampling for age, size and sex composition of sockeye in catch and escapement be completed wherever feasible.

Our attempts to use habitat based approaches to objectively define escapement goals for Okanagan sockeye have, in our view, been reasonably successful in identifying a defensible set of minimum escapement objectives. Specifically, 58,780 sockeye

enumerated at the Wells Dam or 29,390 as peak counts in the Upper Okanagan River escapement "index area" should be regarded as defensible, provisional escapement objectives. We have adopted conservative assumptions at each of several steps in our habitat based analysis of escapement needs. Thus, it is likely that existing spawning and rearing habitat in the Okanagan River and Osoyoos Lake will actually support a higher escapement objective than that specified here. However, it is also clear that all of the evidence examined by us supports the inference that neither spawning ground nor lake rearing capacity currently limits Okanagan sockeye population size. Accordingly, adoption of a provisional escapement goal of 59,000 Okanagan Sockeye passing the Wells Dam should suffice until such time as the stock rebuilds to levels that might actually challenge available habitat and warrant further refinement of escapement objectives.

6.0 Summary Recommendations

We recommend:

(1) Provisional escapement objectives for Okanagan sockeye be set at 58,730 adults (in Wells Dam units) or 29,365 adults as peak visual counts on the spawning grounds.

(2) Biological consequences of smolt size management of Osoyoos Lake sockeye be explored as a requisite to refining escapement objectives that might be adopted if Okanagan sockeye stock rebuilding is successful in future years.

(3) Annual sampling for size and age composition of Okanagan sockeye smolts be completed whenever feasible to facilitate future analysis of smolt to adult survival trends and smolt size management options in Osoyoos Lake.

(4) Annual sampling for age, size and sex composition of sockeye in catch and escapement be completed whenever feasible to facilitate future analysis of stock and recruit relations and to follow smolt to adult survival trends.

(5) Implementation of systematic retrieval and review of source documentation pertaining to SEDS estimates of Okanagan sockeye escapement as well as support for ongoing efforts to complete entry of supplemental comments describing methods used to generate both raw and summary escapement estimates.

(6) Annual summary estimates of Okanagan sockeye escapement from Wells Dam counts be incorporated into SEDS as a formal alternative to spawning ground counts.

(7) Given that neither spawning gravel capacity or lake rearing capacity appear to set the principal limits on Okanagan sockeye population size at current stock levels, additional effort should be expended by the Okanagan Basin Fisheries Working Group to determine the basis for recent stock declines in the absence of any targeted exploitation of Okanagan sockeye.

7.0 References

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Figures

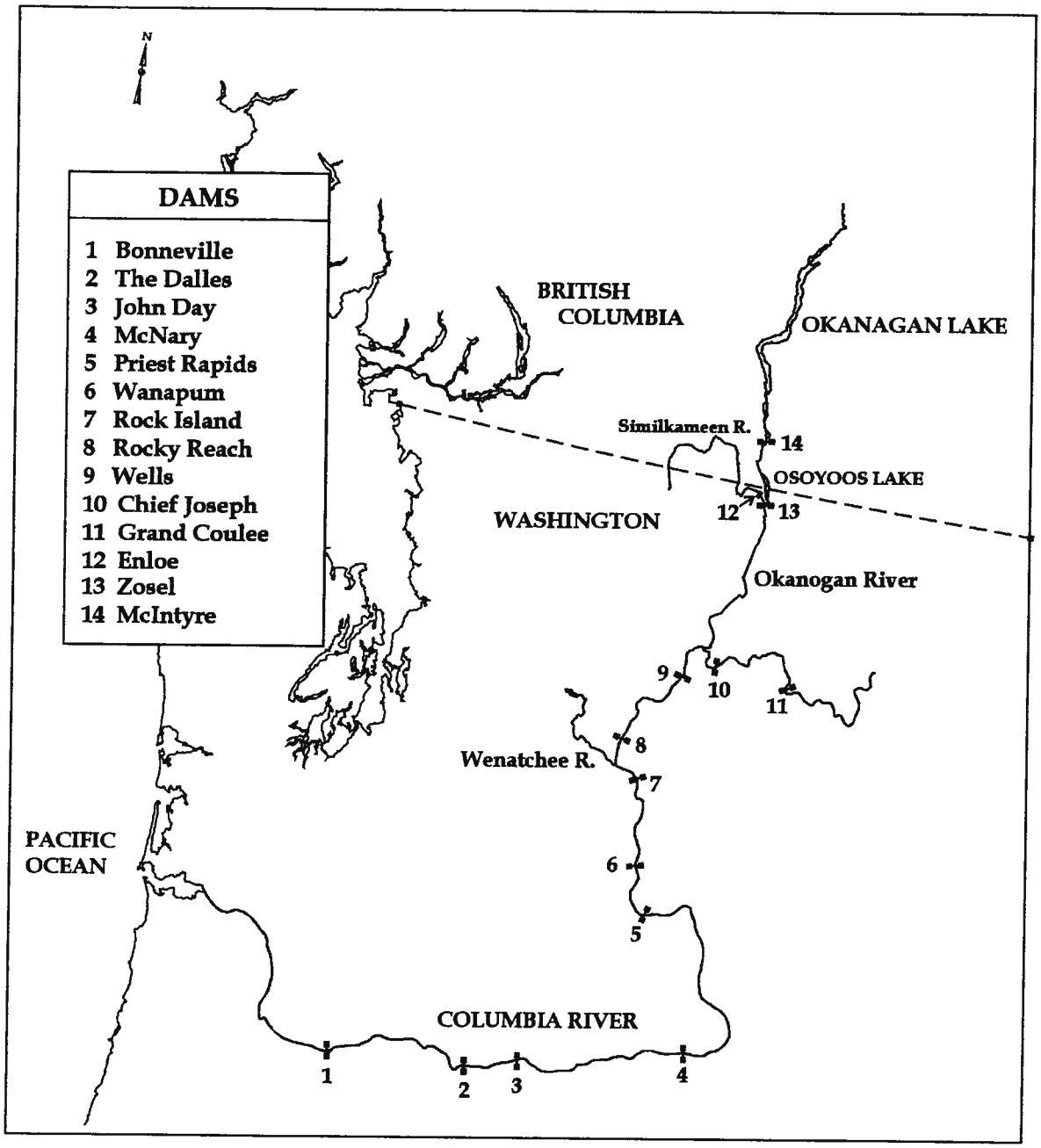

Figure 1. Location of Okanagan River and Osoyoos Lake study areas relative to the Columbia River sockeye migration corridor

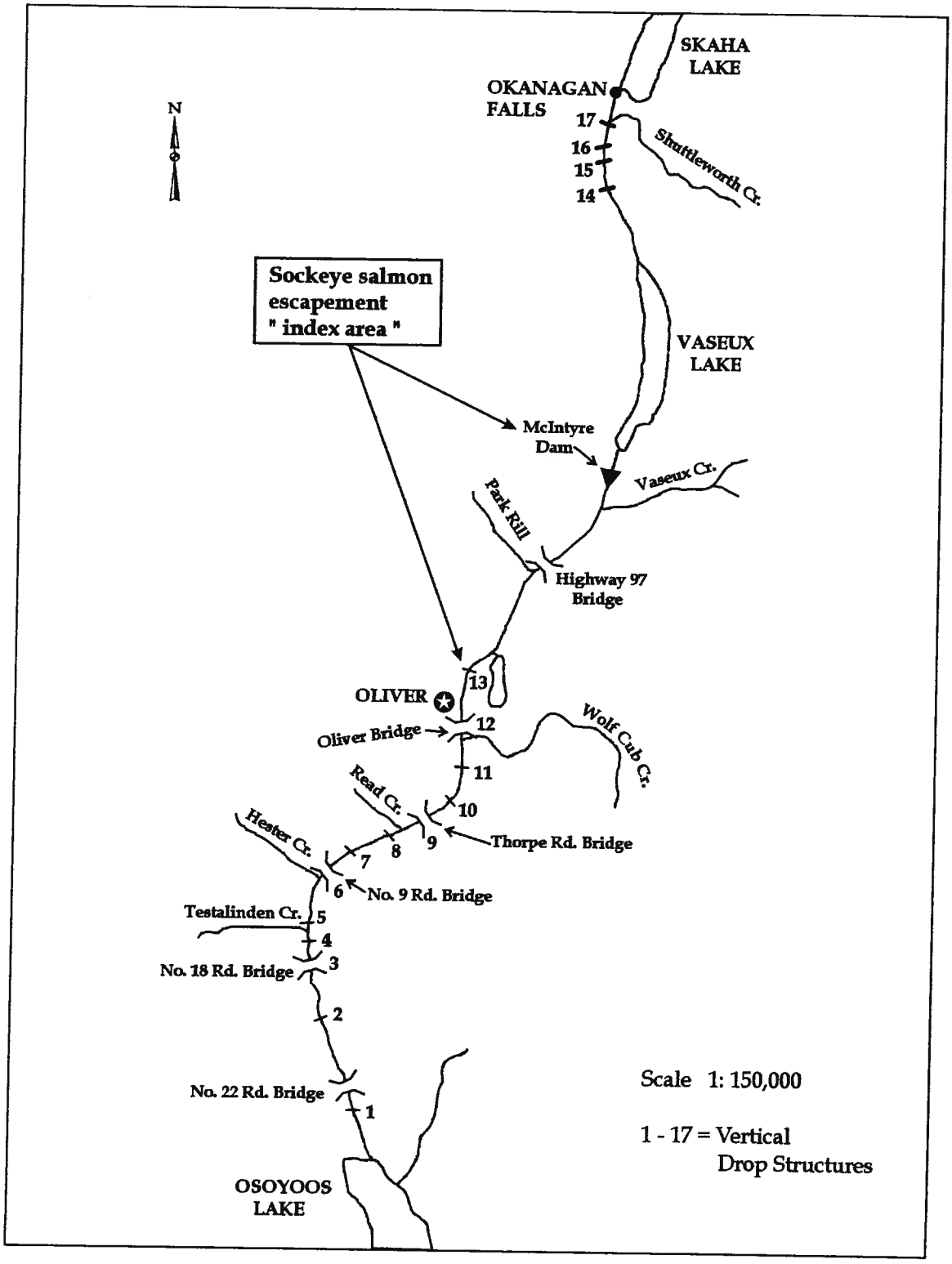

Figure 2. Upper Okanagan River from Skaha Lake to Osoyoos Lake

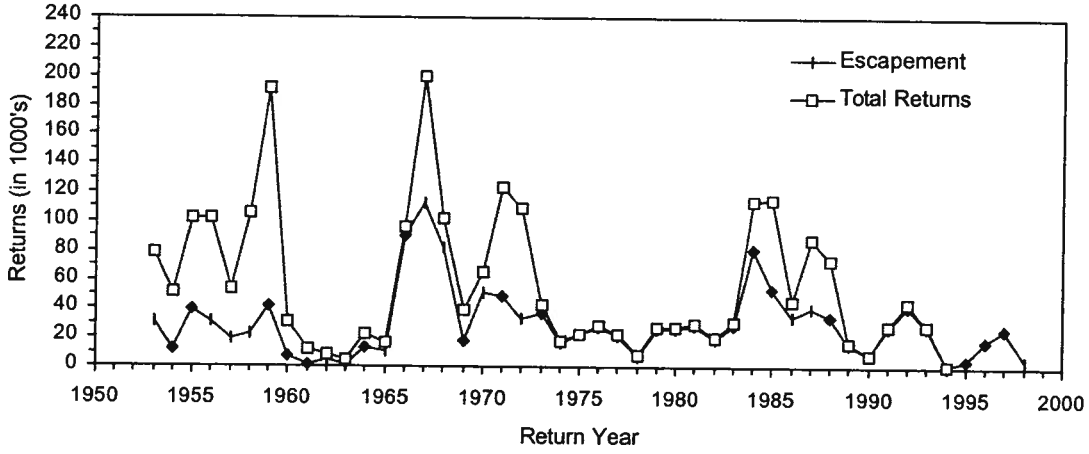

Figure 3. Total Returns and Escapement of Okanagan River Sockeye Salmon from 1953-1998

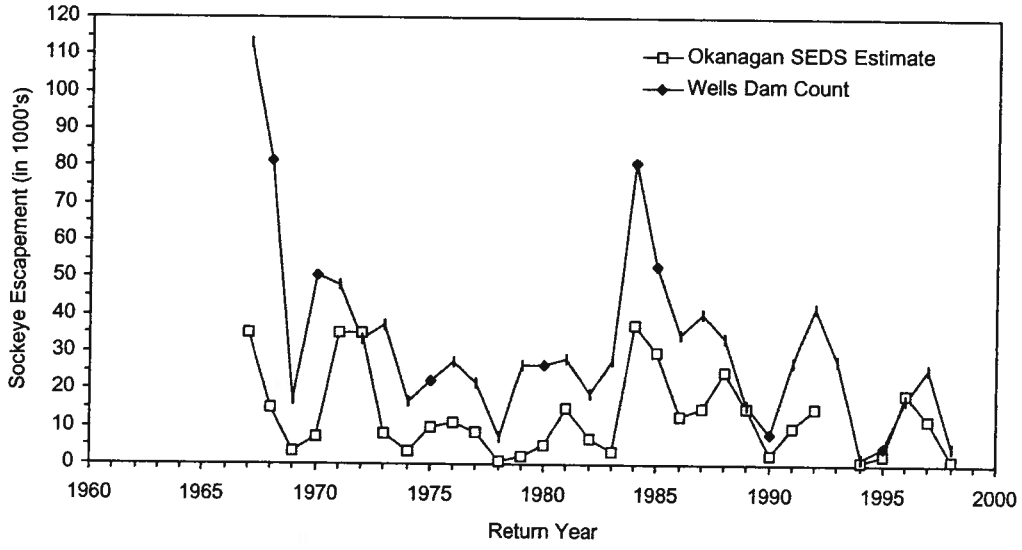

Figure 4. Trends in Okanagan River sockeye spawner abundance from 1967-1998 as per counts at Wells Dam or on the Okanagan River spawning grounds

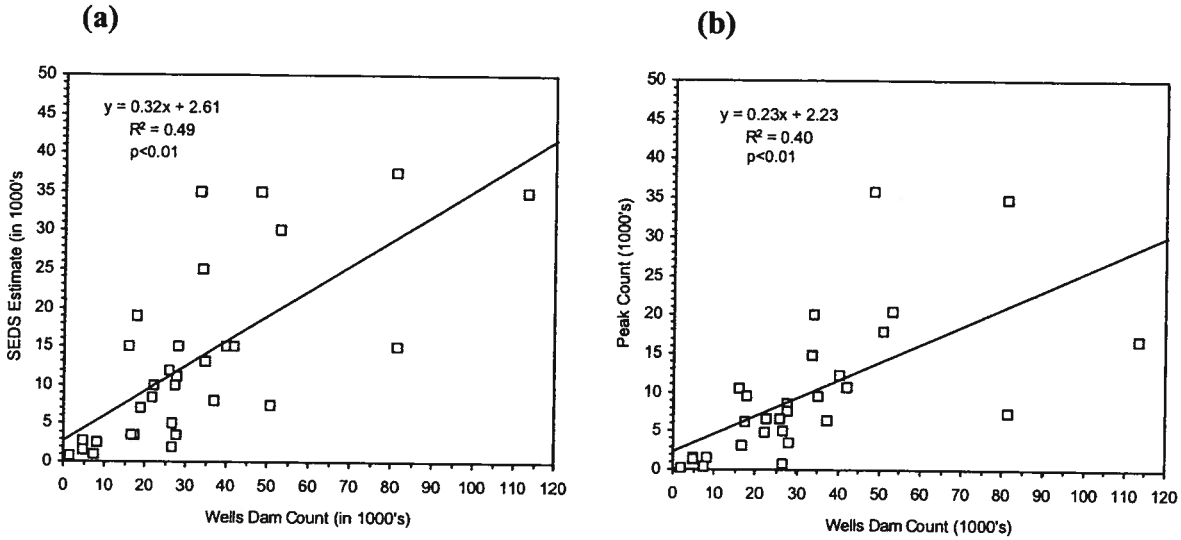

Figure 5. Escapement estimates at Wells Dam versus the Upper Okanagan River as indicated by either (a) SEDS estimates or (b) unadjusted peak live plus dead counts.

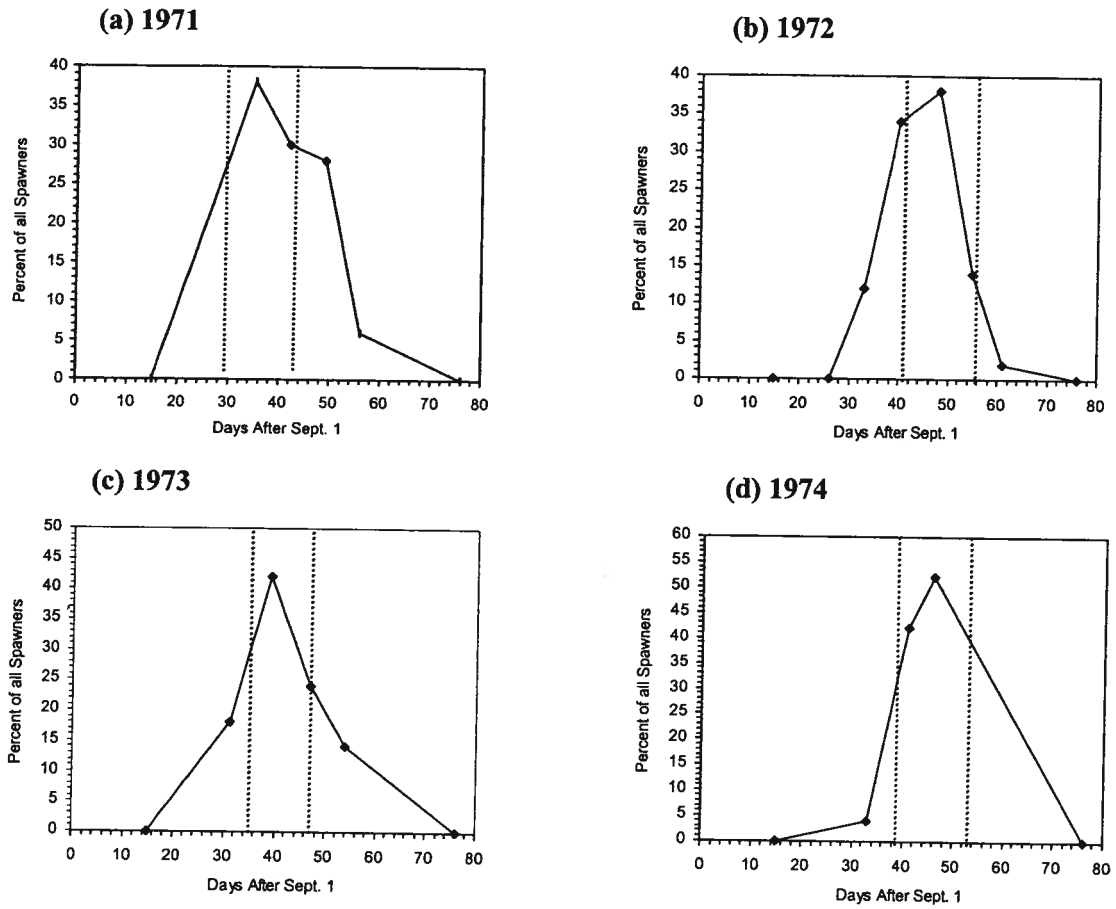

Figure 6. Seasonal abundance variations exhibited by sockeye salmon spawning in the Upper Okanagan River during the years 1971 – 1974. Dashed lines bracket a week before and after the occurrence of peak abundance (Source data modified after Allen and Meekin 1980).

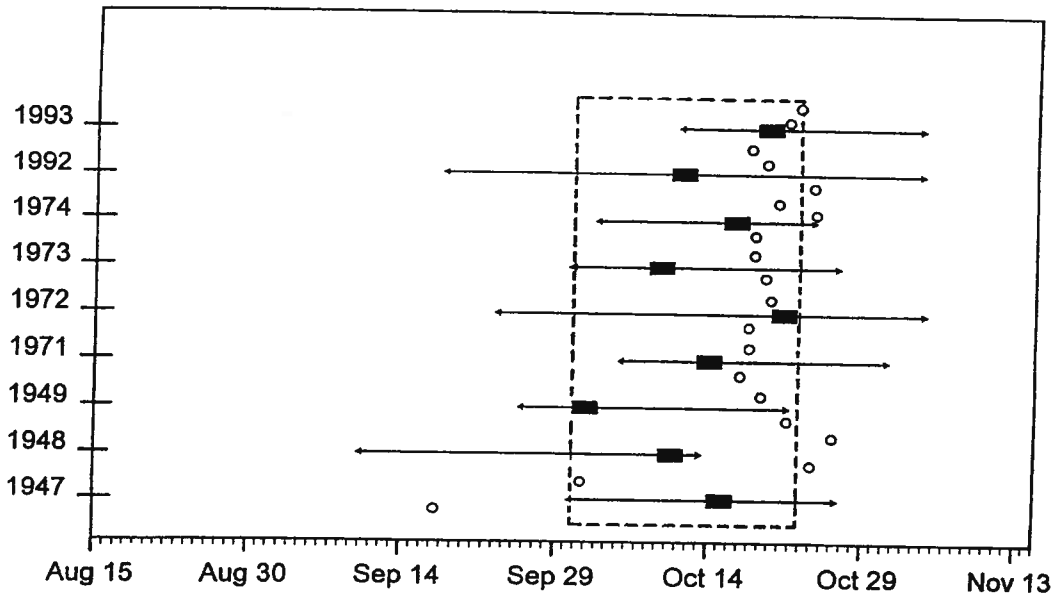

Figure 7. Relative timing of spawning activity of sockeye salmon from the Okanagan Basin (1947 1949 from Gangmark and Fulton 1952; 1971 – 1974 from Allen and Meekin 1980; 1992, 1993 from Hansen 1993 and Hagen and Grette 1994). These data show relative peaks of spawning activity since survey effort and total number of fish observed varied among years. Dates of recent year surveys by personnel from Canada's Department of Fisheries and Oceans (CDFO) are identified on the figure as O.

