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

Chief Executive Officer/Manager:
WILLIAM C. DOBBINS

Public Utility District No.1 of Douglas County

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

April 24, 1998

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

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

Dear Mr. Boergers:

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 seventh annual report covers activities performed in 1997 and planned for 1998.

Very truly yours,

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

nvh

Enclosures

c: (with report, but not appendices)
Mr. Harry T. Hall
Mr. Ron Wright
Mr. James Hastreiter
Mr. Ron Boyce
Mr. Brian Cates
Mr. Mike Erho
Mr. Cary Feldmann
Mr. Stuart Hammond
Mr. Robert Heinith
Mr. Bill Hevlin
Mr. Jerry Marco
Mr. Mark Quehrn
Mr. Bill Frymire
Mr. Niel Moeller
Mr. Alan Stay
Mr. Tim Weaver
Mr. Garfield Jeffers
Mr. Richard Nason
Mr. Tom Scribner
Mr. Rod Woodin

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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 ¶ 61,031 (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
of activities under the Long-Term Settlement Agreement
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County
for the 1997 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 1998

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Foreword

On January 24, 1991, the Federal Energy Regulatory Commission approved a Settlement Agreement to resolve anadromous fish issues for the Wells Hydroelectric Project on the Columbia River in Washington State. The Agreement was a product of negotiations with state and Federal fisheries agencies and tribes on the operations of the Wells Project (No. 2149). The F.E.R.C. directed that the licensee of the Wells Project has certain reporting responsibilities. This document is intended to fulfill portion (E)(d) of the Order requiring an annual report to be filed by April 30. This is the eighth annual report under the Agreement and will cover the period between January 1 to December 31, 1997.

Report to
the Federal Energy Regulatory Commission
of activities under the Long-Term Settlement Agreement
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County
for the 1997 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 1997

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 this plan for 1997 to the WCC for review. The spring and summer migration is monitored by hydroacoustics at Wells. The level of hydroacoustic detections is typically in direct proportion to the magnitude of the salmonid migration. The District added time to the tail ends of the migratory period for 1997 (97-3 [1] ; Appendix A).

The Bypass Team decides on bypass operations at Wells during both spring and summer migration periods. Representatives from the agencies, tribes and District make up the team (Agreement II.F.3). Brian Cates (US Fish and Wildlife Service; USFWS), Jerry Marco (Colville Confederates Tribes; CCT) and Rick Klinge for the District (97-3) were the 1997 Bypass Team members. In 1997, hydroacoustics was monitored for a longer period than any year before; March 15 through September 15 (97-3).

1.2 Radio Telemetry Study for 1997

The Corps of Engineers conducted a study that tagged and released 600 sockeye below Bonneville Dam to monitor these fish through fish ladders of lower Columbia River dams. These sockeye were also available for assessment at mid-Columbia dams since virtually all were destine for either the Wenatchee or Okanogan rivers. The District circulated a study plan to the WCC to assess radio tagged sockeye in the ladders at Wells. Part of this study at Wells was to understand the effect of operating the broodstock traps on passage times of sockeye (97-1).

1.3 Steelhead broodstock spawning protocol

The Wells Hatchery has the largest summer steelhead production in the mid-Columbia. Because of a petition to list summer steelhead as endangered under the Endangered Species Act, the Washington Department of Fish and Wildlife (WDFW) circulated a draft broodstock protocol that explained mating strategies for 1997 brood (97-1). Future broodstock collection in the mid-Columbia would encourage sub-

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[1] (97-3) Refers to minutes of the Wells Coordinating Committee from the third meeting in 1997. See Appendix J.

basin management of populations with collection at Wells Dam and Dryden Dam on the Wenatchee River (97-5).

1.4 Okanogan Sockeye Pilot Program

The District approached the WCC in January stating they had met or exceeded the requirements of the Settlement Agreement for the sockeye pilot effort and wanted the WCC to determine the appropriate program or to change to summer chinook production as had been stipulated under the agreement. There were biological and political reasons why the existing program should not be perpetuated (97-1). Okanogan sockeye are a trans-boundary stock that spend most of their freshwater life in Canadian waters. Fisheries managers in British Columbia have opposed the program. Several members of the WCC felt there were positive results from the program that should be built on. A sub-group of the WCC met and formulated several strategies (Appendix B; 97-2). Strategies were pivotal on cooperation with Canadian fisheries agencies. Alternatives outlined with Canadians cooperation included the use of net pens and release of sub-yearlings into the northern basin of Osoyoos Lake, transportation of adults above the thermal barrier, and development of a spawning channel. Those alternatives considered without Canadian cooperation were releases of accelerated smolts from Cassimer Bar, net pens for accelerated smolts in the Wells pool, yearling smolts in the Rufus Woods Pool. The WCC felt that adult transportation and the Rufus Woods net pen option should be further explored (97-2). Jerry Marco (CCT) submitted a proposal for the 97BY production to have part of the production released as zeros and part released as yearlings (97-3). Later, it was proposed to have the net pen portion of the culture be done by a commercial fish farm in Rufus Woods Reservoir with the release point of these fish at the base of Chief Joseph Dam (97-5). The Yakama Tribe was in disagreement with the release location because this strategy would not bring spawning adults where they could successfully perpetuate themselves (lack of juvenile nursery lake, etc. ; 97-5). Other options such as releases outside the Okanogan drainage were quickly dismissed. The WCC decided to have the culture of sockeye in Rufus Woods and release at the mouth of the Okanogan River for 97 brood (97-6).

1.5 Squawfish Radio Telemetry Study , 1997

The District proposed a study where 40 squawfish would be fitted with radio transmitters, released near Wells Dam and their movement monitored. The WCC discussed the potential of expanding this study to other mid-Columbia reservoirs. The idea was dismissed because other studies had taxed all available equipment and personnel. The WCC approved the study plan submitted by the District (97-1). There was additional interest in obtaining a population census of the squawfish population in the reservoir (97-3). The number of tags required would necessitate the use of an electroshocker to collect squawfish. The WCC was not supportive of the use of the electroshocker (97-4).

1.6 Spring Chinook broodstock collection protocol

The WCC received a proposal from WDFW to collect spring chinook broodstock at Wells Dam three days per week plus use of the "captive broodstock" that have been held since 1993 (97-2). WDFW later stated their commitment to maintain separation of the sub-stocks in the Wenatchee and Methow basins and that a revised protocol would soon be circulated (97-3). Bob Heinith (Columbia River Inter-tribal Fisheries Commission; CRITFC) stated the tribes were concerned about sub-stock brood management and will work with WDFW to develop an acceptable protocol (97-3). Operation of the tributary traps was not believed to be a viable option in 1997 with snow pack at 140% of normal, though some form of evaluation would be seen at the recently completed Fog Horn trap (97-4).

WDFW proposed a captive brood program for the Twisp River as well as two streams in the Wenatchee drainage, where eggs would be removed from redds (97-7). The program would be similar in scope to the captive brood program developed on the Dungeness River.

1.7 Dissolved gas monitoring

The District submitted a proposal for collecting dissolved gas information (TDG) from the forebay and tailrace at Wells (97-2). The proposal called for continuous forebay sampling along with weekly tailwater sampling. Additional tailwater sampling would be done during unusual high spill events. The tailwater sampling would be done from a boat at several points across the river channel. Efforts to develop a gas abatement plan were premature until some meaningful information could be compiled (97-5,7,9). Monitoring for 1998 would be with a real time system capable of transmitting hourly data from both forebay and tailwater (97-9).

1.8 Okanogan Sockeye holding study

WDFW and the District proposed a holding study for Okanogan sockeye adults in 1997 (97-3). The study was to determine if temporally holding adult fish in cool water at a hatchery to avoid the high temperatures in the Okanogan River would have better survival to the spawning grounds than fish allowed to travel through warmer waters. It has been suspected that high pre-spawn losses of adult sockeye occur in the Okanogan due to warm water temperatures in July and August, when fish are migrating to spawning areas. Sixty adults would be fitted with radio transmitters and held at Cassimer Bar Hatchery until the Okanogan temperatures cooled down. Sockeye from the Corps of Engineers radio telemetry study in 1997 would be used as the control (see 1.2). Bob Heinith of CRITFC wanted to include a means to determine spawning success of radio tagged fish. Jerry Marco had concern over the possibility of tribal fisheries that would intercept sockeye that were treated with various chemicals. The District would wait to order tags up to the deadline specified by the supplier to receive additional comments from both CRITFC and the CCT.

Support for the study came from the Canadian Columbia River Intertribal Fisheries Commission (CCRITFC; 97-5). Sixty tags from the lower river study, purchased by the District, could be used for this work. The Colville Tribes also supported the study since their concerns of test fish being consumed by fisherman was adequately addressed. Concerns of CRITFC had also been addressed.

1.9 Other Okanogan Sockeye salmon issues

The 1997 water year (October 1996 - September 1997) was one of the largest on record. Flows in the Okanogan River were regulated during the winter months to meet anticipated spring run off. Normal winter discharge for the Okanogan River near Oliver is between 350 to 700 cfs. The 1997 flows would be double that (97-3). Research sponsored by Department of Fisheries and Oceans in Canada showed that flows at those volumes would cause pre-emergence of sockeye fry. A preliminary estimate of 500,000 fry had been lost this season due to water regulation (97-3). Later it was estimated that between 10 - 15% of the sockeye and kokanee production had been lost as a result of scour of redd from high water releases in the Okanogan (97-4).

1.10 Project Survival Study

The Settlement Agreement specified the District, along with consultation from the JFP, will develop a study of juvenile mortality associated with Wells Dam by 1990 (IV,C,5). Results from this work

would adjust compensation levels of the hatchery programs. The WCC has opted not to pursue this study every year since 1990.

The District proposed a pilot survival study for 1998 to aid in the development of a full scale survival study (97-5,6). The primary goals of the study was to determine recovery rates at Rocky Reach, McNary and John Day and to test single release methodology in the mid-Columbia (97-7). Also, it was of importance to understand how fish directly from the hatchery performed next to in-river migrating fish (97-7, 8). If the two perform comparable, then hatchery fish could be used as surrogate for in-river migrants. Some of the WCC members were interested in going directly into a full scale study or combining this study with similar research at the next project down stream, Rocky Reach (97-7,9). The proposal received the support of the WCC to proceed for 1998 (97-8).

1.11 1998 Bypass Operational Plan

The District submitted to the WCC a Bypass Operational Plan for 1998, as per Section II.F.1 of the Settlement Agreement . The plan outlined scheduled hatchery releases above Wells Dam and anticipated the starting and completion date of bypass operation (Appendix C).

1.12 Adult Salmon and Steelhead Counts at Wells Dam

Ladder counts at Wells Dam have been done historically on a 16 hour count period, between the hours of 0400 and 2200. Because assessment of passage is from review of video records, counting is done for all 24 hours of recorded tape, though summaries for a 16 hour period are reported. Discrepancies have been seen when one compares ladder passage at neighboring projects where a 24 hour count is reported. It was determined that starting in 1998, records should report the 24 hour passage (97-7).

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Operation of the Juvenile Bypass

Hydroacoustic sampling was started in mid-March of 1997 to help collect background index levels of activity prior to the spring migration. Catches from fyke netting did not reflect the rise in the index in late March (97-4). The juvenile bypass was initiated when the Bypass Team determined the hydroacoustic index was reflecting the start of the spring migration. Because of the high flows in the Columbia, there was forced spill that proceeded and followed the spring bypass operation. The juvenile bypass was operated for 79 days for the spring migration and 40 days for the summer migration. A total of 2.37 million acre feet (MAF) of water was used for operation of the bypass (Appendix D).

2.2 Sockeye Pilot Program

Sockeye were transferred to net pens in Osoyoos Lake on April 24 and held until release on May 19. There were 187,913 sockeye with an average size of 56 fish per pound. Because of the unusually high run off conditions in the Okanogan and Similkameen rivers, assessment of the outmigration with a screw trap was not possible. Those efforts are shown in Appendix E.

239 Sockeye brood were collected at Wells Dam in 1997, spawned and eggs incubated and fish reared at the Cassimer Bar facility. The adults and eggs were found to be IHN free. The facility had a 34% pre-spawn loss of adults and 11% green egg - hatch loss. Once results were available on the IHN status and ELISA testing from parents, a test that shows exposure to bacterial kidney disease bacterium

prior to spawning, a portion of the production was placed on chilled water at the Wells Hatchery. These eggs were to be used for a yearling program as per recommendation by the WCC (see Appendix B).

2.3 Dissolved Gas Monitoring

Flows in the Columbia River in the spring and summer of 1997 were the third highest on record. Consequently, large volumes of water were spilled at each dam along the Columbia. Early indications of spill at Wells showed a build of TDG levels between the forebay and tailwater. This was a surprise to the WCC who felt Wells would not add gas (97-4). Monitoring efforts at Wells recorded levels as high as 129.1% in the forebay and 135.1% in the tailrace (Appendix F).

2.4 Spring Chinook Salmon Hatchery

As part of the evaluation of the Spring Chinook Program, an annual review of the culture at the Methow Salmon Hatchery was completed. Parents for the fish released in the spring of 1997 (95 brood) were from an extremely poor return year. The WCC had decided not to collect spring chinook broodstock at the tributary traps or at Wells. A few adults that volunteered into the Methow Hatchery outfall that were collected, spawned, and progeny cultured and released. 14,258 Spring chinook smolts released into the Methow River from this program in 1997.

Spring chinook broodstock were collected from the ladders at Wells Dam three days a week in 1997. Additional spring chinook broodstock that volunteered into the Wells Hatchery were also collected and moved to the Methow Hatchery. Separation of the three populations was done through recovery of coded wire tags and scales to separate hatchery and wild fish not tagged. 88,000 Eggs from parents that were from out-of-basin areas (ie. Dworshak, Powell Rearing Pond, Kooskia) were destroyed. There were 486,000 eggs collected from the Methow Basin fish, 137,133 eggs from Chewuch stock and 36,056 from Twisp brood in 1997.

The WDFW collected 1,002 eggs from 14 redds in the Twisp River with the intention of a long term captive brood rearing strategy. Fry were kept isolated in start-up rearing containers at the end of the calendar year.

2.5 Sockeye Holding Study

The WCC was interested in knowing if adult pre-spawn survival could be improved by holding adult sockeye in cooler water and releasing them back into the Okanogan River once water temperatures had cooled. Sockeye were collected at Wells Dam and fitted with radio tags. These fish were held for seven to nine weeks and returned to the Columbia River near the mouth of the Okanogan River. Those sockeye tagged at Bonneville that migrated past Wells (235 fish) served as the control group. There were 48 fish that were released to migrate up river. A comparison of survival to the spawning area of the two groups showed a 5% survival improvement for adults that were held in cooler water until temperatures in the Okanogan River dropped. This report was in draft form at the end of the year.

An interesting result of this study was determining the precise location of spawning of all radio tagged fish that spawned above Osoyoos Lake. It was determined that up to 61% of the spawning activity occurs outside the index section of the river. Most spawning was occurring at the base of vertical drop structure above Osoyoos Lake at a depth where it was impossible to see the fish. This information indicated that the assumption of a high pre-spawn loss of adult sockeye is wrong and fish can successfully spawn in portions of the river below the Town of Oliver, B.C. , though undetected by visual observations.

2.6 Okanogan Sockeye Spawning Ground Surveys

Sockeye surveys in 1997 were conducted by Trumbley Environmental. Preliminary findings from their surveys showed that of the 25,754 sockeye that crossed Wells Dam in 1997, 4,904 (19%) successfully made it to the spawning index area. It was anticipated that pre-spawn loss would be low because of high run off through out the entire migration could keep water temperatures low. High flows though made recovery of marked carcasses very difficult and may have effected the population estimate (Appendix G). This work was completed in a spawning index portion of the Okanogan. It has assumed a high percent of the spawning occurred within this area. The radio telemetry study described in Section 2.5 shows this assumption was false.

(3) Outline of Action taken toward fulfillment of the Settlement Agreement

3.1 Methow River Spring Chinook Facility

The Settlement Agreement calls 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 and released progeny from 1995 broodstock in the facility during 1997.

The Methow Hatchery was designed to have 4,800 gallons per minute (gpm) was water delivered from four wells. Water production has been dropping off to where around 3,600 gpm is available. This lower capacity of well water has affected how the facility operates. At the end of the calendar year, the District was working to better understand the reasons for the decrease in water delivery at the hatchery.

The Settlement Agreement also calls for evaluation of the hatchery program. Several aspects of the hatchery were evaluated, and additional baseline information on natural spring chinook populations in the Methow Basin. A final report was received for previous years evaluations (Appendix H).

3.2 Cassimer Bar Sockeye Hatchery

The Settlement Agreement calls for a pilot effort to culture Okanogan sockeye for three years at 8,000 pounds of production (IV.A.3.(a)(2)) with an evaluation to gauge the success of the program. Brood have been collected since 1993 at Wells Dam. Information on culture of sockeye at the Cassimer Bar facility was collected by the CCT . Environmental conditions of Osoyoos Lake plus some limited information of growth in the net pens was collected by Dr. Rensel (Appendix I). The CCT also collected information on the outmigration of native sockeye plus the net pen reared sockeye from Lake Osoyoos, though this effort was hampered in 1997 by high water conditions.

3.3 Contract Professional Services in Implementing the Settlement Agreement.

During 1997, the District contracted with Mike Erho to serve as Studies Coordinator for the Wells Coordinating Committee. Mr. Erho also serves as coordinator for the Mid-Columbia Coordinating Committee and Rock Island Coordinating Committee.

The District also contracted with Dr. Skalski to provide statistical evaluation of methods and studies. Dr. 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 1997, 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 L ; 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 377,900 steelhead or 53,353 pounds were liberated in 1997. The discrepancy between the 80,000 and 53,353 pounds was attributed to predation by birds on steelhead while being held in rearing ponds. This situation occurred also in 1996. Measures were taken in 1996 and 1997 to including additional wires across the ponds and a contract with US Department of Agriculture to scare away picivorous birds. Unusually hard winter conditions caused early freezing of the confluence of several tributaries near the hatchery. This displaced birds that moved to the area of the Wells steelhead ponds further compounding this predation problem.

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 Sockeye Pilot Program

As pointed out in Section 1.4, the WCC recommended that the Sockeye Pilot Program continue operation at the 8,000 pound production level in order to gain further information on the culture of these fish. The Settlement Agreement called for a three year effort with evaluation. It was the position of the District, those conditions had been met. The WCC has agreed that cooperation from Canadian interests will best serve any action with this population of sockeye since the majority of their rearing and spawning occurs within Canada.

(5) Chronology of compliance for 1997

Items (3) and (4) above contain chronology of compliance in 1997. 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 J .

(6) Schedule of Activities for 1998

The following schedule of activities is planned for 1998

Dec. (97)	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 15	Begin monitoring juvenile migration via hydroacoustics
April 1	Bypass barriers in place
April 10	Start of Project Survival Study
April 15	Anticipated start of the juvenile migration
May 1	Start collecting spring chinook broodstock at Wells Dam
July 1	Start collecting sockeye broodstock at Wells Dam
July 1	Collect and tag adult sockeye for radio telemetry study to the spawning grounds
Sept. 15	Start spawning ground surveys for sockeye in Okanogan River
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 1997

The Wells Project was removed from the mid-Columbia proceedings on January 24, 1991 as the Settlement Agreement between the Fisheries Agencies and tribes was approved by F.E.R.C. Minutes from the meetings of the WCC for 1997 are attached as Appendix J.

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Appendix B
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Memorandum on Summary of Wells Bypass Operations in 1997

Appendix E
DRAFT REPORT Cassimer Bar Hatchery Juvenile Sockeye Salmon *Oncorhynchus nerka* Outmigration from Lake Osoyoos, Washington - 1977. [2]

Appendix F
Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 1997

Appendix G
DRAFT REPORT 1997 Okanogan River Sockeye Escapement to Spawning Grounds Study.

Appendix H
Summary Report; Methow Basin Spring Chinook Salmon Hatchery; 1995 Brood Year

DRAFT REPORT Methow Basin Spring Chinook Salmon Supplementation Plan; Natural Production Study - 1995 Annual Report.

Appendix I
REVIEW DRAFT: Fourth Annual Report: Water Quality of Lake Osoyoos During 1997.

Appendix J
Minutes of the Wells Coordinating Committee for 1997

Appendix K
1997 Membership list of the Wells Coordinating Committee

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

[2] All draft reports were being reviewd by the WCC at the end of April 1998.

Appendix K

1997 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
Umatilla Tribes

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

ANNUAL BYPASS OPERATION PLAN
FOR
WELLS DAM, 1997

APPENDIX A

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 1997 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 1997above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	14	4/15
Methow (WDFW)	Spr. Chinook	14	4/15
Carlton (WDFW)	Sum. Chinook	400	4/15
Similkameen (WDFW)	Sum. Chinook	500	4/15
Winthrop (USFWS)	Sum. Steelhead	100	4/20
Wells (WDFW)	Sum Steelhead	420	4/20
Winthrop (USFWS)	Coho	250	5/15
Lake Osoyoos (CCT)	Sockeye	220	5/15

Starting Dates and Ending Dates
Bypass barriers will be in place between March 15 and September 15. Hydroacoustic and fyke net sampling will start on March 15 and be collected until September 15.

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.

(03/17/97)

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MEMORANDUM ON SUMMARY OF AD HOC SOCKEYE METING OF JANUARY 21, 1997

APPENDIX B

Memorandum

TO: Wells Coordinating Committee
FROM: Rick Klinge
DATE: January 22, 1997
SUBJECT: Summary of ad hoc sockeye meeting of January 21, 1997

On Tuesday, January 21, a meeting was held at Douglas PUD to discuss options for sockeye with 1997 brood fish (see attendance list).

Jim Heffernan provided information on activity with the Pacific Salmon Commission (PSC) and Canadian parties developing a position for Okanogan sockeye. Jim thought Canada would want to see substantial progress towards resolving equity under the salmon treaty before it would invest in enhancement activities on the Columbia River. U.S. and Canada are utilizing a regional stakeholder process in an attempt to resolve on-going equity disputes.

A technical groups is being formed to address transboundary issues, including Okanogan sockeye. This groups is expected to meet as early as this month. Some word from this groups is expected by this fall. This group could help develop a response to issues entertained through the Wells Coordinating Committee or the HCP process.

We discussed what options were possible for 1997 brood fish. After considerable discussion, we developed two paths based upon either acceptance of or rejection of net pen actions in Lake Osoyoos by the Province.

I. <u>Acceptance of artificially handled replacement sockeye in Lake Osoyoos</u>

1. Release of sub-yearlings in the northern basin to provide a yearling migrant.
   - A. Accelerated spring releases to provide a zero age migrant
   - B. Summer releases to provide a yearling migrant **← PREFERED**
   - C. Delayed fall release to provide a yearling migrant
2. Accelerated smolt in the southern basin to provide a zero age migrate
3. Low Technical options
   - A. Fry collection with a gulper and early rearing
   - B. Transportation of adult beyond the thermal barrier
   - C. Stream side incubators
4. Spawning channel
5. Release of sockeye smolts below Zosel Dam

II. <u>Non acceptance of artificially handled sockeye replacement in Lake Osoyoos</u>

1. Wells Pool net pens
   - A. Accelerate smolts **← ALTERNATE**
     - i. Washburn Island Ponds
     - ii. Colville Trout Hatchery
     - iii. Bridgeport Bar
     - iv. Cassimer Bar Fish Hatchery
   - B. Yearlings

2. Rufus Woods net pen (yearling releases)

The **preferred option** would take on the following form

- ADULT COLLECTION 260 adults collected at Wells Dam in July and held at Cassimer Bar.
- INCUBATION 245,000 eggs incubate at CBFH.
- EARLY REARING 230,000 Fry and fingerlings reared at Cassimer Bar until marked at 85 fpp.
- TRANSFERED TO NET PENS Fingerlings will be transferred across Inter-National Boundary. Fish released near 25 fpp (8,000 lbs.) or when lake conditions are no longer suited for net pen rearing. The fish would over winter and smolt the following spring. Returning adults would spawn with the natural population.

The **alternate option** would take on the following form

- ADULT COLLECTION 260 adults collected at Wells Dam in July and held at Cassimer Bar.
- INCUBATION 245,000 eggs incubate at CBFH.
- EARLY REARING Fry and fingerlings reared at Cassimer Bar until fish marked at 85 fpp.
- TRANSFERED TO NET PENS Fingerlings will be transferred to net pens in ponds adjacent to the Columbia River at Washburn Island. Fish would be released either when the river temperature reach 60° F, before July 1 or when they reached 25fpp. Fish would likely move through the Columbia River that summer. Returning adults would not return to spawn with the natural population, but would be used as a hatchery population. Excess returns would be harvested.

Wells Coordinating Committee Okanogan Sockeye Ad hoc committee meeting Jan 21, 1977.

Attendance.

Jim Heffernen (CRITFC; via phone)
Brian Cates, USFWS
Jerry Marco ,and Avery Cleveland CCT
Cary Feldmann, Puget Power
Bob Clubb, Shane Bickford and Rick Klinge, Douglas PUD
Mike Erho, Wells Coordinating Committee

OKANOGAN SOCKEYE
SUB-COMMITTEE MEETING
EAST WENATCHEE, WA JANUARY 21, 1997

Klinge reviewed the Douglas PUD position relative to the PUD's responsibilities under the Wells Settlement Agreement. The choices spelled out in the agreement call for expansion of the existing sockeye pilot program to 15,000 pounds of production or addition of 15,000 pounds of summer chinook production released from the Carlton Acclimation Pond. Because of lack of Canadian support for and questionable biological merit of the existing program Douglas PUD is unwilling to continue the existing program. Cates said the Coordinating Committee is not ready to go to the alternative summer chinook program and drop Okanogan sockeye since sockeye production will be required as part of the HCP process being developed. Marco agreed and added that he felt the Committee was also saying that they weren't ready to go to an expanded, permanent sockeye program based on the existing pilot program.

Cates asked what kind of discussions were taking place between the tribes and the Canadian fisheries parties. Heffernan responded by reporting on the background of discussions within the US/Canada Treaty forum to address all species including Okanogan sockeye. There is a major equity meeting coming up which may have some bearing on a Canadian position relative to Okanogan sockeye enhancement. A sockeye technical committee is being set up to address questions associated with the Okanogan sockeye question. Clubb asked if the technical committee would represent both the provincial and federal positions. Heffernan said that both would be represented and technical issues would be addressed by this group. It should be possible to get one Canadian position through the technical committee process. Marco asked how the Canadian tribal interests would be involved in the technical committee process. Heffernan said he expected Canadian tribal interests would have input to the technical committee. Klinge asked Heffernan if he thought sockeye enhancement in some form would be possible under the technical committee process. Heffernan stated that he didn't think the technical committee would rule anything out at this point but that the process is being set up to deal with technical issues of this type. He went on to say that there are currently 190 plus first nation groups in Canada that are in some stage of negotiation with the Canadian government and this is changing the dynamics of the Canadian situation. The formation of the Canadian Intertribal Group has also effected the dynamics of the situation in Canada. To the best of his knowledge, Heffernan was not aware of opposition from the Canadian Department of Fisheries and Oceans to the current direction of the U.S. enhancement efforts for Okanogan sockeye and that is the group that would be formulating the Canadian position relative to anadromus fish. Because of questions relating to chinook and equity issues in 1996, the sockeye technical committee was "back burnered". Cates asked if there were some things, relative to 1997 activities, that should be avoided to keep from "upsetting the applecart". Heffernan said that is a good question and stated that maybe there should not be a major change in the program(such as moving the release site into Canada) and any changes involving Canada should be left to the technical committee for input. Klinge said there are numerous things that could be done in the area of sockeye enhancement and the present Mid-Columbia Coordinating Committee sub committee on Okanogan sockeye would like to know how the U.S./Canada Treaty technical committee would view the various options.

Marco said releasing fish in the northern basin of Lake Osoyoos may not provide the growth rate necessary for an accelerated sockeye smolt program. The Colville Tribe are not ruling out any possibilities including a yearling program involving net pen rearing in the Wells Reservoir area. He raised a point that recent NMFS biological opinions may not consider Okanogan sockeye as being a stock that would require natural production enhancement.

Klinge brought the discussion back to the central question, which is, what kind of Okanogan sockeye program should be pursued in 1997 and beyond. There is a reluctance on the part of the coordinating committee to embrace the summer chinook option under the Wells Settlement Agreement, but there is no clear indication of a viable sockeye option. Heffernen said that maybe the first question that should be asked of the technical committee would be "where should the release site be for net pen reared sockeye"? Clubb responded that the first question is "are the Canadians supportive of the net pen enhancement program for Okanogan sockeye". Cates said that along with that would be "do the Canadians support hatchery intervention for Okanogan sockeye". Feldmann said he felt one of the first questions for the Canadians would be do they believe there should be enhancement for Okanogan sockeye and, if so, what form should that enhancement take.

Clubb clarified Douglas PUD's position that if there is an interim program to meet the terms of the Wells Settlement Agreement, it doesn't preclude returning to a sockeye program in the future if the political constraints(i.e. lack of Canadian support) are removed. Under the terms of the Wells Settlement Agreement there are two choices, to continue and expand the existing sockeye program or transfer production to summer chinook. Because of HCP activities, it would be desirable to find an acceptable, biologically sound, way of dealing with Okanogan sockeye enhancement. Clubb said, as a statement of fact, there are two questions: one is the political question regarding Canadian constraints, and the second is the biological question regarding what kind of sockeye program makes sense biologically. Marco said it should be possible to develop options to pursue which would be chosen according to what the Canadian situation is and what the coordinating committee agrees to. Marco went on to state that he isn't willing to let a party that isn't even a member of the coordinating committee(the Canadian entities) dictate the direction of the program. Heffernan agreed, noting that the technical committee would only deal with salmon originating in Canadian waters, thus having no impacat on what people decide to do in U.S. waters.

The sockeye sub-committee then outline the considerations necessary to address in arriving at options to consider for 1997 and beyond. Briefly the outline is as follows:

I. Objectives of the Program
   - A. Natural production enhancement(stock intervention)
   - B. Mitigation requirement
   - C. Harvest augmentation
   - D. Terminal harvest
   - E. Interim place holder until politically and biologically acceptable sockeye program is developed

II. Cultural Options
   - A. Accelerated fingerling program
   - B. Fingerling release, yearling migration
   - C. Low tech enhancement
   - D. Mixed strategies(i.e. yearling and sub-yearling combined)

III. Release Sites
- A. Lake Osoyoos
  - 1. North Basin
  - 2. South Basin
- B. Okanogan River Release
  - 1. Zosel Dam
  - 2. Other
- C. Other
  - 1. Palmer Lake
  - 2. Wells Reservoir
  - 3. Chief Joseph Tailrace
  - 4. Conconully Lake/Reservoir on Salmon Creek

IV. Release Timing
- A. Spring release--sub-yearlings
- B. Fall release--delayed sub-yearlings
- C. Spring release--yearlings

V. Evaluation
- A. Juvenile migration
- B. Adult return
- C. Cultural evaluation

VI. Facility Constraints
- A. Water availability
- B. Rearing vessel capacity
- C. Incubation facilities
- D. Net pen capacity

VII. Other Considerations
- A. Term of extended program
- B. Brood stock requirements

The committee discussed the various factors and arrived at a prioritized list of options based upon whether or not Canadian constraints were removed. The preferred options for each are listed in the attached memo from Rick Klinge along with a proposed sockeye program to be pursued in 1997.

ATTENDANCE LIST

Name	Representing
Brian Cates	U.S. Fish and Wildlife Service
Jerry Marco	Colville Confederated Tribes
Avery Cleveland	Colville Confederated Tribes
Jim Heffernan	Columbia River Intertribal Fisheries Commission(by phone)
Cary Feldmann	Puget Sound Power and Light Company
Rick Klinge	Dougias County Public Utility District
Bob Clubb	Douglas County Public Utility District
Mike Erho	The Committee

DRAFT ANNUAL BYPASS OPERATION PLAN FOR WELLS DAM, 1998

APPENDIX C

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 1998 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 1998 above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	315	4/15
Methow (WDFW)	Spr. Chinook	380	4/15
Carlton (WDFW)	Sum. Chinook	350	4/15
Similkameen (WDFW)	Sum. Chinook	500	4/15
Wells (WDFW)	Sum Steelhead	420	4/20
Cassimer Bar (CCT)	Sockeye	110	5/15

Starting Dates and Ending Dates
Bypass barriers will be in place between March 15 and September 15. 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.

(12/08/97)

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MEMORANDUM ON SUMMARY OF WELLS BYPASS OPERATIONS IN 1997

APPENDIX D

Memorandum

TO: Brian Cates, USFWS
Jerry Marco, Colville Confederated Tribes
FROM: Rick Klinge, Douglas PUD RK
DATE: September 3, 1997
SUBJECT: Summary of Bypass Operations at Wells Dam, 1997

==========

This year marked one of the highest flows in the mid-Columbia on record. Wells had all ten units available during the entire period of bypass operations and still hydraulic capacity of the plant was exceeded. The highest hourly discharge occurred on June 12 at 0600 with 396.7 kcfs. At very high flows bypass barriers are removed to maintain the emergency spill capacity of the dam. Barriers were removed from spillbay 8 before the bypass season started and out of spillbay 6 on May 20 as flows reached 265 kcfs. Barriers were returned to spillbay 6 on July 9. The spring outmigration, based upon brood (BY95) contribution of spring chinook and sockeye, was low. The summer outmigration based upon brood (BY96) contribution of summer / fall chinook was good.

The bypass team used a ten year average from fyke net samples for percent salmonids to adjust the hydroacoustic index. This minimized fyke netting needed for adjusting the raw index. The ten year average was applied to the raw index values from the end of the spring migration through the entire summer migration.

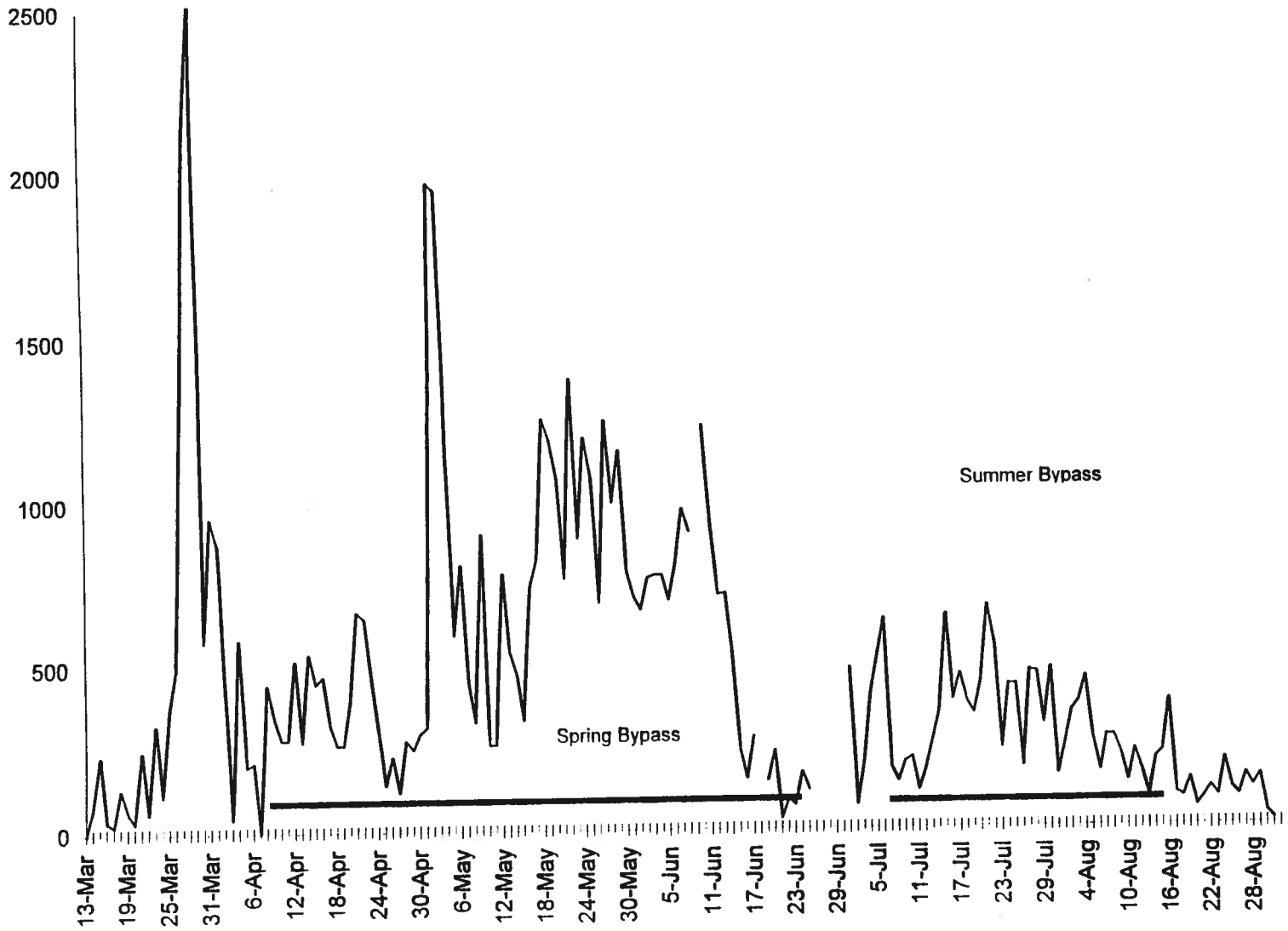
Hydroacoustic sampling started at Wells on March 13 to collect background data prior to the start of the spring migration. Initial levels were higher than anticipated. Fyke netting on March 20 and 27, produced no salmonids or resident fish. Index values for these dates were 247 and 2120. The spring bypass operations were started on April 7 and operated until June 25 for a total of 79 days and used 1,619.1 KAF or 4.2% project inflow.

There were nine days between spring and summer migration where bypass operations were suspended. During this period, five days had forced spill for all 24 hours and the other days had spill during some hours.

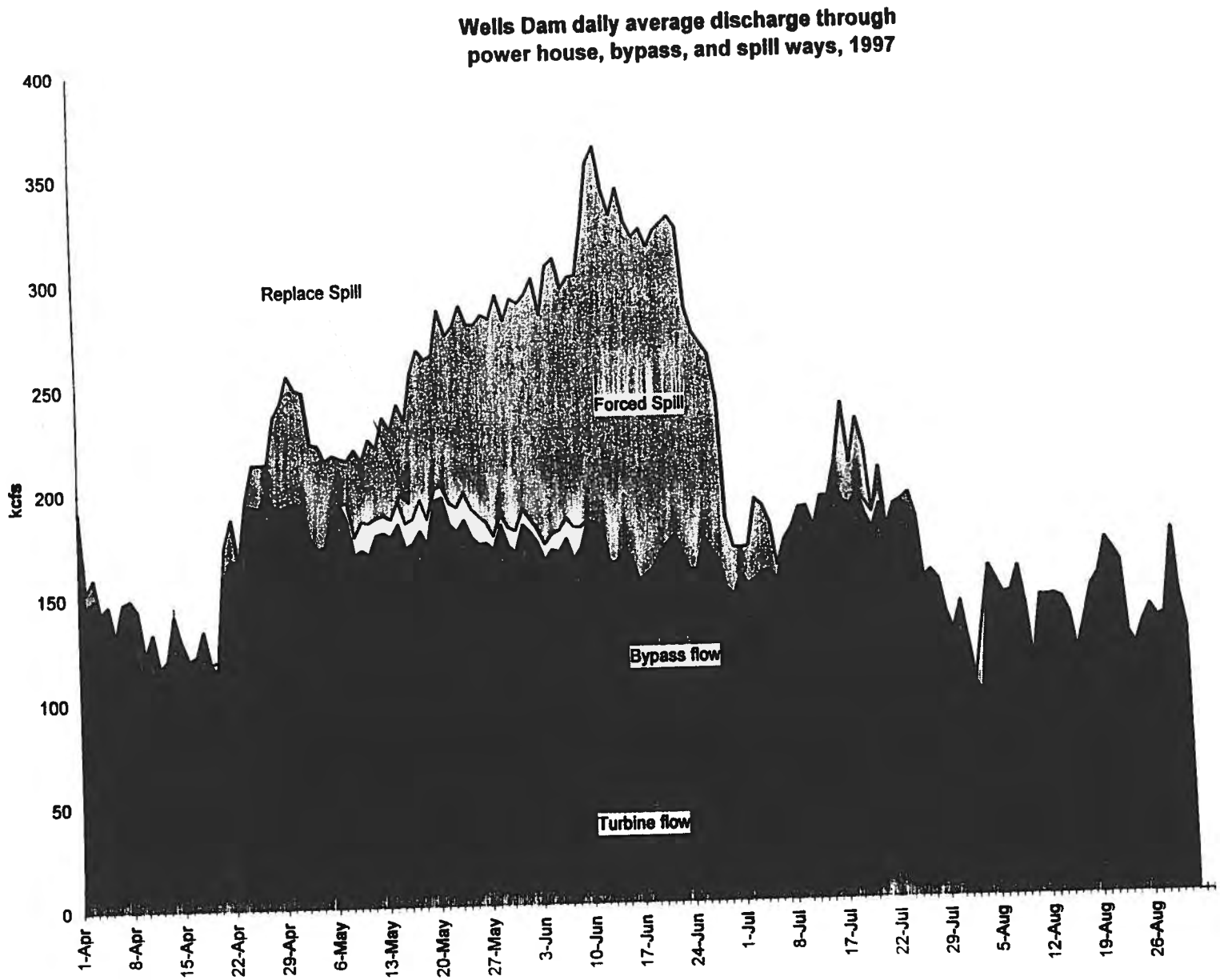
Summer bypass operations started on July 4 and ran until August 15, for a total of 40 days. Summer operations used 755.8 KAF, or 5.6% project inflow.

There were 8 occasions for fyke netting this year to aide in adjustment of the raw index. Fyke netting was done on March 20, 27, 31, April 2, August 6, 13, 15 and 20. Ratios of salmonids closely matched those for the same dates from previous years. Fyke netting on August 13 and 15 produced no fish at all. A decision was made to close the bypass based on this information. On August 20, fyke netting was done in the spillway behind the vertical slot for the bypass barriers. This was done for three hours and again produced no fish. All fyke netting was done in a manner to minimize numbers of salmonids sacrificed while collecting needed information to adjust index values. There were 9 salmonids (1 chin 1+; 8 chin 0's; 0 sockeye, 0 steelhead) removed from the river while collecting information on species composition of the raw index.

Wells Dam Hydroacoustic Index values 1997



Prepared by Rick Klinge 9/2/97


Wells Dam daily average discharge through power house, bypass, and spill ways, 1997
kcfs
400
350
300
250
200
150
100
50
0
Replace Spill
Forced Spill
Bypass flow
Turbine flow
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
17-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug

DRAFT REPORT - CASSIMER BAR HATCHERY JUVENILE SOCKEYE SALMON ONCORTHYNCHUS NERKA OUTMIGRATION FROM LAKE OSOYOOS WASHINGTON, 1997

APPENDIX E

COLVILLE CONFEDERATED TRIBES

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

DRAFT

CASSIMER BAR HATCHERY JUVENILE SOCKEYE SALMON *Oncorhynchus nerka* OUTMIGRATION FROM LAKE OSOYOOS, WASHINGTON - 1997

Prepared by

CHRISTOPHER J. FISHER
FISHERIES BIOLOGIST

January 1998

FOR PUBLIC UTILITY DISTRICT NO.1 OF DOUGLAS COUNTY

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Abstract

Significantly greater flows (t-test$_{tab}$ = 1.67, t-test$_{calc}$ = 5.61, P $\leq 0.2^{-6}$) in 1997 (mean = 2,319 cfs) than in 1996 (mean = 1,920 cfs), reduced the effectiveness of the rotary screw trap and abbreviated the sampling effort. Mean trap efficiency for the rotary screw trap was 0.2 percent. There was no significant difference between the condition of hatchery fish and naturally produced one year plus (t-test$_{tab}$ = 1.65, t-test$_{calc}$ = 0.37, P $\leq$ 0.35) or two year plus (t-test$_{tab}$ = 0.59, t-test$_{calc}$ = 1.78, P $\leq$ 0.28) sockeye (*Oncorhynchus nerka*). The environmental variables of discharge and velocity had a significant effect on the number of smolts entrained and may influence out-migration, but water temperature did not have a significant effect. No virus or bacteria disease was detected in natural production or hatchery-raised sockeye. Future monitoring of the returns of adult sockeye will provide an assessment of the success of the supplemental stocking of sockeye smolts in Lake Osoyoos.

Introduction

This report is an assessment of the outmigration of naturally produced sockeye during the spring of 1997 from Lake Osoyoos, Washington. This assessment is the final component of a four year evaluation process for the Cassimer Bar Fish Hatchery Sockeye Program for Lake Osoyoos, that began in 1993. Broodstock for the hatchery program were trapped at the Wells Dam fish ladder during the fall of 1996. The eggs and juvenile offspring were cultured at the Cassimer Bar Fish Hatchery (located north of Brewster, Washington near the mouth of the Okanogan River). The fish were transported to net pens in the southern basin of Lake Osoyoos between April 24 and April 26. The fish were acclimated in the net pens from 25 to 27 days and released on May 19.

Juvenile sockeye were collected in a rotary screw trap from April 14 to May 13, 1997. River discharge remained high throughout the month of April and May because of rain and snow melt from Canadian watersheds. High flows from the Similkameen River created high upstream flows which caused the screw trap to be ineffective. Consequently the trap was removed approximately two weeks earlier than

scheduled. Water temperature, discharge, and velocity were measured at or near the trap site. Natural produced sockeye smolts were sub-sampled to obtain length, weight, and age data.

Discharge from Lake Osoyoos is controlled by a low head irrigation dam (Zosel Dam). The discharge is regulated via an international agreement that provides for certain lake levels for both irrigation and recreational purposes. Inflow into Lake Osoyoos comes from natural runoff and controlled water releases from a chain-of-lakes originating from Lake Okanagan located near Kelowna, Canada.

Naturally produced fish emerge in spring from spawning gravel located in the Okanagan River near Oliver, British Columbia. They emigrate downstream to Lake Osoyoos where they rear from 1 to 3 years.

Study Area

Lake Osoyoos is a transboundary water located in the Okanagan Valley of British Columbia and Washington State. The lake consists of three basins (Pratt et al. 1991). The northern, middle, and part of the southern basin exist in Canada and are fed by the Okanagan River. The rearing and acclimation net pens were located in the southern basin on the United States side approximately 0.8 km north of the Osoyoos Lake State Veterans Memorial Park, Oroville, Washington. The net pens were towed to the southern end of the lake where approximately 180,000 hatchery-raised sockeye smolts were released. Both natural and hatchery fish navigated a narrow, shallow channel for approximately 0.8 km before they reached Zosel Dam and the outlet of the lake (Figure 1).

The Okanogan River flows in a southerly direction from the outlet of Lake Osoyoos. The river then branches into two channels approximately 150 meters (m) down stream from Zosel Dam. After a distance of approximately 130 m, the river rejoins itself and continues down stream for approximately 1.2 km where it is joined by a branch of the Similkameen River. The Similkameen River is the largest tributary to the Okanogan River and the discharge of the Similkameen River typically exceeds the Okanogan River (Quinn 1965).

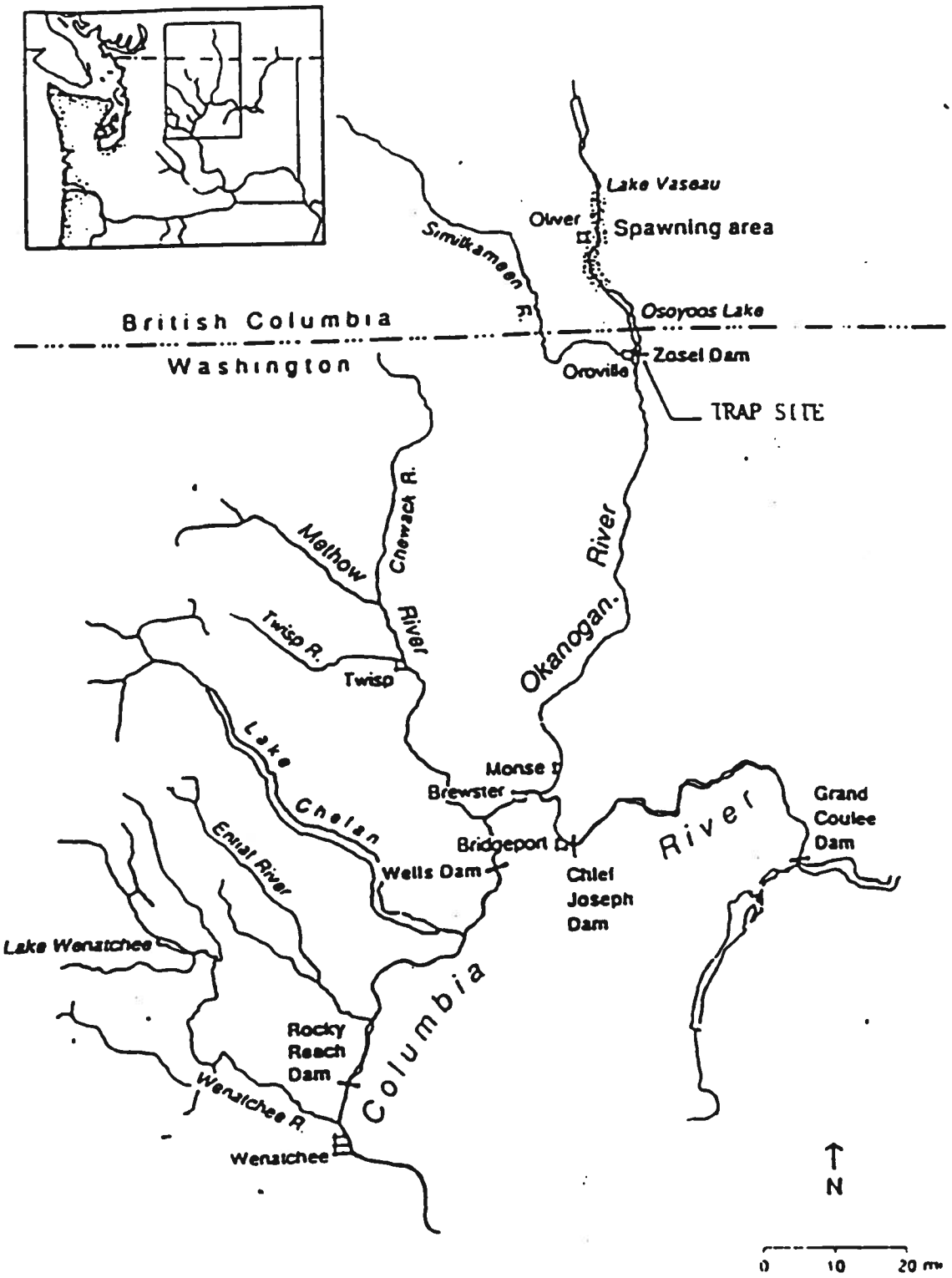

Figure 1.- Map of the study area (adapted from Swan 1994).

Methods

Trapping

Trapping was accomplished with a 2.4 m rotary screw trap. The trap was located approximately 300 m below Zosel Dam. The river, where the trap was located, has been historically divided into two channels. However, due to high flows the island that divided the river was inundated and the channel was not divided. The trap was located along the western bank of the river because: 1) the trap could be secured, accessed, and fished in a safe manner; 2) past experience indicated that backwater flow from the Similkameen River further downstream reduced river velocity below trap operation requirements; 3) the assumption was made that recaptured marked fish would provide an estimate as to the portion of fish that passed down the river.

The trap was lowered in the water column every day from 8:00 p.m. until 6:00 a.m. beginning on April 14. The trap was not fished during the day because historically catch rates were low during daylight hours (Hanson 1997). The rotary screw trap was positioned in the thalwag of the river in approximately 1.5 meters of water.

The field crew checked the trap for fish once an hour. Trapped fish were removed and checked for pelvic (hatchery fish) and dorsal fin clips (marked fish) and released into the river. A portion of the captured fish were sub-sampled for biological data. An additional sub-sample of fish were anesthetized in MS-222, marked by a partially-clipped dorsal fin, and placed in a live well until the fish were relocated upstream the following evening. Fish were marked every other day if at least 60 fish were collected.

Trap Efficiency

For this report, a trap efficiency was generated to: 1) provide an indication of the number of fish that the trap was catching out of each evening's outmigration, 2) generate a population estimate, and 3) provide a means for generating a confidence interval for the 1996 outmigration population. The trap efficiency was estimated by dividing the total number (Appendix A) of recaptured dorsal fin-clipped fish

by the total number of released dorsal fin-clipped fish (Seiler 1992). If less than 60 fish were caught than no fish were marked because the recapture rate was often zero (Hansen 1996a).

Biological Information

Approximately every fortieth fish caught in the trap was removed and sampled for weight, fork length, and scales. The scales of natural production sockeye juveniles were aged to determine residency time in the nursery lake and provide growth rate information. Mean fork length measurements were expanded by 7 percent to generate the total length data used to calculate condition factor information.

Physical Variable Sampling

The field crew measured water velocity directly upstream of the trap with a Marsh-McBirney Flo-Mate meter once, every night during the trapping season. Temperatures were collected every two hours with a Onset Optic StowAway Temperature data logger. Discharge was recorded at the United States Geological Survey station located approximately 122 m upstream of the trap.

Population Estimates

The number of naturally produced fish captured was divided by the project trap efficiency to generate an outmigration estimate for each respective component. A 90 percent confidence interval was calculated for the two population components (hatchery and natural fish). This was accomplished by generating a variance from trap efficiency and marked fish release data. The variance was calculated as: (the trap efficiency)(1 - the trap efficiency) / the number of marked released fish (M. Alexandersdotter, WDFW, pers. comm. 1996). Confidence intervals were determined based on the assumption that the data were binomially distributed. The efficiency based confidence interval values were then applied to the capture values to create upper and lower confidence limits (Seiler et al. 1981).

Disease Analysis

A total of 174 sockeye smolts (90 wild; 84 hatchery-raised) were collected and analyzed for bacteria kidney disease (BKD) and infectious hematopoietic necrosis (IHN). The 84 hatchery-raised smolts were collected from the net pens prior to the fish being released. The 90 wild (natural produced) fish were collected from the trap. The kidney and spleen of each fish were removed, placed in a test tube, and stored on ice. The samples were shipped to the Fish Health Center in Olympia, Washington. Each test tube contained the kidney and spleen of three naturally produced smolts or three hatchery-raised smolts. Fish tissue samples were grouped because the organs from each individual fish were too small to effectively test for disease.

Results

Trapping

The number of natural produced fish captured during 1997 was similar to the number captured during 1996 (Table 1). However, the trap collected fish over a shorter period of time in 1997 (30 d) than in 1996 (45 d). The out-migration characteristics (time of out-migration and pattern) of the naturally produced sockeye were similar to previous years (Figure 2).

Table 1.- Summary of sockeye captured by release year.

Release Year	Natural Production	Hatchery	Total Captured	Marked	Recaptured
1994[1]	2,360	78	2,438	855	25
1995[2]	45,934	238	46,172	3,697	61
1996[3]	6,101	886	6,987	4,341	130
1997	6,235	3	6,238	2,061	4

1 (Hansen 1996a)
2 (Hansen 1996b)
3 (Hansen 1997)

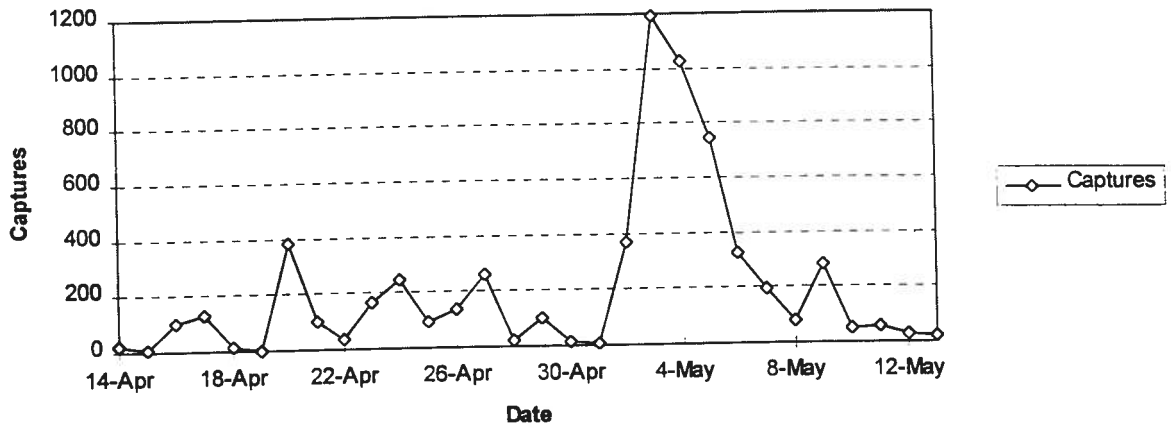

Figure 2.- Natural reproduction of sockeye salmon entrained in a screw trap in Okanogan River during the spring of 1997. Data includes 3 hatchery-raised smolts from the 1996 release.

Three hatchery-raised sockeye, released in 1996, were collected during sampling in 1997. Approximately 180,000 hatchery-raised sockeye were released on May 19, 1997. However, due to high flow conditions the trap became ineffective on May 14 and removed on May 16 prior to the release of the hatchery-raised sockeye. Therefore, for 1997 no trap efficiency estimate was developed for hatchery-raised sockeye.

Trap Efficiency

There was a mean trap efficiency estimate of 0.2 % for the project period (Appendix A). A mean trap efficiency of 2.9% was estimated during 1994 (Hansen 1996a) and 1996 (Hansen 1997). The mean trap efficiency value in 1995 was 1.65 percent (Hansen 1996b).

Biological Information

Based on scale age analysis, the majority of natural production fish were age one plus (Table 2). There was no significant difference between the mean condition factor for hatchery-raised, age 0+ and natural produced age 1+ smolts. However, the variance between the two samples was significantly different (hatchery: age 1+, $F_{tab} = 0.01$: $F_{calc} = 0.74$; hatchery: age 2+, $F_{tab} = 2.97$: $F_{calc} = 3.28$).

Table 2.- Age and length of trapped natural production and hatchery net pen juvenile sockeye.

Type of Fish	Mean Fork Length (mm)	Fork Length Standard Deviation (mm)	Mean Weight (g)	Mean Weight Standard Deviation (g)	Mean Condition (K)	Mean Condition Standard Deviation (K)	N
Hatchery	88.1	5.9	6.8	1.3	0.81	0.07	83
One Plus	111.9	8.7	13.8	8.2	0.80	0.47	206
Two Plus	178.1	29.3	60.4	31.0	0.80	0.04	8

Physical Variables and Out-migration Relationships

A linear additive model (LAM) was used to determine if any of the environmental factors (water velocity, discharge, and water temperature) had an effect upon the number of sockeye entrained in the trap. Both water velocity ($F_{cald} = 2.75$; $F_{ctab} = 0.11$, $P = 0.26$) and discharge ($F_{tcalc} = 2.66$; $F_{ctab} = 0.11$, $P = 6.5^{-26}$) were found to have a significant effect upon the number of sockeye smolts entrained, which may indicate an influence in smolt out-migration, while water temperature ($F_{calc} = 0.01$; $F_{ctab} = 0.90$, $P = 0.35$) did not. Both velocity and discharge were near equally associated with the number of smolts captured (velocity, $R^2 = 29.9$; discharge, $R^2 = 29.4$).

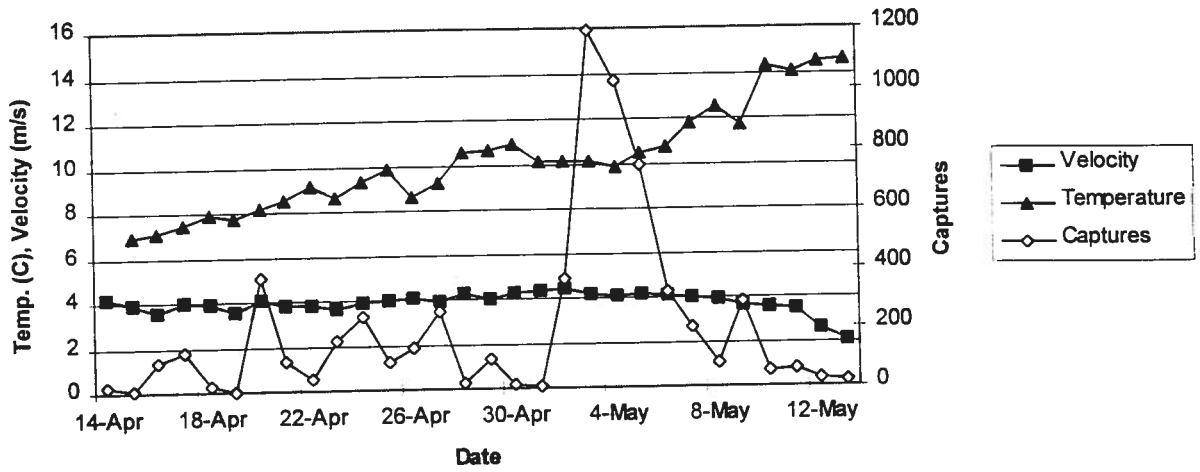

Figure 3. Trap captures versus water temperature and water velocity.

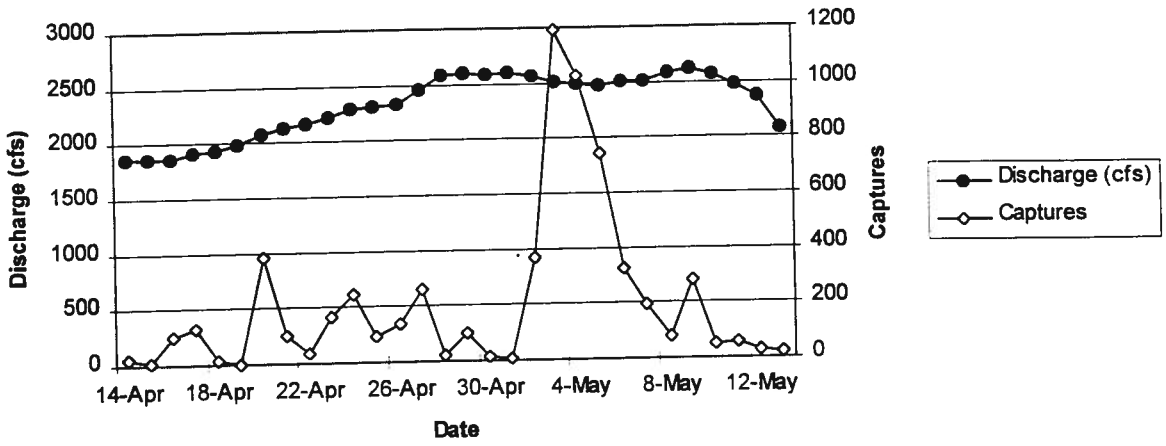

Figure 4. Trap captures versus mean daily discharge. Discharge data provide by U.S. Geological Survey, Spokane Field Office, Washington.

Natural Produced Sockeye Population Estimate

Population estimate for the number of out migrating sockeye smolts during the time the trap was operational in 1997 (3, 213,917) was substantially greater than the estimates during 1994 (161,644) and 1996 (210,379) but less than the estimate for 1995 (5,060,545). The large population estimate for 1997 and associated confidence interval was created by the low number (4) of recaptured smolts. Average daily flows were significantly higher ($t\text{-test}_{tab} = 1.67$, $t\text{-test}_{calc} = 5.61$) during the same time period in 1997 (mean = 2,319 cfs) than in 1996 (mean = 1,920). This greater amount of water provided a larger volume

of water for sockeye smolts to outmigrate and reduced the concentration of fish in the main channel (thalweg). Thus this greater discharge may have reduced the number of recaptures and inflated the population estimate.

Table 3. Population estimate and 95% confidence interval for natural produced juvenile sockeye.

	Low (90% CI)	*Population Estimate*	*High (90% CI)*
Natural Production Fish	1,746,498	3,213,917	20,112,903

Disease Analysis

No viruses were detected by cell culture nor did bacteria grow on the agar from any of the tissue samples from either natural produced or hatchery-raised fish provided to the Olympia Fish Health Center (Morrison, USFWS, unpublished data). *Renibacterium salmoninarum* (the bacteria species which causes bacteria kidney disease) antigen was detected in 11 of 30 (37%) and 4 of 28 (14%) of the natural produced and hatchery-raised fish samples, respectively (Morrison, USFWS, unpublished data). Although there was a greater occurrence (2.6x) of *renibacterium salmoninarum* in the natural-produced fish than the hatchery-raised fish all positive samples were recorded as "very low" (Morrison, USFWS, unpublished data). In the opinion of the analyst there was no difference in the pathogen profiles between the two groups of fish.

Discussion

During the sockeye smolt trapping period in 1997, flows in the Okanogan River were significantly greater than during 1996. This condition abbreviated the trapping season (30 d) and did not allow entrainment of the hatchery-raised smolts when released from the net pens. However the total catch (6,235 smolts) was similar to those of 1996 (6,101 smolts), a year in which the trap was fished for 45 days. Thus, the results of this sampling indicates that the 1996 brood year production is stronger than the 1995, and is also reflected in the adult returns for the respective years (1,665, 1994; 4,916, 1995).

Mortality associated with the trap remained low (16) and was lower than recorded in 1996 (709). As in 1996, marked fish were held for 24 hours in a live well. The reduced mortality was probably due to the modifications installed in the live well (a baffle) as well as the personnel performing fin clips for mark and recapture who had experience handling fish.

Mean trap efficiency was substantially less than any other year. This is probably due to the significantly greater discharge during 1997 than in 1996. This greater discharge probably dispersed fish as well as diluted the thalwag.

There was no significant difference of condition between the different ages of fish, though the standard deviation was greater in the naturally produced age 1+ than the age 2+ or hatchery-raised smolts. Naturally reproduced fish appear to be healthy and indicates there is sufficient/adequate food source for sockeye salmon smolts in Lake Osoyoos ant the Okanogan River.

The results of an analysis of variance (ANOVA) indicated discharge and velocity have significant effect on sockeye smolt outmigration. Although discharge and water velocity did have an effect on the number of smolts collected in the trap, less than 30% of the variability was explained by a linear regression model for either factor. Other factors may be involved in influencing the out-migration of sockeye smolts in Lake Osoyoos and the Okanogan River. Other environmental variables that have been correlated with sockeye smolt out-migration include moon phase and day length and should be considered to be evaluated in the future. Another explanation may be that the relationship between discharge or velocity and sockeye smolt catch rate may not be linear. That is, at some discharge the flow may be more influential on the number of fish entrained, however as discharge increases because of dispersal and diluting the concentrating effect of a well defined thalwag, the influential effects would be reduced. Lower flows and a concentrating effect of the thalwag would probably increase the efficiency of the trap at collecting fish.

The population estimate for 1997 (1996 brood year production) was large and had a wide range confidence interval. This was caused by the low number of recaptures (4 of 2,061). The low amount of recaptures can be explained, again by the high flows which dispersed sockeye smolts during out-migration. This greater amount of flow provided a larger volume of water for sockeye smolts to out-migrate and

reduced the concentration of fish in the main channel (thalweg). Thus this greater discharge probably reduced the number of recaptures and inflated the population estimate.

The results of the disease analysis indicated that positive levels of bacterial kidney disease (BKD) and infectious hematopoietic necrosis (IHN) did exist (11 of 30 Lake Osoyoos; 4 of 28 Cassimer Bar Hatchery) but were in very low levels in both groups of fish. Bacterial kidney disease enters fish via food or transmitted by other fish (Piper et al. 1982). Infectious hematopoietic necrosis is transmitted through the sex products of infected fish (Piper et al. 1982). Disease prevention practices at the Cassimer Bar Hatchery appear to be effectively reducing the risk of cultured fish from contracting either BKD or IHN and consequently reducing the probability of either disease to be transmitted to native stocks. If the prevention practices continue it is expected that hatchery-raised fish would not threaten the natural produced sockeye by transmitting diseases, which was a concern of the Province of British Columbia, Ministry of Environment, Lands & Parks.

To determine the success of this supplemental stocking program, adult sockeye salmon returns to the Okanogan River should be monitored. If successful, the average return would be greater than in past years when stocking was not implemented.

Acknowledgments

I would like to thank the numerous employees and staff members at the Fish and Wildlife Department of the Colville Confederated Tribes for assistance during this project. I would also like to thank the Douglas County Public Utility District for funding this work

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Appendix

Appendix A.- Sockeye trap captures over time during spring of 1997.

Date	Nat. Prod. Captures	Hatchery Captures	Total Captures	Marks	Recoveries	Mortalities
4/14	22		22			
4/15	8		8			
4/16	102	1	103	102	1	1
4/17	132		132			
4/18	18		18			
4/19	1		1			
4/20	382	1	383			
4/21	99		99	301		
4/22	38		38			
4/23	169		169			2
4/24	247		247	137		
4/25	94		94			
4/26	137		137	94		
4/27	262		262			1
4/28	22		22	261	1	
4/29	102		102			
4/30	12		12	102		
5/1	5		5			
5/2	366		366			
5/3	1195		1195	364		
5/4	1029		1029			
5/5	746		746	300	1	
5/6	322		322			4
5/7	198		198	319	1	
5/8	82		82			
5/9	284		284	81		8
5/10	53	1	54			
5/11	60		60			
5/12	27		27			
5/13	21		21			
Total	6235	3	6238	2061	4	16

DISSOLVED GAS MONITORING AT WELLS DAM FOREBAY AND TAILRACE, 1997

APPENDIX F

Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace,1997

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

January 1998

Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 1997

Total dissolved gas (TDG) levels at mid-Columbia dams have been monitored during the spring and summer months since the early 1980's. These data provide information on how projects either contribute or reduce TDG in the Columbia River. Comparison of data measured in 1996 from Wells Dam to the Rocky Reach Dam indicated a drop in gas levels from forebay to forebay. The 1996 observations provided the catalyst for further investigations of TDG and the relation Wells Dam plays in TDG generation or dissipation in the Columbia River.

Spill from hydroelectric dams can produce high levels of TDG during months when migrating adult and juvenile salmonids are in the river. It has been well documented that high levels of dissolved gas can cause injury and death to fish over a sustained period of exposure. TDG in the Columbia River is monitored at the forebay of all hydroprojects plus several additional intermediate locations.

Wells Dam was built as a hydrocombine; that is the spillway is set directly above the powerhouse. There are eleven spill gates at Wells, all operated with vertical lift gates with bottom discharge. The elevation of the tailwater level is close to or above the spill ogee at most flow conditions. The juvenile bypass system modified the entrances to five spillways for passage of salmon and steelhead smolts. Those gates dedicated for bypass operation are gates 2, 4, 6, 8, and 10. Two of the five modified spillways have top spill trash sluice ways. Bypass flow through each top gate (less than 2,000 cfs) drops approximately 70 feet. There is little opportunity for water spilled to plunge to depth because turbine flow is rising directly below spill gates. Forced spill and nitrogen replacement spill is passed through gates (1,3,5,7,9 and 11) not dedicated to the bypass system.

In 1997, TDG was recorded at Wells in the forebay and in the tailrace. This report describes flow and spillway volumes and methods of data collection immediately downstream of Wells Dam.

Introduction

Daily average records of dissolved gas were collected at Wells Dam in 1997 starting on April 11. Readings were made every four hours, starting at 0100 hours. The sensor was located in the forebay, off the deck of the dam at Unit 5 (Figure 2). Data were initially collected with a Sweeney Saturometer, Model DS-1B through May 6. From May 6 through the end of July, data were collected with a HydroLab MiniSonde equipped with a dissolved gas probe. Data from the MiniSonde were displayed on a monitor in the Wells Dam control room. The instrument measured water temperature and gas pressure, in millimeters of pressure, in the river. A separate electronic barometer provided local atmospheric pressure. Tailrace data were collected weekly from 1 - 1.5 miles downstream of the dam (Figure 2) across the river channel at approximately 20%, 40%, 60% and 80% of the channel width starting from the left bank of the river. The probe was lowered from a boat to a depth of 15 feet and occasionally lifted or jigged between 6 - 12 inches to maintain movement of river water across the sensor membrane. The boat drifted with the current for approximately 5 minutes. At the completion of a drift, the probe was raised from the river and placed in a bucket of river water and the boat with the probe taken back to the start of the sampling location. The entire process took approximately forty minutes.

Tailwater samples were collected with two different probes. In April and May, tailwater samples were collected with a Sweeney Model DS-1B. In June and July, samples were collected with a Common Sensing Model WDGL Probe that was connected to a notepad computer. Records for total discharge and amounts of spill were provided by Douglas PUD Power Operations (see Appendices A and B).

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

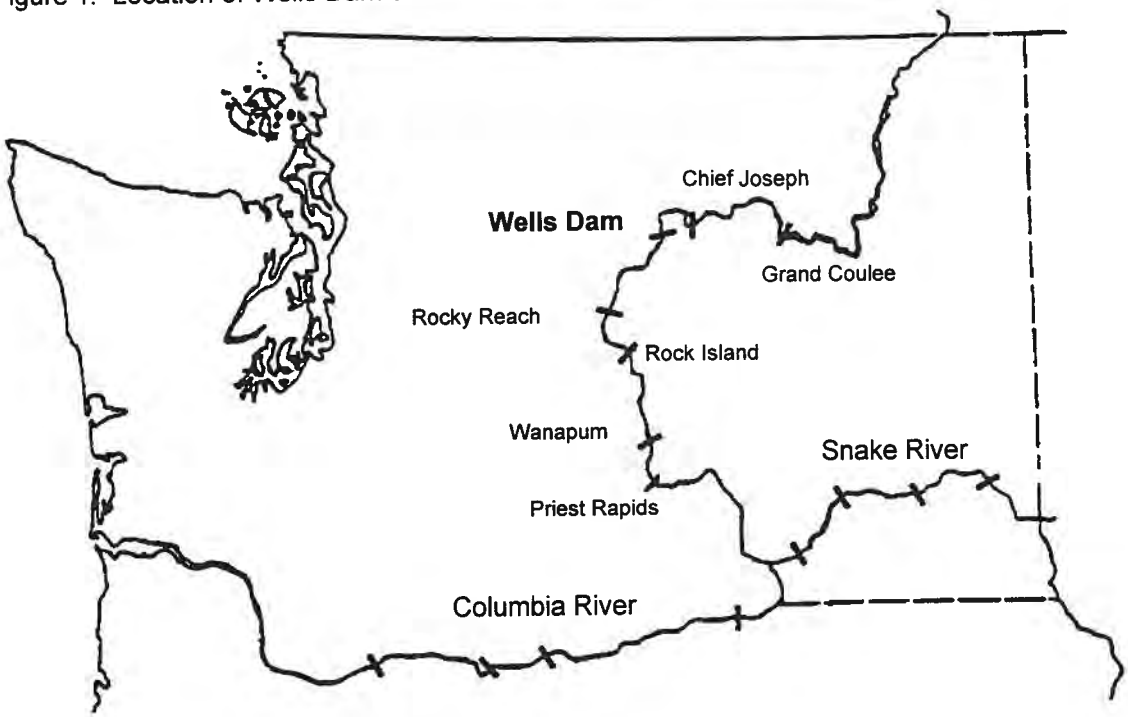
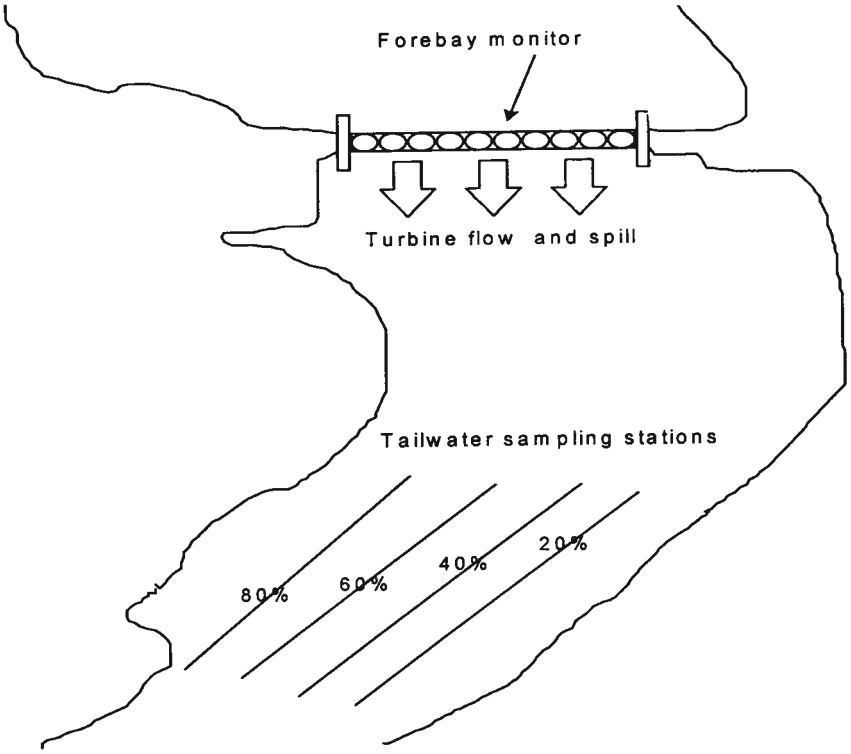


Figure 2. Wells Dam and the TDG sampling locations.



RESULTS

Data collected between April 11 and May 20 for the forebay and April 11 and May 31 for the tailrace were discounted because of uncertain accuracy of the sampling instrument. It was latter determined the instrument had an electrical short that cause the read out values to drift and display erroneous levels. Data between June 1 through July 31 are shown in Figure 3 as well as in Appendix C. The highest TDG value recorded in the Wells forebay was on June 14 at 129.1% at 1700 hours. As daily average discharge exceeded 200 kcfs, TDG in the forebay held around 120%. As flows dropped below 200 kcfs, forebay TDG held around 115%.

Figure 3. Forebay and tailwater TDG from Wells Dam, 1997.

