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

Chief Executive Officer/Manager:
ELDON E. LANDIN

Public Utility District No.1 of Douglas County
1151 Valley Mall Parkway • East Wenatchee, Washington 98802-4497 509/884-7191

April 29, 1996

Ms. Lois Cashell
Federal Energy Regulatory Commission
825 North Capitol Street N. E.
Washington, D. C. 20426

Subject: Wells Hydroelectric Project - FERC No. 2149 WA
Annual Report - Fish Settlement Agreement
Docket No.'s P-2149-002 and E-9569-002

Dear Ms. Cashell:

In accordance with paragraph E of the order approving Settlement Agreement issued January 24, 1991, we submit the enclosed annual report of activities related to our settlement agreement for the Wells Project. 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 sixth annual report covers activities performed in 1995 and planned for 1996.

Very truly yours,

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

nvh

Enclosures

c: (with report, but not appendices)

Mr. John Miyashiro	Mr. Dan Ballbach
Mr. James Hastreiter	Mr. Bill Frymire
Mr. Ron Boyce	Mr. Niel Moeller
Mr. Brian Cates	Mr. Alan Stay
Mr. Mike Erho	Mr. Tim Weaver
Mr. Cary Feldmann	Mr. Garfield Jeffers
Mr. Stuart Hammond	Mr. Richard Nason
Mr. Robert Heinith	Mr. Tom Scribner
Mr. Bill Hevlin	Mr. Rod Woodin
Mr. Jerry Marco	

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Mr. Jerry Marco	

bc: Mr. Eldon Landin
Mr. William Dobbins Mr. Rick Klinge

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UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

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

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

ORDER APPROVING SETTLEMENT AGREEMENT

(Issued January 24, 1991)

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

BACKGROUND

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

1/ 6 FERC ¶ 61,210 (1979).

2/ 45 FERC ¶ 61,401 (1988).

3/ 46 FERC ¶ 61,033 (1989).

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

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

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

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

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

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

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

4/ 30 FERC ¶ 61,285 (1985).

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

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

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

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

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

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

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

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

DISCUSSION

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

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

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

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

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

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

The Commission orders:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(F) This order is final unless a request for rehearing is filed within 30 days from the date of its issuance, as provided in Section 313(a) of the Federal Power Act. The filing of a request for rehearing does not operate as a stay of the effective

date of this order or of any other date specified in this order, except as specifically ordered by the Commission. The licensee's failure to file a request for rehearing shall constitute acceptance of the order.

By the Commission.

(S E A L)

Lois D. Cashell,
Secretary.

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Report to the Federal Energy Regulatory Commission for
Activities under the Long-Term Settlement Agreement
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County Washington
for the 1995 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, 1996

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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 and Douglas County PUD and its Purchasers on the operations of the Wells Project (No. 2149). The F.E.R.C. directed that the District 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 sixth annual report under the Agreement and covers the period between January 1 to December 31, 1995.

Report to the Federal Energy Regulatory Commission for
Activities under the Long-Term Settlement Agreement
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County Washington
for the 1995 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 1995

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 Annual Bypass Plan for 1995 to the WCC for review on December 15, 1994. The WCC accepted the Plan (95-2)[1] (Appendix A). The spring and summer migration is monitored by hydroacoustics at Wells. The level of hydroacoustic detection is proportionally to the magnitude of the salmonid migration.

The Bypass Team for the Wells Project makes decisions on bypass operations during both spring and summer migration periods. Representatives from the agencies, Tribes and District make up the team (Agreement II.F.3). Members selected for the team in 1995 were Brian Cates (US Fish and Wildlife Service; USFWS), Jerry Marco (Colville Confederates Tribes; CCT) and Rick Klinge (District) (95-2).

1.2 Methow Hatchery Evaluation Plan

The Settlement Agreement calls for an evaluation of the program or facilities built by the District (Section IV). The evaluation plan looks at the adequacy of the facility and operations to be able to implement the hatchery plan. The Evaluation was circulated to the committee (95-1, 2, 4) and was finalized (95-6; Appendix B). The evaluation plan emphasized stock demographics and recruitment. It also called for better cooperation between the Winthrop National Fish Hatchery operated by USFWS and the Methow Hatchery, operated by Washington Department of Fish and Wildlife, (WDFW).

The evaluation plan called for a Methow Hatchery Technical Advisory Committee to provide oversight on an annual basis of the evaluation process. This group was made up of Brian Cates (USFWS), Tom Scribner, Yakama Indian Nation (YIN), Jerry Marco, CCT, Rick Klinge, (District) and a WDFW representative (95-4).

[1](95-2) refers to minutes of the Wells Coordinating Committee from the second meeting in 1995. See Appendix J

1.3 Methow Adult Trap

The Settlement Agreement calls for adult collection facilities for spring chinook broodstock (Agreement IV.D.2.c.(3)(a)). Traps on the Twisp and Chewuck Rivers were completed in 1992. The Methow River trap was scheduled for construction with the improvements to the Fog Horn Ditch intake, fish ladder and dam for 1993. The project was delayed a year during the environmental review. In 1995, an agreement between the District, US Fish and Wildlife Service and Washington Department of Fish and Wildlife was amended to consider the increase in cost of the project, to include the trapping facilities with the ditch intake improvements and outline desire for mutual working relationship between the new Methow Hatchery and the US Fish and Wildlife Hatchery at Winthrop (95-1, 2). The project was near completion at the end of the calendar year (95-6,7).

1.4 Methow Hatchery Broodstock Collection Protocol

The Washington Department of Fish and Wildlife (WDFW) submitted to the WCC a spring chinook broodstock trapping protocol for the Methow Hatchery (95-3; Appendix C). Trapping would be moved from tributary traps to Wells Dam due to an extremely low return of adult spring chinook. An attempt would be made to distinguish among the three stocks by analysis of elements found in the early life portions of the scales (95-3, 4). There was concern over removal of any or all adults from natural production and a suggestion that 100 adults and jacks above Wells Dam be established as the minimum natural escapement goal (95-4). Later, WDFW felt it best to suspend all brood collection efforts. This decision was based upon improvement in jack counts pointing to improved run size in 1996, hesitancy in collecting brood from a point where stocks were mixed without a tool to separate, and an unwillingness to compromise the supplementation philosophy of this new facility (95-5). The WCC supported the decision. It was decided to retain only hatchery based fish that may return to hatcheries in the Methow for production (95-5).

1.5 Adult Passage Study

The Mid-Columbia Coordinating Committee (MCCC 95-1, 7[2]) discussed how radio tagged adult salmon and steelhead may provide additional information on passage at mid-Columbia dams. The information from this work would complement the 1992 Telemetry Study at Wells and the 1993 Telemetry Studies performed in the mid-Columbia.

1.6 Squawfish removal in the Wells Dam Tailrace

The District presented plans for control of squawfish in the tailrace and Wells Fish Hatchery outfall area immediately downstream from Wells Dam for 1995 (95-1, 2). The plan called for removal of squawfish with gillnets and sport gear from April through July of 1995. Some biological data and possibly population census information would also be collected. Rod Woodin (WDFW) expressed concern that non-selective gear may catch both salmonids and game fish (95-1). There was decision that the three mid-Columbia PUD's attempt to cooperate in respect to population census estimates (95-2).

---

[2] MCCC 95-1 refers to the first meeting of the Mid-Columbia Coordinating Committee. Discussions of studies that involved Wells Dam and some or all of the other Mid-Columbia Dams were covered in the Mid-Columbia Coordinating Committee. Minutes from these meetings are found in Appendix K.

1.7 Sockeye Salmon Mitigation

The Settlement Agreement calls for four phases of hatchery based compensation. The sockeye salmon pilot project started with 8,000 lbs. of production of fish at 25 fish per pound. If evaluation of the program showed success after three years, then the program would increase to 15,000 pounds of production (Agreement IV.A.3.(a)(2); IV.A.3.(b)(1); and IV.C.2).

A draft broodstock protocol was distributed for review (95-5; Appendix D). The protocol called for collection of 344 adults sockeye at Wells. Collection would coincide with the summer chinook collection activities at the East Ladder at Wells, since both stocks are migrating at the same time.

1.8 Okanogan Sockeye Salmon Planning

The District expressed concern that continuation of a hatchery program for Okanogan Sockeye in British Columbia should come after a clear understanding of Canadian fisheries agencies positions to the net pen program in Lake Osoyoos. Early in the year, members of the WCC developed a draft goal statement to help planning of activities among the Joint Fisheries Parties and the Canadian fisheries interests for Okanogan nerkids (sockeye and kokanee; 95-1). Members of the WCC were concerned because issues outside the purview of the Wells Committee were included in the draft plan (kokanee) and thus the plan was not adopted. The WCC agreed there was a need to have meetings with Canadian fish managers to discuss options (95-2).

Some discussion occurred this year with Canadian fisheries agencies on possible projects with Okanogan sockeye. British Columbia had expressed some openness to an adult transportation study to Lake Osoyoos (95-4). Other research discussed were evaluation of irrigation practices in the Okanagan River in British Columbia (95-5), transportation of adult sockeye around the thermal barrier in the Okanogan and a watershed analysis (95-6).

At the end of the year, plans were being made for a second Okanogan Sockeye Workshop to help with planning and to see if some common ground between Canadian and U.S. fisheries parties could be reached. The workshop was be held in early 1996 (95-7).

1.9 Okanogan Sockeye Spawning Ground Surveys

The District volunteered to head up a spawning ground survey with participation from the various fisheries parties (95-6). The WCC requested that methodology be similar to that of efforts in 1992 and 1993.

1.10 Project Mortality Study

The Settlement Agreement specified the District, with consultation from the Joint Fisheries Parties, will develop a study of juvenile mortality associated with Wells Project by 1990 (IV,C,5). Results from this work would adjust compensation levels of the hatchery programs. The WCC had decided not to pursue this work each year since 1991. The WCC had not planned for this work to be done in 1995, nor was there any planning for 1996.

1.11 1996 Bypass Operational Plan

The District submitted to the WCC a Bypass Operational Plan for 1996, as per Section II.F.1 of the Settlement Agreement (95-7). The plan outlined scheduled hatchery releases above Wells Dam and anticipated the starting and completion date of bypass operation (Appendix F).

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Operation of the Juvenile Bypass

The 1995 Bypass was initiated on April 8 when the Bypass Team determined the hydroacoustic index was reflecting the start of the spring migration. The Bypass was operated for 60 days during the spring migration and used approximately 6% of project inflow for bypass operation. Summer Bypass operations were started on June 21 and continued through August 29. Summer bypass operated for 66 days and used 6% of project in flow.

2.2 Sockeye Pilot Program

The Colville Confederated Tribes prepared a report on the evaluation of 1993 brood sockeye, liberated in the spring of 1994. The draft report showed that 2.8% of the net pen fish migrated out of Lake Osoyoos that spring (Appendix F). Sockeye released were very small (average fork length was 83mm). Environmental Monitoring efforts for the impact from the net pens on the lake showed no impact from holding sockeye during April and May of 1994. The report also shows environmental conditions in Lake Osoyoos from April through September.

Sockeye brood were collected at Wells Dam in 1994, spawned and eggs incubated and fish reared at the Cassimer Bar facility. Adults and eggs were found to be IHN negative (95-2). There were about 41,000 sockeye marked with a right ventral clip and placed in net-pens in Lake Osoyoos (95-4). These fish would be looked for at sampling stations at Rocky Reach and Rock Island dams (95-4). Again, lake monitoring of impacts from the net pen program showed no effect (Appendix G).

Brood goal for 1995 was 334 adults. There were 337 adults collected for the pilot program released in 1996. The adults were smaller than previous years.

2.3 Spring Chinook Salmon Hatchery

As part of the evaluation of the Spring Chinook Program, an annual review is provided of the culture at the Methow Salmon Hatchery. Adults that returned to the Methow in 1993 were collected and held for broodstock and spawned. The resultant progeny from these adults where reared and released in the spring of 1995. There were a total of 117,000 smolts released in the Twisp, 284,000 smolts released in the Chewuck and 211,000 smolts released in the Methow in 1995 (Appendix I). The egg to smolt survival for fish from all three drainages exceeded 90%. The fish were of high quality. The report points out brood collection facilities have a low efficiency and could be causing some displacement of naturally spawning adults.

2.4 Spring Chinook Spawning Surveys in the Methow River Basin

The YIN has conducted annual spawning ground surveys in the Methow basin for spring chinook since 1988. The information on abundance and distribution of spawners will be important for the evaluation of the Methow Supplementation facility.

The 1995 escapement produced 13 redds in the entire basin (95-6). This was the lowest return of adult spring chinook seen since these surveys have been done in 1988. Unusually low numbers of spring chinook were seen throughout the Columbia Basin in 1995. The previous year had been the lowest on record. The two low years back to back has concerned the fisheries agencies and Tribes.

2.5 Okanogan Sockeye Spawning Ground Surveys

Sockeye spawning surveys in 1995 were coordinated by the District with assistance from the joint fisheries parties. Escapement at Wells Dam was 4,801 sockeye, the second lowest ever recorded, only better than 1994. Escapement to the spawning grounds was calculated by a modified area under the curve method and a mark-recapture method, used in 1992 and 1993. There were 2669 spawners estimated by the area under the curve and 2376 spawners by the mark-recapture method. This is 56% and 49% of the ladder counts at Wells Dam.

2.6 Predator Removal at Wells

The District initiated a squawfish removal program to aid in decreasing mortality at the base of Wells Dam and near the hatchery outfall. The use of gillnets were suspended early in the program because of high walleye incidental catch (95-5). During the year, 495 fish were marked and 600 removed. The population estimate for the tailrace area was 10,761 squawfish (95-6). There was no noticeable change in squawfish population at the hatchery outfall immediately after the release of yearling and zero age chinook (Appendix K). Efforts for 1996 will focus on sport gear during periods when catches were most effective, in June and July,

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

3.1 Methow River Spring Chinook Facility

The Settlement Agreement called for a hatchery based compensation program for spring chinook supplementation composed of adult collection sites; a central hatchery facility for incubation, early rearing, and adult holding and acclimation facilities for final rearing (Agreement IV). Hatchery personnel reared progeny from 1993 and 94 broodstock in the facility during 1995. A limited amount of 1995 broodstock were collected at he hatchery outfall channel.

The District worked with US Fish and Wildlife Service to amend an agreement for improvements to a fish ladder at Fog Horn Dam to include an adult fish trap for collecting broodstock from the Methow River (95-1,7). Facilities were built during the year at Fog Horn Dam.

The Settlement Agreement also calls for evaluation of the hatchery program. An evaluation plan had been developed and presented to the WCC for review and comment (95-1, 2, 4). While a formal evaluation was being developed, several aspects of the hatchery were being evaluated as well as collecting baseline information on natural spring chinook populations in the Methow Basin. Final reports were received during 1995 for work done in 1994 (Appendix H and I).

3.2 Cassimer Bar Sockeye Hatchery

The Settlement Agreement calls for a pilot effort to enhance Okanogan sockeye for three years at 8,000 pounds of production (IV.A.3.(a)(2)). This effort includes an evaluation to gauge the success of the program. Brood were collected in 1993, 1994 and 1995 at Wells Dam as part of the three year program. Information on culture of sockeye at the Cassimer Bar facility was collected by the CCT as part of the evaluation. This information is being processed by the Colville Tribe for the first and second years of operation at the hatchery. A draft report was circulated to the WCC for the outmigration from the net pens in 1994 (95-6; Appendix F). The final draft of this report was not out by the end of the year. Environmental conditions of Lake Osoyoos plus some limited information of growth in the net pens was collected by Dr. J. Rensel (Appendix G). The CCT also collected information on the outmigration of native sockeye plus the net pen reared sockeye from Lake Osoyoos.

3.3 Contract Professional Services in Implementing the Settlement Agreement.

During 1995, the District contracted with Mike Erho to serve as Studies Coordinator for the Wells Coordinating Committee. Mr. Erho also serves as an interim coordinator for the Mid-Columbia Coordinating Committee and Rock Island Coordinating Committee in 1995. At the end of the year, there was interest among the committees to assign the position on a permanent basis (MCCC 95-13). An advertisement was extensively made throughout the region. The process for selection of this position continuted past the end of the year.

The District also contracted with Dr. John Skalski to provide statistical evaluation of methods and studies. Dr. Jack Rensel provided direction for the evaluation of the net pen aspect of the sockeye pilot program on Lake Osoyoos.

3.4 Juvenile and Adult Fish Passage Operations at Wells Dam

During 1995, the juvenile bypass system operated as per conditions outlined in the Settlement Agreement (II,C,D,F). The bypass team recommended bypass operation based upon information from hydroacoustics and fyke net samples at Wells.

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

3.5 Steelhead Production at Wells Hatchery

The Settlement Agreement specified that the District will fund additional steelhead compensation of 30,000 pounds at 6 fish per pound after 1991 (IV.3.a), bringing the total obligation to 80,000 pounds. Records from the Wells Hatchery show that 450,345 steelhead at 5.74 fish per pound or 78,457 pounds of steelhead were liberated in 1995.

3.6 Other Actions Toward Fulfillment of the Settlement Agreement

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

(4) Explanation of Alternatives Chosen

4.1 Project Mortality Study

As pointed out in Section 1.4, the WCC recommended that the Project Mortality Study not be pursued in 1995. The WCC felt that the study should wait until additional PIT tag detection points were in place in either the mid-Columbia or in the lower mainstem. The results of this study will verify the level of compensation. Compensation programs are currently in place using an assumed project mortality of 14%. The availability of test fish is a problem with proceeding with the work.

(5) Chronology of Compliance for 1995

Items (3) and (4) above contain chronology of compliance in 1995. 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 K.

(6) A Schedule of Activities for 1996

The following schedule of activities is planned for 1996

Dec. (95)	Develop Annual Bypass System Operation Plan between District, Agencies and Tribes
March 1	Annual Bypass System Operation Plan finalized
March 1	Determine Bypass Team members for bypass season
March 1	Develop Annual Passage Monitoring Plan between District, Agencies and Tribes
March 21	Begin monitoring juvenile migration via hydroacoustics
	Field work to start on Methow Hatchery Evaluation Studies
April 1	Bypass barriers in place
April 15	Have sockeye net pens in Lake Osoyoos
April 15	Anticipated start of the juvenile migration
May 15	Liberate sockeye from net pens in Lake Osoyoos
May 22	Start collecting spring chinook broodstock in Methow
July 1	Start collecting sockeye broodstock for Cassimer Bar
Sept. 15	Start spawning ground surveys for sockeye in Okanogan
October	Production Plan annual review between District, Agencies and Tribes
on going	Planning sockeye mitigative strategies
on going	Planning for operations and protocols of the Methow River Spring Chinook Facilities

(7) Minutes of Meetings

7.1 Minutes of the Wells Coordinating Committee for 1995

The Wells Project was removed from the mid-Columbia proceedings on January 29, 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 1995 are attached as Appendix K.

7.2 Minutes of Select Meeting of the Mid-Columbia Coordinating Committee for 1995

During the year, several study plans and issues that were common to the Wells Project and the other four mid-Columbia projects, were discussed in the Mid-Columbia Coordinating Committee. Minutes of those meetings are presented in Appendix K.

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Appendix M
1995 Membership list of the Wells Coordinating Committee

Appendix N
The Long Term Settlement Agreement for the Wells Hydroelectric Project.

Appendix M
1995 Membership list of the Wells Coordinating Committee

ANNUAL BYPASS OPERATION PLAN
FOR
WELLS DAM, 1995

APPENDIX A

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 1995 Bypass Season

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

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

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

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

Projected Hatchery Releases above Wells Dam
Hatchery releases for 1996 above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	800	4/11
Methow (WDFW)	Spr. Chinook	625	4/15
Carlton (WDFW)	Sum. Chinook	400	4/15
Similkameen (WDFW)	Sum. Chinook	600	4/15
Lake Osoyoos (CCT)	Sockeye	65	5/15
Wells (WDFW)	Sum Steelhead	550	4/20

Starting Dates and Ending Dates
Bypass barriers will be in place between March 27 and August 28. Hydroacoustic and fyke net information at Wells will be used to show the start and completion of spring ans summer migrations. Preseason dates for bypass operation for spring and summer migration are April 10 through May 30 and July 1 through August 15.

METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

APPENDIX B

METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

BY

WELLS PROJECT COORDINATING COMMITTEE

JUNE 20, 1995

METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

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METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

STATEMENT OF PURPOSE

The purpose of the Methow Basin Spring Chinook Salmon Supplementation[1] Plan is to compensate for unavoidable salmon[2] smolt losses at Wells Dam by means of a carefully monitored hatchery supplementation plan designed 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. The Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) was conceived for the expressed purpose of increasing the naturally spawning populations of salmon in the Methow, Chewuch, and Twisp rivers, through a carefully monitored hatchery program. Facilities were constructed and provisions made for operation, maintenance, and evaluation as part of a long term settlement agreement between the Fisheries Parties[3] and Douglas County Public Utility District and it's power purchasers, represented by Puget Power Company. The Fisheries Parties selected supplementation of naturally spawning salmon (RASP 1992, Cuenco et al. 1993) in the Methow Basin as the preferred option to compensate for unavoidable smolt loses at Wells Dam. The parties to the Settlement Agreement (Agreement) recognized the critical uncertainties related to the supplementation concept, and the risks to genetic conservation of hatchery programs (Busack and Currens *in press*), yet reaffirmed their commitment to hatchery supplementation as the appropriate means of compensation. As part of this commitment, the parties believed that it would be desirable to establish Guiding Principles to follow in implementation of the MBSCSP. These principles (Appendix B) represent the consensus position of the parties to the Agreement. A means to address the critical uncertainties specific to the MBSCSP form the basis for the evaluation of the hatchery compensation plan. The Guiding Principles were also used to establish the trategy to implement the Production Plan and the Evaluation Plan for the MBSCSP.

PRODUCTION PLAN

Methow Fish Hatchery (FH) was built to compensate for the estimated losses of salmon smolts as a result of Wells Hydroelectric Project. This hatchery should be capable of producing the spring chinook portion of the Phase I compensation established under the Agreement in a manner that complements natural production and recognizes the importance of long-term viability and diversity of the salmon populations upstream of Wells Dam. The Evaluation Plan will determine whether or not Methow FH operates in a manner that is consistent with this goal.

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1 Refer to Appendix A for a definition of terms.

2 Throughout this document, "salmon" refers to spring chinook salmon that spawn in the Methow River Basin, unless otherwise noted.

3 Washington Department of Fish & Wildlife, Oregon Department of Fish & Wildlife, National Marine Fisheries Service, U.S. Fish and Wildlife Service, Colville Confederated Tribes, Yakama Indian Nation, Columbia River Intertribal Fish Commission.

Hatchery compensation is to replace the estimated number of smolts killed at Wells Dam (described in Appendix A of the Agreement). Compensation has four phases:

- Phase I sets a negotiated production level for compensation during the development of the artificial propagation program facilities and a pilot production program for sockeye salmon.
- Phase II production will be based on evaluation of the pilot sockeye program.
- Phase III will be contingent upon estimates of fish loss at Wells Dam after juvenile fish protection measures have been implemented. The new estimates of mortality will be determined from field studies at the Wells Project.
- Phase IV production may begin when smolt outmigrants achieve 110% of the estimated smolt population used to establish Phase I and Phase II compensation levels.

Under the Agreement, the Fishery Parties developed this production plan, specifying the stocks to be enhanced (Table 1). The production plan served as the base to establish the design criteria for Methow FH. To compensate for fish killed at the Wells Project, hatchery releases must be sufficient, given their survival from release to adult return, to produce a number of adults equal to the number that would have been produced from the unavoidable losses, plus the brood removed from natural production to initiate the hatchery program. The Evaluation Plan should therefore determine the survival rate of hatchery fish from release to adult. The MBSCSP was established at an annual production of 738,000 yearling smolts, yet the primary function of the program is to operate as a supplementation facility (RASP 1992). Hatchery management therefore, will be based upon the guidelines established by Kapuscinski and Miller (1993). Methow FH will produce less than full capacity if information derived from the Evaluation Plan indicates such a strategy is consistent with the Guiding Principles (Appendix B) for the MBSCSP. Innovative fish cultural strategies will be considered in all aspects of the supplementation plan. The Agreement requires that the MBSCSP be consistent with guidelines and procedures developed under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC 1987). The Agreement specifically requires that facilities designed for Phase I production be capable of collecting, rearing, and releasing three discrete stocks of salmon (Table 1). The Phase I facilities include three adult collection sites with concomitant juvenile rearing, acclimation, and release sites to maintain the integrity of these stocks. The production plan and hatchery operating protocols specify broodstock collection and mating procedures to maintain the genetic integrity of the stocks used for hatchery production. The release procedures established for the hatchery are intended to acclimate and imprint the fish to prevent excessive straying of returning hatchery adults into the spawning areas of the other stocks within the Methow Basin, where interbreeding could occur. The release procedures are also intended to imprint the fish so that returning hatchery adults spawn with the donor stock, increasing the total number of salmon spawning naturally. If information derived from the Evaluation Plan provide reasonable evidence to do so, fish cultural strategies or some of the physical plant may be modified, upon consensus of the Wells Coordinating Committee, to meet the intent of the Guiding Principles.

Table 1. Hatchery production plan under Phase I of the Wells Settlement Agreement.

Hatchery	Taxon	Stock	Smolt Production Numbers	Smolt Production Pounds
Wells[a]	Summer chinook	Wells		56,500
	Steelhead	Wells	180,000	30,000
Cassimer Bar [b]	Sockeye	Okanogan	200,000	8,000
Methow	Spring chinook	Chewuch	246,000	16,400
		Methow	246,000	16,400
		Twisp	246,000	16,400

[a]Summer chinook salmon and steelhead production at Wells FH are part of previous agreements between Douglas County P.U.D. and the Washington Department of Fish and Wildlife. Refer to the Wells FH Evaluation Plan for a complete description of the goals for that hatchery.

[b]Refer to the Okanogan Sockeye Salmon Evaluation Plan for a complete description of the goals for Cassimer Bar FH.

STRATEGY FOR IMPLEMENTATION OF PRODUCTION PLAN

The fundamental objective of Methow FH is to supplement natural propagation of salmon in the Methow, Chewuch, and Twisp rivers in a manner that minimizes ecological and genetic risks to the natural population. This objective takes priority. All other objectives (compensation, harvest, evaluations) are ancillary, and should not compromise this fundamental objective. The following strategy for the MBSCSP will ensure that Methow FH operates in a manner that is consistent with the collective objectives of all members of the Fishery Parties, and with the Guiding Principles established for hatchery compensation. The parties recognize the unique character of each stream supplemented by Methow FH, and the diversity of philosophies for management of salmon in the Methow Basin. The parties therefore established individual strategies for each stream (Methow, Chewuch, and Twisp rivers), and for the basin in general. Specific goals, in terms of fish spawning naturally, have been established for each stock to provide a basis for evaluation of progress toward meeting the expectations of the supplementation concept in the Methow Basin, with objectives designed to monitor success in meeting the goals. The strategies to meet these goals are outlined below, and in Appendix C.

Basin-wide

Maintenance of stock integrity is an important objective common to all three streams supplemented in the Methow Basin. Therefore, a strong effort will be made to remove, from Methow FH broodstock, salmon that have strayed from other hatcheries. However, detection and removal of all strays contributing to the Methow FH broodstock is problematical, because: 1) the adult traps are not efficient, 2) not all hatchery fish are marked, and 3) at times, the procedures required to determine the origin of some marked salmon are detrimental to the survival of the population. Moreover, the genetic relationship between fish propagated at Winthrop and Methow

FHs is not fully understood at this time, so a correct procedure to manage gene flow has not been established. If Winthrop NFH does not import exogenous stocks, the fish released from that hatchery and recovered for the Methow stock will not be considered a stray. The Methow, Chewuch, and Twisp programs will have a higher level of tolerance for strays from within the Methow River Basin than for strays from outside the Methow Basin. In general, Methow FH will have different levels of tolerance for strays found in the population, depending the stock that is affected. These tolerance levels will be based upon the severity of the impact, in terms of the origin of strays, their percent of population, their absolute number in the broodstock, and their persistence from year to year.

The means to determine tolerance levels will be based upon the Index of Relative Adaptiveness (IRA) method, as proposed in the *draft* WDFW Wild Salmonid Policy (Anonymous 1994). The annual broodstock protocol will be the recognized tool to develop contingency plans for management of strays at Methow FH. The following matrix outlines the differing levels of tolerance for each population:

SOURCE OF STRAYS	TOLERANCE LEVELS		
	Methow	Chewuch	Twisp
Methow population		high	low
Chewuch population	highest		moderate
Twisp population	highest	high	
Outside Methow Basin	moderate	low	lowest

Methow River

Collaboration between Winthrop FH and Methow FH is of paramount importance for the MBSCSP. Gene flow between the two hatcheries will inevitably occur. To be consistent with this situation, all spring chinook salmon that spawn in the mainstem Methow River upstream of the Chewuch River confluence will be managed as one genome. To be successful, this management strategy requires three conditions: 1) no spring chinook salmon from outside this reach will be imported to either hatchery for propagation and release into the Methow River (exogenous salmon may be reared at the hatcheries if they are acclimated and released into their natal stream), 2) all salmon released from either hatchery into the Methow Basin will be externally marked, and 3) salmon that spawn in the Lost River will be included in this population.

It is expected that the two hatcheries will have the ability to exchange salmon at any life stage, if one or both facilities benefit from it. The benefits of this collaboration include increased flexibility in hatchery programming, improved fish health maintenance, increased statistical power in experimental designs, and a potential for an increase in effective breeder size in years of low escapement. For this collaboration to succeed, it is recommended that Winthrop FH consider the Guiding

Principles of the MBSCSP in its operating plan. A feasible approach may be to reduce its spring chinook salmon production goal to a maximum of 40,000 pounds of production annually (this would likely be 600,000 yearling salmon, which is about half the current production goal), and to produce other species or races of salmon. It is expected that a refinement and clarification of the relationship of the two programs will be required, but that process is beyond the scope of this document.

A terminal harvest on the Methow Stock would be a major consideration, and should be accordingly planned for. If a tribal harvest is established, it should be a ceremonial and subsistence fishery upstream of the Chewuch confluence. This fishery must be selective for marked salmon only. A means to establish an escapement goal, with an incremental harvest strategy, is presented in Appendix C.

Chewuch River

The Fishery Parties recognize the opportunity to implement innovative fish cultural practices at Methow FH, yet also are acutely aware of the need to ensure high survival of the supplemented populations. The Chewuch River population will therefore be the designated stock used for innovative hatchery management. In general terms, the Chewuch stock may be considered an experimental "treatment" stream, compared to the Twisp River population, which will serve as the "reference". Alternative fish culture may include such practices as life skills training (Olla and Davis 1989, Suboski and Templeton 1989), side-channel rearing (Budhabhatti and Maughan 1994), and autumn pre-smolt releases (Bjornn 1978, Bilby and Bisson 1987), or other prototypical hatchery strategies.

Twisp River

The Twisp River stock will be managed in a manner that ensures the highest survival of both natural and hatchery salmon in that river. Low risk production strategies will be implemented in all stages of the program. The Evaluation Plan will place an emphasis on long-term genetic and demographic monitoring of the Twisp population, to evaluate the stability of a small semelparous population. An estimate of minimum viable population (MVP; Shaffer 1981, 1990, Lacava and Hughes 1984) size will be derived, either through empirical or heuristic analysis (Kapuscinski and Lannan 1986). The escapement goal for the Twisp River will then be based upon the estimated MVP.

EVALUATION PLAN

Embodied in the MBSCSP, and the concept of supplementation in general, are a broad array of questions concerning natural production and stock restoration. These questions relate to the conceptual framework of supplementation theory, which in essence assumes that artificial propagation of Pacific salmon can increase numbers of naturally spawning populations with no impacts to the long-term viability of the target populations, and minimal effects upon non target species. Several critical uncertainties were identified in the development of the MBSCSP. The first deals with the physical facilities provided to accomplish the goals of the plan. The remaining critical uncertainties concern the potential risk imposed upon the Methow Basin spring

chinook salmon stocks by the supplementation plan and the efficacy of the supplementation plan as a means to restore these stocks.

First critical uncertainty: Are the facilities provided adequate to meet the needs of the MBSCSP in terms of broodstock collection, incubation, rearing, and acclimation?

Can the egg to returning adult survival meet or exceed the survival rate of naturally produced fish from that donor population?

Can the broodstock collection facilities safely capture sufficient salmon in a manner that is consistent with guidelines established in the broodstock collection protocol for that stock?

Second critical uncertainty: Does implementation of the MBSCSP conserve the genetic integrity and long-term fitness of naturally spawning populations of spring chinook salmon in the Methow Basin.

Do marked and unmarked salmon differ in spawning success?

In the Twisp and Chewuch rivers, is habitat use and redd density per unit of stream proportionate between marked and unmarked salmon?

Are the allele frequency variations between generations no greater than expected from random genetic drift?

Is the effective population size of a donor stream adversely affected by broodstock collection procedures?

Does the average bilateral meristic asymmetry of the supplemented populations increase progressively over time?

Do the progeny to parent ratios of hatchery reared salmon meet or exceed those levels necessary to maintain long-term viability of the supplemented stocks?

Third critical uncertainty: Do salmon released from Methow FH interact adversely with natural production in the Methow River Basin?

Do the returning adults from Methow FH stray excessively and interbreed with other genetically distinct stocks?

Do the salmon released from the acclimation ponds impact naturally-rearing salmon and steelhead in the river?

Is natural production in the donor population diminished when hatchery-reared salmon return to spawn in the natural habitat?

A means to address the critical uncertainties specific to the MBSCSP form the basis for the evaluation of the supplementation plan. The Evaluation Plan states three specific objectives to obtain the data required to address each critical uncertainty. It is expected that these objectives, and their associated tasks, will form the basis for development of an annual evaluation implementation plan (or plans) which will include details of the specific hypothesis to be tested, methods, analysis, and report development, as outlined in Appendix G (Guidelines for Preparation of Study Proposals). The objectives and tasks (outlined in Appendix D) will be used to determine whether the goals of the Phase I hatchery-based compensation plan are being met, and whether the Guiding Principles are being adhered to. Some tasks may be directed toward all three populations--others must be done only on a given stream, to be consistent with the Implementation Strategy. The time frame or frequency of the tasks is defined in Appendix E.

The Evaluation Plan should be dynamic, with provision for assignment of new tasks directed at solving problems that may become apparent from the initial evaluations. A time line has been developed for evaluating progress toward meeting the objectives of the supplementation plan. Check points have been established for evaluating the program to allow for changes in strategies from an "adaptive management" perspective (Appendix E). It is recognized that all tasks listed in the evaluation cannot be done simultaneously without compromising either the survival of salmon, or the scientific merit of a given task. A process to identify the relative need and merit of a given task is described in Appendix F, which should allow managers the ability to establish priorities in evaluations.

Objective 1: Determine if Methow FH is capable of meeting the Phase I production requirements of the Agreement.

The capability of the facilities to produce the intended number and quality of smolts under the specific design features will be evaluated in this objective. Tasks are directed toward data collection that will lead to solutions to attain the design production capability of Methow FH. For the purposes of this evaluation, the term "propagation survival" includes the life history from the point of broodstock collection to time of release. This guideline will be the basis for evaluation in Objective 1. "Overall survival", which includes propagation survival and survival from release to spawning adult, will be considered as an adjunct to this objective. Survival guidelines will be rigorous, relative to other Columbia River hatcheries. The guidelines, stated in Table 2, will meet or exceed those developed by FishPro (1990), which were used in the design of Methow FH.

Propagation survival: The Evaluation Plan will determine if the propagation survival (defined in Appendix A) in the hatchery meets or exceeds the guidelines presented in Table 2. The hatchery and evaluations personnel will keep records of cultural techniques for each life stage. Any problems with operation of the facilities will also be noted. If survival of a particular life stage is below the guideline, then the hatchery operation records could lead to identification and subsequent correction of the problem or studies to determine the cause and remedy.

Table 2. Propagation survival guidelines for spring chinook salmon at Methow FH.

Developmental stage	Criterion	Survival (%)	
Adults/gametes	Collection to spawning	90	
Incubation	Fertilization to start tank	90	
Rearing	Start tank to ponding		86
Acclimation	Ponding to release	99	
Propagation	Collection to release	69	

Overall survival:. The Evaluation Plan will also assess the fisheries contribution and return survival of salmon released from Methow FH. This will ensure that the hatchery complex is successful in replacing those salmon initially collected for broodstock, and in meeting the long-term objective of sustainable natural production (see Objective 2). The adult replacement rate (i.e., adult spawner to adult return) of hatchery salmon will be measured to determine if it meets or exceeds the replacement rate of natural salmon from that donor population. Survival from release to adult will be measured primarily from coded-wire tag recoveries from returns to the donor streams, but information on contribution to various fisheries will be gathered as well. All salmon released from Methow FH will be marked (coded-wire tag and adipose clip). This mark is required for assessment of survival rates, broodstock management, and determination of stray rates.

Broodstock collection: Broodstock will be collected from traps on the Methow, Chewuch, and Twisp rivers. Ideally, these trapping sites should be capable of randomly collecting natural salmon throughout the run timing of target stocks (see Objective 2). Trapping must not injure or stress the fish to the point that pre-spawn mortality exceeds the guideline set in Table 2. The Evaluation Plan will determine if the traps are capable of collecting adults which represent the demographics of the donor population, in sufficient numbers to meet desired production levels, and with minimal impact to the collected fish or those allowed to spawn naturally. The traps and weirs should not alter the location or temporal pattern of riverine spawners. Trap operations on the Twisp and Chewuch rivers may affect the movement and spawning activities of naturally-spawning salmon (Meekin 1993). An evaluation of the trap design and operations will be required to determine if such impacts do occur, and if so, to develop an appropriate means to mitigate these effects. Salmon that die in the trap, or are killed by the weir during upstream migration will be included in the collection tally. Moribund salmon that drift downstream and die on the weir are to be considered river mortalities.

Objective 2: **Determine that actions taken under the MBSCSP conserve the genetic integrity and long-term fitness of naturally spawning populations of salmon in the Methow Basin.**

Genetic integrity: To be consistent with the Columbia River Basin Fish and Wildlife Program and the underlying assumptions of the Fishery Parties, Methow FH should replace fish killed at Wells Dam without compromising the genetic integrity of existing

stocks, including both the donor and other stocks. There are four ways the MBSCSP could fail to meet this objective:

1) Excessive straying of hatchery fish into non-target spawning habitat and interbreeding with other stocks could alter the genome of those stocks through introgression of genes or gene complexes not present in those stocks.

2) Some individuals collected for broodstock could be from the wrong stock, causing introgression of alien genes into the donor stock.

3) Inadvertent selection pressure in broodstock selection and mating could alter the genome of the donor stocks through genetic drift or loss of genetic variation.

4) Removal of salmon for hatchery broodstock could increase genetic drift and reduce genetic diversity by reducing the effective population size of the donor stock. This could happen if returning hatchery adults in the next generation fail to replace the natural adults that would have been produced by the broodstock, particularly for donor stocks with small populations.

The cultural practices established for broodstock selection and mating are critical for maintaining genetic diversity in the donor population. Broodstock trapping should take fish at random from the donor population, including both early and late run fish and different age classes in approximately the proportions that occur in the donor stock (Kapuscinski and Miller 1993). Mating procedures should follow a spawning protocol (Seidel 1983, Withler 1988, Leary et al. 1989). A genetic monitoring program is needed to test whether the broodstock and mating procedures are maintaining the genetic character and diversity of the donor stocks (Meffe 1986).

Spawning and carcass surveys of both the donor stocks and other stocks in several watersheds are needed to determine if hatchery salmon stray and interbreed with other stocks (Scholz et al. 1978, Unwin and Quinn 1993). Surveys in the supplemented streams must be intensive, to determine that sufficient hatchery salmon spawn with the donor stock to replace the salmon taken for broodstock. The Evaluation Plan should retrieve information from carcass surveys by other entities on streams and hatcheries outside the Methow Basin to determine the extent of straying and possible interbreeding of hatchery fish with stocks other than the donor.

Winthrop FH, located adjacent to Methow FH, is operated by U.S. Fish and Wildlife Service under authority of the Grand Coulee Fish Maintenance Project (USFWS 1994). At this time, the management objective of Winthrop FH is not consistent with that of Methow FH. The principle area of conflict is the selection of appropriate broodstock. Under current hatchery management strategies, the only acceptable founder population for the Methow stock are salmon indigenous to the mainstem Methow River, yet there currently is no means to collect these broodstock. Winthrop FH typically propagates Methow stock, but may import salmon from outside the basin if escapement is low. A feasible solution to this dilemma is to manage both hatcheries on a collaborative basis, in which a common stock salmon is to be propagated at both

facilities (Appendix C). The Evaluation Plan will gather information on the genetic status of the Methow stock, and recommend the appropriate means to collect, propagate, and release them from Methow FH.

The Evaluation Plan will monitor the Methow FH broodstock for evidence of introgression of foreign genes, accelerated genetic drift, or loss of genetic variation in the donor stocks that could be caused by the hatchery program (Busack 1990). The broodstock should constitute a random sample of the donor stocks (Meffe 1986). A monitoring program should test for genetic changes in the donor stock that could result from failure of hatchery procedures to maintain the stock's genetic integrity.

The Evaluation Plan will develop a monitoring program for electrophoretic analysis of allele frequency variation at selected monomorphic and polymorphic loci. Allele frequency variations between generations should be no greater than expected from random genetic drift. Polymorphism at a locus previously monomorphic in the donor stock could indicate mixture with another stock (Utter et al. 1987). A program to monitor asymmetry in bilateral characters will be developed. A progressive increase in average asymmetry over time could indicate a loss of genetic variation (Leary et al. 1984, 1985), or other stressors to the population (Valentine et al. 1972, MacGregor and MacCrimmon 1976).

The Evaluation Plan will determine appropriate numbers (and proportions) of the run-at-large to collect for hatchery broodstock (Ryman and Laikre 1991). Efforts should be made to estimate a minimum viable population (MVP) size, which includes salmon that are spawned both in the hatchery and in the river. Evaluations will focus on determination of effective size (Gall 1987) in the Twisp River population (though other donor streams may be used if required). Effective size monitoring will be based upon four components: 1) variation in family sizes among single-pair matings of salmon in the hatchery (Nunney 1991), 2) the sex ratio of the donor population, both in the hatchery and in the river (Waples 1990), 3) long-term monitoring of yearly variations in escapement to the donor stream (Shaffer 1981, Simon et al. 1986, Ellner and Hairston 1994), and 4) estimates of effective size derived from electrophoretic data (Pamilo and Varvio-Aho 1980, Waples and Teel 1990)

Long-term fitness: The Evaluation Plan will conduct spawning and carcass surveys on the spawning areas of the donor stocks to Methow FH. The number of broodstock taken in the parent generation should not exceed the number of hatchery-reared progeny that return to spawn naturally in the donor stream. Progeny-to-parent ratios of hatchery-reared salmon will be monitored to determine those levels necessary to maintain long-term viability of the supplemented stocks. Surveys are required for marked hatchery fish on the spawning areas of salmon stocks that are not part of the MBSCSP. Surveys of strays to other basins will be coordinated with hatchery evaluations under other compensation plans.

Annual and long-term changes in the spawning distribution of the donor stock will be monitored. Hatchery-reared adults should reproduce similarly to natural salmon in terms of distribution, timing, and habitat use. The number of progeny spawners in the donor stream should meet or exceed the number of fish established in the

Management Plan and those that would have been produced had the adults collected for broodstock been allowed to spawn naturally.

The Evaluation Plan will monitor indicators of the fitness of a selected donor population for changes in reproductive success and juvenile production as hatchery salmon contribute to the natural spawners. The productivity of the donor population may be affected by the hatchery program, either through genetic effects or because of physical effects resulting from broodstock trapping, environmental or nutritional effects in the hatchery environment, or behavioral differences between natural and hatchery adults (Fleming and Gross 1992). Evaluations will be based upon juvenile production in a donor stream (Chewuch River) in relation to adult escapement before and after significant hatchery production begins. Several methods might be used to assess juvenile production :

1) annual estimates of parr production on representative index sites in selected habitat types on a natural river environment,

2) annual estimates of smolt yield on a population, and

3) a well-controlled study on a manageable reach of river to measure juvenile production against escapement to that river.

Objective 3: Determine if salmon released from Methow FH interact adversely with natural production in the Methow River Basin.

An important goal of Methow FH is to reduce potential for adverse interactions between hatchery releases and natural production, such as intra- and interspecific competition for food or habitat, and predation (Riddell and Swain 1991). The potential for this goal to be met will be improved if salmon released from Methow FH are healthy and migrate rapidly.

Methow FH has been designed to provide for volitional release of salmon from the acclimation ponds. The expectation is that the salmon will undergo parr/smolt transformation while in the ponds and voluntarily exit through the pond discharge when they are physiologically and behaviorally ready to migrate (Hansen and Jonsson 1985). The optimal release strategy will be determined through observation, operational experience, and, if needed, experimentation with release procedures (Bohlin et al. 1993). Ideally, salmon would emigrate from the acclimation pond when physiologically prepared to do so, and this would coincide with good downstream migration conditions (Rottiers and Redell 1993). However, fish may physiologically smolt before migration conditions are favorable. Fish may exit the ponds without showing physical or behavioral signs of smoltification.

An evaluation of fish behavior and migration is needed at the acclimation ponds, in the river at point of release, and at sampling locations in the Columbia River. Observations are needed prior to, during, and after release. Observations should determine: 1) if fish can be reared in a manner that enables them to adapt well to the river environment (Olla and Davis 1989), and 2) if fish emigrating from the acclimation

ponds remain near the pond outfall or if they disperse and move downstream (Bilby and Bisson 1987).

Determination of the emigration rate will provide information that may be necessary to optimize the cultural and release strategies for each stock. Sampling with PIT tag interrogators, tunnel counters, or inclined plane traps may be needed. Physiological, behavioral, and morphological indicators of parr-smolt transformation may be used to assist in volitional release strategies. Snorkel observations below the pond could determine whether fish migrate and disperse or linger in the immediate area of the release where they could be subject to increased predation or adversely affect naturally produced fish. Retrieval of data from recoveries of marked fish at hydroelectric projects in the Columbia River can provide estimates of travel time and may be used to refine the volitional release strategies. These data could also indicate whether fish from Methow FH migrated through the Columbia River concurrent with naturally-produced fish and during the period when flows and spill for fish protection were in effect.

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APPENDIX A: DEFINITION OF TERMS
METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

These terms have been defined to meet the functional needs of hatchery managers in the Methow Basin Spring Chinook Salmon Supplementation Plan. The Joint Fishery Parties have adopted these definitions for this document only, and do not intend their use elsewhere.

Supplementation The use of hatchery facilities to increase the natural production of spring chinook salmon in the Methow River Basin, while maintaining their long-term fitness, and keeping the ecological impacts on non-target species, both within and outside the basin, within specified limits.

Hatchery salmon A given fish that has been spawned, incubated, and has emerged in a hatchery.

Natural salmon A given fish that has spent the early stages of its life history (at least through emergent stage) in a riverine environment, and can be the progeny of hatchery, natural, or unknown parentage.

Population A group of interbreeding salmon of hatchery, natural, or unknown parentage within each of the three supplemented rivers of the basin (Methow, Chewuch, and Twisp). This term is synonymous with stock.

Propagation survival The percent of progeny from a given fish, or group of fish, that survive from time of parental broodstock collection to time of release for downstream migration. Parents that die in the traps, or are killed by the trap facilities during upstream migration, are to be included in this calculation. Moribund salmon that drift downstream and die on the trap facility are not to be included.

Overall survival The percent of progeny that survive from time of parental broodstock collection to spawning, or interception in a fishery or during migration.

Stray salmon A given fish of hatchery, natural, or unknown origin that returns as an adult to another population.

APPENDIX B: GUIDING PRINCIPLES
METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

General

There are three stocks of spring chinook salmon in the Methow Basin (Methow, Chewuch, and Twisp). Within each stock (Methow, Chewuch, and Twisp), the fish produced in the river and the hatchery are to be considered as one interbreeding population.

Maintenance of existing natural patterns of life history traits is an important objective of the supplementation plan.

The success of the supplementation plan will be based on the ability of the adults produced to spawn successfully in the natural environment and produce viable offspring.

Broodstock Collection

Broodstock collection/selection will follow a protocol developed each year in advance of commencement of collection operations.

Broodstock protocol will seek to prevent inadvertent selection for heritable traits such as size, age composition, and run timing.

Broodstock protocol will follow existing genetic guidelines concerning maintenance of minimum viable population size in each population.

The donor stock to be used for hatchery broodstock will be predominantly from those fish resulting from natural spawning in the individual watersheds scheduled to receive the progeny produced, unless the total number of adults returning to the Methow Basin is so low that extinction is likely.

The integrity of the natural population will receive the highest priority during broodstock collection operations.

Spawning Practices

A spawning protocol will be developed based upon the numbers of adults collected from each of the stocks scheduled to be supplemented.

Mating of adults will be done in such a way as to maximize the "effective population size" of each generation in the hatchery.

When broodstock numbers are low, the spawning protocol will provide for factorial or, in extreme cases, diallel crosses to maximize effective population size.

Incubation Practices

Care will be exercised to prevent modification of the environmental or genetic components of early life history traits through practices designed to simulate natural, intergravel conditions.

Eggs and alevins will be incubated under conditions that simulate the natural, intergravel environment in terms of light, substrate, temperature, and oxygen.

Egg and alevin densities will be adjusted to levels that will assure high survival and quality of the resulting fry.

Rearing Practices

Fish produced under the MBSCSP will be similar to the naturally produced fish in the Chewuch, Twisp and upper Methow Rivers in size, morphology, behavior, physiological status, health, and other ecological attributes.

To the extent practicable, fish produced for the MBSCSP will be reared under conditions that simulate the natural environment.

Rearing procedures and facilities designed to produce fish for release that mimic naturally produced fish in behavioral and physiological characteristics will be tested and evaluated. Innovation and adaptation will be encouraged.

Release Strategies

All fish produced under the MBSCSP will be acclimated to the receiving water prior to release.

All fish will be given the ability to leave the acclimation facilities of their own volition.

Multiple natural release sites within each stream will be considered and efforts will be made to identify natural acclimation sites to complement the formal acclimation ponds on each of the streams being supplemented.

The release of fish produced under the MBSCSP will be similar to the migration patterns of the salmon produced naturally in the Methow Basin.

The size of fish at the time of release, under the MBSCSP, will be similar to that of the naturally produced fish in each of the streams targeted for supplementation.

APPENDIX C: COMPONENTS OF THE IMPLEMENTATION STRATEGY METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

Basin-Wide

1) Flexible hatchery production objectives, based upon collection of predominately unmarked fish for broodstock, gene flow between marked and unmarked fish, and supportive breeding strategies.

2) The Guiding Principles take priority over the Production Plan and the Evaluation Plan.

3) Each stream will be managed as a distinct population. No intensive broodstock segregation practices will be used however, unless substantial evidence indicates otherwise.

4) Mainstem natural spawners and both Winthrop and Methow hatcheries will be managed as one population. This goal requires three conditions:

- no importation of exogenous salmon,
- all hatchery salmon must be externally marked,
- Lost River population included as Methow stock.

5) The hatchery program will contribute information to knowledge base on supplementation and conservation biology.

Methow River upstream of Chewuch River confluence

1) Substantially higher escapement goal than the other two streams, because of larger wetted area and complementary production of Methow and Winthrop hatcheries. Escapement goal set at 1,650 marked fish returning to mainstem Methow:

- Methow FH 250,000 x 0.003 = 750 marked adult returns,
- Winthrop NFH 600,000 x 0.0015 = 900 marked adult returns.

The interim escapement goal for unmarked salmon to the mainstem Methow will be comparable to the 1973 to 1982 average (48 redds in the Mazama to Weeman index area: refer to Appendix A of the Settlement Agreement).

2) A major consideration for the mainstem would be tribal harvest, if compatible with U+A fishery locations. Establish incremental harvest objectives, which will be implemented when escapement goal is met over four consecutive years.

3) "Showcase" stream, using intensive habitat management (side-channel rearing, alternative irrigation and land-use practices) to complement artificial production, and compensation plans established under other settlement agreements.

Chewuch River

1) Innovative hatchery strategies used, with relatively intensive monitoring.

2) Information gained on this population will guide decisions on management of basin.

3) Sustainable population size based upon stream carrying capacity. Set escapement goal at 50% more than carrying capacity.

Twisp River

1) Reference stream, where "low risk" production occurs:
   - highest likelihood for listing (electrophoretically and demographically), poorest trap efficiency,
   - somewhat isolated from Chewuch and upper mainstem.

2) Strong emphasis placed on genetic monitoring, both protein and DNA.

3) Sustainable population size based upon estimates of MVP.

APPENDIX D: EVALUATION OBJECTIVES
METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

Objective 1: Determine if Methow FH is capable of meeting the Phase 1 production requirements of the Agreement.

Broodstock Collection

Task 1.1: Document and evaluate trapping/collection of spring chinook salmon for broodstock.

Evaluate the effectiveness of the adult traps on the Methow, Chewuch, and Twisp rivers for collecting and holding salmon. Make recommendations, and assist with modifications, to improve the effectiveness of the trap for capturing and passing salmon.

Monitor numbers of adult salmon holding upstream or downstream of the weir through periodic snorkel or carcass recovery surveys.

Compare current redd densities and number of carcasses above and below the weir, as well as with earlier years, as an indication of the effects of the weir and trap on spawning distribution.

Collect biological information on trap related mortalities. Determine causes of mortality, if possible.

Keep daily records of trap management, number and condition of fish trapped, and river stage. Trap efficiency will be correlated with flow data.

Provide recommendations to improve adult trapping and reduce delay or avoidance.

Task 1.2: Determine migration timing, movements and habitat use of adult spring chinook salmon in the Methow River.

Evaluate the efficacy of the weir and adult trap for capture and passage of adult salmon on the Methow, Chewuch, and Twisp rivers.

Spawning Practices

Task 1.3: Document and evaluate collection to spawning survival.

Document adult holding and spawning practices, and correlate with changes in survival.

Incubation Practices

Task 1.4: Document and evaluate fertilization to ponding survival.

Document incubation practices, and correlate changes in egg survival, yolk absorption, or development with water temperature and source, treatments given, or other incubation practices.

Rearing Practices
Task 1.5: Document and evaluate juvenile fish rearing at Methow FH.

Monitor growth, densities, mortality rates, and feed conversion of yearling spring chinook salmon reared at Methow FH and acclimated at the ponds prior to release.

Determine monthly, egg-to-fry, and fry-to-smolt survival rates for spring chinook salmon in the hatchery.

Correlate survival rates and fish health with disease prophylactic treatments.

Release Strategies
Task 1.6: Develop release strategies that will increase survival to adulthood for hatchery produced spring chinook salmon.

Evaluate condition of spring chinook salmon prior to release. Evaluate smolt quality, degree of smoltification, sexual precocity, organosomatic indices, and environmental factors at time of release.

Objective 2: 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.

Broodstock Collection
Task 2.1: Develop, or revise an adult broodstock collection, passage, and spawning protocol.

Ensure that collection is consistent with guidelines specified in annual protocol.

Modify collection protocol in-season as appropriate, based upon analysis of run size, timing, and trap efficiency. Document rationale for modification, and results of that action.

Task 2.2: Document characteristics of donor population, to ensure that representative broodstock is collected.

Monitor timing, duration, composition and magnitude of the spring chinook salmon run. Compare demographics of collected broodstock with the run at large.

Spawning Practices
Task 2.3: Identify origins of spring chinook salmon adults at Methow FH during spawning to maintain phenotypic and genotypic characteristics of these stocks.

Extract and read coded-wire tags of all marked chinook salmon at Methow FH during spawning, to determine contribution of stray salmon in hatchery broodstock.

Determine what proportion of strays is acceptable. Develop strategy for management of strays.

Task 2.4: Collect baseline stock profile data on Chewuch, Methow, and Twisp populations of spring chinook salmon.

Sample adult salmon at the hatchery and the spawning grounds for scales, and genetics data (electrophoresis and possible DNA analyses).

Take lengths and weights of returning adults, and determine sex ratios and age distributions. Compare fecundity of natural and hatchery females.

Evaluate genetic characteristics, effective breeding population size, and risk of extinction for Twisp River spring chinook salmon.

Develop proper sampling and archival methods for future DNA analyses.

Task 2.5: Document mating and fertilization practices in hatchery.

Record contribution of gametes by each fish spawned, and mating strategy that was used.

Determine if different fertilization rates occur under various mating strategies.

Correlate genetic and demographic data of the mated parents with that of their offspring.

Task 2.6: Develop means to increase effective breeding size and hatchery management options. Evaluate and improve gamete fertilization, storage, and extension techniques.

Conduct fertilization and cryopreservation experiments to improve techniques.

Cryopreserve milt of chinook salmon adults for future use.

Incubation Practices

Task 2.7: Correlate emergence timing with natural environment, and investigate means to mimic natural incubation.

Rearing Practices

Task 2.8: Test and evaluate rearing procedures to produce fish that are behaviorally and physiologically adapted to the river.

Investigate feasibility of installing habitat structures in selected raceways, and/or modifying rearing practices. Evaluate response (growth, microhabitat use, behavior, disease incidence), and compare to control raceways.

Modify feeding practices in selected raceways to include or mimic natural food and feeding characteristics. Evaluate response, and compare to control raceways.

Natural Production

Task 2.9: Determine if hatchery salmon are similar to natural salmon in spawning characteristics.

Compare fish behavior, and distribution of natural and hatchery salmon on the spawning grounds.

Determine prespawning survival and egg retention of marked and unmarked fish in the donor stock by examining spawners in the river.

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 salmon.

Document adult populations of naturally spawning spring chinook salmon. Conduct redd counts, determine spawner density and escapement, and locations of preferred holding and spawning areas.

Determine parr production and habitat use in a natural river environment through snorkel surveys.

Determine standing crop and carrying capacity using snorkel and smolt trap data collected.

Compare survival rates among life stages for produced spring chinook salmon in a natural river environment.

Task 2.11: Characterize and quantify natural spring chinook salmon juvenile outmigration from a natural environment.

Determine magnitude, duration, and peak period of migration of natural spring chinook salmon smolts.

Evaluate juvenile salmon migrational characteristics in relation to physical stream factors (flow, temperature, turbidity) and environmental factors (precipitation, photoperiod, barometric pressure, ambient light).

Document natural smolt health through such indices as condition factor, fin condition, descaling and organosomatic indices.

Objective 3: Determine if salmon released from Methow FH interact adversely with natural production in the Methow River Basin.

Release Strategies

Task 3.1: Develop hatchery smolt release strategies that result in rapid outmigration, high downstream passage survivals, and have negligible impact on natural production.

Evaluate volitional release strategies, and improve techniques.

Determine the quantity and migration timing of externally marked Chewuch spring chinook salmon smolts, and compare to natural salmon outmigration patterns.

Evaluate interactions between natural and hatchery fish.

Monitor migration timing, migration rates, and relative recapture rates of marked hatchery spring chinook salmon smolts at juvenile collection facilities at Rock Island and McNary dams by retrieving data collected under existing programs.

Design hatchery release strategies that result in spawner distribution that resembles natural salmon.

Task 3.2: Evaluate the feasibility of spring chinook salmon outplants in the Chewuch River.

Identify potential sites for natural acclimation and release into areas of Chewuch River upstream of established acclimation pond.

Develop appropriate strategy to compare releases from a single acclimation pond versus multiple release sites. Comparison should include migration timing and relative survival.

APPENDIX E: EVALUATION TIMELINE
METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

It is in the best interests of both the Fishery Parties and Douglas County PUD to establish a rudimentary timeline, with which to determine the success of the MBSCSP in meeting the two objectives identified in the Evaluation Plan.
Timelines to provide an initial indication of program success, and the criteria used to determine success, are described below:

Objective 1: Determine if Methow FH is capable of meeting the Phase 1 production requirements of the Agreement.

Determination of the adequacy of the facilities provided for the MBSCSP will be made following the release of the third year class of smolts produced (1994 brood year). This evaluation will cover "propagation survival", described on page 6 of this plan. Strategies to be used in making this determination are detailed in Tasks 1-3, 1-4, and 1-5 of the Evaluation Objectives (Appendix D).

Determination of adequacy of Methow FH in meeting the "overall survival" guideline will be made after the return of all age classes produced from the 1992 through 1994 brood. This conceivably would be in 1999. This guideline is ancillary to the "propagation survival" guideline. An assessment of the rolling five-year average release-to-adult survival rates for Methow FH and other mid-Columbia spring chinook hatcheries could provide a long-term guideline for comparison, and a basis for management strategies.

The broodstock collection facilities may never meet the Guiding Principles identified in this Evaluation Plan, because of the difficulties in designing traps that meet the guidelines. If reasonable evidence is gathered under Task 1-1 that the collection facilities are not operating in a manner consistent with the Guiding Principles, they may be modified, under consensus decision by the Wells Coordinating Committee

Objective 2: Determine that actions taken under the MBSCSP conserve the reproductive success, genetic integrity, and long-term fitness of naturally spawning populations of spring chinook salmon in the Methow River.

It is not scientifically feasible to identify a timeline to determine the effects of Methow FH on the long-term viability of the supplemented populations. Some determination will probably never be feasible on an empirical basis--heuristic analysis (Kapuscinski and Lannan 1986, Bjornn and Steward 1990, Cuenco 1994) may be the only means to indicate population viability and robustness. However, some information will be gathered within a sufficient time frame to provide an indication of population viability. These indicators include, but are not limited to:

- Sustainable natural production, measured through redd counts,
- Established collection-to-release survival rates,

- Negligible change in easily quantified demographic characters, e.g. fluctuating meristic symmetry, run timing, age composition, size and fecundity at maturity,and spawner distribution.

Data on these values should be collected yearly, except bilateral symmetry, which should be done annually for three years until adequate baseline data has been established, then periodically thereafter.

At a minimum, the following electrophoretic monitoring strategy should be used:

- one cycle for pre-facility baseline (1992-1995),
- two cycles immediately post-facility (1996-2003), and
- periodically thereafter.

Additional samples of baseline tissues should be held in archive indefinitely, both for electrophoretic and DNA analyses.

Objective 3: Determine if salmon released from Methow FH interact adversely with natural production in the Methow River Basin.

Determination of the effects of smolt releases from the MBSCSP on indigenous production will be made following the release of the third year class of smolts produced (1994 brood year). However, any changes in hatchery release strategies that are made as a result of these, or other studies, will be monitored accordingly. An evaluation of fish health prior to release will be made yearly, unless the assigned fish health specialist recommends this work be discontinued. An assessment of parr/smolt transformation will be made on released salmon if results of other monitoring programs indicate a need.

APPENDIX F: DETERMINATION OF EVALUATION PRIORITIES METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

It is recognized that all tasks listed in the evaluation cannot be done simultaneously without compromising either the survival of salmon, or the scientific merit of a given task. The following outline will be used to identify the relative need and merit of a given task, when it conflicts with another task. This outline will be used by the Wells Coordinating Committee to establish priorities in evaluations.

Factors to consider:

1) Is the study plan to accomplish this task consistent with the Guiding Principles, Production Plan, and the NPPC Fish and Wildlife Program?

2) Does this task affect the overall survival of salmon? Can the effects be quantified? What percent of the natural population will be impacted? What percent of the hatchery population will be impacted? At what life stage does the greatest impact occur? What is the duration of this impact (number of years)?

3) Is this task being done in a comparable hatchery evaluation elsewhere in the Columbia River? Can it be done only in the Methow Basin?

4) Can the results of this task lead to measurable increase in hatchery performance or natural production? If so, can any impacts identified in question 2 be compensated for by this increased performance or natural production?

5) Is there a large enough sample size (and replicates, if required) to have enough statistical power to detect differences, if any, between treatment groups? How will the use of hatchery facilities (start tanks, raceways) and logistics (marking, pond splits) be affected by the experimental design?

6) Can the results of this study be applied to operations at the hatchery? Can these results be applied to other supplementation/conservation hatcheries?

7) How imperative is this task (can it wait until a more appropriate time)?

APPENDIX G: GUIDELINES FOR PREPARATION OF STUDY PROPOSALS METHOW BASIN SPRING CHINOOK SALMON ENHANCEMENT PLAN

The following guidelines will be used to prepare proposals for studies to be conducted in response to the Evaluation Objectives, listed in Appendix D. The proposals received will be evaluated on the basis of how well they respond to the objectives and to the Guiding Principals.

Not all proposals will fit this format exactly, and should be modified as appropriate. However, a proposal should be written with enough detail to describe fully the research to be carried out and its relevance to the Evaluation Objectives.

FORMAT FOR RESEARCH PROPOSALS

1) Basic Information (on standard cover page):
   a. name and address of agency, institution, or organization,
   b. title of project,
   c. funding requested,
   d. duration of effort,
   e. names(s) and phone number(s) of project leaders,
   f. date of submission.

2) Project Summary should not exceed the equivalent of one single-spaced typed page and should convey to the Wells Coordinating Committee the general approach to be followed. It should be specific and focus on:
   a. overall project objective and supporting tasks,
   b. relevance of project to Guiding Principles and Evaluation Objectives,
   c. experimental methods and approach to be followed.

3) Project Description should be in sufficient detail to describe the research to be conducted (maximum of 10 single-spaced pages), and should include the following components:

   a. Introduction. The objectives and supporting tasks of the proposed research should be stated and described in detail. The most significant previous work related to the project, including work of key personnel on the current proposal, should be reviewed. All work cited should be adequately referenced.

   b. Rationale and significance of proposed research should be presented, which will discuss its application to the Guiding Principles and Evaluation Objectives.

   c. Experimental methods should include hypotheses to be tested or questions to be asked. The discussion on methods should include, but not be limited to;

      - description of proposed studies or experiments in the sequence to be carried out,

- identification and justification of sample size, including an analysis of the effect of sampling on natural and hatchery productivity,

- methods by which the data will be analyzed,

- kinds of results expected (with statistical power analysis, if needed),

- problems that might be encountered,

- limits to proposed methods, and

- tentative schedule for major steps in the project, particularly if the study is part of sequential research activities.

d. Facilities and equipment to be used in the project should be described, and changes in hatchery programming should be discussed. Any special or high cost equipment should be justified.

e. Collaborative arrangements. If the proposed project requires collaboration with other research scientists, agencies, or organizations, such arrangements should be fully explained. Any opportunities for synergistic relations among the proposed projects and existing projects should be described.

4) List of Key Personnel, and their duties on the project should be described.

5) Technology Transfer. Describe how the technical information gathered from the project will be distributed and implemented.

6) Budget. A detailed budget should be provided for each year of the proposed project. The project should include time, rate and total cost of personnel, benefits, cost of any equipment and non-expendable property to be purchased, specific supplies, operations and maintenance, capital improvements, travel, indirect costs, and any sub-contracts that are anticipated.

CONDITIONS FOR REVIEW OF STUDY RESULTS

1) Annual Review. A hatchery evaluation subcommittee will be designated by the Wells Coordinating Committee to provide oversight on all projects annual basis to ensure that the objectives of the funded projects are developed by the subcommittee and presented to the Wells Coordinating Committee for consideration. Recommendations for changes in hatchery design or operation, or in management objectives will be reviewed by the subcommittee for practicality and consistency with the Guiding Principles.

2) Peer Review. At the discretion of the hatchery evaluation subcommittee, any aspect of the proposed or ongoing projects may be submitted for review by scientists with known expertise in that discipline, or are in another region and may provide a novel approach to addressing the objectives.

3) Duration of Effort. A "sunset clause" will be included in each project with an expected duration of four years or more. The hatchery evaluation subcommittee will review the need to extend the duration of effort for a given project. This review should be done with adequate lead time to ensure continuity of effort.

METHOW SPRING CHINOOK SALMON HATCHERY; 1995 BROODSTOCK COLLECTION PROTOCOL

APPENDIX C

METHOW SPRING CHINOOK SALMON HATCHERY
1995 BROODSTOCK COLLECTION PROTOCOL

Background

Methow Fish Hatchery (FH) was designed to propagate three spring chinook salmon stocks from the Methow, Chewuch, and Twisp rivers. The hatchery's production goal varies yearly with run strength; maximum production for each stock is 250,000 yearlings at 15 fish per pound. Broodstock required to meet this level of production is 190 spawners (95 ♂ and 95 ♀) per stock, based upon a fecundity of 4,400 and 1:1 sex ratio. Assuming an 80% prespawning survival, 238 salmon need to be collected for full production.

The Washington Department of Fish and Wildlife (WDFW) technical staff conducted extensive deliberations regarding the relative merits and risks associated with the alternatives available for management of the natural production in the Methow Basin and the Methow Hatchery supplementation program. Serious consideration was given to not collecting any broodstock and foregoing supplementation production for the 1995 broodyear. It was determined that due to the extremely low run size projected for the second consecutive year at Wells dam that the risk of continued decline in stock abundance to levels approaching extirpation was sufficient to preclude the no action option.

WDFW also considered the option of attempting to continue tributary trapping operations in the Methow Basin similar to the programs conducted 1992-1994. It was determined that there is a high probability (due to high flows and low adult abundance) of collecting fewer adults for broodstock in 1995 than were collected in 1994. This is an undesirable situation due to extremely small breeding units and the biological logistics of incompatible maturation times for individual fish in these small groups. There is a high potential for females to mature at a time when no males are mature or for the collected fish to be all one sex.
When considering the option to collect broodstock at Wells Dam the WDFW staff considered the genetic risks associated with potentially mixing closely related substocks, including outbreeding depression. The WDFW staff concluded that the broodstock collection at Wells Dam should be considered as a "gene banking" action in response to the recent dramatic reduction in stock abundance for Methow Basin spring chinook.

The WDFW is in the process of having some baseline scale samples from adults collected from the three Methow sub-basins analyzed for rare earth composition, which may allow segregation of adults collected at Wells Dam into their respective substock.

The Wells Coordination Committee solicited the input of WDFW staff at the 31 March and 19 April meetings and has discussed and deliberated the issue of potentially violating our goal of substock specific broodstock collection for the Methow 1995 brood and reached a consensus decision that on a <u>ONE TIME BASIS</u> this was the appropriate

This decision reflects placing a higher priority, at this point in time, due to extremely low adult returns, on "gene banking"and population demographics relative to mixing what appears to be genetically similar substocks.

As outlined in the Action Plan below, we will attempt to maintain substock segregation based upon rare earth analysis of scales, but this capability is uncertain at this point in time.

Methow River: The long-term goal is to collect the founder population for the Methow stock at Foghorn Dam, which is expected to be capable of trapping in fall 1995. The Methow FH outfall channel, which has flows up to 20,000 L\min, is capable of attracting salmon volunteers. In 1993, the hatchery crew collected 99 of these salmon for Methow production in an attempt to establish a founder population. Scale pattern analysis, however, indicated that 67% of these appeared to be of hatchery origin, most likely from Winthrop FH. In 1994, 17 salmon were collected, of which 14 appeared to be of hatchery origin.

Chewuch River: Broodstock are collected at a trap on the Fulton irrigation diversion dam on the Chewuch River, which has had variable trap efficiency. Broodstock collections began in 1992, when 33 salmon were trapped, of which 20 were retained. Based upon redd count expansions, about 10% of the spawners were collected. In 1993, 186 salmon were trapped and 110 were retained, comprising about 30% of the spawning population. In 1994, ten salmon were collected.

Twisp River: Broodstock are collected at a floating weir facility on the Twisp River. It has had a low trap efficiency. Also, there have been concerns that the weir delays upstream passage, and does not collect a representative sample of the population. In 1992, 71 salmon were captured, 30 of which were retained for broodstock. An undetermined, but presumable large number of salmon passed the weir in moderately high flow. It appears that over 300 salmon spawned in the Twisp River in 1992, based upon redd count expansions. Based upon this estimate, the hatchery crew trapped 25% of the spawning population and retained 10% or less for broodstock. In 1992, hatchery staff trapped 70 salmon and retained 42, which appears to be about 25% of the spawners, based upon redd count expansions. In 1994, five salmon were collected.

Historical Escapement

The 1984-1993 average Wells Dam counts for spring chinook salmon is 2,274 (adults and jacks). The typical distribution of redds is 45% Methow River, 28% Chewuch River, and 27% Twisp River. Escapement to these streams (based on spawning ground surveys in index areas) appears to be quite variable. This variation should be considered in yearly broodstock collection plans; fewer fish should be collected in years of low abundance. The 1994 escapement to the Methow Basin was a record low: 258 salmon counted at Wells Dam. As of this date, the TAC predicted Wells Dam run size for 1995 is about 76% of the 1994 run (197).

Several concerns have been raised over the population demographics associated with the low effective breeder size in the Methow FH in 1994. These concerns were

attributed to a small number of salmon in the broodstock, unequal sex ratio, differential rates of maturation, and the division of the number of spawners into distinct mating pools. These difficulties will most likely occur again in 1995. To mitigate these problems, adults will be collected at Wells Dam for broodstock in 1995.

The advantages of collecting broodstock at Wells Dam are: 1) the hatchery crew can collect fish throughout the duration of the run in a manner that is safe to the fish, 2) the potential for delays or displacement at the terminal area traps will be alleviated, 3) a higher proportion of the run will be placed in a hatchery, giving them a survival advantage over naturally-produced salmon, 4) prespawning mortality may be reduced, and 5) the effective population size will be increased. The disadvantage of collecting broodstock at Wells Dam is that efforts to encourage local adaptation of the three distinct populations may be negated for one year. given the critically low run size expected in 1995, the advantages of trapping at Wells Dam outweigh the disadvantage.

Action Plan

The established spring chinook run timing at Wells Dam is 1 May to 28 June. During this period, the east ladder trap will be operated three days a week (43% trap period). There is an overriding goal of achieving a minimum escapement for spring chinook at Wells Dam of 100 fish (adults and jacks). The broodstock collection action and escapement above Wells Dam will be assessed as close to the 50% point in passage as possible. The approximate date for this assessment is 23 May. If the projected escapement at this time does not meet or exceed 100 fish, the broodstock collection will be discontinued. If broodstock collection continues it will be adjusted weekly to balance the 25% per week goal and the 100 fish minimum escapement goal. The status of this program will be reported to Mr. Mike Erho (Mid-Columbia Coordinator) via Douglas County PUD by 10 a.m. on Fridays of each week of east ladder trap operation. The collection goal will be 25% of the run. The run size at Wells Dam (total adult and jack count at east and west fishways plus the trapped fish) will be updated weekly and the east ladder trapping schedule adjusted for the following week to maintain the target collection rate of 25%. Methow FH would therefore operate at about 10% of capacity. Only unmarked salmon will be collected; all adipose-clipped salmon will be released upstream. Salmon will be immediately transferred to the tank truck, and will be transported to Methow FH at least twice a day. Guidelines will be established for tank loadings and duration.

Scale samples from the broodstock will be taken during collection and analyzed prior to spawning, for freshwater growth patterns and rare earth composition. The latter technique will be used, on a probability estimate, to assign a fish to a given stock. If the scale pattern indicates a salmon is hatchery-origin, the fish will be assigned to the Methow stock (which would include Winthrop FH). All fish or eggs taken from fish of hatchery origin will be transferred to Winthrop FH. Logistics of this transfer will be determined by the hatchery managers.

In consideration of the potential impacts of tributary specific broodstock collection on the Twisp and Chewuch rivers, especially in a relatively high run-off year, and the interception of broodstock at Wells Dam, no broodstock will be collected at these two sites in 1995.

The crews at Methow and Winthrop FHs will monitor the numbers of spring chinook salmon that volunteer into both facilities. These fish will be included in the hatcheries' broodstock. If a significant number of salmon volunteer into the channel or hatchery, collections at Wells Dam will be reduced accordingly.

To maximize genetic diversity, all salmon which are not of hatchery origin will be spawned as one population, unless some segregation is feasible from interpretation of the scale data. At this time, the strategy will be to divide the gametes equally among the four stations (Methow, Winthrop, Chewuch, and Twisp), although this strategy may be revised when firm estimates of broodstock size and volunteer rates are known. Likewise, fertilization methods will be determined in late summer when the broodstock size and sex ratio are known.

1995 OKANOGAN SOCKEYE SALMON BROODSTOCK PROTOCOL

APPENDIX D

1995
~~1994~~ Okanogan Sockeye Salmon Broodstock Protocol

INTRODUCTION

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

PROGRAM GOAL

Phase 1 of the production plan under the hatchery based compensation section of the Wells Settlement Agreement includes a production element of 8,000 pounds of sockeye juveniles at 25/pound of 200,000 fish. In order to meet this level of production based on last year's hatchery program results, 260,000 sockeye eggs will be required assuming an 80% survival to ponding (80% of 260,000 eggs = 208,000 sockeye fry). Assuming a fecundity rate of 2100 eggs per female and a 1:1 sex ratio, 248 spawners will be required to meet the egg take goal. Assuming a prespawning mortality rate of 28%, 344 adult sockeye salmon need to be collected for full production.

BROODSTOCK COLLECTION PLAN

Sockeye salmon will be collected during a two-week time frame this year in order to reduce impacts to adult summer chinook. Trapping will be conducted within the mid-80th percentile of the run at large. Daily ladder counts at Wells Dam over the past 5 years indicate the run entry pattern for the mid-80th percentile occurs during a 40 day period between July 8th and August 16th. Trapping will occur during the first two weeks of this window or in a manner that is proportional to weekly passage at the dam if the run pattern significantly changes. Broodstock collection will parallel the relative strength of weekly returns as much as possible through the collection period. Some modifications may be required in weekly quotas in the event of poor or truncated runs.

Collections will be made in concert with the summer chinook broodstock

program operated by WDF as much as possible. Currently this program traps two days a week, therefore it is anticipated that four total trapping days will be required during the two week sockeye broodstock collection period. If it becomes apparent early on that broodstock requirements will not be met with only two trapping days a week, additional trapping days during the collection period will be required.

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

Over the past 5 years, the average sockeye salmon count at Wells Dam has been approximately 21,000. It is estimated that this years count will be substantially less(approx. 5,000). The pre-season forecast estimates a count of 22,900 sockeye to Bonneville Dam with the Wenatchee stock expected to dominate the run. If this forecast is somewhat accurate, escapement to Wells Dam will still be adequate to meet broodstock requirements without adversely impacting the population.

DRAFT ANNUAL BYPASS OPERATION PLAN
FOR
WELLS DAM, 1996

APPENDIX E

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 1996 Bypass Season

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

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

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

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

Projected Hatchery Releases above Wells Dam
Hatchery releases for 1996 above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	113	4/15
Methow (WDFW)	Spr. Chinook	37	4/15
Winthrop (USFWS)	Sum. Chinook	44	4/15
Carlton (WDFW)	Sum. Chinook	400	4/15
Similkameen (WDFW)	Sum. Chinook	500	4/15
Winthrop (USFWS)	Sum. Steelhead	80	4/20
Wells (WDFW)	Sum Steelhead	550	4/20
Lake Osoyoos (CCT)	Sockeye	200	5/15

Starting Dates and Ending Dates
Bypass barriers will be in place between March 27 and August 29. Hydroacoustic and fyke net sampling will start on March 27 and be collected until August 29.

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

(11/15/95)

DRAFT REPORT:
EVALUATION OF JUVENILE SOCKEYE SALMON ONCORHYNCHUS NERKA OUTMIGRATION FROM LAKE OSOYOOS, WASHINGTON
A PILOT PROJECT

APPENDIX F

COLVILLE CONFEDERATED TRIBES

FISH AND WILDLIFE DEPARTMENT
BOX 150, NESPELEM, WA. 99155

DRAFT

EVALUATION OF JUVENILE SOCKEYE SALMON Oncorhynchus nerka OUTMIGRATION FROM LAKE OSOYOOS, WASHINGTON - A 1994 PILOT PROJECT

Prepared by

JON HANSEN
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May 1995

FOR THE DOUGLAS COUNTY PUBLIC UTILITY DISTRICT

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ABSTRACT

A 1994 juvenile sockeye salmon *Oncorhynchus nerka* evaluation found that approximately 98.6 percent of the accelerated 0+ age hatchery fish released into Lake Osoyoos, Washington did not emigrate during the normal natural smolt migration period. Mean fork length measurements show that hatchery fish were 22.0 mm smaller than natural production 1+ fish. Hatchery fish that were acclimated in net pens emigrated from the Lake at approximately the same rate as fish released directly into the Lake. No clear relationships were found between physical variables, trap efficiency, and outmigration events during the bulk of the project. Natural production fish apparently left the Lake in April and early May during 1994. Backwatering from the Similkameen River can effect the operation of a rotary screw trap. It is important to do physiological tests on juvenile hatchery fish to help ascertain the level of smolting. Predictive models are useful tools to help produce a population estimate for non trapping days.

INTRODUCTION

In April of 1994, the Colville Tribes began an assessment of Okanogan River juvenile sockeye salmon. A portion of the assessment includes an evaluation of juvenile hatchery outmigrants from Lake Osoyoos. The hatchery fish evaluation will continue for three years and is part of the Wells Settlement Agreement. The adult broodstock fish were trapped at the Wells Dam fish ladder. The eggs and juvenile offspring were cultured at the Cassimer Bar pilot hatchery program. The juveniles were then outplanted in Lake Osoyoos into a net pen and the open water on May 17 and 18, respectively. The purpose of this report is to provide: 1) an assessment of the success of the hatchery releases; 2) provide a review of some physical variables that may influence migration timing or effect trap efficiencies; 3) provide a cursory review of natural production outmigration numbers.

The 1994 field project was conducted as a pilot for the purpose of establishing fish outmigration timing, to identify potential problems with sampling schemes or techniques, and to provide a foundation for a more intensive 1995 field season.

DESCRIPTION OF THE STUDY AREA

Lake Osoyoos is a transboundary water that is located in the Okanogan valley of British Columbia and Washington State. The Lake primarily consists of three basins (Pratt et al. 1991). The northern, middle, and part of the southern basins lie in Canada and are fed by the Okanogan River. The outlet is controlled by a low head dam (Zosel Dam) that is used to regulate the level of the Lake for recreational, irrigation, and flood control purposes. Flow from Lake Osoyoos is regulated by an International Agreement between Canada and the United States.

The water below the outlet of the Lake consists of the Okanogan River (Figure 1). The River flows south for approximately 1.6 kilometers before it is joined by a branch of the Similkameen River. The Similkameen River is the largest tributary to the Okanogan River and exceeds the Okanogan in terms of spring freshet flows on most years (Quinn 1965).

On May 17, the Tribe released approximately 15,000 juvenile hatchery sockeye from a net pen located approximately 0.8 kilometers north of the Washington State Park by Oroville. On May 18, the Tribe released approximately 95,534 fish into the Lake at the Deep Bay Boat Launch located approximately 1.6 kilometers north of Oroville on the West bank of the Lake (Rod Stensgar, CCT, pers. comm. 1994). The fish were later trapped and counted at the final trap site located approximately 300 meters below Zosel Dam (Figure 1) at River Mile 77.4.

We had to move the rotary screw trap that we were using three times before we could get away from a back water influence from the Similkameen River. Freshets from the Similkameen sometimes influence the flow velocity of the Okanogan River upstream to Zosel Dam (Ray Smith, USGS, pers. comm. 1994). As a result, we moved the trap upstream towards Zosel Dam to avoid reductions in River flow velocities - which allowed the trap to fish effectively.

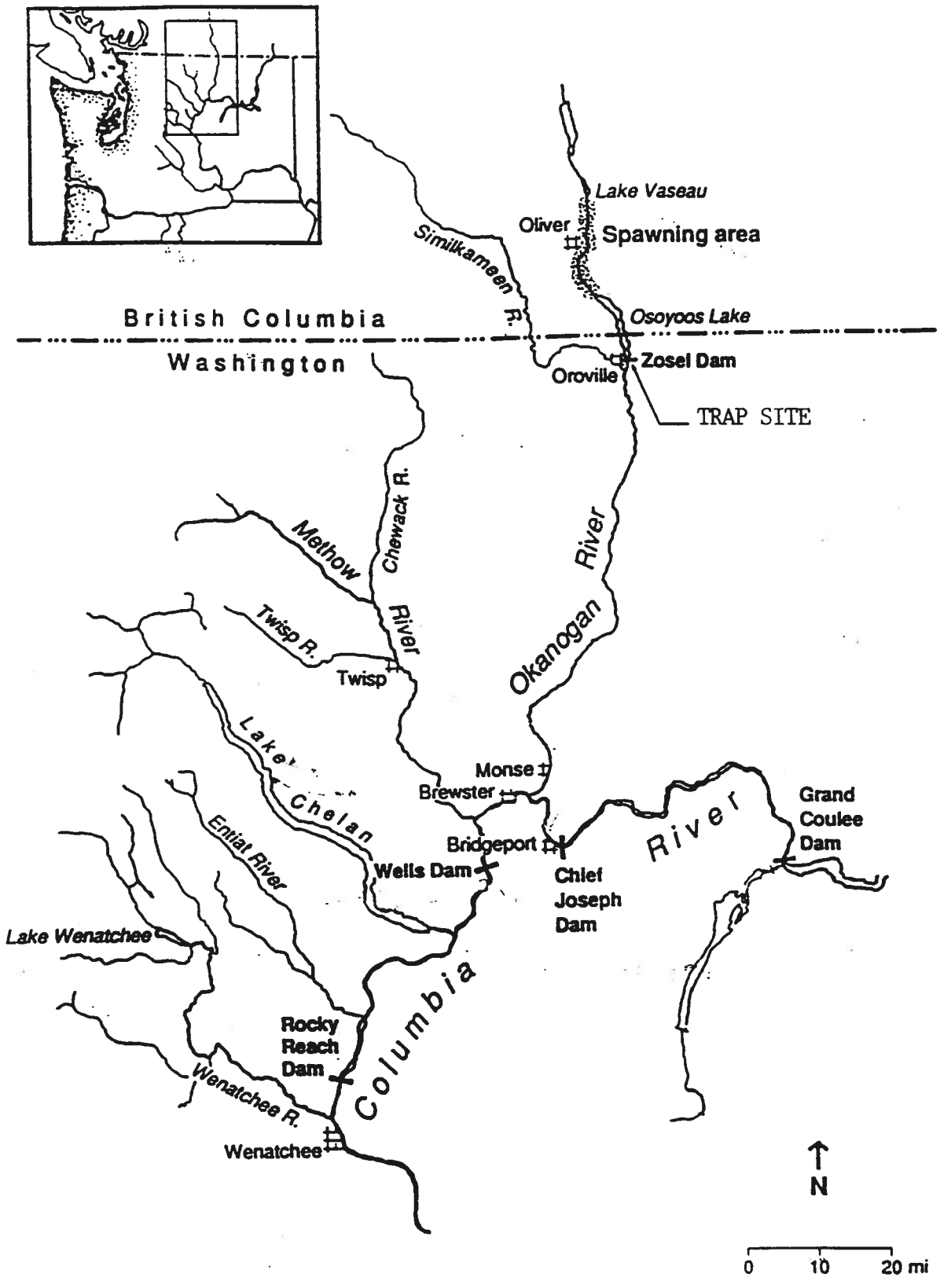


FIGURE 1. Map of study area showing trap site location. (adapted from Swan, 1994)

METHODS

TRAPPING

The final trap site was located approximately 300 meters downstream of Zosel Dam on the right bank of the Okanogan River. Initially, the field crew operated the eight foot screw trap on a twenty-four hour basis until we determined that the natural production fish migrated only during evening hours. Thereafter, we fished for juvenile sockeye during the night. On May 27th, as we relocated the trap, we apparently witnessed a large outmigration of natural production fish that occurred during the day. However, neither the trap numbers or visual indicators led us to believe that there were any additional daytime outmigrations.

We fished the trap in the thalwag in approximately 1.5 meters of water. Every other day the trap "cone" was lowered to within about 7.5 cm of the stream bottom in such a manner as to maximize the cone rotations per minute.

The field crew checked the trap for fish at least hourly. We anethsethized the trapped fish in MS-222 and measured and collected scales from every fifth fish. The fish were marked with a lower caudal clip, checked for any identifying marks and placed in a distribution truck for recovery and relocation. Relocated fish were released approximately 500 meters below Zosel Dam from the right bank before 0100 hours to allow adequate travel time to the trap.

BIOLOGICAL INFORMATION

Natural and hatchery produced fish were measured in millimeters to fork length. Age information from fish scales were verified by John Sneva of the Washington Department of Fish and Wildlife.

PHYSICAL VARIABLES

The field crew took flow velocities, water depth, and water temperature measurements several times per trapping session. Flow velocities were collected with a Marsh-McBirney Flo-Mate meter at approximately 1 meter in front of the trap at a depth of 0.8 of the water column. Water temperatures were collected with a hand held thermometer. Water flow information was collected at the USGS gauging station located approximately 122 meters upstream of the trap site.

POPULATION ESTIMATES

Outmigration populations were estimated in three different ways. Petersen's mark-recapture methodology was used to estimate total populations for actual trapping days that had both capture and recapture data. Some values toward the end of the run were created by using a combination of trap values and trap efficiency because of our inability to recover marked fish. On non trapping days, capture values were generated by creating two pre and post peak predictive equations based on trapping

data. The predicted trap capture estimate was used in conjunction with a trap efficiency value to generate a total population value for non trapping days. I assumed that outmigration conditions remained constant between trapping days.

The numbers of natural and hatchery produced trapped fish were combined to produce a single population estimate. On non trapping days, the hatchery capture component percentage was generated by using the mean of the previous and post daily hatchery component (% hatchery fish of fish trapped - Table 6.). This value was multiplied by the model and efficiency based population daily estimate to produce a hatchery population for non trapping days. On trapping days, the percentage of captures that the hatchery fish comprised of the total catch was multiplied times the total population estimate to generate a hatchery population component. This approach was necessary because the proportion of hatchery to natural fish was skewed heavily in favor of naturally produced fish.

DATA ANALYSIS

Mark-recapture population estimates and statistical data for trapping days were generated using a software program developed by Steven Smith of the National Marine Fisheries Service. An option was used from the program that generated a population value based on an unequal likelihood of recapture.

Tests for data normality, correlation, data transformations, curve fitting, and t-test comparisons were done using Minitab for Windows Software. Statistical input for portions of the project was provided by Dr. William Owen of Central Washington University.

RESULTS

TRAPPING

Results of our trapping efforts are listed below in Table 1. The beginning date of May 12 represents the first day of trapping at the final trap location. The results clearly show that the

Table 1.