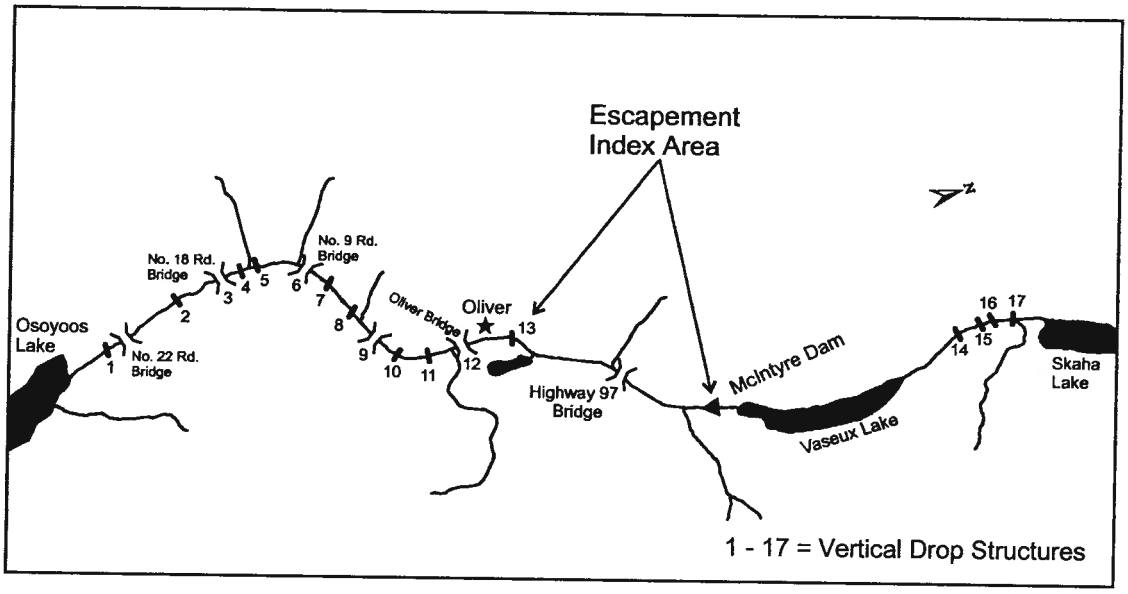

Figure 8a. Map of Upper Okanagan River spawner enumeration sections indicating the unchannelized "index area" as well as channelized sections

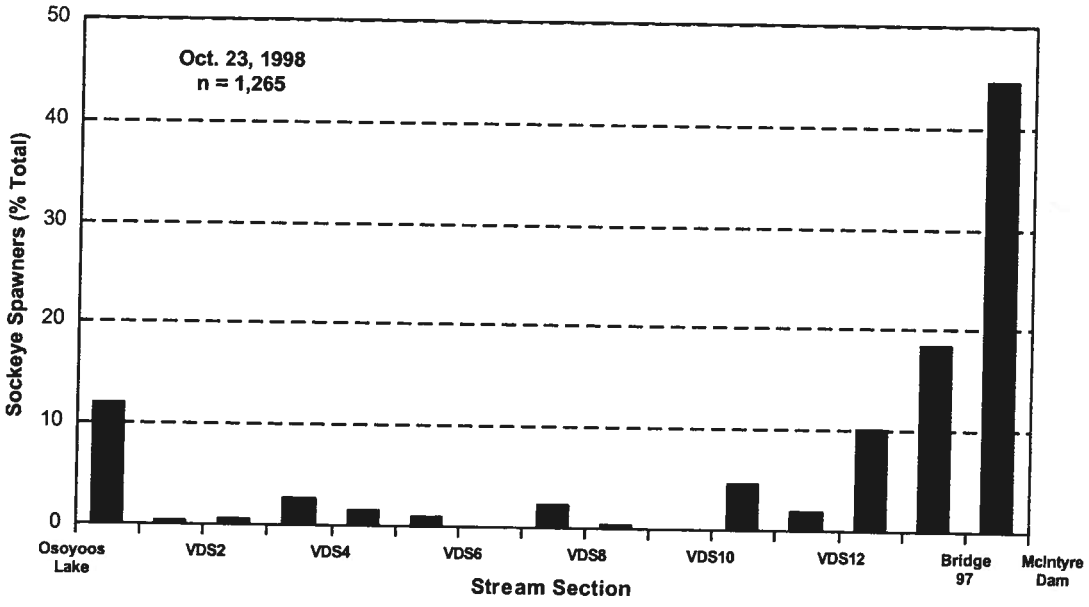

Figure 8b. Typical summary of the distribution of spawning sockeye in the Okanagan River observed during the survey of October 23, 1998 (observations extracted from the CDFO – Stream Inspection Log form for this date).

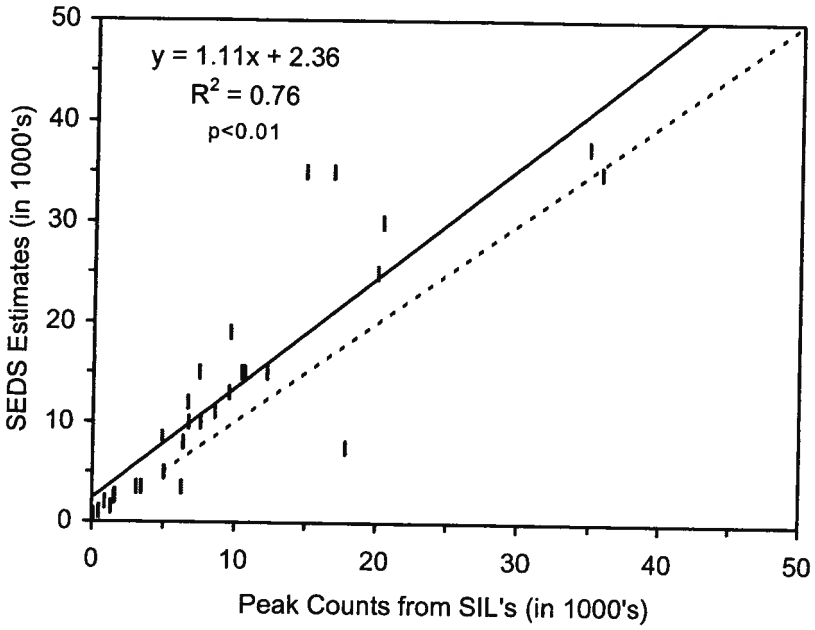

Figure 9. Peak annual count (live plus dead) of spawning sockeye from Stream Inspection Logs (SIL) versus summary estimates in the salmon escapement data system (SEDS)

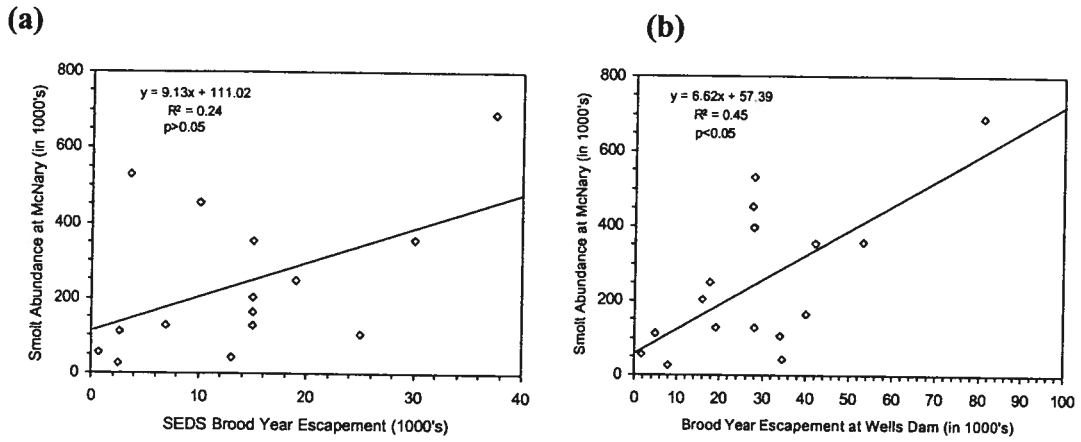

Figure 10. Annual production of Okanagan sockeye smolts (McNary bypass index) versus adult escapement from either (a) SEDS or (b) Wells Dam estimates

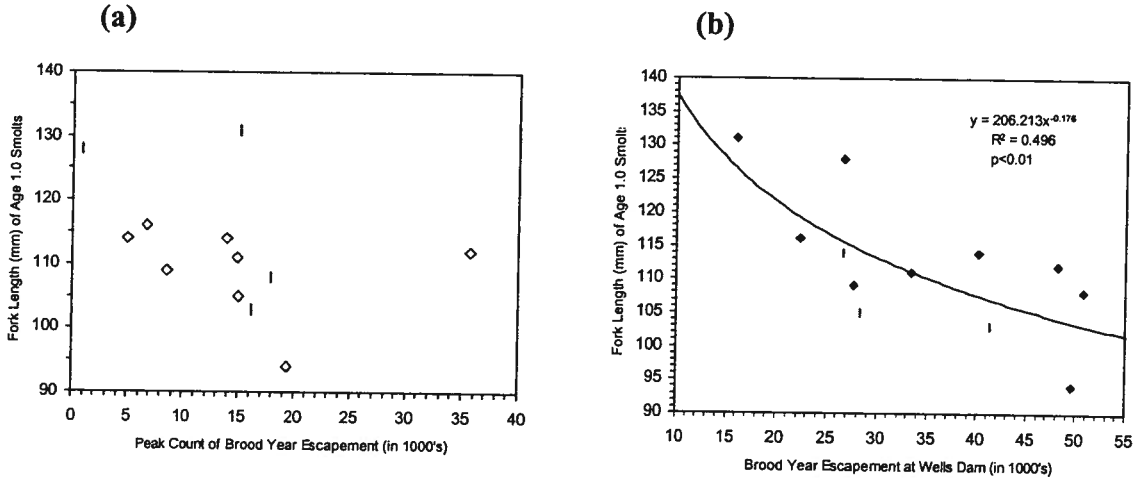

Figure 11. Okanagan sockeye smolt size versus escapement from either (a) SEDS or (b) Wells Dam estimates (data from Chapman et al. 1995)

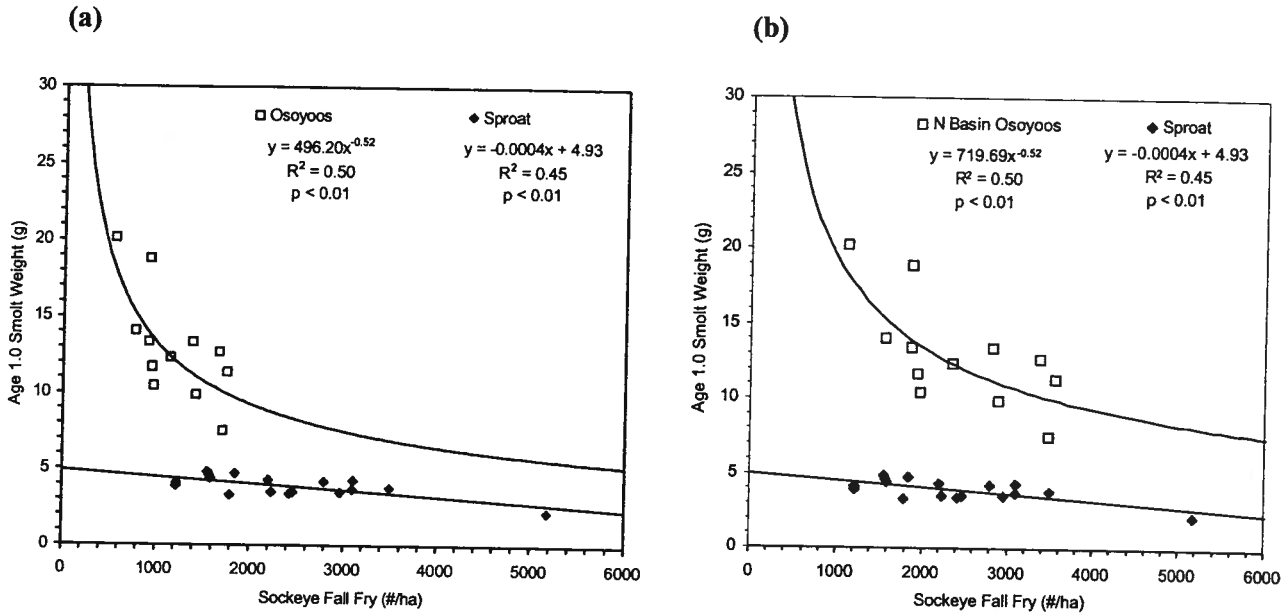

Figure 12. Relation between juvenile sockeye size and rearing density in (a) Osoyoos Lake and (b) North Basin of Osoyoos Lake, versus Sproat Lake

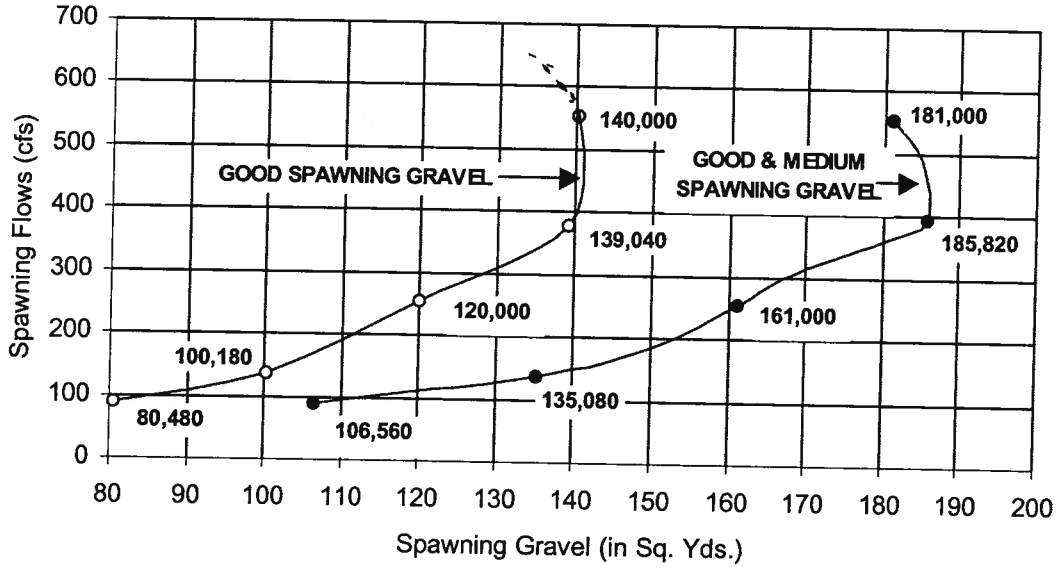

Figure 13: Summary observations of the relation between river discharge during the fall spawning period and surface area of "good" quality and good + medium quality gravels available for spawning sockeye in the unchannelized "index area" of the Upper Okanagan River (from Anonymous 1973)

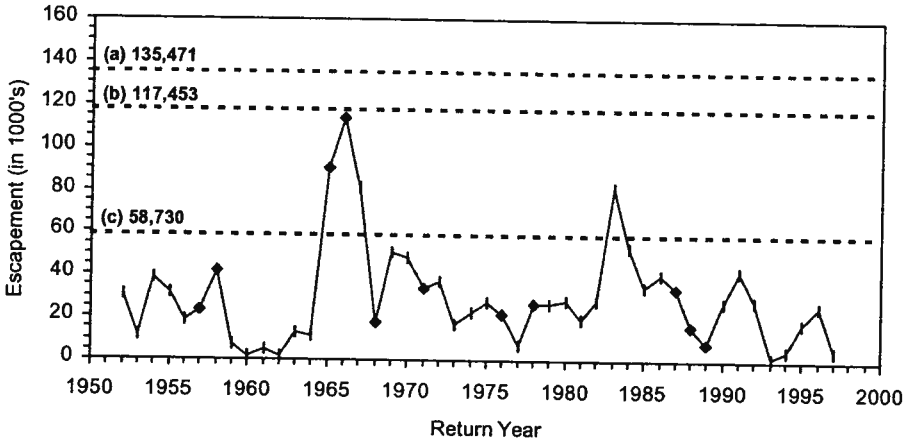

Figure 14. Annual escapement of Okanagan sockeye salmon (calibrated to Wells Dam counts) between 1953 and 1998. Dotted reference levels indicate (a) escapement required at Wells if "index area" spawning habitat will accommodate 0.56 female sockeye per m^{-2}, (b) sockeye escapement required at Wells in order to maintain production of 86 mm (6.2 g) yearling sockeye smolts from Osoyoos Lake, and (c) sockeye escapement required at Wells in order to maintain production of 100mm (9.5 g) yearling sockeye smolts from Osoyoos Lake.

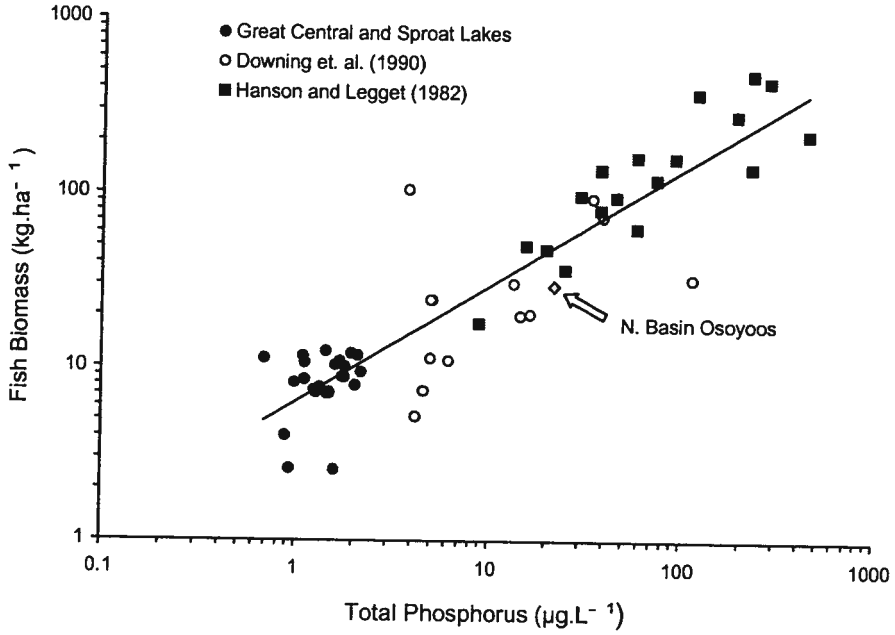

Figure 15. Annual yield of fish (as kg.ha↓≠) in North temperate lakes versus average concentration of phosphorus (∝g.l↓≠) maintained through the growing season. Value determined in present paper for sockeye production in the North Basin of Osoyoos Lake is highlighted (note the log scale used on both axes).