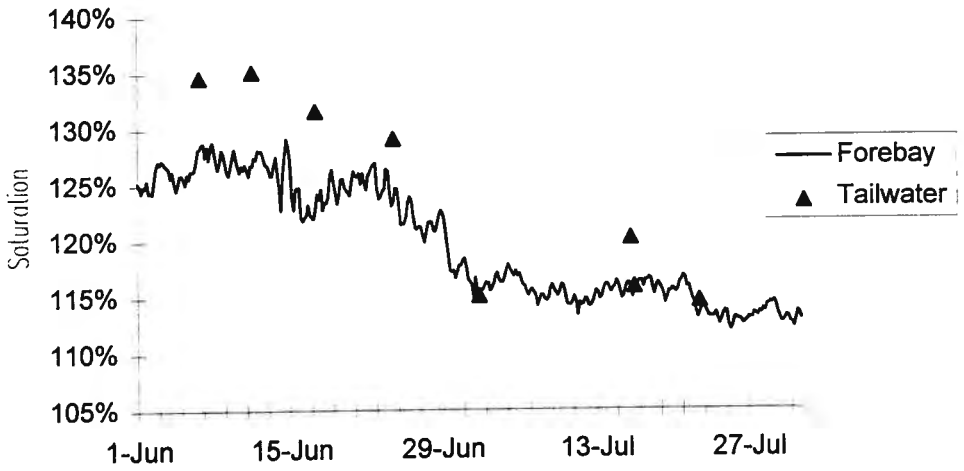
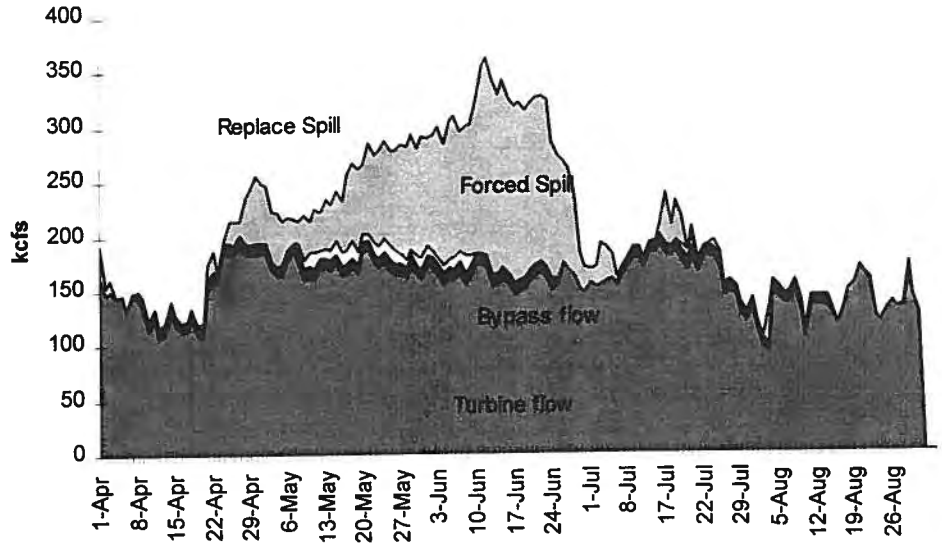


Figure 4. Wells Dam daily average discharge through powerhouse, bypass and spillways, 1997.



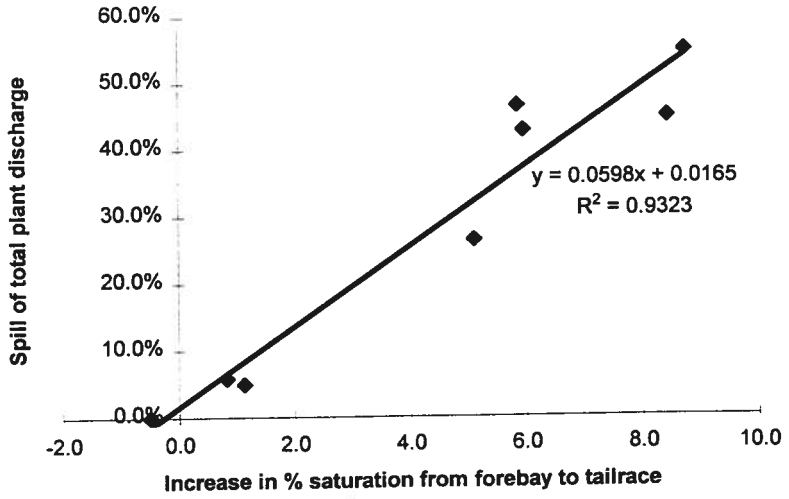
Tailwater TDG readings were collected on eight occasions (Figure 3). The highest tailwater TDG readings were made on June 11, with 135.1% . The forebay levels at this time were at 126.7%. River discharge at the Dam was at 321.7 kcfs and total spill was at 143.2 kcfs, or 44.7% spill. On July 2, there was no spill at the Dam at 0900 and the difference between tailwater and forebay TDG was -0.5%. On July 16 and 22, bypass flow (10.4 kcfs and 10.0 kcfs) was the only spill during the tailwater reading. There was a 0.8 and 1.1% increase between tailwater and forebay TDG. The largest difference between tailwater and forebay TDG was 8.7%. This occurred on June 17, when total river discharge was at 350.2 kcfs and total spill was at 191.3 kcfs, or 54.6% spill. On July 16, there was a total of 59.8kcfs of spill until 0915 hours, when for the rest of the day, only the bypass flow was spilled. A sample was taken at Beebe Bridge, 10 miles below Wells to capture that TDG levels from water spilled earlier. It was estimated that the water sampled at Beebe Bridge at 14:47 had left Wells Dam at 0300 that same day. Values for total discharge and spill discharge are used from this hour against this time.

The tailwater data were averaged between four sampling stations from bank to bank across the river channel at a distance of 1.5 miles from the dam. Between the four stations, there was no consistent difference of high and low TDG. On those dates when the difference was greater than 1% among the four sampling stations, the 60% station (slightly west of mid-channel) was usually highest. The 40% sampling point (slightly east of the mid-channel) seemed to be the best for fitting in between the extreme values. The spread between stations on a given sample never exceeded 2% TDG.

Total spill at Wells was highest on June 13 at 0700 for a volume of 241.2kcfs. This was 69.5% of the project inflow. Figure 4. shows volumes of water used in generation, bypass spill, replacement spill and forced spill. The volume of water spilled did have an effect on TDG in the tailwater of Wells Dam. Figure 5. shows a relationship of increasing TDG when percent spill increases.

Other relationships between TDG generation and total head, tailwater elevation, configuration of spill gates and how elevated TDG affects the ability to further add gasses to the river were not analyzed this year.

Figure 5. Difference in forebay and tailwater TDG as a function of spill, Wells Dam 1997.



Discussion

Columbia River flows in 1997 were some of the highest in recent river operations. Large volumes of water were spilled from Wells as flows exceeded the hydraulic capacity of the generating units. Between April 28 and July 5, daily average flows at Wells exceeded 200 kcfs; a situation where forced spill was unavoidable. Flows, especially in June, provided high levels of spill at all Columbia River dams in 1997. Flows at Wells Dam peaked at 396 kcfs at 0500 hour on June 12. Volume of water at Wells in April, May, June and July for the years 1967 - 1996 average around 6.9, 9.2, 9.4, 8.1 MAF. In 1997, flows volumes for those months were 9.7, 15.5, 17.9, 11.2 MAF respectively.

This study suggests that there is a relationship between high levels of spill and an increase in TDG immediately below Wells Dam. The relationship to changes in TDG to other variables such as the amount of discharge, elevation of both the forebay and tailrace and TDG concentrations in the forebay were not evaluated. Information on relations of plant operations and TDG production, other than percent spilled, was not possible with the sampling schedule used this year. A continuous monitoring station was not considered because of previous bad experiences from other studies. Improvements in sampling equipment has shown recently that a remote station can provide reliable TDG data down stream of dams.

A tailwater sampling station is proposed for 1998 at 2.3 miles below Wells Dam. Data from 1997 indicated that across four points of the river at 1.5 miles below the dam, differences in TDG never exceeded 2%. The Corps of Engineers found as much as a 5% absolute difference between the five mobile sampling locations and up to a 6% absolute difference between fixed sites and river concentrations (Ruffing, 1996). This was attributed to water from the spillway and powerhouse not thoroughly mixing across the river. Similar conditions were found at Priest Rapids and Wanapum dams in 1996 (Parametrix, 1997). Measurements 1.5 miles below Wells Dam with a range of spill from 0 - 54.6% indicated that water was mixed.

Literature Cited

Parametrix, Inc. 1997. Transect Monitoring of Total Dissolved Gas at Wanapum and Priest rapids Dams - Summer 1996. Parametrix, Inc. Kirkland, WA. For Grant County PUD #2, Ephrata, WA , September 17, 1997.

Ruffing, Faith E. 1996. "Water Quality Monitoring of Total Dissolved Gas Below Corps Projects in the Columbia River" reprint from International Water Resources Association Conference, Chicago, September 1996. IN Ruffing, Faith E. 1996. Total Dissolved Gas Fixed Monitoring Program for John Day, The Dalles and Bonneville Projects; Annual Activities Report WY 1996. US Army Corps of Engineers, Portland, OR; December 31, 1996.

Appendix A. Wells Dam Hourly Discharge, Total flow in kcfs, 1997.

DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	Daily AVG
4/1/97	220	193	195	195	190	184	198	201	198	195	198	195	189	177	184	197	193	178	201	177	170	191	199	195	192
4/2/97	174	171	168	149	138	134	138	149	132	128	147	155	159	159	157	150	149	148	143	165	193	185	161	138	154
4/3/97	123	114	123	130	123	113	135	161	168	170	173	168	169	171	187	197	196	179	174	176	182	182	184	155	160
4/4/97	112	127	157	133	118	126	141	146	146	158	173	156	158	157	157	156	142	116	131	171	168	157	122	129	144
4/5/97	128	127	134	142	167	174	167	160	158	126	161	171	171	152	136	130	126	129	140	171	171	158	119	122	147
4/6/97	115	101	0	103	118	135	130	143	142	155	163	156	147	137	127	123	124	127	137	163	172	172	162	123	132
4/7/97	112	112	113	114	88	106	144	160	163	164	173	177	169	162	151	150	149	152	164	167	179	170	162	162	148
4/8/97	163	169	103	94	105	113	150	170	165	173	181	182	180	177	166	146	137	126	126	141	176	186	162	123	151
4/9/97	104	109	117	118	117	118	130	152	168	150	164	170	166	166	165	172	164	156	151	147	160	172	126	125	145
4/10/97	110	88	80	95	98	83	119	141	142	147	156	163	164	170	147	122	121	114	114	114	122	140	122	110	124
4/11/97	92	77	99	105	103	107	125	166	164	154	172	185	187	159	149	143	135	132	141	136	139	139	113	95	134
4/12/97	78	80	74	78	76	74	103	141	182	154	142	129	138	143	149	145	144	133	123	104	129	117	105	88	118
4/13/97	82	64	59	68	71	72	74	93	124	166	170	156	160	114	110	120	144	146	137	153	162	159	166	160	122
4/14/97	152	136	110	71	92	109	123	159	151	156	171	179	177	174	160	148	156	151	155	152	152	147	119	110	142
4/15/97	109	98	104	97	98	80	138	141	139	147	146	139	137	143	140	146	144	127	132	155	178	159	125	99	130
4/16/97	75	60	70	79	90	115	125	117	138	147	157	157	147	142	141	163	144	99	108	129	156	141	120	102	122
4/17/97	83	79	53	57	73	94	131	154	161	173	158	185	171	129	117	120	118	114	128	137	142	158	140	94	124
4/18/97	69	53	53	60	51	70	127	181	167	171	180	166	157	156	169	169	166	166	169	163	157	163	151	104	135
4/19/97	90	87	80	73	75	47	54	104	162	164	170	154	161	147	148	134	132	117	116	131	147	146	122	115	120
4/20/97	110	93	90	89	91	94	96	109	106	88	106	97	125	137	128	136	130	117	125	138	182	167	173	179	121
4/21/97	139	105	103	126	121	140	166	153	160	177	179	187	163	185	181	189	207	192	190	192	213	212	254	272	175
4/22/97	307	283	254	188	170	159	164	172	174	185	190	223	210	188	151	155	147	143	145	166	191	184	184	184	188
4/23/97	162	160	168	128	109	124	134	161	180	175	184	166	175	163	171	147	173	165	163	188	201	207	209	200	167
4/24/97	169	171	161	162	173	171	193	195	198	197	196	198	195	209	211	212	210	210	212	211	212	213	224	224	197
4/25/97	204	192	192	162	150	168	193	201	210	233	242	243	245	237	232	235	234	233	241	245	231	240	192	189	214
4/26/97	191	187	182	184	183	179	162	170	189	193	201	243	243	233	218	211	208	234	239	258	264	263	266	246	214
4/27/97	215	201	189	191	196	196	205	206	208	210	212	237	240	244	239	231	231	214	211	225	225	210	202	218	215
4/28/97	222	223	237	193	195	239	245	246	245	246	254	254	248	248	241	244	242	243	238	240	225	235	244	246	237
4/29/97	242	232	214	205	195	210	220	241	242	255	257	234	231	251	267	265	264	264	261	260	265	270	252	262	244
4/30/97	265	251	254	255	243	253	271	268	268	258	242	240	239	252	263	268	270	259	253	244	251	260	267	267	257
5/1/97	277	273	238	208	201	217	240	253	256	245	243	216	226	239	251	262	274	296	294	277	266	243	249	260	250
5/2/97	280	280	273	234	212	243	244	278	272	282	236	273	257	253	234	220	191	197	209	229	260	269	275	265	249
5/3/97	230	216	196	207	197	208	224	226	283	282	257	226	233	223	212	213	233	229	227	223	215	196	198	221	224
5/4/97	239	237	226	214	209	214	217	224	237	231	217	197	195	219	223	227	232	220	222	218	233	255	225	221	223

Appendix A. Wells Dam Hourly Discharge, Total flow in kcfs, 1997.

DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	AVG
5/5/97	216	202	219	224	227	230	225	229	226	224	220	229	231	229	230	211	177	169	237	214	216	187	188	215	216
5/6/97	225	236	236	237	223	216	217	216	205	199	199	207	221	211	211	213	204	203	202	197	206	248	261	243	218
5/7/97	241	226	213	211	187	199	229	231	245	249	238	224	214	202	201	206	208	223	251	238	193	196	180	196	217
5/8/97	224	202	201	196	223	252	249	243	237	195	200	202	205	204	199	190	197	200	200	193	203	229	264	269	216
5/9/97	247	241	241	235	228	226	226	237	250	251	248	240	226	213	213	212	205	186	178	183	196	210	214	190	221
5/10/97	183	186	195	201	214	227	233	250	233	209	225	228	234	222	196	197	201	216	239	239	233	213	184	209	215
5/11/97	243	248	237	261	230	264	234	166	185	191	199	204	207	205	207	215	226	235	242	233	245	245	235	248	225
5/12/97	250	238	201	191	190	198	208	218	254	266	258	242	219	194	201	198	199	203	222	241	254	241	212	215	221
5/13/97	215	214	217	226	228	244	250	216	242	262	273	280	267	267	263	261	232	230	227	219	206	196	205	220	236
5/14/97	214	213	217	234	253	270	243	236	237	244	243	248	272	271	272	276	199	184	191	197	188	195	204	213	230
5/15/97	205	205	205	203	204	206	227	227	227	245	254	254	269	273	271	270	275	275	281	278	262	246	226	219	242
5/16/97	223	233	235	241	249	237	241	226	221	220	226	226	237	237	229	220	226	234	248	263	250	237	226	232	234
5/17/97	250	249	253	249	239	229	242	245	251	231	243	247	252	257	275	281	281	263	262	280	280	286	262	269	257
5/18/97	272	263	278	277	269	246	244	264	279	271	269	280	281	272	271	280	270	270	262	257	267	270	264	255	268
5/19/97	257	260	260	259	250	273	305	290	273	238	244	252	236	241	261	264	274	277	274	267	267	271	259	268	263
5/20/97	294	291	300	257	250	243	259	259	281	278	265	255	263	258	252	255	256	257	260	267	273	271	258	270	265
5/21/97	273	288	292	289	288	279	282	275	269	304	314	309	304	296	295	279	277	271	265	292	306	280	279	273	287
5/22/97	275	276	281	278	273	281	298	281	305	288	271	258	268	270	279	269	266	261	254	260	281	284	270	266	275
5/23/97	251	264	277	291	290	304	314	289	283	272	271	270	285	291	295	286	282	272	267	254	254	272	278	283	279
5/24/97	273	282	283	285	280	281	277	299	296	314	315	305	260	263	279	278	281	292	294	303	301	308	299	278	289
5/25/97	285	285	281	284	279	280	285	290	275	267	295	300	297	289	288	279	283	259	249	253	264	283	288	276	280
5/26/97	260	258	256	258	271	285	276	282	282	271	274	265	267	275	279	285	271	273	294	302	313	302	312	301	280
5/27/97	299	304	280	276	271	274	274	258	289	291	294	293	298	276	282	285	291	292	290	284	297	279	277	267	284
5/28/97	293	297	283	281	261	295	286	296	294	311	300	272	276	270	268	254	286	278	259	272	302	287	271	284	282
5/29/97	300	288	290	297	305	292	316	279	284	288	293	306	305	299	296	297	295	296	296	291	288	290	282	268	293
5/30/97	249	292	306	331	331	324	302	257	266	270	281	278	279	283	285	284	278	275	259	263	275	263	246	276	281
5/31/97	320	322	322	293	297	277	280	308	307	306	302	302	300	312	306	271	246	266	266	243	281	280	285	308	291
6/1/97	300	314	330	328	329	329	299	198	178	229	265	292	304	283	280	280	281	280	283	286	301	315	307	355	289
6/2/97	309	307	306	290	281	284	260	284	294	317	321	290	291	292	292	290	288	293	289	285	296	304	288	293	294
6/3/97	291	292	296	307	303	312	291	295	289	309	302	291	299	306	298	296	286	302	310	317	317	313	297	301	301
6/4/97	300	279	270	279	274	297	312	289	278	272	272	276	288	258	260	274	287	285	280	281	281	292	303	320	284
6/5/97	322	316	310	312	304	291	300	299	297	301	304	306	307	313	316	307	306	298	304	302	304	316	313	312	307
6/6/97	315	318	312	310	312	311	302	310	316	316	293	313	310	319	320	319	318	317	316	321	320	329	242	286	310
6/7/97	306	305	282	283	287	289	292	288	283	289	296	297	295	296	295	294	297	296	287	290	300	314	322	319	296
6/8/97	335	343	315	300	297	287	302	298	272	301	309	298	296	298	301	303	302	286	279	300	321	328	289	270	301
6/9/97	271	283	304	297	290	280	286	296	299	297	299	304	308	315	313	317	307	314	329	325	322	298	280	308	302

Appendix A. Wells Dam Hourly Discharge, Total flow in kcfs, 1997.

DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	AVG
6/10/97	276	319	312	317	279	268	296	317	315	330	325	323	321	322	333	347	359	368	370	364	356	345	332	318	325
6/11/97	356	379	367	362	368	368	363	371	383	366	314	313	322	330	327	332	331	339	347	357	386	379	381	375	355
6/12/97	375	396	393	372	396	397	365	366	372	373	382	378	371	368	358	337	340	338	329	343	340	340	335	337	363
6/13/97	343	349	346	346	349	350	347	344	343	347	337	327	330	344	353	334	338	339	333	339	327	358	354	334	342
6/14/97	325	333	341	353	334	322	341	338	345	348	338	357	356	349	344	258	178	237	308	341	360	367	382	358	330
6/15/97	357	360	368	363	350	347	317	312	321	358	356	349	353	349	349	344	340	337	325	316	341	346	337	318	342
6/16/97	331	319	316	293	304	311	308	350	339	355	341	343	331	316	314	311	310	326	324	335	345	342	336	333	326
6/17/97	336	310	341	324	310	322	319	315	351	308	277	300	332	336	344	314	315	310	306	302	304	333	318	333	319
6/18/97	324	349	341	333	321	334	320	344	319	355	335	348	336	314	300	288	298	317	327	328	311	315	294	300	323
6/19/97	298	323	311	300	307	307	331	329	311	329	328	324	316	319	308	307	308	311	311	306	323	319	312	314	315
6/20/97	326	335	327	331	327	334	344	350	307	295	279	285	299	311	305	326	320	341	342	327	334	337	327	324	322
6/21/97	316	322	311	319	331	330	324	329	316	323	324	323	323	328	333	332	338	330	328	325	327	330	325	324	325
6/22/97	335	329	327	328	341	333	325	343	351	347	325	322	321	326	324	325	322	328	322	332	337	315	307	321	329
6/23/97	340	317	317	336	332	335	326	321	329	340	348	334	339	336	333	321	327	325	325	307	296	304	293	282	323
6/24/97	274	322	312	316	318	310	305	312	312	308	300	290	285	268	259	247	243	238	231	249	273	320	291	270	285
6/25/97	259	263	287	259	230	248	262	301	283	297	315	294	271	263	249	243	235	244	279	292	302	308	289	294	273
6/26/97	291	303	303	303	273	267	249	255	266	268	279	273	280	282	279	247	248	240	251	259	257	252	249	262	268
6/27/97	288	271	256	237	220	245	267	273	283	294	291	285	271	265	269	263	262	243	241	242	248	264	271	264	263
6/28/97	269	249	251	253	250	250	248	264	251	264	263	262	262	266	265	225	198	205	220	220	218	207	212	219	241
6/29/97	216	193	173	157	158	146	150	152	147	162	168	217	223	219	216	214	196	195	194	188	177	175	174	196	184
6/30/97	177	149	143	137	129	137	137	142	136	155	162	168	157	165	177	201	209	199	206	195	205	194	195	211	170
7/1/97	199	162	134	132	139	132	129	150	169	172	169	169	172	172	169	173	174	175	202	212	211	211	177	172	170
7/2/97	167	155	143	154	156	135	139	154	161	162	159	163	164	166	180	191	215	213	214	198	192	182	158	178	171
7/3/97	197	197	184	182	175	146	152	165	174	178	174	208	213	222	219	214	212	210	205	204	211	222	178	188	193
7/4/97	205	191	144	141	135	130	139	151	164	174	203	215	221	215	211	211	210	220	216	232	231	230	175	197	190
7/5/97	195	186	185	184	174	169	166	147	146	168	182	188	181	175	172	173	180	179	188	226	225	208	173	173	181
7/6/97	158	168	176	164	140	126	133	120	128	161	176	173	172	171	173	177	167	167	172	168	177	188	176	140	161
7/7/97	130	128	131	131	132	132	149	174	187	199	202	197	196	196	199	196	199	195	190	193	192	200	161	149	173
7/8/97	146	159	154	139	135	147	157	175	191	191	191	204	205	189	190	180	199	209	195	208	188	186	193	163	179
7/9/97	164	165	166	161	175	169	163	166	171	179	184	201	211	210	209	208	208	207	207	206	204	197	202	189	188
7/10/97	180	175	175	172	169	167	161	194	201	202	205	205	203	205	198	197	196	197	193	186	183	193	197	181	189
7/11/97	165	154	150	146	145	156	156	177	187	184	188	187	190	188	188	186	188	186	190	188	193	193	204	205	179
7/12/97	193	182	180	186	192	191	164	166	187	205	207	206	205	195	193	190	194	198	200	199	202	204	203	200	193
7/13/97	196	195	186	181	181	178	164	166	187	198	198	198	198	197	197	197	197	196	205	206	206	206	208	210	194
7/14/97	211	211	209	209	208	195	182	170	192	209	212	203	212	217	206	213	220	224	233	220	227	222	219	213	210
7/15/97	214	218	222	231	235	252	242	249	243	244	241	246	242	249	245	233	235	231	221	232	235	244	240	231	236

Appendix A. Wells Dam Hourly Discharge, Total flow in kcfs, 1997.

DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	AVG
7/16/97	225	233	228	231	229	222	216	222	231	237	210	208	209	210	209	209	211	211	205	197	208	210	202	201	216
7/17/97	191	193	197	207	222	219	214	219	214	216	212	220	249	250	251	235	235	223	236	252	257	254	236	228	226
7/18/97	203	217	228	230	229	173	194	197	205	193	205	201	231	233	229	227	228	223	224	221	218	219	229	237	216
7/19/97	234	226	229	230	223	205	188	182	198	209	195	211	210	208	206	207	205	205	195	203	203	202	197	190	207
7/20/97	180	175	168	168	165	160	145	169	171	175	171	168	174	184	174	187	191	203	206	192	184	187	177	198	178
7/21/97	193	197	198	197	191	191	167	175	169	167	171	170	199	204	205	204	191	180	181	182	196	199	174	147	185
7/22/97	180	189	193	170	159	179	205	208	206	206	204	203	201	200	198	197	196	198	197	188	177	191	156	142	189
7/23/97	151	165	179	177	186	178	186	191	191	195	197	204	206	205	204	210	202	203	209	207	206	205	185	152	191
7/24/97	175	192	192	184	181	189	187	189	205	215	199	212	191	189	191	188	205	214	218	193	202	201	183	177	195
7/25/97	176	188	193	180	175	156	147	169	194	199	194	191	191	193	195	194	197	199	199	195	190	188	159	143	183
7/26/97	142	140	138	136	139	143	128	137	156	171	172	165	159	159	155	157	162	165	169	170	166	169	162	145	154
7/27/97	141	136	134	134	134	132	118	123	142	175	182	180	157	153	172	180	184	182	173	178	181	183	169	134	157
7/28/97	96	87	96	100	110	118	141	162	165	190	188	188	191	183	170	189	185	181	170	170	184	168	137	111	153
7/29/97	74	76	79	81	88	101	130	121	182	165	168	174	165	165	158	172	171	158	153	148	154	158	145	115	137
7/30/97	89	70	66	72	74	85	107	157	147	162	155	154	155	151	144	141	160	160	152	157	147	154	115	119	129
7/31/97	112	96	83	80	89	106	136	152	150	165	173	165	167	165	160	170	172	154	165	155	182	166	120	109	141

Appendix B. Wells Dam Hourly Total Spill, in kcfs, 1997

																									Total Spill	
DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	Avg	%
4/1/97	60	32	32	32	32	32	52	36	42	42	28	22	18	0	13	30	29	19	38	0	0	35	42	32	29	15%
4/2/97	21	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	52	27	11	7	4%
4/3/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	38	26	30	29	6	9	18	32	25	10	6%
4/4/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
4/5/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
4/6/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
4/7/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9	9	9	2	1%
4/8/97	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	6%
4/9/97	9	9	9	9	9	9	9	9	9	9	9	11	11	11	11	11	11	11	11	11	11	11	11	11	10	7%
4/10/97	11	10	7	8	9	8	9	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	8%
4/11/97	11	7	9	9	9	9	9	11	11	11	11	11	11	11	11	11	11	9	9	9	13	13	13	13	10	8%
4/12/97	11	11	10	9	9	9	11	13	13	13	13	13	13	13	13	13	13	13	13	11	11	11	11	11	12	10%
4/13/97	11	9	9	9	9	9	9	10	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	12	10%
4/14/97	13	13	13	9	11	11	12	13	13	13	13	13	13	12	12	12	11	11	11	11	11	11	10	9	12	8%
4/15/97	9	9	9	9	9	7	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	8	10	8%
4/16/97	7	6	6	6	6	8	10	9	11	11	11	11	11	11	11	11	11	7	8	9	9	11	11	8	9	7%
4/17/97	7	7	4	4	5	7	10	10	11	11	11	11	11	10	10	10	9	9	9	9	9	11	11	7	9	7%
4/18/97	6	6	4	4	4	5	8	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	23	9	10	7%
4/19/97	7	7	7	7	7	5	5	8	11	11	11	11	11	11	11	11	11	11	9	9	11	11	9	9	9	8%
4/20/97	9	8	7	7	7	7	7	9	9	9	9	8	9	11	11	11	9	9	9	9	11	11	65	86	14	12%
4/21/97	59	18	7	9	9	10	11	11	11	11	11	11	11	11	12	12	20	20	20	20	15	27	122	135	25	14%
4/22/97	128	99	84	22	11	11	11	15	28	41	45	49	49	11	11	11	11	9	9	9	9	9	9	9	29	16%
4/23/97	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	6%
4/24/97	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	33	40	12	6%
4/25/97	32	32	47	10	10	10	10	10	10	34	45	45	45	36	36	36	36	36	45	45	45	53	10	10	30	14%
4/26/97	10	10	10	10	10	10	10	10	10	10	10	51	50	41	24	14	10	38	45	65	76	76	83	61	31	15%
4/27/97	39	18	10	10	10	10	10	10	10	10	13	39	44	49	42	36	32	16	18	32	32	10	10	37	23	11%
4/28/97	37	37	51	10	10	56	56	56	56	56	61	61	55	55	55	55	54	56	56	50	41	69	104	90	54	23%
4/29/97	74	48	21	10	10	54	31	49	49	64	68	43	43	65	78	78	75	75	85	96	78	78	87	103	61	25%
4/30/97	95	75	75	73	68	113	108	77	79	61	44	44	44	66	75	75	75	63	59	52	52	73	91	93	72	28%
5/1/97	93	85	43	10	10	41	66	66	66	52	52	27	37	56	72	86	94	110	107	89	74	55	71	86	65	26%
5/2/97	106	96	83	44	32	70	70	89	89	89	44	90	75	75	63	44	10	10	19	34	60	76	93	88	64	26%
5/3/97	85	34	40	49	38	40	71	71	94	94	68	53	53	53	53	53	53	53	53	49	23	27	49	72	55	25%
5/4/97	80	75	65	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	57	52	68	87	113	59	27%
5/5/97	109	57	79	79	79	77	80	58	50	48	48	48	48	48	48	42	22	10	60	36	36	10	10	44	51	24%
5/6/97	52	60	60	60	60	69	88	49	31	19	10	10	38	27	23	21	10	10	10	10	10	60	89	63	39	18%
5/7/97	63	44	31	31	10	21	54	54	61	57	52	42	27	5	5	10	14	32	59	48	10	10	10	10	32	15%
5/8/97	50	50	50	50	78	86	86	67	55	10	10	10	10	10	10	10	10	10	10	10	14	41	91	103	39	18%

Appendix B. Wells Dam Hourly Total Spill, in kcfs, 1997

																									Total Spill	
DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	Avg	%
5/9/97	103	103	103	103	103	103	103	75	82	70	64	60	54	38	36	36	31	27	27	27	27	27	23	23	60	27%
5/10/97	50	50	50	55	68	89	116	93	63	56	56	60	60	46	10	10	10	30	60	60	51	23	23	80	53	25%
5/11/97	120	136	121	121	101	146	132	62	10	10	10	10	10	10	10	25	36	41	52	52	52	60	93	140	65	29%
5/12/97	112	85	50	50	50	47	50	56	72	75	63	52	27	10	10	10	10	28	54	82	60	56	63	76	52	23%
5/13/97	86	78	78	86	86	86	86	44	63	83	89	89	71	71	71	71	48	48	48	48	30	10	35	68	65	28%
5/14/97	90	90	95	96	103	100	82	67	67	67	52	74	82	82	82	82	10	10	23	23	13	13	27	36	61	27%
5/15/97	54	54	54	54	54	56	79	59	59	67	67	67	79	79	79	79	79	79	88	87	71	57	52	76	68	28%
5/16/97	91	99	99	105	106	106	100	53	46	48	48	48	48	48	44	40	40	51	79	103	79	53	61	103	71	30%
5/17/97	129	118	118	113	101	92	92	78	68	44	48	58	63	63	83	89	89	110	125	116	113	100	102	98	92	36%
5/18/97	104	115	133	121	117	106	116	129	89	74	74	90	90	90	95	96	82	82	82	86	90	90	90	90	97	36%
5/19/97	122	124	123	123	123	154	151	126	103	105	73	73	56	67	75	75	82	82	81	85	82	79	86	117	99	37%
5/20/97	123	116	116	75	69	75	96	96	110	93	72	67	67	67	63	60	60	60	64	71	75	73	69	82	80	30%
5/21/97	89	96	96	96	96	96	96	96	96	123	116	112	103	96	96	82	82	82	82	124	118	92	105	118	100	35%
5/22/97	123	123	123	123	125	116	130	95	122	105	81	74	82	82	93	84	81	81	81	85	96	96	101	108	100	37%
5/23/97	108	116	133	146	146	164	125	110	100	89	89	89	108	114	114	114	102	89	84	79	79	94	94	125	109	39%
5/24/97	129	129	129	129	129	141	167	126	113	116	116	106	61	62	86	94	94	98	107	106	109	109	115	141	113	39%
5/25/97	148	148	148	148	148	148	161	118	90	83	104	106	106	106	106	95	92	73	73	73	81	98	117	115	112	40%
5/26/97	101	111	120	123	141	149	149	140	115	97	91	87	93	101	101	101	89	89	110	118	118	109	144	174	115	41%
5/27/97	169	161	146	146	146	121	106	89	112	112	112	112	112	112	112	112	114	114	116	116	116	91	97	126	119	42%
5/28/97	148	148	131	131	131	144	131	131	131	131	117	90	90	90	90	90	121	121	89	115	136	121	135	134	121	43%
5/29/97	160	165	165	165	150	165	148	98	98	98	109	109	109	109	109	114	114	114	114	110	110	110	110	110	123	42%
5/30/97	110	160	172	194	194	173	140	91	91	91	91	91	91	91	91	91	91	97	102	102	102	102	102	171	118	42%
5/31/97	182	182	182	150	150	135	173	146	134	126	111	111	118	136	136	101	80	88	95	95	121	121	121	159	131	45%
6/1/97	159	159	179	179	179	179	175	68	23	57	97	107	107	85	80	80	80	83	90	90	105	120	133	200	117	40%
6/2/97	163	163	163	151	151	138	120	120	130	141	141	106	106	106	106	106	106	106	106	113	116	109	110	128	125	43%
6/3/97	144	151	155	165	165	149	140	132	126	126	110	104	132	135	135	135	135	137	139	139	135	135	135	135	137	46%
6/4/97	135	135	142	144	144	155	135	114	114	114	124	124	127	131	151	114	114	114	106	106	106	123	139	175	129	45%
6/5/97	183	178	169	169	166	163	150	131	131	131	131	138	138	145	145	138	142	131	131	131	131	139	145	172	147	48%
6/6/97	184	182	176	176	176	176	159	145	145	145	125	148	148	148	148	148	148	148	148	148	148	148	59	155	151	49%
6/7/97	170	170	139	139	139	139	139	117	117	117	117	117	117	117	117	117	117	117	117	117	123	131	156	186	131	44%
6/8/97	186	178	167	167	167	167	167	167	133	162	162	133	133	133	133	133	133	117	117	132	132	132	117	135	146	48%
6/9/97	141	161	169	169	169	169	169	123	124	124	124	131	131	131	131	125	119	133	149	159	159	115	115	162	142	47%
6/10/97	115	151	151	151	136	136	145	137	138	142	129	129	129	145	160	160	175	178	178	178	170	162	162	193	152	47%
6/11/97	214	214	198	198	198	207	206	194	194	177	139	139	143	155	155	155	155	158	163	187	199	199	214	228	183	51%
6/12/97	209	226	226	209	226	226	188	184	184	184	194	194	194	188	178	177	177	177	177	177	177	177	184	184	192	53%
6/13/97	186	186	187	192	196	203	241	199	199	181	167	169	169	182	187	187	187	187	187	187	187	202	191	183	189	55%
6/14/97	186	195	195	195	183	183	204	205	186	174	184	184	183	183	176	99	45	94	156	193	205	205	205	205	176	53%
6/15/97	207	207	207	198	185	185	167	185	185	191	185	180	180	180	180	173	167	167	161	161	180	177	174	185	182	53%
6/16/97	191	167	154	154	164	197	205	207	185	185	167	167	158	148	148	148	148	167	170	174	174	174	183	185	172	53%

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																									Total Spill	
DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	Avg	%
6/17/97	179	187	180	161	161	187	191	191	191	180	142	142	191	191	191	154	154	154	154	154	168	183	196	202	174	55%
6/18/97	206	198	182	177	177	194	209	217	212	210	192	192	173	154	154	130	140	154	171	168	152	146	150	167	176	54%
6/19/97	170	166	153	153	160	169	202	202	172	172	157	157	157	157	157	157	157	157	157	157	165	165	165	165	165	52%
6/20/97	173	173	173	173	173	199	185	185	133	117	126	151	151	151	151	162	157	172	172	172	172	172	172	172	164	51%
6/21/97	173	173	173	173	173	176	176	164	152	152	152	152	160	160	164	164	164	152	152	161	161	169	169	169	164	50%
6/22/97	170	170	170	170	176	176	176	176	176	176	154	154	154	154	154	154	154	154	154	165	165	143	143	178	163	50%
6/23/97	180	155	155	176	176	176	176	176	184	184	173	166	166	166	166	166	166	166	155	155	155	155	144	159	166	51%
6/24/97	159	176	176	176	176	176	176	176	176	150	128	128	128	104	98	92	83	71	71	97	128	146	136	146	136	48%
6/25/97	146	146	126	100	100	131	155	162	147	137	137	114	89	82	73	73	76	90	120	130	130	130	130	130	119	43%
6/26/97	130	130	130	130	109	101	101	101	101	92	92	92	92	92	92	61	61	61	72	76	76	76	76	99	93	35%
6/27/97	106	94	70	66	66	88	118	119	119	119	110	110	91	91	91	86	86	72	72	72	77	110	110	110	94	36%
6/28/97	110	95	95	95	95	95	104	108	94	90	90	90	90	92	96	52	23	24	47	50	45	45	53	74	77	32%
6/29/97	74	53	28	7	7	7	7	7	7	7	12	62	69	69	69	63	45	45	45	29	7	7	10	52	33	18%
6/30/97	35	13	7	7	7	7	7	7	0	0	0	0	0	0	7	44	50	50	50	50	50	33	50	82	23	14%
7/1/97	82	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	38	38	38	26	45	13	8%
7/2/97	45	24	0	0	0	0	0	0	0	0	0	0	0	0	14	28	52	52	58	51	45	31	0	35	18	11%
7/3/97	65	61	56	56	56	31	28	20	0	0	0	32	35	41	41	41	41	41	41	41	52	52	32	52	38	20%
7/4/97	93	93	0	0	0	0	0	0	0	0	25	36	41	31	31	24	24	42	49	75	75	75	9	37	32	17%
7/5/97	37	37	37	37	37	37	53	36	0	0	0	0	0	0	0	0	0	0	15	63	52	43	5	32	22	12%
7/6/97	32	52	52	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	8	5%
7/7/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6%
7/8/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6%
7/9/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	5%
7/10/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	5%
7/11/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6%
7/12/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	5%
7/13/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	5%
7/14/97	10	10	10	10	10	10	10	10	10	10	10	32	22	22	10	10	21	34	35	31	31	31	31	35	19	9%
7/15/97	39	35	35	50	59	82	75	75	68	64	64	64	59	59	59	48	48	44	40	60	60	60	60	60	57	26%
7/16/97	60	60	60	60	60	60	60	60	60	42	10	10	10	10	10	10	10	10	10	10	10	10	10	10	30	13%
7/17/97	10	10	19	31	59	59	59	49	65	52	21	23	52	52	52	39	39	27	44	79	71	63	55	55	45	19%
7/18/97	65	84	93	95	95	56	43	27	27	10	10	10	33	35	35	35	35	27	27	27	27	27	32	49	42	19%
7/19/97	75	81	81	81	74	53	40	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	28	16%
7/20/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	40	12	6%
7/21/97	40	40	40	40	40	40	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	18	9%
7/22/97	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	5%
7/23/97	10	10	10	10	10	10	26	10	10	10	10	10	10	10	10	21	10	10	10	10	10	10	10	10	11	6%
7/24/97	10	10	10	10	10	10	10	10	40	40	22	30	10	10	10	10	30	30	30	10	10	10	10	10	16	8%
7/25/97	21	52	52	21	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	14	8%

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																									Total Spill	
DATE	HE1	HE2	HE3	HE4	HE5	HE6	HE7	HE8	HE9	HE10	HE11	HE12	HE13	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24	Avg	%
7/26/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6%
7/27/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6%
7/28/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	7%
7/29/97	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	7%
7/30/97	8	8	8	8	8	6	8	8	8	8	8	8	8	10	10	10	10	10	10	10	10	10	9	9	9	7%
7/31/97	8	8	8	6	6	6	6	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	9	8	9	6%

Appendix C. TDG forebay and tailwater data at Wells Dam, 1997

1997 TDG Tailwater Sample Wells Dam

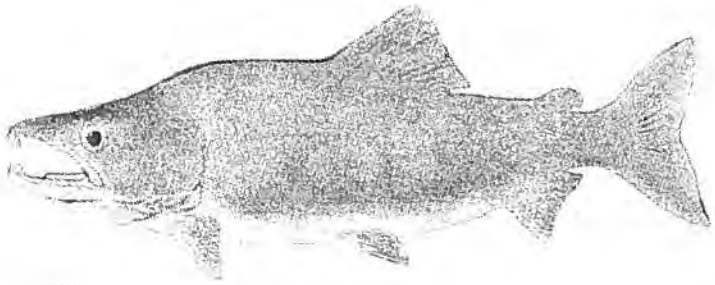
			Foreba	Tailwater sample at RM 514					Difference				
Date	Time	Baromet	% Gas	20%	40%	60%	80%	AVG.	ore - tai	Power Q	Spill Q	% Spill	Comments
6-Jun	15:00	736	128.7	134.9	134.9	134.6	133.8	134.6	5.9	170.9	147.8	46.4%	
11-Jun	13:46	737	126.7	134.5	134.7	136.4	134.9	135.1	8.4	177.5	143.2	44.7%	
17-Jun	9:00	737	122.9	130.7	132.2	132.3	131.3	131.6	8.7	158.9	191.3	54.6%	
24-Jun	11:14	744	123.1	129.4	129.4	129.6	127.8	129.1	5.9	171.2	127.5	42.7%	
2-Jul	9:48	744	115.6		115.1			115.1	-0.5	160.1	0.0	0.0%	no spill, only one reading taken
16-Jul	11:47	741	115.1		120.2			120.2	5.1	166.5	59.8	26.4%	Beebe Br. T-9h or 0300 for river Q
16-Jul	12:35	741	115.1	115.8	116.0	115.9	116.0	115.9	0.8	170.4	10.4	5.8%	Only bypass spill
22-Jul	11:21	740	113.5	114.9	114.7	114.3	114.6	114.6	1.1	193.4	10.0	4.9%	Only bypass spill

DRAFT REPORT - 1997 OKANOGAN RIVER SOCKEYE ESCAPEMENT TO SPAWNING GROUNDS STUDY

APPENDIX G

DRAFT

1997 Okanogan River Sockeye Escapement to Spawning Grounds Study



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

Prepared by:
Trumbley Environmental Consulting Limited
#8 - 4601 23rd Street
Venron, British Columbia, Canada
V1T 4K7

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1997 Okanogan River Sockeye Salmon Spawning Ground Escapement Study

1.0 INTRODUCTION

The Okanogan River is a transboundary river which is spelled Okanagan in Canada and Okanogan in the United States (Klinge, 1996). Since this study was funded by Public Utility District No. 1, of Douglas County, the American spelling was utilized. Annual spawning ground escapement counts are necessary to establish a trends in time data base which is an important tool for developing stock management strategies. The Okanogan River sockeye spawning ground escapement study is an important population monitoring tool. The spawning ground escapement study was conducted in the fall using a mark-recapture population estimate, developed by G. Paulik of the University of Washington, based on the Seber-Jolly multiple mark-recovery model. This method has been utilized since 1992 to determine the Okanogan River spawning ground population.

The Okanogan River Sockeye (*Oncorhynchus nerka)* travel over 1000 km from the mouth of the Columbia River, negotiating 9 dams, before reaching the spawning grounds near Oliver, British Columbia (Figure 1a). This survey concentrated on the main spawning grounds north of Oliver, from the Vertical Drop Structure (VDS) 13 to McIntyre Dam (Figure 1b).

Sockeye are enumerated at Wells Dam in the Columbia River each year. Once beyond Wells Dam, the sockeye are often exposed to warmer water temperatures as they reach the Okanogan River. This warmer temperature is often a barrier to fish migration and may be responsible for the pre-spawn mortality of adult sockeye (Major and Mighell, 1966). An estimated 30-50% of the Wells Dam sockeye are expected to die prior to spawning each year, depending on the water temperatures in July and August (Klinge, 1996). Annually, 50-70% of the Wells Dam count are expected to reach the Okanogan River spawning grounds.

2.0 MATERIALS & METHODOLOGY

2.1 Methods

2.11 Collection of carcasses

The Okanogan River index spawning grounds extended from McIntyre Dam to Vertical Drop Structure (VDS) 13 near Lions Park in Oliver, B.C. Six weekly surveys were conducted to determine the sockeye (*Oncorhynchus nerka)* spawning escapement. The survey area was divided into 5 sections, previously determined using historical concentrations of spawning fish. Each weekly survey consisted of a three day sample period, beginning October 08 and ending November 14 (Table1).

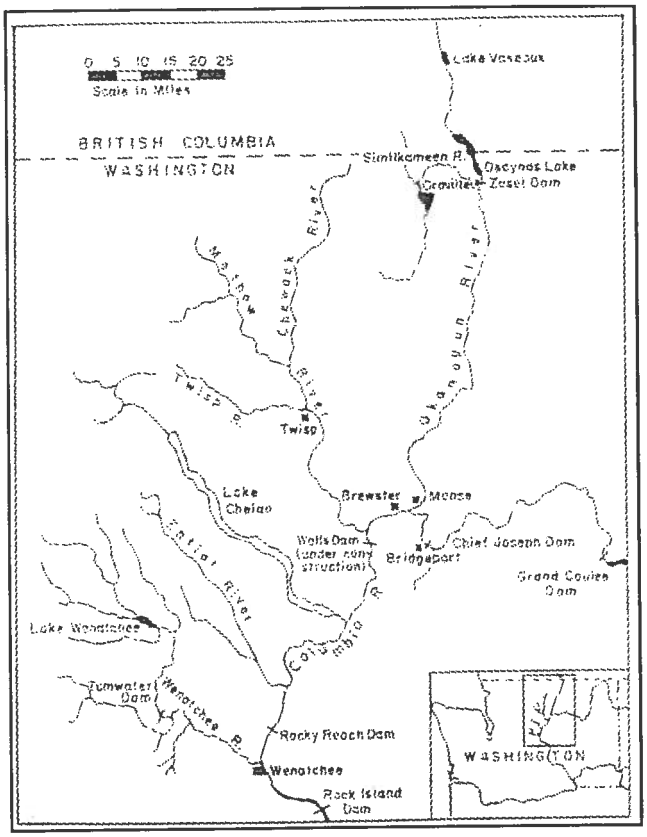


Figure 1a **Map of the migration route of the Okanogan sockeye.**

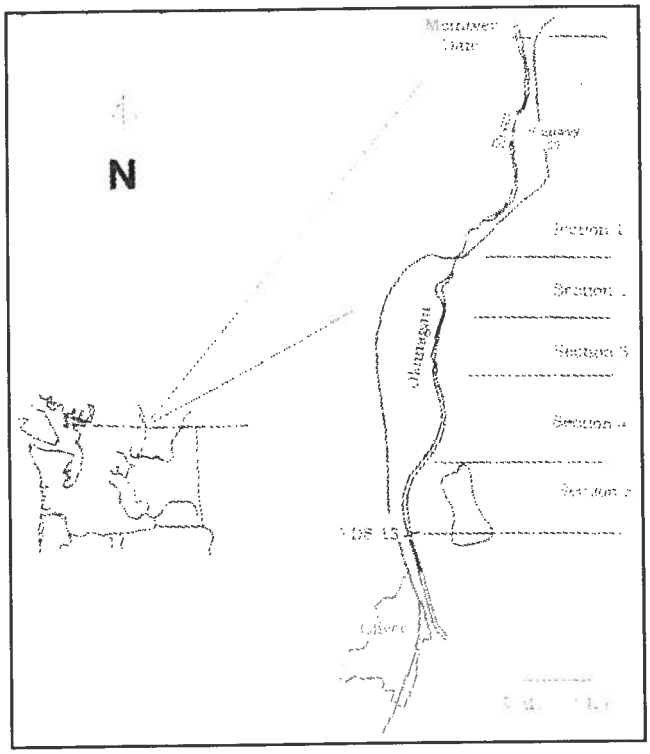


Figure 1b **Map of the Okanogan River sockeye spawning area.**

Table 1 **Schedule for Sockeye Escapement Assessment**

Week	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
10-Oct	Oct 8,9,10					
17-Oct		Oct 15,16,17				
24-Oct			Oct 22,23,24			
31-Oct				Oct 29,30,31		
07-Nov					Nov 5,6,7	
14-Nov						Nov 12,13,14

A four-person crew thoroughly searched the river, banks, side channels and tributaries by foot and raft. All carcasses were retrieved using gaffs and dipnets or by hand. Size (under 30cm) was used as a parameter to identify precocious sockeye (*Oncorhynchus nerka*) and kokanee (*Oncorhynchus nerka*), which were excluded from the enumeration.

A 600m section of river, upstream of McIntyre Dam, was examined once during week 4 for live and dead sockeye and evidence of spawning. This was to determine if any fish migrated upstream of McIntyre Dam during high water periods.

2.12 Sampling of Carcasses

A fish collection permit was obtained through the Department of Fisheries and Oceans, permit number 97.185. All unmarked fish were sexed using external features, examined for fin clips, radio tags, eye tags (numerical or colour coded) and either were marked or removed from the population. Carcasses were marked by punching a hole in the operculum. The fish were then counted and returned to the location from which they were retrieved. The number of holes and the side of the mark changed each week to prevent misidentification. Upon recovery, the carcasses were identified by mark-group and gender, counted, and removed from the population by cutting off the tail. Excessively damaged or decayed carcasses were sexed, counted, and removed. Carcasses were removed if they would not last until the following sample period. This occurred only on severely decayed carcasses.

All fish were examined for fin clips. Fish with ventral clips were sampled for sex, fork length, and scales were collected. One left ventral clip was identified on October 22, 1997. Scales, and data were forwarded to Public Utility District No. 1. Radio tags and various coded tags were removed upon recovery and documented (Appendix 1).

Approximately 50 unmarked fish per week were sampled for gender, fork length and spawning success. All females in this sub-sample were examined for egg retention. A chinook salmon was identified in the tributary coming into the Okonogan River in section one on October 8, 1997. A second chinook salmon was collected on October 22, 1997. The fork length of the female chinook was 81cm. The carcass was turned over to the Department of Fisheries and Oceans during their field sampling.

2.2 *Materials*

The following is a list of materials used to complete the sockeye escapement study in 1997:

-neoprene chest waders	-scale envelopes
-dipnets	-fish measuring board
-hole punches	-polarized glasses
-serrated knives	-shoulder length gloves
-(2) 12 ft. rubber rafts	-oars
-extendible gaffs	-life jackets (PFD)
-hand tallies	-machetes

2.3 *Analysis*

The mark-recovery data was placed in a model supplied by Public Utility District No. 1 of Douglas County. This model was originally developed by G. Paulik with the University of Washington, based on a multiple mark-recapture model developed by Seber-Jolly. It was supplied to the Public Utilities District No. 1 of Douglas County as a spreadsheet by the Washington Department of Fisheries. The model was modified for deaths per period (Di) in the 1995 sockeye escapement estimate (R. Klinge, 1996). This modified form was used to determine the sockeye escapement point estimate for this year.

The following input variables are required for the model.

T_i = number of marks released

C_i = total carcasses examined

R_i = number of marks recovered in C_i

$R_{\cdot i}$ = number of marks recovered from T_i

Z_i = number of carcasses marked before the ith sample period and recovered after the ith sample period

The following output variables are produced by the model:

M_i = number of marked carcasses available

f_i = proportion of population of carcasses that are marked

N_i = total number of carcasses available

u_i = probability of recovering a carcass

D_i = number of fish dying during time interval

B_i = number of D_i available

s_i = proportion of D_i not disappearing during time interval

The spawning escapement estimate is the sum of the estimated fish dying for each interval (D_i).

2.31 Assumptions

The multiple mark-recapture method used depends upon the following :

- The time when the fish are first present on the spawning ground must be known
- There must be at least 5 marking and sampling periods and sampling must be carried out throughout the spawning season
- All fish recovered are either marked or removed from the population
- The time lapse between the first and second sample periods is the same as the time between when the fish first arrived on the spawning grounds and the first sample period

The following assumptions must be met for the model to be reliable (Skalski, 1996):

- The marks are permanent, inconspicuous, and correctly identified upon recovery.
- There is even mixing of the marked carcasses with the unmarked carcasses, so that once a carcass has been marked and returned to the stream it has the same probability of being recovered as an unmarked carcass
- All carcasses have an equal probability of lasting to the next sample period, regardless of their state of decomposition.

3.0 RESULTS

3.1 Mark-Recapture Estimate

The results from the mark-recapture survey are summarized in Table 2. A total of 748 fish were marked of which 289 were recovered for a recovery rate of 39% overall. There were 638 fish removed in total. Weekly summaries of the mark-recapture data can be found in Appendix 2.

Table 2 **A summary of the carcass marking and recovery data used to estimate the 1997 Okanogan River sockeye spawning ground population**

				Mark recoveries (by period)					
Sample Period	Week Ending	Number Marked	Number Removed	2	3	4	5	6	% rec.
1	10-Oct	13	4	1	0	0	0	0	8%
2	17-Oct	63	17		17	1	0	0	29%
3	24-Oct	152	28			61	0	0	40%
4	31-Oct	314	65				86	0	27%
5	07-Nov	206	320					123	60%
6	14-Nov	0	204						
totals		748	638	1	17	62	86	123	39%

Note: No recoveries of any mark group after sample period 2.

The above data was entered into the mark-recapture spreadsheet model and the spawning escapement was calculated. Table 3 contains the results of the spreadsheet calculations. The Okanogan River spawning population in 1997 was estimated to be 4904 fish. This was 19% of the Wells Dam count of 25,754 fish (based on a 16 hour count).

Table 3 **Values used to calculate the 1997 Okanagan River spawning ground population**

i	Ti	Zi	Ri.	R.i	Ci	Mi	fi	Ni	si	ui	Bi	Di
0									0.0000	0.0000	0.00	0.00
1	13	0	0	1	17	0.00	0.0000	0.00	0.0769	0.0000	81.31	1057.00
2	63	0	1	18	81	1.00	0.0123	81.00	0.3094	1.0000	206.38	667.06
3	152	1	17	61	197	19.49	0.0863	225.88	0.4013	0.8722	368.41	918.01
4	314	0	62	86	441	62.00	0.1406	441.00	0.2739	1.0000	526.00	1920.51
5	206	0	86	123	612	86.00	0.1405	612.00	0.5971	1.0000	204.00	341.66
6	0	0	123	0	327	123.00	0.3761	327.00	0.0000	1.0000	0.00	0.00
											Total spawners:	4904

The crew walked upstream of McIntyre Dam for approximately 600m. There were no live or dead sockeye identified upstream of McIntyre Dam on October 29, 1997, nor were any redds found. The crew visually observed people fishing for rainbow trout (*O. mykissi*). On October 24, 1997, five sockeye were observed floating downstream of VDS 13 at Lyons Park. Sockeye were sighted downstream of Skaha Dam (Klinge, pers comm).

3.2 *Sex Ratio*

The sex ratio for all fish examined per period is summarized in Table 4 below. Overall, 37.8% of the carcasses were male while 62.2% were female.

Table 4 **Sex ratio of sockeye carcasses for each period**

Period	Date	Number		Total Fish	Percent	
		male	female		male	female
1	Oct 8-10	8	9	17	47.1	52.9
2	Oct 15-17	46	34	80	57.5	42.5
3	Oct 22-24	88	92	180	48.9	51.1
4	Oct 29-31	150	229	379	39.6	60.4
5	Nov 5-7	156	370	526	29.7	70.3
6	Nov 12-14	76	128	204	37.3	62.7
Total		524	862	1386	37.8	62.2

3.3 *Fish Length*

The mean fork length of the 176 fish sampled was 19.5 inches (496 mm) with a range of 15.9" - 26.4" (405 mm - 670 mm). The mean fork lengths for female and male sockeye were 18.9" (480 mm) and 17.3" (439 mm), respectively (Appendix 3).

3.4 *Egg Retention*

All females sampled were inspected for egg retention. The results for each period are outlined in the Table 5. An average fecundity of 2000 eggs per female was used to calculate the percentage of eggs remaining. The categories are the same as those used in the 1992, 1993 and 1996 sockeye spawning ground escapement studies (Hagen &Grette,1994). Of the females examined, 94.5% were completely spawned, 4.5% were partially spawned, and 1.0% were unspawned.

Table 5 **Egg retention results for each period**

			Eggs Remaining					
			0-5%		6-76%		77-100%	
Sample			completely spawned		partially spawned		unspawned	
Period	Dates	n	# fish	%	# fish	%	# fish	%
1	Oct 8-10	1	0	0	1	100	0	0
2	Oct 15-17	17	15	88.2%	2	11.8%	0	0.0%
3	Oct 22-24	27	25	92.6%	1	3.7%	1	3.7%
4	Oct 26-31	38	38	100.0%	0	0.0%	0	0.0%
5	Nov 5-7	24	23	95.8%	1	4.2%	0	0.0%
6	Nov 12-14	3	3	100.0%	0	0.0%	0	0.0%
Total		110	104	94.5%	5	4.5%	1	1.0%

3.5 *Fish Densities By Sample Section*

The studied portion of the Okanogan River was divided into 5 sections and sampled over 6 periods. Historically the study covered 5 periods, however an additional study period was included in 1997. The carcass counts increased significantly between periods 3 and 4, peaked in period five and then tapered off to period 6 (Table 6). This trend indicates that sampling occurred throughout the spawning period. The peak die-off occurred between the fourth and fifth periods, with period 5 having the highest carcass count.

Table 6 **Okanagan River Sockeye Carcass Count**

		Carcass Count					
Week Ending	Sample Period	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Total
Oct-10	1	10	1	2	2	2	17
17-Oct	2	26	15	7	12	20	80
24-Oct	3	82	40	8	25	25	180
31-Oct	4	113	48	50	84	84	379
07-Nov	5	301	60	85	25	55	526
14-Nov	6	84	15	29	36	40	204
Length (Km)		3.5	0.9	0.65	1.7	0.75	7.5

Section 4 had the lowest fish density throughout the survey, and section 5 had the highest fish density in all but periods 3 and 5. Period 1 had the lowest fish density whereas periods 4 and 5 had the highest fish density (Table 7).

Table 7 **Okanagan River density of Sockeye carcasses**

Fish per Km							
Week Ending	Period	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Total
Oct-10	1	3	1	3	1	3	11
Oct-17	2	7	17	11	7	27	69
Oct-24	3	23	44	12	15	33	127
Oct-31	4	32	53	77	49	112	323
Nov-07	5	86	67	131	15	73	372
Nov-14	6	24	17	45	21	53	160
Total		175	199	279	108	301	

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Mark Recapture Survey

In order for the WDF- Paulik mark recapture model used for this study to be reliable all assumptions must be met. It is believed that this was the case in the current study as explained below.

- The time when the fish are first present on the spawning grounds must be known
- The time lapse between the first and second sample periods is the same as the time between when the fish first arrived on the spawning grounds and the first sample period
- There must be at least 5 marking and sampling periods and sampling must be carried out throughout the spawning season;
  The survey consisted of six weekly sample periods. The carcass counts indicate that the survey dates covered from beginning to the end of the post-spawning die-off.
- All fish recovered are either marked or removed from the population;
  This assumption was met throughout the survey. The Department of Fisheries, and Oceans, (D.F.O.) was on site collecting and marking carcasses on October 22, 1997. D.F.O. used similar markings to this study however the hole punch was smaller in diameter than the hole punches used by Trumbley Environmental Consulting Ltd. (T.E.C.). The hole punch was put on the right side by D.F.O. however, if the carcass was already marked then the opposite side was used. The sampling was conducted in week 3 of the T.E.C. study. Crews were able to identify carcasses marked by D.F.O. in the following sample period. Crews treated these fish as new samples unless marked by T.E.C. previously. D.F.O. collected approximately 100 samples for DNA testing. Fifty four fish were also removed from the study area for disease analysis. Eight carcasses were removed out of McIntyre Creek but contained no radio tags. Fifteen carcasses were removed from the study near VDS 9 because they were in too poor of condition to be returned to the river. Barry Rosenberger of D.F.O. stated that D.F.O. noticed T.E.C. opercule punches in their samples. D.F.O. will be sampling approximately 50 to 60 fish/ year for the next 3 to 4 years. More communication is needed between Trumbley Environmental Consulting and the Department of Fisheries and Oceans so we may coordinate our efforts in retrieving quality data.
- The marks are permanent, inconspicuous and correctly identified upon recovery;
  The hole punch in the opercle worked very well for this survey. The mark was only detectable when fish were removed from the water and closely inspected. To eliminate misidentification of mark periods, the number of holes and the side of the mark alternated from week to week. Upon retrieval, both sides of the fish were checked for marks to ensure that a fish was not marked for two sample periods by mistake. The marks were permanent as long as the opercles and heads remained intact. Even on

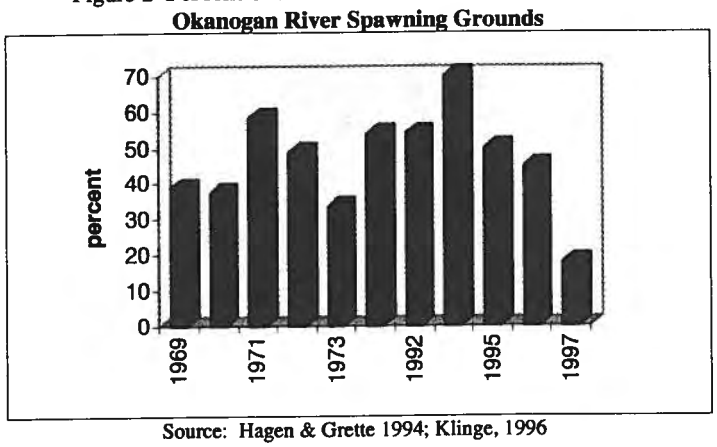
extremely rotten fish the marks were identifiable. The heads and opercles of a few fish were missing due to predation. This problem was unavoidable. These fish were not included in the model as recaptures, because proper mark identification was not possible.

- There is even mixing of the marked carcasses with the unmarked carcasses, so that once a carcass has been marked and returned to the stream it has the same probability of being recovered as an unmarked carcass;
  Because the marks are inconspicuous, and once a fish was marked it was returned to the location from which it was retrieved, there is no reason to believe this assumption was not met. However DFO noted approximately 30 to 35 carcasses on a shoal half out of the water. All T.E.C. personnel have a background in fisheries and knew the importance of returning carcasses to the river. D.F.O. stated that the carcasses had two hole punches. This would have been in the third sample period and would be removals when retrieved.
- All carcasses have an equal probability of lasting to the next sample period, regardless of their state of decomposition;
  The state of decomposition varies from fish to fish because the fish are dying at different times. The newer carcasses have a greater probability of lasting to the next sample period than the older carcasses. This introduces a potential bias. This bias was minimized by sampling fish in all stages of decomposition. A thorough search for extremely decomposed as well as newer carcasses was done throughout the survey. The loss to decomposition was minimal because of the thorough survey techniques.

4.2 *Escapement Estimate*

A comparison of the spawning escapement numbers over past years does not have much value in itself because there is not enough historical data available to determine trends and make projections. More consistent consecutive surveys are necessary for these data to be relevant. What is relevant is a comparison of the percent of the Wells Dam count that has reached the Okanogan River spawning grounds (Figure 2).

Figure 2 **Percent of the Well's Dam count that reach the Okanogan River Spawning Grounds**



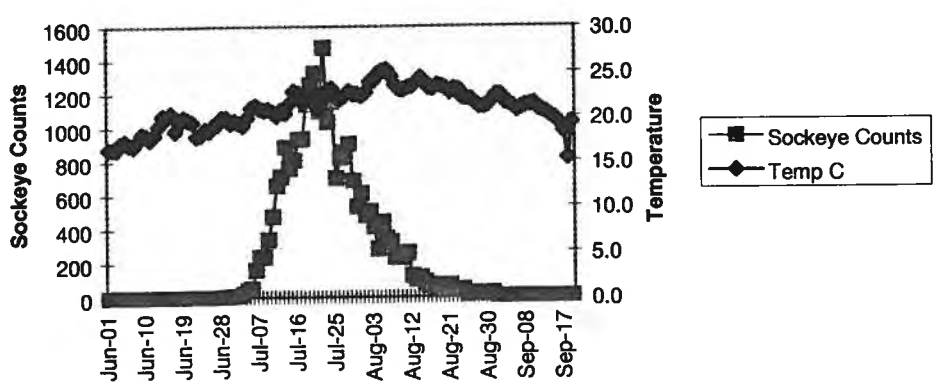
Source: Hagen & Grette 1994; Klinge, 1996

This year it was expected that 70% of the Wells Dam count (25,754 fish, 16 hour count) would reach the spawning grounds, due to the good condition of the fish as

they passed the dam. However, only 19% of the fish reached the spawning grounds. The proportion of the Wells Dam count that reached the spawning ground in 1997 lies below the range found historically (Figure 2). Some variables which may affect the escapement numbers are discussed here.

- There may be unreported fisheries between Wells Dam and the spawning grounds.
- There may be a disturbance downstream affecting the passage of fish.
- Water quality may be a problem downstream, causing some pre-spawn mortality.
- Glen Szerlong noted that 65% of the sockeye travelling through the fish ladder on the Washington side of the Bonneville Dam have symptoms of gas bubble disease. Sockeye swim higher in the water making them more vulnerable. The record runoff in the Columbia River in 1997 caused dams to spill enormous volumes of water. The foaming rapids created as a result of high flows pump high levels of nitrogen into the water below the dams (The Spokesman-Review, 1997).
- Spawning lower in the Okanogan River and in Osoyoos Lake may have occurred. Radio tag retrievals show that spawning occurred outside the survey area between VDS 1 & 2, lower river mouth and in McIntyre Creek, (Klinge, pers comm). Thus the index area is not a good representation of the spawning area. It is recommended that a survey crew traverse the Okanogan River between McIntyre Dam and Skaha Lake Dam to determine the numbers of sockeye travelling upstream during high water conditions. The irrigation ditch downstream of McIntyre Dam should be monitored to gauge the rate and mode of passage of sockeye.
- Fish may have migrated into tributaries before reaching the spawning grounds
- The high water temperatures in the Okanogan River in late July and early August may have caused a thermal barrier to fish passage, resulting in some pre-spawn mortality. The peak sockeye counts at the Wells Dam occurred between July 12 and July 21 (Figure 3).

Figure 3 - Okanogan River Temperatures at Zosel Dam and Wells Dam Sockeye Counts

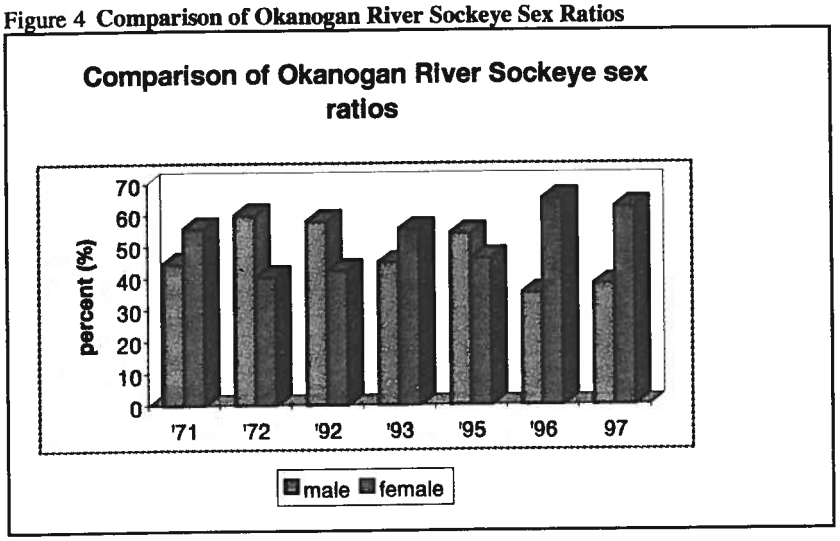


- It takes approximately 3-4 days for the fish to reach Lake Osoyoos from Wells Dam (R.Klinge, pers.comm.). Therefore, the majority of the salmon should have been in Lake Osoyoos by August 5 when the water temperatures peaked (Figure 3). Given that the cooler bottom waters of the lake may be anoxic, therefore not usable by sockeye (Rensel, 1996), the sockeye may not have been able to avoid the undesirable warm water. The effect this would have on the escapement numbers is unknown.
- Fluctuations in discharge rates throughout the sample periods.

4.3 Sex Ratio

The sex ratio of 35.1% male and 64.9% female was based on 100 % of the carcasses handled. The ratio of more females to males is not unusual given that these are the normal findings when sampling is done by dead pitch (B. Shepherd , 1994). Figure 4 compares the sex ratios from past studies. Results for 1971, 1972, and 1992 are based on a sub-sample of the total carcasses. In 1993, 100% of the carcasses handled were used to determine sex ratio (Hagen & Grette, 1994). The 1995 ratio is based on a sub-sample of 149 fish which is approximately 20% of the total carcasses handled (R. Klinge, 1996).

Figure 4 **Comparison of Okanogan River Sockeye Sex Ratios**

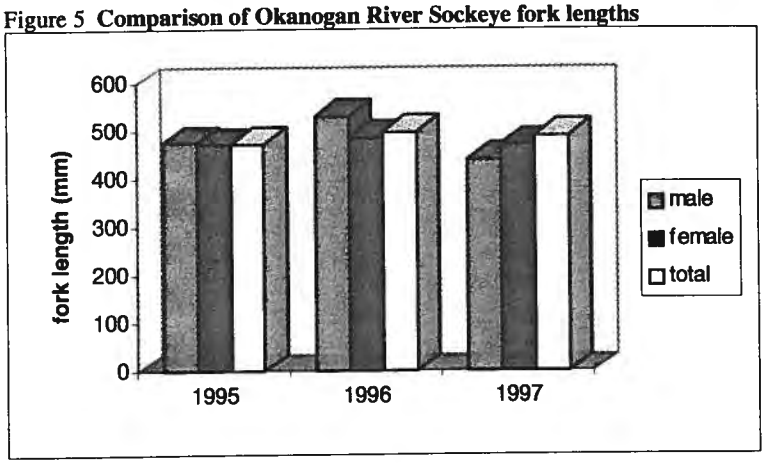


The sex ratios from 1993, 1996 and 1997 are based on actual counts, and not extrapolated as in other years for which data was available. These results represent a truer sex ratio than other years included in this comparison. It is recommended that future sex ratios be based on the entire sample population, not on a sub-sample. A copy of the field form used to organize the field data is located in Appendix 4.

4.4 Fish Length

The sockeye sampled in 1997 were larger than those sampled by Klinge in 1995 (Figure 5). The mean fork lengths in 1995 were 473mm overall (males 475mm and females 471mm) (Klinge, 1996). The average fork lengths in 1996 were 498mm overall (males 530mm and females 487mm). The average fork lengths in 1997 were 496mm overall (males 439mm and females 480mm). The sockeye in 1997 were similar in length to the 1996 sockeye.

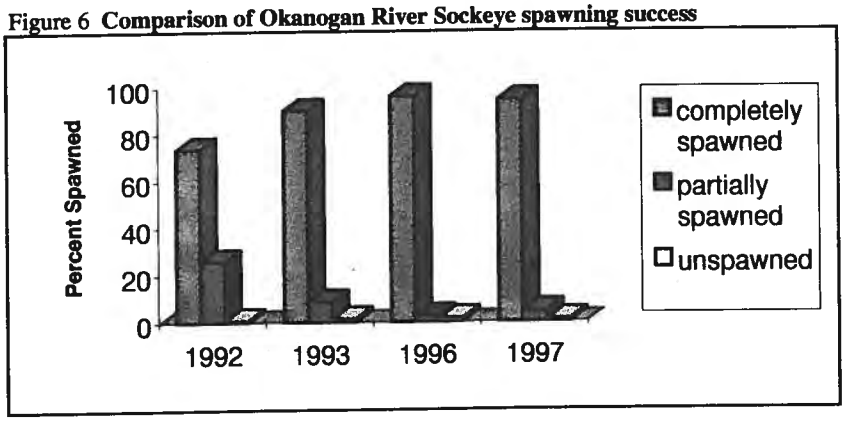
Figure 5 **Comparison of Okanogan River Sockeye fork lengths**



4.5 Egg Retention

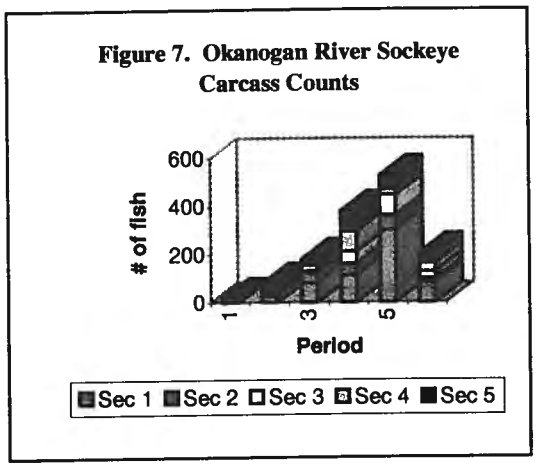
Spawning is considered to be successful if pre-spawn mortality is less than 5% (B.Shepherd, 1994). Therefore, spawning was successful this year as indicated by the egg retention results outlined in Table 5. Results indicate that spawning success was higher in 1996 & 1997 than in both 1992 and 1993 (Figure 6). In 1992, of the 148 fish that were sampled, 73.6% were completely spawned, 25.7% were partially spawned, and 0.7% were unspawned. In 1993, 90% of the 70 fish examined for spawning success were completely spawned, 8.6% were partially spawned, and 1.4% were unspawned (Hagen & Grette, 1994). In 1996, of the 206 females sampled, 96.1% were completely spawned, 2.4% were partially spawned, and 1.5% were unspawned. In 1997, of the 110 fish sampled, 94.5% were completely spawned, 4.5% partially spawned and 1% unspawned.

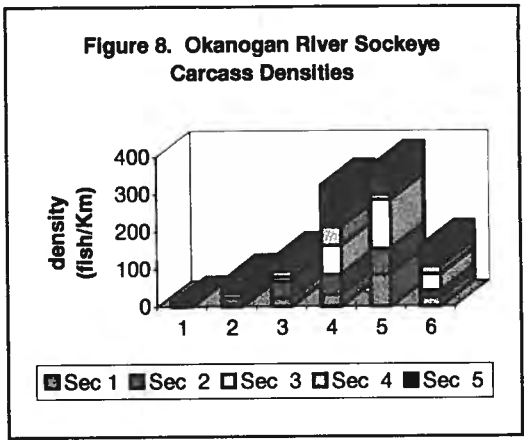
Figure 6 **Comparison of Okanogan River Sockeye spawning success**



4.6 Fish Densities by Sample Section

Drastic fluctuations in discharge and water levels occurred during the sample periods. A comparison of discharge, water level and density indicates these factors had an effect on the recovery of carcasses. The absence of recoveries of any mark group after sample period 2 also indicates that the carcasses were being flushed out of the index area. The peak carcass count and density occurred during the fourth and fifth sample periods (Figures 7 & 8).



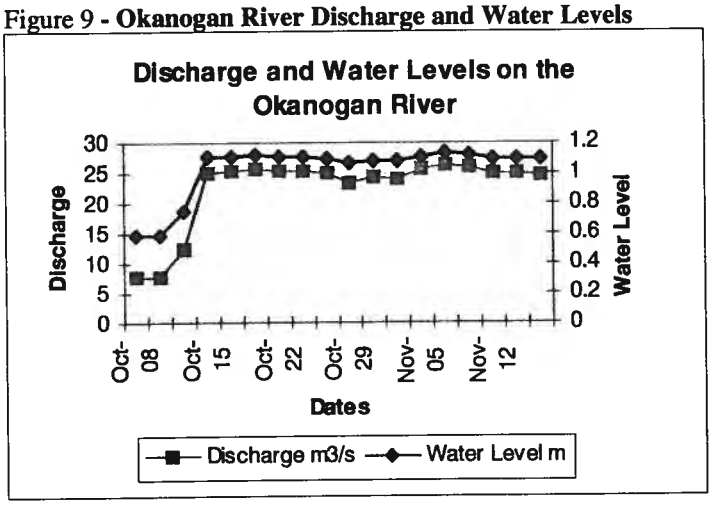


The discharge and water levels fluctuated throughout the sample periods. Increases in discharge caused carcasses to be flushed downstream (Table 8, Figure 9).

Table 8 **Discharge and Water Levels on the Okanogan River**

Date	Discharge m^3/s	Water Level m
Oct-08	7.62	0.585
Oct-09	7.8	0.592
Oct-10	12.5	0.742
Oct-15	25.1	1.101
Oct-16	25.5	1.112
Oct-17	25.7	1.115
Oct-22	25.2	1.104
Oct-23	25.2	1.103
Oct-24	25	1.099
Oct-29	23.4	1.061
Oct-30	24.2	1.082
Oct-31	24.1	1.079
Nov-05	25.6	1.113
Nov-06	26.2	1.127
Nov-07	26	1.124
Nov-12	25	1.099
Nov-13	24.9	1.098
Nov-14	24.8	1.095

Figure 9 - **Okanogan River Discharge and Water Levels**



The discharge was 7.62m^3/s and 7.80m^3/s on October 8 and 9, respectively. On October 10, 1997 the discharge increased to 12.5 m^3/s. Peak discharges occurred during sample period two (25.1m^3/s) and remained high for the duration of the study. A slight decrease in discharge and water levels occurred on October 29, 30 and 31, 1997. Discharges were taken from an Environment Canada monitoring station. In 1997, of the estimated 70% Wells count to reach the index area, 19% were successful. The high discharge flushed carcasses out of the index area. Crews visually observed the carcasses floating out of the index area during their counts. It is recommended that discharge be measured by the survey crews at the beginning and end of each sample day. Discharge rates measured would therefore be site specific. Trends in discharge data would be a useful tool in determining its effect on the escapement estimate. Ultimately this data could be used to establish a maximum and minimum discharge.

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APPENDICES

Appendix 1

Radio Tags

Date	Section	Channel	Code	Tag Color
October 08, 1997	1	22	165	none
October 17, 1997	4	15	52	none
October 23, 1997	2	20	159	none
October 29, 1997	1	21	154	letter code BF4
October 31, 1997	4	20	07	letter code CA5
November 05, 1997	1	15	167	none
November 07, 1997	5	19	169	letter code CC7

Color Tags

October 22, 1997	yellow eye tag on female sockeye in section one.
October 23, 1997	letter code AN6 on female in section two.
October 22, 1997	left ventral clip on female in section one.
October 31, 1997	letter code BP0 on female in section four.

Appendix 2

1997 Okanagan River Sockeye Escapement Summary
October 8, 9, 10

Section	Marked		Removed	
	Male	Female	Male	Female
1	3	4	1	2
2	1	0	0	0
3	1	0	0	1
4	2	0	0	0
5	0	2	0	0
Total	7	6	1	3

A chinook salmon was located and identified in the coming into the Okonogan River in section one
The chinook was not yet expired and was approximately 23cm (9.5 inches)

1997 Okanagan River Sockeye Escapement Summary
October 15, 16, 17

Section	Marked		Removed		Week 1 Recoveries	
	Male	Female	Male	Female	Male	Female
1	6	6	6	8	0	1
2	8	5	1	1	0	0
3	4	2	1	0	0	0
4	10	2	0	0	0	0
5	10	10	0	0	0	0
Total	38	25	8	9	0	1

1997 Okanagan River Sockeye Escapement Summary
October 22, 23, 24

Section	Marked		Removed		Week 1 Recoveries		Week 2 Recoveries	
	Male	Female	Male	Female	Male	Female	Male	Female
1	22	47	6	7	0	0	3	6
2	21	15	3	1	0	0	3	1
3	5	3	0	0	0	0	0	0
4	12	7	4	2	0	0	3	1
5	12	8	3	2	0	0	0	0
Total	72	80	16	12	0	0	9	8

An 81cm (fork length) female Chinook was recovered south of section 1. The carcass was harvested and turned over to the Department of Fisheries and Oceans.