SUMMARY OF JUVENILE SOCKEYE TRAPPED										
1st Period Captures				Marked	2nd Period Captures				Captures Total	Est. Trap Effic.
DATE	Np	Lr	Wi	#	Marked	Np	Lr	Wi		
5/12			24	19	1				24	5.3
5/14			23	18	1				23	5.5
5/16			207	162	8				207	4.9
5/18		1	140	121	3		19		160	2.5
5/20		12	1183	214	5	2	27	368	1592	2.3
5/22	2	3	213	218	4	2	2	69	291	1.9
5/24			19	19		4	1	12	36	
5/26		1	11	12			2	13	27	
5/28			26	25				1	27	
5/30			47	47				4	51	6.4
Total	2	17	1893	855	22	8	51	467	2438	
Np=Net pen fish				Lr=Lake release fish				Wi=Wild fish		

largest component of sockeye trapped (96.8%) consisted of wild fish (Figure 2.). Hatchery fish released into Lake Osoyoos and fish finished in the net pens comprised 2.8 and 0.4 percent respectively of the remaining sockeye trap captures. Outmigration numbers by component are also given in Figure 2. The hatchery fish that were released directly into the Lake appeared in our trapping efforts the same day. One of the larger outmigrations of natural and hatchery fish occurred two days after the fish were released into the lake. The net pen acclimated fish didn't occur in our trapping efforts until May 20, three days after they were released from the pens. The reader should remember that the net pen fish originally comprised only 13.6 percent of the hatchery plants. The percentage of hatchery outmigrants caught in the trap, based on the original plant numbers, varied by less than 1 percent between the two groups of hatchery fish (i.e., 0.06 and 0.07 percent net pen and Lake release fish were caught in the trap, respectively). Hatchery fish had a tendency to be more prevalent in the second period trapping

efforts for some unknown reason.

Table 2. shows the abundance of captured species. Surprisingly, one of the larger components of the miscellaneous catch consisted of juvenile chinook salmon *Oncorhynchus tshawytcha*.

Figure 2.

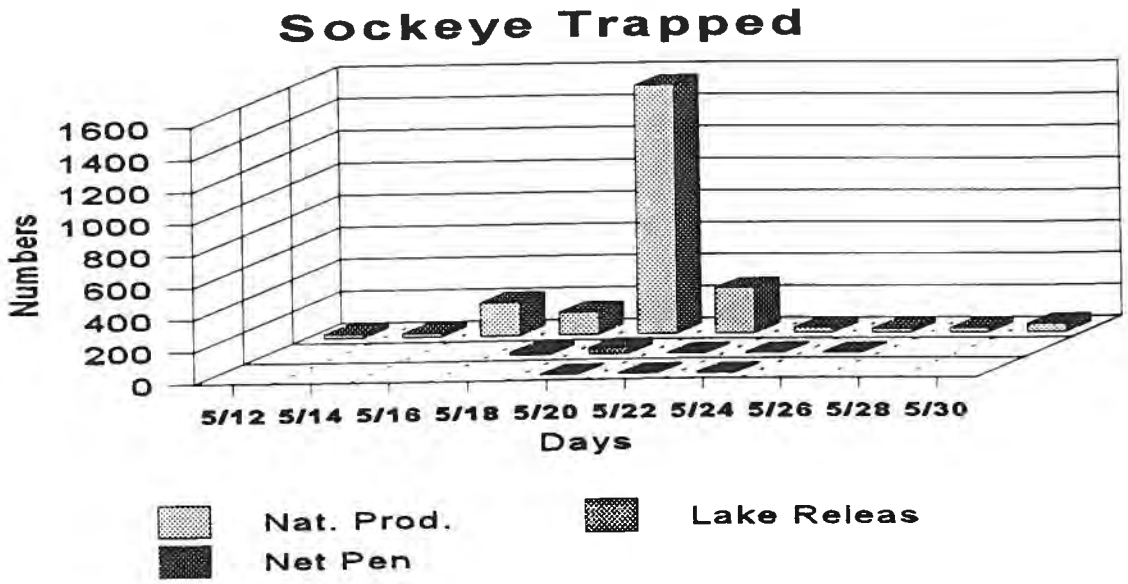


Table 2.

ABUNDANCE OF INCIDENTAL TRAP CATCHES

Species	Abundant	Common	Scarce
Sucker (Catostomus spp.)			*
Rainbow Trout (Salmo gairdneri)			*
Eastern Brook Trout (Salvelinus fontinalis)			*
Yellow Perch (Perca flavescens)		*	
Squawfish (Ptychocheilus oregonensis)			*
Redside Shiner (Richardsonius balteatus)		*	
Shorthead Sculpin (Cottus confusus)		*	
Black Bullhead (Ictalurus melas)			*
Pumpkin Seed (Lepomis gibbosus)			*
Chinook Salmon (Oncorhynchus tshawytscha)	*		

Trapped fish that were marked and released generally appeared in the trap within forty-five minutes to three hours. The longer period of time obviously subjected the marked fish to predation. Trap efficiency averaged approximately 3.6 percent and remained fairly consistent throughout the trapping period. We did not observe any bias regarding the relationship between trap efficiency and fish body size. Fish mortality from trapping and handling was limited to only three fish.

Biological Information

Length and age information from natural production, net pen and lake release sockeye are provided in Table 3. Unfortunately, the sample rate precluded us from collecting much data on hatchery fish. However, based on observation, the fish that were sampled were fairly representative of the run as a whole. All but one of the hatchery fish in our trapping efforts was detectable from size characteristics and dark coloration. The lack of hatchery fish descaling during handling led me to believe that the fish were not smolting. Gill ATP-ase work in 1995 may help us resolve this question for that brood year.

Table 3.

AGE AND LENGTH INFORMATION OF TRAPPED SOCKEYE

	Mean Fork Length (mm)	Max.	Min.	Stand. Dev.	Age	N
Net Pen	90.0				0+	1
Lake Rel.	101.5	105	98		0+	2
Nat. Prod.	118.0	141	101	5.1	1+	153

Older juvenile migrants sometimes have a tendency to leave the system early (John Sneva, WDFW, Pers. Comm. 1994). As a result, we may have missed that portion of the natural run because of our late start in sampling. Mean fork length measurements at the time of release for lake release and net pen fish were 89.6 mm and 83.1 mm, respectively (Rod Stensgar, CCT pers. comm. 1995).

Physical Variables

Table 4. provides mean water temperature, flow, and velocity information. Variables remained fairly constant throughout the trapping period at the final trap location.

Table 5. presents a Spearman correlation matrix showing the relationships between trap efficiency, temperatures, velocities, and flows. The table shows a lack of highly correlated relationships between trap efficiency and the measured physical variables.

There may be a relationship between peak flows and peak juvenile outmigrations. Peak outmigrations appear to occur shortly after a peak in flows (Figure 3).

Table 4.

SUMMARY OF PHYSICAL MEASUREMENTS

Mean Values			
Date	**Temperature ©**	**Velocity (M/S)**	**Flow (CM/S)**
5/12	17.8	0.78	30.6
5/14	16.7	1.05	30.9
5/16	15.6	1.12	32.1
5/18	16.1	1.16	31.8
5/20	15.6	1.15	30.6
5/22	16.7	1.17	30.6
5/24	17.8	1.17	30.9
5/26	18.3	1.15	31.8
5/28	15.0	1.16	28.4
5/30	15.6	1.07	24.7

Table 5.

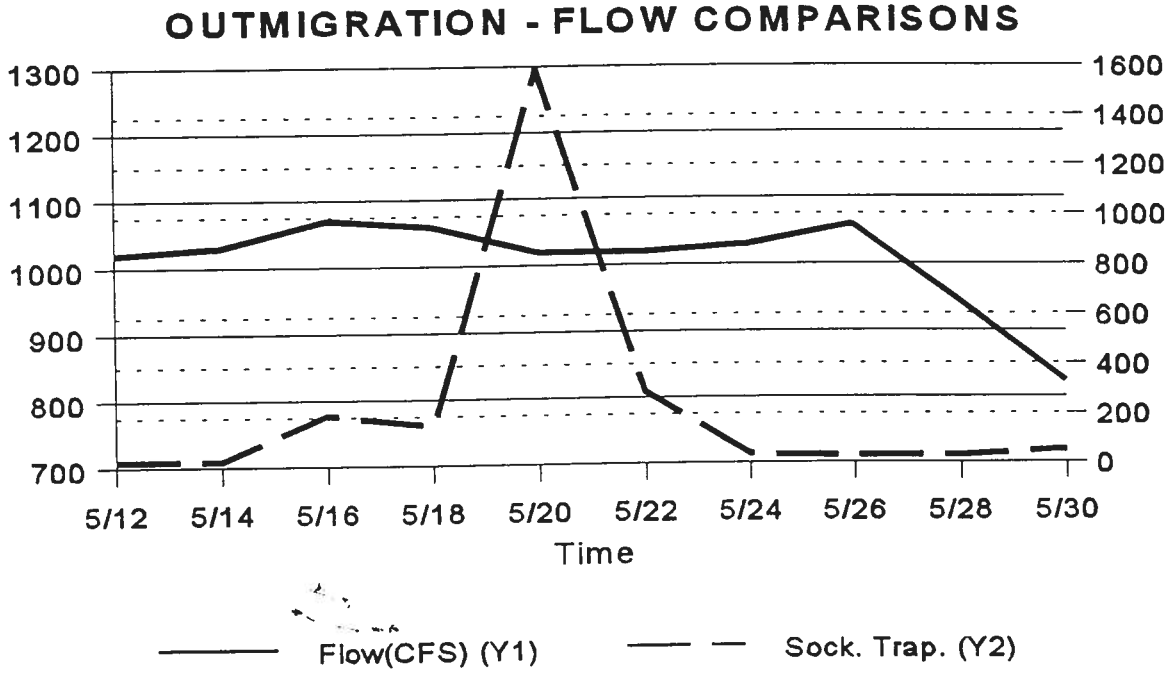
VARIABLE CORRELATION MATRIX

	Trap Eff.	**Wat. Temp.**	**Velocity**
Wat. Temp.	0.016		
Velocity	-0.571	-0.313	
Flow	-0.469	0.422	0.087

Figure 3. shows that flows from Lake Osoyoos peaked on May 16. A peak outmigration event occurred four days later on May 20. Such a relationship was not apparent on May 26 because it was the end of the migration. Earlier, however, I noted that a peak outmigration apparently occurred about May 3. If

so, crosschecking with the flow data indicates a major increase in flow starting on May 4. Some sort of relationship apparently exists between flows and outmigrations. The paucity of the data, however, makes it difficult to draw any conclusions.

Figure 3.



Population Estimates

Population estimates for the juvenile sockeye outmigration are listed in Table 6. By looking at the Table the reader can see that the estimates based on trap capture data and model generated values, in conjunction with trap efficiency, produce larger population values when compared to estimates generated by mark/recapture methods. The natural production population consisted of about 65,000 fish. The hatchery fish population consisted of about 3,085 fish or a little over 4.4 percent of the outmigration population.

After numerous curve fitting efforts I generated two predictive models to describe the outmigration. The first predictive model, log10 smolts = -28.477 + 0.224893X days ($r^2 = 0.862$), is based on prepeak trap captures including the peak of the outmigration (Figure 4.). The equation will produce a value in log base 10 and requires an antilog transformation to provide an equation derived number indicative of

Table 6.

OUTMIGRATION POPULATION ESTIMATES

Date	Pop. Estimate	95% Profile	% Hatchery fish of Fish Trapped	Estimated Hatch. Pop.
5/12	83.5	29.5 , 1266.1		
5/13	710.5*			
5/14	96.5	32.1 , 1,494.7		
5/15	1,995.3*			
5/16	1,060.3	620.9 , 2 , 192.3		
5/17	5,589.0*			
5/18	1,627.1	678.3 , 6,299.6	12.5	203.4 (0,203.4)
5/19	15,743.7*			1,188.6
5/20	16,931.0	8,037.3 , 4,6708.6	2.6	440.2 (22.4 , 417.8)
5/21	10,170.9*			289.9
5/22	4,160.1	1,875.5 , 1,3076.1	3.1	129.0 (56.7 , 72.3)
5/23	5,038.2*			428.2
5/24	10[illegible].1.	59.5,322.3	13.9	14.0 (6.2,7.9)
5/25	2,489.4*			311.1
5/26	729.0**		11.1	80.9 (0,80.9)
5/27	1,231.2*			
5/28	729.0**			
5/29	610.2*			
5/30	1,377.0**			
TOTAL	70,473.0			3,085.3
	*=model and efficiency based estimate **=capture and efficiency based estimate (,)=Net pen and Lake Release estimate			

trapped smolts. The second equation, log10 smolts = 24.1181 - 0.152777X days ($r^2 = 0.633$), reflects trapping efforts from the peak to the end of the run (Figure 5.). The same type of transformations are also required for the second equation to yield a value in smolts trapped. I feel this type of procedure is an accurate way to develop missing information given of the exponential fashion in which the data

behaves. The model generates reasonable values that fall within the 95 percent confidence intervals for adjacent trapping days. I did not attempt further improve the fit of the second equation because of the paucity of the data.

Figure 4.

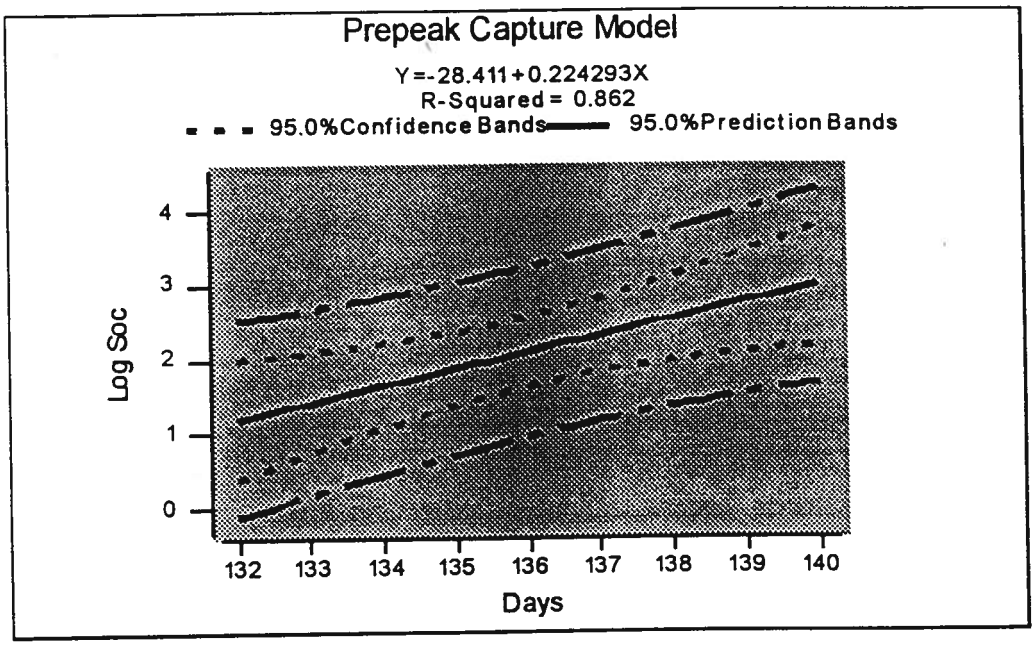
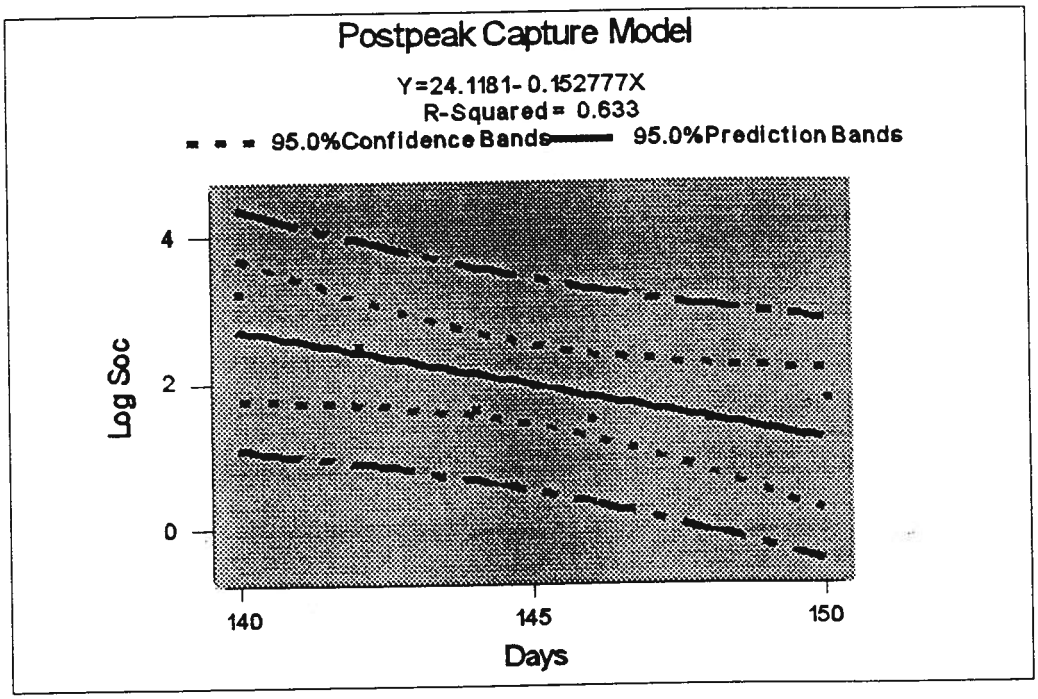


Figure 5.

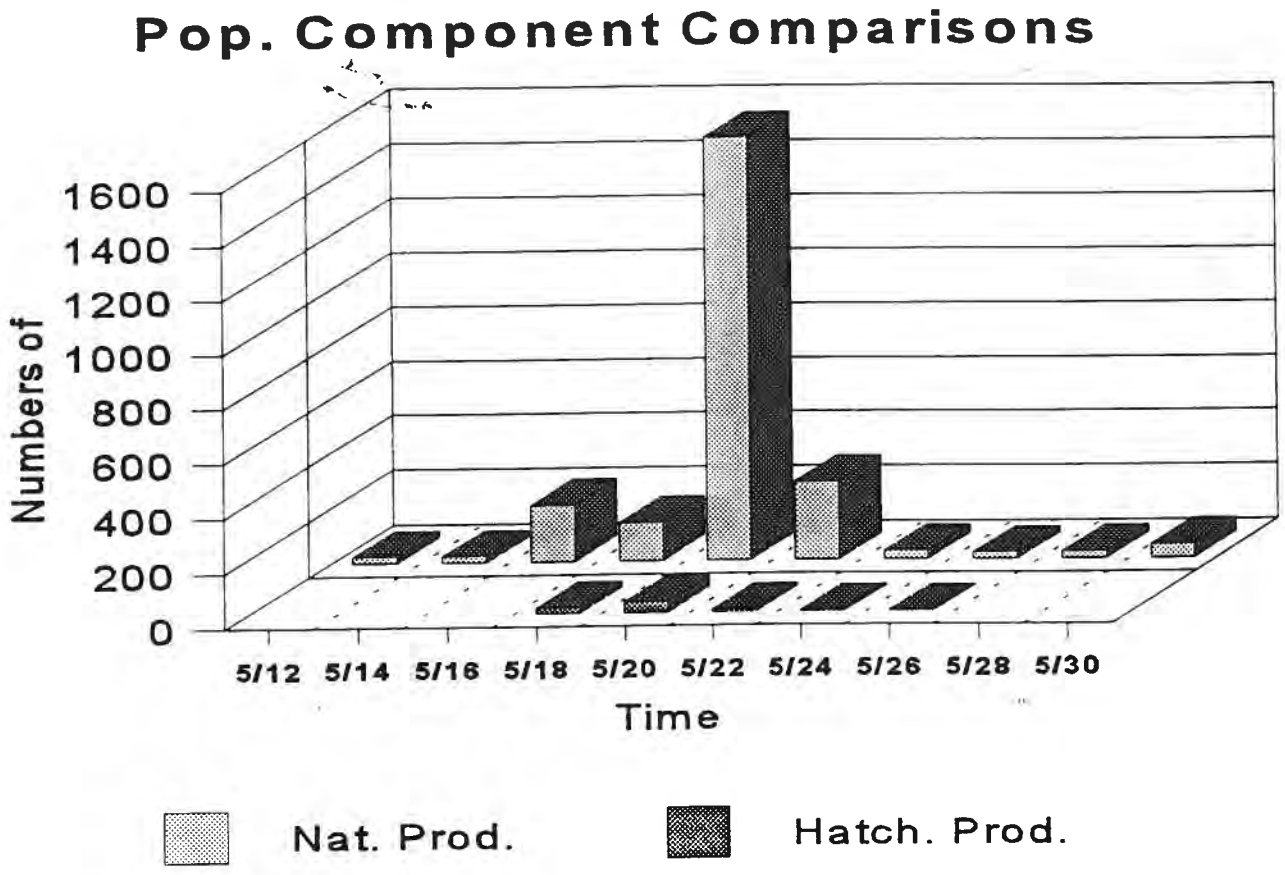


I did not construct a 95 percent confidence interval for population values that were based on model estimates. Such a procedure is fairly complicated because there is variability from both the model estimate and the trap efficiency estimate (B. Owen, CWU, Pers. Comm. 1995). The confidence interval for trap efficiency data is 3.7 + 2.2 percent based on calculations used by Anonymous (1992). An example of the range of log values for trapped smolts that occurs in the prepeak and post peak predictive models are provided in Figures 4. and 5.

Population values toward the end of the trapping period were synthesized using actual trap catch values and mean trap efficiency. Our recapture rates were inconsistent the last few days of the run. Figure 3. shows a decline in flow about the time our recapture rate changed (May 26). It is likely that the drastic reduction in flow that occurred at the very end of the trapping period influenced trap efficiency and recapture rate. Based on observation, flows on June 1 were only about a third of what they were on May 30. This phenomena, coupled with the influence on trap efficiency, is largely responsible for the reduced r^2 value in the above post peak model equation.

Figure 6. shows population comparisons for natural production juveniles and hatchery production juveniles on days when we operated the trap. As the Figure shows, hatchery fish moved out of the Lake in greater numbers at about the same time that the natural production fish numbers peaked.

Figure 6.



I used a t-test to test the hypothesis that the hatchery fish population that was released into the Lake was equal to the hatchery fish population that was censused below the outlet. A test performed at the 95.0 percent confidence level rejected the hypothesis. Therefore, I can conclude that there is a statistically significant difference between the two populations. Of the 110,534 hatchery fish that were planted into the lake, an estimated 3,085 fish emigrated from the lake. A significant number of fish (107,449 or 97.2 percent) did not migrate during the trapping period. I didn't do an analysis of the two different groups of hatchery fish (net pen versus lake release) because of the low number.

DISCUSSION

As the results show, most of the sockeye (96.8%) caught in the screw trap were natural production fish. Only about 2.8 percent of the hatchery fish emigrated from Lake Osoyoos during the trapping period. Net pen and Lake release fish emigrated at approximately the same rate, although net pen fish had a longer period of acclimation. In all cases, the reader should realize that population estimates are trend indicators and not obsolute values because of the necessity to combine several methods to produce a single value. The timing of the outmigration was similar for both hatchery groups of fish and natural production fish. Species of fish caught in the trap were as expected with the exception regarding the abundance of chinook salmon juveniles.

Physical variables undoubtedly play a role in trap efficiencies and outmigration processes (Seiler and Ackley 1981). Some of the biological and physical relationships may be obscured because the Okanogan River by Oroville is regulated system (D. Seiler, WDFW, Pers. Comm. 1994). Out-migrations events may be influenced by physical variables and behavioral tendencies (J. Marco, CCT, Pers. Comm. 1995). Such reasoning may account for the outmigration events that occur after peaks in flow.

Our biological information shows that the hatchery fish were smaller than most natural production fish. Variation in coloration and the "looseness" of scales also raised some concerns over the degree of smoltification of the outmigrating fish. Towing the net pen to the outlet of the Lake before release is a practice that may subject the fish to flushing flows rather than outmigration events. On the other hand, fish released further up the Lake migrated at approximately the same rate and time as fish acclimated in the net pens. It is valid, however, to question the adequacy, of the acclimation period for the lake release fish.

Predictive modeling of trap capture data is valid way to generate values on non trapping days, especially around the peak of outmigrations. Such a methodology, where applicable, has the potential for increasing the accuracy of population estimates.

1995 efforts will focus around a longer field season, obtaining gill ATP-ase samples, predation sampling and locating the trap away from the confluence of the Similkameen River.

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WATER QUALITY
AND
SOCKEYE SALMON ENHANCEMENT
IN
LAKE OSOYOOS DURING 1995

APPENDIX G

Vault copy

SECOND ANNUAL REPORT:

WATER QUALITY AND SOCKEYE SALMON ENHANCEMENT IN LAKE OSOYOOS DURING 1995

PREPARED FOR THE

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EXECUTIVE SUMMARY

This report addresses water quality of Lake Osoyoos in 1995 with a focus on nutrient and plankton dynamics. Studies reported herein were conducted as part of a sockeye salmon enhancement program that involved short-term rearing and release of native-stock from net pens in the lake. Several tentative conclusions offered in prior reports (Rensel 1993,1995a) are revisited herein. A final report in 1997 will synthesize all the information for surveys of the lake from 1994 through 1996.

The 1991 Wells Dam Settlement Agreement between Douglas County PUD and various fish management agencies discusses the use of net pens in Lake Osoyoos to increase the native run of sockeye. Pen operation is funded by the Douglas County Public Utility District. The Colville Confederated Tribes provided fish cultural personnel and produced fry from the native run captured at Wells Dam and held at the Cassimer Bar Hatchery near the mouth of the Okanogan River.

The studies reported herein include monthly sampling from April to October of routine water quality, phytoplankton, zooplankton and related factors to determine the trophic (nutrient) status of the lake. Sampling was extended to include the north basin in 1995, with occasional data collected in the central basin and at other stations in all basins to assess within-basin homogeneity of water quality. Assessment of the total organic carbon content of the lake bottom under and near the temporary pens was also conducted. Ancillary studies in 1995 include collection of water temperature and routine water quality data from several locations in the Okanogan River during the late summer. Zooplankton bioassays of late summer water quality using *Daphnia magna* are also reported. The report develops a hypothesis that seeks to explain interannual variation of smolt production relative to adult spawner escapement and fry rearing.

Trophic State of Lake Osoyoos

The 1995 data suggest a similar, but slightly lower trophic status of the lake than the prior year, at least for the south basin where monitoring occurred in both years. The lake remains within the mesotrophic range, or moderately enriched.

Analyses of three trophic indicators known as Carlson's (1977) trophic state index (TSI) resulted in an average score of 42.6 for the north basin in 1995. Average TSI for the south basin was 44.9, slightly less than the 1994 TSI of 46.8. Chlorophyll a content was the strongest factor pointing to mesotrophy, while Secchi disk transparency was only ranked in the lower range in the same category. Total phosphorus was equally low in the mesotrophic range for the north basin, but midway for the same range in the south basin.

Basic Water Quality

The lake was significantly cooler by 2.0°C during the mid-spring fish cultural period of 1995 compared to the prior year. Peak surface water temperatures in summer were less too, (22.6 versus 27.5°C, respectively), but occurred later than the prior year. Pending availability of local weather data but based on my observations, I speculate that the difference was likely due to the cooler, wetter conditions in 1995, as well as more wind. These factors combined to produce less vertical stratification of the water column in the south basin, which is of particular interest with regard to sockeye fry.

Summer transparency in both basins was remarkably similar with minimal values occurring in July or August. South basin summer transparency averaged 3.3 m in 1995 versus 3.1 m the prior year. Other factors analyzed include dissolved oxygen (DO), pH, conductivity, and reduction-oxidation throughout the water column at several locations. Use of a Hydrolab multiprobe and recording/display unit greatly improved the ability to accurately collect many more data compared to using individual meters the prior year.

Vertical profiles of hypolimnetic (deep) water showed no DO (anoxia) in the south basin from July to September and low concentrations of DO (hypoxia) from July through October in the north basins, respectively. The lowest values in the north basin were in deep water during mid-October ranging down to 1.9 mg/L, indicating that fall turnover of that basin had not occurred by the completion of the field surveys.

Physical Habitat Suitability for Sockeye Salmon

In last year's report I tentatively concluded that if sockeye fry inhabited the south basin during mid to late summer of 1994 they must have been sandwiched in a narrow layer near the thermocline (i.e., the metalimnion: warm to cool transition depth), avoiding low dissolved oxygen concentrations below and high water temperatures above. That information and review of limited prior data led me to believe that sockeye fry did not utilize the south basin during comparable years, depending on water temperature and dissolved oxygen. The results from 1995 present an interesting contrast with implications for sockeye fry.

Surface water temperatures of the south basin during August 1995 were monitored twice and found to be above preferred ranges for sockeye fry reaching 21.5°C at 2 meters depth and 22.6°C at the surface. However, this compares favorably to the approximately 26 to 27.5°C water temperatures recorded in 1994 at the same depths. The literature indicates 15 - 17°C as the optimum range and the upper lethal limit has been estimated to be 24.5°C. As conditions during other months were much less extreme, I tentatively conclude that sockeye fry could have survived in the south basin in 1995. The available depth range during the worse recorded conditions (August) would have been from near surface to approximately 9 meters.

Suitable physical habitat was available in the north basin during all sampling periods although depths >20 m in October were hypoxic. Since water temperature at the surface had cooled to about 14°C at that time, the low DO at >20 m probably did not present a major limitation to sockeye fry in that basin.

Hypothesis Regarding Unexplained Variation in Smolt Recruitment

Large and unexplained variation in spawner number to smolt production has been estimated for sockeye salmon in Lake Osoyoos. There have been hints of density dependence for in-lake rearing in some years, but the relationship has been termed statistically non-significant overall (Pratt et al. 1991). I suggest a hypothesis that may explain how recruitment of smolt varies greatly without apparent relationship to adult spawner escapement. The hypothesis is necessary to further discussion about environmental factors that may limit production of sockeye smolt from Lake Osoyoos.

The hypothesis states that fry resultant of small or perhaps moderate adult spawner escapements have adequate space and food to rear in the northern basin, as long as kokanee abundance is modest too. Fry from large escapements or years with large kokanee abundance also move into the central and southern basins before their first summer in the lake. In cool years these fish continue rearing over the summer and outmigrate the following spring. In warmer years, the fate of these fish is unknown; they may suffer chronic mortality due to thermal or other stress and may be subject to predation by other species of fish. Some may also migrate back to the north basin, although the central basin presents a probable temperature barrier in warm years. It would be logical if some of the south basin fry outmigrated as zero-aged fish, but the literature suggests this does not occur. The large size of smolt in virtually all years may be explained by the outmigrants from north basin that have adequate space and food in all years. The variation in total number of smolt may be due to the all or nothing production from the south and central basins which have a significant portion of the total rearing space and fry in some years.

This report notes that summer thermal stratification is variable between years in the south and central basins of Lake Osoyoos. There may be accompanying interannual variation in the suitability of fry-rearing habitat in the summer. Historical water temperature data in the lake are scarce, but a surrogate location just downstream in the Okanogan River were used to evaluate data. Cooler late summer water temperatures there correlated with much better (~ 5.5%) egg-smolt results for the brood year rearing in the lake. Conversely, warmer than normal water temperatures matched poor (~0.8%) egg-smolt survival. The water temperature data were limited to four years, but mean water temperature data were based on many years. Egg to smolt survival also correlated with a well-documented minor shift in Pacific Northwest climate before and after 1976 from relatively cool/wet to warm/dry periods. Some suggestions for further testing the hypothesis are provided including refinement of the smolt production estimates that in the past may have not been as accurate as needed for management purposes.

Nutrient Dynamics

Compared to 1994, total phosphorus (total P) concentrations in the near surface waters of the south basin were consistently less in every month of 1995, averaging about 25% lower. The pattern of declining total P concentration over the summer was seen again in 1995. Total P was lower in the near surface waters of the north basin by 27% during summer months compared to the south basin.

Total nitrogen concentration of near-surface water was also less in the south basin in the summer of 1995 (447 µg/L versus 627 µg/L). The pattern of increasing summer concentration from the south basin in 1994 was not seen in either basin in 1995. Near-surface total nitrogen in the north basin averaged 360 µg/L in the summer of 1995, but did decline over the sampling period along with total phosphorus.

As suggested in the prior report, patterns of phosphorus concentration in bottom water indicate that internal phosphorus loading may be a significant nutrient source to the lake. Internal loading may be defined as the release of orthophosphate from bottom sediments during periods of low or no dissolved oxygen in the hypolimnion (bottom water) that involves shifts in iron binding properties. The south basin exhibited a similar pattern in 1994, but in 1995 total P did not follow the trend although orthophosphate did so. The present year provided an interesting contrast to 1994 because the degree of loading was apparently much less. This corresponds with the physical limnology and weather differences mentioned above. Comparison of lake inflow versus outflow of nutrient load of the Okanogan River also support this interpretation. Outflow concentrations of total N and P exceeded inflow concentrations in every month sampled (July to October).

The ratio of near-surface water dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (orthophosphate) suggest that nitrogen could be limiting to some forms of phytoplankton growth in surface waters when supply rates of dissolved nutrients were low.

Plankton Dynamics

South and north basins had similar phytoplankton dynamics in 1995, with shifts from diatoms to blue-greens in the late summer and fall. However, a major blue-green algae bloom occurred in August in the south basin that was not duplicated in the north basin. Unexpectedly, species of phytoplankton that were potentially valuable to crustacean zooplankton (and therefore sockeye salmon fry) were not significantly depressed by the bloom and overall were similar in biovolumes in both basins.

Zooplankton population biomass was dominated by crustaceans including the desirable sockeye fry prey, *Daphnia* spp (a cladoceran) during most sampling periods. Similar patterns of abundance and biomass occurred in both basins, but the August blue-green algal bloom appeared to depress south basin crustacean density, relative

to other summer months and the north basin. No apparent decline of cladocerans was noted overall, but *Daphnia* spp. were not present in September in either basin or in August in the north basin samples. A few 100 per m^3 were seen in the south basin sample from August. Nevertheless, crustacean zooplankton that are potentially useful prey for sockeye fry were present during the entire sampling period.

Collectively, the plankton data can be interpreted to suggest that prey was not limiting to sockeye fry or smolt in the lake in 1995. The data show the adverse effect of the existing mesotrophy/blue-green algal dynamics, but I consider high water temperature and low dissolved oxygen relatively more important. Foerster (1968) ranked Lake Osoyoos as the most productive lake of the sockeye lakes he reviewed with 21.4 crustacean zooplankton per liter. In 1995, we found much greater production, with about 57 per liter in the north basin and 47 per liter in the south basin from April to September. Even the lowest observed density (north basin, April, 13/L) is not low compared to other sockeye lakes, although no cladocerans were observed in the sample.

Fish Cultural Results and Impacts

In 1995 the pen program was again operated on a pilot scale and was successful by most measures. Increased numbers of larger fish were released compared to 1994, but the period of rearing in the lake was shorter than the prior year for reasons discussed herein.

Temporarily-placed net pens were stocked with 38,934 sockeye fry averaging 4.4 g in mid April of 1995. The fish transferred to the net pens did very well, with less than 0.1% mortality and good growth in the 14 days that they were cultured. Average weight was about 6.7 g at release. The Lake Osoyoos net-pen program is rather ambitious in that it is attempting to produce a large size smolt (about 18 g) in only six months after hatching compared to the wild smolts that have are in the lake for 1+ years. In 1995 the program was still far short of the pilot scale goal of 200,000 smolts released. However, a larger number of fry are expected to be available for the pen program at an earlier date in 1996 based on current projections.

Feed conversion ratio (i.e., feed used to fish biomass gained) improved to about 0.8in 1995, which is excellent for this type of program. As in the prior year, the fish were reared at a very low density and natural feed may have been in part responsible for the good food conversion ratio as well as multiple daily feedings by staff.

Sediments beneath and near the net pens were sampled for total organic carbon content prior to operation of the pens in 1995 and no increase relative to last year's content were detected. The lack of impacts to the bottom could be attributed to the very small amount of feed used and the pilot scale fish production. Macrophyte (aquatic plant) species and areal coverage was estimated along the nearest shoreline during August. No impact to macrophytes from pen operation was detected, and in

fact macrophyte abundance was severely reduced compared to the prior year, possibly due to shading from the intense blue-green algal bloom of August 1995.

Recommendations for 1996 program

Fish Culture Practices

It is important to try to increase the size of the net-pen reared smolts being released by rearing them in the cages as long as possible, at least until mid-May. By attaining a larger size the fish will be comparable to the lake-reared yearling fish that normally outmigrate in the late spring. The Wells Dam Settlement Agreement specifies a mean release size of 18.4 grams (i.e., 25 fish per pound), but the mean size of release has been about 6 to 7 grams in 1994 and 1995, respectively. It appears that the goal of 18.4 grams at release for these "zero-aged" fish may be unrealistically large. However, accelerating growth at the Cassimer Bar Hatchery in the winter of 1995-96 to allow a slightly earlier planting date than mid April would help in this regard. An interim goal of 12 grams is certainly achievable if fish continue to grow at the rate initially forecast by Rensel (1993). The report discusses factors influencing release date and timing and provides recommendations to coordinate efforts of cooperating parties, while minimizing costs.

Fish Distribution Study: South Basin

As noted in the prior report, there have been no population assessments (hydroacoustic soundings or nettings) of Lake Osoyoos sockeye fry in the late summer, although it was recommended by a prior study. Gillnet sampling was conducted only on one night in the south basin on August 10, 1972, but no fish were captured. Hydroacoustic surveys before and after smolt outmigration suggest that at least some fry use the south basin in some years (Biosonics 1983a, 1983b). However, those surveys were done the following spring, not in the prior summer of interest. If sockeye fry do not inhabit the south basin during the late summer, what happens to fish that are there prior to that time? Vertical gill net sampling could be conducted in the south basin in late July or early August, concurrent with water quality monitoring including water temperature and DO to shed more light on this issue. The water quality monitoring could be augmented with data provided by Department of Ecology Volunteer Lake Monitoring Program.

Other Recommendations

The report includes other recommendations for future water quality sampling, zooplankton bioassays and improvement of lake tropic status that could benefit all salmonids populations in the lake.

INTRODUCTION

This report is the third in a series of four studies and reports focused on Lake Osoyoos and the indigenous run of sockeye salmon that rear there. The first report (Rensel 1993) provided background information on water quality in the lake and the possible environmental effects of a pen rearing program for enhancing the sockeye salmon. The second report (Rensel 1995a) reported spring through fall monthly sampling results from 1994 as well as interpretation and comparison to historical data. Sediment sampling and fish cultural information was included. The present report is similar to the previous one, but includes information on the north basin of Lake Osoyoos that was not sampled in the prior year. Because lake sampling will be conducted at least one more year in 1996, conclusions regarding historical trends are deferred.

Net pens are being used in Lake Osoyoos for short-term rearing of the native stock of sockeye salmon for several reasons. The Wells Dam Settlement Agreement discusses the use of net pens in Lake Osoyoos to increase the native run of sockeye, as a temporary measure while habitat restoration in the subbasin is planned. Net pens are known to be one of the most cost efficient means of "low tech" salmon enhancement (Senn et al. 1984). Moreover, they are highly portable and when properly sited produce little or no long-lasting environmental effects (WDF 1991).

Net-pen operation in Lake Osoyoos is funded by the Douglas County Public Utility District. The Colville Confederated Tribes provided fish cultural personnel and produce the fry from native stock gathered from Wells Dam and incubated/first fed at the Cassimar Bar hatchery.

METHODS

Routine water quality data were collected monthly from April through October with the assistance of a Douglas County PUD staff member and vessel. Two primary sampling locations were selected, one in each major basin of the lake (i.e., the south and north basins). In 1994 only limited data were collected in the north basin, but after reviewing unpublished literature and data from Canada it was clear that potential differences in water quality between the basins were large enough to warrant sampling in each. The south basin sampling location was in mid channel at Boundary Point (the international border with Canada, Fig. 1). The north basin location was at a deep area adjacent to an apple processing facility known as Monashee Cooperative, also the location used by Canadian water quality workers in the past. Supplementary data were collected in the center of the relatively shallow and small central basin, as well as midway through the south basin and near the net pen location ("south-central basin").

In 1995 most of the in situ water quality data were collected with a Hydrolab H20 multiprobe attached to 50 m of cable and a Hydrolab Surveyor III data logger and

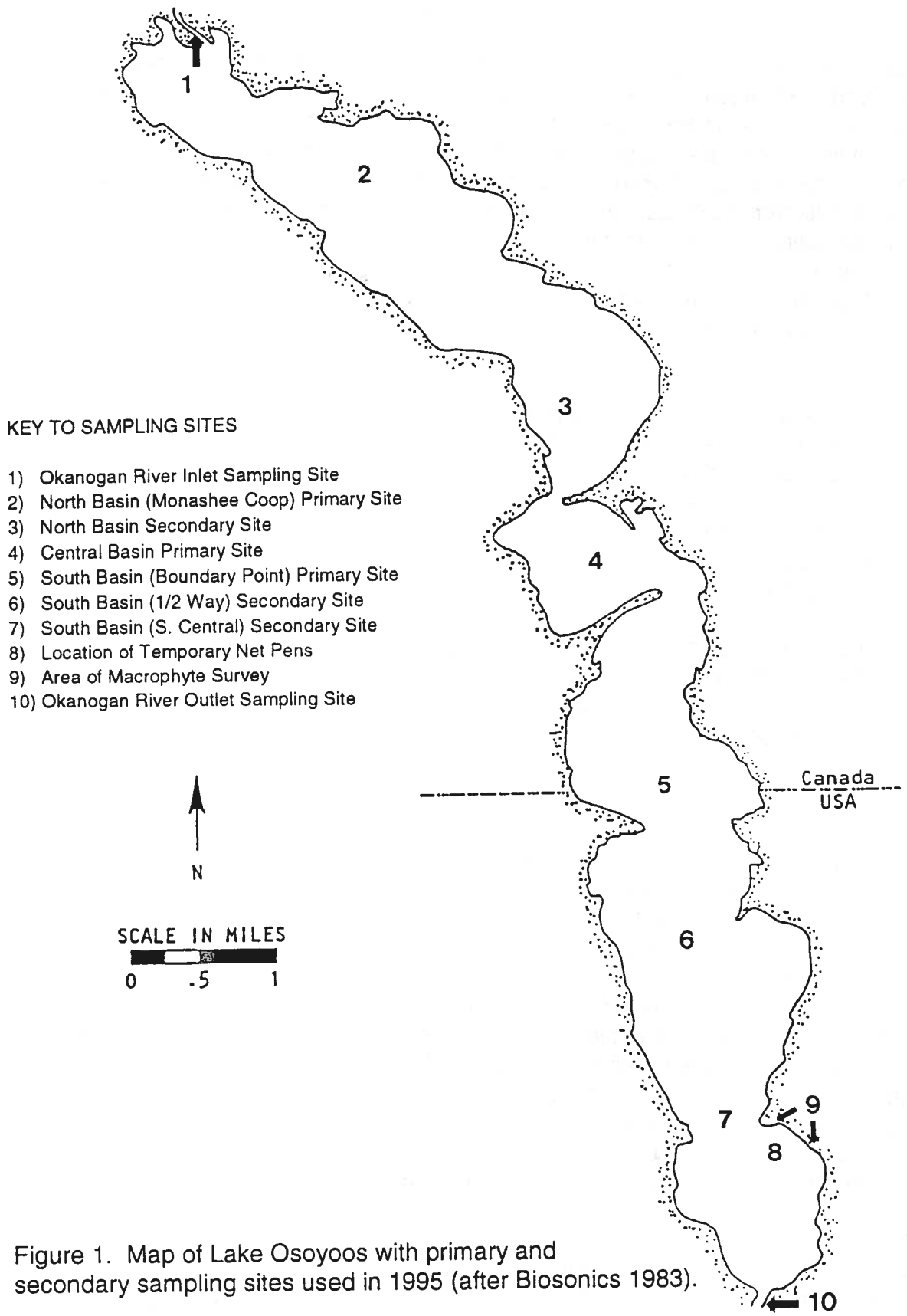

Figure 1. Map of Lake Osoyoos with primary and secondary sampling sites used in 1995 (after Biosonics 1983).

remote reading unit. The unit collected the following: water temperature, dissolved oxygen, pH, specific conductivity, redox, time of day and depth of the probe. Calibration of depth, dissolved oxygen, pH and specific conductivity was performed immediately before use, usually in the parking lot of the boat launch. Redox was not calibrated regularly, as it is not necessary. Barometric pressure compensation for percent saturation of dissolved oxygen was set at 735 mm Hg to account for the altitude at the site, according to manufacturer's recommendations. No problems were encountered with the unit, except intermittent signals during one trip early in the year. The cable was subsequently repaired but the problem did not effect data quality. One remarkable aspect of the Hydrolab equipment was its ability to maintain a very small variance from calibration values during the sampling.

Monthly sampling dates in 1995 were April 18, May 16, June 8, July 12, August 8, September 13 and October 17. An effort was made to space the sampling dates to approximately one month apart, given the constraints of weather, boat availability, etc. Only nutrient and water quality data were analyzed from the October sample as laboratory budgets had been exceeded and plankton data were judged less important from that date. Nutrient data from October was not included in many of the analyses because the laboratory report was not received until just prior to the completion of this report. Moreover, it is not as important in trophic state determination as the summer data.

A Scott water bottle was used to retrieve subsurface samples and a depth finder was used to locate the boat over the deepest part of the lake at each location. Time of sampling, sky conditions, wind speed and direction, wave conditions and air temperature were also recorded for each location and sampling session. Nutrient samples and replicates were collected from the same water bottle or mixture of water bottle casts and placed in acid-rinsed poly bottles. The bottle were iced immediately and frozen within a day for processing by autoanalyzer at the Routine Chemistry Laboratory at the School of Oceanography, University of Washington. The analyst at this laboratory (K. Krogslund) has many years experience with nutrient analyses and the data reflect the excellent (i.e., low) detection limits. All other analyses were conducted at Aquatic Research Inc. using EPA Puget Sound or ASTM protocols for analyses of freshwater and sediment.

Zooplankton and phytoplankton samples were analyzed by Water Environmental Services, Inc. of Bainbridge Island, Washington as follows: Phytoplankton enumeration, identification, and cell volume determinations were made on preserved water samples collected from Lake Osoyoos. The samples were from composite depths of 1, 3 and 6 meters. Average counts for each species were computed from the sample. Algal cell densities were reported as numbers per ml. For each sample, cell dimensions of at least 10 organisms of each species were computed to obtain average cell volume per species. Determination of cell volumes and identifications were made at 400X using a nannoplankton counting cell and calibrated whipple disc. Cell volumes were reported as cubic microns per ml, and also converted to cubic

millimeters per liter (mm^3/l). Species identifications were made primarily according to Prescott (1975, 1980) and Patrick and Reimer (1966, 1975).

Zooplankton determinations were made on samples collected by making a vertical tow with a plankton net from the 5 meter depth to surface. In the laboratory, aliquots of each zooplankton sample were examined in an open chamber under a binocular dissecting microscope as outlined in Edmondson and Winberg (1971) and Downing and Rigler 1984). The entire volume of each sample was inspected for dipteran immatures (*Chaoborus)*. Organisms were identified to species wherever possible according to Brooks (1957), Edmondson (1959), Stermberger (1979), Pennak (1989), and Thorp and Covich (1991). Calanoid and cyclopoid nauplii were treated as one group. Organism densities were reported in numbers per cubic meter of water volume. Zooplankton biomass (micrograms per cubic meter) was estimated for each organism according to literature values of average dry weight per organism (summarized in Downing and Rigler, 1984). Linear dimensions of each lake organism for use in the length-dry weight relations were calculated using a calibrated ocular micrometer under 100 to 400X magnification.

Sediment samples were collected for total carbon analysis at the net pen site after pen installation in mid-April, but before the fish were stocked. As per Washington Department of Natural Resources lease requirements, sampling will not be conducted again until prior to the next season of sampling. See Rensel (1993) for an explanation of techniques involved in this task.

Table 1. Location, depths, and equipment for sampling in Lake Osoyoos in 1995.

PARAMETER	SOUTH BASIN (BOUNDARY POINT)	NORTH BASIN (NEAR MONAHEE COOP)	CENTRAL BASIN, MIDWAY SOUTH BASIN AND SOUTH-CENTRAL BASIN
Water Temperature	Hydrolab Multiprobe every two meters depth	Hydrolab Multiprobe every two meters depth	Hydrolab Multiprobe every two meters depth
Conductivity	Hydrolab Multiprobe every two meters depth	Hydrolab Multiprobe every two meters depth	Hydrolab Multiprobe every two meters depth
Secchi Disk	Collect in consistent manner and time of day with 20 cm all white disk	Collect in consistent manner and time of day with 20 cm all white disk	Collect in consistent manner and time of day with 20 cm all white disk
Dissolved Oxygen	Hydrolab Multiprobe and titration or corning probe as double check/backup	Hydrolab Multiprobe and titration or corning probe as double check/backup	Hydrolab Multiprobe and titration or corning probe as double check/backup
pH	Hydrolab Multiprobe every two meters depth	Hydrolab Multiprobe every two meters depth	Hydrolab Multiprobe every two meters depth
Total Nitrogen & Total Phosphorus	two composite samples: 1+3+6 m and 10+14 m triplicates (above/below the thermoclines)	two composite samples: 1+3+ 6 m and 50 m triplicates (above/below the thermoclines) & 10+14 m single sample	No additional samples
Nitrate, Nitrite, Ammonium+ ammonia, Orthophosphate	same as above but single samples only	same as above but single samples only	No additional samples
Chlorophyll a (and phaeophytin)	Composite of water bottle collection of 3 near surface depths: 1, 3 and 6 m	Composite of water bottle collection of 3 near surface depths: 1, 3 and 6	No additional samples but former two sites had duplicate samples taken in April and May for different methods of analyses
Phytoplankton	Composite of water bottle collection of 3 near surface depths: 1, 3 and 6 m	Composite of water bottle collection of 3 near surface depths: 1, 3 and 6 m	No additional samples
Zooplankton	net tow from 5m to surface using a 64 µm mesh net	net tow from 5m to surface using a 64 µm mesh net	No additional sample
Sediment Carbon	N/A	N/A	cores from 0.01 m^2 Van Veen grab samples at pens and reference sites

RESULTS AND DISCUSSION

Basic Water Quality Data

Routine water quality parameters are compared here among the three basins and with available historical data when available. Overall the climate was cooler in the summer of 1995 compared to the prior year, although NOAA data reports for specific monitoring sites in Washington State has not been published as of this writing. Tables 2 and 3 below provide a quick comparison of some of the 1995 results in the south and north basin. Appendices 1, 2 and 3 show nutrient data for north basin, south basin and Okanogan River. Appendix 13 has details of other routine water quality parameters collected with the Hydrolab multiprobe.

Table 2. Summary of basic surface and deepest water quality for the North Basin near Monashee Coop during sampling in 1995. Spec. cond. = specific conductivity, Secchi = Secchi disk transparency, D.O.= dissolved oxygen.

DATE	TIME	WIND Dir.	WIND SPEED	WAVE HEIGHT	DEPTH	WATER TEMP.	SPEC. COND.	pH	SEC-CHI	D.O.	REDOX
			kts	ft.	m	°C	µS		m	mg/l	mV
18-Apr	1423	S	8	0.1	0.5	7.5	283	8.1	3.2	10.9	369
					42	5.4	290	7.9		10.2	370
16-May	1100		0	0	0.5	14.3	253	8.4	2.0	9.6	337
					50	6.6	293	8.0		9.2	357
8-Jun	1045	S	1	0	0.5	18.9	248	8.3	4.8	9.0	293
					50	7.6	292	7.8		8.6	334
12-Jul	1100	N	10	0.7	0.5	21.3	243	8.7	3.0	8.8	277
					50	8	277	7.7		6.8	323
8-Aug	1050	S	8	0	0.5	21.1	249	8.7	3.2	8.5	293
					50	8.2	277	7.8		5.3	405
13-Sep	1058	N	9	0.5	0.5	19.7	266	8.6	3.7	8.8	392
					50	8.4	284	7.4		3.6	389
17-Oct	1025	N	5-15	1.0	0.5	13.6	278	8.2	3.5	9.6	329
					50	8.6	281	7.2		1.9	332

Table 3. Summary of basic surface and deepest water quality for South Basin (Boundary Point only) during sampling in 1995. The August 30th collection was a special collection relating to the zooplankton bioassay discussed later in this report.

DATE	TIME	WIND DIR.	WIND SPEED	WAVE HEIGHT	DEPTH	WATER TEMP.	SPEC. COND.	pH	SEC-CHI	D.O.	REDOX
			kts	ft.	m	°C	µS		m	mg/l	mV
18-Apr	1555		0	0	0.5	9.1	294	8.2	3.2	10.7	342
					22	6.7	299	8.1		9.4	351
16-May	1242		0	0	0.5	15.8	296	8.7	3.3	9.6	314
					20	10.0	305	8.2		7.1	342
8-Jun	1200	N	3	0.2	0.5	19.6	274	8.5	5.3	9	311
					22	13.5	307	7.7		3.9	344
12-Jul	1220	N	8	0.5	0.5	22.5	262	8.9	3.3	8.9	271
					22	12.1	305	7.6		0	317
8-Aug	1335		0	0	0.5	22.6	252	9.0	1.7	8.8	229
					22	13.5	291	8.1		0	-2
30-Aug	1415	N	1	0	0.5	20.5	263	8.6	2.6	8.5	316
13-Sep	1238	N	2	0	0.5	21.2	268	8.7	3.0	9.1	244
					22	14.3	315	7.7		0.1	-19
17-Oct	1144	N	5-10	0.8	0.5	14.4	287	8.1	2.8	8.4	354
					22	14.4	288	8.0		7.9	351

Water Temperature

The plot of north basin water temperature (Fig. 2) shows gradual formation of vertical stratification with a maximum reached in July and August. However, only gradual changes were seen in the central basin and south basin with no sharp discontinuities occurring throughout the study period (Figs. 3 and 4). The differences are due to the much greater depth of the north basin that apparently allows vertical stratification to become more established. Difference in X axis scales of sampling depth inadvertently distorts the relationship slightly.

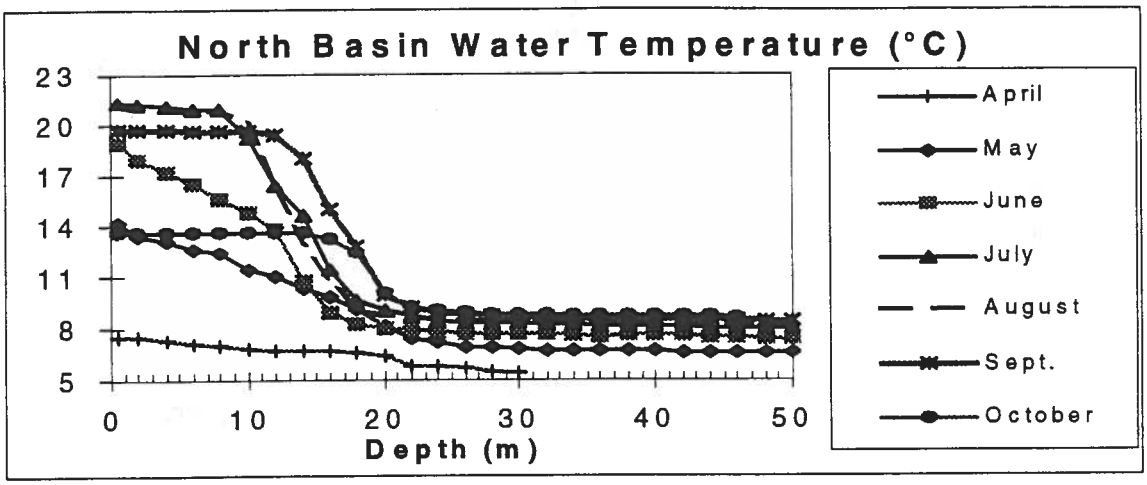

Figure 2. North basin Lake Osoyoos monthly water temperatures in 1995.

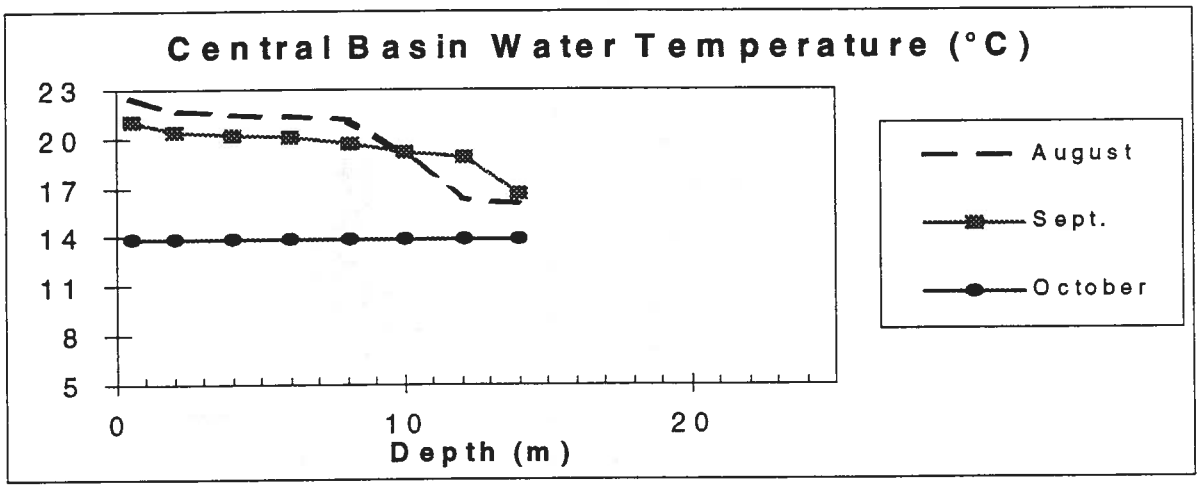

Figure 3. Central basin Lake Osoyoos monthly water temperatures in 1995.

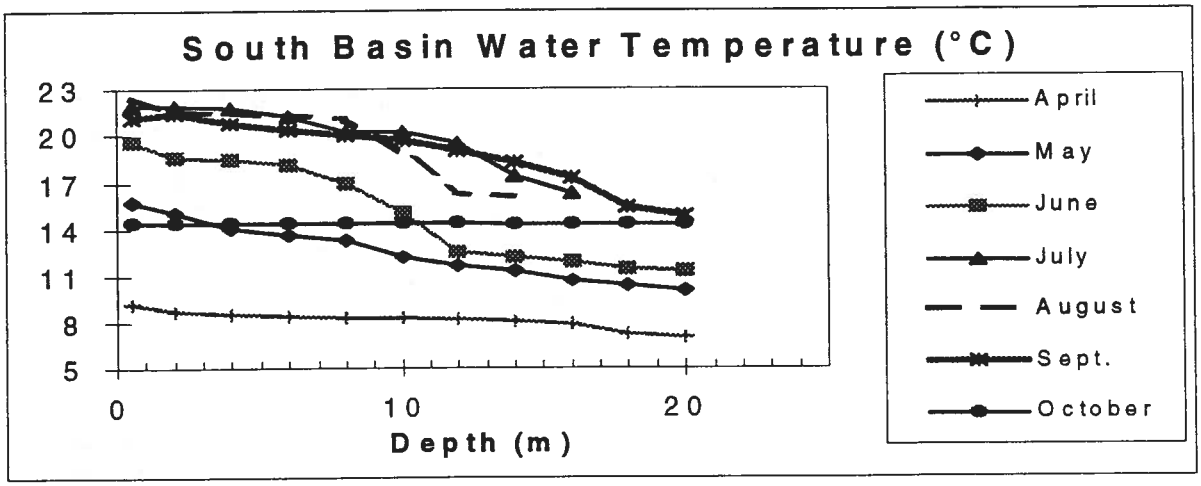

Figure 4. South basin Lake Osoyoos monthly water temperatures in 1995.

A comparison of peak water temperatures among the basins showed August 8th had the warmest recorded surface temperatures in 1995 (Fig. 5). There may have been higher temperatures in surface waters on prior or later dates, but an additional sample on August 30th had lower temperatures (Table 3). Compared to 1994 when peak temperatures in the south basin of over 27 °C were recorded in late July, the temperature peaks were a month later in 1995. This was likely due to the generally cooler, wetter weather that occurred in the area at that time in 1995. Conversely, August and September surface water temperatures were slightly warmer than corresponding months in 1995.

Figure 5 also shows the effect of solar radiation and air temperature on the three basins. In every case surface waters increased stepwise from north to south corresponding to detention time of Okanogan River flow through the lake.

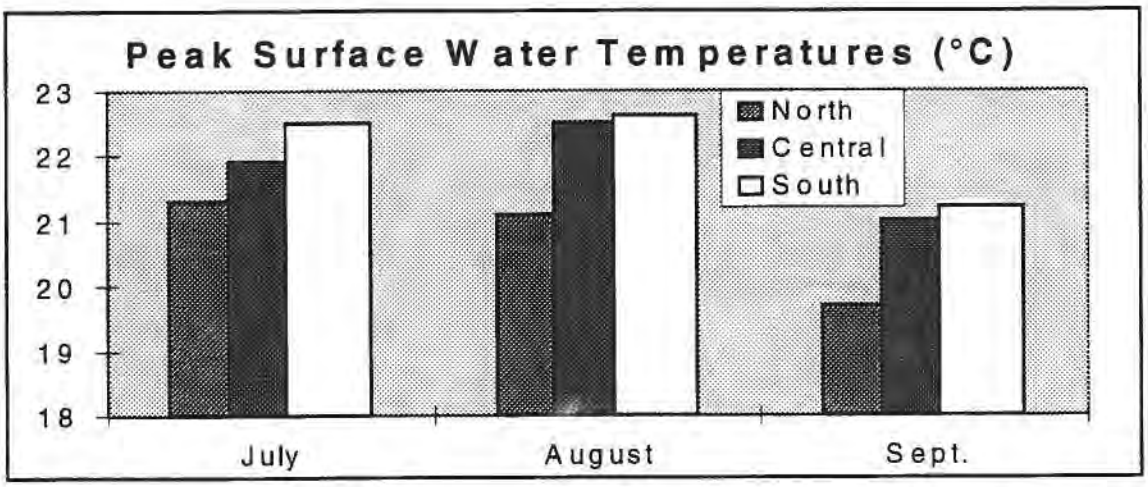

Figure 5. Comparison of peak water temperatures in all basins during monthly sampling in Lake Osoyoos during 1995.

Conductivity

Tables 2 and 3 show that conductivity increased with depth in both basins, but the differences between surface and bottom were large during the summer. In the north basin conductivity differences increased until June, then diminished. In the south basin differences between shallow and deep were generally less, but increased throughout the sampling period with only one month (August) showing a slight decline. The probe used in 1995 was more accurate than the equipment used in 1994.

pH

pH ranged from 8.1 to 8.7 and 8.2 to 9.0 at the surface of the north and south basins, respectively. The deepest samples ranged from 7.4 to 8.0 and 7.6 to 8.2 in the same areas. pH increased in the surface waters and generally decreased in bottom waters

throughout the sampling period, corresponding to surface plankton activity and hypoxia or anoxia of bottom waters.

Water Transparency

Secchi disk transparency was similar in both south and north basins during the sampled period of 1995 with averages of 3.3 m in each location (Tables 2 and 3, Figs. 6 and 7). However, during summer only (June to Sept.) the transparency was slightly greater in the north basin (3.7 m SD = 0.8, n =4) compared to the south basin (3.3 m SD = 1.5, n = 4). Differences can be due to river runoff in May that was noticed throughout much of the north basin (Fig. 6). South basin water transparency for the entire sample period was similar in both 1994 (3.1 m) and 1995 (3.3 m) and compared to historical data from the north basin in 1971 (3.3 m, Stockner and Northcote 1974). Stein and Coulthard (1971a) reported mean Secchi disk readings of 3.7 to 4.0 m

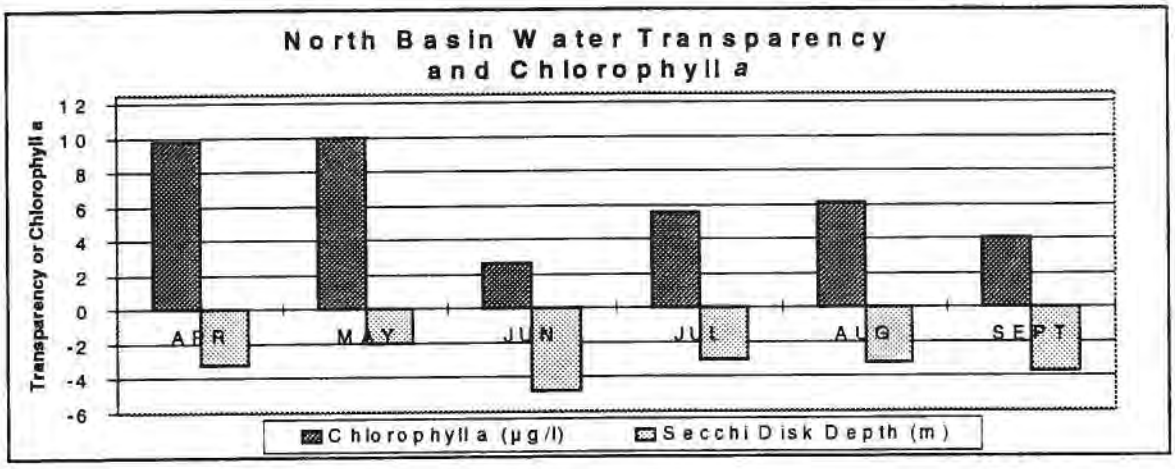

Figure 6. North basin water transparency and chlorophyll *a* content in Lake Osoyoos during 1995.

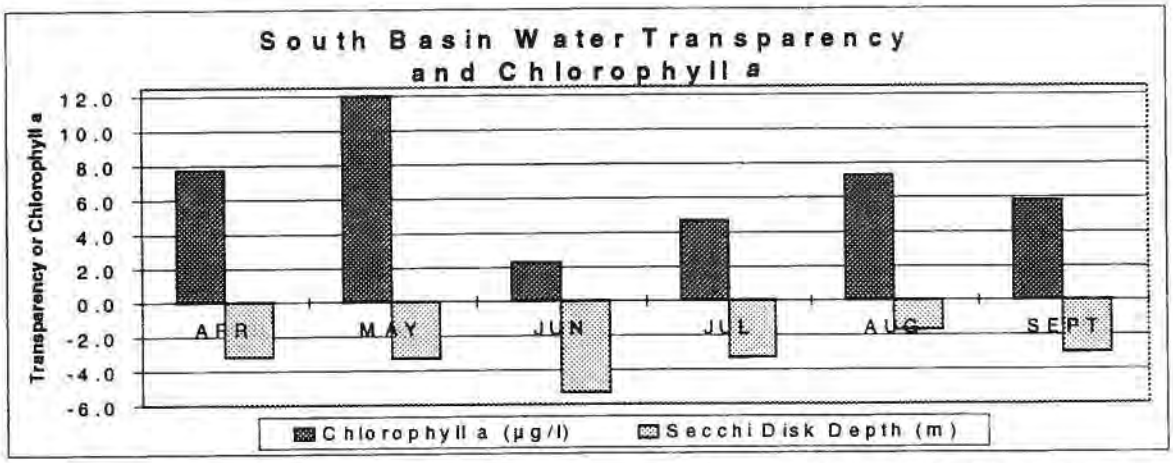

Figure 7. South basin water transparency and chlorophyll *a* content in 1995.

in summer and autumn during one year in the late 1960s, but exact year and locations are difficult to decipher from the report. I was able to calculate a mean summer Secchi disk value of 4.2 m for the south basin from the appendix of that report (p. 161). This value is significantly greater than the above transparency, but the size of disk used was not reported.

A linear regression analysis (not shown here) showed that water transparency in the south basin was not strongly correlated with the inverse of chlorophyll *a* with a R^2 value of only 0.26. The poor correlation is discussed later in the section on chlorophyll *a*. The relationship was stronger, but not compelling, in the north basin with a coefficient of variation (R^2) of 0.68.

Dissolved Oxygen and Water Temperature

As discussed in prior reports, the rate of dissolved oxygen (DO) depletion below the thermocline in seasonally stratified lakes is a general measure of the state of eutrophication. More importantly for sockeye salmon, DO and water temperature interactions have previously been identified as potentially limiting the distribution or rearing success of sockeye fry in the lake during the summer and early fall and possibly excluding them from the central and south basins during some summers (Allen and Meekin 1980, Pratt et al. 1991, Rensel 1993, 1995a).

Vertical profiles of dissolved oxygen are shown in figures 8 to 10 with the same X axis to facilitate comparison. The north basin (Fig. 8) had no DO stratification in April through June, and increasing stratification from July to October. Depths in the north basin below approximately 20 m in October had insufficient DO for salmonids (i.e., < 5 mg/l), but at other times the entire water column had acceptable concentrations.

Central and south basins in 1995 had similar DO profiles in mid to late summer and anoxia of deep waters occurred from July through September with the most extreme conditions in August. At that time depths below approximately 9 meters had insufficient DO to maintain salmonid growth and possibly survival due to a steep vertical gradient of DO (Figs. 9, 10, and 11). Near surface water temperatures in oxygenated zones of the south basin during August were 20.3 to 21.5°C, which is above preferred ranges for sockeye fry at all depths (i.e., >15 - 17 °C), although much below the estimated upper

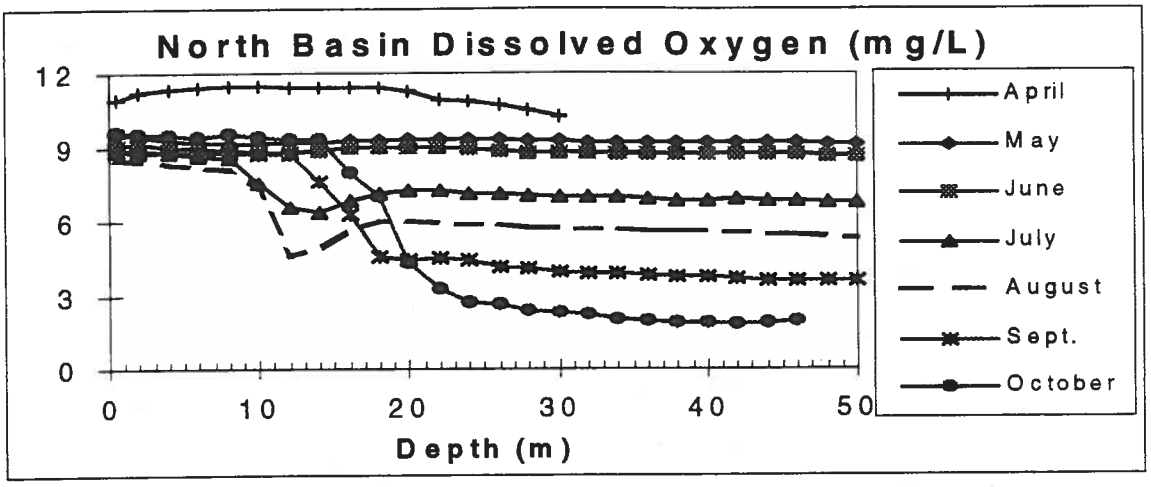

Figure 8. North basin monthly dissolved oxygen concentrations in 1995.

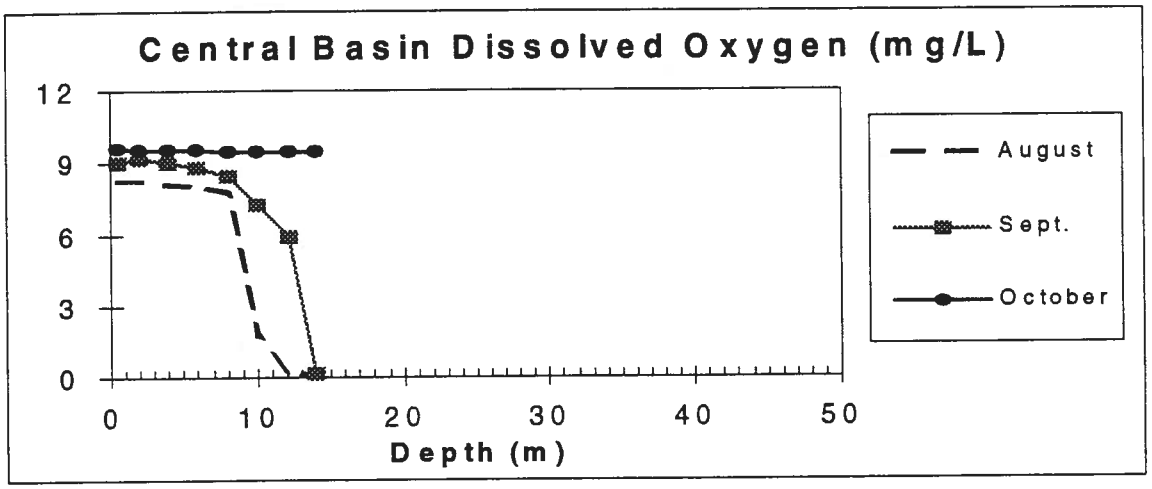

Figure 9. South basin monthly dissolved oxygen concentrations in 1995.

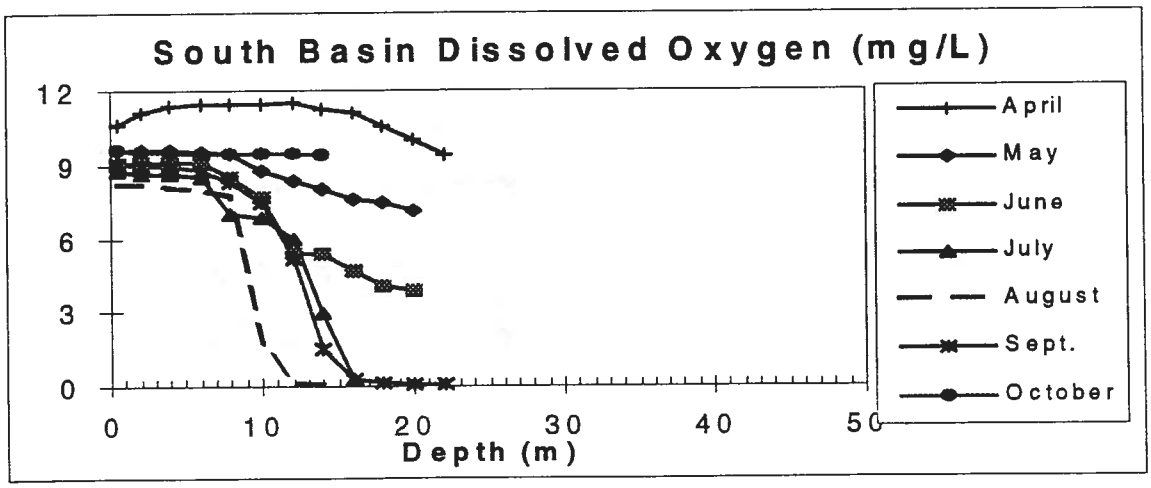

Figure 10. Central basin monthly dissolved oxygen concentrations in 1995.

lethal limit of 24.5°C (Table 3, Figs. 4, 10 and 11). As conditions at other times were less extreme, I tentatively conclude that sockeye fry could have survived in the south basin in 1995, possibly throughout the upper water column from near the surface to approximately 9 meters deep during the worse period, but over a greater range at other times.

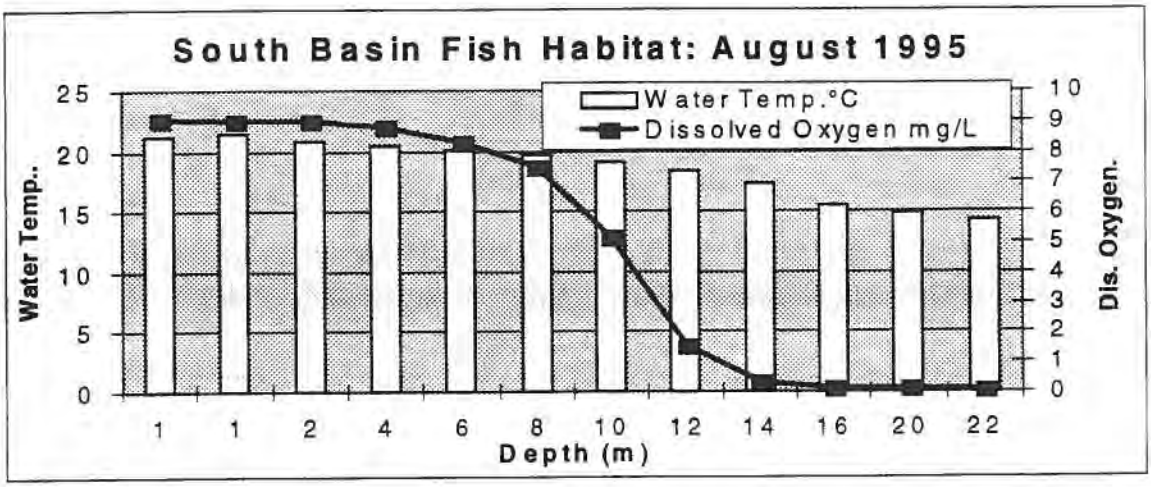

Figure 11. South basin dissolved oxygen and water temperature in August 1995.

A companion plot for the north basin (Fig. 12) shows that all depths in August were acceptable for sockeye survival. However, conditions were far from ideal at that time, and in particular an abrupt "sag" in DO concentration was noted at 10 to 14 m. The sag was also noted forming in July (Fig. 8), but was gone by September. The reason for this sag is unknown. Phaeophytin content from 1, 3 and 6 meters combined was low (discussed later and in Table 5), suggesting that substantial algal decomposition was not occurring, at least a few meters above the sag. Examination of the raw data shows no indication that the probe battery or other factors were compromised.

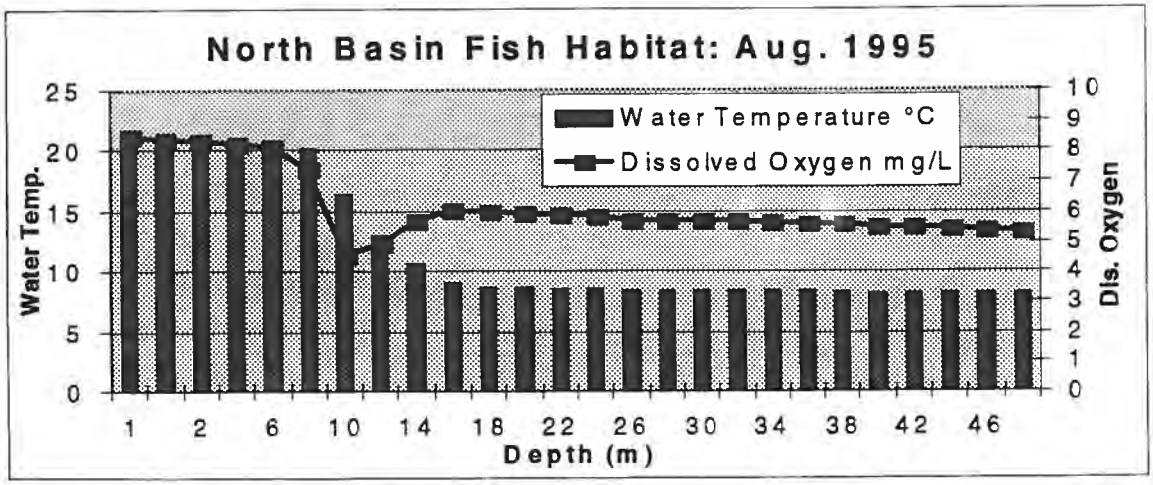

Figure 12. North basin dissolved oxygen and water temperature in August 1995.

I compared historical data for the north basin (vertical profiles collected once per year in the late August to mid-September period 1987-91 by Canadian workers) with the September 13, 1995 data for water temperature and DO (Fig. 13). Water temperature was similar among the years, but DO was at least 1 mg/l less in 1995 for all depths. Although this could be due to calibration errors or natural variation, it also could be due to lower phytoplankton production of oxygen. Compared to the same period, chlorophyll a (discussed in Rensel 1995a) averaged 7.8 µg/L. The September value for 1995 was only 4.1 µg/L, lending credence to this possibility.

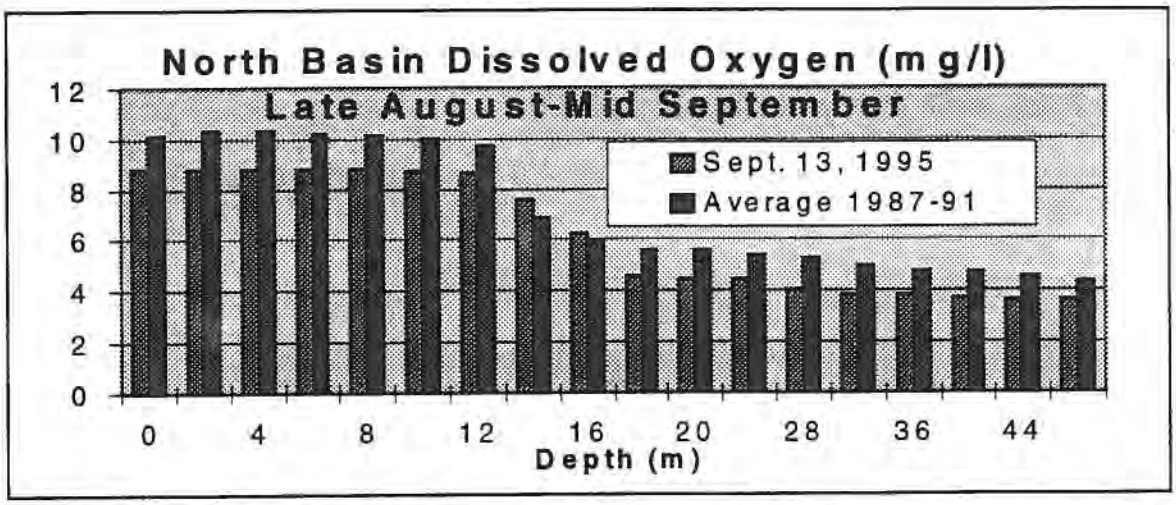

Figure 13. North basin Lake Osoyoos dissolved oxygen concentrations in late August to early-mid September 1987-1991 (from B.C. Environment) compared to September 13, 1995.

Hypothesis Regarding Smolt Production

I previously speculated that the sockeye fry in the south basin must have been limited to a narrow stratum of only a meter or two during late July 1994 (Rensel 1995a). The present report indicates that sockeye fry could have survived in the south basin in 1995, possibly throughout the upper water column from near the surface to approximately 9 meters during the worse period. The contrasting physical variability between years and unexplained variability in smolt production relative to size of escapement discussed below spurred me to consider a new hypothesis regarding smolt production from the lake. Prior workers have considered some of these factors:

Pratt et al. (1991) concluded that relatively large smolt size and young age composition of smolts "from Lake Osoyoos do not indicate saturation of available rearing space in the lake". Four years of smolt length versus smolt production numbers between 0.4 and 2.1 million were plotted by the same authors to show no relationship between the two. More recently, Chapman et al. (1995, p. 102)

suggested that "mean size of smolts from Lake Osoyoos negatively relates to abundance of parent spawners", although supporting data were not included. The conclusion apparently was based on possible relationships suggested by Mullan (1986) and reported as statistically non-significant by Pratt et al. (1991, their Fig. 2).

Additionally, Pratt et al. (1991, their Fig. 2) plotted estimated smolt production versus estimated escapement for Lake Osoyoos sockeye. Six years had small to moderately small smolt production (< 2.1 million) and were clustered along the X axis, but two other years had very much larger production of 4.6 and 6.1 million smolts. Along with a third year of moderate smolt production (1973), the high smolt production years suggest linear density dependent. It seemed reasonable that the two separate data groupings could be due to environmental variation and related rearing capacity changes of the south and central basins. Pratt et al (1991) suggested the possibility that in drought years manipulation of flows, reduced rearing area and elevated water temperatures in the lake could negatively impact smolt production and reduce the size of smolts. Appendix 13 shows that Okanogan River outflow averaged 3.2°C warmer than the inflow on a monthly basis from May to October, 1995. Certainly inflowing water could help cool the lake but air temperature and cloud cover/solar radiation are also important factors controlling fish rearing conditions in the lake.

Egg to smolt survival of Lake Osoyoos and Lake Wentachee sockeye stocks is reportedly high compared to other stocks in the world (Foerster 1968). Smolt to adult survival apparently is more of a problem overall (Fryer 1995). However, the confidence interval of annual egg to smolt survival is very large (Fryer 1995, his fig. 5.1), suggesting that in some years major problems occur in these stages. Moreover, these estimates are based on differing methodologies (e.g., hydroacoustic surveys, riverine trapping) which likely have differing degrees of accuracy that could be large.

If south and perhaps central basins were capable of producing smolts in years of cooler water temperatures, as discussed above, smolt production capacity would change dramatically depending on weather that controls conditions in the lake. Assuming an all or nothing production scenario for the south and central basin (explained later), production could vary from a maximum of 3.1 million (north basin only) to 7.1 million (all basins), using the areal carrying capacity estimates of Pratt et al. (1991).

Initial Tests of the Hypothesis

To begin testing this possibility I examined several environmental data sets until I found water temperature records for the Ecology station just downstream of Lake Osoyoos on the Okanogan River. The station has late spring and summer water temperatures consistently equal to or greater than the lake's south basin surface water and may be used as surrogate data for the lake (Rensel 1993, appendix 13). Only four years of concurrent water temperature and egg to smolt survival data were available to test the hypothesis (Table 4). Fortunately, the available data included a

wide range of smolt production years. Monthly mean water temperatures for 1961-65 and 1974-91 (n = 7 to 19 observations/month, total N = 216) were included to compared water temperatures during the 4 available years.

A simple linear correlation estimate (Zar 1984) of the water temperature deviation versus the egg to smolt survival yielded a coefficient of variation (R^2) of = 0.89 using all the data in Table 4, and (R^2) of = 0.67 without the May 1965 data. Therefore, much of the egg-smolt production variation in these years could be accounted for by deviation of water temperature from the mean. Of course there may be other covarying or causal factors and there is a need to increase the total number of observations. Although the water temperature deviations from the mean seem minimal, any variation near the upper lethal temperature limit could be biologically important to the fry rearing in the south basin.

Table 4. Egg to smolt survival and water temperature data from the Dept. of Ecology monitoring station on the Okanogan River immediately downstream of Lake Osoyoos. Statistical factors highlighted in bold print. Smolt year = smolt outmigration year. Summer rearing year = first year of fry residence in the lake. Egg to smolt survival calculated from [Fyrer (1995) escapement data x 2,250 eggs/adult female]/smolt production estimates summarized by Pratt et al. (1991).

Smolt Year	Summer Rearing Year	Egg to Smolt Survival	Water Temp Sampling Date	Lake Outlet °C	Reference Period Mean Water Temperature °C	Deviation from Ref. Per. Mean
1966	1965	**6.7%**	15 May 65	8.9	13.6	-4.7
			11 Sept 65	18.9	19.5	-0.6
					Mean →	**-2.65**
1976	1975	**4.3%**	19 Aug 75	21.2	21.8	**-0.6**
1982	1981	**0.7%**	9 Sept 81	20.0	19.5	**+0.5**
1983	1982	**0.9%**	8 Sept 82	21.3	19.5	**+1.8**

The rationale for including the May 1965 temperature is as follows: The date of this measurement was exactly in the middle of the month, thus it approximated the mean sampling date for the monthly mean temperature. Water temperatures change quickly in May, therefore only mid-month data were acceptable. Other years (1981 and 1982) had data from May but it was from the first week of the month and was therefore biased too low. The May 1965 data point represents a very large deviation from the mean that may have carried into the entire summer, just as cool water temperatures in May 1995 were followed by cooler than normal summer water temperatures. It is probably legitimate to use the water temperature deviation in this analysis, not the actual water temperature because just a few degrees C water temperature is very important in the upper end of the sockeye's survival range.

These data also fit with the concept of climate variation that has occurred in the Pacific Northwest as identified by Ebbesmeyer (1989) for a host of physical and biological variables; the concept has also been applied to phytoplankton ecology by Rensel Associates and PTI Environmental Services (1991). Although relatively complex, it boils down to a cold, wet period in the years before 1976 and an abrupt change to relatively dry, warm years in the period after 1976. Shifts in the average location of the Aleutian low pressure cell were thought to cause the changes. There is also strong evidence of cyclic shifts between the two weather regimes back to the beginning of the 20th century, but data from recent years have not been analyzed.

Hypothesis Rationale and Discussion

Fry emerge from redds in the Okanogan River upstream of the lake and initially move downstream into the north basin to begin rearing. In years of small to moderate recruitment of fry (not necessarily the same as escapement), food and space are sufficient in the north basin to provide rearing for the fry, assuming kokanee abundance is not large. Some fish may move into the south basin, but in warm years these either suffer cumulative stress syndrome from lack of temperature refuge or may succumb to predation by any number of species of warm water fish that inhabit the lake. Some of the fish may migrate back to the north basin, although the central basin's configuration and conditions provide a formidable barrier. Even the concept of chronic and mass mortality of fry in the south and central basin in some extreme years is not beyond question. Salmonids often sink to the bottom when killed in algal bloom events, even in marine waters that provide more floatation than freshwater (Rensel 1995b).

In years of large numbers of spawners and/or kokanee abundance, the hypotheses suggests that significant numbers of fry may also move into the south into the central and south basins in the spring. This does not necessarily imply density dependence in the north basin, only the random effect of larger populations dispersing further. Hydroacoustic data from post-migration timings shows similar concentrations of fry in both north and south basins in at least one year (e.g., Biosonics 1983, June survey), although researchers have always concentrated on the north basin. Other years showed low numbers in the south basin in early spring, but timing of the surveys and target separation of fry and smolt was not possible. There has never have been mid to late summer surveys to assess fish distribution during the critical summer rearing months. If water temperatures and dissolved oxygen are biologically acceptable during the years of large recruitment, fry will survive in all basins or at least the north and south basins resulting in a high egg-smolt production. If water temperatures and dissolved oxygen conditions are not suitable, fish may suffer one of the fates described above.

The central basin may play an additional important role in fish distribution during summer. The connecting sill to the south basin is very shallow and narrow; access

to the north basin is similarly restricted. The central basin mirrored the south basin in terms of water temperature in 1995, but may be warmer in average or hotter years.

Knowledge Gaps

To date there has been a paucity of data synthesis regarding factors that influence smolt production to be so erratic in Lake Osoyoos. In part this is due to a lack of environmental and smolt production data. The hypothesis provided here is to stimulate discussion, and may or may not be accurate. Data gaps are include:

- Smolt production numbers are not very solid, as there have been no acoustic estimate in the mid to late summer to factor out the fry from the smolts in the spring estimates (Biosonics 1983). There has also been no concurrent net sampling to "ground-truth" the hydroacoustic work. I am not questioning the quality of the work completed, only the timing of surveys that the above authors admit need to be supplemented. Smolt production estimates in some years may also be significantly in error as post-fry emergent surveys were not even conducted in the central or south basins. It is not known if hydroacoustic surveys in June detect some of the fry that may still be rearing near the littoral (shore) zone (Biosonics 1983). To distinguish sockeye from kokanee it would be necessary to take samples for electrophoresis. Assuming no recent plants of kokanee in the lake, the methodology allows for population separation (e.g., Redfish Lake, Idaho studies, personal communication Dr. R. Gustafson, NMFS, Seattle). The presence of residual sockeye, if they exist in Lake Osoyoos, could also complicate the analysis.