Tables

Table 1. Total Returns of Okanagan Sockeye

Return Year	Columbia Catch	Okanagan Catch	% Okanagan	Okanagan Escape.	Total Returns	Exploit. rate	% as 1.1	No. of 1.1's	% as 1.2	No. of 1.2's	Stock	Returns as 1.1's	Returns as 1.2's	Recruits	Stock
1953	63,011	48,077	76.3	30,330	78,407	61	0.87	68,214	0.13	10,193	30,330	25,679	37,503	63,182	30,330
1954	90,406	39,507	43.7	11,346	50,853	78	0.21	10,679	0.79	40,174	11,346	16,073	16,991	33,064	11,346
1955	119,206	63,656	53.4	38,640	102,296	62	0.13	13,298	0.87	88,998	38,640	89,204	162,812	252,016	38,640
1956	121,943	71,581	58.7	31,134	102,715	70	0.25	25,679	0.75	77,036	31,134	28,731	20,984	49,715	31,134
1957	70,017	35,009	50	18,566	53,575	65	0.3	16,073	0.7	37,503	18,566	10,336	2,405	12,741	18,566
1958	205,320	83,155	40.5	23,040	106,195	78	0.84	89,204	0.16	16,991	23,040	9,046	3,548	12,594	23,040
1959	188,965	149,849	79.3	41,694	191,543	78	0.15	28,731	0.85	162,812	41,694	5,105	2,128	7,233	41,694
1960	122,390	24,478	20	6,842	31,320	78	0.33	10,336	0.67	20,984	6,842	1,305	13,642	14,947	6,842
1961	41,435	10,069	24.3	1,382	11,451	88	0.79	9,046	0.21	2,405	1,382	8,361	10,596	18,957	1,382
1962	19,050	4,001	21	4,652	8,653	46	0.59	5,105	0.41	3,548	4,652	6,495	49,911	56,406	4,652
1963	24,345	3,433	14.1	1,402	4,835	71	0.38	1,305	0.62	2,128		46,072	101,914	147,986	
1964	37,572	9,431	25.1	12,572	22,003	43	0.38	8,361	0.62	13,642	12,572	97,918	87,958	185,876	12,572
1965	13,206	6,167	46.7	10,924	17,091	36	0.38	6,495	0.62	10,596	10,924	14,319	32,025	46,344	10,924
1966	10,250	6,253	61	89,730	95,983	7	0.48	46,072	0.52	49,911	89,730	7,030	4,613	11,643	89,730
1967	98,642	86,509	87.7	113,323	199,832	43	0.49	97,918	0.51	101,914	113,323	61,281	116,581	177,862	113,323
1968	30,200	20,747	68.7	81,530	102,277	20	0.14	14,319	0.86	87,958	81,530	7,441	53,508	60,949	81,530
1969	39,460	21,703	55	17,352	39,055	56	0.18	7,030	0.82	32,025	17,352	55,692	32,270	87,962	17,352
1970	22,829	15,227	66.7	50,667	65,894	23	0.93	61,281	0.07	4,613	50,667	10,757	10,432	21,189	50,667
1971	99,410	75,850	76.3	48,172	124,022	61	0.06	7,441	0.94	116,581	48,172	6,954	14,041	20,995	48,172
1972	105,280	75,802	72	33,398	109,200	69	0.51	55,692	0.49	53,508	33,398	8,605	17,759	26,364	33,398
1973	9,700	5,849	60.3	37,178	43,027	14	0.25	10,757	0.75	32,270	37,178	10,884	14,072	24,956	37,178
1974	1,450	670	46.2	16,716	17,386	4	0.4	6,954	0.6	10,432	16,716	8,625	4,986	13,611	16,716
1975	1,000	360	36	22,286	22,646	2	0.38	8,605	0.62	14,041	22,286	3,056	17,279	20,335	22,286
1976	1,200	1,024	85.3	27,619	28,643	4	0.38	10,884	0.62	17,759	27,619	10,591	17,284	27,875	27,619
1977	3,400	724	21.3	21,973	22,697	3	0.38	8,625	0.62	14,072	21,973	10,594	17,505	28,099	21,973
1978	975	584	59.9	7,458	8,042	7	0.38	3,056	0.62	4,986	7,458	10,729	11,783	22,512	7,458
1979	2,800	1,215	43.4	26,655	27,870	4	0.38	10,591	0.62	17,279	26,655	7,222	17,314	24,536	26,655
1980	1,833	1,305	71.2	26,573	27,878	5	0.38	10,594	0.62	17,284	26,573	10,612	50,253	60,865	26,573
1981	2,430	1,378	56.7	28,234	29,612	5	0.38	10,729	0.62	17,505	28,234	30,801	71,643	102,444	28,234
1982	1,440	816	56.7	19,005	19,821	4	0.38	7,222	0.62	11,783	19,005	43,911	27,780	71,691	19,005
1983	5,828	3,304	56.7	27,925	31,229	11	0.38	10,612	0.62	17,314	27,925	17,026	54,620	71,646	27,925
1984	58,473	33,154	56.7	81,054	114,208	29	0.38	30,801	0.62	50,253	81,054	33,476	21,066	54,542	81,054
1985	131,994	62,565	47.4	52,989	115,554	54	0.38	43,911	0.62	71,643	52,989	12,912	15,497	28,409	52,989
1986	13,894	10,018	72.1	34,788	44,806	22	0.38	17,026	0.62	27,780	34,788	479	3,598	4,077	34,788
1987	103,868	47,987	46.2	40,109	88,096	54	0.38	33,476	0.62	54,620	40,109	4,969	24,270	29,239	40,109
1988	79,525	40,160	50.5	33,978	74,138	54	0.38	12,912	0.62	21,066	33,978	4,623	35,941	40,564	33,978
1989	2,324	1,174	50.5	15,976	17,150	7	0.03	479	0.97	15,497	15,976	7,889	28,333	36,222	15,976
1990	2,621	595	22.7	7,972	8,567	7	0.58	4,969	0.42	3,598	7,972				7,972
1991	3,526	1,403	39.8	27,490	28,893	5	0.16	4,623	0.84	24,270	27,490				27,490
1992	2,505	1,879	75	41,951	43,830	4	0.18	7,889	0.82	35,941	41,951				41,951

Return Year	Columbia Catch	Okanagan Catch	% Okanagan	Okanagan Escape.	Total Returns	Exploit. rate	% as 1.1	No. of 1.1's	% as 1.2	No. of 1.2's	Stock	Returns as 1.1's	Returns as 1.2's	Recruits	Stock
1993	726	490	67.5	27,843	28,333	2	0		1	28,333	27,843				27,843
1994		0	10	1,666	1,666	0					1,666				1,666
Mean							**0.38275**		**0.61725**						

(1) Catch is the total of commercial catch in zones 1-5, Indian catch in zone 6 and by the Colville and Okanagan Tribes as per Table 1 of Chapman et al. (1995)

(2) Proportion of Okanagan sockeye in the catch is taken from data in Chapman et al. (1995) Tables 1 and 2 plus Figure 5.

(3) Okanagan catch as a proportion of total was not broken out in 81-84, 88 or 89 so the mean of catch for three year on either side of these years was used to crudely estimate Okanagan catch in each of these years.

(4) Escapement for the 1953-1966 return years has been set at twice the peak spawning ground count from Table 2 of Chapman et al. (1995) to account for the low bias in stream survey estimates relative to escapement counts at Wells Dam which are used as the preferred annual estimate of escapement in1967 and thereafter.

Table 2. Summary of peak live plus dead counts of adult sockeye on the spawning grounds in the Okanagan River and of adult sockeye passing Wells Dam.

Year	SEDS Entry or equivalent	Reconciled* Peak Counts (RPC's)	Counts @ Wells	SEDS as % of RPC's	RPC's as % of Wells	SEDS as % @ Wells	Peak Counts from CDFO-SIL's	PC's from Table 2 in Chapman (1995)
1967	35,000	16,786	113,323	208.51	14.81	30.89		16,786
1968	15,000	7,440	81,530	201.61	9.13	18.40		7,440
1969	3,500	6,235	17,352	56.13	35.93	20.17		6,235
1970	7,500	17,810	50,667	42.11	35.15	14.80		17,810
1971	35,000	35,728	48,172	97.96	74.17	72.66		35,728
1972	35,000	14,796	33,398	236.55	44.30	104.80		14,796
1973	8,000	6,328	37,178	126.42	17.02	21.52		6,328
1974	3,500	3,080	16,716	113.64	18.43	20.94		3,080
1975	10,000	6,684	22,286	149.61	29.99	44.87		6,684
1976	11,040	8,535	27,619	129.35	30.90	39.97		8,535
1977	8,475	4,870	21,973	174.02	22.16	38.57		4,870
1978	1,050	420	7,458	250.00	5.63	14.08		420
1979	2,000	839	26,655	238.38	3.15	7.50		839
1980	5,000	5,000	26,573	100.00	18.82	18.82		5,000
1981	15,000		28,234			53.13		
1982	7,000		19,005			36.83		
1983	3,500	3,430	27,925	102.04	12.28	12.53	3,430	
1984	37,500	34,832	81,054	107.66	42.97	46.27	34,832	
1985	30,000	20,342	52,989	147.48	38.39	56.62	20,342	16,246
1986	13,000	9,520	34,788	136.55	27.37	37.37	9,520	9,056
1987	15,000	12,190	40,109	123.05	30.39	37.40	12,190	13,867
1988	25,000	19,971	33,978	125.18	58.78	73.58	19,971	11,790
1989	15,000	10,419	15,976	143.97	65.22	93.89	10,419	
1990	2,500	1,498	7,972	166.89	18.79	31.36	1,498	2,028
1991	10,000	7,540	27,490	132.63	27.43	36.38	7,540	7,481
1992	15,000	10,618	41,951	141.27	25.31	35.76	10,618	22,587
1993	21,505	21,505	27,843	100.00	77.24	77.24		2,150
1994	700	98	1,666	714.29	5.88	42.02	98	226
1995	2,669	1,536	4,916	173.76	31.24	54.29	1,536	
1996	19,000	9,572	17,701	198.50	54.08	107.34	9,572	
1997	12,000	6,615	25,754	181.41	25.69	46.59	6,615	
1998	1,500	1,265	4,669	118.58	27.09	32.13	1,265	
Mean				164.58	30.92	43.08		
Range				42.1 - 714.3	3.15 - 74.17	7.5 - 107.3		

* Reconciled peak counts have been adopted from either Table 2 (estimates from 1967-1980) of Chapman et al. (1995) or from CDFO-SIL's (1983-1998).

Table 3. Okanagan River Escapement Survey Dates 1983-1998

Year	Inspection Dates	"Peak Count" Date	Peak Count	Carcasses as percent of count	Comments re: Peak Count
1998	Oct. 23, Oct. 27	Oct. 23	1,265	1.4	
1997	Oct. 22	Oct. 22	7,176	10.1	- possibly past peak.
1996	Oct. 18	Oct. 18	9,572	1.3	
1995	Oct. 20	Oct. 20	1,536	RNA	
1994	Oct. 24	Oct. 24	98	RNA	
1992	Oct. 19	Oct. 19	10,618	15.3	- possibly past peak.
1991	Oct. 24	Oct. 24	7,540	12.3	- possibly past peak.
1990	Oct. 17	Oct. 17	1,498	RNA	
1989	Oct. 17	Oct. 17	10,419	2.1	
1988	Oct. 18	Oct. 18	19,971	RNA	
1987	Oct. 20	Oct. 20	12,190	RNA	- fisheries patrol staff reduced to
1986	Oct. 17, Oct. 22	Oct. 17	9,520	0.8	a single survey per season for years
1985	Oct. 17, Oct. 24	Oct. 17	20,342	2.4	later than 1987.
1984	Sept. 16, Oct. 1, Oct. 1	Oct. 16	34,832	2.7	
1983	Oct. 19	Oct. 19	3,430	RNA	

RNA = record not available

Table 4. Okanagan sockeye spawn timing

Date	Live	Dead	Total	% Dead	Days from Sept.1	% of Seasonal Total
15-Sep-57	0	0	0	0	15	0
25-Sep-57	985	0	985	0	25	4
01-Oct-57	3,207	4	3,211	0.12	31	13
08-Oct-57	8,499	34	8,533	0.4	38	36
15-Oct-57	6,719	680	7,399	9.19	45	31
22-Oct-57	1,858	1,848	3,706	49.87	52	16
15-Nov-57	0	0	0	0	76	0
Total	21,268	2,566	23,834	10.77		
15-Sep-71	0	0	0	0	15	0
05-Oct-71	21,731	36	21,767	0.16	35	38
12-Oct-71	13,750	3,363	17,113	19.6	42	30
19-Oct-71	9,543	6,777	15,320	44.2	49	27
26-Oct-71	3,208	1,000	3,208	31.2	56	6
15-Nov-71	0	0	0	0	76	0
Total	48,232	11,176	57,408	19.5		
15-Sep-72	0	0	0	0	15	0
26-Sep-72	36	0	36	0	26	0
03-Oct-72	3,285	0	3,285	0	33	13
10-Oct-72	9,213	8	9,221	0.09	40	36
18-Oct-72	9,152	289	9,441	3.1	48	37
25-Oct-72	2,489	952	3,441	27.7	55	13
31-Oct-72	361	0	361	0	61	1
15-Nov-72	0	0	0	0	76	0
Total	24,536	1,249	25,785	4.8		

Date	Live	Dead	Total	% Dead	Days from Sept.1	% of Seasonal Total
15-Sep-73	0	0	0	0	15	0
01-Oct-73	2,770	80	2,850	2.8	31	19
09-Oct-73	6,039	289	6,328	4.6	39	42
17-Oct-73	2,900	759	3,659	20.7	47	24
24-Oct-73	1,569	650	2,219	29.3	54	15
15-Nov-73	0	0	0	0	76	0
Total	13,278	1,778	15,056	11.8		
15-Sep-74	0	0	0	0	15	0
03-Oct-74	246	0	246	0	33	4
11-Oct-74	2,496	1	2,497	0.04	41	43
16-Oct-74	3,057	23	3,080	0.75	46	53
15-Nov-74	0	0	0	0	76	0
Total	5,799	24	5,823	0.41		

(1) Survey observations for 1957 are from Craddock (1958) and for other years are from Table 13 of Allen and Meekin (1980).

(2) Survey observations above have been "altered" here by closing off spawn start and stop dates with counts of zero assumed for each year on Sept. 15th and Nov. 15th.

(3) Note that additional years of spawn timing observations are available for other years in a variety of reports that were not summarized here. Completion of these summaries will yield additional data re: peak and mean spawn times to check for associations with bias on single surveys or peak timing and annual temperature variations.

Table 5. SEDS as % of Wells sockeye escapement estimates from survey dates with an abundance (>10% of counts) or scarcity (<3%) of carcasses.

Survey years @ carcasses > 10 %	SEDS as % of Wells	Survey years @ carcasses < 3%	SEDS as % of Wells
1997	47	1998	32
1992	36	1996	107
1991	36	1989	94
		1986	37
		1985	57
		1984	46
Mean	39.67		62.17
Range	36 - 47		32 - 107

Table 6. Distribution of sockeye spawners by year and river section from McIntyre Dam to Osoyoos Lake.

Start Point	Mcl. Dam	Hwy 97 Bridge	VD13	VD12	VD11	VD10	VD9	VD8	VD7	VD6	VD5	VD4	VD3	VD2	VD1	
End Point	Hwy 97 Bridge	VD13	VD12	VD11	VD10	VD9	VD8	VD7	VD6	VD5	VD4	VD3	VD2	VD1	Lake	
Section	S-15	S-14	S-13	S-12	S-11	S-10	S-9	S-8	S-7	S-6	S-5	S-4	S-3	S-2	S-1	
Year	Percent of all Sockeye Observed															N
1998	45	18	10	2	5	0	0	2	0	1	2	3	0	0	12	1,265
1997	32	59	4	1	1	0	1	1	1	0	0	0	0	0	0	6,615
1992	26	68	5	0	0	0	0	0	0	0	0	0	0	0	0	10,618
1991	27	68	1	1	0	0	0	1	0	0	0	1	0	0	0	7,540
1990	34	64	0	1	0	0	0	0	0	0	0	0	0	0	0	1,498
1989	16	82	1	0	0	0	0	0	0	0	0	0	0	0	0	10,419
1988	20	66	9	0	0	1	1	0	0	2	0	0	0	0	0	19,971
1986	15	73	2	1	0	4	1	1	3	0	0	0	0	1	0	9,520
1985	17	79	0	0	0	0	0	0	0	0	0	1	0	0	0	20,342
1984	18	80	0	0	0	1	0	0	0	0	0	0	0	0	0	34,832
Mean	25	65.7	3.2	0.6	0.6	0.6	0.3	0.5	0.4	0.3	0.2	0.5	0	0.1	1.2	12,262
1952	52	40	3	1	1	1	1	1	1	0	0	0	0	0	0	24,714
1953	38	41	8	2	2	2	2	2	2	0	0	0	0	0	0	34,284

VD = vertical drop structure as per Figure 2

Raw counts of sockeye taken from DFO stream inspection log (SIL) summaries.

Table 7. Spawning ground distribution of sockeye in 1997 from visual (CDFO-SIL) versus radiotag (DCPUD-LGL) observations.

Start Point	McIntyre Dam	VD13	VD12	VD11	VD10	VD9	VD8	VD7	VD6	VD5	VD4	VD3	VD2	VD1	
End Point	VD13	VD12	VD11	VD10	VD9	VD8	VD7	VD6	VD5	VD4	VD3	VD2	VD1	Lake	
Section	S15 + S14	S-13	S-12	S-11	S-10	S-9	S-8	S-7	S-6	S-5	S-4	S-3	S-2	S-1	
Survey Method	**Percent of all Sockeye Observed**														**N**
DFO/SIL	91	4	1	1	0	1	1	1	0	0	0	0	0	0	6,615
Rtags pooled	37	12	8	5	2	3	3	1	3	2	7	2	6	9	219
Rtag1 from Bonneville	37	13	10	4	2	2	2	2	3	2	7	2	6	10	178
Rtag2 from Wells Dam	42	7	2	7	2	5	7	0	2	2	5	5	7	5	41

(1) VD = vertical drop structure as per Figure 2

(2) DFO/SIL - raw counts from DFO stream inspection log summary of Oct.22, 1997 survey.

(3) Rtag1 and Rtag 2 - spawning ground "recoveries" of sockeye adults radiotagged at Bonneville Dam as per results in Figures 9 and 10 respectively of Alexander et al. (1998).

Table 8. Comparisons of Peak Counts of Spawner Abundance by Year from Various Sources

Year	"Raw" Peak Counts*	Chapman Peak Counts**	SEDS	Chapman Peak as % of Raw	SEDS as % of Raw	Comments
1971	21,767	35,728	35,000	164.14	160.79	* 1971-1974 raw survey observations from
1972	9,441	14,796	35,000	156.72	370.72	Allen and Meekin (1980); 1983-1998 raw
1973	6,328	6,328	8,000	100.00	126.42	survey observations from CDFO-SIL's obtained
1974	3,080	3,080	3,500	100.00	113.64	from the Salmon Arm Office and summarized here.
1983	3,430		3,500		102.04	** "peak counts" tabulated in Table 2. of Chapman
1984	34,832		37,500		107.66	et al. (1995).
1985	20,342	16,246	30,000	79.86	147.48	
1986	9,520	9,056	13,000	95.13	136.55	On the basis of these limited observations, the
1987	12,190	13,867	15,000	113.76	123.05	Chapman et al. "peak counts" represent a range of
1988	19,971	11,790	25,000	59.04	125.18	raw count expansions from 1.0 to 2.3 and a mean
1989	10,419		15,000		143.97	expansion of 1.29 times peak survey counts
1990	1,498	2,028	2,500	135.38	166.89	to generate mean annual escapement estimates.
1991	7,540	7,481	10,000	99.22	132.63	
1992	10,618	22,587	15,000	212.72	141.27	
1993		2,150	2,150			
1994	98	226	700	230.61	714.29	SEDS estimates utilize a wider range (1.02- 7.14)
1995	1,536		2,669		173.76	and a higher mean (1.83) expansion factor than
1996	9,572		19,000		198.50	Chapman et al. to generate annual escapement
1997	6,615		12,000		181.41	estimates from raw counts.
1998	1,265		1,500		118.58	
Mean				128.88	183.41	

Table 9. Summary of escapement by brood year (either as SEDS spawning ground units or as Wells Dam counts) and of sockeye smolt abundance at McNary Dam.

Brood Year	Smolt Year	Adult Sockeye Rsnbrgr Excel	Adult Sockeye Wells Dam	McNary Smolt Index
1981	1983	15,000	28,234	126,493
1982	1984	7,000	19,005	127,272
1983	1985	3,500	27,925	529,673
1984	1986	37,500	81,054	689,110
1985	1987	30,000	52,989	356,857
1986	1988	13,000	34,788	41,148
1987	1989	15,000	40,109	163,889
1988	1990	25,000	33,978	105,627
1989	1991	15,000	15,976	202,123
1990	1992	2,500	7,972	26,571
1991	1993	10,000	27,490	454,041
1992	1994	15,000	41,951	352,539
1993	1995		27,843	397,070
1994	1996	700	1,666	55,009
1995	1997	2,669	4,916	110,659
1996	1998	19,000	17,701	248,551
1997	1999	12,000	25,754	
1998	2000	1,500	4,669	

Table 10. Osoyoos age 1.0 sockeye smolt size, in-lake fry abundance (in ATS units) and annual production estimates (in kg per ha).

Smolt Year	Size FL (mm)	Size (g)	North Basin # as ATS Equivalent	Ann.prod. North Basin (kg.ha)	Whole Lake # as ATS Equivalent	Ann.prod. Whole Lake (kg.ha)	"SEDS" Escapement	Escapement @Wells
1957	94	7.53	3467.8	26.12	1710	12.88	19,320	49,538
1958	103	9.88	2884	28.50	1422	14.05	16,067	41,197
1972	108	11.38	3546.69	40.35	1749	19.90	17,810	50,667
1973	112	12.68	3372.04	42.74	1663	21.08	35,728	48,172
1974	111	12.34	2337.86	28.85	1153	14.23	14,796	33,398
1977	116	14.07	1560.02	21.95	769	10.82	6,684	22,286
1978	109	11.69	1933.33	22.61	953	11.15	8,535	27,619
1981	128	18.84	1865.85	35.16	920	17.34	839	26,655
1982	114	13.36	1860.11	24.85	917	12.25	5,000	26,573
1983	105	10.46	1976.38	20.68	975	10.20	15,000	28,234
1989	114	13.36	2807.63	37.51	1384	18.49	13,867	40,109
1991	131	20.19	1118.32	22.58	551	11.13	15,000	15,976
Mean				29.32		14.46		
Range				20.7 - 42.7		10.2 - 21.08		

Table 11. Summary of acoustic and trawl based surveys of nerkid abundance in Osoyoos Lake.