1997 Okanagan River Sockeye Escapement Summary
October 29, 30, 31

Section	Marked		Removed		Week 1 Recoveries		Week 2 Recoveries		Week 3 Recoveries	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	40	62	1	10	0	0	0	0	16	14
2	15	23	3	7	0	0	0	1	3	7
3	12	23	4	11	0	0	0	0	2	0
4	25	42	11	6	0	0	0	0	5	7
5	32	40	7	5	0	0	0	0	6	1
Total	124	190	26	39	0	0	0	1	32	29

1997 Okanagan River Sockeye Escapement Summary
November 5, 6, 7

Section	Marked		Removed		Week 1 Recoveries		Week 2 Recoveries		Week 3 Recoveries		Week 4 Recoveries	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	26	109	61	105	0	0	0	0	0	0	8	38
2	4	15	13	28	0	0	0	0	0	0	2	11
3	4	19	20	42	0	0	0	0	0	0	2	9
4	3	7	3	12	0	0	0	0	0	0	4	5
5	4	15	18	18	0	0	0	0	0	0	2	5
Total	41	165	115	205	0	0	0	0	0	0	18	68

1997 Okanagan River Sockeye Escapement Summary

November 12, 13, 14

Section	Marked		Removed		Week 1 Recoveries		Week 2 Recoveries		Week 3 Recoveries		Week 4 Recoveries		Week 5 Recoveries	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	0	0	21	63	0	0	0	0	0	0	0	0	12	76
2	0	0	8	7	0	0	0	0	0	0	0	0	6	7
3	0	0	13	16	0	0	0	0	0	0	0	0	3	6
4	0	0	18	18	0	0	0	0	0	0	0	0	3	6
5	0	0	16	24	0	0	0	0	0	0	0	0	1	3
Total	0	0	76	128	0	0	0	0	0	0	0	0	25	98

Appendix 3

1997 Okanagan River Sockeye Escapement Sample Data - Week 1			
Gender	Length (mm)	# of Eggs	% Eggs Remaining
F	528	350	18
M	584	0	0
	Total	Male	Female
Average	556	584	528
Escapement Sample Data - Week 2			
F	450	450	23
M	520	0	0
F	495	20	1
M	528	0	0
M	530	0	0
M	560	0	0
M	545	0	0
F	442	0	0
F	468	200	1
F	480	0	0
F	509	0	0
F	459	20	1
M	480	0	0
F	480	50	0
M	500	0	0
M	521	0	0
F	470	0	0
M	555	0	0
M	480	0	0
F	500	0	0
F	520	40	2
F	450	0	0
M	510	0	0
F	465	100	5
F	510	0	0
F	450	0	0
F	465	30	2
M	510	0	0
M	455	0	0
F	510	0	0
	Total	Male	Female
Average	494	515	478

Escapement Sample Data - Week 3

Gender	Length (mm)	# of Eggs	% Eggs Remaining
F	510	0	0
F	450	0	0
F	460	0	0
F	490	0	0
F	410	0	0
M	560	0	0
M	530	0	0
M	510	0	0
F	490	0	0
F	490	40	2
M	510	0	0
F	450	20	1
M	505	0	0
M	470	0	0
M	500	0	0
M	480	0	0
F	510	0	0
F	405	3000	150
F	485	200	10
F	450	50	3
F	480	0	0
F	510	0	0
M	460	0	0
F	425	0	0
F	440	0	0
F	490	0	0
F	570	0	0
M	510	0	0
F	500	0	0
M	580	0	0
M	580	0	0
F	460	0	0
F	470	0	0
M	470	0	0
M	540	0	0
M	550	0	0

Gender	Length (mm)	# of Eggs	% Eggs Remaining
F	520	0	0
M	470	0	0
F	460	0	0
M	475	0	0
M	670	0	0
M	500	0	0
F	490	0	0
F	470	0	0
F	470	0	0
M	520	0	0
M	460	0	0
M	500	0	0
F	440	0	0

	Total	Male	Female
Average	493	516	474

Escapement Sample Data - Week 4

Gender	Length (mm)	# of Eggs	% Eggs Remaining
F	460	0	0
F	470	0	0
F	420	0	0
M	510	0	0
M	520	0	0
F	520	0	0
M	500	0	0
F	480	0	0
F	500	0	0
F	490	80	4
F	500	0	0
F	450	10	1
F	460	0	0
F	450	0	0
F	490	10	1
M	510	0	0
M	470	0	0
M	465	0	0
M	480	0	0
M	505	0	0
F	485	0	0
F	450	0	0
F	470	0	0
F	450	0	0
F	440	0	0
F	490	0	0
F	445	20	1
F	475	0	0
M	530	0	0
M	540	0	0
M	480	0	0
F	475	0	0
M	510	0	0
F	490	0	0
M	490	0	0
M	510	0	0
F	440	0	0
F	470	0	0
M	630	0	0

Gender	Length (mm)	# of Eggs	% Eggs Remaining
F	490	0	0
F	470	0	0
M	490	0	0
F	460	0	0
F	450	0	0
F	480	0	0
F	435	0	0
M	500	0	0
F	478	0	0
F	450	0	0
F	445	0	0
F	470	0	0
F	460	0	0
F	460	0	0
M	500	0	0
M	500	0	0
M	485	0	0
M	495	0	0
F	490	0	0
M	630	0	0
F	480	0	0

	Total	Male	Female
Average	493	518	468

Escapement Sample Data - Week 5			
Gender	Length (mm)	# of Eggs	% Eggs Remaining
M	485	0	0
F	490	0	0
F	505	0	0
M	530	0	0
F	455	0	0
F	450	0	0
F	450	0	0
M	510	0	0
F	452	0	0
M	512	0	0
F	490	0	0
F	475	0	0
F	470	0	0
M	445	0	0
F	460	0	0
F	450	0	0
F	490	0	0
F	460	0	0
F	480	0	0
F	450	0	0
F	470	0	0
F	410	0	0
M	530	0	0
M	520	0	0
F	450	0	0
F	470	0	0
F	450	0	0
F	500	0	0
F	485	200	10
F	475	0	0
F	460	0	0
M	460	0	0
	Total	Male	Female
Average	475	499	467

Escapement Sample Data - Week 6			
Gender	Length (mm)	# of Eggs	% Eggs Remaining
F	480	0	0
F	450	0	0
F	460	20	1
	Total	Male	Female
Average	463	0	463

Trumbley Environmental Consulting Limited

Sockeye Escapement Tally Form

Date:
Tallier:

Week One		Week Two		Week Three		Week Four		Week Five	
Male	Female	Male	Female	Male	Female	Male	Female	Male	Female

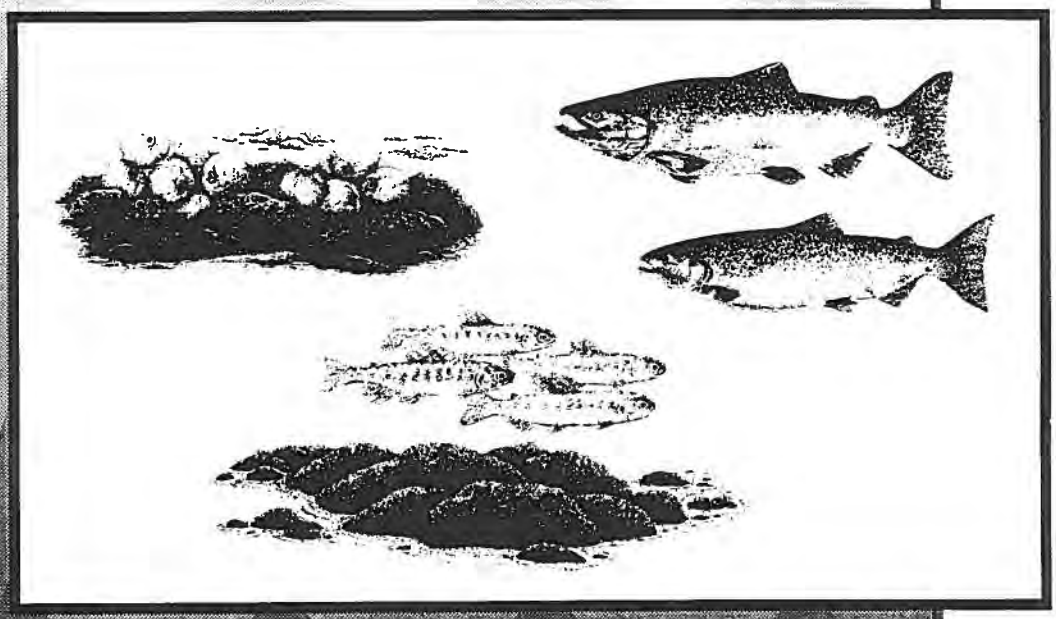
SUMMARY REPORT: METHOW BASIN SPRING CHINOOK SALMON HATCHERY 1995 BROOD YEAR

DRAFT REPORT: METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN NATURAL PRODUCTION STUDY 1995 ANNUAL REPORT

APPENDIX H

STATE OF WASHINGTON June 1997

1995 Summary Report for Methow Basin Spring Chinook Salmon Hatchery Program



by Heather R. Bartlett

Washington Department of
FISH AND WILDLIFE
Hatcheries Program
Assessment and Development Division

prepared for Douglas County
Public Utility District

Report # 97-11

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Abstract

The juvenile migrant bypass system at Wells Dam (river km 830.1 Columbia River) near Chelan, Washington was completed in 1988. The bypass system has a fish passage efficiency of 89%, which exceeds the goals established in the Wells Settlement Agreement (Skalski et al. 1996). However, it was understood at Wells Dam there may still be a certain amount of unavoidable, and to date unmeasured, juvenile losses. To compensate for losses, Douglas County Public Utility District #1 agreed to construct and fund the operations of several fish hatcheries at the 14% compensation level. The Methow FH is one of those facilities. The goal of the Methow Fish Hatchery (MFH) is to supplement adult spring chinook production in a manner that minimizes ecological and genetic risks to the natural population. The specific objective for the hatchery is to produce 22,700 kg of spring chinook salmon yearlings, released at 30 g each. This requires the collection of enough adult brood stock to meet the release numbers. MFH is directed to use fish cultural methods that maintains the unique genetic characterisitics of the stocks in the Methow, Chewuch, and Twisp rivers, and to release high quality smolts (Peck 1993).

In 1995, 67 adult (age 3+) spring chinook salmon and 36 jacks escaped past Wells Dam. The 1995 run marked the lowest escapement above Wells Dam since the project completion in 1967. The most recent ten year average for spring chinook salmon over Wells Dam is 1,978 adults and 57 jacks, with half the run counted by 24 May. Spring chinook salmon are counted at Wells Dam 1 May through 28 June.

The Winthrop National Fish Hatchery (WNFH) spring chinook salmon escapement in 1995 was seven adults (five females and two males). Yakama Indian Nation field crew counted nine redds in the Methow River, two in the Chewuch River, and four in the Twisp River (Hubble et al. 1995 in review).

The MFH collected five adults and two jacks from the hatchery outfall channel. In addition, the WNFH transferred seven adult chinook they collected to the MFH, but one female died during transfer. Adult pre-spawn survival was 93%. Adjusted egg take was 29,813, with a green egg to fry survival of 97.9%, a fry to smolt survival of 99.5%, and a green egg to smolt survival of 98.7%. The Methow FH released 14,238 smolts (431 kg) in spring 1997. We did not operate the adult traps, nor collect any adult salmon from the Chewuch or Twisp rivers.

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Acknowledgments

The 1995 Methow Fish Hatchery evaluation report is the product of a number of peoples' work, both administratively and technically within the Washington Department of Fish and Wildlife. I thank Larry Brown, Tami Black, Kathy Hopper, Gary Schurmann, Patty Michak, Craig Busack, Jim Shaklee, John Sneva, and Rod Woodin for helping to make this project work. In addition, I would like to thank Geraldine Vander Haegen for reviewing and providing helpful comments on the report.

Complex manager Jerry Moore, hatchery managers Bob Jateff and Guy Wiest, and fish culturist Dave Dinsmore were cooperative and supportive to the hatchery sampling needs. The WNFH crew were also helpful and supportive to the hatchery sampling needs.

Electrophoretic analyses were done by WDFW genetics unit; Craig Busack, Anne Marshall, and Jim Shaklee. John Sneva analyzed all the scales for age and origin.

Rick Klinge, Douglas County PUD has been helpful and supportive regarding the evaluation project's objectives and needs.

Section 1: Introduction

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 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 Wells Coordinating Committee developed a comprehensive evaluation plan to monitor progress towards 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, 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 (YIN), 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:

1. Determine if the MFH can meet a negotiated production level for compensation during development of the artificial propagation program facilities as required in the Wells Project Settlement Agreement.

2. Determine that the Phase 1 Methow hatchery program conserves 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.

Although the objectives provide a framework for operation and monitoring, adaptive management plays a strong role. Therefore, the objectives may be modified yearly to better accomplish the goals. This flexibility has resulted in each year of operation being different from another, either in the location of adult collection, origin of adults collected, number of adults collected, and/or juvenile rearing water source. The hatchery program was also intended to escalate to the established adult collection and juvenile release numbers. In the face of low adult populations, we did our best to meet goals established for the facility at the same time we addressed stock decline concerns. This report summarizes the 1995 BY evaluation of the MFH. The contract period is 1 July 1996 to 30 June 1997 between Douglas County PUD and WDFW.

Section 2: Study Site

2.1 Methow Fish Hatchery

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

The MFH provides separate incubation and rearing of the three Methow Basin spring chinook salmon stocks. It is located in Winthrop WA, along the Methow River 83 km from its confluence with the Columbia River. The hatchery has three canopy covered adult salmon holding ponds, 12 canopy covered juvenile raceways, 24 indoor start tanks, and one plastic lined acclimation pond, where fish can be released directly into the Methow River. There are three separate incubation rooms with 15 single stack vertical incubators. About 200 m upstream from the MFH is a small boulder dam and the intake for the Foghorn Irrigation Ditch. There is an adult collection trap at the irrigation intake, which was completed in fall 1995.

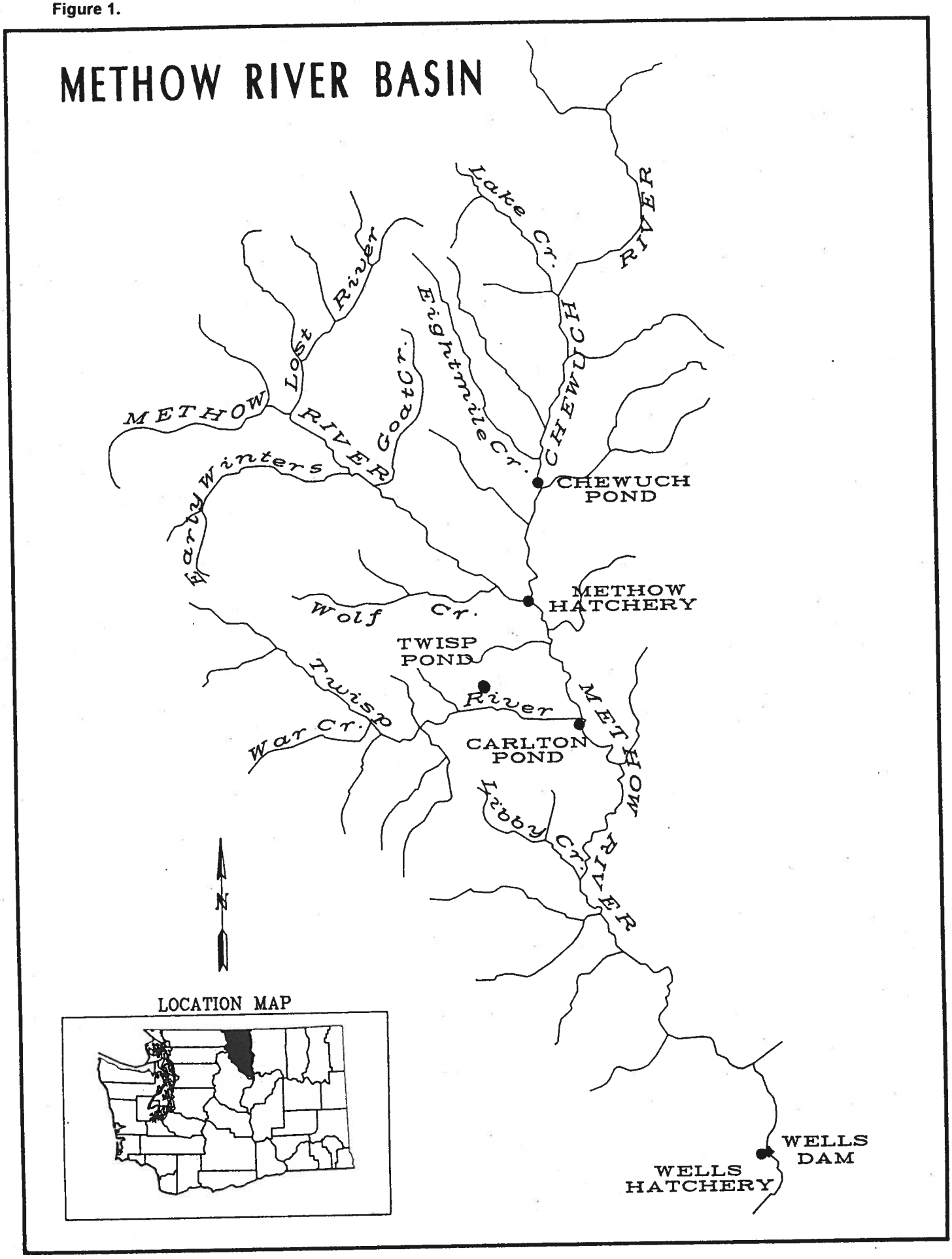
Four ground water wells provide 0.28 m^3/s of water. The water temperature is a constant 9°C all year. The MFH also uses up to 0.31 m^3/s of Methow River water. An additional 0.2 m^3/s is shared with the WNFH during the spring. The WNFH is 2.4 km downstream from the MFH.

The MFH program was designed to use only naturally produced spring chinook salmon for brood stock. The actual number and origin (hatchery or wild) is dependent upon the availability of brood stock. In the hatchery, the juveniles are reared in ways that may better prepare them for the natural environment. For example, the maximum density index the fish are reared under at the MFH is 69 kg of fish/m^3/mm length of fish, and baffles have been added to some raceways to increase flow. The production goal is 250,000 yearling spring chinook salmon for each of the Methow, Chewuch and Twisp rivers.

2.2 Chewuch acclimation pond and adult trap

Chewuch Pond is located 9.6 km up the Chewuch River from its confluence with the Methow River. It is a large cobble lined pond, with Chewuch River water supplied by gravity from the Chewuch Canal Company's irrigation ditch. Maximum flow is 0.17 m^3/s. Chewuch brood stock are collected at Fulton Dam, river km 2.4. The Dam is a man-made barrier of boulders directing upstream migrants to a denil (steep-pass) ladder and into a v-trap.

Figure 1.


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

2.3 Twisp acclimation pond and adult trap

Twisp Pond is 8 km up the Twisp River from its confluence with the Methow River. Like the Chewuch Pond, it is also cobble lined. The pond is gravity fed with Twisp River water from the Twisp Valley Power irrigation canal. The adult trap, is adjacent to the outfall of the acclimation pond and includes a floating picket weir to direct fish into a v-trap.

Section 3: Brood stock management

3.1 Methow spring chinook salmon

3.1.1 Adult collection

Methow River adult spring chinook were collected in the acclimation pond outfall channel at the MFH. The cooler well water from the hatchery probably attracted the fish. In June, a finger weir was placed at the upper end of the channel to separate it from a small natural holding pool. The adults jumped the weir and stayed in the pool until transfer to the adult holding pond. Three females, two males and two jacks were collected at the MFH. Five females and two males were collected at the WNFH and transferred to the MFH (Table 1). The finger weir was placed in the outfall channel in the middle of June. The first adult arrived at the MFH 2 July. Collection continued through the end of spawning at both facilities.

Spawner/redd ratio of 6.6 indicates the Methow River had a spring chinook salmon escapement of 59 fish, although only nine redds were observed (Hubble et al. 1995 in review). Daily discharge for the Methow River is included in Appendix A.

The hatchery crew transferred the adult salmon to the covered adult holding raceway as they arrived. A rubber sock filled with water protected the salmon during transfer. Well water flowed to the adult holding raceway at 0.018 m^3/s. The raceway loading density in 1995 was one fish/4.5 m^3. Natural escapement to the Methow River had priority, so we collected and read scales on site to ensure the fish were of hatchery origin.

Table 1. Summary of collection and spawning for the Methow River chinook

Week Ending	Adults collected		Fish spawned				
	Adult	Jack	Mortalities	Males	Jacks	Females	Egg take
03Jun95	0	0					
10Jun95	0	0					
17Jun95	0	0					
24Jun95	0	0					
01Jul95	0	0					
08Jul95	2	0					
15Jul95	1	0					
22Jul95	0	2	1				
29Jul95	1	0					
05Aug95	0	0					
12Aug95	0	0					
19Aug95	0	0		3 live	2 live	5	22,500
26Aug95	0	0	1	2 live	1 live	2	9,000
02Sep95	1	0					
Adjusted Totals	5	2	2	3	2	7	29,813

Five females and two male were transferred from the WNFH. One of the females died at transfer.

3.1.2 Prophylaxis

Standard formalin treatments began with the first arrivaling adults. Standard treatment is 1 part formalin to 6,000 parts water for one hour, every other day or at least three times per week. If the fish were handled, then they received a treatment for three consecutive days before returning to the standard treatment schedule. We injected all the retained females with 15 mg/kg of erythromycin on 18 July. The erythromycin injection is intended to protect the eggs from the vertical transmission of bacterial kidney disease (BKD).

3.1.3 Spawning

The first five females were spawned on 17 August (Table 1). The remaining two females spawned on 23 August. All males were live spawned when used. Before fertilization, each females' eggs were separated into three lots. Each of the three lots was fertilized with milt from a different male or jack. After about 30 seconds, the males were rotated so that a different one contributed as the back-up. This produced more crosses to increase the effective population size (Gall

in Ryman and Utter editors 1987). After about 15 minutes of incubation, the unrinsed eggs were water hardened and disinfected in a solution of 1 part iodophor to 150 parts water for one hour. The adjusted egg take was 29,813, with an average fecundity of 4,259 eggs/female, and a range of 3,399 to 5,303 eggs/female (Appendix B). We determined the adjusted egg take after 100% coded-wire tag (CWT) marking of the juveniles.

3.1.4 Pathological results of MFH chinook spawners

Ovarian fluid and kidney/spleen tissue from the females were tested for the presence of Infectious Hematopoietic Necrosis virus (IHNv) and Infectious Pancreatic Necrosis virus (IPNv). All the samples were negative for both these viruses (Table 2). We collected additional kidney tissue from the females to test for BKD using enzyme-linked immunosorbant assay (ELISA) (Table 2). To date, IPNv has not been isolated from the Methow Basin spring chinook stocks. IHNv was isolated several years ago, but its occurrence is irregular. BKD is common among the natural as well as hatchery populations. When possible, the progeny of high ELISA females are reared separately to protect the others from the horizontal transmission of the disease. The first adult returns from hatchery releases will be in 1996. At this time we may be able to document some disease history.

Table 2. MFH chinook adult virology and ELISA results

Sex	Sample size	Virology		ELISA			
		IHNv	IPNv	B. Low	Low	Moderate	High
Female	7	0	0	1	3	1	2

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

3.1.5 Adult sampling and analysis of MFH chinook spawners

Lengths, scales and sex were recorded from all chinook collected at the MFH and the WNFH. We did not collect tissue for genetic stock identification since the spawning population was so low, and only the females were killed. Thirteen of the fourteen fish were of hatchery origin. The scales collected from one female were regenerated, so age or origin could not be determined. We did not

collect any biological information from the natural spawners because of their low escapement numbers. The sex ratio of the collected fish was almost equal, while the age composition of the females was predominately four year olds (Table 3).

Table 3. Age composition, sex ratio and post-orbital hypural length of the MFH chinook spawners

Sex		Age 3	Age 4	Age 5	Unknown	Total
Male	Number	2	1	3	0	6
	Mean length	40 cm	52 cm	70 cm		57 cm
Female	Number	0	7	0	1	8
	Mean length		57.3 cm		60 cm	57.7 cm
Total	Number	2	8	3	1	14
	Mean length	40 cm	56.6 cm	70 cm		57.4 cm

Section 4: Juvenile rearing

4.1 1995 Methow spring chinook salmon

4.1.1 Incubation

After spawning and disinfection, the Methow chinook eggs were incubated in Heath trays. When the eggs accumulated about 500 to 750 temperature units (TU)[1], the hatchery crew transferred the eggs to clean Heath trays. This movement turned the unfertilized or dead eggs white for easy removal and counting. A tabletop scale was used to weigh the live eggs and determine individual female fecundity. Approximately seven days before hatching, plastic substrate (vexar) was placed in each tray to mimic natural substrate. Vexar reduces movement of the hatching eggs, and allows the yolk to be used for development of the fry. Green egg to fry survival was 97.9%.

[1] Temperature unit = one degree above 32°F in a 24 hour period.

4.1.2 Start tank and early rearing

The MFH crew moved the progeny of the seven females to indoor start tanks beginning 16 December 1995. Each start tank contained a complete family unit. The average weight of the fry at first feeding was 0.39 g. On 26 March, when the fish were about 2.3 g, they were adipose fin clipped and CWT marked. Each family unit received a unique tag code for future identification. Immediately after CWT marking, about half of each family was transferred to the WNFH to complete juvenile rearing (Table 4). Families 3 and 5 were the high ELISA progeny.

Table 4. Methow chinook family identification and transfer information.

Family Number	Number CWT	Number transferred	CWT code
1	4,762	2,373	63/60-38
2	3,822	1,904	63/60-41
3	3,618	1,885	63/60-43
4	5,260	2,632	63/60-37
5	4,179	2,128	63/60-40
6	3,317	1,636	63/60-42
7	4,094	2,055	63/60-40

4.1.3 Raceway rearing and acclimation

Following CWT marking, the progeny remaining at the MFH were moved into one of two juvenile raceways. One of the raceways contained baffles from a previous year's study. The baffled raceway (RW11) received the high ELISA progeny, and the remaining five families were reared in the traditional hatchery raceway (RW 12). The density index remained well below 69 kg of fish/m^3/mm length of fish for both raceway populations.

Methow River water was introduced into the raceways the first week of May 1996. Excluding occasional introductions of well water to temper river water temperature extremes, these populations reared primarily on Methow River water (Figure 2). Raceway 12 received water at a turnover rate of once every hour. Raceway 11 received flow at a turnover rate twice RW 12 (Figure 3).

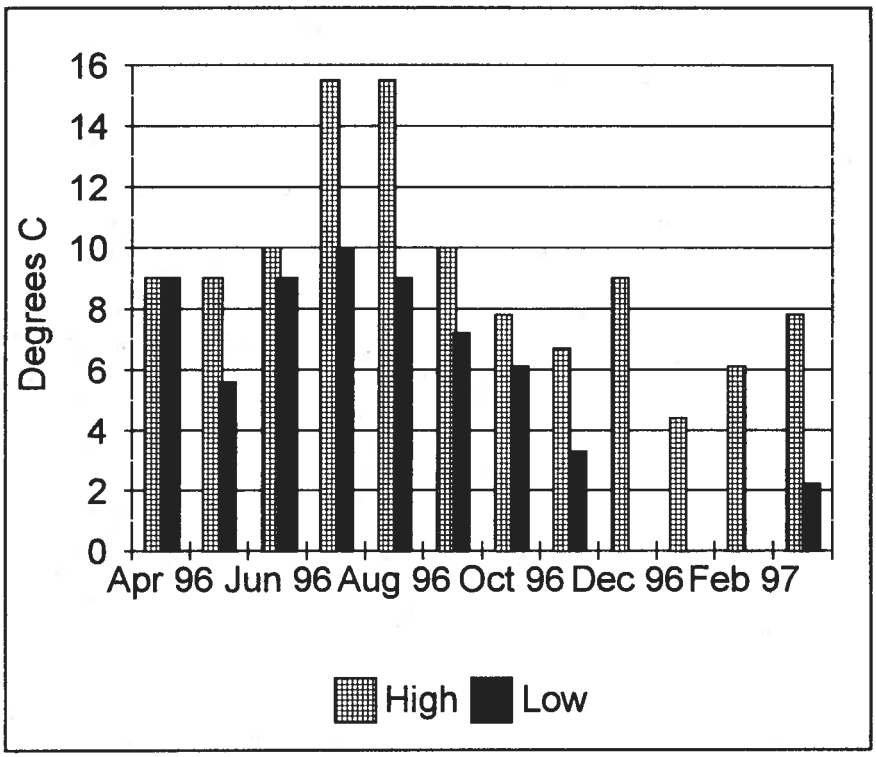


Figure 2. Monthly high-low rearing temperatures for the 1995 Methow spring chinook.

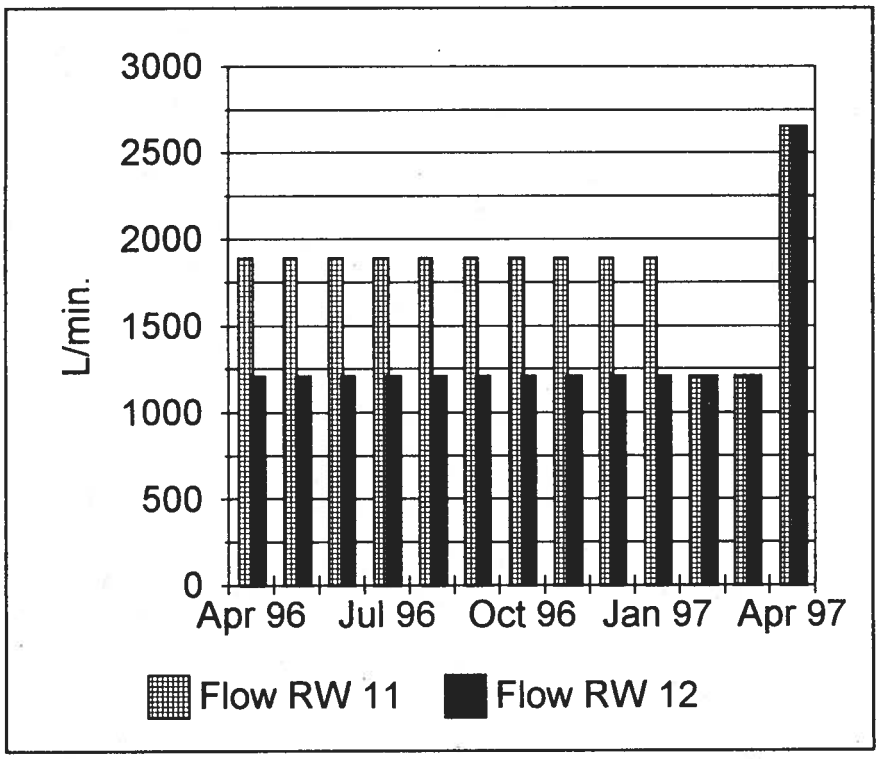


Figure 3. Flow to the 1995 Methow spring chinook raceways.

4.1.4 Smolt release

Volitional release began 15 April 1997, and the raceways were empty by 18 April. In fact, all the fish in the baffled raceway migrated the night of 15 April. Flow to both raceways was increased to encourage migration (Figure 3).

Methow River water discharge increased from 946 to 1,240 m^3/s (USGS-Methow River gage at Winthrop, WA) during the release period. In April 1997, 14,238 Methow chinook smolts (431 kg) migrated from the MFH juvenile raceways. Fry to smolt survival for this stock was 99.5%. The fish reared 490 days in the MFH. At release, fish weighed an average of 32.2 g, and measured an average of 134.9 mm, with a coefficient of variation for the lengths of 6.2% and a condition factor of 1.24 (n=100) (Figure 4). This condition factor is high, but not abnormal for this stock.

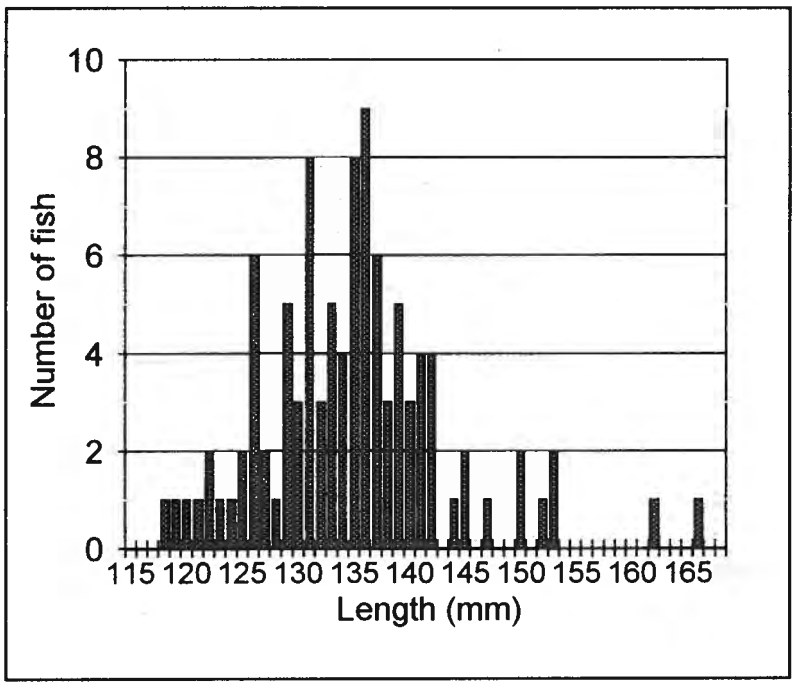


Figure 4. 1995 Methow chinook juvenile length frequency at release.

4.1.5 Fish health monitoring

Fish were visually observed by the fish health specialist every four to six weeks. Since the population was small, and the fish maintained good health throughout the hatchery rearing period, only four of the examinations were lethal (Table 5).

Table 5. 1995 Methow chinook fish health examination

Date	Life stage	Weight (g)	Mean daily % loss	Water temp °C	Comments
07Feb96	fry	350	0.01	9	Uniform in size, healthy.
26Sept97	juvenile	10	0	10.0-7.2	Fat levels of +2 to +3.
26Dec97	juvenile	15	0	1.0-0.0	Baffles in RW11 kept it from freezing. Mortalities in RW12 a result of ice on the surface.
11Feb97	juvenile	19	0.5	4.4-1.7	One moribund fish with gross clinical signs of BKD.

Mortalities during the winter resulted from fish stranding themselves on a layer of ice covering the unbaffled raceway. Although gross clinical signs of BKD were seen in some of the moribund and dead fish, no epizootic occurred.

4.1.6 Juvenile sampling

Before smolt release, we sampled 20 fish for organosomatic indexing (OSI). OSI assesses the general health of the population through examination of the external and internal organs (Goede and Barton 1990). Since the population was small, we limited lethal sampling to necessary release information. Table 6 gives the pre-liberation organosomatic indexing results.

Table 6. 1995 Methow chinook juvenile organosomatic indexing results.

Date	Fork length (mm) (sd)	Weight (g) (sd)	Condition factor (sd)	Mean fat	Male	Female
15Apr97	137.2 (7.6)	32.2 (5.8)	1.24 (0.05)	2.7	50%	50%

Organosomatic indexing showed the Methow chinook had a normality index of 91.0%. A value above 90.0% is considered healthy (Goede 1993).

Discussion

The brood stock collection protocol in 1995 supported a minimum escapement of 100 fish (adults and jacks) to Wells Dam. Unfortunately, the 50% passage point indicated the total escapement would not reach 100. This prevented the trapping of any spring chinook for brood stock. The only fish

allowed for brood stock in 1995 were those that volunteered into either of the Methow River hatcheries. We could have collected all the fish at Wells Dam, but with no effective way of separating the three stocks from the composite collection we would have violated an original objective to maintain the genetic integrity of the three stocks (Methow Basin Spring Chinook Supplementation Plan 1995). Although we made multiple crosses with the brood stock at the hatchery, the 1995 Methow Basin hatchery spawners incurred a severe bottleneck (Gall 1987). Furthermore, repeated generations within the hatchery could hamper survival for future generations in the natural environment (Bowles 1995).

The 1995 brood year Methow spring chinook remained healthy during. This included the high ELISA progeny, although some clinical signs of BKD were observed. Because of an insufficient sample size, we could not detect any difference in survival between families within the MFH. Family three lost five to seven times as many eggs as the other families, and families three, five and seven lost twice the number of fish as the other families. But overall, survival of all families was still above 93% (Appendix B.). Egg weight did not have the large variance seen in past years. In addition, the fecundity range was also not as large. This may be a product of small sample size or the females being hatchery origin four year olds.

Survival at all life stages continues to be very high within the MFH. Excellent fish culture minimizes differential mortalities. When possible, combinations of more natural rearing strategies (baffles, flow, temperature and densities) are employed, with the intent of minimizing changes in genetic, behavioral, and health characteristics while the fish are in the hatchery (Bowles 1995).

The YIN field crew counted only 15 redds for the entire Methow Basin in 1995 (Hubble, personal communication). Replacement rate for the Methow Basin spring chinook from the most recent data available is 0.669 recruits/spawner (1985-1990) (L. LaVoy, WDFW personal communication). This followed some productive years in the early 1980's (1.82 recruits/spawner). Although the Methow Basin spring chinook run had symptoms of decline, no one forecasted the run to collapse. In a desire to minimize our impacts to the Methow Basin stocks, we have proceeded conservatively with the supplementation program and used adaptive management. After all, supplementation is not a panacea (Cuenco et al. 1993 and Bowles 1995), nor does it guarantee replacement or augmentation of the natural production (Miller et al. 1993 in WDFW-DEIS Wild Salmonid Policy). Adaptive management is employed when the working environment is surrounded with a high degree of uncertainty or disagreement. This is true for the Methow Basin Spring Chinook Supplementation Project. It allows flexibility for change when change is necessary to meet the established objectives. On the other hand, it reduces our commitment to a particular strategy. Evaluation of the long term impact of the

Methow FH has been and will continue to be difficult until we establish a strategy we can adhere to. Since the escapement of spring chinook has dropped considerably, and it appears as though we will be using the MFH for more than a supplementation facility, this may be a good time to reassess the framework of the Evaluation Plan and the information derived from it.

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Appendix A.

1995 Wells Dam counts, Methow river flow, and fish collection.
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-95	0	66.08		01-Jun-95	0	274.12		01-Jul-95		89.04		01-Aug-95		19.04	
02-May-95	0	68.60		02-Jun-95	2	269.08		02-Jul-95		91.00	1	02-Aug-95		18.31	
03-May-95	0	74.76		03-Jun-95	0	256.48		03-Jul-95		85.40		03-Aug-95		17.72	
04-May-95	0	77.00		04-Jun-95	6	253.12		04-Jul-95		77.28		04-Aug-95		17.19	
05-May-95	0	77.00		05-Jun-95	11	240.52		05-Jul-95		68.60	1	05-Aug-95		16.63	
06-May-95	0	83.44		06-Jun-95	2	198.80		06-Jul-95		62.44		06-Aug-95		16.41	
07-May-95	0	92.68		07-Jun-95	0	169.68		07-Jul-95		60.76		07-Aug-95		17.81	
08-May-95	0	97.16		08-Jun-95	2	154.56		08-Jul-95		64.68		08-Aug-95		17.28	
09-May-95	0	122.64		09-Jun-95	1	156.80		09-Jul-95		61.32		09-Aug-95		16.13	
10-May-95	0	182.84		10-Jun-95	0	156.24		10-Jul-95		61.32		10-Aug-95		15.32	
11-May-95	0	200.20		11-Jun-95	1	199.36		11-Jul-95		55.16		11-Aug-95		15.46	
12-May-95	0	166.04		12-Jun-95	6	186.76		12-Jul-95		49.84		12-Aug-95		14.95	
13-May-95	0	140.28		13-Jun-95	3	155.12		13-Jul-95		45.64	1	13-Aug-95		14.48	
14-May-95	1	148.96		14-Jun-95	3	134.96		14-Jul-95		43.12		14-Aug-95		13.80	
15-May-95	1	186.48		15-Jun-95	2	124.88		15-Jul-95		42.28		15-Aug-95		13.36	
16-May-95	2	242.76		16-Jun-95	1	125.44		16-Jul-95		40.88		16-Aug-95		12.57	
17-May-95	2	265.72		17-Jun-95	0	128.24		17-Jul-95		39.20	2	17-Aug-95		12.77	
18-May-95	0	240.24		18-Jun-95	1	127.12		18-Jul-95		38.36	6	18-Aug-95		13.27	
19-May-95	0	205.52		19-Jun-95	5	123.76		19-Jul-95		37.52		19-Aug-95		12.77	
20-May-95	1	189.84		20-Jun-95	7	113.40		20-Jul-95		36.12		20-Aug-95		12.32	
21-May-95	5	184.24		21-Jun-95	1	107.80		21-Jul-95		35.28		21-Aug-95		11.76	
22-May-95	1	178.08		22-Jun-95	0	125.72		22-Jul-95		33.04		22-Aug-95		10.98	
23-May-95	0	180.60		23-Jun-95	2	129.92		23-Jul-95		31.08		23-Aug-95		10.47	
24-May-95	1	182.00		24-Jun-95	2	130.20		24-Jul-95		29.12		24-Aug-95		10.08	
25-May-95	1	191.24		25-Jun-95	10	133.00		25-Jul-95		27.50	1	25-Aug-95		9.77	
26-May-95	1	206.36		26-Jun-95	2	121.52		26-Jul-95		27.08		26-Aug-95		9.52	
27-May-95	0	215.04		27-Jun-95	5	106.68		27-Jul-95		26.82		27-Aug-95		9.27	
28-May-95	0	238.00		28-Jun-95	5	95.48		28-Jul-95		24.84		28-Aug-95		9.02	
29-May-95	1	285.60		29-Jun-95		90.44		29-Jul-95		22.90		29-Aug-95		8.82	
30-May-95	2	322.00		30-Jun-95		90.72		30-Jul-95		21.50		30-Aug-95		8.62	
31-May-95	4	308.00						31-Jul-95		20.10		31-Aug-95		8.40	
												01-Sep-95		8.15	
TOTALS	23				80						12				

Appendix B.

1995 Brood stock spring chinook salmon MFH contribution

Methow spring chinook salmon

Spawn Date	Injection Date	Total Eggs	Eyed Eggs	Dead Eggs	Percent Egg Loss	Dead Fry @ ponding	Green Egg-Fry Survival	Eggs per Lbs.	Start Tank	Ponded Fry
17-Aug-95	18-Jul-95	4886	4821	65	1.33	0	98.7	2246	1	4821
17-Aug-95	18-Jul-95	3892	3828	64	1.64	0	98.4	2739	2	3828
17-Aug-95	18-Jul-95	3884	3634	250	6.44	0	93.6	2348	24	3634
17-Aug-95	18-Jul-95	5303	5273	30	0.57	0	99.4	2177	3	5273
17-Aug-95	18-Jul-95	4220	4183	37	0.88	0	99.1	2189	23	4183
23-Aug-95	18-Jul-95	3399	3326	73	2.15	0	97.9	2492	4	3326
23-Aug-95	18-Jul-95	4229	4107	122	2.88	0	97.1	2219	5	4107
		29813	29172	641	2.15%		97.90%			29172

Start Tank Loss	Tag codes	Kept at MFH	Recovered CWT/total loss	Percent Loss/Family	Fry to smolt Survival	Green egg to smolt survival	Projected Release
51	63-60/38	2397	4	0.17			2385
23	63-60/41	1901	3	0.16			1892
41	63-60/43	1708	8	0.47			1699
27	63-60/37	2614	4	0.15			2600
26	63-60/40	2029	10	0.49			2017
36	63-60/42	1654	5	0.30			1645
41	63-60/39	2011	8	0.40			2000
245		14314	42/56		99.60%	99.20%	14238

Summary information for 1995 Methow chinook

Fecundity range 3399 - 5303
Green egg - fry survival = 97.9%
Fry - smolt survival 99.6%
Green egg - smolt survival 99.2%

Appendix C.

Brood stock collection protocol for the 1995 collection year at the MFH.

Action plan-brood stock collection

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 brood stock collection action and escapement above Wells Dam will be assessed as close to the 50% point of passage as possible. The approximate date for this assessment is 23 May. If the projected escapement at that this time does not meet or exceed 100 fish, the brood stock collection will be discontinued. If brood stock collection continues it will be adjusted weekly to balance the 25% per week goal and the 100 fish minimum escapement goal. The collection goal will be 25% of the run. Methow FH would therefore operate at about 10% of capacity. Only unmarked salmon will be collected; all adipose-absent salmon will be released upstream. Salmon will be immediately transferred to the tank truck, and transported to the MFH at least twice a day.

Scale samples from the brood stock 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 population. If the scale pattern indicates a salmon is hatchery origin, the fish will be assigned to the Methow stock (which would include WNFH). All hatchery origin fish or their gametes will be transferred to WNFH.

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

The crews at MFH and WNFH will monitor the numbers of spring chinook salmon that volunteer into both facilities. These fish will be included in the hatchery's brood stock. 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 scale data. The gametes will be divided equally among the four stations (Methow, Winthrop, Chewuch and Twisp). Fertilization methods will be determined in late summer when the brood stock size and sex ratio is known.

Appendix D.

Number and kilograms released of the 1995 brood year from the MFH.

Stock	Tag code	Number Identified	Number released	Size at release (g)	Kilograms	Release date	Type of release	Site of release
Methow	63-60/38	4770	2385	32.2		15-Apr-97	volitional	MFH
	63-60/41	3805	1892	32.2		15-Apr-97	volitional	MFH
	63-60/43	3593	1699	32.2		15-Apr-97	volitional	MFH
	63-60/37	5246	2600	32.2		15-Apr-97	volitional	MFH
	63-60/40	4157	2017	32.2		15-Apr-97	volitional	MFH
	63-60/42	3290	1645	32.2		15-Apr-97	volitional	MFH
	63-60/39	4066	2000	32.2		15-Apr-97	volitional	MFH
TOTAL		28927	14238		458.5			

Appendix E.

Performance standards outlined for the Methow Fish Hatchery (Peck 1993)

The performance standards outlined are for the facility when it is at maximum management capacity. Although annual production was established at 738,000 yearling smolts, the primary function of the hatchery program is to operate as a supplementation facility.

Measures	Stock	Standard set	Standard Achieved 1992	1993	1994	1995
Adult capture	Chewuch	238	20 (8.40%)	110 (46.00%)	10 (4.20%)	0
	Methow	238		99 (42.00%)	17 (7.10%)	14 (5.90%)
	Twisp	238	30 (12.60%)	42 (18.00%)	5 (2.10%)	0
Adult prespawn survival	Chewuch	80.00%	85.00%	94.40%	100.00%	0
	Methow	80.00%		97.90%	100.00%	2 (83.30%)
	Twisp	80.00%	80.00%	92.90%	100.00%	0
Egg collection	Chewuch	350000	47660 (13.60%)	307448 (88.00%)	12734 (3.60%)	0
	Methow	350000		228654 (65.00%)	48546 (13.90%)	29813 (8.50%)
	Twisp	350000	39164 (11.20%)	126705 (36.00%)	20833 (6.00%)	0
Green egg-fry survival	Chewuch	85.00%	88.80%	96.50%	94.60%	0
	Methow	85.00%		96.20%	99.40%	97.90%
	Twisp	85.00%	94.20%	97.70%	99.40%	0
Fry-smolt survival	Chewuch	70.00%	97.20%	95.80%	98.50%	0
	Methow	70.00%		95.90%	98.40%	99.60%
	Twisp	70.00%	97.20%	94.30%	96.00%	0
Fish released	Chewuch	250000	40862 (16.30%)	284161 (114.00%)	11854 (4.70%)	0
	Methow	250000		211157 (84.00%)	4477 (1.80%)	14238 (5.70%)
	Twisp	250000	35861 (14.30%)	116749 (47.00%)	19835 (7.90%)	0
Adults upstream	Chewuch	66.00%	89.50%	65.00%	80.40%	*13 (100.00%)
	Methow	66.00%		88.00%	86.10%	*60 (81.10%)
	Twisp	66.00%	73.00%	92.00%	90.60%	*26 (100.00%)
Percent survival	Chewuch	1.00%	N/A	N/A	N/A	N/A
	Methow	1.00%	N/A	N/A	N/A	N/A
	Twisp	1.00%	N/A	N/A	N/A	N/A

* These values based upon spawner/redd ratio calculated by the Yakama Indian Nation field survey crews.

METHOW BASIN SPRING CHINOOK SALMON SUPPLEMENTATION PLAN

DRAFT

NATURAL PRODUCTION STUDY

1995 ANNUAL REPORT

Prepared by

Joel Hubble
and
David Harper

Fisheries Resource Management Program
Yakama Indian Nation
Toppenish, Washington

Prepared for

Douglas Public Utility District
East Wenatchee, Washington
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2. 0. ABSTRACT

Research conducted in 1995 was in fulfillment of the Natural Production tasks that are stated under the Evaluation Objectives in the Methow Basin Spring Chinook Salmon Enhancement Program (MBSCSP) document (June 20, 1995).

An estimated 4,546±482 spring chinook and 2,130±300 steelhead smolts outmigrated from the Chewuch basin in spring, 1995. The median date of passage was April 27 for spring chinook and April 29 for steelhead/rainbow. As in previous years, the spring chinook smolt outmigration peaked prior to the spring run-off. River discharge began to considerably increase around May 1. The mean fork length for spring chinook and steelhead smolts was 100 mm and 171 mm, respectively.

Both the Fulton and Chewuch irrigation ditches proved unsuccessful as sites to operate the screw trap for the summer monitoring period due to fluctuating water elevations in both the ditches and river. The trap was redeployed at rm 0.1 at the Highway 20 bridge, where it was previously operated during the spring season. Sixty-four spring chinook young-of-the-year (YOY) and 29 rainbow/steelhead parr were captured between July 22 and August 31. The mean fork length for spring chinook and steelhead/rainbow was 82 mm and 159 mm, respectively.

An estimated 2,058±158 spring chinook and 99±33 steelhead/rainbow fall migrants outmigrated from the Chewuch basin from October 4 through December 3, 1995. The mean fork length was 101 mm for spring chinook YOY and 182 mm for rainbow/steelhead parr.

An estimated 3,610±287 spring chinook and 870±153 steelhead/rainbow smolts (255 of these fish were classified as non-smolted, being either non-smolted steelhead or resident rainbow trout) outmigrated from the Chewuch basin in spring, 1996. The median date of

passage was April 8 for spring chinook and April 23 for steelhead/rainbow. The mean fork length for spring chinook and steelhead smolts was 100 mm and 170 mm respectively.

The late-summer spring chinook parr (1994 broodyear) estimate in the Chewuch River was 5,334 fish. Reaches II and III accounted for 74.8% (3,989 fish) of the total estimated number of parr in the basin (Figure 14). An estimated 3,310 steelhead/rainbow (age 1+) were found in the Chewuch River with the highest percentage (28%) of them residing in reach III.

Physical attribute measurements were recorded from 13 redds in the Methow Basin to describe the physical characteristics of naturally spawned redds.

Fifteen redds were located in the Methow Basin. This compares to the 1988-94 basin average of 498 redds, a 33-fold decrease. Subbasin redd totals were as follows: Methow- 9, Early Winters- 0, Lost- 0, Chewuch- 2 and Twisp- 4. For comparison, the 1988-94 subbasin averages were as follows: Methow- 190, Early Winters- 5, Lost- 41, Chewuch- 129 and Twisp- 132.

In the summer/fall of 1996 the Methow Basin was surveyed for potential acclimation/rearing sites for juvenile spring chinook. A summary of locations and the associated description are found in Table 6-8.

Four questions cited in the Evaluation Plan of the MBSCSP designed to monitor and evaluate the success of the program are examined for required parameters necessary to answer the question and feasibility/logistical constraints. The questions discussed are: 1) Can the egg-to-returning adult survival meet or exceed the survival rate of the naturally produced fish from the donor population?, 2) 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?, 3) Do marked and unmarked salmon differ in spawning success?, and 4) Is natural production in the donor population diminished when hatchery-reared salmon return to spawn in the natural habitat?

3. 0. INTRODUCTION

The Natural Production Study is part of the Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) (June 20, 1995). This study is part of ongoing research outlined under the Evaluation Objectives (Appendix D), covering tasks 2.9-2.11 in the MBSCSP that was initiated in 1993. However, basin wide spring chinook spawning ground surveys were initiated in 1987.

The MBSCSP is a compensation program directed towards the enhancement of the wild spring chinook (*O. tshawytscha*) stocks in the Methow Basin. The MBSCSP is the result of the Wells Settlement Agreement between the fishery agencies, tribes, Douglas PUD and the power purchasers of the Wells Project. The goal of this agreement is to compensate for unavoidable losses of juvenile anadromous fishes at Wells Dam. The stated purpose of the MBSCSP "...is to increase natural propagation of salmon in the Methow, Chewuch, and Twisp rivers in a manner that minimizes or eliminates ecological and genetic risks to the natural population.", through a monitored hatchery supplementation plan. The settlement agreement requires that the MBSCSP be operated according to procedures outlined by the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC, 1987). A specific outcome is that the MBSCSP "be capable of collecting, rearing, and releasing three potentially discrete stocks of salmon"(Methow, Chewuch and Twisp), which is part of the Phase I compensation requirements under the settlement agreement.

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 a considerable amount of growth especially residential and commercial development. The lower Methow valley is a fertile agricultural area that experiences heavy irrigation demands. Water quality in the lower Methow Basin nonetheless remains high, with an AA rating from the Washington Department of Ecology.

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 covers 530 square miles and drains in a southern direction into the Methow River. The upper portion of the Chewuch River is located in the Pasayten Wilderness (above RM 32.4) and is heavily forested. Most of the anadromous fish occupy the area downstream from rm 32.4 which is used extensively for recreation and residential development.

The Twisp basin encompasses about 250 square miles of watershed and enters the Methow River at near rm 40. The elevation descends from 8,500 ft to 1,600 ft and drains in a southeast direction. The headwater and upslope areas lay within the Lake Chelan-Sawtooth Wilderness. 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

Forest, November 1994) and in the Twisp River Watershed Analysis (Twisp Ranger District, Okanogan National Forest, June 1995).

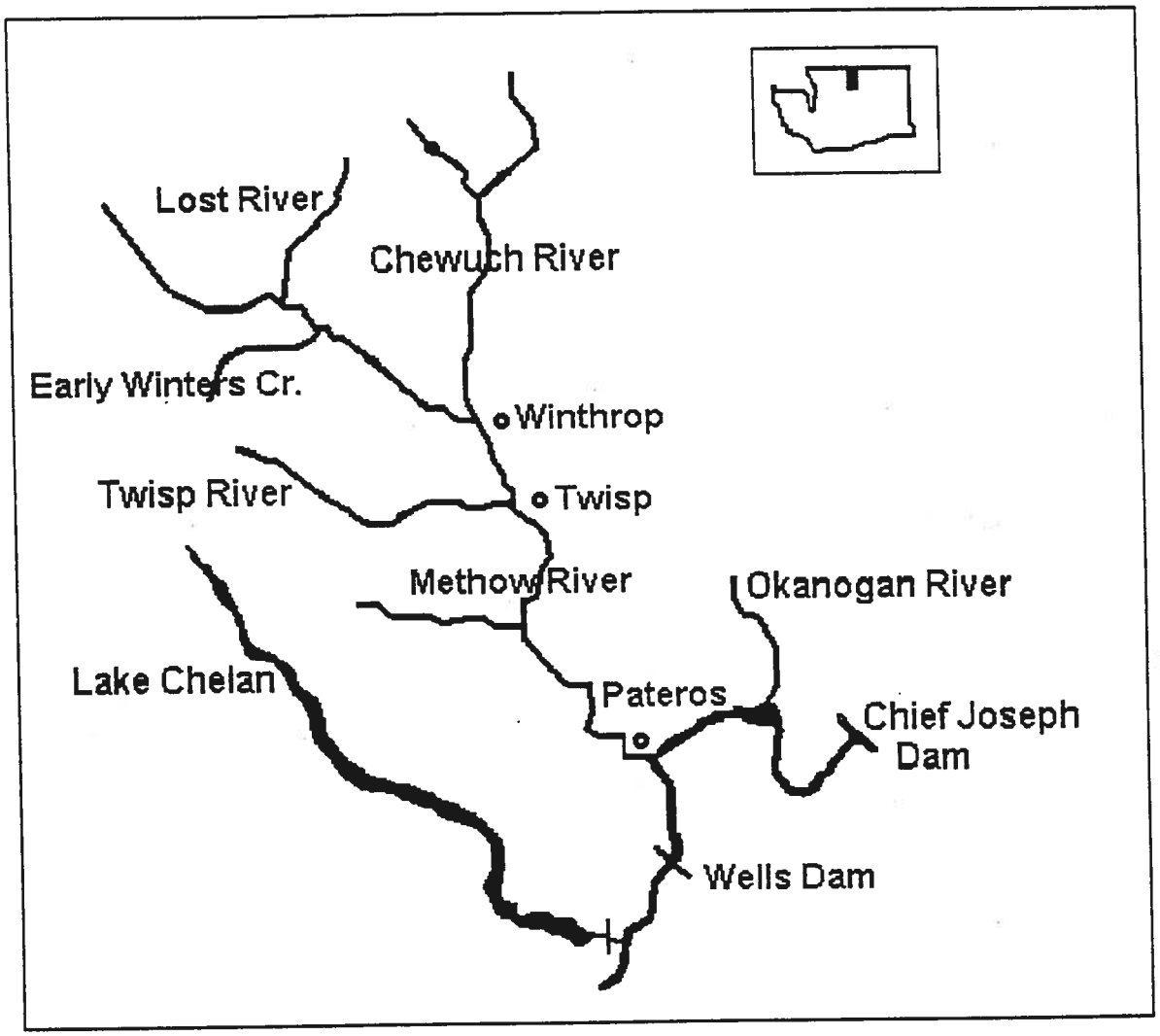

Figure 1. Map of the Methow Basin and the adjacent upper Columbia River and Chelan basins.

5.0. METHOD AND MATERIALS

5.1. OUTMIGRATION

5.1.1. Spring Season, 1995

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 April 9, to May 26, 1995. The screw trap was placed in the thalweg region toward the right bank of the river during the entire spring trapping period.

The trap was normally operated seven days a week, 24 hours each day, except for times when the cone was lifted for cleaning. However, the trap was not operated April 18-20 to to not interfere with passage of the Chewuch hatchery spring chinook smolts which were volitionally released from the acclimation pond (rm 7.8) on April 18. In addition, the trap was not operated May 9, 11 and May 16-21 due to high river discharge and heavy debris loads. During these periods a linear regression was used to estimate the daily fish passage based on the preceding five days catch predicted forward to encompass the non-trapping days. On May 26th the trap was banked due to high river discharge. While banked, the trap was damaged during a rapid snowmelt event, which ended spring chinook smolt monitoring for the season. No further adjustment to estimating the number of smolt outmigrants was made for the period after May 26. This was justified on the basis of daily smolt counts of zero to two fish per day between May 22-26, indicating that outmigration was essentially over.

The stream discharge data was collected from the USGS stream gauging station (#12448000) located at rm 0.1 on the Chewuch River.

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 1993 and 1994, 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 a dorsal caudal clip and were allowed to recover about nine hours in a meshed cube net located in a calm area of the river and were released at 1800 hours. All test fish were released upstream at rm 0.3 from the right bank into a fast run type section of river.

The 1994 and 1995 entrainment test release data sets[1] were statistically evaluated with a forward and backward step-wise weighted logistic regression analysis (unpublished document, Neeley, 1995) to derive a more robust logistic flow-entrainment model to use in 1995. The parameters examined were flow (mean daily cfs), year (1994 or 1995) and bank (right and left). This analysis determined that the bank parameter (trap location) best explained the variation in the entrainment rate, and that flow did not significantly reduce the overall entrainment rate variation. This does not mean that flow did not effect the entrainment rate, but rather that any effect it may have is sufficiently correlated with bank location. Therefore, trap location explains most the entrainment rate variability associated with flow. The pooled right bank entrainment rate used to estimate daily smolt passage was 10.8%.

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

$$AN(j) = \sum_{I = 1 \text{ to } j} N(I);$$

where $AN(j)$ is the cumulative estimated daily passage.

---

[1]In 1994 only a left bank entrainment rate was calculated since the trap fished entirely at the left bank location the entire season. In 1995 an entrainment rate was calculated for both the left and right banks as the trap was fished at both locations.

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 a way to describe outmigration timing and the relative magnitude of the outmigration over time. The actual entrainment rate of steelhead is probably lower because of their larger size and subsequent 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) 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. After work-up, the fish were allowed to recover for 30-60 minutes in a bucket of freshwater and were then released in a quiet area along the stream margin.

5.1.2. Summer Season, 1995

An additional objective to monitoring the summer juvenile outmigrants, was to test two additional monitoring sites for how well the screw trap operated. These two sites were the Fulton and Chewuch irrigation ditches. The downstream movement of spring chinook parr was monitored on the Chewuch River using a E.G. Solutions five foot screw trap in the Fulton irrigation ditch (rm 0.8) from June 15 to June 29. The fish entrainment rate proved to be too low at Fulton ditch due to the bottom draw nature of the headgate, and the trap was subsequently relocated to the Chewuch ditch (rm 7.8) on June 29. However, flow within the Chewuch ditch proved to be too variable (primarily the water depth became too low) for effective monitoring, and the trap was relocated to its former site below the highway 20 bridge in Winthrop on July 17. The trap was fished below the bridge from July 17 to August 30. At that time the trap became inoperable due to insufficient water depth. The low daily catch of spring chinook parr precluded entrainment test releases during the summer trapping period.

To begin to understand spring chinook parr (YOY) outmigration from production areas (ie., Chewuch) into the lower Methow River juvenile monitoring was initiated in the lower Methow River. The downstream movement of chinook parr was monitored on the Methow River using an eight foot screw trap located near the Carlton acclimation ponds (rm 37.8) from July 27 through August 31, at which time the trap became inoperable due to low water elevation and water velocity. Monitoring was not conducted Friday through Sunday and the trap was normally re-deployed Sunday afternoon. This was the first year juvenile salmonids were monitored at this site, and as a result there were several days the trap was not operated due low water elevations and velocities. As with any new monitoring site there is a learning curve, and thus most of our effort was directed towards location specific spots where the trap would fish successfully.

All fish species captured were identified and enumerated and fork lengths were recorded for most of them each day. Fish handling procedures were similar to those previously described for the Chewuch. Some fish entrainment test releases were made, however, no marked fish were recovered from these releases.

5.1.3. Fall Season, 1995

The five foot screw trap was installed in the Chewuch River downstream of a bedrock break below the highway 20 bridge in Winthrop and fished at this site from October 3 to December 3, when severe icing conditions made trapping impossible. This site was located about 50 m downstream from its original location used during the spring (1995) summer. The trap was operated continuously except for October 18, 28-29 and November 22-25. Fish handling techniques were similar to that for smolt monitoring except spring chinook intended for entrainment test releases were given a ventral caudal clip. All fish were held for recovery in a covered flow-through live bucket and held until approximately 1600 hrs. Unmarked and recaptured fish were released into calm water downstream of the trap. Clipped entrainment test fish were released into the center of the thalweg approximately 300 meters upstream of the trap (Appendix Table 1).

In the Methow River the eight foot screw trap that was fished in the summer was relocated upstream approximately 75 meters for the fall monitoring season. It was fished from October 16 through November 9, when high water damaged the trap. Fish handling techniques were similar to those employed at the Chewuch River screw trap, except that all fish used for entrainment test releases were marked with a dorsal caudal clip. This was done to insure that Chewuch River fish could be distinguished from Methow River efficiency test release fish (Appendix Table 1).

5.1.4. Spring Season, 1996

The methodology aforementioned described for monitoring the 1995 smolt outmigration was similar to that in 1996. Thus, only significant differences will be described here. Mean daily flow data was obtained from Taylor (pers comm., 1996) for the Chewuch River. The eight foot screw trap was fished in the thalweg region toward the right bank until April 10, then relocated at the right bank site at the higher river discharge[2]. Smolt monitoring began March 14 through June 30. The trap was not operated April 23-30 (mechanical problems with the trap), May 18 and May 25- June 18 (due high river discharge and floating debris). The same method previously described in the Spring Season, 1995 Section (5.1.1) was used to estimate fish passage when the trap was inoperable in 1996. Two spring chinook smolts were captured the remainder of the monitoring season, June 19-30 and were not included in the season total estimated smolt outmigration. Reasons for this were: 1) that no efficiency test releases were possible during the higher river discharge to accurately estimate the actual number of outmigrants during the non-monitoring period of May 25-June 18 was a much larger error in the season total smolt estimate than that associated with the exclusion of these two fish.

As previously mentioned, when the river discharge becomes too high the monitoring site, the trap is typically relocated from the thalweg (left bank) more inshore towards the right

[2]When the river discharge becomes too high the trap is typically moved from the left bank site (thalweg region) inshore close to the right bank. This is necessary to avoid fishing the trap in large standing waves which form and increase in size as the discharge increases.

bank. Typically, the screw trap begins operation at the left bank location when flows are low and then is re-located at the right bank site during higher flows. This requires developing a flow-entrainment relationships for left and right bank locations. Unlike 1995, the trap was fished at both the left and right bank locations in 1996. The 1996 entrainment test release data set was used to calculate the fish entrainment rate and subsequent estimated daily fish passage. The entrainment rate was assumed, like in 1995, to be dependent upon the bank location rather than river discharge. The mean left and right bank entrainment rate was 27.8% and 19.6%, respectively (Appendix Table 1).

5.2. LATE SUMMER PARR (1995) DENSITIES

5.2.1. Spring Chinook

Daytime snorkel surveys were used to determine late-summer (August 7-September 13, 1995) spring chinook and steelhead/rainbow parr standing crop estimates in the Chewuch River from its confluence to rm 32.4. Survey reaches and parr estimates were determined based on a methodology similar to that described by Hankin and Reeves (1988). For each habitat unit (riffle, pool, glide) its length and several widths were measured using a hip-chain and tape measure. In addition, every fifth habitat unit type was snorkeled except for reaches V and VI. Since few parr have been observed in reaches V and VI in the past two years, a single representative reach was snorkeled, opposed to every fifth habitat unit. Stream reaches were based on the U.S. Forest Service Chewuch River 1993 stream survey Molesworth, 1993). As in 1994, the Chewuch River was divided into eight stream reaches, totaling 32.4 river miles. The snorkel units are summarized in Appendix Table 2.

Typically, each habitat unit was snorkeled between 0900-1650 hour by three divers that moved upstream while enumerating fish that they were encountered. A more detailed description of the snorkel procedures can be found in the 1994 Annual Report (Hubble and Sexauer, 1994).

Only salmonid species were identified and enumerated during the surveys. The two cover types- instream woody debris and instream boulders that fish were associated with was

recorded.

A mark-recapture type study was carried out in selected pool and riffle habitat units that were previously snorkeled, from September 9-13. The purpose of this study was to help determine the accuracy of the snorkel technique use in enumerating spring chinook parr. To accomplish this, habitat units were seined with a 50 ft fine mesh beach seine immediately preceding and following dusk (1950-2200hrs) to collect spring chinook parr. Multiple passes were made through each habitat unit to try to obtain a minimum of 30% of the chinook parr originally enumerated by snorkeling. Once collected, the fish were anesthetized with MS-222, given a dorsal caudal clip and allowed to recover in a plastic bucket. After recovery the fish were released back into the same area of the habitat unit that they were collected from. The following afternoon, the habitat units were resnorkelled using the same effort as in the original snorkeling survey and the number of marked to unmarked fish was recorded. This allowed for pool and riffle habitat type "correction" factors to be developed, and used in the calculation of the spring chinook parr standing crop estimate. The "correction" factors were determined as follows:

$$N_{habitat\ unit} = n_{habitat\ unit} / (M / R);$$

where $N_{habitat\ unit}$ is the corrected parr estimate (pool or riffle habitat type), $n_{habitat\ unit}$ is the number of parr enumerated during the original snorkel survey (pool or riffle habitat type), M is the number of fish fin clipped and released, and R is the number of fin clipped fish observed under the second snorkel survey. Assumptions are: 1) that the marked and unmarked fish remained (no emigration) in the habitat unit and that there was no immigration of new fish between the first and second snorkel surveys. This assumption was necessary since the river width and discharge, and the number of habitat units sampled precluded the use of block nets, and 2) that the marked and released fish redistributed equally with the non-marked and behaved similarly to the non-marked fish.

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:

$$BPE = \Sigma_{i=1 \text{ to } 8} RPE_i ;$$

where: BPE = the Chewuch Basin Parr estimate.

To provide consistency the "corrected" parr estimates were not used to compare with past years results, but are summarized in the Results and Discussion Section (Table 1) to point out that the number of parr reported may be underestimated.

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 distinguished by age classes, with fish described as either 0+ parr or 1+ parr.

5.3. SPAWNING GROUND SURVEYS

5.3.1. Redd Surveys

The same spawning reaches were surveyed in the Methow, Chewuch and Twisp basins and their respective tributaries in as in previous 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 a previously 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 when each redd was surveyed.

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.

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.

5.3.2. Redd Measurements

Nine redds in the Methow and two redds each in the Twisp and Chewuch basins were described by recording various physical attributes about each redd. These attributes were: length, width, pit depth, tailspill depth, water velocity in the redd pit and over the tailspill, distance and direction (up/downstream) to nearest cover, cover type (ie. large and small woody debris, undercut banks, boulders, rootwads, overhaning vegetation) and redd location (river section number). Eight of the redds were measured four weeks after the redd was initially located and the other three were measured on the same. In most cases the actual water depth was somewhat greater when the fish constructed the redd than when the measurements were taken. Measurements were taken using a meter tape and a Swoffer digital flow meter.

5.4. POTENTIAL ACCLIMATION/REARING SITES

In the summer/fall of 1996 the Methow Basin was surveyed for potential spring chinook acclimation/rearing sites. The survey was limited to off-channel ponds and side channels

that would not be substantially influenced by mainstem flows.

Acclimation/rearing sites or potential river reaches (ie. flood plains) were initially located from USFS aerial photographs and from USGS 7.5 minute quadrangle maps. A survey crew walked each river reach and recorded various habitat measurements for each site. The following measurements were recorded: survey date-, location (descriptive and river mile); length of the site; the mean, minimum and maximum width-, the mean, minimum and maximum water depth; mean bankfull depth; dominate and subdominate substrate type; the number of pieces of in-channel wood (brush, small and large categories)- and water discharge. All linear measurements were recorded in meters using a hip-chain and 50 m surveyor's tape. Discharge was measured using a Swoffer's digital flow meter. The substrate and in-channel wood was classified according to the definitions described in the USFS Stream Inventory Handbook (ver. 7.0, 1993).

Typically the site length was measured using a hip-chain pulled upstream along the stream bank. Three to five width measurements were recorded depending on the length of the site. The survey crew used their judgement to determine where along the length of the site to take width measurements, to best reflect the overall mean width. Along each width transect three water depths (left bank, thalweg and right bank) were taken, and the substrate type noted. The composite of all the substrate types were used to determine the overall substrate dominate and subdominate classification for each site. As inchannel wood (partially out of the water counted) was encountered moving upstream through the site it was classified and recorded. The water discharge was taken at the outfall or at the downstream end of the site.

6.0. RESULTS AND DISCUSSION

6.1. OUTMIGRATION

6.1.1. Spring Season, 1995

6.1.1.1. spring chinook

The estimated number of smolt outmigrants from the Chewuch basin was 4,546±482 fish (Appendix Table 3), compared to an estimated 8,908 and 12,494 fish in 1993 and 1994, respectively. As in 1993 and 1994, smolt outmigration presumably began prior to the first day of trapping, since 6 (actual catch) spring chinook smolts were captured the first day. It appears that the 1995 smolt outmigration was later than in previous years (Figure 2). In 1995 the highest daily estimated fish passage occurred April 27. This compares to April 4 in 1994 and April 18 in 1993. Similarly, the median passage date (April 27) was later in 1995 than in 1994 (April 10) and 1993 (April 19). The 25% and 75 passage dates were April 25 and May 3 in 1995.

As observed in 1993 and 1994, the majority (68.0%) of smolts outmigrated prior to a significant increase in river discharge. Stream discharge on April 9 the first day of monitoring was 472 cfs and it increased to 658 cfs by April 27, after which it increased five-fold to 3,320 cfs by May 17 (Figure 3). The peak outmigration occurred April 25-27, which accounted for 32.2% of the entire smolt outmigration. This is considerably later than the peak oumigration in 1994 which occurred April 2-4.

The mean spring chinook smolt fork length was 100 mm (n=491) with a coefficient of variation equal to 10.1% (Figure 4). Their mean weight and condition factor were 10.95 g and 1.09 (n=388) respectively.

A total of three spring chinook YOY were captured in the screw trap from April 9 to May 26.

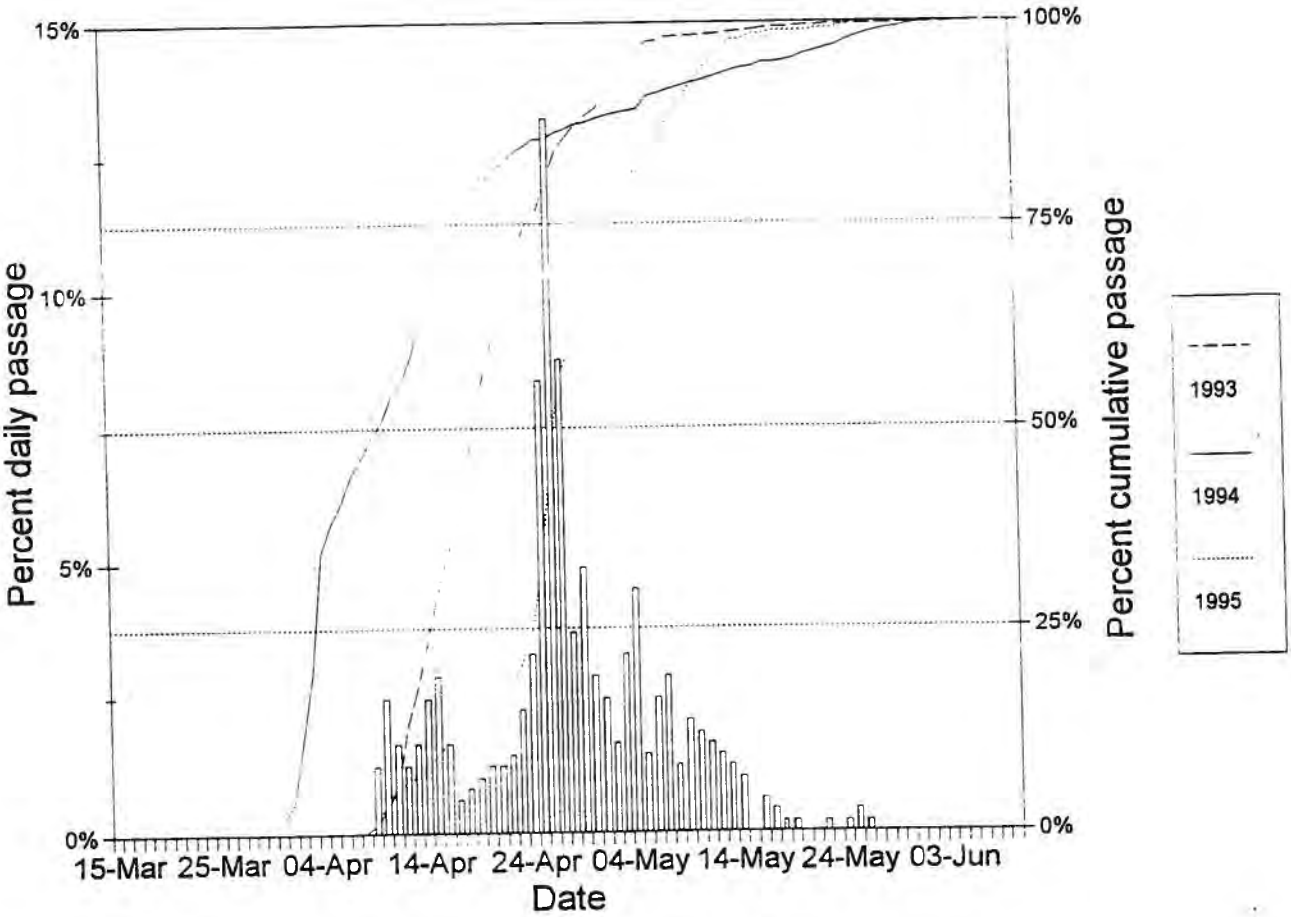

Figure 2. Chewuch basin spring chinook 1995 daily passage, and 1993, 1994 and 1995 cumulative passage.

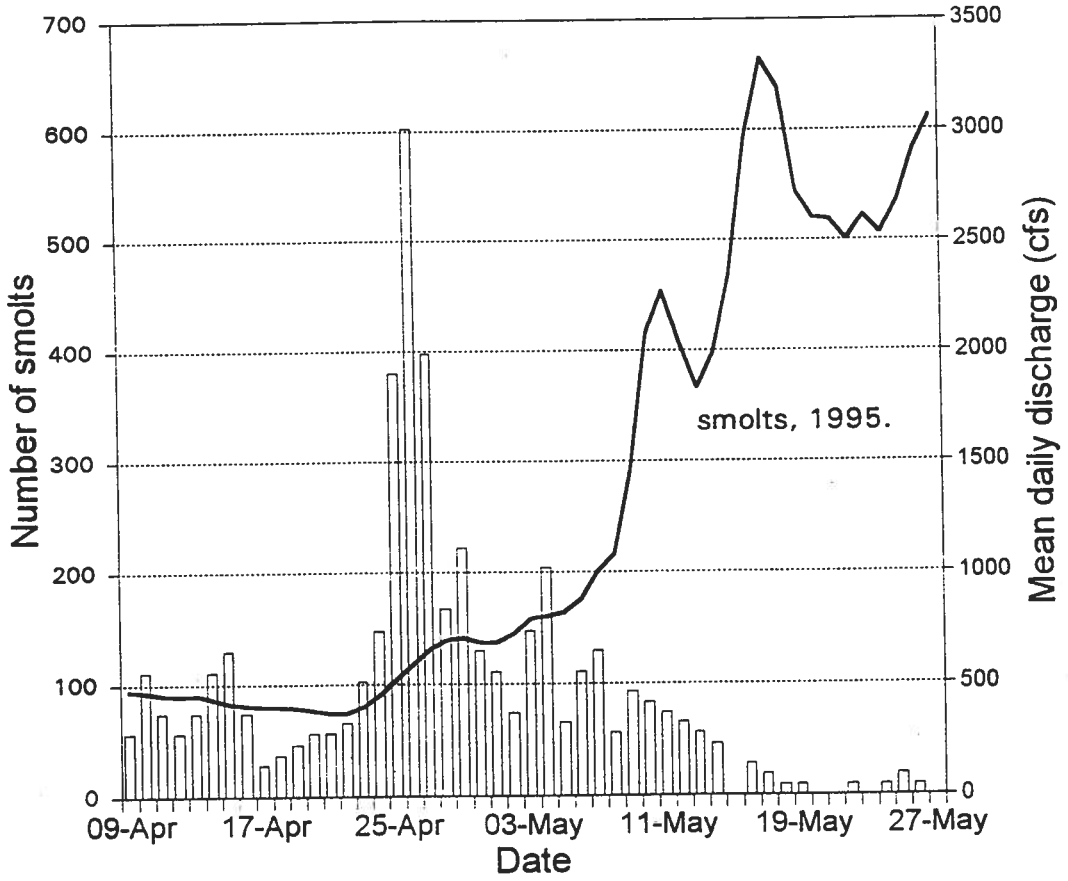

Figure 3. Estimate daily spring chinook smolt outmigration and mean daily discharge for the Chewuch basin, 1995.