- There is little information regarding sockeye fry versus kokanee competition in the lake or how it affects sockeye smolt abundance. Obviously, escapement numbers of sockeye adults is important too, but not accounted for in the present hypothesis, except in a general sense.

- The hypothesis advanced here might be more palatable if there was evidence of significant zero-aged smolt production from Lake Osoyoos. This would help explain what happens to sockeye fry (or kokanee) that enter the south basin in spring seasons followed by a warm summer. This is discussed in appendix 4.

Analysts in the past have concluded that the large size of smolts produced from Lake Osoyoos indicated no density dependence (i.e., food, space or predation interactions). While this is likely true for the years with available data, no smolt size data is available from years of large smolt recruitment (e.g., 1965 and 1966). Fish size could have been smaller in large smolt production years, possibly causing density dependence. Collection of these data in the future, along with July-August period water temperature/dissolved oxygen data from the lake could clarify the processes leading to validation or rejection of the hypothesis offered here.

Another means to test the "south basin variable smolt rearing" hypothesis would be to investigate links between water and air temperatures for nearby weather monitoring stations (e.g., Tonasket). If sufficiently strong, air temperature data, with and without flow, could be used as a surrogate variable to predict egg to smolt survival.

NUTRIENTS

Total Phosphorus and Total Nitrogen

Total phosphorus ("total P") is a measure of the trophic or nutrient status of a lake and is best collected over the summer months in surface waters (Welch 1992). The mean summer 1995 (June to Sept.) total P of surface water in Lake Osoyoos was 13.0 µg/L for the north basin and 17.7 for the south basin (Figs. 14 and 15, appendices 1 and 2). Total P declined from April or May peaks to lower values in summer as was the case for data collected in 1994. Compared to 1994, total P concentrations were consistently less in every month of 1995, averaging about 25% lower.

The cause of the moderate interannual variation of total P is unknown. However, spawning escapement of adult sockeye in the prior years (1993 and 1994) roughly correlated with these changes. About 21,000 spawners were present in 1993 versus approximately 600 in 1994 (R. Klinge, personal communication). Other factors not reviewed here could also influence total P values, such as flushing rates caused by Okanogan River flows. The spring and summer of 1995 were cooler and wetter than 1994, which could have resulted in less irrigation withdrawal upstream and higher river flows. Mass balance models of lake nutrient response invariably use flushing rate as a major component (Vollenwieder 1969 and may others subsequently). Flushing rate data will be reviewed in the final report for the years 1994-1996, along with spawning escapement estimates and nutrient contribution of fish carcasses.

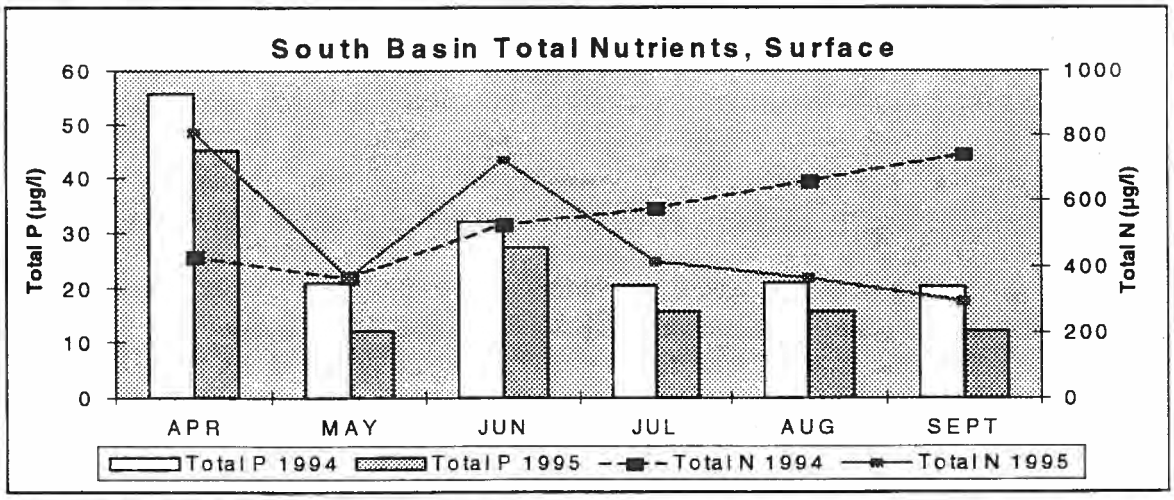

Figure 14. Monthly total nitrogen and total phosphorus for surface water in the south basin of Lake Osoyoos during 1994 and 1995 (Boundary Point location).

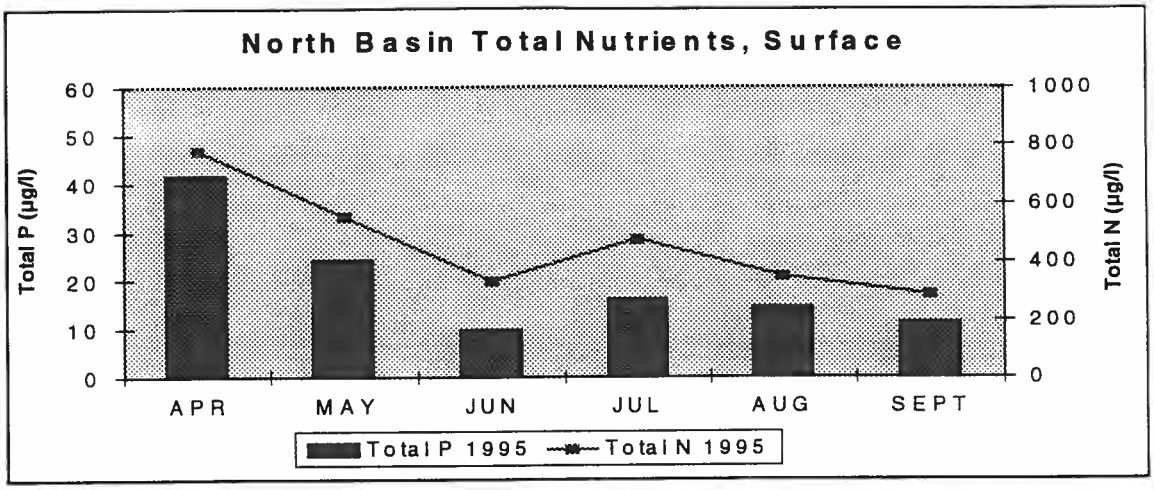

Figure 15. Monthly total nitrogen and total phosphorus for surface water in north basin of Lake Osoyoos during 1995 (Monashee Coop location).

Average summer total nitrogen (total N) concentration in near-surface waters of the south basin was 447 µg/L in 1995 versus 627 µg/L in 1994. The pattern of increasing total N concentration throughout the season did not repeat in the south basin in 1995 (Fig. 14), but rather a general decline. A declining trend was noted for total N in the north basin where summer total N averaged 360 µg/L (Fig. 15).

Dissolved Inorganic Nitrogen and Orthophosphate

Although dissolved N and P fractions are less useful in determining the trophic status of a lake, they are useful for determining which, if either dissolved nutrient was possibly limiting to algal growth. As expected after reviewing the total N and P concentrations, DIN (nitrate+nitrite+ammonium+ammonia) was significantly less in the south basin in 1995 than in 1994 (Fig. 16). Orthophosphate concentration was similar during the summer months, but was much less in the spring. The high orthophosphate concentrations seen in the spring of 1994 are unexplained, but are based triplicate samples and therefore not likely to all be in error.

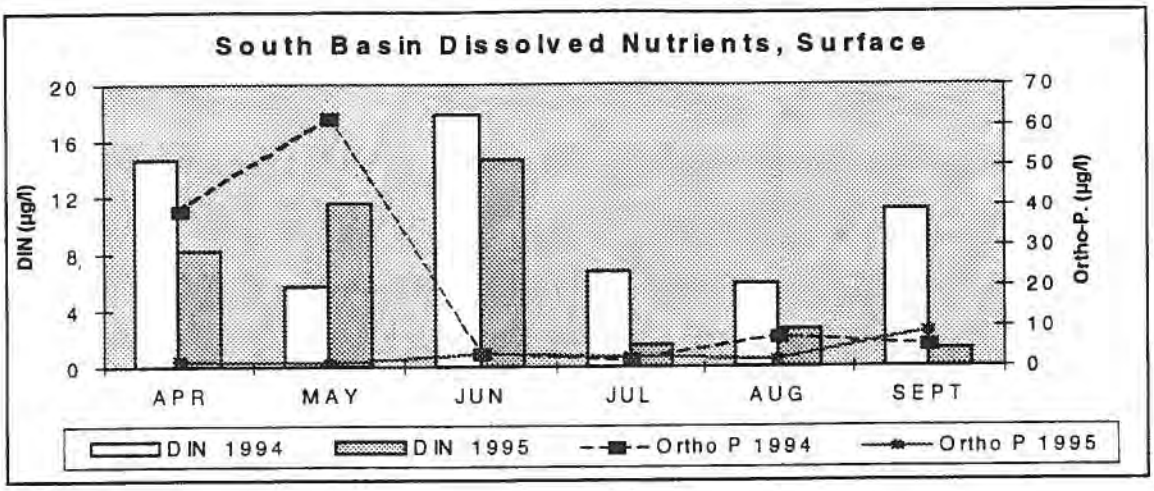

Figure 16. Monthly DIN (nitrate+nitrite+ ammonium/ammonia) versus orthophosphate for south basin in 1994 and 1995.

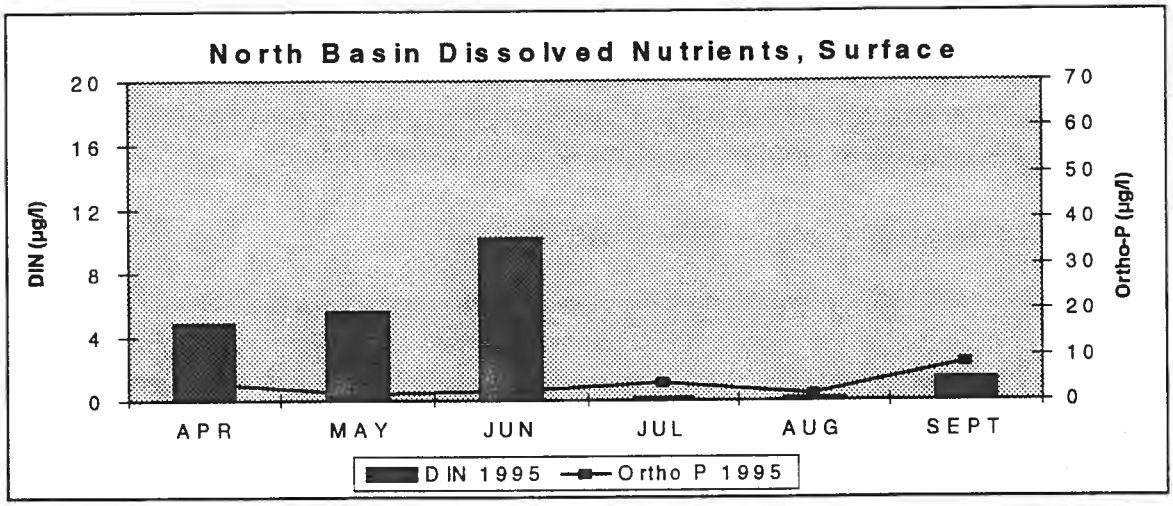

Figure 17. Monthly DIN (nitrate+nitrite+ ammonium/ammonia) versus orthophosphate for north basin in 1995.

As discussed in prior reports, a ratio of dissolved inorganic N to P of 7:1 is considered neutral with regard to the physiological requirements of algae. When much greater or less than the neutral value and coupled with nominal concentrations of the potentially limiting nutrient that are very low, a case for nutrient limitation of microalgal growth may be made. Keeping the data from figures 16 and 17 in mind, figure 18 shows that during July and August nitrogen was potentially limiting to the growth of microalgae in all three basins of the lake. A similar situation prevailed in the same period during 1994. The evidence is only correlative and moreover the concentration of iron in the south basin in July was below detection limits. Iron is a necessary micronutrient for algal growth although the concentration was much higher in August, suggesting patchiness or some sort of sampling stratification.

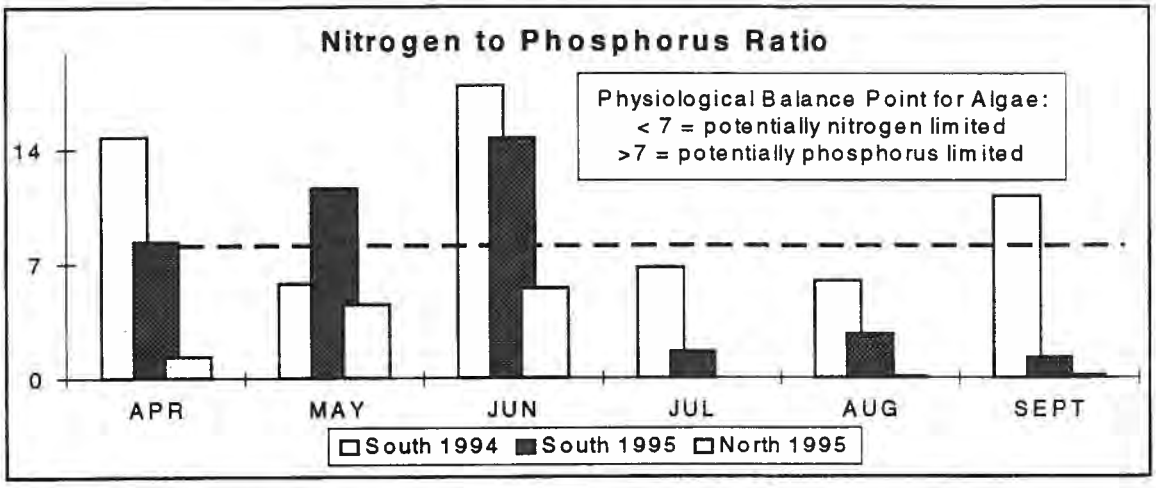

Figure 18. Monthly nitrogen to phosphorus ratios for near-surface waters of the three basins. The north basin in late summer was too low to register in this plot.

Similar patterns of nitrate, nitrite and ammonium+ammonia concentrations in surface and deep water occurred in 1995 as were seen in 1994 in the south basin. See Rensel (1995a) for more details regarding interpretation.

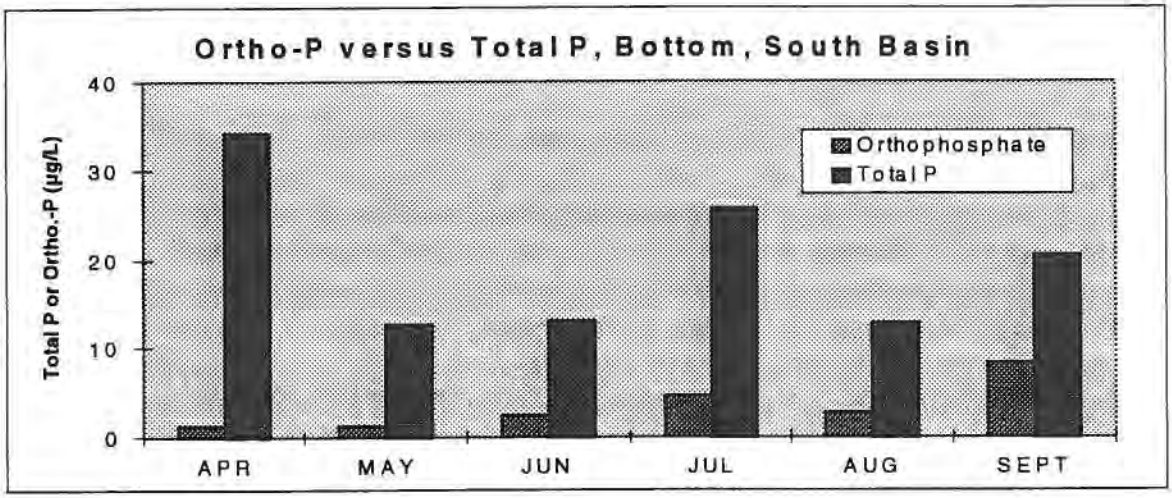

Figure 19. Monthly orthophosphate and total P from deepest samples collected in the south basin, Lake Osoyoos during 1995.

Dissolved and total P in bottom waters of the south basin in 1995 showed an increasing trend in orthophosphate (Figs. 19 and 20), but concentrations were less than 1994. Total P of those same bottom waters increased throughout the season in 1994, but not in 1995 for unknown reasons. The difference may be due to the less vertically stratified condition of the lake in 1995 previously discussed. It also may mean that a nutrient budget for the lake could vary significantly from year to year depending on these factors (appendix 3 *and Okanogan River: Inflow and Outflow*).

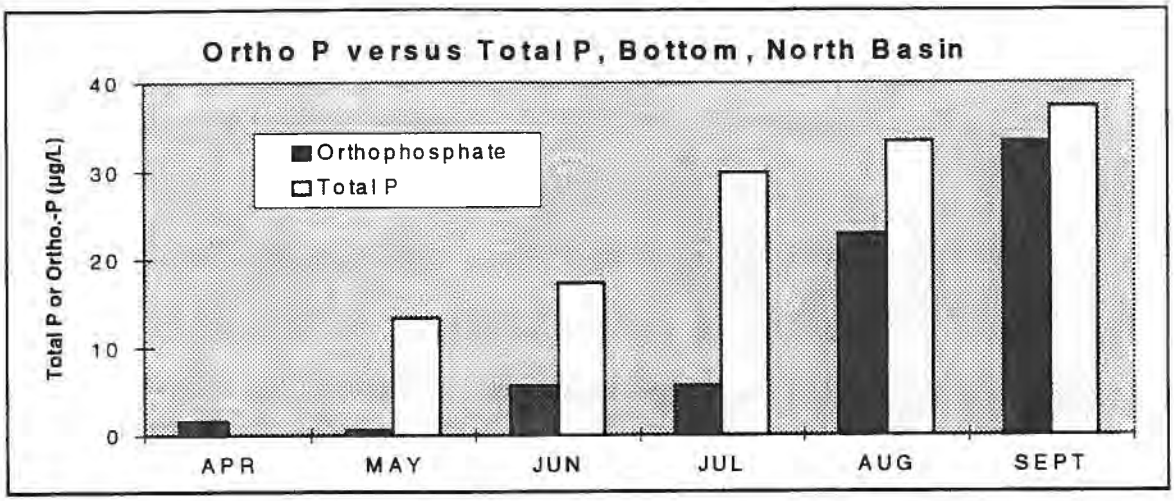

Figure 20. Monthly orthophosphate and total P from deepest samples collected in the north basin, Lake Osoyoos during 1995.

Figure 20 shows the same parameters for the north basin. Both measures of phosphorus increased in a stepwise fashion throughout the summer and early fall. The pattern resembled the results from the south basin in 1994, but again the scale was less by roughly half in this case.

Okanogan River Inflow and Outflow

A plot of total N and total P inflow versus outflow for limited months available (Fig. 21) indicates a net gain in both macronutrients after the Okanogan River flows through the lake. For total P this result was expected, given the internal loading that was previously identified (Rensel 1995a). For total N, the differences are less pronounced, but nevertheless consistent throughout the critical summer and fall months. These data could be interpreted to indicate a significant internal loading for phosphorus, but there could be other significant sources of nitrogen. Municipal wastes are collected from the towns of Osoyoos and Oliver for treatment and land application, reducing the possibility of their input to the lake. However, septic tanks are used in many areas surrounding the lake including all of the south basin and much of the north basin. Both residential and tourist use in the area appears to be increasing, and their is concern by some that septic tanks could be leaking poorly treated sewage to the lake (B. Shephard, personal communication). See *Recommendations* regarding this topic.

Many of the same species present in 1994 were noted again in 1995 beginning with the blue-green alga *Oscillatoria tenuis that was* numerically dominant even in April

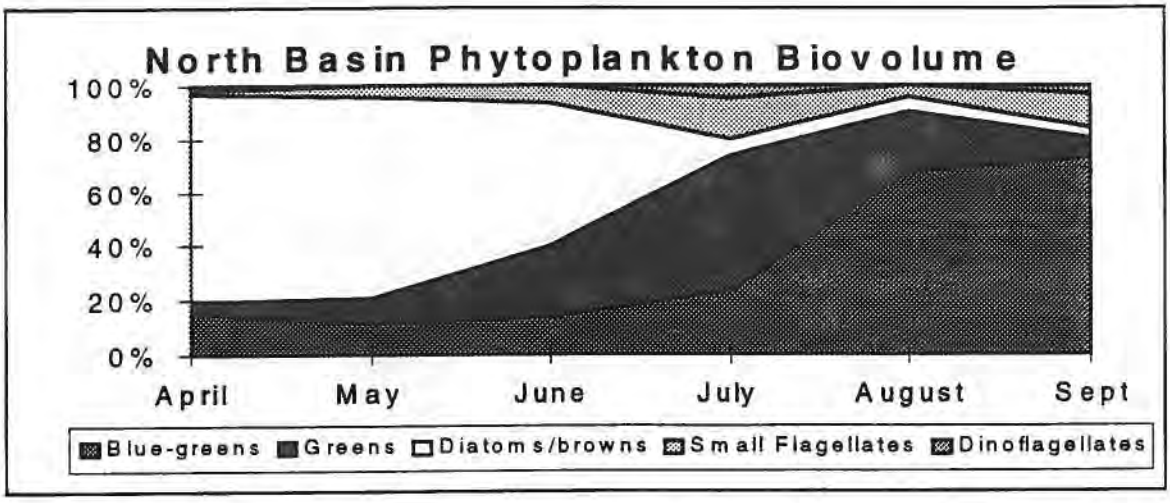

Figure 26. Percent distribution for biovolume of major taxa of phytoplankton in the north basin of Lake Osoyoos during 1995.

(Appendix 12). The clear prevalence of a Lyngbya-like sp. was noted later in the summer with volumetric dominance by September. This species sometimes forms surface scums of unsightly brown clumps that was noted in September of 1994, but not sampled. No major accumulations were noted on the surface in 1995. This may have been due to wind-caused mixing of the epilimnion which appeared to be stronger in the late summer of 1995 than in 1994.

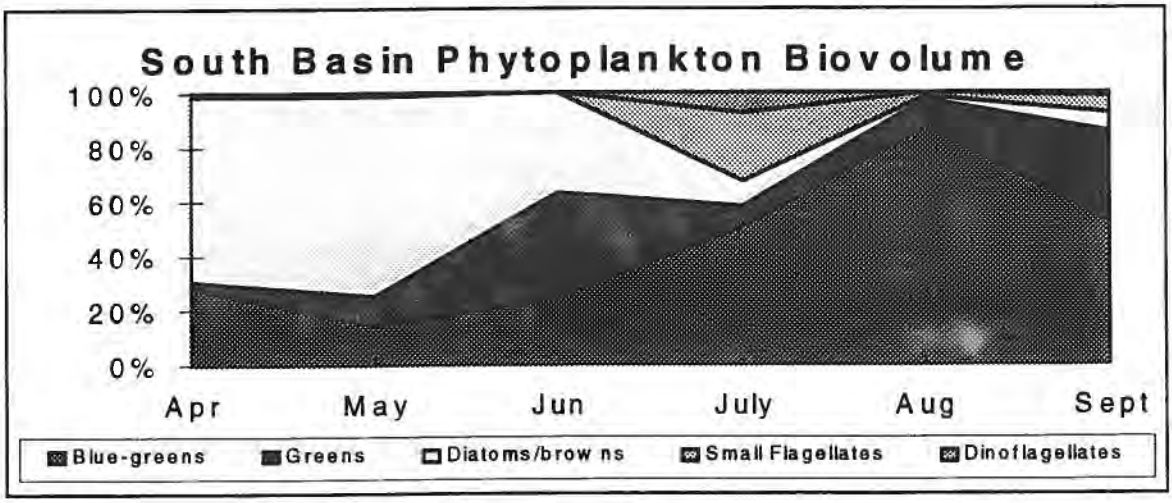

Figure 27. Percent distribution for biovolume of major taxa of phytoplankton in the south basin of Lake Osoyoos during 1995.

Total monthly phytoplankton biovolume (Fig. 28) show similar to slightly less values for the north basin, particularly during the blue-green algal bloom period of August.

Figure 29 is a comparison of diatom and green microalgal biovolume for the two basins. This figure may be viewed as comparing the density of microalgal forms generally more available for crustacean zooplankton. Averages were 1,195,000

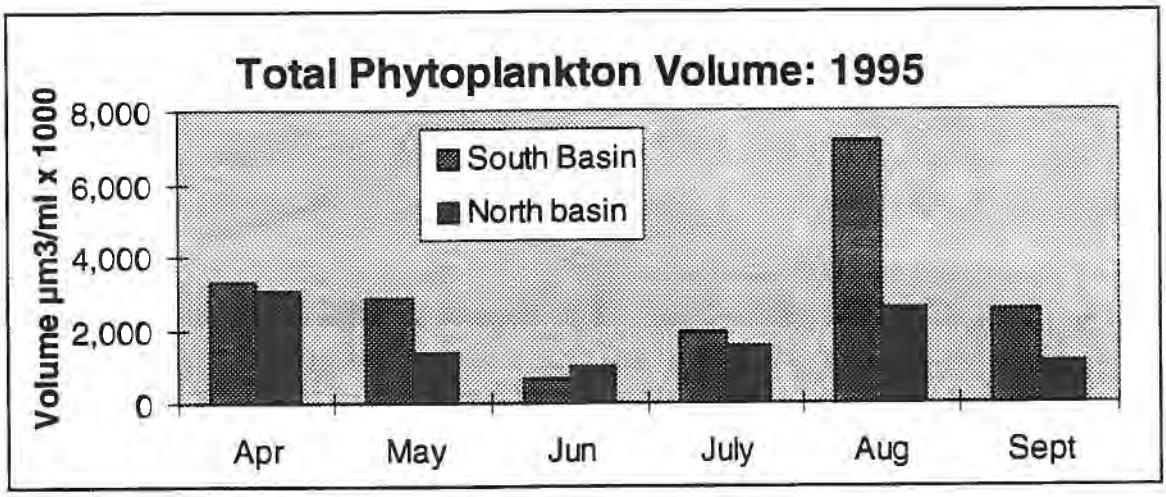

Figure 28. Comparison of total phytoplantkon volume in south and north basins of Lake Osoyoos during 1995.

μm^3/ml versus 1,028,000 μm^3/ml for the south versus north basins, respectively. I expected less of the desirable species for the south basin, but it was slightly greater for the entire period and for the late summer during the blue-green algal bloom.

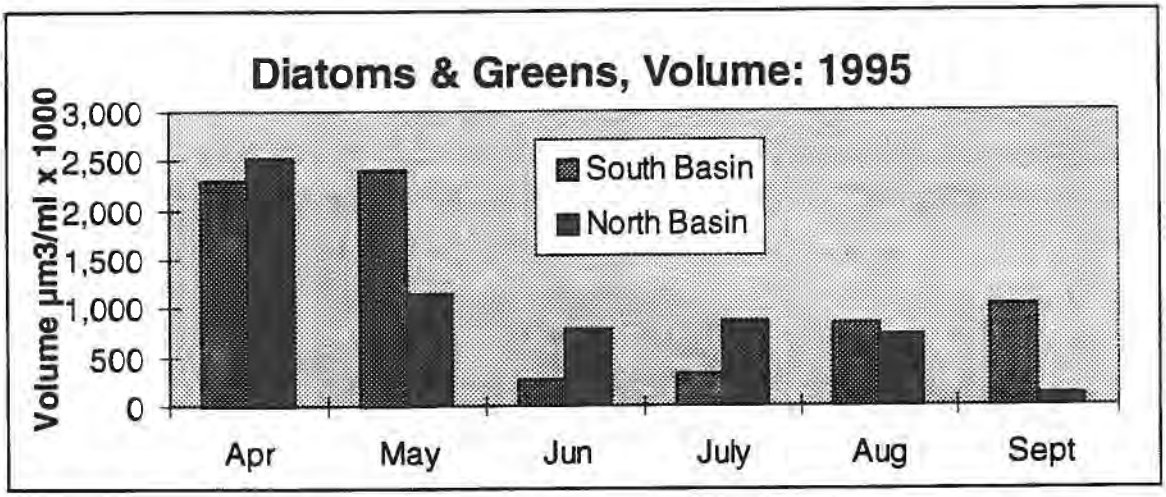

Figure 29. Biovolume of diatoms and green microalgae in near surface waters of north and south basins of Lake Osoyoos during 1995.

As previously pointed out, (Rensel 1995a) there are no reliable density or biomass or biovolume data (other than chlorophyll *a*) from the 1960s or 1970s to compare the present data. This is unfortunate because shifts in species composition can be highly important to the food web and sockeye salmon ecology. However, the general shift

from beneficial diatoms in the spring to undesirable, inedible or in some cases harmful blue-green in the later summer is still the same for the two time periods (Stein and Coulthard 1971a, 1971b). I reviewed those author's data summaries for 1969-70 and noted many of the same species dominant or present, with some exceptions. They cite work by Booth (1969) in a prior year that showed some variability in species dominance and abundance of *Lyngbya limnetica.*

From these data and the chlorophyll *a* information previously discussed I may conclude that south and north basins had similar phytoplankton dynamics in 1995. However, a major blue-green bloom occurred in August in the south basin that was not duplicated in the north basin. Unexpectedly, species of phytoplankton that were potentially valuable to crustacean zooplankton (and sockeye salmon fry) were not significantly depressed by the bloom. The significance of this is discussed in more detail in the next section.

Zooplankton: Species Dynamics

Zooplankton are animal plankton that are the primary consumers of phytoplankton. Background material for this topic relative to Lake Osoyoos was previously discussed in Rensel (1993, 1995a). It is important to re-emphasize that plankton populations may have major interannual variation of density and biomass and even species composition, so comparisons offered below should be viewed as only a glimpse of the true dynamics that exists in Lake Osoyoos.

In many aquatic environments; crustacean zooplankton may be highly important as sockeye fry prey. Zooplankton also include rotifers as a major categories in lakes but are too small to be prey for fry. As mentioned in the last report, a fundamental relationship between eutrophication and the size of zooplankton has been noted throughout many eutrophic lakes of the world. The more eutrophic a lake, the smaller the average size of the zooplankton and less importance of these zooplankton in controlling the phytoplankton populations.

The major categories of zooplankton discussed here include generally desirable crustaceans such as the calanoid and cyclopoid copepods, especially cladocerans such as *Daphnia* sp. Not all of these are desirable as sockeye prey, generally just the larger ones. Rotifers are less desirable non-crustaceans and indicative of trophic shifts to undesirable small or large, inedible phytoplankton species. In eutrophic lakes there are often more filamentous forms of phytoplankton prevalent that are less susceptible to predation by zooplankton. The best example of desirable zooplankton is the larger-bodied cladoceran *Daphnia magna* or *D. pulex.* These forms are able to prosper in many eutrophic lakes, unless blue-greens dominate the phytoplankton or predation by forage fish crops too many of them (Welch 1992).

Zooplankton data from Lake Osoyoos in 1995 are considered by density (absolute numbers and a percentage) or biomass. The former is useful for comparison to

historical data, the latter is biologically more significant because it represents total weight of the zooplankton per unit area or volume.

A striking difference between percent density and percent biomass of zooplankton categories can be seen comparing Figure 30 to 31 and 32 to 33 for the two basins considered here. Rotifer density was great except for May and September, but their biovolume was insignificant for the total period. Crustecean zooplankton had a similar pattern of abundance and biovolume in both basin. Peak percent biovolume of the important cladoceran category occurred from June through August.

Compared to 1994 data from the south basin (see Figures 13 and 14 of Rensel 1995), calanoid biomass was more prevalent in the spring of 1995 but shifted to similar dominance percentages by fall. Percent calanoid biomass increased in 1995 at coincident with decrease of percent cladoceran biomass (Figs. 31 and 33).

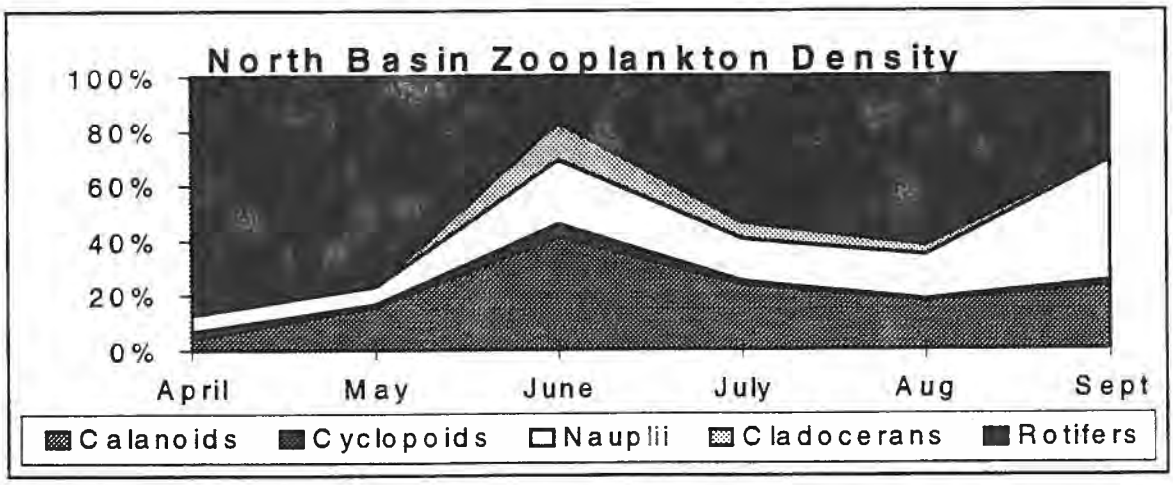

Figure 30. North basin Lake Osoyoos zooplankton density by percent in 1995.

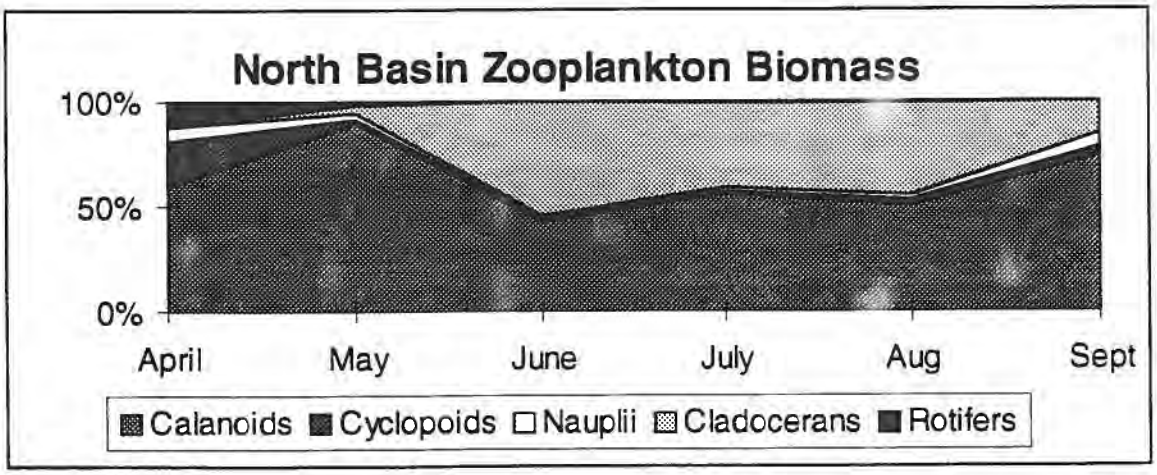

Figure 31. North basin Lake Osoyoos zooplankton biomass by percent in 1995.

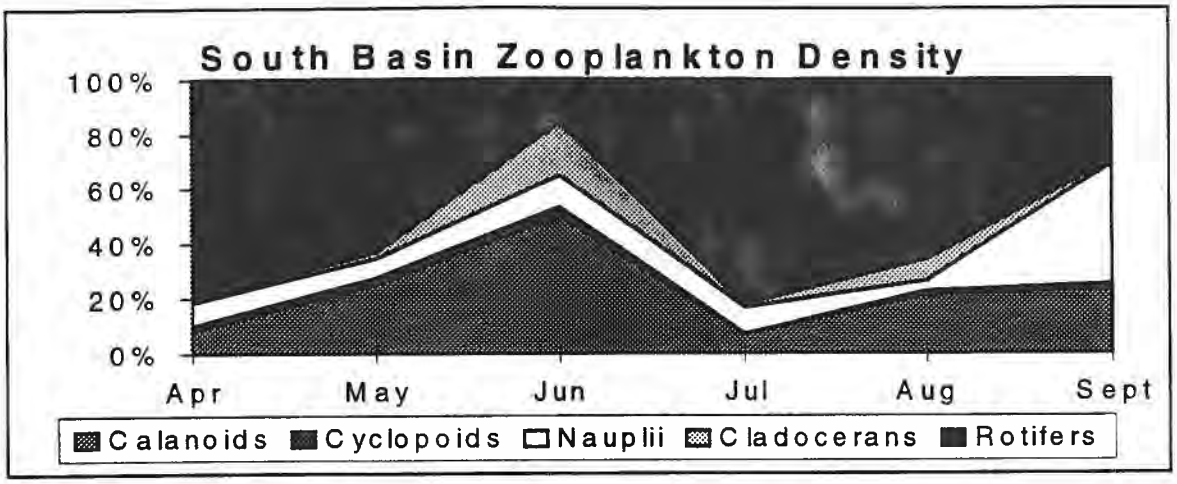

Figure 32. South basin Lake Osoyoos zooplankton density by percent in 1995.

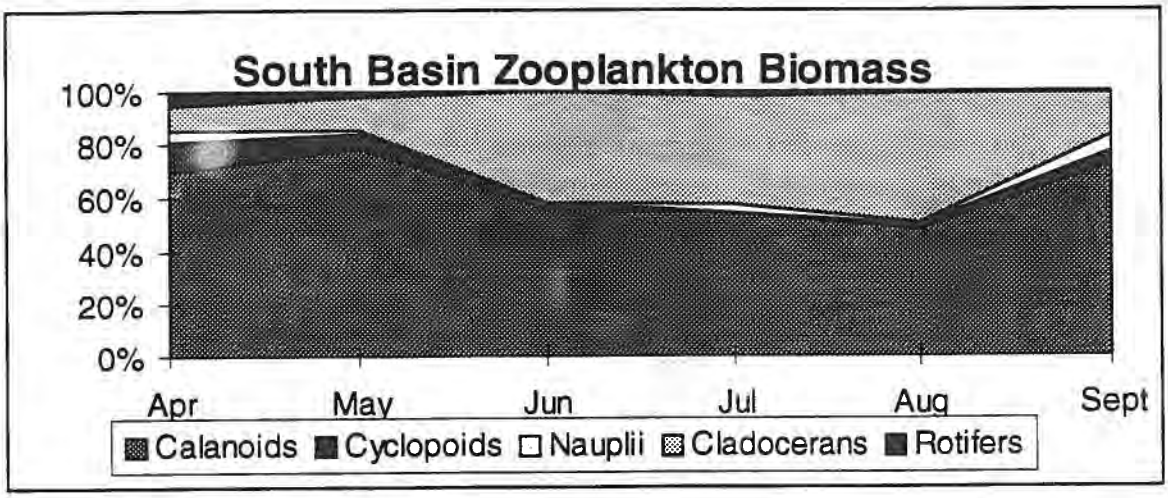

Figure 33. South basin Lake Osoyoos zooplankton biomass by percent in 1995.

North and south basins zooplankton density without rotifers (i.e., crustacean zooplankton) are shown compared to historical data in Figures 34 and 35, respectively. Please note the much greater Y axis for the former necessitated by the large peaks in May and June of 1972-73 (Fig. 34). July through September zooplankton density in the north basin during 1995 was similar to or greater than historical values.

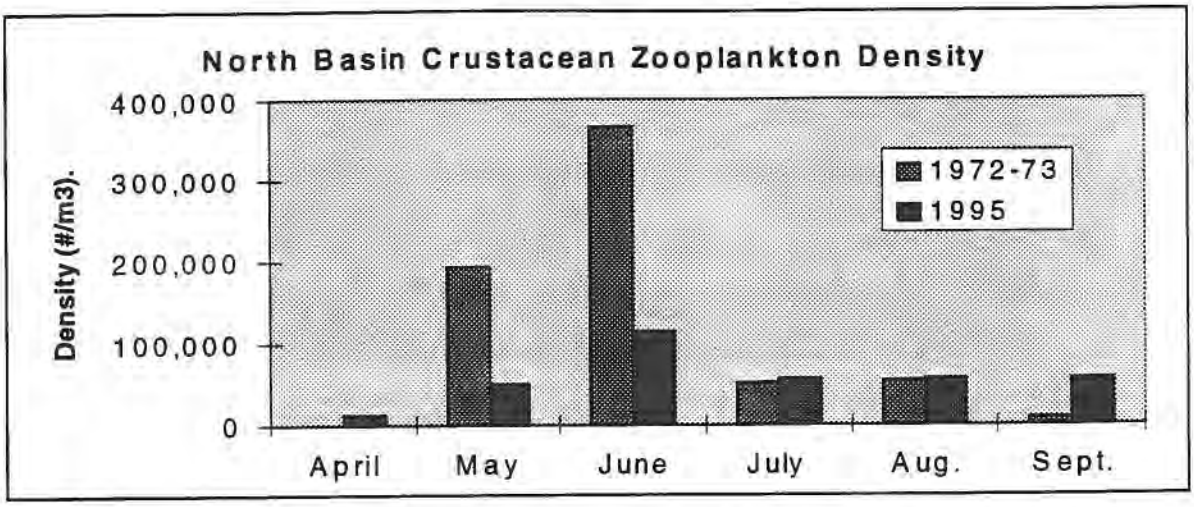

Figure 34. Density of zooplankton (except rotifers) in the north basin of Lake Osoyoos during this study (1994 and 1995) versus 1972-73 study of Allen and Meekin (1980). See appendices 9 and 11 for raw data.

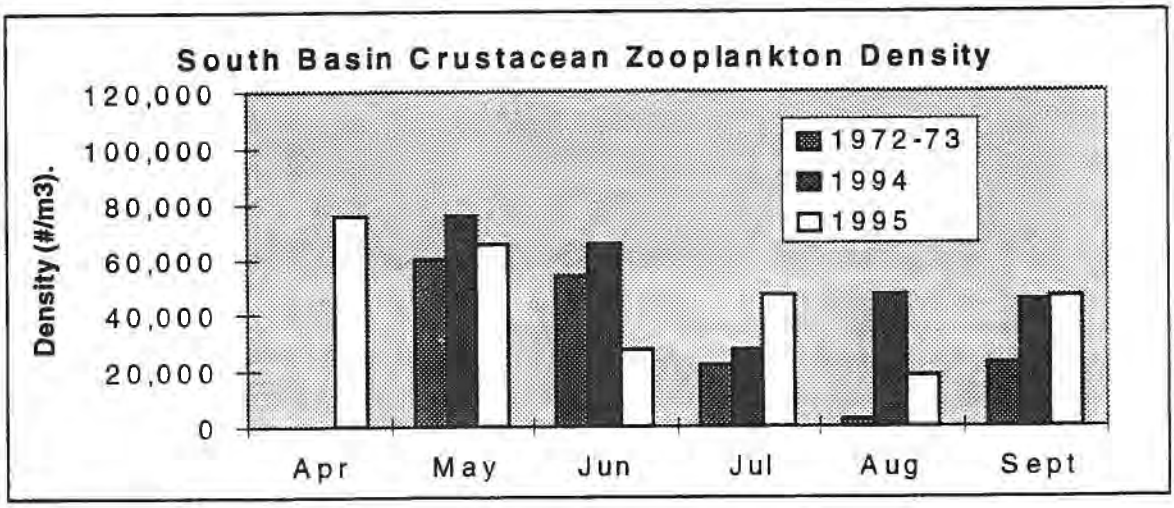

Figure 35. Density of zooplankton (except rotifers) in the south basin of Lake Osoyoos during this study (1994 and 1995) versus 1972-73 study of Allen and Meekin (1980). See appendices 10 and 11 for raw data.

Density of crustacean zooplankton in the south basin (Fig. 35) was similar for historical and 1994/1995 values, although there was higher density in the critical month of August for the recent results. The two basins are directly compared in Figure 36, showing differing density in April, June and August. Reduced density of crustaceans during August in the south basin could have been due to adverse interaction with the intense blue-green algal bloom. It is probably not due to a lack of appropriate diatom or green microalgae, as their availability was not significantly affected by the blue-green bloom, as discussed in the prior section.

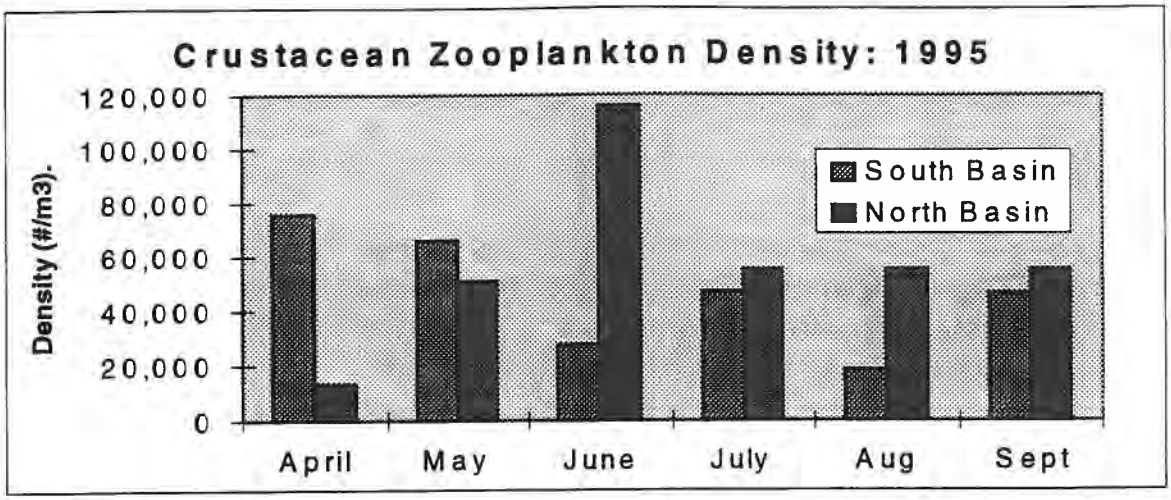

Figure 36. Crustacean zooplankton density in Lake Osoyoos in 1995.

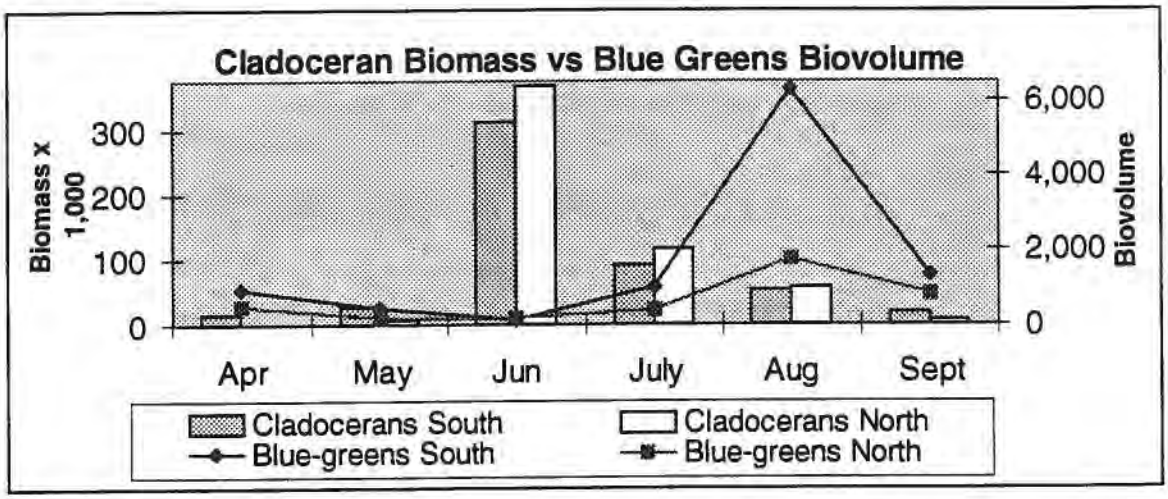

Figure 37. Comparison of cladoceran zooplankton biomass (in $\mu g/m^3$ dry weight estimate) and blue-green algal volume ($\mu m^3/ml$) for north and south basins of Lake Osoyoos in 1995.

A comparison is made in Figure 37 showing cladoceran zooplankton biomass versus blue-green algal volumes in 1995. This comparison was made to test the hypothesis advanced in the previous report that the abundance of desirable cladoceran zooplankton such as *Daphnia* spp. is inversely related to the blue-green algal blooms in lake Osoyoos. The plot shows relatively low cladoceran biomass in the spring, a huge peak in both basins in June, followed by a gradual decline. Concurrently, blue-green algal biomass was low in the spring and early summer, with peaks in August. Within the summer period, therefore, it does appear that there is a general inverse relationship between the two factors, but there is considerable variation.

Figure 37 also shows that the south basin had a more consistent concentration of cladocerans and the north basin had the lowest standing stock during the April and

May period. This may be due to predation by sockeye fry and pre-smolts and other predators in the north basin, and does not necessarily suggest density dependence based on limited food supply. It does, however, show the value of the south basin in providing rich feeding grounds in the spring as fry move through the system and smolts move out to the river.

Secondly, and not shown in the figure but in the appendices, biomass of the valuable sockeye prey *Daphnia* spp. declined to zero in August and September in the north basin and to 8 $\mu g/m^3$ or zero in the respective months in the south basin. Otherwise a plot of blue-green biovolume versus *Daphnia* biomass looks very similar to Figure 37.

Figure 38 shows an expected diatom bloom in the fall, followed by a normal lag and peak in cladoceran zooplankton consumers in June, tapering off through the summer. This plot suggests that availability of diatoms had much to do with cladoceran biomass and by extension that blue-green biovolume did not, but the occurrence of the two types of microalgae are inextricably linked in bloom succession.

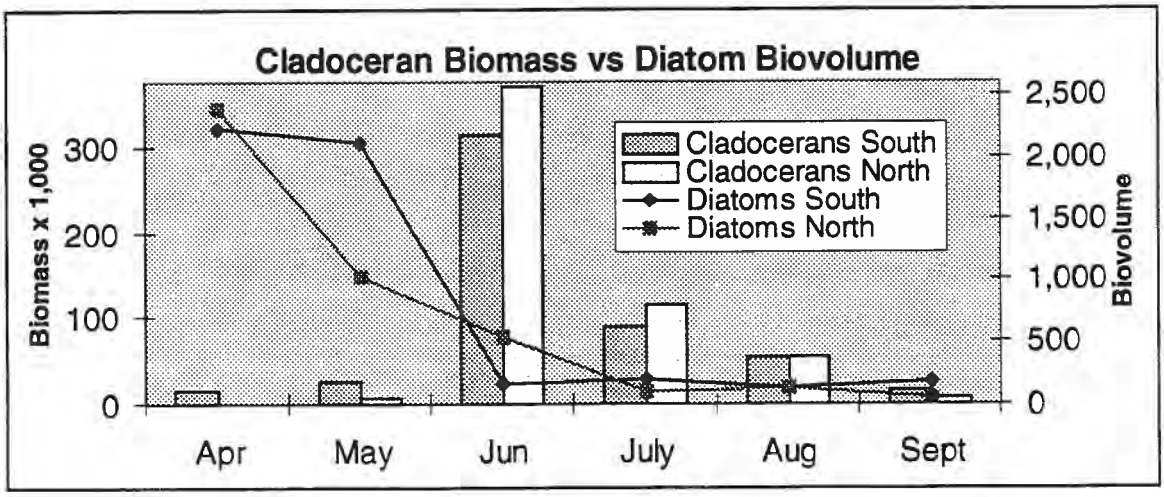

Figure 38. Comparison of cladoceran zooplankton biomass (in $\mu g/m^3$ dry weight estimate) and diatom algal volume ($\mu m^3/ml$) for north and south basins of Lake Osoyoos in 1995.

Finally, it is useful to compare Lake Osoyoos zooplankton abundance from this study with other sockeye lakes, after converting to equivalent units. Lake Osoyoos has been reported to be one of the most productive sockeye lakes with regard to crustacean zooplankton. Foerster (1968) ranked Lake Osoyoos as the most productive lake of the sockeye lakes he reviewed averaging 21.4 crustaceans per Liter. In 1995, we found much greater production, with about 57 per liter in the north basin and 47 per liter in the south basin during the April to September. Even the lowest observed density (north basin, April, 13/L) is not low compared to other sockeye lakes, although no cladocerans were observed in that particular sample. It would be better, of course, to compare biomass rather than density but that is not possible.

Daphnia Bioassays

Laboratory bioassays using the cladoceran zooplankton *Daphnia magna* were conducted using water from the south basin collected on August 30, 1995. The goal of this work was to see if an acute toxic effect was caused by exposure to blue-green algal blooms. It was especially appropriate because of the questions raised above about cladoceran biomass being potentially controlled by blue-green algae blooms.

This work was prompted by the apparent great density of the August 8th bloom and I hoped to sample some of that same event in the bioassay. However, I was unable to return until 3 weeks later and by that time the bloom appeared to be greatly reduced using Secchi disk and dissolved oxygen (Table 3) as surrogate bloom indicators.

The first bioassay conducted August 31 had 2 each *Daphnia* in 8 beakers of unfiltered south basin water in a 20°C environmental room, with no controls. Within 24 hours four of the *Daphnia* had strings of material attached to them that was obviously impeding their mobility and ability to maintain a water column position. Light microscopic examination of the water showed *Anabena* and *Aphanizomenon* spp. and other species. Subsequent controlled bioassays had problems with survival of controls and apparent starvation, although I attempted feeding various treatments. I collected more water in September, but the bloom had not recurred. Had I been able to use water from the major bloom of early August, the results may have shown much greater mortality of the *Daphnia* due to entanglement with filamentous blue-greens.

Laboratory studies of the survival of *Daphnia* spp. fed blue-green and other algae reviewed by colleagues of mine (Hartman and Kunkel 1991) show conflicting results, although the majority suggest rejection or inhibition of food collection by *Daphnia* spp. when fed blue-greens. These authors, associated with our laboratory at the University of Washington, used scanning electron microscope methods to show that Daphnia will select cylindrical prey and avoid or reject long strands of filamentous blue-green algae. Entanglement with *Oscillatoria aghardii* strands ($\geq$ 80 µm) of *Daphnia* limbs and claws was also documented. Major differences were noted between small and large *Daphnia*, with smaller ones (0.9 mm) much more likely to clear blue-greens from the water than large (2.4 mm) ones. The small ones, however, were clearing the blue-greens through entanglement, not actual consumption. The possibility of feeding inhibition due to toxin content in the blue-greens remains a possibility that has not been adequately addressed in the literature.

Trophic State Determination

The trophic state of Lake Osoyoos may be determined using data reported here applied to Carlson's (1977) trophic state index or TSI. TSI was previously described (Rensel 1995a) and is an indication of the degree of enrichment of a lake both in this case determined by water transparency (Secchi disk depth), total phosphorus and

chlorophyll *a* content during the summer months. TSI works best in north temperate lakes that tend to be P limited and have turbidity primarily due to phytoplankton. Because Lake is Osoyoos is apparently N limited and has turbidity not strongly correlated with chlorophyll *a* concentration, it should not be considered as perfectly appropriate. The index does not work in lakes that are turbid from erosion or in lakes dominated by macroalgae (EPA 1990). Often not all three components of the TSI will agree exactly, as is the case for Lake Osoyoos, discussed below.

Formula for TSI calculations are shown here followed by results for 1995 in Lake Osoyoos:

Transparency TSI = 60 - 14.41 ln Secchi disk (m)

Chlorophyll *a* TSI = 9.81 ln chl a (µg/l) + 30.6

Total Phosphorus (surface) TSI = 14.42 ln TP (µg/l) + 4.15

Secchi Disk

North Basin = 3.7 (SD = 0.8, n =4) TSI value of 41.1
South Basin = 3.3 (SD = 1.5, n = 4) TSI value of 42.8

Chlorophyll a Pigment

North basin = 4.6 (SD = 1.5, n = 4) TSI value of 45.6
South Basin = 5.0 (SD = 2.1, n = 4) = TSI value of 46.4

Total Phosphorus

North basin = 13.0 (SD = 2.8, n = 4) TSI value of 41.1
South Basin = 17.7 (SD = 6.6, n = 4) = TSI value of 45.6

Total Nitrogen (Not part of TSI, but discussed later)

North basin = 360.4 (SD = 81.4, n = 4)
South Basin =447.4 (SD = 188.9, n = 4)

Summary of Trophic State Index

Weighing the 3 TSI components equally, the overall Carlson Trophic State Index value for the North basin of Lake Osoyoos in 1995 would be 42.6, or in the lower-mesotrophic range (Table 6, apply to Figure 16 in Rensel 1995a). The average for the south basin was slightly higher at 44.9, very similar to the 46.8 value noted for 1994. Accordingly, comparisons to historical data presented in last year's report remain valid. Briefly, it appeared that there has been a slight increase in the trophic state of

Lake Osoyoos since the early 1970s. The increased total N and total P is partly offset by lower chlorophyll *a* concentrations. It is possible that lower chlorophyll a is due to higher production and biomass of blue-green algae that does not use chlorophyll a as much as a primary photosynthetic pigment. This explanation was also advanced previously as a possibility to explain the poor transparency versus chlorophyll *a* relationship. Another possibility relates to the protocol I used to collect surface water, i.e., pooling of water samples from 1, 3 and 6 m. In 1996 that method should be compared to discrete sample from 1 m in the summer to see if major differences occur.

Table 6. Summary of current (1995) and recent (1994) trophic state index (TSI) and other possible trend indicators for Lake Osoyoos mostly compared to conditions in the early 1970s or 1980s (see Rensel 1993,1995a for details of other databases).

NORTH BASIN	SOUTH BASIN	HISTORICAL COMPARSION
1995 transparency = 3.7 m	1994 transparency = 3.1 1995 transparency = 3.3	Better than 3.3 m average for 1971 in the north basin, much better than 2.6 m average from 1989-92 volunteer collected data from south basin
1995 chlorophyll a 4.6 µg/l	1994 chlorophyll a 5.4 µg/l 1995 chlorophyll a 5.0 µg/l	Very large decreases from historical data (23 µg/l in 1970s) and slight decrease from 1994 concentrations
1995 total phosphorus 13.0 µg/l	1994 total P 24.0 µg/l 1995 total P 17.7 µg/l	At upper end of TP range seen from sporadic data from the 1980s
1995 total nitrogen 360.0 µg/l	1994 Total N 616.6 µg/l 1995 Total N 447.4 µg/l	Large increases compared to all prior data for north basin for 1970s, slight decrease for south basin versus 1994

SUMMARY OF FISH CULTURE DATA

The following narrative summarize fish cultural results for fry reared in net pens in 1995. Much of the data were obtained from detailed notes and records of Rod Stensgar of the Colville Confederated Tribes Fish and Wildlife Dept. Daily records of water quality and fish cultural details were kept by Avery Cleveland, Stephen Hall and Stephen Francis of the same agency.

Approximately 38,934 fish or 378 lb. of sockeye fry were transported to the pens from the Cassimar Bar hatchery on April 19, 1995. Each transfer container held about 1/3 of the total, or about 12,978 fish (126 lb.) per tank. One tank of fish was stocked into each of three, small mesh (3/16") pens with an initial volumetric rearing density of 0.09 lb per ft^3 (Table 7, appendix 14).

Compared to 1994 when 12,500 fish were stocked in the pens, approximately three times as many fry were transported to Lake Osoyoos in 1995. Although this was an improvement, the pilot program was designed for release of 200,000 fish per year. The 1995 fish were initially larger than the prior year (4.4 g versus 2.4 g) and placed in the pens about a week later. By the time of release 14 days later, they were slightly larger than the 1994 group by an average of about 0.4 g. Water temperatures were much cooler during April 1995 than the prior year. Average surface water temperatures were 10.9°C in 1995 versus 12.9°C in 1994 during the period April 19 to May 1 (based on comparisons of daily surface water temperatures in appendices of this and the prior year's reports). Cooler temperatures in 1995 may have reduced the growth of the sockeye fry slightly. Brett et al. (1969) concluded that optimum temperature for growth of sockeye fry would occur at about 15°C.

Table 7. Summary of fish cultural data for smolts released in 1994 and 1995. Dates correspond to stocking and release from net pens.

		1994		1995	
Parameter	Units	**14-Apr**	**17-May**	**19-Apr**	**2-May**
Initial Weight	grams	2.3	-----	4.4	-----
Final Weight	grams	-----	6.25	-----	6.67
Initial Length	mm	ND	-----	82.7	-----
Final Length	mm	-----	ND	-----	95.0
Days in Osoyoos Pens	days	-----	34	-----	14
Number of Cages		1	-----	3	-----
Mortality	percent	-----	0.2%	-----	0.08%
Samples	percent	-----	1.5%	-----	0.69%
Initial Number	-----	12,500	-----	38,934	-----
Final Number	-----	-----	12,433	-----	38,093
Initial Biomass	kg	28.8	-----	171.3	-----
Final Biomass	kg	-----	77.7	-----	254.1
Initial Density (metric)	kg./m3	0.238	-----	1.416	
Final Density (metric)	kg./m3	-----	0.642		2.100
Initial Density (US)	lbs./cu.ft.	0.015	-----	0.089	-----
Final Density (US)	lbs./cu.ft.	-----	0.040	-----	0.132
Maximum Allowed *	lbs./cu.ft.	-----	0.330	-----	0.330
Max. Recommended**	lbs./cu.ft.	-----	0.120	-----	0.120
Food Conversion Ratio	ratio	-----	1.40	-----	0.82

* as per correspondence with Mr. Rod Woodin, WDF&W
** Personal communication, Mr. Bill Duplaga, 16 Sept. 92, Lake Wenatchee pen manager, WDF&W
ND = no data

Food conversion ratio (FCR) averaged about 0.8 (most feed to wet flesh) in 1995 which is very good given the moist diet ("Biodiet") that has a relatively high moisture

METHOW RIVER BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN; NATURAL PRODUCTION STUDY 1994 ANNUAL REPORT

APPENDIX H

METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

NATURAL PRODUCTION STUDY

1994 ANNUAL REPORT

Prepared by

Joel Hubble
and
Hilda Sexauer

Fisheries Resource Management Program
Yakama Indian Nation
Toppenish, Washington

Prepared for

Douglas Public Utility District
East Wenatchee, Washington

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1.0. ACKNOWLEDGEMENTS

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Thanks is given to Douglas PUD fisheries biologists Rick Klinge (Douglas PUD) and Mike Erho (consultant) for their assistance in facilitating the contract and for their input in the various research tasks.

2. 0. ABSTRACT

Research conducted in 1994 was in fulfillment of the Natural Production tasks that are stated under the Evaluation Objectives in the draft (October, 1994) Methow Basin Spring Chinook Salmon Enhancement Program document.

An estimated 12,494 spring chinook and 2,347 steelhead smolts/rainbow, of which 76% were classified as steelhead smolts, outmigrated from the Chewuch basin. The median date of passage was April 10 for spring chinook and April 30 for steelhead/rainbow. As in 1993, the spring chinook smolt outmigration peaked prior to the spring run-off. River discharge began to significantly increase beginning April 18. The mean fork length for spring chinook and steelhead smolts was 98 mm and 151 mm respectively.

An estimated 2,233 spring chinook parr moved downstream past the screw trap June 3 through July 20, after which downstream parr monitoring ceased because the water depth was too shallow to operate the screw trap. The weekly mean fork length ranged from 51 mm to 71 mm and averaged 59 mm overall. Forty-one steelhead/rainbow parr were captured with a mean length of 116 mm. A total of 224 residualized hatchery steelhead were captured, of which 80.4% past the trap between June 30 - July 3.

The late-summer spring chinook parr estimate in the Chewuch River was 9,362 fish. The highest parr densities (fish/rm) occurred in reaches II and III (rm 2.3 to rm 19.4) which accounted for 78.6% of the total number of parr. Unlike in 1993, a higher parr density (275 fish/rm) was seen in reach VII. In addition, in reach VIII, excluded in 1993, the parr density was 294 fish. An estimated 2,543 steelhead/rainbow (age 0+ and age 1+) were found in the Chewuch River with the majority of them residing in reach II.

Spring chinook spawning ground surveys were conducted in the Methow, Chewuch and Twisp subbasins in 1994, and a total of 133 redds were enumerated. This compares to the 1987-93 basin average of 576 redds, a 4.3 fold decrease. Subbasin redd totals were as follows: Methow- 64, Early Winters- 4, Lost- 6, Chewuch- 27 and Twisp- 32. For comparison, the 1987-93 subbasin averages were as follows: Methow- 217, Early Winters- 7, Lost- 48, Chewuch- 153 and Twisp- 151.

3. 0. INTRODUCTION

The Natural Production Study is part of the Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) (draft February 27, 1995). This study is part of ongoing research outlined under the Evaluation Objectives, covering tasks 2.9-2.11 in the MBSCSP that was initiated in 1993. However, systematic spring chinook spawning ground surveys were initiated in 1987.

The MBSCSP is a compensation program directed towards the enhancement of the wild spring chinook stocks in the Methow Basin. The MBSCSP is the result of the Wells Settlement Agreement between Douglas PUD and the fishery agencies and tribes to compensate for unavoidable smolt losses 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 discrete stocks of salmon"(Methow, Chewuch and Twisp), which is part of the Phase I compensation requirements under the settlement agreement.

4.0. 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 significant growth in 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.

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

The Twisp basin encompasses about 250 square miles and enters the Methow River at about 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. In recent years spring chinook spawning has extended upstream to South Creek (rm ~28).

A more extensive discussion of the Chewuch and Twisp basins can be found in the Chewuch River Watershed Analysis (Winthrop Ranger District, Okanogan National

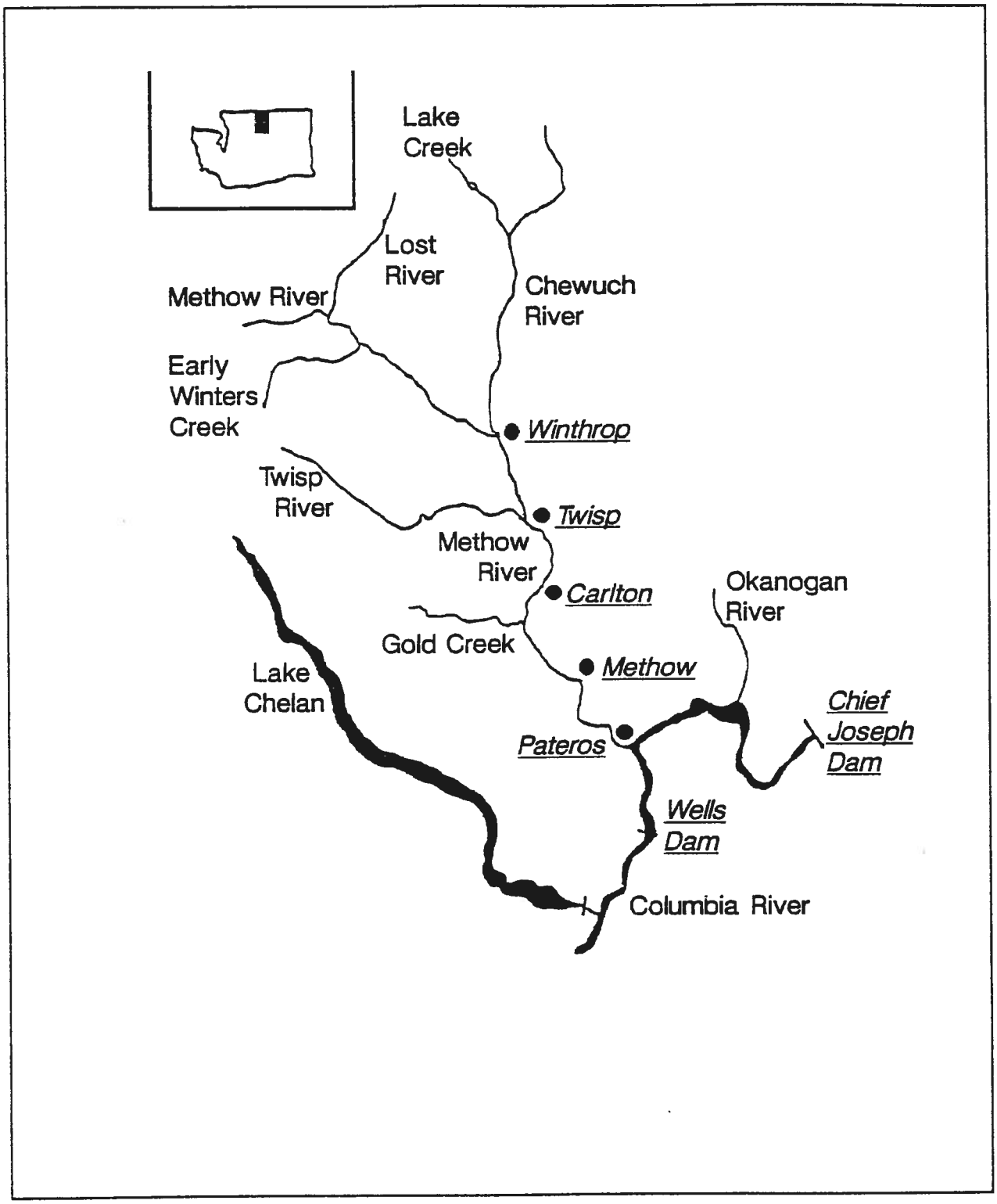

Figure 1. Map of the Methow Basin.

Forest, 1994) and in the draft Twisp River Watershed Analysis (Twisp Ranger District, Okanogan National Forest, 1994).

5.0. METHOD AND MATERIALS

5.1. OUTMIGRATION

5.1.1. Spring Season

An eight foot diameter E. G. Solutions screw trap was used to monitor spring chinook and steelhead/rainbow smolt outmigration at rm 0.1 on the Chewuch River from March 31 to June 2, 1994. The screw trap was placed in the thalweg region favoring the left bank of the river from March 31 to April 19, and was moved near the right bank April 24 due to turbulent flow conditions, and remained there through June 2.

The stream discharge data was collected from an USGS stream gauging station located at rm 0.1 on the Chewuch River.

The trap was normally operated seven days a week, 24 hours each day, with brief periods where the cone was lifted for cleaning. However, the trap was not operated April 20-24 and May 7-12 because of high river discharge. In addition, the trap was only operated for 15 hours on April 19 and for 21 hours on May 13, due high river flows. For these periods a linear regression was used to estimate daily fish passage that was based on the smolt catch five days preceding and following the high water event.

To determine the smolt entrainment-to-flow relation for the trap, a series of marked

wild smolt releases were made throughout the season (Appendix Table 1). Similar to last year, the number of entrainment test releases conducted, and number of fish available for each release was impaired by the low number of wild smolts available. Fish from each day's catch were marked with either a dorsal or ventral caudal clip and were allowed to recover about nine hours in a meshed cube located in a calm area of the river and were released around 1800 hours. Test fish were released upstream at rm 0.3 from the right bank into a fast run type reach. Marks were alternated between entrainment test releases, and with one exception, all the recaptured fish for a given release were recovered within a 24 hour period.

The first five entrainment test releases were alternated between the left and right banks to determine if there was a difference in entrainment rates. The results of these tests indicate there was no significant difference ($t_{.05} = 3.2$, df = 3) between the right and left banks, however there is much variation in entrainment rates within bank releases. Subsequent entrainment test releases were conducted from the right bank, since access to the river was not an issue (later it became one).

A weighted logistic regression was used to describe the entrainment-rate-to-flow relation for spring chinook. The form of the equation was

p = exp[b0 + b1 * f]/ { 1 + exp[b0 + b1 * f]}, where:

"p" is the predicted entrainment, "exp" is the exponential constant, "f" is the mean daily river discharge, and "b0" and "b1" are estimated coefficients. The values for "b0" and "b1" were -0.8626 and -0.00141 respectively.

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 entrainement.

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

$AN(j) = \sum_{i=1 \text{ to } j} N(i)$; where AN(i) is the cumulative estimated daily passage.

Since there was an insufficient number of steelhead smolts to conduct entrainment test releases, the spring chinook entrainment-flow relation was used to estimate daily smolt passage. It is realized that use of the spring chinook entrainment-flow relationship is not accurate for estimating actual smolt passage, however, it does provide way to describe outmigration timing and its relative magnitude over time. The actual entrainment rate of steelhead is probably lower because of their greater ability to avoid capture and would result in underestimating the actual number of smolts.

Both target (spring chinook and steelhead) and non-target (other salmonids and non-salmonids, Appendix Table 2) were worked-up daily at around 0900. The fish were anesthetized with MS-222. Normally the fork length was recorded to the nearest millimeter from all species and random weights to the nearest tenth of a gram were recorded from the spring chinook and steelhead/rainbow. Random scale samples from up to 20 fish were collected from spring chinook and steelhead smolts each day. After work-up, the fish were allowed to recover in a bucket of freshwater and were then released in a quiet area along the stream margin.

5.1.2. Summer Season

The downstream movement of spring chinook parr was monitored at the screw trap from June 3 to July 20. Monitoring ceased after July 20 when the trap became inoperable due to the low river elevation. The trap was fished adjacent to the right bank June 3 through June 25 and was fished adjacent to the left bank June 26 through July 20 after the river became too shallow to fish the trap on the right bank. The trap was operated 24 hours per day, seven days a week and there were no periods of non-fishing.

The same procedures used to determine the spring chinook smolt entrainment-to-flow relation were used for spring chinook parr, and four entrainment test releases were made (Appendix Table 1). After permission was denied for access to the right bank entrainment test release site, the last two releases were made from the left bank

immediately below Fulton Dam. The low daily catch of spring chinook parr precluded making more releases. The mean entrainment rate for the right bank was 13.4%, while it was 17.4% for the left bank.

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 mean entrainement rate for each respective period.

Fish handling procedures and the data collected was similar to that for smolt monitoring.

5.1.3. Fall Season

Low river elevations at the trap monitoring site (Highway 20 Bridge in Winthrop) prevented monitoring fall/winter spring chinook outmigration in the Chewuch River.

5.2. LATE SUMMER PARR DENSITIES

5.2.1. Spring Chinook

Daytime snorkeling surveys were used to determine late-summer spring chinook and steelhead/rainbow parr standing crop estimates in the Chewuch River from its confluence to rm 32.4, August 4 through September 15. Survey reaches and parr estimates were determined based on a methodology similar to that described by Hankin and Reeves (1988). Length and widths were measured for every habitat unit using a hip-chain, and every fifth habitat unit type (riffle, pool or glide) was snorkeled. Stream reaches were based on the U.S. Forest Service Chewuch River 1993 stream survey. During 1994, the Chewuch River was divided into eight stream reaches instead of seven, as in 1993. A total of 32.4 rivermiles were surveyed during 1994 compared to 31.2 rivermiles in 1993.

Typically, each habitat unit was snorkeled between 0900-1650 hour by three divers that moved upstream while enumerating fish as they were encountered. When the stream width was greater than 26 meters, two passes were made, one on each bank, spacing the three snorklers between the bank and the thalweg. At sites less than 26 meters wide the three snorkelers conducted a single pass with a single snorkeler in the thalweg region and the other two snorkelers next to the bank.

Only salmonid species were identified and enumerated during the surveys. The cover type (wood, boulder or none) associated with each fish was recorded.

Parr estimates for each stream reach was calculated using the following formula:

$RPE_i = \{[(P_r)/(S_r/L_r)] + [(P_p)/(S_p/L_p)] + [(P_g)/(S_g/L_g)]\}$; where:

RPE_i = reach parr estimate; P_r = number of parr in riffles; S_r = snorkeled length of riffles; L_r = total length of riffles in reach; P_p = number of parr in pools; S_p = snorkeled length of pools; L_p = total length of pools in reach; P_g = number of parr in glides; S_g = snorkeled length of glides; L_g = total length of glides in reach.

Total parr estimate for the Chewuch River Basin was calculated as follows:

$BPE = \sum_{i=1 \text{ to } 8} RPE_i$; where:

BPE = the Chewuch Basin Parr estimate.

5.2.2. Steelhead/Rainbow Trout

The steelhead/rainbow parr estimates were determined using the same methodology as described for spring chinook parr. The steelhead/rainbow were not distinguished by age classes, therefore the population estimate includes both of age 0+ and fish of older year classes.

5.3. SPAWNING GROUND SURVEYS

The same spawning reaches were surveyed in the Methow, Chewuch and Twisp basins and their respective tributaries in 1994, as in past years. The historically key spawning reaches were usually surveyed weekly, while those reaches where nominal spawning occurs were surveyed less frequently. However, all spawning reaches were surveyed at least once during or after the historic peak spawning period.

Spawner surveys were conducted by walking or by rafting when flows were sufficient. To ensure survey consistency, the same survey crew normally was assigned to the same spawning reach. To avoid recounting or missing previously a counted redd, it was marked with surveyor's tape on the river bank adjacent to the redd. A different flag color was used for each survey to distinguish redd from each survey.

All live spawners were counted during each survey. Carcasses were recovered and checked for sex, tags, fin clips, and spawning success. Scales were collected when possible from each carcass and post-eye-to-hypural-plate length was recorded.

Water temperatures were measured at the beginning and end of each survey.

The total number of spring chinook spawning in the Methow Basin was calculated by subtracting from the Wells Dam count the number of chinook returning to the

Winthrop National Fish Hatchery (WNFH) and those collected for broodstock for the Methow FH, and no adjustments were made for pre-spawning mortality.

6.0. RESULTS AND DISCUSSION

6.1. OUTMIGRATION

6.1.1. Spring Season

6.1.1.1. spring chinook

The estimated number of smolt outmigrants from the Chewuch basin was 12,494 ± 3,626 fish (Appendix Table 3), compared to an estimated 8,908 fish in 1993. Smolt outmigration presumably began prior to March 31, since 53 (actual catch) spring chinook smolts were captured the first night of monitoring. While smolt monitoring began eight days earlier than in 1993, it appears that the 1994 smolt outmigration occurred earlier (Figure 2). This is supported by the higher estimated number of smolts observed the first day of operation in 1994 (207 fish) compared to an estimate of 19 smolts the first day (April 8) of operation last year, and by an earlier median passage date (April 10) in 1994 than in 1993 (April 19). The approximate 25% and 75% passage dates were April 3 and April 18.

As observed in 1993, the majority (70.8%) of smolts outmigrated prior to a significant increase (1.9x) in river discharge (416 cfs) which occurred April 18 (Figure 3). Prior to this, the mean stream discharge for April was 223 cfs. Peak outmigration occurred April 2-4 which accounted for 30.9% of the total number of smolt outmigrants.

The mean spring chinook smolt fork length was 98 mm (n=1,808) with a coefficient of variation equal to 7.0% (Figure 4). Their mean weight and condition factor were

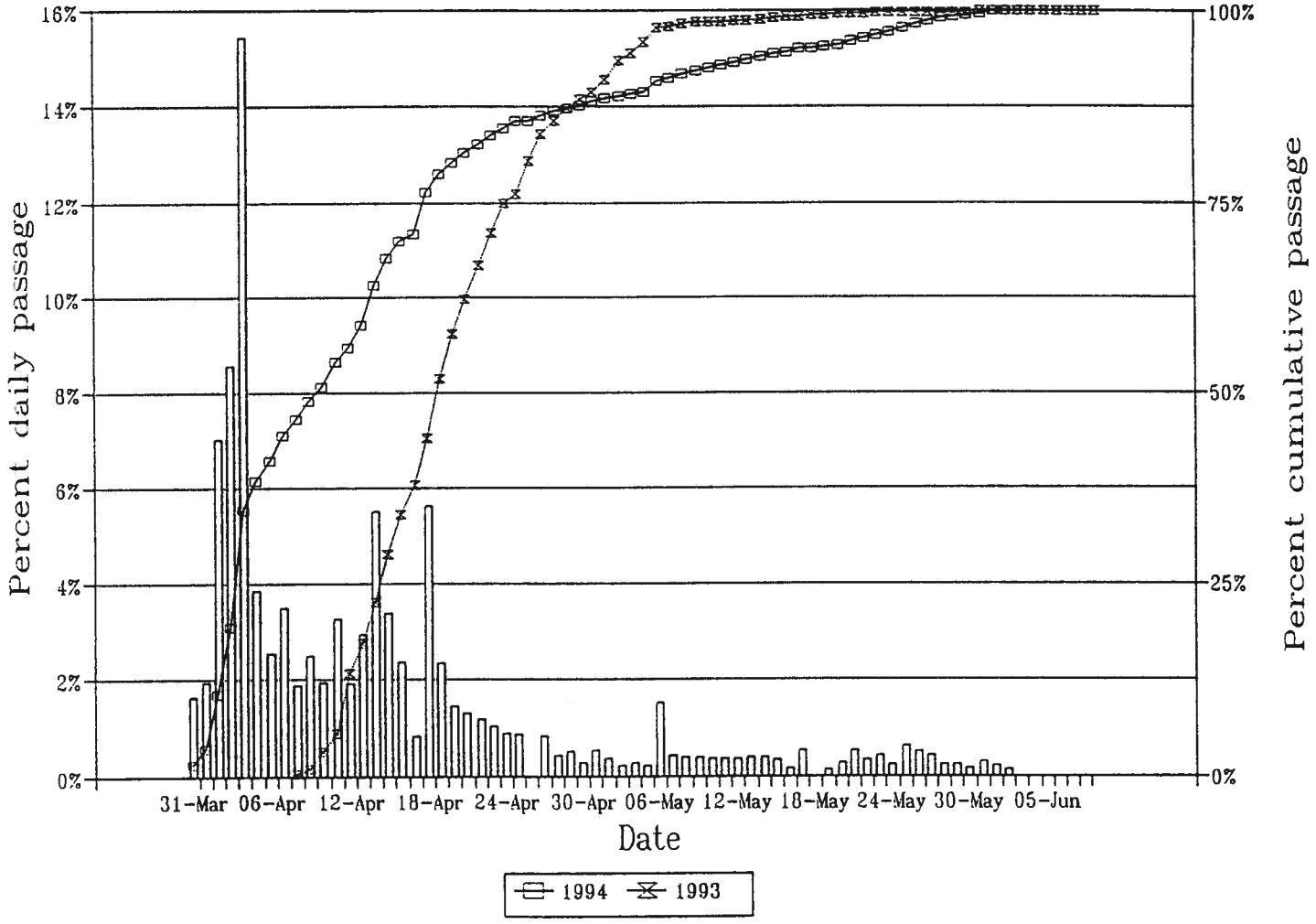

Figure 2. Estimated daily (1994) and cumulative (1993 and 1994) spring chinook smolt outmigration from the Chewuch basin.

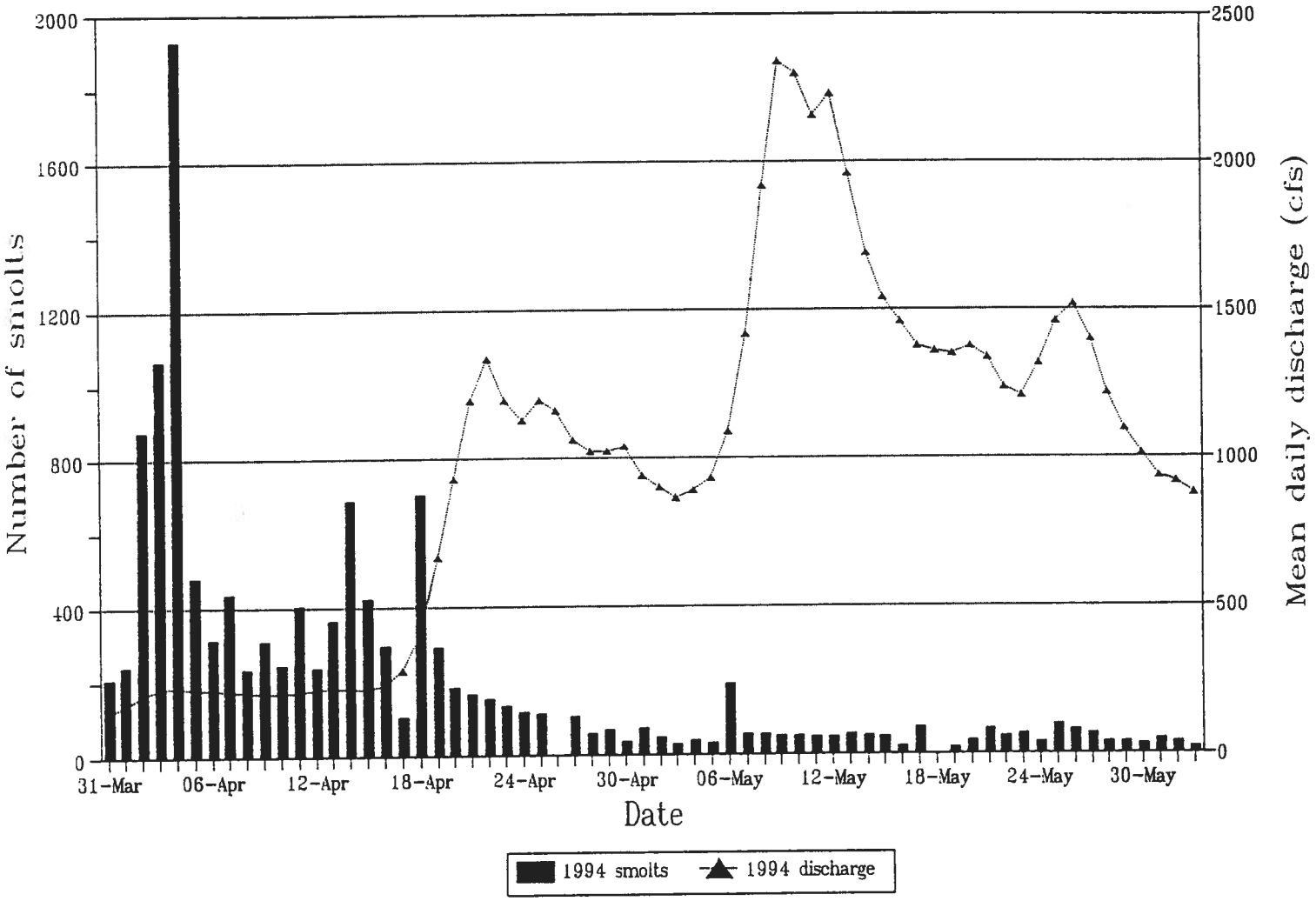

Figure 3. Estimated daily spring chinook smolt outmigration and mean daily discharge for the Chewuch basin, 1994.

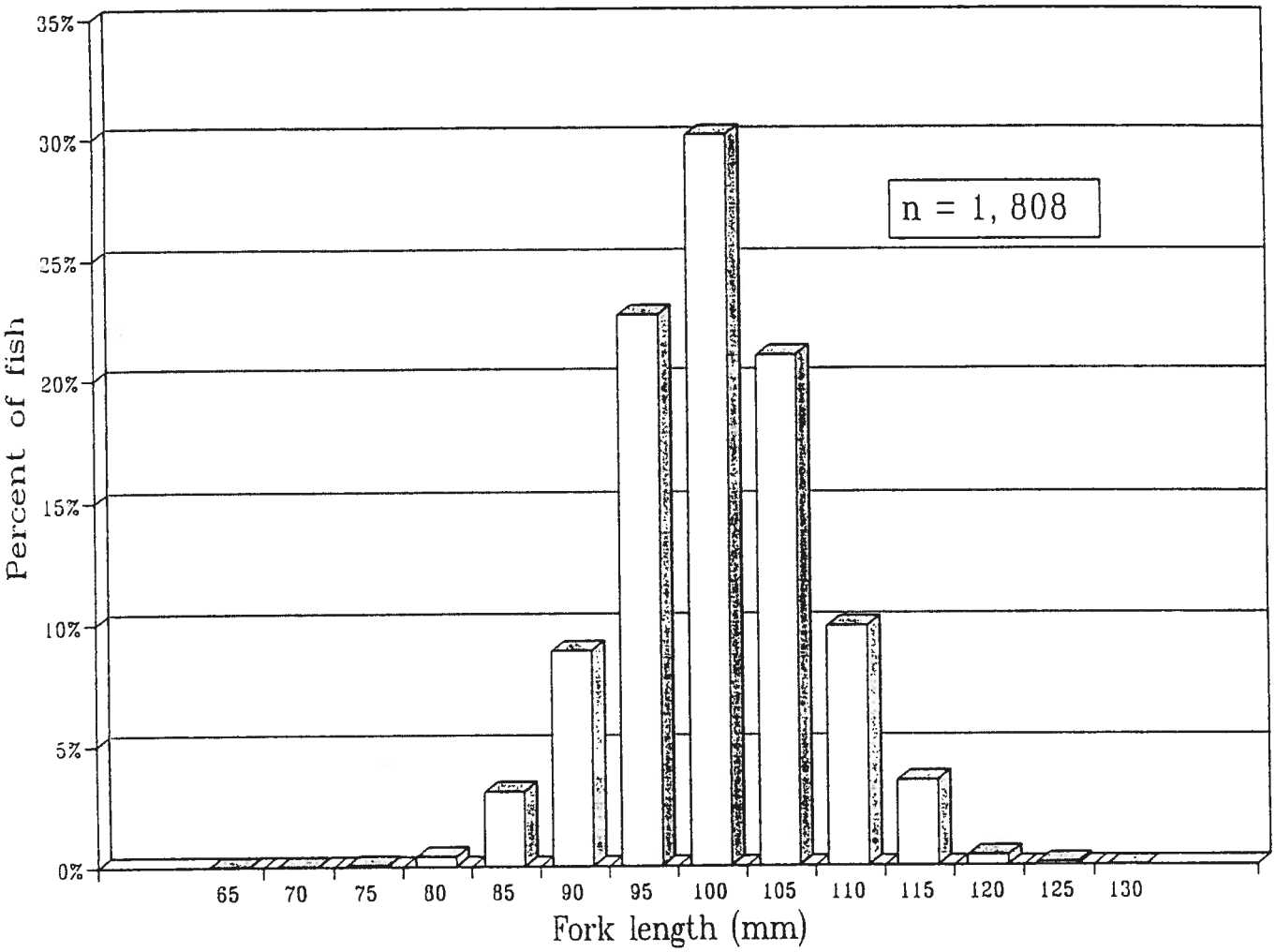

Figure 4. length frequency distribution of Chewuch basin spring chinook smolts, 1994.