Basin Area (ha)	North 937	Central 208	South 883	Total 2028	No. ha North 937	No. ha All 2028	Trawl #	Hailed Catch	By Aults @ Wells	Nerkids . spwnr via ATS	Nerkid Production North basin	kg per ha All Basins
ATS Date												
Jul-97	1.45	0.00	0.00	1.45	1,551	706	2	12	17,701	82		
Sep-97	1.24	0.03	0.07	1.33	1,320	648	7	258	17,701	75		
Nov-97	0.94	0.08	0.15	1.16	1,001	563	5	480	17,701	65		
Mean 1997	1.21	0.03	0.07	1.31	1290.67	639			17,701	74	17.42	8.63
May-98	3.04	0.16	0.38	3.57	3,813	1,762	9	485	25,754	139		
Jul-98	2.50	0.08	0.00	2.58	2,756	1,273	5	268	25,754	100		
Oct-98	3.77	0.00	0.16	3.93	4,195	1,938	10	250	25,754	152		
Mean 1998	3.10	0.08	0.18	3.36	3,588	1,657.67			25,754	130	48.44	22.38
Mean 1973				2.10	2,241	1,035.50			33,398	63	30.25	13.98
Mean 1974				0.50	534	246.55			37,178	13	7.21	3.33

(1) Nerkid per spawner calculation will be potentially confounded by unknown contributions of kokanee.

(2) Assume smolts produced in ATS lake survey years will achieve 13.5 g as 1.0 (i.e. an average FL of 112 mm) as per Table 30 of Mullan. Note, this value is conservative because given escapement abundance in brood years of origin smolts should always end up larger than 112 mm FL (as per Figure 11b).

(3) Table 30 of Mullan (1984) indicates that wild age 1.0 smolts leaving Lake Wenatchee average only 6.2 g (range 5.2-6.0, n=5) and 8.6 mm FL (range 8.1-8.8, n=5).

Table 12. Mark recapture estimates of sockeye salmon smolts (in thousands) at Priest Rapids Dam 1984-1988 (from Table 4.7 of Fryer 1995).

	Total run *		Wenatchee		Okanagan		Okanagan Brood Year Escapement	Smolts per Spawner from Priest MRP
Year	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	@ Wells	Estimates
1984	11361	2763	5992	2280	6143	1901	19,005	323.231
1985	7949	806	2602	361	5529	860	27,925	197.995
1986	19067	3480	25104	13642	6349	1064	81,054	78.330
1987	7014	1278	2306	536	3959	1187	52,989	74.714
1988	4703	1152	2106	291	1843	1093	34,788	52.978
					Mean (excluding1984)			101.004

* Total smolt run estimates do not equal the sum of the Wenatchee and Okanagan population estimates as different simulations were conducted for each of the three population estimates.

Table 13. Annual summary of Sproat Lake sockeye yearling size, abundance and production.

Brood Year	Fork Length (mm)	SE	Lake Year	PSARC ATS no. (millions)	No. per ha	Fresh Std. Weight(g)	Ann. prod. (kg.ha)	Standard Error	Sample Size
1975	70	0.3	1976			2.7	0.00	0.04	243
1976	81	0.6	1977			4.6	0.00	0.11	168
1977	70	0.2	1978			2.9	0.00	0.03	639
1978	77	0.3	1979	4.62	1224	4.1	5.02	0.05	439
1979	81	0.3	1980	5.84	1574	4.6	7.24	0.05	549
1980	73	0.3	1981	11.19	2964	3.5	10.37	0.04	382
1981	74	0.3	1982	8.43	2233	3.5	7.82	0.04	394
1982	79	0.2	1983	11.72	3105	4.3	13.35	0.04	483
1983	64	0.2	1984	19.56	5181	2.2	11.40	0.03	313
1984	83	0.5	1985	6.97	1846	4.7	8.68	0.09	211
1985	77	0.3	1986	8.3	2199	4.3	9.46	0.04	497
1986	73	0.2	1987	9.3	2464	3.5	8.62	0.02	1150
1987	75	0.1	1988	13.2	3497	3.8	13.29	0.02	1099
1988	77	0.2	1989	10.55	2795	4.2	11.74	0.04	581
1989	72	0.2	1990	9.16	2426	3.4	8.25	0.03	972
1990	82	0.3	1991	5.88	1558	4.8	7.48	0.05	412
1991	76	0.2	1992	4.6	1219	3.9	4.75	0.04	909
1992	78	0.3	1993	5.99	1587	4.4	6.98	0.04	982
1993	72	0.2	1994	6.77	1793	3.3	5.92	0.04	1019
1994	74	0.2	1995	11.7	3099	3.7	11.47	0.03	1301
Mean							7.59		
Range							2.23 - 10.03		

Table 14. Summary of Okanagan spawning area utilization in 1971 (adapted from Allen and Meekin 1980).

Year	Location	No. at Peak	Wells Equivalent (Peak X 2)	
1971	Index Section (IS)	21,767	43,534	No. at peak count from Allen and Meekin (1980) surveys.
	VDS13-Lake	3,761	7,522	Index section is from McIntyre Dam to VDS13.
	Lake	1,200	2,400	
	Total	26,728	53,456	
	Proportion females	0.560	0.560	Samples for sex composition from spawning grd. surveys.
	Sample size	626		
	Total females	14,968	29,936	
	Tot. egg deposition (millions)	37.420	74.840	Assuming an average fecundity of 2500 eggs for female
	Index females	12,190	29,935	sockeye that average 48 cm in length.
	Index egg deposition (millions)	30.475	74.838	
	m^2 per female	8.930	3.637	Assumes index area has 108,860 square meters of useable
	% of spawn area used	80.0%		spawning gravel at river flows of 325 cfs (from Anonymous
	Females req'd. to fill index area	15,237.50	37,418.75	1973).
	IS m^2 per female at saturation	7.144	2.909	Expanded to 100 % use based on no. of females at 80 % and
				assuming a multiyear proportion of 41 % females.

Table 15. Summary of sockeye females per m^2 required to utilize available spawning habitat in various spawning areas.

Spawning Location	Spawning Area (m^2)	Max. Females per m^2	Source
Chilko River	359,000	0.56	- for efficient spawning and a high rate of egg-to-fry survival
Weaver Creek Spawning Chann	NA	0.84	Cooper (1977)
Babine Spawning Channel	NA	2	Groot in Williams (1996)
Adams River	NA	2	Williams (1996)
Horsefly River	302,689	2	Williams (1996). Extensive measures from air photo interpretation plus highly significant relation between measured egg-to-fry surv. and abundance of spawners in the 1985, 86, 89 and 90 brood years.
Mean of all		1.48	
Range of all		0.56 - 2.0	
Okanagan Index Section (OIS)			Calculations based on 1971-1974 surveys in Table 14
1971	108,860	0.14	Based on SEDS annual escapement units.
1971	108,860	0.34	Based on Wells annual escapement units.
1973	108,860	0.08	Based on SEDS annual escapement units.
1973	108,860	0.25	Based on Wells annual escapement units.

Table 16. Estimates of annual escapement required to fully utilize the area of spawning gravel available in the Okanagan River between McIntyre Dam and VDS13.

"Optimal" no. of female sockeye per m^2	Source of female sockeye per m^2 values	Estimate of annual escapement required to fully utilize * all spawnable area in the Okanagan River Index Section		
		Escapement req'd. as females (in "Wells count units")**	Total escapement*** required (in "Wells count units")	Total escapement required (in "SEDS count units")****
0.34	1971 Okanagan R. surveys (Allen and Meekin 1980)	37,012	82,248	41,124
1.48	Mean from non-Okanagan stocks (NOS) cited in Williams (1996)	161,113	358,028	179,014
0.56	NOS minimum	60,962	135,471	67,736
2	NOS maximum	217,720	483,822	241,911

* Assume Okanagan River Index Section between McIntyre Dam and VDS13 has 108,860 square meters of useable spawning gravel at a river flow of 325 cfs (Anonymous 1973).

** Calculations have been identified as equivalent to Wells count units because spawning ground estimates for non Okanagan stocks are based on mark and recapture or fence count estimates which are more comparable to Wells Dam counts of Okanagan sockeye than to peak visual counts in the Okanagan R. index section.

*** Assumes the multiyear proportion of females is 0.45 as per Allen and Meekin (1980).

**** Assumes SEDS estimates are one half of the counts obtained at the Wells Dam.

MINUTES OF THE WELLS COORDINATING COMMITTEE FOR 2003

APPENDIX N

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
February 13, 2003

Agreements Reached:
1.

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I. GENERAL MID-COLUMBIA ISSUES

A. Next Meeting Time and Place

The Committee agreed to hold the next meeting of the Mid-Columbia Coordinating Committee on March 18 at Sea/Tac on the 10th floor of the Kilroy Building. The Committee also agreed to hold a mid-Columbia projects tour and meeting on the 13 and 14 of May.

B. Transition from Mid-Columbia Coordinating Committee to HCP Coordinating Committee

Dennis Rohr was called on to update Committee members on progress on moving from operating under the provisions of the various Mid-Columbia Settlement Agreements and ongoing Mid-Columbia Proceeding, to the pending HCP processes. Rohr said he had been asked to facilitate the transition process. He reviewed the status of the HCP Agreements and said it was expected that those agreements would be finalized and orders issued by FERC sometime this summer. Rohr reported that the Joint Fisheries Parties and Chelan and Douglas PUD's had met on January 16 and at that meeting agreed on several organizational issues for the HCP Coordinating Committee(s). These are:

1. The HCP Coordinating Committees will meet on the same day to reduce the number of meetings members will have to fit into their schedules.

2. The Chelan and Douglas HCP Coordinating Committees will utilize the same chairman.

3. A request for proposal for the HCP Coordinating Committee chairman will be prepared by Peven. Rohr was asked to be the interim chair of the HCP Coordinating Committees until a chairman has been appointed.

Rohr reported that the Policy Committee will be having process discussions soon. Appointments to the Policy Committee have already been made. Likewise appointments to the HCP Coordinating Committee have already been made and that committee will be holding technical discussions. Chelan and Douglas PUD's will have a pre-filing meeting with FERC on February 19, in advance of the filing of the HCP Agreements. Rohr said there was a conference call on January 31, and a meeting on February 13, to discuss the pre-filing meeting.

C. 2003 Spring Chinook Broodstock Collection

Truscott presented information on projections for spring chinook escapement in the mid-Columbia area. Total projected escapement to the Wenatchee Basin is 3,157 fish, 2,731 hatchery

returns and 426 wild returns. Chiwawa River escapement is projected to be 350 fish with 90 hatchery and 260 wild. Other Wenatchee tributaries are projected to have an escapement of 166 wild fish. Leavenworth Hatchery escapement is projected as 2641 hatchery fish.

Total projected escapement to the Methow Basin is 1781 fish, 1721 hatchery and 60 wild. Escapement to the Methow and Winthrop Hatcheries is projected to be 925 and 572 respectively. In the Chewuch River, projected escapement is 144 hatchery and 10 wild. Twisp River escapement is projected to be 80 hatchery and 14 wild. Escapement to the upper Methow River is projected as 36 wild fish.

Truscott said he was working on a broodstock collection protocol for the 2003 spring chinook run. He said broodstock collection on the Methow Basin was compromised by poor collection efficiency at the trap sites on the Chewuch, Twisp and upper Methow River at Foghorn Dam. The low wild spring chinook escapement projected for 2003 makes collection of adequate non-hatchery broodstock problematic this year. Truscott said he is reluctant to suggest that full production at the Methow and Winthrop Hatcheries in 2003 be based on collection of all hatchery broodstock. With only 10 wild fish projected for the Chewuch River there is a question as to whether collection efforts on that stream would be worthwhile. The projected escapement to the two hatcheries could allow adequate hatchery broodstock for full production of the 2003 brood. The question though, is whether that is the right thing to do from a genetic perspective. Truscott said he would be putting together a proposed broodstock protocol for Committee review.

D. Summer Chinook Study Proposal

Heinith distributed a copy of a Columbia River Intertribal Fisheries Commission proposal for a Methow Basin summer chinook study. He said this is a cooperative study proposal from CRITFC and the Yakama Nation. This would be a three year study with funding from the SE Alaska stake holders and the Alaska Department of Fish and Game. He said they are proposing to collect juveniles in the Methow River and would be using both PIT and Coded-wire tags. They will be looking at life history parameters and timing through the Columbia River system. He said they would also be looking at potential capture distribution on the high seas. He went on to say that they would look at adult spawners in the Methow Basin and would address size, age, and timing of the escapement. They will be using an Alaska style viewing tower on the lower Methow River to assess adult escapement. He said Dani Evenson and Andre Talbot would be heading up the study. He will plan to have someone discuss the study at the next Mid-Columbia Coordinating Committee meeting.

E. Coordination of Mid-Columbia and Canadian Juvenile Sockeye Research-2003

Hyatt reviewed formation of the Okanagan Technical Work Group. He said he had personally been involved with Okanagan sockeye for five or six years. He reviewed the work they are doing on sockeye assessment. He pointed out that the status of Okanagan sockeye involves a number of groups on each side of the border. Their sockeye assessment involves several areas of study. One of these is determining where juvenile sockeye rear. He said they are doing acoustic and trawl surveys and making echo counts as well as species identification. They have found that in winter, juvenile sockeye are scattered throughout the water column whereas in summer the distribution is confined to the area of the thermocline. He said they were looking at the relationship between juvenile size and abundance. Their estimate of the 2003 smolt migration is 2.35 million and for 2004 their estimate is 200,000.

Hyatt called attention to the studies being conducted by Paul Rankin and the fact that he was unable to secure samples of sockeye smolts from the mid-Columbia in 2002. Hyatt said he was at the meeting today to see if arrangements could be made to assure that Rankin would be able to get mid-Columbia sockeye samples for his studies in 2003. He said Rankin would need three samples over a 7-10 day period for a total of 300 to 500 fish.

Hyatt said he would like to report to the Committee, at a later date, on progress being made on the Douglas PUD funded water management optimization program. He said they are required to report the final results of this past year's work to Douglas PUD in August.

Hyatt reported that they are getting close to having SAR data available for Okanagan sockeye. They will then be able to address effectiveness of water management in terms of sockeye production.

II. WELLS DAM

A. Adult PIT-Tag Detection Evaluation at Wells Dam

Bickford reviewed the history of the PIT-Tag detection system evaluation at Wells Dam. He said the evaluation protocol was accepted by the Committee in July 2002. One hundred and fifty-nine adult sockeye were tagged and released into the ladders at Wells. Bickford reported that 99.9% of the tags were detected in the two sets of coils at each ladder. One fish was not detected at one coil while the other 158 fish were each detected at two coils. In addition to the study fish tagged and released in the Wells ladders, there were many (approximately 1500) PIT-tagged fish from various other studies that also were detected at the Wells ladders.

Bickford said there did not appear to be any delay associated with passage at the detection weirs. Average passage time for in-river PIT-tagged fish was 1.6 minutes from first detection to passage at the second detection coil. PIT-tagged sockeye which were anesthetized, tagged, and released back into the fish ladder several weirs below the detection coils took an average of 5 minutes for passage.

In addition to the evaluation of detection at the coils, there were some interesting quantitative data collected. Bickford said there were two components to the Winthrop Hatchery spring chinook run passing Wells Dam. Also, Winthrop Hatchery coho PIT-tagged in 2000, winter migrants, returned in September through November. Winthrop Hatchery coho PIT-tagged in 2001, spring migrants, returned in May through August. Bickford also reported that survival study fish PIT-tagged and released in 2000, had a 1% return rate. Fish released during the 2000 Wells steelhead survival study at Pateros and Wells Dam tailrace returned at the same percentage rate.

B. Tributary Trapping Sub-Group Activities

Bickford reported that the Tributary Trap sub-Group of the Wells Coordinating Committee (including the Wells HCP Coordinating Committee) met on January 14 to discuss issues concerning broodstock collection in the Methow and Wenatchee Basins. This group will also be meeting on February 14 at Douglas PUD Headquarters in East Wenatchee.

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The next meeting of the Mid-Columbia Coordinating Committee will be March 18 at Sea/Tac.

ATTENDANCE LIST

Name	Representing	e-mail address
Thad Mosey	Chelan Public Utility Dist.	thadm@chelanpud.org
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Mike Erho	The Committee	mike.erho@verizon.net

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
March 18, 2003

Agreements Reached:
1.

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I. GENERAL MID-COLUMBIA ISSUES

A. HCP Coordinating Committee Meeting Report

Rohr reported on the HCP Coordinating Committee meeting held at Sea/Tack on March 17. He reviewed the agenda and commented briefly on each agenda item. Rohr's comments on each agenda item follows;

1) Selection of Chairman for the HCP Coordinating Committee
   Rohr reported that an RFQ is being developed under the direction of the HCP
   Coordinating Committee and will be out soon. The selection process will be on-going as responses to the RFQ are received.
2) 2003 Bypass Operations
   Consensus has been arrived at on the 2003 bypass operations plans for Chelan and Douglas PUD projects although some tweaking will be taking place.
3) A Fish Forum will be held in Wenatchee on April 3&4. This will focus on improving fish survival in the Columbia Basin. This forum, headed up by Chelan PUD, may have broader participation than just the mid-Columbia or even the whole Columbia Basin.
4) Updates on schedules, etc. will be provided at the next Mid-Columbia Coordinating Committee meeting.

Heinith asked if the matters discussed at the HCP Coordinating Committee meeting will be brought to the Mid-Columbia Coordinating Committee today. Rohr said these are on the agenda and will be discussed today. Heinith said that would be helpful to he and Rose.

B. Corps of Engineers Transportation Study

Ocker reported on progress toward the 2003 transportation study. He said that due to budget cuts, they would not be tagging sub-yearling chinook for the 2003 study. They hope to do sub-yearlings in 2004. The sub-yearling study will run at least three years beginning in 2004. He reported that another change involves alternating treatment of PIT-tagged fish, i.e. bypassing every other day and transporting on the alternate days. All of the PUD PIT-tagged fish will be bypassed. Ocker reported that, in 2002, approximately 99% of the PUD PIT-tagged fish were detected. This provides a high level of confidence that the Corps study won't compromise PUD studies. The changes in treatments will

occur at 7 AM each day. The study is scheduled to begin on April 20. Ocker said all of the study fish in the mid-Columbia are now tagged. Tagging began in September of 2002. Fish will be interrogated as they leave the rearing ponds and tags recorded.

Heinith asked Ocker if he knows what the spill level will be at McNary Dam during the study. Ocker said he doesn't know but he should have that information this week.

Ocker said that because of budget cuts other studies are also taking a hit. One potential casualty is the bird island PIT tag recovery program. The decision on which efforts might be cut will be made next week. Bickford said the bird island PIT-tag recoveries aren't being used in PUD survival calculations anyway.

C. 2003 Spring Chinook Broodstock Collection Protocol

Truscott reported on his current thinking on a protocol for the Methow Basin. He said a meeting of the fisheries managers was held on March 10 and disagreement on how to deal with Methow Basin spring chinook strategy was discussed. He said there will be another meeting of fisheries managers on March 20 to, hopefully, iron out any continuing disagreement.

D. CRITFC Summer Chinook Study

Heinith referred to the study proposal he presented at the last Mid-Columbia Coordinating Committee meeting. Evenson and Talbot were called on to discuss the details of the study proposal. Evenson explained they have received funding from stake holders in Alaska in support of the proposed study. The study proposal was distributed to the Committee. Evenson went over the major elements of the study.

Woodin asked if they expect to have any trouble separating summer chinook adults from steelhead. Evenson said they felt that they would be able to distinguish the two species using the technique they were planning to use with a counting panels at a location that was well suited for that process. They will be attempting to validate or disprove the 3.1 fish per redd expansion factor developed by WDF&W in the 1960's. Graves asked if they intended to try to separate spring chinook, summer chinook, and steelhead as the fish were crossing the counting panels. Evenson said they will only attempt to separate chinook from steelhead. Rose asked if they had considered using video tape of passage at the counting panels to be evaluated later for species identification. Evenson said they were not planning to use video tape this year.

Evenson said they will be estimating abundance of naturally produced juvenile summer chinook beginning in 2004. They will not attempt to tie 2003 adult escapement to numbers of emigrating juvenile chinook. Genetic typing tools will be used to separate sub-yearling summer from sub-yearling spring chinook. Rose said he expects there will be some good data coming from this work. He asked if there is assurance of continued funding. Evenson said they have assurance of three years of funding, at this time.

Woodin questioned whether 5,000 sub-yearling fish of the proper size would be available from the screw trap collections on the lower Methow to PIT-tag. There was discussion concerning whether the juvenile trapping effort was adequate to provide precise enough information to make the effort worthwhile. Talbot reiterated that this is a pilot effort in 2003 and it will be a learning process.

Talbot said the proposed study is expected to provide information that could eventually be used to move toward managing stocks according to productivity of the stocks rather than managing according to escapement. Graves said it would have been helpful to NOAA Fisheries if there had been earlier coordination with their agency. He suggested that a meeting, between their office and the CRITFC researchers, in the near future would be helpful. Talbot said they had an ESA person on their staff and he will suggest a meeting in the near future to provide the necessary level of coordination.