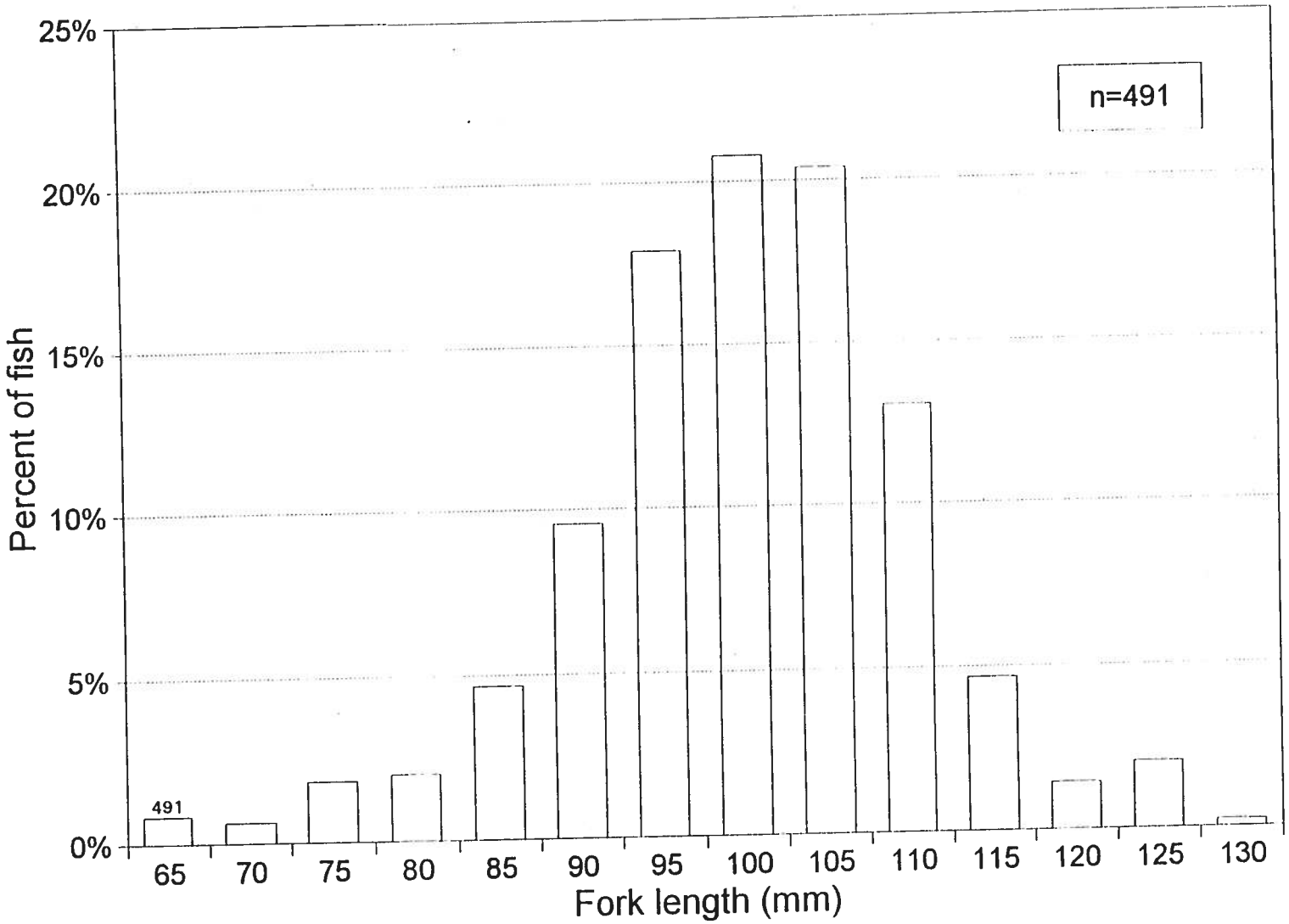

Figure 4. Length frequency distribution of Chewuch basin spring chinook smolts, 1995.

6.1.1.2. steelhead/rainbow trout

An estimated 2,130±300 steelhead smolts/rainbow trout outmigrated from the Chewuch basin in 1995, of these 80% were classified as steelhead smolts[3] (Appendix Table 4). The steelhead smolt estimate of 2,130 compares to 1,784 and 828 smolts in 1994 and 1993, respectively. The median date of passage was April 30 and the 25% and 75% cumulative dates of passage were April 26 and May 6 (Figure 5).

The mean steelhead smolt fork length was 171 mm (n = 160) with a coefficient of variation equal to 8.3% (Figure 6). The mean weight and condition factor were 45.2 g and 9.1 (n = 159) respectively.

A total of three hatchery steelhead smolts were captured in the screw trap during the spring season. These most likely were carry-over fish from the 1994 steelhead release made in late spring for the purpose of providing recreational fishing (Miller, pers comm., 1995).

6.1.1.3. non-target species

Non-salmonid species captured at the Chewuch screw trap are presented in Appendix Table 5. Species recorded in decreasing abundance were longnose dace, whitefish, lamprey, sucker and sculpin.

6.1.2. Summer, 1995

6.1.2.1. spring chinook

All but five of the fish were captured at the Highway 20 bridge site during the summer juvenile outmigrant season. A total of 64 parr were counted (Appendix Table 6). The majority (57 fish) of these were captured between July 22 and August 31, after which the trap became inoperable due to low river discharge.

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[3]The other fish (20%) could either be steelhead smolts which have not yet displayed strong external characteristics or resident rainbow trout.

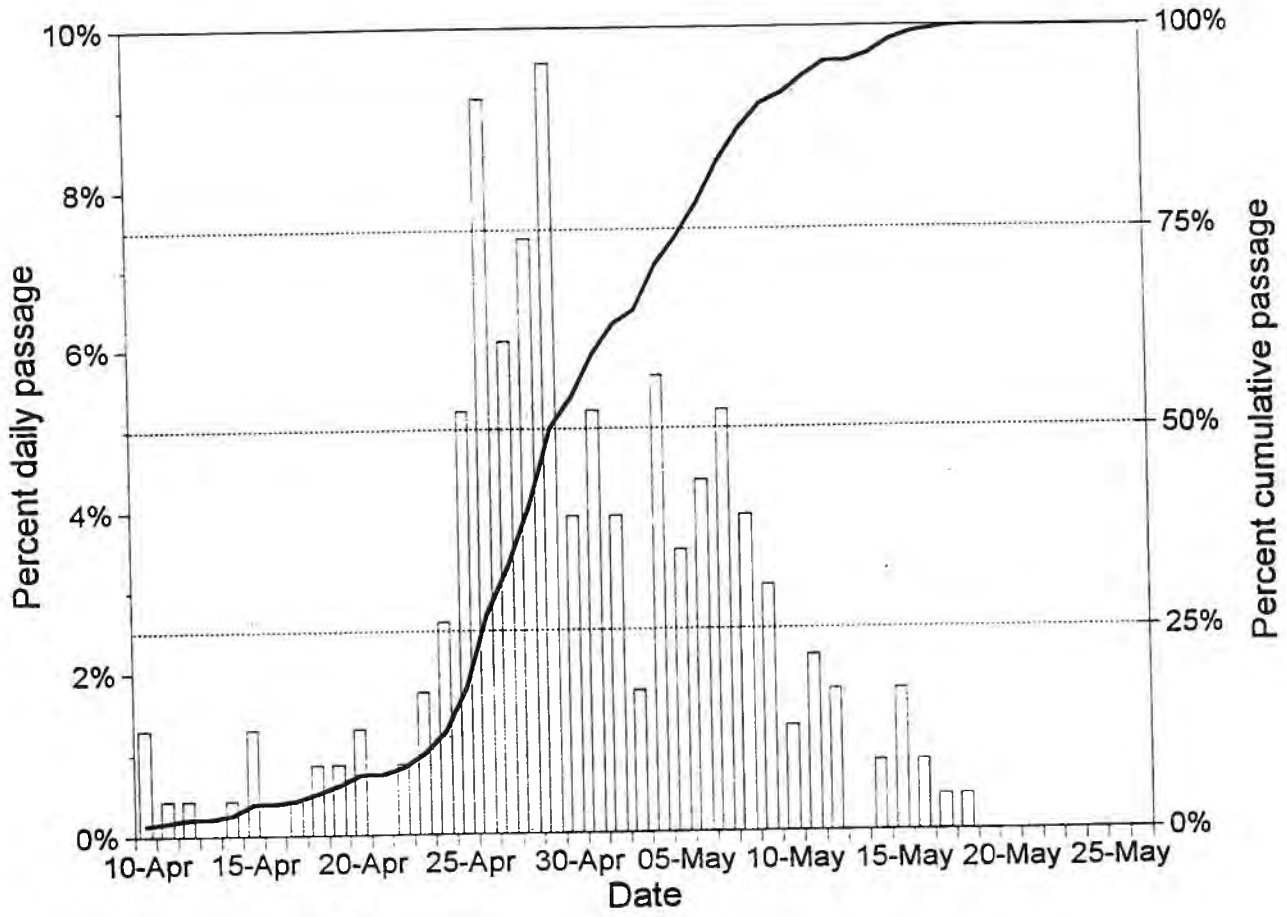

Figure 5. Estimated daily and cumulative steelhead/rainbow smolt and parr outmigration from the Chewuch basin, spring 1995.

Their mean fork length was 82 mm (n = 64) with a coefficient of variation equal to 15.2%. Ten precocious spring chinook were captured between July 24 and August 24, with a mean fork length of 127 mm, with a coefficient of variation equal to 13.3%, and a mean weight of 30.7g.

6.1.2.2. steelhead/rainbow trout

A total of 29 steelhead/rainbow trout, with a mean fork length of 159 mm, a coefficient of variation of 14.9%, and a mean weight of 46.2 g were captured between June 25 and August 30 (Appendix Table 6).

One hatchery steelhead parr was captured during the summer season, compared to 224 in 1994. This is a result of discontinuation in outplanting of non-smolted hatchery steelhead in the upper Chewuch River in 1995.

6.1.2.3. Methow River

A total of 22 juvenile chinook were captured in the Methow screw trap from July 27 through August 31 (Appendix Table 7). Their mean fork length was 91 mm with a coefficient of variance of 4.0%. The largest fish observed was 132 mm and the smallest 47 mm. Because of the large spawning concentration of summer chinook upstream to the trap it was not possible to distinguish spring from summer chinook. Three steelhead/rainbow trout were captured ranging in fork length from 84 to 180 mm. The dominate non-salmonid species captured was longnose dace.

6.1.3. Fall Season, 1995

6.1.3.1. spring chinook

An estimated 2,058±158 spring chinook parr outmigrated during the fall screw trap monitoring period. Ninety-one fish were estimated past the trap the last day of monitoring, which indicates that the outmigration of parr was not complete as of December 3 (Figure 7 and Appendix Table 8). A similar outmigration pattern was seen in

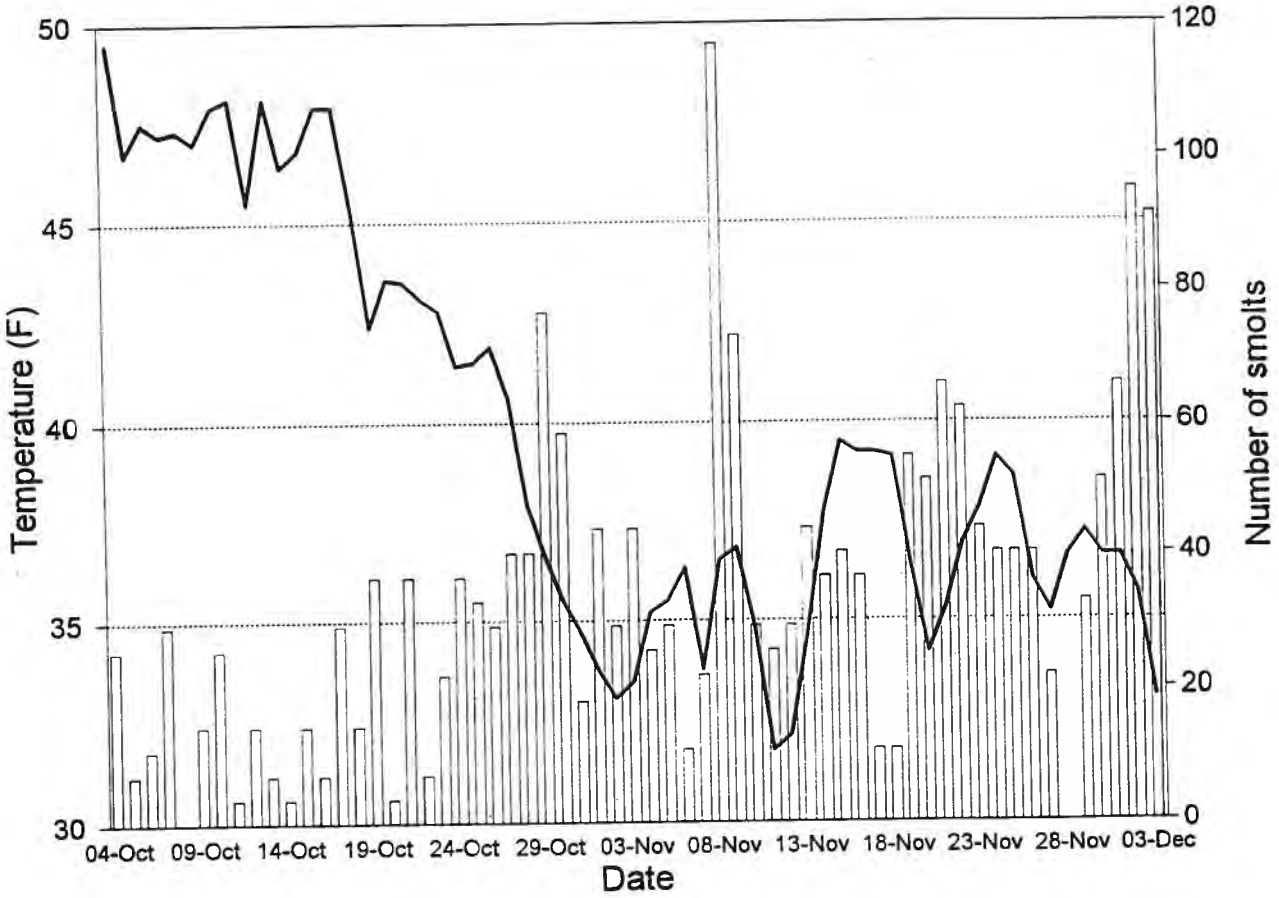

Figure 7. Estimated daily spring chinook parr outmigration and mean daily temperature for the Chewuch River, fall 1995.

the fall of 1993 when an estimated 1,982 parr ourtmigrated from the Chewuch River, with the greatest number occurring in November (monitoring ceased November 18 due to river ice). Unlike in 1993, there was no consistent increase parr outmigration with decreasing water temperature. In 1993 there was a sharp decrease in water temperature the first half of November from about 40° F to 32° F. However, in 1995 the water temperature was about 34° F November 1, but oscillated between 32° F and 39° F through November and earlier December with no sharp decline in water temperature. The mean spring chinook fork length was 101 mm with a coefficient of variation of 7.0% (Figure 8). The mean weight and condition factor were 9.9 g and 0.9, respectively.

6.1.3.2. steelhead/rainbow trout.

An estimated 99 wild steelhead/rainbow trout outmigrated during the fall monitoring season (Appendix Table 9). The mean fork length was 182 mm (n=23), and the coefficient of variation was 21.4%. The mean weight and condition factor was 60.6 g. and 1.0.

A total of 12 (actual catch) hatchery steelhead parr were captured, which ranged in length from 185 to 223 mm. These fish, presumably, were residualized steelhead from the spring 1994 smolt outplant.

6.1.3.3. Methow River

During the 17 days the Carlton screw trap was in operation 238 spring chinook were captured, along with 74 rainbow/steelhead, 3 cutthroat trout and 12 bull trout (Appendix Table 10). There was no discernable outmigration pattern during the 17 day period. Unfortunately, a localized storm event in the Twisp watershed rapidly raised the discharge in the lower Methow River on November 8 which resulted in damage to the trap, terminating further outmigrant monitoring.

Of significance, however, was the recapture of 10 marked spring chinook that were

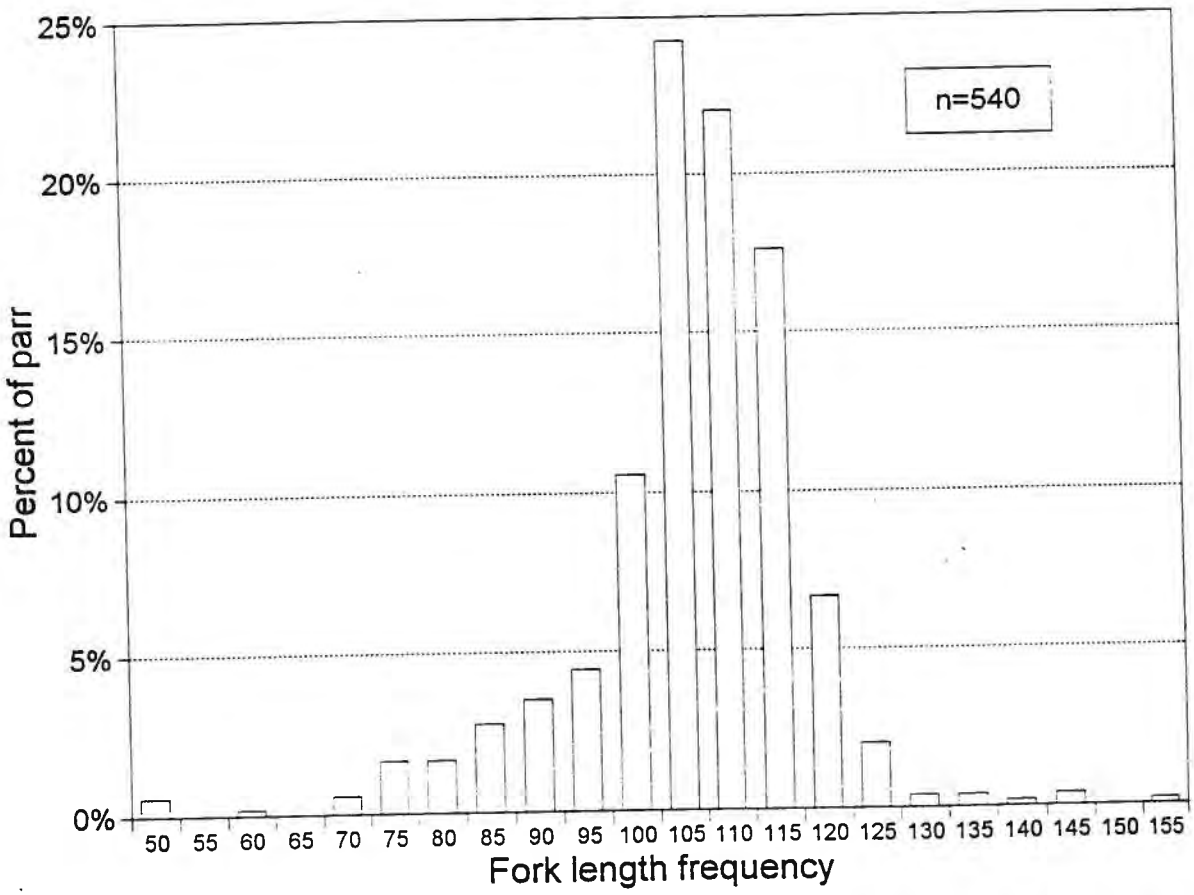

Figure 8. Length frequency distribution of Chewuch basin spring chinook parr October 3 - December 3, 1995.

initially captured in the Chewuch screw trap (Appendix Table 11). From a group of 103 spring chinook that were marked and released at the Chewuch screw trap for efficiency tests, ten fish were subsequently recaptured at the Carlton screw trap, a distance of 12.4 river miles. This indicates, at least for the Chewuch spring chinook, that a portion of the fall outmigrant population is over-wintering downstream to this point in the Methow River. The exact travel time of spring chinook fall migrants from the Chewuch trap to the Methow trap can not be determined, however, it appears they are traveling this distance in 1-2 days or 12.4 to 6.2 river miles per day.

6.1.4. Spring Season, 1996

6.1.4.1. spring chinook

The 1996 estimated smolt outmigration from the Chewuch basin was 3,610±287 fish (Appendix Table 12). This compares to an estimated 8,908; 12,494 and 4,546 spring chinook smolts in 1993, 1994 and 1995, respectively.

The March 15 start date in 1996 was the earliest of the four years, even so ten fish were captured the first day indicating that the outmigration season began prior to this date. As observed in all previous years, the majority (81.0%) of smolts had outmigrated prior to a significant increase in the stream discharge (Figure 9). By April 8 53.5% of the smolts had outmigrated which also was when river discharge began to increase. Between April 7-15 stream discharge increased from 304 cfs to 908 cfs (crested) and then decreased to 778 cfs. During this time period smolt outmigration increased accounting for 32.2% of the total estimated number of outmigrants. Smolt outmigration continued to decline until May 14 when there was a brief increase in outmigration in response to increasing stream discharge. High stream discharge from May 25-June 18 precluded smolt monitoring, however, estimated daily outmigration for the week preceding this ranged from zero to ten fish. Thus it appeared that the smolt outmigration period was essentially over. When monitoring resumed June 19-30 only two smolts were captured. Relative to the past four years, the 1996 smolt outmigration was similar to that of 1994 which was earlier than in

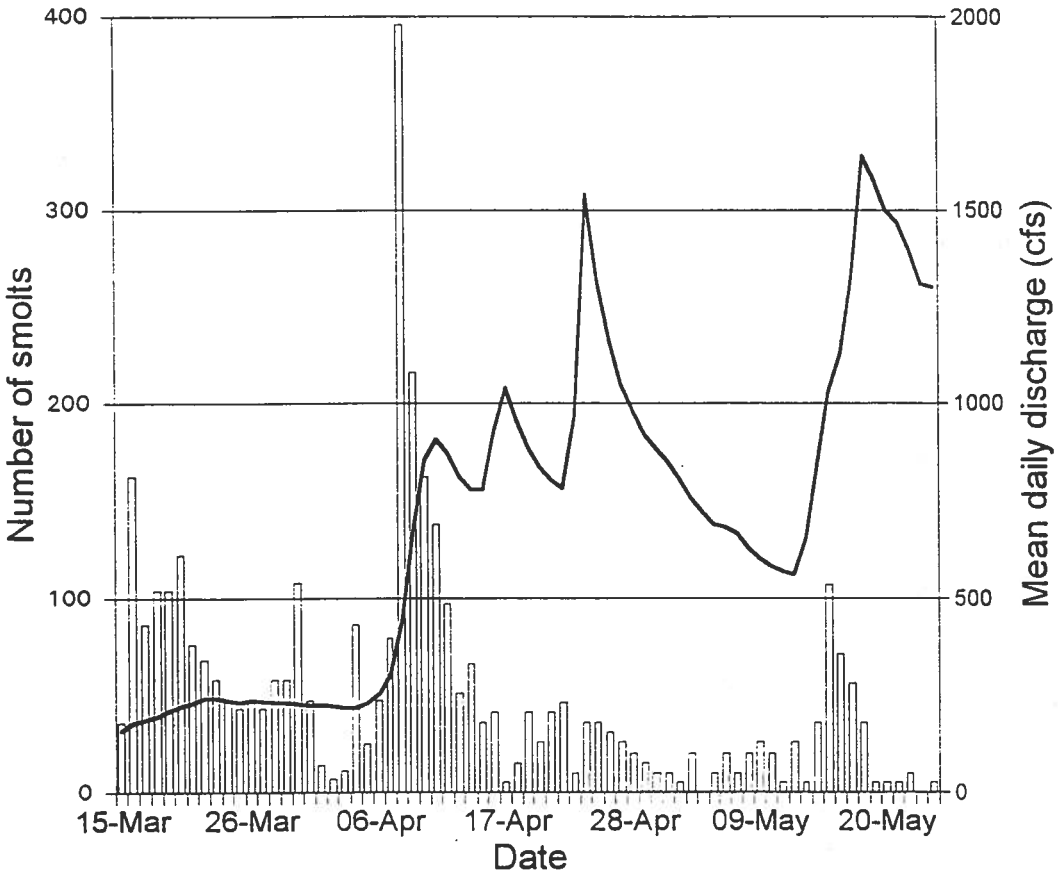

Figure 9. Estimated daily spring chinook smolt outmigration and mean daily discharge for the Chewuch basin, 1996.

1993 and 1995 (Figure 10). The median date of passage was April 8 in 1996, April 10 in 1994 and, April 19 and April 27 in 1993 and 1995, respectively. The mean spring chinook smolt fork length was 100 mm (n=829) with a coefficient of variation equal to 7.7% (Figure 11). The mean weight and condition factor was 11.1 g (n=827) and 10.3, respectively.

6.1.4.2. steelhead/rainbow

An estimated 1,007±161 steelhead/rainbow trout outmigrants were enumerated passed the screw trap in the Chewuch basin in 1996 (Appendix Table 13), of these 706 were considered steelhead smolts and the remaining 255 fish were classified as non-smolts[4]. The 1996 smolt estimate compares to 1,731 fish in 1995; 1,784 fish in 1994 and 828 in 1993. The median date of passage was April 23 and the 25% and 75% cumulative dates of passage were April 12 and May 15 (Figure 12).

The mean steelhead smolt fork length was 170 mm (n=108) with a coefficient of variation equal to 9.4 (Figure 13). The mean weight and condition factor were 48.3 g and 0.79 (n= 108), respectively.

6.2. LATE SUMMER PARR DENSITIES, 1995

6.2.1. spring chinook

The late-summer spring chinook parr estimate for the Chewuch basin was 5,334 fish, compared to 9,362 fish in 1994, and 5,838 fish in 1993 (Table 1). If the snorkel "correction" values are used in the calculation, the new late-summer parr estimate is 6,906 fish[5]. The 1995 snorkeling results (fish/river mile) are presented in Figure 14. The 1995 parr distribution was similar to that observed in 1993 and 1994, with the greatest total

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[4]These fish could either be steelhead smolts which have not yet displayed strong external characteristics or resident rainbow trout.

[5]This is an increase of 1,572 fish and results in a 22.8% higher point estimate. To be consistent with past year's data for comparative purposes the uncorrected data will be presented.

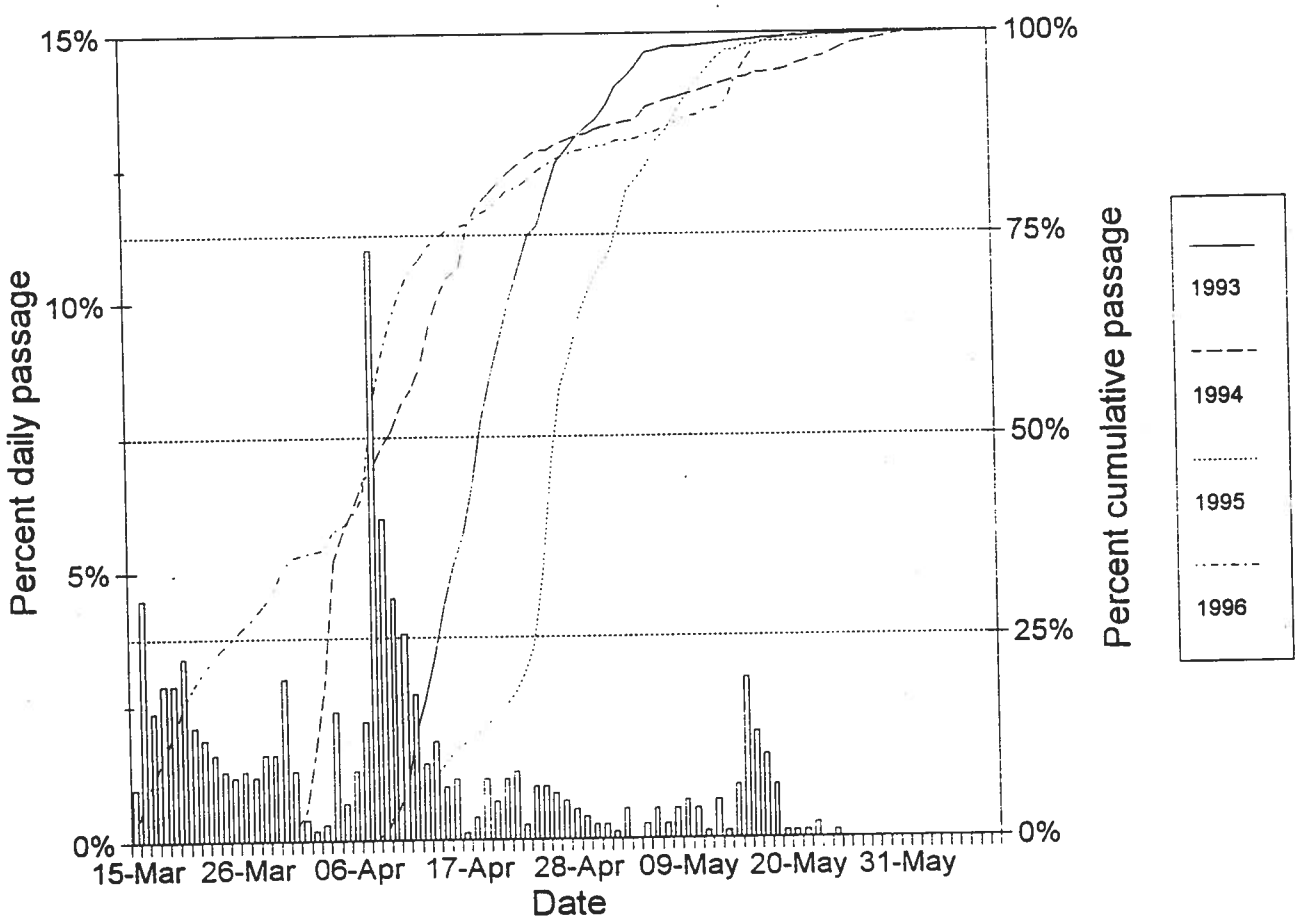

Figure 10. Chewuch basin spring chinook 1996 daily passage, and 1993 - 1996 cumulative passage.

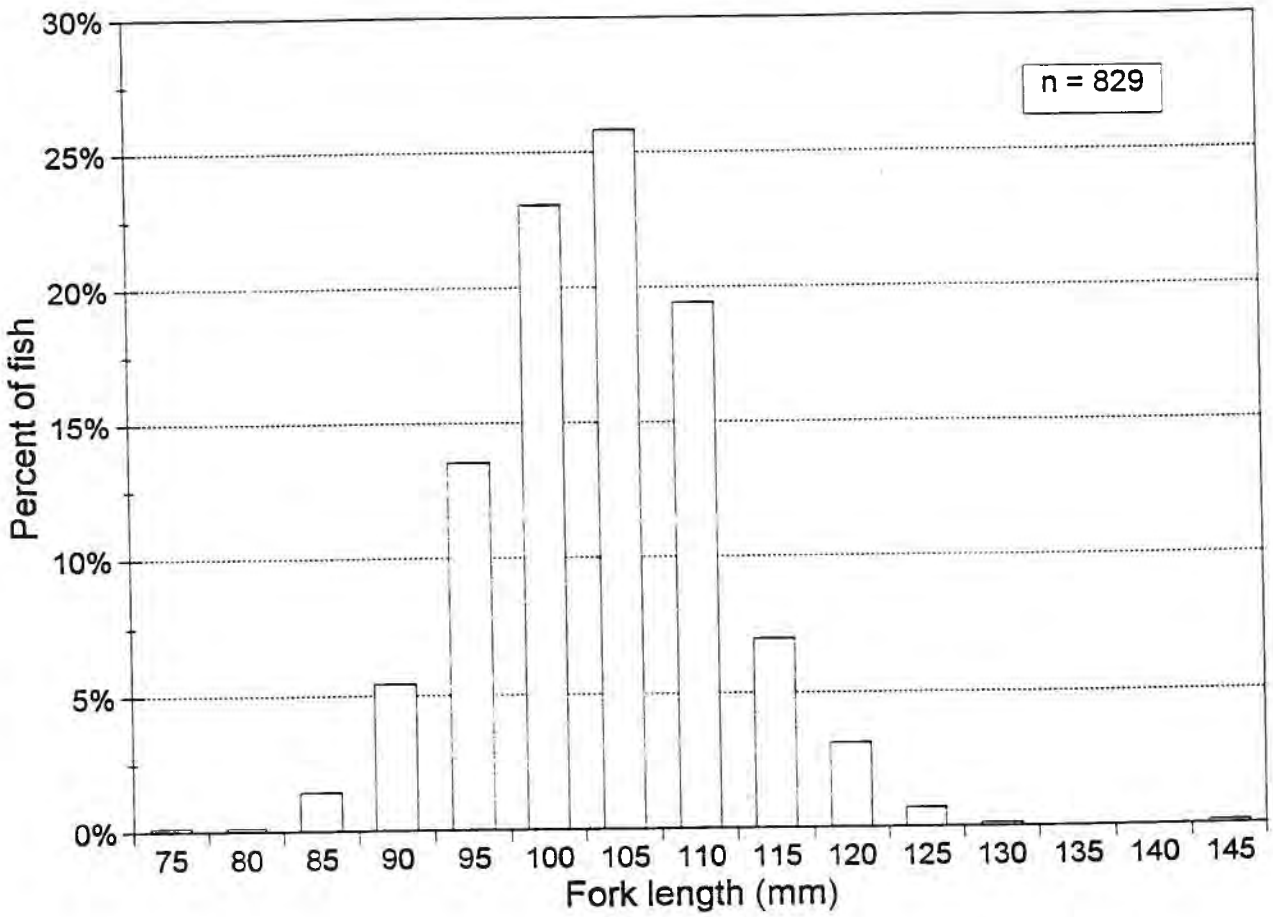

Figure 11. Length frequency distribution of Chewuch basin spring chinook smolts, 1996.

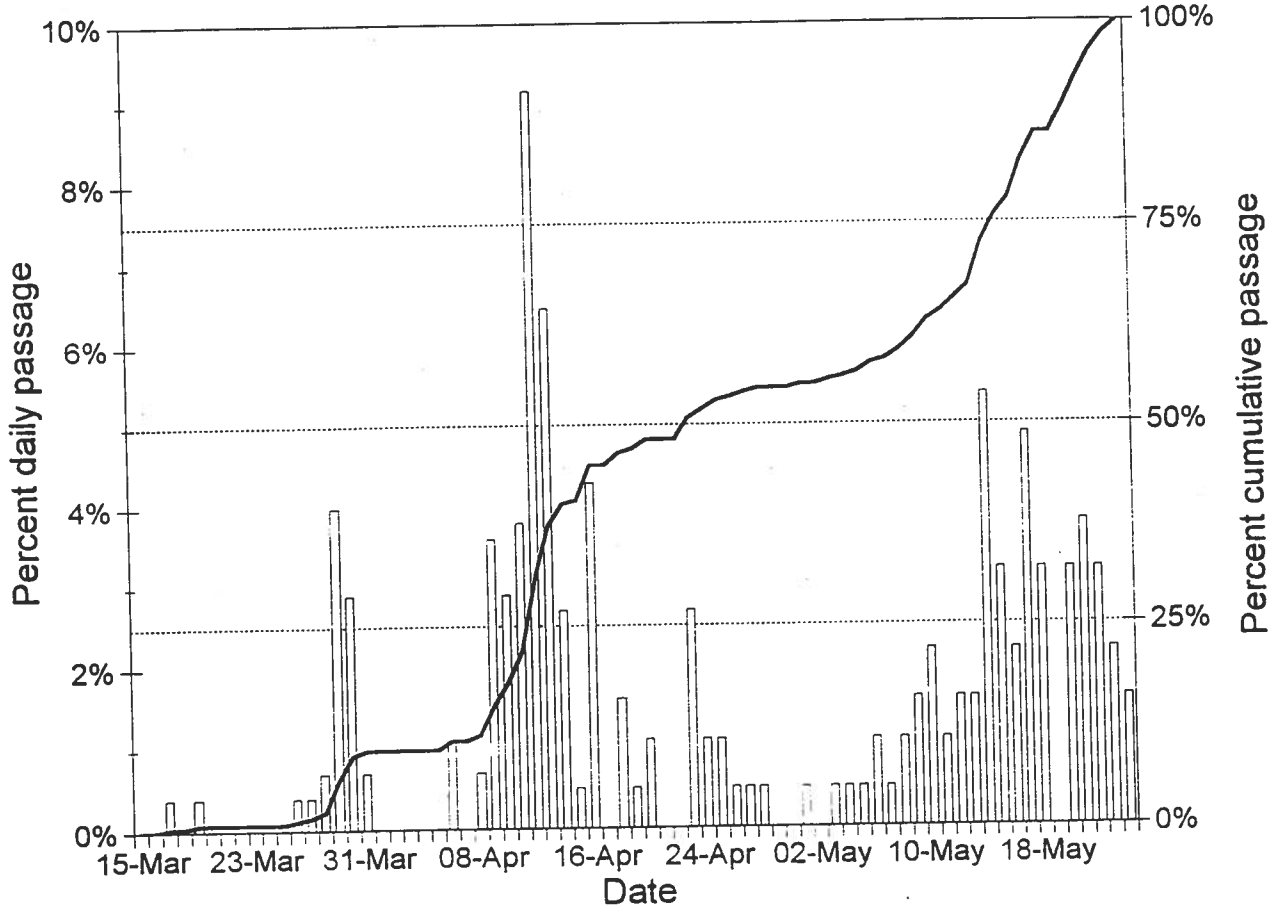

Figure 12. Estimated daily and cumulative steelhead/rainbow smolt and parr outmigration from the Chewuch basin, spring 1996.

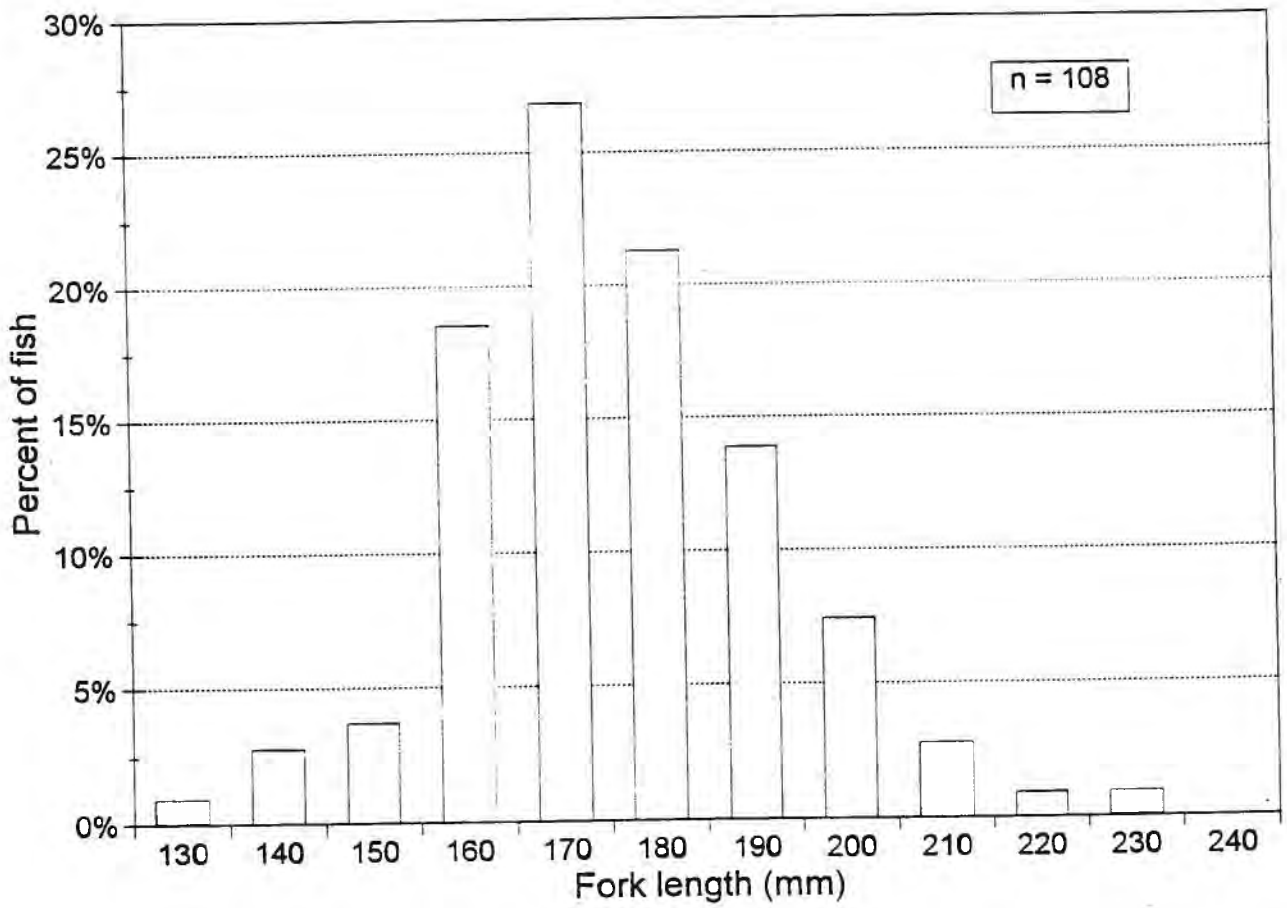

Figure 13. Length frequency distribution of Chewuch basin steelhead smolts, 1996.

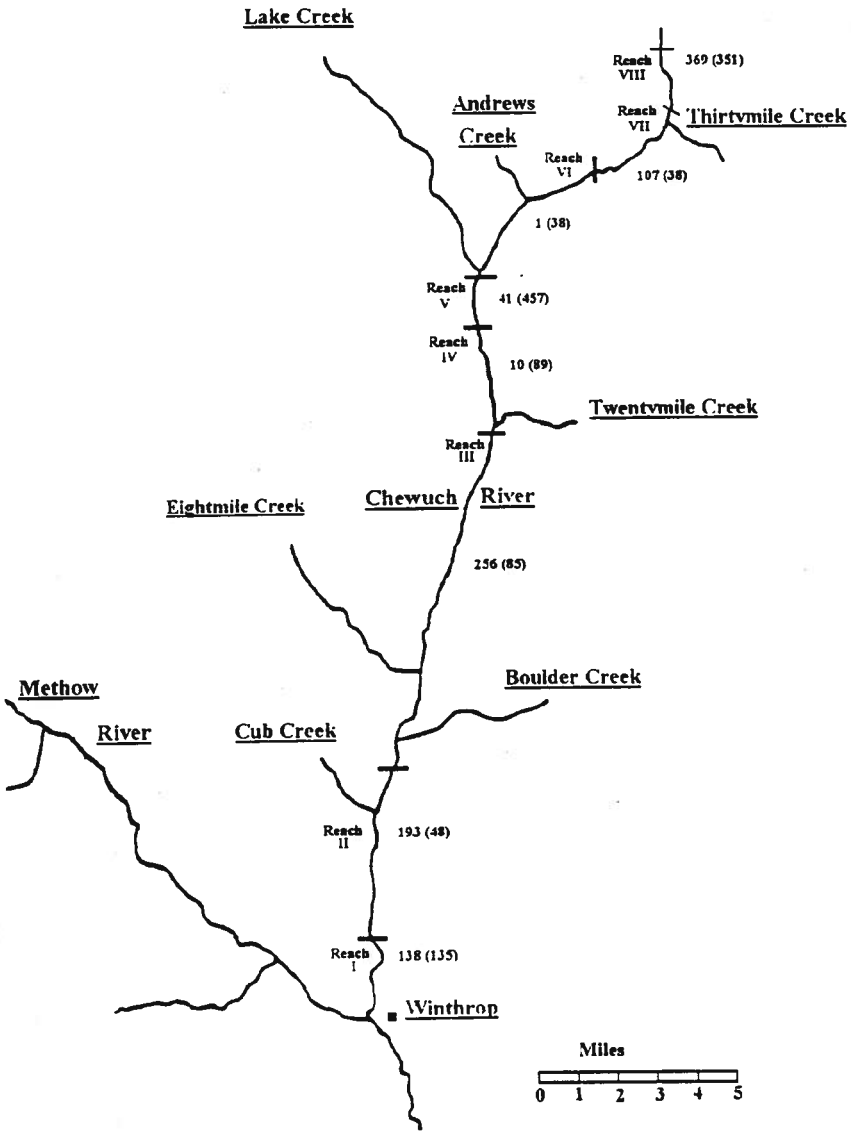

Figure 14. Estimated spring chinook and steelhead/rainbow (in parentheses) parr densities (fish/ river mile) by reach in the Chewuch River, summer 1995.

Table 1. Summary of spring chinook parr population estimates for the Chewuch River 1993, 1994, and 1995.

	Spring chinook 1993			Spring chinook 1994			Spring chinook 1995 w/o correction			Spring chinook 1995 w/ correction		
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
I (0.0-2.3)	99	227	3.9%	151	348	3.7%	138	318	6.0%	179	412	6.0%
II (2.3-8.4)	262	1,597	27.4%	337	2,054	21.9%	193	1175	22.0%	250	1521	22.0%
III (8.4-19.4)	276	3,041	52.1%	438	5,308	56.7%	256	2814	52.8%	331	3643	52.8%
IV (19.4-23.3)	230	899	15.4%	105	409	4.4%	10	183	3.4%	13	237	3.4%
V (23.3-24.6)	44	56	1.0%	2	2	0.0%	41	53	1.0%	53	69	1.0%
VI (24.6-28.0)	4	12	0.2%	2	8	0.1%	1	5	0.1%	1	6	0.1%
VII (28.0-31.2)	2	6	0.1%	275	880	9.4%	107	343	6.4%	139	444	6.4%
VIII (31.2-32.4)	--	--	--	294	353	3.8%	369	443	8.3%	478	574	8.3%
Total		5,838			9,362			5,334			6906	
Mean	180			289			165			213		

percentage of fish occurring in reach III (52.8%) and reach II (22.0%). These two reaches represent 52.8% of the mainstem river miles used by spring chinook, and account for 74.8% (3,989 fish) of the entire parr population. The percent of fish found in reaches II and III in 1995 was similar to that in 1993 and 1994 (Table 1).

Reach VIII had the highest parr density, with 369 fish/river mile, but because it is the shortest reach, at 1.2 river mile, it accounted for only 574 fish or 8.3% of the total estimate parr population. The next highest parr density occurred in reaches III and II with 256 and 193 fish/rm, respectively. Reach I had the fourth highest parr density with 138 fish/rm, which differs from 1994, and may reflect the unusually high numbers of redds (10) found in the lower river in 1994, followed by reach VII with 107 fish/rm.

The parr estimate in reach VII was 343 fish and it represents 6.4% of the spring chinook parr population. The lower density of fish found in reach VII in 1995 compared to 1994 may be the result of a decrease in water temperature. In the lower river (where the thermograph was located) the mean daily temperature decreased from 59° F the day prior to snorkeling this reach to 55° F on the day of the snorkel survey. Because reach VII is located in the headwater region the drop in water temperature may have been more pronounced. It hypothesized that this may have resulted in underestimating of the actual number of parr present, as they were not active in the water column. Reach VII has abundant cover which makes it more difficult relative to the other reaches to observe fish if they are not active. During the habitat survey of this reach two weeks prior to the snorkel survey many parr were visible. Night time snorkel surveys in 1994 in reach VII indicated that parr estimates made during the day time snorkel surveys underestimated the number of fish present in the glide habitat (the only unit type snorkeled). Another possible contributing factor in 1995 is the fact that only one redd was deposited in this reach in 1994 compared to eight redds in 1993.

As in 1993 and 1994, reaches V and VI had low parr densities. In reaches V and VI there were 41 and 1 fish/rm, which comprised 3.4% and 1.0% of the total parr population,

respectively. There was an estimated 53 parr in reach V and 5 parr in reach VI.

The parr distribution in both 1993 and 1994 was similar to that of the redd distribution for corresponding brood years 1992 and 1993. Similarly, this held true for 1995. For all three years the highest redd counts occurred in reach III (1992- 163 redds, 1993- 69 redds and 1994- 12 redds) (Figure 15). The 10 redds found at the lower end of reach II represented a much higher percentage of the total redds during 1994 than in previous years (37% of the total). This may explain the relatively high (6.0%) number of the parr found in reach I in 1995 compared to 1993 and 1994.

As observed during the 1993 and 1994 snorkel surveys, spring chinook were associated primarily with woody debris complexes. Fifty percent of the spring chinook parr were associated with woody debris, followed by boulders (17%). The remaining 33% of the spring chinook parr were not associated any cover. Typically small pods or groups of fish were associated with the two cover types and solitary fish associated with no specific cover type.

The percentage of fish usage by habitat type was compared to the percent habitat type available by river reach (Table 2). With the exception of reach VII, the dominate habitat type is riffle ranging in percent composition from 81.9% (reach II) to 95.1% (reach IV). The percentage of total fish residing in riffle habitat ranged from 23.6% to 73.9% ($\bar{x}$ = 44.4%). Conversely, excluding reach VII, percent pool habitat ranged from 4.0% (reach IV) to 15.2% (reach VIII) and the percentage of fish residing in pool habitat ranged from 26.2% (reach I) to 76.5% (reach IV) ($\bar{x}$.= 49.9%). Reach VII, unlike the others, is dominated by glide habitat (75.8%), however the majority of fish (75.2%) were found in pool habitat which comprised 16.6% of the reach. As previously discussed, however, the number of fish estimated in reach VII is thought to be underestimated. Reaches V and VI

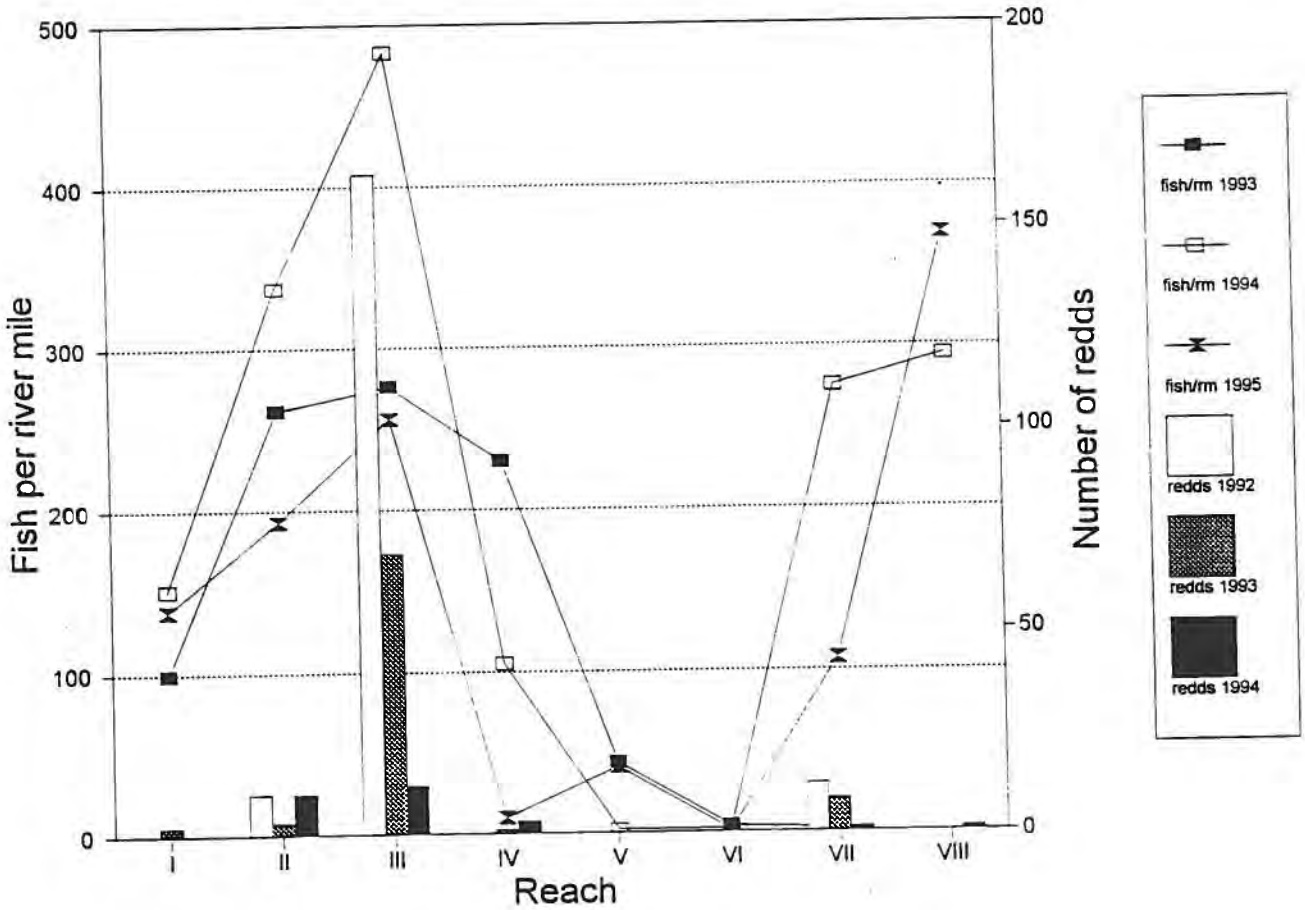

Figure 15. Comparison of spring chinook redd counts and parr density by reach in the Chewuch basin, 1993, 1994 and 1995.

Table 2. Habitat availability and use by spring chinook parr, 1995.

	% riffle habitat	% fish using riffle habitat	% pool habitat	% fish using pool habitat	% glide habitat	% fish using glide habitat
Reach I	84.9%	73.8%	15.1%	26.2%	0.0%	0.0%
Reach II	81.9%	64.0%	8.5%	36.0%	1.8%	0.0%
Reach III	82.6%	23.6%	9.3%	47.8%	8.1%	28.6%
Reach IV	95.1%	23.5%	4.0%	76.5%	1.0%	0.0%
Reach V	na \a	na \a	na \a	na \a	na \a	na \a
Reach VI	na \a	na \a	na \a	na \a	na \a	na \a
Reach VII	7.6%	0.0%	16.6%	75.2%	75.8%	24.8%
Reach VII	84.8%	36.8%	15.2%	63.2%	0.0%	0.0%

\a Reaches V and VII were not stream surveyed in 1995.

were not completely surveyed for habitat types, however, it's known from past year's data that these reaches are dominated by high gradient riffles (+95%).

6.2.2. steelhead/rainbow trout

The population estimate for age 1+ steelhead/rainbow was 3,310 fish (Table 3 and Figure 14). Highest age 1+ steelhead/rainbow densities occurred in reaches V (457 fish/rm) and VIII (351 fish/rm). This was followed in decreasing order by reach I (135 fish/rm), reach IV (89 fish/rm), reach II (48 fish/rm), and reaches VI and VII (each with 38 fish/rm). Fifty-nine percent of the age 1+ steelhead/rainbow population (1,963 fish) resided in reaches III, IV and V.

The population estimate for age 0+ steelhead/rainbow YOY was 216 fish (Table 3). As experienced in the previous two years, the number of steelhead/rainbow YOY was probably under-counted because of the inability to survey adequately the shallow edge habitat where they are typically located.

6.3. SPAWNING GROUND SURVEYS

6.3.1. Spring Chinook Run Size

The 1995 Wells Dam spring chinook count was 113 (72 adults, 41 jacks) fish (pers comm. Douglas PUD, 1996) (Table 4), which is a 18.8-fold decrease compared to the 1985-94 average run size of 2,128 fish.

6.3.2. Winthrop National Fish Hatchery (WNFH) and Methow Fish Hatchery (Methow FH) broodstock

A total of 14 (8 F, 6 M) spring chinook were collected for broodstock between the WNFH and Methow FH in 1995.

Table 3. Summary of spring chinook and steelhead/rainbow parr population estimates for the Chewuch River 1993 and 1994.

	Steelhead/rainbow age 0+ 1993			Steelhead/rainbow age 1+ 1993			Steelhead/rainbow age 0+/1+1994			Steelhead/rainbow age 0+ 1995			Steelhead/rainbow age 1+ 1995		
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)	154	355	60.4%	74	170	6.2%	127	292	11.5%	3	6	2.7%	135	311	9.4%
II (2.3-8.4)	15	92	15.6%	90	551	19.9%	178	1,085	42.7%	7	42	19.4%	48	292	8.8%
III (8.4-19.4)	3	31	5.3%	59	650	23.5%	55	607	23.9%	11	121	56.0%	85	933	28.2%
IV (19.4-23.3)	10	38	6.5%	129	501	18.1%	76	295	11.6%	1	3	1.4%	89	436	13.2%
V (23.3-24.6)	50	66	11.2%	625	813	29.4%	40	52	2.0%	8	11	5.1%	457	594	17.9%
VI (24.6-28.0)	2	6	1.0%	23	79	2.9%	29	100	3.9%	3	10	4.6%	38	203	6.1%
VII (28.0-31.2)	0	0	0.0%	0	0	0.0%	32	103	4.1%	7	23	10.6%	38	120	3.6%
VIII (31.2-32.4)	--	--	--	--	--	--	8	9	--	0	0	0.0%	351	421	12.7%
Total		588			2,764			2,543			216			3,310	
Mean	18			85			78			7			102		

Table 4. Summary of spring chinook adults passing Wells Dam, number of broodstock collected at Winthrop National Fish Hatchery and Methow Valley Spring Chinook Hatchery, and estimate of natural spawners in the Methow Basin, 1967-1995.

Year	Wells Dam Counts		Total	Hatchery broodstock WNFH	Hatchery broodstock MFH	Methow Basin spawners (est)
	Adults	Jacks				
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
1980	941	241	1,182	155	--	1,027
	1970-1980 (avg)		2,831		--	2,801
1981	1,367	98	1,465	399	--	1,066
1982	2,270	131	4,252	601	--	3,651
1983	2,726	143	2,869	755	--	2,114
1984	3,066	214	3,280	510	--	2,770
1985	5,151	116	5,267	1201	--	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	1327	--	1,613
1989	1,633	87	1,720	195	--	1,525
1990	927	12	939	121	--	818
	1981-1990 (avg)		2,804	654	--	2,150
1991	682	100	782	92	--	690
1992	1,596	27	1,623	271	60	1,232
1993	2,422	22	2,444	646	252	1,546
1994	243	15	258	29	34	195
1995	72	41	113	0	14	99

Personal communication, R. Klinge, Douglas County PUD.

Personal communicaiton, W. Wallein, Winthrop National Hatchery Manager.

Personal communicaiton, B. Jateff, Methow Valley Hatchery Manager.

An additional 107 adults & 4 jacks were video-recorded during "non-counting" hours.

An additional 197 adults & 6 jacks were video-recorded during "non-counting" hours.

6.3.3. Spawning Ground Surveys

6.3.3.1. Methow River

A total of 9 redds were found in the Methow River which comprised 60.0% of the Methow Basin's total redd count. Within the index area (reaches 5 and 6) 7 redds (78%) were counted. The remaining two redds were located immediately downstream to the Foghorn diversion dam.

6.3.3.2. Lost River

No redds.

6.3.3.3. Chewuch River

Two redds or 13.3% of the total Methow Basin's redd count were deposited in the Chewuch River. Both redds were located in section 6 (Buck Cr. to Camp Four bridge).

6.3.3.4. Twisp River

Four redds (26.7%) total were counted in the Twisp River; one redd each in sections 5,7,12 and 13.

6.3.3.5. Other Tributaries

No redds were located in Early Winters, Lake, Gold, or Wolf creeks.

6.3.4. Fish Per Redd

Based on the number of adults past Wells Dam (113) minus the broodstock fish (14) the estimated spawner escapement to the Methow Basin was 99 fish. The spawner to redd ratio is 6.6, which is the highest ever recorded. The 1987-94 mean spawner to redd ratio is 2.21 and the range is 1.46 to 2.93. The primary factor appears to be the unusually high percentage (36.3%) of jacks that comprised this run. However, even when the jacks are excluded from the calculation the number of spawners per redd is 4.8. This suggests a higher than normal level of pre-spawning mortality occurred.

6.3.5. Redd Measurements

One of the critical uncertainties of the MBSCSP is whether or not F_1 supplementation adults spawn with equal success as do the naturally produced adults. One of the factors that may potentially effect the F_1 adults ability to reproduce is the location and various physical attributes of the redd. In 1995 we began to record several attributes which described each redd and its location. The objective was to begin to create a template, based on redds deposited by natural spawners, from which future redds produced by supplemented fish can be compared. Unfortunately, the poor spawner escapement resulted in only 13 redds from which measurements were recorded. This data is summarized in Table 5. The mean redd length and width was 5.4 m and 2.6 respectively. The mean redd pit depth (measured from the deepest point in the pit to the water surface) was 1.4 m and mean tailspill (measured from the highest point to the water surface) was .75 m. The mean water velocity in the pit was 1.5 ft/sec and 2.6 ft/sec over the tailspill. The mean distance to nearest cover was 17.9 m, however, this distance was highly variable and was not within a reasonable distance for two of the redds.

6.4. POTENTIAL ACCLIMATION/REARING SITES

The Methow Basin was surveyed during the summer/fall of 1996 for potential spring chinook acclimation and rearing sites. The sites located are summarized in Tables 6, 7 and 8. The survey focused on off-channel ponds and side channels. The purpose of this survey was to locate all potential acclimation/rearing sites and to record basic physical habitat measures for each site. This list of sites is intended to be used as a start point for developing future pre-smolt and smolt acclimation sites and/or subyearling outplanting sites as deemed necessary by the MBSCSP.

This candidate list needs to be refined by conducting the following steps:

1. Determine land ownership of the site and adjacent to the site.
2. Evaluate each site to determine its aquacultural potential for spring chinook rearing.
3. Evaluate each site for access on a year-round basis.

Table 5. Summary of measured redds in the Methow Basin, 1995.

Attribute	Methow									Twisp		Chewuch	
	Redd 1	Redd 2	Redd 3	Redd 4	Redd 5	Redd 6	Redd 7	Redd 8	Redd 9	Redd 1	Redd 2	Redd 1	Redd 2
Width (m)	1.1	5.5	4.6	4.6	2.8	2.1	1.6	2.2	2.3	2.0	2.1	2.1	1.3
Length (m)	1.8	7.3	7.4	8.8	8.6	4.3	2.3	8.0	7.9	3.2	3.2	6.1	1.4
Pit depth (m)	0.9	1.5	2.0	1.2	1.0	1.5	1.2	1.7	1.6	1.5	1.5	1.1	1.0
Tailspill depth (m)	0.7	1.3	0.9	0.3	0.2	0.7	1.0	1.2	1.2	1.0	0.7	0.3	0.3
Pit velocity (ft/sec)	1.0	0.5	2.3	1.3	0.6	1.2	1.6	2.3	3.0	2.9	1.4	0.6	0.8
Tailspill velocity (ft/sec)	1.9	2.3	3.2	2.6	2.0	1.8	1.9	3.2	4.0	4.7	2.4	1.4	2.1
Nearest distance to cover	30.0	/a	/a	20.0	20.0	30.0	50.0	8.6	8.6	7.6	10.0	11.0	1.6
Direction to nearest cover	U-ce	--	--	D	U-lb	U-ce	U-rb	U-lb	U-lb	U-ce	U-ce	D-ce	D-ce
Cover type	b	--	--	swd	ov	b	lwd	ub	ub	lwd	swd,rw	--	swd,ov
Depth at cover	--	--	--	--	--	--	--	2.1	2.1	--	1.5	--	--
Date measured	08/01	09/01	09/01	09/01	09/01	09/01	09/01	08/01	08/01	08/01	09/01	09/01	09/01
Date flagged	08/01	08/01	08/01	08/01	08/01	09/01	08/01	08/01	08/01	08/01	08/01	08/01	08/01
Section reach number	9	6	6	6	6	9	6	5	5	5	7	6	6

/a nearest cover was not within a reasonable distance to measure.

D-ce = dowstream with no bank preference, U-ce = upstream with no bank preference, U-lb = upstream to left bank cover, U-rb = upstream to right bank cover.

b = boulders, na = no cover, swd = small woody debris, ov = overhanging vegetation, lwd = large woody debris, ub = undercut bank, rw = rootwad,

Table 6. Summary of side channal inventory in the Chewuch River.

Date surveyed	Location	River-mile	Length (m)	Width (m)			Depth (m)			Bankful width (m)	Substrate		Wood			Discharge
				Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Dominate	Subdominate	Brush	Small	Large	(cfs)
10/08/96	R.B. near the MBSCSP acclaimation pond	8.0	1,176	42.8	54.0	34.0	1.6	2.0	2.0	3.6	boulder	cobble			2	25.5
10/08/96	R.B. immediately downstream to Memorial bridge	8.6	927	25.0	33.0	21.0	1.7	2.4	2.4	3.3	boulder	cobble				42.2
10/08/96	R.B. immediately downstream to WDFW fishing access \a	11.4	293	66.7	72.0	60.0	2.5	2.5	2.5	3.6	detritus	detritus				dry
10/08/96	L.B. immediately downstream to WDFW cmp. gr.	11.8														0.3
10/08/96	L. B. across from a undesignated cmp. gr.	12.0														21.3
10/08/96	L.B. East Chewuch USFS Rd. 430	16.4														
10/08/96	L.B. immediately downstream to Twenty-Mile Cr.	17.5														6.1
10/09/96	R.B. 0.25 mi downstream to Camp Four cmp. gr.	20.3	1,131	48.8	59.0	35.0				2.3	boulder	cobble	11	7	3	dry
10/09/96	L.B. immediately upstream from Twenty-Mile bridge	20.9														2.4
10/09/96	R. B. immediately upstream from Buck Cr.	22.0	509	21.3	27.0	12.0	1.5	3.7	3.7	3.7	gravel	cobble	15	11	9	10.9
10/09/96	R.B. 0.25 mi upstream from Andrews Cr.	27.3	566	11.8	17.0	5.0	0.5	0.7	0.7	2.7	cobble	sand	27	6	2	0.2
10/09/96	L.B. immediately downstream to end of the low gradient area	30.2	1,117	14.5	21.0	8.0	1.4	2.2	2.2	3.4	gravel	sand	11	6	4	3.2

\a Denotes a potential acclimation site.

Table 7. Summary of side channal inventory in the Methow River.

Date surveyed	Location	River-mile	Length (m)	Width (m)			Depth (m)			Bankful width (m)	Substrate		Wood			Discharge (cfs)
				Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Dominate	Subdominate	Brush	Small	Large	
10/24/96	2 mi upstream from Pateros		845	46.0	63.0	30.0	1.0	1.5	1.5	5.4	cobble	boulder	14	6	3	22.9
10/22/96	immediately downstream to the pink roofed house		840	51.0	60.0	39.0	3.8	4.0	4.0	6.2	cobble	gravel		11		20.8
10/17/96	R.B. immediately upstream from Cow Cr.		857	62.0	70.0	51.0	1.7	2.8	2.8	4.5	cobble	boulder		15	3	35.0
10/17/96	L.B. 0.5 mi upstream from Gold Cr. Rd.		1,061	34.3	39.0	31.0	1.4	1.5	1.5	4.3	cobble	gravel				6.6
10/17/96	L.B. 0.75 mi downstream to Libby Cr.		1,724	42.3	63.0	20.0	0.0	0.0	0.0	4.4	cobble	gravel			2	dry
10/16/96	R.B. 1 mi upstream from Carlton		831	46.3	58.0	37.0	2.4	2.6	2.6	5.4	cobble	gravel				100+
10/16/96	R.B. immediately downstream to Beaver Cr.		548	67.0	86.0	50.0				5.8	cobble	gravel			5	dry
10/16/96	L.B. 0.75 mi downstream to the Eastbank acc. pond		992	57.5	69.0	35.0	1.9	2.8	2.8	4.6	cobble	gravel				130.9
10/15/96	L.B. 3 mi downstream to Winthrop	45.9	1,330	77.5	96.0	61.0	1.2	1.5	1.5	4.4	cobble	boulder				41.4
10/15/96	R.B. enters a pool at Highway 20	47.1	1,854	100.8	142.0	61.0				4.2	cobble	boulder			2	dry
09/12/96	R.B. immediately downstream to Chewuch R.	50.0	1,534	22.5	29.0	7.0	1.6	2.7	2.7	2.8	cobble	sand				17.2
09/12/96	L.B. immediately downstream to the WDFW signs \a	53.9	800	25.8	35.0	20.0	1.6	2.8	2.8	3.1	cobble	sand				9.2
09/12/96	R.B. 100+ m upstream from the WDFW signs	54.0	2,879	35.3	60.0	21.0	0.8	1.0	1.0	2.5	cobble	gravel				4.7
09/12/96	L.B. 0.25 mi upstream from the WDFW signs \a	54.4	1,718	11.5	14.0	9.0	1.1	1.6	1.6	3.7	cobble	gravel		7	3	0.9
09/12/96	R.B. 0.5 mi upstream from the end of the B.V. ranch	55.0	611	19.7	31.0	13.0	0.8	1.4	1.4	2.4	gravel	cobble				0.9
09/12/96	R.B. directly underneath the cable crossing	55.5	523	34.1	35.0	32.4	1.2	1.3	1.3	4.8	cobble	gravel				19.6
09/17/96	L.B. immediately upstream from the cable crossing	55.7	989	61.3	72.0	51.0					cobble	gravel		22	10	dry
09/17/96	L.B. 0.25 mi upstream from the cable crossing \a	55.9	1,125	28.0	51.0	15.0	2.2	3.6	3.6	10.8	sand	detritus		5	2	0.6
09/17/96	R.B. 0.75 mi upstream from the cable crossing	56.5	252	15.5	22.0	9.0	1.0	1.5	1.5	4.3	sand	gravel				0.1
09/17/96	R.B. 0.5 mi downstream to the upstream end of B. V. ranch	57.3	597	21.5	22.0	21.0	0.9	0.9	0.9	4.5	gravel	gravel		2		dry
09/17/96	L.B. 0.33 mi downstream to upstream end of Heath ranch	57.4	300	20.3	39.0	6.0	1.7	2.7	2.7	3.1	detitus	sand		3		1.3
09/17/96	L.B. across from Boesel Canyon	57.8	488	30.0	56.0	10.0	1.8	2.0	2.0	3.2	cobble	gravel				0.4
09/17/96	R.B. across Boesel Canyon	58.0	1,525	64.8	108.0	14.0	1.1	1.5	1.5	3.0	cobble	gravel		3	2	1.4
09/18/96	L.B. near upper of the Heath ranch access	58.2	6,087	37.2	51.0	14.0	1.7	3.3	3.3	3.4	cobble	gravel		4	5	8.7
09/18/96	R.B. near upper of the Heath ranch access	58.4	690	26.7	32.0	21.0					gravel	cobble		3	5	dry
09/18/96	L.B. between Weeman bridge & upper end of B.V. ranch	58.5	556	35.0	45.0	25.0					cobble	cobble		13	9	dry
09/18/96	R.B. between Weeman & upper end of B.V. ranch	58.7	1,316	20.8	56.0	6.0	1.2	2.2	2.2	2.8	gravel	sand		10	6	4.5
09/18/96	R.B. 0.33 mi downstream to Weeman bridge	59.2	1,038	20.3	28.0	8.0	0.7	1.0	1.0	2.7	cobble	gravel		1	2	1.7
09/26/96	R.B. 0.25 mi downstream to Weeman bridge	59.4	717	11.0	11.0	11.0	0.3	0.3	0.3	1.8	cobble	gravel		10	9	0.4
09/26/96	L.B. at irrigation ditch downstream to Weeman bridge \a	59.5	884	26.0	26.0	26.0	1.5	1.9	1.9	3.4	cobble	gravel		15		1.0

\a Denotes a potential acclimation site

Table 7. Cont. Summary of side channel inventory in the Methow River.

Date surveyed	Location	River-mile	Length (m)	Width (m)			Depth (m)			Bankful width (m)	Substrate		Wood			Discharge (cfs)
				Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Dominate	Subdominate	Brush	Small	Large	
10/01/96	L.B. immediately upstream from Weeman bridge	59.8	1,231	13.0	19	7	1.5	2.4	2.4	3.5	gravel	sand				0.4
10/01/96	L.B.. where river runs adjacent to Highway 20	60.0	1,626	22.0	42	4	0.8	1.7	1.7	2.4	detritus	boulder	15	10	15	0.3
10/01/96	L.B. where river runs adjacent to Highway 20 \a	60.7	1,011	17.0	26	8	0.5	0.5	0.5	3.0						2.0
10/01/96	L.B near Edelweis. meadow.	61.7	1,471	45.5	78	18				2.3	cobble	gravel	20	15	10	dry
10/01/96	L.B. immediately downstream to the MVSTA footbridge	61.8	130													dry
10/01/96	R.B. at the MVSTA footbridge	62.0	1,205	28.6	37	21	0.9	1.2	1.2	2.,2	gravel	sand				17.0
10/02/96	L.B. 0.5 mi upstream from Mazama bridge	65.8	1,001	16.3	24	12				2.4	sand	sand	10	4	4	dry
10/02/96	R.B. immediately upstream from the b. & b. on Highway 20	66.2	754	47.3	58	28				3.0	cobble	gravel			7	dry
10/02/96	R-B. immediately upstream from Early Winters Cr.	67.5	1,043	16.5	26	5	0.4	0.6	0.6	2.2	detritus	detritus	12		10	0.2
10/02/96	R.B. 0.5 rni upstream from Early Winters Cr.	67.9	717	34.0	56	21				2.9	cobble	gravel	15	13	7	dry
10/02/96	R.B. At the open field	69.0	641	21.7	26	19				2.8	sand	detritus	13	6	11	dry
10/02/96	L.B. 3.2 mi upstream to Mazama \a	69.6	1,549	29.3	53	17	0.5	0.6	0.6	2.2	gravel	cobble	22	18	11	dry
10/03/96	L.B. immediately downstream to red roofed houses.	70.0	915	30.0	35	25				2.5	gravel	cobble			7	dry
10/03/96	L.B. at red roofed houses	70.2	1,313	29.4	42	20	1.2	1.2	1.2	2.7	cobble	gravel	50	30	20	5.2
10/03/96	L.B. 0.75 upstream from a big log jam	70.6	823	20.0	23	17	1.2	1.4	1.4	2.6	cobble	gravel				17.6
10/01/96	L.B. immediately upstream from Weeman bridge	59.8	1,231	13.0	19	7	1.5	2.4	2.1	3.5	gravel	sand				0.4
10/01/96	L.B. where river runs adjacent to Highway 20	60.0	1,626	22.0	42	4	0.8	1.7	1.7	2.4	detritus	boulder	15	10	15	0.3
10/01/96	L.B. where river runs adjacent to Highway 20 \a	60.7	1,011	17.0	26	8	0.5	0.5	0.5	3.0						2.0
10/01/96	L.B near Edelweis meadow.	61.7	1,471	45.5	78	18				2.3	cobble	gravel	20	15	10	dry
10/01/96	L.B. immediately downstream to the MVSTA footbridge	61.8	130													dry
10/01/96	R-B. at the MVSTA footbridge	62.0	1,205	28.6	37	21	0.9	1.2	1.2	2.2	gravel	sand				17.0
10/02/96	L.B. 0.5 mi upstream from Mazama bridge	65.8	1,001	16.3	24	12				2.4	sand	sand	10	4	4	dry

\a Denotes a potential acclimation site.

Table 8. Summary of side channel inventory in the Twisp River.