10.1 g and 1.05 (n=1,281) respectively.

A total of 196 spring chinook young-of-the-year (YOY) were captured in the screw trap from March 31 to June 2 (Appendix Table 2). Their mean fork length was 40 mm and they ranged in length from 16 mm to 65 mm.

Confounding results exist between the 1993 late-summer parr population estimate of 5,838 fish and the 1994 smolt outmigration estimate of 12,494 fish. The most probable explanation is that the late-summer parr population was underestimated. The unusually wet summer in 1993 caused stream flows to be above normal the entire summer throughout the basin. In the Chewuch River the mean discharge throughout the snorkel survey period was 345 cfs, compared to a mean discharge of 74 cfs in 1994 (which was lower than normal). It is likely this negatively impacted our snorkeling efficiency. The snorkelers experienced much higher water velocities and water volume in 1993 than in 1994. The high water levels may have forced spring chinook parr to remain more associated with dense cover along the channel margin, and coupled with low light levels, probably impaired the snorkeler's ability to get an accurate count. The re-distribution of parr as stream discharge declined, as the snorkel survey was being conducted, could also be another confounding factor in 1993. An underlying assumption necessary to obtain an accurate spatial-abundance picture of parr distribution is that the fish remain geographically static throughout the survey period. This assumption was most likely violated to a higher degree in 1993 than in

1994.

6.1.1.2. steelhead/rainbow trout

An estimated[1] 2,347± 2,383 steelhead smolts/rainbow trout outmigrated from the Chewuch basin in 1994, of these 76% were classified as steelhead smolts (Appendix Table 4). The steelhead smolt estimate of 1,784 smolts is 2.1 times greater than in 1993 (828 fish). The median date of passage was April 30, while the 25% and 75% cumulative dates of passage were April 19 and May 14 (Figure 5).

The mean steelhead smolt fork length was 152 mm (n = 206) with a coefficient of variation equal to 21.3% (Figure 6). The mean weight and condition factor were 40.9 g and 0.92 (n = 134) respectively.

A total of 13 hatchery steelhead smolts were captured in the screw trap during the spring season. These most likely were carry-over fish from the 1993 steelhead release made in late spring for the purpose of providing recreational fishing (Miller, pers comm., 1995).

6.1.2. Summer Season

6.1.2.1. spring chinook

An estimated 2,223 spring chinook parr (age 0+) moved downstream past the screw

[1]Estimated passage is based upon the spring chinook entrainment-to-flow relation.

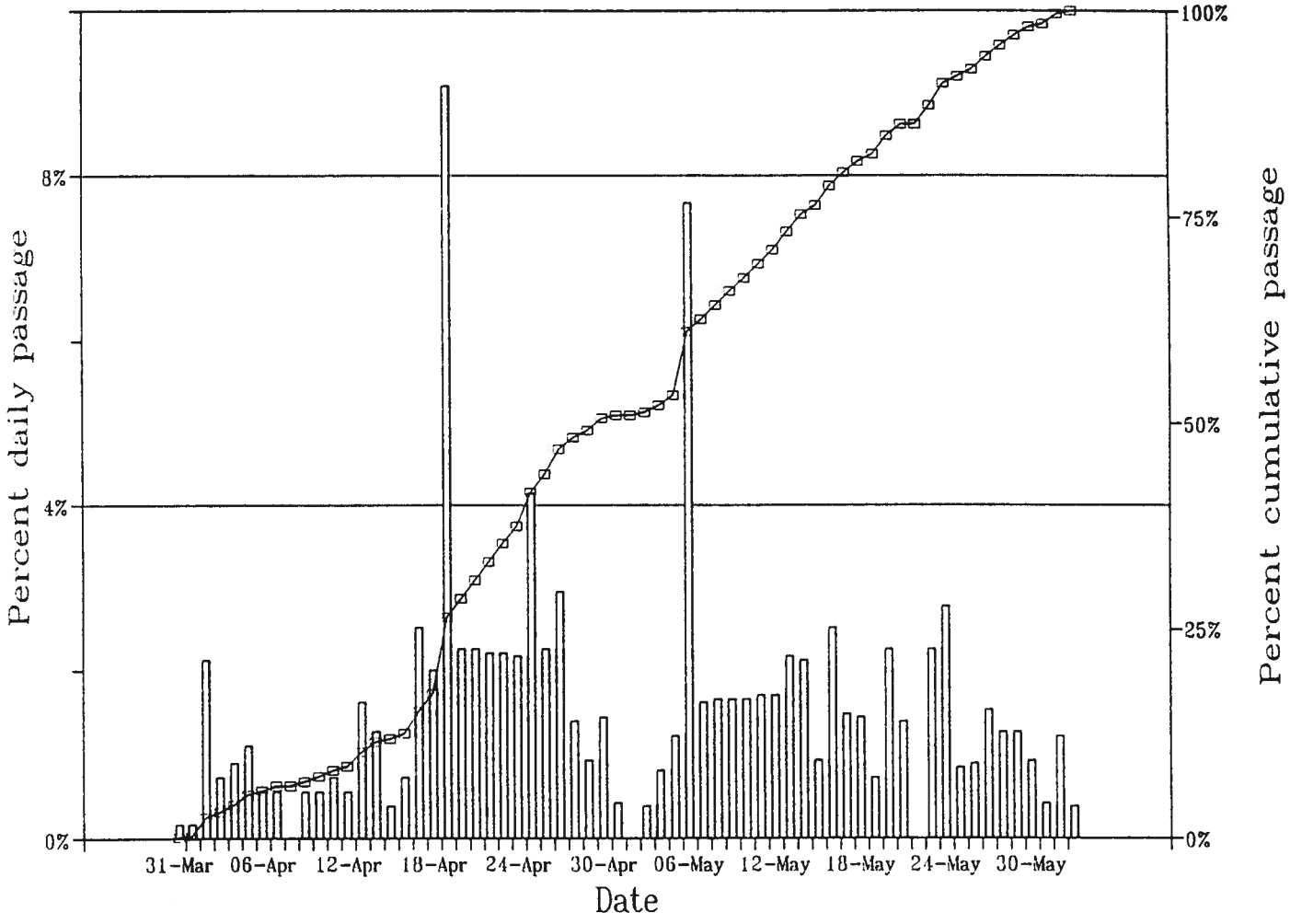

Figure 5. Estimated daily and cumulative steelhead/rainbow smolt and parr outmigration from the Chewuch basin, 1994.

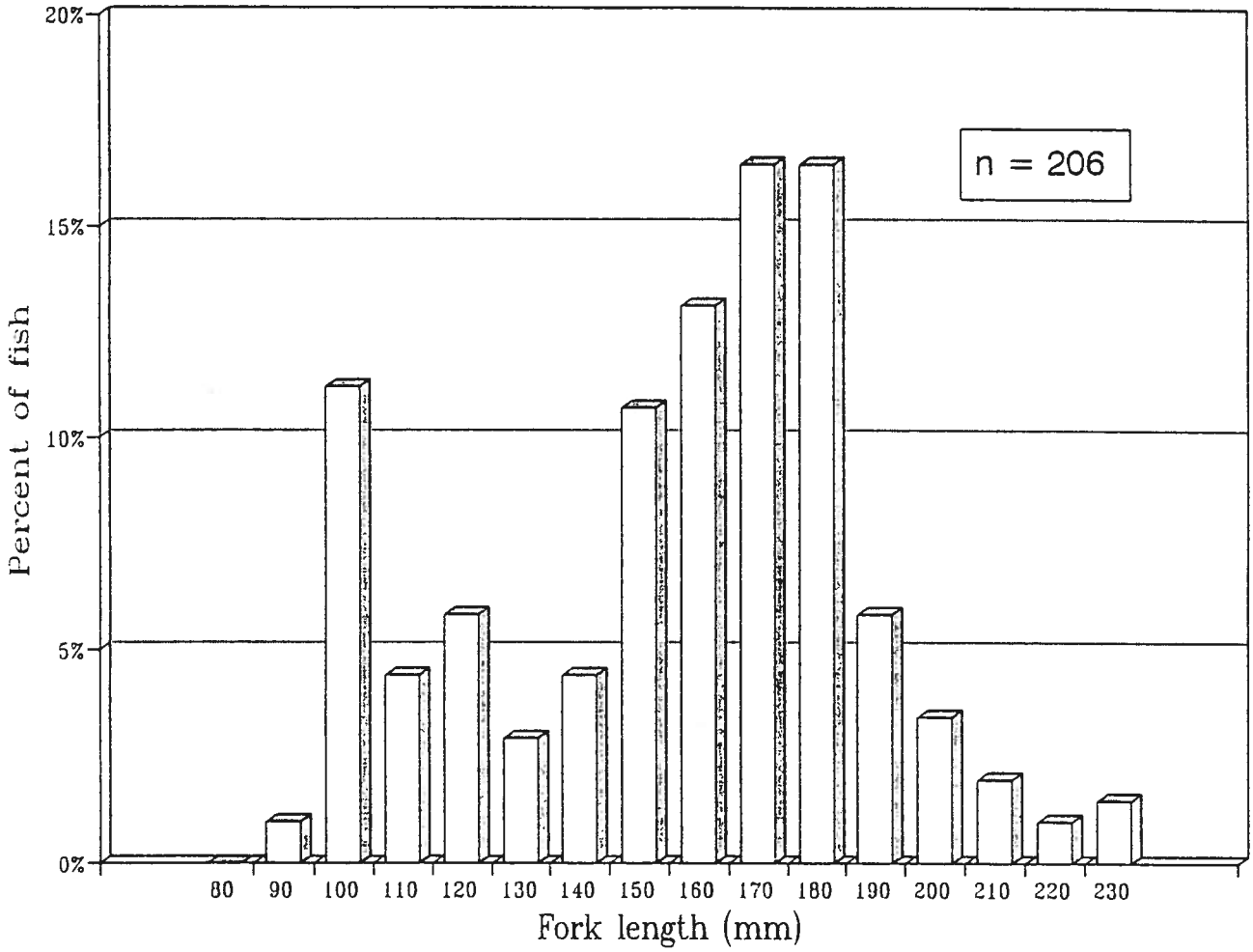

Figure 6. Length frequency distribution of Chewuch basin steelhead smolts, 1994.

trap from June 3 to July 20 (Figure 7 and Appendix Table 5). Low stream elevations and velocities precluded summer parr monitoring beyond this date. Their mean fork length was 59 mm (n = 359) with a coefficient of variation equal to 17.0% (Figure 8). Their mean weight and condition factor were 2.7 g and 1.24 (n = 359) respectively. The weekly mean fork lengths increased from 51 mm the first week of June to 70 mm by mid-July (Figure 9). Seven spring chinook parr were captured that were determined most likely to be age 1+ fish based on their size. These fish ranged in fork length from 87 mm to 120 mm and were captured between June 8 and July 17.

6.1.2.2. steelhead/rainbow trout

A total of 41 steelhead/rainbow trout, with a mean fork length of 116 mm (coefficient of variation = 30.3%) and a mean weight of 16.0 g were captured during the summer season.

A total of 224 hatchery steelhead parr were captured during the summer season, most (80.4%) of which entered the trap between June 30 through July 3. These fish originated from a release made by WDFW on June 27, 1994 between Twenty-Mile Creek and thirty-mile bridge (Miller, pers comm., 1995).

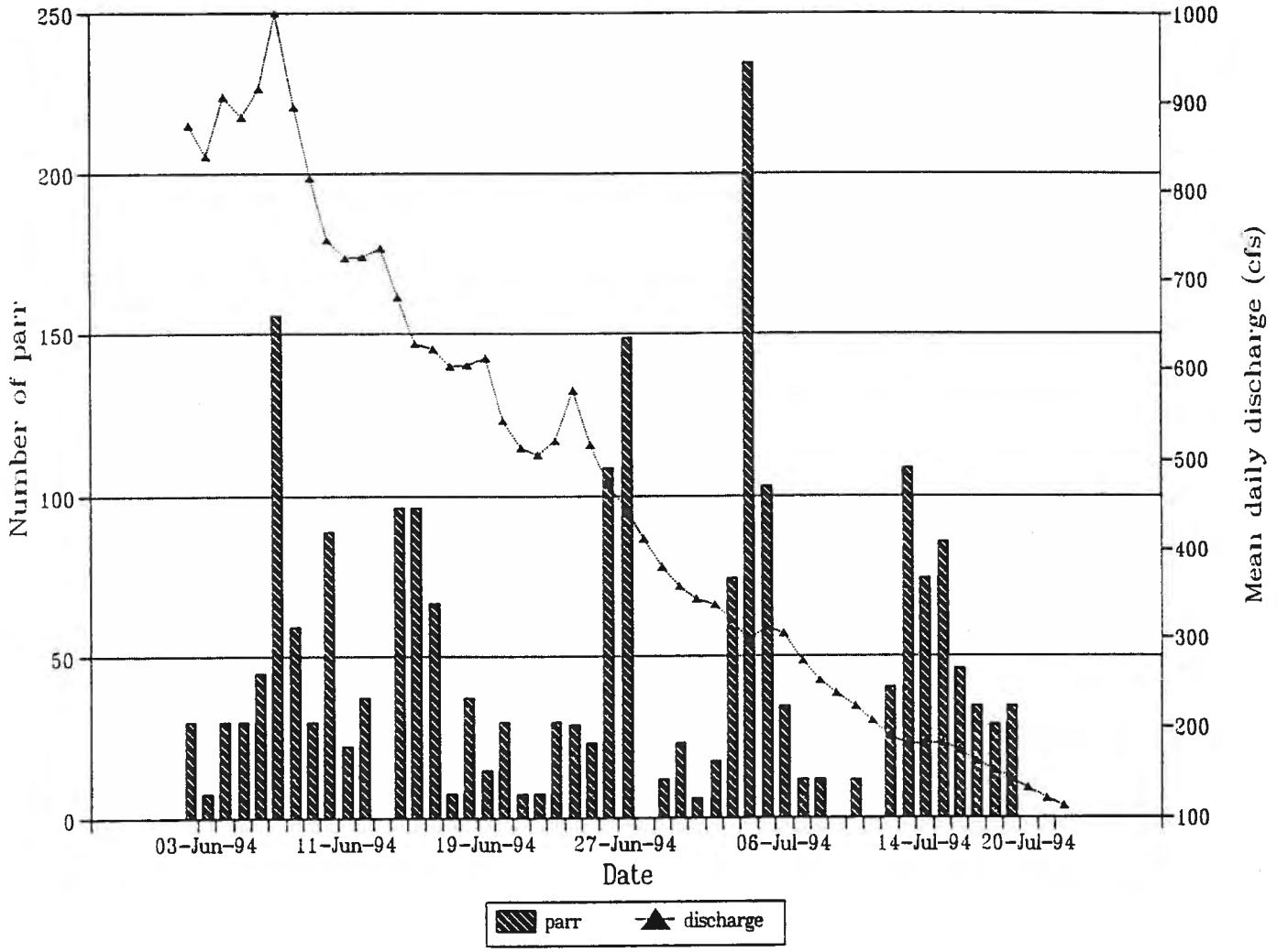

Figure 7. Estimated daily spring chinook parr outmigration and mean daily discharge for the Chewuch basin, 1994.

SUMMARY REPORT;
METHOW BASIN SPRING CHINOOK SALMON HATCHERY;
1993 BROOD YEAR

APPENDIX I

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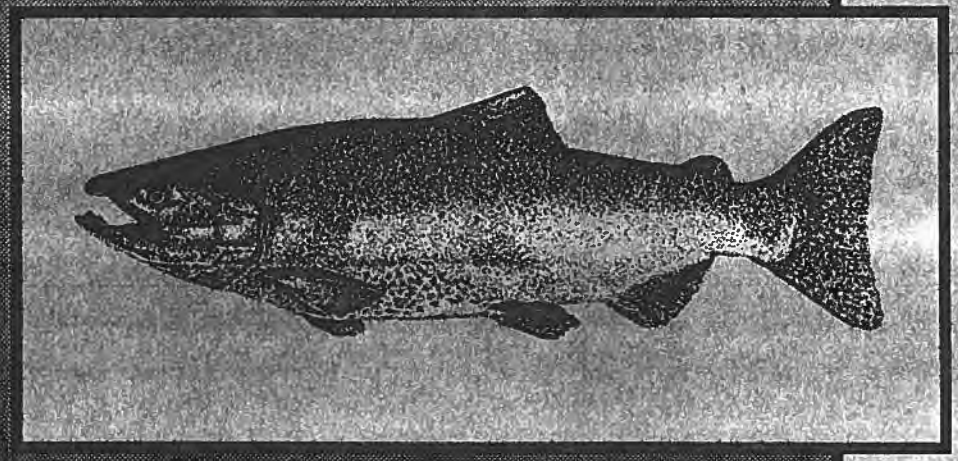
1993 BROOD YEAR ANNUAL REPORT August 1995

Summary Report for Methow Basin Spring Chinook Salmon Hatchery Program



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Report # H96-03

ABSTRACT

Mitigation for the effects of hydroelectric development on downstream migrant salmon and steelhead was not considered in the agreements which guided past fishery mitigation efforts for Wells Dam. Following the low flow years experienced in the 1970's, fisheries agencies and tribes petitioned the Federal Energy Regulatory Commission (FERC) to require Douglas County Public Utility District (PUD) to provide a migrant bypass system for juvenile salmonids. This would prevent the juveniles from passing through the turbines. The migrant bypass system was completed in 1988, however, some losses still occurred. To compensate for these losses, Douglas County PUD built a hatchery on the Methow River. The goal of the Methow Fish Hatchery Complex (MFHC) is to supplement adult production in a manner that minimizes ecological and genetic risks to the natural population. The specific objective for the hatchery production is 22,700 kg (50,000 lbs.) of spring chinook salmon yearlings released as 30 +/- g. This requires trapping sufficient broodstock to meet the release numbers. The MFHC must use fish cultural methods that maintain genetic integrity of Chewuch, Methow and Twisp River native stock(s) and release high quality smolts from the facility (Peck 1993).

In 1993, 2,422 adult (age 3+) spring chinook salmon and 20 jacks (Appendix A) returned to Wells Dam. The ten year average for spring chinook salmon over Wells Dam is 2,245 adults and 76 jacks, with half the run counted by 24 May. Spring chinook salmon are counted May 1 through 28 June. Columbia River water temperature increased steadily from 6.1 to 14.5 ^{0}C during the passage period.

The Winthrop National Fish Hatchery (WNFH) spring chinook salmon escapement in 1993 was 646 adults (383 females and 263 males) and zero jacks. Yakama Indian Nation field crew counted 83 redds in the Chewuch River, 342 in the Methow River and 192 in the Twisp River (Scribner et. al. 1993). These equaled 13.5%, 55.4%, and 31.1% of the basin total, respectively. The Methow Basin redd count percentage in the Chewuch River was substantially lower than its 5-year average of 30.1% (1988-1992).

The Methow FH trapped 185 adults in the Chewuch River trap. Seventy-five were passed upstream, and 110 were collected for hatchery broodstock. Prespawn survival was 94.5%. Adjusted egg take was 307,448, with a green egg to fry survival of 96.5%, a fry to smolt survival of 95.8%, and a green egg to smolt survival of 92.4%.

Seventy adults were trapped in the Twisp River trap. Twenty-eight were passed upstream, and 42 were collected for hatchery broodstock. The hatchery crew returned six males to the Twisp River 25 August. Prespawn survival was 92.9%. Adjusted egg take was 126,705, with a green egg to fry survival of 97.7%, a fry to smolt survival of 94.3%, and a green egg to smolt survival of 92.1%.

Ninety-nine Methow River adults were collected for Methow FH broodstock. Prespawn survival was 98%. Adjusted egg take was 228,654, with a green egg to fry survival of 96.3%, a fry to smolt survival of 95.9%, and a green egg to smolt survival of 92.3%.

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SECTION 1: INTRODUCTION

The Wells Coordinating Committee developed a comprehensive evaluation plan to monitor progress toward meeting the objectives of the hatchery programs required under the Wells Project Settlement Agreement. The Wells Coordinating Committee includes representatives of the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife, Columbia River Intertribal Fish Commission, the Yakama Indian Nation, the Colville Confederated Tribes and Douglas County PUD and its purchasers.

The following objectives provide a framework for long-term monitoring of the hatchery based compensation plan. The objectives are as follows:

1. **Determine if the Methow Fish Hatchery Complex can meet Phase I requirements of the Wells Project Settlement Agreement.**
2. **Determine that the Methow Phase I hatchery program conserve the genetic success, genetic integrity, and long-term fitness of the natural spawning populations of salmon in the Columbia River above Wells Dam.**
3. **Determine whether smolts released from the acclimation facilities disperse and migrate downstream without affecting the natural populations.**

The objectives may be modified yearly to better accomplish the goals of the evaluation plan. This report summarizes the 1993 evaluation of the MFHC. The contract period is 1 August 1994 to 31 July 1995 between Douglas County PUD and WDFW.

SECTION 2: STUDY SITE

The MFHC consists of a central hatchery, two satellite acclimation ponds, and two satellite adult trapping facilities (Figure 1). The complex, designed by Fish Pro Inc., has many unique features.

2.1. Methow Fish Hatchery

The Methow Fish Hatchery (FH) provides separate incubation and rearing of the three Methow Basin spring chinook salmon stocks. It is located in Winthrop, WA along the Methow River about 83 km from its confluence with the Columbia River. The hatchery has three canopy covered adult salmon holding ponds (2.4 m x 24.4 m x 1.2 m), twelve canopy covered juvenile raceways (2.4 m x 24.4 m x 1.2 m) and twenty-four indoor start tanks (0.91 m x 4.6 m x 0.76 m). There are three separate incubation rooms with 15 single stack (eight trays/stack) vertical incubators and a plastic lined acclimation pond (33.5 m x 18.3 m x 1.4 m) where fish can be released into the Methow River.

Four ground water wells provide 0.28 m^3/s of water. The water temperature

remains at 9.0°C all year. The Methow FH also uses 0.31 m^3/s of Methow River water, and an additional 0.2 m^3/s Methow River water is shared with the Winthrop National Fish Hatchery (WNFH) during the spring. The WNFH is 2.4 km downstream from the Methow FH.

The Methow FH program uses only naturally produced fish as broodstock. In the hatchery, the fish are reared at densities and under conditions that may better prepare them for their natural environment. For example, the maximum density index the fish are reared under at the Methow FH is 69 $kg/m^3/mm$. Other WDFW spring chinook facilities may rear fish in densities as high as 101 $kg/m^3/mm$. The production goal is 250,000 yearling spring chinook salmon for each of the Chewuch, Methow and Twisp Rivers. The actual number will depend on the availability of the broodstock.

2.2. Chewuch Acclimation Pond and Adult Trap

Chewuch pond is 9.6 km up the Chewuch River from its confluence with the Methow. Chewuch pond is a large (33.5 m x 21.3 m x 1.4 m) cobble lined pond. Chewuch River water is supplied by gravity from the Chewuch Canal Company's irrigation ditch. Maximum flow is 0.16 m^3/s. Chewuch broodstock are collected at Fulton Dam, river km 2.4. Fulton Dam is a barrier of boulders redirecting upstream migrants to a denil (steep-pass) ladder and into a v-trap.

2.3. Twisp Acclimation Pond and Adult Trap

Twisp acclimation pond is 8 km up the Twisp River from its confluence with the Methow. It is a large (33.5 m x 18.3 m x 1.4 m) cobble lined pond, with an adjacent adult trap. The pond is gravity fed with Twisp River water from the Valley Power irrigation canal. Maximum flow is 0.16 m^3/s. The adjacent trap includes a floating picket weir to redirect fish into a v-trap.

SECTION 3: BROODSTOCK MANAGEMENT

3.1. Chewuch Spring Chinook Salmon

3.1.1. Trapping

Trapping began 31 May 1993 and continued throughout the run, ending 28 August 1993 (Figure 2.). One hundred-eighty five adult Chewuch chinook[1] were trapped during the season. Of those, 46 males and 29 females were passed upstream. During the trapping season, more than fifty fish were observed jumping

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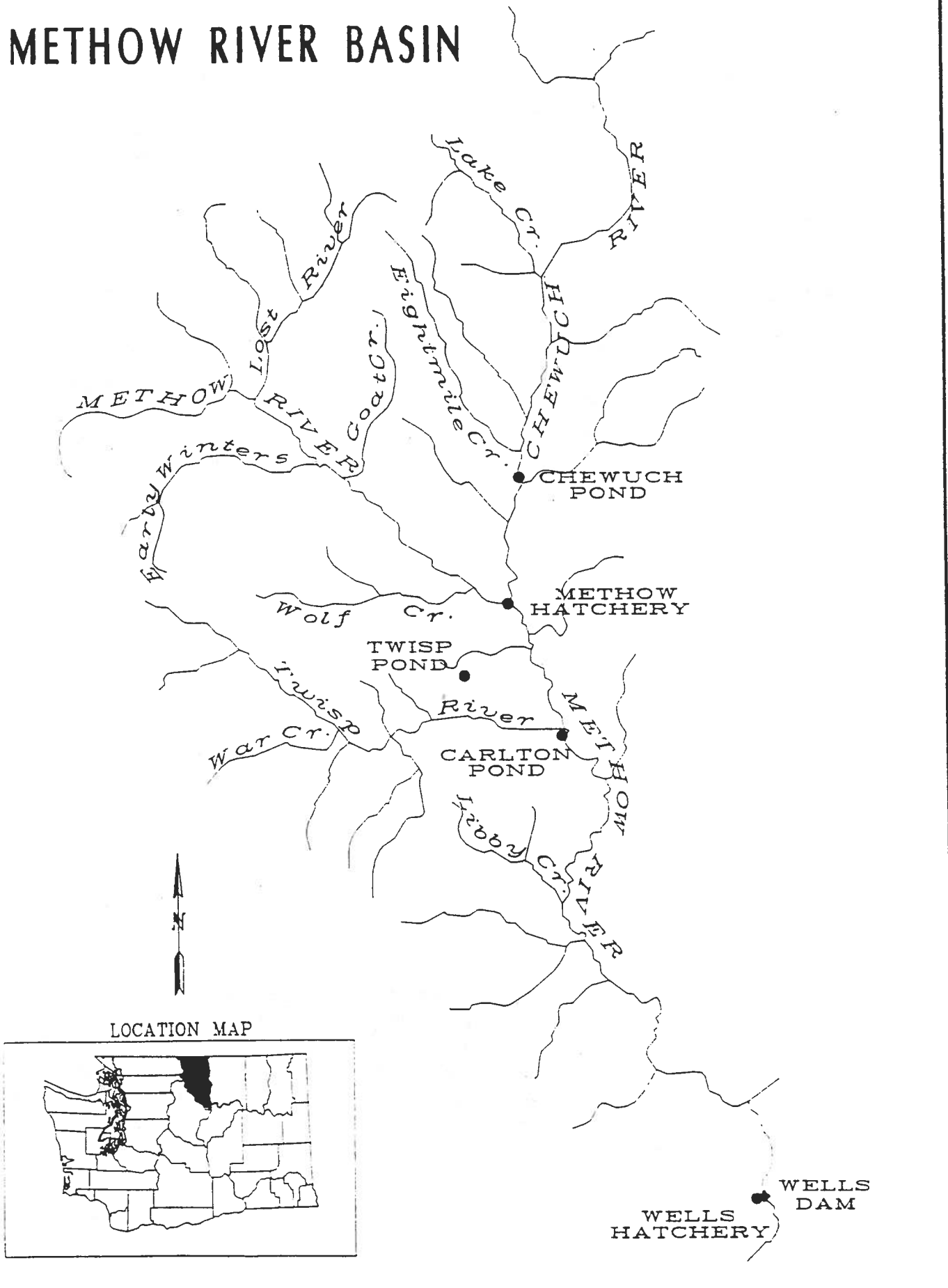
[1]Chinook implies spring chinook salmon.

Figure 1.


METHOW RIVER BASIN
Lake Cr.
METHOW RIVER
Lost River
Eightmile Cr.
CHEWUCH
METHOW
RIVER
Goat Cr.
Early Winters
CHEWUCH POND
METHOW HATCHERY
Wolf Cr.
TWISP POND
Twisp River
War Cr.
METHOW
CARLTON POND
Libby Cr.
RIVER
N
LOCATION MAP
WELLS DAM
WELLS HATCHERY

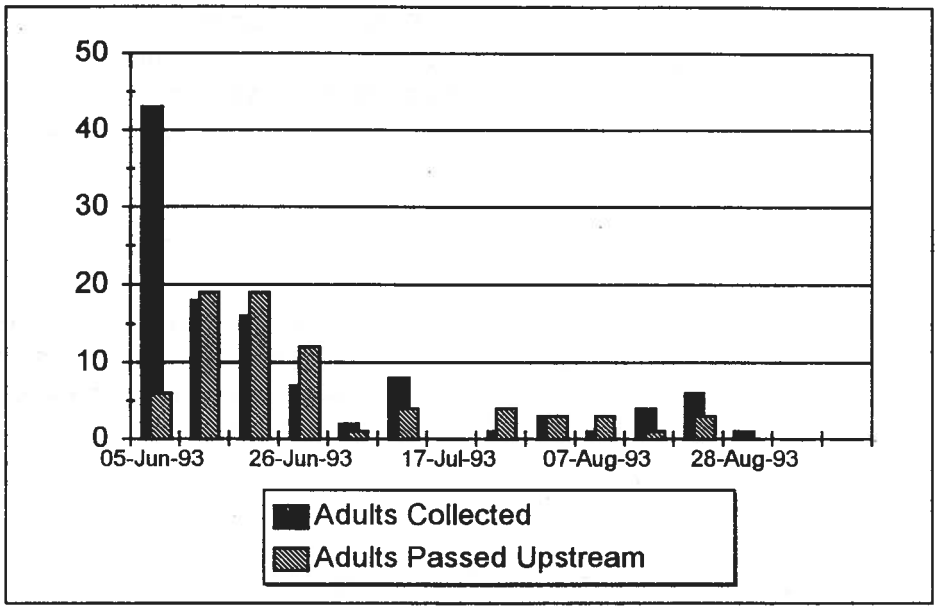
Fulton Dam. To ensure the hatchery broodstock approached a 1:1 sex ratio, more females needed to be retained than males. There were 83 redds observed in the Chewuch River (Scribner et. al. 1993). Using redd count expansion, the Chewuch river attained a natural escapement of approximately 208 adults (Scribner et. al. 1993). If the Chewuch River trap was not operational in 1993, then approximately 318 fish would have escaped to the spawning grounds. Since the trap collected 185 of a possible 318, the trap achieved a 58% efficiency. The Methow FH retained for broodstock about 35% of the Chewuch River run. Increased attraction flow through the denil ladder improved trapping efficiency from the 10% achieved in 1992. Daily discharge for the Chewuch River is included with the trapping summary in Appendix A.

Table 1. Summary of trapping and spawning of Chewuch River chinook, 1993

Week Ending	Number Male	Upstream Female	Adults Collected	Mortalities	Fish Males	Spawned Females	Eggtake
05-Jun-93	3	3	43	1			
12-Jun-93	12	7	18	0			
19-Jun-93	14	5	16	1			
26-Jun-93	8	4	7	0			
03-Jul-93	1	0	2	0			
10-Jul-93	2	2	8	0			
17-Jul-93	0	0	0	0			
24-Jul-93	2	2	1	0			
31-Jul-93	2	1	3	1			
07-Aug-93	1	2	1	1	10 live	10	40,000
14-Aug-93	1	0	4	0	19 live	19	76,000
21-Aug-93	0	3	6	2	12 live	20	80,000
28-Aug-93	0	0	1	1	4	4	16,000
04-Sep-93	0	0	0	0	4	4	16,000
11-Sep-93	0	0	0	0	1	1	4,000
Adjusted Totals	46	29	110	7	45	58	307,448

To reduce handling stress and abrasions, a rubber sock filled with water protected fish during transfer from the trap to the truck. Travel time from the trap to the MFH was about 15 minutes. Flow to the adult holding pond was 0.018 m^3/s. The maximum loading density set for the MFH is one fish/0.28 m^3 (Wells Settlement Agreement 1990). In 1993, the loading density was one fish/0.6 m^3. Average monthly well water temperature remained stable at 9.0°C during the holding period. A sprinkler system over the pond calmed the fish.

Figure 2. Weekly Chewuch River adult trapping summary, 1993



3.1.2. Prophylaxis

Formalin (one part formalin to 6,000 parts water) was used to control fungus during holding. Treatments began with the first arrival of fish and followed a three day per week schedule, unless the fish were handled. If the fish were handled, then they were treated for three consecutive days before returning to the routine schedule. A single erythromycin injection to protect the eggs from the vertical transmission of BKD was scheduled on 2 August 1993 for all the females in the holding pond. Eleven females that spawned that day did not receive an injection, because at least two weeks between injection and spawning is preferred. Females collected after 2 August received an injection at the trap unless ripe. We injected a total of 37 females with 10 mg/kg of erythromycin. Twenty-two females were not injected.

3.1.3. Spawning

Spawning began 2 August and finished 7 September. The hatchery crew live-spawned males with females the first three weeks. Fifty-eight females and 45 males contributed to the 1993 Chewuch progeny (Table 1). Eggs from a female spawned 2 August were destroyed because she had clinical signs of BKD and the eggs did not release from the skein. The original egg collection was adjusted once the fish were 100% coded wire tag marked. The adjusted egg collection was 307,448. Average fecundity was 5,301 eggs/female, with a range of 2,938-8,056 eggs/female. Six adult mortalities occurred prior to spawning. One male died after he had been used in

spawning. Adult prespawn survival was 94.5%.

Standard spawning procedure is as follows: 1) Females are spawned into individual buckets. 2) Primary male milt is added, mixed and allowed to incubate for 30 seconds. 3) Secondary male milt is added, mixed and allowed to incubate for 15 minutes. Unrinsed eggs are water hardened and disinfected in a solution of 1 part iodophor to 150 parts water for one hour.

3.1.4. Pathological results for Chewuch chinook hatchery spawners

Ovarian fluid and kidney/spleen tissue from the 58 spawned females and the one diseased female were tested for Infectious Hematopoietic Necrosis (IHN) and Infectious Pancreatic Necrosis (IPN) viruses. All samples were negative for these pathogens (Table 2). Additional kidney tissue was collected from the females and 43 males to test for bacterial kidney disease (BKD) using enzyme-linked immunosorbent assay (ELISA) (Table 2).

Table 2. Chewuch adult virology and BKD results

B. Low = optical density < 0.100
Low = optical density 0.100 - 0.199
Mod. = optical density 0.200 - 0.449
High = optical density > 0.45

	Sample Size		ELISA			Virology	
		B. low	Low	Mod.	High	IHNV	IPNV
Female	59	18	20	4	17	0	0
Male	43	13	16	5	9		

3.1.5. Adult sampling and analysis of Chewuch chinook spawners

We collected tissue and scales, and recorded sex and length of 104 adult Chewuch chinook for genetic stock identification (GSI) (Table 3). In addition, 40 adult natural spawners were sampled for scales, sex and length during the Chewuch River spawning ground surveys (Table 4). Scales provided the age and origin of each fish. The sex ratio for the MFH Chewuch broodstock matched the natural spawners. Both had 1.0 male to 1.15 females (Figures 3 and 5). Although the ages of all the hatchery spawners could not be determined, the age distribution appears to be consistent with the natural spawners (Figures 4 and 6).

Table 3. Age composition, sex ratio, and mean post-orbital hypural length (POH) of Chewuch chinook spawners at the Methow FH

SEX		Age 3	Age 4	Age 5	Unknown	TOTAL
Male	Number	0	22	16	7	45
	Length		60.3 cm	72.4 cm	60.7 cm	64.6 cm
Female	Number	0	7	40	12	59
	Length		59 cm	70.6 cm	70.1 cm	69.1 cm
Total	Number	0	29	56	19	104
	Length		59.9 cm	71.1 cm		67.2 cm

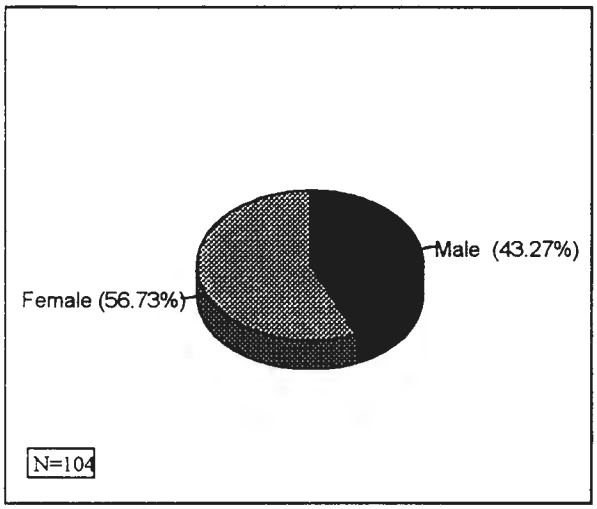


Figure 2. Sex ratio of Chewuch chinook spawners at the MFH

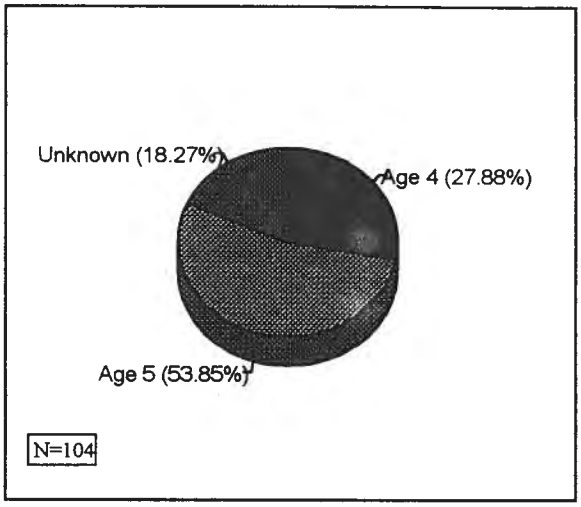


Figure 4. Age composition of Chewuch chinook spawners at the MFH

Table 4. Age composition, sex ratio and mean POH length of Chewuch chinook natural spawners

SEX		Age 3	Age 4	Age 5	Unknown	TOTAL
Male	Number	0	9	7	1	17
	Length		61.6 cm	71.9 cm	74.0 cm	66.5 cm
Female	Number	0	8	15	0	23
	Length		59 cm	71.3 cm		67.0 cm
Total	Number	0	17	22	1	40
	Length		60.4 cm	71.5 cm		66.8 cm

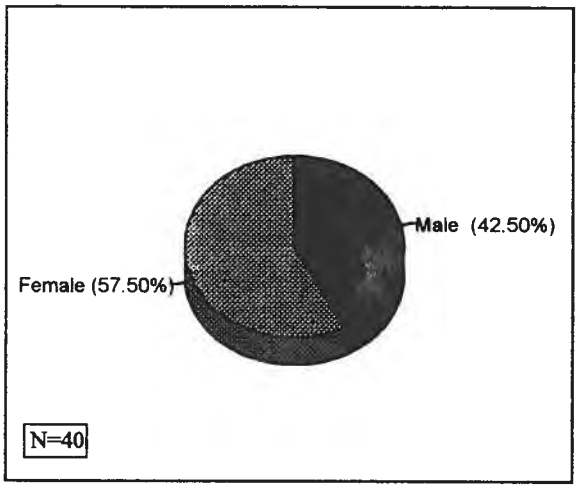


Figure 5. Sex ratio of Chewuch chinook natural spawners

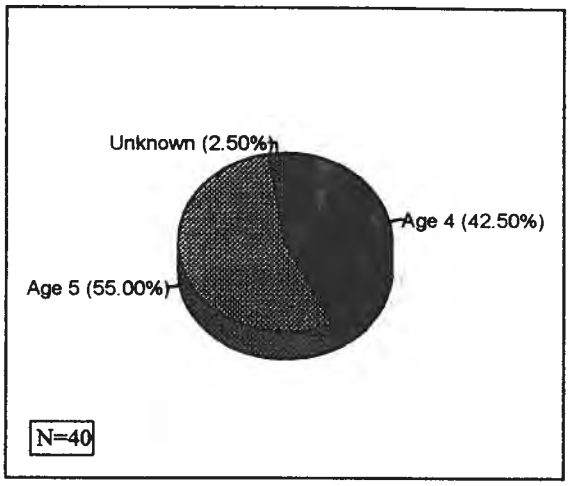


Figure 6. Age composition of Chewuch chinook natural spawners

3.2. Methow Spring Chinook Salmon

3.2.1. Adult collection

Methow river adult chinook voluntarily entered the MFH acclimation pond outfall channel. Ninety-nine (49 males and 50 females) were retained for broodstock (Table 5). Most of the collected broodstock was unmarked, although scale analyses showed 62 were of hatchery origin, presumably from WNFH. The first adult chinook arrived 19 June 1993. Collection continued until 24 August. Sixty-two percent of the broodstock arrived in August (Table 5). Based upon redd count expansion, about 855 adults returned to the Methow River for natural spawning (Scribner et. al. 1993). Daily discharge for the Methow River is included in Appendix A.

On 19 July, the retained adults were transferred to the adult holding pond. Later arriving fish were added at arrival. A rubber sock filled with water protected fish during transfer from the acclimation pond to the holding pond. Well water flowed to the pond at 0.018 m^3/s. In 1993, the loading density was one fish/0.70 m^3. Average monthly well water temperature remained stable at 9.0^{0}C during the holding period.

Table 5. Summary of collection and spawning of Methow chinook at the MFH.

Week Ending	Fish Collected	Mortalities	Fish Spawned Male	Female	Eggtake
19-Jun-93	1	0			
26-Jun-93	10	0			
03-Jul-93	11	1			
10-Jul-93	6	0			
17-Jul-93	1	0			
24-Jul-93	7	0			
31-Jul-93	2	0	live	4	16,000
07-Aug-93	4	0	live	5	20,000
14-Aug-93	17	0	live	8	32,000
21-Aug-93	24	1	live	15	60,000
28-Aug-93	16	0	39	16	64,000
04-Sep-93	0	0	8	1	4,000
Adjusted				1-spawn out	
Totals	99	2	47	50	228,654

3.2.2. Prophylaxis

Standard formalin treatments of 1:6,000 parts three times per week began with the first arrival. If the fish were handled, then adults received a treatment for three consecutive days before returning to the routine schedule. We injected all retained females with 10 mg/kg of erythromycin on 19 July. Females collected after this date received an injection at arrival unless they were ripe. Of the forty-nine females used in hatchery spawning, thirty-five were injected.

3.2.3. Spawning

Spawning began 26 July and finished 1 September. The hatchery crew live-spawned males during the first four weeks. Forty-nine females and 47 males comprised the Methow chinook broodstock (Table 5). Hatchery fish were spawned with the naturally produced fish. Two males died during the adult holding period. One female spawned in the pond. Prespawn survival was 98%. The adjusted egg take was 228,654, with an average fecundity of 4,666 eggs/female and a range of 2,074-5,915 eggs/female.

The spawning procedure is outlined in 3.1.3.

3.2.4. Pathological results of Methow chinook hatchery spawners

Fifty Methow females were tested for the presence of IHNV, IPNV, and BKD as outlined in 3.1.4. An additional 40 Methow males were tested for BKD (Table 6).

Table 6. Methow chinook adult virology and ELISA results

B. low = optical density < 0.100
Low = optical density 0.100 - 0.199
Mod. = optical density 0.200 - 0.449
High = optical density > 0.45

	Sample Size	ELISA				Virology	
		B. low	Low	Mod	High	IHNV	IPNV
Female	49	19	23	2	5	0	0
Male	40	27	10	0	3		

3.2.5. Adult sampling and analysis of Methow chinook spawners

We collected tissue and scales for GSI, and recorded lengths and sex from 93 Methow chinook (Table 7). This included 90 adult hatchery spawners and 3 adult Methow River natural spawners. During the Methow and Lost River spawning ground surveys, lengths, sex and scales were recorded for 136 natural spawners (Table 8). The age and origin of each fish was determined from their scale sample. The sex ratio of the hatchery spawners resembled that of the natural spawners (Figures 7 and 9). Although the ages of all the scale sampled fish was not determined, the hatchery spawners contained substantially more four year old fish than the natural spawners (Figures 8 and 10). Specifically, sixty-seven percent of the hatchery spawners were of hatchery origin. In comparison, only 37% of the natural spawners were of hatchery origin. This may partially explain the age discrepancy.

Table 7. Age composition, sex ratio and POH length of Methow chinook spawned at the MFH

SEX		Age 3	Age 4	Age 5	Unknown	TOTAL
Male	Number	0	23	8	9	40
	Length		60.5 cm	67.5 cm	63.3 cm	62.5 cm
Female	Number	0	18	26	6	50
	Length		60.6 cm	71.1 cm	64.2 cm	66.5 cm
Total	Number	0	41	34	15	90
	Length		60.5 cm	70.3 cm		64.7 cm

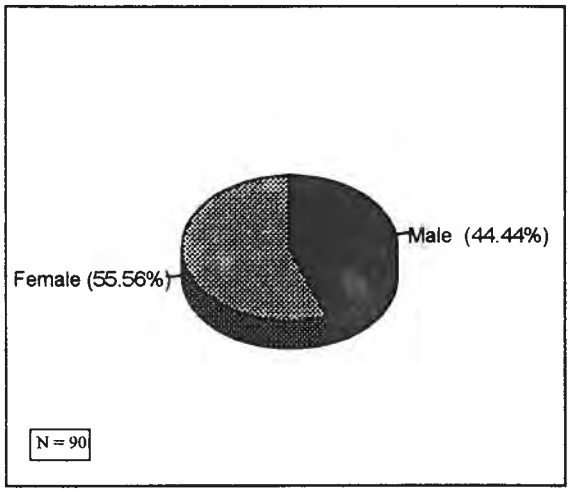


Figure 7. Sex ratio of Methow chinook hatchery spawners

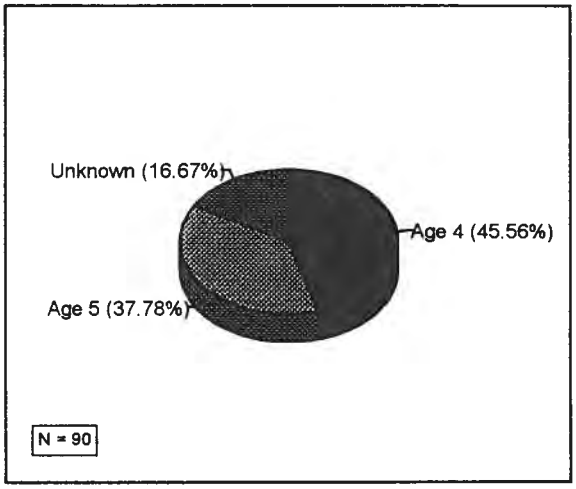


Figure 8. Age composition of Methow chinook hatchery spawners

Table 8. Age composition, sex ratio and mean POH length of Methow chinook natural spawners

SEX		Age 3	Age 4	Age 5	Unknown	TOTAL
Male	Number	0	11	39	4	54
	Length		60.6 cm	76.8 cm	72.8 cm	73.2 cm
Female	Number	0	22	59	4	85
	Length		61.3 cm	71.5 cm	71.3 cm	68.9 cm
Total	Number	0	33	98	8	139
	Length		61.1 cm	73.6 cm		70.6 cm

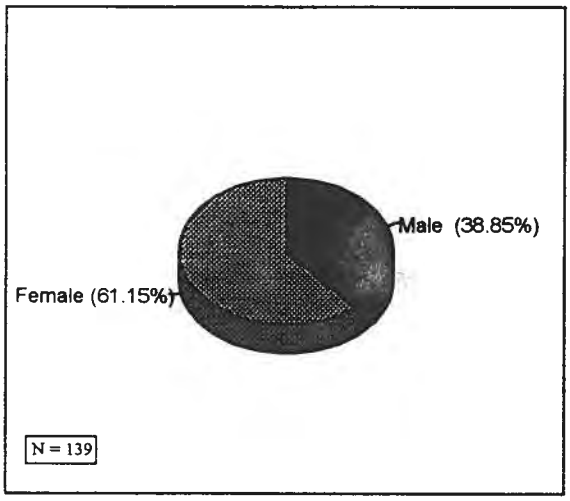


Figure 9. Sex ratio of Methow chinook natural spawners

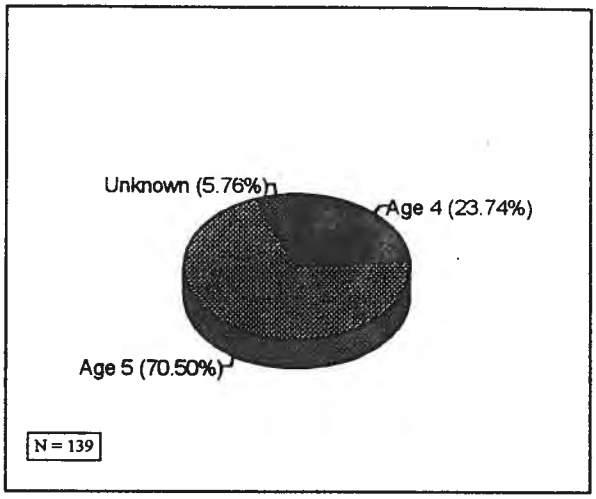


Figure 10. Age composition of Methow chinook natural spawners

3.3. Twisp Spring Chinook Salmon

3.3.1. Trapping

Trapping began 8 May and finished 28 August (Figure 11). High water rendered the trap inoperable 15 May through 22 May. The Twisp River trap collected 70 adult chinook during the adult migration. The hatchery crew passed 11 males and 17 females upstream, and collected 16 males and 26 females for the MFH broodstock (Table 9). Based upon redd count expansion, about 480 adults returned to the Twisp River spawning grounds (Scribner et. al. 1993). This means the Twisp River trap achieved a 13.4% efficiency.

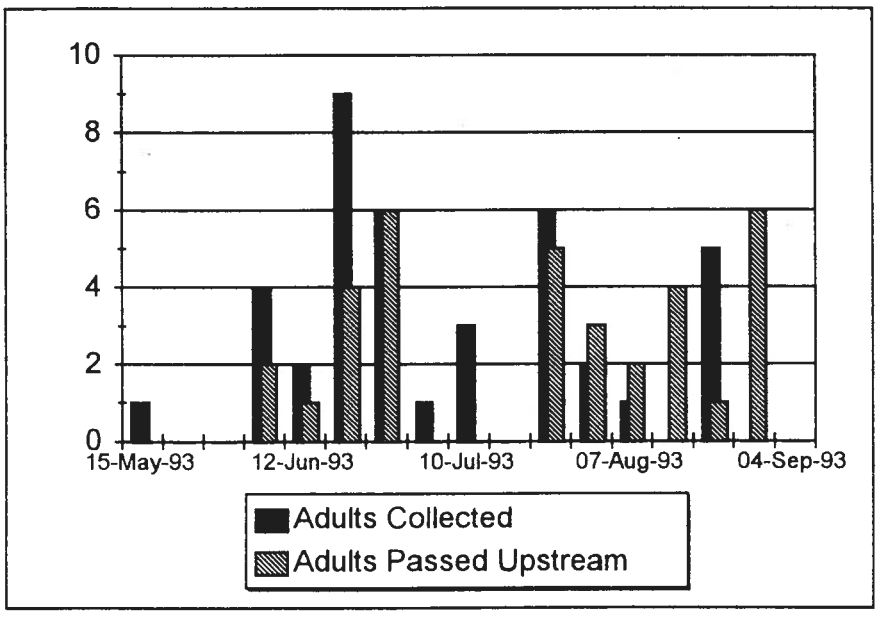
Collected fish were moved from the trap to a 300 gallon tank truck in a rubber sock. Transport to the MFH was about 20 minutes. At the hatchery, the fish were released into the Twisp chinook adult holding pond. Flow to the pond was set at 0.018 m^3/s. The maximum loading density was one fish/1.6 m^3. Well water temperature remained stable at 9.0^{0}C throughout the holding period.

Table 9. Summary of trapping and spawning of Twisp chinook, 1993

Week Ending	Number Upstream Male	Female	Adults Collected	Mortalities	Fish Spawned Males	Females	Eggtake
15-May-93	0	0	1	0			
22-May-93	0	0	0	0			
29-May-93	0	0	0	0			
05-Jun-93	1	1	4	1			
12-Jun-93	0	1	2	0			
19-Jun-93	3	1	9	0			
26-Jun-93	3	3	6	0			
03-Jul-93	0	0	1	0			
10-Jul-93	0	0	3	0			
17-Jul-93	0	0	0	0			
24-Jul-93	2	3	6	0			
31-Jul-93	2	1	2	0			
07-Aug-93	0	2	1	2*	live	8	32,000
14-Aug-93	0	4	0	0	live	4	16,000
21-Aug-93	0	1	5	0	live	6	24,000
28-Aug-93	6**	0	0	0	10	5	20,000
04-Sep-93	0	0	0	0	0	0	
Adjusted Totals	17	17	40	3	10	23	126,705

**These fish were males included in the hatchery broodstock. When spawning was complete at the MFH, they were returned to the Twisp River.

Figure 11. Weekly Twisp River adult trapping summary, 1993



3.3.2. Prophylaxis

To control fungus, collected adults were treated with formalin (1 part formalin to 6,000 parts water) three times per week. Treatments began when the first fish were collected. If the fish were handled, they were treated for three consecutive days before returning to the routine schedule. On 2 August, the hatchery crew injected all collected females with 10 mg/kg erythromycin. Eight females that spawned that day were not injected. Females collected after this date were injected at the trap unless ripe. Fourteen females received an injection, nine did not.

3.3.3. Spawning

Spawning began 2 August and finished 25 August. The hatchery crew live-spawned males until 25 August. Twenty-three females and 16 males comprised the hatchery broodstock (Table 9). Two females died prior to spawning. One of these was found dead in the adult trap. Prespawn survival was 93%. At completion of hatchery spawning, six males in good condition were returned to the Twisp River on 25 August. Two males were released at each of three separate locations from War Creek Campground to Mystery Bridge. Adjusted egg take was 126,705. Average fecundity was 5,509 egg/female with a range of 3,761-6,522 eggs/female.

The spawning procedure is outlined in 3.1.3.

3.3.4. Pathological results for the Twisp chinook hatchery spawners

Twenty-three Twisp females were tested for the presence of IHNV, IPNV, and BKD as outlined in 3.1.4. Nine Twisp males were BKD tested (Table 10).

Table 10. Twisp chinook adult virology and ELISA results

B. low = optical density < 0.100
Low = optical density 0.100 - 0.199
Mod. = optical density 0.200 - 0.449
High = optical density > 0.45

	Sample Size	ELISA				Virology	
		B. low	Low	Mod.	High	IHNV	IPNV
Female	23	1	12	6	4	0	0
Male	9	2	6	0	1		

3.3.5. Adult sampling and analysis of Twisp chinook spawners

We tissue and scale sampled, and recorded lengths and sex for 32 hatchery and 15 natural spawners (Tables 11 and 12). Length, sex and scale samples were also collected from an additional 44 natural spawners during the Twisp River spawning ground surveys (Table 12). Age and origin of fish was determined from their scale samples. The hatchery broodstock's sex ratio and age composition was similar to the natural spawners (Figures 12-15).

Table 11. Age composition, sex ratio and mean POH length of the Twisp chinook spawners at the MFH

SEX		Age 3	Age 4	Age 5	Unknown	TOTAL
Male	Number	1	6	0	2	9
	Length	35.0 cm	56.7 cm		66.5 cm	56.4 cm
Female	Number		2	19	2	23
	Length		66.5 cm	72.7 cm	72.5 cm	72.1 cm
Total	Number	1	8	19	4	32
	Length	35.0 cm	59.1 cm	72.7 cm		67.1 cm

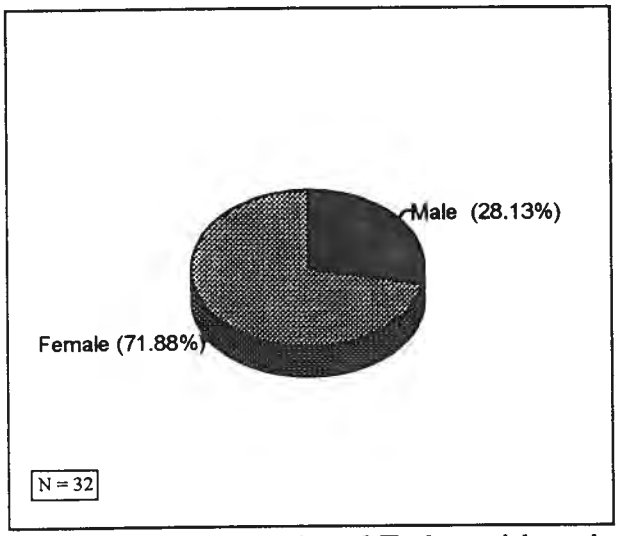


Figure 12. Sex ratio of Twisp chinook spawners at the MFH

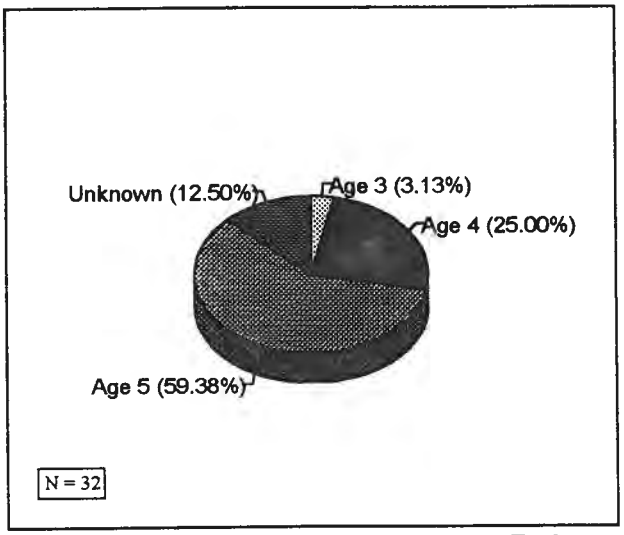


Figure 13. Age composition of Twisp chinook spawners at the MFH

Table 12. Age composition, sex ratio and mean POH length of Twisp chinook natural spawners

SEX		Age 3	Age 4	Age 5	Unknown	TOTAL
Male	Number	0	5	12	1	18
	Length		66.2 cm	77.7 cm	74.0 cm	74.3 cm
Female	Number	0	9	28	3	40
	Length		60.7 cm	72.5 cm	72.0 cm	69.8 cm
Total	Number	0	14	40	4	58
	Length		62.6 cm	74.0 cm		71.2 cm

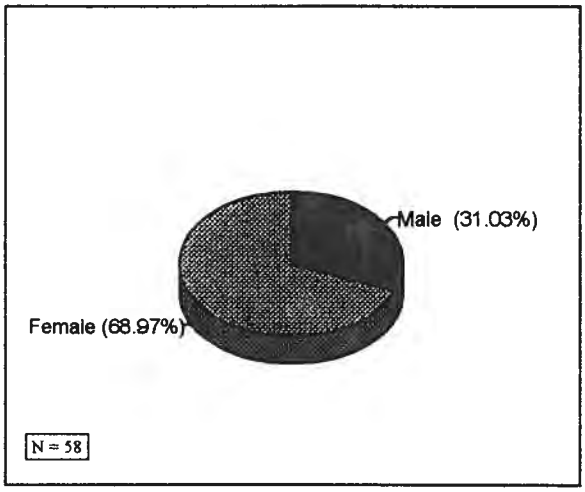


Figure 14. Sex ratio of Twisp chinook natural spawners

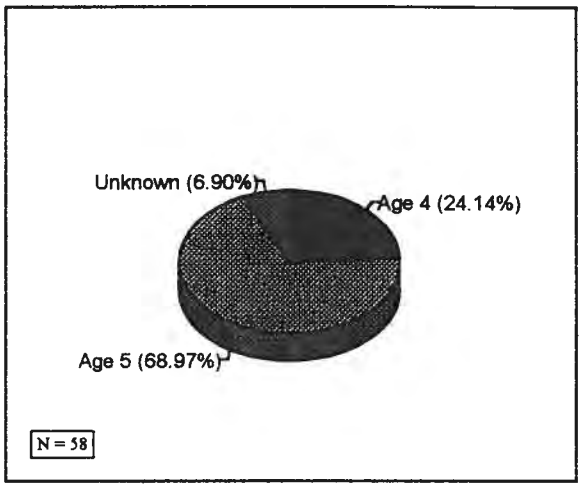


Figure 15. Age composition of Twisp chinook natural spawners

SECTION 4: JUVENILE REARING

4.1. 1993 Chewuch spring chinook salmon

4.1.1. Incubation

After spawning and disinfection, the Chewuch chinook eggs were incubated in 9.5 liter isobuckets. Each bucket contained a foam float to reduce water disturbance on developing eggs. Well water flowed at 0.02 cm^3/s, and included a formalin drip 3 times per week at a concentration of 1 part formalin to 600 parts water.

When eggs accumulated about 500 to 750 temperature units (TU)[2] the hatchery crew moved them to vertical stack incubators (heath stacks) and distributed them one family (female x male) per tray. This movement turned the unfertilized or dead eggs white for easy enumeration and removal. A tabletop scale (accuracy to 0.02 grams) was used to weigh the live eggs and determine female fecundity. Approximately seven days before hatching, plastic substrate was placed in each tray to mimic natural substrate and reduce movement. The 1993 BY Chewuch chinook had a green egg to fry survival of 96.5%.

4.1.2. Start tank and early rearing

Chewuch fry were moved from the incubators to indoor start tanks beginning 28 November. Because we had more fry in 1993 than in 1992, and no more facilities available, the start tanks contained combinations of families. Weight (egg/kg or fry/kg), date of egg take, ELISA value and erythromycin injection history of female parent determined combinations (Appendix B). Eight start tanks contained progeny of 16 high ELISA (BKD value) females. When density index[3] within a start tank approached 51 kg/m^3/mm, the population was split into juvenile raceways. The first splitting of a population occurred 11 December when low ELISA progeny were 0.4 grams. Splits and pond transfers occurred regularly there after to keep densities below 51 kg/m^3/mm and make start tank room available. Transfer of fry from incubators to start tanks or raceways finished 10 January.

All fish were coded wire tagged (CWT) and adipose fin clipped in late June. 293,698 1993 BY Chewuch chinook received three unique tag codes. The tag code 63-41/27 went to 181,990 low ELISA progeny; tag code 63-53/50 went to 24,283 low ELISA progeny intended for a fall outplant into the Chewuch River; and tag code 63-51/61 went to 87,425 high ELISA progeny. At CWT marking the fish weighed 6-8 grams each. The families appeared uniform in size and handled well during tagging. Including initial ponding, population splits, transfers, and CWT marking, families were handled between two and five times.

4.1.3. Fish health monitoring of juveniles

Eighteen fish health exams occurred during the juvenile rearing period (Table 13). The fish grew well and maintained clean gills and fins, although several episodes of BKD occurred during the hatchery rearing cycle. Initial transmission of the disease probably occurred vertically from parent to progeny.

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[2]Temperature unit = one degree above 32^{0}F in a 24 hour period.

[3]Density index is a measurement of weight of total fish, divided by size of rearing structure, divided by length of individual fish.

The fish health specialist diagnosed BKD first in the 93 BY Chewuch on 11 January 1994. Start tank 16 contained progeny of two high ELISA females. Only one female was injected with erythromycin. The fish health specialist recommended an Aquamycin treatment for this group on 28 January, when loss of fish approached 0.066%/day. During hatchery rearing, this group received six separate Aquamycin treatments. Mortalities stabilized and remained low in the winter while they reared in river water. The other Chewuch juvenile raceways contained progeny of high ELISA erythromycin-injected females, or progeny of low ELISA females. Only some of the low ELISA females received an injection (see 3.1.2.). Six of the nine raceway populations received at least one Aquamycin treatment. Excluding the group first diagnosed, the Chewuch stock did not show signs of BKD until August 1994.

Table 13. 1993 Chewuch chinook juvenile fish health monitoring

RW = raceway
T = start tank
BKD = bacterial kidney disease

Date	Life Stage	Weight (g)	Mean Daily % Loss	Water Temp °C	Gills	Body	Pathogen
07-Jan-94	fry	0.6	0.01	9			
11-Jan-94	fry	0.8	0.02	9			BKD in T16
28-Jan-94	juvenile	1.1	0.066	9			
18-Feb-94	juvenile	1.3	0.01	9	Good		
11-Mar-94	juvenile	2.0	0.01	9	Excellent	Excellent	
01-Apr-94	juvenile	2.6	0.06	9	Good	Good	BKD present
29-Apr-94	juvenile	3.5	0.001	9			BKD in RW 1B
23-May-94	juvenile	5.0	0.08	9			BKD in RW 1B
09-Jun-94	juvenile	6.0	0.015	9	Good	Good	BKD in RW 1B
02-Aug-94	juvenile	8.2	0.02	9			BKD
01-Sep-94	juvenile	10.1	0.03	9	Good	Good	BKD
29-Sep-94	juvenile	11.3	0.007	9			
28-Oct-94	juvenile	13.3	0.08	9			BKD epizootic in RW 1B.
21-Nov-94	juvenile	15.6	0.01	6.7 - 4.4	Good	Good	All loss = BKD
16-Dec-94	juvenile	17.4	0.02	9 - 4.4			Loss from BKD
12-Jan-95	juvenile	18.9	0.03	7.2 - 5.6			BKD present in RW 1B, 2, 4 and 12
09-Mar-95	juvenile	24.8	0.01	8.2 - 5.6			
05-Apr-95	smolt	27.7					

4.1.4. Raceway rearing and acclimation

Fish were incubated and reared for 15 months on well water. In November 1994, mixing of surface and well water began. Mixing continued through January 1995. The water source changed to 100% surface water in February 1995, except during Aquamycin treatments or river intake freezes, when well water was used. The well water temperature remained constant at 9^0C, well and surface water mixture ranged from 7.2 - 4.4^{0}C, and surface water ranged from 8.2 - 0^0C.

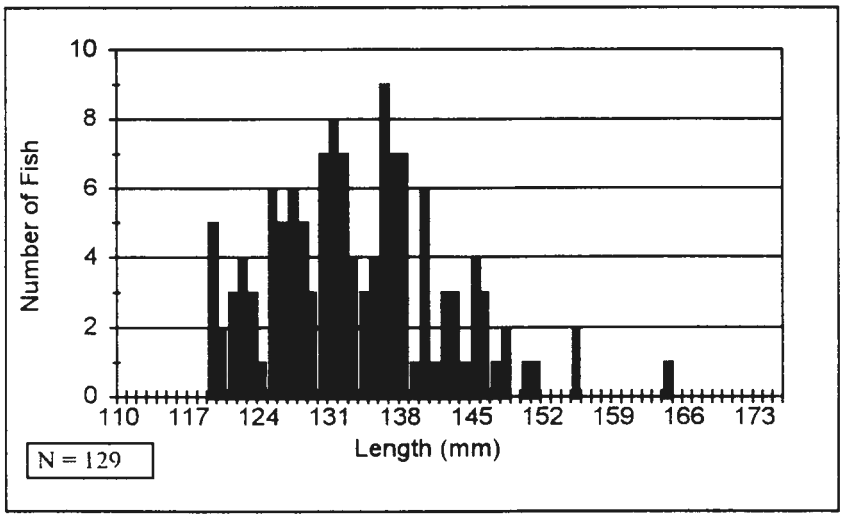
The increased population for the 93 BY caused the density index to reach 69 (Black internal memo. 1994), but densities did not exceed the operational guideline of 12 kg/m^3 (Wells Settlement Agreement 1990).

We transferred 236,695 fish (6,701 kg) to the Chewuch River acclimation pond between 13-17 and 23-24 March. In April, we transferred 47,693 more fish (1,444 kg). This latter group remained at the MFH until mid-April because of BKD outbreaks and a high acclimation pond density. The smolts transferred in March received 24 to 37 days of acclimation time. The April transfer group received 0 to 12 days of acclimation time. This latter group did not have unique CWT data sets to evaluate possible straying at return.

4.1.5. Smolt release

A volitional release began on 17 April 1995 with virtually all the smolts migrating within the first 48 hours. Chewuch River discharge was 11 m^3/s (USGS-Chewuch River gage at Winthrop). In April 1995, 284,161 Chewuch chinook smolts (7,871 kg) migrated from the Chewuch River acclimation pond. Chewuch chinook had a fry to smolt survival of 95.8%. The fish reared 508 days at the MFHC. At release fish weighed an average of 27.7 g each. They measured an average of 134.5 mm, with a coefficient of variation (CV) of 11.7% (Figure 14) and a condition factor (K) of 1.1 (n = 129 fish)

Figure 16. 1993 Chewuch chinook juvenile length frequency at release



4.1.6. Juvenile sampling

We collected 100 GSI and DNA tissue samples from the juveniles of each stock (Table 14). This included eyes, heart, liver, and two skeletal muscle samples. We sampled gill tissue every two weeks for six weeks for ATPase analysis (Table 14). At release, twenty fish were sampled for organosomatic indexing (OSI) (Table 15). OSI assesses the general health of the population through examination of the external and internal organs (Goede and Barton 1990). Whole kidney samples were taken from 60 juvenile fish to test for BKD using enzyme linked immunosorbent assay (ELISA) (results unavailable at publishing). Fifty fish were sampled for monitoring of meristic counts (Table 16). This information will be compared with past and future brood years.

Table 14. 1993 Chewuch chinook juvenile sampling schedule

Date	Length/Weight	ATPase	OSI	Mer.	ELISA	GSI
3/06/95	40/0			30		95DB1-40
3/13/95	20/0	68201-68220			20	95DB41-60
3/27/95	20/0	68221-68240		20	20	95DB61-80
4/17/95	20/20	68241-68260	20		20	95DB81-100

Table 15. 1993 Chewuch chinook juvenile chinook organosomatic indexes results

Value in parenthesis is the standard deviation.

Date	Fork Length (mm)	Weight (g)	Condition Factor	Mean Fat	Male	Female
4/17/95	130.85 (12.8)	28.4 (8.8)	1.27 (0.06)	2.9	65%	35%

Chewuch chinook had a normality index of 91.5. A value above 90 is considered healthy (Goede 1993).

Table 16. 1993 Chewuch chinook juvenile meristic count results

	Upper gill rakers	Lower gill rakers	Pectoral rays	Pelvic rays
Mean total count	6.37	10.42	14.47	9.99
Mean magnitude of asymmetry	0.17	0.49	0.09	0.10

ATPase and ELISA values for the 1993 brood year will be included in a future report because processing was incomplete at time of publication. See Appendix F for ELISA and ATPase information for the 1992 BY Chewuch chinook released in April 1994.

4.2. 1993 Methow spring chinook salmon

4.2.1. Incubation

See 4.1.1. for procedure. The 1993 BY Methow chinook had a green egg to fry survival of 96.3%.

4.2.2. Start tank and early rearing

Fry were moved from incubators to start tanks between 27 November and 6 January. The hatchery crew combined families into start tanks and raceways based upon weight (egg/kg or fry/kg), date of egg take, ELISA value and injection history of female parent (Appendix B). Four of the ten start tanks contained families from five high ELISA females. Three of these five received an erythromycin injection before spawning. By 26 March, all the Methow fry were in two raceways.

All fish were coded wire tagged and adipose fin clipped between 26 March and 8 April. The 1993 BY Methow chinook received two unique tag codes. The tag code 63-54/10 went to 21,800 high ELISA progeny, and tag code 63-55/51 went to 195,866 low ELISA progeny. An overage of 6,412 fish was counted. At tagging the fish weighed 2.3 g each. Rearing space was limited. Instead of handling the fish multiple times, it was better to tag them small and put them into the Methow River acclimation pond. The families appeared uniform in size and handled well. The fish were handled between two and three times before reaching 4.5 grams.

4.2.3. Fish health monitoring of juveniles

Twelve fish health examinations occurred during the juvenile rearing period

(Table 17). Fry started well on feed and remained in healthy condition during the early rearing period. In June 1994, the fish appeared to smolt. They had minor descaling and some frayed fins.

We collected mortalities, from the pond for seven consecutive days once a month, and extracted the CWT to determine if more high ELISA progeny died than the low ELISA progeny. The high group represented 10% of the pond population. In the months of May and June, the high group accounted for 45% (five of eleven) and 60% (eleven of eighteen) of the pond mortalities, respectively. Weekly mortalities averaged less than 20 fish. In July the high group accounted for only 26% (22 of 85). Weekly mortalities in July increased to about 50 fish per week. The fish health specialist diagnosed BKD in the population August 1994. CWT extraction from a portion of one days loss in August showed that the mortalities were predominately from the low group (14 of 15 or 93%). An Aquamycin treatment began in early September, and by the end of the month, mortalities had decreased.

Mortalities associated with BKD increased again in February 1995, but the water temperatures were too cold to treat. Before release, we extracted CWT from a sample of the pond mortalities on 4 and 12 April 1995. The low ELISA group accounted for 95% (18 of 19) and 100% (20 of 20) of the recovered tags, respectively. At release, the high ELISA progeny still represented 10% of the population.

Table 17. 1993 Methow chinook juvenile fish health monitoring

Date	Life Stage	Weight (g)	Mean Daily % Loss	Water Temp °C	Gills	Body	Pathogen
07-Jan-94	fry	0.6	0.017	9			
18-Feb-94	juvenile	1.3	0	9	Good		
11-Mar-94	juvenile	2.0	0.01	9	Excellent	Excellent	
29-Apr-94	juvenile	3.5	0.001	9			
09-Jun-94	juvenile	6.6	0	9	Good	Fins slightly frayed	
02-Aug-94	juvenile	9.1	0.007	14.4 - 9			Suspect BKD
29-Sep-94	juvenile	13.3	0.001	14.4 - 10			
28-Oct-94	juvenile	15.6	0.001	9 - 5.6	Hyperplastic		Minimal loss to BKD.
21-Nov-94	juvenile	17.4	0.002	3.3 - 0.5			Low loss to BKD
16-Dec-94	juvenile	18.1	0.01	3.3 - 0.5			
12-Jan-95	juvenile	20.6	0.01	3.3 - 0.5	Good	Good	
09-Mar-95	juvenile	23.1	0.015	6.7-2.8	Good	Good	Loss from BKD
05-Apr-95	smolt	28.5		6.7-2.8			

4.2.4. Raceway rearing and acclimation

The 93 BY Methow chinook incubated and reared for 8 months on well water. The well water temperature remained constant at 9°C. In June 1994, mixing of surface and well water began. Mixing continued until September 1994, when the water source was switched to 100% surface water. River water temperature fluctuated up to 6°C daily. The stock remained on Methow River water except when the river intake froze.

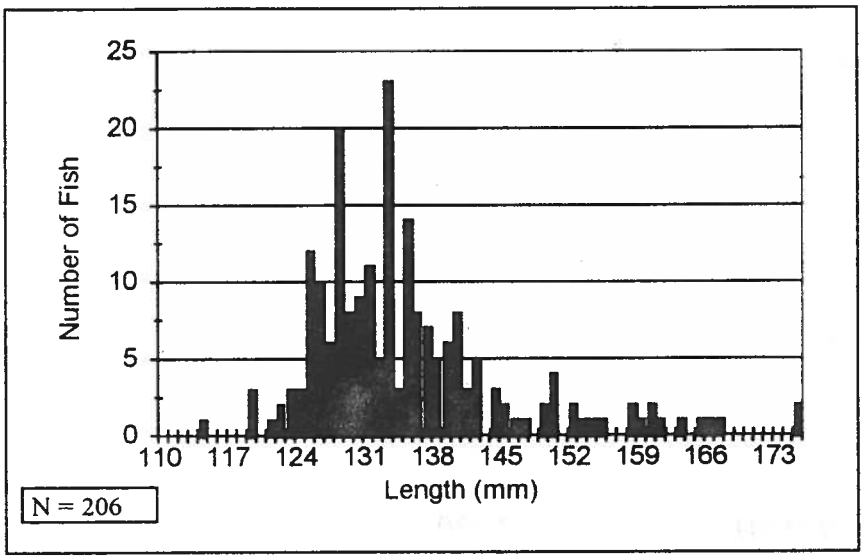
Bird netting covered the entire pond to prevent bird predation. Periodically there were signs of a river otter or mink or both in and around the pond.

4.2.5. Smolt release

Volitional release began 15 April 1994. The hatchery crew periodically breached three beaver dams in the outfall channel to allow migration of the smolts. The breached dams did not present a hazard to the fish. Initially the fish migrated slowly, with only 15,000 leaving in the first 48 hours. Most of the pond population migrated on the sixth through eighth days. This corresponded with an increase in entrainment of wild yearling spring chinook salmon in the Chewuch River smolt trap (Hilda Sexauer pers. comm.). Volitional release finished 25 April.

In April 1995, 211,157 (6,018 kg) Methow chinook smolts migrated from the acclimation pond. The fish reared 496 days at the Methow Fish Hatchery Complex. At release fish weighed an average of 28.5 g each. They measured an average of 134.8 mm, with a CV of 7.6% and a K of 1.16 (n = 206 fish). Methow chinook had a fry to smolt survival of 95.9%.

Figure 17. 1993 Methow chinook juvenile length frequency at release



4.2.6. Juvenile sampling

See 4.1.6. for explanation of type and number of samples taken. Table 18 shows the number and date of sampling, and table 19 lists organosomatic indexes results.

Table 18. 1993 Methow chinook juvenile sampling schedule

Date	Length/Weight	ATPase	OSI	Mer.	ELISA	GSI
3/10/95	40/0			30		95DC1-40
3/13/95	20/0	68301-68320			20	95DC41-60
3/27/95	20/0	68321-68340		20	20	95DC61-80
4/13/95	20/20	68341-68360	20		20	95DC81-100

Table 19. 1993 Methow chinook juvenile organosomatic indexes results

Value in parenthesis is the standard deviation.

Date	Fork Length (mm)	Weight (g)	Condition Factor	Mean Fat	Male	Fem.
4/13/95	142.6 (15.7)	36.9 (13.2)	1.27 (0.09)	2.4	65%	35%

Methow chinook had a normality index of 82. Some minor, but prevalent petechial hemorrhaging in the thymus reduced the normality index. Petechial hemorrhaging is a sign of stress, and for this population probably indicated smoltification.

Table 20. 1993 Methow chinook juvenile meristic count results

	Upper gill rakers	Lower gill rakers	Pectoral rays	Pelvic rays
Mean total count	6.45	10.65	14.76	10.01
Mean magnitude of asymmetry	0.06	0.71	0.32	0.07

ATPase and ELISA values for the 1993 brood year will be included in a future report because processing was incomplete at time of publication.

4.3. 1993 Twisp spring chinook salmon

4.3.1. Incubation

See 4.1.1. for procedure. The 1993 BY Twisp chinook had a green egg to fry survival of 97.7%.

4.3.2. Start tank and early rearing

Fry were transferred from the incubators to the start tanks beginning 3 December. Early rearing combinations of families were made based upon weight (egg/kg or fry/kg), date of egg take, ELISA value and injection history of female parent (Appendix B). By 30 December, all 23 families had moved from the incubators to the

start tanks. The density index was maintained at or below 51.

All fish were coded wire tagged and adipose fin clipped between 12 and 21 July. The 1993 BY Twisp chinook received two unique tag codes. The tag code 63-56/09 went to 18,015 high ELISA progeny, and tag code 63-53/29 went to 103,592 low ELISA progeny. An extra 1,474 fish were counted. At tagging the fish weighed 8 g each. The families handled well, although some showed signs of BKD. Including initial ponding, population splits, transfers and tagging, this stock was handled between two and four times before reaching 9 g.

4.3.3. Fish health monitoring of juveniles

Eighteen fish health exams occurred during the juvenile rearing period (Table 21). The fish health specialist first detected BKD in start tank 9 on 7 January 1994. This tank contained progeny of three high ELISA females, none of which received erythromycin injections. The first Aquamycin treatment for this group began in mid-February when the fish weighed 1 g each and loss had approached 0.07%/day. During the juvenile rearing period, this group received five Aquamycin treatments to reduce mortalities from BKD. The other three Twisp juvenile raceways received at least one Aquamycin treatment during the hatchery rearing period. Excluding BKD, the Twisp stock remained free of other pathogens. The healthy fish examined during the rearing period had clean gills and fins, and fat levels increased to a pre-release value of +3.

Table 21. 1993 Twisp chinook juvenile fish health monitoring

RW = raceway
T = start tank
BKD = bacterial kidney disease

Date	Life Stage	Size (g)	Mean Daily % Loss	Water Temp °C	Gills	Body	Pathogen
07-Jan-94	fry	0.6	0.017	9			
11-Jan-94	fry	0.8	0.02	9			Suspect BKD in T9.
28-Jan-94	juvenile	1.1	0.066	9			BKD in T9
18-Feb-94	juvenile	1.3	0.01	9	Good		
11-Mar-94	juvenile	2.0	0.01	9	Excellent	Excellent	
01-Apr-94	juvenile	2.6	0.01	9	Good	Good	BKD in RW 1A
29-Apr-94	juvenile	3.5	0.001	9			BKD in RW 1A
23-May-94	juvenile	5.0	0.06	9			
09-Jun-94	juvenile	5.5	0.02	9	Good	Good	BKD in RW 7
20-Jul-94	juvenile	8.2	0.03	9		Bad fin clips	
02-Aug-94	juvenile	8.6	0.02	9			BKD in RW 1A
01-Sep-94	juvenile	10.1	0.025	9	Good	Good	BKD in RW 1A and 7
29-Sep-94	juvenile	11.3	0.013	9			
28-Oct-94	juvenile	14.2	0.016	9			
21-Nov-94	juvenile	16.2	0.01	6.7 - 4.4	Good	Good	BKD in RW 6 and 8
12-Jan-95	juvenile	18.1	0.01	6.1 - 5.6	Excellent	Excellent	
09-Mar-95	juvenile	24.8	0.01	8.2 - 5.6			
05-Apr-95	smolt	29.8		8.2 - 5.6			

4.3.4. Juvenile rearing and acclimation

The 93 BY Twisp chinook incubated and reared for 15 months on well water. In November 1994, mixing of surface and well water began and continued through January 1995. During Aquamycin treatments or river intake freezes the water source was 100% well. In February 1995, the water source was moved to 100% surface. The well water temperature remained constant at 9°C, the well and surface water mixture ranged from 7.2 - 4.4°C, and the surface water ranged from 8.2 - 0°C.

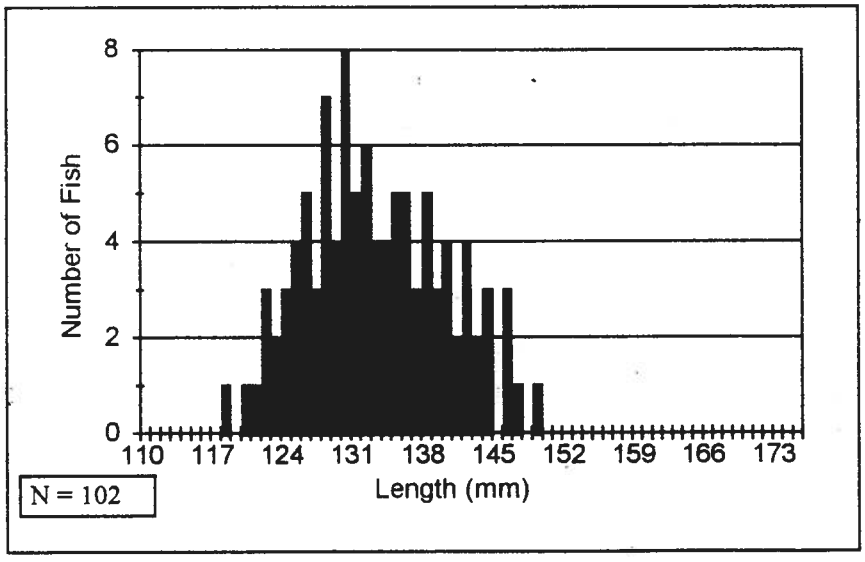
The hatchery crew kept the density at or below the operation guideline of 12 kg/m^3. The increased population in the 1993 brood year placed demands on water and rearing space. Densities did exceed the recommended DI, but only in the last 2-3 months of rearing when it reached 69 kg/m^3/mm.

The fish were transferred to the Twisp River acclimation pond on 20-22 March. One raceway population remained at the MFH until 11 April because of the prevalence of BKD. The 100,045 smolts (2,839 kg) transferred in March received 27 to 34 days of acclimation time. The April transfer of 16,753 smolts (783 kg) were acclimated for seven to twelve days.

4.3.5. Smolt release

Volitional release began 18 April and ended 23 April. Discharge for the Twisp River was 8.9 m^3/s (USGS-Twisp River gauge). In April 1995, 116,749 Twisp chinook smolts (3,479 kg) migrated from the Twisp River acclimation pond. The fish reared 501 days at the Methow Fish Hatchery Complex. At release, the fish weighed an average of 29.8 g. They measured an average of 132.9 mm, with a CV of 5.2% and a K of 1.29 (n = 102 fish). Twisp chinook had a fry to smolt survival of 94.3%.

Figure 18. 1993 Twisp chinook juvenile length frequency at release



4.3.6. Juvenile sampling

See 4.1.6. for explanation of type and number of samples taken. Table 22 lists date and type of samples taken. Table 23 and table 24 gives organosomatic indexes and meristic results, respectively.

Table 22. 1993 Twisp chinook juvenile sampling schedule

Date	Length/Weight	ATPase	OSI	Mer.	ELISA	GSI
3/07/95	40/0			30		95DD1-40
3/16/95	20/0	68401-68420			20	95DD41-60
3/31/95	20/0	68421-68440		20	20	95DD61-80
4/18/95	20/20	68441-68460	20		20	95DD81-100

Table 23. 1993 Twisp chinook juvenile organosomatic indexes results

Values in parenthesis are the standard deviations.

Date	Fork Length (mm)	Weight (g)	Condition Factor	Mean Fat	Male	Fem.
4/18/95	137.7 (14.0)	32.9 (9.9)	1.26 (0.07)	2.5	60%	40%

Twisp chinook had a normality index of 91.5.

Table 24. 1993 Twisp chinook juvenile meristic count results

	Upper gill rakers	Lower gill rakers	Pectoral rays	Pelvic rays
Mean total count	6.05	10.22	14.51	9.83
Mean magnitude of asymmetry	0.11	0.53	0.64	0.14

ATPase and ELISA values for the 1993 brood year will be included in a future report because processing was incomplete at time of publication. See Appendix F for ELISA and ATPase information collected from the 1992 BY Twisp chinook released in April 1994.

SECTION 5: DISCUSSION

Based upon redd count expansion, about 208 fish returned to the Chewuch River and 480 fish returned to the Twisp River spawning grounds in 1993 (Scribner et. al. 1993). A fundamental objective for the collection of adult broodstock at the MFHC is that the collection be throughout the return and be representative of the migrants. For the Chewuch stock, 78% of the hatchery spawners were collected by the end of June. Based upon 208 adult natural spawners and the number of fish collected at the trap and passed upstream, 77% of the natural spawners had passed the Chewuch River trap. For the Twisp stock, 56% of the hatchery spawners had been collected by the end of June. Based upon 480 adult natural spawners and the number of fish collected at the trap and passed upstream, 50% of the natural spawners had passed the Twisp River trap. The trapping and collection of adult chinook in 1993 appeared to represent the upriver migration.

Collection of Methow River broodstock from the MFH outfall channel was a mixed blessing. The adult chinook entered the hatchery, providing the hatchery crew with an easy means of collection. Unfortunately, more than half the adults were of hatchery origin. Incorporating these fish into the MFH broodstock does not support the original program intent. Recovery of scales from natural spawners showed hatchery origin fish spawning throughout the Methow River in 1993. The Methow River stock has not escaped hatchery influence. Since MFH management of the Methow stock incorporates known hatchery origin fish, and the Methow River has hatchery origin natural spawners, the goal for the Methow stock should be reestablished.

Non-injected females with high ELISA values produced progeny that showed signs of BKD shortly after ponding. These families probably contracted the disease from their female parent (vertical transmission). The groups that contracted the disease later, may have contracted it vertically or horizontally (fish to fish). A number of low ELISA females were not injected with erythromycin, so their progeny were not protected. During the first four months of rearing, 1993 progeny of injected Twisp females had a loss of 0.0015%/day versus non-injected females loss of 0.035%/day. Thus, in comparison, erythromycin reduced the BKD related mortalities in the progeny. The lower infection level of the low ELISA females may have delayed the symptoms in their progeny. By the time symptoms appeared, BKD had horizontally passed to the other fish in the same rearing structure. Increased densities or handling elevated stress and prompted a disease outbreak. BKD typically has a slowly progressive, relentless course that is difficult to control and nearly impossible to completely cure (Warren 1991). Aquamycin reduced and controlled mortalities at the hatchery.

The eggs collected in 1993 approached the hatchery program goals. This, coupled with excellent early survival, showed the limitations of water availability at the central facility. Extended river water rights to off-site acclimation ponds did not help in

1995 because the harsh winter environment limited access and use of the ponds. This also happened in 1994. The ponds are accessible in the fall, so a fall transfer would increase imprint time in the natal river, expose the fish to natural river temperatures, reduce winter water demands at the central facility, and prevent handling during spring smoltification. Volitional releases could begin when the rivers thaw and the fish are ready to migrate. Overwintering fish at the acclimation sites would require some ground water in the intake to prevent freezing, and a remote alarm system. It would also require time and travel constraints by the hatchery crew. An alternative would be to use off-channel rearing sites. A number of sites on private and public lands could be considered. Most sites need a rack at the confluence to evaluate and monitor migrants and to manage returning adults. Fish could be planted into these sites during early fall, allowing the fish to adjust to their new environment or move to a more suitable one if necessary.

Currently all three stocks are reared mostly on well water while in the hatchery. This reduces the incidence of pathogens contacting the fish and ensures the fish reach their programmed release size. However, using mostly well water also requires the hatchery crew to manipulate feed to prevent the fish from getting too big. If river water were available to the start tank and incubation rooms, it could be introduced to slow growth with natural river temperatures. An appropriate time would be after natural spawning adults above the hatchery intake were no longer a disease concern, probably around the first part of November. The 93 BY Methow chinook began rearing on Methow River water about six months before the other stocks. While in the hatchery they achieved the desired size, remained healthy, and did not need to have their feed manipulated to keep them from growing too fast.

The 1993 juveniles overwintered in Methow River water, so all experienced natural river temperature fluctuations. Yet, their smolt transition phases and migration patterns varied. The Methow stock entered smolt transition in the first weeks of March and stayed in this phase until mid-April. Their migration peaked at the same time wild smolts increased in number in the Chewuch River smolt trap April 22-23, although the screens were pulled 15 April. In contrast, the Chewuch and Twisp stocks did not enter smolt transition until after their transfer to the acclimation ponds. By mid-April they appeared silvery with some minor descaling, and when the pond screens were pulled, the fish migrated quickly. Factors influencing smoltification are complex. The covered raceways probably altered the photoperiod the Chewuch and Twisp stocks received. Maybe the photoperiod cycles received, altered the timing of smoltification (Berge et. al. 1995). Evaluation and observations at the hatchery showed neither stock suffered because of these events. In fact, they may have benefitted. When transfer to the natal river acclimation ponds is delayed because of weather, imprint time is shortened. Delayed smoltification this year reduced the hazards of holding fish too long or releasing them too early.