Woodin asked if they had checked with the Fish Passage Center on PIT-tagging plans for sub-yearlings to try to avoid any subsequent tagging of fish PIT-tagged as sub-yearlings. Heinith said he would make sure that coordination takes place if it hasn't already taken place.

II. WELLS DAM

A. Wells Juvenile Bypass Operations

Bickford distributed a proposal on future bypass operations designed to meet HCP obligations. He said he has analyzed historic data at Wells Dam and Douglas PUD is proposing to change the process for guiding juvenile bypass operations as presented in the proposal. Based on historic cumulative passage distribution, Bickford said that an April 12 starting time for bypass operations, the historic 4.5% cumulative passage date, would provide protection for 95.5% of the spring migration if operations continued through the period between the end of the spring migration and the beginning of the summer migration. Bickford explained that by operating continuously from the April 12 starting date until August 26 (the historic 95% point in the cumulative summer passage distribution) would achieve the HCP objective of operating for 95% of both spring and summer migrations. Bickford went on to explain that, alternatively, if the Committee prefers to shut down the bypass between the spring and summer migrations an April 7 starting date (the historic 2.5% cumulative passage date) and termination on June 8 (the historic 97.5% cumulative passage date) would still provide protection for at least 95% of the spring migration. Under that scenario, a June 17 starting date for summer migrant protection (the historic 2.5% cumulative passage date) and a termination date of August 28 (the historic 97.5% cumulative passage date) would still achieve protection for 95% of the summer migration. Bickford said that the operating proposal was discussed and agreed upon at the March 17 HCP Coordinating Committee.

Heinith asked Bickford if he had considered water temperature in relation to migration timing. He said there appears to be an early migration out of the Snake and Hanford Reach this year. He said he is concerned that an April 12 starting date might miss some fish. Bickford referred to Figure 1 in his analysis which showed virtually no migration prior to the proposed start date. Heinith asked about kelts and when they show-up at Wells. Bickford said that during past telemetry studies 95% of the kelt migrated between mid-April and late May.

Woodin said the agreement on Wells juvenile bypass operations also called for monitoring of hatchery releases to determine if any adjustments to the starting date should be made. Woodin asked when the Wells bypass spill barriers would be installed. Bickford said most years the barriers would be installed two weeks in advance of the scheduled start date.

Heinith asked about Wells bypass representatives for 2003. Bickford said that this year would be the first year of operating to meet HCP requirements and instead of three bypass representatives, they would utilize representatives from those entities that signed the HCP to make decisions regarding Wells bypass operations. Heinith asked if the decision made in the HCP Coordinating Committee was by consensus. Woodin said it was a unanimous decision. Graves pointed out that Marco wasn't present at the March 17 meeting but subsequently expressed his agreement with that decision.

B. Tributary Trapping Sub-Group

Bickford said it appears things are moving along on plans for 2003. Truscott is moving on a collection protocol. Klinge mentioned that the Corps is asking for a consultation with NOAA Fisheries and USF&W on the plans for temporary modifications to the Twisp River trap. Petersen is in contact with the Corps explaining that this temporary in-stream structure is covered under the existing hatchery facilities permit. Committee members are hopeful that this potential hurdle can be overcome, allowing the temporary structure to be installed in time to be of use in 2003. Woodin said he would like to see progress continue toward provisions for 2004. The Committee set March 27 at 1:30 PM as the date and time for a conference call to discuss operations for 2003 in the Methow Basin.

C. Okanagan Sockeye Research

Klinge reported that there is a lot of work going forward in Canada on Okanagan River water management. The model has been developed and is currently being used. This year hasn't been a big challenge. They are able to maintain reasonable flows and the Lake Okanagan surface elevation is where they want it. The Canadians are in a shake-down mode where they are using the model but able to see where some things are working a little different than they anticipated. The 100% sockeye hatch was March 15 and they have also determined emergence dates.

Water managers are gaining confidence that use of the model won't jeopardize flows. The Canadian parties will be making a presentation to the Committee during the May 13-14 tour and meetings in the mid-Columbia. Klinge said Hyatt will be giving a presentation to the North Pacific Chapter of the American Fisheries Society meeting.

Heinith asked about operation of Zosel Dam and whether flows would be adequate to move the large sockeye migration expected in 2003. Klinge said Zosel is owned by the DOE and operated under the US/Canada Joint Commission. Marco called attention to the fact that the parties get together this time of the year to discuss how flows can be managed to avoid impacts. Bickford said that prior to the run-off in 2001 (a low flow year) early sockeye migrants were held up for a time at Zosel. Following this observation, the DOE placed notched spill gates into the leaf gate slots at Zosel Dam. The notched gates dramatically improved safe and rapid passage through the structure during low flow conditions. The notched gates may be utilized this year if fish delay is observed.

Marco reported on the Corps meeting on their risk assessment project. He said they were looking at potential for re-introduction of sockeye into Skaha Lake. A summary report is coming out soon. He suggested that Grant and Chelan PUDs might find some opportunity for future production increases. Marco also called attention to a

reported four fold increase in *mysis* shrimp in the north basin of Lake Osoyoos. He said the Canadians are having some limited success in harvesting *mysis* in Lake Okanagan.

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The next meeting of the Wells Coordinating Committee will be May 13-14 in Wenatchee and will include a tour of mid-Columbia projects.

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
May 14, 2003

Agreements Reached:

1. **The Committee agreed to allow trapping of steelhead broodstock at both ladder traps at Wells Dam in 2003.**

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I. GENERAL MID-COLUMBIA ISSUES

A. Adult Steelhead 2001 Telemetry Study Review

Karl English reviewed the 2001 adult steelhead telemetry study results and made references to comparisons with the 1999 study. The draft report of the 2001 study was distributed to the Committee on 3/6/03. English said that one of the important objectives of the 2001 study was to collect information on steelhead kelts. Because of overlapping tag codes of adult steelhead tags and juvenile tags in the 1999 study, kelt information from that study was considered not reliable.

Woodin asked English about differences between the1999 and 2001 studies in terms of project passage time. English reviewed the passage times for 2001 in comparison to the earlier study. These differences were relatively small considering the substantial differences in flow between years.

A question was raised concerning what "fall-back" rate means at Priest Rapids Dam. Hammond pointed out that these questions were recognized going into the study including the problem with trying to understanding what fall-back would mean at a dam where the fish being tagged were collected at that dam.

English said, in conclusion, that all study objectives were met in this replication of the previous (1999) study. He said similar results were achieved despite major changes in river flow between years.

Woodin said his only question, concerning the results of the study, have to do with how representative the tagged fish are to the untagged population. He asked English if there would be any advantage to releasing some tagged fish above Priest Rapids. English said that he could see no reason to conduct the study any differently.

B. HCP Committees and Transition from Mid-Columbia to the HCP Forum

It was reported that the HCP Coordinating Committee would meet this evening (May 13, 2003). There was no further report.

C. Broodstock Protocol for 2003

Truscott had previously distributed a proposed broodstock protocol to the Committee. He said there were two important features he wanted to point out. These were, 1) increasing the wild steelhead percentage in the Wells steelhead broodstock collection and 2) adult summer chinook collection at Wells Dam as it relates to rainbow trout and summer chinook rearing at Wells Hatchery and the ground water needs in consideration of yearling chinook rearing for Grant PUD

survival studies. Clubb suggested that Douglas and Grant PUD's and WDF&W meet to see what possible options exist. Bickford asked for clarification regarding use of Foghorn Dam trap. There is a question as to who has responsibility for operation of that trap for spring chinook broodstock collection, particularly when it comes to collection of wild spring chinook. Truscott responded to Bickford's question by stating that the USFWS was to operate the trap and that any natural origin fish were to be provided to the Methow Program. Woodin suggested that Grant PUD be encouraged to participate in discussions on tributary broodstock collection. Woodin said he felt at least informal participation by Grant PUD in tributary broodstock collection discussions would be in Grant PUD's long term best interest.

Bickford asked for clarification regarding collection of steelhead broodstock at both ladder traps at Wells Dam in light of the evidence that trapping operations at mainstem dams causes increased passage time. Truscott said he felt that the increased passage time was warranted by the important objective to increase the wild component of the broodstock. Bickford said he was concerned that there was a possibility that Douglas PUD would be faced, in the future, with requests to "fix the problem". He asked if everyone, on the Committee, was comfortable with the increased passage time at Wells Dam if both ladders are used for steelhead broodstock collection. Woodin, Truscott, and Marco, expressed support for the use of both ladders for steelhead broodstock collection in spite of the increased passage time. Graves said he needed to coordinate with other NOAA Fisheries staff and would provide their collective position, to the committee tomorrow. On May 15, after coordination with other NOAA Fisheries staff, Graves sent an e-mail to the Committee which reported that they recognize that during trap operation, passage at Wells Dam can be delayed. Graves said that Kris Petersen agreed that collecting steelhead for broodstock is an activity consistent with the developing hatchery biological opinion and Take Permits for Upper Columbia steelhead and Kris pointed out that the east ladder at Wells Dam is used because it reduces the incidental take of summer chinook and that trap operation is limited to three days per week and often occurs only two days per week. Graves stated that although NOAA Fisheries typically strives to reduce passage time through fishways "based on this information, and taking into consideration the life-history UCR steelhead (spawning approximately four months later in time) and the 2001 radio-telemetry study as a whole (i.e., the median travel time from Priest Rapids to Wells Dam was approximately 11 days or 20 km/day), I concur with the other MCCC members that a delay of 1 to 2 days at Wells Dam is acceptable."

II. WELLS DAM

A. Okanagan River Flow Management Model Demonstration

Klinge reviewed the background of the Okanagan River Flow Management Project and introduced Alexander and Marmorek who described the model and provided a demonstration of the model features. They mentioned that Kim Hyatt had expected to be at the meeting but was travelling from the east coast yesterday and had not yet arrived in Wenatchee. Marmorek stood in for Hyatt and introduced the project. He reviewed the make-up of the Okanagan Basin Technical Work Group who over saw the development of the flow management model. The entities involved include the Federal Government in Canada (Department of Fisheries and Oceans), British Columbia Ministry of Land, Water, and Air Protection, Okanagan Nation Alliance, Douglas County Public Utility District, ESSA Technologies, and Summit Environmental Consultants.

Marmorek stated that early on the group recognized that egg/fry losses could be reduced by better water management in the Okanagan Basin. He said the group was interested in broadening the scope of the effort to include all water management issues including irrigation, recreation, and flood control as well as sockeye and kokanee protection. The model was developed and field observations were used to "ground truth" model inputs. The work is being done under the leadership of the Okanagan Technical Work Group.

Alexander gave a PowerPoint presentation showing the work being done. He said the goal is to develop a decision support tool for water management in the Okanagan Basin. He explained the process of development of the model through testing in 2003. Woodin inquired about what was used for future water temperature parameters. Marmorek said that historical means are used to project water temperatures. He said this is one area where they may need to have real-time weather factored into the model. Clubb asked how often the model is updated, e.g. flow predictions. The response was that these inputs are updated on a daily basis. If the inflow prediction is not met one day, the future prediction will reflect that.

Woodin asked if there has been any sensitivity analysis of the model. Symonds said that they adjust perspective real-time depending upon volume forecast, etc. Guy related operations to operations at The Dalles Dam. Woodin asked if there were any priorities assigned to various performance measure. Marmorek said the intent is to get people to work together to stay out of the "red zone" for any performance measure.

Marmorek said the model allows interested parties to share their analysis with other parties. Final decision on water management rests with Symonds. Symonds said he had been uncomfortable having to make decisions without adequate input and analysis for the various objectives of water management. He sees the development of the model as being a major improvement in providing information upon which to base water management decisions.

Marmorek and Alexander proceeded to run a demonstration of the model. Woodin acknowledged that the model has some utility for doing some "gaming" to look at various management schemes to see if you can do a better job of meeting objectives. Symonds reiterated the position that the model provides a useful tool for trying to do a better job of meeting multiple water management objectives.

Klinge said that since Hyatt was apparently unable to attend the meeting he wanted to give Bull an opportunity to comment. Bull said the three management agencies, Department of Fisheries and Oceans, B.C. Fisheries, and First Nations all worked together to respond to Douglas PUD's request for what mitigation measures would be acceptable to all three. He said they all agreed on the value of improved water management in the Okanagan Basin as being their highest priority. The development of the model has been well received by these agencies. Symonds said the model is a key element which will enable them to do a better job of managing flows in the Okanagan Basin.

Klinge said what was seen today is basically the first year of a three year effort. There will be additional tweaking and ground truthing in the next two years. Woodin said he would like to see continued refinement of predictive capabilities of the model in terms of hydrology elements.

Marmorek said the CD that is available includes references to joint efforts by the Colville Confederated Tribes and the First Nations to look at reintroduction of sockeye into Skaha Lake. He said he would leave copies of the CD with Klinge to make available to interested parties.

B. Methow Basin Tributary Trap sub-Group

Bickford said he had talked to Truscott regarding the status of tributary traps in the Methow Basin. He said the trap for the Chewuch Diversion has been fabricated and will be installed next week. The Twisp River trap addition will be ready next week. There is a question whether the addition should be installed before or after high water. Early spring chinook run timing may be a factor in that decision. Trapping is currently taking place in the existing trap structure.

It was proposed that a tour of the Methow tributary trapping sites be scheduled during high flows so that everyone could see what problems exist at each site. It is hoped that engineers will attend that tour. The week of June 10 was considered for the tour. A follow-up meeting should be scheduled following the NOAA Fisheries release of trapping criteria and the results of 2003 operations. Late July or early August was considered for such a meeting. NOAA Fisheries will be releasing the trapping criteria in July. This will allow planning for trap improvements under the HCP. Bickford stated that capital construction of tributary traps will not take place until after the HCP is approved by FERC. He said modifications to existing facilities could be considered such as modifications to Fulton Dam as done previously, or the trap modifications planned at Twisp trap, or the trap to be tested at Chewuch Dam this year. He said Douglas PUD is willing to do engineering for trap facilities in advance of HCP approval but capital construction would not take place prior to HCP approval by FERC.

There was discussion of the need to improve tributary trapping facilities. Douglas PUD would prefer to wait on HCP approval for major trapping facilities. Woodin suggested going to FERC for an expedited license amendment to allow tributary trapping structures. Clubb reiterated Douglas PUD's position that it is willing to do engineering for tributary trapping facilities prior to FERC approval of the HCP, but not capital construction.

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
September 5, 2003

Agreements Reached:

1. No Committee members present at the meeting expressed objection to the proposal by the Yakama Nation to radio tag coho adults at Wells Dam and collect some coho for broodstock providing logistics are worked-out with WDF&W personnel at Wells Hatchery.

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I. GENERAL MID-COLUMBIA ISSUES

A. HCP Coordinating Committee Meeting Report

Peven said the Project Operation Bio-Op has been posted on the NMFS web-site. When the Hatchery Bio-Op is complete they will be sent to FERC as part of the package for license amendments approving the Habitat Conservation Programs.

II. WELLS DAM

A. Methow Tributary Trap Planning Update

Bickford said they will have a construction window for the Fulton Dam work within a couple weeks. It took some time to get the construction drawings together since they had to develop stream bed profiles in the area of the dam. It will take a couple hundred cubic yards of material for the dam improvements, most of which is already at the site. Bickford said they chose to go with a 1 to 1 rather than a 1 to 2 slope recognizing that a 1 to 2 slope would be more stable. He said they think, in the long term, they will be likely to develop a different site so they only need to have one year of operation at the Fulton Dam trap. He said two other sites are being investigated. Bickford also reported that no fish were caught at the Chewuch Dam trap in 2003 and that site is not being pursued for future broodstock collection.

Foghorn Dam trap was not operated according to criteria in 2003. Operation manuals were distributed to all interested parties during the year. Bickford said that, under current conditions at Foghorn Dam, trapping can probably only take place during high flows due to a velocity barrier that develops at that time.

At the Twisp River trap, modifications that were discussed at earlier meetings are being designed and engineered. Bickford said a meeting should be held in October to make sure everyone is comfortable with the direction these modifications are going.

B. Proposed Adult Coho Tagging and Broodstock Collection at Wells Dam

Keely Murdock joined the meeting by telephone to participate in the discussion of the coho proposal submitted on behalf of the Yakama Nation. Murdock reviewed the proposal to tag coho adults at Wells Dam in 2003 as part of their coho study which is primarily focused on coho adults trapped at Priest Rapids. She said they won't be doing any trapping at Wells in addition to ongoing broodstock collection at Wells. She said they will have one biologist on site to deal with coho adults trapped. They also would like to take about 144 coho for broodstock in 2003.

Murdock said they will target the west ladder trap at Wells for broodstock. There is potential for collection of some fish from the east ladder trap but those would present some difficulties in transporting the fish to Wells Hatchery.

Woodin asked if Murdock had a projected run-size for coho arriving at Wells Dam. Murdock said she did not but there is a phenomenal coho run returning to the Columbia River. Woodin said he thinks there should be more formalized criteria for the trapping effort based on predicted run size, etc. and identification of what is projected for collection at Winthrop Hatchery. He said a protocol should be developed as is the case with other species. Murdock said they view Wells broodstock collection as supplementing Winthrop Hatchery collection. Truscott said his primary concern is that WDF&W be able to handle the effort logistically. Klinge pointed out that they will require personnel involved in the project to check-in with the control room when they arrive at the project due to heightened security concerns. The Committee members present at the meeting expressed no objections to the coho tagging and broodstock collection proposed subject to details being worked out with WDF&W logistically at Wells Hatchery.

C. Okanagan River Flow Management

Klinge said a report is due on the flow management program but has been delayed due to fire conditions in British Columbia recently. He said he had talked to Kim Hyatt and found they have been doing some "ground truthing" and those efforts will be continued next year. Acoustic surveys to assess fry abundance in Lake Osoyoos have not been analyzed yet. Klinge said he heard that temperatures in Lake Okanagan reached 80 degrees F. last week. He said they have determined that they need to evaluate the temperature/oxygen "squeeze in Lake Osoyoos and feel this could be an important factor in production. Klinge said 2004 is the third year of Okanagan River flow management efficacy. A decision on how effective flow management has been in increasing production will be made following the 2004 evaluation. Klinge said that the level of Okanagan Lake is already approaching levels usually seen in late October. They are approaching the second year of drought conditions which would signal a number of different management actions. It is unlikely that flows will be increased above 200 cfs during the sockeye spawning period.

D. Wells Bypass Operations

Klinge distributed a summary of bypass operations in 2003. He said the bypass was operated according to HCP operating parameters. Spring bypass covered 63 days and summer bypass covered 74 days. Woodin asked if there were any repercussions in the operating community over operation based on historical timing. Klinge and Bickford said they had alerted operations people of the operating program Douglas PUD was signed-up for and there were no repercussions.

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No date was set for the next Wells Coordinating Committee meeting.

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WELLS COORDINATING COMMITTEE
CONFERENCE CALL SUMMARY
OCTOBER 21, 2003

Conference Call Participants:

Tom Scribner	Yakama Nation
John Jorgenson	Yakama Nation
Keely Murdock	Yakama Nation
Brian Cates	USFWS
Kris Petersen	NOAA Fisheries
Rod Woodin	WDF&W
Laura Praye	WDF&W
Bob Jateff	WDF&W
Shane Bickford	Douglas County PUD
Rick Klinge	Douglas County PUD
Mike McGowan	Fish Pro
Mike Erho	The Committee

Twisp Acclimation Pond Water Supply Screen Modifications

Rick Klinge opened the meeting with a discussion of the need for modifying the screens on the irrigation ditch diversion that feeds the Twisp Acclimation Pond. Klinge said the screens have generally worked alright but, this spring a disaster was narrowly averted when the watchman at the acclimation pond noticed the screen was plugged and water was being cut off from the pond. Klinge asked Mike McGowan, Fish Pro, to describe the screen modifications being proposed. Drawings of the proposed modifications had been distributed to the committee last week. The change would involve changing the existing flat screen to a screen that was tilted, similar to the screen at the Methow Hatchery where surface water is withdrawn from Foghorn Irrigation Ditch. There are two proposed designs both of which have received Bryan Nordlund's approval. McGowan said there would also be a compressed air system for screen cleaning. Scribner asked if the cleaning system would be operated on a timer or if it would operate automatically. McGowan said it would either operate on a timer or could operate automatically based on pressure differentials. Woodin asked if the cleaning system would be extensive enough to prevent "burping" the debris to another part of the screen. McGowan said the system was designed to prevent that from happening.

Klinge said that they have considered the possibility of moving the screening system further down the channel to the point where the intake for the pond is located. In doing so, they would be reducing the flow available for the pond since a portion of the water diverted from the river would used to sweep the screen and would have to be returned to the river with the debris load. Klinge said they were unwilling to reduce the water available for the acclimation pond. Woodin suggested that the Washington Department of Ecology be contacted to see if additional

flow for screen sweeping could be diverted and returned to the river beyond the acclimation pond intake. Klinge said Fish Pro already has drawings of a screen design at the point of diversion from the irrigation ditch and if Ecology is willing to consider an increase of one or two cfs in the flow diverted during the period prior to the beginning of irrigation diversion this could be done. It was pointed out that the diversion of water from the river for acclimation pond use usually begins about a month prior to irrigation diversion. Once irrigation diversion commences, there is abundant water available to provide the sweeping flows past the screen needed for screen cleaning. Woodin suggested a two-pronged approach which would involve 1) an attempt to secure the approval of Ecology for the flows necessary to keep the screen clean if the screen is moved to the point of diversion from the ditch, or 2) redesign of the screen in the existing location at the point of diversion from the river. The Committee felt the first option was most desirable from an operations standpoint. Klinge summarized the discussion and said they would pursue the necessary approval from Ecology for moving the screen to the point of diversion of acclimation pond flow from the irrigation ditch and if they are unsuccessful they would proceed with re-design of the screen in the existing location. Woodin suggested that they attempt to secure Ecology's approval for use of one or two additional cfs flow for screen cleaning operations with the additional water returned to the river immediately past the point of pond water diversion. This may be viewed more favorably than an increase in the water usage permit.