Date surveyed	Location	River-mile	Length (m)	Width (m)			Depth (m)			Bankful width (m)	Substrate		Wood			Discharge (cfs)
				Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Dominate	Subdominate	Brush	Small	Large	
08/20/96	R.B. immediately upstream from Highway 20 bridge	0.4	972	18.6	33.0	11.0	0.9	1.4	1.4	3.0	cobble	gravel	2	2		2.7
08/20/96	L.B. immediately downstream to Poorman Cr. bridge	1.3	497	24.0	35.0	18.0	1.6	1.9	1.9	3.5	cobble	gravel	1	8		18.1
08/20/96	L.B. downstream to the large cut bank	2.5	526	32.6	41.0	17.0	0.6	1.0	1.0	2.9	gravel	gravel	5	2		1.6
08/20/96	R.B. immediately downstream to Elbow Coulee Rd.	5.0	304	31.0	36.0	26.0									1	41.1
08/21/96	R.B. across from Elbow Coulee Rd.	5.6	268	14.0	20.0	8.0	0.8	1.1	1.1	3.4	boulder	cobble	6	1		4.1
08/21/96	R.B. across from Elbow Coulee Rd.	5.7	767	25.0	30.0	19.0	1.0	1.4	1.4	3.2	boulder	cobble	15	6		9.2
08/21/96	L.B. bottom end of the MBSCSP aclimation pond	6.3	1,190	35.0	44.0	27.0	1.5	2.0	2.0	3.7	boulder	cobble	11	3	5	40.3
08/21/96	R.B. upstream from the MBSCSP acclimation pond	6.5	170	36.5	38.0	35.0							3	2		dry
08/21/96	R.B. immediately downstream to Newby Cr.	6.8	639	50.2	76.0	28.0	1.6	2.0	2.0	3.7	boulder	cobble	3	2	1	30.6
08/21/96	L.B. 0.3 mi upstream from Little Cr. bridge	9.2	574	28.3	34.0	25.0	0.1	0.2	0.2	2.1						dry
08/22/96	R.B. immediately upstream from private bridge	12.1	183	24.0	30.0	1.8				3.4	boulder		8	3		dry
08/22/96	L.B. downsteam to Buttemiilk Cr. bridge	12.3	520	29.3	55.0	13	1.0	2.4	2.4	3.1	cobble	gravel	25	4	2	3.7
08/22/96	L.B. immediately upstream from Buttermilk Cr. \a	12.5	537	19.6	31.0	10.0	1.0	2.3	2.3	2.5	gravel	sand	2	1		3.4
08/22/96	L.B. 2nd side channel upstream from Buttermilk Cr.	12.6	770	29.4	46.0	19.0	1.2	1.5	1.5	2.7	cobble	gravel	10			25.5
09/04/96	L.B. 0.5 mi upstream from Buttermilk Cr.	12.8	570	13.7	20.0	8.0	0.6	1.1	1.1	2.8	cobble	gravel	3	3	3	0.4
09/04/96	L.B. 0.75 mi upstream from Buttermilk Cr.	13.0	704	23.8	36.0	1.1	1.8	3.0	3.0	4.0	detritus	gravel	4	10		0.6
09/04/96	R.B. 0.75 mi upstream from Buttermilk Cr.	13.3	1,283	23.2	35.0	12.0	0.9	2.0	2.0	3.3	cobble	sand	20	5	1	1.0
09/04/96	R.B. 0.87 mi upstream from Buttermilk Cr.	13.5	1,556	22.5	26.0	15.0	0.7	1.7	1.7	2.4	cobble	gravel	7	4		0.5
09/04/96	L.B. 1 mi upstream from Buttermilk Cr.	14.0	656	35.8	52.0	20.0	1.7	2.2	2.2	3.0	cobble	gravel	22	6	3	40.1
09/04/96	R.B. 1+ mi upstream from Buttermilk Cr.	14.1	1,219	19.0	26.0	1.1	1.1	2.0	2.0	3.4	cobble	gravel	13	10	1	6.3
09/05/96	L.B. beaver dam area entering USFS land \a	15.4	764	9.3	24.0	0.1	0.8	1.9	1.9	2 6	gravel	sand	5	3		0.1
09/05/96	L.B. downstream to War Cr. bridge, next to cmp. gr.	16.6	30								gravel	cobble				dry
09/05/96	L.B. immediately upstream from War Cr. bridge \a	16.8	574	11.9	25.8	0.9	1.1	1.3	1.3	2.3	sand	detritus	24	12	20	0.9
09/10/96	L.B. 0.5 mi upstream from War Cr.	17.2	1,530	14.7	18.0	1.1	0.5	0.9	0.9	2.3	cobble	gravel	2	1	2	0.7
09/10/96	L.B. 0.5 mi upstream from War Cr., below cmp. gr.	17.5	1,430	10.0	10.0	10.0	0.3	0.3	0.3	2.3	sand	gravel				1.2
09/10/96	R. B. 1 mi upstream from War Cr. bridge	17.9		9.0	9.0	9.0	1.3	1.3	1.3	4.3	gravel	sand	10	2		dry
09/10/96	R.B. upstream from Reynold Cr.	21.9	400	12.3	22.0	7.0	0.5	0.5	0.5	2.2	cobble	gravel	6	2	3	1.1
09/10/96	L.B. 0.25 mi upstream from Reynolds Cr.	22.2	371	19.3	25.0	15.0	0.9	1.0	1.0	2.2	cobble	gravel	5	2		7.6
09/10/96	L.B. 0.5 mi upstream from Reynolds Cr.	22.4	298	5.0	6.0	4.0	0.4	0.6	0.6	1.6	cobble	gravel	5	1		0.5
09/10/96	L.B. 0.75 mi. upstream from Reynolds Cr.	22.6	199	6.5	7.0	6.0	0.5	0.6	0.6	1.7	cobble	gravel	3		4	1.1

\a Denotes a potential parr acclimation pond.

Table 8. Cont. Summary of side channel inventory in the Twisp River.

Date surveyed	Location	River-mile	Length (m)	Width (m)			Depth (m)			Bankful width (m)	Substrate		Wood			Discharge (cfs)
				Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Dominate	Subdominate	Brush	Small	Large	
09/10/96	L.B. 0.5 mi upstream from Reynolds Cr.	22.7	331	15.7	21.0	10.0	1.1	1.6	1.6	2.8	cobble	sand	7	2	2	3.2
09/11/96	L.B. 0.25 mi downstream to Poplar Flats	23.0	675	10.7	14.0	7.0	0.8	0.9	0.9	2.1	cobble	gravel	11	3	5	1.1
09/11/96	R.B. 0.25 mi downstream to Poplar Flats	23.2	650	12.0	15.0	11.0	0.7	0.9	0.9	2.0	cobble	gravel	21			3.2
09/11/96	R.B. 0.12 ml downstream to Poplar Flats	23.3	456	6.5	7.0	6.0	0.5	0.5	0.5	2.4	sand	cobble	23	7	5	0.4
09/11/96	L.B. immediately upstream from Poplar Flats cmp. gr.	23.6	1,432	11.5	17.0	7.0	1.0	1.7	1.7	2.2	cobble	gravel	33	18	9	1.3
09/11/96	L.B. 0.75 mi upstream from Poplar Flats cmp. gr.	24.0	284	9.0	10.0	8.0	0.6	0.8	0.8	2.0	cobble	gravel	4	1	1	0.0

\a Denotes a potential parr acclimation pond

4. Evaluate each site for site development considerations (if required).

6.5. MONITORING & EVALUATION

Stated in the Evaluation Plan of the Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) document are three areas of "critical uncertainty" (the hatchery facility; genetic integrity and long-term fitness of the naturally spawning populations; and interaction between the supplemented and natural populations) each with specific questions designed to evaluate the success of the MBSCSP. Overall success of the MBSCSP is defined, "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 purpose of this discussion is to examine the parameters required and the feasibility/logistical constraints in order to answer each question. This discussion will limit its focus to those questions which address comparative survival and reproductive success between the supplemented and natural populations. Those questions addressed will be referenced with their corresponding Critical Uncertainty (CU) and question number from the MBSCSP document. For this discussion the stated assumptions associated with each question were not examined for degree of validity. They are simply stated to note their association to various parameters required to address the question.

QUESTIONS

A. **Can the egg-to-returning adult survival meet or exceed the survival rate of the naturally produced fish from that donor population? (CU 1, question 1)**

The Null Hypothesis

H_o: The egg-to-returning adult survival rate[61] for the broodstock population is ≥ than for the donor population.

[6]It is implied in the Evaluation Plan that "returning adults" is defined through the act of spawning, opposed to the spawner escapement to the spawning ground.

Required Parameters

Natural Population

To estimate the egg-to-returning adult survival for the natural population, four numeric parameters are required:

1. The number of redds deposited in each subbasin.
2. The mean number of eggs deposited per female spawner for each subbasin.
3. The number of F_1 spawners produced from a given brood year by subbasin.
4. The age composition of the F_1 spawner population by subbasin.

Broodstock Population

To estimate the egg-to-returning adult survival for the supplemented population, three numeric parameters are required:

1. The number of eggs spawned from the broodstock population for each subbasin.
2. The number of F_1 spawner produced from a given brood year by subbasin.
3. The age composition of the F_1 spawner population by subbasin.

Feasibility/Logistical Constraints & Required Assumptions

Natural Population

1. **Constraints:** The redd counts (R_{nat}) for each subbasin are considered to be accurate, though no statistical evaluation has been made to determine the degree of accuracy. It is believed no serious constraints apply to this parameter.

   Assumptions: The total number of redds enumerated for each subbasin is precisely the number of redds that were actually deposited.

2. **Constraints:** The mean number of eggs deposited per female (M_{fec}) for each subbasin is determined from the broodstock spawners for that subbasin and respective broodyear. This parameter is considered accurate and no serious constraints apply.

Assumptions: The mean number of eggs per female for the broodstock population is the same to that of the natural population. In practice this means that a random sample of broodstock is captured from the entire female spawner population passing the collection sites.

3. **Procedure & Constraints:** The most difficult parameter to estimate is the spawner escapement to each subbasin. If the adult weirs were 100% efficient this would be otherwise, however current estimates of trap efficiency at the Chewuch and Twisp adult collection facilities are approximately 30-40% (the new Methow trap at Foghorn Dam is untested). The best estimate of natural spawner escapement (Se_{F1nat}) is:

$$Se_{F1nat} = (R_{nat} \cdot SR) - Se_{F1sup};$$

where R_{nat} is the number of redds deposited by natural spawners by subbasin, Se_{F1sup} is the supplementation spawner escapement by subbasin, and SR is the mean number of spawners per redd; and

$$SR = R_{total} / W_{total};$$

where R_{total} is redd total for the Methow Basin and W_{total} is the total number of adult spawners past Wells Dam minus spawners collected for broodstock, and Se_s is the supplementation spawner escapement (its derivation will be explained in the <u>Supplementation Population</u> discussion).

Assumptions: That: 1) the fish count passed Wells Dam is 100% accurate (ie. summer chinook are not incorporated into the count), 2) no spawner mortality/straying occurs from the time the fish pass over Wells Dam to when they spawn, 3) redd counts are 100% accurate, 4) that the spawner per redd ratio is identical for each subbasin, 5) that no fall back occurs at Wells Dam through the spillways or turbines.

4. **Procedure & Constraints:** The best method to determine the age composition of the F_1 spawner adult population returning to each subbasin is from the broodstock population. It is a less bias estimate of the spawner age composition than from the spawner carcasses collected off the spawning grounds.

Assumptions: That the broodstock population is an unbiased estimate of the true age structure of the F_1 spawner population, and that it represents the age structure of the F_1 natural spawner population.

Test Parameter For The Null Hypothesis

To evaluate the null hypothesis, the egg-to-returning adult survival rate for the natural ($Sn_{egg\text{-}to\text{-}adult}$) is calculated as follows:

$$(Sn_{egg\text{-}to\text{-}adult}) = (R_{nat} \cdot M_{fec}) \quad (Se_{F1nat})$$

Supplementation Population

1. **Procedures & Constraints:** The number of eggs spawned (B_{eggs}) from the broodstock spawners is accurate, as each female's egg take is measured. Thus no serious constraints apply to this parameter.

   Assumptions: None.

2. **Procedures & Constraints:** As for the natural spawner population, determination of the supplementation spawner escapement (Se_{F1sup}) is the most difficult and requires the most assumptions. It is calculated as follows:

$$Se_{F1sup} = (Sp_{sup} / Sp_{nat}) \cdot Se_{total};$$

where Sp_{sup} is the number of supplementation (adipose clipped) spawners recorded

at the subbasin adult collection facility[7], Sp_{nat} is the number of natural (not adipose clipped) spawners recorded at the subbasin adult collection facility, and Se_{total} is the total spawner escapement to the subbasin; and

$$Se_{total} = SR \cdot R_{total};$$

where R_{total} is the total number of redds deposited by subbasin.

Assumptions: That the adipose-to-unadipose clipped ratio for the fish recorded at the adult collection facilities is identical to that of the natural spawner population, in addition to the previously mentioned assumptions listed for number three under Natural Population.

Test Parameter For The Null Hypothesis

To evaluate the null hypothesis, the egg-to-returning adult survival rate for the supplementation population ($Ss_{egg\text{-}to\text{-}adult}$) is calculated as follows:

$$(Ss_{egg\text{-}to\text{-}adult}) = (B_{eggs}) / (\mathrm{Se}_{\mathrm{F1sup}})$$

B. **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? (CU 2, question 6)**

The Null Hypothesis

H_o: The productivity (progeny-to-parent) of the broodstock population over several brood years is high enough, given the current productivity of the donor population, to achieve an overall productivity greater than 1.0.

This is a key question of the MBSCSP, for it examines whether or not the productivity "boost" afforded by the supplementation fish is sufficient enough to rebuild the donor

[7]During the broodstock collection period the number of adipose and unadipose clipped fish will be recorded at each adult collection facility.

population, given the current constraints (ie. habitat, management/policy) upon this population's productivity.

Required Parameters

Stock productivity (Cuenco, 1994) or recruitment rate (Ricker, 1954, 1973, 1975) is defined as the ratio of recruits-to-spawners, which is called the "progeny-to-parent" ratio in the MBSCSP. When the stock productivity is >1.0, more F_1 spawners are produced from the parent spawners than the original number, and the run is rebuilding. When stock productivity <1.0, less F_1 spawners are produced from the parent spawners than the original number, and the run is declining.

To estimate stock productivity for each subbasin requires the following parameters:

1. The natural, parent spawner escapement (Se_{pnat}) to each subbasin, and the number of supplementation, parent broodstock (Se_{psupt}) collected from each subbasin.
2. The number of natural (Se_{F1nat}) and supplementation (Se_{F1sup}) F_1 spawners that return to spawn in the Methow Basin (or elsewhere in the case of strays).
3. The age composition of the F_1 spawner population by subbasin.

Feasibility/Logistical Constraints & Assumptions

1. **Procedures & Constraints:** The same procedure applies for the natural parent spawners as discussed for question A, parameter three for the natural F_1 spawners. For the supplementation parent broodstock it is simply the number of spawners taken for broodstock for each subbasin.

   Assumptions: The same as stated for question A, parameters three, and there are no required assumptions for the supplementation parent broodstock.

2. **Procedures & Constraints:** The same procedure applies as discussed for question A, parameter three under Natural Population for the F_1 spawners, and question A, parameter two under the Supplementation Population. The only difference is that it

is the parameter is calculated for the F_1 spawners instead of parent spawners.

Assumptions: The same as stated for question A, parameter three (Natural Population) and parameter two (Supplementation Population).

3. **Procedures & Constraints:** The same procedure applies as discussed for question A, parameter four under Natural Population for the F_1 spawners, and question A, parameter three under the Supplementation Population.

Assumptions: The same as stated for question A, parameter four (Natural Population) and parameter three (Supplementation Population).

Test Parameter For The Null Hypothesis

The test parameter to evaluate the null hypothesis is the comparison of the natural productivity (P_{nat}) to the supplementation productivity (P_{sup}). Stock productivities are calculated as follows:

$$P_{nat} = Se_{F1nat} / Se_{pnat} \text{ and } P_{sup} = Se_{F1sup} \quad Sepsup$$

C. **Do marked and unmarked salmon differ in spawning success? (CU 2, question 1)**

Question C is similar to question A. The difference is that question C addresses whether or not there is a net benefit or increase in the number of supplementation F_1 spawners produced from the supplementation parent broodstock, after the number of F_1 spawners that would have resulted if those broodstock fish had been allowed to spawn naturally is subtracted off.

The Null Hypothesis

H_o: The number of supplementation F_1 spawners that successfully spawn, minus the hypothetical resultant number of F_1 spawners had the broodstock fish spawned naturally, is ≥ the number of broodstock originally taken to produce them (Is the donor stock being "mined" by the MBSCSP?).

Required Parameters

To evaluate the null hypothesis requires the same parameters for question A. These are for the natural population:

1. The number of redds deposited in each subbasin.
2. The mean number of eggs deposited per female spawner for each subbasin.
3. The number of F_1 spawners produced from a given brood year by subbasin.
4. The age composition of the F_1 spawner population by subbasin.

For the broodstock population these are:

1. The number of eggs spawned from the broodstock spawners for each subbasin.
2. The number of returning F_1 spawners to each subbasin.
3. The hypothetical number of F_1 spawners that would have been produced had the broodstock spawners not been collected and allowed to spawn naturally.

Feasibility/Logistical Constraints & Assumptions

Natural Population

1-4. **Procedures & Constraints:** The same procedures discussed for question A, parameters 1-4 apply.

Assumptions: The same assumptions discussed for question A, parameters 1-4 apply.

Supplementation Population

1-2. **Procedures & Constraints:** The same procedures discussed for question A, parameters 1-4 apply.

Assumptions: The same assumptions discussed for question A, parameters 1-3 apply.

The hypothetical number of F_1 spawners (Se_{hypo}) that would have been produced had the

broodstock spawners been allowed to spawn naturally is calculated as follows:

$$Se_{hypo} = B_{hypo} \cdot M_{fec} \cdot Sn_{egg\text{-}to\text{-}adult});$$

where B_h is the number of female broodstock spawners collected, B_{fec} is the mean fecundity, $Sn_{egg\text{-}to\text{-}adult}$ is the estimated natural egg-to-adult return survival rate.

Test Parameter For The Null Hypothesis

To evaluate the null hypothesis, the natural F_1 spawner escapement (Se_{F1nat}) is compared to the supplementation F_1 spawner escapement (Se_{F1sup}) minus the hypothetical F_1 spawner escapement (Se_{hypo}) of the broodstock if they had been allowed to spawn naturally, and is determined as follows:

$$Se_{F1nat} \text{ compared to } Se_{F1sup} - Se_{hypo}$$

D. **Is natural production in the donor population diminished when hatchery-reared salmon return to spawn in the natural habitat? (CU 3, question 3)**

This question addresses the issue of potential negative interaction of the MBSCSP on the donor populations in the Methow Basin over a period of several generations.

The Null Hypothesis

H_o: <u>The donor stock's productivity (progeny-to-parent) is not impacted as supplementation spawners contribute to the natural spawners over several generations</u>.

Parameters Required & Measured Attribute

The Evaluation Plan cites reproductive success and juvenile production as two possible attributes to monitor fitness of the donor population over time. Possible measures of juvenile production listed are:

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".**

However, these three measures are not easily estimable. The common constraint to all three juvenile production attributes is the continuous outmigration of juvenile spring chinook from the time they emerge from the gravel until the fish smolt the following spring. In addition, annual variability in stream discharge and temperature can affect the outmigration patterns, as well as, our ability to measure these attributes. This knowledge has been learned through our juvenile outmigrant and parr snorkeling monitoring the past three years in the CHEWUCH basin. Therefore, the use of any of these three attributes to evaluate the donor population's productivity does not appear feasible.

However, reproductive success or the progeny-to-parent survival measured trans-generational is a viable parameter, and better addresses the null hypothesis.

Parameters Required

Reproductive success is implied to mean the progeny-to-parent survival measured over several generations. Required parameters to calculate this are:

1. The natural, parent spawner escapement (Se_{pnat}) to each subbasin.
2. The natural F_1 spawner escapement (Se_{F1nat}) to each subbasin.

Feasibility/Logistical Constrains & Assumptions

Refer to question B for the required parameters and corresponding constraints and assumptions required to calculate (Se_{pnat}) and (Se_{F1nat}).

Test Parameter For The Null Hypothesis

To answer the null hypothesis requires monitoring the donor stock's productivity (P_{nat}) over several years and determine how well (or not so well) it maintains replacement.

Future Recommendations

1. Form a monitoring and evaluation work group in FY1997, comprised of a fishery biologist from the YIN, WDFW and Douglas and a statistician. Their mission would be: 1) to further examine methodologies to monitor and evaluate the MBSCSP, 2) to investigate new mark and interrogation technologies available to researchers and, 3) to determine statistical sample sizes required to evaluate the aforementioned questions, as stated in the MBSCSP document.

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 and Methow rivers, 1995 and 1996.

Appendix Table 2. Summary of the snorkeling sites for the Chewuch River, summer 1995.

Appendix Table 3. Daily actual and predicted spring chinook smolt counts for the Chewuch screw trap, spring 1995.

Appendix Table 4. Daily actual and predicted steelhead/rainbow smolt counts for the Chewuch screw trap, spring 1995.

Appendix Table 5. Daily catch of non-target species in the Chewuch River screw trap, 1995.

Appendix Table 6. Summary of spring chinook parr (age 0+) and steelhead-/rainbow trout counts for the Chewuch River, summer 1995.

Appendix Table 7. Methow River screw trap daily catch data, summer 1995.

Appendix Table 8. Daily actual and predicted spring chinook parr counts for the Chewuch screw trap, fall 1995.

Appendix Table 9. Daily actual and predicted steelhead/rainbow counts for the Chewuch screw trap, fall 1995.

Appendix Table 10. Methow River screw trap daily catch data, fall 1995.

Appendix Table 11. Summary of marked Chewuch River spring chinook releases at the Chewuch screw trap, and recaptures at the Methow screw trap (Carlton pond), fall 1995.

Appendix Table 12. Daily actual and predicted spring chinook smolt counts for the Chewuch screw trap, spring 1996.

Appendix Table 13. Daily actual and predicted steelhead/rainbow smolt counts for the Chewuch screw trap, spring 1996.

Appendix Table 1. Summary of spring chinook entrainment test releases for the Chewuch and Methow rivers, 1995 and 1996.

Date	Bank of release	Trap location	Mean daily discharge (cfs)	Number released	Number recaptured	Entrainment rate
1995 spring releases						
April 09	left	right bank	472	6	0	0.0%
April 10	left	right bank	466	10	0	0.0%
April 11	left	right bank	453	7	1	14.3%
April 12	left	right bank	447	6	1	16.7%
April 13	left	right bank	453	8	0	0.0%
April 14	left	right bank	433	12	1	8.3%
April 15	left	right bank	414	14	2	14.3%
April 16	left	right bank	404	8	0	0.0%
April 21	left	right bank	370	6	0	0.0%
April 22	left	right bank	374	7	1	14.3%
April 23	left	right bank	401	11	0	0.0%
April 26	left	right bank	591	50	5	10.0%
April 27	left	right bank	658	43	5	11.6%
April 28	left	right bank	697	18	2	11.1%
April 29	left	right bank	711	24	1	4.2%
April 30	left	right bank	687	11	2	18.2%
May 01	left	right bank	689	12	3	25.0%
May 04	left	right bank	806	22	5	22.7%
May 06	left	right bank	878	5	1	20.0%
May 07	left	right bank	1000	9	0	0.0%
Chewuch River 1995 fall releases						
Oct. 20	center	left bank	99	10	3	30.0%
Oct. 22	center	left bank	95	10	2	20.0%
Oct. 25	center	left bank	93	10	2	20.0%
Oct. 26	center	left bank	98	9	4	44.4%
Oct. 30	center	left bank	80	21	8	38.1%
Oct. 31	center	left bank	75	16	6	37.5%
Nov. 01	center	left bank	72	4	0	0.0%
Nov. 03	center	left bank	72	8	0	0.0%
Nov. 05	center	left bank	78	7	2	28.6%
Nov. 06	center	left bank	79	8	4	50.0%
Nov. 07	center	left bank	82	3	0	0.0%
Nov. 08	center	left bank	91	6	2	33.3%
Nov. 09	center	left bank	93	32	10	31.3%
Nov. 14	center	left bank	89	12	4	33.3%

Appendix Table 1. Cont. Summary of spring chinook entrainment test releases for the Chewuch and Methow rivers. 1995 and 1996.

Date	Bank of release	Trap location	Mean daily discharge (cfs)	Number released	Number recaptured	Entrainment rate
Chewuch River						
1995 fall releases cont.						
Nov. 16	center	left bank	91	11	5	45.5%
Nov. 19	center	left bank	110	15	4	26.7%
Nov. 20	center	left bank	97	14	3	21.4%
Nov 21	center	left bank	97	18	5	27.8%
Nov. 27	center	left bank	102	6	1	16.7%
Dec. 02	center	left bank	214	44	10	22.7%
				264	75	28.4%
Methow River						
1995 fall releases						
Oct. 24	right bank	right bank	n/a	14	1	7.1%
Oct. 25	right bank	right bank	n/a	12	3	25.0%
Oct. 30	right bank	right bank	n/a	9	5	55.6%
Oct. 31	right bank	right bank	n/a	15	2	13.3%
Nov. 01	right bank	right bank	n/a	12	2	16.7%
Nov. 02	right bank	right bank	n/a	18	2	11.1%
Nov. 03	right bank	right bank	n/a	7	3	42.9%
Nov. 06	right bank	right bank	n/a	12	5	41.7%
				99	23	23.2%
Chewuch River						
1996 spring releases						
Mar. 16	right bank	left bank	180	45	9	20.0%
Mar. 17	right bank	left bank	187	24	6	25.0%
Mar. 18	right bank	left bank	196	29	9	31.0%
Mar. 20	right bank	left bank	222	34	4	11.8%
Mar. 22	right bank	left bank	242	19	6	31.6%
Mar. 23	right bank	left bank	242	16	5	31.3%
Mar. 24	right bank	left bank	235	13	5	38.5%
Mar. 28	right bank	left bank	231	28	11	39.3%
Mar. 29	right bank	left bank	231	16	5	31.3%
Mar. 30	right bank	left bank	227	7	1	14.3%
Mar. 31	right bank	left bank	224	13	1	7.7%
Apr. 05	right bank	left bank	231	7	4	57.1%
Apr. 07	right bank	left bank	304	22	10	45.5%
				273	76	27.8%

Appendix Table 1. Cont. Summary of spring chinook entrainment test releases for the Chewuch and Methow rivers, 1995 and 1996.

Date	Bank of release	Trap location	Mean daily discharge (cfs)	Number released	Number recaptured	Entrainment rate
Chewuch River 1996 spring releases cont.						
Apr. 13	right bank	right bank	814	10	2	20.0%
Apr. 14	right bank	right bank	778	13	2	15.4%
Apr. 15	right bank	right bank	778	7	1	14.3%
Apr. 20	right bank	right bank	836	8	2	25.0%
Apr. 22	right bank	right bank	782	8	2	25.0%
				46	9	19.6%

Appendix Table 2. Summary of the snorkeling sites for the Chewuch River, summer 1995.

Date	Reach number	Habitat type	Mean daily discharge (cfs) (at rm 0.1)	Temperature	Species	
					Spring chinook	Steelhead/ rainbow tr.
07-Aug-95	r1	riffle	183	57	0	6
07-Aug-95	r1	pool	183	57	0	16
08-Aug-95	r1	riffle	183	59	0	2
08-Aug-95	r1	pool	183	59	0	0
08-Aug-95	r1	pool	183	59	17	7
08-Aug-95	r1	riffle	183	59	0	18
08-Aug-95	r1	riffle	183	59	0	7
08-Aug-95	r1	riffle	183	59	48	0
09-Aug-95	r2	pool	167	59	3	5
09-Aug-95	r2	riffle	167	59	19	3
09-Aug-95	r2	riffle	167	59	1	1
09-Aug-95	r2	pool	167	59	87	3
09-Aug-95	r2	riffle	167	59	66	0
09-Aug-95	r2	riffle	167	59	92	20
10-Aug-95	r2	riffle	159	58	0	6
10-Aug-95	r2	riffle	159	58	12	0
10-Aug-95	r2	pool	159	58	0	0
10-Aug-95	r2	pool	159	58	0	1
10-Aug-95	r2	pool	159	58	0	0
10-Aug-95	r2	pool	159	58	18	9
10-Aug-95	r2	riffle	159	58	0	3
10-Aug-95	r2	glide	159	58	0	0
10-Aug-95	r2	riffle	159	58	0	1
10-Aug-95	r2	glide	159	58	0	0
10-Aug-95	r2	riffle	159	58	0	0
10-Aug-95	r2	pool	159	58	0	3
10-Aug-95	r2	riffle	159	58	0	0
10-Aug-95	r2	riffle	159	58	2	1
14-Aug-95	r2	pool	146	50	0	3
14-Aug-95	r2	pool	146	55	0	4
14-Aug-95	r2	riffle	146	53	0	5
14-Aug-95	r2	riffle	146	52	5	0
14-Aug-95	r2	riffle	146	51	0	2
14-Aug-95	r2	riffle	146	53	0	10
14-Aug-95	r2	pool	146	52	7	3
14-Aug-95	r3	riffle	146	53	0	18
15-Aug-95	r3	riffle	140	49	0	3
15-Aug-95	r3	pool	140	50	0	1
15-Aug-95	r3	riffle	140	50	0	40
15-Aug-95	r3	pool	140	50	0	5
15-Aug-95	r3	glide	140	54	0	0
15-Aug-95	r3	pool	140	54	0	0
15-Aug-95	r3	riffle	140	59	8	0

Appendix Table 2. Cont. Summary of the snorkeling sites for the Chewuch River, summer 1995.

Date	Reach number	Habitat type	Mean daily discharge (cfs) (at rm 0.1)	Temperature	Species	
					Spring chinook	Steelhead/ rainbow tr.
15-Aug-95	r3	glide	140	54	3	0
15-Aug-95	r3	pool	140	57	41	12
15-Aug-95	r3	pool	140	56	0	0
15-Aug-95	r3	glide	140	57	51	12
16-Aug-95	r3	riffle	134	48	29	2
16-Aug-95	r3	pool	134	49	2	1
16-Aug-95	r3	riffle	134	49	0	4
16-Aug-95	r3	riffle	134	49	2	8
16-Aug-95	r3	riffle	134	50	0	8
16-Aug-95	r3	pool	134	54	36	4
16-Aug-95	r3	glide	134	56	15	1
16-Aug-95	r3	riffle	134	56	7	15
16-Aug-95	r3	glide	134	57	64	9
16-Aug-95	r3	pool	134	57	36	18
16-Aug-95	r3	glide	134	59	99	4
17-Aug-95	r3	riffle	136	49	14	1
17-Aug-95	r3	glide	136	49	1	0
17-Aug-95	r3	pool	136	49	0	0
21-Aug-95	r3	riffle	130	55	0	0
21-Aug-95	r3	riffle	130	53	0	1
21-Aug-95	r3	riffle	130	52	5	18
21-Aug-95	r3	glide	130	56	50	4
21-Aug-95	r3	riffle	130	57	25	0
21-Aug-95	r3	pool	130	57	27	0
21-Aug-95	r3	riffle	130	58	120	1
21-Aug-95	r3	riffle	130	58	29	0
21-Aug-95	r3	pool	130	58	123	3
23-Aug-95	r3	glide	110	49	79	3
23-Aug-95	r3	riffle	110	49	12	1
23-Aug-95	r3	pool	110	50	3	0
23-Aug-95	r3	glide	110	52	3	0
23-Aug-95	r3	glide	110	51	1	0
23-Aug-95	r3	pool	110	53	161	16
23-Aug-95	r3	pool	110	52	3	3
23-Aug-95	r3	riffle	110	52	5	0
23-Aug-95	r3	pool	110	54	55	11
23-Aug-95	r3	riffle	110	53	21	7
23-Aug-95	r3	pool	110	53	79	16
24-Aug-95	r3	riffle	105	n/a	1	1
24-Aug-95	r3	pool	105	n/a	11	2
24-Aug-95	r3	pool	105	n/a	10	2
24-Aug-95	r3	riffle	105	n/a	4	4
24-Aug-95	r3	riffle	105	n/a	17	1
28-Aug-95	r3	riffle	93	n/a	4	0
28-Aug-95	r3	pool	93	n/a	0	0

Appendix Table 2. Cont. Summary of the snorkeling sites for the Chewuch River, summer 1995.

Date	Reach number	Habitat type	Mean daily discharge (cfs) (at rm 0.1)	Temperature	Species	
					Spring chinook	steelhead/ rainbow tr.
28-Aug-95	r3	pool	93	n/a	0	0
28-Aug-95	r4	riffle	93	n/a	0	0
28-Aug-95	r4	riffle	93	n/a	0	0
28-Aug-95	r4	pool	93	n/a	11	0
28-Aug-95	r4	glide	93	n/a	1	1
28-Aug-95	r4	riffle	93	n/a	5	1
28-Aug-95	r4	riffle	93	n/a	11	11
28-Aug-95	r4	riffle	93	n/a	5	1
28-Aug-95	r4	pool	93	n/a	23	4
28-Aug-95	r4	riffle	93	n/a	0	0
29-Aug-95	r4	riffle	87	n/a	3	5
29-Aug-95	r4	pool	87	n/a	18	16
29-Aug-95	r4	riffle	87	n/a	0	1
29-Aug-95	r4	riffle	87	n/a	2	4
29-Aug-95	r4	riffle	87	n/a	0	14
29-Aug-95	r4	pool	87	n/a	0	8
29-Aug-95	r4	riffle	87	n/a	0	13
31-Aug-95	r6	riffle	81	n/a	0	3
31-Aug-95	r6	riffle	81	n/a	0	2
31-Aug-95	r6	riffle	81	n/a	0	3
31-Aug-95	r6	pool	81	n/a	0	5
31-Aug-95	r6	riffle	81	n/a	1	3
31-Aug-95	r6	pool	81	n/a	0	1
31-Aug-95	r6	riffle	81	n/a	0	10
05-Sep-95	r6	riffle	65	n/a	0	6
05-Sep-95	r6	pool	65	n/a	0	1
05-Sep-95	r6	riffle	65	n/a	0	7
05-Sep-95	r7	glide	65	n/a	0	0
05-Sep-95	r7	pool	65	n/a	0	4
05-Sep-95	r7	pool	65	n/a	0	4
05-Sep-95	r7	glide	65	n/a	0	6
05-Sep-95	r7	pool	65	n/a	0	6
06-Sep-95	r7	glide	66	48	0	2
06-Sep-95	r7	pool	66	48	0	3
06-Sep-95	r7	riffle	66	48	0	1
06-Sep-95	r7	pool	66	48	0	1
06-Sep-95	r7	glide	66	49	0	0
06-Sep-95	r7	riffle	66	50	0	1
06-Sep-95	r7	riffle	66	52	0	0
06-Sep-95	r7	riffle	66	52	0	1
06-Sep-95	r7	glide	66	52	0	0
06-Sep-95	r7	riffle	66	51	0	0

Appendix Table 2. Cont. Summary of the snorkeling sites for the Chewuch River, summer 1995.

Date	Reach number	Habitat type	Mean daily discharge (cfs) (at rm 0.1)	Temperature	Species	
					Spring chinook	Steelhead/ rainbow tr.
07-Sep-95	r7	pool	69	48	103	8
07-Sep-95	r7	glide	69	48	38	6
07-Sep-95	r8	riffle	69	48	124	37
07-Sep-95	r8	pool	69	48	83	13
07-Sep-95	r8	pool	69	49	96	32
07-Sep-95	r8	riffle	69	50	33	6
07-Sep-95	r8	pool	69	50	34	11
07-Sep-95	r8	pool	69	48	67	3
07-Sep-95	r8	riffle	69	48	18	24

Appendix Table 3. Daily actual and predicted spring chinook smolt counts for the Chewuch screw trap, spring 1995.

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
09-Apr-95	6	0	472	0.1080	56	537	23	56	537	23	1.30%	1.30%
10-Apr-95	12	2	466	0.1080	111	1231	35	167	1769	42	3.89%	2.59%
11-Apr-95	8	1	453	0.1080	74	751	27	241	2520	50	5.61%	1.73%
12-Apr-95	6	0	447	0.1080	56	226	15	2[illegible]	2746	52	6.20%	1.30%
13-Apr-95	8	0	453	0.1080	74	309	18	[illegible]	3056	55	6.99%	1.73%
14-Apr-95	12	0	433	0.1080	111	486	22	481	[illegible]541	60	8.18%	2.59%
15-Apr-95	14	0	414	0.1080	130	579	24	611	[illegible]21	64	9.56%	3.02%
16-Apr-95	8	0	404	0.1080	74	751	27	685	4872	70	11.29%	1.73%
17-Apr-95	3	0	400	0.1080	28	249	16	713	5121	72	11.94%	0.65%
18-Apr-95	4	0	400	0.1080	37	341	18	750	5462	74	12.80%	0.86%
19-Apr-95	5	0	391	0.1080	46	437	21	796	5898	77	13.88%	1.08%
20-Apr-95	6	0	381	0.1080	56	537	23	852	6436	80	15.17%	1.30%
21-Apr-95	6	0	370	0.1080	56	537	23	907	6973	84	16.47%	1.30%
22-Apr-95	7	0	374	0.1080	65	642	25	972	7615	87	17.98%	1.51%
23-Apr-95	11	0	401	0.1080	102	1105	33	1074	8720	93	20.35%	2.37%
24-Apr-95	16	0	454	0.1080	148	1781	42	1222	10501	102	23.81%	3.45%
25-Apr-95	41	0	522	0.1080	380	6798	82	1602	17299	132	32.66%	8.85%
26-Apr-95	65	0	591	0.1080	602	14176	119	2204	31475	177	46.69%	14.03%
27-Apr-95	43	0	658	0.1080	398	7317	86	2602	38792	197	55.97%	9.28%
28-Apr-95	18	0	697	0.1080	167	2082	46	2769	40875	202	59.85%	3.89%
29-Apr-95	24	0	711	0.1080	222	3090	56	2991	43965	210	65.03%	5.18%
30-Apr-95	14	4	687	0.1080	130	1498	39	3120	45463	213	68.06%	3.02%
01-May-95	12	0	689	0.1080	111	1231	35	3231	46694	216	70.65%	2.59%
02-May-95	8	0	728	0.1080	74	751	27	3306	47446	218	72.37%	1.73%
03-May-95	16	0	793	0.1080	148	1781	42	3454	49227	222	75.83%	3.45%
04-May-95	22	0	806	0.1080	204	2737	52	3657	51964	228	80.57%	4.75%
05-May-95	7	0	822	0.1080	65	642	25	3722	52606	229	82.09%	1.51%
06-May-95	8	4	878	0.1080	111	751	27	3833	53357	231	83.81%	2.59%
07-May-95	14	0	1000	0.1080	130	1498	39	3963	54855	234	86.83%	3.02%
08-May-95	6	0	1080	0.1080	56	537	23	4019	55392	235	88.13%	1.30%
09-May-95	10	0	1460	0.1080	93	983	31	4111	56375	237	90.29%	2.16%
10-May-95	9	0	2080	0.1080	83	865	29	4194	57240	239	92.23%	1.94%
11-May-95	8	0	2270	0.1080	74	751	27	4269	57991	241	93.96%	1.73%
12-May-95	7	0	2030	0.1080	65	642	25	4333	58633	242	95.47%	1.51%
13-May-95	6	0	1830	0.1080	56	537	23	4389	59170	243	96.76%	1.30%
14-May-95	5	0	1990	0.1080	46	437	21	4435	59607	244	97.84%	1.08%
15-May-95	0	0	2340	0.1080	0	0	0	4435	59607	244	97.84%	0.00%
16-May-95	3	0	2980	0.1080	28	249	16	4463	59856	245	98.49%	0.65%
17-May-95	2	0	3320	0.1080	19	0	0	4481	59856	245	98.49%	0.00%
18-May-95	1	0	3190	0.1080	9	162	13	4491	60018	245	98.92%	0.43%
19-May-95	1	0	2720	0.1080	9	0	0	4500	60018	245	98.92%	0.00%
20-May-95	0	0	2600	0.1080	0	0	0	4500	60018	245	98.92%	0.00%
21-May-95	0	0	2590	0.1080	0	0	0	4500	60018	245	98.92%	0.00%
22-May-95	1	0	2500	0.1080	9	79	9	4509	60096	245	99.14%	0.22%
23-May-95	0	0	2610	0.1080	0	0	0	4509	60096	245	99.14%	0.00%
24-May-95	1	0	2530	0.1080	9	79	9	4519	60175	245	99.35%	0.00%
25-May-95	2	0	2670	0.1080	19	162	13	4537	60337	246	99.78%	0.00%
26-May-95	1	0	2910	0.1080	9	79	9	4546	60415	246	100.00%	0.43%

Shaded dates denotes days which trap data was interpolated due to release of hatchery spring chinook smolts or high river discharge.

Appendix Table 4. Daily actual and predicted steelhead/rainbow smolt counts for the Chewuch screw trap, spring,1995.

Day	Daily count, mortalities, discharge and entrainment				Daily estimated passage			Cumulative estimated passage			Percent passage	
	Actual count	Mortalities	Mean Q (cfs)	Entrainment rate	Estimated count	Variance	SE	Estimated count	Variance	SE	Cumulative	Daily
09-Apr-95	0	0	472	0.1080	0	0	0	0	0	0	0.00%	0.00%
10-Apr-95	3	2	466	0.1080	28	251	16	28	251	16	1.31%	1.30%
11-Apr-95	1	0	453	0.1080	9	76	9	37	328	18	1.74%	0.43%
12-Apr-95	1	0	447	0.1080	9	76	9	46	404	20	2.16%	0.43%
13-Apr-95	0	0	453	0.1080	0	0	0	46	404	20	2.16%	0.00%
14-Apr-95	1	0	433	0.1080	9	76	9	55	480	22	2.58%	0.43%
15-Apr-95	3	0	414	0.1080	28	251	16	83	732	27	3.90%	1.30%
16-Apr-95	0	0	404	0.1080	0	0	0	83	732	27	3.90%	0.00%
17-Apr-95	1	0	400	0.1080	9	76	9	92	808	28	4.32%	0.43%
18-Apr-95	2	0	400	0.1080	19	166	13	111	974	31	5.21%	0.87%
19-Apr-95	2	0	391	0.1080	19	166	13	130	1140	34	6.10%	0.87%
20-Apr-95	3	0	381	0.1080	28	251	16	158	1391	37	7.42%	1.30%
21-Apr-95	0	0	370	0.1080	0	0	0	158	1391	37	7.42%	0.00%
22-Apr-95	2	0	374	0.1080	19	166	13	177	1557	39	8.31%	0.87%
23-Apr-95	4	0	401	0.1080	37	340	18	214	1898	44	10.05%	1.74%
24-Apr-95	6	0	454	0.1080	56	542	23	270	2440	49	12.68%	2.61%
25-Apr-95	12	0	522	0.1080	111	1230	35	381	3670	61	17.89%	5.22%
26-Apr-95	21	0	591	0.1080	194	2559	51	575	6229	79	27.00%	9.13%
27-Apr-95	14	0	658	0.1080	130	1503	39	705	7732	88	33.10%	6.09%
28-Apr-95	17	0	697	0.1080	157	1923	44	862	9655	98	40.47%	7.39%
29-Apr-95	22	0	711	0.1080	204	2742	52	1066	12397	111	50.05%	9.56%
30-Apr-95	9	0	687	0.1080	83	861	29	1149	13258	115	53.94%	3.91%
01-May-95	12	0	689	0.1080	111	1230	35	1260	14488	120	59.15%	5.22%
02-May-95	9	0	728	0.1080	83	861	29	1343	15348	124	63.05%	3.91%
03-May-95	4	0	793	0.1080	37	340	18	1380	15689	125	64.79%	1.74%
04-May-95	13	0	806	0.1080	120	1357	37	1500	17046	131	70.42%	5.65%
05-May-95	8	0	822	0.1080	74	750	27	1574	17796	133	73.90%	3.48%
06-May-95	10	0	878	0.1080	93	988	31	1667	18784	137	78.26%	4.35%
07-May-95	12	0	1000	0.1080	111	1230	35	1778	20014	141	83.47%	5.22%
08-May-95	9	0	1080	0.1080	83	861	29	1861	20875	144	87.37%	3.91%
09-May-95	7	0	1460	0.1080	65	644	25	1926	21519	147	90.42%	3.04%
10-May-95	3	0	2080	0.1080	28	251	16	1954	21770	148	91.74%	1.30%
11-May-95	5	0	2270	0.1080	46	434	21	2000	22204	149	93.90%	2.17%
12-May-95	4	0	2030	0.1080	37	340	18	2037	22544	150	95.63%	1.74%
13-May-95	0	0	1830	0.1080	0	0	0	2037	22544	150	95.63%	0.00%
14-May-95	2	0	1990	0.1080	19	166	13	2056	22710	151	96.53%	0.87%
15-May-95	4	0	2340	0.1080	37	340	18	2093	23051	152	98.26%	1.74%
16-May-95	2	0	2980	0.1080	19	166	13	2112	23217	152	99.15%	0.87%
17-May-95	1	0	3320	0.1080	9	76	9	2121	23293	153	99.58%	0.43%
18-May-95	1	0	3190	0.1080	9	76	9	2130	23370	153	100.00%	0.43%
19-May-95	0	0	2720	0.1080	0	0	0	2130	23370	153	100.00%	0.00%
20-May-95	0	0	2600	0.1080	0	0	0	2130	23370	153	100.00%	0.00%
21-May-95	0	0	2590	0.1080	0	0	0	2130	23370	153	100.00%	0.00%
22-May-95	0	0	2500	0.1080	0	0	0	2130	23370	153	100.00%	0.00%
23-May-95	0	0	2610	0.1080	0	0	0	2130	23370	153	100.00%	0.00%
24-May-95	0	0	2530	0.1080	0	0	0	2130	23370	153	100.00%	0.00%
25-May-95	0	0	2670	0.1080	0	0	0	2130	23370	153	100.00%	0.00%
26-May-95	0	0	2910	0.1080	0	0	0	2130	23370	153	100.00%	0.00%

Shaded dates denote days which trap data was interpolated due to release of hatchery spring chinook smolts or high river discharge.

Appendix Table 5. Daily catch of non-target species in the Chewuch River screw trap, 1995

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Spring chinook fry	Bull trout	Cutthroat	Hatchery steelhead
09-Apr-95									
10-Apr-95									
11-Apr-95	4	1							
12-Apr-95									
13-Apr-95	2								
14-Apr-95						1			
15-Apr-95		1				1			
16-Apr-95						8			
17-Apr-95			2						
18-Apr-95									
19-Apr-95									
20-Apr-95									
21-Apr-95									
22-Apr-95		3							
23-Apr-95		1	1						
24-Apr-95			1						1
25-Apr-95	1	3							
26-Apr-95	22	2	5	1					1
27-Apr-95		3							
28-Apr-95	1								
29-Apr-95	11								
30-Apr-95			1						
01-May-95									
02-May-95				1					
03-May-95				1					
04-May-95				1					
05-May-95	4	1		1					
06-May-95			1						
07-May-95		2		2					
08-May-95	4			2					
09-May-95									
10-May-95				2					
11-May-95									
12-May-95									
13-May-95									
14-May-95									
15-May-95		4		2					
16-May-95	25	1							
17-May-95									
18-May-95									
19-May-95									
20-May-95									
21-May-95									
22-May-95				1					
23-May-95				1					
24-May-95				1					
25-May-95		1							
26-May-95				2					
16-Jun-95	2	4							
17-Jun-95		2							
18-Jun-95	2	4							
19-Jun-95		1							
20-Jun-95		1							
21-Jun-95	2	2		2					
22-Jun-95	2	5		2					
23-Jun-95	1	1							
24-Jun-95		2							
25-Jun-95		4							
26-Jun-95		3	1						
27-Jun-95	4	3		1					

Appendix Table 5 cont. Daily catch of non-target species in the Chewuch River screw trap, 1995.

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Spring chinook fry	Bull trout	Cutthroat	Hatchery steelhead
28-Jun-95	1	3	1	3					
29-Jun-95		1							
30-Jun-95	1	4	2						
01-Jul-95	1	2	2	1					
02-Jul-95	1	4	2						
03-Jul-95		2	1						
04-Jul-95	3	3	1						
05-Jul-95	1	1							
06-Jul-95	1	5	1	1					
07-Jul-95	4	7							
08-Jul-95	4	3							
09-Jul-95	5	4	2						
10-Jul-95		2							
11-Jul-95		1	1						
12-Jul-95		1	23						
13-Jul-95		1							
14-Jul-95		1	1						
15-Jul-95									
17-Jul-95	6	15	5	1					
18-Jul-95									
19-Jul-95									
20-Jul-95	1	1	2		1				
21-Jul-95		1		1	2			1	
22-Jul-95	2	4			3				
23-Jul-95		4	1		3				
24-Jul-95		6	1	1	1				
25-Jul-95		1			1				
26-Jul-95		3			4				
27-Jul-95		3			2				
28-Jul-95		15		1	7				
29-Jul-95			1						
30-Jul-95									
31-Jul-95									
01-Aug-95		4							
02-Aug-95		4							
03-Aug-95		5			4				
04-Aug-95		3			1				
05-Aug-95									1
06-Aug-95		4							
07-Aug-95		1							
08-Aug-95									
09-Aug-95		2							
10-Aug-95									
11-Aug-95									
12-Aug-95									
28-Jun-95	1	3	1	3					
29-Jun-95		1							
30-Jun-95	1	4	2						
01-Jul-95	1	2	2	1					
02-Jul-95	1	4	2						
03-Jul-95		2	1						
04-Jul-95	3	3	1						
05-Jul-95	1	1							
06-Jul-95	1	5	1	1					
07-Jul-95	4	7							
08-Jul-95	4	3							
09-Jul-95	5	4	2						
10-Jul-95		2							
11-Jul-95		1	1						
27-Aug-95									

Appendix Table 5 cont. Daily catch of non-target species in the Chewuch River screw trap, 1995.

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Spring chinook fry	Bull trout	Cutthroat	Hatchery steelhead
28-Aug-95									
29-Aug-95		2			1				
30-Aug-95		6			1				
31-Aug-95		5			1				
04-Oct-95		4							
05-Oct-95		3							
06-Oct-95		1			1				
07-Oct-95					11				
08-Oct-95		4			3				1
09-Oct-95		4			3				
10-Oct-95									
11-Oct-95									
12-Oct-95					3				
13-Oct-95					2				
14-Oct-95					4				
15-Oct-95									
16-Oct-95		6							
17-Oct-95		1			2				
18-Oct-95									
19-Oct-95					4				
20-Oct-95					3				1
21-Oct-95									
22-Oct-95					5				
23-Oct-95		1			1				
24-Oct-95									1
25-Oct-95					10				2
26-Oct-95					4				
27-Oct-95					5				
28-Oct-95									
29-Oct-95									
30-Oct-95					7				
31-Oct-95					1				
01-Nov-95					2				
02-Nov-95									
03-Nov-95		2							
04-Nov-95									
05-Nov-95									1
06-Nov-95		3			2				2
07-Nov-95					1				
08-Nov-95									
09-Nov-95									
10-Nov-95					3				
11-Nov-95									
12-Nov-95									
13-Nov-95									
14-Nov-95		1			2				1
15-Nov-95									
16-Nov-95				1	2				1
17-Nov-95									
18-Nov-95									
19-Nov-95									
20-Nov-95				1					
21-Nov-95									
22-Nov-95									
23-Nov-95									
24-Nov-95									
25-Nov-95									
26-Nov-95									1
27-Nov-95									
28-Nov-95									

Appendix Table 5 cont. Daily catch of non-target species in the Chewuch River screw trap, 1995.

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Spring chinook fry	Bull trout	Cutthroat	Hatchery steelhead
29-Nov-95									
30-Nov-95									
01-Dec-95									
02-Dec-95									
03-Dec-95									1

Appendix Table 6. Summary of spring chinook parr (age 0+) and steelhead/rainbow trout counts for the Chewuch River, summer 1995.

Date	Actual daily counts		Mortalities	
	Spring chinook	Steelhead/ rainbow trout	Spring chinook	Steelhead/ rainbow trout
16-Jun-95	1	0	0	0
24-Jun-95	1	0	0	0
25-Jun-95	0	1	0	0
30-Jun-95	1	0	0	0
03-Jul-95	0	1	0	0
04-Jul-95	1	0	0	0
05-Jul-95	1	0	0	0
07-Jul-95	1	0	0	0
10-Jul-95	1	0	0	0
11-Jul-95	[illegible]	1	0	0
22-Jul-95	1	1	0	0
23-Jul-95	2	1	0	0
24-Jul-95	2	0	0	0
25-Jul-95	6	2	0	0
26-Jul-95	2	1	0	0
27-Jul-95	2	2	0	0
28-Jul-95	12	2	0	0
01-Aug-95	1	1	0	0
02-Aug-95	0	1	0	0
06-Aug-95	2	0	0	0
09-Aug-95	1	2	0	0
14-Aug-95	9	0	0	0
15-Aug-95	4	0	0	0
16-Aug-95	2	0	0	0
22-Aug-95	7	6	0	0
23-Aug-95	4	1	0	0
24-Aug-95	6	0	0	0
29-Aug-95	15	3	0	0
30-Aug-95	5	3	0	0
31-Aug-95	6	0	0	0

Appendix Table 7. Mellow River screw trap daily catch data, summer 1995.

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Bull Trout	Cutthroat	Chinook	Steelhead/ rainbow trout
28-Jul-95	4	10	5					3	
31-Jul-95	7	26	12		1			2	
04-Aug-95		15	9					1	
07-Aug-95		1		1				1	
08-Aug-95		2						2	1
09-Aug-95		4	2	1				4	
10-Aug-95		11							
15-Aug-95		1						1	1
16-Aug-95		5						5	
23-Aug-95		2	3						
24-Aug-95	2	1						2	
29-Aug-95		8						2	
30-Aug-95		5						1	

Appendix Table 8. Daily actual and predicted spring chinook parr counts for the Chewuch screw trap, fall 1995.

Day	Daily count, mortalities, discharge and entrainment				Daily estimated passage			Cumulative estimated passage			Percent passage	
	Actual count	Mortalities	Mean Q (cfs)	Entrainment	Estimated count	Variance	SE	Estimated count	Variance	SE	Cumulative	Daily
04-Oct-95	7	0	106	0.274	26	192.2	13.9	26	192.2	13.9	1.2%	1.2%
05-Oct-95	2	2	109	0.274	7	50.7	7.1	33	243.0	15.6	1.6%	0.4%
06-Oct-95	3	1	109	0.274	11	77.4	8.8	44	320.3	17.9	2.1%	0.5%
07-Oct-95	8	0	106	0.274	29	223.0	14.9	73	543.4	23.3	3.5%	1.4%
08-Oct-95	0	0	103	0.274	0	0.0	0.0	73	543.4	23.3	3.5%	0.0%
09-Oct-95	4	0	100	0.274	15	104.8	10.2	88	648.2	25.5	4.3%	0.7%
10-Oct-95	7	0	105	0.274	26	192.2	13.9	113	840.4	29.0	5.5%	1.2%
11-Oct-95	1	0	118	0.274	4	25.0	5.0	117	865.4	29.4	5.7%	0.2%
12-Oct-95	4	0	114	0.274	15	39.7	6.3	131	905.1	30.1	6.4%	0.7%
13-Oct-95	2	0	109	0.274	7	19.6	4.4	139	924.7	30.4	6.7%	0.4%
14-Oct-95	1	0	105	0.274	4	9.7	3.1	142	934.5	30.6	6.9%	0.2%
15-Oct-95	4	0	104	0.274	15	39.7	6.3	157	974.2	31.2	7.6%	0.7%
16-Oct-95	2	0	105	0.274	7	19.6	4.4	164	993.8	31.5	8.0%	0.4%
17-Oct-95	8	0	106	0.274	29	81.5	9.0	193	1075.3	32.8	9.4%	1.4%
18-Oct-95	4	0	105	0.274	15	39.7	6.3	208	1115.0	33.4	10.1%	0.7%
19-Oct-95	10	0	102	0.274	36	103.2	10.2	244	1218.2	34.9	11.9%	1.8%
20-Oct-95	1	0	99	0.274	4	9.7	3.1	248	1228.0	35.0	12.1%	0.2%
21-Oct-95	10	0	97	0.274	36	103.2	10.2	285	1331.2	36.5	13.8%	1.8%
22-Oct-95	2	0	95	0.274	7	19.6	4.4	292	1350.8	36.8	14.2%	0.4%
23-Oct-95	6	0	93	0.274	22	60.4	7.8	314	1411.1	37.6	15.2%	1.1%
24-Oct-95	10	0	93	0.274	36	103.2	10.2	350	1514.3	38.9	17.0%	1.8%
25-Oct-95	9	4	93	0.274	33	92.3	9.6	383	1606.6	40.1	18.6%	1.6%
26-Oct-95	8	0	98	0.274	29	81.5	9.0	412	1688.1	41.1	20.0%	1.4%
27-Oct-95	11	0	92	0.274	40	114.2	10.7	452	1802.4	42.5	22.0%	2.0%
28-Oct-95	11	0	88	0.274	40	114.2	10.7	493	1916.6	43.8	23.9%	2.0%
29-Oct-95	21	0	83	0.274	77	231.7	15.2	569	2148.3	46.4	27.7%	3.7%
30-Oct-95	16	0	80	0.274	58	171.4	13.1	628	2319.7	48.2	30.5%	2.8%
31-Oct-95	5	4	75	0.274	18	50.0	7.1	646	2369.7	48.7	31.4%	0.9%
01-Nov-95	12	0	72	0.274	44	125.4	11.2	690	2495.1	50.0	33.5%	2.1%
02-Nov-95	8	0	68	0.274	29	81.5	9.0	719	2576.6	50.8	34.9%	1.4%
03-Nov-95	12	0	72	0.274	44	125.4	11.2	763	2702.0	52.0	37.1%	2.1%
04-Nov-95	7	0	78	0.274	26	70.9	8.4	788	2772.9	52.7	38.3%	1.2%
05-Nov-95	8	0	78	0.274	29	81.5	9.0	817	2854.4	53.4	39.7%	1.4%
06-Nov-95	3	0	79	0.274	11	29.6	5.4	828	2884.0	53.7	40.2%	0.5%
07-Nov-95	6	0	82	0.274	22	60.4	7.8	850	2944.4	54.3	41.3%	1.1%
08-Nov-95	32	0	91	0.274	117	376.0	19.4	967	3320.4	57.6	47.0%	5.7%
09-Nov-95	20	0	93	0.274	73	219.4	14.8	1040	3539.8	59.5	50.5%	3.5%
10-Nov-95	8	0	91	0.274	29	81.5	9.0	1069	3621.3	60.2	52.0%	1.4%
11-Nov-95	7	0	83	0.274	26	70.9	8.4	1095	3692.2	60.8	53.2%	1.2%
12-Nov-95	8	0	112	0.274	29	81.5	9.0	1124	3773.7	61.4	54.6%	1.4%
13-Nov-95	12	0	92	0.274	44	125.4	11.2	1168	3899.1	62.4	56.7%	2.1%
14-Nov-95	10	0	89	0.274	36	103.2	10.2	1204	4002.3	63.3	58.5%	1.8%
15-Nov-95	11	0	89	0.274	40	114.2	10.7	1244	4116.5	64.2	60.5%	2.0%
16-Nov-95	10	0	91	0.274	36	103.2	10.2	1281	4219.7	65.0	62.2%	1.8%
17-Nov-95	3	0	92	0.274	11	29.6	5.4	1292	4249.3	65.2	62.8%	0.5%
18-Nov-95	3	0	107	0.274	11	29.6	5.4	1303	4278.9	65.4	63.3%	0.5%
19-Nov-95	15	0	110	0.274	55	159.7	12.6	1358	4438.6	66.6	66.0%	2.7%
20-Nov-95	14	0	97	0.274	51	148.1	12.2	1409	4586.7	67.7	68.4%	2.5%
21-Nov-95	18	0	97	0.274	66	195.1	14.0	1474	4781.8	69.2	71.6%	3.2%
22-Nov-95	17	0	94	0.274	62	183.2	13.5	1536	4965.0	70.5	74.6%	3.0%
23-Nov-95	12	0	94	0.274	44	125.4	11.2	1580	5090.4	71.3	76.8%	2.1%
24-Nov-95	11	0	95	0.274	40	114.2	10.7	1620	5204.7	72.1	78.7%	2.0%
25-Nov-95	11	0	108	0.274	40	114.2	10.7	1660	5318.9	72.9	80.7%	2.0%
26-Nov-95	11	0	106	0.274	40	114.2	10.7	1701	5433.1	73.7	82.6%	2.0%
27-Nov-95	6	0	102	0.274	22	60.4	7.8	1722	5493.5	74.1	83.7%	1.1%
28-Nov-95	0	0	107	0.274	0	0.0	0.0	1722	5493.5	74.1	83.7%	0.0%
29-Nov-95	9	0	194	0.274	33	92.3	9.6	1755	5585.8	74.7	85.3%	1.6%
30-Nov-95	14	0	280	0.274	51	148.1	12.2	1806	5733.9	75.7	87.8%	2.5%
01-Dec-95	18	0	245	0.274	66	195.1	14.0	1872	5929.0	77.0	91.0%	3.2%
02-Dec-95	26	0	214	0.274	95	295.4	17.2	1967	6224.4	78.9	95.6%	4.6%
03-Dec-95	25	0	179	0.274	91	282.4	16.8	2058	6506.8	80.7	100.0%	4.4%

Shaded dates denotes days which trap data was interpolated.

Appendix Table 9. Daily actual and predicted steelhead/rainbow trout counts for the Chewuch screw trap, fall 1995.

Day	Daily count, mortalities, discharge and entrainment				Daily estimated passage			Cumulative estimated passage			Percent passage	
	Actual count	Mortalities	Mean Q (cfs)	Entrainment	Estimated count	Variance	SE	Estimated count	Variance	SE	Cumulative	Daily
04-Oct-95	0	0	106	0.274	0	0	0	0	0	0	0.0%	0.0%
05-Oct-95	0	2	109	0.274	0	0	0	0	0	0	0.0%	0.0%
06-Oct-95	0	1	109	0.274	0	0	0	0	0	0	0.0%	0.0%
07-Oct-95	0	0	106	0.274	0	0	0	0	0	0	0.0%	0.0%
08-Oct-95	0	0	103	0.274	0	0	0	0	0	0	0.0%	0.0%
09-Oct-95	0	0	100	0.274	0	0	0	0	0	0	0.0%	0.0%
10-Oct-95	0	0	105	0.274	0	0	0	0	0	0	0.0%	0.0%
11-Oct-95	0	0	118	0.274	0	0	0	0	0	0	0.0%	0.0%
12-Oct-95	1	0	114	0.274	4	10	3	4	10	3	3.7%	3.7%
13-Oct-95	0	0	109	0.274	0	0	0	4	10	3	3.7%	0.0%
14-Oct-95	1	0	105	0.274	4	10	3	7	20	5	7.4%	3.7%
15-Oct-95	0	0	104	0.274	0	0	0	7	20	5	7.4%	0.0%
16-Oct-95	0	0	105	0.274	0	0	0	7	20	5	7.4%	0.0%
17-Oct-95	0	0	106	0.274	0	0	0	7	20	5	7.4%	0.0%
18-Oct-95	0	0	105	0.274	0	0	0	7	20	5	7.4%	0.0%
19-Oct-95	0	0	102	0.274	0	0	0	7	20	5	7.4%	0.0%
20-Oct-95	1	0	99	0.274	4	10	3	11	30	6	11.1%	3.7%
21-Oct-95	0	0	97	0.274	0	0	0	11	30	6	11.1%	0.0%
22-Oct-95	0	0	95	0.274	0	0	0	11	30	6	11.1%	0.0%
23-Oct-95	0	0	93	0.274	0	0	0	11	30	6	11.1%	0.0%
24-Oct-95	3	0	93	0.274	11	33	6	22	64	8	22.2%	11.1%
25-Oct-95	2	4	93	0.274	7	21	5	29	85	9	29.6%	7.4%
26-Oct-95	1	0	98	0.274	4	10	3	33	95	10	33.3%	3.7%
27-Oct-95	0	0	92	0.274	0	0	0	33	95	10	33.3%	0.0%
28-Oct-95	0	0	88	0.274	0	0	0	33	95	10	33.3%	0.0%
29-Oct-95	0	0	83	0.274	0	0	0	33	95	10	33.3%	0.0%
30-Oct-95	0	0	80	0.274	0	0	0	33	95	10	33.3%	0.0%
31-Oct-95	0	4	75	0.274	0	0	0	33	95	10	33.3%	0.0%
01-Nov-95	0	0	72	0.274	0	0	0	33	95	10	33.3%	0.0%
02-Nov-95	0	0	68	0.274	0	0	0	33	95	10	33.3%	0.0%
03-Nov-95	0	0	72	0.274	0	0	0	33	95	10	33.3%	0.0%
04-Nov-95	0	0	78	0.274	0	0	0	33	95	10	33.3%	0.0%
05-Nov-95	2	0	78	0.274	7	21	5	40	116	11	40.7%	7.4%
06-Nov-95	2	0	79	0.274	7	21	5	47	137	12	48.1%	7.4%
07-Nov-95	0	0	82	0.274	0	0	0	47	137	12	48.1%	0.0%
08-Nov-95	0	0	91	0.274	0	0	0	47	137	12	48.1%	0.0%
09-Nov-95	3	0	93	0.274	11	33	6	58	171	13	59.3%	11.1%
10-Nov-95	0	0	91	0.274	0	0	0	58	171	13	59.3%	0.0%
11-Nov-95	0	0	83	0.274	0	0	0	58	171	13	59.3%	0.0%
12-Nov-95	0	0	112	0.274	0	0	0	58	171	13	59.3%	0.0%
13-Nov-95	0	0	92	0.274	0	0	0	58	171	13	59.3%	0.0%
14-Nov-95	3	0	89	0.274	11	33	6	69	204	14	70.4%	11.1%
15-Nov-95	0	0	89	0.274	0	0	0	69	204	14	70.4%	0.0%
16-Nov-95	1	0	91	0.274	4	10	3	73	214	15	74.1%	3.7%
17-Nov-95	0	0	92	0.274	0	0	0	73	214	15	74.1%	0.0%
18-Nov-95	1	0	107	0.274	4	10	3	77	224	15	77.8%	3.7%
19-Nov-95	0	0	110	0.274	0	0	0	77	224	15	77.8%	0.0%
20-Nov-95	0	0	97	0.274	0	0	0	77	224	15	77.8%	0.0%
21-Nov-95	1	0	97	0.274	4	10	3	80	234	15	81.5%	3.7%
22-Nov-95	0	0	94	0.274	0	0	0	80	234	15	81.5%	0.0%
23-Nov-95	0	0	94	0.274	0	0	0	80	234	15	81.5%	0.0%
24-Nov-95	0	0	95	0.274	0	0	0	80	234	15	81.5%	0.0%
25-Nov-95	0	0	108	0.274	0	0	0	80	234	15	81.5%	0.0%
26-Nov-95	0	0	106	0.274	0	0	0	80	234	15	81.5%	0.0%
27-Nov-95	0	0	102	0.274	0	0	0	80	234	15	81.5%	0.0%
28-Nov-95	0	0	107	0.274	0	0	0	80	234	15	81.5%	0.0%
29-Nov-95	0	0	194	0.274	0	0	0	80	234	15	81.5%	0.0%
30-Nov-95	0	0	280	0.274	0	0	0	80	234	15	81.5%	0.0%
01-Dec-95	0	0	245	0.274	0	0	0	80	234	15	81.5%	0.0%
02-Dec-95	2	0	214	0.274	7	21	5	88	256	16	88.9%	7.4%
03-Dec-95	3	0	179	0.274	11	33	6	99	289	17	100.0%	11.1%

Shaded dates denote days which trap data was interpolated.

Appendix Table 9. Daily actual and predicted steelhead/rainbow parr counts for the Chewuch screw trap, fall 1995.

Day	Daily count, mortalities, discharge and entrainment				Daily estimated passage			Cumulative estimated passage			Percent passage	
	Actual count	Mortalities	Mean Q (cfs)	Entrainment	Estimated count	Variance	SE	Estimated count	Variance	SE	Cumulative	Daily
04-Oct-95	0	0	106	0.2740	0	0	0	0	0	0	0.00%	0.00%
05-Oct-95	0	2	109	0.2740	0	0	0	0	0	0	0.00%	0.00%
06-Oct-95	0	1	109	0.2740	0	0	0	0	0	0	0.00%	0.00%
07-Oct-95	0	0	106	0.2740	0	0	0	0	0	0	0.00%	0.00%
08-Oct-95	0	0	103	0.2740	0	0	0	0	0	0	0.00%	0.00%
09-Oct-95	0	0	100	0.2740	0	0	0	0	0	0	0.00%	0.00%
10-Oct-95	0	0	105	0.2740	0	0	0	0	0	0	0.00%	0.00%
11-Oct-95	0	0	118	0.2740	0	0	0	0	0	0	0.00%	0.00%
12-Oct-95	1	0	114	0.2740	4	10	3	4	10	3	3.70%	3.70%
13-Oct-95	0	0	109	0.2740	0	0	0	4	10	3	3.70%	0.00%
14-Oct-95	1	0	105	0.2740	4	10	3	7	20	5	7.41%	3.70%
15-Oct-95	0	0	104	0.2740	0	0	0	7	20	5	7.41%	0.00%
16-Oct-95	0	0	105	0.2740	0	0	0	7	20	5	7.41%	0.00%
17-Oct-95	0	0	106	0.2740	0	0	0	7	20	5	7.41%	0.00%
18-Oct-95	0	0	105	0.2740	0	0	0	7	20	5	7.41%	0.00%
19-Oct-95	0	0	102	0.2740	0	0	0	7	20	5	7.41%	0.00%
20-Oct-95	1	0	99	0.2740	4	10	3	11	30	6	11.11%	3.70%
21-Oct-95	0	0	97	0.2740	0	0	0	11	30	6	11.11%	0.00%
22-Oct-95	0	0	95	0.2740	0	0	0	11	30	6	11.11%	0.00%
23-Oct-95	0	0	93	0.2740	0	0	0	11	30	6	11.11%	0.00%
24-Oct-95	3	0	93	0.2740	11	33	6	22	64	8	22.22%	11.11%
25-Oct-95	2	4	93	0.2740	7	21	5	29	85	9	29.63%	7.41%
26-Oct-95	1	0	98	0.2740	4	10	3	33	95	10	33.33%	3.70%
27-Oct-95	0	0	92	0.2740	0	0	0	33	95	10	33.33%	0.00%
28-Oct-95	0	0	88	0.2740	0	0	0	33	95	10	33.33%	0.00%
29-Oct-95	0	0	83	0.2740	0	0	0	33	95	10	33.33%	0.00%
30-Oct-95	0	0	80	0.2740	0	0	0	33	95	10	33.33%	0.00%
31-Oct-95	0	4	75	0.2740	0	0	0	33	95	10	33.33%	0.00%
01-Nov-95	0	0	72	0.2740	0	0	0	33	95	10	33.33%	0.00%
02-Nov-95	0	0	68	0.2740	0	0	0	33	95	10	33.33%	0.00%
03-Nov-95	0	0	72	0.2740	0	0	0	33	95	10	33.33%	0.00%
04-Nov-95	0	0	78	0.2740	0	0	0	33	95	10	33.33%	0.00%
05-Nov-95	2	0	78	0.2740	7	21	5	40	116	11	40.74%	7.41%
06-Nov-95	2	0	79	0.2740	7	21	5	47	137	12	48.15%	7.41%
07-Nov-95	0	0	82	0.2740	0	0	0	47	137	12	48.15%	0.00%
08-Nov-95	0	0	91	0.2740	0	0	0	47	137	12	48.15%	0.00%
09-Nov-95	3	0	93	0.2740	11	33	6	58	171	13	59.26%	11.11%
10-Nov-95	0	0	91	0.2740	0	0	0	58	171	13	59.26%	0.00%
11-Nov-95	0	0	83	0.2740	0	0	0	58	171	13	59.26%	0.00%
12-Nov-95	0	0	112	0.2740	0	0	0	58	171	13	59.26%	0.00%
13-Nov-95	0	0	92	0.2740	0	0	0	58	171	13	59.26%	0.00%
14-Nov-95	3	0	89	0.2740	11	33	6	69	204	14	70.37%	11.11%
15-Nov-95	0	0	89	0.2740	0	0	0	69	204	14	70.37%	0.00%
16-Nov-95	1	0	91	0.2740	4	10	3	73	214	15	74.07%	3.70%
17-Nov-95	0	0	92	0.2740	0	0	0	73	214	15	74.07%	0.00%
18-Nov-95	1	0	107	0.2740	4	10	3	77	224	15	77.78%	3.70%
19-Nov-95	0	0	110	0.2740	0	0	0	77	224	15	77.78%	0.00%
20-Nov-95	0	0	97	0.2740	0	0	0	77	224	15	77.78%	0.00%
21-Nov-95	1	0	97	0.2740	4	10	3	80	234	15	81.48%	3.70%
22-Nov-95	0	0	94	0.2740	0	0	0	80	234	15	81.48%	0.00%
23-Nov-95	0	0	94	0.2740	0	0	0	80	234	15	81.48%	0.00%
24-Nov-95	0	0	95	0.2740	0	0	0	80	234	15	81.48%	0.00%
25-Nov-95	0	0	108	0.2740	0	0	0	80	234	15	81.48%	0.00%
26-Nov-95	0	0	106	0.2740	0	0	0	80	234	15	81.48%	0.00%
27-Nov-95	0	0	102	0.2740	0	0	0	80	234	15	81.48%	0.00%
28-Nov-95	0	0	107	0.2740	0	0	0	80	234	15	81.48%	0.00%
29-Nov-95	0	0	194	0.2740	0	0	0	80	234	15	81.48%	0.00%
30-Nov-95	0	0	280	0.2740	0	0	0	80	234	15	81.48%	0.00%
01-Dec-95	0	0	245	0.2740	0	0	0	80	234	15	81.48%	0.00%
02-Dec-95	2	0	214	0.2740	7	21	5	88	256	16	88.89%	7.41%
03-Dec-95	3	0	179	0.2740	11	33	6	99	289	17	100.00%	11.11%

Shaded dates denote days which trap data was interpolated.

Appendix Table 10. Methow River screw trap daily catch data, fall 1995.

Date	Eel	Longnose dace	Sculpin	Sucker	Whitefish	Bull Trout	Cutthroat	Chinook	Steelhead/ rainbow trout
17-Oct-95						1		7	2
19-Oct-95		3			5	1		7	3
20-Oct-95						2		25	5
21-Oct-95		1			1			22	2
22-Oct-95						4		15	2
23-Oct-95				1	2			8	4
24-Oct-95		1			5			14	2
25-Oct-95					4			13	3
26-Oct-95						2		18	1
30-Oct-95					1			11	
31-Oct-95					13		2	15	2
01-Nov-95					15		1	12	2
02-Nov-95						1		21	2
03-Nov-95								7	2
04-Nov-95		1	1					17	
05-Nov-95								12	
06-Nov-95				1				12	
07-Nov-95						1		2	

Appendix Table 11. Summary of marked Chewuch River spring chinook releases at the Chewuch screw trap, and recaptures at the Methow screw trap (Carlton pond), fall 1995.

Date	Number released (Chewuch)	Date	Number recaptured (Methow)
10/20/95	10	10/21/95	1
10/22/95	10		
10/25/95	10		
10/26/95	9	10/26/95	3
10/30/95	21	10/30/95	1
10/31/95	16		
11/01/95	4	11/02/95	3
11/03/95	8	11/04/95	2
11/05/95	7		
11/06/95	8		
Total	103		10

Appendix Table 12. Daily actual and predicted spring chinook smolt counts for the Chewuch screw trap, spring, 1996.

Day	Daily count, mortalities, discharge and entrainment				Daily estimated passage			Cumulative estimated passage			Percent passage	
	Actual count	Mortalities	Mean Q (cfs)	Entrainment rate	Estimated count	Variance	SE	Estimated count	Variance	SE	Cumulative	Daily
15-Mar-96	10	0	159	0.278	36	105.8	10.3	36	105.8	10.3	1.0%	1.0%
16-Mar-96	45	1	180	0.278	162	670.4	25.9	198	776.2	27.9	5.5%	4.5%
17-Mar-96	24	0	187	0.278	86	293.7	17.1	284	1,069.9	32.7	7.9%	2.4%
18-Mar-96	29	0	196	0.278	104	373.0	19.3	388	1,442.9	38.0	10.7%	2.9%
19-Mar-96	29	0	210	0.278	104	373.0	19.3	492	1,815.9	42.6	13.6%	2.9%
20-Mar-96	34	0	222	0.278	122	458.4	21.4	614	2,274.4	47.7	17.0%	3.4%
21-Mar-96	21	0	230	0.278	76	252.3	15.9	690	2,526.7	50.3	19.1%	2.1%
22-Mar-96	19	0	242	0.278	68	220.6	14.9	758	2,747.3	52.4	21.0%	1.9%
23-Mar-96	16	0	242	0.278	58	182.6	13.5	816	2,929.9	54.1	22.6%	1.6%
24-Mar-96	13	0	235	0.278	47	143.1	12.0	863	3,073.0	55.4	23.9%	1.3%
25-Mar-96	12	0	229	0.278	43	129.3	11.4	906	3,202.3	56.6	25.1%	1.2%
26-Mar-96	13	0	236	0.278	47	143.1	12.0	953	3,345.4	57.8	26.4%	1.3%
27-Mar-96	12	0	234	0.278	43	129.3	11.4	996	3,474.6	58.9	27.6%	1.2%
28-Mar-96	16	0	231	0.278	58	182.6	13.5	1,054	3,657.3	60.5	29.2%	1.6%
29-Mar-96	16	0	231	0.278	58	182.6	13.5	1,112	3,839.9	62.0	30.8%	1.6%
30-Mar-96	30	0	227	0.278	108	391.5	19.8	1,220	4,231.3	65.0	33.8%	3.0%
31-Mar-96	13	0	224	0.278	47	143.1	12.0	1,267	4,374.4	66.1	35.1%	1.3%
01-Apr-96	4	0	226	0.278	14	38.2	6.2	1,281	4,412.7	66.4	35.5%	0.4%
02-Apr-96	2	0	222	0.278	7	18.6	4.3	1,288	4,431.3	66.6	35.7%	0.2%
03-Apr-96	3	0	217	0.278	11	29.7	5.5	1,299	4,461.0	66.8	36.0%	0.3%
04-Apr-96	24	0	219	0.278	86	293.7	17.1	1,385	4,754.7	69.0	38.4%	2.4%
05-Apr-96	7	0	231	0.278	25	70.9	8.4	1,410	4,825.6	69.5	39.1%	0.7%
06-Apr-96	13	0	255	0.278	47	143.1	12.0	1,457	4,968.7	70.5	40.4%	1.3%
07-Apr-96	22	0	304	0.278	79	264.5	16.3	1,536	5,233.2	72.3	42.5%	2.2%
08-Apr-96	110	1	440	0.278	396	2520.3	50.2	1,932	7,753.5	88.1	53.5%	11.0%
09-Apr-96	60	0	674	0.278	216	1004.8	31.7	2,148	8,758.4	93.6	59.5%	6.0%
10-Apr-96	45	0	855	0.278	162	670.4	25.9	2,310	9,428.8	97.1	64.0%	4.5%
11-Apr-96	27	0	908	0.196	138	2264.3	47.6	2,448	11,693.1	108.1	67.8%	3.8%
12-Apr-96	19	0	872	0.196	97	1236.9	35.2	2,545	12,930.0	113.7	70.5%	2.7%
13-Apr-96	10	0	813	0.196	51	441.1	21.0	2,596	13,371.2	115.6	71.9%	1.4%
14-Apr-96	13	0	778	0.196	66	659.2	25.7	2,662	14,030.4	118.4	73.7%	1.8%
15-Apr-96	7	0	778	0.196	36	263.2	16.2	2,698	14,293.6	119.6	74.7%	1.0%
16-Apr-96	8	0	924	0.196	41	318.1	17.8	2,739	14,611.7	120.9	75.9%	1.1%
17-Apr-96	1	0	1040	0.196	5	22.7	4.8	2,744	14,634.4	121.0	76.0%	0.1%
18-Apr-96	3	0	957	0.196	15	81.6	9.0	2,759	14,716.0	121.3	76.4%	0.4%
19-Apr-96	8	0	885	0.196	41	318.1	17.8	2,800	15,034.1	122.6	77.6%	1.1%
20-Apr-96	5	0	836	0.196	26	166.9	12.9	2,826	15,201.0	123.3	78.3%	0.7%
21-Apr-96	8	0	801	0.196	41	318.1	17.8	2,867	15,519.1	124.6	79.4%	1.1%
22-Apr-96	9	0	782	0.196	46	377.4	19.4	2,913	15,896.5	126.1	80.7%	1.3%
23-Apr-96	2	0	969	0.196	10	49.9	7.1	2,923	15,946.4	126.3	81.0%	0.3%
24-Apr-96	7	0	1540	0.196	36	263.2	16.2	2,959	16,209.7	127.3	82.0%	1.0%
25-Apr-96	7	0	1320	0.196	36	263.2	16.2	2,995	16,472.9	128.3	83.0%	1.0%
26-Apr-96	6	0	1160	0.196	31	212.9	14.6	3,026	16,685.8	129.2	83.8%	0.9%
27-Apr-96	5	0	1050	0.196	26	166.9	12.9	3,052	16,852.7	129.8	84.5%	0.7%
28-Apr-96	4	0	979	0.196	20	117.7	10.8	3,072	16,970.4	130.3	85.1%	0.6%
29-Apr-96	3	0	919	0.196	15	81.6	9.0	3,087	17,052.0	130.6	85.5%	0.4%
30-Apr-96	2	0	882	0.196	10	49.9	7.1	3,097	17,102.0	130.8	85.8%	0.3%
01-May-96	2	0	849	0.196	10	49.9	7.1	3,107	17,151.9	131.0	86.1%	0.3%
02-May-96	1	0	804	0.196	5	22.7	4.8	3,112	17,174.7	131.1	86.2%	0.1%
03-May-96	4	0	757	0.196	20	117.7	10.8	3,132	17,292.4	131.5	86.8%	0.6%
04-May-96	0	0	720	0.196	0	0.0	0.0	3,132	17,292.4	131.5	86.8%	0.0%
05-May-96	2	0	690	0.196	10	49.9	7.1	3,142	17,342.3	131.7	87.0%	0.3%
06-May-96	4	0	681	0.196	20	117.7	10.8	3,162	17,460.0	132.1	87.6%	0.6%
07-May-96	2	0	665	0.196	10	49.9	7.1	3,172	17,510.0	132.3	87.9%	0.3%
08-May-96	4	0	630	0.196	20	117.7	10.8	3,192	17,627.7	132.8	88.4%	0.6%
09-May-96	5	0	602	0.196	26	166.9	12.9	3,218	17,794.6	133.4	89.1%	0.7%
10-May-96	4	0	581	0.196	20	117.7	10.8	3,238	17,912.3	133.8	89.7%	0.6%
11-May-96	1	0	568	0.196	5	22.7	4.8	3,243	17,935.0	133.9	89.8%	0.1%
12-May-96	5	0	561	0.196	26	166.9	12.9	3,269	18,102.0	134.5	90.6%	0.7%
13-May-96	1	0	654	0.196	5	22.7	4.8	3,274	18,124.7	134.6	90.7%	0.1%
14-May-96	7	0	846	0.196	36	263.2	16.2	3,310	18,388.0	135.6	91.7%	1.0%
15-May-96	21	0	1030	0.196	107	1459.9	38.2	3,417	19,847.8	140.9	94.7%	3.0%
16-May-96	14	0	1130	0.196	71	740.8	27.2	3,488	20,588.6	143.5	96.6%	2.0%
17-May-96	11	0	1320	0.196	56	509.4	22.6	3,544	21,098.0	145.3	98.2%	1.6%
18-May-96	7	0	1640	0.196	36	263.2	16.2	3,580	21,361.2	146.2	99.2%	1.0%
19-May-96	1	0	1580	0.196	5	22.7	4.8	3,585	21,384.0	146.2	99.3%	0.1%
20-May-96	1	0	1500	0.196	5	22.7	4.8	3,590	21,406.7	146.3	99.4%	0.1%
21-May-96	1	0	1470	0.196	5	22.7	4.8	3,595	21,429.5	146.4	99.6%	0.1%
22-May-96	2	0	1400	0.196	10	49.9	7.1	3,605	21,479.4	146.6	99.9%	0.3%
23-May-96	0	0	1310	0.196	0	0.0	0.0	3,605	21,479.4	146.6	99.9%	0.0%
24-May-96	1	0	1300	0.196	5	22.7	4.8	3,610	21,502.1	146.6	100.0%	0.1%

Shaded dates denote days which the trap data was interpolated.