The extremely low adult returns in 1994 and 1995 have required changes in the

Methow FH program, like collecting predominately hatchery origin fish, or forgoing collection of any fish. Flexible management is therefore important, but evaluation in some areas will be compromised until annual consistency is achieved. In any event, the juvenile rearing standards achieved in 1992, 1993, and preliminary 1994 exceed the standards set for the MFHC (Appendix E) (Peck 1993). The comprehensive facility design, coupled with excellent fish cultural practices have made this possible. The standards set should be adjusted to better reflect the hatchery's abilities.

content. This was a major improvement from 1994 and is also commendable in that the feed had a higher moisture content than that used in 1994 and thus less nutrient value per unit weight.

During the 13 days of net pen operation in 1995 the fish increased their weight by about 50%, but the final release size was much were smaller than originally planned for the program, i.e., 4.5 grams initially and 18.4 grams at release. This was due to the relatively small size at entry into the pens, later than planned stocking date, shorter culture period, and possibly cooler water temperatures discussed above.

Pratt et al. (1991) reviewed the available literature showing that larger sockeye smolts were needed to have optimum survival in the Pacific Ocean. Average size of naturally-produced Lake Osoyoos smolts has been about 110 mm, relatively large and in the upper end of the range of smolt size produced by other sockeye lakes in the world. Efforts should be made in 1996 to increase the size of the both the fry planted in the pens and the smolts released from the net-pen, as discussed below in the final section: *Recommendations*.

We had initially planned to rear the fish up to 0.24 lbs./cu.ft loading density, but the limited number of fry in 1995 resulted in a maximum density of 0.13 lbs.ft^3, about ½ the planned maximum. The number of fry available for planting in the pens in 1996 should be closer to the 200,000 fish goal, and as of December 19, 1995 there were 202,000 fish being reared (personal communication, R. Stensgar). They were also reported to be about 2 weeks ahead of the prior year's brood. The plan for 1996 is to use 8 separate pens for the larger fish with densities not to exceed 0.10 lbs.ft^3 (assuming 5 grams at entry and 8 grams at release). Even if the fish were twice as large at release (16 g) the final density would be good (0.20 lbs.ft^3) and less than the maximum allowed for this project (Table 7). Lower than initially planned loading density will help prevent fish disease and increase the use of natural feed.

As in 1994, there were no antibiotics used, nor were there any signs of disease or parasitism for the 1995-released fish. Overall, these are encouraging results that bode well for the potential success of the program if adequate egg take and survival in the hatchery phase can be achieved.

Gut content study

As in 1994, samples of fish to be released were collected, preserved and inspected later to estimate gut content and fullness. I inspected gut contents of ten fish collected just prior to release. The sampled fish averaged 84.6 mm fork length, but that was after preservation that results in some shrinkage. The body cavity had been cut open, although it was difficult to identify specific taxa of crustacean zooplankton prey due to the state of preservation. Only a qualitative estimate of fullness was made. All but one of the fish had stomachs and intestine that were relatively full of plankton. Average fullness was estimated to be 81% (SD=23.6). The fish had been

fed pelleted feed the prior day, but at the ambient water temperatures of the time and the passage of 24 hours, the guts could have been mostly evacuated of artificial feed by the time of sampling.

Fish Culture Impact: Lake Bottom

Samples of bottom sediment were taken at and nearby the pens before and after the fish were reared in the net pens in1994 and before fish culture in 1995. Lease requirements require sampling before and after the first year, and subsequently only before fish area stocked. Results of total organic carbon (TOC) analysis are presented below in Table 8 based on the laboratory report from appendix 15.

Table 8. Total organic carbon and percent solids data from lake bottom near net pens before and after fish culture in Lake Osoyoos in 1994 and before in 1995. The units mg/kg are the same as parts per million as dry weight basis.

DATE	LOCATION AND REPLICATE	TOTAL ORGANIC CARBON (MG/KG)	PERCENT TOC CHANGE FROM PRIOR PERIOD
13 Apr 94	Under pens	45,057	-----
	50 m north	41,478	-----
	100 m north	45,919	-----
16 May 94	Under pens #1 (SW)	40,318	-11%
	Under pens #2 (NE)	38,973	+6%
	100 m north	44,751	-----
18 April 95	Under pens #1 (center)	38,105	-5%
	Under pens #2 (NE edge)	44,820	+13%
	50 m north	42,987	-4%

No clear-cut trends emerge from the data. Total carbon concentrations apparently decreased over the three intervals beneath the middle of the pens. Immediately adjacent to the pens the values appear to be increasing, and only a minor change was seen compared to reference areas 50 to 100 m north. The amount of variation seen in these data could be due to natural variability in bottom sediments. I doubt that the sampling locations are exactly the same from year to year, as there is always a small amount of movement in a net-pen system. The same anchoring system was used each year and the pens were located both years by professional surveyors. See Rensel (1993) for other data comparisons of Lake Osoyoos sediments.

As an aside, I inspected the general appearance of the sediments at 50 and 100 m north of the pens for relative particle size composition, as discussed in Rensel (1995a). As expected, nearer to shore (I.e., 100 m north of the pens), but in similar

depth water, the sediments appeared more coarse than 50 m north of the pens. All locations had a slight hydrogen sulfide smell. A few small chironomid larvae were noted in bottom samples, but their number was not correlated with closeness to the pens (range 3 to 10 individuals per 0.01 m^2 Van Veen grab).

Fish Culture Impact: Macrophytes

In addition to sampling of the sediments, a qualitative estimate of the species composition and distribution of macrophytes along the nearest shoreline to the pens was made to comply with Washington Dept. of Natural Resources (WDNR) lease requirements.

On August 8th Mr. Shane Bickford and I surveyed the entire shoreline from Smith Point southeasterly to a point east south east of the area of the net pen complex where there are several homes. That point was approximately 2,300 feet from the former location of the net pens. The survey was done during August when in normal years plant biomass is probably near maximum for the year. Six photographs were taken along representative reaches of the shoreline, for comparison to future years.

In 1994 we found several species of native macrophytes growing along the shoreline including Richardson's Pondweed (*Potamogeton richardsonii*), Curly-leaved pond weed (*P. crispus*), large-leaved pond weed (*P. amplifolius*) and Berchtold's pondweed (*P. berchtoldii*). The macrophyte growths were not continuos, but spaced unevenly along the shoreline in depths of a few meters. Some of the plants looked past their physiological optimum, and many had a partial coating of some kind of epiphytic green algae.

Surprisingly in 1995 we found very few macrophytes growing near the shore and most appeared to be in very poor condition with heavy epiphytic growth. The reason for the decline from 1994 macroalgal biomass levels is unknown, but could relate to weather or possibly even the major blue-green algal bloom that occurred in early August. The bloom appeared very concentrated near the surface (Secchi disk transparency <2 m). It is common for macrophytes to be replaced by microalgae in lakes approaching or in eutrophy due to shading of light.

RECOMMENDATIONS

Net pen Rearing Program

Although the hatchery/net-pen fish growth rate, survival and food conversion ratio was much better than the prior year, I recommend that the fish be reared in the pens for a longer period and to a larger size than was accomplished in 1995. The size of fish released in 1995 was smaller than the average size of naturally-reared fish produced in the past (95 mm versus 110 mm length) and therefore the pen fish would be at a competitive disadvantage. If predation of outmigrants is an issue, smaller fish would be more vulnerable to the many species of warmwater fish that inhabit Lake Osoyoos and the Okanogan and Columbia Rivers.

In early May 1995 the sockeye appeared to be smolting, were apparently attempting to migrate and were overly active in the pens. Concurrently the daily environmental reports (appendix 15) and verbal reports from net pen staff suggested relatively strong winds at the pen site. I suspect that the fish were responding to the sustained currents that winds produce in surface waters. To maximize the size of the fish released in 1996 I suggest that inexpensive plastic tarps and sand-bottle weights be on hand should similar conditions occur. By suspending the tarps on the windward side of the cages current velocity can be reduced, possibly calming the fish and allowing further culture. Measurement of fish hormones (gill sodium/potassium ATPase which energizes the active transport portion of the osmoregulatory system) is of interest in this regard. However, it has been shown by NMFS researchers that active migration (e.g., swimming downstream) causes an increase in ATPase, so it is possible that just increasing swimming activity in the pens can cause hormone levels to increase.

Regarding logistics of fish release, I recommend some changes in dealing with release timing. The goal should be to do what is biologically best for the fish, releasing them at the largest possible size (up to 18 g) at the most optimum time. Permits require moving the pens toward the end of the lake where the Okanogan River flows out, but I do not believe it is necessary to have the contract divers and construction workers on hand for this operation. The pens are relatively small and may be pushed (not towed!) by two small skiffs toward the river after disconnecting the anchor balls. The fish could be released and the pens towed back for reattachment to two or more of the floats until the divers or contractors arrive for removal of the pens. This approach will allow use of existing Tribal personnel and vessel(s), along with one person and boat from Douglas County PUD. The expense and problems associated with advance warning for the contractors and mobilization on short notice could be avoided if the above approach is practiced.

Finally, efforts should be made to release the fish in late afternoon or evening to allow initial migration in the hours of darkness when predation could be reduced. The may not be practical, but should be attempted if at all possible.

Water Quality Monitoring and Data Assessment in 1996

Most of the recommendations from the prior report with regard to water quality monitoring were incorporated and generally proved useful in 1995. In 1996 efforts should be made to collect data on calendar days midway between those used in 1994 and 1995 to minimize the effects of shifting time frames. Given the available budget and need to produce a report summarizing all three years of work, I recommend not collecting data from the mid to late October period, as comparison to prior years is not possible. Efforts should also be made to compare chlorophyll *a* from 1 m versus the composite samples of 1, 3 and 6 m during the summer. This may explain differences in historical results versus the present study. Additionally, iron from bottom samples (not the surface) should be assayed during the summer months to aid in the internal loading estimates.

More time will be devoted to data analyses for the 1996 report because it will be a summary report for all years 1994 to 1996. The effort will necessitate obtaining some unpublished "grey" literature not yet obtained regarding Lake Osoyoos. Interesting water temperature, nutrient and other data were collected at up to 11 different lake, Okanogan and Similkameen Rivers during July and August 1995. We will attempt to duplicate that in 1996 to explore water quality conditions during adult upstream migration.

Daphnia Bioassay

Acute exposure bioassays could be useful to assess the effects of Lake Osoyoos water from oxygenated depths on key sockeye prey such as *Daphnia* spp. Not unexpectedly, preliminary work in 1995 showed that *Daphnia* can be entangled in algae from near-surface waters of the lake. The work was volunteer in nature and not well controlled, and the major bloom of early August was not sampled. Should this work be repeated in 1996, efforts should be made to prepare for a summer bloom in July or August, with water collection and bioassays cued to Secchi disk readings of 2 m or less.

Sockeye Fry Distribution Assessment

As discussed in the prior report, there have been no populations assessments (hydroacoustic soundings or nettings) of Lake Osoyoos sockeye fry in the south basin in summer, although it was recommended by a prior study. The key question here is...

> Do significant numbers of sockeye fry rear in the south and central basins during the summer? Does residency vary between warm summers with strong vertical stratification and high surface water temperatures versus cooler summers with less stratification such as 1995?

Vertical gill net sampling could be conducted in the south basin in late July or August, concurrent with water quality monitoring to shed more light on this issue, although that is well beyond the current scope of this work. As noted in the report, samples for electrophoresis are concurrently needed to distinguish between sockeye and kokanee. If the work could be conducted in a relatively cool water temperature year such as 1995 that was coupled with a good adult escapement the prior year, I suspect that significant numbers of fry would be found rearing in the south basin. Such information might explain the large variation between adult escapement and smolt production discussed herein. Other suggestions for investigating smolt production variability were previously discussed in *Hypothesis Regarding Smolt Production* and appendix 4.

Improvement of Lake Trophic State

Nitrogen to phosphorus ratio and inflow-outflow nutrient data for the Okanogan River strongly points to nitrogen limitation of phytoplankton during the late summer in Lake Osoyoos. The Canadians no longer discharge treated sewage into the lake or from the upstream town of Oliver. Use of septic tanks, however, is common around much of the lake shore and tourist facilities in both the US and Canada appear to be increasing rapidly. Reduction of nitrogen discharge from old, unservices or failing septic tanks and fields could result in a direct reduction in blue-green algal blooms during the summer and possibly even the degree of anoxia of the hypolimnion. This would benefit both Canadian and American users of the lake and the sockeye/kokanee too. If non-point sources of nitrogen (and phosphorus) continue to increase, as expected due to rapid population growth, the long-term future of aesthetic water quality uses and salmonid populations in Lake Osoyoos could be threatened.

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Appendix 1. Lake Osoyoos: North Basin (Monashee Coop) Nutrients, 1995							
	Results in µg at./L except summary lines in bold that are in µg/L						
Date	Depth	Nitrate	Nitrite	Ammonium +Ammonia	Ortho-phosphate	Total N	Total P
April 18	1,3,6 m	0.34	0.01	0.23	0.12	60.64	1.69
						43.65	1.12
						62.64	1.21
	µg/L—>	**4.76**	**0.14**	**3.22**	**3.72**	**779.01**	**41.50**
	10, 14 m	0.3	0.04	0.19	0.05	25.09	0.56
	µg/L—>	**4.2**	**0.56**	**2.66**	**1.55**	**351.26**	**17.34**
	40 m	0.05	2.37	0.96	0.05	89.48	4.18
	µg/L—>	**0.7**	**33.18**	**13.44**	**1.55**	**1252.72**	**129.45**
May 16	1,3,6 m	0.35	0.05	1.41	0.04	33.91	0.73
						42.48	0.84
						41.18	0.78
	µg/L—>	**4.9**	**0.7**	**19.74**	**1.24**	**548.66**	**24.26**
	10, 14 m	0.91	0.09	0.67	0.02	19.84	0.48
		12.74	1.26	9.38	0.62	277.76	14.87
	40 m	2.12	0.22	1.54	0.02	19.38	0.46
						19.25	0.36
						22.02	0.48
	µg/L—>	**29.68**	**3.08**	**21.56**	**0.62**	**283.03**	**13.42**
June 8	1,3,6 m	0.69	0.04	0.35	0.06	21.72	0.31
						24.35	0.31
						24.27	0.34
	µg/L—>	**9.66**	**0.56**	**4.9**	**1.86**	**328.25**	**9.91**
	10, 14 m	1.57	0.04	0.31	0.09	17.94	0.32
		21.98	0.56	4.34	2.79	251.16	9.91
	40 m	6.09	0.03	0.14	0.18	27.67	0.49
						25.98	0.43
						31.19	0.75
	µg/L—>	**85.26**	**0.42**	**1.96**	**5.57**	**395.92**	**17.24**
July 12	1,3,6 m	0	0.01	0.31	0.12	33.35	0.53
						31.12	0.52
						37.64	0.50
	µg/L—>	**0**	**0.14**	**4.34**	**3.72**	**476.51**	**16.00**
	10, 14 m	0.55	0.01	0.47	0.08	24.75	0.39
		7.7	0.14	6.58	2.48	346.50	12.08
	50 m	6.09	0.03	0.14	0.18	31.00	0.82
						33.17	1.02
						32.18	1.04
	µg/L—>	**85.26**	**0.42**	**1.96**	**5.57**	**449.63**	**29.73**
August 8	1,3,6 m	0	0.01	0.16	0.04	24.57	0.44
						25.76	0.44
						24.40	0.53
	µg/L—>	**0**	**0.14**	**2.24**	**1.24**	**348.74**	**14.56**
	10, 14 m	0.71	0.03	0.12	0.05	18.08	0.36
		9.94	0.42	1.68	1.55	253.12	11.15
	50 m	11.82	0.04	0.14	0.74	28.36	1.07
						29.06	1.09
						28.24	1.08
	µg/L—>	**165.48**	**0.56**	**1.96**	**22.92**	**399.75**	**33.45**
September 13	1,3,6 m	0.06	0.04	0.23	0.27	20.35	0.38
						20.02	0.33
						21.35	0.39
	µg/L—>	**0.84**	**0.56**	**3.22**	**8.36**	**288.03**	**11.36**
	10, 14 m	0.59	0.03	0.28	0.31	16.00	0.36
		8.26	0.42	3.92	9.60	224.00	11.15
	50 m	14.3	0.02	0.08	1.08	27.36	1.18
						26.97	1.20
						27.75	1.23
	µg/L—>	**200.2**	**0.28**	**1.12**	**33.45**	**383.04**	**37.27**

Appendix 2. Lake Osoyoos: South Basin (Boundary Point) Nutrients, 1995

Results in µg at./L except summary lines in bold that are in mg/L

Date	Depth	Nitrate	Nitrite	Ammonium +Ammonia	Ortho-phosphate	Total N	Total P
April 18	1,3,6 m	0.31	0.02	0.26	0.05	62.78	1.71
						62.61	1.69
						47.97	0.99
	µg/L—>	**4.34**	**0.28**	**3.64**	**1.55**	**809.01**	**45.32**
	10,14 m	0.01	0.01	0.14	0.04	35.08	1.10
	µg/L—>	**0.14**	**0.14**	**1.96**	**1.24**	**491.12**	**34.07**
May 16	1,3,6 m	0.12	0.02	0.69	0.03	25.82	0.39
						26.59	0.41
						26.65	0.37
	µg/L—>	**1.68**	**0.28**	**9.66**	**0.93**	**368.95**	**12.08**
	14 m	0.12	0.02	0.33	0.04	25.68	0.54
						19.61	0.35
						18.58	0.33
	µg/L—>	**1.68**	**0.28**	**4.62**	**1.24**	**298.06**	**12.59**
June 8	1,3,6 m	0.28	0.03	0.74	0.10	37.89	0.53
						77.46	1.35
						39.09	**0.77**
	µg/L—>	**3.92**	**0.42**	**10.36**	**3.10**	**720.72**	**27.36**
	14 m	0.22	0.02	1.31	0.08	19.80	0.42
	µg/L—>	**3.08**	**0.28**	**18.34**	**2.48**	**277.20**	**13.01**
July 12	1,3,6 m	0	0	0.11	0.08	29.74	0.51
						29.67	0.54
						29.18	0.47
	µg/L—>	**0**	**0**	**1.54**	**2.48**	**413.42**	**15.69**
	14 m	4.22	0.29	0.47	0.15	29.17	0.64
						32.38	0.58
						42.97	1.27
	µg/L—>	**59.08**	**4.06**	**6.58**	**4.65**	**487.76**	**25.71**
August 8	1,3,6 m	0.06	0.02	0.11	0.06	26.22	0.53
						25.29	0.48
						26.32	0.50
	µg/L—>	**0.84**	**0.28**	**1.54**	**1.86**	**363.21**	**15.59**
	14 m	0	0.02	0.02	0.09	28.11	0.43
						26.96	0.42
						27.61	0.39
	µg/L—>	**0**	**0.28**	**0.28**	**2.79**	**385.84**	**12.80**
September 13	1,3,6 m	0.06	0.01	0.02	0.28	22.06	0.43
						20.35	0.43
						20.19	0.33
	µg/L—>	**0.84**	**0.14**	**0.28**	**8.67**	**292.13**	**12.28**
	14 m	0.05	0.12	12.37	0.27	30.23	0.72
						30.01	0.69
						29.07	0.57
	µg/L—>	**0.7**	**1.68**	**173.18**	**8.36**	**416.78**	**20.44**

Appendix 3. Okanogan River Inflow or Outflow to Lake Osoyoos Nutrients, 1995								
	Results in µg at./L except summary lines in bold that are in µg/L							
Date	Location	Nitrate	Nitrite	Ammonium +Ammonia	Ortho-phosphate	Total N	Total P	DIN
May 16	Inflow	0.98	0.01	0.23	0.02	19.86	0.94	
	µg/L—>	**13.72**	**0.14**	**3.22**	**0.62**	**278.04**	**29.11**	**17.08**
June 16	Inflow	3.29	0.06	0.20	0.06	lost	lost	
	µg/L—>	**46.06**	**0.84**	**2.80**	**1.86**			**49.70**
July 12	Inflow	5.58	0.09	0.21	0.10	36.67	0.47	
	µg/L—>	**78.12**	**1.26**	**2.94**	**3.10**	**513.38**	**14.56**	**82.32**
	Outflow	0.00	0.00	1.17	0.03	39.65	1.58	
	µg/L—>	**0.00**	**0.00**	**16.38**	**0.93**	**555.10**	**48.93**	**16.38**
8-Aug	Inflow	3.61	0.04	0.33	0.05	23.98	0.37	
	µg/L—>	**50.54**	**0.56**	**4.62**	**1.55**	**335.72**	**11.46**	**55.72**
	Outflow	0.00	0.02	0.22	0.03	27.82	0.54	
	µg/L—>	**0.00**	**0.28**	**3.08**	**0.93**	**389.48**	**16.72**	**3.36**
13-Sep	Inflow	2.61	0.07	0.14	0.28	16.71	0.24	
	µg/L—>	**36.54**	**0.98**	**1.96**	**8.67**	**233.94**	**7.43**	**39.48**
	Outflow	0.00	0.01	0.27	0.24	19.09	0.30	
	µg/L—>	**0.00**	**0.14**	**3.78**	**7.43**	**267.26**	**9.29**	**3.92**
17-Oct	Inflow	6.17	0.07	0.41	0.17	22.94	0.43	
	µg/L—>	**86.38**	**0.98**	**5.74**	**5.26**	**321.16**	**13.32**	**93.10**
	Outflow	0.96	0.16	4.92	0.09	29.53	0.67	
	µg/L—>	**13.44**	**2.24**	**68.88**	**2.79**	**413.42**	**20.75**	**84.56**

Appendix 4. Freshwater Residency Time for Lake Osoyoos Sockeye

The literature clearly points to a 1 year freshwater residency time for Lake Osoyoos sockeye, although no actual validation of ages have been possible (Fryer 1995). The possibility of zero-aged freshwater smolt production apparently has not been critically evaluated. Scale analysis appears to have been focused on determining years in the ocean, based on my limited review of this matter and discussion with experts. Aging of smolt from Lake Osoyoos has relied on size estimates alone or in combination with scale or otolith interpretation. Scale analysis involves counting or computer digitizing annuli on the scales, or zones of closely spaced circuli that occur during periods of slow growth, such as winter in some environments. As shown in Fryer (1995, his figure A1.1), the determination of freshwater annuli is more difficult than placing the seawater entry marker.

Other factors auger for the possibility zero-age production from the lake in some years. First, early emerging fry are physiologically capable of achieving smolt size by their first spring in the lake, as shown by growth rates of the hatchery produced fry. In 1994 and 1995 these fish grew very close to rates I previously estimated (Rensel 1993: Table 9). Although hatchery fish were released early in both years, they could have reached a smolt size (i.e., approx. 13 g or larger, Allen and Meekin 1980) if held another month and if growth followed the initial forecast (see *Summary of Fish Culture Data*, this report). Hatchery fish have the advantage of warmer water in early spring (about 12°C), compared to 4-6°C for wild fish emerging in the river in 1994, but the lake is slightly warmer (compare Shepard and Inkster 1995 with Rensel 1995). Brett et al. (1969) concluded, on the basis of growth and food conversion efficiency, that water temperatures from 5 to 17°C were favorable for young sockeye, when adequate ration was available.

Second, in some years the range of smolt sizes has been large and included relatively small fish. Range of fish length is a poor statistic to categorize the entire population but population size distributions are not readily available. Pratt et al. (1991) cite three studies showing timing of outmigration in some years shows a bimodal shape, with peaks in the 3rd week of April and again in mid-May. The different peaks could be from different populations. It seems reasonable to investigate these data further.

It could also be useful to compare the scales of the net-pen produced fish to naturally-produced smolts to see if comparable patterns can be seen. Marking of emergent fry and collection of water temperature data with recording thermisters could be coordinated with smolt sampling to definitively address the zero age production issue. Warm spring and summer water temperature coupled with moderate or greater fry production would result in zero-aged smolts moving out of the lake.

Appendix Table 5. Density and biovolume of phytoplankton by percent from monthly collections in surface waters (1, 3 and 6 m) of the **north basin** of Lake Osoyoos near Monashee Coop in 1995.

DENSITY (by percent)	April	May	June	July	August	Sept.
Cyanophyta	67.5	74.1	68.7	83.5	98.8	98.4
(blue-greens)						
Chlorophyta	0.5	2.8	8.9	6.8	0.6	0.3
(greens)						
Chrysophyta	2.5	19.0	9.8	1.2	0.1	0.1
(diatoms/browns)						
Cryptophyta	0.5	4.2	12.4	8.4	0.4	1.2
(small flagellates)						
Euglenophyta	0.0	0.0	0.0	0.0	0.0	0.0
(Euglena sp.)						
Pyrrhophyta	0.0	0.00	0.0	0.0	0.0	0.0
(dinoflagellates)						
BIOVOLUME	April	May	June	July	August	Sept.
(by percent)						
Cyanophyta	15.0	11.9	14.2	23.5	67.6	73.4
(blue-greens)						
Chlorophyta	4.3	8.6	25.4	50.0	22.8	7.1
(greens)						
Chrysophyta	77.6	75.2	53.9	6.2	5.1	3.8
(diatoms/browns)						
Cryptophyta	1.3	4.3	6.9	15.7	4.4	12.8
(small flagellates)						
Euglenophyta	0.0	0.0	0.0	0.0	0.0	0.0
(Euglena sp.)						
Pyrrhophyta	1.9	0.0	0.0	4.6	0.1	2.9
(dinoflagellates)						

Appendix Table 6 Density and biovolume of phytoplankton by percent from monthly collections in surface waters (1, 3 and 6 m) of the **south basin** of Lake Osoyoos at Boundary Point during 1995.

DENSITY (by percent)	April	May	June	July	August	Sept.
Cyanophyta	92.0	74.5	4.8	76.9	97.5	97.6
(blue-greens)						
Chlorophyta	0.4	2.6	8.1	1.7	1.3	1.3
(greens)						
Chrysophyta	7.3	22.1	24.5	1.0	0.2	0.3
(diatoms/browns)						
Cryptophyta	0.2	0.8	0.0	20.4	0.5	0.8
(small flagellates)						
Euglenophyta	0.0	0.0	0.2	0.0	0.0	0.0
(Euglena sp.)						
Pyrrhophyta	0.0	0.00	0.0	0.0	0.0	0.0
(dinoflagellates)						
BIOVOLUME	April	May	June	July	August	Sept.
(by percent)						
Cyanophyta	28.0	14.5	15.8	50.6	87.2	52.4
(blue-greens)						
Chlorophyta	2.4	10.4	24.7	7.2	10.0	33.3
(greens)						
Chrysophyta	68.2	73.9	24.0	9.9	1.8	7.1
(diatoms/browns)						
Cryptophyta	0.7	1.2	0.0	24.6	0.9	6.0
(small flagellates)						
Euglenophyta	0.0	0.0	16.0	0.0	0.0	0.0
(Euglena sp.)						
Pyrrhophyta	0.7	0.0	0.0	7.7	0.0	1.3
(dinoflagellates)						

Appendix Table 7. Density and biovolume of zooplankton by percent from monthly collections in surface tows (5 m to surface) of the **north basin** of Lake Osoyoos near Monashee Coop during 1995.

DENSITY by percent	April	May	June	July	August	Sept.
Calanoid Copepods	4.3	15.9	40.8	24.0	17.6	23.1
Cyclopoid Copepods	2.2	0.7	5.2	1.3	1.1	1.7
Nauplii	6.9	6.3	22.9	15.5	15.8	43.9
Cladocerans	0	0.5	13.9	5.7	3.7	1.4
Rotifers	88.8	76.5	17.2	53.6	61.8	29.8
BIOVOLUME by percent	April	May	June	July	August	Sept.
Calanoid Copepods	59.4	89.2	42.0	55.3	50.4	78.8
Cyclopoid Copepods	21.13	2.7	2.4	1.5	2.3	4.1
Nauplii	7.1	2.0	1.2	1.6	2.6	6.7
Cladocerans	0.0	3.9	54.4	41.0	43.7	16.0
Rotifers	12.3	2.4	0.1	0.5	1.0	0.4

Appendix Table 8. Density and biovolume of zooplankton by percent from monthly collections in surface tows (5 m to surface) of the **south basin** of Lake Osoyoos near Boundary Point during 1995.

DENSITY by percent	April	May	June	July	August	Sept.
Calanoid Copepods	8.2	24.8	50.0	7.0	21.2	23.1
Cyclopoid Copepods	1.9	2.5	3.3	0.0	1.2	1.7
Nauplii	8.2	7.5	11.8	9.7	4.0	43.9
Cladocerans	0.6	2.0	18.6	1.3	7.4	1.4
Rotifers	81.1	63.2	16.3	82.1	66.1	29.8
BIOVOLUME by percent	April	May	June	July	August	Sept.
Calanoid Copepods	69.7	78.4	56.0	54.3	48.0	78.8
Cyclopoid Copepods	10.9	5.8	1.7	0.0	1.8	4.1
Nauplii	4.6	1.5	0.5	2.9	0.5	6.7
Cladocerans	9.4	12.1	41.8	40.5	48.7	16.0
Rotifers	5.4	2.1	0.1	2.4	1.0	0.4

Appendix Table 9. Density of zooplankton from monthly collections in surface tows (5 m to surface) of the **north basin** of Lake Osoyoos near Monashee Coop during 1995.

DENSITY (number per m^3)	April	May	June	July	August	Sept.
Calanoid Copepods	4,306	34,268	56,931	28,587	14,509	15,168
Cyclopoid Copepods	2,220	1,592	7,312	1,516	866	1,032
Nauplii	6,529	13,535	31,860	18,408	12,994	28,892
Cladocerans	0	1,114	19,325	6,726	3,064	935
Rotifers	86,177	164,804	24,028	63,884	50,893	19,605
Total w/ Rotifers	99,236	215,318	139,452	119,121	67,817	50,464
Total w/o Rotifers	13,059	50,514	115,424	55,237	16,924	30,859

Appendix Table 10. Density of zooplankton from monthly collections in surface tows (5 m to surface) of the **south basin** of Lake Osoyoos at Boundary Point during 1995.

DENSITY (number per m3)	April	May	June	July	August	Sept.
Calanoid Copepods	32,815	44,109	64,318	18,161	11,342	15,168
Cyclopoid Copepods	7,669	4,433	4,204	0	642	1,135
Nauplii	32,994	13,299	15,134	25,223	2,140	28,892
Cladocerans	2,318	3,547	23,962	3,240	3,965	935
Rotifers	324,590	112,261	21,019	213,553	35,312	19,605
Total w/ Rotifers	400,382	177,657	128,637	260,177	53,401	65,735
Total w/o Rotifers	75,792	65,396	27,465	46,624	18,089	46,130

Appendix Table 11. Density of zooplankton in 1972 and 1973 from prior study of the the south basin of Lake Osoyoos at Boundary Point by Allen and Meekin (1980).

DENSITY number/m^3	May	June	July	Aug.	Sept.
1972					
All zooplankton except rotifers: south basin, 2 m	12,529	20,272	23,064	5,423	
All zooplankton except rotifers: north basin, 2 m		26,770	12,169	6,997	1,134
1973					
All zooplankton except rotifers: south basin, 2 m	106,932	86,667	20,759		45,385
All zooplankton except rotifers: north basin: 2 m	194,272	340,000	40,910	48,148	9,195
Average of 1972-73 south basin	59,731	53,470	21,912	2,712	22,693
Average of 1972-73 north basin	194,272	366,770	53,079	55,145	9,195

Appendix 12.

LAKE OSOYOOS ZOOPLANKTON DATA — ***WATER Environmental Services, Inc.***
STATION: North Basin — **NOTE: Zoop net diam 20cm**
DATE: 18 Apr 95

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid		0.6-0.7	3,656	0	2.5	9,140	
Leptodiaptomus ashlandi	1.16	1.33	653	6	10	4,439	
Order Cyclopoida							
Copepodid		0.6-0.7	2,089	0	2	4,178	
Diacyclops bicuspidatus thomasi	1.00	1.12	131	3	5	653	
Nauplii (cal+cyc)		<.3	6,529	0	0.25	1,632	
Class Branchiopoda(cladocerans)							
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	7,834	0	0.02	157	
Keratella cochlearis		0.16	39,172	0	0.01	392	
Keratella hiemalis		0.14	1,306	0	0.04	52	
Keratella quadrata		0.18	26,115	0	0.069	1,802	
Notholca acuminata		0.30	1,306	0	0.1	131	
Type 2 (mostly illoricate virgates/incudates)							
Synchaeta sp.		0.13	3,917	0	0.017	67	
Type 3 (mostly malleoramates)							
Conochilus sp. (small)		0.10	1,306	0	0.01	13	
Filinia sp.		0.15	5,223	0	0.04	209	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	99,236	**99.24**	**22,865**	**22.86**
% Calanoid Copepods	4.34		59.39	
% Cyclopoid Copepods	2.24		21.13	
% Nauplii	6.58		7.14	
% Cladocerans	0.00		0.00	
% Rotifers	86.84		12.34	
% Dipterans	0.00		0.00	
Number of species	**10**			

LAKE OSOYOOS ZOOPLANKTON DATA — ***WATER Environmental Services, Inc.***
STATION: Boundary Pt. — **NOTE: Zoop net diam 20cm**
DATE: 18 Apr 95

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid		0.6-0.7	25,860	0	2.5	64,650	
Leptodiaptomus ashlandi	1.16	1.33	6,955	6	10	60,994	
Order Cyclopoida							
Copepodid		0.6-0.7	6,242	0	2	12,484	
Diacyclops bicuspidatus thomasi	1.00	1.12	1,427	3	5	7,134	
Nauplii (cal+cyc)		<.3	32,994	0	0.25	8,248	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	535	0	5	2,675	
Daphnia sp. (rnd-hlmt gal mend?)		1.70	535	8	25	13,376	
Bosmina longirostris (adult)		0.35	178	0	1	178	
Bosmina longirostris (juv)		0.28	178	0	0.7	125	
Chydorus sphaericus		0.28	892	0	0.65	580	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	28,535	0	0.02	571	
Keratella cochlearis		0.16	178,344	0	0.01	1,783	
Keratella quadrata		0.18	73,121	0	0.069	5,045	
Notholca foliacea		0.15	1,783	0	0.014	25	
Notholca squamula		0.14	1,783	0	0.009	16	
Type 2 (mostly illoricate virgates/incudates)							
Polyarthra sp. (small)		0.10	2,675	0	0.03	80	
Polyarthra sp. B		0.13	20,510	0	0.06	1,231	
Synchaeta sp. A		0.28	3,567	0	0.2	713	
Type 3 (mostly malleoramates)							
Conochilus sp.		0.15	10,701	0	0.025	268	
Conochilus sp. (small)		0.10	2,675	0	0.01	27	
Filinia sp.		0.15	892	0	0.04	36	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	400,382	**400.38**	**180,238**	**180.24**
% Calanoid Copepods	8.20		69.71	
% Cyclopoid Copepods	1.92		10.88	
% Nauplii	8.24		4.58	
% Cladocerans	0.58		9.40	
% Rotifers	81.07		5.43	
% Dipterans	0.00		0.00	
Number of species	15			

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: North Basin
DATE: 16 May 95

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid		0.6-0.7	21,497	0	2.5	53,742	
Leptodiaptomus ashlandi	1.16	1.33	12,739	6	10	95,541	
Epischura nevadensis	2.10		32	20	30	955	
Order Cyclopoida							
Copepodid		0.6-0.7	955	0	2	1,911	
Diacyclops bicuspidatus thomasi	1.00	1.12	637	3	5	2,548	
Nauplii (cal+cyc)		<.3	13,535	0	0.25	3,384	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	796	0	5	3,981	
Daphnia sp.		1.30	159	8	15	2,389	
Bosmina longirostris (juv)		0.28	159	0	0.7	111	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	9,554	0	0.02	191	
Keratella cochlearis		0.16	113,057	0	0.01	1,131	
Keratella quadrata		0.18	27,070	0	0.069	1,868	
Type 2 (mostly illoricate virgates/incudates)							
Polyarthra sp. B		0.15	7,962	0	0.06	478	
Polyarthra sp. B		0.18	796	0	0.09	72	
Synchaeta sp. A		0.25	796	0	0.1	80	
Type 3 (mostly malleoramates)							
Conochilus sp.		0.17	2,389	0	0.03	72	
Conochilus sp. (small)		0.10	1,592	0	0.01	16	
Filinia sp.		0.15	1,592	0	0.04	64	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	215,318	**215.32**	**168,532**	**168.53**
% Calanoid Copepods	15.91		89.15	
% Cyclopoid Copepods	0.74		2.65	
% Nauplii	6.29		2.01	
% Cladocerans	0.52		3.85	
% Rotifers	76.54		2.36	
% Dipterans	0.00		0.00	

Number of species 12

LAKE OSOYOOS ZOOPLANKTON DATA *WATER Environmental Services, Inc.*
STATION: Boundary Pt. **NOTE: Zoop net diam 20cm**
DATE: 16 May 95

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid		0.6-0.7	32,140	0	2.5	80,350	
Leptodiaptomus ashlandi	1.16	1.33	11,969	6	10	92,209	
Order Cyclopoida							
Copepodid		0.6-0.7	3,103	0	2	6,206	
Diacyclops bicuspidatus thomasi	1.00	1.12	1,330	3	5	6,650	
Nauplii (cal+cyc)		<.3	13,299	0	0.25	3,325	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	1,330	0	5	6,650	rounded helmets
Daphnia sp. (rnd-hlmt gal mend?)		1.70	665	8	25	16,624	
Daphnia sp.		1.12	222	8	10	2,217	
Bosmina longirostris (adult)		0.35	443	0	1.4	621	
Bosmina longirostris (juv)		0.28	887	0	0.7	621	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	8,866	0	0.02	177	
Keratella cochlearis		0.16	48,764	0	0.01	488	
Keratella quadrata		0.18	24,382	0	0.069	1,682	
Notholca foliacea		0.15	2,217	0	0.014	31	
Type 2 (mostly illoricate virgates/incudates)							
Asplanchna sp.		0.63	332	0	4	1,330	
Polyarthra sp. (small)		0.10	3,325	0	0.03	100	
Polyarthra sp. B		0.13	9,975	0	0.06	598	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	2,217	0	0.01	22	
Conochilus sp.		0.17	6,650	0	0.03	199	
Conochilus sp. (small)		0.10	5,541	0	0.01	55	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	177,657	**177.66**	**220,155**	**220.16**
% Calanoid Copepods	24.83		78.38	
% Cyclopoid Copepods	2.50		5.84	
% Nauplii	7.49		1.51	
% Cladocerans	2.00		12.14	
% Rotifers	63.19		2.13	
% Dipterans	0.00		0.00	
Number of species	**14**			

LAKE OSOYOOS ZOOPLANKTON DATA — ***WATER Environmental Services, Inc.***

STATION: North Basin — **NOTE: Zoop net diam 20cm**

DATE: 8 Jun 95

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	33,427	0	2.5	83,567	
Copepodid (Epischura)		<1.4	1,045	0	10	10,446	
Leptodiaptomus ashlandi	1.16	1.33	21,414	6	10	159,822	
Epischura nevadensis	2.10		1,045	20	30	31,338	
Order Cyclopoida							
Copepodid		0.6-0.7	6,790	0	2	13,580	
Diacyclops bicuspidatus thomasi	1.00	1.12	522	3	5	2,611	
Nauplii (cal+cyc)		<.3	31,860	0	0.25	7,965	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	6,790	0	5	33,949	
Daphnia sp. (rnd-hlmt gal mend?)	1.40	1.82	10,968	8	30	317,554	males present
Bosmina longirostris (juv)		0.28	522	0	0.7	366	
Diaphanosoma sp.		1.50	1,045	0	17	17,758	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	1,045	0	0.02	21	
Keratella cochlearis		0.16	12,013	0	0.01	120	
Type 2 (mostly illoricate virgates/incudates)							
Gastropus stylifer		0.13	2,089	0	0.03	63	
Gastropus stylifer(small)		0.10	1,567	0	0.014	22	
Polyarthra sp. (small)		0.10	1,567	0	0.03	47	
Polyarthra sp. B		0.15	1,045	0	0.06	63	
Synchaeta sp. A		0.21	522	0	0.06	31	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	1,567	0	0.01	16	
Conochilus sp.		0.17	2,089	0	0.03	63	
Conochilus sp. (small)		0.10	522	0	0.01	5	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	139,452	**139.45**	**679,405**	**679.40**
% Calanoid Copepods	40.82		41.97	
% Cyclopoid Copepods	5.24		2.38	
% Nauplii	22.85		1.17	
% Cladocerans	13.86		54.40	
% Rotifers	17.23		0.07	
% Dipterans	0.00		0.00	
Number of species	14			

LAKE OSOYOOS ZOOPLANKTON DATA — ***WATER Environmental Services, Inc.***
STATION: Boundary Pt. — **NOTE: Zoop net diam 20cm**
DATE: 8 Jun 95

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	25,643	0	2.5	64,108	
Copepodid (Epischura)		<1.4	841	0	10	8,408	
Leptodiaptomus ashlandi	1.16	1.33	34,471	6	10	258,955	
Epischura nevadensis	2.10		3,363	20	30	88,280	
Order Cyclopoida							
Copepodid		0.6-0.7	2,522	0	2	5,045	
Diacyclops bicuspidatus thomasi	1.00	1.12	1,682	3	5	7,567	
Nauplii (cal+cyc)		<.3	15,134	0	0.25	3,783	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	13,873	0	5	69,363	rounded helmets
Daphnia sp. (rnd-hlmt gal mend?)		1.82	6,726	8	30	201,783	high round helm
Diaphanosoma sp.		1.50	2,102	0	17	35,732	
Diaphanosoma sp. (small)		1.00	1,261	0	5	6,306	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	1,682	0	0.02	34	
Keratella cochlearis		0.16	5,045	0	0.01	50	
Keratella quadrata		0.18	841	0	0.069	58	
Trichotria sp.			841	0	0.02	17	
Type 2 (mostly illoricate virgates/incudates)							
Gastropus stylifer		0.13	1,682	0	0.03	50	
Gastropus stylifer(small)		0.10	5,045	0	0.014	71	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	3,363	0	0.01	34	
Conochilus sp.		0.20	2,522	0	0.03	76	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	128,637	**128.64**	**749,720**	**749.72**
% Calanoid Copepods	50.00		55.99	
% Cyclopoid Copepods	3.27		1.68	
% Nauplii	11.76		0.50	
% Cladocerans	18.63		41.77	
% Rotifers	16.34		0.05	
% Dipterans	0.00		0.00	
Number of species	12			

LAKE OSOYOOS ZOOPLANKTON DATA — ***WATER Environmental Services, Inc.***
STATION: North Basin — **NOTE: Zoop net diam 20cm**
DATE: 12 Jul 95

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	12,561	0	2.5	31,401	
Copepodid (Epischura)		<1.4	650	0	10	6,497	
Leptodiaptomus ashlandi	1.16	1.33	15,376	6	10	118,242	
Order Cyclopoida							
Copepodid		0.6-0.7	1,083	0	2	2,166	
Diacyclops bicuspidatus thomasi	1.00	1.12	433	3	5	2,166	
Nauplii (cal+cyc)		<.3	18,408	0	0.25	4,602	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	2,382	0	5	11,911	rounded helmets
Daphnia sp. (thorata?)	2.28	1.82	2,815	8	45	86,624	high round hlmts
Diaphanosoma birgei		1.75	433	0	24	10,395	
Diaphanosoma sp. (juv)		1.00	1,083	0	5	5,414	
Leptodora kindtii		10.00+	13	0	100	1,278	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	6,497	0	0.02	130	
Keratella cochlearis		0.16	6,497	0	0.01	65	
Keratella sp. (robust)		0.21	1,083	0	0.02	22	dessicated
Type 2 (mostly illoricate virgates/incudates)							
Polyarthra sp. (small)		0.10	27,070	0	0.03	812	
Polyarthra sp. B		0.15	3,248	0	0.06	195	
Synchaeta sp. A		0.18	1,083	0	0.06	65	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	16,242	0	0.01	162	
Others							
Undeter rotifer 1		0.10	2,166	0	0.01	22	

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	119,121	**119.12**	**282,168**	**282.17**
% Calanoid Copepods	24.00		55.34	
% Cyclopoid Copepods	1.27		1.53	
% Nauplii	15.45		1.63	
% Cladocerans	5.65		40.98	
% Rotifers	53.63		0.52	
% Dipterans	0.00		0.00	

Number of species in sample 14

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: Boundary Pt.
DATE: 12 Jul 95

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	4,372	0	2.5	10,930	
Leptodiaptomus ashlandi	1.16	1.33	13,789	6	10	108,963	
Order Cyclopoida							
Nauplii (cal+cyc)		<.3	25,223	0	0.25	6,306	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	336	0	5	1,682	rounded helmets
Daphnia sp. (thorata?)		2.45	1,177	8	50	58,854	high round hlmts
Diaphanosoma birgei		1.80	841	0	24	20,178	
Diaphanosoma birgei (juv)		1.00	841	0	5	4,204	
Leptodora kindtii		10.00+	45	0	100	4,456	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	8,408	0	0.02	168	
Keratella cochlearis		0.16	2,522	0	0.01	25	
Type 2 (mostly illoricate virgates/incudates)							
Gastropus stylifer		0.13	1,682	0	0.03	50	
Polyarthra sp. (small)		0.10	8,408	0	0.03	252	
Polyarthra sp. B		0.14	1,682	0	0.06	101	
Trichocerca sp. C		0.08	841	0	0.006	5	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	9,248	0	0.01	92	
Conochilus sp.		0.20	134,522	0	0.03	4,036	
Conochilus sp. (small)		0.10	46,242	0	0.01	462	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	260,177	**260.18**	**220,765**	**220.76**
% Calanoid Copepods	6.98		54.31	
% Cyclopoid Copepods	0.00		0.00	
% Nauplii	9.69		2.86	
% Cladocerans	1.25		40.48	
% Rotifers	82.08		2.35	
% Dipterans	0.00		0.00	

Number of species in sample 12

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: North Basin
DATE: 8 Aug 95

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	10,828	0	2.5	27,070	
Leptodiaptomus ashlandi	1.16	1.23	3,248	6	10	25,121	
Epischura nevadensis	2.10	2.17	433	20	30	10,828	
Order Cyclopoida							
Copepodid		0.6-0.7	541	0	2	1,083	
Diacyclops bicuspidatus thomasi	1.00	1.20	325	3	5.5	1,787	
Nauplii (cal+cyc)		<.3	12,994	0	0.25	3,248	
Class Branchiopoda(cladocerans)							
Diaphanosoma birgei		1.40	3,032	0	17	51,541	
Leptodora kindtii		10.00+	32	0	100	3,183	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	1,083	0	0.02	22	
Keratella cochlearis		0.16	1,083	0	0.01	11	
Type 2 (mostly illoricate virgates/incudates)							
Polyarthra sp. (small)		0.10	2,166	0	0.03	65	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	11,911	0	0.01	119	
Conochilus sp.		0.22	34,650	0	0.03	1,039	
Others							

	Total Density		**Total Dry Wt. Biomass**	
	#/m3	**#/L**	**ug/m3**	**ug/L**
	82,325	**82.32**	**125,118**	**125.12**
% Calanoid Copepods	17.62		50.37	
% Cyclopoid Copepods	1.05		2.29	
% Nauplii	15.78		2.60	
% Cladocerans	3.72		43.74	
% Rotifers	61.82		1.00	
% Dipterans	0.00		0.00	

Number of species in sample **10**

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: Boundary Pt.
DATE: 8 Aug 95

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	7,490	0	2.5	18,726	
Leptodiaptomus ashlandi	1.16	1.23	3,531	6	10	27,180	
Epischura nevadensis	2.10	2.17	321	20	30	7,490	
Order Cyclopoida							
Copepodid		0.6-0.7	428	0	2	856	
Diacyclops bicuspidatus thomasi	1.00	1.20	214	3	5.5	1,177	
Nauplii (cal+cyc)		<.3	2,140	0	0.25	535	
Class Branchiopoda(cladocerans)							
Daphnia sp. (thorata?)		1.61	321	8	25	8,025	high round hlmts
Bosmina longirostris (adult)		0.40	1,070	0	1.7	1,819	
Diaphanosoma birgei		1.40	2,568	0	17	43,659	
Leptodora kindtii		10.00+	6	0	100	642	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	1,070	0	0.02	21	
Keratella cochlearis		0.16	8,561	0	0.01	86	
Type 2 (mostly illoricate virgates/incudates)							
Polyarthra sp. (small)		0.10	6,420	0	0.03	193	
Trichocerca cylindrica		0.46	2,140	0	0.16	342	
Trichocerca sp. C		0.08	1,070	0	0.006	6	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	3,210	0	0.01	32	
Conochilus sp.		0:22	12,841	0	0.03	385	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	53,403	**53.40**	**111,175**	**111.18**
% Calanoid Copepods	21.24		48.03	
% Cyclopoid Copepods	1.20		1.83	
% Nauplii	4.01		0.48	
% Cladocerans	7.43		48.70	
% Rotifers	66.12		0.96	
% Dipterans	0.00		0.00	
Number of species in sample	**14**			

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: North Basin
DATE: 13 Sep 95

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	11,427	0	2.5	28,567	
Leptodiaptomus ashlandi	1.16	1.23	4,637	6	10	35,771	
Epischura nevadensis	2.10	2.17	83	20	30	1,656	
Order Cyclopoida							
Copepodid		0.6-0.7	1,159	0	2	2,318	
Diacyclops bicuspidatus thomasi	1.00	1.20	662	3	5.5	3,229	
Nauplii (cal+cyc)		<.3	19,873	0	0.25	4,968	
Class Branchiopoda(cladocerans)							
Bosmina longirostris (juv)		0.28	414	0	0.7	290	
Diaphanosoma birgei		1.40	331	0	17	5,631	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	828	0	0.02	17	
Keratella cochlearis		0.16	828	0	0.01	8	
Type 2 (mostly illoricate virgates/incudates)							
Polyarthra sp. (small)		0.10	1,656	0	0.03	50	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	3,312	0	0.01	33	
Conochilus sp.		0.16	7,452	0	0.025	186	
Others							

	Total Density		**Total Dry Wt. Biomass**	
	#/m3	**#/L**	**ug/m3**	**ug/L**
	52,662	**52.66**	**82,724**	**82.72**
% Calanoid Copepods	30.66		79.78	
% Cyclopoid Copepods	3.46		6.71	
% Nauplii	37.74		6.01	
% Cladocerans	1.42		7.16	
% Rotifers	26.73		0.36	
% Dipterans	0.00		0.00	

Number of species in sample **10**

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: Boundary Pt.
DATE: 13 Sep 95

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm

Taxon	Ave lngth male(mm)	Ave lngth fem (mm)	#/m3	Estim. Dry wt. ug/male	Estim. Dry wt. ug/fem	ug/m3	Comments
PHYLUM ARTHROPODA							
Subphylum Crustacea							
Subclass Copepoda							
Order Calanoida							
Copepodid (diaptomid)		0.6-0.7	7,223	0	2.5	18,057	
Leptodiaptomus ashlandi	1.16	1.23	7,739	6	10	54,688	
Epischura nevadensis	2.10	2.17	206	20	30	6,191	
Order Cyclopoida							
Copepodid		0.6-0.7	516	0	2	1,032	
Diacyclops bicuspidatus thomasi	1.00	1.20	619	3	5.5	3,405	
Nauplii (cal+cyc)		<.3	28,892	0	0.25	7,223	
Class Branchiopoda(cladocerans)							
Diaphanosoma birgei		1.50	929	0	18	16,716	
Leptodora kindtii		10.00+	6	0	100	640	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Keratella cochlearis		0.16	1,032	0	0.01	10	
Type 2 (mostly illoricate virgates/incudates)							
Polyarthra sp. (small)		0.10	12,382	0	0.03	371	
Type 3 (mostly malleoramates)							
Collotheca sp.		0.21	6,191	0	0.01	62	
Others							

	Total Density		**Total Dry Wt. Biomass**	
	#/m3	**#/L**	**ug/m3**	**ug/L**
	65,735	**65.74**	**108,396**	**108.40**
% Calanoid Copepods	23.07		72.82	
% Cyclopoid Copepods	1.73		4.09	
% Nauplii	43.95		6.66	
% Cladocerans	1.42		16.01	
% Rotifers	29.82		0.41	
% Dipterans	0.00		0.00	

Number of species in sample 8

LAKE OSOYOOS PHYTOPLANKTON
DATE: 04/18/95
STATION: North Basin Composite (1m,3m,6m) **SAMPLE STATUS: Lugol PRESERVED**

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Oscillatoria sp. (limnetica?)	9,240.00	19	174,082	very thin celled
Oscillatoria tenuis	2,240.00	129	288,096	
Taxon Subtotal	**11480**		**462,178**	
Chlorophyta				
Ankistrodesmus sp.	10.00	167	1,675	
Ankistrodesmus falcatus	1.00	1,103	1,103	
Closteriopsis longissima	2.00	14,067	28,134	
Elakatothrix gelatinosa	4.00	126	502	
filamentous green (Mougeotia?)	40.00	2,394	95,745	cells collapsed
colonial green(sph)	4.00	1,436	5,744	
Taxon Subtotal	**61**		**132,903**	
Chrysophyta				
Mallomonas sp. A	3.00	2,713	8,139	
Bacillariophyceae				
Asterionella formosa	208.00	371	77,264	
Cyclotella glomerata	4.00	1,407	5,627	
Cymbella sp.	1.00	6,029	6,029	
Fragilaria sp.	10.00	600	6,000	
Gomphonema sp.	1.00	3,231	3,231	
Melosira italica	10.00	2,261	22,608	
Melosira sp. B	14.00	1,780	24,925	
Stephanodiscus niagarae	23.00	95,745	2,202,132	
Synedra acus	7.00	2,638	18,463	
Synedra sp.	6.00	419	2,512	
Tabellaria fenestrata	4.00	4,800	19,200	
Taxon Subtotal	**291**		**2,396,130**	
Cryptophyta				
Cryptomonas ovata	1.00	3,165	3,165	
Cryptomonas sp.	14.00	1,758	24,618	
Rhodomonas sp.	44.00	251	11,053	
Taxon Subtotal	**59.00**		**38,836**	
Euglenophyta				
Pyrrhophyta				
Peridinium sp.	2.00	1,231	2,462	tiny cell
Gymnodinium sp.	3.00	18,840	56,520	
Taxon Subtotal	**5**		**58,982**	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**11896**	**Total Volume**	**3,089,029**	**3.09**
% Cyanophyta	**96.50**	% Cyanophyta	**14.96**	
% Chlorophyta	**0.51**	% Chlorophyta	**4.30**	
% Chrysophyta	**2.45**	% Chrysophyta	**77.57**	
% Cryptophyta	**0.50**	% Cryptophyta	**1.26**	
% Pyrrhophyta	**0.04**	% Pyrrhophyta	**1.91**	

Note: *=colony/ml **Note:**=filament/ml**

LAKE OSOYOOS PHYTOPLANKTON
DATE: 04/18/95
STATION: Boundary Point Composite (1m,3m,6m) **SAMPLE STATUS: Lugol PRESERVED**

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Aphanizomenon flos-aquae	169.00	118	19,942	no heterocysts
Oscillatoria sp. (limnetica?)	9,834.00	19	185,273	very thin celled
Oscillatoria tenuis	5,520.00	129	709,951	
Taxon Subtotal	**15523**		**915,166**	
Chlorophyta				
Ankistrodesmus sp.	2.00	515	1,029	
Ankistrodesmus falcatus	1.00	1,103	1,103	
Closteriopsis longissima	2.00	14,067	28,134	
Elakatothrix gelatinosa	2.00	126	251	
* *Scenedesmus quadricauda*	1.00	1,055	1,055	
filamentous green (Mougeotia?)	15.00	2,261	33,912	cells collapsed
colonial green(sph)	52.00	268	13,933	
Taxon Subtotal	**75**		**79,417**	
Chrysophyta				
Dinobryon bavaricum	1.00	1,172	1,172	
Dinobryon sp.	2.00	1,047	2,093	
Mallomonas sp. A	10.00	2,713	27,130	
Mallomonas sp. B	2.00	14,151	28,302	
chrysophyte unicell	1.00	10,467	10,467	
Bacillariophyceae				
Asterionella formosa	912.00	371	338,773	
Cyclotella glomerata	20.00	1,077	21,540	
Cyclotella sp.	2.00	6,154	12,309	
Cymbella sp.	1.00	6,029	6,029	
Fragilaria crotonensis	70.00	683	47,810	
Fragilaria sp.	10.00	600	6,000	
Melosira italica	82.00	2,261	185,386	
Melosira sp. B	58.00	1,407	81,590	
Stephanodiscus niagarae	13.00	95,745	1,244,683	
Synedra ulna	4.00	31,500	126,000	
Synedra acus	12.00	2,355	28,260	
Synedra sp.	6.00	293	1,758	
Synedra sp.	20.00	419	8,373	
Tabellaria fenestrata	10.00	4,800	48,000	
Taxon Subtotal	**1236**		**2,225,676**	
Cryptophyta				
Cryptomonas ovata	1.00	3,165	3,165	
Cryptomonas sp.	4.00	1,758	7,034	
Rhodomonas sp.	25.00	251	6,280	
Chroomonas sp.	6.00	879	5,275	
Taxon Subtotal	**36.00**		**21,754**	
Euglenophyta				
Pyrrhophyta				
Peridinium sp.	4.00	1,231	4,924	tiny cell
Gymnodinium sp.	1.00	18,840	18,840	
Taxon Subtotal	**5**		**23,764**	
			(um3/ml)	**(mm3/L)**
Total Number/ml	**16875**	**Total Volume**	**3,265,777**	**3.27**
% Cyanophyta	**91.99**	% Cyanophyta	**28.02**	
% Chlorophyta	**0.44**	% Chlorophyta	**2.43**	
% Chrysophyta	**7.32**	% Chrysophyta	**68.15**	
% Cryptophyta	**0.21**	% Cryptophyta	**0.67**	
% Pyrrhophyta	**0.03**	% Pyrrhophyta	**0.73**	

Note: *=colony/ml **Note:**=filament/ml**

12-14

LAKE OSOYOOS PHYTOPLANKTON
DATE: 05/16/95
STATION: North Basin Composite (1m,3m,6m) **SAMPLE STATUS: Lugol PRESERVED**

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Oscillatoria sp. (limnetica?)	120.00	19	2,261	very thin celled
Oscillatoria tenuis	1,248.00	129	160,511	
Taxon Subtotal	**1368**		**162,772**	
Chlorophyta				
Clamydomonas sp.	1.00	1,876	1,876	
Quadrigula sp.	3.00	340	1,021	
filamentous green (Mougeotia?)	48.00	2,394	114,894	cells collapsed
Taxon Subtotal	**52**		**117,790**	
Chrysophyta				
Dinobryon bavaricum	148.00	1,340	198,281	
Dinobryon sp.	3.00	1,047	3,140	
Mallomonas sp. A	9.00	3,014	27,130	
chrysophyte unicell	3.00	8,373	25,120	
Bacillariophyceae				
Asterionella formosa	160.00	371	59,434	
Cyclotella sp.	1.00	6,154	6,154	
Fragilaria crotonensis	10.00	683	6,830	
Melosira italica	2.00	2,261	4,522	
Melosira sp. B	6.00	1,780	10,682	
Stephanodiscus niagarae	2.00	43,175	86,350	
Stephanodiscus niagarae	4.00	150,720	602,880	
Synedra sp.	1.00	293	293	
Synedra sp.	1.00	419	419	
Taxon Subtotal	**350**		**1,031,234**	
Cryptophyta				
Cryptomonas sp.	19.00	1,758	33,410	
Rhodomonas sp.	40.00	251	10,048	
Chroomonas sp.	18.00	879	15,826	
Taxon Subtotal	**77.00**		**59,283**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**1847**	**Total Volume**	**1,371,079**	**1.37**
% Cyanophyta	**74.07**	% Cyanophyta	**11.87**	
% Chlorophyta	**2.82**	% Chlorophyta	**8.59**	
% Chrysophyta	**18.95**	% Chrysophyta	**75.21**	
% Cryptophyta	**4.17**	% Cryptophyta	**4.32**	

Note: *=colony/ml **Note:**=filament/ml**

LAKE OSOYOOS PHYTOPLANKTON
DATE: 05/16/95
STATION: Boundary Point Composite (1m,3m,6m) **SAMPLE STATUS: Lugol PRESERVED**

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Aphanizomenon flos-aquae	39.00	118	4,602	no heterocysts
Gomphosphaeria lacustris	40.00	16	659	
Oscillatoria sp. (limnetica?)	1,320.00	19	24,869	very thin celled
Oscillatoria tenuis	2,976.00	129	382,756	
Taxon Subtotal	**4375**		**412,887**	
Chlorophyta				
Ankistrodesmus sp.	1.00	167	167	
Ankistrodesmus falcatus	1.00	735	735	
Clamydomonas sp.	1.00	1,876	1,876	
Gloeocystis sp.	4.00	335	1,340	
filamentous green (Mougeotia?)	120.00	2,394	287,235	cells collapsed
colonial green(sph)	24.00	180	4,308	
Taxon Subtotal	**151**		**295,661**	
Chrysophyta				
Dinobryon bavaricum	714.00	1,407	1,004,398	
Dinobryon sp.	47.00	1,047	49,193	
Mallomonas sp. A	20.00	2,713	54,259	
Bacillariophyceae				
Asterionella formosa	352.00	371	130,755	
Cyclotella glomerata	6.00	1,608	9,646	
Cyclotella sp.	5.00	3,140	15,700	
Cymbella sp.	1.00	20,515	20,515	large cell
Fragilaria crotonensis	115.00	683	78,545	
Melosira italica	4.00	2,261	9,043	
Melosira sp. B	4.00	1,653	6,613	
Stephanodiscus niagarae	7.00	95,745	670,214	
Synedra ulna	3.00	15,900	47,700	
Synedra sp.	20.00	419	8,373	
Taxon Subtotal	**1298**		**2,104,955**	
Cryptophyta				
Cryptomonas sp.	15.00	1,758	26,376	
Rhodomonas sp.	30.00	251	7,536	
Taxon Subtotal	**45.00**		**33,912**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**5869**	**Total Volume**	**2,847,414**	**2.85**
% Cyanophyta	**74.54**	% Cyanophyta	**14.50**	
% Chlorophyta	**2.57**	% Chlorophyta	**10.38**	
% Chrysophyta	**22.12**	% Chrysophyta	**73.93**	
% Cryptophyta	**0.77**	% Cryptophyta	**1.19**	

Note: *=colony/ml **Note:**=filament/ml**

12-16

LAKE OSOYOOS PHYTOPLANKTON
DATE: 06/8/95
STATION: North Basin Composite **SAMPLE STATUS: Lugol PRESERVED**

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena sp.	10.00	160	1,596	
Aphanizomenon flos-aquae	247.00	118	29,146	few heterocysts
Gomphosphaeria lacustris	40.00	16	659	
Oscillatoria sp. (limnetica?)	264.00	19	4,974	very thin celled
Oscillatoria tenuis	816.00	129	104,949	
Taxon Subtotal	**1377**		**141,324**	
Chlorophyta				
Clamydomonas sp.	3.00	1,876	5,627	
Closteriopsis longissima	1.00	21,101	21,101	
filamentous green (Mougeotia?)	79.00	2,394	189,096	cells collapsed
colonial green(sph)	96.00	382	36,625	
Taxon Subtotal	**179**		**252,449**	
Chrysophyta				
Mallomonas sp. A	18.00	4,103	73,853	
Mallomonas sp. A	12.00	1,809	21,704	
chrysophyte unicell	32.00	8,373	267,947	
Bacillariophyceae				
Asterionella formosa	48.00	371	17,830	
Fragilaria crotonensis	85.00	683	58,055	
Melosira italica	2.00	2,261	4,522	
Stephanodiscus niagarae	2.00	43,175	86,350	
Taxon Subtotal	**199**		**530,260**	
Cryptophyta				
Cryptomonas sp.	2.00	1,758	3,517	
Rhodomonas sp.	242.00	251	60,790	
Chroomonas sp.	5.00	879	4,396	
Taxon Subtotal	**249.00**		**68,703**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**2004**	**Total Volume**	**992,736**	**0.99**
% Cyanophyta	**68.71**	% Cyanophyta	**14.24**	
% Chlorophyta	**8.93**	% Chlorophyta	**25.43**	
% Chrysophyta	**9.93**	% Chrysophyta	**53.41**	
% Cryptophyta	**12.43**	% Cryptophyta	**6.92**	

Note: *=colony/ml **Note:**=filament/ml**

12-17

LAKE OSOYOOS PHYTOPLANKTON
DATE: 06/8/95
STATION: Boundary Point Composite **SAMPLE STATUS: Lugol PRESERVED**

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena sp.	170.00	160	27,128	
Aphanizomenon flos-aquae	143.00	118	16,874	few heterocysts
Gomphosphaeria lacustris	40.00	16	659	
** *Lyngbya sp.*	1.00	31,761	31,761	1 filament
Oscillatoria sp. (limnetica?)	330.00	19	6,217	very thin celled
Oscillatoria tenuis	352.00	129	45,272	
Taxon Subtotal	**1036**		**127,912**	
Chlorophyta				
Clamydomonas sp.	1.00	1,876	1,876	
Oocystis sp.	2.00	2,374	4,748	
filamentous green (Mougeotia?)	36.00	2,394	86,170	cells collapsed
colonial green(sph)	40.00	268	10,718	
Taxon Subtotal	**79**		**103,512**	
Chrysophyta				
Dinobryon sp.	1.00	1,047	1,047	
Mallomonas sp. A	3.00	3,014	9,043	
chrysophyte unicell	6.00	8,373	50,240	
chrysophyte unicell	1.00	4,823	4,823	
Bacillariophyceae				
Asterionella formosa	32.00	371	11,887	
Cyclotella sp.	4.00	6,154	24,618	
Fragilaria crotonensis	80.00	683	54,640	
Melosira sp. B	2.00	1,653	3,306	
Synedra sp.	6.00	293	1,758	
Taxon Subtotal	**135**		**161,362**	
Cryptophyta				
Cryptomonas sp.	29.00	1,758	50,994	
Rhodomonas sp.	358.00	251	89,930	
Chroomonas sp.	20.00	791	15,826	
Taxon Subtotal	**407.00**		**156,749**	
Euglenophyta				
Pyrrhophyta				
Peridinium sp.	1.00	43,175	43,175	
Peridinium sp.	1.00	1,231	1,231	tiny cell
Ceratium hirundinella	1.00	60,000	60,000	
Taxon Subtotal	**3**		**104,406**	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**1660**	**Total Volume**	**653,940**	**0.65**
% Cyanophyta	**62.41**	% Cyanophyta	**19.56**	
% Chlorophyta	**4.76**	% Chlorophyta	**15.83**	
% Chrysophyta	**8.13**	% Chrysophyta	**24.68**	
% Cryptophyta	**24.52**	% Cryptophyta	**23.97**	
% Pyrrhophyta	**0.18**	% Pyrrhophyta	**15.97**	

Note: *=colony/ml **Note:**=filament/ml**

LAKE OSOYOOS PHYTOPLANKTON
DATE: 07/12/95
STATION: North Basin Composite(1,3,6m) SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena sp.	120.00	79	9,420	slight flex
Anabaena sp. A (straight)	400.00	382	152,604	no akinetes
Aphanizomenon flos-aquae	182.00	118	21,476	few heterocysts
Aphanocapsa sp.	750.00	4	3,140	
Chroococcus sp.	8.00	182	1,459	
Gomphosphaeria lacustris	160.00	16	2,638	
Lyngbya-like (limnetica?)	3,288.00	19	61,946	thin-cell,faint sheath evid
Oscillatoria tenuis	960.00	113	108,518	
Taxon Subtotal	**5868**		**361,201**	
Chlorophyta				
Ankistrodesmus sp.	8.00	209	1,675	
Clamydomonas sp.	8.00	1,876	15,005	
Closteriopsis longissima	5.00	15,826	79,128	
Elakatothrix gelatinosa	2.00	126	251	
Nephrocytium sp.	4.00	536	2,144	
* *Oocystis sp.*	8.00	469	3,751	
Staurastrum pingue	1.00	3,939	3,939	
filamentous green (Mougeotia?)	378.00	1,696	640,937	cells collapsed
colonial green(sph)	60.00	382	22,891	flagel cells
Taxon Subtotal	**474**		**769,720**	
Chrysophyta				
Dinobryon sociale	30.00	916	27,475	
Mallomonas sp. A	1.00	4,103	4,103	
Mallomonas sp. A	12.00	2,562	30,747	
Bacillariophyceae				
Asterionella formosa	8.00	371	2,972	
Cyclotella glomerata	3.00	1,407	4,220	
Cyclotella sp.	1.00	6,154	6,154	
Fragilaria crotonensis	15.00	683	10,245	
Navicula sp.	1.00	2,093	2,093	
Synedra acus	1.00	3,580	3,580	
Synedra sp.	12.00	293	3,517	
Synedra sp.	2.00	461	921	
Taxon Subtotal	**86**		**96,027**	
Cryptophyta				
Cryptomonas sp.	53.00	1,524	80,769	
Rhodomonas sp.	500.00	251	125,600	
Chroomonas sp.	40.00	879	35,168	
Taxon Subtotal	**593.00**		**241,537**	
Euglenophyta				
Pyrrhophyta				
dinoflagellate	3.00	23,550	70,650	
Taxon Subtotal	**3**		**70,650**	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**7024**	**Total Volume**	**1,539,135**	**1.54**
% Cyanophyta	**83.54**	% Cyanophyta	**23.47**	
% Chlorophyta	**6.75**	% Chlorophyta	**50.01**	
% Chrysophyta	**1.22**	% Chrysophyta	**6.24**	
% Cryptophyta	**8.44**	% Cryptophyta	**15.69**	
% Pyrrhophyta	**0.04**	% Pyrrhophyta	**4.59**	

Note: *=colony/ml **Note:**=filament/ml**

12-19

LAKE OSOYOOS PHYTOPLANKTON
DATE: 07/12/95
STATION: Boundary Point Composite (1,3,6m$AMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena sp.	1,720.00	50	86,413	loose coil,no hetero/akin
Anabaena sp. A (straight)	920.00	382	350,989	few heterocysts
Aphanizomenon flos-aquae	78.00	118	9,204	few heterocysts
Aphanocapsa sp.	1,000.00	4	4,187	
Chroococcus sp.	20.00	124	2,487	
Gomphosphaeria lacustris	80.00	16	1,319	
Lyngbya Birgei	500.00	935	467,585	1 filament
Lyngbya-like. (limnetica?)	2,328.00	19	43,860	thin-cell,faint sheath evid
Taxon Subtotal	**6646**		**966,043**	
Chlorophyta				
Ankistrodesmus sp.	1.00	251	251	
Eudorina elegans	16.00	180	2,872	
* *Oocystis sp.*	10.00	402	4,019	
Quadrigula sp.	8.00	340	2,721	
* *Scenedesmus sp. B*	2.00	1,675	3,349	
Staurastrum pingue	1.00	3,939	3,939	
filamentous green (Mougeotia?)	66.00	1,696	111,910	cells collapsed
colonial green nanno (ell)	8.00	50	402	
colonial green(sph)	32.00	268	8,574	
Taxon Subtotal	**144**		**138,038**	
Chrysophyta				
Dinobryon sociale	5.00	742	3,709	
Mallomonas sp. A	1.00	3,014	3,014	
Bacillariophyceae				
Cyclotella sp.	1.00	6,154	6,154	
Cyclotella sp.	2.00	1,608	3,215	
Cymbella sp.	1.00	15,072	15,072	
Fragilaria crotonensis	20.00	683	13,660	
Melosira sp. B	36.00	1,653	59,516	
Rhizolenia sp.	1.00	43,960	43,960	
Synedra acus	1.00	1,832	1,832	
Synedra sp.	5.00	293	1,465	
Synedra sp.	6.00	461	2,763	
Tabellaria fenestrata	6.00	5,760	34,560	
Taxon Subtotal	**85**		**188,921**	
Cryptophyta				
Cryptomonas sp.	12.00	1,407	16,881	
Rhodomonas sp.	1,727.00	251	433,822	
Chroomonas sp.	25.00	791	19,782	
Taxon Subtotal	**1,764.00**		**470,485**	
Euglenophyta				
Pyrrhophyta				
dinoflagellate	1.00	26,376	26,376	
Ceratium hirundinella	2.00	60,000	120,000	
Taxon Subtotal	**3**		**146,376**	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**8642**	**Total Volume**	**1,909,863**	**1.91**
% Cyanophyta	**76.90**	% Cyanophyta	**50.58**	
% Chlorophyta	**1.67**	% Chlorophyta	**7.23**	
% Chrysophyta	**0.98**	% Chrysophyta	**9.89**	
% Cryptophyta	**20.41**	% Cryptophyta	**24.63**	
% Pyrrhophyta	**0.03**	% Pyrrhophyta	**7.66**	

Note: *=colony/ml **Note:**=filament/ml**

12-20

LAKE OSOYOOS PHYTOPLANKTON
DATE: 08/8/95
STATION: North Basin Comp (1,3,6m)

WATER Environmental Services, Inc.

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena planktonica	1,700.00	382	648,567	few heterocysts
Aphanizomenon flos-aquae	91.00	118	10,738	few heterocysts
Aphanocapsa sp.	4,800.00	4	20,096	
Chroococcus sp.	24.00	228	5,471	
Gomphosphaeria aponina	32.00	33	1,072	
Gomphosphaeria lacustris	840.00	16	13,847	
Lyngbya-like. (limnetica?)	52,800.00	19	994,752	thin-cell,faint sheath evid
Oscillatoria tenuis	480.00	129	61,735	
Taxon Subtotal	**60767**		**1,756,278**	
Chlorophyta				
Ankistrodesmus sp.	6.00	84	502	
Ankistrodesmus sp.	8.00	327	2,617	
Ankistrodesmus falcatus	1.00	882	882	
Clamydomonas sp.	3.00	1,641	4,924	
Crucigenia rectangularis	8.00	151	1,206	
* *Crucigenia quadrata*	1.00	523	523	1 colony
Quadrigula sp.	10.00	340	3,402	
filamentous green (Mougeotia?)	340.00	1,696	576,504	cells collapsed
colonial green(sph)	20.00	113	2,261	
Taxon Subtotal	**397**		**592,820**	
Chrysophyta				
Dinobryon bavaricum	2.00	1,407	2,813	
Dinobryon sociale	2.00	742	1,484	
Mallomonas sp. A	9.00	2,713	24,417	
small flagel chrysophyte	14.00	1,641	22,976	
Bacillariophyceae				
Asterionella formosa	16.00	371	5,943	
Cyclotella sp.	3.00	3,140	9,420	
Rhizolenia sp.	2.00	22,106	44,211	
Synedra acus	4.00	2,290	9,158	
Synedra sp.	2.00	293	586	
Tabellaria fenestrata	2.00	5,376	10,752	
Taxon Subtotal	**56**		**131,761**	
Cryptophyta				
Cryptomonas erosa	16.00	1,758	28,134	
Cryptomonas sp.	14.00	879	12,309	
Cryptomonas sp. (big)	1.00	3,768	3,768	
Rhodomonas sp.	220.00	251	55,264	
Chroomonas sp.	20.00	791	15,826	
Taxon Subtotal	**271.00**		**115,301**	
Euglenophyta				
Pyrrhophyta				
Peridinium sp.	1.00	1,231	1,231	tiny cell
Taxon Subtotal	**1**		**1,231**	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**61492**	**Total Volume**	**2,597,391**	**2.60**
% Cyanophyta	**98.82**	% Cyanophyta	**67.62**	
% Chlorophyta	**0.65**	% Chlorophyta	**22.82**	
% Chrysophyta	**0.09**	% Chrysophyta	**5.07**	
% Cryptophyta	**0.44**	% Cryptophyta	**4.44**	
% Pyrrhophyta	**0.00**	% Pyrrhophyta	**0.05**	

Note: *=colony/ml **Note:**=filament/ml**

12-21

LAKE OSOYOOS PHYTOPLANKTON
DATE: 08/8/95
STATION: Boundary Point Comp (1,3,6m)

WATER Environmental Services, Inc.

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena sp.	1,780.00	50	89,427	loose coil,no hetero
Anabaena planktonica	3,850.00	382	1,468,814	few heterocysts
Anabaena sp. B	195.00	42	8,164	very thin-celled
Aphanizomenon flos-aquae	312.00	118	36,816	few heterocysts
Aphanocapsa sp.	3,000.00	4	12,560	
Chroococcus sp.	40.00	228	9,119	
Gomphosphaeria aponina	32.00	33	1,072	
Gomphosphaeria lacustris	400.00	16	6,594	
Lyngbya Birgei	4,320.00	935	4,039,937	
Microcystis aeruginosa	200.00	14	2,826	
Lyngbya-like. (limnetica?)	28,380.00	19	534,679	thin-cell,faint sheath evid
Oscillatoria tenuis	496.00	129	63,793	
Taxon Subtotal	**43005**		**6,273,800**	
Chlorophyta				
Ankistrodesmus falcatus	2.00	809	1,617	
Clamydomonas sp.	6.00	1,641	9,847	
Crucigenia rectangularis	16.00	151	2,412	
Gloeocystis sp.	8.00	132	1,055	
* *Oocystis sp.*	8.00	680	5,443	
Pandorina morum	48.00	335	16,077	
Quadrigula sp.	12.00	340	4,082	
* *Scenedesmus sp. A*	2.00	2,462	4,924	
* *Scenedesmus sp. B*	4.00	938	3,751	
Staurastrum pingue	5.00	3,682	18,412	
filamentous green (Mougeotia?)	460.00	1,413	649,980	cells collapsed
Taxon Subtotal	**571**		**717,599**	
Chrysophyta				
Mallomonas sp. A	3.00	2,412	7,235	
Bacillariophyceae				
Cyclotella sp.	4.00	3,140	12,560	
Fragilaria crotonensis	80.00	683	54,640	
Rhizolenia sp.	1.00	43,960	43,960	
Synedra acus	6.00	2,067	12,403	
Synedra sp.	4.00	461	1,842	
Taxon Subtotal	**98**		**132,640**	
Cryptophyta				
Cryptomonas erosa	4.00	1,758	7,034	
Cryptomonas sp.	6.00	879	5,275	
Rhodomonas sp.	220.00	251	55,264	
Taxon Subtotal	**230.00**		**67,573**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**43904**	**Total Volume**	**7,191,611**	**7.19**
% Cyanophyta	**97.95**	% Cyanophyta	**87.24**	
% Chlorophyta	**1.30**	% Chlorophyta	**9.98**	
% Chrysophyta	**0.22**	% Chrysophyta	**1.84**	
% Cryptophyta	**0.52**	% Cryptophyta	**0.94**	

Note: *=colony/ml **Note:**=filament/ml**

12-22

LAKE OSOYOOS PHYTOPLANKTON
DATE: 09/13/95
STATION: North Basin Comp (1,3,6m) SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena circinalis	60.00	150	9,027	reg coil
Anabaena planktonica	230.00	301	69,331	few heterocysts
Anabaena planktonica-like	117.00	170	19,839	elongate cells,few hetero
Aphanizomenon flos-aquae	403.00	118	47,554	few heterocysts
Aphanocapsa sp.	1,000.00	4	4,187	
Chroococcus sp.	40.00	182	7,295	
Gomphosphaeria lacustris	120.00	16	1,978	
Lyngbya-like. (limnetica?)	32,208.00	19	606,799	thin-cell,faint sheath evid
Oscillatoria tenuis	272.00	129	34,983	
Taxon Subtotal	**34450**		**800,993**	
Chlorophyta				
Ankistrodesmus sp.	2.00	327	654	
Clamydomonas sp.	10.00	1,641	16,412	
Crucigenia rectangularis	8.00	151	1,206	
* *Eudorina elegans*	1.00	4,187	4,187	small colony
Gloeocystis sp.	8.00	132	1,055	
Quadrigula sp.	4.00	340	1,361	
* *Scenedesmus sp. C*	1.00	262	262	
filamentous green (Mougeotia?)	26.00	1,696	44,086	cells collapsed
colonial green(sph)	16.00	150	2,407	
colonial green(sph)	20.00	268	5,359	
Taxon Subtotal	**96**		**76,988**	
Chrysophyta				
Dinobryon sociale	2.00	742	1,484	
Mallomonas sp. A	3.00	2,110	6,330	
small flagel chrysophyte	5.00	1,641	8,206	
Bacillariophyceae				
Cyclotella sp.	2.00	3,140	6,280	
Fragilaria crotonensis	5.00	683	3,415	
Rhizolenia sp.	2.00	6,594	13,188	
Synedra sp.	6.00	461	2,763	stellate
Taxon Subtotal	**25**		**41,666**	
Cryptophyta				
Cryptomonas erosa	8.00	1,758	14,067	
Cryptomonas sp.	6.00	879	5,275	
Rhodomonas sp.	385.00	251	96,712	
Chroomonas sp.	30.00	791	23,738	
Taxon Subtotal	**429.00**		**139,793**	
Euglenophyta				
Pyrrhophyta				
dinoflagellate	5.00	6,359	31,793	
Taxon Subtotal	**5**		**31,793**	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**35005**	**Total Volume**	**1,091,231**	**1.09**
% Cyanophyta	**98.41**	% Cyanophyta	**73.40**	
% Chlorophyta	**0.27**	% Chlorophyta	**7.06**	
% Chrysophyta	**0.07**	% Chrysophyta	**3.82**	
% Cryptophyta	**1.23**	% Cryptophyta	**12.81**	
% Pyrrhophyta	**0.01**	% Pyrrhophyta	**2.91**	

Note: *=colony/ml **Note:**=filament/ml**

12-23

LAKE OSOYOOS PHYTOPLANKTON

WATER Environmental Services, Inc.