Jateff said that regardless of where the screen is located, there needs to be provision for increasing the head at the point of diversion of irrigation ditch flow from the river. He said that under some early spring conditions, there has been a problem in diverting adequate flow for acclimation pond supply. McGowan said they were looking into the possibility of providing for increased head at the point of diversion.

Twisp River Broodstock Collection Trap Modifications

Bickford reviewed the activities associated with Twisp River Broodstock Trap modifications. He had previously distributed information and drawings to the Committee. Bickford pointed out the questions raised by Nordlund which the committee had received by e-mail. McGowan had met with Nordlund on October 10 to work out details on acceptable trap design. Nordlund had initially stated a strong preference for moving the attachment point of the weir panels from the top of the concrete sill to the apron below the sill. Bickford said that with the proposed operational change to lowering the panels during peak flows, Nordlund was neutral on whether the panel attachment point should be the top of the sill or the apron.

Bickford said they were recommending six modifications to the Twisp River trap. These modifications are as follows:

1) Moving the trap position toward mid-channel
2) Installation of a debris barrier
3) Installation of an access bridge to the trap
4) An air bladder under the weir panels allowing a steeper angle on the weirs
5) Counter-weighting the weir panels to allow them to sink when the bladder is deflated
6) Notching the concrete sill at the entrance to the trap

Scribner asked what evidence there is that fish don't move through during high flows. Bickford explained that peak flows on the Twisp River have historically been earlier than peak passage of spring chinook at Wells Dam. Jateff said they have always observed fish movement at the trap following the peak flows in the Twisp. Bickford said that he feels operation of the trap through

peak flows is not necessary and lowering the weir panels by deflating the bladder will not result in significant loss of trapping opportunity.

Woodin asked if the bladder would be installed in a way that would not result in twisting of the weir panels. Bickford said the bladder would be in two sections running from either bank to the trap. They could be operated in such a way to prevent the panels from racking and assure more reliable operation.

Jateff expressed some concern about the placement of the trap over 20 feet from the left bank. He said he had concerns for the safety of the operators using the bridge to the trap during higher flows. Bickford said that LGL told him they had found that the traps used in British Columbia were more effective if they were at least 12 feet from shore. Bickford said they could move the location toward shore to maybe 15 to 18 feet from the left bank. The Committee agreed that moving the trap location to within 15 to 18 feet of the left bank would be acceptable.

Bickford said if there were any changes from the direction discussed during this conference call, he would get back to the Committee. Cates asked Bickford to be sure to keep Mark Miller's office informed as we move forward.

Fulton Dam Modifications

Bickford reviewed previous discussions regarding the re-habilitation of Fulton Dam to assist in broodstock collection in 2004. He said they initially were planning to create a more formidable barrier but after seeing the dam at low water this summer where fish passage was questionable, they feel that making the dam more of a barrier is not in the best interest of the resource. They have made extensive surveys of the Chewuch River from the acclimation pond downstream to Fulton Dam and identified 16 potential trapping sites. These 16 sites were reviewed and through further investigation three sites were selected as having the most desired characteristics for placement of a trap similar to the ones used in British Columbia. LGL and Fish Pro are working on the design of a trap and collecting land survey and ownership information.

Bickford said an attractive feature of the concept is that during non-trapping periods there is nothing showing to indicate that is a trap site. The entire trap would be installed and removed annually. LGL has told Bickford that the favored site is ideally suited for the type of trap they are using successfully in British Columbia. Bickford said there primary objective is to trap broodstock. They aren't interested in building a several million dollar irrigation diversion dam just so they can add fish collection facilities. Bickford said the B.C. type trap concept, in the location identified, is a much more attractive option. Woodin told Bickford to be sure and keep the WDF&W Habitat group informed of what is being planned.

Yakama Proposal to Extend Coho Trapping at Wells Through the First Week of November

Scribner described the objectives of the coho study being undertaken by the Yakama Nation. He said they are interested in extending the time frame for tagging coho at Wells Dam and collecting fish for broodstock. He said they have already extended the time frame at Dryden and Tumwater Dams on the Wenatchee River and Murdock added they have also increased the time frame for the collection of fish at Priest Rapids Dam. Scribner said they would like to extend the work at Wells Dam to the end of the first week in December.

Klinge said Douglas PUD will require more than one operator when the ladder traps at Wells Dam are being used. Scribner pointed out that the Yakama Nation has helped out during steelhead trapping and other activities at Wells and they feel some compensatory help should be

given to their coho trapping activities. Scribner asked Klinge if the contract for this work next year could be increased to cover the extra costs this year. Klinge said he would like to see the Yakama Nation and WDF&W work things out together and come back to Douglas PUD with what arrangements have been agreed to. A "time for time" agreement was discussed and considered the most expeditious way to proceed this year. Klinge said he would like to see these details worked out in advance next year. Scribner said he would like to see a provision made for Yakama Nation personnel to operate the trap themselves next year when steelhead are no longer being collected by WDF&W and only coho are present. Bickford reviewed the problems Douglas PUD has had in the past with various entities wanting to operate the traps and collect or sample fish. Douglas PUD has chosen to stick to the decision to have only WDF&W personnel operate the traps. However, Bickford said they would be willing to discuss this further with the Yakama Nation as time goes on. Scribner pointed out that the YN plans to be involved in these coho efforts for the "long haul".

Klinge pointed out that annual ladder maintenance scheduling could effect when trap operation can take place. They normally take the ladders at Wells Dam out, one at a time, beginning the first week of December. One trap each year would receive more extensive maintenance, with a longer outage. He wasn't sure which ladder was scheduled for the most extensive maintenance in 2003 but if it was the east ladder, that would effect the use of the trap. Klinge said he would check on the maintenance schedule and let Scribner know if the trap would be available the first week of December. Jorgenson explained that radio tagging is scheduled to end at the end of November. He asked if WDF&W, as part of their steelhead trapping operation, could transport coho to the net pens in the raceway near the steelhead holding area. From there the Yakama people would be responsible for removing the fish from the net pens and transporting them to the Winthrop Hatchery for spawning. Jateff said this could probably be worked out.

The conference call ended at 12:30 PM.

2003 MEMBERSHIP LIST OF THE WELLS COORDINATING COMMITTEE

APPENDIX O

Appendix O

2003 Membership List of the Wells Coordinating Committee

Ron Boyce
Oregon Department of Fish and Wildlife

Brian Cates
U.S. Fish and Wildlife Service

Ritchie Graves
NOAA Fisheries

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 Indian Nation

Rod Woodin
Washington Department of Fish and Wildlife

THE LONG TERM SETTLEMENT AGREEMENT FOR THE WELLS HDYROELECTRIC PROJECT

APPENDIX P

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

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

SETTLEMENT AGREEMENT

This Settlement Agreement is entered into this 1st day of October, 1990, by the 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, Portland General Electric Company (collectively the Power Purchasers), 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 Reservation, and the Confederated Tribes of the Colville Reservation (collectively the Joint Fishery Parties).

I. GENERAL

A. PURPOSE AND SCOPE

1. This Agreement establishes the PUD's obligations with respect to the installation and operation of juvenile downstream migrant bypass facilities and measures; hatchery compensation for fish losses; and adult fishway operation at least until March 1, 2004, as described in subsection I.C. For purposes of the Wells Project, these measures, in conjunction with existing hatchery

compensation programs, and when carried out pursuant to this Agreement, shall be conclusively considered to fulfill the PUD's obligation to protect, mitigate, and compensate for the anadromous fish resource at least until March 1, 2004. These measures are expected to contribute to the Northwest Power Planning Council's goals of rebuilding the natural spawning populations of salmon and steelhead in the Columbia Basin and providing harvest opportunities.

2. This Agreement establishes the Joint Fishery Parties' obligations in support of this settlement. This Agreement also requires evaluation programs for fishery measures and establishes procedures for coordination between the PUD and Power Purchasers and the Joint Fishery Parties.

3. It is the intent of the Parties that this Agreement shall be the basis for the dismissal of the Mid-Columbia proceeding, Docket No. E-9569, insofar as it pertains to the Wells Project, and for compliance by the PUD with the Northwest Power Planning Council's 1987 Columbia River Basin Fish and Wildlife Program, as amended.

4. The fish passage, mitigation, and compensation measures set out in this Agreement are intended to implement Article 41 of the License for Project No. 2149 issued by FERC to the PUD. The PUD's obligations under this Agreement shall be enforceable as if they were conditions of its FERC license. Notwithstanding any other provision of its FERC license, once this Agreement is approved by FERC the PUD shall be bound by the terms of this

Agreement.

5. For purposes of this Agreement, except under subsections VI.B, VII.B and E, VIII.B and D, the Power Purchasers collectively will be a single Party. For all purposes under this Agreement, except under subsections VI.B, VII.B and E, VIII.B and D, the Power Purchasers shall participate through a single representative, whom they will designate from time to time.

B. DURATION

The term of this Agreement shall commence on the date of execution by all Parties and shall continue for the term of the current license for the Wells Project, plus the term of any annual licenses which may be issued after the current license has expired.

C. MODIFICATIONS TO THE AGREEMENT

1. Notwithstanding subsection I.B, at any time after March 1, 2004, any Party may request all other Parties to commence negotiations to modify the terms and conditions of this Agreement in whole or in part. Any such modification shall be subject to FERC approval, except that the Parties may agree to implement on an interim basis, pending FERC approval, any measure not requiring prior FERC approval. No Party shall file a petition with FERC pursuant to subsection I.C.2 to modify this Agreement without first presenting the proposed modification to all Parties and allowing a reasonable opportunity to negotiate, not to exceed 90 days without consent of all Parties.

2. Subject to the limitation stated in the above subsection, at any time after March 1, 2004, any Party to this Agreement may:

(a) Request the imposition by the FERC of different, additional, reduced or modified fish protection measures;

(b) Bring any cause of action, raise any defense or claim, or rely on any theory related to this Agreement in any appropriate forum;

(c) Petition any appropriate administrative agency or political body for relief, including the deletion or addition of one or more measures otherwise in effect under this Agreement; or

(d) Take other appropriate action relating to any issue or matter addressed by this Agreement or which could have been addressed by this Agreement or that otherwise relates to the fisheries issues of the Wells Project.

3. In any action under this subsection I.C, the petitioning Party shall have the burden of proof. The Parties will continue to implement this Agreement pending final resolution of any modification sought in the FERC, or until the relief sought becomes effective by operation of law, or unless otherwise agreed.

4. With respect to any petition or suit filed pursuant to this subsection I.C and any subsequent judicial review thereof, nothing in this Agreement shall bar, limit or restrict any Party from raising any relevant issue of fact or law, regardless of whether such issue is or could have been addressed by this Agreement. Notwithstanding any other provision of this Agreement, no claim shall be made for damages arising from the failure to provide or the provision of inadequate downstream fish passage facilities or programs, or upstream adult passage facilities, or

both, that might have arisen during the period March 7, 1979, through March 1, 2004.

5. Notwithstanding any other provision of this subsection I.C, any Party may participate in any legislative or administrative proceeding dealing with fish protection or compensation issues provided, that, consistent with this subsection, no Party shall advocate or support the imposition of fish protection, mitigation, or compensation measures at the Wells Project that are different from or in addition to those required by this Agreement until after March 1, 2004.

6. The Parties intend that this subsection I.C shall apply to each and every provision of this Agreement, and therefore the terms of this subsection are hereby incorporated by reference into and shall apply to every other provision of this Agreement as if set out fully in each such provision.

D. RESOLUTION OF DISPUTES

1. Any dispute between the Parties concerning compliance with this Agreement shall be referred for consideration to the Wells Project Coordinating Committee (the Coordinating Committee) established under Section V. The Coordinating Committee shall convene as soon as practicable following issuance of a written request by any Party. All decisions of the Coordinating Committee must be unanimous. In the event the Coordinating Committee cannot resolve the dispute within fifteen (15) days after its first meeting on a dispute, it will give notice of its failure to resolve the dispute to all Parties. Thereafter, if the dispute qualifies

under subsection I.D.2, any Party may request the FERC to refer the dispute to (1) the presiding judge in the Mid-Columbia proceeding; or (2) in the event the Mid-Columbia proceeding is terminated, to the Chief Administrative Law Judge of the Commission; or (3) to the Division of Project Compliance and Administration within the Office of Hydropower Licensing, or its successor (any one of which is hereinafter referred to as the Decisionmaker), in the order listed herein (unless otherwise agreed by the Parties or directed by FERC), for expedited review in accordance with the procedures set forth in this subsection. Any issue in dispute that is not subject to the expedited review process may be referred to the FERC for resolution pursuant to the FERC's Rules of Practice and Procedure.

2. The expedited review process specified in this subsection shall be utilized, unless otherwise agreed pursuant to subsection I.D.5, to resolve any issue(s) in dispute between the Parties that arises under this Agreement where the amount in controversy is less than $325,000 (1988 dollars). For the purpose of this subsection I.D, the amount in controversy shall be determined by calculating the difference between the calculated annual cost of the Joint Fishery Parties' proposal for resolution of the dispute and the calculated annual cost of the PUD's proposal for resolution of the dispute.

3. Under the expedited review process, each Party that desires to present an initial position statement to the Decisionmaker shall file the statement with the Decisionmaker and all other Parties within twenty (20) days of mailing of notice by a

Party that expedited review is requested. Responsive statements shall be filed and served within forty (40) days of the mailing of the notice. The Decisionmaker shall set a date for submission of any briefing, affidavits or other written evidence and a further date for hearing of oral evidence and argument. Except by agreement of all Parties involved in the dispute, the hearing shall be held not later than seventy (70) days after the date of mailing of the requesting Party's notice or as soon thereafter as the Decisionmaker shall be available. The hearing shall be held in Seattle, Portland or any other location agreed upon by the Parties, or mandated, upon a finding of special circumstances, by the Decisionmaker. The Decisionmaker shall decide all matters presented within fifteen (15) days of the hearing or as soon thereafter as possible.

4. All decisions under the expedited review process shall be effective upon issuance and pending appeal, if any. Nothing in this subsection I.D shall limit or restrict the right of any Party to petition the FERC for de novo review of any decision under the expedited review process. All such appeals shall be in accordance with the FERC's Rules of Practice and Procedure.

5. The Parties may agree to refer any issue subject to expedited review to a third party Decisionmaker other than someone within FERC for processing pursuant to this subsection or as otherwise agreed by the Parties.

E. EFFECTIVE DATES

1. Except as otherwise specified in this subsection I.E, this Agreement shall become effective upon the issuance of a final order by the FERC approving this Agreement.

2. Notwithstanding subsection I.E.1 above, the Parties will immediately upon execution of this Agreement, implement the provisions of the Agreement that do not require formal FERC approval.

3. The Parties agree to immediately seek interim approval by the FERC of Section IV of this Agreement in order to implement construction of hatchery facilities.

II. JUVENILE FISH PASSAGE

A. GENERAL SCOPE OF JUVENILE PASSAGE MEASURES

1. Subject to the schedules, criteria, and conditions in this Agreement, the PUD will fund the installation, operation, maintenance, and evaluation of juvenile fish bypass systems and measures at the Wells Project. Bypass systems and measures are those intended to attract and route juvenile salmonids past operating powerhouse generating units.

2. All facilities under this Agreement shall be designed and constructed using quality materials and then current engineering standards for the purpose of obtaining a high quality product designed to require low maintenance and have a long useful life.

B. BYPASS SYSTEM

The PUD will continue to implement a program of controlled spill using five (5) bypass baffles at the Wells Project to meet the criteria set out in subsections II.C, D, and E.

C. NORMAL BYPASS OPERATIONS CRITERIA

1. No turbine will be operated during the juvenile migration period unless the adjacent bypass system is operating according to the following criteria.

2. The five (5) bypass system bays will be Nos. 2, 4, 6, 8, and 10. Operation of the turbines will be in pairs with the associated bypass system bays, as follows:

Turbines Operated	Bypass Bays Operated
1 and/or 2	2
3 and/or 4	4
5 and/or 6	6
7 and/or 8	8
9 and/or 10	10

(For example, if turbines 1, 5, and 6 are operating, bypass systems 2 and 6 will be operating.)

3. At least one bypass will be operating continuously throughout the juvenile migration period, even if no turbines are operating.

4. The bypass systems and spillgates will be operated in configuration K of the 1987 bypass system report (bottom spill, 1 foot spill gate opening, 2,200 cfs, vertical baffle opening) for all bypass system bays.

5. If top spill is shown to be as effective as bottom spill in bypass bays 2 and 10, then top spill will be allowed in these bays.

6. If the Chief Joseph Dam Uncoordinated Discharge Estimate is 140,000 cubic feet per second (140 Kcfs) or greater for the following day, all five bypass systems will be operated continuously for 24 hours regardless of turbine unit operation.

7. If the Chief Joseph Dam Uncoordinated Discharge Estimate is less than 140 Kcfs, bypass system operation will be as follows:

Number Turbines Operating	Minimum Number Bypass Systems Operating
10	5
9	5
8	4
7	4
6	3
5	3
4	2
3	2
2	1
1	1
0	1

D. BYPASS OPERATIONS TIMING CRITERIA

1. Bypass systems will be in place at least two (2) weeks prior to preseason forecasted beginning of juvenile migration.

2. Bypass systems will remain in place for at least two (2) weeks after the juvenile migration period ends.

3. Monitoring of fish runs will begin when bypass baffles are in place and will end when the baffles are removed.

4. Bypass systems will be available to operate continuously, 24 hours per day, during the juvenile migration period.

E. BYPASS PERFORMANCE CRITERIA

1. At a minimum, bypass system operations will be provided as described in subsections II.B, C, and D for the entire juvenile migration period as defined in the annual operations plan under subsection II.F, and subject to the provisions of subsection II.F.3.

2. Bypass operations as described in subsections II.B, C, and D are intended to provide fish passage efficiency (FPE) of at least eighty percent (80%) for the juvenile spring migration, and FPE of at least seventy percent (70%) for the juvenile summer migration. For purposes of this Agreement, FPE is expressed by the following formula:

Where A = Sum of daily migrants successfully passed by the device during the spring or summer migration

and B = Sum of daily migrants passing through the turbine unit intakes during the same migration

$$FPE = \frac{A}{A + B} \times 100$$

3. If bypass operations under subsections II.B, C, and D do not meet the minimum FPE levels specified in subsection II.E.2, the PUD will modify those operations by implementing one or more of the following measures:

(a) Change in configuration or addition of lights or other physical changes.

(b) Change in "normal operation" under subsection II.C to operation of five bypass system bays at forecast flow of 120 Kcfs.

4. Unless and until these modifications are in place to meet the minimum FPE levels specified in subsection II.E.2, or if these modifications are not sufficient to meet the FPE levels specified therein, then the PUD will increase spillbay bypass flow up to two times normal operation (up to a total of 4.4 Kcfs) per bypass at night (1 hour before sunset to sunrise) for the period:

(a) During which 80% of the spring migration pass the Wells Project;

(b) During which 80% of the summer migration pass the Wells Project, or for 40 days, whichever is less.

5. If portions of the runs do not receive protection at the minimum FPE levels specified under subsection II.E.2, then compensation will be provided based on the difference between the minimum FPE levels specified in subsections II.E.2 and 3 and the actual FPE achieved during the evaluation provided under subsections II.H.1 and 2. The appropriate level of compensation will be calculated based on actual loss. The form of this additional compensation (i.e., fish production) will be determined by the Joint Fishery Parties in consultation with the PUD.

F. ANNUAL OPERATIONS PLANS

1. The PUD will develop an annual bypass systems operations plan consistent with the criteria in subsections II.B, C, D, and E in consultation with the Joint Fishery Parties by the December prior to each migration period. The plan will be reviewed and approved by the Coordinating Committee by March 1 of each year. The plan will be developed from inseason projected hatchery release

dates from facilities above Wells and previous passage monitoring data. The plan will contain predicted dates for the beginning and end of the juvenile migration period; criteria for identifying the beginning and end of the spring and summer runs; and procedures for bypass operations within the constraints of subsections II.B, C, D, and E, including dates for installation and removal of spill baffles, dates for run time monitoring, and criteria for initiation and cessation of bypass operations. If unanimous agreement cannot be reached within the Coordinating Committee regarding all items in the plan, disagreements will be resolved by expedited dispute resolution under subsection I.D.

2. A Bypass Team will be established composed of one representative each for the Party fishery agencies, the Party tribes, and the PUD.

3. Notwithstanding the provisions of subsections II.F.1 and 2 above, the Bypass Team may agree to relax the operations and performance criteria of subsections II.C and E for a period between the end of the juvenile spring migration and the beginning of the juvenile summer migration. Such a modification can only be made with the agreement of all of the members of the Bypass Team, and will be limited to one or more of the following measures:

(a) Less than continuous 24-hour operation of bypass systems.