The trap was unoperable due to high river discharge May 25-June 18.

REVIEW DRAFT: FOURTH ANNUAL REPORT WATER QUALITY OF LAKE OSOYOOS DURING 1997

APPENDIX I

FOURTH ANNUAL REPORT: WATER QUALITY OF OSOYOOS LAKE DURING 1997

PREPARED FOR

PUBLIC UTILITY DISTRICT NO. 1 OF DOUGLAS COUNTY
MR. RICK KLINGE, PROJECT MANAGER
1151 VALLEY MALL PARKWAY
EAST WENATCHEE, WASHINGTON, 98802

February 19, 1998

PREPARED BY:

Rensel Associates,
Aquatic Sciences Consultants
4209 234th Street N.E.
Arlington, Washington 98223

IN COOPERATION WITH:

Aquatic Research, Inc., Seattle
Arni Litt, Zooplankton Specialist
Routine Chemistry Laboratory, University of Washington
Water Environmental Services, Inc. Bainbridge Island

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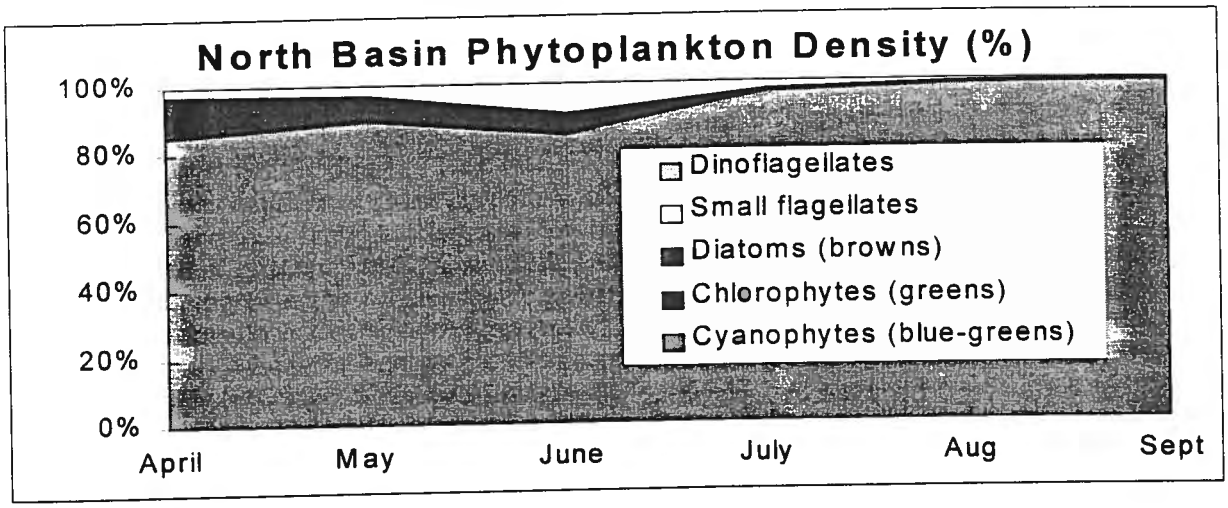
The author wishes to thank a number of individuals for their participation in the data collection, analyses and funding for this work. Field sampling was conducted with the capable assistance of Wayne Marsh and Dick Weinstein. Maribeth Gibbons of WATER Environmental Services provided taxonomic analyses of plankton and Arni Litt of the University of Washington provided additional zooplankton analyses. Aquatic Research, Inc. of Seattle provided some of the laboratory analyses. Nutrient and chlorophyll *a* analyses were performed by the Routine Chemistry Laboratory at the University of Washington. This report was produced with funding from Public Utility District No. 1 of Douglas County. The project manager was Rick Klinge.

Errata

The following errors should be noted from the prior annual report (Rensel 1997, sampling year 1996).

In Table 4 (Chlorophyll *a* and phaeophytin concentrations in near-surface waters of Lake Osoyoos in 1996, averages for all months & June to September (summer) only).
The cited months are correct but specific dates are not. The correct dates are given in Tables 2 and 3.

Figure 30, page 33 showed the percent distribution for density of major taxa of phytoplankton in the north basin of Lake Osoyoos during 1996 and was incorrect. It actually showed data from 1995. The figure below is the proper version.



Finally, prior reports have noted that a Van Veen grab sampler of 0.01 m^2 was used to sample the lake bottom, In fact the correct area was 0.025 m^2. The unit is heavily built and easily fills to maximum capacity in the soft bottom sediments of Lake Osoyoos.

Executive Summary

This document summarizes the fourth consecutive year of seasonal water quality sampling in Osoyoos Lake, a transboundary lake located in north-central Washington State and south-central British Columbia. The lake provides juvenile fish rearing habitat for one of two remaining mid-Columbia River Basin sockeye salmon (*Oncorhyncus nerka*) stocks. Adult fish migrate through the Columbia River, up the Okanogan River, through the lake and into spawning grounds in Canadian reaches of the river. After emergence from natal gravel, fry move downstream into the lake for a year or more of rearing.

This study was funded by the Public Utility District No. 1 of Douglas County, as part of an enhancement project for the native sockeye salmon. The project utilized short-term rearing and release of zero-aged smolts from net pens in Osoyoos Lake. Most of the effort in this study was focused on documenting nutrient, phytoplankton and zooplankton characteristics, as there has been concern about eutrophication of the lake in the past. To the extent possible, the results of the study are discussed with regard to the welfare of juvenile sockeye salmon rearing in the lake. This report confirms several trends and findings identified in a prior report (Rensel 1998) summarizing results from 1994 to 1996 as follows:

Weather and Flushing Rates:

1997 was a record year for both volumetric discharge of the Okanogan River and flushing rates of Osoyoos Lake. There has been a trend of increasingly wet and cooler years since the relatively warm and dry 1994 sampling season. As noted in prior reports, variation of flushing rates may have a profound effect on some aspects of the biology of Osoyoos Lake; other factors were independent of river discharge.

Thermographs and Lake Monitoring

Maximum near-surface water temperatures in the lake during 1997 were similar to 1995 and 1996, but considerably lower than those observed in 1994. Placement of a thermograph on the river bottom, downstream from the lake outlet, provided a reasonably good approximation of near-surface water temperatures in the lake. This is important because placement of thermographs in near-surface waters of the lake is likely to result in lost instruments and data. The correlation between near surface water temperature in the lake and bottom temperature in the river also supports the use of existing, historical river water temperature data as a surrogate measure of water temperatures in the surface of the lake's south basin.

Nutrients

There was a high probability that phytoplankton growth was limited by the availability of dissolved inorganic nitrogen and phosphorus at different times in Osoyoos Lake in 1997. Dissolved inorganic phosphorus limitation, indicated by low concentrations and high N:P ratios, was evident in July and possibly later months in the north basin. Possible nitrogen limitation was noted in April in the south basin, but measures of phytoplankton standing stock (cell counts and chlorophyll a) did not indicate a significant difference between basins. Trends of internal loading (release of phosphorus from sediments into anoxic bottom waters) were similar to prior years in the north basin, but for the first time were different and probably much less pronounced in the south basin.

These data show that nutrient loading in the watershed is important in controlling the trophic state of Osoyoos Lake. Any additional nutrients flowing into the lake, particularly in the summer, are very undesirable from both fisheries and water quality points of view. For reasons discussed in prior reports, it is desirable to reduce the nutrient content of the lake, particularly during the mid-summer to fall period, through source controls and increased low rates of the Okanogan River (i.e., reduced water withdrawal).

Phytoplankton

Despite obvious morphometric and physical differences, the north and south basins of the lake appear to have similar phytoplankton standing stock characteristics, as measured by chlorophyll *a* and cells counts. Blue-green algae present in the lake include several species capable of producing harmful toxins and interfering with the feeding of zooplankton known to be important sockeye salmon prey.

Trophic Status

Trophic (enrichment) status has decreased slightly each year since 1994, correlating inversely with river discharge and lake flushing rate. North and south basins were rated as highly similar, contrary to the findings of previous, shorter-term studies conducted several decades ago. Overall, the lake may presently be rated as mesotrophic, or moderately enriched. The highest weighting factor for mesotrophic results was total phosphorus. Unlike Secchi disk water transparency and chlorophyll *a* metrics, total P did not significantly decline as annual discharge of the river increased over the past four years.

Summer Habitat Availability for Sockeye Salmon Fry

This report further documents a habitat availability problem for sockeye fry in the south basin during mid to late summer. It is caused by low dissolved oxygen in the hypolimnion and warm water temperatures in most of the oxygenated epilimnion. The resulting horizontal strata of suitable conditions for sockeye fry was as shallow as 1 meter or less in 1994, 1996 and again in 1997. Although air temperatures were cooler

in 1997 than in 1994 and 1995, a relatively short-term warm period in late summer resulted in inhospitable water temperature and hypoxic conditions for sockeye fry in the south basin. These data, compared to prior years, may be interpreted to suggest that short-term weather variation, in terms of days and weeks, are more important to determining the intensity of the problem than the entire seasonal or annual weather trends. The findings may also be useful in the study of adult salmon migration, which is often impeded by warm water during the same July to August period.

Sockeye Food Supply Bottleneck

The existence of a probable food supply "bottleneck" in the north basin of the lake in April was once again documented in 1997. As most of the young of the year fry and many of the yearling presmolts apparently rear in the north basin in April, a shortage of preferred food at this critical time could have several adverse effects on the sockeye population. Other authors have found large variation in annual egg to smolt survival in the system which could in part be explained by the food supply bottleneck. Density and biomass of important, large-bodied cladoceran zooplankton were greatly reduced in April, most likely due to fish predation rates that exceed the zooplankton's reproduction rate. Average spring and summer abundance of crustacean zooplankton was lower in 1997 than in prior years, which may have been caused by washout from the record-setting rates of river discharge. Although density of crustacean zooplankton increased in the north basin in April of 1997 compared to the prior year, the relatively small average size of these organisms greatly reduced their suitability for sockeye fry.

Net Pen Rearing Impacts

Net-pen rearing impacts from the small and short-term rearing program such as has been conducted in Osoyoos Lake were not obvious or pronounced. Interannual changes in bottom conditions at reference areas suggest other, unknown factors (e.g, water currents) are more important in determining the distribution and amount of total organic carbon in surficial sediments of the lake bottom.

Recommendations

A prior three-year summary report had several conclusions and recommendations dealing with fisheries and water quality protection of Osoyoos Lake. The present report in general validates most of the prior conclusions and it would be redundant to repeat all the recommendations in detail. Briefly, recommendations included 1) study of the feasibility of accelerated flushing rates during the summer to improve water quality and fisheries, 2) means to determine carrying capacity determination for juvenile sockeye salmon, 3) use of net pens in the future for enhancement of the sockeye run, 4) need for juvenile fish distribution and diet studies in the spring and late summer, 5) future water quality and plankton monitoring considerations.

1.0 Introduction

This document summarizes the fourth sequential year of spring and summer water quality sampling in Osoyoos Lake, a transboundary lake in north central Washington State that supports a run of sockeye salmon (*Oncorhyncus nerka*). The study was funded by Public Utility District No. 1 of Douglas County, as part of a sockeye salmon enhancement project utilizing short-term rearing and release of zero-aged smolts from temporary net pens.

As noted in prior reports, the goals of the study were initially to:

1) Study the potential impact of the net-pens on the lake's ecosystem
2) Characterize the limnology of the south basin of Osoyoos Lake, as detailed by Rensel (1993) in a pre-study report regarding conditions in the lake.

Over time, goals of the study were expanded or shifted to include:

3) Limnological study of other major basins of the lake, especially the north basin that lies in entirely within Canada
4) Documentation of water temperatures in summer that may limit the availability of habitat for sockeye salmon fry
5) Collection of limited amounts of inflowing and outflowing river nutrient data.
6) Study of food availability for sockeye fry and presmolts

Osoyoos Lake was probably oligotrophic (nutrient poor) in the mid 19th century. Presently the lake is variably mesotrophic (e.g., moderately nutrient enriched, see Rensel Associates 1993, 1995, 1996, 1998), but my recent reports demonstrate that the lake is improving by many measures compared to three decades ago.

The present study was conducted to document conditions in the lake as a condition of state and local permits for a PUD sponsored salmon net pen rearing and release program. The initial background review and net pen siting document (Rensel 1993) found several data gaps in the basic limnology of the lake. Because the net pen program was relatively small and to be operated for only very short periods, no measurable environmental impact was predicted based on a quantitative estimate of waste loss and assimilation. The major thrust of the present study, therefore, was systematic collection of basic water quality data including nutrients, water temperature, dissolved oxygen, phytoplankton and zooplankton population estimates.

By many measures, Osoyoos Lake and the Okanogan River constitute an atypical sockeye salmon system. Surface waters are much warmer in summer and the lake in general is more eutrophic than most other sockeye salmon lakes (Pratt et al. 1991). Most sockeye lakes are cold, deep and oligotrophic (nutrient poor) and are at higher latitudes, such as those in British Columbia and Alaska. The unusual nature of the

Osoyoos Lake system presents a special opportunity to learn more about the adaptability of the sockeye salmon that have evolved there.

This report summarizes the final year of four consecutive years of lake monitoring. Prior reports include the initial pre-study report (produced in 1993), the year one report (sampled in 1994, dated 1995), the year two report (sampled in 1995, dated 1996), the year three report (sampled in 1996, dated 1998) and the year four report (sampled in 1997, this report). A summary report of the first three years of sampling was also prepared (to be dated 1998) and to the extent possible this final, year four report is an extension of that summary report. All reports were prepared by Dr. Jack Rensel of Rensel Associates Aquatic Science Consultants under contract to the Public Utility District No. 1 of Douglas County. All prior reports were offered as drafts for review by member of the Wells Coordinating Committee and several other reviewers.

1.1 Morphometrics of Osoyoos Lake

Osoyoos Lake is the last and most southerly lake in a series of six lakes draining the Okanogan Valley in south-central British Columbia and a small area of north-central Washington State (Figs. 1 and 2). The river flows nearly due south from Osoyoos Lake and joins the middle reaches of the Columbia River at Lake Pateros. The entire Okanogan River basin is considered a mixture of semi-arid (continental) and maritime climate. Rainfall decreases with decreasing latitude along the river valley and increases toward the Cascade Mountains crest.

Osoyoos Lake is a natural lake with outlet at river mile 79.0 (127.2 km) that was modified by the addition of the Zosel Dam at river mile 77.4 (124.6 km, USGS 1985-90). The USGS operates several gauging stations in the area, but the station at river mile 77.3 (124.4 km) below the Zosel Millpond is used by international agreement (Station 12439500). Streamflow measurements are also collected near Oliver B.C., upstream of Osoyoos Lake by the Canadian Government.

Zosel Dam was originally constructed to create a mill pond for log storage. Fish passage is provided by two ladders around the 2 m high dam. Seventeen miles upstream of the north end of Osoyoos Lake, McIntyre Dam is used to control elevation and flows out of Vaseux Lake, a relatively small and shallow lake. International agreements provide for minimum flows from this dam and elevation control at Zosel Dam.

Osoyoos Lake is the 3rd largest of the Okanogan Valley lakes in surface area and fourth largest by volume. It is composed of two major basins and one minor basin with a total surface area of 23.0×10^6 m^2 and a volume of 397×10^6 m^3. The north basin has a mean depth of 21 m and a maximum depth of 63 m. The south basin's average depth is 10 m with a maximum depth of 29m. The north basin of Osoyoos Lake lies entirely in British Columbia, the south basin is split between both countries. There is a

smaller, shallower central basin; some authors have lumped it with the south basin in their reports. In comparison, Lake Okanogan, upriver from Osoyoos Lake, is much larger with a surface area of 348 x 10^6 m^2, a volume of 26,200 x 10^6 m^3 and a mean depth of 76 m (Stockner and Northcote 1974). Booth (1969) also reviews morphology of Osoyoos Lake and describes soils in the surrounding watershed.

2.0 Methods and Materials

Routine water quality data and other samples were collected once monthly during April through September in 1997. As previously reported, this was a continuation of sampling conducted for the years 1994, 1995 and 1996. An effort was made to space the sampling dates to approximately one month apart and select the middle of the month, given the constraints of weather, boat availability, and other factors (Table 1). Initial sampling in April was constrained to matching the timing of fish transfer from the hatchery to the net pens in the lake.

Table 1. Sampling dates for Osoyoos Lake in 1994 through 1997.

	1994	1995	1996	1997	Mean
April	13	15	17	23	17
May	16	16	14	14	15
June	16	08	10	18	13
July	25	12	15	14	17
August	30	8 and 30	13	13	19
September	29	13	17	17	19
October		17			

Two primary sampling locations were utilized, one in each major basin of the lake: the south and north basins. The south basin sampling location was in mid channel just north of the international boundary at Boundary Point (Fig. 2). The north basin location was at a deep area in mid lake offshore of an apple processing facility known as the Monashee Cooperative. This location is also used by Canadian government water quality samplers in their twice annual collections.

Data were also collected in the approximate center of the relatively small and shallow central basin. Other supplementary data were collected midway between the south basin sampling location at Boundary Point and the net pen site (termed "half way" station), as well as just west of the net pen location in mid channel near the southern end of the lake (labeled "south-central basin"). Table 2 summarizes the types of data collected at primary and supplementary stations. Several instruments and analytical techniques were used to sample water quality (Table 2). 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 remote reading unit. The unit collected the

following data: water temperature, dissolved oxygen, pH, specific conductivity, redox, time of day and depth of the probe. Calibration of depth, dissolved oxygen, pH and

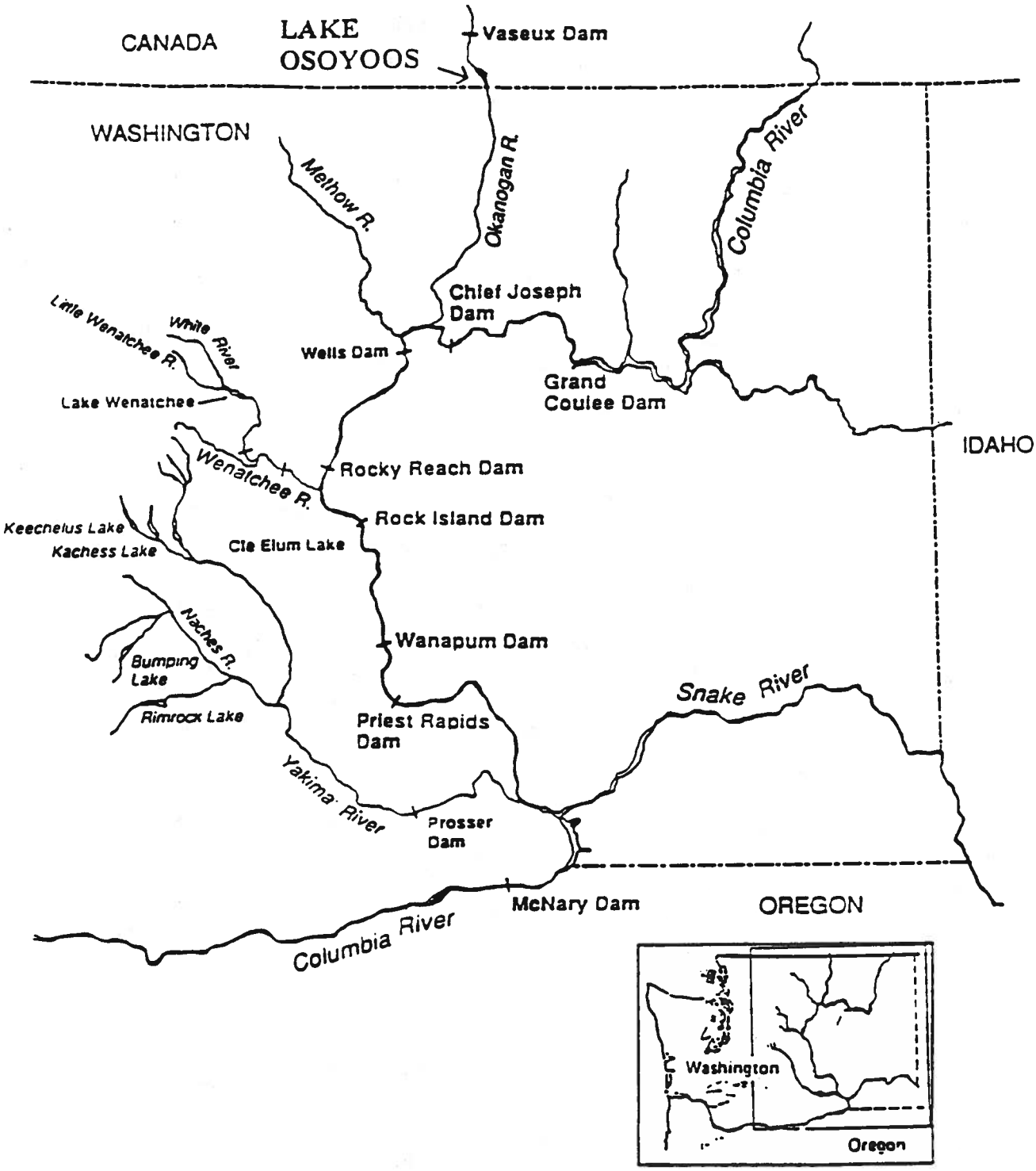


Figure 1. Vicinity map of portions of the Columbia Basin in Washington State, including the Okanogan River and Lake Osoyoos after Flagg et al. (1991).

specific conductivity were performed immediately before use, usually in the parking lot of the boat launch. Post-sampling re-calibration of the dissolved oxygen probe was also routinely practiced, which was sometimes useful in correcting a slight drift of the instrument's accuracy over the day. Shipboard power was used so that the Hydrolab unit was left on and hence was ready to operate sooner after being submerged. The Hydrolab probe was kept covered with a wet towel to keep the unit moist and cool.

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.

Sampling was conducted with the assistance of one or two Douglas County PUD staff members using a 21' Boston Whaler. A 2 liter PVC Scott water bottle and calibrated 50 m line was used to retrieve water samples and a depth finder was used to locate the boat over the deepest part of the lake at each sampling 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 composite mixture of water bottle casts and placed in acid-rinsed poly bottles. Samples for dissolved inorganic nutrient analysis were filtered immediately in the field using 25 mm A/E filters held in easy pressure holders. This procedure insured more accurate dissolved nutrient data, as leakage of nutrients from particulate forms is prevented. Nutrient and other sample bottles 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. 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 Osoyoos Lake. 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).

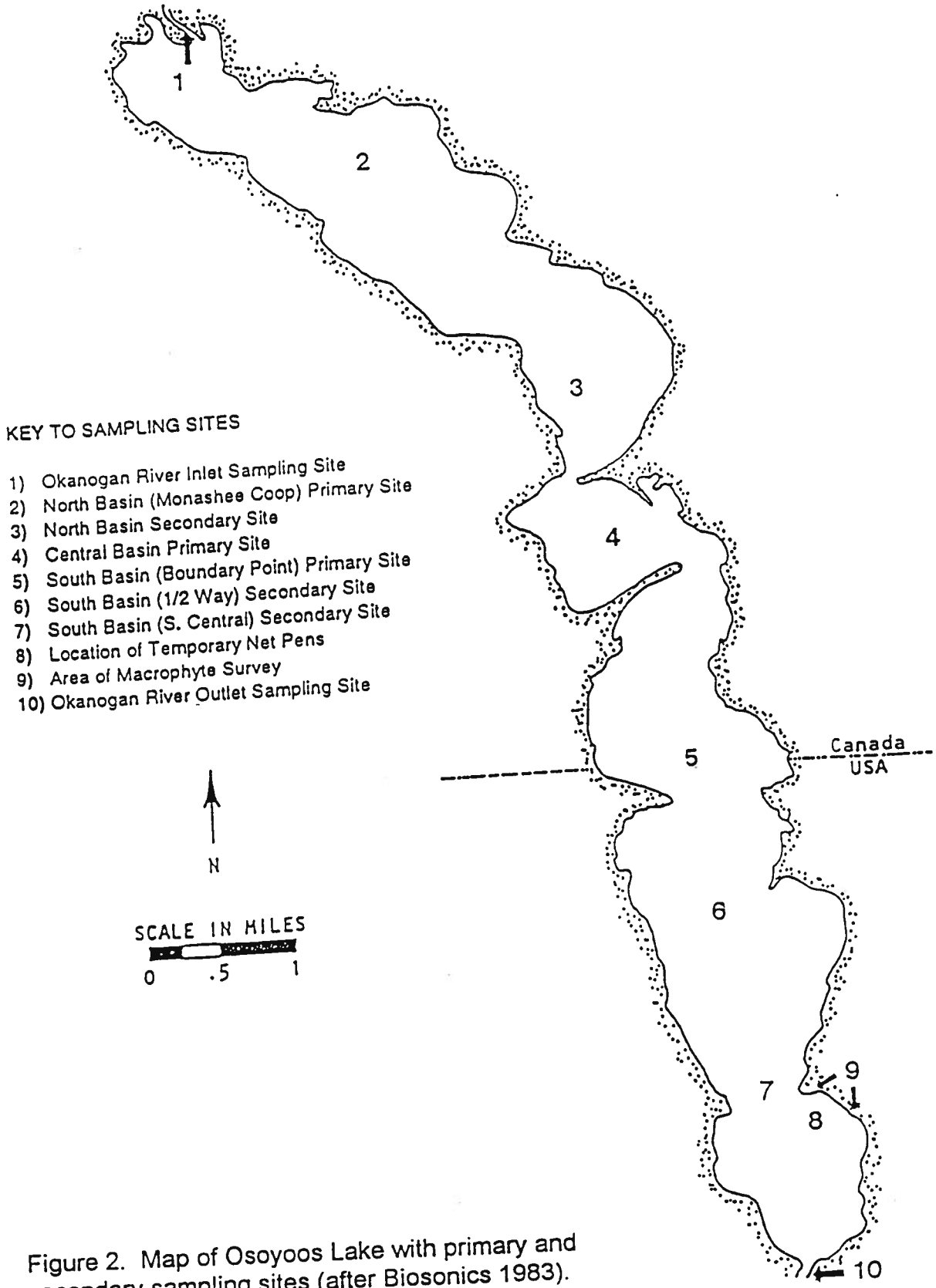


Figure 2. Map of Osoyoos Lake with primary and secondary sampling sites (after Biosonics 1983).

secondary sampling sites (after Biosonics 1983).

Table 2. Location, depths, and equipment for sampling in Osoyoos Lake in 1995-97.

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 air calibration with post deployment check	Hydrolab Multiprobe and air calibration with post deployment check	Hydrolab Multiprobe and air calibration with post deployment check
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 thermocline)	two composite samples: 1+3+ 6 m and 50 m triplicates (above/below the thermocline) & 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
Iron	Surface and Bottom in April, bottom only every other month thereafter	Surface and Bottom in April, bottom only every other month thereafter	No additional samples
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\1	net tow from 5m to surface using a 64 µm mesh net\1	No additional sample
Sediment Carbon Infauna Screening	Cores from 0.025 m^2 Van Veen grab samples at pens and reference sites Used 1 mm stainless screen to sample an entire grab sample for invertebrates.		

1/ Additional zooplankton samples collected in May and August 1997 as described in this report.

Zooplankton sampling and analysis were done with samples collected by making a vertical tow with a 64 µm plankton net from the 5 meter depth to surface, or in some cases 10 m to the surface. As the net was reserved for this project, and carefully cleaned after using each time no corrections were applied for reduced sampling efficiency over time. 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. Additional zooplankton samples were also analyzed also analyzed by Arni Litt, an experienced zooplankton specialist known for her work on Lake Washington near Seattle with Dr. W.T. Edmondson.

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. We used a 0.025 m^2 Van Veen grab sampler. Because of the very soft bottom at the site, large volumes of bottom sediment were easily obtained and cored through a small access door on the top of the sampler with a 2.5 cm diameter corer. Cores were removed, sectioned to remove the top 2 cm and the section immediately placed in zip-lock bags, placed in an ice-filled cooler and frozen later the same day. Core samples were homogenized and analyzed for total organic carbon using accepted protocols at a Dept. of Ecology certified laboratory. The grab sample locations were fairly close from year to year because professional surveyors located the pen site using accurate techniques. In 1997, grab samples were also taken with the same sampler for infauna analysis. A 1 mm stainless steel screen was used as a sieve in the field, and samples preserved in 10% formalin for later identification and enumeration.

Recording thermographs were placed at 2 m depth in Osoyoos Lake just west of Smith Point in an area with 30' total depth (about ¼ mile east of No. 7 in Fig. 2). Another thermograph was placed in the Okanogan River about 400 m south of the State Park in the western portion of the mid-channel, on the bottom. The units were manufactured by the Ryan Company; the model was the "Temp Mentor". The lake thermograph was checked in April (installation) and September (recovery) and found to be consistent with the highly accurate HYDROLAB H20 probe's thermister.

Statistical tests were performed using SYSTAT 4.0 and SYSTAT 7.0 computer programs, using a variety of tests including the student's T test. The T test is known to be robust in that it is relatively insensitive to heterogeneously distributed data sets. Both paired and one sample versions were utilized, but in all cases alpha (the chance of rejecting the null hypothesis when it actually should be accepted) was selected to be 0.05. The reader is reminded that statistical differences need not reflect actual biologically change or difference.

The monitoring objectives enabled a comparison of the south versus the north basin and surface versus bottom water. Total phosphorus (and total nitrogen as it is analyzed in the same procedure) was selected as a important parameter and therefore triplicate samples were collected at both major stations in the lake and a the surface and near bottom. Dissolved nutrients were normally single samples. In my experience, they are subject to less variation on a given sampling day because of *in situ* filtration. Moreover, they are less important in most trophic classification. Single nutrient samples were collected at river inflow and outflow. This was inadequate to fully characterize the river accurately, but river water quality description was a secondary goal of this study. Plankton samples were normally single grab for phytoplankton or from vertical tows with nets for zooplankton, although multiple samples were collected and analyzed in May and August 1997 to get some indication of the degree of within basin density variation.

3. RESULTS AND DISCUSSION

3.1 Weather and River Discharge

Weather during the spring and summer of 1997 was similar to the prior year, but cooler than 1994 and 1995. No data were available from the immediate locality of the lake but the nearest NOAA sampling locations in the Okanogan Valley demonstrate the differences (Fig. 3, see Rensel 1998 for details of station locations).

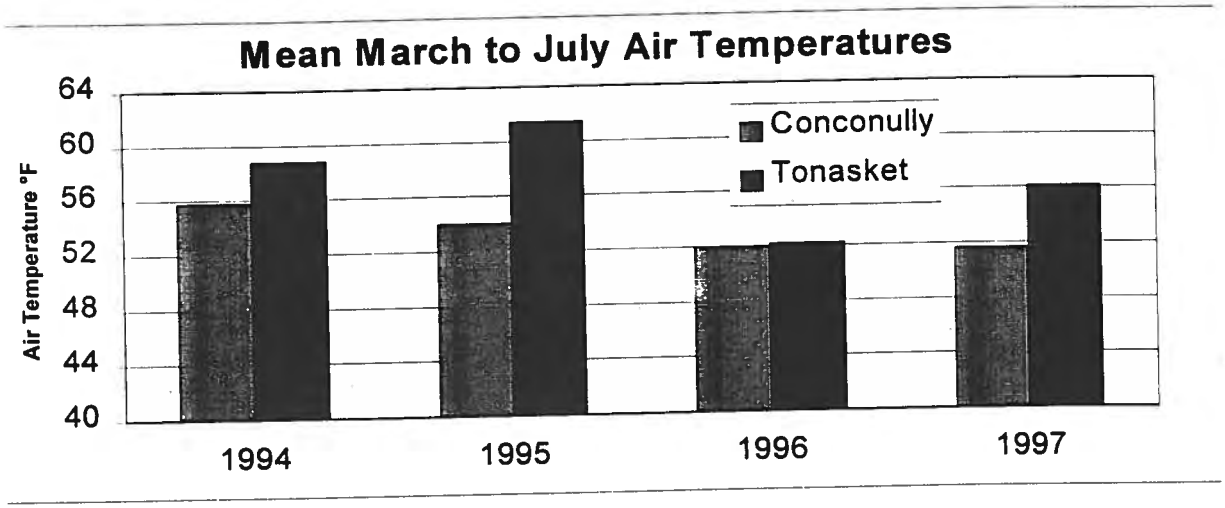


Figure 3. Mean March to July air temperature for nearby NOAA weather stations during the period of study. March to July was the only period with continuous recordings for both stations.

Snowpak and precipitation in the winter of 1996-1997 in the Okanogan basin and headwaters was probably much greater than normal. This resulted in extremely large

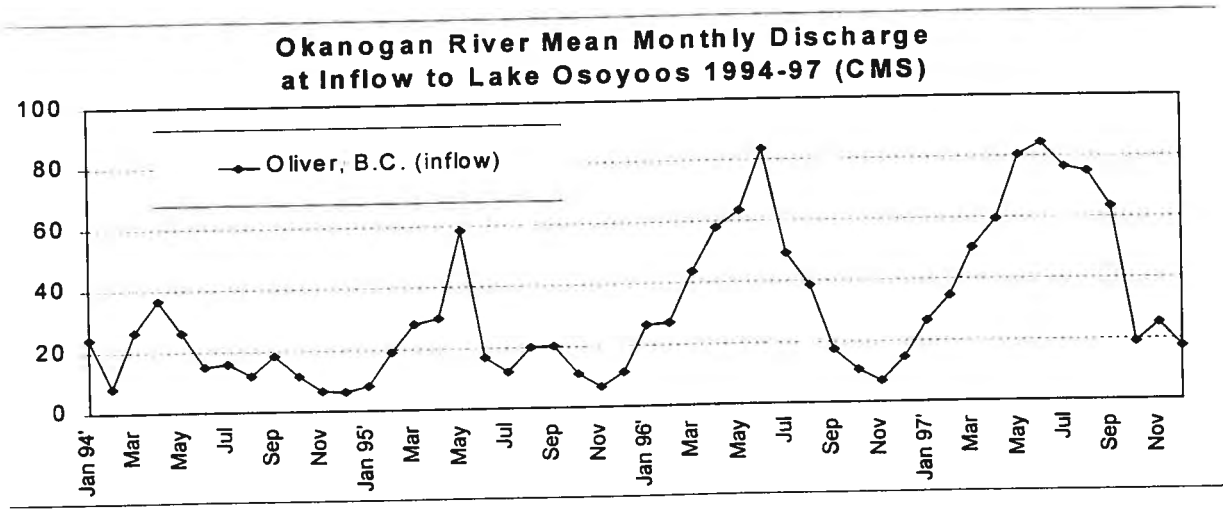


Figure 4. Okanogan River mean monthly discharge at Oliver, B.C. from January 1994 to December 1997.

annual discharge in the Okanogan River (Fig. 4). Mean annual discharge is shown in Figure 5, and it is readily apparent that total annual discharge in 1997 far surpassed any of the previous records, 51.0 cms versus the 1943-1996 average of 19.1 cms.

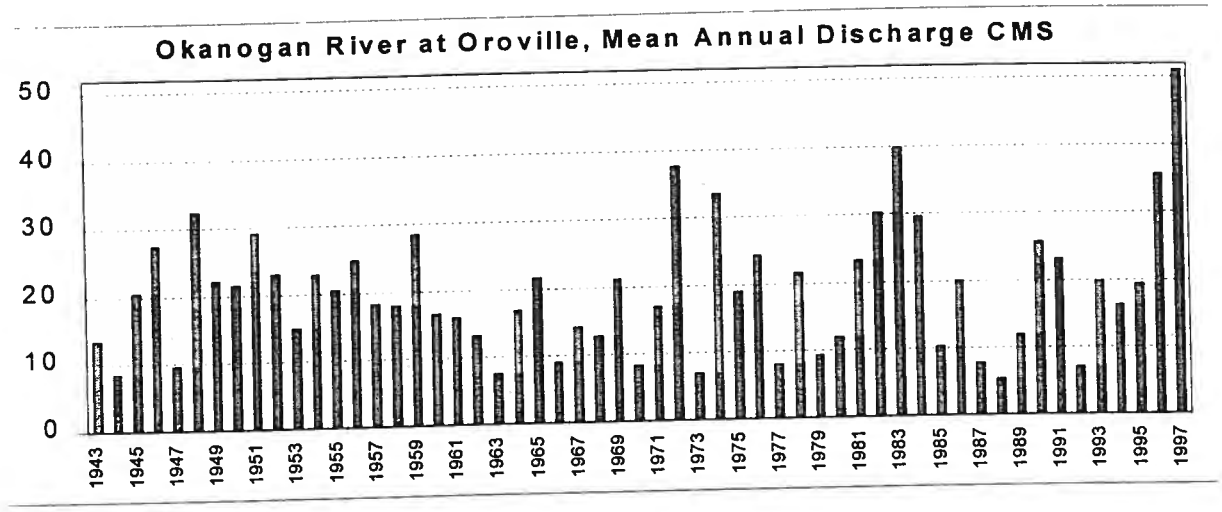


Figure 5. Mean annual discharge in cubic meters per second at Oroville for 1943-1996 versus flow at Oliver, B.C. in 1997 (data not available yet from Oroville 1997).

3.2 Water Quality Survey Results

Results of routine water quality sampling from 1997 are compared here among and within the three basins.

Tables 3 and 4 below provide a quick overview of some of the 1997 results in the north and south basins for surface and bottom waters. Appendices 1, 2 and 3 show nutrient data for north basin, south basin and Okanogan River. Appendix 11 has details of other routine water quality parameters collected with the Hydrolab multiprobe. Data collection was most difficult on the last sampling date in September 1997 as there was a major storm with high winds at the lake. Additional notes were made regarding wind wave patterns and heights throughout the lake.

Table 3. Summary of basic surface and deepest water quality for the **North Basin** near Monashee Coop during sampling in 1997. Z = depth, Spec. cond. = specific conductivity, Secchi = Secchi disk transparency, D.O.= dissolved oxygen, % Sat. = percent saturation.

DATE	TIME	WIND Dir.	WIND SPEED	WAVE HEIGHT	Z	WATER TEMP.	SPEC. COND.	PH	SEC-CHI	D.O.	D.O. % Sat.	IRON
			kts	ft.	m	°C	µS		m	mg/l		mg/l
---	---	---	---	---	---	---	---	---	---	---	---	---
23-Apr	1000	N	5	0.5	0.5	8.2	269	8.4	2.9	12.1	106.1	
					42	5.3	273	8.2		12.1	98.8	0.074
14-May	1210	NA	0	0	0.5	14.3	243	8.1	2.0	10.6	107.3	
					50	5.8	271	7.9		10.5	86.8	
18-Jun	1040	S	5	0.2	0.5	19.4	232	8.3	3.2	8.5	95.9	
					50	6.9	265	7.8		8.4	71.6	0.021
14-Jul	1015	NA	0	0.0	0.5	20.6	237	8.4	4.2	9.0	103.3	
					50	7.4	264	7.6		7.3	63.0	
13-Aug	0939	N	1	0.0	0.5	22.6	251	8.3	4.6	8.7	104.8	
					50	7.8	265	7.4		5.8	50.3	0.040
17-Sep	1005	S	10-20	0.2 - 0.5	0.5	19.0	261	8.3	4.5	8.3	89.8	
					50	13.0	277	8.0		0.5	4.7	

Table 4. Summary of basic surface and deepest water quality for **South Basin** (Boundary Point only) during sampling in 1997. See notes from Table 3.

DATE	TIME	WIND DIR.	WIND SPEED	WAVE HEIGHT	Z	WATER TEMP.	SPEC. COND.	pH	SEC-CHI	D.O.	D.O. % Sat.	IRON
			kts	ft.	m	°C	µS		m	mg/l		mg/l
---	---	---	---	---	---	---	---	---	---	---	---	---
23-Apr	1110	NA	0	0	2.0	9.0	278	8.5	3.6	12.4	107.2	
					22	7.1	281	8.4		12.1	103.5	0.024
14-May	1315	S	1 - 2	0	0.5	17.8	274	8.4	3.5	10.3	112.0	
					20	7.9	280	7.9		7.9	68.5	
18-Jun	1125	NA	0	0	0.5	20.2	235	8.3	4.0	8.7	99.8	
					22	10.2	275	7.7		4.2	38.4	0.021
14-Jul	1140	NA	0	0	0.5	23.1	243	8.5	3.8	8.8	106.2	
					22	10.9	285	7.4		0.4	3.3	
13-Aug	939	N	1	0	0.5	23.6	251	8.4	5.0	8.7	106.2	
					22	11.8	278	7.5		0.3	2.6	0.039
17-Sep	1100	S	10+	0.2 - 0.4	0.5	18.5	261	8.3	4.2	8.4	91.6	
					22	8.0	266	7.4		3.8	33.2	

3.2.1 Water Temperature: Monthly Records

Water temperature data collection continued in 1997 with both monthly vertical profiles collected with the multiprobe sampler and through the use of thermographs at fixed locations. This section discusses the monthly vertical profile results.

A plot of north basin water temperature profiles (Fig. 6) shows gradual formation of vertical water temperature stratification. Although maximum water temperatures were found in August, the sharpness of the thermocline was more pronounced in September. As in the prior year, however, only gradual changes and little discontinuity was seen in the central basin (Fig. 7). The south basin (Fig. 8) showed yet a different response with gradual change at all depths until September when a sharp thermocline was formed. As previously noted, the differences among basins are due to greater depth and volume of the north basin that allows vertical stratification to become more established. Vertical stratification is caused by surface heating that reduces density and resistance to wind mixing.

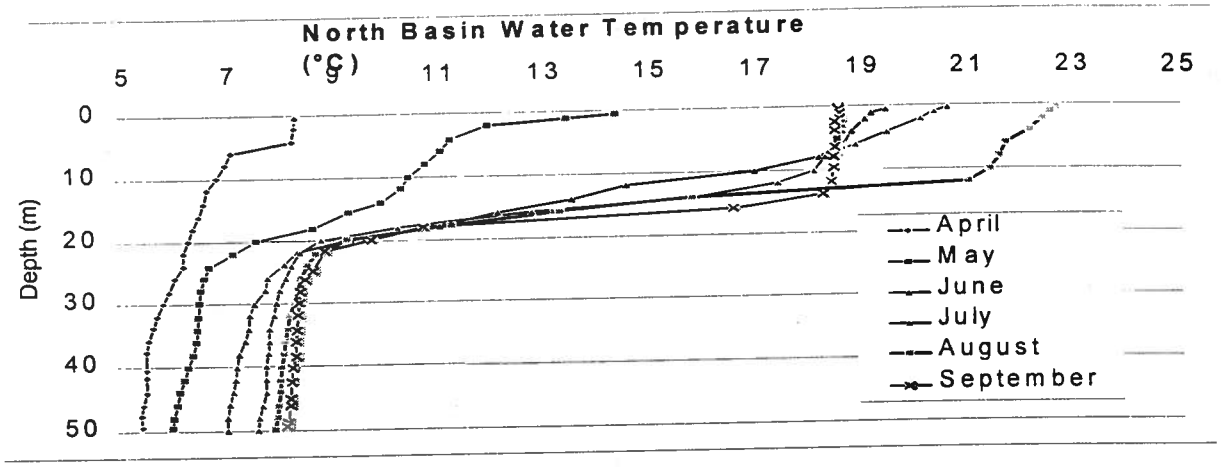


Figure 6. North basin Osoyoos Lake monthly water temperatures in 1997.

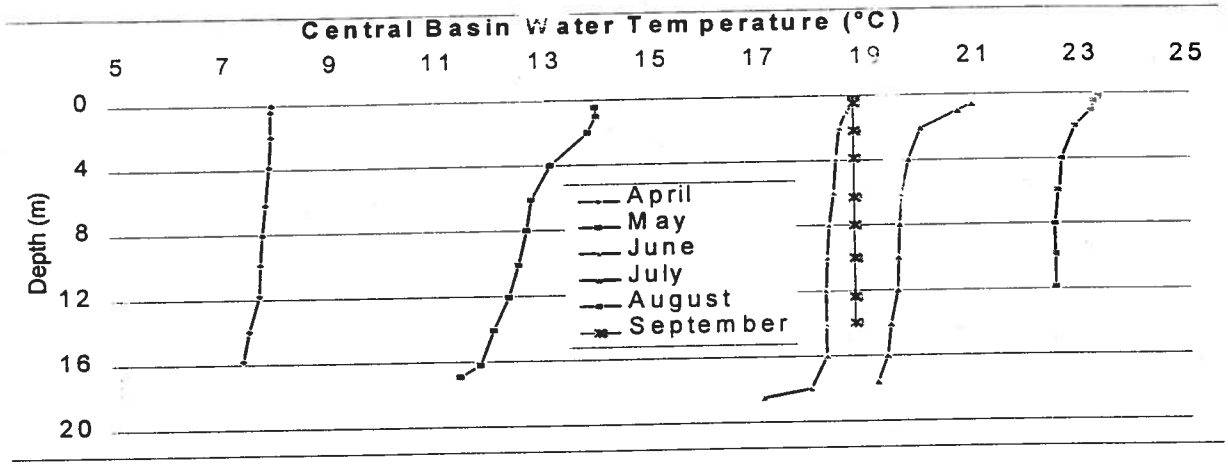


Figure 7. Central basin Osoyoos Lake monthly water temperatures in 1997.

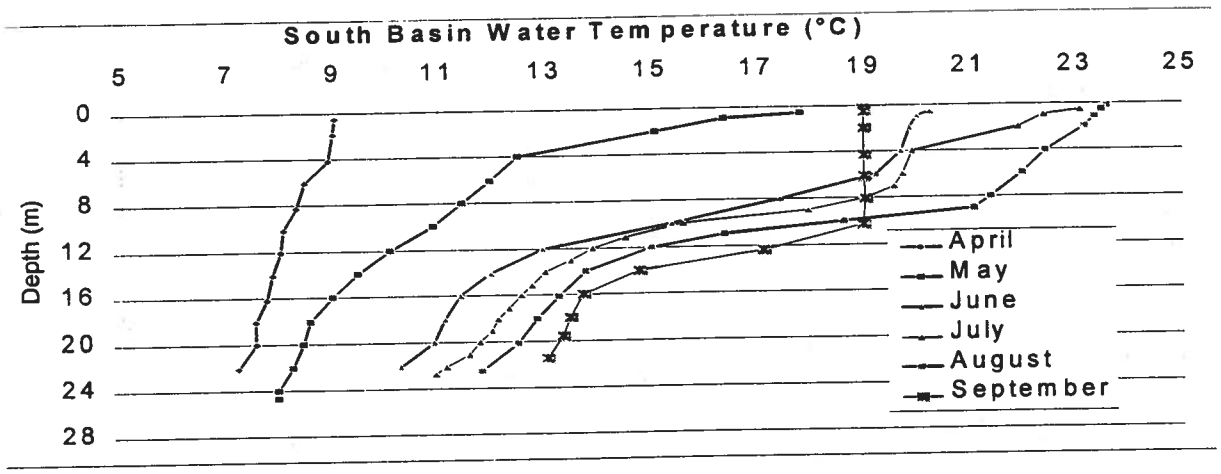


Figure 8. South basin Osoyoos Lake monthly water temperatures in 1997.

A comparison of peak water temperatures among the basins showed August had the warmest recorded surface water temperatures in 1997 (Fig. 9, 23.6°C in the south basin). As in past years, surface water temperatures increased stepwise along a transect from north to south in the lake. Although the lake flushes relatively fast, the retention time is certainly long enough to allow the accumulation of heat from solar radiation.

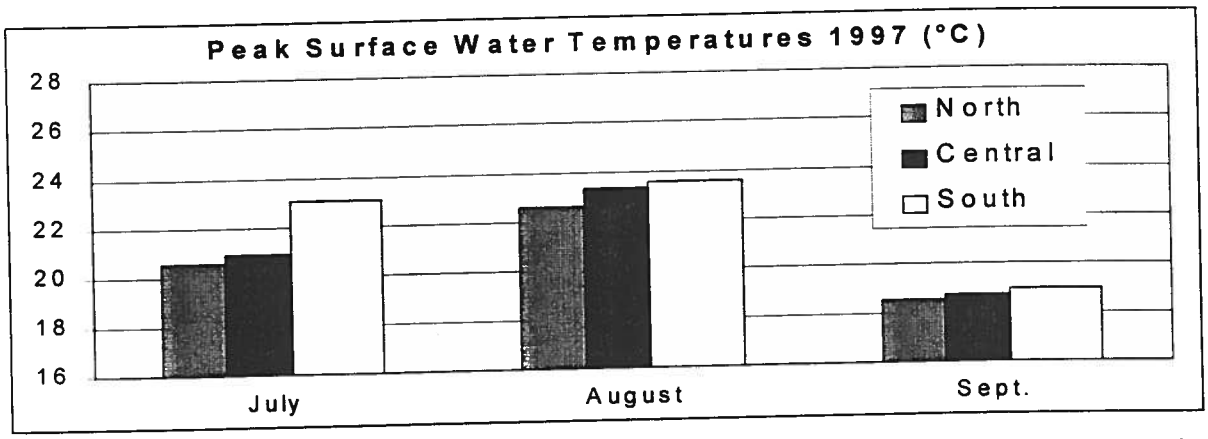


Figure 9. Comparison of peak water temperatures in all basins during monthly sampling in Osoyoos Lake during 1996 (above) versus 1997 (below).

In general, lake water temperatures in 1997 were much cooler in July, similar to slightly cooler in August, and nearly identical in September compared to the prior year. Water temperature data from thermographs is discussed next, and later in section 3.2.6 Dissolved Oxygen and Water Temperature.

3.2.2 Water Temperature: Thermographs

Rationale for use and placement of thermographs was discussed in prior reports. In 1997, a thermograph was installed in the same location as the prior year near Smith Point in the south basin (Fig. 2, to the east of location No. 7). The unit was initially positioned about 1.5 m below the surface, but was found at recovery at about 1 m below the surface after some lateral movement.

Another thermograph was placed on the bottom, offshore of a private dock about 400 m south of the state park in the Okanogan River, just downstream of the lake outlet. Additionally, surface and bottom thermographs were placed offshore of Boundary Point. The Boundary Point thermographs were not recovered. In part that was probably due to very rough weather during the September 1997 recovery attempt. It may also have been inadequately anchored and drifted out of the initial placement area. A secondary anchor system with a tag line leading to shallow water was utilized, but also was also not found. I suspect the unit was removed by boaters.

Thermograph results from 2m depth near Smith Point and the net pen site (Fig. 10) shows similar results in 1997 versus the prior year, although water temperatures were cooler in July 1997, as expected from the monthly sampling as previously discussed. By August in both years, however, there was an extended period of maximum water temperatures near 23°C. This period also coincides with the annual up river migration of adult sockeye at Zosel Dam and the outlet of Osoyoos Lake, depending on water temperatures. A five-hour maximum water temperature record of 26.0°C was recorded at 1705 hours on August 8th, 1997 in the lake.

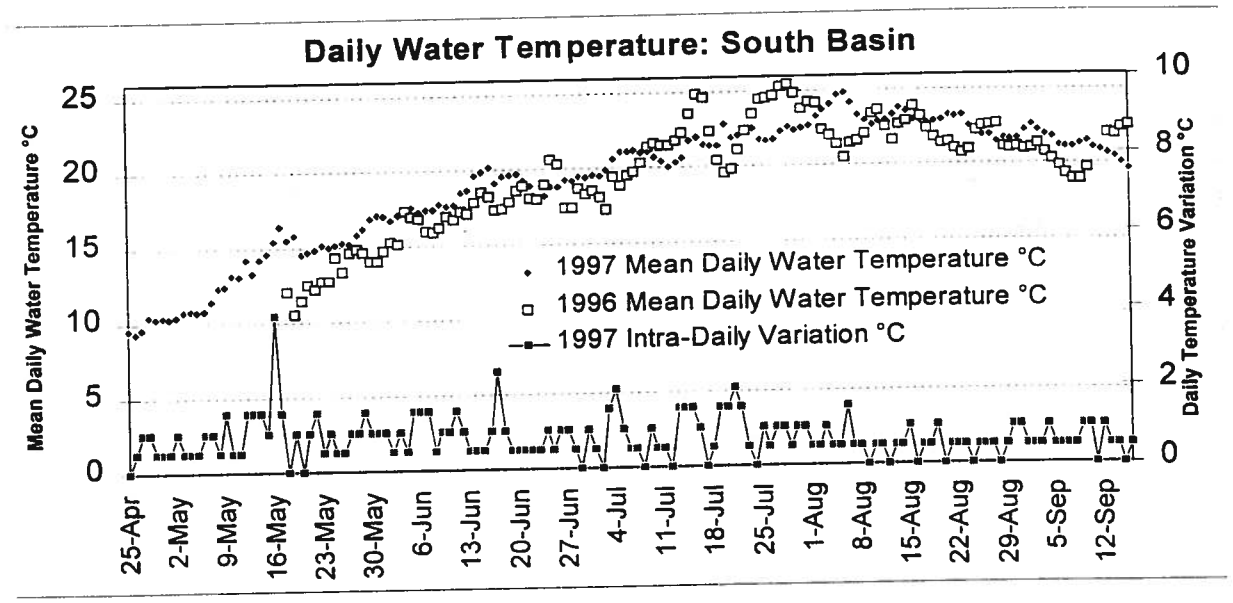


Figure 10. Mean Daily water temperature and range from 2m depth thermograph placed near Smith Point in the south Basin 1996 and 1997 with 1997 intra-daily variation.

Comparison of water temperature in the lake and downstream in the Okanogan River (Fig. 11) shows a close correlation ($r = 0.99$, SE of Estimate = 0.48, $p = 0.001$). There was, however, more intra-daily variation for the river thermograph for all but the final month (i.e., compare lower lines in Figs. 10 and 11).

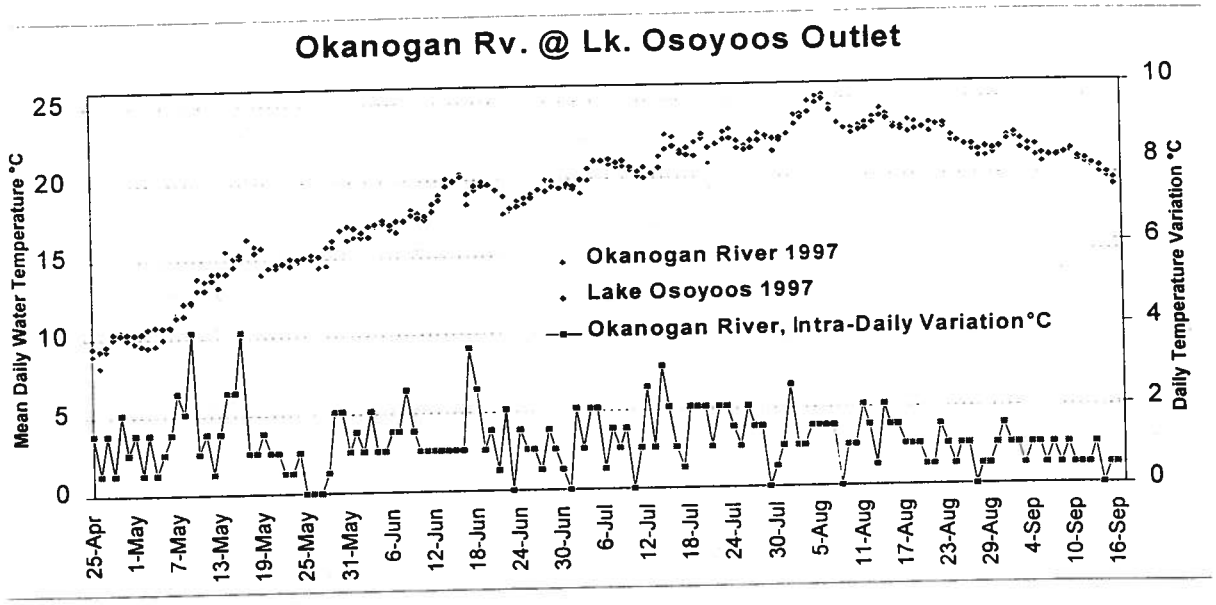


Figure 11. Mean Daily water temperature and range from Okanogan River thermograph in 1997 versus Smith Point, Osoyoos Lake thermograph.

These data suggest that placement of a thermograph on the river bottom just downstream of the lake outflow provides an excellent approximation of conditions in the surface water of the lake. Last year the comparison was between the Smith Point in-lake station and a river location near the Cherry Street bridge in Oroville. The correlation was good, but not as good as our results in 1997.

3.2.3 Conductivity

Tables 3 and 4 show that conductivity increased with depth in both basins, with the largest differentials in June and July. All values were above 230 µS, indicative of a moderate degree of total dissolved solids.

3.2.4 pH

pH ranged from 8.1 to 8.4 and 8.3 to 8.5 at the surface of the north and south basins, respectively (Tables 3 and 4). These values were little changed from the prior year. pH of the deepest samples ranged from 7.4 to 8.2 and 7.4 to 8.4 in the north and south basins, respectively. These are neutral to slightly basic conditions and similar to the prior years of this study.

3.2.5 Water Transparency

Mean Secchi disk transparency was slightly greater in the south basin in 1997 (April to Sept. mean = 4.0 m) versus the north basin (April to Sept. mean = 3.6 m, Tables 3 and 4, Fig. 12). Lower relative transparency in April through June in the north basin related to river flow, and as in the prior year was offset by clearer water in late summer. Transparency increased throughout the study period in the north basin, although not in a statistically significant manner except for the April compared to September. Variation of secchi disk in the south basin was much less throughout the study period, with a relatively clear-water period in June. Relationships between Secchi disk transparency and chlorophyll *a* in Osoyoos Lake were discussed in prior reports.

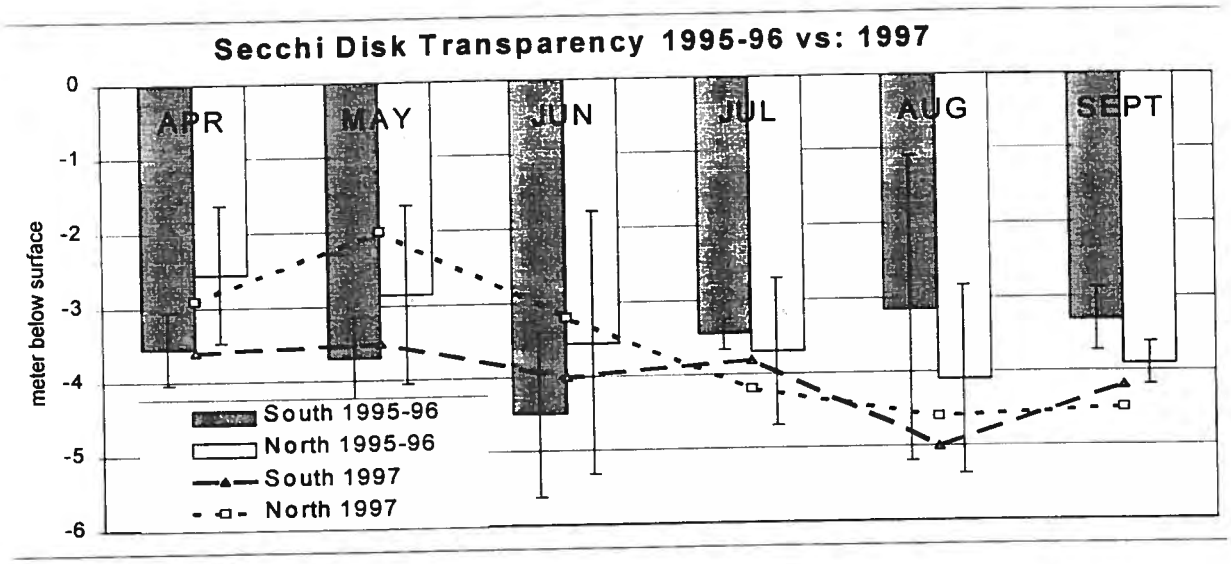


Figure 12. South and north basin water transparency 1997 versus the prior two years with 1 SD error bars.

3.2.6 Dissolved Oxygen and Water Temperature

Monthly vertical profiles of dissolved oxygen (DO) are shown in Figures 13 to 15. The north basin (Fig. 13) had little DO stratification in April through mid June, but increasing stratification from July to September. Compared to the prior year, there were similar periods of sufficient DO for salmonids (i.e., > 5 mg/l), and only in September did DO concentrations drop significantly at depth. As in the prior year, a curious DO "sag" was noted at 15 m in July and to a lesser extent in August.

The central basin (Fig. 14) had differing DO profiles, showing the effects of mixing throughout the water column and little stratification except in June. This was similar to 1996, although July and August were the periods of most stratification then. Only a

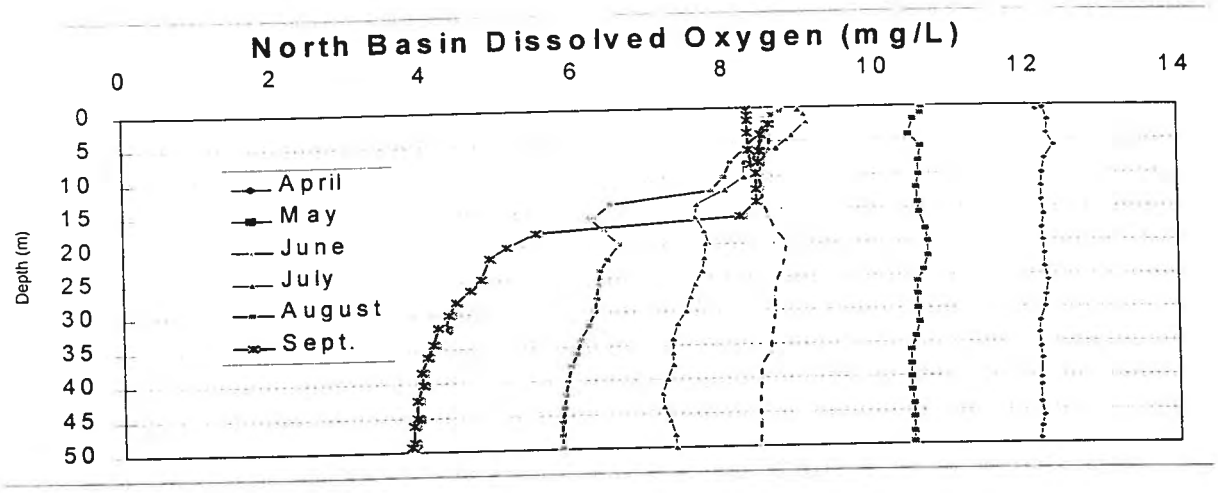


Figure 13. North basin monthly dissolved oxygen concentrations in 1997.

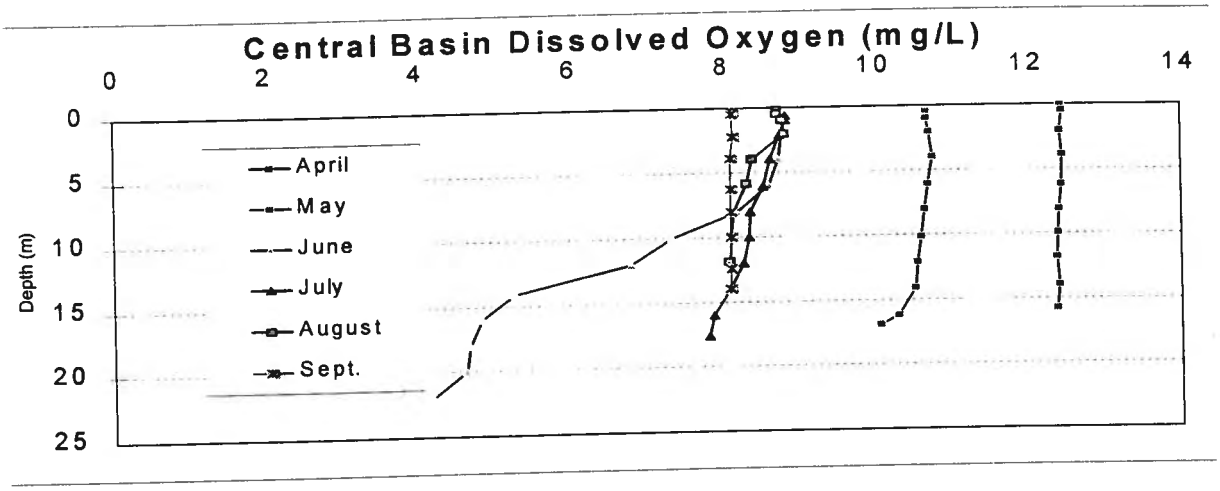


Figure 14. Central basin monthly dissolved oxygen concentrations in 1997.

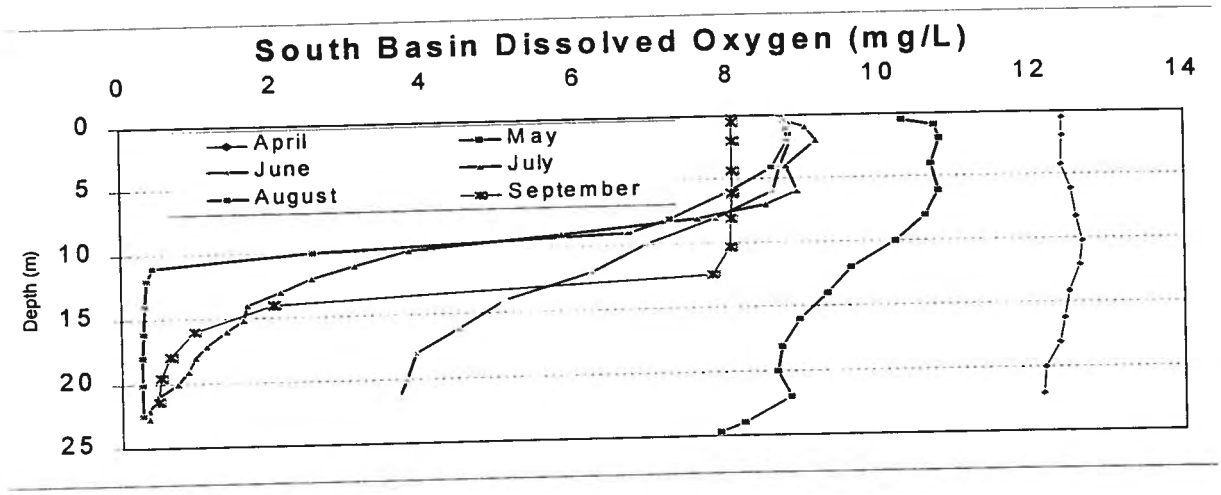


Figure 15. South basin monthly dissolved oxygen concentrations in 1997.

small portion of the deepest waters in June were insufficiently oxygenated for use by salmonids (i.e., < 5 mg/l).

The south basin had the greatest variety of vertical profiles of DO, with some degree of stratification in all months except April 1997 (Fig. 15). As early as June there were hypoxic conditions at depth with DO < 5 mg/l below about 14 m, similar to past years. Anoxia or near-anoxic conditions in deep waters occurred from July through September with the most extreme conditions in August. At that time depths below approximately 10 meters had insufficient DO to maintain salmonid growth and possibly survival. Near surface water temperatures in oxygenated zones of the south basin during August were about 19 to 23°C, which is marginally or greater than the preferred ranges for sockeye fry at all depths (i.e., >15 - 17 °C), and nearly reaching the upper lethal limit of 24.5°C.

While conditions were good for sockeye all summer long in the north basin (Fig. 16), given the DO and water temperature conditions, I tentatively conclude that sockeye fry could have survived in the south basin in 1997, but not with much depth range. The suitable range was in a very narrow band from about 9 meters deep during the worst periods (Figs. 17, green box indicates range). The mean daily water temperature data from the thermograph recordings also indicate that the early August period was the warmest. Fry could have survived in shallower, warmer water too, but would be subject to catabolic stress. They could also have survived in deeper water also, particularly if this stock moves to hypoxic depths during the day as has been found in some other sockeye populations (i.e., diel migration, Narver 1970).

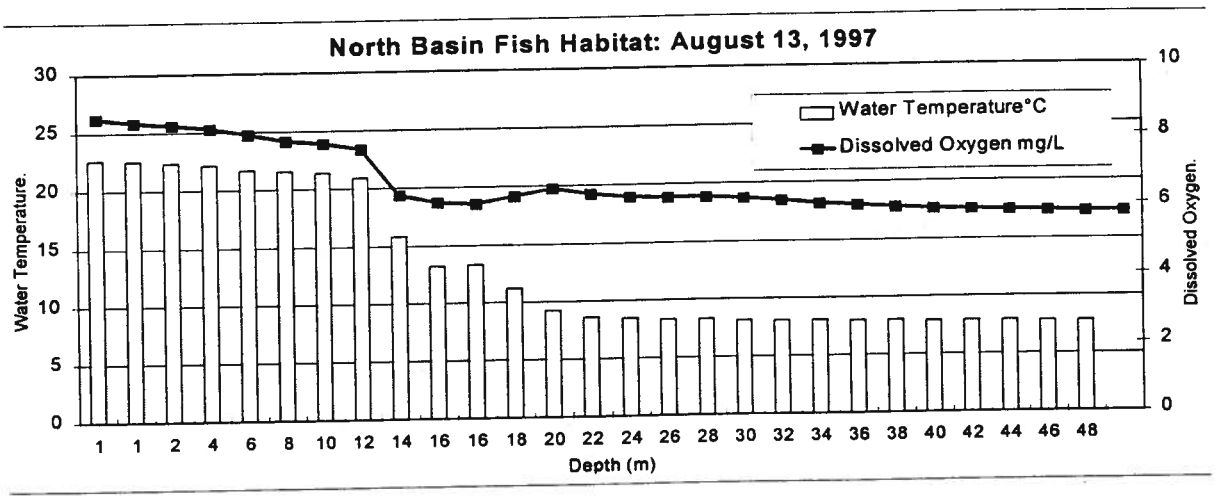


Figure 16. North basin dissolved oxygen and water temperature on August 13, 1997.

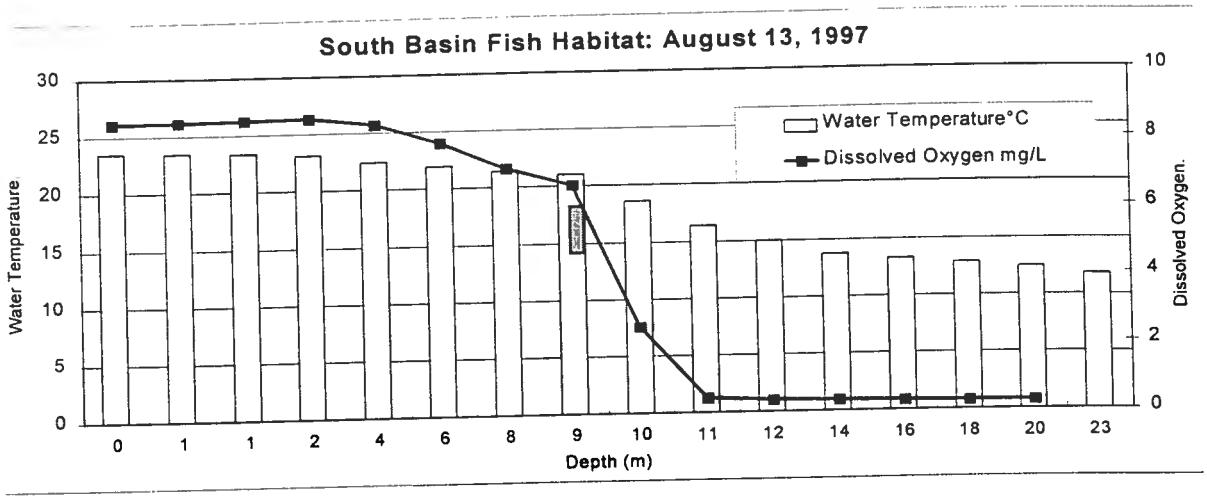


Figure 17. South basin dissolved oxygen and water temperature in August 13, 1997. Green box indicates suitable sockeye habitat of D.O. > 5 mg/L & water temperature < 17°C.

3.3 Nutrients

3.3.1 Total Phosphorus and Total Nitrogen

Total phosphorus ("total P") is a primary measure of the trophic (enrichment) status of a lake when considered over the summer months and for surface waters only (Welch 1992). The mean summer (June to Sept.) total P of surface water in Osoyoos Lake was 20.0 µg/L for the north basin and 17.0 µg/L for the south basin in 1997 (Figs. 18 & 19, appendices 1 and 2).

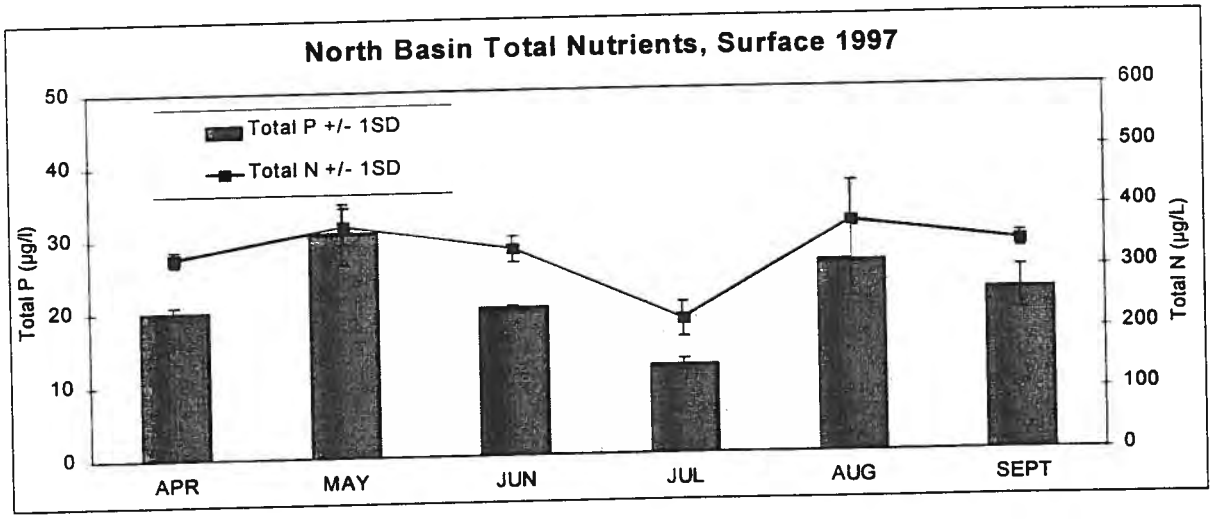


Figure 18. Monthly total nitrogen and total phosphorus for surface water in north basin of Osoyoos Lake in 1997 (Monashee Coop location).

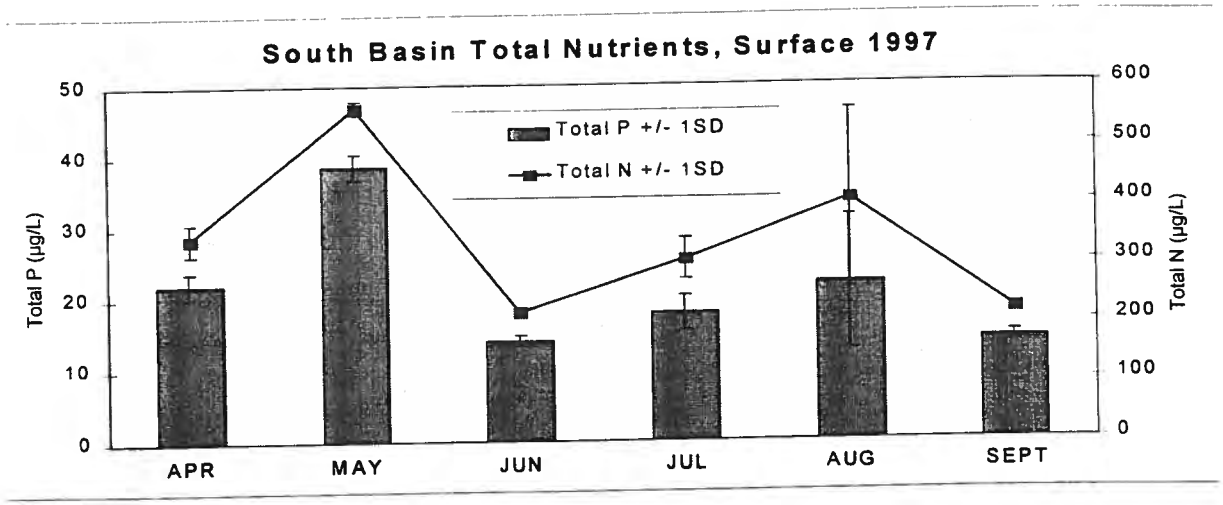


Figure 19. Monthly total nitrogen and total phosphorus for surface water in the south basin of Osoyoos Lake in 1997 (Boundary Point location).