DATE: 09/13/95

STATION: Boundary Point Comp (1,3,6m) SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Anabaena circinalis	385.00	150	57,926	reg coil
Anabaena planktonica	850.00	382	324,284	few heterocysts
Anabaena planktonica-like	30.00	170	5,087	elongate cells,few hetero
Anabaena sp. B	533.00	42	22,315	very thin-celled
Aphanizomenon flos-aquae	884.00	118	104,312	few heterocysts
Aphanocapsa sp.	1,400.00	4	5,861	
Aphanothece sp.	200.00	6	1,256	
Chroococcus sp.	32.00	182	5,836	
Gomphosphaeria lacustris	120.00	16	1,978	
Lyngbya-like. (limnetica?)	41,250.00	19	777,150	thin-cell,faint sheath evid
Oscillatoria tenuis	128.00	129	16,463	
Taxon Subtotal	**45812**		**1,322,467**	
Chlorophyta				
Ankistrodesmus sp.	8.00	393	3,140	
Arthrodesmus sp.	2.00	4,103	8,206	
Clamydomonas sp.	27.00	1,641	44,312	
Cosmarium sp. A	7.00	2,093	14,653	
Crucigenia rectangularis	8.00	231	1,846	
Elakatothrix gelatinosa	4.00	126	502	
Gloeocystis sp.	8.00	132	1,055	
* *Oocystis sp. (unicell)*	2.00	5,443	10,885	
Quadrigula sp.	10.00	340	3,402	
* *Scenedesmus sp. C*	1.00	262	262	
filamentous green (Mougeotia?)	514.00	1,413	726,282	cells collapsed
green lamellate unicell(sph)	4.00	904	3,617	
colonial green(sph)	24.00	904	21,704	
Taxon Subtotal	**619**		**839,866**	
Chrysophyta				
Dinobryon sociale	2.00	742	1,484	
Mallomonas sp. A	3.00	2,412	7,235	
small flagel chrysophyte	20.00	2,144	42,871	
Bacillariophyceae				
Cyclotella sp.	1.00	3,140	3,140	
Fragilaria crotonensis	65.00	683	44,395	
Melosira italica	22.00	2,041	44,902	
Rhizolenia sp.	1.00	15,386	15,386	
Synedra acus	3.00	2,290	6,869	
Synedra sp.	2.00	544	1,089	
Synedra sp.	24.00	461	11,053	stellate
Taxon Subtotal	**143**		**178,423**	
Cryptophyta				
Cryptomonas erosa	25.00	1,524	38,099	
Cryptomonas sp.	41.00	879	36,047	
Rhodomonas sp.	275.00	251	69,080	
Chroomonas sp.	12.00	565	6,782	
Taxon Subtotal	**353.00**		**150,008**	
Euglenophyta				
Pyrrhophyta				
Peridinium sp.	2.00	1,231	2,462	tiny cell
dinoflagellate	5.00	6,005	30,026	
Taxon Subtotal	**7**		**32,488**	
			(um3/ml)	**(mm3/L)**
Total Number/ml	**46934**	**Total Volume**	**2,523,252**	**2.52**
% Cyanophyta	**97.61**	% Cyanophyta	**52.41**	
% Chlorophyta	**1.32**	% Chlorophyta	**33.29**	
% Chrysophyta	**0.30**	% Chrysophyta	**7.07**	
% Cryptophyta	**0.75**	% Cryptophyta	**5.95**	
% Pyrrhophyta	**0.01**	% Pyrrhophyta	**1.29**	

Note: *=colony/ml **Note:**=filament/ml**

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APPENDIX 13

Lake Osoyoos May 1995 Survey

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 051695 120927 : OKANOGAN RIVER INFLOW								
51695	121121.0	12.9	8.5	220.0	9.2	329.0	0.3	15.4
Annotation at 051695 110322 : NORTH BASIN LAKE OSOYOOS (MONASHEE COOP)								
Variable or Calibration changed at 051695 110442								
51695	110546.0	14.3	8.4	253.0	9.6	337.0	0.5	15.5
51695	110620.0	13.4	8.3	255.0	9.4	340.0	2.0	15.5
51695	110651.0	13.1	8.3	261.0	9.3	341.0	4.0	15.5
51695	110735.0	12.6	8.3	260.0	9.2	343.0	6.0	15.5
51695	110808.0	12.4	8.2	256.0	9.1	345.0	8.0	15.5
51695	110832.0	11.4	8.2	263.0	9.1	346.0	10.0	15.5
51695	110905.0	11.0	8.2	264.0	9.2	347.0	12.0	15.5
51695	110933.0	10.3	8.2	266.0	9.2	348.0	14.0	15.5
51695	111022.0	9.8	8.1	270.0	9.2	350.0	16.0	15.4
51695	111104.0	9.1	8.1	276.0	9.3	350.0	18.0	15.4
51695	111139.0	8.1	8.1	284.0	9.3	352.0	20.0	15.4
51695	111258.0	7.5	8.1	288.0	9.3	353.0	22.0	15.4
51695	111323.0	7.3	8.1	289.0	9.3	354.0	24.0	15.4
51695	111348.0	6.9	8.0	290.0	9.3	355.0	26.0	15.4
51695	111426.0	6.9	8.0	291.0	9.3	355.0	28.0	15.4
51695	111453.0	6.8	8.0	292.0	9.2	355.0	30.0	15.4
51695	111537.0	6.7	8.0	292.0	9.2	356.0	32.0	15.4
51695	111618.0	6.7	8.0	293.0	9.2	356.0	34.0	15.4
51695	111641.0	6.7	8.0	292.0	9.2	356.0	36.0	15.4
51695	111712.0	6.7	8.0	293.0	9.2	356.0	38.0	15.3
51695	111740.0	6.7	8.0	292.0	9.2	356.0	40.0	15.4
51695	111810.0	6.6	8.0	293.0	9.2	356.0	42.0	15.4
51695	111845.0	6.6	8.0	293.0	9.2	356.0	44.0	15.4
51695	111923.0	6.6	8.0	293.0	9.2	357.0	46.0	15.4
51695	112006.0	6.6	8.0	293.0	9.1	357.0	48.0	15.4
51695	112028.0	6.6	8.0	293.0	9.1	357.0	50.0	15.4
average	111306.3	8.7	8.1	280.2	9.2	351.3	25.0	15.4
Annotation at 051695 124321 : BOUNDARY POINT								
51695	124327.0	15.8	8.7	296.0	9.6	314.0	0.5	15.3
51695	124420.0	15.1	8.7	290.0	9.6	317.0	2.0	15.4
51695	124453.0	14.1	8.6	283.0	9.6	321.0	4.0	15.4
51695	124517.0	13.7	8.6	281.0	9.6	323.0	6.0	15.3
51695	124606.0	13.3	8.5	283.0	9.5	325.0	8.0	15.3
51695	124703.0	12.3	8.5	295.0	8.8	328.0	10.0	15.3
51695	124752.0	11.8	8.4	298.0	8.4	331.0	12.0	15.3
51695	124858.0	11.3	8.3	300.0	8.0	334.0	14.0	15.3
51695	124951.0	10.7	8.3	302.0	7.6	337.0	16.0	15.3
51695	125045.0	10.4	8.2	304.0	7.4	339.0	18.0	15.3
51695	125218.0	10.0	8.2	305.0	7.1	342.0	20.0	15.3
average	115187.3	9.9	8.2	284.3	9.1	344.6	10.0	15.3
Annotation at 051695 133148 : MIDWAY SOUTH BASIN								
51695	133759.0	16.4	8.7	295.0	9.4	321.0	0.5	15.3
51695	133835.0	15.2	8.7	292.0	9.6	323.0	2.0	15.3
51695	133915.0	14.7	8.6	290.0	9.6	325.0	4.0	15.2
51695	133946.0	14.2	8.6	295.0	9.5	326.0	6.0	15.3
51695	134017.0	13.3	8.6	294.0	9.2	329.0	8.0	15.3
51695	134107.0	12.5	8.5	296.0	8.8	333.0	10.0	15.3
51695	134212.0	10.7	8.3	303.0	7.4	342.0	12.0	15.3
51695	134256.0	10.2	8.2	304.0	7.2	344.0	14.0	15.3
51695	134424.0	10.0	8.2	305.0	7.0	346.0	15.4	15.3
average	134052.3	13.0	8.5	297.1	8.6	332.1	8.0	15.3
Annotation at 051695 135148 : SOUTH CENTRAL BASIN								
51695	135650.0	16.0	8.7	295.0	9.9	320.0	0.5	15.3
51695	135730.0	15.3	8.7	295.0	9.9	321.0	2.0	15.3
51695	135806.0	14.8	8.7	296.0	9.8	323.0	4.0	15.3
51695	135851.0	13.7	8.6	296.0	9.3	326.0	6.0	15.3
51695	135949.0	12.1	8.5	298.0	8.3	334.0	8.0	15.3
51695	140052.0	11.2	8.3	303.0	7.4	340.0	10.0	15.2
51695	140224.0	10.8	8.2	304.0	6.9	344.0	12.0	15.2
51695	140335.0	10.7	8.1	304.0	6.8	345.0	13.4	15.2
average	137449.6	13.1	8.5	298.9	8.5	331.6	7.0	15.3
Annotation at 051695 141258 : OKANOGAN RIVER OUTFLOW								
51695	141432.0	16.6	8.8	297.0	9.4	312.0	0.4	15.2
Recovery finished at 051795 101513								

Lake Osoyoos June 1995 Survey

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	DO mg/L	Redox mV	Depth meters	Batt volts
Annotation at 060895 101610 : JUNE 8 OSOYOOS OKAN.RV INFLOW								
60895	103137.0	15.5	8.4	208.0	10.4	300.0	0.1	15.5
Annotation at 060895 103911 : NORTH BASIN COOP								
60895	105332.0	18.9	8.3	248.0	9.0	293.0	0.5	15.4
60895	105404.0	17.9	8.3	249.0	9.1	295.0	2.0	15.4
60895	105431.0	17.3	8.3	250.0	9.0	297.0	4.0	15.4
60895	105454.0	16.5	8.3	249.0	8.9	301.0	6.0	15.4
60895	105529.0	15.6	8.2	248.0	8.8	305.0	8.0	15.4
60895	105550.0	14.8	8.2	249.0	8.8	308.0	10.0	15.4
60895	105619.0	13.8	8.1	250.0	8.8	311.0	12.0	15.3
60895	105651.0	10.7	8.0	271.0	8.8	317.0	14.0	15.4
60895	105720.0	8.9	8.0	282.0	9.0	320.0	16.0	15.3
60895	105749.0	8.2	7.9	287.0	9.0	322.0	18.0	15.4
60895	105841.0	8.0	7.9	288.0	9.0	324.0	20.0	15.4
60895	105918.0	7.9	7.9	288.0	9.0	325.0	21.9	15.3
60895	105947.0	7.8	7.9	290.0	8.9	325.0	24.0	15.4
60895	110017.0	7.7	7.8	289.0	8.8	326.0	26.0	15.4
60895	110046.0	7.7	7.8	289.0	8.8	327.0	28.0	15.4
60895	110114.0	7.7	7.8	290.0	8.8	327.0	30.0	15.4
60895	110144.0	7.7	7.8	290.0	8.8	328.0	32.0	15.3
60895	110222.0	7.6	7.8	292.0	8.7	328.0	34.0	15.4
60895	110242.0	7.5	7.8	292.0	8.7	328.0	36.0	15.3
60895	110956.0	7.6	7.9	290.0	8.8	331.0	34.1	15.3
60895	111033.0	7.6	7.8	291.0	8.7	331.0	36.0	15.3
60895	111117.0	7.6	7.8	291.0	8.7	332.0	38.0	15.3
60895	111137.0	7.5	7.8	291.0	8.7	332.0	40.0	15.3
60895	111210.0	7.5	7.8	291.0	8.7	332.0	42.0	15.3
60895	111239.0	7.5	7.8	292.0	8.7	333.0	44.0	15.3
60895	111301.0	7.4	7.8	292.0	8.7	333.0	46.0	15.3
60895	111323.0	7.4	7.8	292.0	8.6	333.0	48.0	15.3
60895	111347.0	7.3	7.8	292.0	8.6	334.0	50.0	15.3
average	110462.2	7.6	7.8	290.9	8.7	330.0	36.8	
Annotation at 060895 122004 : BOUNDARY PT.								
60895	122237.0	19.6	8.5	274.0	9.0	311.0	0.5	15.3
60895	122315.0	18.6	8.5	273.0	9.1	312.0	2.0	15.3
60895	122407.0	18.5	8.5	273.0	9.1	312.0	4.0	15.3
60895	122436.0	18.1	8.5	273.0	9.1	313.0	6.0	15.3
60895	122538.0	16.9	8.4	275.0	8.5	318.0	8.0	15.3
60895	122615.0	15.1	8.2	282.0	7.7	326.0	10.0	15.2
60895	122718.0	12.6	8.0	299.0	5.3	337.0	12.0	15.3
60895	122752.0	12.3	7.9	301.0	5.3	339.0	14.0	15.3
60895	122848.0	11.9	7.8	304.0	4.6	342.0	16.0	15.2
60895	122933.0	11.5	7.8	306.0	4.1	344.0	18.0	15.3
60895	123012.0	11.4	7.7	307.0	3.9	344.0	19.0	15.2
average	120138.8	13.5	8.1	288.7	7.0	328.2	17.4	
Annotation at 060895 130522 : MIDWAY SOUTH BASIN								
60895	130713.0	19.9	8.5	273.0	9.1	304.0	0.5	15.3
60895	130803.0	18.5	8.5	273.0	9.2	307.0	2.0	15.2
60895	130840.0	17.8	8.5	272.0	9.1	309.0	4.0	15.3
60895	130929.0	17.5	8.5	273.0	8.9	312.0	6.0	15.3
60895	131032.0	15.7	8.2	282.0	7.5	322.0	8.0	15.3
60895	131121.0	14.5	8.1	289.0	6.8	328.0	10.0	15.3
60895	131222.0	14.1	8.0	291.0	6.4	332.0	12.0	15.3
60895	131442.0	13.1	7.8	299.0	4.9	339.0	14.0	15.2
60895	131531.0	12.6	7.8	301.0	4.2	341.0	15.0	15.3
60895	131623.0	12.2	7.7	304.0	4.0	342.0	16.0	15.2
average	128584.8	14.6	8.1	290.2	6.4	328.2	11.3	
Annotation at 060895 132650 : SOUTH CENTRAL BASIN								
60895	132828.0	19.5	8.5	277.0	9.5	310.0	0.5	15.3
60895	132930.0	17.5	8.5	274.0	9.1	315.0	2.0	15.3
60895	133106.0	17.0	8.4	275.0	8.8	318.0	4.0	15.2
60895	133159.0	16.4	8.3	279.0	8.3	321.0	6.0	15.2
60895	133241.0	15.8	8.3	278.0	8.1	325.0	8.0	15.2
60895	133333.0	15.7	8.2	279.0	8.0	326.0	10.0	15.2
60895	133508.0	14.7	8.0	289.0	6.7	334.0	12.0	15.3
average	132047.2	15.2	8.1	286.2	7.0	327.2	9.2	
Annotation at 060895 134224 : OK.OUT								
60895	134519.0	19.3	8.5	275.0	9.2	311.0	0.5	15.2
60895	134555.0	19.3	8.5	276.0	9.1	311.0	1.5	15.2
average	132786.2	16.4	8.3	281.9	7.8	322.4	6.7	

Lake Osoyoos July 1995 Survey

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	DO %Sat	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 071295 102132 : OKANOGAN RV. INFLOW									
71295	102824.0	19.4	8.4	266.0	93.9	8.4	316.0	0.1	15.5 &
71295	102843.0	19.4	8.4	266.0	93.7	8.3	315.0	0.5	15.5 &
average	102833.5	19.4	8.4	266.0	93.8	8.3	315.5	0.3	15.5
Annotation at 071295 103815 : NORTH BASIN									
71295	103938.0	21.3	8.7	243.0	103.2	8.8	277.0	0.5	15.5 &
71295	103956.0	21.3	8.7	244.0	103.0	8.8	277.0	2.0	15.5 &
71295	104253.0	21.1	8.7	243.0	101.6	8.7	280.0	4.0	15.5 &
71295	104319.0	20.9	8.7	243.0	100.0	8.6	281.0	6.0	15.5 &
71295	104351.0	20.9	8.7	242.0	98.9	8.5	281.0	8.0	15.5 &
71295	104413.0	19.2	8.5	241.0	83.9	7.5	294.0	10.0	15.5 &
71295	104434.0	16.4	8.3	240.0	69.4	6.6	307.0	12.0	15.4 &
71295	104450.0	14.6	8.2	244.0	64.7	6.4	311.0	14.0	15.4 &
71295	104515.0	11.4	8.1	257.0	64.4	6.8	315.0	16.0	15.5 &
71295	104534.0	9.6	8.1	270.0	64.8	7.1	317.0	18.0	15.5 &
71295	104600.0	9.0	8.0	274.0	65.0	7.3	318.0	20.0	15.5 &
71295	104623.0	8.7	8.0	275.0	64.2	7.2	319.0	21.9	15.4 &
71295	104701.0	8.4	7.9	271.0	62.9	7.1	320.0	24.0	15.4 &
71295	104733.0	8.4	7.9	274.0	62.3	7.1	320.0	26.0	15.4 &
71295	104759.0	8.3	7.9	273.0	61.7	7.0	321.0	28.0	15.4 &
71295	104827.0	8.3	7.8	265.0	61.5	7.0	321.0	30.0	15.4 &
71295	104844.0	8.2	7.8	264.0	61.2	7.0	321.0	32.0	15.4 &
71295	104906.0	8.2	7.8	258.0	61.0	7.0	322.0	34.0	15.4 &
71295	105012.0	8.1	7.8	281.0	60.5	6.9	322.0	36.0	15.4 &
71295	105038.0	8.1	7.8	288.0	60.1	6.9	323.0	34.1	15.3 &
71295	105121.0	8.1	7.8	273.0	60.1	6.9	323.0	38.0	15.4 &
71295	105212.0	8.1	7.7	269.0	60.1	6.9	323.0	38.0	15.4 &
71295	105231.0	8.0	7.7	259.0	59.8	6.8	323.0	40.0	15.4 &
71295	105248.0	8.0	7.7	294.0	59.6	6.8	323.0	42.0	15.4 &
71295	105307.0	8.0	7.7	256.0	59.3	6.8	323.0	44.0	15.4 &
71295	105334.0	8.0	7.7	287.0	59.3	6.8	323.0	46.0	15.5 &
71295	105353.0	8.0	7.7	277.0	59.3	6.8	323.0	48.0	15.4 &
average	104741.2	11.7	8.1	263.1	70.1	7.3	311.4		15.4
Annotation at 071295 115354 : CENTRAL BASIN									
Variable or Calibration changed at 071295 120436									
71295	120458.0	21.9	8.7	244.0	103.4	8.8	271.0	0.5	15.4 &
71295	120530.0	21.9	8.7	245.0	102.3	8.7	272.0	1.1	15.3 &
71295	120541.0	21.8	8.7	245.0	102.2	8.7	272.0	2.0	15.3 &
71295	120603.0	21.2	8.7	243.0	98.7	8.5	275.0	4.0	15.3 &
71295	120633.0	20.3	8.5	246.0	79.8	7.0	287.0	5.8	15.3 &
71295	120649.0	20.3	8.4	245.0	78.6	6.9	288.0	6.0	15.3 &
71295	120703.0	19.4	8.3	240.0	66.8	5.9	297.0	8.0	15.3 &
71295	120727.0	17.4	8.0	243.0	31.9	3.0	309.0	10.0	15.3 &
71295	120828.0	16.3	7.8	254.0	2.8	0.3	315.0	12.1	15.2 &
average	120630.2	20.0	8.4	245.0	74.1	6.4	287.3	5.5	15.3
Annotation at 071295 121642 : BOUNDARY PT.									
71295	122404.0	22.5	8.9	262.0	106.6	8.9	271.0	0.5	15.3 &
71295	122422.0	22.5	8.9	260.0	106.1	8.9	271.0	0.9	15.3 &
71295	122440.0	22.3	8.9	262.0	105.9	8.9	271.0	2.0	15.2 &
71295	122502.0	22.0	8.9	260.0	105.3	8.9	272.0	4.0	15.3 &
71295	122535.0	21.8	8.8	264.0	100.1	8.5	274.0	6.0	15.2 &
71295	122602.0	18.9	8.5	266.0	65.0	5.8	295.0	8.0	15.2 &
71295	122622.0	16.6	8.2	272.0	36.8	3.5	307.0	10.0	15.2 &
71295	122748.0	14.9	7.9	283.0	11.2	1.1	317.0	12.0	15.2 &
71295	122900.0	14.3	7.7	286.0	5.9	0.6	319.0	14.0	15.2 &
71295	122943.0	13.6	7.7	280.0	2.0	0.2	320.0	16.0	15.2 &
71295	123021.0	13.4	7.6	279.0	1.0	0.1	320.0	18.0	15.2 &
71295	123105.0	13.0	7.6	297.0	0.5	0.1	320.0	20.0	15.2 &
71295	123151.0	12.1	7.6	305.0	0.4	0.0	317.0	21.9	15.2 &
average	122722.7	17.5	8.2	275.1	49.8	4.3	298.0	10.3	15.2
Annotation at 071295 131246 : MIDWAY SOUTH BASIN									
71295	131444.0	22.2	8.8	262.0	104.6	8.8	274.0	0.5	15.2 &
71295	131503.0	22.1	8.8	262.0	104.7	8.8	274.0	1.0	15.2 &
71295	131525.0	22.0	8.9	262.0	104.6	8.8	274.0	2.0	15.2 &
71295	131551.0	21.6	8.8	262.0	102.3	8.7	276.0	3.9	15.2 &
71295	131645.0	21.4	8.8	263.0	96.0	8.2	279.0	6.1	15.2 &
71295	131750.0	20.7	8.6	265.0	82.1	7.1	286.0	7.9	15.1 &
71295	131849.0	16.0	8.1	278.0	31.8	3.0	313.0	10.0	15.1 &
71295	131945.0	14.9	7.9	282.0	11.2	1.1	320.0	11.9	15.1 &
71295	132023.0	14.4	7.8	284.0	5.2	0.5	322.0	13.9	15.1 &
71295	132117.0	13.6	7.7	286.0	1.6	0.2	324.0	15.1	15.1 &
average	131735.2	18.9	8.4	270.6	64.4	5.5	294.2	7.2	15.2
Annotation at 071295 132619 : SOUTH CENTRAL BASIN									
71295	133225.0	22.5	8.8	261.0	105.2	8.8	274.0	0.5	15.1 &
71295	133242.0	22.3	8.8	263.0	105.4	8.9	275.0	1.0	15.1 &
71295	133258.0	22.3	8.8	259.0	105.6	8.9	275.0	2.0	15.1 &
71295	133323.0	21.9	8.9	263.0	105.4	8.9	275.0	4.0	15.1 &
71295	133354.0	21.6	8.8	256.0	102.8	8.6	277.0	5.9	15.1 &
71295	133449.0	19.9	8.5	275.0	72.6	6.4	293.0	8.0	15.1 &
71295	133545.0	17.9	8.1	281.0	41.3	3.8	310.0	9.9	15.0 &
71295	133736.0	15.7	7.8	284.0	14.0	1.3	320.0	12.1	15.0 &
71295	133833.0	14.5	7.7	287.0	1.8	0.2	323.0	12.9	15.0 &
average	133440.6	19.9	8.5	269.9	72.7	6.2	291.3	6.3	15.1
Annotation at 071295 133923 : OK. RV. OUT.									
71295	135555.0	23.2	8.9	261.0	116.3	9.6	324.0	0.6	15.1 &
71295	135636.0	22.9	8.9	263.0	113.3	9.4	321.0	2.0	15.1 &
average	135595.5	23.1	8.9	262.0	114.8	9.5	322.5	1.3	15.1
Annotation at 071295 144354 : SIMILKAMEEN AT OROVILLE									
71295	144542.0	17.0	8.3	1.0	103.7	9.7	341.0	0.0	15.1 &
71295	144553.0	17.0	8.4	99.2	103.0	9.6	339.0	0.0	15.1 &
average	144547.5	17.0	8.4	50.1	103.4	9.7	340.0	0.0	15.1
Annotation at 071295 145643 : OKANOGAN AT BRIDGE S. OF OROVILLE									
71295	145730.0	24.5	8.9	264.0	120.8	9.7	323.0	0.5	15.1 &
71295	145752.0	24.4	8.9	262.0	119.7	9.7	321.0	0.7	15.1 &
average	145741.0	24.4	8.9	263.0	120.3	9.7	322.0	0.6	15.1
Annotation at 071295 152358 : OKANOGAN RIVER AT TONASKET									
71295	152424.0	18.3	8.2	134.3	99.6	9.1	350.0	0.1	15.1 &
71295	152442.0	18.3	8.2	134.4	99.4	9.0	348.0	0.1	15.1 &
average	152433.0	18.3	8.2	134.4	99.5	9.1	349.0	0.1	15.1
Annotation at 071295 165822 : OKANOGAN RIVER AT COLUMBIA RIVER CONFLUENCE									
71295	165336.0	21.7	8.3	150.0	103.5	8.8	339.0	0.6	15.1 &
71295	165400.0	21.5	8.3	149.0	102.0	8.7	338.0	1.0	15.1 &
71295	165446.0	20.8	8.2	148.0	96.1	8.3	339.0	2.0	15.1 &
71295	165543.0	20.5	8.1	148.0	93.4	8.1	339.0	3.1	15.1 &
average	165431.3	21.1	8.3	148.8	98.8	8.5	338.8	1.7	15.1
Annotation at 071295 170747 : OKANOGAN RIVER AT MONSE BRIDGE									
71295	170836.0	21.2	8.3	154.0	97.0	8.3	364.0	0.5	15.0 &
71295	170857.0	21.2	8.2	155.0	96.5	8.3	361.0	1.0	15.0 &
71295	170932.0	21.1	8.2	154.0	96.0	8.3	359.0	2.0	15.0 &
average	170874.7	21.2	8.2	154.3	96.5	8.3	361.3	1.2	15.0

August 30 Lake Osoyoos and Okanogan Rv.

Date	Time	Temp	pH	SpCond	Salin	DO	DO	Redox	Depth	Batt
MMDDYY	HHMMSS	degC	units	uS/cm	ppt	%Sat	mg/l	mV	meters	volts
Annotation at 083095 144510 : Lake OSOYOOS. AT ST. PARK DOCK										
83095	144609	20.79	8.58	262	0.1	98.5	8.52	318	1	15.1
83095	144634	20.79	8.59	263	0.1	98.4	8.51	316	0.5	15.1
83095	144703	20.79	8.6	264	0.1	98.3	8.51	314	2	15.1
Annotation at 083095 152353 : SIMILKAMEEN RV. @ OROVILLE										
83095	152822	17.37	8.24	188	0.1	100.8	9.35	313	0.1	15.1
Annotation at 083095 154237 : OK. RV. AT BRIDGE S. OF ORVILLE										
83095	154612	20.86	8.62	253	0.1	105.1	9.08	304	0.2	15
Annotation at 083095 160852 : Ok. Rv. at TONASKET.										
83095	160908	19.51	8.47	244	0.1	99.4	8.82	370	0.1	15
83095	160931	19.51	8.44	245	0.1	99.2	8.8	366	0.6	15
Annotation at 083095 171013 : Ok Rv. at MALLOT										
83095	171138	20.44	8.56	257	0.1	110.8	9.65	391	0.2	15
83095	171207	20.48	8.54	257	0.1	110.4	9.61	387	0.9	15

Lake Osoyoos September 1995 Survey

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	DO %Sat	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 091395 104508 : OKANOGAN RIVER INLET IN CANADA									
91395	104822.0	19.7	8.4	273.0	99.4	8.8	284.0	0.5	15.3
91395	104846.0	19.7	8.4	271.0	99.5	8.8	285.0	1.0	15.3
average	104834.0	19.7	8.4	272.0	99.5	8.8	284.5	0.8	15.3
Annotation at 091395 111806 : NORTH BASIN									
91395	111822.0	19.7	8.6	266.0	99.5	8.8	392.0	0.6	15.3
91395	111840.0	19.7	8.5	266.0	99.3	8.8	390.0	1.0	15.3
91395	111858.0	19.7	8.5	266.0	99.2	8.8	389.0	1.9	15.3
91395	111919.0	19.6	8.5	270.0	99.1	8.8	388.0	4.3	15.3
91395	111934.0	19.6	8.5	268.0	99.0	8.8	387.0	6.2	15.3
91395	112002.0	19.6	8.5	265.0	98.2	8.7	386.0	8.1	15.4
91395	112018.0	19.5	8.5	263.0	97.6	8.7	385.0	10.3	15.4
91395	112039.0	18.0	8.4	272.0	83.1	7.6	394.0	12.0	15.3
91395	112103.0	15.0	8.1	259.0	64.1	6.3	404.0	14.4	15.2
91395	112125.0	12.8	8.0	262.0	44.3	4.5	411.0	15.8	15.3
91395	112152.0	9.9	7.8	267.0	40.4	4.4	415.0	17.7	15.3
91395	112232.0	9.2	7.7	263.0	40.2	4.5	417.0	20.3	15.3
91395	112248.0	9.0	7.7	271.0	39.5	4.4	418.0	22.3	15.3
91395	112315.0	8.8	7.6	280.0	37.0	4.2	418.0	23.9	15.3
91395	112336.0	8.7	7.6	267.0	36.0	4.1	419.0	26.0	15.3
91395	112412.0	8.6	7.6	276.0	34.9	3.9	419.0	28.2	15.3
91395	112449.0	8.5	7.5	282.0	34.1	3.9	419.0	30.0	15.2
91395	113032.0	8.5	7.4	282.0	34.2	3.9	385.0	32.2	15.2
91395	113049.0	8.5	7.4	268.0	33.6	3.8	386.0	34.3	15.2
91395	113111.0	8.5	7.4	283.0	32.7	3.7	387.0	35.7	15.2
91395	113123.0	8.5	7.4	286.0	32.6	3.7	387.0	37.9	15.2
91395	113147.0	8.5	7.4	270.0	32.2	3.6	387.0	39.7	15.2
91395	113214.0	8.5	7.4	281.0	31.9	3.6	387.0	41.7	15.2
91395	113229.0	8.5	7.4	266.0	31.8	3.6	388.0	44.2	15.2
91395	113241.0	8.5	7.4	273.0	31.8	3.6	388.0	45.9	15.2
91395	113322.0	8.5	7.4	278.0	31.5	3.6	389.0	48.4	15.2
91395	113342.0	8.4	7.4	284.0	31.6	3.6	389.0	50.0	15.2
average	112504.2	12.2	7.8	271.6	54.4	5.4	397.2	24.2	15.3
Annotation at 091395 121424 : CENTRAL BASIN									
91395	121818.0	21.0	8.7	266.0	104.7	9.0	312.0	0.5	15.2
91395	121841.0	20.4	8.7	266.0	104.8	9.1	312.0	2.0	15.3
91395	121904.0	20.2	8.6	268.0	102.8	9.0	314.0	4.0	15.2
91395	121927.0	20.0	8.6	269.0	100.5	8.8	316.0	6.0	15.3
91395	121948.0	19.6	8.6	265.0	95.5	8.5	317.0	8.1	15.2
91395	122008.0	19.1	8.4	264.0	81.4	7.3	324.0	10.0	15.2
91395	122043.0	18.8	8.2	271.0	65.7	5.9	331.0	12.1	15.2
91395	122236.0	16.7	7.7	270.0	1.1	0.1	108.0	14.0	15.2
average	121965.6	19.5	8.4	267.4	82.1	7.2	291.8	7.1	15.2
Annotation at 091395 123100 : BOUNDARY PT.									
91395	123259.0	21.2	8.7	268.0	105.5	9.1	244.0	0.5	15.2
91395	123333.0	21.4	8.7	268.0	105.1	9.0	245.0	1.0	15.2
91395	123406.0	20.8	8.7	266.0	103.8	9.0	246.0	2.0	15.2
91395	123442.0	20.4	8.7	264.0	101.0	8.8	248.0	4.0	15.2
91395	123511.0	20.0	8.6	268.0	94.5	8.3	251.0	6.0	15.2
91395	123539.0	19.7	8.5	266.0	84.4	7.5	256.0	7.9	15.2
91395	123611.0	19.1	8.3	268.0	57.4	5.1	266.0	10.0	15.2
91395	123646.0	18.3	7.9	288.0	16.9	1.5	279.0	12.1	15.2
91395	123714.0	17.3	7.8	281.0	3.2	0.3	134.0	14.1	15.2
91395	123757.0	15.5	7.8	293.0	1.2	0.1	27.0	16.0	15.1
91395	123858.0	14.9	8.0	296.0	0.8	0.1	-10.0	20.3	15.1
91395	123917.0	14.3	8.0	315.0	0.7	0.1	-19.0	22.1	15.1
average	123582.8	18.6	8.3	278.4	56.2	4.9	180.6	9.7	15.2
Annotation at 091395 131036 : MIDWAY SOUTH BASIN									
91395	131359.0	21.3	8.8	267.0	106.8	9.2	289.0	0.5	15.2
91395	131420.0	21.1	8.8	268.0	106.9	9.2	286.0	1.1	15.2
91395	131445.0	20.9	8.8	270.0	106.8	9.2	284.0	2.0	15.2
91395	131516.0	20.8	8.8	268.0	104.7	9.1	282.0	4.0	15.2
91395	131546.0	20.6	8.7	271.0	102.9	8.9	281.0	6.0	15.2
91395	131623.0	20.3	8.7	270.0	92.6	8.1	281.0	8.0	15.2
91395	131646.0	18.4	8.2	278.0	38.4	3.5	302.0	10.0	15.2
91395	131711.0	17.9	8.0	276.0	9.9	0.9	307.0	12.0	15.2
91395	131753.0	15.8	7.8	296.0	1.4	0.1	14.0	14.0	15.2
91395	131830.0	15.4	8.0	305.0	1.0	0.1	-14.0	16.0	15.1
average	131584.9	19.2	8.4	276.9	67.1	5.8	231.2	7.4	15.2
Annotation at 091395 131910 : SOUTH CENTRAL BASIN									
91395	132712.0	22.1	8.8	269.0	108.3	9.1	195.0	0.5	15.2
91395	132740.0	21.5	8.8	268.0	109.1	9.3	197.0	1.1	15.2
91395	132809.0	21.2	8.8	268.0	109.5	9.4	200.0	2.0	15.3
91395	132835.0	21.0	8.8	270.0	106.3	9.2	203.0	4.0	15.1
91395	132902.0	20.4	8.7	271.0	100.9	8.8	206.0	6.1	15.2
91395	132929.0	19.7	8.6	266.0	82.4	7.3	214.0	8.0	15.2
91395	132958.0	18.7	8.1	272.0	37.2	3.4	231.0	10.0	15.1
91395	133033.0	17.2	7.9	289.0	4.2	0.4	138.0	12.0	15.1
91395	133120.0	15.8	7.9	301.0	1.2	0.1	5.0	14.1	15.1
average	132893.1	19.7	8.5	274.9	73.2	6.3	176.6	6.4	15.2
Annotation at 091395 133225 : OKANOGAN RIVER OUTLET									
91395	134454.0	21.6	8.8	268.0	109.2	9.3	204.0	0.5	15.1
91395	134529.0	21.6	8.8	269.0	109.3	9.3	206.0	1.1	15.1
average	134491.5	21.6	8.8	268.5	109.3	9.3	205.0	0.8	15.1

Lake Osoyoos October 1995 Survey

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	DO %Sat	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 101795 100015 : OKANOGAN RIVER INLET									
101795	100044.0	11.7	8.0	297.0	95.8	10.0	324.0	0.6	15.4
101795	100101.0	11.7	8.0	296.0	95.6	10.0	323.0	0.7	15.4
average	100072.5	11.7	8.0	296.5	95.7	10.0	323.5	0.7	15.4
Annotation at 101795 102259 : NORTH BASIN									
101795	102506.0	13.6	8.2	278.0	95.4	9.6	329.0	0.7	15.4
101795	102519.0	13.6	8.2	279.0	94.8	9.5	329.0	1.9	15.4
101795	102540.0	13.6	8.2	280.0	94.2	9.5	328.0	3.7	15.4
101795	102627.0	13.6	8.2	279.0	93.6	9.4	326.0	6.4	15.3
101795	102744.0	13.6	8.3	278.0	94.5	9.5	318.0	7.9	15.3
101795	102826.0	13.6	8.3	282.0	93.5	9.4	317.0	9.5	15.3
101795	102852.0	13.6	8.2	282.0	92.9	9.3	317.0	12.6	15.3
101795	102909.0	13.6	8.2	282.0	92.9	9.3	317.0	13.5	15.3
101795	102934.0	13.2	8.1	277.0	78.5	8.0	323.0	15.4	15.3
101795	103116.0	12.4	7.8	282.0	67.7	7.0	324.0	18.0	15.3
101795	103151.0	10.0	7.6	280.0	39.5	4.3	333.0	20.5	15.3
101795	103210.0	9.2	7.5	280.0	29.4	3.3	336.0	21.5	15.3
101795	103233.0	9.0	7.5	281.0	24.1	2.7	338.0	23.3	15.3
101795	103247.0	8.9	7.4	281.0	23.3	2.6	338.0	26.7	15.3
101795	103333.0	8.8	7.4	281.0	21.0	2.4	339.0	28.6	15.3
101795	103354.0	8.8	7.4	281.0	20.2	2.3	339.0	29.8	15.3
101795	103411.0	8.8	7.3	281.0	19.8	2.2	339.0	32.6	15.2
101795	103511.0	8.7	7.3	281.0	17.5	2.0	340.0	35.1	15.2
101795	103548.0	8.7	7.3	282.0	16.9	1.9	340.0	36.2	15.2
101795	103608.0	8.7	7.3	282.0	16.7	1.9	340.0	38.0	15.2
101795	103640.0	8.7	7.2	282.0	16.4	1.9	339.0	39.2	15.2
101795	103711.0	8.7	7.2	282.0	16.2	1.8	339.0	41.6	15.2
101795	103725.0	8.7	7.2	282.0	16.4	1.9	339.0	44.3	15.2
101795	103745.0	8.6	7.2	282.0	16.9	1.9	339.0	45.8	15.2
average	103166.7	10.8	7.7	280.7	49.7	5.1	331.9	23.0	15.3
Annotation at 101795 112616 : CENTRAL BASIN									
101795	112717.0	13.9	8.3	282.0	95.9	9.6	346.0	1.0	15.3
101795	112741.0	13.9	8.3	283.0	95.4	9.5	345.0	1.9	15.2
101795	112757.0	13.9	8.3	284.0	95.1	9.5	345.0	4.0	15.2
101795	112812.0	13.9	8.3	278.0	94.9	9.5	344.0	6.0	15.2
101795	112829.0	13.9	8.3	278.0	94.8	9.5	343.0	8.0	15.2
101795	112846.0	13.9	8.3	277.0	94.7	9.5	343.0	9.9	15.2
101795	112908.0	13.9	8.3	276.0	94.5	9.4	342.0	12.0	15.2
101795	112926.0	13.9	8.3	276.0	94.3	9.4	342.0	14.1	15.2
average	112817.0	13.9	8.3	279.3	95.0	9.5	343.8	7.1	15.2
Annotation at 101795 113033 : BOUNDARY POINT									
101795	114432.0	14.4	8.1	287.0	85.5	8.4	354.0	1.0	15.2
101795	114447.0	14.4	8.1	287.0	84.8	8.4	353.0	2.0	15.2
101795	114502.0	14.4	8.1	287.0	84.3	8.3	352.0	3.8	15.2
101795	114526.0	14.4	8.1	287.0	83.7	8.3	352.0	6.1	15.2
101795	114540.0	14.4	8.1	289.0	83.4	8.2	351.0	7.9	15.2
101795	114559.0	14.4	8.0	283.0	81.9	8.1	351.0	10.3	15.2
101795	114621.0	14.4	8.0	288.0	81.1	8.0	350.0	11.8	15.2
101795	114707.0	14.4	8.0	291.0	75.3	7.4	352.0	13.9	15.2
101795	114749.0	14.4	7.9	284.0	73.4	7.3	351.0	15.7	15.2
101795	114830.0	14.3	7.9	293.0	72.7	7.2	350.0	17.7	15.2
101795	114856.0	14.3	7.9	290.0	72.7	7.2	349.0	20.1	15.2
average	114615.4	14.4	8.0	287.8	79.9	7.9	351.4	10.0	15.2
Annotation at 101795 121530 : HALF WAY									
101795	121700.0	14.3	8.1	286.0	81.6	8.1	364.0	0.7	15.1
101795	121720.0	14.4	8.0	285.0	80.9	8.0	363.0	2.0	15.2
101795	121735.0	14.4	8.0	288.0	80.7	8.0	363.0	3.9	15.1
101795	121749.0	14.3	8.0	289.0	80.4	8.0	362.0	5.9	15.1
101795	121811.0	14.4	8.0	283.0	80.2	7.9	361.0	7.5	15.1
101795	121844.0	14.3	8.0	289.0	78.9	7.8	360.0	10.1	15.1
101795	121912.0	14.3	8.0	281.0	78.3	7.7	360.0	12.0	15.1
101795	121947.0	14.4	8.0	291.0	78.5	7.8	358.0	14.1	15.1
101795	122022.0	14.4	8.0	288.0	78.1	7.7	357.0	16.1	15.1
average	121826.7	14.3	8.0	286.7	79.7	7.9	360.9	8.0	15.1
Annotation at 101795 122808 : SOUTH CENTRAL BASIN									
101795	123114.0	14.3	8.0	284.0	79.7	7.9	349.0	1.0	15.1
101795	123128.0	14.3	8.0	284.0	79.8	7.9	349.0	2.0	15.1
101795	123152.0	14.3	8.0	289.0	79.2	7.8	348.0	3.9	15.1
101795	123210.0	14.3	8.0	280.0	79.3	7.8	348.0	6.1	15.1
101795	123221.0	14.3	8.0	287.0	80.1	7.9	347.0	7.9	15.1
101795	123235.0	14.3	8.0	285.0	80.4	8.0	347.0	10.0	15.1
101795	123247.0	14.2	8.0	293.0	81.6	8.1	345.0	12.0	15.1
101795	123311.0	14.2	8.0	294.0	81.9	8.1	345.0	13.9	15.1
average	123202.3	14.3	8.0	287.0	80.3	7.9	347.3	7.1	15.1
Annotation at 101795 123450 : OKANOGAN RIVER OUTLET									
101795	124422.0	14.2	8.1	285.0	88.0	8.7	361.0	1.0	15.1
101795	124447.0	14.2	8.1	285.0	87.9	8.7	359.0	2.0	15.1
average	124434.5	14.2	8.1	285.0	88.0	8.7	360.0	1.5	15.1

Appendix 14.
Fish Cultural Data: Lake Osoyoos Net pens 1995, transcribed from Colville Tribe Daily records

Date	Water Temp. (°C)	Dissolved Oxygen (mg/L)	Secchi Disk (m)	Feedings per day	Feed Use (lbs.)	Morts or Samples (number)	Comments
April 19	9.3						Fish Transferred to pens
20	9.4	10.2	4.7	3	18	7	morts from transfer injury, minor number
21	10.4	10.7	4.7	12	18	1	Fish feeding well, seem healthy
22	10.2	10.9	4.7	12	18	19	same
23	11.4	10.8	5.8	12	18	0	same
24	11.3	11.2	3.4	12	18.9	1	Feeding well, strong north winds in PM
25	11.1	11.4	3	8	18.9	0	fed well, moderate SE wind
26	11.6	9.6	2.7	9	18.9	0	winds continue
27	11.3	12.3	2.3	9	18.9	60	morts sacrificed for gill ATP samples, fish color bluer
28	11.6	10.7	2.1	3	9.1	2	Feeding well, held back feed due to smolting activity
29	11.8	10.7	3.3	0	0	1	No feeding
30	11.4	10.5	2.7	0	0	0	No feeding, fish still very active
May 1	11.3	10.1	4.7	0	0	210	fish sampled for virus and gill ATP
Sum					156.7	301	
Average	10.9	10.8	3.7	8.9	17.4		
Range	9.2 - 17.6	8 - 13.2	2 - 3.75	0 - 6	4.5 - 8		

Fish size at start (g) =	4.4	Fish population start =	38,934	Biomass	171.3 kg @ start
Fish size at end (g) =	6.67	Fish population end =	38,633	Biomass	257.7 kg @ end
feed use (kg) =	71.1	Increase biomass (kg) =	86.4		
		Percent mortality + samples =	0.008		
		Feed conversion ratio =	0.82	lbs. feed (X% moisture) to wet fish flesh	

Initial stocking density (kg/m3) =	1.416	0.089	lbs./cu.ft.	
final stocking density (kg/m3) =	2.130	0.133	lbs./cu.ft.	Wells Agreement calls for < 0.33 lbs.\cu.ft., we had planned not to exceed 0.24 lbs./cu.ft.

APPENDIX 15.

RA0794.XLS

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: RA001-09 **PAGE 1**

REPORT DATE: 05/11/95

DATE SAMPLED: 04/18/95 **DATE RECEIVED:** 04/20/95

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM JACK RENSEL / LAKE OSOYOOS

CASE NARRATIVE

Three sediment and two water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

SEDIMENT DATA - DRY WEIGHT BASIS

SAMPLE ID	TOC (mg/kg)
#1 CENTER OF PENS	38,105
#2 EDGE OF PENS	44,820
#3 50M NORTH OF PENS	42,987

WATER DATA

SAMPLE ID	CHLA (ug/l)	PHAEOA (ug/l)
#4 NORTH BASIN 1,3 M	9.8	<0.1
#5 INTERNATION BOUNDARY 1,3	7.7	<0.1

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CASE FILE NUMBER: RA001-09 **PAGE 2**
REPORT DATE: 05/11/95
DATE SAMPLED: 04/18/95 **DATE RECEIVED:** 04/20/95
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM JACK RENSEL / LAKE OSOYOOS

QA/QC DATA

QC PARAMETER	TOC (mg/kg)	CHLA (ug/l)	PHAEOA (ug/l)
METHOD	EPA 415.1	EPA 415.1	EPA 415.1
DATE ANALYZED	05/05/95	04/24/95	04/24/95
DETECTION LIMIT	150	150	150
DUPLICATE			
SAMPLE ID	#1 CENTER	BATCH	BATCH
ORIGINAL	38,192	16	12
DUPLICATE	38,106	15	15
RPD	0.23%	6.45%	22.22%
SPIKE SAMPLE			
SAMPLE ID	#1 CENTER		
ORIGINAL	38,192		
SPIKED SAMPLE	134,000		
SPIKE ADDED	100,000		
% RECOVERY	95.81%	NA	NA
QC CHECK			
FOUND	10130		
TRUE	9960		
% RECOVERY	101.71%	NA	NA
BLANK	<150	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff
Laboratory Director

Appendix 16. Errata for Prior Report (1994 surveys)

- The table of CTD (conductivity, temperature, depth) in the appendix 3 for July at Boundary Point were incorrect. Associated figures, text and conclusions were correct despite that error. Duplicative data were collected with separate instruments and that data is relied on for most of the report.

- 39, 2nd full paragraph. Should read "In 1994..." not In 1995.

ASSESSMENT AND REMOVAL OF NORTHERN SQUAWFISH AT WELLS DAM TAILRACE, 1995

APPENDIX J

Assessment and Removal of Northern Squawfish at the Wells Dam Tailrace, 1995

Rick Klinge
Shane Bickford

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

March 8, 1996

INTRODUCTION

Northern squawfish (*Ptychocheilus oregonensis*) are an important predator of juvenile salmonids (Oncorhynchus spp.) in the Columbia River. They are found in heavy concentrations in the tailraces of hydroelectric plants, and near juvenile bypass and hatchery outfalls (Sims et al., 1978 and Buchanan et al., 1981). Lynch (1993) estimated at the Dalles Dam in 1992-1993 that from 141,608 to 525,553 squawfish congregated below the project during the spring and summer months.

Northern squawfish congregate in dam tailraces from spring until around July, or when water temperatures approach 15 to 17° C. Lynch (1993) found from July on, squawfish congregate for spawning, but then disperse throughout the reservoirs. Loch et al. (1994) found that after water temperatures reached 12° C., reproductively mature squawfish congregate for spawning in areas with hard substrate and reduced flow. After spawning, the mature fish will disperse through the reservoirs. This movement can confound attempts to census squawfish populations at dam tailrace areas. During the 1993 Mid-Columbia Predator Index Study, only 1.2% (21 tags) of the total tags deployed were recovered, and all of these downstream of their release site (Loch et. al, 1994).

Squawfish greater than 300 mm in length are primarily piscivorous, though they also consume mollusks, crayfish and terrestrial insects (Jeppson and Platts, 1959). Diet of mid-Columbia squawfish in 1993 was primarily salmonid smolts during the spring months, where salmonids made up only 33% of the diet in the summer months (Sauter et al., 1994). Some agency and tribal fisheries biologist believe that predation by squawfish on juvenile salmonids is a serious problem, requiring intensive removal measures.

There are currently several different removal measures being tested along the anadromous portions of the Columbia and Snake Rivers (Willis and Nigro, 1991). The Army Corps of Engineers is funding a sport angling bounty program for squawfish captured in reservoirs they managed. Tribal fishermen are paid to fish gillnets, long lines and sport gear near dams and hatchery outfalls. Lynch (1993) reports little success has been seen from Merwin traps, baited pots and purse seines. Others have attempted to destroy squawfish spawning habitat and to remove squawfish in spawning aggregations in early summer (Erho, pers. comm.).

Douglas County Public Utility District (District) is the licensed operator of Wells Dam, located at river mile 515 on the Columbia River. In 1993, the District contracted the Washington Department of Wildlife (WDW) to determine the relative degree of squawfish predation in the Wells tailrace and reservoir. The resulting report identified that the outfall of the Wells Hatchery, near the tailrace of Wells Dam, had relatively high concentrations of squawfish. Wells Hatchery

personnel also confirmed that squawfish congregate in the outfall area (Jerry Moore, personal communication).

The District initiated a squawfish removal program in1995. The goals were to assess efficiency of gear for removal of squawfish, estimate the squawfish population and remove squawfish from the hatchery outfall channel and tailrace of the dam.

METHODS

Sinking gillnets, were 6 feet by 75 feet having a bar mesh of 1.75 and 2.00 inches. Fishermen deployed nets in the hatchery outlet and along the shoreline of the Wells tailrace (Figure 2). Fishermen worked nets during daylight hours, from 0700 to 1600. Nets were fished for less than an hour before being lifted and the catch removed. Fishermen immediately released all non target fish back into the river. Records of time in and out of the water, location and catch were kept.

Fishermen also used sport gear between the hours of 0700 and 1700, and occasionally as late as 2200. Initially heavy weight poles with 17 pound test line was used and one ounce lead-head jigs with plastic worms. From mid-April through July, lighter poles, lighter line and a variety of spinners, grubs, baited hooks and lures were tried. Juvenile salmon moralities from the Wells Hatchery and lamprey ammocoetes collected during fyke netting at Wells Dam were used as bait. Fishermen also used artificial bait and scent ("Power Bait") to enhance attraction of plastic jigs. Fishermen fished both banks of the tailrace, along the hatchery outfall channel, or from a boat anchored in 20 to 30 feet of water (Figure 2).

The District contracted a fisherman with a commercial jigging machine to fish for squawfish. The jigging machine allowed for the rapid deployment of lures on a spreader bar in the river. Three sets of lures and hooks attached to a spreader bar were deployed from the jigging machine. Both bait and lures were used.

Fishermen tagged squawfish along the lower left jaw with a Monel #10 jaw tag (inside diameter 21/64"; Figure 3 and 4) during two periods, between March 30 and May 11 and from June 12 to June 30 . The tags were inscribed "Wells Dam 95" and were numbered from 001 - 500. Squawfish caught by gillnet were freed from webbing and placed into a tub of water in a boat and held until the entire net was lifted from the river. Fishermen applied tags while the squawfish were kept in the tub of water. The fish were docile and did not require anesthetic for handling, especially when the fish were held by the lower jaw. Fishermen held squawfish by the chin with mouth open and placed a spread tag over the lower left jaw. The tag was closed firm while not breaking the skin with a pair of pliers. Fish were released back into the river immediately after tagging.

Figure 1. Location of Wells Dam.

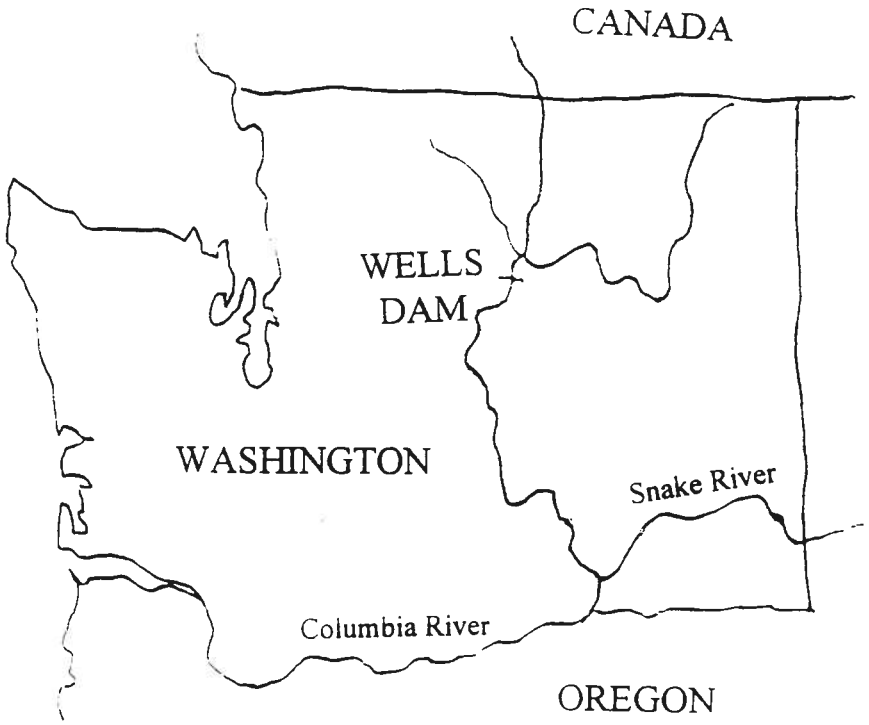
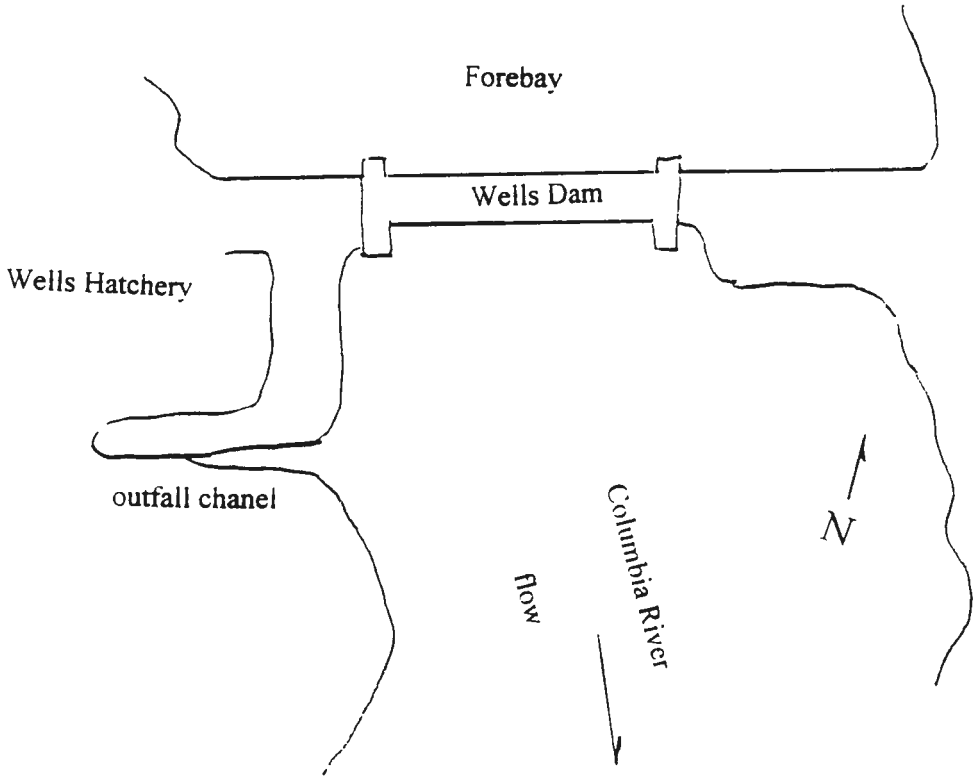


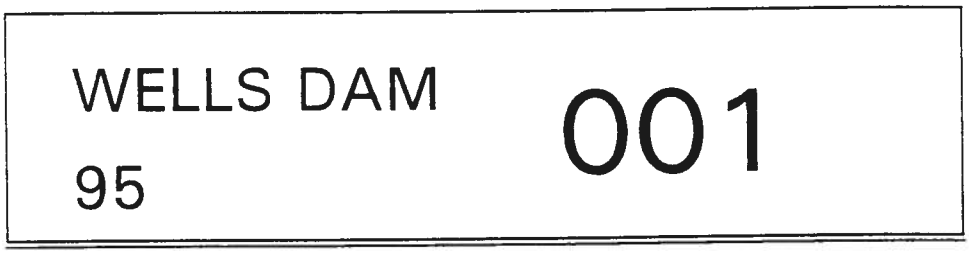
Figure 2. Wells Dam tailrace area and hatchery outfall.



Fish caught with sport gear were immediately tagged and returned to the river. Fishermen could remove the hook from the squawfish mouth and apply the tag less than a minute. Squawfish were dipped back in the river if tagging procedure was prolonged.

Removed squawfish were placed in plastic bags and stored in a freezer. Fishermen took length, weight, removed scales and determined gender by external features of every tenth fish. The entire daily catch was weighed and placed in a freezer for latter delivery to a rendering plant.

Figure 3. Example of identification on jaw tag used for census study.



RESULTS

Gillnets captured 116 squawfish, eight of which were recaptured fish that were returned to the river. There were 205 sets made with 163.7 hours of fishing time, for an average soak time of 48 minutes (Table 1). Highest catches of squawfish were made in early May. We anticipated an increase of squawfish activity in the hatchery outfall channel following the release of yearling chinook on April 15 and the release of zero age chinook on June 15. This was not evident from catches in gillnets. Daily average gillnet catch per unit effort (CPUE; Figure 5) ranged between 0.00 and 9.09 with an average of 0.71. The high CPUE on June 2, 19 and 22 were, in part, a result of a single set from 13 - 20 minutes in length.

Fishermen stopped gillnetting by mid-May when incidental catch (bi-catch) of other resident and some anadromous fish became unacceptable. Suckers were the most common species in gillnet catches with 560 caught and released during the season. Walleye were the second highest species captured (79 fish). Additional bi-catch with gillnet include Whitefish (57), Rainbow trout (< 250 mm; 17), steelhead kelts (≥ 250 mm; 13), Smallmouth Bass (5), Spring Chinook (3), Cutthroat trout (2), Dolly Varden (2), and Carp (1) (Figure 6).

Fishermen caught 1079 squawfish with sport gear for 756.2 hours of fishing time (Table 2; Figure 7). Daily CPUE varied between 0.00 to 9.08. Bi-catch with sport gear was considerable less, with only 27 fish caught. Fishermen's bi-catch with sport gear was

Figure #4: An example of the location of jaw tags on adult squawfish.

Figure 5. 1995 Wells Dam squawfish CPUE for gillnet and sport gear

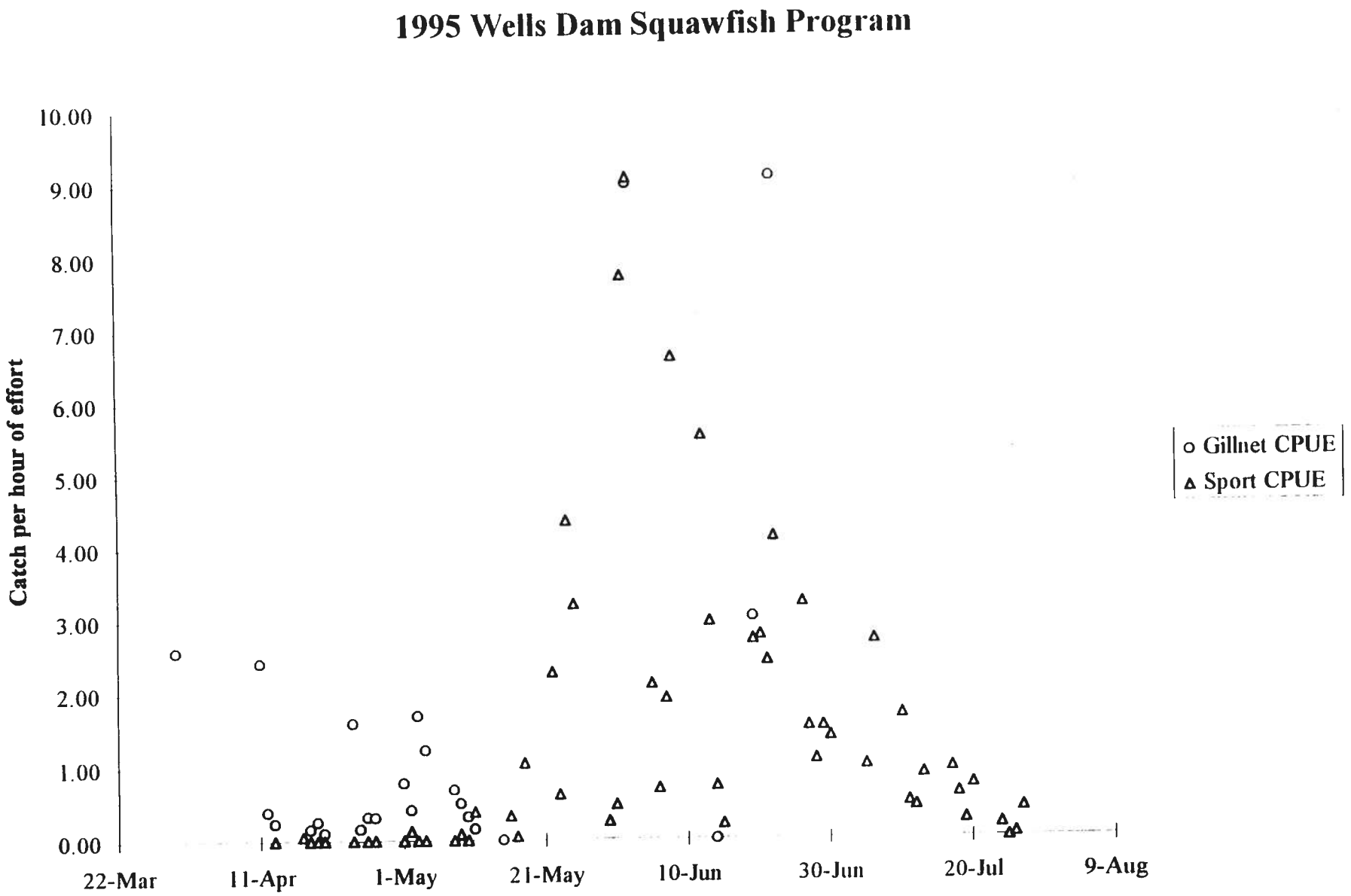


Figure 6. 1995 Wells Dam Squawfish removal, gillnet catch composition.

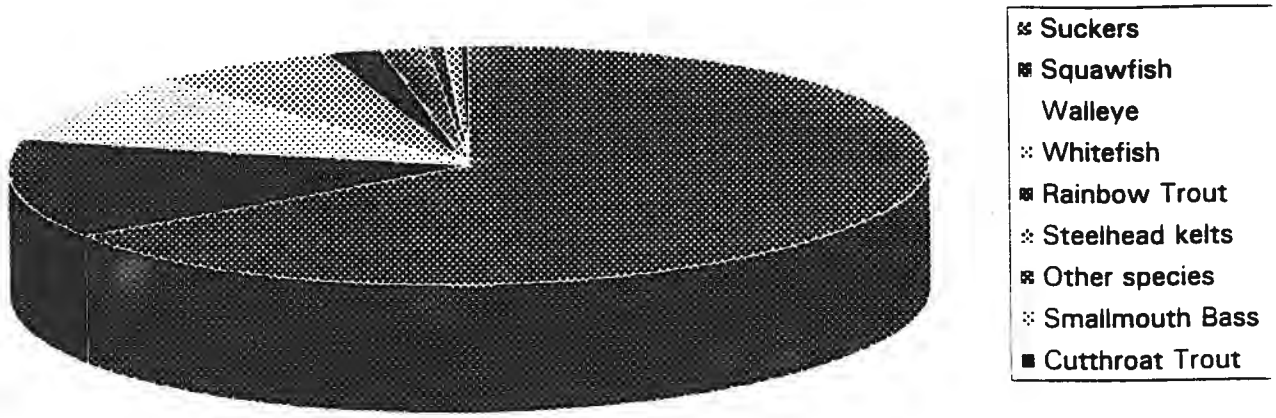
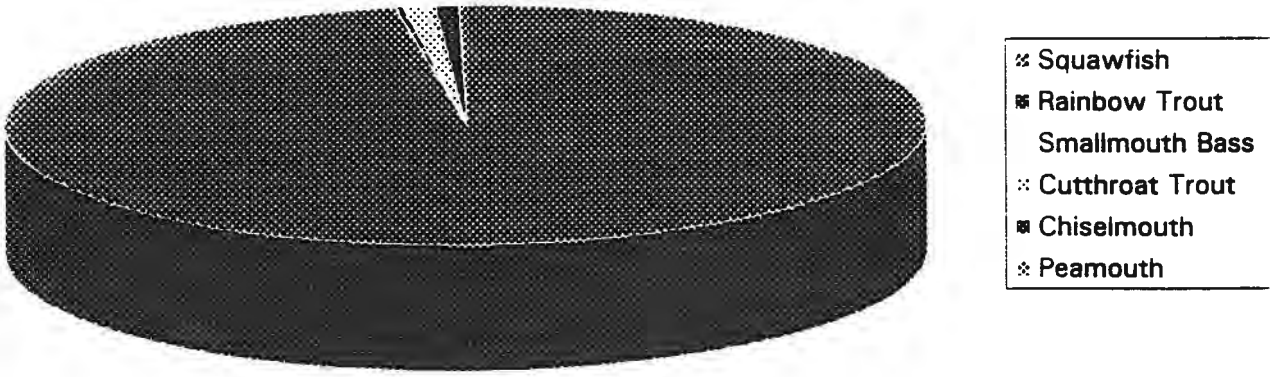


Figure 7. 1995 Wells Dam Squawfish removal, sport gear catch composition.



Chiselmouth (11), Smallmouth Bass (11), Peamouth (2), Rainbow Trout (2), and a Cutthroat trout. Lamprey ammocoetes captured in fyke net samples at Wells Dam were the bait of choice. High CPUE on June 1, 2, 8 and 12 were attributed to using ammocoetes as bait. Spinners (Black Rooster tails) and diving lures were also effective.

A commercial jigging machine was tested on July 17 and 18 for evaluation as a means of squawfish removal. The gear fished for 2.8 hours and caught 3 squawfish (CPUE squawfish per hour 1.1). Mechanical problems with the boat and equipment prevented a lengthier evaluation.

Measurements of length and weight were taken on 62 squawfish that were removed. Average length and weight of squawfish removed was 305 mm and 337 grams (Figure 8).

The District paid approximately $20,000 for the squawfish tagging, removal and data collection in 1995. The approximate cost per fish for the 692 fish removed is $29.00. Of course, included in this price are close to 500 marked squawfish that provided census information.

POPULATION ESTIMATES

Fishermen tagged 495 squawfish in two periods and recaptured 10 tagged fish. Of the fish recaptured, three occurred on the same day from gillnets. We chose not to include these three recaptured fish in population models since it is likely they did not mix with the squawfish population. We also observed that only fish tagged from the first period (March 30 through May 11) where recovered. The second group of fish were tagged when at other projects, squawfish are shown to move out of tailrace areas to spawn (Lynch, 1993 and Welsh et al., 1994).

Acquiring accurate population estimates from open populations can be difficult without an estimate of the population rates of immigration and emigration. A moving Peterson or Schnabel population estimate has been used to compensate for this fact. One can estimate these two components with ladder counts at the dam and the application of highly visible tags. No attempt in 1995 were made to determine the rate of movement. Instead, the 1995 population estimate was accomplished by a simple Peterson population estimator as described in Lynch (1993).

We estimated the population with both a simple Petersen population estimator (Lynch 1993) and a Schnabel estimator (Welsh, et. al 1994 and Lynch 1993). For the Petersen, tags from the first tag period were used and recoveries were made only after all tags were out. This left three tag recoveries. The Schnabel estimator helped correct for immigration and emigration since this can be utilized where continual tagging and recapturing occurs.

Assumptions

1. All marked fish mixed back into the population to be censuses.
2. Equal catchability of all fish tagged or untagged.
3. No immigration or emigration from the population.

The third assumption apeared to be violated since no tagged fish from the second tagging period were recovered.

Simple Petersen Estimate

From the 108 squawfish fishermen tagged and released during the first tagging period, three valid Petersen recoveries occurred. Fishermen caught 497 squawfish during the first period tagging and recovery session. The Petersen population estimate for Wells tailrace squawfish is 17,892 fish (±16,941 90% C.I. and ± 20,186 95% C.I.). The confidence intervals where estimated with a Z-statistic via the Delta Method (Ricker, 1975).

$$M*C/R=N \qquad (108)(497)/(3)= 17,892$$

where M is total marks or tags in the population
C is number of captured fish
R is number of recaptured tags

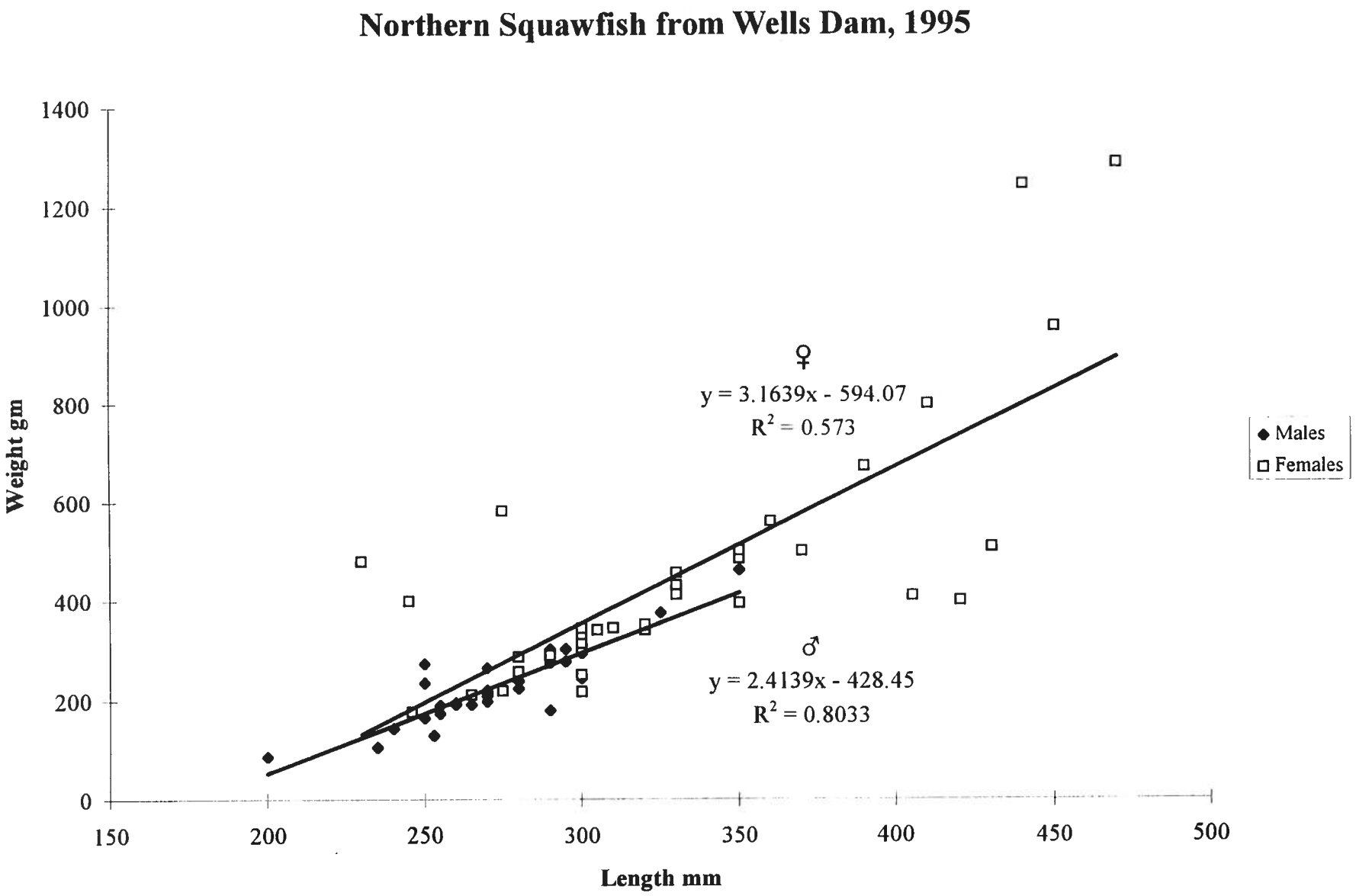
Schnabel Estimate

The Schnabel Population estimate for Wells tailrace was 10,761 (±4,734 90% C.I. and ±5,640 95% C.I.). The confidence intervals where estimated with a Z-statistic via the Delta Method (Ricker, 1975). This estimator utilized all 7 valid tag recaptures, using each day that a recovery occurred as the end of a sample block.

Date of Recapture	(C) Total Catch to Date	(M) Total number of Marks Available	(R) Daily Recaptures	(C x M)
1-May	55	55	1	3025
3-May	74	74	1	5476
8-May	94	94	1	8836
9-May	98	98	1	9604
24-May	196	108	1	21168
1-Jun	252	108	2	27216
			7	75325

$$\text{Population Estimate} = \frac{\Sigma(C \times R)}{\Sigma(R)} = \frac{75325}{7} = 10{,}761 \text{ squawfish}$$

Figure 8. Length vs. weight of Northern Squawfish removed at Wells Dam, 1995.



DISCUSSION

We expected gillnets to remove many squawfish from the hatchery outfall and tail race areas. We based this upon previous efforts in this area and experience seen in other parts of the Columbia (Collis, et al 1995). When gillnets were used for the entire day, CPUE was initially fair, but would fall off. This was true even after the release of yearling and young of the year chinook from the Wells Hatchery. In 1993, fishermen fished gillnets in the early morning hours compared to sampling during the day hours in 1995. Squawfish may have been able to detect gillnets better with day light in part may be the reason for low success.

Sport gear was more effective when fishermen moved away from the shore and located groups of fish with a fish finder from a boat. The most productive spot was also were the currents were slower. Bank angling along both shores of the Wells tailrace proved to be poor. River currents in the Wells tailrace are fairly swift along both banks and may not provide suitable holding areas for foraging squawfish. Angling near the hatchery outfall channel, where currents were slower, had a higher rate of success.

Lamprey ammocoetes dramatically improved success when they were used as fresh bait. The 1993 research did not indicate that ammocoetes were part of the squawfish forage (Burely, et.al,. 1994). Scott and Crossman (1973) report ammocoetes are used as bait for trout and sturgeon. We feel that based upon the immediate response of squawfish to the ammocoete bait that they are the prey of choice in early June. The use of ammocoetes for squawfish removal may be questioned in the Columbia Basin with the current concern over declines of lamprey populations.

Of the sixty nine squawfish that were sampled for biological information, thirty five were less than 300mm; a length that biologist say squawfish are large enough to be a successful predator of juvenile salmon and steelhead. Age information from the sampled squawfish is not available for this report.

The 1995 population census was successful in generating estimates for the tailrace of Wells Dam. We assume that since no recaptures occurred from the second marking period, these squawfish left the tailrace. Lynch (1993) and Burley, et. al (1994) observed a similar phenomena where fish tagged in the latter portion of the summer migrated out of the study area. Further evidence of squawfish movement is the increase of squawfish passage through the Wells fish ladder during June and July. The Peterson estimate is fairly sensitive to this type of model violation. However, the Schnabel estimator provides several instantaneous pictures of the population and

collectively develop a better population estimate. We feel the Schnabel estimate of 10,761 squawfish in the Wells Tailrace is the best of the two estimates. This model uses all valid tag recapture tags and occurred when the population was not moving.

RECOMMENDATIONS

Based upon our experience in 1995, future removal efforts will focus on sport angling when the CPUE was the highest, from mid-May to mid-July. A variety of lures and hours during the day will also be compared. Because of the high bi-catch in the Wells tailrace, gillnet will not be used as a means for removal of squawfish. Gillnets may be used in the future for removal in the Wells pool should they demonstrate a minimal bi-catch. The commercial jigging gear was not adequately evaluated in 1995 and should be tested as a tool for squawfish removal. Also census efforts will focus on periodic tagging (i.e. one day a week) to help in determination of the population and migration of these fish.

ACKNOWLEDGMENTS

We would like to thank Keith Dukes, Travis Maitland and Alan McDaniel who spent numerous hours on the water tagging and catching squawfish. We also thank Jerry Moore and the staff at the Wells Hatchery for assistance with freezer space to store removed squawfish.

Table 1. 1995 Wells Dam gillnet catch and effort.

Wells Dam Squawfish Removal Program 1995

Records of gillnet fishing effort | Bi-catch Species

Date	DAY	# Sets	Hours	Squawfish	Squawf CPUE	Cutthroat Trout	Rainbow Trout	Smallmouth Bass	Steelhead kelts	Suckers	Walleye	Whitefish	Other species
30-Mar	TH	3	1.17	3	2.57					5		1	
11-Apr	TU	8	5.78	14	2.42					30			
12-Apr	WE	11	7.53	3	0.40					18			
13-Apr	TH	4	4.10	1	0.24					14			
18-Apr	TU	7	6.17	1	0.16		9		1	17			
19-Apr	WE	12	11.58	3	0.26		1		1	25	2	3	
20-Apr	TH	10	9.58	1	0.10				1	17	2		
24-Apr	MO	10	9.98	16	1.60	1	1		3	36		2	
25-Apr	TU	14	12.17	2	0.16	1	1		2	51	9	4	
26-Apr	WE	8	6.17	2	0.32					18	6	2	
27-Apr	TH	8	6.33	2	0.32				1	0	5	6	
1-May	MO	16	12.75	10	0.78				2	41	8	9	1
2-May	TU	6	4.82	2	0.42				1	5	5	3	
3-May	WE	17	11.82	20	1.69		1		1	63	5	2	
4-May	TH	14	10.57	13	1.23					36	4	3	
8-May	MO	16	11.52	8	0.69		1			55	8	4	1
9-May	TU	10	7.98	4	0.50			1		24	7	4	
10-May	WE	14	12.37	4	0.32		1	3		35	9	8	
11-May	TH	8	6.33	1	0.16		1			24	3		1
15-May	MO	4	3.07	0	0.00					20	4	3	1
2-Jun	FR	1	0.33	3	9.00					1	1	3	2
14-Jun	WE	2	1.07	0	0.00					14	1		
19-Jun	MO	1	0.33	1	3.03			1		4			
22-Jun	TH	1	0.22	2	9.09		1			7			
Total		205	163.73	116	0.71	2	17	5	13	560	79	57	6

Squawfish CPUE is described as catch per hour of fishing time

The dimensions of the nets used are 6' by 75'

Table 2. 1995 Wells Dam Sport gear catch and effort.

Wells Dam Squawfish Removal Program 1995

Record of Fishing Effort with Sport gear

Date	DAY	Hours	Squawfish	Squaw CPUE	Suckers	Walleye	Other	Comments
13-Apr	TH	4.00	0	0.00				No catch; used heavy gear
17-Apr	MO	17.00	1	0.06				Tagged and released all squawfish
18-Apr	TU	5.00	0	0.00				
19-Apr	WE	5.00	0	0.00				
20-Apr	TH	4.00	0	0.00				No catch; used heavy gear
24-Apr	MO	4.00	0	0.00				No catch; used heavy gear
26-Apr	WE	7.00	0	0.00				No catch; used heavy gear
27-Apr	TH	5.00	0	0.00				
1-May	MO	4.50	0	0.00				
2-May	TU	7.50	1	0.13			1	1 Cutthroat
3-May	WE	15.00	0	0.00				
4-May	TH	10.50	0	0.00				
8-May	MO	7.00	0	0.00				
9-May	TU	11.00	1	0.09				
10-May	WE	8.00	0	0.00				
11-May	TH	12.75	5	0.39				Last day tagging first period
16-May	TU	18.00	6	0.33				Removed all squawfish starting today
17-May	WE	19.00	1	0.05				River muddy from rain
18-May	TH	20.00	21	1.05				Fished from boat;
22-May	MO	18.00	41	2.28				Fished from boat;
23-May	TU	13.00	8	0.62				No fish from bank
24-May	WE	6.42	28	4.36				
25-May	TH	14.00	45	3.21			1	1Peamouth;
30-May	TU	8.00	2	0.25				
31-May	WE	16.50	8	0.48				Catch between 1000 and 1100, otherwise slow
1-Jun	TH	13.17	102	7.74				Fished with lamprey ammocoetes.
2-Jun	FR	10.46	95	9.08				Fished with ammocoetes;slow in afternoon
5-Jun	MO	15.57	33	2.12			1	1 Chiselmouth; salmon morts for bait
6-Jun	TU	11.50	8	0.70			1	1 Chiselmouth; rain today
7-Jun	WE	15.66	30	1.92			2	2 Chiselmouth
8-Jun	TH	12.08	80	6.62			4	3 Chiselmouth, 1 Peamouth; ammocoetes for bait
12-Jun	MO	7.76	43	5.54			1	1 Chiselmouth; start of second tagging period
13-Jun	TU	15.50	46	2.97		1		Tagged all squawfish
14-Jun	WE	22.00	16	0.73			1	1 Chiselmouth
15-Jun	TH	19.50	4	0.21			1	1 Chiselmouth
19-Jun	MO	12.50	34	2.72				
20-Jun	TU	15.46	43	2.78				Fished east and west side of river
21-Jun	WE	5.75	14	2.43				Fished channel and later from boat

Table 2. 1995 Wells Dam Sport gear catch and effort.

Wells Dam Squawfish Removal Program 1995

Record of Fishing Effort with Sport gear

Date	DAY	Hours	Squawfish	Squaw CPUE	Suckers	Walleye	Other	Comments
22-Jun	TH	15.50	64	4.13			1	1 Chiselmouth
26-Jun	MO	14.84	48	3.23				Very windy after 1600
27-Jun	TU	15.00	23	1.53				Grubs & smolts used for bait
28-Jun	WE	17.66	19	1.08				Salmon morts & rooster tails used
29-Jun	TH	15.66	24	1.53				
30-Jun	FR	14.40	20	1.39				Finished tagging; removed 10 squawfish
5-Jul	WE	11.00	11	1.00				Part in river and hatchery channel
6-Jul	TH	17.00	46	2.71				River and hatchery outfall channel
10-Jul	MO	15.94	27	1.69			2	2 Smallmouth Bass
11-Jul	TU	16.00	8	0.50				
12-Jul	WE	20.66	9	0.44			1	1 Smallmouth Bass
13-Jul	TH	15.84	14	0.88			5	3 Smallmouth Bass; 2 Rainbow Trout
17-Jul	MO	15.61	15	0.96				
18-Jul	TU	21.34	13	0.61				
19-Jul	WE	16.16	4	0.25				
20-Jul	TH	16.50	12	0.73			2	2 Smallmouth Bass
24-Jul	MO	17.00	3	0.18			1	1 Smallmouth Bass
25-Jul	TU	19.00	0	0.00				
26-Jul	WE	19.00	1	0.05			1	1 Smallmouth Bass
27-Jul	TH	5.00	2	0.40			1	1 Smallmouth Bass
Total		756.19	1079	1.43	0	1	27	

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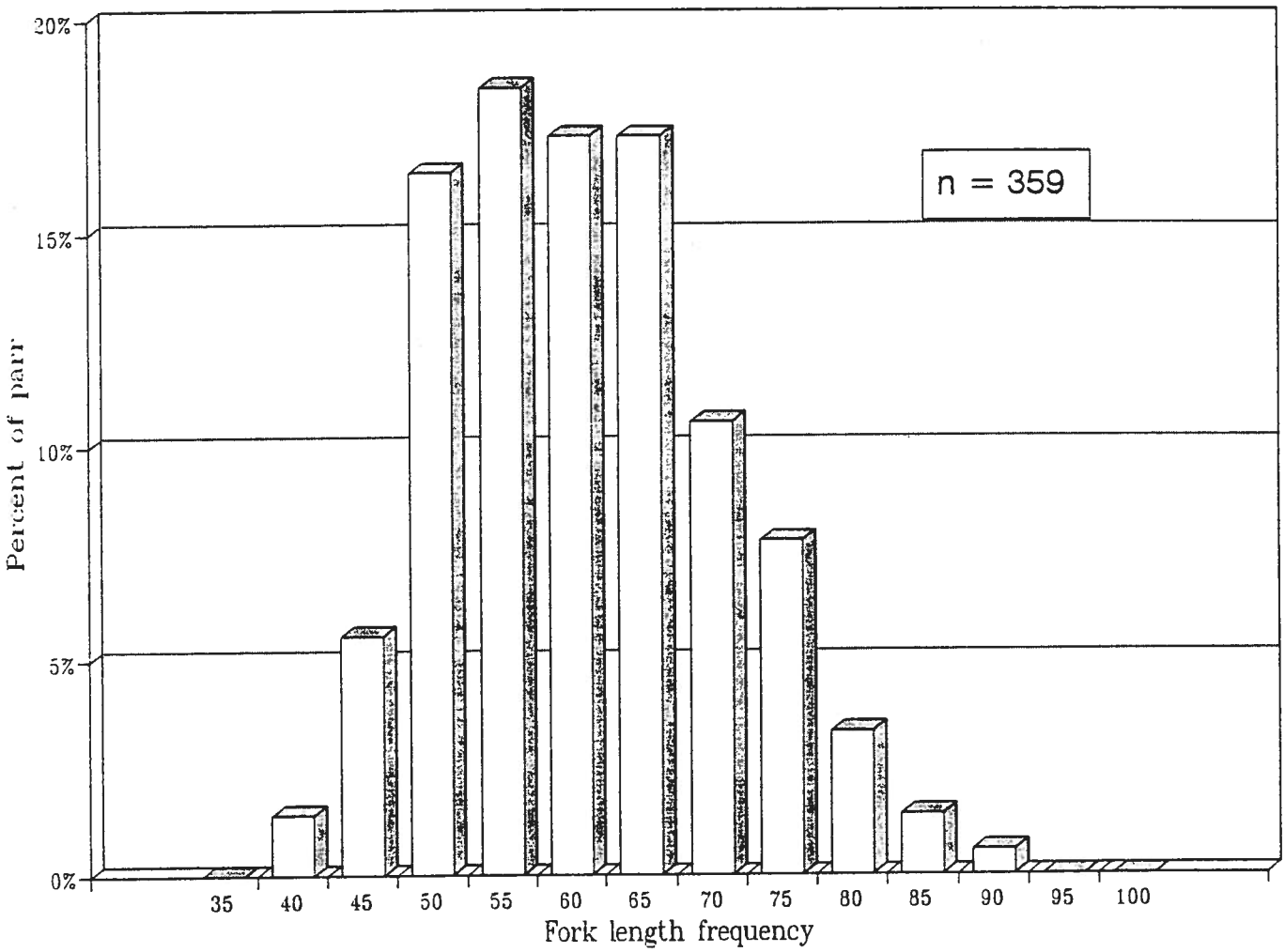

Figure 8. Length frequency distribution of Chewuch basin spring chinook parr, 1994.

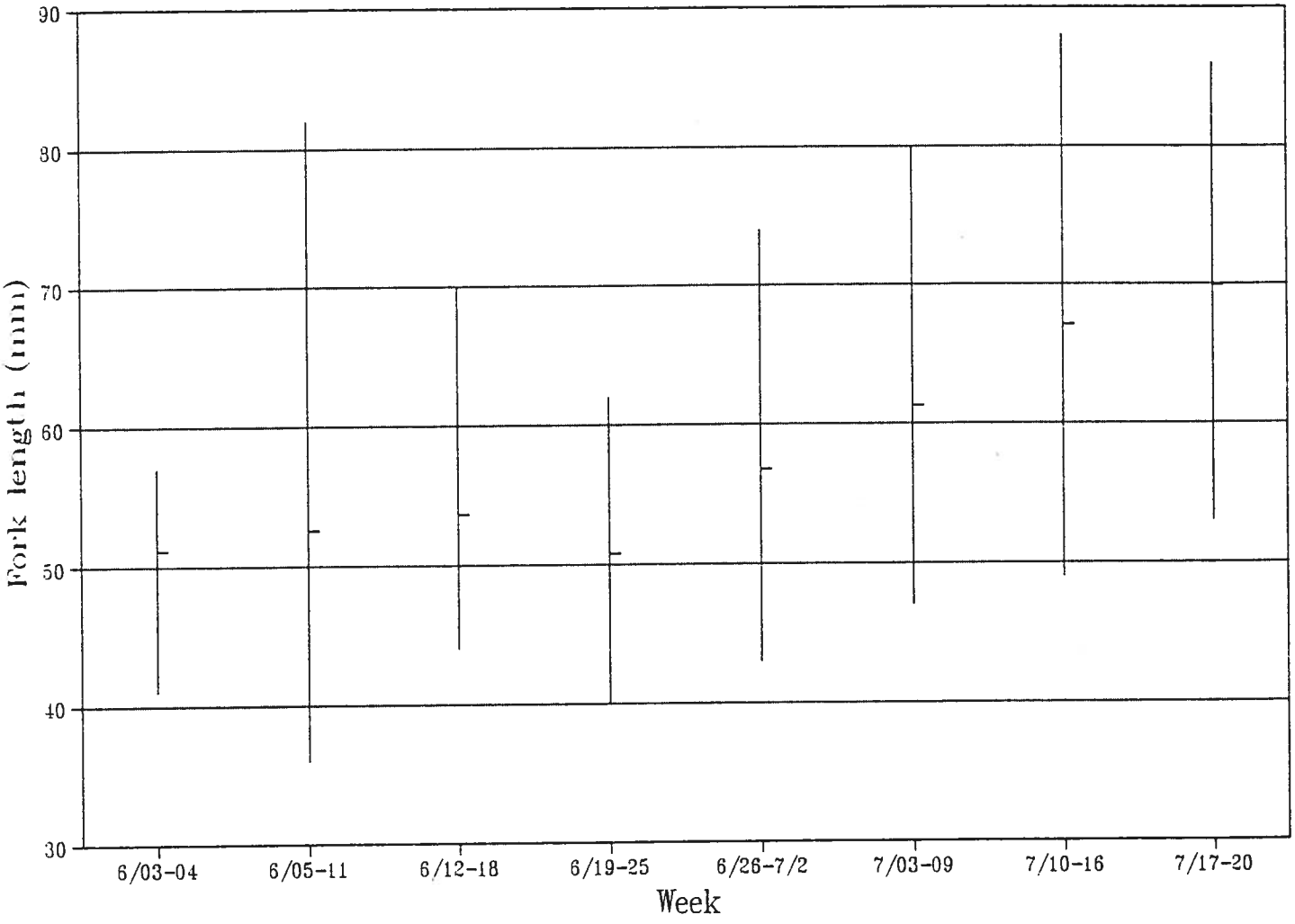

Figure 9. Weekly mean fork length for spring chinook parr in the Chewuch River, 199-

6.2. LATE SUMMER PARR DENSITIES

6.2.1. spring chinook

The spring chinook parr population estimate for the Chewuch basin was estimated at 9,362 fish (Table 1), compared to 5,838 parr in 1993. The presence of newly emergent spring chinook YOY and spring chinook parr captured in the screw trap between March 31 through July 20 indicates that a portion of the population continues its rearing outside of the Chewuch basin. This is similar to what was observed in 1993, which indicates that several freshwater life history rearing patterns occur for the Chewuch basin spring chinook population.

The 1994 parr distribution was similar to that observed in 1993, with the exception of reach VII where a higher number of parr were observed (Table 1). As in 1993, the greatest parr density (fish/rm) occurred in reaches II and III with 337 and 483 fish/rm, respectively. Reaches II and III, represent 52.8% of the mainstem rivermiles used by spring chinook and account for 78.6% of the late-summer parr (7,362 fish) residing in the Chewuch River.

Unlike in 1993, a large number of parr (275 fish/rm) resided in reach VII which had the fourth highest density. Reach VIII (rm 31.2-32.4), which was excluded in 1993, had a parr density of 294 fish. The higher number of fish found in reach VII in 1994 is due, possibly, to less numbers of fish outmigrating but is more likely a result of a more intense snorkeling effort. In addition, it's thought that the 1994 spring chinook

Table 1. Summary of spring chinook and steelhead/rainbow parr population estimates for the Chewuch River 1993 and 1994.

	Spring chinook 1993			Spring chinook 1994			Steelhead/rainbow age 0+ 1993			Steelhead/rainbow age 1+ 1993			Steelhead/rainbow age 0+/1+ 1994		
Reach (rm's)	Fish/rm	Total fish	% Total fish	Fish/rm	Total fish	% Total fish	Fish/rm	Total fish	% Total fish	Fish/rm	Total fish	% Total fish	Fish/rm	Total fish	% Total fish
I (0.0-2.3)	99	227	3.9%	151	348	3.7%	154	355	60.4%	74	170	6.2%	127	292	11.5%
II (2.3-8.4)	262	1, 597	27.4%	337	2, 054	21.9%	15	92	15.6%	90	551	19.9%	178	1, 085	42.7%
III (8.4-19.4)	276	3, 041	52.1%	438	5, 308	56.7%	3	31	5.3%	59	650	23.5%	55	607	23.9%
IV (19.4-23.3)	230	899	15.4%	105	409	4.4%	10	38	6.5%	129	501	18.1%	76	295	11.6%
V (23.3-24.6	44	56	1.0%	2	2	0.0%	50	66	11.2%	625	813	29.4%	40	52	2.0%
VI (24.6-28.0)	4	12	0.2%	2	8	0.1%	2	6	1.0%	23	79	2.9%	29	100	3.9%
VII (28.0-31.2)	2	6	0.1%	275	880	9.4%	0	0	0.0%	0	0	0.0%	32	103	4.1%
VIII (31.2-32.4)	--	--	--	294	353	3.8%	--	--	--	--	--	--	8	9	--
Total		5, 838			9, 362			588			2, 764			2, 543	
Mean	180			289			18			85			78		

parr estimate for reach VII could be low. For example, in a specific glide surveyed, no parr were found during the daytime snorkel survey. However, during the nighttime snorkel survey 12 parr were counted, and much of this reach is comprised of glide habitat.

The estimated number of parr in reaches VII and VIII was 1,233 fish which represents 13.2% of the spring chinook parr population.

The parr density in reach I was higher (151 fish/rm) than in 1993 (99 fish/rm). Similar to 1993, low parr densities (4 fish/rm) were occurred in reaches V and VI, however, the parr density in reach V was greater (44 fish/rm) in 1993.

The parr distribution in both 1993 and 1994 was similar to that of the redd distribution for corresponding broodyears 1992 and 1993 (Figure 10). The highest redd counts occurred in reach III with 163 redds in 1992 and 69 redds in 1993, which accounted for 88% and 83% of the basin's total redds, respectively. The presence of parr both years in reach IV, where no redds were found in 1992 and only one redd in 1993, indicates that parr are either moving downstream from reach VII or upstream from reach III. In both 1993 and 1994 little parr rearing has occurred in reaches V and VI. No spawning has occurred in either reach for the corresponding broodyears of 1992 and 1993.

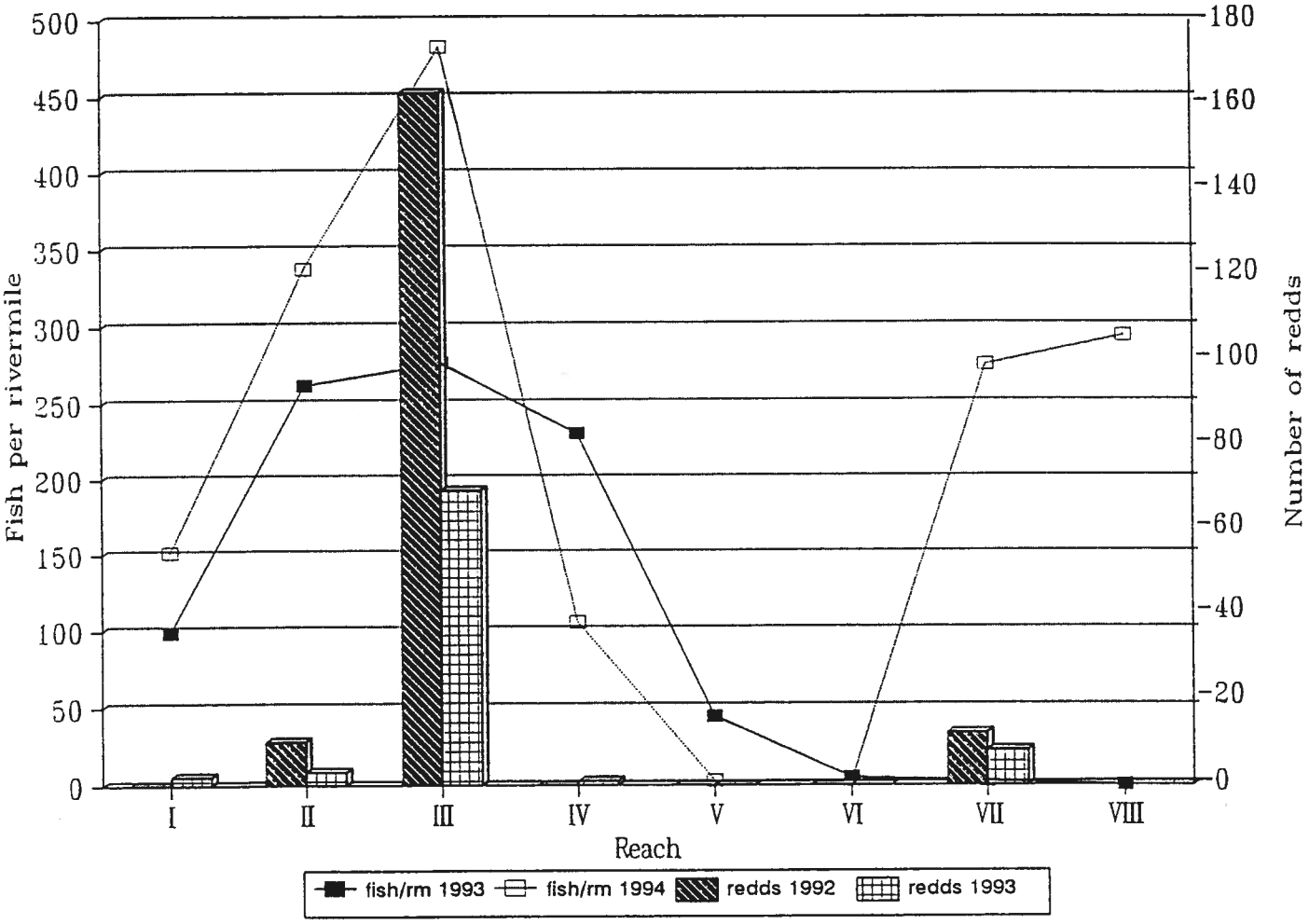

Figure 10. Comparison of spring chinook redd counts and parr density by reach in the Chewuch basin, 1993 and 1994.