(b) Fewer than one bypass system operated for two adjacent turbines operated.

(c) Less than 1 foot spill gate slot opening.

4. Once the annual bypass plan is adopted, decisions regarding adjustments to the plan will be made by unanimous agreement of the Bypass Team. If unanimous agreement cannot be reached, the decision on such adjustments will be by majority vote of the Bypass Team.

G. ANNUAL PASSAGE MONITORING PLAN

1. The PUD shall develop an Annual Passage Monitoring Plan, in consultation with the Joint Fishery Parties for review and approval by the Coordinating Committee by March 1 of each year. The Plan will include development of inseason indices of relative fish abundance on a daily basis and annual estimates of juvenile migrant production. Estimates of relative abundance will be used to guide bypass operations decisions under subsections II.E.4, II.F.1, II.F.3, and II.F.4. Estimates of juvenile migrant production will be used as the basis for compensation adjustments (Hatchery-Based Compensation - Phase IV) as provided in subsection IV.A.3.

H. FPE EVALUATION PLAN

1. The PUD shall develop an FPE evaluation plan, in consultation with the Joint Fishery Parties, for review and approval by the Coordinating Committee by March 1, 1990. The purpose of the plan shall be to evaluate whether minimum FPE levels set out in subsection II.E are being met. The plan will provide for evaluation beginning in 1990 and continuing for at least three consecutive years after baffles are installed and operating in accordance with this Agreement in all five (5) bypass bays. If physical or

operational changes are made to the bypass systems, additional FPE evaluation under a new or amended plan will be required to provide at least three consecutive years of evaluation after completion of the changes.

2. It is the goal of evaluations under the plan to be able to determine FPE within plus or minus five percent (5%) at the ninety-five percent (95%) confidence level. If the FPE point estimates are equal to or greater than eighty-five percent (85%) for the spring run and seventy five percent (75%) for the summer run, then the accuracy of plus or minus ten percent (10%) at the ninety percent (90%) confidence level is acceptable. If the FPE point estimate for the spring run is between eighty (80) and eighty-five (85) percent, or the FPE point estimate for the summer run is between seventy (70) and seventy-five (75) percent, the PUD will implement one of the following actions:

(a) Take the necessary steps to achieve a FPE accuracy of plus or minus five percent (5%) at the ninety-five percent (95%) confidence level, or

(b) Take steps outlined in subsection II.E.3 to increase the FPE point estimates to eighty-five percent (85%) and seventy-five percent (75%) for the spring and summer runs, respectively.

3. The PUD will fund a biometrician or statistician selected by unanimous agreement of the Coordinating Committee to review the draft plan to ensure that the plan meets the objectives of subsections II.H.1 and 2, and to review results developed under the plan.

III. ADULT FISH PASSAGE

A. GENERAL SCOPE OF ADULT PASSAGE MEASURES

The current operating and maintenance criteria for facilities for the passage of adult anadromous fish over the Wells Project Dam are specified in this Section III. Changes in these criteria must be by unanimous agreement of the Coordinating Committee.

B. WATER DEPTH CRITERIA

The water depth over the weirs of the adult fish ladder will be 1.0 to 1.2 feet.

C. ENTRANCE CRITERIA

1. Head: 1.5 feet

2. Gate Settings:

a) March 1 - November 30

		Side Wing Gate	End Wing Gate
(i)	Spill less than 80 Kcfs	4 ft	6 ft
(ii)	Spill greater than 80 Kcfs	Closed	8 ft

(iii) Low level fixed orifice entrance to be open whenever side gate is closed.

b) December 1 - February 28

(i) Side and end gates open 2 feet six days per week for 24-hour periods.

(ii) Side and end gates open 4 feet and 6 feet, respectively, one day per week for a 24-hour period.

D. ATTRACTION JET CRITERIA

1. Jets are located in a vertical line immediately upstream of the side wing gates.

2. Lower jet (30-inch diameter) will operate only when the low level fixed orifice entrance is open.

3. Three 24-inch diameter jets (at elevations 700, 708, and 717 msl) will each be discharging when tailwater reaches that level.

E. STAFF GAUGE AND WATER LEVEL INDICATOR CRITERIA

Staff gauge and water level indicators will:

1. Be located upstream and downstream of all entrances, and at convenient locations for viewing along ladder.

2. Be located upstream and downstream of adult fishway exit trashrack.

3. Be readable at all water levels and be kept clean.

4. Be checked against panel board water surface readings to insure proper adjustment of water level sensing equipment.

F. TRASHRACK CRITERIA

1. Visible buildups of debris will be cleaned immediately from picketed leads near counting stations, and from trashracks at adult fishway exits.

2. The staff gauges upstream and downstream of the adult fishway exit trashrack will be monitored for water surface differential, which will reflect buildup on submerged trashrack. The trashrack will be cleaned immediately if the differential reading is greater than 0.3 feet.

G. MONITORING AND EVALUATION OF ADULT PASSAGE

1. In 1990, the PUD, in consultation with the Joint Fishery Parties, will develop a study plan to determine the extent of adult

delay and mortality at the Wells Project. The study plan will be reviewed and approved in advance by the Coordinating Committee. Studies will begin in 1991 and continue for a period of time determined by the Coordinating Committee based on preliminary results.

2. If the study identifies delays and/or mortality, the operating criteria specified in this Section III will be changed to alleviate these problems. If changes in the operating criteria do not alleviate the problems, adult passage facility modifications will be made. Provided, however, that any disagreements over the appropriateness of facility modifications of $325,000 or less (1988 dollars) may be taken through the expedited dispute resolution procedure in subsection I.D. And, provided further, that any disagreements over the appropriateness of facility modifications of more than $325,000 (1988 dollars) may be resolved under the FERC Rules of Practice and Procedure at any time.

IV. HATCHERY-BASED COMPENSATION

The PUD will fund a hatchery-based compensation program (the "Program") as provided in this Section IV. The Program will include the design, construction, operation, maintenance and evaluation of facilities required to implement the elements of a production plan (the "Production Plan") as set forth in this Section. The purpose of the Program is to mitigate for fish passage losses at Wells Dam. The Program is composed of adult collection sites; a central hatchery facility for incubation, early

rearing, and adult holding; and acclimation facilities in the tributaries above Wells Dam for final rearing and release.

A. PRODUCTION PLAN

1. The Joint Fishery Parties have developed the Production Plan to define the requirements of hatchery-based compensation under this Agreement. The Production Plan describes juvenile rearing and release requirements, including species mix and target release sizes; and related broodstock requirements under subsection IV.D.

2. The Production Plan will be reviewed annually by the Joint Fishery Parties, and may be modified by the Joint Fishery Parties in consultation with the PUD. Modifications to the Production Plan may include changes to the species mix and rearing and release strategies as required to accommodate the Joint Fishery Parties' management needs. Modifications to the Production Plan will not require an increase in the rearing capability of the Program beyond that required to satisfy Phases One and Two of the Production Plan as shown in subsections IV.A.3(a) and (b) or Phases Three and Four of the Production Plan to be determined as shown in sections IV.A.3(c) and (d). The Production Plan and any modifications thereto will be consistent with guidelines and procedures developed under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program.

3. The Production Plan is comprised of four phases of hatchery-based compensation as described below. It also includes related broodstock requirements under subsection IV.D.

(a) Phase One

Phase One will begin in 1991 and will consist of the following compensation elements:

(1) 49,200 pounds of spring chinook yearlings at about 15/pound;

(2) 8,000 pounds of sockeye juveniles at about 25/pound; and

(3) 30,000 pounds of steelhead smolts at about 6/pound

(4) After 1991, space to rear additional steelhead will be provided by the PUD at Wells Hatchery, if such space is available and not needed to meet other PUD fish production responsibilities. The PUD will not be obligated to fund or supply well water to rear the fish.

(b) Phase Two

Phase Two will begin after evaluation of the Phase One Production Plan and will be restricted to the Program required by either the Phase Two A or Two B Production Plan as shown below. At the time of implementation, the Phase Two A or Phase Two B Production Plan may be modified based on other Phase One evaluations described in subsection IV.C, Studies and Evaluations, subject to the provisions of subsection IV.A.2.

(1) Phase Two A

Increase sockeye production from 8,000 pounds to 15,000 pounds of juveniles at about 25/pound.

(2) Phase Two B

(i) Eliminate sockeye production;

(ii) Add 15,000 pounds of summer chinook yearlings at

about 10/pound; and 6,500 pounds of zero-age summer chinook juveniles at about 40/pound.

(c) Phase Three

Phase Three will begin as soon as practicable following Coordinating Committee approval of the results of the Wells Project juvenile mortality/survival study or no later than the third brood year after Coordinating Committee determination of the adjustments required and will consist of the following compensation elements:

(1) Except for steelhead, which shall remain at 30,000 pounds, adjust compensation requirement to reflect the difference between the juvenile mortality rate determined by the mortality/survival study under subsection IV.C.5 and the assumed mortality rate shown in Appendix A; and

(2) Adjust compensation requirement to reflect unavoidable and unmitigated adult losses, as determined by Coordinating Committee approved estimates from studies conducted under subsection III.G, and converted to juvenile production based on adult to smolt ratio estimates as described in Appendix B.

(d) Phase Four

Phase Four will begin at such time as the Coordinating Committee approved five-year rolling average estimate of juvenile run size, estimated as described in subsection IV.C.6 and Appendix A, increases to at least 110% of the 9,034,700 estimated juvenile migrant salmon production used to establish the Phase One and Phase Two compensation levels shown in subsections IV.A.3(a) and

IV.A.3(b). Phase Four will consist of compensation adjustment, if requested by the Joint Fishery Parties, to reflect the percentage increase in juvenile run size, except for steelhead, which shall remain at 30,000 pounds. The Joint Fishery Parties, in consultation with the PUD, will determine the appropriate form of compensation (i.e., fish production) for any adjustments required in Phase Four.

B. COMPENSATION PROGRAM

1. The facilities provided in the Program will be designed, constructed, operated, maintained, and evaluated to produce the hatchery-based compensation set forth in the Production Plan.

2. If the evaluations described in subsection IV.C indicate that the Program is not meeting the production levels called for in the Production Plan, then reasonable modifications to the Program will be made.

3. The PUD will only be obligated to assure the capability of facilities provided under this Agreement to produce high quality juvenile fish at the compensation levels shown in subsection IV.A.3.

4. The Program facilities described in this Agreement are in addition to the existing mitigation program at Wells. The existing mitigation program at Wells consists of annual production of 50,000 pounds of steelhead and 56,500 pounds of summer chinook salmon. Under the 1984 Mid-Columbia Stipulation, which expired in 1989, 400,000 summer chinook at 90/pound have been reared at Wells for release into the Methow River. This production will continue until

Phase One production is initiated. Nothing in this Agreement will affect the annual production of 25,000 pounds of steelhead under the Oroville-Tonasket agreement between the PUD and the U.S. Bureau of Reclamation.

5. Facilities provided in the Program will consist of:

(a) Phase One

Phase One compensation facilities, including satellite facilities, shall be capable of rearing and releasing 57,200 pounds of salmon and 30,000 pounds of steelhead annually.

(b) Phase Two

Phase Two compensation facilities shall be capable of increased production to accommodate the Production Plan as described in subsection IV.A.3(b).

(c) Phase Three

Phase Three compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(c).

(d) Phase Four

Phase Four compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(d). Facilities for the required adjustments will be constructed by the PUD as soon as practicable and be operational no later than the third brood year following the Joint Fishery Parties request under subsection IV.A.3(d).

6. Production and acclimation facilities used in the Program shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The biological criteria and guidelines described in subsection IV.D shall apply to production and acclimation facilities used in the Program.

C. STUDIES AND EVALUATIONS

1. The PUD will develop and fund studies in 1990, approved by unanimous agreement of the Coordinating Committee, to determine:

(a) Potential for spawning and rearing sockeye in unutilized habitat in the Okanogan and Similkameen systems;

(b) Potential for establishing sockeye populations in the new habitat.

2. The PUD will fund the Joint Fishery Parties' effort to determine the success of Phase One sockeye compensation based on review of smolt production. The Joint Fishery Parties may make this determination after the evaluation of the third brood year's production.

3. The PUD will fund the Joint Fishery Parties to develop and conduct studies to evaluate the adequacy of the Program and the effectiveness and success of the Production Plan subject to the provisions of Section V, Coordinating Committee. The studies will meet standards developed for similar efforts under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program. The studies will pass the test of reasonableness with respect to cost and duration.

(a) The studies will involve marking a portion of the juvenile fish produced under subsection IV.B and will involve recoveries of juvenile and adult fish to estimate various parameters such as fish health, fishery contribution, survival, spawning time and spawning locations.

(b) The PUD will fund recovery efforts at Wells Dam and hatchery and tributary spawning areas above Wells Dam. Existing recovery operations, currently funded through different sources, will be utilized to the extent possible. Approved studies may require the PUD's participation in funding a portion of other recovery efforts.

(c) The evaluations provide data necessary to determine the success of the Program to produce the intended compensation levels and the effectiveness of the Production Plan to meet management objectives.

(d) Evaluation of the Production Plan and Program effectiveness will be initiated in Phase One for all species in the Production Plan.

(e) To the extent that the Joint Fishery Parties elect to modify the Production Plan, the PUD will fund studies to evaluate the modifications. The studies will be mutually agreeable and are intended to evaluate only the changes called for in the modification. The studies will be consistent with the provisions of Section V, Coordinating Committee.

(f) The PUD will fund an analysis of annual fish production and adult contribution to harvest and escapement to be conducted

by the Joint Fishery Parties. The analysis will be consistent with the provisions of Section V, Coordinating Committee. Draft and final reports will be provided to the Parties.

5. No later than 1990, a Wells Project juvenile mortality/survival study will be developed by the PUD in consultation with the Joint Fishery Parties and approved by unanimous agreement of the Coordinating Committee. The studies will begin in 1991, after the installation of new turbine runners at the Wells Project, for the purpose of determining juvenile losses.

6. The PUD will provide data from its ongoing, annual adult passage monitoring program that will allow the Joint Fishery Parties to compute the five-year rolling average estimate of juvenile run size which will be the basis for Phase Four compensation, as indicated in subsection IV.A.3(d). Calculation of increases in juvenile run size will be based on fish from existing mitigation programs, natural production and future compensation programs. The method of calculation will be as described in Appendices A and B.

D. PRODUCTION/ACCLIMATION FACILITIES

Production and acclimation facilities under this Section shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The following biological criteria and guidelines shall apply to production and acclimation facilities under this subsection IV.D. Criteria are not to be exceeded. Guidelines are not to be exceeded if practicable.

1. Salmon Criteria

(a) Adult Holding

(i) Density not to exceed one (1) fish per ten (10) cubic feet of space.

(ii) Flow must be at least one (1) gallon per minute per 20 pounds of fish.

(b) Juvenile Rearing

(i) Density not to exceed 0.75 pounds of fish per cubic foot of rearing space for yearling chinook to a size of 10 fish per pound. Maximum density is achieved at release date. The density through out the rearing period is proportionately lower and directly related to fish size.

(ii) Pond or raceway loading rate not to exceed 6.0 pounds of fish per gallon of water per minute inflow for yearling chinook at a size of 10 fish per pound. Maximum loading rate is achieved at release date. The loading rate throughout the rearing period is proportionately lower and directly related to fish size.

(iii) Density for sockeye juveniles in net pens not to exceed 0.33 pounds of fish per cubic foot of rearing space.

(c) Water Supply

(i) Water will be of highest quality practicably available at appropriate sites. Ground water may be required at sites. All water supplies will be pathogen free if practicable. The water source must not preclude transfer of the stocks being reared to their point of origin due to presence of fish disease organisms in the rearing water supply.

(ii) Reuse of water is not acceptable for either egg incubation or juvenile rearing.

(iii) Reuse water is acceptable for adult holding.

(iv) Effluent water from egg incubation may require treatment for fish diseases (e.g., chlorination/dechlorination).

(v) Construction of facilities must accommodate the potential to treat the juvenile rearing and adult holding water for disease pathogens.

(d) General

(i) Facilities must have the capability to maintain stock segregation from adult holding through incubation and rearing.

(ii) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(iii) Protection from mammalian and avian predators must be provided.

2. Salmon Guidelines

(a) Water Temperatures

(i) Egg incubation - no greater than 55°F nor less than 38°F.

(ii) Fry starting - 48-52°F.

(iii) Juvenile rearing - not to exceed 52°F.

(iv) Adult holding - not to exceed 55°F.

(b) Release Size, Time, and Location

(i) Yearling spring chinook - 15 fish/pound in late April.

(ii) Yearling summer chinook - 10 fish/pound in late April.

(iii) Subyearling summer chinook - 40 fish/pound in June.

(iv) Subyearling sockeye - 25 fish/pound in June.

(v) Juvenile fish will be acclimated and released in tributaries above Wells Dam.

(c) Adult Brood Stock

(i) Sufficient adults of the appropriate species and stocks will be trapped and held to meet the egg requirements for each phase of salmon production.

(ii) Fifty percent (50%) of the adults trapped will be females and it is assumed there will be

approximately eighty percent (80%) survival of eggs from trapping of females to ponding of fry.

(iii) Adult brood stock will be collected at the following sites:

a) Spring chinook - Chewack River, Methow River above Winthrop, and Twisp River above river mile 2.0.

b) Summer chinook and sockeye - at Wells Dam

(iv) Tributary brood stock collection facilities will require an annually installed rack and a semi-permanent box trap.

(v) Wells Dam brood stock collection may require a separator/sorter in the left bank fishway. The final design of the left bank trap and any modification of the right bank trap will be approved by unanimous agreement of the Coordinating Committee.

(vi) The adults will be transferred in a water-to-water system from traps to tank trucks to holding ponds.

(vii) The PUD shall provide funds for personnel to separate and sort adult fish in the right bank fishway at Wells Dam and at other required adult collection sites. All brood stock collection shall be conducted in a manner to

minimize delay of non-target species and individual fish.

3. Steelhead Criteria

The goal for this program is to use the existing facilities including well and river water, raceways, rearing ponds, house, shop, freezer, office, etc., in the manner they are being used now. Most of the following criteria and guidelines fit the existing program.

(a) Adult Holding

(i) Density not to exceed 2.5 pounds of fish per cubic foot of water.

(ii) Flow must be at least one gallon per minute for 3.3 pounds of fish.

(b) Juvenile Rearing

(i) Density: Calculated density limit not to exceed Pipers density formula: $W = D \times V \times L$ where

W = Permissible weight in pounds.

D = Density index (.25 for raceways and .03 for rearing ponds).

V = Useable volume in container in cubic feet.

L = Fish length in inches.

ii) Water flow: Calculated flow should not allow weight to exceed Pipers flow formula:

$W = F \times L \times I$ where

W = Permissible weight in pounds.

F = The loading factor from Table 1.

L = Fish length in inches.

I = Water flow in gallons per minute.

Table 1. Load factor as related to water temperature and elevation.

Water Temperature(°F)	Load Factor(lbs/in/gpm) Raceways(1)	Rearing Ponds(2)
40	2.70	3.62
41	2.61	3.53
42	2.52	3.44
43	2.43	3.35
44	2.34	3.26
45	2.25	3.17
46	2.16	3.08
47	2.07	2.99
48	1.98	2.90
49	1.89	2.81
50	1.80	2.72
51	1.73	2.65
52	1.67	2.59
53	1.61	2.53
54	1.55	2.47
55	1.50	2.42
56	1.45	2.37
57	1.41	2.33
58	1.36	2.28
59	1.32	2.24
60	1.29	2.21
61	1.25	2.17
62	1.22	2.14
63	1.18	2.10
64	1.15	2.07

1) From Piper et al. 1978
2) From Wells hatchery

(c) Water Supply

(i) Water supply to be of highest quality practicably available using ground and river water. Any disease contracted because of water source

must not stop release of fish in local watersheds.

(ii) Reuse water not acceptable for egg incubation.

(iii) Reuse water normally acceptable (unless disease problem) for adult holding.

(iv) Effluent water from egg incubation will require treatment for fish diseases.

(v) Adult holding and juvenile rearing water may have to be treated for disease pathogens.

(d) General

(i) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(ii) Protection from mammalian and avian predators must be provided.

4. Steelhead Guidelines

(a) Water Temperatures

(i) Egg incubation: 38°F to 55°F

(ii) Fry starting: 48°F to 54°F

(iii) Juvenile Rearing not to exceed 57°F

(iv) Pre-smolt not to exceed 54°F

(v) Adult holding not to exceed 54°F

(b) Release age, time, size and location

(i) Released as yearlings

(ii) April 10 to May 10 at six to the pound.

(iii) Juvenile steelhead will be released in tributaries or into the mainstem above Wells Dam.

(c) Adult Broodstock

(i) Fifty percent (50%) will be females and assume eighty percent survival of eggs to ponding of fry.

(ii) Adults will normally be trapped at the existing facilities on the right bank, however new trap at left bank may be used sometimes.

(iii) Adults will be transferred in water from traps to holding ponds.