In both basins peak values were seen in May followed by lowest measures in June or July. Total nitrogen concentrations mirrored total P results. Compared with prior years, concentrations of total P and total N did not decline in 1997. Reasons for high values of these metrics were discussed in the previous report and are also discussed later in this report in *3.7 Trophic State Determination*.

3.3.2 Dissolved Inorganic Nitrogen, Orthophosphate and Iron

Although dissolved N and P fractions are less useful for determining the trophic status of a lake, they are useful for determining which, if either dissolved nutrient was possibly limiting to algal growth when their concentrations are very low or undetectable.

With the exception of April, orthophosphate and dissolved inorganic nitrogen (DIN) concentrations were similar throughout the study period in the south basin (Fig. 20) versus the north basin (Fig. 21). Orthophosphate was non-detectable in July in the north basin and quite low in April, May and September as well. In the south basin orthophosphate as always detectable, but at only at low concentrations at all times. Compared to 1996, the results were nearly identical for orthophosphate (grand means: 1996 North = 3.3 µg/l-P, 1996 South = 2.4 µg/l-P, 1997 North = 2.2 µg/l-P, 1997 South = 22.3 µg/l-P). However, dissolved inorganic nitrogen concentrations were much greater in 1997 (grand means: 1996 North = 8.5 µg/l-N, 1996 South = 5.1 µg/l-N, 1997 North = 20.5 µg/l-N, 1997 South = 15.0 µg/l-N), possibly due to the greater volume of river discharge and the fact that nitrogen is generally more mobile than phosphorus in riparian soils and is less likely to be absorbed to particles.

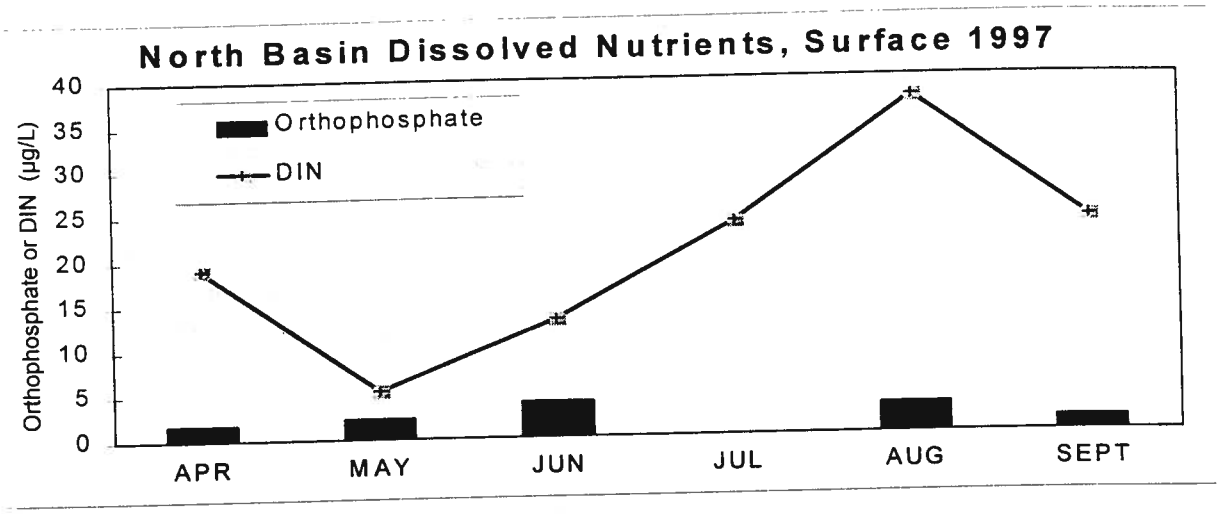


Figure 20. Monthly DIN (nitrate+nitrite+ ammonium/ammonia) versus orthophosphate for north basin in 1997.

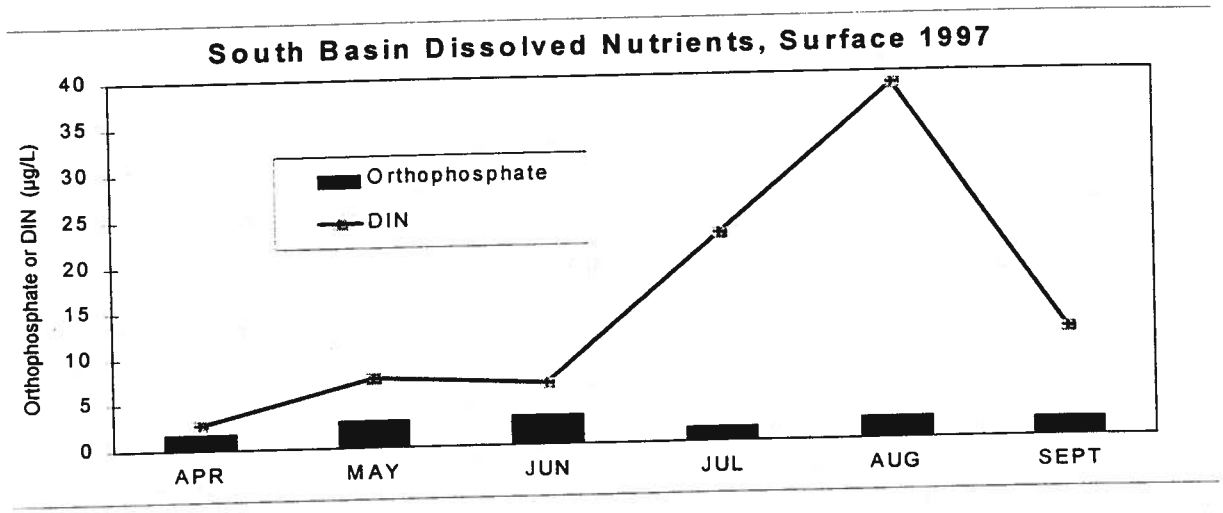


Figure 21. Monthly DIN (nitrate+nitrite+ ammonium/ammonia) versus orthophosphate for south basin in 1997.

The upshot of this large increase in dissolved inorganic nitrogen in 1997 was a major change from prior years in the inorganic N to P ratios in the lake. 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 concentrations of the potentially limiting nutrient are very low, a case for nutrient limitation of microalgal growth may be made pending confirmation by other, more sophisticated techniques (e.g., MacIsaac and Stocker 1995). Keeping the data from Figures 20 and 21 in mind, Figure 22 shows a blend of time periods when nitrogen or phosphorus was potentially limiting to the growth of microalgae in all both major basins of the lake. In July, for example, it was probable that phosphorus availability was low enough limiting the growth of phytoplankton in the north and perhaps south basins, given that orthophosphate was undetectable and the N:P ratio

was therefore high. For several other months the situation may have been similar for the north basin too.

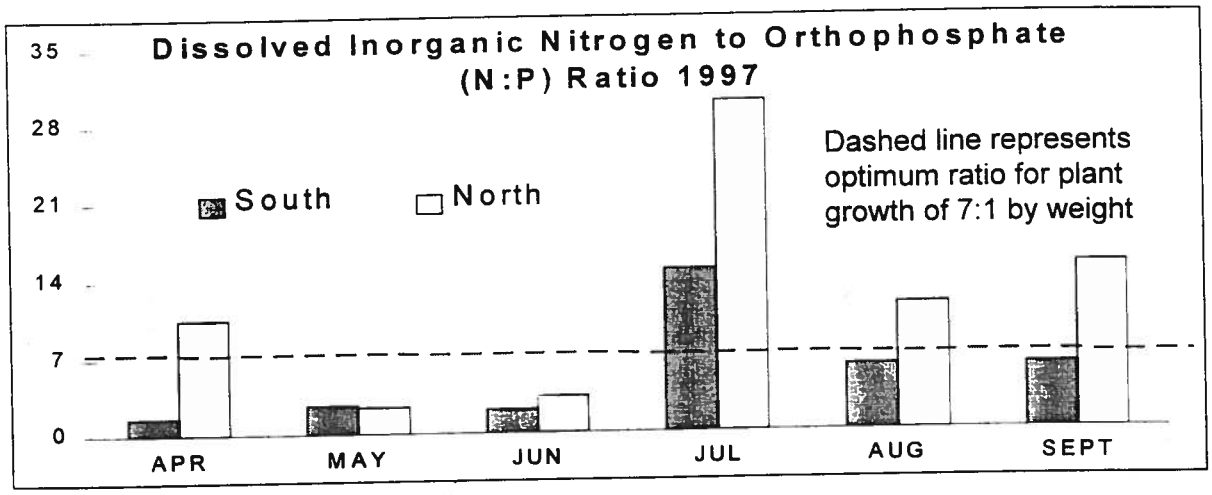


Figure 22. Monthly nitrogen to phosphorus ratios for near-surface waters of the north and south basins in 1997.

With regard to nitrogen limitation, it may have occurred in April in the south basin, but at other times, despite low N:P ratios, the nominal concentrations were probably too high to significantly limit the growth of phytoplankton. See prior reports and Rensel 1993 in particular for more background on this topic.

Dissolved orthophosphate and total P in near bottom waters of the north basin showed a seasonally increasing trend (Fig. 23), as in all previous sampled years. However, the south basin (Fig. 24), for the first time in this study did not show such a trend. Steady seasonal increases are particularly strong evidence of internal loading of phosphorus from the sediments that occurs during hypoxic and anoxic conditions (Welch 1992). I have argued in the past that in fast flushing lakes like Osoyoos (0.7 years mean replacement rate), however, the effects of internal loading may be limited as the strong thermal stratification in summer and fall limits the transport of these nutrients to the photic zone. It is reasonable to assume that much higher river discharge through the lake contributes to more rapid flushing of the hypolimnion during the summer months too, through entrainment , mixing and friction between the river influenced epilimnion and the deeper hypolimnion. Combined with lower primary and secondary productivity that would produce less organic "fallout" to the hypolimnion, this results in less internal loading in shallower basins with less volume such as the south basin. It also demonstrates the value of high rates of water exchange during the algal growing season in maintaining a lower overall trophic rating, as discussed later in this report.

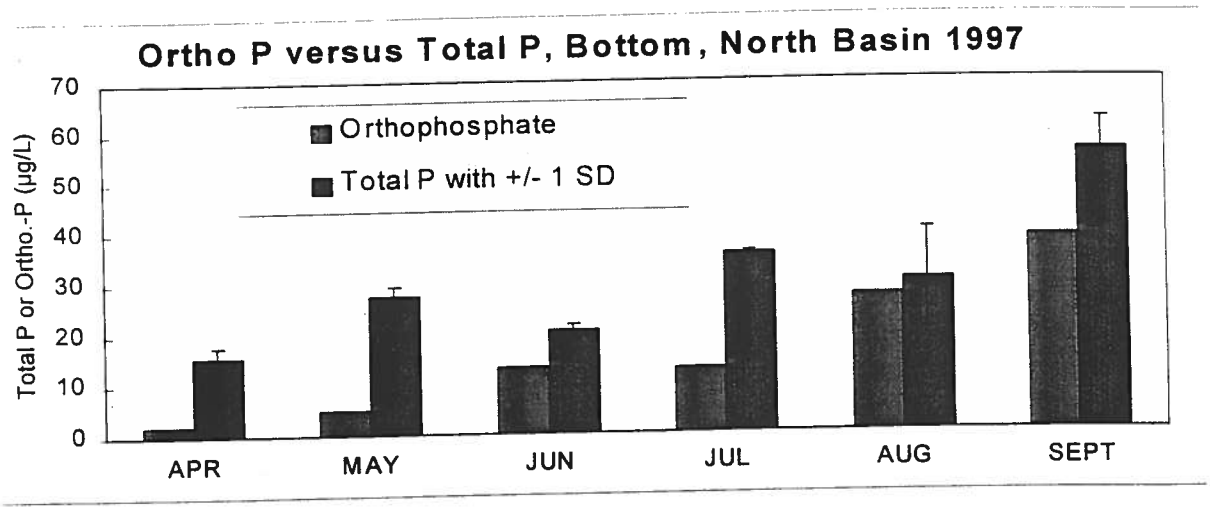


Figure 23. Monthly orthophosphate and total P from deepest samples collected in the north basin, Osoyoos Lake during 1997.

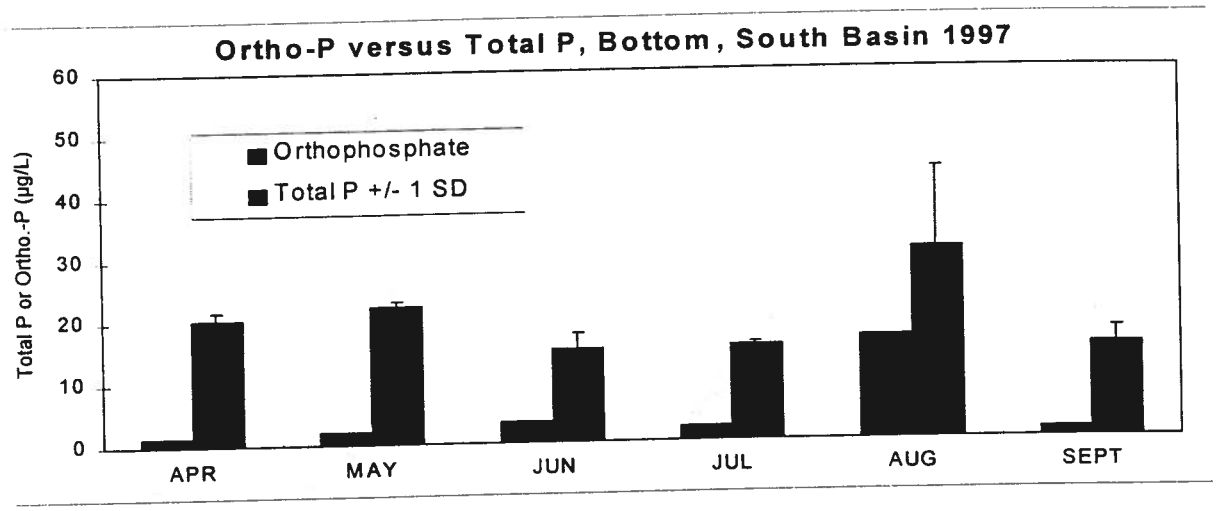


Figure 24. Monthly orthophosphate and total P from deepest samples collected in the south basin, Osoyoos Lake during 1997.

3.3.3 Okanogan River Inflow and Outflow

A plot of total N and total P inflow versus outflow (Figs. 25 and 26) show a net loss for total phosphorus, as was the case in 1996. Total nitrogen had a net gain, also similar to the results in 1996. As previously mentioned, phosphorus tends to be associated with solids that may be lost to sedimentation in quiescent lakes and reservoirs.

Comparing riverine inflow and outflow for dissolved nutrients (Fig. 26), similar patterns as seen in 1996 were noted again in 1997. DIN was much less in the outflow, and orthophosphate was similar or perhaps slightly less in the outflow. Some missing data from broken or missing bottles hampered this analysis.

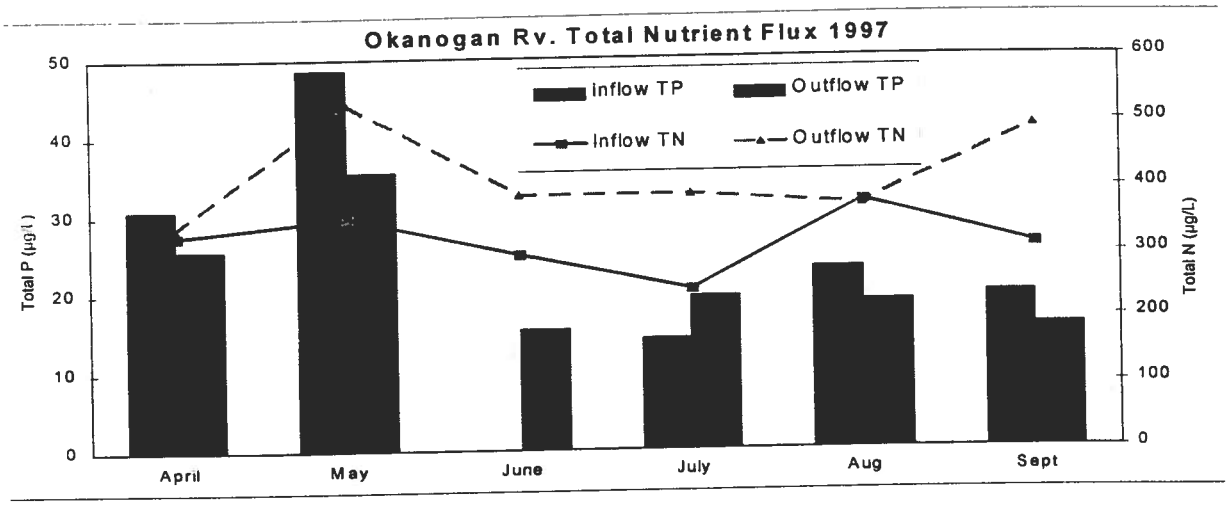


Figure 25. Total N and P flux of the Okanogan River entering and flowing out of Osoyoos Lake in 1997. June total N from interpolation.

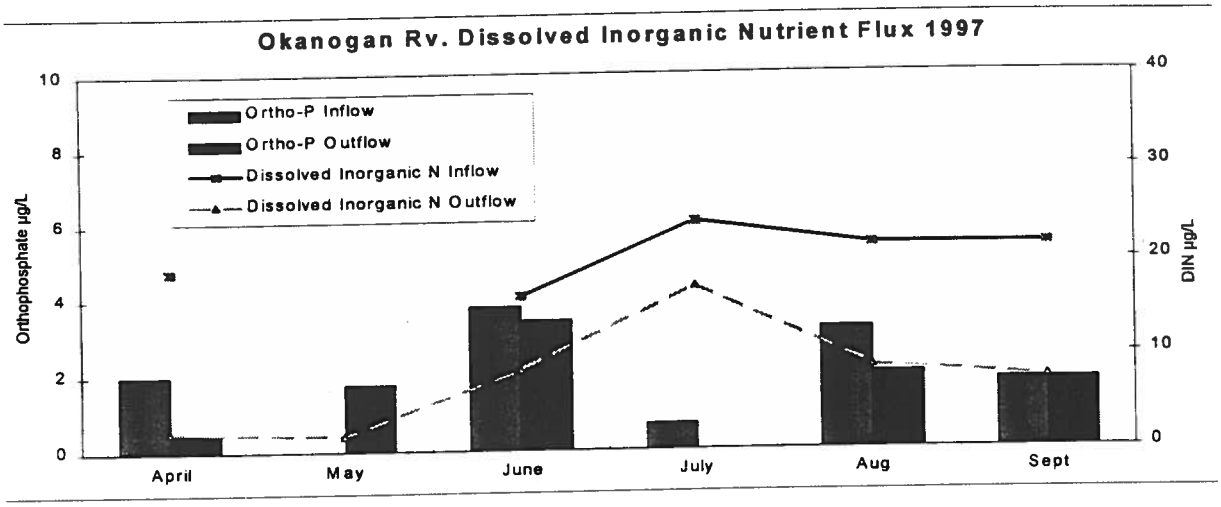


Figure 26. Orthophosphate and DIN flux of the Okanogan River entering and flowing out of Osoyoos Lake in 1997. July ortho-P at the outflow was undetected.

3.4 Chlorophyll *a*

Monthly chlorophyll *a* concentration were similar in the north and south basins (Fig. 27); for both the spring and summer and the summer only they averaged 3 µg/L in the north and about 4 µg/L in the south basin (Table 5). Compared to mean values from 1995 and 1996, there was no major peak in the spring due to diatom blooms in 1997, and overall concentrations were less in both basins. Compared to the high water flow year of 1996 alone, both years lacked a significant spring bloom, at least during the period of sampling beginning in April.

These data corroborate my previous conclusion that phytoplankton standing stock and possibly primary productivity is quite similar in both basins, and tend to challenge prior studies' conclusions that the south basin is more eutrophic than the north basin (Rensel 1998).

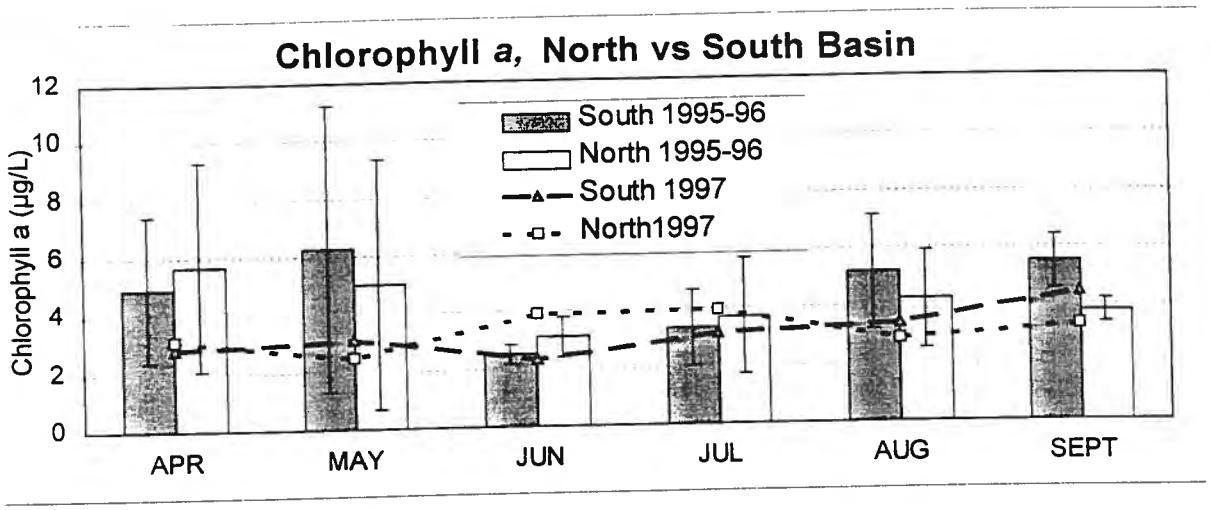


Figure 27. Monthly near surface water chlorophyll *a* pigment concentration in the south and north basins of Osoyoos Lake during 1997, compared with 1995-96.

Table 5. Chlorophyll *a* and phaeophytin concentrations in near-surface waters of Osoyoos Lake in 1997, averages for all months & June to September (summer) only.

	CHLOROPHYLL *a*		PHAEOPHYTIN		CHLOR. *a* - PHAEO.	
	µg/l		µg/l		Ratio	
Date	**North**	**South**	**North**	**South**	**North**	**South**
---	---	---	---	---	---	---
23-Apr	3.1	2.8	0.47	0.47	6.6	6.0
14-May	2.5	3.1	0.14	0.32	17.9	9.7
18-Jun	3.9	2.4	0.21	0.33	18.6	7.3
14-Jul	4	3.2	0.32	0.34	12.5	9.4
13-Aug	2.9	3.4	0.22	0.39	13.2	8.7
17-Sep	3.3	4.5	0.29	0.46	11.4	9.8
Average	**3.3**	**3.2**	0.3	0.4	13.3	8.5
Jun-Sept	**3.5**	**3.4**	0.3	0.4	13.9	8.8

The other parameter reported in Table 4, phaeophytin, reflects the amount of recently degraded chlorophyll *a*. The two may be combined in a ratio to yield an index of the general "health" of the phytoplankton population. Low ratios indicate less healthy cells.

The results show a peak in the north basin in May and June and higher overall levels than the south basin. Not much monthly variation was noted in the south basin. In the past higher values in the spring have been interpreted to indicate the high chlorophyll *a* content per unit cell matter of diatoms at that time, followed by a the mid summer minimum in productivity, and the late summer dominance or bloom of blue-green algae with relatively lower chlorophyll *a* content per unit cell matter. The lower overall values for the south basin may be due to the possibility of sustained nitrogen or phosphorus limitation, previously discussed.

3.5 Phytoplankton Species Dynamics

The species composition of phytoplankton are of particular interest because they are an important, base component of the food web. The presence or absence of various phytoplankton groups or species are useful tools to analyze the suitability of lakes for various types of fish populations and to qualify the trophic status.

In 1997, the percent phytoplankton density distributions were very similar to 1996, with blue green algae dominating the counts in both basins (Figs. 28 and 29). Diatoms were present in small, but relatively constant numbers during all months.

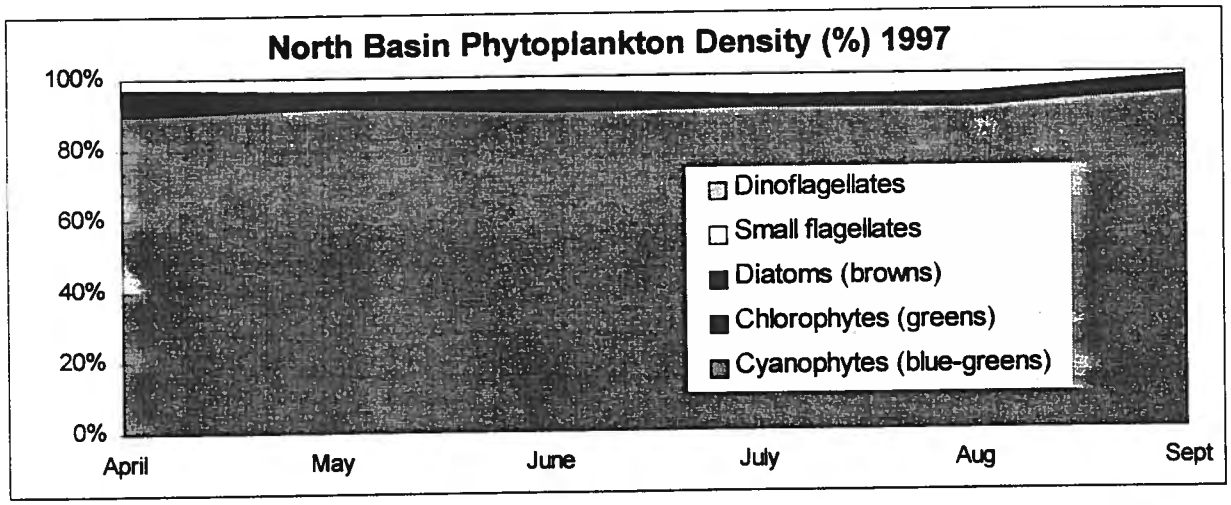


Figure 28. Percent density distribution of major taxa of phytoplankton in the north basin of Osoyoos Lake during 1997.

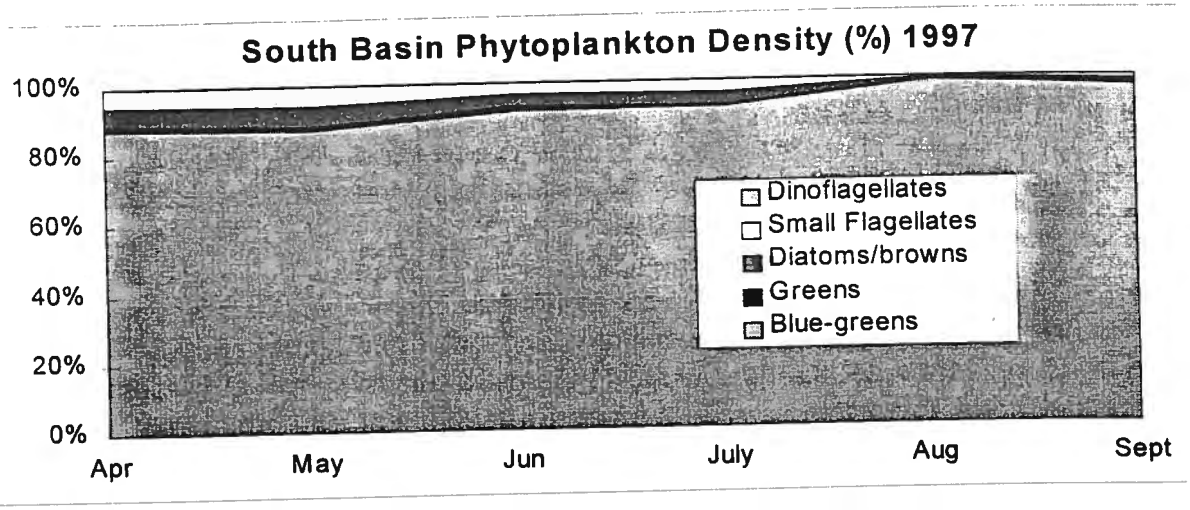


Figure 29. Percent density distribution of major taxa of phytoplankton in the south basin of Osoyoos Lake during 1997.

With regard to biovolume (Figs. 30 and 31), diatoms were dominant in late spring and early summer for both basins with a gradual shift to blue-green dominance by late summer. In the north basin, however, diatoms were more dominant later in the summer than in prior years. Other major taxonomic groups had similar distributions compared with prior years.

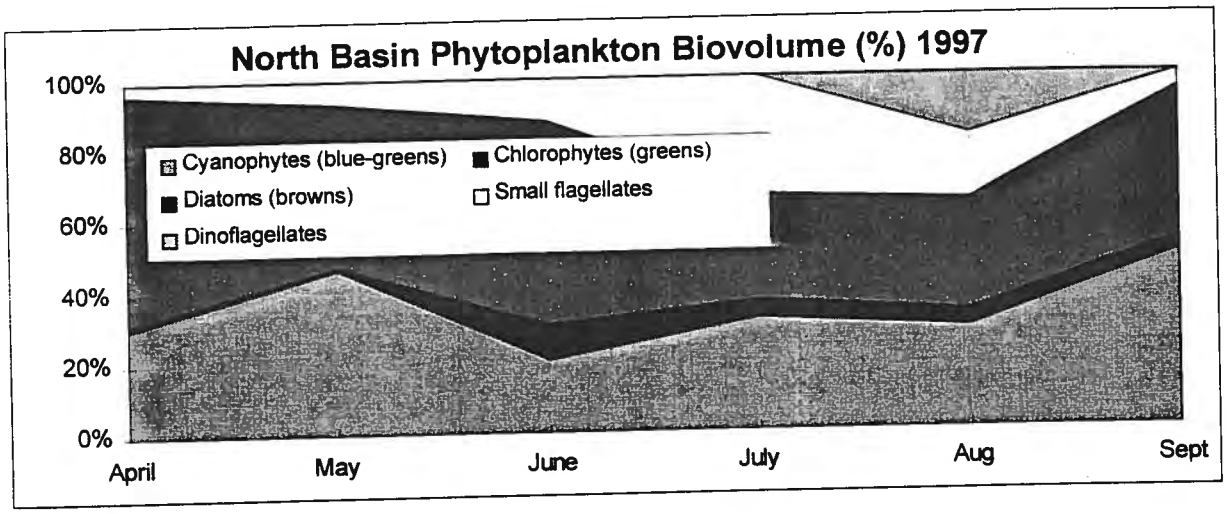


Figure 30. Percent biovolume distribution of major taxa of phytoplankton in the north basin of Osoyoos Lake during 1997.

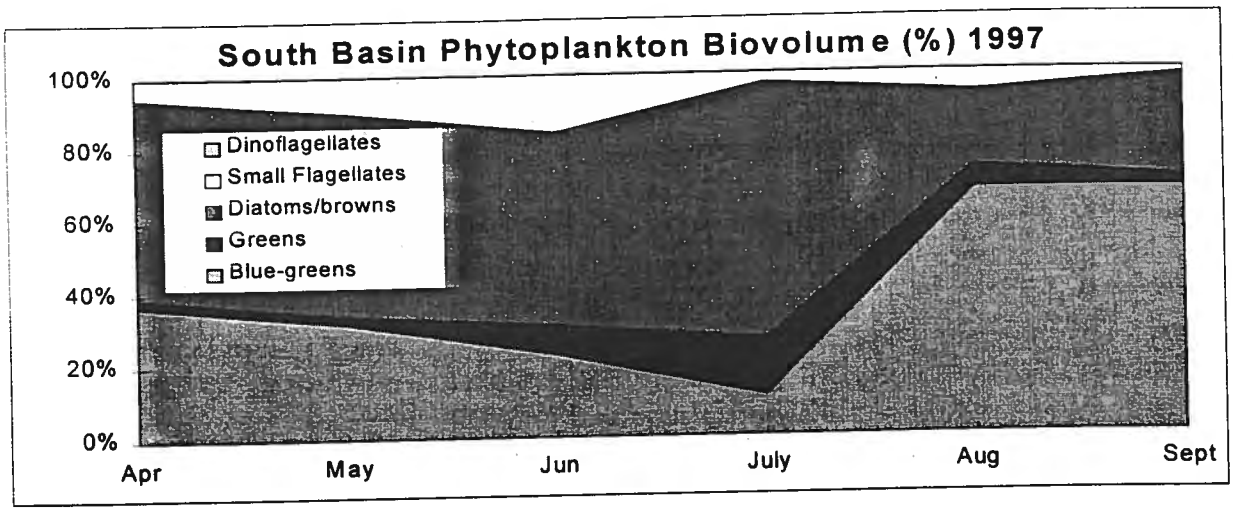


Figure 31. Percent biovolume distribution of major taxa of phytoplankton in the south basin of Osoyoos Lake during 1997.

Once again, the prevalence of a blue-green alga known as *Lyngbya* sp. was noted in the summer and early fall with large density and volumetric values (appendix 9). This species sometimes forms unsightly brown clumps over large surface areas that were noted in the warm and calm September of 1994. Such visually-apparent aggregation have not been noted since, probably due to the difference in weather and winds. The species was still present in the phytoplankton samples, but stronger winds and other weather factors apparently prevented the large surface accumulations.

Monthly phytoplankton biovolume (Fig. 32) was very similar to the prior year in scale and relative trends. The north basin once again had greater biovolume in April, with reduced estimates thereafter. The south basin was similar, but had a trend toward increasing biovolume by late summer, due to the prevalence of blue-green algae.

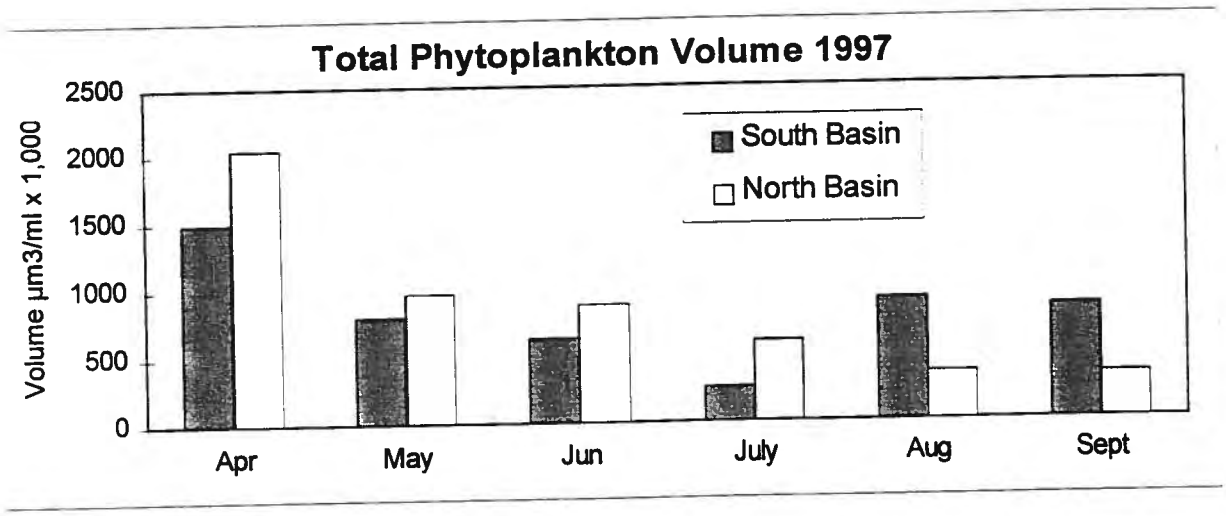


Figure 32. Comparison of total phytoplankton volume in south and north basins of Osoyoos Lake during 1997.

A comparison of diatom and green microalgal biovolume for the two basins is displayed in Figure 33. This figure may be viewed as comparing the density of microalgal forms generally more available as food for crustacean zooplankton.

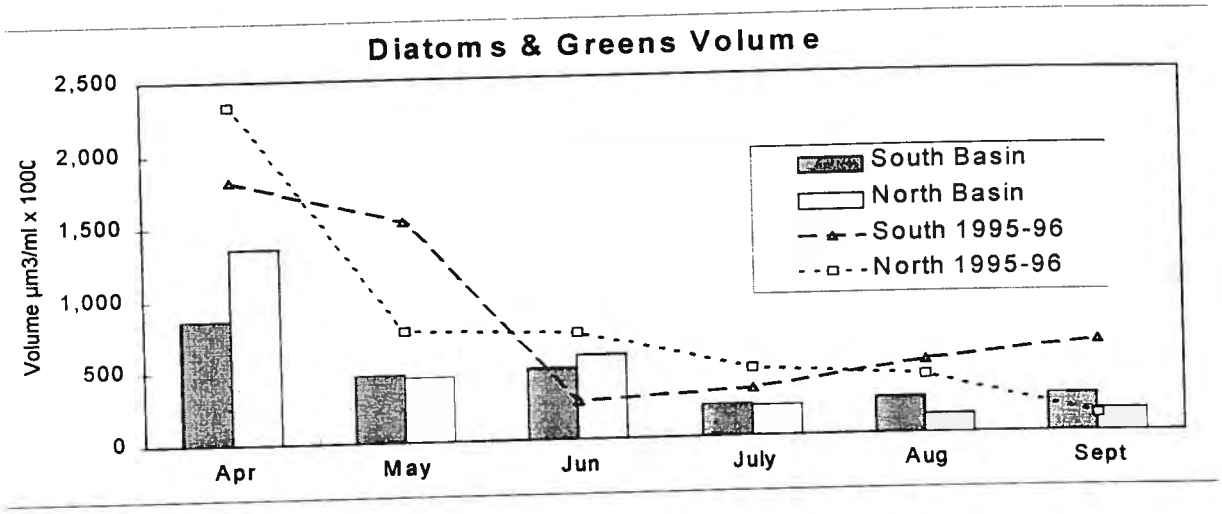


Figure 33. Biovolume of diatoms and green microalgae in near surface waters of north and south basins of Osoyoos Lake during 1997, compared with mean of prior two years.

Once again few differences between basins were noted, although biovolume in the north basin in April appeared to be greater than in the south basin. By pooling data from all study years for April, however, no statistically significant differences were noted for this month between basins (Mean N = 2,008 mean S = 1,506 both x 1,000, t = 3.09, p = 0.09, 2 df, 95% C.I. of difference = -196 to 1,200 x 1,000 μm^3 ml^{-1}). This is consistent with my prior conclusion from 1995 and 1996 that there were no differences of monthly phytoplankton standing stock measurements from the two major basins.

3.6 Zooplankton Species Dynamics

3.6.1 Routine Surveys

Zooplankton are plankton animals that are the primary consumers of phytoplankton. Background material for this topic relative to Osoyoos Lake was previously discussed in Rensel (1993, 1995, 1996, 1998).

The major categories of zooplankton discussed here include generally desirable crustaceans such as the calanoid and cyclopoid copepods, and the cladocerans such as *Daphnia* sp. Not all of these are desirable as sockeye prey, generally just the larger ones (greater than 1 to 1.5 mm). Rotifers are less desirable non-crustaceans and when abundant are 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.

Zooplankton data from Osoyoos Lake in this report are considered by density (numbers of individuals per volume) or biomass (a term used interchangeably with biovolume). 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 volume of sampled lake water.

Percent zooplankton density plots (Figs. 34 and 35) show rotifers dominating in the spring in both basins, as in prior years. After that, however, the basins diverge in pattern with much lower percent rotifers in the north basin, until September.

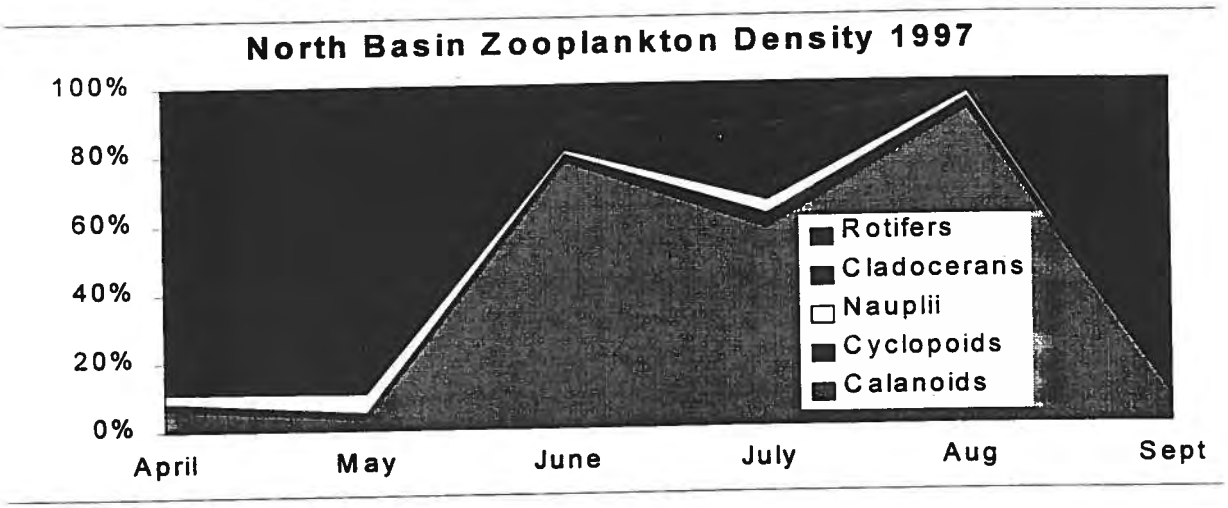


Figure 34. North basin Osoyoos Lake zooplankton density by percent in 1997.

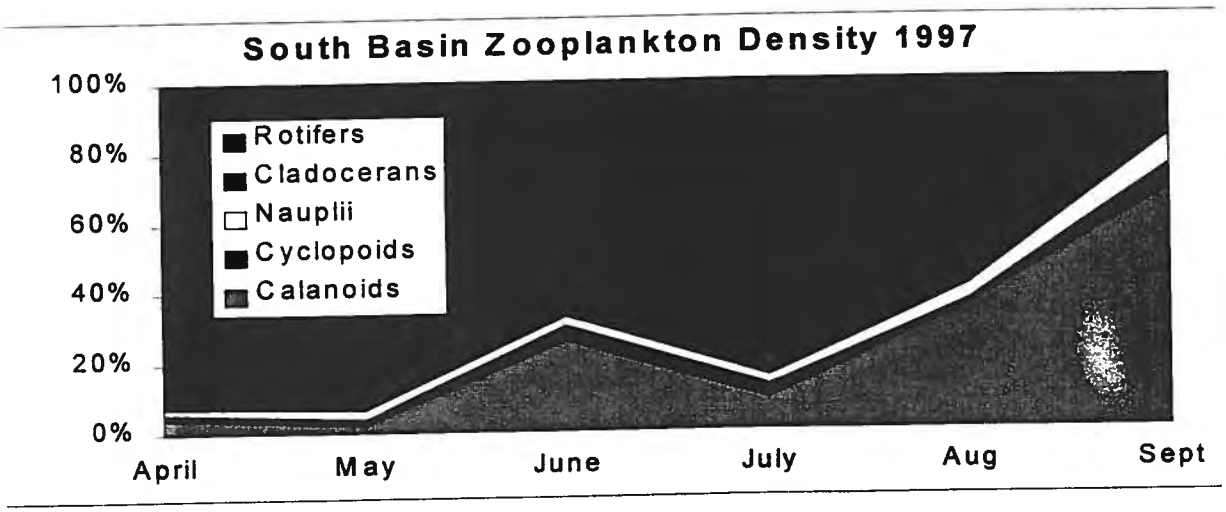


Figure 35. South basin Osoyoos Lake zooplankton density by percent in 1997.

Next I compare crustacean zooplankton density within each basin (Figs. 36 and 37) and with the mean of the two prior years. In the north basin (Fig. 36), there was generally lower density of these organisms, and no repeat of the large numbers seen in June of 1995. April density was significantly greater than in the prior two years.

For the south basin (Fig. 37), generally lower density results were noted in 1997. In particular, June and July results were much less than the prior two years. Reviewing the phytoplankton results, there were no significant differences in diatom and green algae biomass (Fig. 32), that could account for lower crustacean density. The alternative explanations could include washout due to high rates of lake flushing and predation by phytophagous fish, although brood year 1995 for the sockeye had relatively low escapement (see Rensel 1998).

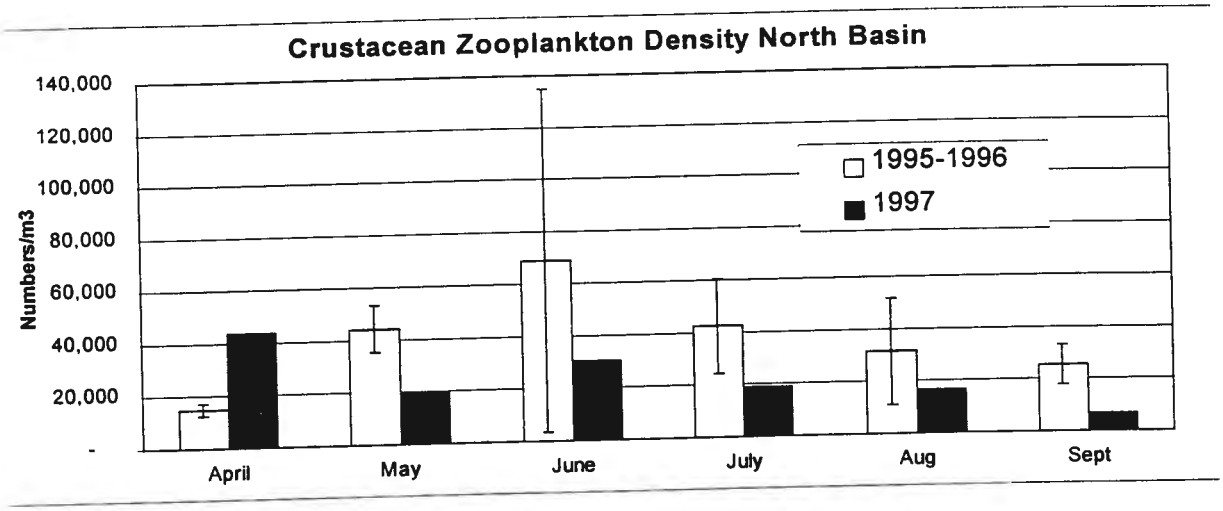


Figure 36. Crustacean zooplankton density, north basin of Osoyoos Lake in 1997.

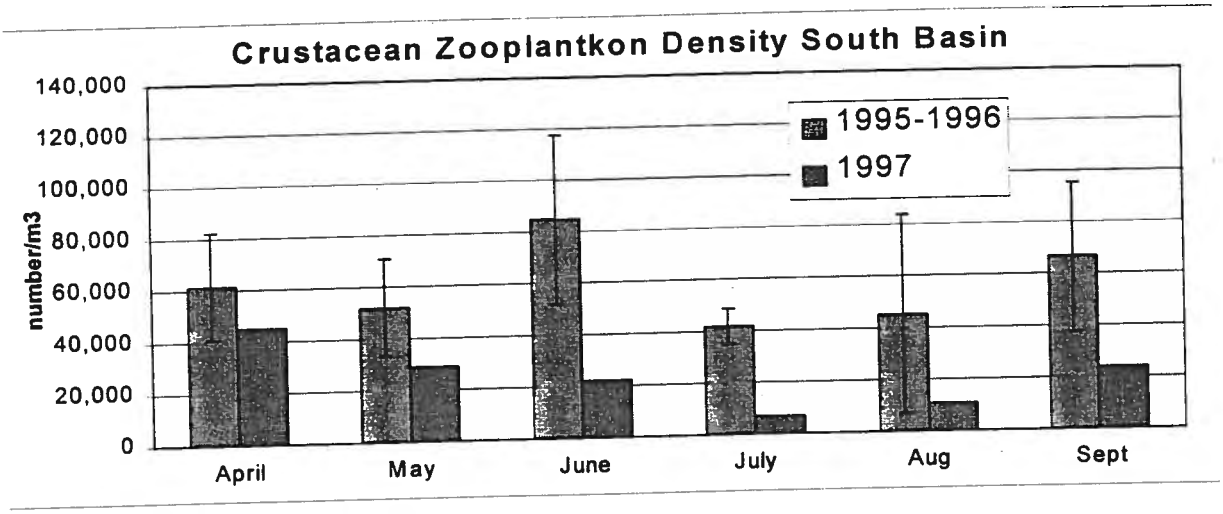


Figure 37. Crustacean zooplankton density, south basin of Osoyoos Lake in 1997. (Includes only Boundary Point data for south basin, for additional analysis, see below).

The north and south basins averaged 22.7 and 23.0 crustacean zooplankton per liter, respectively, during the study period in 1997. For comparison in 1996, the north and south basins averaged 28.8 and 57.2 crustacean zooplankton per liter, respectively. These data confirm that the abundance of crustacean zooplankton in Osoyoos Lake is among the greatest of all sockeye lakes in the world, as discussed in my prior report. The average data, however, may be misleading in terms of shorter time intervals that may present bottlenecks for juvenile sockeye, as discussed below. Moreover, mean size of the available crustacean zooplankton in the north basin in April 1997 was much smaller than the normal, large-bodied prey of sockeye fry, as noted in the raw data (see density data of Appendix 10, mostly small copepodids, and nauplii of 0.7 mm that also is evident from the low biomass results).

In the a recent report (Rensel 1998), I presented two years of data showing that that there may be a shortage of appropriate prey for juvenile sockeye during April in the north basin. As no data were collected in earlier months, I could not speculate on what occurs at that time. The shortage is of large-bodied crustacean zooplankton especially cladocerans such as *Daphnia* sp.

In 1997, the same trends noted in prior report continued for cladoceran density (Fig. 38). There were no significant differences of cladoceran density between the north and south basin again in 1997 ($t = 1.64$, $p = 0.161$). The same general trend of very low density in April, followed by a minor increase in May and a major peak in June was noted again (Fig. 38). On average, mean monthly density of cladocerans was lower in 1997 than in the prior two years. Biovolume (Fig. 39) also showed the same patterns with nearly an order of magnitude less for the north basin versus the south basin in April. These data indicate that there may be significant competition for prey in the north basin in April that could be detrimental to the survival of both young of the year fish and yearling fish about to out-migrate.

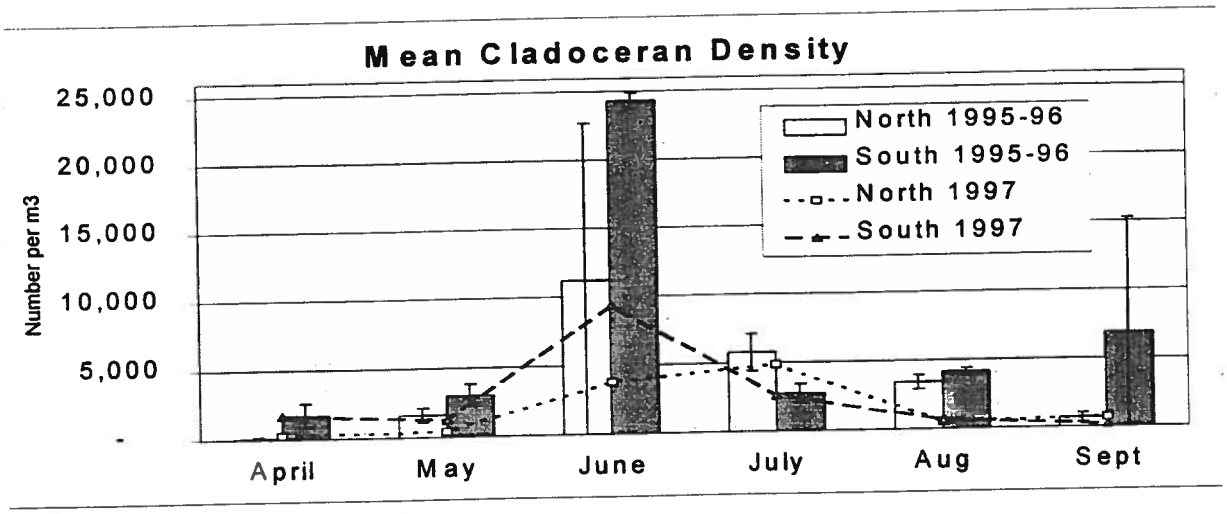


Figure 38. Mean monthly cladoceran density for north and south basin of Osoyoos Lake in 1997 versus 1995-96 means with 1 SD bars.

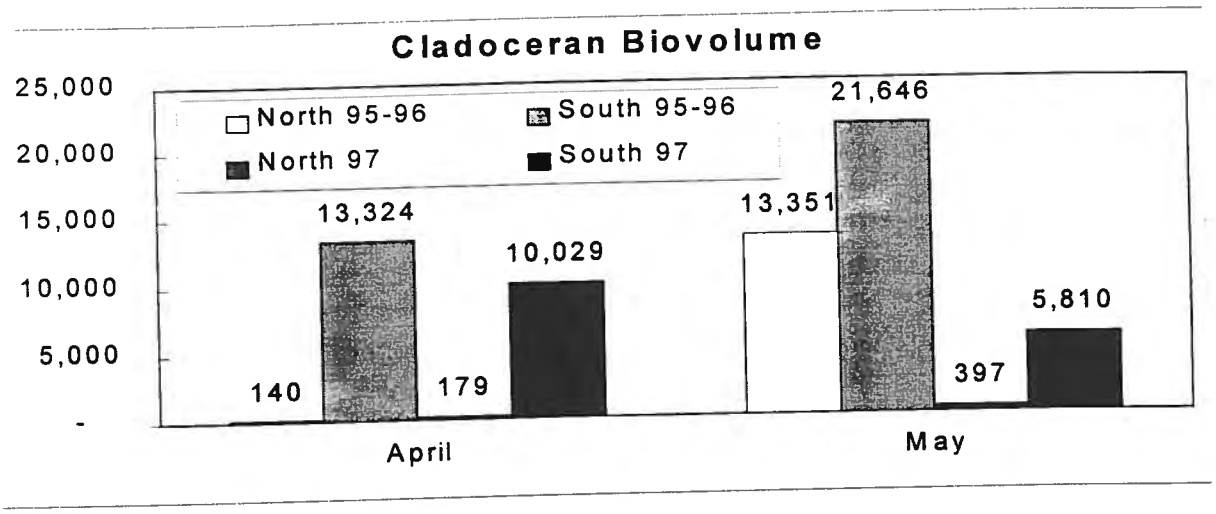


Figure 39. Mean monthly cladoceran biovolume for north and south basin of Osoyoos Lake in 1997 versus 1995-96 means.

3.6.2 Within Basin Variability of Zooplankton Density

During the May sampling, three sets of 5m to surface net tows were collected to begin assessing variability of zooplankton distribution with the north and south basins. The three sample locations were spaced equally along the long (north to south) axis of the north and south basin.

No significant difference in the degree of variance between basins was detected by Bartlett's Test (Table 6, bottom). Bartlett's test for homogeneity of variances is sensitive to abnormal or non-normal distributions. Judging from the range of means, standard deviation, and coefficient of variation (not shown) this was not a major concern with these data.

The results and statistical tests of the crustacean zooplankton data in Table 6 suggest statistical difference of the mean density between the basins. Note that I used the more rigorous and appropriate one sided t distribution that determines any single difference, greater or lesser. Had I selected the two sided t distribution, which is arguably less appropriate for the hypothesis being tested, no difference would have been detected.

These data tentatively indicate that one sample from each basin provides a reasonably good approximation of the crustacean zooplankton population. To more fully test that assumption, however, a more elaborate sampling and analysis would be required. Samples from approximately 10 stations per basin would be necessary. From that data one could accurately measure the population mean for each taxa and

an associated 95% confidence interval. By comparing the number of samples necessary to achieve a suitable confidence interval, the number of samples per basin needed could be ascertained. Similarly, the number of samples per basin needed to detect all species present could be determined. This is sometimes done in benthic and other sampling studies as a pre-study measure to determine appropriate sampling efforts. Sampling for such an analysis of zooplankton is trivial, but the cost of careful and detailed taxonomic analysis is relatively large and beyond the scope of the present study.

Table 6. Comparison of zooplankton density (no. per m^3) counts from multiple within basin samples collected on May 14, 1997. Sample locations noted below table.

Tow Number →	North-1	North-2	North-3	South1	South-2	South-3
Calanoid Copepods	6,234	9,422	6,828	8,460	17,888	18,130
Cyclopoid Copepods	2,925	5,517	11,698	8,330	14,133	15,851
Nauplii	10,182	1,103	955	11,179	6,000	4,202
Cladocerans	3,839	246	229	1,252	1,146	3,629
Rotifers	6,234	364,135	250,948	402,431	484,134	464,845
Total	182,803	380,424	270,657	431,608	523,301	506,657
Crustacean Zoops. Only	23,179	16,288	19,709	29,220	39,167	41,812
Mean by Basin, C.Z only	19,725			36,733		
SD	3,445			6,639		
T statistics: between basin differences	T = 3.10 P = 0.09, One tailed hypothesis, tabular T = 2.92 Reject H_o i.e., mean of N does not equal Mean of S					
Bartlett's Test for Homogeneity of Variance	Bc = 0.80, $X^2_{0.05,2}$ = 5.991, Do not reject H_o, i.e., variance of mean of N and S are similar					

N1 = Monashee Coop. main sampling location, N2 = ½ to the highway bridge in the town of Osoyoos, N3 = 300 m north of the same bridge, S1 = Boundary Point sampling location, S2 = ½ way station, S3 South central basins station, see Fig. 2.

3.6.3 Depth Differences during Critical Period

Zooplankton sampling throughout this study has been limited to net tows of the top 5 meters of the water column. Judging from known physiological tolerance data of major zooplankton groups, discussed in prior reports, I did not think that maximum surface water temperatures in the summer would be too high for crustacean

zooplankton in general. To begin testing this assumption, I collected tows from 5 m to the surface and from 10 m to the surface in both north and south basins in August of 1997 (Table 7).

Table 7. Comparison of 5 m to surface and 10 m to surface vertical zooplankton tow results during August 13, 1997 sampling. Units are density in numbers per m^3.

Basin →	North	North	South	South
Depth of Tow →	**5-0 m**	**10-0m**	**5-0 m**	**10-0 m**
Calanoid Copepods	15,278	16,545	8,437	7,936
Cyclopoid Copepods	509	764	446	382
Nauplii	340	541	1,019	934
Cladocerans	545	789	673	245
Rotifers	43	923	13,623	6,371
Total	16,715	19,563	24,198	15,868
Mean for Crustacean Zooplankton Only	16,673	18,640	10,574	9,497
Mean by Basin, C.Z. only	17,656		10,035	
SD	1,394		762	
T statistics: between basin differences	T = 6.79 P = 0.021, Do not reject H_o i.e., mean of 0-5m density = Mean of 0-10m density			
Bartlett's Test for Homogeneity of Variance	Bc = 0.343, $X^2_{0.05,1}$ = 3.841, Do not reject H_o, i.e., variance of mean of 5m and 10m density results are similar			

These data indicate no probable differences of crustacean zooplankton density between the 5m to surface and 10 meter to surface depth tows, especially in the south basin. The data are limited, and the analysis would have benefited from an additional replicate and the power of the test is probably not strong. An opening/closing type plankton net (e.g. Clark-Bumpus sampler) would also have been more useful for discretely sampling the two separate depth intervals. Nevertheless, the data indicate that sampling of either depth interval would yield statistically similar data, in terms of variance. Sampling deeper than 10 m would have yielded differing results in the south basin, as dissolved oxygen concentrations declined rapidly below about 9.5 meters in August 1997 (Fig. 15) and crustacean zooplankton are not able to live in hypoxic conditions.

The results from Osoyoos Lake may be compared to another regional sockeye lake, Lake Washington, although the lakes are in different ecoregions. In that case, there is no hypoxic or anoxic hypolimnion, but nevertheless, zooplankton do not vertically migrate very much according to the University of Washington limnologist involved in that phase of an ongoing study (A. Litt, personal Communication, Email 21 July 1997). During the summer, most of the zooplankton biomass has been found in the upper 10

meters. During the winter, there is a general shift in biomass toward the 10 to 20 m depths.

3.7 Trophic State Determination

The trophic state of Osoyoos Lake may be determined using data reported here and applied to Carlson's (1977) Trophic State Index, abbreviated TSI. This index, as previously described (Rensel 1995, 1996, 1998), is an indication of the degree of enrichment of a lake using water transparency (Secchi disk depth), total phosphorus and chlorophyll *a* concentrations during summer months (June to September).

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 alternatively N and then P limited in some years, and transparency is not strongly correlated with chlorophyll *a* concentration (Rensel 1998), the index should not be considered as perfectly appropriate. The index is not well suited for 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 Osoyoos Lake, discussed below.

Formula for TSI calculations are shown here followed by the calculated results for 1997 in Osoyoos Lake:

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 total P (µg/l) + 4.15

Secchi Disk

North basin = 4.1 (SD = 0.64, n = 4) TSI value of 39.7
South basin = 4.3 (SD = 0.53, n = 4) TSI value of 39.0

Chlorophyll a Pigment

North basin = 3.5 (SD = 0.5 n = 4) TSI value of 42.9
South basin = 3.35 (SD = 0.9, n = 4) = TSI value of 42.5

Total Phosphorus

North basin = 20.0 (SD = 5.9, n = 4) TSI value of 47.3
South basin = 17.0 (SD = 3.8, n = 4) = TSI value of 45.0

Total Nitrogen (Not part of TSI, but a potentially useful index)

North basin = 318.8 (SD = 69.1, n = 4)

South basin = 286.2 (SD = 90.3, n = 4)

Summary of Trophic State Index

Weighing the 3 TSI components equally, the overall Trophic State Index value for the North basin of Osoyoos Lake in the summer of 1997 was 43.3, equivalent to the lower-mesotrophic range (Tables 8 and 9, see Fig. 25 in Rensel 1998 for scale). The average for the south basin in the summer of 1997 was slightly less at 42.2.

Table 8. Summary of recent Trophic State Index (TSI) components and another possible trend indicator (Total N) for Osoyoos Lake mostly compared to historical data (see Rensel 1993,1995a, 1996, 1998 for details of other databases). Note that these data are summer means, i.e., average of June to September results.

NORTH BASIN	SOUTH BASIN	HISTORICAL COMPARISON
1995 transparency = 3.7 m 1996 transparency = 4.0 m 1997 transparency = 4.1 m Mean = 3.9 m	1994 transparency = 3.1 m 1995 transparency = 3.3 m 1996 transparency = 3.9 m 1997 transparency = 4.3 m Mean = 3.65 m	3.3 m average for 1971 in the north basin less than past 3 years. 2.6 m average from 1989-92 volunteer collected data from south basin much less than past 4 years. Note gradual increase in both basins in recent data.
1995 chlorophyll *a* = 4.6 µg/l 1996 chlorophyll *a* = 3.0 µg/l 1997 chlorophyll *a* = 3.5 µg/l Mean = 3.7 µg/l	1994 chlorophyll *a* = 5.4 µg/l 1995 chlorophyll *a* = 5.0 µg/l 1996 chlorophyll *a* = 4.0 µg/l 1997 chlorophyll *a* = 3.35 µg/l Mean = 4.45 µg/;	Very large decreases from historical data (23 µg/l in 1970s) and recent decreases that inversely correlate with annual discharge. See Rensel 1998.
1995 total P = 13.0 µg/l 1996 total P = 21.0 µg/l 1997 total P = 20.0 µg/l Mean = 18.0 µg/l	1994 total P = 24.0 µg/l 1995 total P = 17.7 µg/l 1996 total P = 16.0 µg/l 1997 total P = 17.0 µg/l Mean = 18.7 µg/l	At upper end of TP range seen from sporadic data from the 1980s. As expected, generally did not decrease with increasing annual discharge.
1995 total N = 360.0 µg/l 1996 total N = 391.4 µg/l 1997 total N = 318.8 µg/l Mean = 356.7 µg/l	1994 total N = 627.0 µg/l 1995 total N = 447.4 µg/l 1996 total N = 352.1 µg/l 1997 total N = 286.2 µg/l Mean = 428.2 µg/l	Large increases compared to all prior data for north basin for 1970s, decreasing trend for recent data in the south basin

The 1995-97 three year TSI average for the north basin of 43.0 was nearly identical to the south basin rating of 43.3 (Table 9). Once again, these data may be interpreted to show that there is little difference in trophic status of the two major basins of the lake, despite the obvious morphometric differences. Secchi disk transparency and

chlorophyll *a* results were inversely correlated with volumetric discharge of the Okanogan River through the lake, as discussed in Rensel (1998). Total phosphorus did not follow the same pattern, for reason discussed in the same report.

Table 9. Summary of overall TSI ratings for Osoyoos Lake from 1994 through 1997.

Year	North Basin	South Basin
1994	---	46.8
1995	42.6	44.9
1996	43.2	42.9
1997	43.3	42.2
1995-97 mean	**43.0**	**43.3**
SD	0.4	1.4

3.8 Fish Culture Impact: Lake Bottom

Samples of bottom sediment were taken at and nearby the pens before and after the hatchery-reared sockeye juveniles were reared in the net pens in 1994 and annually before fish culture commenced each year in 1995, 1996 and 1997. State of Washington Lease requirements require sampling before and after the first year, and subsequently only before fish were stocked. Results of total organic carbon (TOC) analysis are presented in Table 10 as drawn from the laboratory report (appendix 12).

Table 10. The units mg/kg are the same as parts per million as dry weight basis.

DATE (D-M-Y)	LOCATION AND REPLICATE	TOTAL ORGANIC CARBON (MG/KG)	PERCENT 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%
17 April 96	Under pens #1 (center)	27,496	-28%
	Under pens #2 (NE edge)	30,113	-33%
	50 m north	30,916	-28%
14 April 97	Under pens #1 (center)	44,900	+ 61.2%

	Under pens #2 (NE edge)	38,900	+22.6%
	50 m north	38,400	+24.3%

All three bottom samples in 1997 had a similar gray-green appearance, as in past years. For the first time, however, all three samples showed an increase in total organic carbon compared to the prior year's pre-rearing season data (Table 7). However, TOC concentrations beneath the pens remained less than the initial results found in 1994. The fact that the 50 m distant location increased greatly in 1997 and all samples within prior years change somewhat similarly indicates that some other factor(s) are possibly contributing to this relatively large interannual change. Even very large (i.e., 2 million+ lbs. annual production) commercial net pens in Puget Sound do not have significant, measurable impacts beyond about 30 m (Rensel 1997). There is virtually no chance that the relatively tiny Osoyoos Lake net pens were affecting sediments at the 50 m distant stations.

As noted in prior reports, I doubt that the sampling locations for these TOC samples were exactly the same from year to year, as there was always a small amount of movement in the net-pen system allowed by the anchoring system. However, the same anchoring system was left in place each year and the pens were surveyed in place by professional surveyors. Nevertheless, some variation in sampling location is inevitable. See Rensel (1993) for other Osoyoos Lake sediments data.

Additional grab samples of the bottom were screened through a 1 mm sieve in April 1997 to yield the following results:

1) Center of pens: 2 small chironomids (<10mm), 3 large chironomids (>10 -22 mm)
2) NE edge of pens: 1 large chironomid, 1 small chironomid
3) 50 m north of pens: 1 small chironomid

These infauna data suggest the possibility of enrichment of the bottom from waste feed and feces immediately below the pens. However, I believe that there are other, more important factors that may be driving these differences, as TOC at the 50 m station varied considerably over the years too. In retrospect, sediment grain size data should have been collected along with every TOC sample each year (although not required), to help sort out possible differences.

4. Recommendations

A prior report, summarizing the 1994 to 1996 data, included a number of conclusions and recommendations regarding water quality and the sockeye salmon of Osoyoos Lake (Rensel 1998). Specifically, that report addressed carrying capacity determination for sockeye salmon, use of net pens in the future, need for juvenile fish distribution and diet studies, future water quality and plankton monitoring and possible means to improve lake water quality for all uses. It would be redundant to repeat them

again, particularly as virtually all of the conclusions from the prior report were validated further by 1997 finding discussed in the present report.