Similar to 1993, it appears that the late-summer parr population represents a small portion of the expected population. There were 83 redds found in 1993 (Scribner et al., 1993). There is a wide range in salmonid egg-to-fry survival rates reported in the literature depending on the percent fines and the study cited. For a range in percent fines of 10% to 30%, the median percent emergence, taken from the literature, ranged from about 89% to 40% (Bjornn and Reiser, 1991). The estimated egg deposition was 439,900 using a mean fecundity of 5,301 eggs per female (Bartlett, pers comm., 1995). This equates to an estimated fry emergence of 390,700 - 175,600 using the aforementioned range in fry survival. Since no fry-to-parr survival rate data exists for the Chewuch basin, a Beverton and Holt model (National Marine Fisheries Service, 1993) taken from the literature was used to estimate the range in the late-summer parr population in the Chewuch basin. This model takes into account percent seeding level and sets the low density survival rate at 0.5. The model predicts fry-to-parr survival rates to range between 13% and 32% depending on the basin's percent seeding level. This equates to an estimated late-summer parr population between 124,800 to 22,750 fish, which is 13.3 to 2.4 times greater than the estimated population of 9,362 fish. For comparison, in 1993 the calculated late-summer parr population estimate was 21.4 to 3.9 times greater than the observed late-summer parr population estimate of 5,838 fish.

There was 2.2 times more redds in 1992 (185 redds) than in 1993 (83 redds), and thus one would have expected to see a substantially greater number of late-summer parr in

1993. As discussed earlier, the 1993 parr estimate was probably underestimated due to unusually high summer stream flows which negatively affected snorkeling efficiency. The 1994 smolt estimate of 12,494 fish compared to the 1993 late-summer parr estimate of 5,838 fish supports this contention. Thus the 1993 parr estimate is probably much closer to the 1994 late-summer parr estimate than it appears. Given this, one possible explanation why the 1993 late-summer parr estimate is low relative to the number of redds, is that a substantial portion of the parr population may have emigrated from the Chewuch basin prior to or during the snorkel surveys as a result of the higher than normal stream flows. As stated earlier, the average daily discharge from July 9 (the divergent point in summer discharge between years) through September 22 (last survey date) in 1993 was 345 cfs. This compares to an average daily discharge of 74 cfs from July 9 through September 15 (last survey date) in 1994 (Figure 11).

As observed during the 1993 snorkel surveys, spring chinook were closely associated with woody debris complexes during the daytime. Sixty-one percent of the spring chinook parr were found associated with woody debris. However, during a nighttime survey in reach VII, in the glide habitat, spring chinook parr were found evenly dispersed across the sandy gravel flats. Likewise, rainbow trout were out in the open, but were more closely associated with the deeper pool areas, and bull trout were found singularly resting on the sandy gravel flats similar to spring chinook.

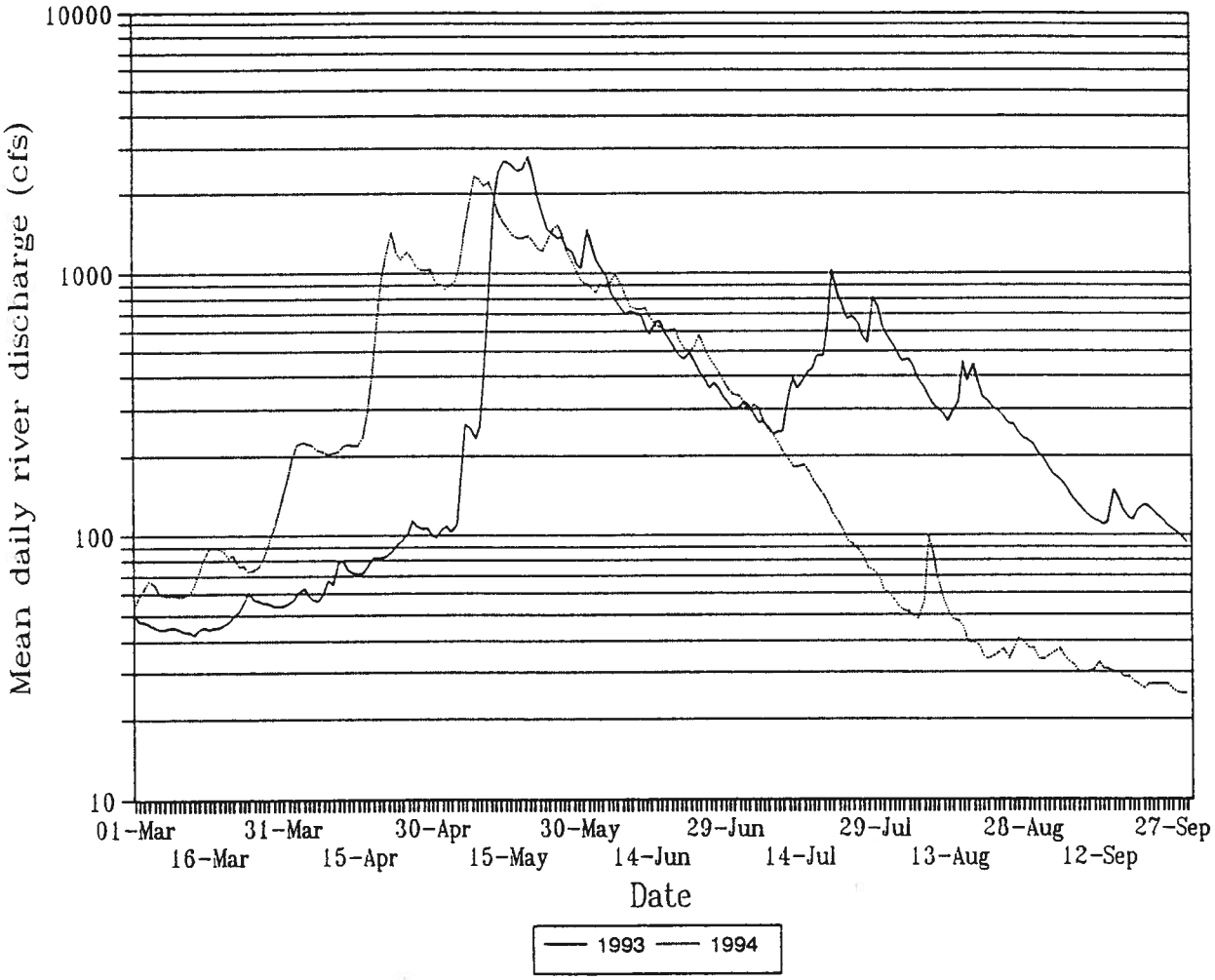

Figure 11. Comparison of the mean daily discharge for the Chewuch River at rm 0.1, 1993 and 1994.

6.2.2. steelhead/rainbow trout

The population estimate for age 0+ and age ≥1+ steelhead/rainbow, most of which were age ≥1+, was 2,543 fish (Table 1). The highest steelhead/rainbow densities occurred in reaches I (127 fish/rm) and II (178 fish/rm), this accounted for 54.1% of the total estimate number fish in the basin. Parr density for the remaining reaches, in decreasing order were: reach IV (76 fish/rm), reach III (55 fish/rm), reach V (40 fish/rm), reach VII (32 fish/rm), reach VI (29 fish/rm) and reach VIII (8 fish/rm). As experienced in 1993, the number of steelhead/rainbow YOY was probably under-counted because of the inability to survey the shallow water along the margins where these fish typically reside. Unlike spring chinook parr, the steelhead/rainbow parr and YOY distribution was not similar to that seen in 1993.

6.3. SPAWNING GROUND SURVEYS

6.3.1. Spring Chinook Run Size

The 1994 Wells Dam spring chinook count was 257 (242 adults, 15 jacks) fish (pers comm. Douglas PUD, 1995) (Table 2), which is a 10.2-fold decrease compared to the 1980-89 average run size of 2,643 fish.

6.3.2. Winthrop National Fish Hatchery (WNFH) and Methow Fish Hatchery Broodstock (Methow FH)

A total of 29 (16 F, 13 M) spring chinook were collected for broodstock at the WNFH in 1994. For the Methow FH in 1994, five (4 F, 1 M) spring chinook were collected from the Twisp River, twelve (6 F, 6 M) spring chinook from the Chewuch River, and seventeen (9 F, 8 M) spring chinook from the Methow River (Table 2).

6.3.3. Spawning Ground Surveys

6.3.3.1. Methow River

A total of 64 redds were found in the Methow River which comprised 48.1% of the Methow Basin's total redd count (Table 3). Redds were found as far upstream as the Lost River confluence downstream to the Twisp River bridge. Fifty-three percent (34) of the redds were located in the Weeman Bridge to Highway 20 (along the river) reach which is historically where most spawning occurs. Within the index area (reaches 5 and 6) 42 redds (65.6%) were counted.

The peak period of spawning was the week of 8/29 - 9/1 with 19 redds (14.3%).

Table 2. Summary of Wells Dam passage, broodstock collection and spawner escapement for the Methow Basin spring chinook, 1967–94.

Year	Wells Dam counts		Total	Winthrop	Methow hatchery			Spawner
	Adult	Jack		hatchery	Twisp	Chewuch	Methow	escapement
1967	541	616	1, 157	—	—	—	—	1, 157
1968	4, 086	845	4, 931	—	—	—	—	4, 931
1969	3, 048	551	3, 599	—	—	—	—	3, 599
1970	2, 092	578	2, 670	—	—	—	—	2, 670
1971	2, 535	633	3, 168	—	—	—	—	3, 168
1972	3, 368	248	3, 616	—	—	—	—	3, 616
1973	2, 505	507	3, 012	—	—	—	—	3, 012
1974	3, 199	221	3, 420	—	—	—	—	3, 420
1975	2, 096	129	2, 225	—	—	—	—	2, 225
1976	1, 510	1, 249	2, 759	—	—	—	—	2, 759
1977	3, 976	235	4, 211	—	—	—	—	4, 211
1978	3, 532	83	3, 615	38	—	—	—	3, 577
1979	971	132	1, 103	102	—	—	—	1, 001
Average	2, 574	464	3, 037					3, 027
1980	941	241	1, 182	155	—	—	—	1, 027
1981	1, 367	98	1, 465	399	—	—	—	1, 066
1982	2, 270	131	2, 401	601	—	—	—	1, 800
1983	2, 726	143	2, 869	755	—	—	—	2, 114
1984	3, 066	214	3, 280	510	—	—	—	2, 770
1985	5, 151	116	5, 267	1, 201	—	—	—	4, 066
1986	2, 896	65	2, 961	836	—	—	—	2, 125
1987	2, 272	74	2, 346	594	—	—	—	1, 752
1988	2, 844	96	2, 940	1, 327	—	—	—	1, 613
1989	1, 633	87	1, 720	195	—	—	—	1, 525
Average	2, 517	127	2, 643					1, 986
1990	927	12	939	121				818
1991	682	100	782	92				690
1992	1, 596	27	1, 623	331	40	20	0	1, 232
1993	2, 422	22	2, 444	646	43	110	99	1, 546
1994	242	15	257	29	5	12	17	194
Average	1, 174	35	1, 209					896

Table 3. Summary of spring chinook spawner survey information for the Methow River, 1994.

River section	July	August					September			Redds
	25 & 26	1	8, 9, 11	15, 18	22, 25	29, 31, 9/1	6, 7, 8	12, 13, 14	19, 20, 12	%
1. W. Fork Ballard C.G. to Lost R. confl.	—	—	—	0	—	—	—	—	—	0 0.0%
2. Lost R. confl. to Gate Creek	0	0	0	1	2	2	0	—	—	5 7.8%
3. Gate Creek to Early Winters Cr.	0	0	1	1	0	—	—	—	—	2 3.1%
4. Early Winters Cr. to Mazama Bridge	0	0	0	1	4	3	0	—	—	8 12.5%
5. Mazama Bridge to Weeman Bridge	0	0	1	3	0	2	2	0	—	8 12.5%
6. Weeman Bridger to Hwy. 20 along river	0	0	0	4	5	12	10	3	0	34 53.1%
7. Hwy. 20 along river to Wolf Creek	0	0	0	2	0	0	0	0	0	2 3.1%
8. Wolf Creek to Diversion dam	0	0	0	0	1	0	2	0	—	3 4.7%
9. Diversion dam to Winthrop Bridge	0	0	0	0	0	0	0	0	—	0 0.0%
10. Winthrop Bridge to Diversion dam	—	—	—	—	—	0	1	0	0	1 1.6%
11. Diversion dam to Twisp bridge	—	—	—	—	—	0	0	1	0	1 1.6%
12. Twisp Bridge to Carlton Bridge	—	—	—	—	—	—	—	—	0	0 0.0%
Totals	0	0	2	12	12	19	15	4	0	64 100.0%
Temperature range (F)		57-6	50-6	51-6	51-6	50-62	50-6	49-6	50-60	

A total of six dewatered redds were documented in the Lost River to Weeman Bridge reach. One redd was partially excavated to determine the extent of egg development in mid-October near Goat Wall. Surveyors found nearly 100% sac fry in this redd, all of which were mortalities. In digging into the substrate, it was found to be completely dry and subsurface flow was well below the egg deposition zone.

6.3.3.3. Lost River

A total of six redds were located in the Lost River in 1994, all of which were in the confluence to Eureka Creek reach (Table 4). Spawning in the Lost River comprised 4.5% of the Methow Basin's total redd count, the lowest percentage since 1987 when records were first kept.

Four of the six redds were deposited the week of August 15.

6.3.3..4. Chewuch River

In 1994 twenty-seven redds or 20.3% of the total Methow Basin's redd count (Table 5) were deposited in the Chewuch River. This percentage is less than the 27.6% mean Chewuch River average for the period 1987-1993. Spawning occurred downstream from Thirty-Mile Bridge (Dibble Springs area) to nearly Fulton Dam, with 29.6% of the redds occurring from Camp Four bridge downstream to the Chewuch campground (reaches 7 and 8). Reach 14 (Chewuch River bridge downstream to the "halfway point") comprised 22.2% of the redds in the Chewuch River.

Table 4. Summary of spring chinook spawner survey information for the Lost River, 1994.

River section	July	August					
	25	1	8	15	22	29	Redds (%)
1. Sunset Cr. to Eureka Cr.	0	0	0	0	0	0	0 0.0%
2. Eureka Cr. to Bridge	0	0	0	4	2	0	6 100.0%
3. Bridge to Methow River	0	0	0	0	0	0	0 0.0%
Totals	0	0	0	4	2	0	100.0%
Temperature Range (F)	--	50-56	--	50-58	50-56	--	

Table 5. Summary of spring chinook spawner survey information for the Chewuch River, 1994.

River section	July	August					September				
	26, 27, 28	2	9	16	23	30	6	13	19	26	Redds %
1. Falls to Thrity-Mile Bridge	—	—	—	0	—	—	—	—	—	—	0 0.0%
2. Thrity-Mile Bridge to Roadside camp	0	—	0	1	1	0	—	—	—	—	2 7.4%
3. Roadside camp to Andrews Creek	—	—	—	—	—	—	—	—	—	—	0 0.0%
4. Andrews Creek to Lake Creek C.G.	0	—	—	—	—	—	—	—	—	—	0 0.0%
5. Lake Creek C.G. to Buck Creek	—	0	—	—	—	—	—	—	—	—	0 0.0%
6. Buck Creek to Camp 4	0	0	0	0	0	3	0	—	—	—	3 11.1%
7. Camp 4 to Roadside camp	0	0	0	4	0	0	0	—	—	—	4 14.8%
8. Roadside camp to Chewuch C.G.	0	0	0	0	0	0	4	0	—	—	4 14.8%
9. Chewuch C.G. to Mile 6	0	0	0	0	0	1	0	—	—	—	1 3.7%
10. Mile 6 to Falls Creek C.G.	0	0	0	0	0	0	1	1	—	—	2 7.4%
11. Falls Creek C.G. to Eight-Mile Ranch	0	0	0	0	0	1	0	—	—	—	1 3.7%
12. Eight-Mile Ranch to Memorial Bridge	0	0	0	0	0	0	0	—	—	—	0 0.0%
13. Memorial Bridge to Chewuch R. bridge	—	—	0	—	—	—	—	—	0	—	0 0.0%
14. Chewuch R. bridge to halfway point	0	—	—	—	—	—	—	5	1	0	6 22.2%
15. halfway point to confluence	0	—	—	—	—	—	—	2	2	0	4 14.8%
Totals	0	0	0	5	1	5	5	8	3	0	27 100.0%
Temperature range (F)		54-6	53-6	52-6	54-6	51-58	49-6	48-6	53-6	51-54	

The peak spawning occurred the week of September 13 with 8 redds or 29.6% of the total Chewuch River redd count.

6.3.3.5. Twisp River

A total of 32 redds were counted in the Twisp River this year (Table 6) which accounted for 24.1% of the total redds in the Methow Basin. This percent composition to the Methow Basin redd total is somewhat below the 1987-93 average of 26.6%. Most of the redds were deposited in reaches 4 and 7 which comprised 78.1% (25 redds) of the Twisp River redd total. Spawning extended from Popular Flats campground downstream to Little Bridge Creek.

Peak spawning occurred the week of August 17 with 20 redds (62.5%).

6.3.3.6. Other Tributaries

In 1994 four redds were deposited in Early Winters Creek and all were deposited the week of September 1 (Table 7).

As in 1993, no redds were located in Lake, Gold, or Wolf creeks.

6.3.3.7. Index Reaches

A summary of spawning in, downstream to and upstream of the index reach for each subbasin is presented in Table 8. In all but the Methow (54.9%) and Lost (100.0%)

Table 6. Summary of spring chinook spawner survey information for the Twisp River, 1994.

River section	August					September		Redds %
	3	10	17	24	31	7	14	
1. Two miles upriver to Road end C.G.	--	--	--	--	--	0	--	0 0.0%
2. Road end C.G. to South Creek Bridge	--	--	0	--	--	--	--	0 0.0%
3. South Creek Bridge to Poplar Flats C.G.	0	0	0	--	--	--	--	0 0.0%
4. Popular Flats C.G. to Mystery Bridge	0	3	10	0	--	--	--	13 40.6%
5. Mystery Bridge to War Creek	0	1	0	--	--	--	--	1 3.1%
6. War Creek to Cabin on left bank rd.	0	0	0	0	--	--	--	0 0.0%
7. Cabin on left bank rd. to Buttermilk Bridge	0	0	9	3	0	--	--	12 37.5%
8. Buttermilk Bridge to bridge with gate	0	0	1	0	0	--	--	1 3.1%
9. bridge with gate to Little Bridge Creek	0	0	--	0	3	2	0	5 15.6%
10. Little Bridge Creek to Newby Bridge	--	--	--	0	--	--	--	0 0.0%
11. Newby Bridge to fish weir	--	--	--	0	--	--	--	0 0.0%
12. fish weir to wooden bridge	0	0	0	0	--	--	--	0 0.0%
13. wooden bridge to Poorman Bridge	0	0	0	0	--	--	--	0 0.0%
14. Poorman Bridge to Twisp R. rd. bridge	0	--	--	0	--	0	--	0 0.0%
15. Twisp R. rd. bridge to confluence	--	--	--	0	--	--	--	0 0.0%
Totals	0	4	20	3	3	2	0	32 100.0%
Temperature range (F)	49-6	48-6	49-6	49-6	55-58	49-5	54-56	

Table 7. Summary of spring chinook spawner survey information for Early Winters Creek, 1994.

River section	July	August			September		Redds (%)
	27	4	18	25	1	8	
1. Klipchuck C.G. to Early Winters Br.	0	0	0	0	3	0	3 75.0%
2. Early Winters Br. (C.G. Rd.) to Highway 20 Bridge	0	0	0	0	0	0	0 0.0%
3. Highway Br. to Diversion Dam	0	0	0	0	0	0	0 0.0%
4. Diversion Dam to Highway 20 Bridge	0	0	0	0	1	0	1 25.0%
5. Highway Bridge to Mouth	0	0	0	0	0	0	0 0.0%
Totals	0	0	0	0	4	0	
Temperature range '(F)	--	52-59	49-54	49-51	49-52	49-51	

Table 8. Summary of spring Chinook redd counts within, downstream from and upstream to the index reaches for the Methow Basin, 1994.

River	Redds Above Index Area (%)	Redds within Index Area (%)	Redds Below Index Area (%)	Percent of basin redd total	Total
Methow	15	42	7	48.1	64
	(23.4)	(65.6)	(11.0)		
Chewuch	5	11	11	20.3	27
	(18.5)	(40.7)	(40.7)		
Lost	0	6	0	4.5	6
	(0)	(100)	(0)		
Twisp	13	13	6	24.1	32
	(40.6)	(40.6)	(18.8)		
Early Winters	3	1	0	3.0	4
	(75)	(25)	(0)		
Basin Total	36	73	24	100.0	133
	(27.1)	(54.9)	(18.0)		

rivers, less than half of the total number of redds were located in the index reach. For the Methow Basin as a whole 54.9% of the redds were located in the index reaches, while the average (1987-93) percent of redds located in the index reaches has been 45.7% and ranged from 42.7% (1992) to 50.7% (1989) (Table 9).

6.3.4. Carcass Recovery

During the surveys, 22 carcasses were examined (Table 10). All of the six females examined were completely spawned and of the 16 males examined none were considered to be green.

6.3.5. Fish Per Redd

Based on the number of adults (257) past Wells Dam, minus broodstock (63) collected the estimated spawner escapement to the Methow Basin was 194 fish. The spawner to redd ratio is estimated at 1.5 to 1.

Table 9. Redd distribution in relation to the index reaches for the Methow Basin, 1987-1994.

Year	Redds Above Index Area (%)	Redds within Index Area (%)	Redds Below Index Area (%)	Total (%)
1987	124 (10.4)	288 (42.8)	261 (38.8)	673
1988	165 (22.5)	294 (40.1)	274 (37.4)	733
1989	69 (13.3)	262 (50.7)	186 (36.0)	517
1990	73 (14.6)	252 (50.5)	174 (34.9)	499
1991	47 (18.8)	117 (46.8)	86 (34.4)	250
1992	96 (13.0)	315 (42.7)	327 (44.3)	738
1993	122 (19.8)	287 (46.5)	208 (37.7)	617
1994	36 (27.1)	73 (54.9)	24 (18.0)	133

Table 10. Summary of spring chinook spawner live counts and carcass count by subbasin, 1994.

Week ending	Methow River			Chewuch River			Lost River			Twisp River			Early Winters Cr.			Lake Cr.			Total		
	Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses	
		M	F		M	F		M	F		M	F		M	F		M	F		M	F
7/28	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0
8/04	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
8/18	7	1	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	11	1	0
8/25	13	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	13	0	0
9/01	52	0	1	4	0	0	0	0	0	5	0	0	1	0	0	0	0	0	64	0	1
9/08	28	3	1	3	0	3	0	0	0	3	0	0	0	0	0	0	0	0	34	3	4
9/15	12	1	4	3	1	1	0	0	0	0	0	1	0	0	0	0	0	0	15	2	6
9/21	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
9/26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	114	5	7	13	1	8	3	0	0	10	0	1	1	0	0	1	0	0	142	6	16

7.0. LITERATURE CITED

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8.0. APPENDIX TABLES

Appendix Table 1. Summary of spring chinook entrainment test releases for the Chewuch screw trap, 1994.

Date	Bank of release	Trap location	Mean daily discharge (cfs)	Number released	Number recaptured	Entrain-ment rate
Spring releases						
April 05	right	left bank	226	113	19	16.8%
April 06	left	left bank	225	69	16	23.2%
April 08	right	left bank	214	56	10	17.9%
April 09	left	left bank	210	70	21	30.0%
April 11	right	left bank	214	96	34	35.4%
April 12	right	left bank	222	55	12	21.8%
April 13	right	left bank	229	84	16	19.0%
April 27	right	right bank	1060	17	1	5.9%
April 28	right	right bank	1020	5	0	0.0%
April 29	right	right bank	1020	6	1	16.7%
April 30	right	right bank	1040	3	1	33.3%
May 01	right	right bank	940	7	1	14.3%
May 02	right	right bank	897	5	0	0.0%
May 03	right	right bank	864	5	0	0.0%
May 04	right	right bank	892	3	1	33.3%
Summer releases						
June 08	right	right bank	895	14	2	14.3%
June 11	right	right bank	725	8	1	12.5%
Mean						13.4%
July 06	left /a	left bank	305	17	2	11.8%
July 15	left /a	left bank	183	13	3	23.1%
Mean						17.4%

/a Fish were released from the left bank after landowner ceased to permission to gain access to the right bank.

Appendix Table 2. Daily catch of non-target species in the Chewuch River screw trap, 1994.

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Spring chinook fry	Bull trout	Cutthroat	Hatchery steelhead
31-Mar-94						1			
01-Apr-94		2							
02-Apr-94	1	2							
03-Apr-94	3								
04-Apr-94		1				3			
05-Apr-94	2	1				2			1
06-Apr-94		1				3			2
07-Apr-94						1			
08-Apr-94						1			
09-Apr-94						5			
10-Apr-94						15			
11-Apr-94						12			
12-Apr-94			1			46			
13-Apr-94		1				12			
14-Apr-94						3			
15-Apr-94						4			
16-Apr-94									1
17-Apr-94						5			1
18-Apr-94	6	1	1			41			
19-Apr-94		1							4
20-Apr-94									
21-Apr-94									
22-Apr-94									
23-Apr-94									
24-Apr-94									
25-Apr-94	4								
26-Apr-94			2						
27-Apr-94	1								
28-Apr-94			1						
29-Apr-94		2							
30-Apr-94			1						
01-May-94									
02-May-94						1			
03-May-94			1			1			
04-May-94			4						
05-May-94									
06-May-94			2						
07-May-94									
08-May-94									
09-May-94									
10-May-94									
11-May-94									
12-May-94									
13-May-94									
14-May-94	3			1					
15-May-94				1					
16-May-94	2			1		1			
17-May-94	3								
18-May-94	3		1	14		5			
19-May-94				14		6		1	
20-May-94	2			7					
21-May-94		1		12					
22-May-94		2		1					
23-May-94	3	1	2	1				2	
24-May-94	1			3				1	
25-May-94	2	1	2	3					
26-May-94		1							
27-May-94	1	1	2	7					
28-May-94				2					
29-May-94		1		3					
30-May-94	3			5					
31-May-94	2	1	1	4					

Appendix Table 2 Cont'. Daily catch of non-target species in the Chewuch River screw trap, 1994.

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Spring chinook fry	Bull trout	Cutthroat	Hatchery /b steelhead
01-Jun-94			2	4					
02-Jun-94	2	4		7					
03-Jun-94	3	2		4					
04-Jun-94	2			2					
05-Jun-94	1	1	2	1					
06-Jun-94	4	1		2					
07-Jun-94	4			1					
08-Jun-94		7		3					
09-Jun-94	1	2		2					
10-Jun-94		4		3					
11-Jun-94		3		2					
12-Jun-94		2		6					
13-Jun-94		1	1	3					
14-Jun-94		2		4					
15-Jun-94		1						1	
16-Jun-94		2		3					
17-Jun-94		1		1					
18-Jun-94			1	2				1	
19-Jun-94	1		2	2					
20-Jun-94									
21-Jun-94			1						
22-Jun-94									
23-Jun-94									
24-Jun-94	2								
25-Jun-94									
26-Jun-94	1 \a	3		2					
27-Jun-94		4	1						
28-Jun-94		15	1		1				
29-Jun-94									
30-Jun-94	1	14							35
01-Jul-94		7		1					54
02-Jul-94			7	1				1	44
03-Jul-94		3		2					47
04-Jul-94	1	4							12
05-Jul-94		4	2						12
06-Jul-94	1	9	2	2					7
07-Jul-94		11		1				1	3
08-Jul-94		8	1						2
09-Jul-94	1	15		1					3
10-Jul-94		7						1	2
11-Jul-94		9							2
12-Jul-94									
13-Jul-94		11							
14-Jul-94		5						2	
15-Jul-94		5		1					
16-Jul-94		12	1					2	
17-Jul-94		4	1		2				
18-Jul-94		8					1		1
19-Jul-94		14		2				2	
20-Jul-94		6			1				
21-Jul-94		3						1	
22-Jul-94									
23-Jul-94									
24-Jul-94									
25-Jul-94									
26-Jul-94				2					
27-Jul-94									
28-Jul-94		9							
29-Jul-94									
30-Jul-94									
31-Jul-94									
01-Aug-94		1							

/a Was an adult.

Appendix Table 3. Daily actual and predicted spring chinook smolt counts for the Chewuch screw trap, 1994.

Day	Daily count, mortalities, discharge and entrainment				Daily estimated passage			Cumulative estimated passage			Percent passage	
	Raw count	Mortalities /a	Mean Q (cfs)	Entrainment rate	Estimated count	Variance	SE	Estimated count	Variance	SE	Cumulative	Daily
31-Mar-94	53	0	146	0.2557	207	946	31	207	946	31	0.0166	0.0166
01-Apr-94	60	0	175	0.2480	242	1137	34	449	2819	53	0.0359	0.0194
02-Apr-94	210	2	206	0.2399	875	7461	86	1324	15402	124	0.1060	0.0700
03-Apr-94	250	0	229	0.2341	1068	10132	101	2392	42406	206	0.1914	0.0855
04-Apr-94	450	0	231	0.2336	1927	27864	167	4319	124486	353	0.3457	0.1542
05-Apr-94	113	0	226	0.2348	481	2921	54	4800	151843	390	0.3842	0.0385
06-Apr-94	74	1	225	0.2351	315	1604	40	5115	171221	414	0.4094	0.0252
07-Apr-94	103	0	218	0.2369	435	2523	50	5550	200091	447	0.4442	0.0348
08-Apr-94	56	0	214	0.2379	235	1086	33	5785	216718	466	0.4630	0.0188
09-Apr-94	74	1	210	0.2389	310	1567	40	6095	239696	490	0.4878	0.0248
10-Apr-94	58	1	211	0.2386	243	1132	34	6338	258519	508	0.5073	0.0194
11-Apr-94	96	3	214	0.2379	404	2268	48	6742	291252	540	0.5396	0.0323
12-Apr-94	56	1	222	0.2358	237	1101	33	6979	311260	558	0.5586	0.0190
13-Apr-94	85	0	229	0.2341	363	1956	44	7342	342918	586	0.5876	0.0291
14-Apr-94	161	0	226	0.2348	686	4981	71	8028	407065	638	0.6425	0.0549
15-Apr-94	99	0	225	0.2351	421	2408	49	8449	449232	670	0.6762	0.0337
16-Apr-94	68	1	239	0.2315	294	1472	38	8743	479449	692	0.6998	0.0235
17-Apr-94	23	0	287	0.2197	105	439	21	8848	489943	700	0.7082	0.0084
18-Apr-94	133	37	416	0.1901	700	9516	98	9548	557089	746	0.7642	0.0560
19-Apr-94	41	2	670	0.1410	291	6769	82	9839	588450	767	0.7875	0.0233
20-Apr-94	19	–	930	0.1021	183	7088	84	10022	617819	786	0.8021	0.0146
21-Apr-94	12	–	1200	0.0721	166	11038	105	10187	662543	814	0.8154	0.0133
22-Apr-94	9	–	1340	0.0600	149	12078	110	10336	725430	852	0.8273	0.0119
23-Apr-94	9	–	1200	0.0721	132	6610	81	10468	784601	886	0.8378	0.0105
24-Apr-94	8	–	1130	0.0790	115	4866	70	10582	843187	918	0.8470	0.0092
25-Apr-94	8	0	1200	0.0721	111	5381	73	10693	911667	955	0.8559	0.0089
26-Apr-94	0	0	1160	0.0760	0	0	0	10693	911667	955	0.8559	0.0000
27-Apr-94	9	0	1060	0.0865	104	3571	60	10797	973383	987	0.8642	0.0083
28-Apr-94	5	0	1020	0.0911	55	1166	34	10852	1006438	1003	0.8686	0.0044
29-Apr-94	6	0	1020	0.0911	66	1548	39	10918	1047736	1024	0.8739	0.0053
30-Apr-94	3	0	1040	0.0887	34	594	24	10952	1070114	1034	0.8766	0.0027
01-May-94	7	1	940	0.1008	69	1402	37	11021	1112240	1055	0.8821	0.0055
02-May-94	5	0	897	0.1065	47	707	27	11068	1140035	1068	0.8859	0.0038
03-May-94	3	0	864	0.1110	27	310	18	11095	1155611	1075	0.8880	0.0022
04-May-94	4	1	892	0.1071	37	506	22	11132	1178274	1085	0.8910	0.0030
05-May-94	3	0	932	0.1019	29	397	20	11161	1197402	1094	0.8933	0.0023
06-May-94	16	0	1090	0.0832	192	11243	106	11353	1357836	1165	0.9087	0.0154
07-May-94	3	–	1420	0.0539	53	2533	50	11406	1426494	1194	0.9129	0.0042
08-May-94	1	–	1920	0.0274	51	2730	52	11457	1493304	1222	0.9170	0.0041
09-May-94	1	–	2340	0.0153	50	11509	107	11507	1653529	1286	0.9210	0.0040
10-May-94	1	–	2300	0.0162	48	10038	100	11555	1815215	1347	0.9248	0.0038
11-May-94	1	–	2160	0.0197	47	6215	79	11602	1947629	1396	0.9286	0.0038
12-May-94	1	–	2230	0.0179	45	7899	89	11647	2108004	1452	0.9322	0.0036
13-May-94	0	0	1960	0.0259	51	0	0	11698	2108004	1452	0.9363	0.0041
14-May-94	0	0	1690	0.0375	50	0	0	11748	2108004	1452	0.9403	0.0040
15-May-94	2	1	1540	0.0459	44	2082	46	11792	2192459	1481	0.9438	0.0035
16-May-94	1	0	1460	0.0511	20	570	24	11812	2228727	1493	0.9454	0.0016
17-May-94	4	0	1380	0.0569	70	3475	59	11882	2353481	1534	0.9510	0.0056
18-May-94	0	0	1360	0.0584	0	0	0	11882	2353481	1534	0.9510	0.0000
19-May-94	1	0	1350	0.0592	17	394	20	11899	2383319	1544	0.9524	0.0014
20-May-94	2	0	1380	0.0569	35	1160	34	11934	2447966	1565	0.9552	0.0028
21-May-94	4	0	1340	0.0600	67	2967	54	12001	2569193	1603	0.9605	0.0054
22-May-94	3	0	1240	0.0684	44	1272	36	12045	2643368	1626	0.9641	0.0035
23-May-94	0	0	1210	0.0712	53	0	0	12098	2643368	1626	0.9683	0.0042
24-May-94	2	0	1320	0.0616	32	933	31	12130	2703752	1644	0.9709	0.0026
25-May-94	4	0	1460	0.0511	78	4763	69	12208	2872989	1695	0.9771	0.0062
26-May-94	3	0	1520	0.0472	64	3712	61	12272	3022734	1739	0.9822	0.0051
27-May-94	3	0	1400	0.0554	54	2346	48	12326	3141319	1772	0.9866	0.0043
28-May-94	0	0	1220	0.0703	30	0	0	12356	3141319	1772	0.9890	0.0024
29-May-94	0	0	1100	0.0821	30	0	0	12386	3141319	1772	0.9914	0.0024
30-May-94	2	0	1010	0.0922	22	307	18	12408	3173115	1781	0.9931	0.0018
31-May-94	4	0	935	0.1015	39	598	24	12447	3225721	1796	0.9962	0.0031
01-Jun-94	3	0	915	0.1041	29	373	19	12476	3263399	1806	0.9986	0.0023
02-Jun-94	2	0	875	0.1095	18	193	14	12494	3286011	1813	1.0000	0.0014

1. Shaded areas denote days the catch was interpolated when the trap was not fishing due to high river discharge.

/a. The high mortalities incurred April 18 were due excessive debris in the cone caused by an increase in river flow.

Appendix Table 4. Daily actual and predicted steelhead smolt counts for the Chewuch screw trap, 1994.

Day	Daily count, mortalities, discharge and entrainment				Daily estimated passage			Cumulative estimated passage			Percent passage	
	Raw count	Mortalities	Mean Q (cfs)	Entrainment rate	Estimated count	Variance	SE	Estimated count	Variance	SE	Cumulative	Daily
31-Mar-94	1	0	146	0.2557	4	12	3	4	12	3	0.0017	0.0017
01-Apr-94	1	0	175	0.2480	4	12	4	8	24	5	0.0034	0.0017
02-Apr-94	12	0	206	0.2399	50	174	13	58	203	14	0.0247	0.0213
03-Apr-94	4	0	229	0.2341	17	58	8	75	272	17	0.0320	0.0072
04-Apr-94	5	0	231	0.2336	21	73	9	96	364	19	0.0409	0.0089
05-Apr-94	6	0	226	0.2348	26	87	9	122	480	22	0.0520	0.0111
06-Apr-94	3	0	225	0.2351	13	42	7	135	541	23	0.0575	0.0055
07-Apr-94	3	0	218	0.2369	13	42	6	148	603	25	0.0631	0.0055
08-Apr-94	0	0	214	0.2379	0	0	0	148	603	25	0.0631	0.0000
09-Apr-94	3	0	210	0.2389	13	41	6	161	666	26	0.0686	0.0055
10-Apr-94	3	0	211	0.2386	13	41	6	174	732	27	0.0741	0.0055
11-Apr-94	4	0	214	0.2379	17	56	7	191	822	29	0.0814	0.0072
12-Apr-94	3	0	222	0.2358	13	42	6	204	893	30	0.0869	0.0055
13-Apr-94	9	0	229	0.2341	38	134	12	242	1118	33	0.1031	0.0162
14-Apr-94	7	0	226	0.2348	30	102	10	272	1305	36	0.1159	0.0128
15-Apr-94	2	0	225	0.2351	9	28	5	281	1360	37	0.1197	0.0038
16-Apr-94	4	0	239	0.2315	17	59	8	298	1475	38	0.1270	0.0072
17-Apr-94	13	0	287	0.2197	59	232	15	357	1899	44	0.1521	0.0251
18-Apr-94	9	0	416	0.1901	47	232	15	404	2302	48	0.1721	0.0200
19-Apr-94	30	0	670	0.1410	213	3972	63	617	7381	86	0.2629	0.0908
20-Apr-94	5	--	930	0.1021	53	808	28	670	10450	102	0.2855	0.0226
21-Apr-94	4	--	1200	0.0721	53	1702	41	723	16878	130	0.3081	0.0226
22-Apr-94	3	--	1340	0.0600	52	1865	43	775	25695	160	0.3302	0.0222
23-Apr-94	4	--	1200	0.0721	52	1702	41	827	36167	190	0.3524	0.0222
24-Apr-94	4	--	1130	0.0790	51	1289	36	878	46519	216	0.3741	0.0217
25-Apr-94	7	0	1200	0.0721	97	4276	65	975	72512	269	0.4154	0.0413
26-Apr-94	4	0	1160	0.0760	53	1452	38	1028	88362	297	0.4380	0.0226
27-Apr-94	6	0	1060	0.0865	69	1831	43	1097	108880	330	0.4674	0.0294
28-Apr-94	3	0	1020	0.0911	33	551	23	1130	118839	345	0.4815	0.0141
29-Apr-94	2	0	1020	0.0911	22	318	18	1152	125725	355	0.4908	0.0094
30-Apr-94	3	0	1040	0.0887	34	594	24	1186	137015	370	0.5053	0.0145
01-May-94	1	0	940	0.1008	10	104	10	1196	139970	374	0.5096	0.0043
02-May-94	0	0	897	0.1065	0	0	0	1196	139970	374	0.5096	0.0000
03-May-94	1	0	864	0.1110	9	83	9	1205	142372	377	0.5134	0.0038
04-May-94	2	0	892	0.1071	19	204	14	1224	147654	384	0.5215	0.0081
05-May-94	3	0	932	0.1019	29	397	20	1253	156745	396	0.5339	0.0124
06-May-94	15	0	1090	0.0832	180	10006	100	1433	235038	485	0.6106	0.0767
07-May-94	2	--	1420	0.0539	38	1343	37	1471	261018	511	0.6268	0.0162
08-May-94	1	--	1920	0.0274	39	2730	52	1510	300993	549	0.6434	0.0166
09-May-94	1	--	2340	0.0153	39	11509	107	1549	402891	635	0.6600	0.0166
10-May-94	1	--	2300	0.0162	39	10038	100	1588	510333	714	0.6766	0.0166
11-May-94	1	--	2160	0.0197	40	6215	79	1628	600755	775	0.6937	0.0170
12-May-94	1	--	2230	0.0179	40	7899	89	1668	713384	845	0.7107	0.0170
13-May-94	0	0	1960	0.0259	51	0	0	1719	713384	845	0.7324	0.0217
14-May-94	1	0	1690	0.0375	50	1243	35	1769	753655	868	0.7537	0.0213
15-May-94	1	0	1540	0.0459	22	747	27	1791	783567	885	0.7631	0.0094
16-May-94	3	0	1460	0.0511	59	2952	54	1850	861405	928	0.7882	0.0251
17-May-94	2	0	1380	0.0569	35	1160	34	1885	906347	952	0.8032	0.0149
18-May-94	2	0	1360	0.0584	34	1079	33	1919	950355	975	0.8176	0.0145
19-May-94	1	0	1350	0.0592	17	394	20	1936	972242	986	0.8249	0.0072
20-May-94	3	0	1380	0.0569	53	2173	47	1989	1044282	1022	0.8475	0.0226
21-May-94	2	0	1340	0.0600	33	1003	32	2022	1089362	1044	0.8615	0.0141
22-May-94	0	0	1240	0.0684	0	0	0	2022	1089362	1044	0.8615	0.0000
23-May-94	0	0	1210	0.0712	53	0	0	2075	1089362	1044	0.8841	0.0226
24-May-94	4	0	1320	0.0616	65	2741	52	2140	1178099	1085	0.9118	0.0277
25-May-94	1	0	1460	0.0511	20	570	24	2160	1209418	1100	0.9203	0.0085
26-May-94	1	0	1520	0.0472	21	698	26	2181	1245679	1116	0.9293	0.0089
27-May-94	2	0	1400	0.0554	36	1248	35	2217	1302235	1141	0.9446	0.0153
28-May-94	2	0	1220	0.0703	30	649	25	2247	1340040	1158	0.9574	0.0128
29-May-94	5	0	1100	0.0821	30	1618	40	2277	1411618	1188	0.9702	0.0128
30-May-94	2	0	1010	0.0922	22	307	18	2299	1434625	1198	0.9795	0.0094
31-May-94	1	0	935	0.1015	10	103	10	2309	1444037	1202	0.9838	0.0043
01-Jun-94	3	0	915	0.1041	29	373	19	2338	1470882	1213	0.9962	0.0124
02-Jun-94	1	0	875	0.1095	9	85	9	2347	1478897	1216	1.0000	0.0038

1. Shaded areas denote days the catch was interpolated when the trap was not fishing due to high river discharge.

2. Estimated daily steelhead passage is based upon the spring chinook smolt entrainment rate-to-flow relation.

Appendix Table 5. Summary of spring chinook parr (age 0+) and steelhead/rainbow trout counts for the Chewuch River summer 1994.

Date	Raw counts		Mortalities		Mean entrainment rate	Estimated count for spr. chinook	Mean Q (cfs)
	Spr. chinook	Sth./rb. trout	Spr. chinook	Sth./rb. trout			
03-Jun-94	4	0	2	0	13.5%	30	840
04-Jun-94	1	6	1	0	13.5%	7	906
05-Jun-94	4	3	0	0	13.5%	30	884
06-Jun-94	4	3	0	0	13.5%	30	916
07-Jun-94	6	2	0	0	13.5%	44	1,000
08-Jun-94	21	0	0	0	13.5%	156	895
09-Jun-94	8	1	0	0	13.5%	59	816
10-Jun-94	4	1	0	0	13.5%	30	746
11-Jun-94	12	1	0	0	13.5%	89	725
12-Jun-94	3	2	0	0	13.5%	22	727
13-Jun-94	5	0	0	0	13.5%	37	737
14-Jun-94	0	1	0	0	13.5%	0	681
15-Jun-94	13	0	0	0	13.5%	96	629
16-Jun-94	13	1	0	0	13.5%	96	623
17-Jun-94	9	2	0	0	13.5%	67	604
18-Jun-94	1	1	0	0	13.5%	7	606
19-Jun-94	5	0	0	0	13.5%	37	613
20-Jun-94	2	1	0	0	13.5%	15	544
21-Jun-94	4	0	0	0	13.5%	30	514
22-Jun-94	1	0	0	0	13.5%	7	505
23-Jun-94	1	0	0	0	13.5%	7	521
24-Jun-94	4	0	0	0	13.5%	30	577
25-Jun-94	5	0	0	0	17.5%	29	517
26-Jun-94	4	0	0	0	17.5%	23	473
27-Jun-94	19	0	1	0	17.5%	109	446
28-Jun-94	26	0	0	0	17.5%	149	413
29-Jun-94	0	0	0	0	17.5%	0	381
30-Jun-94	2	0	0	0	17.5%	11	358
01-Jul-94	4	3	0	0	17.5%	23	344
02-Jul-94	1	0	0	0	17.5%	6	338
03-Jul-94	3	0	0	0	17.5%	17	320
04-Jul-94	13	2	0	0	17.5%	74	297
05-Jul-94	41	1	0	0	17.5%	234	312
06-Jul-94	18	0	0	0	17.5%	103	305
07-Jul-94	6	1	0	0	17.5%	34	274
08-Jul-94	2	0	0	0	17.5%	11	253
09-Jul-94	2	0	0	0	17.5%	11	238
10-Jul-94	0	0	0	0	17.5%	0	224
11-Jul-94	2	0	0	0	17.5%	11	208
12-Jul-94	0	0	0	0	17.5%	0	191
13-Jul-94	7	2	0	0	17.5%	40	182
14-Jul-94	19	2	0	0	17.5%	109	181
15-Jul-94	13	0	0	0	17.5%	74	183
16-Jul-94	15	2	0	0	17.5%	86	175
17-Jul-94	8	0	0	0	17.5%	46	162
18-Jul-94	6	0	0	0	17.5%	34	153
19-Jul-94	5	2	0	0	17.5%	29	142
20-Jul-94	6	1	0	0	17.5%	34	132
Total	352	41				2,223	

Appendix Table 6. Summary of the snorkeling sites for the Chewuch River, summer 1994.

Date	Reach number	Habitat type	Mean daily discharge (cfs)	Temperature	Species	
					Spring chinook	Steelhead/ rainbow tr.
04-Aug-94	r1	riffle	52	58	3	7
04-Aug-94	r1	riffle	52	58	0	19
04-Aug-94	r1	pool	52	58	0	0
04-Aug-94	r1	riffle	52	58	5	6
08-Aug-94	r1	riffle	56	57	4	5
08-Aug-94	r1	riffle	56	57	44	14
08-Aug-94	r1	riffle	56	58	25	17
08-Aug-94	r2	riffle	56	56	87	12
08-Aug-94	r2	riffle	56	57	23	9
08-Aug-94	r2	glide	56	56	78	1
09-Aug-94	r2	riffle	99	51	26	18
09-Aug-94	r2	riffle	99	53		7
09-Aug-94	r2	riffle	99	55	4	21
09-Aug-94	r2	pool	99	56	44	5
11-Aug-94	r2	riffle	68	53	31	11
11-Aug-94	r2	riffle	68	52	1	2
11-Aug-94	r2	glide	68	56	1	0
11-Aug-94	r2	riffle	68	57	2	2
11-Aug-94	r2	pool	68	57	0	0
11-Aug-94	r2	riffle	68	56	1	0
11-Aug-94	r2	pool	68	60	75	0
11-Aug-94	r2	riffle	68	61	21	6
11-Aug-94	r2	riffle	68	62	29	4
12-Aug-94	r2	riffle	56	55	4	7
12-Aug-94	r2	riffle	56	56	2	37
12-Aug-94	r3	pool	56	55	38	2
15-Aug-94	r3	riffle	47	54	0	2
15-Aug-94	r3	glide	47	54	0	0
15-Aug-94	r3	pool	47	54	0	0
15-Aug-94	r3	riffle	47	55	0	0
15-Aug-94	r3	pool	47	55	0	0
15-Aug-94	r3	pool	47	56	0	0
15-Aug-94	r3	riffle	47	56	12	3
15-Aug-94	r3	riffle	47	56	35	1
16-Aug-94	r3	riffle	44	52	6	0
16-Aug-94	r3	riffle	44	52	15	1
16-Aug-94	r3	glide	44	53	39	0
16-Aug-94	r3	glide	44	53	125	5

Appendix Table 6 Cont'. Summary of the snorkeling sites for the Chewuch River, summer 1994.

Date	Reach number	Habitat type	Mean daily discharge (cfs)	Temperature	Species	
					Spring chinook	Steelhead/ rainbow tr.
16-Aug-94	r3	riffle	44	54	10	1
16-Aug-94	r3	glide	44	54	64	2
16-Aug-94	r3	riffle	44	54	214	30
17-Aug-94	r3	riffle	39	50	19	16
17-Aug-94	r3	riffle	39	51	2	0
17-Aug-94	r3	riffle	39	51	11	2
17-Aug-94	r3	riffle	39	53	29	0
17-Aug-94	r3	riffle	39	53	146	5
18-Aug-94	r3	glide	39	52	45	0
18-Aug-94	r3	riffle	39	52	10	1
18-Aug-94	r3	glide	39	52	92	6
18-Aug-94	r3	riffle	39	56	57	2
18-Aug-94	r3	riffle	39	56	27	7
22-Aug-94	r3	riffle	35	48	0	2
22-Aug-94	r3	riffle	35	49	2	1
22-Aug-94	r3	riffle	35	49	26	2
22-Aug-94	r4	riffle	35	49	1	6
22-Aug-94	r4	glide	35	53	0	0
22-Aug-94	r4	pool	35	55	43	4
22-Aug-94	r4	riffle	35	56	6	0
22-Aug-94	r4	riffle	35	57	7	4
24-Aug-94	r4	riffle	37	48	0	0
24-Aug-94	r4	riffle	37	48	0	0
24-Aug-94	r4	riffle	37	50	0	0
24-Aug-94	r4	riffle	37	52	0	1
24-Aug-94	r4	pool	37	53	14	1
24-Aug-94	r4	riffle	37	54	6	6
24-Aug-94	r4	riffle	37	55	14	2
24-Aug-94	r4	riffle	37	55	0	9
26-Aug-94	r5	riffle	37	48	0	0
26-Aug-94	r5	riffle	37	48	0	1
26-Aug-94	r5	riffle	37	50	0	0
26-Aug-94	r5	pool	37	50	1	1
26-Aug-94	r5	riffle	37	51	0	3
26-Aug-94	r5	pool	37	51	1	0
30-Aug-94	r5	riffle	37	45	0	0

Appendix Table 4 Cont'. Summary of the snorkeling sites for the Chewuch River, summer 1994.

Date	Reach number	Habitat type	Mean daily discharge (cfs)	Temperature	Species	
					Spring chinook	Steelhead/ rainbow tr.
30-Aug-94	r6	riffle	37	45	0	0
30-Aug-94	r6	riffle	37	46	0	0
30-Aug-94	r6	riffle	37	47	0	2
30-Aug-94	r6	riffle	37	49	0	1
06-Sep-94	r6	riffle	33	48	0	1
06-Sep-94	r6	riffle	33	48	0	0
06-Sep-94	r6	pool	33	48	0	0
06-Sep-94	r6	riffle	33	48	0	1
07-Sep-94	r6	riffle	32	45	0	0
07-Sep-94	r6	pool	32	45	0	0
07-Sep-94	r6	riffle	32	45	0	0
07-Sep-94	r6	riffle	32	45	0	2
09-Sep-94	r6	riffle	30	45	1	2
09-Sep-94	r6	riffle	30	45	0	2
09-Sep-94	r6	riffle	30	45	0	2
09-Sep-94	r7	glide	30	45	0	1
13-Sep-94	r7	glide	31	--	3	1
13-Sep-94	r7	glide	31	--	0	0
13-Sep-94	r7	glide	31	--	0	0
13-Sep-94	r7	pool	31	--	4	2
13-Sep-94	r7	glide	31	--	0	0
13-Sep-94	r7	pool	31	--	0	0
13-Sep-94	r7	riffle	31	--	12	1
13-Sep-94	r7	glide	31	--	8	5
13-Sep-94	r7	pool	31	--	11	0
14-Sep-94	r7	glide	31	--	0	1
14-Sep-94	r7	glide	31	--	102	6
14-Sep-94	r7	glide	31	--	6	1
14-Sep-94	r7	riffle	31	--	18	0
14-Sep-94	r7	pool	31	--	28	4
14-Sep-94	r7	glide	31	--	18	1
14-Sep-94	r8	pool	31	--	51	0
14-Sep-94	r8	riffle	31	--	14	0
14-Sep-94	r8	riffle	31	--	0	0

MINUTES OF THE WELLS COORDINATING COMMITTEE FOR 1995

APPENDIX K

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
25 JANUARY 1995

A. Wells Dam Predator Control

Klinge gave a status report on the proposed predator removal project for Wells Dam and Fish Hatchery (FH) outfall. Woodin said WDFW had some concerns about non-selective removal methods, as this may impact Salmonids and walleye in the area. He said his final comments will be made after the upcoming predator control workshop. Klinge said very little biological measurements will be made--mostly lengths from a sample of the squawfish collected. Sullivan suggested he take some scales also, since this will give an indication of cohort strength, and the need to remove predators on a yearly basis. Klinge said he will look into this.

B. Methow FH

1. Foghorn trap plans

Klinge said Douglas PUD submitted an amendment to its agreement with the USFWS and WDFW on renovation of the fishway at Foghorn Dam. This amendment would have provision for installation of a trap in the fishway, and had verbiage requiring close coordination of Methow and Winthrop hatcheries. After approval by USFWS, the amended MOU will be sent to WDFW for adoption. Cates said he would contact his regional office to expedite the process. Hevlin asked when construction of the fishway trap will begin. Klinge reported that it will be this summer. He stated the "work window" set by the WDFW regional habitat manager is set for July and August, but he did not believe this is a biologically appropriate time. Bugert said that if Klinge provided a proposal for a better work window, the habitat manager could modify the permit accordingly.

2. Comments on Methow Evaluation Plan

Klinge called upon Erho to discuss the draft Methow Evaluation Plan. Erho said the plan was, in general, well received. As to be expected, the significant hurdle for adoption of the plan is to resolve the relationship between the Methow and Winthrop hatcheries, which operate under separate and conflicting legal requirements. The revised draft will further address this dilemma. He also said that some verbiage had been placed in the plan on management of strays at the hatchery. Erho said that the next draft, to be submitted in February, will incorporate the comments of the committee.

C. Okanogan Sockeye

1. Comments on CRITFC Enhancement Plan

Klinge responded to Heinith's letter on behalf of the JFP, which recommended Douglas PUD continue biological monitoring of Okanogan Sockeye. Klinge said Douglas PUD has concerns about continued work when the Canadian authorities have not been supportive. Heinith said there is work that could be done within the U.S. that would be beneficial to sockeye. The most important need was an assessment of out-migration duration and timing, to allow WCC to determine bypass strategies that provide optimal protection to these fish. Klinge said he would investigate some means to fund continued smolt trap work on the Okanogan in 1995. Hevlin stressed the need to expedite this process; Klinge said he will respond to the committee on this proposal in two weeks.

2. Sockeye work group

Bugert distributed a draft goal statement for Okanogan nerkids, which was developed by the *ad hoc* work group. He noted that many aspects of this goal statement were outside the jurisdiction of the Wells Committee, yet they need to be addressed for any progress to be made on sockeye enhancement. He asked for comments from the committee. Bugert and Cates said they sought authorization from their respective agencies to begin discussions with Canadian managers. It is their hope they can begin informal discussions with the Canadians this spring.

The next meeting of the WCC is set for 1 March 1995 at Chelan PUD.

ATTENDANCE LIST

ATTENDANCE LIST

NAME	REPRESENTING
Bob Pearce	National Marine Fisheries Service
Bill Hevlin	National Marine Fisheries Service
Brian Cates	U.S. Fish and Wildlife Service
Tom Scribner	Yakama Indian Nation
Bob Heinith	Columbia River Intertribal Fish Commission
Rod Woodin	Washington Department of Fish and Wildlife
Bob Bugert	Washington Department of Fish and Wildlife
Rick Klinge	Douglas PUD
Cary Feldman	Puget Power Company
Don Weitkamp	Parametrix
Bob Sullivan	Parametrix
Bruce Ransom	HTI, Inc.
Mike Erho	Private consultant

RECEIVED
MAR 24 1995
Douglas County PUD

Memorandum

To: Wells Coordinating Committee

From: Mike Erho, Chairman

Date: March 22, 1995

Subject: Summary of Wells Coordinating Committee Meeting of 1 March 1995

Enclosed please find a draft summary of the subject meeting. If I don't hear from you by 1 May 1995, I will conclude you have no comments or suggestions and will finalize the summary.

DRAFT

WELLS 95-2

WELLS PROJECT COORDINATING COMMITTEE MEETING ON 1 MARCH 1995 SUMMARY[1]

A. Wells Dam

1. Predator control

Klinge gave a status report on the proposed predator removal project for Wells Dam and Fish Hatchery (FH) outfall. Woodin expressed concerns about the benefits of marking fish for estimates of the size of the predator population, and the resultant rate of exploitation. Hays agreed that the bound on the point estimate for population size is not precise. However, the data are useful in determining the efficacy of the removal programs. Klinge said the marks may also allow us to determine movements of the predators between projects. Hays suggested the three districts should consult with a biometrician on the sample sizes required for these studies, and the expected validity of the interpretation of the results. Woodin agreed to this strategy. The Wells Project Coordinating Committee (WCC) approved the use of angling and gill nets by Douglas PUD in the tailrace of Wells Dam.

2. Bypass plan

The WCC approved the 1995 plan for bypass operations at Wells Dam, which in essence, is the same as the 1994 plan. Likewise, the committee appointed the same bypass team as last year--Klinge, Marco, and Cates, with Heinith as the alternate to Marco.

B. Wells FH

Klinge asked for an update on the proposed transfer of 1994 brood summer chinook from Wells and Eastbank hatcheries to Winthrop NFH. Bugert responded that the committee approved the transfer in the 25 January 1995 meeting, yet did not decide where the location of release should be. He said this issue needs to be addressed by PAC as well. Scribner agreed, and suggested that a formal proposal be made to PAC. Bugert agreed to do this. If the transfer is approved by PAC, the WCC can then deal with the issue of where (and when) to release these fish.

C. Methow FH

1. Foghorn trap plans

Klinge said Douglas PUD submitted an amendment to its agreement with the USFWS and WDFW on renovation of the fishway at Foghorn Dam. This amendment was agreed to by USFWS, and has now been submitted to WDFW for approval. Klinge said work is scheduled to begin during this summer work window.

1 Prepared by R. Bugert

2. Comments on Methow Evaluation Plan

Erho and Bugert distributed the second draft of the Methow Evaluation Plan. Bugert noted the salient changes, which included a plan for management of strays at the hatchery, and a shift in emphasis to demographic and stock recruitment indicators of stock vigor, rather than analysis of cell and protein genetics. The committee agreed to a 30 day review period for this draft.

D. Okanogan Sockeye

1. Smolt outmigration

Klinge stated that Douglas PUD modified its contract with the Colville Tribe to include smolt trapping of Okanogan sockeye from Lake Osoyoos in 1995. This information will then be given to the appropriate Canadian authorities for Okanogan River water management. Heinith and Woodin asked for a copy of the study plan. Marco said he will provide it to the committee. Erho also asked about the status of the report on the 1994 outmigration studies, so that appropriate comments could then be made on the 1995 plan. Marco responded that the 1994 report will be available within thirty days.

2. Sockeye work group

Klinge reported that the *ad hoc* work group had tentative plans to meet with the Canadian representatives during the annual chapter meeting of the American Fisheries Society. Bugert said Cates, Klinge, and he will meet these representatives on 6 April 1995 in Vancouver B.C. Feldman may attend. Heinith noted CRITFC is having discussions with their counterpart tribal authorities in British Columbia on these issues, yet no definite plan had been developed at this time. Also, he stressed that many aspects of the goal statement set by the *ad hoc* group were outside the jurisdiction of the Wells Committee, and therefore emphasized that these meeting should not be promoted as sanctioned by the WCC. The *ad hoc* members agreed, that they would represent their respective agencies only.

3. Cassimer Bar production

Marco reported that the 1994 production is between 50,000 and 60,000. Tests for IHN were negative for all adults this year. They are being fed at a high rate to achieve the projected release size (25 fpp). The fish were marked differently from last year's production. The Colville Tribe will hire an outside consultant (Fish Pro) to review the fish culture strategies at Cassimer Bar.

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DRAFT

ATTENDANCE LIST

Steve Hays	Chelan PUD
Bill Hevlin	National Marine Fisheries Service (via telephone)
Cary Feldman	Puget Power Company
Tom Scribner	Yakama Indian Nation
Bob Heinith	Columbia River Intertribal Fish Commission
Rod Woodin	Washington Department of Fish and Wildlife
Rich Eltrich	Washington Department of Fish and Wildlife
Jerry Marco	Colville Confederated Tribe
Mike Erho	Private consultant
Rick Klinge	Douglas PUD
Brian Cates	U.S. Fish and Wildlife Service
Bob Bugert	Washington Department of Fish and Wildlife

WELLS PROJECT COORDINATING COMMITTEE
CONFERENCE CALL MEETING SUMMARY
31 MARCH 1995

Agreements Reached

1. The committee agreed to defer approval of a proposed broodstock collection protocol for the Methow Hatchery pending completion of baseline "elemental discrimination analysis" of scale samples from spring chinook collected from the spawning grounds in the Chewuch, Twisp and Methow Rivers in 1993 and 1994.

2. The committee agreed that collection of broodstock from the Twisp River would not be attempted in 1995 due to the small run size projected for 1995 and concerns for naturally spawning fish which might be effected by installation of the Twisp weir.

3. The committee agreed to send a letter to the federal Columbia River operating agencies requesting that flows in the mid-Columbia be increased on 13 April, one week earlier than currently planned, to provide for migrants scheduled to be released from mid-Columbia hatcheries and naturally produced smolts expected to be entering the Columbia River from tributary streams.

I. Joint Studies

A. Columbia River Water Management

(For discussion see summary of Mid-Columbia Coordinating Committee Conference Call Meeting)

B. 1995 River Operations

(For discussion see summary of Mid-Columbia Coordinating Committee Conference Call Meeting)

II. Wells Dam

A. Methow Hatchery Broodstock Protocol-1995

Bob Bugert summarized a proposed broodstock protocol for the Methow Hatchery. He explained that the proposal had undergone extensive internal review within Washington Department of Fisheries and Wildlife. The proposal called for collection of fish at Wells Dam instead of collection from tributary traps. Numbers of fish to be collected would be one quarter of the spring chinook run at Wells or 80 fish, which ever is less. The proposal calls for elemental discrimination analysis of scales of known origin, i.e. Methow, Chewuch, and Twisp Rivers from the 1993 and 1994 brood collections. If it is found that fish from the three sub-basins can be separated on the basis of this analysis, fish collected could be allocated to the appropriate sub-basin. If it is determined that elemental analysis cannot separate the stocks by sub-basin of origin, scale pattern analysis will be used to separate hatchery fish from naturally produced fish with the former being used for Methow production and the latter divided between the Chewuch and Twisp Rivers.

In response to Hevlin's question, Bugert stated that the 80 fish or one quarter of the run maximum collection rate conceptually includes fish collected as volunteers at the hatcheries(Methow and Winthrop) although in practice it would be difficult to make this determination in real time. Hevlin asked if a goal had been established for escapement for natural spawning. This was discussed and it was felt that adequate consideration was being given to natural escapement with the maximum collection provisions established. Klinge pointed out that if the run did not exceed 160 fish, all would be returned to the river.

Bugert asked the committee if it was necessary, given the proposed broodstock protocol, to install the Twisp weir in 1995. The committee agreed that the installation of the weir would not be desirable in 1995. Bugert agreed to convey this message to the Methow Hatchery personnel.

Scribner expressed concern that the current proposal for broodstock collection may be contrary to the goals established for the Methow Program. The supplementation goal of the Methow Program could be compromised by the failure to maintain stock segregation by sub-basin of origin. Supplementation implies adherence to genetic principles. He raised the question of whether the current status of the spring chinook run was leading to a stock emergency program rather than the supplementation goals established for the Methow Program. Scribner proposed collection of broodstock at Fulton Dam on the Chewuch River, as has been done the past three years, collection of volunteers to the hatchery for the Methow portion of the program, and no collection on the Twisp River. Following a discussion of the genetic risks associated with the original proposal compared to the risks associated with Scribner's proposal, Woodin suggested delaying a decision until the 19 April 1995 meeting when the results of the elemental analysis will be available. The committee agreed to discuss the matter at the April meeting.

The next meeting of the Wells Project Coordinating Committee will be held at Sea/Tac on 19 April 1995.

CONFERENCE CALL PARTICIPANTS

NAME	REPRESENTING
Bob Bugert	Washington Department of Fish and Wildlife
Craig Busack	Washington Department of Fish and Wildlife
Rod Woodin	Washington Department of Fish and Wildlife
Brian Cates	U. S. Fish and Wildlife Service
Bill Hevlin	National Marine Fisheries Service
Tom Scribner	Yakama Indian Nation
Jerry Marco	Colville Confederated Tribes
Cary Feldman	Puget Sound Power and Light Co.
Dick Nason	Chelan County Public Utility District
Steve Hays	Chelan County Public Utility District
Stuart Hammond	Grant County Public Utility District
Rick Klinge	Douglas County Public Utility District
Mike Erho	The Committee

WELLS PROJECT COORDINATING COMMITTEE
MEETING SUMMARY
19 APRIL 1995

Agreements Reached

1. Agreed to establish a Methow Hatchery technical advisory committee which will meet for the first time on June 15, 1995 at Sea/Tac.

2. Agreed to extend the date for comment on the proposed mid-Columbia steelhead evaluation plan to May 1, 1995.

A. Methow Hatchery Broodstock Protocol-1995

Woodin reported on the status of the laboratory analysis of scales taken from spring chinook collected from the Methow, Chewuch, and Twisp Rivers. The results of the analysis are not available at this time, however, he suggested that the committee go ahead with a decision to collect broodstock at Wells Dam instead of the traps on the Chewuch and Twisp Rivers in the absence of the laboratory data. Scribner responded that he could go along with a decision to prepare for trapping at Wells but if the lab analysis failed to determine that spring chinook from the three basins could be separated on the basis of discriminatory elemental analysis, he was reluctant to go ahead with collection at Wells. Considerable discussion took place regarding the pros and cons of trapping at Wells in lieu of collection from tributary traps in years of low returns.

The issue of minimum escapement above Wells Dam was raised by Hevlin. The committee supported the concept of a minimum escapement level for spring chinook above Wells Dam which would be taken into consideration when developing a broodstock collection protocol. Considerable discussion took place regarding the appropriate value for minimum escapement. Woodin suggested that 100 adults and jacks be established as the minimum escapement goal and that the proposed broodstock collection protocol be adjusted to accommodate this minimum escapement. The committee, with the exception of Scribner, agreed that this was the appropriate coarse of action considering the status of the 1995 spring chinook run. Scribner will check with others at the YIN and will inform the committee regarding support for the modified protocol.

NOTE: Subsequent to this meeting, Scribner notified the committee of his support for the modified protocol.

Woodin called on Busack to discuss the collection of broodstock at Wells in relation to Minimum Viable Population concerns. Busack acknowledged some small risk from out-breeding depression but in his opinion, if there was any place where spring chinook stocks could be crossed with little genetic risk it would be the Methow River. He stated that the risk from very low populations, that could result in the absence of supplementation, would be greater than the risks

associated with going ahead with the proposed protocol. Busack acknowledged that some geneticists disagree with him, however, since this proposal is not considered a long term change in protocol but only a short term operation in response to low population numbers, he feels the proposal should be adopted for 1995. Hevlin stated that he feels that there is still an opportunity to help the Methow spring chinook stocks recover. He contrasted this to the case of Snake River sockeye where opportunities were foreclosed by the time recovery actions were put in motion. Busack raised the question, How low should the run be allowed to drop before we take action?

Woodin reminded the committee that the decision that needs to be made is, Do we trap at Wells or not? Scribner stated that he was reluctant to make the decision in the absence of the laboratory results. If those results are positive, then he would feel comfortable in going ahead with the proposal. If the elemental analysis does not show promise he is concerned that mixing stocks by collection at Wells, could lead to a situation where the development of locally adapted stocks in the Chewuch and Twisp Rivers would be compromised. It was agreed that when the results of the discriminatory elemental analysis is available, there would be a conference call to decide the issue of whether or not to trap at Wells.

B. Okanogan Sockeye

Klinge reported on his contact with Bruce Shepherd, B.C. Environment, at the American Fisheries Society meeting in Vancouver, B.C. They would like an evaluation of potential hatchery programs on the fisheries in Lake Osoyoos. Klinge asked him how they would feel about the possible transport of adult sockeye across the U.S./Canada border for release in Lake Osoyoos. Shepherd said that he would not rule that out but that he could not say if that would be their official position.

Hevlin informed the committee of a Lake Osoyoos Fisheries Advisory Board meeting in Oroville, WA on April 27. Hevlin said he would be in attendance and Marco said Jon Hansen would represent the Colville Tribe.

Klinge reported that the net pens were installed in Lake Osoyoos and the fingerling sockeye from Cassimer Bar Hatchery will be transported to the pens this week. Marco stated that the fish were running about 100/pound (80 mm) and all have been marked with a right ventral clip. The total number of fingerling sockeye being reared is 41 thousand. Last year the fish were marked with a left ventral clip. Nason asked Klinge to prepare a memo concerning the Okanogan sockeye fin clips that may be observed at downstream sampling stations so that it could be posted as a reminder to the sampling crews.

C. Methow Hatchery Evaluation Plan

Klinge called on Bugert to report on the status of the Methow Hatchery Evaluation Plan. Bugert stated that the deadline for comment had passed. Scribner said he had some comments that he would submit. The committee agreed that final comments would be due by May 15.

Bugert urged the establishment of a Methow Hatchery Technical Advisory Committee as called for in the draft evaluation plan. The committee appointed Cates, Klinge, Scribner(or an alternate), Marco and a representative from WDFW to the MHTAC. The first meeting of the committee will take place on June 15 at Sea/Tac.

D. Foghorn Dam Intake Improvements and Trap Construction

Klinge reported that the agreements between Douglas PUD, USFWS, and WDF&W were in place. The USFWS has gone out for bid on the project and four contractors showed up at the site during a pre-bid site visit. Bid opening is set for May 5, 1995.

E. Wells Hatchery

Summer chinook from the 1994 brood egg take are being taken to Winthrop and Methow Hatcheries. Winthrop Hatchery will receive 50,000 fingerlings which are excess to the Wells and Eastbank requirements. Methow Hatchery will receive 200,000 fingerlings which represent one half of the 400,000 which make up the Methow(Carlton Acclimation Pond) portion of the Eastbank program. The objective of the Methow Hatchery rearing is to evaluate the benefits of over-wintering on Methow River water on survival to adult compared to the survival of fish transported to the Carlton Pond in the spring just prior to release.

F. Mid-Columbia Steelhead Evaluation

Woodin reported that no comments have been received on the proposed mid-Columbia steelhead evaluation plan. Hays raised a question regarding the procedure for commenting on the proposed plan. Nason pointed out that since the proposal had been presented to the Mid-Columbia Coordinating Committee by WDF&W, the proper procedure would be to direct comments or suggestions to Woodin. Hays observed that the proposal and the Wenatchee River steelhead management plan don't necessarily mesh. He plans to talk to people involved in management before commenting. The committee agreed to extend the deadline for comment to May 1, 1995.

The next meeting will be in Wenatchee on May 17 and 18 and will include a tour of the mid-Columbia projects

ATTENDANCE LIST

NAME	REPRESENTING
Jerry Marco	Colville Confederated Tribes
Tom Scribner	Yakama Indian Nation
Brian Cates	U.S. Fish and Wildlife Service
Bill Hevlin	National Marine Fisheries Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Craig Busack	Washington Department of Fisheries and Wildlife
Stuart Hammond	Grant County Public Utility District
Rick Klinge	Douglas County Public Utility District
Dick Nason	Chelan County Public Utility District
Steve Hays	Chelan County Public Utility District
Bob Bugert	Mid-Columbia Public Utility Districts
Cary Feldman	Puget Sound Power and Light Company
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
17 MAY 1995

Agreements Reached:

1. The committee agreed to discontinue collection of spring chinook brood stock for the Methow Hatchery and to return to the river the six fish previously collected due to the declining run-size projection for the 1995 Methow River spring chinook run.

2. The committee agreed to suspend the use of gill nets for predator removal with the caveat that there could be one or two additional attempts to use gill nets when squawfish become more abundant and before the beginning of the sockeye run.

A. Methow Hatchery/Spring Chinook Broodstock Collection Protocol

The previously agreed upon broodstock protocol was reviewed by the chair and Rod Woodin. Woodin called on LaVoy to update the committee on the latest projections for spring chinook run-size in the mid-Columbia. LaVoy distributed the projected run-size projections and pointed out that the run-size projections continue to decline and that the projection for the Methow River is less than the target agreed to in the protocol previously approved by the committee. Scribner asked Woodin to fill the committee in on his agencies' latest position regarding collection of brood stock for the Methow Hatchery in 1995. Woodin reported that after considerable discussion and review of the situation, Washington Department of Fisheries and Wildlife did not feel that they were facing an emergency situation regarding the 1995 Methow River spring chinook run. This position is based on the 1995 spring chinook jack escapement, which indicates the probability of improved escapement in 1996. Furthermore, they felt that collection of all of the 1995 brood spring chinook, at Wells Dam, without the ability to separate the fish on the basis of tributary of origin, would compromise the concept that the Methow Hatchery is based on. They are unwilling to compromise the philosophy underlying the Methow spring chinook program even if it means that no brood stock will be collected from the 1995 brood year. Heinith asked if WDF&W had reviewed the Cuenco report that Intertribe had distributed. Woodin said they had reviewed the report but feel that, due to the fact that the run is made-up of multiple age classes which moderate the effect of one poor age class in the run, the situation is not as dire as it might appear. Scribner asked Woodin if the WDF&W position was related to the loss of stock productivity from stock mixing. Woodin acknowledged that it was related to that concern.

Hevlin stated that his agency supports the WDF&W position. They are also concerned about the mixing of stocks if broodstock is collected at Wells Dam. Their policy is to maintain stocks in their sub-basin of origin in the natural environment. They are also concerned about the

mixing of spring and summer chinook brood stock due to the arbitrary and imprecise date for separation of the spring and summer chinook runs.

Woodin called attention to the previously approved protocol which called for an escapement goal of 100 fish. He said that the latest run-size projections indicate that it is unlikely that goal will be reached, even without collection of brood stock. WDF&W feels that it would be counter productive to work with a dab of fish in the hatchery. They feel that all brood stock collection should cease and that the fish already collected should be returned to the river. Hevlin concurred. Scribner and Heinith also agree that either all of the fish should be collected or none should be collected. The committee agreed that no additional spring chinook should be collected and the six fish already collected should be returned to the river.

Woodin raised the question about what to do with any spring chinook that might return to the hatchery as volunteers this year. Klinge stated that he would like to see any hatchery volunteers retained and a determination made as to the best use of those fish. He would like to see some way of utilizing the two hatcheries on the Methow in the best interest of the resource. Scribner agreed that efforts should be made to maximize the potential production. The best use of the available fish should be the primary objective. Woodin asked Scribner what he would propose to do with naturally produced fish which volunteered to the hatcheries. Woodin stated that he would release those fish to the river. After discussion, the committee agreed that any naturally produced fish that returned to either the Methow or Winthrop Hatchery this year would be returned to the river.

B. Captive Brood Stock

Woodin raised the issue of captive brood stock programs for the stocks that currently are at low numbers. He recommended that a sub-committee be formed to deal with the question of the use of captive brood stock programs in dealing with stocks that are experiencing low abundance. Woodin pointed out that there are currently approximately 250 fish from each of the Methow Basin sub-groups that are being held at the Methow Hatchery. These fish had been retained from the 1994 smolt release for the purpose of producing precocious males that could be used, if necessary, during the 1995 spawning operations. These fish could be used for a captive brood stock program. Scribner mentioned the captive brood stock efforts currently being pursued by Oregon and Idaho on the Snake River. He suggested that the committee follow the progress of Snake River captive brood stock activities in the interest of determining the efficacy of that concept for Methow Basin spring chinook. He asked if the committee was interested in receiving information on the Snake River program. Cates said he view captive brood stock as a possible contingency plan that could be considered in the future. The committee agreed that Scribner should track the Snake River activities and keep the committee informed on progress.

B. Wells Hatchery/Summer Chinook Broodstock Collection Protocol

Woodin asked LaVoy to review the current 1995 mid-Columbia summer chinook run size projection. LaVoy provided an historical perspective on the contribution of the Wells summer chinook program to Columbia River summer chinook run. The percentage contribution averaged about 12%, however , the contribution to the 1994 run was about 26%. This was probably effected by the contribution of the Similkameen and Carlton acclimation pond production. The early projection for the 1995 run is 9600 fish at Bonneville Dam with a Wells escapement of 1900 fish. Scribner suggested that Heinith and Cuenco run their model as a starting point for

developing a brood stock collection protocol. Woodin suggested that a good place to start would be the original protocol developed in 1994 before the large escapement was realized. Marco called attention to the fact that the summer chinook collection protocol affects the collection of sockeye brood stock for the Okanogan sockeye program, especially as it relates to the number of days per week that the trap is operated. Woodin suggested establishing the summer chinook protocol and adjusting the sockeye protocol around that. The committee agreed that Heinith and Cuenco should evaluate the 1994 protocol and report back to the committee. Comments will be due by June l.

C. Okanogan Sockeye Broodstock Collection Protocol

Marco distributed a brood stock collection protocol for Okanogan sockeye. He stressed the importance of collecting adequate numbers of adults to allow a full complement of juveniles to be reared. He pointed out that that these fish would be migrating as sub-yearlings along with the yearling progeny from the 1994 brood which were at near record low numbers. Comments on the draft protocol are due by June 1.

Heinith asked for an update on the Okanogan water management meeting held in early May. Hevlin reported that an agreement had been reached with the Canadians to provide additional flow for the juvenile out-migration. Normally they release 25 cfs from Lake Okanogan through April and then drop the flow to 15 cfs through May. This year's agreement calls for 25 cfs to be released through May 11 dropping to 10 cfs by May 15. Klinge reported that conditions for the 1995 juvenile migration in the Okanogan system were excellent. Heinith inquired about provisions for adult spawning. Marco said they had not responded favorably to suggestions for operations to benefit adult spawning when asked in 1994.

Hevlin reported that the Canadians were ready to evaluate irrigation withdrawals downstream from McIntyre Dam. However, they are running into funding problems. Hevlin and Heinith both feel this would be good place to spend enhancement dollars.

D. Predator Removal Program

Klinge reported on the results, to date, on the predator removal program at Wells Dam. Because of high incidental catch of non-target species, gill netting has been discontinued. Total catch thus far in 1995 includes 108 squawfish, 73 walleye, 13 steelhead kelts, 16 rainbow trout, 50 whitefish, one dolly varden, 4 smallmouth bass, and 1 spring chinook. Angling for squawfish removal will continue. Klinge reported on a proposal from a commercial fisherman to try a mechanical jigging device for squawfish removal. This reportedly has been used with some success in Alaska for cod. Douglas and Chelan PUD's are considering entering into a contract with this individual on a demonstration project where the fisherman would be paid on a "per fish caught" basis.

Hevlin expressed concern with the use of gill nets for the predator removal effort due to the high incidental catch of non-target species. Klinge stated that he would like to retain the option to try gill netting again when squawfish become more abundant and the spring chinook run is past. Woodin stated that he too was concerned about the high incidental catch, and would be particularly cautious when the sockeye run begins. He said he would not object to one or two additional gill net sets if they were prior to the start of the sockeye run. Hevlin and Marco both

concerned about gill net use. The committee agreed to allow one or two additional gill net sets when squawfish are more abundant as long as they were made prior to the sockeye run.

No additional meetings of the Wells Project Coordinating Committee were scheduled at this meeting.

ATTENDANCE LIST

NAME	REPRESENTING
Tim Welch	Federal Energy Regulatory Commission-Wash. D.C.
Jim Hastreiter	Federal Energy Regulatory Commission-Portland
Bill Richkus	Federal Energy Regulatory Commission (contractor)
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry LaVoy	Washington Department of Fisheries and Wildlife
Bob Heinith	Columbia River Intertribal Fisheries Commission
Jerry Marco	Colville Confederated Tribes
Tom Scribner	Yakama Indian Nation (by telecom)
Rick Klinge	Douglas County Public Utility District
Cary Feldman	Puget Sound Power and Light Company
Bob Bugert	Mid-Columbia Public Utility Districts
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
14 SEPTEMBER 1995

A. General Mid-Columbia Issues

1. Adult Studies

See Adult Studies under General Mid-Columbia Issues in the draft Summary of the Mid-Columbia Coordinating Committee meeting of September 14, 1995

2. Dissolved Gas Standards

See Adult Studies under General Mid-Columbia Issues in the draft Summary of the Mid-Columbia Coordinating Committee meeting of September 14, 1995

3. Brood Stock Protocols

See Adult Studies under General Mid-Columbia Issues in the draft Summary of the Mid-Columbia Coordinating Committee meeting of September 14, 1995

B. Wells Dam

Klinge distributed a packet of information to committee members. This contained the following information:

Results of the 1995 Squawfish Removal Program at Wells Dam
Summary of bypass operations at Wells Dam in 1995
Summary of fyke net activity at Wells Dam in 1995
Memo to the Wells Coordinating Committee on the 1995 schedule for sockeye spawning ground surveys in the Okanogan
Proposed telemetry studies at Wells Dam for 1996
Final Methow Hatchery evaluation
Final summaries of meetings of the Wells Coordinating Committee

1. Squawfish Removal Program

Klinge reviewed the 1995 squawfish removal program. Not as many squawfish were collected as expected. Four hundred ninety-five fish were tagged and over 600 were removed

from the population. Two different methods of analysis(Peterson and Schnablel Population Estimators) were used to estimate the squawfish population in the Wells Dam tailrace area. The Schnabel Population Estimate, 10,761 with a 90% and 95% confidence interval of 15,495 to 6,027 and 16,401 to 5,121 respectively, is considered the most reliable of the two estimates.

Klinge discussed the proposed Predator Removal Program for Wells Dam in 1996. Based on results of the 1995 program, the fishing effort in 1996 will start in June and run through July. The number of fishermen will be increased and a commercial jigging operation will be tested for applicability to the program. Klinge stated that unless there was a substantial increase in the 1996 catch over that experienced in 1995, Douglas would feel additional efforts were not warranted. They may consider looking for squawfish spawning areas in the Wells Reservoir to target for predator removal efforts. Klinge said he would not rule out use of gill nets for squawfish removal at reservoir spawning areas. Heinith asked if it would be worth considering targeting the hatchery outfall for removal efforts when hatchery released are made. Klinge stated that the 1995 experience demonstrated there was no appreciable increase in squawfish numbers at the hatchery outfall following release of hatchery fish. He noted that peaks in catch in 1995 coincided with availability of lamprey ammocetes for bait.

2. Bypass Operations

Klinge reported on Wells bypass operations for 1995. Bypass began on April 8 and ended on June 8 for the spring migration. Hevlin asked why bypass wasn't started after the catch of 103 fish on April 6. Heinith inquired about the decision to operate the bypass 12 hours per day from April 8 through April 12. Woodin expressed appreciation for the data provided on bypass operation. He said, however, he would like to see the indices related to the estimates of abundance based on the juvenile estimation procedures outlined in the Wells Settlement Agreement. There needs to be an adjustment of the indices based on the estimates of the juvenile migrant abundance. Hevlin expressed a concern regarding the number of fyke net sets made in relation to bypass operational parameters. He would like to see a reduction in the number of fish sacrificed. Klinge said he felt that the amount of fyke netting had been reduced and that they didn't feel the amount of netting was excessive. He feels that it is necessary to back up the hydroacoustic data with fish-in-hand to give species composition data when resident fish species are present. Klinge said he understood Hevlins concerns and Douglas will not fyke net when historical information indicates only salmonids are likely to be present. Woodin asked Klinge to develop criteria for necessary operation which would minimize impacts to smolts. For instance, when catch is 50% salmonids, don't fyke net for two weeks.

3. Okanogan Sockeye

Klinge asked Marco to recap the 1995 brood stock collection results. Marco reported that collections started July 7 and ended July 28, a four week collection period. This is the first year that they have collected a full complement of fish for brood stock. To date, 17 adults have been lost out of the total number collected. Marco expressed concern over the number of fish that showed visible signs of injury. This could result in elevated mortality as the spawning period approaches. The mortality rate, thus far, is about 5%. Marco pointed out that the number of iso-buckets on hand may not be adequate for the number of female sockeye likely to be spawned. Klinge said they were working on the problem and he would see that adequate numbers of iso-buckets were available.

4. 1993 Sockeye Evaluation

Klinge reported that a draft report is out for review and comments have been received from Woodin. The 60 day comment period will expire on September 20. Marco had indicated the intent to prepare two reports, one on juvenile migration evaluations and one covering hatchery operations. Klinge had asked that the reports be combined to present a comprehensive picture of the results for the whole brood year program. Marco stated that they would try to get future information out earlier since it won't be too long before the committee will need to make a decision on the Okanogan Sockeye Program under the terms of the Wells Settlement Agreement.

Marco reported that the size of the 1994 brood year fish reared and released in 1995 was different than the size of the 1993 brood year fish reared and released in 1994. Klinge observed that the 1995 sockeye smolts were smaller than typical Okanogan River sockeye and the net pen reared fish seen were comparable in size to the naturally produced fish. It was noted that the 1995 Okanogan sockeye migration appears to be quite strong as indicated from monitoring activities throughout the mid-Columbia.

5. 1995 Sockeye Spawning Ground Surveys

Heinith reported that his agency has contacted the Department of Fisheries and Oceans in Canada to get their position on sockeye enhancement in the Okanogan River. He distributed copies of letters from CRIFC to the Douglas PUD manager and from DFO to CRIFC regarding support for the Canadian Intertribal Fisheries Commission to conduct spawning ground surveys. Klinge reported that he had invited their participation in the scheduled surveys for 1995. Heinith expressed concern regarding the methodology being considered for the 1995 surveys. He felt that due to the low sockeye escapement this year, there should be extra effort to quantify results on the spawning grounds. Klinge pointed out that the methodology proposed has been used by others in the past and while not necessarily the best, it is a viable methodology. Hevlin pointed out that his participation last year left him with the impression that the results were not very precise. Klinge said that arrangements have already been made for participation in the surveys in 1995 and the methodology is adequate. Heinith questioned why the PUD is unwilling to fund the survey. Clubb pointed out that the Settlement Agreement provided for a three year evaluation of the net pen program. There was no commitment for continuing stock assessment in the agreement. A discussion followed regarding the Canadian position regarding sockeye enhancement. Hevlin expressed disappointment in the PUD position regarding support for sockeye spawning ground surveys. Woodin suggested that if a pre-approved evaluation plan was available, there would likely be little confusion over methodology. Klinge pointed out that Marco had submitted an evaluation plan which was reviewed and it was based on evaluation of juvenile out-migration. There was no mention of evaluation based on adult spawning. Feldman remarked that the problem we're faced with, at this point in time, is confusion between evaluation of the enhancement program and assessment of the stock-at-large.

6. Foghorn Adult Trap

Cates reported on the Foghorn construction schedule. The contractor has received an extension of the hydraulic permit through the end of September. Construction will not be complete at that time. There will be a meeting between the contractor and the US Fish and Wildlife Service on September 21 concerning what will be done with the coffer dam if the work is

stopped and how the work already done would be protected over the winter. Bob Steele, WDF&W will attend the meeting.

7. Steelhead Rearing at Winthrop Hatchery

Cates reported that USFWS has been asked to consider rearing about 61,000 steelhead which are progeny of naturally produced adult returns collected at Wells Dam trap in 1994 and spawned this spring. These fish are being reared at Eastbank Hatchery on the warmer ground water in an attempt to get them up-to-size to become smolts in the spring of 1996. The Section 10 permit for Wells Hatchery does not allow release of these fish since they are in excess of the number allowed by the permit. The Winthrop Hatchery could release that number of fish without exceeding their limit. There were no in opposition to the proposal.

8. Methow River Spring Chinook Program

Klinge asked Scribner to update the committee on the results of spring chinook spawning ground surveys in 1995. Scribner expressed disappointment in the decision that had been made this spring to not collect Methow Basin spring chinook for brood stock in 1995. To date, 13 redds have been located on the spawning grounds in the Methow Basin. This indicates a much higher fish per redd figure than seen in previous years, indicating that fish are having a difficult time finding each other on the spawning grounds this year with the small number of fish in the run. Heinith asked about the 1993 brood year fish being held at the Methow Hatchery. Woodin responded that they were still being held at the hatchery and, at last count, were approximately three fish per pound. Some were dying as a result of sexual maturity and there also appeared to be some loss from Bacterial Kidney Disease.

No date was set for the next Wells Coordinating Committee meeting.

ATTENDANCE LIST

NAME	REPRESENTING
Tom Scribner	Yakama Indian Nation
Jerry Marco	Colville Confederated Tribes
Bob Heinith	Columbia River Intertribal Fisheries Commission
Brian Cates	US Fish and Wildlife Service
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Rod Woodin	Washington Department of Fisheries & Wildlife
Stuart Hammond	Grant County Public Utility District
Stephen Brown	Grant County Public Utility District
Chris Carlson	Grant County Public Utility District
Joe Lucas	Grant County Public Utility District
Rick Klinge	Douglas County Public Utility District
Bob Clubb	Douglas County Public Utility District
Cary Feldman	Puget Sound Power and Light Company
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
8 NOVEMBER 1995

Agreements Reached:
1. The committee agreed to November 27, 1995 as a starting date for the maintenance of the adult fish passage facilities at Wells Dam and December 14, 1995 as the date for a tour of the adult passage facilities at Wells.