V. WELLS PROJECT COORDINATING COMMITTEE

A. COORDINATING COMMITTEE

There shall be a Wells Project Coordinating Committee composed of one (1) technical representative of each Party to this Agreement. The Coordinating Committee shall meet whenever requested by any two (2) Parties following a minimum of ten (10) days written notice (unless waived), or pursuant to subsection I.D, and shall act only by unanimous agreement of all Parties. Any Joint Fishery Party may, at any time, elect by written notice not to participate in the Coordinating Committee. The PUD shall fund a neutral third party to record and distribute minutes of Coordinating Committee meetings.

B. USE OF COMMITTEE

The Coordinating Committee will be used as the primary means of consultation and coordination between the PUD and the Joint Fishery Parties in connection with the conduct of studies and implementation of the measures set forth in this Agreement and for dispute resolution pursuant to subsection I.D. All study designs and modifications to study designs will be subject to agreement by all Parties.

C. STUDIES AND REPORTS

1. All studies and reports prepared under this Agreement will be available to all Parties as soon as reasonably possible. Draft reports will be circulated through Coordinating Committee representatives for comment, and comments will either be addressed in order or made an appendix to the final report.

2. All studies will be conducted following accepted techniques and methodologies in use for similar studies in the Columbia Basin. All studies will be based on sound statistical design and analysis.

3. Fish passage efficiency tests will be conducted using hydroacoustic means and direct capture methods for species identification.

VI. JOINT FISHERY PARTIES' RESPONSIBILITIES

A. LIMITATION OF MID-COLUMBIA PROCEEDING

The Joint Fishery Parties agree to join with the PUD to request that the FERC terminate the Mid-Columbia proceeding insofar

as it pertains to the Wells Project. The Parties specifically agree to reserve the right to enforce the terms and conditions of this Agreement before the FERC.

B. SUPPORT FOR RELICENSE

The PUD's FERC license for the Wells Hydroelectric Project expires in 2012. The Joint Fishery Parties agree to be supportive of the PUD's new or renewal license application to the FERC, provided that the PUD has adhered to the terms and conditions of this Settlement Agreement, as well as any future terms, conditions, and obligations agreed upon by the Parties hereto or imposed upon the PUD by the FERC. To the extent that the PUD has met such terms and conditions, the Joint Fishery Parties agree that the PUD is a competent license holder with respect to its obligations to anadromous fish resources. Nothing in this paragraph shall limit or preclude any Party hereto from requesting at the time of any license renewal the provision of or supporting different, modified or additional fish protection measures and compensation; or from requiring that the fishery protection measures contained in a competing license application be included as a condition of the PUD's new license, or in the absence of such additional or modified measures in a new license, or in the absence of measures contained in a competing license application requested by the Joint Fishery Parties, from requesting that the PUD's new or renewal license application be denied.

C. STIPULATION OF ADEQUACY

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement constitutes adequate fish protection and full compensation for all fishery losses caused by the Wells Project at least until March 1, 2004. It is further stipulated that this Agreement satisfies any obligations of any Party relating to the adequacy of fish protection and compensation for fish losses caused by the Wells Project, and arising under applicable laws and regulations, including but not limited to the Federal Power Act, the Pacific Northwest Electric Power Planning and Conservation Act, and the Electric Consumers Protection Act of 1986, at least until March 1, 2004. This Agreement shall not otherwise affect the rights of any Party except as expressly covered by this Agreement.

D. FISH AND WILDLIFE PROGRAM

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement shall constitute full compliance with the applicable provisions of the Northwest Power Planning Council's 1987 Fish and Wildlife Program, at least until March 1, 2004. The Joint Fishery Parties stipulate that the PUD shall receive full credit for its hatchery production in meeting any requirements that may be established as a result of implementation of Section 203 of the Council's Program.

E. LIMITATION ON REOPENING

The Joint Fishery Parties shall not invoke or rely upon any reopener clause set forth in any license applicable to the Wells

Project for the purpose of obtaining additional fish measures or changes in project structures or operations pertaining to fishery issues until after March 1, 2004.

F. ADDITIONAL MEASURES

The Joint Fishery Parties shall refrain from contending on their own behalf or supporting any contention by other persons in any proceeding or forum that additional fish measures or changes in project structures or operations pertaining to fishery issues should be imposed at the Wells Project until after March 1, 2004.

VII. MISCELLANEOUS

A. COOPERATION

The Parties shall cooperate in conducting studies and shall provide assistance in obtaining any approvals or permits which may be required for implementation of this Agreement.

B. NOTICES

All written notices to be given pursuant to this Agreement shall be mailed by first-class mail, postage prepaid, to each Party at the address listed below or such subsequent address as a Party shall identify by written notice to all other Parties. Notices shall be deemed to be given three (3) days after the date of mailing.

C. WAIVER OF DEFAULT

Any waiver at any time by any Party hereto of any right with respect to any other Party with respect to any matter arising in

connection with this Agreement shall not be considered a waiver with respect to any subsequent default or matter.

D. ENTIRE AGREEMENT -- MODIFICATIONS

All previous communications between the Parties hereto, either verbal or written, with reference to the subject matter of this Agreement are hereby abrogated, and this Agreement duly accepted and approved, constitutes the entire agreement between the Parties hereto, and no modifications of this Agreement shall be binding upon any Party unless executed or approved in accordance with the procedures set forth in subsection I.C.

E. BENEFIT AND ASSIGNMENT

This Agreement shall be binding upon and inure to the benefit of the Parties hereto and their successors and assigns provided, no interest, right or obligation under this Agreement shall be transferred or assigned by any Party hereto to any other Party or to any third party without the written consent of all other Parties, except by a Party:

(a) To any person or entity into which or with which the Party making the assignment or transfer is merged or consolidated or to which such Party transfers substantially all of its assets; or

(b) To any person or entity that wholly owns, is wholly owned by or is wholly owned in common with the Party making the assignment or transfer.

F. FORCE MAJEURE

The PUD shall not be liable for failure to perform or for delay in performance due to any cause beyond its reasonable control. This may include, but is not limited to, fire, flood, strike or other labor disruption, act of God, act of any governmental authority or of the Joint Fishery Parties, embargo, fuel or energy unavailability, wrecks or unavoidable delays in transportation, and inability to obtain necessary labor, materials or manufacturing facilities from generally recognized sources in the applicable industry. The PUD will make all reasonable efforts to resume performance promptly once the force majeure is eliminated.

G. INFLATION CALCULATIONS

All dollars specified in this Agreement are 1988 dollars. Dollar figures shall be adjusted annually for each year after 1988 based on the "Consumer Price Index for All Urban Consumers" published by the Bureau of Labor Statistics of the U.S. Department of Labor. If this index is discontinued or becomes unavailable, a comparable index agreeable to all Parties will be substituted.

H. METHOW RIVER HATCHERY WATER SUPPLY

1. The PUD agrees to cooperate with the Washington Department of Fisheries (WDF) to secure the necessary water rights and permits for facilities to be provided under this Agreement.

2. With respect to the proposed Methow River hatchery, the Parties agree that WDF and the PUD may utilize for the proposed Methow River hatchery facility up to 7 cfs of the water right now

held by the U.S. Fish and Wildlife Service (FWS), and subject to full or partial recall by FWS for any reason. The PUD shall not obtain legal title or ownership of the FWS water right.

3. To the extent that the utilization of water does not occur or is recalled or returned to FWS, the PUD and WDF shall use their best efforts to acquire an alternative source of water that meets applicable State requirements for water rights in order to satisfy obligations under this Agreement.

4. The PUD agrees to cooperate with WDF to secure the necessary permits in order to construct and provide for the operation of the proposed Methow River hatchery. The hatchery will be designed and constructed with the capability of installing pump-back facilities for returning the flow to the point of diversion.

5. If hatchery and/or river water supply requirements dictate the need for installation of a pump-back scheme, the PUD shall install and WDF shall operate the pump-back facilities.

VIII. REGULATORY APPROVAL

A. FERC ORDERS

All Parties agree to join in the filing of an offer of settlement with the FERC based on this Agreement and to request that the FERC issue appropriate orders approving the settlement. All Parties shall refrain from seeking judicial review of the FERC orders approving this Agreement.

B. PERFORMANCE CONTINGENT ON APPROVAL

Performance of all Parties' obligations under this Agreement

is expressly made contingent on obtaining all necessary regulatory approvals, specifically including all FERC orders referred to in subsection VIII.A above, and all applicable federal, state and local permits. It is expressly agreed by all Parties that this Agreement shall be submitted to the FERC as a unit and any material modification of its terms, approval of less than the entire Agreement, or addition of material terms by the FERC shall make this Agreement voidable at the option of any Party.

C. NO PREJUDICE

All Parties stipulate that neither FERC approval nor any Party's execution of this Agreement shall constitute approval or admission of, or precedent regarding, any principle, fact or issue in the Mid-Columbia proceedings, or any other FERC proceeding, including subsequent modification proceedings under Section I.

D. EXECUTION

This Agreement may be executed in counterparts. A copy with all original executed signature pages affixed shall constitute the original Agreement. The date of execution shall be the date of the final Party's signature. Approval of this Agreement must be acknowledged by the Commissioner of Indian Affairs and the Secretary of the Interior, or their delegates, to the extent required by 25 U.S.C. § 81.

E. AUTHORITY

Each Party to this Agreement hereby represents and acknowledges that it has full legal authority to execute this Agreement and shall be fully bound by the terms hereof.

F. ACTION FOR NONCOMPLIANCE

Notwithstanding any other provision of this Agreement, any Party may seek relief arising solely from noncompliance with this Agreement by any Party; provided, all requests for specific performance of any provision of this Agreement shall be filed with the FERC pursuant to subsection I.D.

IN WITNESS WHEREOF, the Parties have executed this Agreement the day and year first written above.

APPENDIX A

JUVENILE MIGRANT LOSS ESTIMATES USED FOR COMPENSATION PLANS IN THE WELLS DAM SETTLEMENT AGREEMENT

1. Steelhead

The number of juvenile steelhead migrants killed by passage through the Wells Project reservoir and dam were not estimated for the purposes of this Settlement Agreement. As an alternative the parties have agreed to continue steelhead production programs and plans initiated under previous Mid-Columbia settlements.

2. Salmon Loss Estimates

The number of juvenile salmon migrants killed by passage through the Wells Project reservoir and dam were estimated as follows:

a. The number of juvenile migrant salmon, by species and race, entering the Wells Reservoir was estimated for natural production by applying sex ratios, egg per female data and theoretical egg to migrant survival rates to the numbers of adults passing above Wells Dam to spawn. These juvenile migrant numbers were computed annually and averaged over the passage years 1975-1984 for spring and summer chinook and averaged over the passage years 1975-1986 for sockeye. The recent average level of hatchery releases at Winthrop National Fish Hatchery were added to the spring chinook migrant estimates. The resulting estimates of average annual numbers

of juvenile migrant salmon entering Wells reservoir are:

Spring Chinook	=	1,504,400
Summer Chinook	=	2,913,300
Sockeye	=	4,617,000
Total	=	9,034,700

b. The total project mortality at Wells, including reservoir mortality, was estimated to be 14%. Applying this mortality rate to the population estimates in Item 1 above results in the following estimates of juvenile migrants killed by species:

Spring Chinook	=	210,600
Summer Chinook	=	407,900
Sockeye	=	646,400
Total loss	=	1,264,900

3. Derivation of Production Plan

a. The Phase I compensation Production Plan and Program is an initial step in production which is not intended to provide full compensation for juvenile migrant losses. The lack of full compensation is due to the experimental nature and developmental aspects of the sockeye Production Plan and Program.

b. To accommodate logistic and per-unit cost factors in Phase I development, about 225,000 (15,000 pounds) spring chinook were substituted for 231,000 sockeye.

c. Items (1) through (3) below describe the derivation of the hatchery-based compensation levels included in the body of the Agreement.

(1) Steelhead production is set at 30,000 lbs./year to continue the successful program initiated under prior Mid-Columbia Settlement Agreements.

(2) Phase I compensation includes a pilot program for hatchery production of sockeye. The sockeye production level is set to allow assessment of Program success rather than provide full compensation for the estimated juvenile losses at Wells.

(3) The Phase II Chinook/Sockeye Production Plan is sized to mitigate for estimated juvenile losses:

	Estimated Annual Losses at Wells	Annual Production Phase IIA or Phase IIB	
Spring Chinook	210,600	450,000	450,000
Summer Chinook	407,900	400,000	810,000
Sockeye	646,400	375,000	-
TOTALS	1,264,900	1,225,000	1,260,000

4. Chelan PUD/Douglas PUD Compensation Exchange

In recognition of the specific requirements for spring and summer chinook rearing facilities and the characteristics of the water supply at the PUD's proposed spring chinook rearing facility on the Methow River, the Joint Fisheries Parties, Douglas PUD and Chelan County PUD have reviewed the respective compensation

obligations of Douglas PUD as set forth in this Agreement, and Chelan County PUD under terms of the Rock Island Settlement. In consideration of biological efficiency and logistical effectiveness, the parties have agreed to adjusted compensation obligations under this agreement and the Rock Island Settlement in the following manner:

a. Douglas PUD will assume responsibility for 19,200 pounds of Methow River sub-basin spring chinook production.

b. Chelan PUD will assume responsibility for 40,000 pounds of Methow River summer chinook production.

The resulting changes in production with the Douglas-Chelan compensation exchange agreement are (number of juveniles/year):

	Douglas Production	Chelan Production
Spring Chinook	Increases 288,000	Decreases 288,000
Summer Chinook	Decreases 400,000	Increases 400,000
Sockeye	No Effect	No Effect

c. The resultant Douglas PUD annual compensation program under this agreement (Phase II Production) is:

Phase IIA

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Sockeye @ 25/lb.

OR

Phase IIB

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Summer Chinook @ 10/lb.

6,500 lbs. of Summer Chinook at 40/lb.

APPENDIX B

DETERMINATION OF RESPONSIBILITY FOR HATCHERY COMPENSATION

For each year of determination, calculate an average smolt output as follows:

1. Calculate a 5-year running average adult run (by species) for naturally spawned fish (Ays) as follows:

$$\bar{A}ys = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

Where Ay is the total adult count for each species at Wells minus the hatchery escapement for the species in year y;

Ay-1 = the same in the previous year (y-1) and so on.

2. Multiply Ays by the average expected adult to smolt production factor Kys for each species, where Kys is calculated as follows:

a. Spring Chinook:

Ksp = 0.94 (Wells Dam to spawner survival)
x 0.50 (sex ratio) x 5000 (eggs/female)
x 0.10 (av. survival to smolt) = 235

b. Summer Chinook:

Ksu = 0.94 x 0.50 x 5000 x 0.30 = 705

c. Sockeye:

$$Kso = 0.94 \times 0.50 \times 2700 \times 0.12 = 152$$

3. Add the number of hatchery smolts HSys by species, which is a running average of the same 5 years as in Ays.

$$\overline{\overline{HSys}} = \frac{HSy + HSy\text{-}1 + HSy\text{-}2 + HSy\text{-}3 + HSy\text{-}4}{5}$$

4. Total smolts (by species):

$$\bar{S}ys = Kys \times \bar{A}ys + \overline{\overline{HS}}ys$$

5. Grand Total = Sum of all species:

$$Sgt = \bar{S}sp + \bar{S}su + \bar{S}so + \ldots$$

6. If other salmon species or races, for which the above smolt production factors (Kys) do not apply, become established in the production areas above Wells Dam, appropriate K factors for these fish will be established by consensus of the Coordinating Committee. Juvenile migrant production will be computed for these species or races. These numbers will be included in the grand total for juvenile migrant production and the 5-year running averages.

WELLS PHASE IV THEORETICAL CALCULATION EXAMPLE

NATURAL PRODUCTION

DATA USED IN EXAMPLE CALCULATION OF NATURAL PRODUCTION

Adult Count	Ay	Ay-1	Ay-2	Ay-3	Ay-4	5 Year Average
Spring Chinook	3,000	2,200	3,100	5,000	2,900	3,240
Summer Chinook	2,400	2,800	3,700	4,000	4,700	3,520
Sockeye	40,000	20,000	35,000	15,000	30,000	28,000

Ay = Wells Count Minus Hatchery Escapement for Year Y

Ksp = Calculated Spring Chinook Smolts

Ksu = Calculated Summer Chinook Smolts

Ksoe = Calculated Sockeye Smolts

Spring Chinook $\bar{A}y = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$

$= \frac{3000 + 2200 + 3100 + 5000 + 2900}{5}$

$= 3240$

Summer Chinook $\bar{A}y = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$

$= \frac{2400 + 2800 + 3700 + 4000 + 4700}{5}$

$= 3520$

Sockeye $\bar{A}y = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}5}{5}$

$= \frac{40,000 + 20,000 + 35,000 + 15,000 + 30,000}{5}$

$= 28,000$

Ksp, su, soc = Adult/redd factor x sex ratio x eggs/female x eggs to smolt survival x dam count minus hatchery return

Calculated Average Total Smolts (Natural)

Spring Chinook Ksp = .94 x .50 x 5000 x .10 x 3240
= 235 x 3240
= 761,400

Summer Chinook Ksu = .94 x .50 x 5000 x .30 x Ay
= 705 x 3520
= 2,481,600

Sockeye Ksoc = .94 x .50 x 2700 x .12 x Ay
= 152 x 28,000
= 4,263,800

Average Total Natural Smolts

= Ksp + Ksu + Ksoc
= 761,400 + 2,481,600 + 4,263,800
= 7,506,800

HATCHERY PRODUCTION

DATA USED IN EXAMPLE DETERMINATION OF HATCHERY PRODUCTION

SMOLT PRODUCTION IN MILLIONS BY YEAR

Hatchery	Y	Y-1	Y-2	Y-3	Y-4	5 Year Average
Winthrop	1.5	1.1	1.0	.95	.95	1.1
Methow	.8	.8	.675	.40	.25	.585
Twisp Acclimation	.40	.40	.40	.25	.2	.33
Sockeye Net Pens	.2	.2	.2	.15	.1	.17

Hatchery Smolt Production

Winthrop Hatchery = $\frac{1,500,000 + 1,100,000 + 1,000,000 + 950,000 + 950,000}{5}$

= 1,100,000

Methow Hatchery = $\frac{800,000 + 800,000 + 675,000 + 400,000 + 250,000}{5}$

= 585,000

Twisp Accl. Pond = $\frac{400,000 + 400,000 + 400,000 + 250,000 + 200,000}{5}$

= 330,000

Sockeye Net Pens* = $\frac{200,000 + 200,000 + 200,000 + 150,000 + 100,000}{5}$

= 170,000

*Need Adjustment Factor For Survival To Migration

Average Total Hatchery Smolts

Winthrop	=	1,100,000
Methow	=	585,000
Twisp	=	330,000
Net Pens	=	170,000
		2,185,000

Average Total Hatchery/Natural Smolts
(5 Year Average for Years Y-4, Y-3, Y-2, Y-1 and Y)

Natural	=	7,779,000
Hatchery	=	2,185,000
Total	=	9,964,000

PHASE IV DETERMINATION

Base Number Smolts Used for Initial Compensation = 9,034,700

Calculated Average Natural + Hatchery Smolts in Years Y-4, Y-3, Y-2, Y-1 and Y = 9,964,000

Calculated Average Natural + Hatchery Smolts Minus Base Number Smolts = 929,300

Difference Between Base Number Smolts and Calculated Natural + Hatchery Smolts X Wells Project Mortality Rate = 929,300 X .14

= Additional Smolts Possible Under Phase IV 130,102

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

Howard Frey
Commissioner

Michael Gaunt
Commissioner

T. James Davis
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

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FOR PACIFIC POWER & LIGHT COMPANY:

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

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FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

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FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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Commissioner

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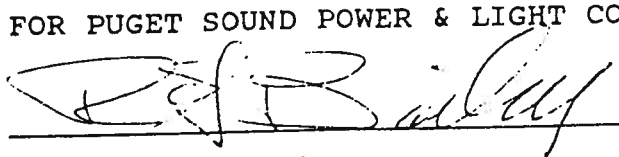
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:



FOR PACIFIC POWER & LIGHT COMPANY:

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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OF FISHERIES:

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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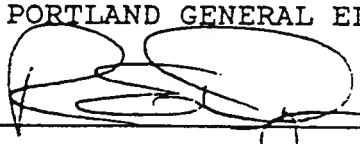

FOR THE WASHINGTON DEPARTMENT
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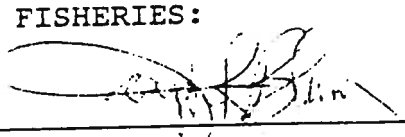
6/11/90

FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

Ray Ryan 6/11/90

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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FOR THE NATIONAL MARINE
FISHERIES SERVICE:

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FOR THE U.S. FISH & WILDLIFE SERVICE:

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FOR THE CONFEDERATED TRIBES AND BANDS
OF THE YAKIMA INDIAN NATION:

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FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES
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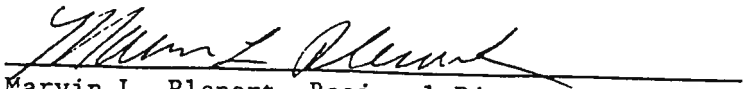

Marvin L. Plenert, Regional Director
FOR THE U.S. FISH & WILDLIFE SERVICE

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FOR THE CONFEDERATED TRIBES AND BANDS
OF THE YAKIMA INDIAN NATION:

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FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES
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Lewis George
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OF THE UMATILLA INDIAN RESERVATION:

Edward H. Patawa

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FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

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