A. General Mid-Columbia Issues

1. Mid-Columbia Coordinating Committee Chairman
   See summary of Mid-Columbia Coordinating Committee meeting of November 8, 1995

2. Adult Passage Studies
   See summary of Mid-Columbia Coordinating Committee meeting of November 8, 1995

3. Fishery Agency and Tribal Mid-Columbia Production Meeting
   See summary of Mid-Columbia Coordinating Committee meeting of November 8, 1995

4. Draft 1993 Findings
   See summary of Mid-Columbia Coordinating Committee meeting of November 8, 1995

B. Wells Dam

1. Maintenance Schedule for Wells Dam Fish Ladders

Klinge handed out a summary of Wells Dam adult salmon and steelhead counts and brood stock collection information for the period October 1 through November 7. He discussed the numbers represented which show little recent passage over Wells Dam. The counts since the first of November have been by videotape which results in a lag in information availability so the ladder counts since that time are not complete. Klinge stated that Douglas would like to begin annual maintenance on the Wells Dam fish ladders as early as possible and given the low numbers currently using the ladders they are suggesting a November 13 start. Woodin questioned the necessity of starting the annual maintenance that early. Klinge explained that their desire was to begin the maintenance as early as possible so the work could be completed and the ladders returned to operation. This would allow more time to accomplish repairs, if needed, so the ladders would be available prior to the beginning of fish movement in the spring. Woodin said he was reluctant to agree to maintenance beginning as early as suggested since water temperatures were still warm enough that movement of fish was still possible and he would prefer to see passage access available. Hevlin raised the point that the Corps and others have historically requested an early beginning date for ladder maintenance and the Wells situation is no different. He suggested delaying the start of Wells ladder maintenance until November 27. The committee agreed that November 27 was an appropriate date to begin the annual maintenance program. Klinge suggested that the tour of ladder facilities mentioned in his October 31, 1995 memo to the committee, be rescheduled to December 14. The committee concurred.

Hevlin expressed his appreciation for Douglas County's willingness to perform annual maintenance on the adult fish passage facilities at Wells Dam.

2. Okanogan Sockeye

Klinge reported on the results of sockeye spawning ground surveys on the Okanogan River. As a result of concerns expressed by some committee members at the September meeting of the Wells Coordinating Committee, proposed plans for the 1995 sockeye spawning ground surverys were modified in the interest of providing more precise information on the results of sockeye spawning in the Okanogan River. Klinge reported that a number of individuals had participated with him in the conduct of the surverys. Klinge expressed his appreciation for the help provided. On the November 9 survey, he will be accompanied by Bill Green of the Canadian Columbia River Intertribal Fish Commission. Klinge handed out a summary of the results of the sockeye surveys to date. Hevlin asked what mark recovery percentage was necessary to provide reasonable accuracy. Klinge pointed out that the study conducted by Parametrix in 1993, resulted in 33% mark recovery. Klinge said he anticipated a similar recovery rate this year.

Klinge reported that decreased flow in the Okanogan River during the course of the spawning ground surveys had resulted in some de-watering of redds. Hevlin said these observations should be reported to the water management group that oversees flows in the Okanogan.

Klinge distributed a letter from Bruce Shepard, B. C. Environment, to Bill Green which attempted to clarify the position of B.C. Environment regarding sockeye enhancement efforts in the Okanogan River system. He stated that his agency was not opposed to all enhancement efforts but that they were opposed to technologically risky projects that propose "quick fixes" such as the use of net-pens in Lake Osoyoos. He expressed support for projects that addressed watershed problems effecting resident fish as well as sockeye. He also said they would not object to the pilot project to transport adult sockeye from Wells Dam to the northern basin of Lake Osoyoos to address temperature-related mortality.

Klinge suggested that it would be desirable to hold a sockeye workshop to explore options for Okanogan sockeye enhancement. He pointed out that the Wells Settlement Agreement requires a decision on the current sockeye program after the third year juvenile migration. This will occur in the spring of 1996. Options for sockeye enhancement under the Wells Settlement Agreement were discussed by the committee. Woodin and Hevlin raised the possibility of increased "interim" production which would allow for future evaluation of adult returns. It was pointed out that this is not an option under the Wells Settlement Agreement but that this could be discussed during the proposed workshop. Hevlin suggested that the workshop should be held as soon as possible, maybe as early as mid-January. The committee discussed potential dates for the workshop and agreed to set aside January 17 and 18, 1996 as possible dates for a sockeye workshop. Klinge said he would attempt to set up a workshop for those dates and report back to the committee.

3. 1996 Wells Bypass Operations

Klinge discussed the expected hatchery releases above Wells Dam in 1996 in relation to Wells bypass operation. Woodin had expressed interest in possible modification of the use of index numbers in making decisions concerning operation of the Wells bypass given the small numbers of migrants expected in 1996. Hevlin expressed interest in moving toward the following three objectives for Wells bypass operations:

1. Less fyke net use to guide bypass operations
2. More 24 hour bypass operation
3. Modification of the index trigger for start of bypass operations to reflect expected numbers of fish

Klinge said he had already talked to people at Douglas about the need to provide adequate protection for juveniles even though the numbers of fish expected may be small in 1996 compared to previous years.

4. Foghorn Intake/Ladder/Trap Construction

Klinge and Cates reported on the construction progress at the Foghorn Irrigation Ditch intake and trap. Three spring chinook redds had been located in the vicinity of the construction activities and caused some concern relative to possible impacts from siltation when the sheet piling was removed. Steps were taken to protect the redds and no problems were encountered when the sheet piling was removed. Work outside the wetted perimeter of the Methow River at the site is continuing and it is expected that the intake and trap will be completed soon.

The next meeting of the Wells Coordinating Committee will be December 13, 1995 at Sea/Tac.

ATTENDANCE LIST

NAME	REPRESENTING
Rick Klinge	Douglas County Public Utility District
Cary Feldman	Power Purchasers
Rod Woodin	Washington Department of Fisheries & Wildlife
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Brian Cates	US Fish and Wildlife Service
Dick Nason	Chelan County Public Utility District
Stuart Hammond	Grant County Public Utility District
Mike Erho	The Committee

SELECT MINUTES OF THE MID-COLUMBIA COORDINATING COMMITTEE FOR 1995

APPENDIX L

MEMORANDUM

MID-COL 95-1
Docket # E-9569

TO: Hon. Stephen L. Grossman
Administrative Law Judge, FERC

FROM: Robert Bugert

DATE: 26 January 1995

SUBJECT: Summary of meeting of mid-Columbia Coordinating Committee held on 25 January 1995

Agreements reached:

1) The Mid-Columbia Coordinating Committee (MCCC) appointed Erho as the interim chair, with Bugert his assistant, until a replacement is found for Dr. Whitney.

2) A subcommittee will be formed to develop plans for adult passage operations and potential evaluations in 1995 and beyond. NMFS will sponsor a workshop on this.

I. **Joint Studies**

A. Appointment of Committee Chair

The MCCC appointed Erho as the interim chair, with Bugert his assistant, until a replacement is found for Dr. Whitney, who retired as chair. Hammond submitted to the committee a draft job description for review (comments are due to him by February 3); a formal search will begin thereafter.

B. Adult Passage Sub-committee

Hevlin suggested a subcommittee be established to evaluate adult passage through the five mid-Columbia projects in 1995. He proposed that this group would develop recommendations for fishway operations in 1996, when fish that were radio tagged in the lower Columbia River will be passing the mid-Columbia projects. Their passage could then be evaluated under the recommended passage strategies. Nason said Chelan PUD would be interested and Hays would contact the Corps of Engineers to begin coordination, and develop plans for 1995 and beyond. Hevlin said he would coordinate a work session to look at results from the 1993 and 1994 passage studies, and to develop recommendations for 1995 operating plans and 1996 studies. The workshop could be funded through ESA monies, and will include passage scientists from NMFS, University of Idaho, and the Corps.

C. Response to NPPC Resolution

Heinith notified the committee of a passage in the draft Fish and Wildlife Program amendments from the Northwest Power Planning Council (NPPC), in which it states a need for resolution of disputes on power operation and water management for the mid-Columbia region. He was concerned about the role NPPC should play in an aiready established arena for discussion, coordination, and dispute resolution in the mid-Columbia. The group was not aware of this passage in the Program, but felt there was no need to address it at this time.

D. Status report on Habitat Conservation Program (HCP)

Heinith asked the three districts for an update of the proposed HCP for the midColumbia Region. Nason responded that the three districts retained Beak Consultants to develop a five-project mainstem HCP. Beak assembled a briefing document for agency and tribal administrators for policy review and coordination. Thereafter, the document will be fully distributed for review and comment. He also described the goal to establish four site-based coordinating teams, one for each major mid-Columbia tributary. These groups would be comprised of landowners and agency technical representatives. A facilitator would be hired to assist in development and implementation of tributary-specific HCPS, which would be coordinated with the mainstem HCP.

Scribner asked when and how the committee will be briefed on the HCP. Nason said the committee will be involved once the agency principles commit to the HCP concept. He stressed that this is not an attempt by the PUDs to circumvent the committee. Hevlin stated that an analysis of overall project impacts and means to address these cumulative impacts are needed, and this HCP will be useful for that purpose.

Heinith asked for a status report on the HCP modelling process. Nason responded that the work is underway, but has been hampered recently because the WDFW participants were currently involved in ESA related issues. Heinith, and others, stated this modelling effort will be of much use to the committee, and pushed for its development.

E. Meeting Minutes

Bugert asked the committee to provide comments on all outstanding draft minutes by the next meeting.

II. **Chelan County P.U.D.**

A. Rocky Reach Dam

1. Surface attraction device

Nason gave a status report on the construction of the surface attraction prototype at Rocky Reach Dam. Work is progressing on schedule, with projected completion date of 1 April 1995. Hevlin asked about the possibility for a tour. Nason and Christman will arrange a tour, which is tentatively set for 28 February 1995. A tour of Wanapum Dam will be available at this time also--Hammond and Brown will arrange this.

Woodin asked about the draft study plan to evaluate the prototype. Nason responded that he recently reviewed the proposal from HTI for the hydroacoustic work; he will distribute it to the committee within the week. Hays has been developing the plan for the bypass sampler, which will be distributed soon. Woodin asked if video monitoring will be included-Nason said cameras will be placed on the wall of the fish ladder adjacent to the outfall site.

2. Turbine Runner Replacement

Nason reported that the first turbine runner replacement, at Rocky Reach, will be made this fall on Unit 6. It will be evaluated in 1996--no definite plans on the means to evaluate the replacement have been made yet.

3. Extension of Stipulation

Nason said Chelan PUD has reviewed the proposed spill and bypass schedule at Rocky Reach for the upcoming stipulation, which was developed by CRITFC. He said the district would prefer incremental increases in survival, rather than fish guidance efficiency, in the language of the stipulation. Nason said he likes the idea of incremental improvements in each year of the stipulation; this would allow an evaluation of prototype modifications. Heinith asked if any work on the prototype model is being done at ENSR. Pearce said he believes an evaluation of forebay hydraulics is currently underway.

Scribner expressed concern that no meaningful data on the performance of the prototype may be available by August 1995--the time the stipulation is authorized. Nason said some changes on the timing of the stipulation extension could probably be made to accommodate this--he will need to check with his attorneys. Hevlin asked if other aspects of the stipulation (compensation and related studies) could be addressed prior to the development of agreed language for bypass and spill. Nason reiterated that Chelan will address the stipulation as a whole. Woodin suggested that a subcommittee work on the compensation aspect of the stipulation to achieve an agreeable plan, so this would not delay authorization of the stipulation. Nason agreed to this. The subcommittee will meet in Wenatchee on 28 February, when the tour of the prototype will be given.

Ill. **Grant County P.U.D.**

A. Surface attraction device

Hammond reported that construction of the prototype was progressing, yet construction may be delayed because of FERC concerns about agency and tribal responses to the Draft EIS for the FERC order. Most of FERC's concerns were centered on comments by NMFS. Hevlin responded that most of the verbiage in the letter was standard procedures for review of such projects. Hammond noted that a settlement agreement would circumvent these problems; often there is a general understanding among the committee members about the status of the prototype, yet third party interpretations may often be different.

Hevlin asked Pearce to describe a potential problem NMFS foresees with the surface attraction prototype, as it is currently designed. Pearce discussed the potential for juvenile fish to accumulate in an area between the floor of the "surface collector" and the roof of the turbine intake

. Hammond and Brown acknowledge this could be a problem, but at this time do not have the capability to deal with this potential. After considerable discussion, the group could come up with no feasible means to prevent this possibility. Hevlin asked if a video monitor could be deployed in this area to determine if fish do indeed accumulate in this area. Brown said they could investigate this possibility.

Hammond called upon Pock to discuss the prototype evaluation plan, which was distributed prior to the meeting for comments. Woodin distributed his comments on the evaluation plan to the committee. Hevlin stated that the verbiage in the objective statement should be modified. He said it was not necessary that the prototype "exceed" the screen bypass FGE; verbiage stating that the surface attraction prototype would "meet or exceed" the screen FGE would suffice. Hevlin also expressed concern that the amount of light required for underwater video monitoring may discourage fish away from the prototype entrance. Weitkamp agreed, and will investigate several options to mitigate these effects. The committee agreed that further discussion, on the evaluation plan, was needed.

B. Implementation of Spill Plan

Hammond distributed a draft outline of the proposed spill plan for 1995. He said it was difficult to establish a spill plan without any indication from the water quality agencies on tolerable gas supersaturation levels. Hevlin suggested he develop a plan based upon "reasonable" standards (about 1 1 0% to 1 1 5%), on the assumption that these will be the standards adopted by those agencies. Hammond said Grant is willing to pursue 70% passage for 80% of the outmigrants. He will develop a plan based upon that strategy, and the gas standards suggested by Hevlin. Hevlin stressed the need for an evaluation of gas levels. Hammond said we would revise the draft spill plan, include a means to monitor gal levels, and distribute it to the spill subcommittee. Hammond said hydroacoustic monitoring will begin April 17, prior to major peaks in outmigration.

C. Fishway Inspections

Hevlin asked for comments on the memo prepared by Nordlund and distributed to the committee last meeting. The memo stated that Grant PUD was deficient in meeting some fishway conditions. Carlson said Grant PUD cannot meet all the conditions set in the operating criteria, because some were not logistically feasible. He set up a meeting on 9 February with Fish Passage Center on the fishway operating plans for Priest Rapids and Wanapum dams, to work out a solution to this dilemma. Some members of the committee will attend this meeting.

D. Status of hydraulic models

Hammond called upon Brown to give an update on the modelling work in Iowa. He said the work on the Wanapum tailrace is completed, and the work on Priest Rapids is underway. Some modelling on the hydraulics of the pillings of the piers that support the outfall of the juvenile bypass system and channel hydraulics of the prototype are scheduled to be done also.

Hammond distributed tentative dates for design and construction of the Wanapum Dam juvenile bypass system. Hevlin asked if a similar schedule is available for Priest Rapids; Hammond said that a total project schedule will be distributed after this draft schedule for

Wanapum is reviewed. Brown said this schedule is based upon a 30 day review period provided for agencies and tribes.

D. Predator Control

Hammond called upon Carlson to review Grant PUD's proposed predator control program at the tailraces of the dams in 1995. Carlson said they will evaluate hook and line removal at both dams and at the outfall channel to Priest Rapids hatchery. Hevlin expressed hope that the three districts would do a cooperative project to evaluate predator movement. Hammond and Klinge said they are willing to tag fish at Wells, Priest Rapids, and Wanapum. Carlson will contact Chelan PUD to coordinate this plan. Woodin stated that WDFW had concerns about Grant PUDs proposed use of non-selective removal gear. He was concerned about impacts to salmonids and walleye. He will provide comment soon. Grant PUD is sponsoring a predator control workshop on 2 February in Portland. Most of the concerns and coordination will be addressed at this workshop.

Hammond called upon Sullivan to discuss the evaluation of predators near the proposed outfall site at Wanapum Dam. They proposed the use of boat electrofishers and gill nets to sample, and remove predators. Some squawfish will be radio tagged to determine movements in the tailrace. The committee will comment on the plan after the workshop.

The next meeting of the MCCC is set for 1 March 1995 at Chelan PUD.

ATTENDANCE LIST

NAME	REPRESENTING
Bill Hevlin	National Marine Fisheries Service
Bob Pearce	National Marine Fisheries Service
Brian Cates	U.S. Fish and Wildlife Service
Rick Klinge	Douglas PUD
Tom Scribner	Yakama Indian Nation
Bob Heinith	Columbia River Intertribal Fish Commission
Rod Woodin	Washington Department of Fish and Wildlife
Bob Bugert	Washington Department of Fish and Wildlife
Rick Klinge	Douglas County Public Utility District
Dick Nason	Chelan County Public Utility District
Stuart Hammond	Grant County Public Utility District
Steve Brown	Grant County Public Utility District
Darrel Pock	Grant County Public Utility District
Chris Carlson	Grant County Public Utility District
Cary Feldman	Puget Sound Power and Light Company
Don Weitkamp	Parametrix
Bob Sullivan	Parametrix
Bruce Ransom	HTI, Inc.
Mike Erho	Private consultant

MEMORANDUM

MID-COL 95-7

Docket # E-9569

To: Hon. Stephen L. Grossman
Administrative Law Judge

From: Mike Erho, Chairman Mid-Columbia Coordinating Committee

Date: September 28, 1995

Subject: Summary of Mid-Columbia Coordinating Committee meeting of May 17 and 18, 1995.

Agreements Reached:

1. The committee agreed to meet on July 14, 1995 to consider extension of the Rocky Reach Stipulation.

2. The committee agreed to meet by conference call on May 22 to consider what changes in the configuration or operation of the Wanapum Dam prototype surface attraction system could be made and evaluated this year, and to review the probable causes of the mortality experienced in the "A" slot of unit 4 and possible remedies.

This meeting was held in conjunction with a tour of activities at Rocky Reach, Rock Island, and Wanapum Dams on May 17, and 18.

I. JOINT STUDIES

1. Radio Telemetry Studies for 1996

Hevlin proposed to re-activate the radio telemetry sub-committee to begin planning for radio telemetry studies of adult passage in the mid-Columbia in 1996. Woodin also urged the committee to conduct the studies in 1996 to take advantage of the tags that will be applied to adult salmon in the lower Columbia under the adult passage studies being planned by the Corps of Engineers. Heinith questioned if the number of tags being applied under the Corps study would be adequate to provide meaningful information in the mid-Columbia. Hammond stated that Grant County would want to augment the numbers of fish tagged by the Corps to provide enough tagged fish for mid-Columbia studies. There followed a discussion of the number of radio tags available in the mid-Columbia that could be used for the adult studies in 1996. Erho pointed out that he had been in contact with the lead person for the Corps study(Ted Bjornn) who would like to borrow any excess telemetry equipment owned by the mid-Columbia PUD,s that would not be

in use in 1996. Erho agreed to stay in touch with Bjornn as the mid-Columbia plans for 1996 develop.

II. CHELAN COUNTY PUD

1. Rocky Reach Surface Collection Prototype

Nason called on Peven to review the preliminary data on the surface collection prototype effectiveness. Peven distributed information on horizontal distribution, collected through 24 hour per day hydroacoustic monitoring, which compared fish distribution at the prototype to distribution at units one through five. Peven also presented a graph showing passage through the prototype through mid-May. Hevlin asked if there were estimates of passage through other units. Peven said only hydroacoustic estimates of passage. Data were presented showing vertical distribution at the prototype, unit one, the center bay of unit two, and unit three upstream of the roof associated with the prototype. Peven also showed a video of passage through the prototype and explained that passage was being videotaped 24 hours per day and that a complete record of seasonal use of the prototype would be available. Hevlin said he would like to see a comparison of prototype passage to passage through units one through five since it is possible that fish could be displaced upstream by the presence of the prototype. Peven stated that the hydroacoustic data collected thus far did not support that hypothesis. Nason pointed out that if the unit operation at Rocky Reach were normalized, the horizontal distribution at the powerhouse would probably not be different than observed in past years.

Nason reminded the committee that the primary objective of the prototype evaluation in 1995 was to determine if the surface collection concept is valid. Secondarily, is the determination of ways to improve the effectiveness of the prototype for passing juvenile migrants. Nason stated that they are convinced that the prototype results to date have demonstrated the validity of the concept. Hevlin asked how we can say that the prototype surface collection concept is working. In response, Nason pointed out that the prototype had passed as many as 29,000 fish in one hour compared to total intake screened passage of 80,000 fish all of last year. That to him is a strong indication of the validity of the concept. Determination of fish guidance efficiency (FGE) was never an objective this year. Woodin urged the committee to concentrate on ways to improve the effectiveness of the surface collection prototype rather than getting caught-up in trying to determine precisely what the FGE is. Nason agreed and stated that determination of ways to reduce juvenile passage through units one, two, and three should receive priority consideration.

Hevlin urged the committee to consider major changes in the prototype flow and/or configuration. Peven and Bickford pointed out that flow at the entrance of the prototype has varied up to 2400 cfs, the current design maximum. This resulted in an increase in entrance velocity from 2.1 to 2.4 feet per second. The response of juveniles to changes in entrance velocity awaits evaluation.

Nason called on Stieg to present data on the distribution of fish in the immediate forebay area at Rocky Reach. Stieg presented a preliminary display showing one day's data on fish distribution and direction of movement in the area of the prototype. Additional data were displayed showing fish density and velocity in relation to the prototype and unit one. In response

to Woodin's suggestion, HTI had previously placed a target in the forebay to help with orientation relative to the hydroacoustic data being collected.

2. Predator Removal

Nason called on Hays to report on the predator removal program at Rocky Reach and Rock Island Dams. Hays stated that angling for squawfish removal began earlier in 1995 than in 1994. Water temperatures are lower this year and flows are different than experienced at this time last year. Fish do not appear to be concentrated below the powerhouse at Rocky Reach as they were last year. Most of the angling success has been from the rip rap below Rocky Reach on the right bank.

Hevlin asked about the angling effort at Rock Island. Hays said the anglers are experiencing the most success from the deck of the center fish ladder entrance between powerhouse one and the spillway. However, the fish do seem to move around and are found in different locations on different days. Bait seems to be more effective than lures at Rock Island. Catch per unit of effort, for the first week of the predator removal effort, was 0.4 fish per angler hour at Rock Island and 1.4 fish per angler hour at Rocky Reach. Hays reported that they have contacted John Skalski about squawfish tagging considerations but, as yet, they have nothing definitive on which to base a tag/recapture study. They are continuing to pursue criteria for a tagging study.

3. Rocky Reach Stipulation

Heinith expressed concern regarding the fact that the Rocky Reach Stipulation will be expiring in August 1995. He proposed a meeting to consider extension of the current stipulation as soon as prototype data becomes available. The committee agreed to meet July 14 to consider extension of the Rocky Reach Stipulation.

III. GRANT COUNTY PUD

1. Prototype Surface Attraction Bypass

Hammond reviewed the details of the surface attraction prototype at Wanapum Dam. The entrance to the prototype is adjustable in width and depth. It is currently operating with a 16 foot wide by 30 foot deep entrance with an attraction flow of 1400 cfs. Hammond called on Ransom to review hydroacoustic monitoring at Wanapum. He reported on the estimation of run timing based on the accumulative seasonal hydroacoustic index of abundance. Using an estimated seasonal hydroacoustic index of three million fish, it appears that approximately 62% of the spring migration has passed Wanapum Dam through May 16. Ransom pointed out that 1 to 4% of the total estimated hydroacoustic index has passed each day since April 24.

Ransom reviewed the hydroacoustic estimates of passage through the powerhouse, prototype, spillway and sluiceway. Passage over the sluiceway has been running about 10% with a range of 9 to 14% of the total passage. The passage in spill has been running 40% with the spill volume at 29-30% of the daily average flow. This is the highest passage efficiency ever observed

at the Wanapum spillway. Fish passage in units 2 and 4 are very high and passage in units 7, 8, and 9 are low in comparison to recent years. Prototype passage efficiency, in relation to unit 8, has been running 8 to 22%. In relation to passage through units 7, 8, and 9, efficiency of the prototype has been running about 9%. On two recent days, May 13 and 14, the efficiency in relation to unit 8 had increased to 29 to 30%, an improvement but still below the level desired.

Hevlin asked Ransom what the horizontal distribution at Wanapum had looked like in the past. Ransom responded that it has been variable, over the years, depending on operations. Hammond reported that the passage in unit 8 has been an order of magnitude lower this year than observed in the past. Hevlin remarked that the prototype channel extended approximately 15 feet below the top of the turbine intake and this may be causing more fish to bypass units 7, 8, and 9. Hammond reviewed a change in the configuration of the prototype entrance which involved closing the bottom portion of the entrance to create a shallower opening. Rainey asked what the rationale was for creating a shallower entrance. Hammond and Brown responded that the intent was to increase the entrance velocity by reducing the cross-sectional area of the entrance. Ransom said that he had proposed making a drastic change in the prototype in an attempt to make a significant increase in the fish passage effectiveness of the prototype. Rainey asked Ransom to comment on the prototype passage results since the entrance was reduced in depth. Ransom said that they hadn't been able to analyze the data yet. He said that there was still time to make other modifications before the migration was over and that they would try to accelerate the data analysis to allow additional testing. Woodin asked the committee what other changes might be made in the prototype configuration or operation. It was suggested that the prototype be operated on gravity flow only(no pumped flow) with the entrance set to create the same attraction velocity as the original conditions.

Hammond called on Hagen to report on the status of the video monitoring of passage through the prototype. Hagen said the two objectives of the video monitoring were to assess fish behavior in relation to the prototype entrance and to quantify the passage of fish through the prototype. Klinge noted that the data presented by Hagen indicated somewhat random timing of passage through the prototype. He remarked that similar phenomena were noted at Wells Dam this year.

Rainey stated that a number of behavioral studies have been conducted using lights to increase effectiveness of juvenile migrant facilities. He believes that there is potential for the use of lights to incrementally increase fish guidance efficiency at the prototype.

Hevlin said that he had two general comments. Fish are apparently being kept out of units 7, 8, and 9 by the presence of the prototype. He believes that extending the channel up the powerhouse could result in improved spill effectiveness. He also feels that it would be profitable to consider the use of radio-tagged juvenile migrants, in 1995, at Wanapum and Rocky Reach to study fish distribution and behavior in relation to the surface attraction prototypes at both projects.

Heinith inquired about fish getting behind the prototype between the channel wall and the upstream face of the dam. Pock showed a video taken to assess fish accumulation in that area. The video showed some fish in this area, mainly below about 30 feet in depth. Hevlin suggested additional video surveys to fully assess the magnitude of fish numbers collecting in those areas.

Rainey asked if debris had been much of a problem in the operation of the prototype during the spring migration. Polk stated that trash had been removed from the prototype channel about five times over the duration of construction and operation to date.

Woodin asked if there would be any additional changes in the prototype before the numbers of fish declined to the point where evaluation would be difficult. Heinith asked if there were other prototype configurations that could be evaluated. Several changes were suggested including 1) a "no pump" test with maximum gravity flow and some venturi flow for attraction, and 2) opening the end of the 8 foot wide channel for an entrance and removing the perforated plate that separates the 8 foot and 12 foot wide channel sections. Hammond suggested waiting until the data from the reduced depth opening were analyzed and then deciding, by conference call, what should be done. The committee agreed to meet by conference call on May 22 at 2 PM.

Brown suggested that the upper portion of the turbine intake trash racks at Wanapum could be covered with plywood to simulate the effect of the prototype channel on units 7, 8, and 9. Hammond stated that it would probably not be possible to make that change this year but that it is something that could be considered for 1996. Hammond said another possibility would be to wait for lower flows and to concentrate the flow at the units associated with the prototype. Brown pointed out the potential for testing trash rack covers at unit 4 since that seems to be the area where the most fish are passing. Rod expressed concern with that idea since FGE at unit 4 appears to be good and this serves as a fish protection provision.

2. Prototype Intake Screen Bypass in Unit Four

Hammond called on Pock to show a video of the "A" slot of unit 4. This video was taken after elevated mortality of smolts was observed when fish from this slot were examined. Large numbers of fish were dipped from this slot and upon examination, 2768 out of 9130 fish were found to be mortalities. The screens were then removed from the unit 4 intakes to prevent a repeat of the mortality problem. Rainy asked if the uniform velocity across the vertical barrier screen had been checked. Brown said that it was designed for uniform velocity. Woodin raised the question of the possible effect on unit operation at Wanapum due to the "no spill " test of bypass effectiveness over the last few days which could have effected flow through unit 4. He asked what the magnitude of the problem was before the "no spill" test.

Hevlin pointed out that when mortality exceeds 1 to 2% in a screen bypass system, they get concerned and begin looking for the problem. He expressed concern with the level of mortality discovered in the unit 4 "A" slot. Hevlin observed that the intake screen bypass systems are not made to accumulate fish and then gatewell dip them. Without orifices these systems are operating contrary to best operating procedures. Woodin suggested that the screens be left out of unit 4. Heinith said that he believed the unit 4 salvage operation was useful and could be used by operating the unit part-time. Rod asked if it would be possible to dip the gatewells at unit 4 more often than once per day. Hammond said that it was a half-day process to dip the A, B, and C slots in unit 4 and that dipping more than once per day was not feasible, at this time. He said that he felt the problem was caused, in large part, by operating unit 4 with a discharge in excess of 14000 cfs. He has instructed the Wanapum operators to limit unit loading to 14000 cfs or less for the duration of the migration. The committee agreed to have Grant County continue to investigate the

causes of the mortality in the "A" slot of unit 4 and to report the findings to the committee by conference call on May 22.

3. Dissolved Gas Monitoring

Hevlin asked if there had been any further discussion on dissolved gas abatement. Rainey called attention to the dissolved gas abatement report recently produced by the Corps of Engineers. He said he would see that Grant County received a copy. Hevlin encouraged Grant County to look at the potential for dissolved gas abatement since the efficiency of spill for juvenile migrant passage appears to be favorable.

4. Predator Removal Program

Carlson reported that 3 squawfish had been caught, to date. Hammond said they were in the process of hiring additional anglers even though there did not appear to be much squawfish activity, as yet. Woodin asked if they would be attempting to remove squawfish from the Priest Rapids Hatchery outfall. Hammond answered in the affirmative.

5. Spill

Carlson reported on the results of dissolved gas saturation transects taken across the area below the Wanapum tailrace and across the Priest Rapids forebay. Hammond stated that the dissolved gas levels were higher west of unit 7 and lower east of unit 7 in the Priest Rapids tailrace. These gradients are still evident as far downstream as Vernita Bridge. Hevlin reported that the dissolved gas levels at McNary Dam were very low indicating an erosion of dissolved gas levels through the Hanford Reach and McNary Reservoir.

Carlson reported that the NMFS had placed net pen live boxes on the east side of the Priest Rapids Reservoir across from Buckshot Ranch. This is an element of the bio-monitoring effort funded by Grant County to assess the effects of dissolved gas on fish at the Grant County projects.

The next meeting of the Mid-Columbia Coordinating Committee will be held, by conference call, on May 22 at 2 PM.

MEMORANDUM

MID-COL 95-13
Docket #E-9569

To: Hon. Stephen L. Grossman

From: Mike Erho, Chairman
Mid-Columbia Coordinating Committee

Date: November 13, 1995

Subject: Summary of November 8, 1995 Mid-Columbia Coordinating Committee Meeting

Agreements Reached:
1. The committee delayed a decision on the appointment of the new chairman of the Mid-Columbia Coordinating Committee until November 17 to allow all committee members to express an opinion.

2. The committee agreed to extend the deadline for comment on the 1993 findings to December 8, 1995.

A. General Mid-Columbia Issues

1. Coordinating Committee Chairman

The committee discussed the position of committee chairman and agreed to delay decision on appointment of the permanent committee chair until the members not present at the November meeting had a chance to express their opinion. Hammond agreed to poll those members prior to November 17, after which the committee will appoint the committee chairman.

2. Adult Studies

Nason reported on the meeting PUD representatives had with Ferguson and Bjornn concerning the adult radio-telemetry studies being planned by the Corps of Engineers for 1996-97. They will have 23 receivers at Bonneville Dam and McNary Dam and will be monitoring tributaries above Bonneville. They also plan to monitor passage at each dam where surface bypass activities are being conducted. When all receivers have been installed, the Corps will have one spare receiver in 1996. They are interested in borrowing any spare equipment the PUD's might have to more adequately cover the studies in 1996. Spring chinook are the species of interest in 1996 and 700 adults will be tagged for the Corps study. They have estimated that 126 of these will show up at Priest Rapids. While the interest in the mid-Columbia is to use sockeye for test animals for adult passage studies, the Corps study in 1996 will probably not include tagging sockeye. The Corps and their contractors expect low numbers of sockeye in 1996 and it is unlikely there will be a tribal fishery. Hevlin stated that he had been led to believe the Corps would be tagging sockeye in 1996. Hevlin and Woodin will contact the Corps for clarification on the studies planned for 1996, particularly as they relate to sockeye.

Nason said that Chelan would be using all their equipment for juvenile radio-telemetry studies in the spring of 1996 but after about the first of June their equipment could be used for Corps studies. Woodin asked if Grant PUD would consider evaluating spring chinook passage at Priest Rapids in 1996 since 126 Corps tagged spring chinook were expected to arrive at that project. Hammond indicated that Grant would like to proceed with ladder evaluation at Priest Rapids in 1996. Nordund encouraged Grant to proceed with adult studies in 1996 as he feels that good information could be developed using the tagged spring chinook from the Corps study.

Woodin inquired about Douglas PUD's plans for 1996. Klinge responded that Douglas would prefer to use sockeye for adult passage studies. He explained that the Corps planned to conduct adult studies for four years so there would be opportunity to use sockeye at another time. He added, however, that monitoring of sockeye passage at Wells for fallback and evaluation of sockeye transport to Lake Osoyoos could be accomplished in 1996. Woodin said he recognized the potential for Wells specific studies in 1996 but stated that Priest Rapids was the highest priority for adult studies in 1996 due to the expectation that Corps tagged fish would be available. He felt that it might be preferable to use Douglas PUD equipment at Priest Rapids to accommodate the spring chinook passage study at that location. Additionally, Woodin expressed some concern with the radio-telemetry studies proposed by Douglas, especially radio-tagging sockeye for transport to Lake Osoyoos. He felt that the tags could inhibit spawning and consequently, could effect recovery on the spawning grounds. He suggested consideration of PIT tags for evaluation. Woodin asked Klinge what Douglas planned to do in 1996. Woodin mentioned the possibility of loaning equipment to Grant for spring chinook passage evaluation at Priest Rapids and then retrieving the equipment for Wells specific sockeye studies. This would also free-up equipment for the Corps to more adequately cover their studies since they were planning to use their equipment at Priest Rapids to monitor passage in the mid-Columbia. Klinge said they would discuss this possibility in-house and he would get back to the committee.

Woodin raised a question about the potential for conflict between the juvenile studies being planned and the adult passage studies that would be in progress concurrently. He stressed the importance of coordination between the studies to avoid duplication of tag codes that could confuse the data. The committee agreed that there should be coordination between the studies to avoid tag duplication. Nason said he would touch base with the Corps and also the tag manufacturer to make sure this problem didn't arise.

3. Fishery Agency and Tribal Mid-Columbia Production Meeting

Hevlin distributed copies of a draft agenda for the agency/tribal production meeting scheduled for November 16. Woodin briefly stated the purpose of the meeting which is to develop a joint understanding regarding certain concerns which have lacked consensus in the past. The committee agreed that this was an appropriate first step in resolving issues that had come up in the past regarding production issues in the mid-Columbia.

4. Draft 1993 Findings

Woodin reminded the committee of the deadline for comment on the 1993 findings. Hevlin asked for an extension of the deadline for comment to December 8 since he did not think he had received the draft. The committee agreed to extend the deadline for comment to December 8, 1995.

B. Grant County PUD Studies

1. Surface Collector

Hammond reported that the Grant County PUD Commission had just passed an emergency resolution to allow the PUD to contract with the same contractor used last year for construction of the surface collector at Wanapum. He reported on the discussions that had taken place at the Wanapum

Technical Work Group meetings and distributed a sketch of proposed modifications to the surface collector for 1996. The TWG agreed that the channel should be extended to cover unit 4 if this can be accomplished for the 1996 season. Design work is necessary since the new section will provide horizontal entrances which require a change in the structural members. Hammond stated that there is a question concerning how much construction can be accomplished in time for testing in 1996. If the channel can be extended over unit 4 it would be possible to simulate a full powerhouse system since flow could be concentrated at the units which were covered by the surface collector. Using the same contractor as last year should be a major advantage in the amount of construction that can be accomplished prior to the 1996 migration.

Woodin remarked that the screens in unit 4 would probably be removed if the channel is extended over that unit. If the channel only extends as far as unit 5 then steps would have to be taken to prevent a re-occurrence of the problem experienced last year with the number of fish that accumulated in the gatewells of unit 4.

2. Dissolved Gas Abatement

Hammond reported on plans for installing a flip-lip at spill bay two at Wanapum. Spill bay two was selected based on the results of model testing and an analysis of hydraulic conditions in the tailrace. Hammond referred to a memo from Rex Elder which discussed the placement of the flip-lip based on conditions for evaluation of tailrace conditions. Spill bay two was considered the most desirable location for testing tailrace conditions resulting from flip-lip installation because it allows for the most complete separation of flow. Hammond also reported that spill bay twelve will be modified to provide surface spill capability. He reported that the spillway model is up and running. It will be used to establish operational parameters for the modified spill bays. The model can simulate any of the spill bays even though there are just three bays in the model.

3. Fish Injury Studies

Hammond reported that RMC will be contacted concerning studies of passage injury over the modified and existing spill bays. Hevlin asked that NMFS be involved in the planning of these studies. Hammond also stated that Grant is interested in looking at mortality through the existing turbines as a pre-condition injury evaluation prior to installation of new turbines. Woodin suggested that this evaluation be conducted in the first turbine scheduled for refitting with new runners.

4. Comments on the FERC Draft EIS and

Hevlin inquired as to the schedule for comments on the draft EIS. Hammond replied that Grant County had requested and extension of time for comment on the draft EIS.

5. Report to FERC Required by the Spill Order

Hevlin suggested the need for a letter to FERC that reports how things went in 1995. Hammond said he had done this in the past and he was attempting to use the HTI report for that purpose for 1995. Hevlin and Woodin both stated that they do not feel the HTI reports are in the appropriate format for meeting the requirements of the Spill Order. Hammond said that the HTI spill reports due this week would be filed with FERC next week as final reports .Woodin asked about agency comments concerning the need for additional information to meet the FERC reporting requirements. Woodin and Hammond agreed that there is a need for clarification on the time periods being reported for spill effectiveness in relation to the requirements of the FERC order. Hevlin said he would like to see a report that specifically addresses spill management. He suggested that they might send a letter to FERC pointing out short comings in the HTI report from a management perspective. Hammond stated that if the HTI reports don't meet the reporting needs envisioned by the agencies and tribes, the committee should be able to work out details on how that need would be met. He reiterated that it is Grant's responsibility to provide information to FERC.

Hammond reported that the HTI report on the results of the surface collector evaluation in 1995, was also due this week. He said it was Grants intention to submit that report to FERC next week as a preliminary report. When the surface collector evaluation analysis is complete the report will be updated and submitted as a final report.

C. Chelan PUD Studies

1. Rocky Reach Stipulation

Nason reported on progress on the status of the Rocky Reach Stipulation. He stated that Chelan desires to finalize the stipulation so that it can be forwarded to FERC. Hevlin and Woodin discussed potential changes to the draft with Nason.

2. Studies for 1996

Nason said that comments were needed on the proposed 1996 study plans previously distributed. Erho encouraged the committee to provide comments on items when they are circulated for comment and if a committee member has no comment they should so indicate rather than remaining silent.

Woodin inquired about Chelan's plans for liberation of radio-tagged juveniles for Rocky Reach surface collector evaluation. Nason replied that it was their plan to use the gatewell salvage release barges for that purpose. Woodin expressed a concern with forced release of the radio-tagged fish for evaluation purposes. He suggested that it would be preferable to use some type of net frame equipment that would allow volitional release. Nason said that type of equipment was available from the Lake Wenatchee sockeye program.

December 13, 1995 was tentatively set as the date for the next committee meeting.

ATTENDANCE LIST

NAME	REPRESENTING
Cary Feldman	Power Purchasers
Rick Klinge	Douglas County Public Utility District
Stuart Hammond	Grant County Public Utility District
Dick Nason	Chelan County Public Utility District
Bryan Nordlund	National Marine Fisheries Service
Bill Hevlin	National Marine Fisheries Service
Brian Cates	US Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries & Wildlife
Mike Erho	The Committee

1995 MEMBERSHIP LIST
OF THE
WELLS COORDINATING COMMITTEE

APPENDIX M

Appendix M

1995 Membership list of the Wells Coordinating Committee

Ron Boyce
Oregon Department of Fish and Wildlife

Mike Erho
Wells Coordinating Committee Chairman

Cary Feldmann
Power Purchasers

Bob Heinith
Columbia River Inter-Tribal Fisheries Commission

Bill Hevlin
National Marine Fisheries Service

Rick Klinge
Douglas County P.U.D.

Jerry Marco
Colville Confederated Tribes

Tom Scribner
Yakama Indian Nation

Brian Cates
U.S. Fish and Wildlife Service

Rod Woodin
Washington Department of Fish and Wildlife

THE LONG-TERM SETTLEMENT AGREEMENT FOR THE WELLS HYDROELECTRIC PROJECT

APPENDIX N

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:

$$\overline{Ays} = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

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.

$$\overline{HSys} = \frac{HSy + HSy\text{-}1 + HSy\text{-}2 + HSy\text{-}3 + HSy\text{-}4}{5}$$

4. Total smolts (by species):

$$\bar{S}ys = Kys \times \bar{A}ys + \overline{HS}ys$$

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 Sorensen
Commissioner

T. James Davis
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

_____

FOR PACIFIC POWER & LIGHT COMPANY:

_____

FOR THE WASHINGTON WATER POWER COMPANY:

_____

FOR PORTLAND GENERAL ELECTRIC COMPANY:

_____

FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

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FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

_____

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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Commissioner

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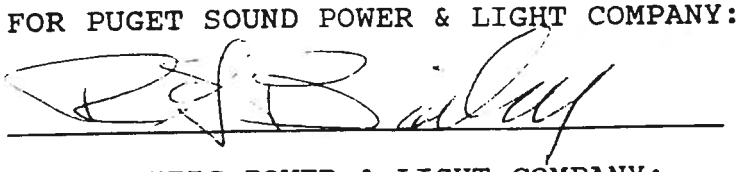
Commissioner

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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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:

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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:

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FOR PACIFIC POWER & LIGHT COMPANY:

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FOR THE WASHINGTON WATER POWER COMPANY:

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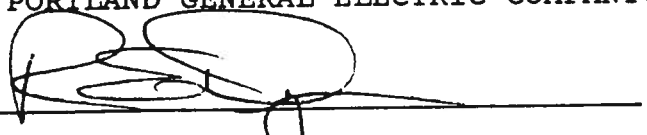
FOR PORTLAND GENERAL ELECTRIC COMPANY:



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:

_____
Commissioner

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Commissioner

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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:

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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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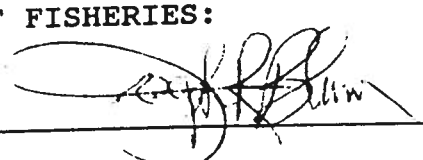
FOR THE WASHINGTON DEPARTMENT
OF FISHERIES: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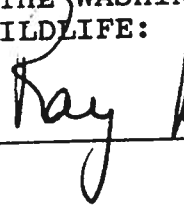
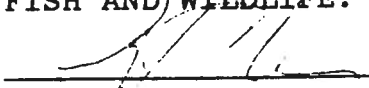
FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:


6/11/90

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:



FOR THE NATIONAL MARINE
FISHERIES SERVICE:

FOR THE U.S. FISH & WILDLIFE SERVICE:

FOR THE CONFEDERATED TRIBES AND BANDS
OF THE YAKIMA INDIAN NATION:

FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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FOR THE NATIONAL MARINE
FISHERIES SERVICE:

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
OF THE COLVILLE RESERVATION:

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FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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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
OF THE COLVILLE RESERVATION:

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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:

Levi George

FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

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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:

_____

FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

Edward H. Pitt

FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

_____

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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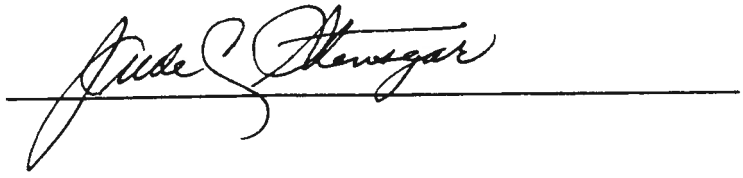
FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:



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1993 Chewuch river flow, trapping and Wells Dam spring chinook salmon counts.

Chewuch river at Winthrop - source agency USGS

Date	Wells Dam	Chewuch river cms	Chewuch trap	Fish collected	Date	Wells Dam	Chewuch river cms	Chewuch trap	Fish collected	Date	Wells Dam	Chewuch river cms	Chewuch trap	Fish collected	Date	Wells Dam	Chewuch river cms	Chewuch trap	Fish collected
01-May-93	0	2.75	0	0	01-Jun-93	15	41.36	26	26	01-Jul-93		8.50	0	0	01-Aug-93		15.98	0	0
02-May-93	0	3.00	0	0	02-Jun-93	24	36.26	1	1	02-Jul-93		8.64	0	0	02-Aug-93		14.93	0	0
03-May-93	0	3.09	0	0	03-Jun-93	31	31.73	3	3	03-Jul-93		9.09	0	0	03-Aug-93		13.85	0	0
04-May-93	1	2.92	0	0	04-Jun-93	120	29.75	3	3	04-Jul-93		8.87	3	2	04-Aug-93		12.98	0	0
05-May-93	0	3.12	0	0	05-Jun-93	29	27.54	11	5	05-Jul-93		8.05	2	2	05-Aug-93		13.49	0	0
06-May-93	1	4.84	0	0	06-Jun-93	9	23.74	19	8	06-Jul-93		7.56	1	1	06-Aug-93		12.92	2	0
07-May-93	0	7.45	0	0	07-Jun-93	14	22.35	8	5	07-Jul-93		7.65	1	0	07-Aug-93		11.62	2	1
08-May-93	0	7.14	0	0	08-Jun-93	13	20.45	2	1	08-Jul-93		7.31	0	0	08-Aug-93		10.74	2	1
09-May-93	3	6.49	0	0	09-Jun-93	18	19.69	4	2	09-Jul-93		6.77	1	1	09-Aug-93		9.97	0	0
10-May-93	1	7.31	0	0	10-Jun-93	30	20.40	2	1	10-Jul-93		6.94	4	2	10-Aug-93		9.26	2	2
11-May-93	1	12.98	0	0	11-Jun-93	44	19.72	2	1	11-Jul-93		7.00	0	0	11-Aug-93		8.78	0	0
12-May-93	8	27.34	0	0	12-Jun-93	16	19.52	0	0	12-Jul-93		10.06	0	0	12-Aug-93		8.36	0	0
13-May-93	10	50.99	0	0	13-Jun-93	18	17.59	4	3	13-Jul-93		11.16	0	0	13-Aug-93		7.88	0	0
14-May-93	104	68.28	0	0	14-Jun-93	24	16.54	6	2	14-Jul-93		10.28	0	0	14-Aug-93		8.44	1	1
15-May-93	49	76.49	0	0	15-Jun-93	25	18.56	3	1	15-Jul-93		11.05	0	0	15-Aug-93		9.35	2	2
16-May-93	22	75.36	0	0	16-Jun-93	25	18.56	10	5	16-Jul-93		11.84	0	0	16-Aug-93		13.26	3	2
17-May-93	74	72.24	0	0	17-Jun-93	12	16.71	2	1	17-Jul-93		12.21	0	0	17-Aug-93		11.28	2	1
18-May-93	118	69.13	0	0	18-Jun-93	48	15.33	5	2	18-Jul-93		13.66	0	0	18-Aug-93		12.95	0	0
19-May-93	177	71.39	0	0	19-Jun-93	30	14.33	5	2	19-Jul-93		13.74	0	0	19-Aug-93		11.19	0	0
20-May-93	171	79.04	0	0	20-Jun-93	26	13.51	7	3	20-Jul-93		17.96	0	0	20-Aug-93		9.80	0	0
21-May-93	132	69.41	0	0	21-Jun-93	14	13.29	6	1	21-Jul-93		29.18	2	1	21-Aug-93		9.52	2	1
22-May-93	110	54.39	0	0	22-Jun-93	12	14.02	1	1	22-Jul-93		23.29	1	0	22-Aug-93		8.78	0	0
23-May-93	84	46.46	0	0	23-Jun-93	11	12.72	2	1	23-Jul-93		21.11	1	0	23-Aug-93		8.61	1	1
24-May-93	136	41.65	0	0	24-Jun-93	9	11.87	0	0	24-Jul-93		18.70	1	0	24-Aug-93		8.27	0	0
25-May-93	78	39.66	0	0	25-Jun-93	8	11.05	2	1	25-Jul-93		19.35	0	0	25-Aug-93		7.68	0	0
26-May-93	47	38.53	0	0	26-Jun-93	12	10.28	1	0	26-Jul-93		18.33	1	1	26-Aug-93		7.65	0	0
27-May-93	65	38.81	0	0	27-Jun-93	10	10.82	2	1	27-Jul-93		16.20	2	2	27-Aug-93		7.20	0	0
28-May-93	146	35.41	0	0	28-Jun-93	12	10.03	1	1	28-Jul-93		15.18	1	0	28-Aug-93		6.77	0	0
29-May-93	78	34.00	0	0	29-Jun-93		9.29	0	0	29-Jul-93		22.86	0	0	29-Aug-93		6.63	0	0
30-May-93	32	30.60	0	0	30-Jun-93		8.95	0	0	30-Jul-93		21.19	0	0	30-Aug-93		6.43	0	0
31-May-93	137	29.46	5	5						31-Jul-93		17.63	2	0	31-Aug-93		5.92	0	0
															01-Sep-93		5.55	0	0
															02-Sep-93		5.21	0	0
															03-Sep-93		4.93	0	0
															04-Sep-93		4.70	0	0
															05-Sep-93		3.68	0	0
Summary	1785		5	5		659		138	81				23	12				19	12

1993 Methow river flow, trapping, and Wells Dam counts.
Methow river at Winthrop - source USGS

Date	Wells Dam	Methow river cms	Fish collected	Date	Wells Dam	Methow river cms	Fish collected	Date	Wells Dam	Methow river cms	Fish collected	Date	Wells Dam	Methow river cms	Fish collected
01-May-93	0	15.01		01-Jun-93	15	119.84		01-Jul-93		24.65	0	01-Aug-93		36.55	0
02-May-93	0	17.65		02-Jun-93	24	109.07		02-Jul-93		24.39	0	02-Aug-93		34.28	1
03-May-93	0	19.04		03-Jun-93	31	97.17		03-Jul-93		24.31	1	03-Aug-93		32.01	0
04-May-93	1	18.98		04-Jun-93	120	94.34		04-Jul-93		23.46	0	04-Aug-93		30.03	0
05-May-93	0	21.53		05-Jun-93	29	89.52		05-Jul-93		22.10	0	05-Aug-93		30.31	3
06-May-93	1	29.75		06-Jun-93	9	81.87		06-Jul-93		21.08	2	06-Aug-93		29.46	0
07-May-93	0	37.96		07-Jun-93	14	77.91		07-Jul-93		21.11	1	07-Aug-93		27.37	0
08-May-93	0	35.98		08-Jun-93	13	69.69		08-Jul-93		20.11	2	08-Aug-93		25.58	0
09-May-93	3	33.43		09-Jun-93	18	64.31		09-Jul-93		19.29	0	09-Aug-93		24.05	0
10-May-93	1	37.11		10-Jun-93	30	63.18		10-Jul-93		19.21	1	10-Aug-93		22.69	6
11-May-93	1	70.54		11-Jun-93	44	58.36		11-Jul-93		18.90	0	11-Aug-93		21.53	4
12-May-93	8	138.82		12-Jun-93	16	55.24		12-Jul-93		21.62	0	12-Aug-93		20.43	4
13-May-93	10	215.87		13-Jun-93	18	50.71		13-Jul-93		23.03	1	13-Aug-93		19.46	1
14-May-93	104	253.84		14-Jun-93	24	48.16		14-Jul-93		22.75	0	14-Aug-93		19.49	2
15-May-93	49	255.54		15-Jun-93	25	51.28		15-Jul-93		23.29	0	15-Aug-93		20.88	3
16-May-93	22	237.97		16-Jun-93	25	50.99		16-Jul-93		23.60	0	16-Aug-93		24.96	4
17-May-93	74	217.86		17-Jun-93	12	48.73		17-Jul-93		24.08	0	17-Aug-93		22.32	7
18-May-93	118	202.56		18-Jun-93	48	47.03		18-Jul-93		26.55	2	18-Aug-93		23.74	5
19-May-93	177	213.89		19-Jun-93	30	45.33	1	19-Jul-93		27.06	0	19-Aug-93		21.93	3
20-May-93	171	231.17		20-Jun-93	26	42.21	0	20-Jul-93		34.00	0	20-Aug-93		20.09	0
21-May-93	132	196.33		21-Jun-93	14	39.95	0	21-Jul-93		52.98	0	21-Aug-93		19.35	2
22-May-93	110	146.47		22-Jun-93	12	39.10	5	22-Jul-93		48.44	3	22-Aug-93		18.39	4
23-May-93	84	118.70		23-Jun-93	11	35.98	0	23-Jul-93		46.46	1	23-Aug-93		18.16	6
24-May-93	136	105.10		24-Jun-93	9	33.15	0	24-Jul-93		41.93	1	24-Aug-93		17.62	6
25-May-93	78	104.54		25-Jun-93	8	30.88	1	25-Jul-93		41.36	0	25-Aug-93		16.54	0
26-May-93	47	107.94		26-Jun-93	12	29.75	4	26-Jul-93		39.10	1	26-Aug-93		24.70	0
27-May-93	65	112.19		27-Jun-93	10	32.01	0	27-Jul-93		35.98	0	27-Aug-93		15.44	0
28-May-93	146	111.62		28-Jun-93	12	30.03	2	28-Jul-93		34.28	0	28-Aug-93		14.79	0
29-May-93	78	104.82		29-Jun-93		27.79	5	29-Jul-93		46.18	0	29-Aug-93		14.50	0
30-May-93	32	93.21		30-Jun-93		26.12	3	30-Jul-93		45.61	1	30-Aug-93		14.17	0
31-May-93	137	87.54						31-Jul-93		39.95	0	31-Aug-93		13.32	0
												01-Sep-93		12.78	0
												02-Sep-93		12.21	0
												03-Sep-93		11.73	0
												04-Sep-93		11.30	0
												05-Sep-93		10.96	0
Summary	1785				659		21				17				61

APPENDIX A

1993 Twisp river flow, trapping and Wells Dam counts.
Twisp river near Twisp - source USGS

Date	Wells Dam	Twisp river cms	Twisp trap	Fish collected	Date	Wells Dam	Twisp river cms	Twisp trap	Fish collected	Date	Wells Dam	Twisp river cms	Twisp trap	Fish collected	Date	Wells Dam	Twisp river cms	Twisp trap	Fish collected
01-May-93	0	3.74			01-Jun-93	15	29.75	2	2	01-Jul-93		4.96	0	0	01-Aug-93		4.79	0	0
02-May-93	0	4.11			02-Jun-93	24	30.31	0	0	02-Jul-93		4.96	0	0	02-Aug-93		4.62	0	0
03-May-93	0	3.97			03-Jun-93	31	28.61	1	1	03-Jul-93		4.73	1	1	03-Aug-93		4.33	1	1
04-May-93	1	3.74			04-Jun-93	120	25.72	0	0	04-Jul-93		4.42	1	1	04-Aug-93		4.11	0	1
05-May-93	0	3.94			05-Jun-93	29	23.77	3	1	05-Jul-93		4.28	2	2	05-Aug-93		3.94	2	0
06-May-93	1	5.61			06-Jun-93	9	22.64	3	2	06-Jul-93		4.16	0	0	06-Aug-93		3.82	0	0
07-May-93	0	7.14			07-Jun-93	14	21.67	0	1	07-Jul-93		4.36	0	0	07-Aug-93		3.48	0	0
08-May-93	0	6.69			08-Jun-93	13	18.95	0	0	08-Jul-93		4.08	0	0	08-Aug-93		3.37	0	0
09-May-93	3	6.20			09-Jun-93	18	17.79	0	0	09-Jul-93		3.85	0	0	09-Aug-93		3.29	0	0
10-May-93	1	7.14			10-Jun-93	30	17.03	0	0	10-Jul-93		3.71	0	0	10-Aug-93		3.09	0	0
11-May-93	1	15.58	1	1	11-Jun-93	44	14.82	0	0	11-Jul-93		3.63	0	0	11-Aug-93		2.58	0	0
12-May-93	8	32.30	0	0	12-Jun-93	16	13.09	0	0	12-Jul-93		3.74	0	0	12-Aug-93		2.38	0	0
13-May-93	10	49.58	0	0	13-Jun-93	18	11.62	0	0	13-Jul-93		3.68	0	0	13-Aug-93		2.32	0	0
14-May-93	104	57.23	0	0	14-Jun-93	24	11.47	3	2	14-Jul-93		3.74	0	0	14-Aug-93		2.32	0	0
15-May-93	49	53.26	0	0	15-Jun-93	25	12.95	1	1	15-Jul-93		3.97	0	0	15-Aug-93		2.44	1	1
16-May-93	22	50.71	0	0	16-Jun-93	25	13.06	2	1	16-Jul-93		3.71	0	0	16-Aug-93		2.63	2	1
17-May-93	74	46.46	0	0	17-Jun-93	12	12.44	2	1	17-Jul-93		3.71	0	0	17-Aug-93		2.55	0	0
18-May-93	118	45.61	0	0	18-Jun-93	48	12.27	4	4	18-Jul-93		3.80	0	0	18-Aug-93		2.32	0	0
19-May-93	177	49.29	0	0	19-Jun-93	30	11.90	1	0	19-Jul-93		3.82	0	0	19-Aug-93		2.21	0	0
20-May-93	171	52.69	0	0	20-Jun-93	26	10.51	0	0	20-Jul-93		4.93	0	0	20-Aug-93		2.12	2	2
21-May-93	132	42.50	0	0	21-Jun-93	14	9.38	3	3	21-Jul-93		9.15	4	2	21-Aug-93		2.10	1	1
22-May-93	110	36.83	0	0	22-Jun-93	12	8.56	3	2	22-Jul-93		7.76	3	2	22-Aug-93		1.90	0	0
23-May-93	84	27.25	0	0	23-Jun-93	11	7.59	0	0	23-Jul-93		7.42	4	2	23-Aug-93		1.90	0	0
24-May-93	136	24.93	0	0	24-Jun-93	9	6.71	1	0	24-Jul-93		6.77	0	0	24-Aug-93		1.90	0	0
25-May-93	78	26.83	0	0	25-Jun-93	8	6.09	1	0	25-Jul-93		6.20	0	0	25-Aug-93		1.84	0	0
26-May-93	47	27.40	0	0	26-Jun-93	12	6.03	3	1	26-Jul-93		5.98	0	0	26-Aug-93		1.78	0	0
27-May-93	65	28.61	0	0	27-Jun-93	10	6.60	0	0	27-Jul-93		5.55	0	0	27-Aug-93		1.73	0	0
28-May-93	146	28.61	0	0	28-Jun-93	12	6.23	0	0	28-Jul-93		5.38	0	0	28-Aug-93		1.61	0	0
29-May-93	78	26.55	0	0	29-Jun-93		5.58	0	0	29-Jul-93		6.15	0	0	29-Aug-93		1.56	0	0
30-May-93	32	23.74	0	0	30-Jun-93		5.10	0	0	30-Jul-93		5.72	5	2	30-Aug-93		1.53	0	0
31-May-93	137	23.60	0	0						31-Jul-93		5.16	0	0	31-Aug-93		1.50	0	0
															01-Sep-93		1.47	0	0
															02-Sep-93		1.33	0	0
															03-Sep-93		1.22	0	0
															04-Sep-93		1.13	0	0
															05-Sep-93		1.10	0	0
Summary	1785		1	1		659		33	22				20	12				9	7

APPENDIX B.

1993 spring chinook salmon broodstock contribution at the Methow FH

1993 Chewuch adult chinook

Spawn Date	Injection Date	Female Number	Total Eggs	Eyed Eggs	Dead Eggs	Percent Egg Loss	Dead Fry @ ponding	Egg-Fry Survival	Eggs per Kg.	Ponded Fry	Tag Code
02-Aug-93		no tag	8056	6496	1560	19.4	63	79.9	1609	6433	63-51/61
02-Aug-93		00115	4899	4880	19	0.4	23	99.1	746	4857	63-51/61
02-Aug-93		00154	4702	4652	50	1.1	20	98.5	943	4632	63-51/61
02-Aug-93		00168	5218	5180	38	0.7	17	98.9	845	5163	63-51/61
02-Aug-93		00109	4452	4427	25	0.6	13	99.1	1446	4414	63-41/27
02-Aug-93		00156	5384	5322	62	1.2	23	98.4	789	5299	63-41/27
02-Aug-93		00139	5367	5231	136	2.5	32	96.9	1005	5199	63-41/27
02-Aug-93		00148	4792	4777	15	0.3	10	99.5	1386	4767	63-41/27
02-Aug-93		00117	6026	5263	763	12.7	21	87.0	987	5242	63-41/27
02-Aug-93		00081	4970	4832	138	2.8	15	96.9	733	4817	63-41/27
09-Aug-93	02-Aug-93	00125	6171	6085	86	1.4	25	97.7	840	6029	63-51/61
09-Aug-93	02-Aug-93	00094	6703	6680	23	0.3	7	99.6	966	6673	63-51/61
09-Aug-93	02-Aug-93	00103	5914	5874	40	0.7	0	99.2	928	5868	63-41/27
09-Aug-93	02-Aug-93	00079	5494	5458	36	0.7	0	99.2	869	5451	63-41/27
09-Aug-93		no tag	5083	5053	30	0.6	0	99.3	838	5046	63-41/27
09-Aug-93	02-Aug-93	00143	5927	5848	79	1.3	0	98.6	900	5842	63-41/27
09-Aug-93	02-Aug-93	00121	6409	6376	33	0.5	0	99.4	870	6369	63-41/27
09-Aug-93	02-Aug-93	00122	5463	5382	81	1.5	0	98.4	1036	5375	63-41/27
09-Aug-93	02-Aug-93	00151	5467	5443	24	0.4	0	99.5	870	5437	63-41/27
09-Aug-93	02-Aug-93	00133	4636	4615	21	0.5	0	99.4	1151	4609	63-41/27
09-Aug-93	02-Aug-93	00147	5452	5351	101	1.9	0	97.6	852	5320	63-51/61
09-Aug-93	02-Aug-93	00137	6667	6630	37	0.6	0	99.3	908	6623	63-41/27
09-Aug-93		00152	4693	4313	380	8.1	36	91.0	991	4271	63-41/27
09-Aug-93	02-Aug-93	00100	6762	6654	108	1.6	0	98.3	859	6647	63-41/27
09-Aug-93	02-Aug-93	00160	6429	6338	91	1.4	6	98.5	916	6332	63-41/27
09-Aug-93	02-Aug-93	00145	4674	4593	81	1.7	7	98.1	892	4586	63-41/27
09-Aug-93	02-Aug-93	00135	5626	5599	27	0.5	12	99.3	1102	5587	63-51/61
09-Aug-93	02-Aug-93	00167	6485	5085	1400	21.6	11	78.2	972	5074	63-51/61
09-Aug-93	02-Aug-93	00132	5213	5188	25	0.5	7	99.4	858	5181	63-41/27
18-Aug-93		00067	5617	5326	291	5.2	132	92.5	818	5194	63-51/61
18-Aug-93	02-Aug-93	00128	5784	5725	59	1.0	15	98.7	808	5710	63-41/27
18-Aug-93	02-Aug-93	00175	6066	6061	55	0.9	128	97.8	881	5933	63-51/61
18-Aug-93	02-Aug-93	00153	3665	3632	33	0.9	11	98.8	804	3621	63-41/27
18-Aug-93	02-Aug-93	00119	5715	5661	54	0.9	12	98.8	765	5649	63-51/61
18-Aug-93	02-Aug-93	00090	5887	5826	61	1.0	16	98.7	1026	5810	63-41/27
18-Aug-93	02-Aug-93	00075	5050	5024	26	0.5	19	99.1	709	5005	63-41/27
18-Aug-93	02-Aug-93	00150	5657	5571	86	1.5	15	98.2	925	5556	63-41/27
18-Aug-93	02-Aug-93	00136	4123	4010	113	2.7	17	96.8	748	3993	63-41/27
18-Aug-93	02-Aug-93	00106	5407	5232	175	3.2	24	96.3	723	5208	63-41/27
18-Aug-93		00071	6111	5981	130	2.1	12	97.7	765	5969	63-51/61
18-Aug-93	02-Aug-93	00171	2938	2931	7	0.2	15	99.3	1055	2916	63-41/27
18-Aug-93		00086	4093	3896	197	4.8	46	94.1	1094	3850	63-51/61
18-Aug-93		00061	4983	4966	17	0.3	11	99.4	785	4955	63-41/27
18-Aug-93	02-Aug-93	00157	5381	5288	93	1.7	24	97.8	797	5264	63-41/27
18-Aug-93		no tag	4588	4568	20	0.4	16	99.2	1009	4552	63-41/27
18-Aug-93		no tag	7216	7161	55	0.8	29	98.8	1049	7132	63-51/61
18-Aug-93		no tag	5632	5432	200	3.6	34	95.8	923	5398	63-41/27
18-Aug-93	02-Aug-93	00158	5100	5080	20	0.4	22	99.2	1095	5058	63-41/27
18-Aug-93	02-Aug-93	00088	4583	4533	50	1.1	19	98.5	686	4514	63-41/27
25-Aug-93	02-Aug-93	00096	5974	5908	66	1.1	2	98.9	930	5906	63-51/61
25-Aug-93		no tag	5876	5830	46	0.8	1	99.2	726	5829	63-41/27
25-Aug-93	02-Aug-93	00104	5238	5158	80	1.5	7	98.3	895	5151	63-41/27
25-Aug-93		no tag	4072	4023	49	1.2	3	98.7	894	4020	63-41/27
01-Sep-93	02-Aug-93	00113	3644	2744	900	24.7	157	71.0	782	2587	63-53/50
01-Sep-93	02-Aug-93	00089	4205	4127	78	1.9	131	95.0	857	3996	63-53/50
01-Sep-93	02-Aug-93	00116	4926	4726	200	4.1	238	91.1	942	4488	63-53/50
01-Sep-93	02-Aug-93	00118	5381	5238	143	2.7	207	93.5	791	5031	63-53/50
07-Sep-93	02-Aug-93	00084	5417	5288	134	2.5	37	96.9	1149	5251	63-53/50

SUMMARY

Average Fecundity = 5,301

Fecundity Range = 2,938 - 8,056

Green Egg to Fry Survival = 96.5 %

Fry to Smolt Survival = 95.8%

Egg to Smolt Survival = 92.4%

APPENDIX B.

1993 **Methow adult chinook**

Spawn Date	Injection Date	Female Number	Total Eggs	Eyed Eggs	Percent Egg Loss	Dead Eggs	Dead Fry @ ponding	Egg-Fry Survival	Eggs per Kg.	Ponded Fry	Tag Code
26-Jul-93	19-Jul-93	00061	4046	3371	16.68	675	33	82.50	986	3338	63-55/51
26-Jul-93	18-Jul-93	00027	5384	5313	1.32	71	30	98.12	964	5283	63-55/51
26-Jul-93	29-Jun-93	00152	5334	5209	2.34	125	45	96.81	774	5164	63-55/51
26-Jul-93	06-Jul-93	00096	5883	5792	1.55	91	45	97.69	847	5747	63-55/51
02-Aug-93	30-Jul-93	00136	3691	3645	1.25	46	23	98.13	907	3622	63-55/51
02-Aug-93	19-Jul-93	00043	3486	3413	2.09	73	22	97.27	792	3391	63-55/51
02-Aug-93	22-Jul-93	00164	3835	3487	9.07	348	94	88.47	722	3393	63-54/10
02-Aug-93		00071	5598	5541	1.02	57	24	98.55	810	5517	63-55/51
02-Aug-93	19-Jul-93	00124	4836	4663	3.58	173	21	95.99	949	4642	63-55/51
09-Aug-93	19-Jul-93	00172	6753	6711	0.62	42	0	99.38	946	6711	63-55/51
09-Aug-93	22-Jul-93	00071	5915	5861	0.91	54	0	99.09	924	5861	63-55/51
09-Aug-93	19-Jul-93	00077	4317	4289	0.65	28	3	99.28	916	4286	63-54/10
09-Aug-93	19-Jul-93	00181	5387	5149	4.42	238	16	95.28	1062	5133	63-55/51
09-Aug-93		00092	5535	5479	1.01	56	0	98.99	706	5479	63-55/51
09-Aug-93	19-Jul-93	00178	4609	4567	0.91	42	0	99.09	671	4567	63-55/51
09-Aug-93	02-Aug-93	00173	4315	4303	0.28	12	1	99.70	933	4302	63-55/51
09-Aug-93	19-Jul-93	00009	3877	3848	0.75	29	11	98.97	1046	3837	63-55/51
18-Aug-93		00057	5533	5486	0.85	47	15	98.88	771	5471	63-55/51
18-Aug-93		00029	6169	6161	0.13	8	33	99.34	830	6128	63-55/51
18-Aug-93	WNFH	00166	4711	4633	1.66	78	11	98.11	740	4622	63-54/10
18-Aug-93		00198	4410	4398	0.27	12	28	99.09	747	4370	63-55/51
18-Aug-93	19-Jul-93	00046	4092	4087	0.12	5	18	99.44	1031	4069	63-55/51
18-Aug-93		00191	2074	2054	0.96	20	18	98.17	870	2036	63-55/51
18-Aug-93	02-Aug-93	00188	4031	3904	3.15	127	203	91.81	1113	3701	63-55/51
18-Aug-93	19-Jul-93	00070	4893	4883	0.20	10	34	99.10	1458	4849	63-55/51
18-Aug-93		00072	5535	5078	8.26	457	1600	62.84	1315	3478	63-55/51
18-Aug-93	19-Jul-93	00147	3467	3449	0.52	18	19	98.93	1077	3430	63-55/51
18-Aug-93	02-Aug-93	00190	5685	5665	0.35	20	22	99.26	799	5643	63-55/51
18-Aug-93	02-Aug-93	00158	3493	3395	2.81	98	20	96.62	856	3375	63-55/51
18-Aug-93	19-Jul-93	00146	4286	4035	5.86	251	18	93.72	689	4017	63-55/51
18-Aug-93	02-Aug-93	00176	2818	2792	0.92	26	14	98.58	772	2778	63-55/51
18-Aug-93	19-Jul-93	00004	3632	2223	38.79	1409	18	60.71	1110	2205	63-55/51
25-Aug-93	22-Aug-93	00407	4377	4297	1.83	80	4	98.08	836	4293	63-55/51
25-Aug-93		00060	3442	3431	0.32	11	4	99.56	836	3427	63-55/51
25-Aug-93	23-Aug-93	00415	4713	4664	1.04	49	4	98.88	625	4660	63-55/51
25-Aug-93		00064	4499	4479	0.44	20	9	99.36	978	4470	63-55/51
25-Aug-93	18-Aug-93	00026	4196	4174	0.52	22	4	99.38	746	4170	63-55/51
25-Aug-93	19-Aug-93	00404	3296	3291	0.15	5	4	99.73	811	3287	63-55/51
25-Aug-93	22-Aug-93	00408	5006	4929	1.54	77	7	98.32	743	4922	63-54/10
25-Aug-93	22-Aug-93	00410	6307	6235	1.14	72	9	98.72	1029	6226	63-55/51
25-Aug-93		00058	5499	5454	0.82	45	4	99.11	725	5450	63-55/51
25-Aug-93		no tag	4188	4169	0.45	19	0	99.55	1039	4169	63-54/10
25-Aug-93		00059	3026	2607	13.85	419	4	86.02	770	2603	63-55/51
25-Aug-93		00402	2632	2592	1.52	40	2	98.40	792	2590	63-55/51
25-Aug-93	21-Aug-93	00405	3710	3605	2.83	105	9	96.93	1011	3596	63-55/51
25-Aug-93	18-Aug-93	00125	3994	3953	1.03	41	8	98.77	1124	3945	63-55/51
25-Aug-93	02-Aug-93	00020	5775	5732	0.74	43	38	98.60	1855	5694	63-55/51
25-Aug-93		00132	5262	5232	0.57	30	2	99.39	741	5230	63-55/51
01-Sep-93	22-Aug-93	00409	4690	4668	0.47	22	0	99.53	671	4668	63-55/51

SUMMARY

Average Fecundity = 4,666

Fecundity Range = 2,074 - 5,915

Green Egg to Fry Survival = 96.3%

Fry to Smolt Survival = 95.9%

Egg to Smolt Survival = 92.3%

APPENDIX B.

1993 Twisp adult chinook

Spawn Date	Arrival Date	Female Number	Total Eggs	Eyed Eggs	Dead Eggs	Percent Egg Loss	Dead Fry @ ponding	Egg - Fry Survival	Eggs per Kg.	Ponded Fry	Tag Code
02-Aug-93	26-Jun-93	00024	4487	4460	27	0.60	48	98.3	951	4412	63-56/09
02-Aug-93	15-Jun-93	00011	5809	5779	30	0.52	48	98.7	880	5731	63-53/29
02-Aug-93	11-May-93	00001	4345	4307	38	0.87	45	98.1	726	4262	63-53/29
02-Aug-93	23-Jul-93	00033	4252	4207	45	1.06	48	97.8	982	4159	63-56/09
02-Aug-93	21-Jul-93	00030	5434	5417	17	0.31	49	98.8	748	5368	63-56/09
02-Aug-93	21-Jun-93	00020	5600	5534	66	1.18	34	98.2	778	5500	63-53/29
02-Aug-93	22-Jun-93	00022	6357	6302	55	0.87	59	98.2	742	6243	63-53/29
02-Aug-93	14-Jun-93	00009	6167	6081	86	1.39	59	97.6	964	6022	63-53/29
09-Aug-93	22-Jun-93	00023	5340	5303	37	0.69	0	99.3	726	5303	63-56/09
09-Aug-93	21-Jul-93	00029	6522	6467	55	0.84	2	99.1	821	6465	63-53/29
09-Aug-93	22-Jul-93	00032	5731	5669	62	1.08	0	98.9	763	5669	63-53/29
09-Aug-93	30-Jul-93	00036	3761	3694	67	1.78	4	98.1	755	3690	63-53/29
17-Aug-93	23-Jul-93	00034	6312	5312	1000	15.84	0	84.2	775	5312	63-53/29
17-Aug-93	18-Jun-93	00016	6160	5995	165	2.68	0	97.3	700	5995	63-53/29
17-Aug-93	06-Jun-93	00007	4581	4481	100	2.18	0	97.8	726	4481	63-53/29
18-Aug-93	22-Jul-93	00031	5834	5774	60	1.03	0	99.0	698	5774	63-53/29
18-Aug-93	07-Jun-93	00008	6851	6791	60	0.88	0	99.1	749	6791	63-53/29
18-Aug-93	18-Jun-93	00017	4670	4645	25	0.54	0	99.5	896	4645	63-53/29
25-Aug-93	01-Jun-93	00003	5787	5567	220	3.80	0	96.2	696	5567	63-53/29
25-Aug-93	20-Aug-93	00041	4943	4908	35	0.71	0	99.3	645	4908	63-53/29
25-Aug-93	06-Jun-93	00006	5122	4992	130	2.54	0	97.5	764	4992	63-53/29
25-Aug-93	05-Jul-93	00027	5991	5955	36	0.60	0	99.4	745	5955	63-53/29
25-Aug-93	01-Jun-93	00002	5175	5035	140	2.71	0	97.3	805	5035	63-53/29

SUMMARY

Average Fecundity = 5,509

Fecundity Range = 3,761 - 6,522

Green Egg to Fry Survival = 97.7%

Fry to Smolt Survival = 94.3%

Egg to Smolt Survival = 92.1%

APPENDIX C.

Broodstock collection protocol for the 1993 collection year at the MFHC

Action Plan

Salmon must be collected throughout the duration of the run, to ensure representation from the entire population. Jacks should be collected in proportion to what they appear in the run at large. Three additional criteria are established for collection of salmon on the Twisp and Chewuch rivers;

1) a set collection goal for salmon to be collected at the traps, which would be based upon actual counts of adults at Wells Dam,
2) a percentage of salmon to be collected at the traps in relation to those passed upstream to spawn naturally, and
3) collection of adults in late summer on the spawning grounds if broodstock collection at the traps compromises less than 10% of the estimated run for that stream, or if the sex ratio of the broodstock is more disproportionate than 60:40.

The overall strategy is to set an appropriate balance between the number of broodstock collected, and those passed upstream. Therefore, the three criteria are complimentary.

Adult collection with the traps

For both the Twisp and Chewuch facilities, no more than one third of the estimated salmon run should be retained for broodstock. The estimated run for each stream will be based upon one third of the Wells Dam count for spring chinook salmon, and adjust for the ten year average for that given period.

Spring chinook adult counts at Wells Dam will provide an indication of run strength relative to the previous ten-year average. The objective for broodstock collection would then be to collect a proportionate amount of full capacity (238 salmon per run). For example, if spring chinook counts at Wells Dam are 70% of the 1982-1991 average, then collection objectives should be 70% of capacity (167 salmon). Evaluation of run strength would be ongoing, therefore collection goals would probably be adapted throughout the run.

If there is substantial evidence that salmon are circumventing the trap, the percentage of trapped fish retained for broodstock will be increased to achieve a net effect of 33% of the estimated overall run size. A sentry will be posted at the Twisp trap to continuously monitor salmon passage at the weir.

After 30 June, some or all the trap panels will be removed from the weir on the

Twisp River, if more than 20% of the estimated run is holding downstream of the weir. This action will eliminate the potential for blockage or delays to upstream migrating adults during the low flow period. Panels will be replaced prior to 1 August to collect late arriving fish.

Methow River broodstock collection

Collection will be done on the Methow River, since the Foghorn trap will not be complete for the 1993 season. The collection goal will be ten pairs of spawners, providing an eggtake of about 37,000. No more than 20% of this eggtake will be made per km of stream. The primary collection tools will be gaffs and seines.

Fertilization methods

The following guidelines are given for mating MFHC spring chinook salmon;

1) matings will be single-pair, with a male back-up and individual family incubation for each population.

2) live spawn males, and note their mark after use to prevent redundant use. The intent is to fertilize the eggs from each female with sperm from a single male (with a back-up male) and use each male only twice (once as primary and once as the back-up). If the absolute numbers of fish or the sex ratio are incompatible with this intent, exceptions to the spawning guidelines may be appropriate, but will not be attempted until discussed with the WDFW Genetics Unit staff.

3) cryopreserve milt for successive years. Priority will be placed upon freezing gametes from age 5 males, which will be identified by size.

These methods will be used regardless of number of fish collected for broodstock.

Number and kilograms released of the 1993 brood year from the MFHC

1993 brood year Chewuch spring chinook salmon released into Chewuch River

Stock	Tagcode	Number Tagged	* Estimated # at Release	Size at Release	Kilograms	Release Date	Type of Release	Site of Release
Chewuch	63-41/27	181967	178999	27.7 grams	4958	**17-Apr-95**	Volitional	Chewuch Acclimation Pond
	63-53/50	24279	23705	27.7 grams	657	**17-Apr-95**	Volitional	Chewuch Acclimation Pond
	63-51/61	87425	81457	27.7 grams	2256	**17-Apr-95**	Volitional	Chewuch Acclimation Pond
TOTAL		293671	**284161**		**7871**			

1993 brood year Methow spring chinook salmon released into the Methow River

Stock	Tagcode	Number Tagged	* Estimated # at Release	Size at Release	Kilograms	Release Date	Type of Release	Site of Release
Methow	63-54/10	21800	20880	28.5 grams	595	**15-Apr-95**	Volitional	Methow Acclimation Pond
	63-55/51	195866	190277	28.5 grams	5423	**15-Apr-95**	Volitional	Methow Acclimation Pond
TOTAL		217666	**211157**		**6018**			

1993 brood year Twisp spring chinook salmon released into the Twisp River

Stock	Tagcode	Number Tagged	* Estimated # at Release	Size at Release	Kilograms	Release Date	Type of Release	Site of Release
Twisp	63-56/09	18015	16704	29.8 grams	491	**18-Apr-95**	Volitional	Twisp Acclimation Pond
	63-53/29	103592	100045	29.8 grams	2988	**18-Apr-95**	Volitional	Twisp Acclimation Pond
TOTAL		121607	**116749**		**3479**			

Notes:

1) 100% of the population was tagged.

APPENDIX E.

Performance standards outlined for the Methow Fish Hatchery (Peck 1990)

Adults passed upstream is the number of fish for the entire run spawning in the natural environment.

Measures	Stock	Standard Set	Standard Achieved
Adult Capture	Chewuch	238	110 (46%)
	Methow	238	99 (42%)
	Twisp	238	42 (18%)
Adult Prespawn Survival	Chewuch	80%	94.4%
	Methow	80%	97.9%
	Twisp	80%	92.9%
Egg-Take	Chewuch	350,000	307,448 (88%)
	Methow	350,000	228,654 (65%)
	Twisp	350,000	126,705 (36%)
Green Egg-to-Fry Survival	Chewuch	85%	96.5%
	Methow	85%	96.2%
	Twisp	85%	97.7%
Fry-to-Smolt Survival	Chewuch	70%	95.8%
	Methow	70%	95.9%
	Twisp	70%	94.3%
Fish Releases	Chewuch	250,000	284,161 (114%)
	Methow	250,000	211,157 (84%)
	Twisp	250,000	116,749 (47%)
Adults Passed Upstream	Chewuch	66%	65%
	Methow	66%	88%
	Twisp	66%	92%
Percent Survival	Chewuch	1.0%	N/A
	Methow	1.0%	N/A
	Twisp	1.0%	N/A

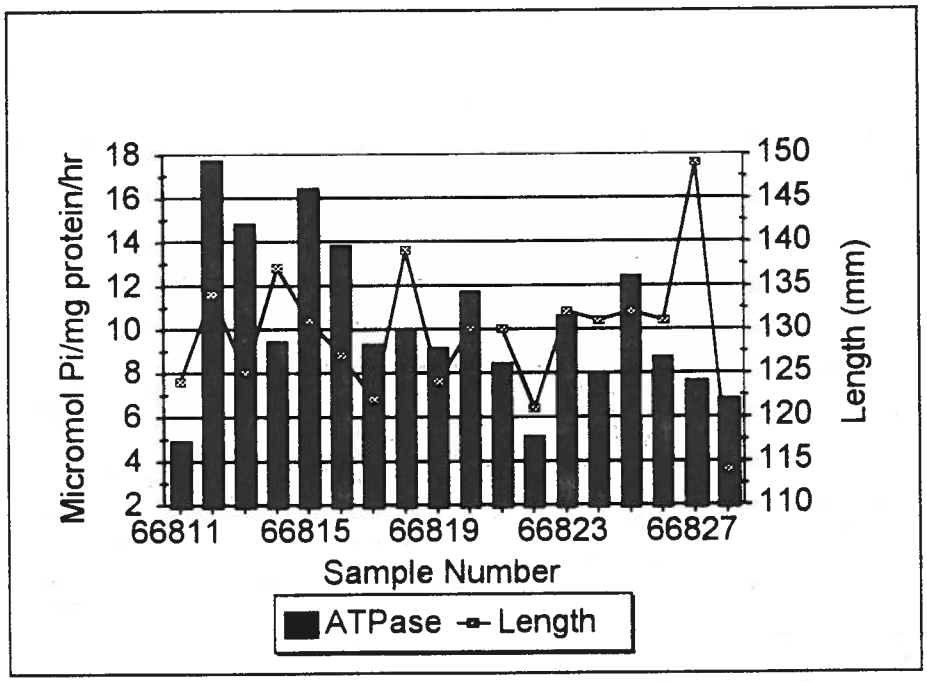
APPENDIX F.

ELISA - BKD results for 1992 BY Chewuch Chinook

B. low = optical density < 0.100
Low = optical density 0.100 - 0.199
Mod. = optical density 0.200 - 0.449
High = optical density > 0.45

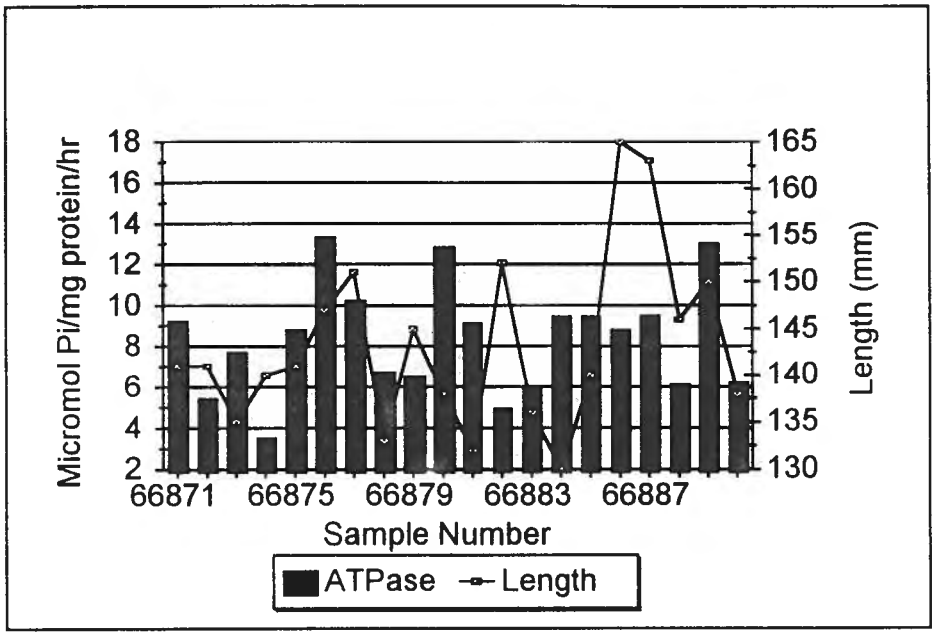
Date	Number	B. Low (%)	Low (%)	Moderate (%)	High (%)
3/14/94	40	95	5	0	0
4/15/94	20	100	0	0	0

1992 Chewuch Chinook - March 11, 1994 ATPase values with fork length (mm)



APPENDIX F. (cont.)

1992 Chewuch Chinook - April 15, 1994 ATPase values with fork length (mm)

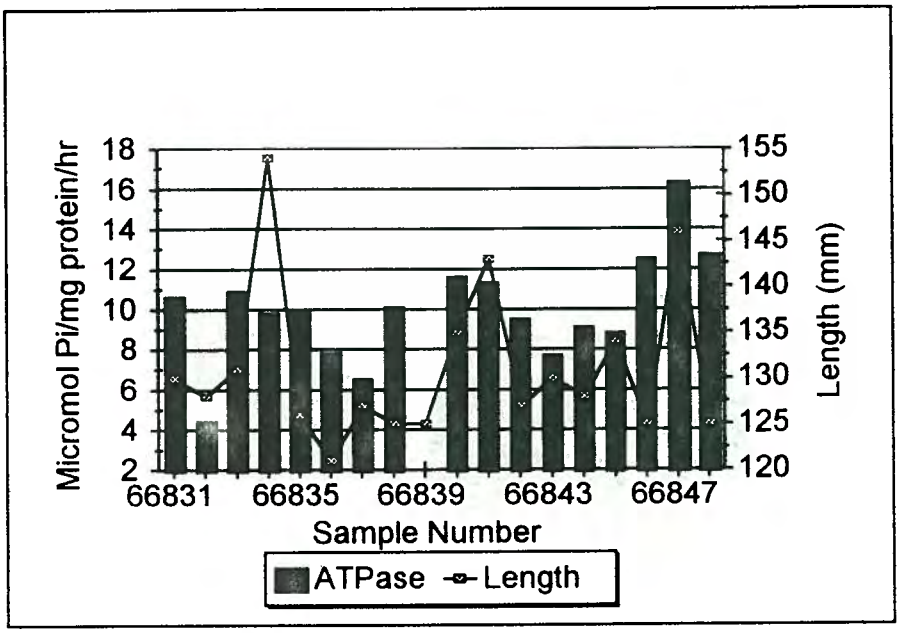


ELISA - BKD results for <u>1992</u> BY Twisp Chinook

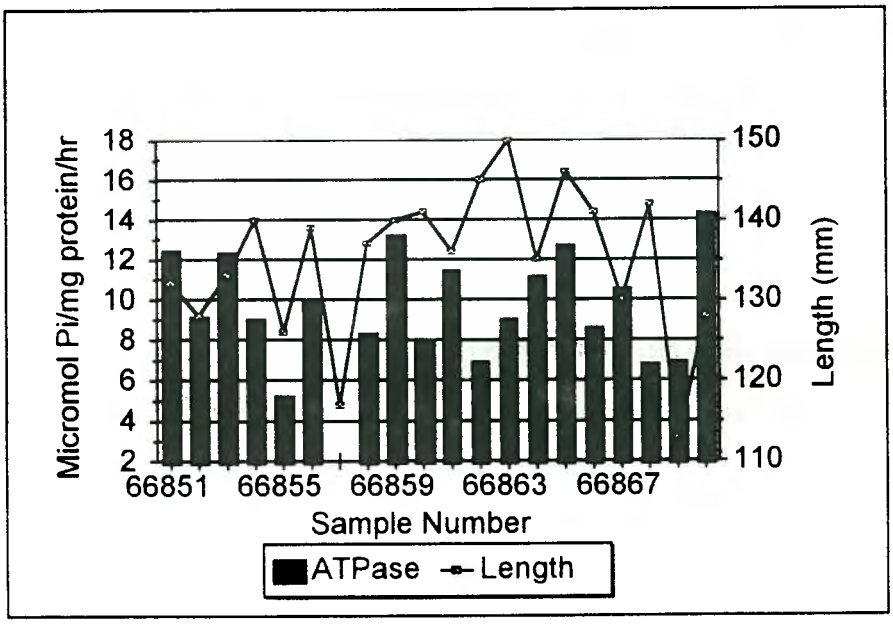
B. low = optical density < 0.100
Low = optical density 0.100 - 0.199
Mod. = optical density 0.200 - 0.449
High = optical density > 0.45

Date	Number	B. Low (%)	Low (%)	Moderate (%)	High (%)
3/14/94	40	100	0	0	0
4/15/94	20	100	0	0	0

1992 Twisp chinook - March 11, 1994 ATPase values and fork length (mm)



1992 Twisp chinook - April 15, 1994 ATPase values and fork length (mm)



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