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Appendix 1. Lake Osoyoos: North Basin (Monashee Coop) Nutrients, 1997

Results in mg/L except bold in µg/L

Date	Depth	Nitrate	Nitrite	Ammonium +Ammonia	Ortho-phosphate	Total N	Total P	SD of TP	SD of TN
Apr-23	1,3,6 m	0.0160	0.0003	0.0027	0.0018	0.317	0.019		
						0.327	0.021		
						0.342	0.020		
	µg/L→	**16.01**	**0.28**	**2.73**	**1.82**	**328.87**	**20.06**	0.86	12.62
	10, 14 m	0.0016	0.0002	0.002	0.0005	0.331	0.022		
	µg/L→	**1.58**	**0.18**	**2.27**	**0.46**	**2.27**	**22.46**		
	50 m	0.0021	0.0003	0.013	0.002	0.392	0.026		
						0.365	0.027		
						0.291	0.023		
	µg/L→	**2.08**	**0.33**	**12.73**	**2.14**	**349.32**	**25.25**	1.98	52.34
May-14	1,3,6 m	0.0011	0.0003	0.004	0.002	0.357	0.027		
						0.415	0.035		
						0.365	0.029		
	µg/L→	**1.08**	**0.29**	**4.09**	**2.27**	**379.28**	**30.62**	4.20	31.34
	10, 14 m	0.0010	0.0003	0.002	0.002	0.285	0.026		
	µg/L→	**1.02**	**0.29**	**2.00**	**1.59**	**2.00**	**26.26**		
	50 m	0.0038	0.0018	0.038	0.005	0.312	0.026		
						0.308	0.023		
						0.307	0.023		
	µg/L→	**3.76**	**1.78**	**38.18**	**4.96**	**309.13**	**24.11**	1.72	2.97
Jun-18	1,3,6 m	0.0097	0.0004	0.003	0.004	0.312	0.020		
						0.348	0.020		
						0.353	0.020		
	µg/L→	**9.69**	**0.37**	**3.17**	**3.96**	**337.39**	**20.01**	0.26	22.22
	10, 14 m	0.0109	0.0010	0.005	0.004	0.327	0.025		
	µg/L→	**10.90**	**0.98**	**4.85**	**3.60**	**4.85**	**25.30**		
	50m	0.0872	0.0003	0.001	0.013	0.338	0.026		
						0.392	0.028		
						0.277	0.029		
	µg/L→	**87.17**	**0.27**	**0.88**	**13.01**	**335.63**	**27.71**	1.21	57.81
Jul-14	1,3,6 m	0.0031	0.0000	0.021	0.000	0.189	0.011		
						0.219	0.012		
						0.248	0.013		
	µg/L→	**3.07**	**0.04**	**20.71**	**0.00**	**218.56**	**11.99**	0.79	29.40
	10, 14 m	0.0066	0.0006	0.013	0.000	0.244	0.012		
	µg/L→	**6.63**	**0.59**	**12.76**	**0.00**	**12.76**	**11.99**		
	50 m	0.1244	0.0004	0.018	0.013	0.291	0.030		
						0.266	0.030		
						0.272	0.031		
	µg/L→	**124.36**	**0.40**	**17.56**	**12.68**	**276.50**	**30.00**	0.52	13.18
Aug-13	1,3,6 m	0.001	0.0003	0.0364	0.0033	0.438	0.0313		
						0.387	0.0247		
						0.305	0.0217		
	µg/L→	**1.00**	**0.30**	**36.40**	**3.30**	**376.67**	**25.90**	4.91	67.10
	10, 14 m	0.001	0.0004	0.0077	0.0019	0.333	0.0214		
	µg/L→	**1.00**	**0.40**	**7.70**	**1.90**	**333.00**	**21.40**		
	50 m	0.173	0.0007	0.0055	0.0270	0.329	0.0186		
						0.327	0.0179		
						0.596	0.0355		
	µg/L→	**173.00**	**0.70**	**5.50**	**27.00**	**417.33**	**24.00**	9.97	154.73
Sep-17	1,3,6 m	0.003	0.0005	0.0205	0.0016	0.348	0.0203		
						0.353	0.0202		
						0.327	0.0254		
	µg/L→	**3.00**	**0.50**	**20.50**	**1.60**	**342.67**	**21.97**	2.97	13.80
	10, 14 m	0.001	0.0004	0.0053	0.0016	0.338	0.0265		
	µg/L→	**1.00**	**0.40**	**5.30**	**1.60**	**338.00**	**26.50**		
	50 m	0.220	0.0006	0.0057	0.0385	0.3920	0.0281		
						0.2765	0.0288		
						0.3783	0.0182		
	µg/L→	**220.00**	**0.60**	**5.70**	**38.50**	**348.95**	**25.06**	5.96	63.11

Appendix 2. Lake Osoyoos: South Basin (Boundary Point) Nutrients, 1997

Results in µg at./L except summary lines in bold that are in mg/L

	Depth	Nitrate	Nitrite	Ammonium +Ammonia	Ortho-phosphate	Total N	Total P	SD of TP	SD of TN
23-Apr	1,3,6 m	0.001	0.0001	0.0018	0.0018	0.357	0.0219		
						0.357	0.0238		
						0.311	0.0202		
	µg/L--->	**0.82**	**0.10**	**1.82**	**1.80**	**341.71**	**21.96**	**1.80**	**26.57**
	10,14 m	0.001	0.0001	0.0009	0.0014	0.265	0.0194		
						0.313	0.0196		
						0.350	0.0219		
	µg/L--->	**0.76**	**0.09**	**0.91**	**1.45**	**309.13**	**20.31**	**1.37**	**42.59**
14-May	1,3,6 m	0.001	0.0003	0.0064	0.0029	0.571	0.0399		
						0.555	0.0375		
	µg/L--->	**0.90**	**0.27**	**6.36**	**2.92**	**562.86**	**38.69**	**1.75**	**11.10**
	14 m	0.001	0.000	0.004	0.002	0.295	0.0217		
						0.302	0.0219		
						0.368	0.0232		
	µg/L--->	**0.99**	**0.12**	**4.45**	**2.07**	**321.73**	**22.27**	**0.83**	**40.29**
18-Jun	1,3,6 m	0.002	0.000	0.005	0.003	0.224	0.0148		
						0.216	0.0136		
						0.210	0.0135		
	µg/L--->	**1.85**	**0.11**	**4.78**	**3.18**	**216.37**	**13.95**	**0.76**	**6.89**
	14 m	0.002	0.009	0.023	0.003	0.203	0.0134		
						0.260	0.0180		
						0.206	0.0138		
	µg/L--->	**2.29**	**9.16**	**22.57**	**3.33**	**222.80**	**15.02**	**2.55**	**32.35**
14-Jul	1,3,6 m	0.004	0.000	0.019	0.002	0.340	0.0177		
						0.306	0.0203		
						0.270	0.0154		
	µg/L--->	**3.66**	**0.21**	**18.94**	**1.55**	**305.61**	**17.80**	**2.47**	**34.86**
	14 m	0.068	0.001	0.010	0.002	0.270	0.0148		
						0.296	0.0158		
						0.282	0.0154		
	µg/L--->	**68.19**	**1.14**	**10.33**	**2.28**	**282.66**	**15.29**	**0.50**	**12.61**
13-Aug	1,3,6 m	0.000	0.0003	0.0384	0.0023	0.580	0.0328		
						0.316	0.0165		
						0.322	0.0166		
	µg/L--->	**0.00**	**0.30**	**38.40**	**2.30**	**406.00**	**21.97**	**9.38**	**150.72**
	14 m	0.000	0.0232	0.0666	0.0167	0.3900	0.0179		
						0.3798	0.0441		
						0.5092	0.0305		
	µg/L--->	**0.00**	**23.20**	**66.60**	**16.70**	**426.35**	**30.82**	**13.08**	**71.97**
17-Sep	1,3,6 m	0.000	0.0005	0.0113	0.0020	0.224	0.0150		
						0.216	0.0137		
						0.210	0.0136		
	µg/L--->	**0.00**	**0.50**	**11.30**	**2.00**	**216.67**	**14.10**	**0.78**	**7.02**
	14 m	0.000	0.0004	0.0109	0.0015	0.203	0.0136		
						0.260	0.0182		
						0.206	0.0140		
	µg/L--->	**0.00**	**0.40**	**10.90**	**1.50**	**223.00**	**15.27**	**2.55**	**32.08**

Appendix 3. Okanogan River Inflow or Outflow to Lake Osoyoos Nutrients, 1997

Results in mg/L except bold that are µg/L-N or P

Date	Location	Nitrate	Nitrite	Ammonium +Ammonia	Ortho-phosphate	Total N	Total P	DIN
23-Apr	Inflow	0.0160	0.0003	0.0027	0.0020	0.330	0.0308	
	µg/L--->	**16.01**	**0.28**	**2.73**	**2.00**	**330.00**	**30.80**	**19.02**
	Outflow	0.0016	0.0003	0.0003	0.0005	0.358	0.0257	
	µg/L--->	**1.62**	**0.27**	**0.27**	**0.48**	**358.00**	**25.70**	**2.16**
14/May	Inflow	ND	ND	ND	ND	0.3581	0.0487	
	µg/L--->					**358.12**	**48.66**	**ND**
	Outflow	0.0006	0.0001	0.0010	0.0018	0.4851	0.0356	
	µg/L--->	**0.64**	**0.08**	**1.00**	**1.77**	**485.10**	**35.56**	**1.72**
18-Jun	Inflow	0.0125	0.0002	0.0035	0.0038			
	µg/L--->	**12.54**	**0.24**	**3.55**	**3.80**	**300.00**		**16.33**
	Outflow	0.0006	0.0002	0.0076	0.0034	0.220	0.015	
	µg/L--->	**0.61**	**0.15**	**7.64**	**3.43**	**220.00**	**15.40**	**8.41**
14-Jul	Inflow	0.0040	0.0006	0.0194	0.0007	0.2451	0.0142	
	µg/L--->	**4.05**	**0.62**	**19.44**	**0.70**	**245.15**	**14.17**	**24.11**
	Outflow	0.0041	0.0001	0.0131	0.0000	0.2552	0.0195	
	µg/L--->	**4.10**	**0.05**	**13.11**	**0.00**	**255.22**	**19.51**	**17.27**
13-Aug	Inflow	0.014	0.0010	0.0066	0.0032	0.3786	0.0231	
	µg/L--->	**14.00**	**1.00**	**6.60**	**3.20**	**378.64**	**23.13**	**21.60**
	Outflow	0.0000	0.0005	0.0082	0.0020	0.2214	0.0187	
	µg/L--->	**0.00**	**0.50**	**8.20**	**2.00**	**221.41**	**18.73**	**8.70**
17-Sep	Inflow	0.014	0.0006	0.0070	0.0018	0.3119	0.0198	
	µg/L--->	**14.00**	**0.60**	**7.00**	**1.80**	**311.89**	**19.75**	**21.60**
	Outflow	0.0000	0.0004	0.0071	0.0018	0.2201	0.0157	
	µg/L--->	**0.00**	**0.40**	**7.10**	**1.80**	**220.11**	**15.66**	**7.50**

Appendix Table 4. Lake Osoyoos and Okanogan River Thermograph Data, 1997
Data are daily means from 4 or 5 recordings per day

Date	Lake	Min	Max	Difference	River	Min	Max	Difference
25-Apr-97	9.5	9.5	9.5	0.0	9.0	8.0	9.5	1.5
26-Apr-97	9.3	9.0	9.5	0.5	8.2	8.0	8.5	0.5
27-Apr-97	9.6	9.0	10.0	1.0	9.3	8.5	10.0	1.5
28-Apr-97	10.4	10.0	11.0	1.0	10.1	10.0	10.5	0.5
29-Apr-97	10.3	10.0	10.5	0.5	10.5	9.5	11.5	2.0
30-Apr-97	10.4	10.0	10.5	0.5	10.0	9.5	10.5	1.0
1-May-97	10.3	10.0	10.5	0.5	9.8	9.0	10.5	1.5
2-May-97	10.4	10.0	11.0	1.0	9.6	9.5	10.0	0.5
3-May-97	10.7	10.5	11.0	0.5	9.5	8.5	10.0	1.5
4-May-97	10.8	10.5	11.0	0.5	9.6	9.5	10.0	0.5
5-May-97	10.8	10.5	11.0	0.5	10.0	9.5	10.5	1.0
6-May-97	10.8	10.5	11.5	1.0	10.7	10.0	11.5	1.5
7-May-97	11.4	11.0	12.0	1.0	11.5	10.5	13.0	2.5
8-May-97	12.3	12.0	12.5	0.5	11.5	10.5	12.5	2.0
9-May-97	12.4	12.0	13.5	1.5	12.3	10.5	14.5	4.0
10-May-97	13.1	13.0	13.5	0.5	13.9	13.5	14.5	1.0
11-May-97	13.1	13.0	13.5	0.5	13.7	13.0	14.5	1.5
12-May-97	14.2	13.5	15.0	1.5	13.8	13.5	14.0	0.5
13-May-97	13.3	12.5	14.0	1.5	14.2	13.5	15.0	1.5
14-May-97	14.2	13.5	15.0	1.5	15.6	14.5	17.0	2.5
15-May-97	14.6	14.0	15.0	1.0	15.1	13.5	16.0	2.5
16-May-97	15.4	13.5	17.5	4.0	15.2	13.5	17.5	4.0
17-May-97	16.4	15.5	17.0	1.5	16.3	16.0	17.0	1.0
18-May-97	15.5	15.5	15.5	0.0	15.9	15.5	16.5	1.0
19-May-97	15.8	15.5	16.5	1.0	14.1	13.5	15.0	1.5
20-May-97	14.5	14.5	14.5	0.0	14.5	14.0	15.0	1.0
21-May-97	14.7	14.5	15.5	1.0	14.5	14.0	15.0	1.0
22-May-97	14.8	14.5	16.0	1.5	14.7	14.5	15.0	0.5
23-May-97	15.1	15.0	15.5	0.5	14.6	14.5	15.0	0.5
24-May-97	15.0	14.5	15.5	1.0	14.9	14.5	15.5	1.0
25-May-97	15.1	15.0	15.5	0.5	15.0	15.0	15.0	0.0
26-May-97	15.3	15.0	15.5	0.5	15.0	15.0	15.0	0.0
27-May-97	15.2	14.5	15.5	1.0	14.5	14.5	14.5	0.0
28-May-97	15.8	15.5	16.5	1.0	14.6	14.5	15.0	0.5
29-May-97	16.2	15.5	17.0	1.5	15.8	15.0	17.0	2.0
30-May-97	16.9	16.5	17.5	1.0	16.9	15.5	17.5	2.0
31-May-97	17.1	16.5	17.5	1.0	16.2	16.0	17.0	1.0
1-Jun-97	17.0	16.5	17.5	1.0	16.4	15.5	17.0	1.5
2-Jun-97	16.7	16.5	17.0	0.5	16.4	16.0	17.0	1.0
3-Jun-97	17.1	16.5	17.5	1.0	16.4	15.0	17.0	2.0
4-Jun-97	17.3	17.0	17.5	0.5	17.1	16.5	17.5	1.0
5-Jun-97	17.5	17.0	18.5	1.5	17.3	17.0	18.0	1.0
6-Jun-97	17.2	16.5	18.0	1.5	16.9	16.0	17.5	1.5
7-Jun-97	17.4	16.5	18.0	1.5	16.7	16.0	17.5	1.5
8-Jun-97	17.4	17.0	17.5	0.5	17.3	16.0	18.5	2.5
9-Jun-97	17.8	17.5	18.5	1.0	18.1	17.5	19.0	1.5
10-Jun-97	17.6	17.0	18.0	1.0	17.9	17.5	18.5	1.0
11-Jun-97	17.7	17.0	18.5	1.5	17.5	17.0	18.0	1.0
12-Jun-97	18.5	18.0	19.0	1.0	18.0	17.5	18.5	1.0
13-Jun-97	18.7	18.5	19.0	0.5	19.0	18.5	19.5	1.0
14-Jun-97	19.6	19.5	20.0	0.5	20.1	19.5	20.5	1.0
15-Jun-97	19.9	19.5	20.0	0.5	20.0	19.5	20.5	1.0
16-Jun-97	20.2	19.5	20.5	1.0	20.4	20.0	21.0	1.0
17-Jun-97	19.1	17.5	20.0	2.5	18.4	16.5	20.0	3.5
18-Jun-97	19.6	19.0	20.0	1.0	19.3	18.0	20.5	2.5
19-Jun-97	19.6	19.5	20.0	0.5	19.9	19.5	20.5	1.0
20-Jun-97	19.7	19.5	20.0	0.5	19.6	19.0	20.5	1.5
21-Jun-97	19.3	19.0	19.5	0.5	19.4	19.0	19.5	0.5
22-Jun-97	18.9	18.5	19.0	0.5	17.8	16.5	18.5	2.0
23-Jun-97	18.1	18.0	18.5	0.5	18.0	18.0	18.0	0.0
24-Jun-97	18.3	18.0	19.0	1.0	18.6	18.0	19.5	1.5
25-Jun-97	18.8	18.5	19.0	0.5	18.4	18.0	19.0	1.0
26-Jun-97	18.8	18.5	19.5	1.0	19.0	18.5	19.5	1.0
27-Jun-97	19.3	19.0	20.0	1.0	19.2	19.0	19.5	0.5
28-Jun-97	19.2	19.0	19.5	0.5	19.9	19.0	20.5	1.5
29-Jun-97	19.5	19.5	19.5	0.0	19.9	19.5	20.5	1.0
30-Jun-97	19.4	19.0	20.0	1.0	19.3	19.0	19.5	0.5
1-Jul-97	19.6	19.5	20.0	0.5	19.5	19.5	19.5	0.0
2-Jul-97	19.5	19.5	19.5	0.0	19.3	18.5	20.5	2.0
3-Jul-97	19.9	19.0	20.5	1.5	19.0	18.5	19.5	1.0
4-Jul-97	20.6	20.0	22.0	2.0	19.9	19.0	21.0	2.0

5-Jul-97	21.1	20.5	21.5	1.0	21.0	20.0	22.0	2.0
6-Jul-97	21.1	21.0	21.5	0.5	21.2	21.0	21.5	0.5
7-Jul-97	21.2	21.0	21.5	0.5	20.9	20.0	21.5	1.5
8-Jul-97	21.0	21.0	21.0	0.0	20.7	20.0	21.0	1.0
9-Jul-97	21.1	20.5	21.5	1.0	20.8	20.0	21.5	1.5
10-Jul-97	20.7	20.5	21.0	0.5	20.5	20.5	20.5	0.0
11-Jul-97	20.4	20.0	20.5	0.5	20.1	19.5	20.5	1.0
12-Jul-97	20.0	20.0	20.0	0.0	20.7	19.5	22.0	2.5
13-Jul-97	20.3	20.0	21.5	1.5	20.4	20.0	21.0	1.0
14-Jul-97	20.6	20.0	21.5	1.5	21.4	20.0	23.0	3.0
15-Jul-97	21.8	21.5	23.0	1.5	22.8	22.0	24.0	2.0
16-Jul-97	22.0	21.5	22.5	1.0	22.6	22.0	23.0	1.0
17-Jul-97	21.5	21.5	21.5	0.0	21.7	21.5	22.0	0.5
18-Jul-97	21.4	21.0	21.5	0.5	21.9	21.0	23.0	2.0
19-Jul-97	21.4	21.0	22.5	1.5	22.3	21.5	23.5	2.0
20-Jul-97	22.8	22.0	23.5	1.5	22.5	21.5	23.5	2.0
21-Jul-97	21.9	21.0	23.0	2.0	20.9	20.5	21.5	1.0
22-Jul-97	22.1	21.5	23.0	1.5	22.0	21.0	23.0	2.0
23-Jul-97	22.4	22.0	22.5	0.5	22.9	22.0	24.0	2.0
24-Jul-97	22.5	22.5	22.5	0.0	23.1	22.5	24.0	1.5
25-Jul-97	21.8	21.5	22.5	1.0	22.3	22.0	23.0	1.0
26-Jul-97	21.7	21.5	22.0	0.5	22.0	21.0	23.0	2.0
27-Jul-97	21.8	21.5	22.5	1.0	22.3	21.5	23.0	1.5
28-Jul-97	22.3	22.0	23.0	1.0	22.8	22.0	23.5	1.5
29-Jul-97	22.6	22.5	23.0	0.5	22.5	22.5	22.5	0.0
30-Jul-97	22.4	22.0	23.0	1.0	21.6	21.5	22.0	0.5
31-Jul-97	22.5	22.0	23.0	1.0	22.3	22.0	23.0	1.0
1-Aug-97	22.7	22.5	23.0	0.5	22.7	21.5	24.0	2.5
2-Aug-97	23.3	23.0	23.5	0.5	23.9	23.5	24.5	1.0
3-Aug-97	23.8	23.5	24.5	1.0	24.0	23.5	24.5	1.0
4-Aug-97	24.1	24.0	24.5	0.5	24.8	24.0	25.5	1.5
5-Aug-97	24.7	24.5	25.0	0.5	25.1	24.5	26.0	1.5
6-Aug-97	24.9	24.5	26.0	1.5	25.2	24.5	26.0	1.5
7-Aug-97	24.2	24.0	24.5	0.5	24.5	24.0	25.5	1.5
8-Aug-97	23.4	23.0	23.5	0.5	23.5	23.5	23.5	0.0
9-Aug-97	23.0	23.0	23.0	0.0	23.0	22.5	23.5	1.0
10-Aug-97	22.7	22.5	23.0	0.5	23.0	22.5	23.5	1.0
11-Aug-97	22.9	22.5	23.0	0.5	23.2	22.5	24.5	2.0
12-Aug-97	23.0	23.0	23.0	0.0	23.4	22.5	24.0	1.5
13-Aug-97	23.4	23.0	23.5	0.5	23.8	23.5	24.0	0.5
14-Aug-97	23.8	23.5	24.0	0.5	24.3	23.5	25.5	2.0
15-Aug-97	23.6	23.0	24.0	1.0	23.9	23.0	24.5	1.5
16-Aug-97	23.0	23.0	23.0	0.0	23.2	22.5	24.0	1.5
17-Aug-97	22.9	22.5	23.0	0.5	23.1	22.5	23.5	1.0
18-Aug-97	22.8	22.5	23.0	0.5	23.5	23.0	24.0	1.0
19-Aug-97	22.9	22.5	23.5	1.0	23.4	23.0	24.0	1.0
20-Aug-97	23.0	23.0	23.0	0.0	23.1	23.0	23.5	0.5
21-Aug-97	23.3	23.0	23.5	0.5	22.7	22.5	23.0	0.5
22-Aug-97	23.2	23.0	23.5	0.5	23.1	22.5	24.0	1.5
23-Aug-97	23.3	23.0	23.5	0.5	23.0	22.5	23.5	1.0
24-Aug-97	22.5	22.5	22.5	0.0	22.1	22.0	22.5	0.5
25-Aug-97	22.1	22.0	22.5	0.5	22.0	21.5	22.5	1.0
26-Aug-97	21.9	21.5	22.0	0.5	21.9	21.5	22.5	1.0
27-Aug-97	21.9	21.5	22.0	0.5	21.5	21.5	21.5	0.0
28-Aug-97	21.5	21.5	21.5	0.0	21.1	21.0	21.5	0.5
29-Aug-97	21.7	21.5	22.0	0.5	21.1	21.0	21.5	0.5
30-Aug-97	21.6	21.0	22.0	1.0	21.3	21.0	22.0	1.0
31-Aug-97	21.7	21.0	22.0	1.0	21.8	21.0	22.5	1.5
1-Sep-97	22.2	22.0	22.5	0.5	22.4	22.0	23.0	1.0
2-Sep-97	22.6	22.5	23.0	0.5	22.4	22.0	23.0	1.0
3-Sep-97	22.2	22.0	22.5	0.5	21.6	21.5	22.0	0.5
4-Sep-97	21.9	21.5	22.5	1.0	21.4	21.0	22.0	1.0
5-Sep-97	21.8	21.5	22.0	0.5	21.1	20.5	21.5	1.0
6-Sep-97	21.2	21.0	21.5	0.5	20.7	20.5	21.0	0.5
7-Sep-97	21.1	21.0	21.5	0.5	21.0	20.5	21.5	1.0
8-Sep-97	21.1	21.0	21.5	0.5	21.2	21.0	21.5	0.5
9-Sep-97	21.3	21.0	22.0	1.0	21.3	21.0	22.0	1.0
10-Sep-97	21.5	21.0	22.0	1.0	21.4	21.0	21.5	0.5
11-Sep-97	21.0	21.0	21.0	0.0	20.8	20.5	21.0	0.5
12-Sep-97	20.9	20.5	21.5	1.0	20.6	20.5	21.0	0.5
13-Sep-97	20.6	20.5	21.0	0.5	20.4	20.0	21.0	1.0
14-Sep-97	20.4	20.0	20.5	0.5	20.0	20.0	20.0	0.0
15-Sep-97	20.0	20.0	20.0	0.0	19.7	19.5	20.0	0.5
16-Sep-97	19.6	19.5	20.0	0.5	19.2	19.0	19.5	0.5

Appendix Table 5. Density and biovolume of phytoplankton, North Basin 1997

DENSITY	April	May	June	July	Aug	Sept
by percent						
Blue-greens	89.7	91.6	89.9	91.2	90.7	95.2
Greens	0.3	0.4	1.6	0.5	1.8	0.5
Diatoms (browns)	7.1	4.1	4.4	2.4	1.9	3.3
Small flagellates	2.9	3.9	4.1	6.0	5.6	1.0
Euglena spp.	0	0	0	0	0	0
Dinoflagellates	0	0	0	0	0	0
BIOVOLUME	**April**	**May**	**June**	**July**	**August**	**Sept**
by percent						
Blue-greens	30.1	46.7	20.6	31.7	28.6	48.9
Greens	1.5	0.4	9.8	5.0	4.6	4.3
Diatoms/browns	65.0	46.4	57.3	29.7	31.0	42.2
Small Flagellates	3.5	6.5	12.0	33.7	18.7	4.6
Euglena spp.	0	0	0.3	0	0	0
Dinoflagellates	0	0	0	0	17.2	0
DENSITY	**April**	**May**	**June**	**July**	**Aug**	**Sept**
number per m3 divided by 1,000						
Blue-greens	8,606	5,297	3,698	5,891	3,428	4,810
Greens	25	21	64	33	69	27
Diatoms/browns	685	238	181	152	70	169
Small Flagellates	276	224	170	387	213	49
Euglena spp.	0	0	1	0	0	0
Dinoflagellates	0	0	0	0	1	0
Total	9,592	5,780	4,114	6,463	3,781	5,055
Total Greens+Diatoms	710	259	245	185	139	196
BIOVOLUME	**April**	**May**	**June**	**July**	**August**	**Sept**
um3/ml divided by1,000						
Blue-greens	613	447	179	188	100	163
Greens	30	4	85	29	16	14
Diatoms/browns	1,325	443	497	177	108	141
Small Flagellates	71	62	105	201	65	15
Euglena spp.	0	0	3	0	0	0
Dinoflagellates	0	0	0	0	60	0
Total	2,038	957	869	595	349	334
Total Greens+Diatoms	1,355	448	583	206	124	155

Appendix Table 6. Density and biovolume of phytoplankton, South Basin 1997

DENSITY	April	May	June	July	Aug	Sept
by percent						
Blue-greens	90.6	88.6	91.2	94.2	98.7	98.0
Greens	1.1	0.9	1.3	0.1	0.4	0.3
Diatoms (browns)	5.5	6.0	3.4	3.8	0.4	1.4
Small flagellates	2.8	4.6	4.1	1.9	0.6	0.3
Euglena spp.	0.01	0	0	0	0	0
Dinoflagellates	0	0	0	0	0	0

BIOVOLUME	April	May	June	July	August	Sept
by percent						
Blue-greens	36.7	31.6	22.4	11.1	67.0	67.2
Greens	2.2	2.2	8.4	15.3	6.3	2.8
Diatoms/browns	55.5	56.2	53.4	70.7	20.8	28.3
Small Flagellates	5.5	10.1	15.9	3.0	5.8	1.7
Euglena spp.	0.1	0	0	0	0	0
Dinoflagellates	0	0	0	0	0	0

DENSITY	April	May	June	July	Aug	Sept
number per m3 divided by 1,000						
Blue-greens	10,197	5,499	5,459	1,500	29,592	14,630
Greens	123	54	75	2	108	49
Diatoms/browns	620	373	204	61	120	204
Small Flagellates	311	284	246	30	175	47
Euglena spp.	0	0	0	0	0	0
Dinoflagellates	1	0	0	0	0	0
Total	11,252	6,210	5,984	1,593	29,995	14,930
Total Greens+Diatoms	743	427	279	63	228	253

BIOVOLUME	April	May	June	July	August	Sept
um3/ml divided by1,000						
Blue-greens	546	251	180	28	604	569
Greens	33	18	68	39	57	24
Diatoms/browns	826	447	430	180	187	239
Small Flagellates	81	80	128	8	52	14
Euglena spp.	0	0	0	0	0	0
Dinoflagellates	2	0	0	0	0	0
Total	1,487	797	625	255	900	846
Total Greens+Diatoms	859	465	498	220	244	263

Appendix Table 7. 1997 zooplankton results, North Basin Lake Osoyoos

DENSITY						
By Percent	April	May	June	July	Aug	Sept
Calanoids	6.5	3.4	77.3	57.4	91.4	8.1
Cyclopoids	1.7	1.6	2.0	4.0	3.0	0.7
Nauplii	2.8	5.6	1.5	4.0	2.0	0.1
Cladocerans	0.1	0.2	11.4	22.6	3.3	1.0
Rotifers	89.0	89.2	7.7	12.0	0.3	90.1
Dipterans	0	0	0	0	0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0
DENSITY						
Number per m3	April	May	June	July	Aug	Sept
Calanoids	25,837	6,234	25,551	12,376	15,278	5,683
Cyclopoids	6,669	2,925	662	859	509	516
Nauplii	11,102	10,182	509	859	340	48
Cladocerans	280	384	3,769	4,870	545	719
Rotifers	355,455	163,060	2,546	2,578	43	63,463
Dipterans	0	0	0	0	0	102
Total	399,343	182,803	33,037	21,543	16,715	70,428
Total Crust. Zoop	43,888	19,724	30,491	18,964	16,673	6,965
BIOVOLUME						
µg per m3	April	May	June	July	Aug	Sept
Calanoids	92,195	28,982				
Cyclopoids	16,521	6,306				
Nauplii	2,775	2,550				
Cladocerans	179	397				
Rotifers	7,433	3,095				
Total	119,115	41,326				
Total Crust. Zoop	111,670	38,235				
Additional data given in main text						

Appendix Table 8. 1997 zooplankton results, South Basin Lake Osoyoos

DENSITY						
By Percent	**April**	**May**	**June**	**July**	**Aug**	**Sept**
Calanoids	4.0	2.0	25.8	8.5	34.9	67.4
Cyclopoids	1.7	1.9	4.3	4.1	1.8	7.3
Nauplii	1.7	2.6	2.6	2.4	4.2	8.3
Cladocerans	0.3	0.3	23.5	9.7	2.8	0.7
Rotifers	92.3	93.2	43.9	75.3	56.3	16.3
Total	100.0	100.0	100.0	100.0	100.0	100.0
DENSITY						
Number per m3	**April**	**May**	**June**	**July**	**Aug**	**Sept**
Calanoids	23,339	8,460	10,290	2,294	8,437	19,380
Cyclopoids	10,145	8,330	1,719	1,114	446	2,101
Nauplii	9,851	11,179	1,019	637	1,019	2,387
Cladocerans	1,701	1,252	9,358	2,599	673	191
Rotifers	541,419	402,431	17,507	20,212	13,623	4,679
Total	586,395	431,608	39,891	26,856	24,198	28,738
Total Crust. Zoop.	45,035	29,220	22,385	6,644	10,574	24,059
BIOVOLUME						
µg per m3	**April**	**May**	**June**	**July**	**Aug**	**Sept**
Calanoids	80,422	56,634				
Cyclopoids	23,995	19,375				
Nauplii	2,383	2,798				
Cladocerans	10,029	5,810				
Rotifers	10,488	8,043				
Total	127432	92660				
Total Crust. Zoop.	116,830	84,617				
Additional data given in main text						

LAKE OSOYOOS PHYTOPLANKTON
DATE: 04/23/97
STATION: North Basin Composite (1,3,6m) SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Aphanizomenon flos-aquae	26.00	118	3,068	few heterocysts
Lyngbya-like (limnetica?)	4,500.00	19	84,780	thin-cell,faint sheath evid
Oscillatoria tenuis	4,080.00	129	524,747	
Taxon Subtotal	**8606**		**612,595**	
Chlorophyta				
Ankistrodesmus sp.	6.00	201	1,206	
Ankistrodesmus sp.	6.00	445	2,669	
Closteriopsis longissima	1.00	15,072	15,072	
filamentous green (Mougeotia?)	4.00	2,261	9,043	cells collapsed
colonial green nanno (ell)	8.00	205	1,641	cells collapsed
Taxon Subtotal	**25**		**29,631**	
Chrysophyta				
Mallomonas sp.	3.00	10,048	30,144	
small flagel chrysophyte	6.00	1,641	9,847	
Bacillariophyceae				
Asterionella formosa	328.00	371	121,840	
Asterionella formosa	48.00	531	25,472	
Cyclotella sp.	2.00	2,289	4,578	
Fragilaria crotonensis	165.00	683	112,695	
Melosira granulata	14.00	2,355	32,970	
Melosira sp. 3	40.00	2,653	106,132	short-chain
Melosira sp.	33.00	1,206	39,790	thin-celled
Stephanodiscus astraea	3.00	29,080	87,239	
Stephanodiscus niagarae	5.00	134,628	673,138	
Synedra ulna	2.00	28,350	56,700	
Synedra acus	11.00	1,172	12,895	
Synedra sp.	2.00	293	586	
Synedra sp.	8.00	419	3,349	stellate
Synedra sp.	15.00	502	7,536	
Taxon Subtotal	**685**		**1,324,910**	
Cryptophyta				
Cryptomonas sp.	1.00	2,110	2,110	
Rhodomonas sp.	275.00	251	69,080	
Taxon Subtotal	**276.00**		**71,190**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**9592**	**Total Volume**	**2,038,326**	**2.04**
% Cyanophyta	89.72	% Cyanophyta	30.05	
% Chlorophyta	0.26	% Chlorophyta	1.45	
% Chrysophyta	7.14	% Chrysophyta	65.00	
% Cryptophyta	2.88	% Cryptophyta	3.49	

Note: *=colony/ml Note:**=filament/ml

LAKE OSOYOOS PHYTOPLANKTON
DATE: 4/23/97
STATION: South Basin Composite(1,3,6m) SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Aphanizomenon flos-aquae	26.00	118	3,068	few heterocysts
Lyngbya-like. (limnetica?)	6,975.00	19	131,409	thin-cell,faint sheath evid
Oscillatoria tenuis	3,196.00	129	411,052	
Taxon Subtotal	10197		545,529	
Chlorophyta				
Ankistrodesmus sp.	3.00	458	1,374	
Quadrigula sp.	20.00	262	5,233	
filamentous green (Mougeotia?)	4.00	2,261	9,043	cells collapsed
colonial green(sph)	96.00	180	17,232	
Taxon Subtotal	123		32,883	
Chrysophyta				
Dinobryon sociale	2.00	670	1,340	
small flagel chrysophyte	8.00	1,641	13,129	
Bacillariophyceae				
Asterionella formosa	248.00	371	92,123	
Asterionella formosa	96.00	531	50,943	
Cyclotella sp.	2.00	2,289	4,578	
Cyclotella sp.	2.00	3,799	7,599	
Fragilaria crotonensis	80.00	683	54,640	
Melosira sp.	88.00	1,653	145,482	
Melosira sp. 3	54.00	2,653	143,278	short-chain
Navicula sp.	1.00	1,780	1,780	
Nitzschia sp.	1.00	4,239	4,239	
Rhizosolenia sp.	1.00	15,386	15,386	
Stephanodiscus astraea	1.00	29,080	29,080	
Stephanodiscus niagarae	1.00	115,395	115,395	
Synedra ulna	6.00	21,000	126,000	
Synedra acus	11.00	1,172	12,895	
Synedra sp.	6.00	293	1,758	
Synedra sp.	12.00	502	6,029	
Taxon Subtotal	620		825,675	
Cryptophyta				
Cryptomonas sp.	3.00	1,319	3,956	
Rhodomonas sp.	308.00	251	77,370	
Taxon Subtotal	311.00		81,326	
Euglenophyta				
Pyrrhophyta				
Peridinium sp.	1.00	1,809	1,809	tiny cell
Taxon Subtotal	1		1,809	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**11252**	**Total Volume**	**1,487,221**	**1.49**
% Cyanophyta	90.62	% Cyanophyta	36.68	
% Chlorophyta	1.09	% Chlorophyta	2.21	
% Chrysophyta	5.51	% Chrysophyta	55.52	
% Cryptophyta	2.76	% Cryptophyta	5.47	
% Pyrrhophyta	0.01	% Pyrrhophyta	0.12	

Note: *=colony/ml Note:**=filament/ml

LAKE OSOYOOS PHYTOPLANKTON
DATE: 05/14/97
STATION: North Basin (N-1) Grab

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Aphanizomenon flos-aquae	39.00	118	4,602	few heterocysts
Lyngbya-like (limnetica?)	2,130.00	19	40,129	thin-cell,faint sheath evid
Oscillatoria tenuis	3,128.00	129	402,306	
Taxon Subtotal	**5297**		**447,037**	
Chlorophyta				
Ankistrodesmus sp.	1.00	366	366	
Elakatothrix gelatinosa	4.00	126	502	
colonial green nanno (ell)	16.00	205	3,282	
Taxon Subtotal	**21**		**4,151**	
Chrysophyta				
Dinobryon bavaricum	45.00	1,407	63,302	
Dinobryon sp.	4.00	848	3,391	
Bacillariophyceae				
Asterionella formosa	64.00	371	23,774	
Asterionella formosa	44.00	531	23,349	
Cyclotella sp.	2.00	2,289	4,578	
Fragilaria crotonensis	10.00	683	6,830	
Fragilaria sp.	15.00	792	11,880	
Melosira granulata	20.00	2,041	40,820	
Melosira sp. 3	12.00	2,769	33,234	short-chain
Rhizosolenia sp.	4.00	7,850	31,400	
Stephanodiscus astraea	1.00	34,882	34,882	
Stephanodiscus niagarae	1.00	84,780	84,780	
Synedra ulna	2.00	29,400	58,800	
Synedra ulna	1.00	14,700	14,700	
Synedra delicatissima	4.00	1,172	4,689	
Synedra sp.	5.00	293	1,465	
Synedra sp.	3.00	469	1,407	stellate
Synedra sp.	1.00	167	167	
Taxon Subtotal	**238**		**443,449**	
Cryptophyta				
Cryptomonas sp.	3.00	2,110	6,330	
Rhodomonas sp.	220.00	251	55,264	
Chroomonas sp.	1.00	791	791	
Taxon Subtotal	**224.00**		**62,386**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**5780**	**Total Volume**	**957,023**	**0.96**
% Cyanophyta	91.64	% Cyanophyta	46.71	
% Chlorophyta	0.36	% Chlorophyta	0.43	
% Chrysophyta	4.12	% Chrysophyta	46.34	
% Cryptophyta	3.88	% Cryptophyta	6.52	

Note: *=colony/ml

Note:**=filament/ml

LAKE OSOYOOS PHYTOPLANKTON
DATE: 5/14/97
STATION: South Basin Grab (S-1)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	
Cyanophyta				
Aphanizomenon flos-aquae	286.00	118	33,748	few heterocysts
Lyngbya-like. (limnetica?)	4,125.00	19	77,715	thin-cell,faint sheath evid
Oscillatoria tenuis	1,088.00	129	139,932	
Taxon Subtotal	**5499**		**251,395**	
Chlorophyta				
Ankistrodesmus sp.	4.00	393	1,570	
Elakatothrix gelatinosa	2.00	126	251	
amentous green (Mougeotia?)	4.00	1,696	6,782	cells collapsed
colonial green(sph)	44.00	205	9,026	
Taxon Subtotal	**54**		**17,630**	
Chrysophyta				
Dinobryon bavaricum	164.00	1,407	230,702	
Dinobryon sp.	8.00	848	6,782	
Bacillariophyceae				
Asterionella formosa	112.00	371	41,604	
Asterionella formosa	24.00	531	12,736	
Cymbella sp.	1.00	20,515	20,515	large cell
Fragilaria crotonensis	20.00	683	13,660	
Fragilaria sp.	5.00	720	3,600	
Melosira sp.	20.00	1,653	33,064	
Melosira sp. 3	6.00	2,462	14,771	short-chain
Navicula sp.	1.00	1,780	1,780	
Rhizosolenia sp.	1.00	15,386	15,386	
Stephanodiscus astraea	1.00	29,080	29,080	
Synedra ulna	1.00	18,000	18,000	
Synedra delicatissima	3.00	1,172	3,517	
Synedra sp.	3.00	293	879	
Synedra sp.	3.00	419	1,256	stellate
Taxon Subtotal	**373**		**447,331**	
Cryptophyta				
Cryptomonas sp.	9.00	1,231	11,078	
Rhodomonas sp.	275.00	251	69,080	
Taxon Subtotal	**284.00**		**80,158**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**6210**	**Total Volume**	**796,515**	**0.80**
% Cyanophyta	88.55	% Cyanophyta	31.56	
% Chlorophyta	0.87	% Chlorophyta	2.21	
% Chrysophyta	6.01	% Chrysophyta	56.16	
% Cryptophyta	4.57	% Cryptophyta	10.06	

Note: *=colony/ml

Note:**=filament/ml

LAKE OSOYOOS PHYTOPLANKTON
DATE: 06/18/97
STATION: North Basin Comp (1,3,6m)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Anabaena sp.	20.00	124	2,487	short,loose coil; heterocysts
Aphanizomenon flos-aquae	26.00	118	3,068	few heterocysts
Lyngbya-like (limnetica?)	2,700.00	19	50,868	thin-cell,faint sheath evid
Oscillatoria tenuis	952.00	129	122,441	
Taxon Subtotal	**3698**		**178,864**	
Chlorophyta				
Ankistrodesmus sp.	1.00	366	366	
* *Botryococcus braunii*	1.00	38,773	38,773	
Elakatothrix gelatinosa	4.00	126	502	
filamentous green (Mougeotia?)	6.00	1,583	9,495	cells collapsed
colonial green(sph)	52.00	697	36,221	
Taxon Subtotal	**64**		**85,358**	
Chrysophyta				
Dinobryon bavaricum	1.00	1,407	1,407	
Mallomonas sp.(small)	3.00	1,658	4,974	
Rhizochrysis limnetica	1.00	5,024	5,024	
chrysophyte unicell	2.00	10,638	21,277	flagellate
Bacillariophyceae				
Asterionella formosa	28.00	531	14,858	
Cyclotella glomerata	4.00	1,077	4,308	
Cyclotella sp.	1.00	2,289	2,289	
Cymbella sp.	1.00	4,689	4,689	
Fragilaria crotonensis	30.00	683	20,490	
Fragilaria sp.	50.00	792	39,600	
Melosira sp. 3	28.00	2,154	60,313	short-chain
Melosira sp.	16.00	1,077	17,232	thin-celled
Nitzschia sp.	1.00	5,652	5,652	
Stephanodiscus astraea	1.00	34,882	34,882	
Stephanodiscus niagarae	3.00	84,780	254,340	
Synedra delicatissima	3.00	1,172	3,517	
Synedra sp.	3.00	293	879	
Synedra sp.	3.00	469	1,407	stellate
Synedra sp.	2.00	167	335	
Taxon Subtotal	**181**		**497,473**	
Cryptophyta				
Cryptomonas sp.	27.00	2,110	56,972	
Cryptomonas sp.	3.00	2,713	8,139	
Rhodomonas sp.	132.00	251	33,158	
Chroomonas sp.	8.00	791	6,330	
Taxon Subtotal	**170.00**		**104,600**	
Euglenophyta				
Trachelomonas sp. (sph,smooth)	1.00	2,571	2,571	
Taxon Subtotal	**1**		**2,571**	
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**4114**	**Total Volume**	**868,866**	**0.87**
% Cyanophyta	**89.89**	% Cyanophyta	**20.59**	
% Chlorophyta	**1.56**	% Chlorophyta	**9.82**	
% Chrysophyta	**4.40**	% Chrysophyta	**57.26**	
% Cryptophyta	**4.13**	% Cryptophyta	**12.04**	
% Euglenophyta	**0.02**	% Euglenophyta	**0.30**	

Note: *=colony/ml **Note:**=filament/ml**

LAKE OSOYOOS PHYTOPLANKTON
DATE: 6/18/97
STATION: South Basin Comp (1,3,6m)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Anabaena sp.	30.00	170	5,087	short,loose coil; heterocysts
Aphanizomenon flos-aquae	247.00	118	29,146	few heterocysts
Lyngbya-like. (limnetica?)	4,740.00	19	89,302	thin-cell,faint sheath evid
Oscillatoria tenuis	442.00	129	56,848	
Taxon Subtotal	**5459**		**180,382**	
Chlorophyta				
Elakatothrix gelatinosa	2.00	126	251	
Quadrigula sp.	4.00	262	1,047	
Spondylosium sp.	4.00	1,526	6,104	
filamentous green (Mougeotia?)	25.00	1,978	49,455	cells collapsed
colonial green(sph)	40.00	268	10,718	
Taxon Subtotal	**75**		**67,575**	
Chrysophyta				
Dinobryon bavaricum	2.00	1,407	2,813	
Mallomonas sp.(small)	2.00	1,946	3,892	
chrysophyte unicell	7.00	10,132	70,922	flagellate
Bacillariophyceae				
Asterionella formosa	32.00	371	11,887	
Asterionella formosa	56.00	531	29,717	
Cyclotella sp.	1.00	2,289	2,289	
Fragilaria crotonensis	55.00	683	37,565	
Melosira italica	8.00	1,000	8,001	
Melosira sp. 3	26.00	2,462	64,006	short-chain
Stephanodiscus astraea	1.00	29,080	29,080	
Stephanodiscus niagarae	1.00	115,395	115,395	
Synedra delicatissima	1.00	1,172	1,172	
Synedra sp.	1.00	502	502	
Tabellaria fenestrata	11.00	4,800	52,800	
Taxon Subtotal	**204**		**430,041**	
Cryptophyta				
cryptomonad	11.00	754	8,290	
Cryptomonas sp.	58.00	1,231	71,391	
Cryptomonas sp.	1.00	3,768	3,768	
Rhodomonas sp.	176.00	251	44,211	
Taxon Subtotal	**246.00**		**127,660**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**5984**	**Total Volume**	**805,657**	**0.81**
% Cyanophyta	91.23	% Cyanophyta	22.39	
% Chlorophyta	1.25	% Chlorophyta	8.39	
% Chrysophyta	3.41	% Chrysophyta	53.38	
% Cryptophyta	4.11	% Cryptophyta	15.85	

Note: *=colony/ml

Note:**=filament/ml

LAKE OSOYOOS PHYTOPLANKTON
DATE: 07/14/97
STATION: North Basin Comp (1,3,6m)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Aphanizomenon flos-aquae	104.00	118	12,272	few heterocysts
Lyngbya-like (limnetica?)	5,175.00	19	97,497	thin-cell,faint sheath evid
Oscillatoria tenuis	612.00	129	78,712	
Taxon Subtotal	**5891**		**188,481**	
Chlorophyta				
Elakatothrix gelatinosa	2.00	126	251	
Quadrigula sp.	4.00	340	1,361	
filamentous green (Mougeotia?)	11.00	1,978	21,760	cells collapsed
colonial green(sph)	16.00	382	6,104	
Taxon Subtotal	**33**		**29,476**	
Chrysophyta				
Dinobryon bavaricum	22.00	1,407	30,948	
Dinobryon sp.	104.00	848	88,171	
Mallomonas sp.(small)	5.00	1,658	8,290	
chrysophyte unicell	2.00	10,638	21,277	flagellate
Bacillariophyceae				
Fragilaria crotonensis	5.00	683	3,415	
Melosira sp. 3	8.00	2,154	17,232	short-chain
Nitzschia sigmoidea	1.00	5,275	5,275	
Synedra sp.	1.00	293	293	
Synedra sp.	4.00	469	1,876	stellate
Taxon Subtotal	**152**		**176,776**	
Cryptophyta				
Cryptomonas sp.	55.00	2,110	116,054	
Rhodomonas sp.	330.00	251	82,896	
Chroomonas sp.	2.00	791	1,583	
Taxon Subtotal	**387.00**		**200,533**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**6463**	**Total Volume**	**595,267**	**0.60**
% Cyanophyta	**91.15**	% Cyanophyta	**31.66**	
% Chlorophyta	**0.51**	% Chlorophyta	**4.95**	
% Chrysophyta	**2.35**	% Chrysophyta	**29.70**	
% Cryptophyta	**5.99**	% Cryptophyta	**33.69**	

Note: *=colony/ml

Note:=filament/ml**

LAKE OSOYOOS PHYTOPLANKTON
DATE: 7/14/97
STATION: South Basin Comp
(1,3,6m)

SAMPLE STATUS: Lugol PRESERVED
--not well-pres on receipt at lab

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Lyngbya-like. (limnetica?)	1,500.00	19	28,260	thin-cell,faint sheath evid
Taxon Subtotal	**1500**		**28,260**	
Chlorophyta				
Ankistrodesmus sp.	1.00	393	393	
Botryococcus braunii	1.00	38,773	38,773	
Taxon Subtotal	**2**		**39,165**	
Chrysophyta				
Bacillariophyceae				
Asterionella formosa	4.00	371	1,486	
Fragilaria crotonensis	10.00	683	6,830	
Melosira italica	12.00	791	9,495	
Melosira sp.	10.00	1,908	19,076	
Melosira sp. 3	8.00	2,462	19,694	short-chain
Stephanodiscus niagarae	1.00	58,875	58,875	
Synedra ulna	1.00	5,652	5,652	
Synedra delicatissima	1.00	1,172	1,172	
Synedra sp.	1.00	234	234	
Synedra sp.	1.00	293	293	
Tabellaria fenestrata	12.00	4,800	57,600	
Taxon Subtotal	**61**		**180,408**	
Cryptophyta				
Rhodomonas sp.	30.00	251	7,536	
Taxon Subtotal	**30.00**		**7,536**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**1593**	**Total Volume**	**255,369**	**0.26**
% Cyanophyta	94.16	% Cyanophyta	11.07	
% Chlorophyta	0.13	% Chlorophyta	15.34	
% Chrysophyta	3.83	% Chrysophyta	70.65	
% Cryptophyta	1.88	% Cryptophyta	2.95	

Note: *=colony/ml

Note:**=filament/ml

LAKE OSOYOOS PHYTOPLANKTON
DATE: 08/12/97
STATION: North Basin Comp (1,3,6m)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Anabaena sp.	60.00	124	7,461	short,loose coil; heterocysts
Anabaena wisconsinense	24.00	50	1,206	very thin-celled
Aphanizomenon flos-aquae	104.00	118	12,272	few heterocysts
Aphanocapsa sp.	60.00	4	251	
Gomphosphaeria lacustris	40.00	16	659	
Lyngbya-like (limnetica?)	2,970.00	19	55,955	thin-cell,faint sheath evid
Oscillatoria tenuis	170.00	129	21,864	
Taxon Subtotal	**3428**		**99,668**	
Chlorophyta				
Ankistrodesmus sp.	1.00	126	126	
Sphaerocystis shroeteri	32.00	65	2,093	
colonial green(sph)	36.00	382	13,734	paired cells
Taxon Subtotal	**69**		**15,953**	
Chrysophyta				
Dinobryon sociale	6.00	742	4,451	
Mallomonas sp.	3.00	8,792	26,376	
Bacillariophyceae				
Fragilaria crotonensis	45.00	683	30,735	
Melosira sp. 3	4.00	1,583	6,330	short-chain
Synedra ulna	1.00	29,400	29,400	
Synedra acus/delicatissima grp	2.00	1,172	2,345	
Synedra sp.	4.00	469	1,876	
Synedra sp.	4.00	209	837	
Tabellaria fenestrata	1.00	5,760	5,760	
Taxon Subtotal	**70**		**108,110**	
Cryptophyta				
Cryptomonas sp.	6.00	879	5,275	
Cryptomonas erosa	9.00	1,143	10,287	
Rhodomonas sp.	198.00	251	49,738	
Taxon Subtotal	**213.00**		**65,299**	
Euglenophyta				
Pyrrhophyta				
Ceratium hirundinella	1.00	60,000	60,000	
Taxon Subtotal	**1**		**60,000**	
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**3781**	**Total Volume**	**349,031**	**0.35**
% Cyanophyta	**90.66**	% Cyanophyta	**28.56**	
% Chlorophyta	**1.82**	% Chlorophyta	**4.57**	
% Chrysophyta	**1.85**	% Chrysophyta	**30.97**	
% Cryptophyta	**5.63**	% Cryptophyta	**18.71**	
% Pyrrhophyta	**0.03**	% Pyrrhophyta	**17.19**	

Note: *=colony/ml **Note:**=filament/ml**

LAKE OSOYOOS PHYTOPLANKTON
DATE: 8/12/97
STATION: South Basin Comp (1,3,6m)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Anabaena sp.	35.00	132	4,616	short,loose coil; heterocysts
Anabaena planktonica	24.00	301	7,235	few hetero
Anabaena wisconsinense	120.00	50	6,029	very thin-celled
Aphanizomenon flos-aquae	338.00	118	39,884	few heterocysts
Aphanocapsa sp.	120.00	4	502	
Gomphosphaeria lacustris	80.00	16	1,319	
Lyngbya-like. (limnetica?)	28,875.00	19	544,005	thin-cell,faint sheath evid
Taxon Subtotal	**29592**		**603,589**	
Chlorophyta				
Ankistrodesmus sp.	1.00	167	167	
Carteria sp.	12.00	1,641	19,694	4 flagella/cell
Gloeocystis sp.	24.00	79	1,884	
Nephrocytium sp.	16.00	733	11,723	
Quadrigula sp.	4.00	262	1,047	
filamentous green (Mougeotia?)	3.00	1,374	4,121	cells collapsed
colonial green(sph)	48.00	382	18,312	paired cells
Taxon Subtotal	**108**		**56,949**	
Chrysophyta				
Dinobryon sociale	16.00	502	8,038	
Mallomonas sp. A	3.00	7,122	21,365	
Mallomonas sp.(small)	1.00	1,769	1,769	
small flagel chrysophyte	4.00	1,641	6,565	
Bacillariophyceae				
Asterionella formosa	24.00	371	8,915	
Cymbella sp.	1.00	17,584	17,584	large cell
Fragilaria crotonensis	30.00	683	20,490	
Melosira sp.	25.00	1,908	47,689	
Melosira sp. 3	4.00	1,809	7,235	short-chain
Synedra acus/delicatissima grp	2.00	1,172	2,345	
Synedra sp.	2.00	293	586	
Tabellaria fenestrata	8.00	5,600	44,800	
Taxon Subtotal	**120**		**187,380**	
Cryptophyta				
Cryptomonas ovata	1.00	3,165	3,165	
Cryptomonas erosa	5.00	1,055	5,275	
Cryptomonas sp.	4.00	628	2,512	
Rhodomonas sp.	165.00	251	41,448	
Taxon Subtotal	**175.00**		**52,400**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**29995**	**Total Volume**	**900,318**	**0.90**
% Cyanophyta	**98.66**	% Cyanophyta	**67.04**	
% Chlorophyta	**0.36**	% Chlorophyta	**6.33**	
% Chrysophyta	**0.40**	% Chrysophyta	**20.81**	
% Cryptophyta	**0.58**	% Cryptophyta	**5.82**	

Note: *=colony/ml

Note:=filament/ml**

LAKE OSOYOOS PHYTOPLANKTON
DATE: 9/17/97
STATION: South Basin Comp (1,3,6m)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Anabaena sp.	80.00	132	10,550	short,loose coil; heterocysts
Anabaena planktonica	504.00	301	151,926	few hetero
Anabaena wisconsinense	1,056.00	50	53,053	very thin-celled
Aphanizomenon flos-aquae	572.00	118	67,496	few heterocysts
Aphanocapsa sp.	180.00	4	754	
Chroococcus sp.	12.00	231	2,769	
Gomphosphaeria lacustris	200.00	16	3,297	
Lyngbya-like. (limnetica?)	11,550.00	19	217,602	thin-cell,faint sheath evid
Oscillatoria tenuis	476.00	129	61,220	
Taxon Subtotal	**14630**		**568,668**	
Chlorophyta				
Ankistrodesmus sp.	8.00	393	3,140	
Ankistrodesmus sp.	1.00	654	654	
Carteria sp.	4.00	1,641	6,565	4 flagella/cell
Pandorina morum	16.00	335	5,359	
Quadrigula sp.	14.00	262	3,663	
filamentous green (Mougeotia?)	2.00	1,374	2,748	cells collapsed
colonial green(sph)	4.00	382	1,526	paired cells
Taxon Subtotal	**49**		**23,655**	
Chrysophyta				
Dinobryon bavaricum	4.00	1,407	5,627	
Mallomonas sp. A	1.00	7,122	7,122	
Mallomonas sp.(small)	1.00	1,769	1,769	
small flagel chrysophyte	3.00	1,641	4,924	
Bacillariophyceae				
Asterionella formosa	36.00	371	13,373	
Fragilaria crotonensis	15.00	683	10,245	
Fragilaria sp.	18.00	480	8,640	
Melosira sp.	70.00	550	38,465	
Melosira sp.	24.00	1,908	45,781	
Melosira sp. 3	8.00	1,809	14,469	short-chain
Rhizosolenia sp.	4.00	10,000	40,000	
Synedra ulna	2.00	8,478	16,956	
Synedra acus/delicatissima grp	6.00	1,172	7,034	
Synedra sp.	6.00	293	1,758	
Synedra sp.	2.00	419	837	
Tabellaria fenestrata	4.00	5,600	22,400	
Taxon Subtotal	**204**		**239,399**	
Cryptophyta				
Cryptomonas erosa	3.00	1,143	3,429	
Rhodomonas sp.	44.00	251	11,053	
Taxon Subtotal	**47.00**		**14,482**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**14930**	**Total Volume**	**846,204**	**0.85**
% Cyanophyta	97.99	% Cyanophyta	67.20	
% Chlorophyta	0.33	% Chlorophyta	2.80	
% Chrysophyta	1.37	% Chrysophyta	28.29	
% Cryptophyta	0.31	% Cryptophyta	1.71	

Note: *=colony/ml

Note:**=filament/ml

LAKE OSOYOOS PHYTOPLANKTON
DATE: 09/17/97
STATION: North Basin Comp (1,3,6m)

SAMPLE STATUS: Lugol PRESERVED

Taxon	Cells/ml	µm3/cell	µm3/ml	Comments
Cyanophyta				
Anabaena planktonica	208.00	301	62,700	few heterocysts
Anabaena wisconsinense	84.00	50	4,220	very thin-celled
Aphanizomenon flos-aquae	91.00	118	10,738	few heterocysts
Aphanocapsa sp.	180.00	4	754	
Chroococcus sp.	8.00	182	1,459	
Gomphosphaeria lacustris	80.00	16	1,319	
Lyngbya-like (limnetica?)	4,125.00	19	77,715	thin-cell,faint sheath evid
Oscillatoria tenuis	34.00	129	4,373	
Taxon Subtotal	**4810**		**163,277**	
Chlorophyta				
Ankistrodesmus sp.	6.00	167	1,005	
Carteria sp.	1.00	1,641	1,641	4 flagella/cell
* *Oocystis sp.*	2.00	2,051	4,103	
* *Scenedesmus sp. A*	1.00	264	264	
filamentous green (Mougeotia?)	1.00	1,374	1,374	cells collapsed
colonial green(sph)	16.00	382	6,104	paired cells
Taxon Subtotal	**27**		**14,491**	
Chrysophyta				
Dinobryon bavaricum	2.00	1,407	2,813	
Mallomonas sp.	2.00	8,792	17,584	
Mallomonas sp.(small)	1.00	1,658	1,658	
Bacillariophyceae				
Asterionella formosa	8.00	371	2,972	
Cyclotella sp.	1.00	2,289	2,289	
Fragilaria sp.	12.00	528	6,336	
Melosira sp. 3	8.00	1,583	12,660	short-chain
Melosira sp.	108.00	352	37,981	thin-celled
Nitzschia sp.	1.00	3,140	3,140	
Rhizosolenia sp.	3.00	8,400	25,200	
Synedra acus/delicatissima grp	8.00	1,172	9,378	
Synedra sp.	7.00	469	3,282	
Synedra sp.	2.00	209	419	
Tabellaria fenestrata	4.00	3,600	14,400	
pennate diatom	2.00	294	589	
Taxon Subtotal	**169**		**140,702**	
Cryptophyta				
Cryptomonas sp.	2.00	879	1,758	
Rhodomonas sp.	44.00	251	11,053	
Chroomonas sp.	3.00	791	2,374	
Taxon Subtotal	**49.00**		**15,185**	
Euglenophyta				
Pyrrhophyta				
Chloromonadophyta				

			(um3/ml)	(mm3/L)
Total Number/ml	**5055**	**Total Volume**	**333,654**	**0.33**
% Cyanophyta	95.15	% Cyanophyta	48.94	
% Chlorophyta	0.53	% Chlorophyta	4.34	
% Chrysophyta	3.34	% Chrysophyta	42.17	
% Cryptophyta	0.97	% Cryptophyta	4.55	

Note: *=colony/ml

Note:**=filament/ml

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: North Basin (N-1)
DATE: 23 Apr 97

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	22,217	0	2.5	55,541	
Leptodiaptomus ashlandi	1.20	1.40	3,610	6	12	36,657	red-orange
Order Cyclopoida							
Copepodid		0.6-0.7	5,554	0	2	11,108	
Diacyclops bicuspidatus thomasi	1.00	1.16	1,111	3	5.5	5,415	
Nauplii (cal+cyc)		<.3	11,108	0	0.25	2,777	
Class Branchiopoda(cladocerans)							
Chydorus sphaericus		0.28	278	0	0.65	181	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	44,433	0	0.02	889	
Keratella cochlearis		0.16	199,949	0	0.01	1,999	
Keratella cochlearis (robust)		0.21	30,548	0	0.02	611	
Keratella earlineae		0.20	5,554	0	0.02	111	
Keratella hiemalis		0.14	4,166	0	0.04	167	
Keratella quadrata		0.18	5,554	0	0.069	383	
Notholca foliacea		0.20	6,943	0	0.022	153	
Notholca squamula		0.14	15,274	0	0.009	137	
Notholca acuminata (large)		0.32	6,943	0	0.09	625	
Type 2 (mostly lilloricate virgates/incudates)							
Polyarthra sp. B		0.18	18,051	0	0.09	1,625	
Synchaeta sp.		0.16	8,331	0	0.03	250	
Type 3 (mostly malleoramates)							
Filinia sp.		0.16	9,720	0	0.05	486	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	399,343	399.34	119,115	119.12
% Calanoid Copepods	6.47		77.40	
% Cyclopoid Copepods	1.67		13.87	
% Nauplii	2.78		2.33	
% Cladocerans	0.07		0.15	
% Rotifers	89.01		6.24	
% Dipterans	0.00		0.00	
No. of species in sample	15			

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: South Basin (S-1)
DATE: 23 Apr 97

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	19,083	0	2.5	47,707	
Leptodiaptomus ashlandi	1.20	1.40	3,544	6	12	32,713	red-orange
Order Cyclopoida							
Copepodid		0.6-0.7	8,178	0	2	16,357	
Diacyclops bicuspidatus thomasi	1.00	1.16	1,636	3	5.5	7,633	
Nauplii (cal+cyc)		<.3	9,541	0	0.25	2,385	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	273	0	5	1,363	
Daphnia sp. (thorata?)		1.61	273	8	25	6,815	high round hlmts
Bosmina longirostris (adult)		0.40	1,090	0	1.7	1,854	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	95,414	0	0.02	1,908	
Keratella cochlearis		0.16	327,134	0	0.01	3,271	
Keratella cochlearis (robust)		0.21	2,726	0	0.02	55	
Keratella earlineae		0.20	6,815	0	0.02	136	
Keratella hiemalis		0.14	4,089	0	0.04	164	
Keratella quadrata		0.18	36,803	0	0.069	2,539	
Notholca foliacea		0.20	13,631	0	0.022	300	
Notholca squamula		0.14	4,089	0	0.009	37	
Notholca acuminata (large)		0.32	2,726	0	0.09	245	
Type 2 (mostly lilorlcate virgates/incudates)							
Polyarthra sp. B		0.18	14,994	0	0.09	1,349	
Synchaeta sp.		0.16	10,904	0	0.03	327	
Type 3 (mostly malleoramates)							
Filinia sp.		0.16	5,452	0	0.05	273	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	568,395	568.39	127,432	127.43
% Calanoid Copepods	3.98		63.11	
% Cyclopoid Copepods	1.73		18.83	
% Nauplii	1.68		1.87	
% Cladocerans	0.29		7.87	
% Rotifers	92.33		8.32	
% Dipterans	0.00		0.00	
No. of species in sample	16			

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: North Basin (N-1)
DATE: 14 May 97

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm;
soft-bodied forms deteriorated

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	3,439	0	2.5	8,599	
Copepodid (Epischura)		<1.4	127	0	10	1,274	
Leptodiaptomus ashlandi	1.27	1.40	2,675	6	12	19,108	
Order Cyclopoida							
Copepodid		0.6-0.7	2,803	0	2	5,605	
Diacyclops bicuspidatus thomasi	1.00	1.16	127	3	5.5	701	
Nauplii (cal+cyc)		<.3	10,191	0	0.25	2,548	
Class Branchiopoda(cladocerans)							
Bosmina longirostris (adult)		0.40	127	0	1.7	217	
Bosmina longirostris (juv)		0.28	255	0	0.7	178	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	29,299	0	0.02	586	
Keratella cochlearis		0.16	101,911	0	0.01	1,019	
Keratella cochlearis (robust)		0.21	6,369	0	0.02	127	
Keratella earlineae		0.20	3,822	0	0.02	76	
Keratella quadrata		0.18	3,822	0	0.069	264	
Notholca foliacea		0.20	2,548	0	0.022	56	
Notholca acuminata (large)		0.32	1,274	0	0.09	115	
Type 2 (mostly illoricate virgates/incudat							
Polyarthra sp. B		0.18	6,369	0	0.09	573	
Synchaeta sp.		0.16	5,096	0	0.03	153	
Type 3 (mostly malleoramates)							
Filinia sp.		0.16	2,548	0	0.05	127	
Others							

	Total Density #/m3	Total Density #/L	Total Dry Wt. Biomass ug/m3	Total Dry Wt. Biomass ug/L
	182,803	182.80	41,326	41.33
% Calanoid Copepods	3.41		70.13	
% Cyclopoid Copepods	1.60		15.26	
% Nauplii	5.57		6.17	
% Cladocerans	0.21		0.96	
% Rotifers	89.20		7.49	
% Dipterans	0.00		0.00	
No. of species in sample	13			

LAKE OSOYOOS ZOOPLANKTON DATA
STATION: South Basin (S-1)
DATE: 14 May 97

WATER Environmental Services, Inc.
NOTE: Zoop net diam 20cm;
soft-bodied forms deteriorated

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	3,478	0	2.5	8,694	
Leptodiaptomus ashlandi	1.27	1.40	4,844	6	12	45,459	
Epischura nevadensis	2.10	2.17	124	20	30	2,484	
Order Cyclopoida							
Copepodid		0.6-0.7	7,452	0	2	14,904	
Diacyclops bicuspidatus thomasi	1.00	1.16	869	3	5.5	4,471	
Nauplii (cal+cyc)		<.3	11,178	0	0.25	2,795	
Class Branchiopoda(cladocerans)							
Daphnia (juv)		<1.0	621	0	5	3,105	
Bosmina longirostris (adult)		0.40	248	0	1.7	422	
Bosmina longirostris (juv)		0.28	248	0	0.7	174	
Diaphanosoma birgei		1.40	124	0	17	2,111	
Class Insecta							
Order Diptera							
PHYLUM ROTIFERA							
Type 1 (mostly loricated malleates)							
Kellicottia longispina		0.21	157,739	0	0.02	3,155	
Keratella cochlearis		0.16	186,306	0	0.01	1,863	
Keratella cochlearis (robust)		0.21	12,420	0	0.02	248	
Keratella earlineae		0.20	6,210	0	0.02	124	
Keratella quadrata		0.18	8,694	0	0.069	600	
Notholca foliacea		0.20	6,210	0	0.022	137	
Type 2 (mostly illoricate virgates/incudat							
Polyarthra sp. B		0.18	18,631	0	0.09	1,677	
Synchaeta sp.		0.16	3,726	0	0.03	112	
Type 3 (mostly malleoramates)							
Filinia sp.		0.16	2,484	0	0.05	124	
Others							

	Total Density #/m3	#/L	Total Dry Wt. Biomass ug/m3	ug/L
	431,608	431.61	92,660	92.66
% Calanoid Copepods	1.96		61.12	
% Cyclopoid Copepods	1.93		20.91	
% Nauplii	2.59		3.02	
% Cladocerans	0.29		6.27	
% Rotifers	93.24		8.68	
% Dipterans	0.00		0.00	

No. of species in sample 15

Appendix Table 10 continued
Zooplankton density results

Date	18-Jun-97	18-Jun-97	14-Jul-97	14-Jul-97	12-Aug-97	12-Aug-97	12-Aug-97	12-Aug-97	17-Sep-97	17-Sep-97
Depth	North 5-0m	South 5-0m	North 5-0m	South 5-0m	North 5-0	North 10-0m	South 5-0	South 10-0	South	North
Dilution volume ml	40	100	150	125	100	100	100	200	150	75
Volume counted ml	10	10	10	15	15	10	10	15	10	25
factor	**4.0**	**10.0**	**15.0**	**8.3**	**6.7**	**10.0**	10.0	13.3	15.0	3.0
2nd factor if necessary	8.0	20.0	15.0	25.0	2.2	1.0	2.9	3.1	1.0	1.0
	# of animals per bottle	# of animals per bottle	# of animals per bottle	# of animals per bottle	# of animals per bottle	# of animals per bottle	# of animals p	# of animals p	# of animals p	# of animals p
Copepoda Calanoid species										
(Diaptomus ashlandi sp.) males >= 1mm	32.0	160.0	645.0	75.0	360.0	490.0	220.0	426.7	225.0	3.0
(Diaptomus ashlandi sp.) males <= 1mm but	0.0	46.7	253.3	33.3	240.0	580.0	33.0	253.3	400.0	60.0
(Diaptomus ashlandi) female >= 1mm	200.0	100.0	453.3	73.3	746.7	1,240.0	37.0	333.3	360.0	26.7
(Diaptomus ashlandi) immature >=1mm Big	193.3	146.7	100.0	0.0	13.3	70.0	10.0	80.0	20.0	0.0
(Diaptomus ashlandi) immature <1mm smal	3,553.3	1,040.0	373.3	40.0	1,000.0	2,760.0	890.0	1,200.0	1,853.3	800.0
(Diaptomus ashlandi) nauplii	5,866.7	233.3	213.3	386.7	526.7	3,460.0	2,080.0	3,626.7	2,246.7	2,820.0
(Diaptomus ashlandi) eggs	960.0	746.7	4,920.0	580.0	4,426.7	6,880.0	2,690.0	3,680.0	2,500.0	253.3
total Diaptomus copepod	3,978.7	1,493.3	1,825.0	221.7	2,360.0	5,140.0	1,190.0	2,293.3	2,858.3	889.7
Epischura nevadensis males >1mm	3.0	23.0	18.0	23.0	15.6	25.0	49.2	64.6	25.0	-
Epishcura females >1mm	8.0	10.0	11.0	24.0	13.3	23.0	60.0	95.4	26.0	-
Epishcura immatures >=1mm	16.0	50.0	45.0	66.7	8.9	10.0	24.6	26.7	-	-
Epishcura immatures <1mm	8.0	40.0	45.0	25.0	2.2	-	1.5	13.3	135.0	3.0
Epishcura nauplii	8.0	90.0	60.0	16.7	40.0	100.0	70.0	53.3	480.0	-
total Calanoid copepodids	**4,013.7**	**1,616.3**	**1,944.0**	**360.3**	**2,400.0**	**5,198.0**	1,325.3	2,493.3	3,044.3	892.7
Cyclopoda total copeopod >=1mm Big	32.0	110.0	15.0	91.7	13.3	150.0	-	80.0	165.0	6.0
Cyclopoda total copeopod <1mm	72.0	160.0	120.0	83.3	66.7	90.0	70.0	40.0	165.0	75.0
cyclopoda nauplii	80.0	160.0	135.0	100.0	53.3	170.0	160.0	293.3	375.0	7.5
cyclopoda eggs	-	230.0	-	-	-	-	-	266.7	390.0	21.0
total Cyclopoid Copepods	**104.0**	**270.0**	**135.0**	**175.0**	**80.0**	**240.0**	70.0	120.0	330.0	81.0
Cladocera										
Daphnidae										
Daphnia thorata mature females >=1mm Big	124.0	220.0	165.0	166.7	54.0	140.0	88.6	58.5	10.0	27.0
Daphnia thorata mature females <1mm small	-	880.0	-	-	-	-	-	-	-	-
Daphnia thorata immature fem. >=1mm Big	92.0	100.0	105.0	100.0	23.0	92.0	11.4	15.4	5.0	6.0
Daphnia thorata immature fem. <1mm small	228.0	250.0	450.0	141.7	2.0	16.0	5.7	3.1	10.0	16.0
Daphnia thorata eggs	396.0	860.0	525.0	675.0	52.0	120.0	34.3	36.9	-	57.0
Daphnia thorata males	4.0	10.0	-	-	-	-	-	-	-	-
D. galeata =>1mm	8.0	-	45.0	-	-	-	-	-	1.0	-
D. galeata <1mm	128.0	-	-	-	-	-	-	-	4.0	4.0
Ceriodaphnia females >=1mm small										-
Ceriodaphnia females <1mm small										27.0
Ceriodaphnia eggs										6.0
Bosmina <1mm	**8.0**	**10.0**	-	-	**6.7**	-	-	-	-	33.0

Appendix Table 10 continued
Zooplankton density results

Bosmina eggs	-	10.0	-	-	-	-	-	-	-	12.0
Total Cladocerans Juves. and Adults	**592.0**	**1,470.0**	**765.0**	**408.3**	**85.7**	**248.0**	105.7	76.9	30.0	113.0
Leptodora	**1.0**	**2.0**	**3.0**	**6.0**	**6.7**	**2.0**	14.3	15.4	2.0	-
sp #1 Cycdorus sphearicus ?										
sp #2 Alona like										
Macrothrixidae										
Diaphanasoma females	**80.0**	**220.0**	**210.0**	**158.3**	**613.3**	**930.0**	310.0	453.3	18.0	51.0
Diaphanasoma eggs & embryos	56.0	160.0	480.0	166.7	473.3	740.0	380.0	533.3	4.0	18.0
Rotifera										
Keratella cochlearis	144.0	220.0	15.0	50.0	-			80.0	45.0	30.0
K. eggs	-	20.0	-	-	-			-	-	-
Keratella (quadrata)	-	20.0	-	-	6.7			133.4	-	-
K. eggs	-	20.0	-	-	-			-	15.0	-
Kellicottia	104.0	1,420.0	105.0	450.0	-	20.0	100.0	480.1	90.0	-
K. eggs	56.0	400.0	75.0	175.0	-	-	20.0	26.7	15.0	-
Polyarthra	64.0	200.0	165.0	2,125.0	-	160.0			480.0	1,170.0
P. eggs	-	-	-	50.0	-	-			135.0	30.0
collotheca mutabilis	-	100.0	75.0	375.0	-		120.0	560.7	375.0	660.0
collotheca mutabilis eggs	-	220.0	30.0	500.0	-		110.0	560.7	210.0	690.0
Notholca accuminata	-	-	-	-	-				-	-
Notholca squamula	-	-	-	-	-				-	-
Notholca foliacea	24.0	20.0	-	-	-				-	-
Notholca labis	-	-	-	-	-				-	-
Filinia	8.0	20.0	15.0	-	-				-	-
Gastropus	12.0	30.0	15.0	25.0	-				-	3.0
Synchaeta pectinata	40.0	820.0	75.0	500.0	-	-	-	-	-	5.0
Trichocerca			15.0	-	-				-	1.0
Monostyla			-	25.0	-				-	-
Bdellolde rotifer	-	-	-	-	-				-	-
Oligocheaeta	4.0	-	-	-	-				-	-
Syncheata spp (tiny)						110.0	2,040.0	1,308.3	60.0	8,730.0
Stephanocerca									30.0	-
Conochillus									30.0	-
Asplanchna priodonata										30.0
Total Rotifers	**400.0**	**2,750.0**	**405.0**	**3,175.0**	**6.7**	**290.0**	**2,140.0**	**2,001.7**	**735.0**	**9,969.0**

Appendix 11. Hydrolab Multiprobe Results 1997

23-Apr-97

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	TDS Kmg/l	DO %Sat	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 042397 092810 : RIVER INFLOW										
Variable or Calibration changed at 042397 092911										
4/23/97	92931	6.99	8.32	252	0.161	101.6	11.95	366	0.1	15.4
4/23/97	92943	6.99	8.31	252	0.161	101.6	11.95	365	0.1	15.4
Annotation at 042397 094218 : NORTH BASIN										
Variable or Calibration changed at 042397 094416										
4/23/97	94437	8.20	8.40	269	0.172	106.1	12.12	359	0.7	15.3
4/23/97	94450	8.22	8.40	269	0.172	107.1	12.22	358	0.5	15.4
4/23/97	94516	8.19	8.40	269	0.172	107.5	12.28	358	2.2	15.4
4/23/97	94545	8.15	8.39	269	0.172	107.3	12.28	358	4.2	15.3
4/23/97	94612	7.00	8.37	269	0.172	105.2	12.36	360	6.0	15.3
4/23/97	94638	6.89	8.35	265	0.169	103.8	12.23	361	7.9	15.3
4/23/97	94659	6.73	8.32	263	0.168	103.1	12.20	362	10.0	15.3
4/23/97	94724	6.53	8.32	264	0.169	102.4	12.19	361	12.0	15.3
4/23/97	94802	6.48	8.31	264	0.169	102.3	12.18	361	14.1	15.3
4/23/97	94817	6.38	8.31	266	0.17	102.3	12.22	361	16.2	15.3
4/23/97	94846	6.26	8.30	267	0.171	101.8	12.19	362	18.2	15.3
4/23/97	94908	6.18	8.30	269	0.172	101.7	12.20	362	20.1	15.3
4/23/97	94942	6.08	8.30	270	0.173	101.6	12.22	362	22.0	15.3
4/23/97	95007	6.07	8.29	271	0.174	101.5	12.22	362	24.0	15.3
4/23/97	95035	5.92	8.28	272	0.174	101.6	12.27	362	26.0	15.3
4/23/97	95055	5.81	8.28	272	0.174	101	12.24	362	28.2	15.3
4/23/97	95124	5.69	8.28	272	0.174	100.6	12.22	362	30.0	15.3
4/23/97	95207	5.57	8.26	272	0.174	99.8	12.16	363	32.0	15.3
4/23/97	95239	5.51	8.25	273	0.174	99.4	12.13	363	33.8	15.3
4/23/97	95301	5.41	8.24	273	0.175	99.3	12.16	364	35.9	15.3
4/23/97	95321	5.36	8.25	273	0.175	99.3	12.17	363	37.6	15.3
4/23/97	95351	5.37	8.24	273	0.175	99.2	12.16	363	40.5	15.3
4/23/97	95408	5.36	8.24	273	0.175	99.3	12.16	363	41.6	15.2
4/23/97	95432	5.36	8.24	273	0.175	99.3	12.16	363	44.1	15.3
4/23/97	95529	5.29	8.24	273	0.175	99.3	12.19	363	46.0	15.3
4/23/97	95547	5.26	8.23	273	0.175	99	12.16	363	47.7	15.3
4/23/97	95607	5.27	8.23	273	0.175	98.8	12.13	363	49.4	15.3
Annotation at 042397 105753 : CENTRAL BASIN										
4/23/97	105908	7.86	8.41	272	0.174	108	12.43	428	0.1	15.3
4/23/97	105923	7.84	8.41	273	0.175	108	12.44	427	0.5	15.3
4/23/97	105944	7.83	8.41	272	0.174	107.8	12.42	426	2.0	15.3
4/23/97	110010	7.78	8.41	270	0.173	107.9	12.44	426	3.9	15.3
4/23/97	110031	7.71	8.40	266	0.17	107.6	12.43	426	6.2	15.3
4/23/97	110050	7.66	8.39	276	0.177	107.2	12.40	426	8.1	15.3
4/23/97	110108	7.61	8.39	271	0.173	106.9	12.38	426	9.9	15.2
4/23/97	110128	7.59	8.39	285	0.182	106.7	12.36	426	11.8	15.3
4/23/97	110147	7.38	8.38	271	0.173	106.3	12.39	426	14.0	15.3
4/23/97	110205	7.27	8.38	267	0.171	106	12.37	426	15.8	15.2
Annotation at 042397 111020 : BOUNDARY POINT										
4/23/97	111217	9.03	8.53	278	0.178	110.8	12.40	420	0.5	15.2
4/23/97	111240	8.98	8.54	281	0.18	110.7	12.40	419	1.9	15.2
4/23/97	111314	8.89	8.55	272	0.174	110.3	12.38	418	4.2	15.2
4/23/97	111338	8.43	8.53	269	0.172	110.1	12.50	419	6.1	15.2
4/23/97	111359	8.27	8.52	280	0.179	110.3	12.57	419	8.3	15.2
4/23/97	111431	8.02	8.52	270	0.172	110.2	12.64	419	10.2	15.2
4/23/97	111447	7.97	8.52	287	0.183	109.8	12.61	419	12.1	15.2
4/23/97	111513	7.81	8.49	266	0.17	108.2	12.47	419	14.1	15.2
4/23/97	111529	7.69	8.48	285	0.182	107.4	12.41	419	16.2	15.2
4/23/97	111547	7.50	8.47	275	0.176	106.4	12.35	419	18.1	15.2
4/23/97	111616	7.50	8.46	282	0.181	104.7	12.15	419	20.0	15.2
4/23/97	111632	7.14	8.42	281	0.18	103.5	12.12	421	22.1	15.2
Annotation at 042397 115215 : MID										
4/23/97	115506	9.20	8.48	276	0.177	109.9	12.24	424	0.2	15.2
4/23/97	115528	9.04	8.49	277	0.177	110.4	12.35	423	0.5	15.2
4/23/97	115600	8.81	8.51	273	0.175	110.5	12.43	422	1.9	15.2
4/23/97	115652	8.53	8.52	284	0.182	110.3	12.49	420	4.2	15.2
4/23/97	115710	7.96	8.52	269	0.172	108.8	12.49	421	5.9	15.3
4/23/97	115735	7.53	8.50	266	0.17	107.2	12.44	421	7.9	15.2
4/23/97	115808	7.50	8.49	270	0.173	106.3	12.34	421	9.8	15.2
4/23/97	115839	7.48	8.48	283	0.181	106.1	12.32	420	11.2	15.2
4/23/97	115915	7.48	8.48	271	0.174	105.8	12.29	420	12.1	15.2
4/23/97	120003	7.33	8.46	269	0.172	104.4	12.17	420	14.0	15.1
4/23/97	120044	7.33	8.45	268	0.172	104.1	12.14	419	16.0	15.1
4/23/97	120117	7.32	8.44	265	0.169	103.8	12.10	420	18.1	15.1
4/23/97	120142	7.27	8.44	285	0.183	103.4	12.07	419	20.1	15.1
4/23/97	120224	7.12	8.40	278	0.178	101.9	11.94	420	22.0	15.2
4/23/97	120236	7.04	8.39	277	0.177	101	11.87	420	22.5	15.2
Annotation at 042397 121037 : SCB										
4/23/97	121319	8.42	8.52	278	0.178	109.3	12.41	398	0.2	15.3
4/23/97	121342	8.25	8.52	278	0.178	109	12.42	398	1.7	15.1
4/23/97	121402	7.94	8.52	278	0.178	108.5	12.47	398	4.3	15.1
4/23/97	121431	7.65	8.50	277	0.177	106.4	12.31	400	5.9	15.1
4/23/97	121458	7.51	8.49	279	0.178	105.3	12.22	400	8.0	15.1
4/23/97	121539	7.46	8.47	278	0.178	104.2	12.11	400	10.2	15.2
4/23/97	121611	7.42	8.45	279	0.179	102.7	11.95	401	12.1	15.2
4/23/97	121643	7.40	8.43	285	0.182	100.8	11.73	401	14.0	15.1
4/23/97	121700	7.37	8.40	280	0.179	99.6	11.60	402	15.4	15.1
Annotation at 042397 123346 : RIV OUT										
4/23/97	123618	8.48	8.53	279	0.179	108.9	12.35	371	0.3	15.1
4/23/97	123629	8.46	8.53	280	0.179	109.2	12.39	371	1.7	15.1
4/23/97	123637	8.45	8.53	278	0.178	109.2	12.39	371	1.9	15.1

Recovery finished at 042497 154633

Appendix 11. Hydrolab Multiprobe Results 1997
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Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	TDS Kmg/l	DO %Sat	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 051497 112317 : RV IN										
Variable or Calibration changed at 051497 112530										
51497	112620	11.90	7.84	226	0.145	99.6	10.39	420	0.4	14.3
Annotation at 051497 114142 : NO BASIN										
Variable or Calibration changed at 051497 114302										
51497	114430	14.32	8.12	243	0.155	107.3	10.6	399	0.5	13.2
51497	114449	13.38	8.13	232	0.149	104.9	10.6	399	1.1	13.1
51497	114512	11.90	8.11	224	0.143	100.6	10.5	401	2.0	13.1
51497	114545	11.20	8.08	237	0.152	98.3	10.4	401	4.1	13.1
51497	114557	11.18	8.08	238	0.153	98.3	10.4	401	4.2	13
51497	114812	11.00	8.09	241	0.154	99.4	10.6	398	6.0	12.9
51497	114839	10.70	8.08	241	0.154	98.4	10.6	398	8.1	12.9
51497	114920	10.39	8.07	250	0.16	97.8	10.6	398	10.2	12.8
51497	115004	10.23	8.07	249	0.16	97.1	10.5	398	12.0	12.8
51497	115026	9.84	8.07	249	0.159	96.3	10.6	398	14.2	12.8
51497	115052	9.22	8.06	255	0.163	95.0	10.6	398	15.7	12.8
51497	115132	8.55	8.05	258	0.165	94.3	10.7	399	18.2	12.7
51497	115217	7.45	8.03	262	0.168	92.1	10.7	400	20.0	12.7
51497	115243	7.02	8.02	264	0.169	91.1	10.7	400	22.1	12.7
51497	115315	6.56	7.99	267	0.171	89.5	10.6	401	24.2	12.7
51497	115343	6.48	7.98	267	0.171	88.7	10.5	401	26.0	12.7
51497	115414	6.40	7.96	268	0.172	88.4	10.5	401	27.9	12.6
51497	115441	6.37	7.95	268	0.172	88.4	10.5	401	30.0	12.6
51497	115553	6.35	7.95	269	0.172	88.5	10.6	400	32.1	12.6
51497	115714	6.33	7.94	269	0.172	88.1	10.5	400	34.2	12.5
51497	115800	6.30	7.93	269	0.172	87.4	10.4	400	36.1	12.5
51497	115844	6.23	7.92	269	0.172	87.4	10.4	399	38.2	12.5
51497	115914	6.15	7.92	270	0.173	87.1	10.4	399	40.1	12.5
51497	115952	6.07	7.92	270	0.173	87.0	10.4	399	42.1	12.4
51497	120049	5.99	7.91	271	0.173	87.0	10.5	398	44.0	12.4
51497	120133	5.94	7.91	270	0.173	87.0	10.5	398	46.0	12.4
51497	120225	5.87	7.90	271	0.174	86.8	10.5	398	48.1	12.3
51497	120302	5.84	7.90	271	0.174	86.8	10.5	398	49.6	12.3
Annotation at 051497 125059 : CENT										
51497	125430	13.92	8.20	263	0.168	106.9	10.7	426	0.5	13.2
51497	125507	13.94	8.20	262	0.168	107.0	10.7	424	1.0	13.1
51497	125543	13.78	8.21	256	0.164	106.9	10.7	423	2.0	13.1
51497	125623	13.08	8.21	258	0.164	105.7	10.7	423	4.0	13
51497	125700	12.70	8.20	257	0.164	104.3	10.7	422	6.1	13
51497	125746	12.61	8.19	257	0.164	103.5	10.6	421	8.0	12.9
51497	125830	12.47	8.18	257	0.164	102.7	10.6	421	10.1	12.9
51497	125909	12.29	8.17	257	0.164	101.9	10.5	420	12.1	12.9
51497	125954	11.98	8.17	256	0.164	100.9	10.5	420	14.1	12.8
51497	130045	11.74	8.14	258	0.165	98.1	10.3	420	16.2	12.8
51497	130100	11.34	8.11	260	0.166	94.9	10.0	421	16.9	12.7
Annotation at 051497 130904 : BOUND										
51497	131210	17.80	8.40	274	0.175	112.0	10.3	417	0.5	13.1
51497	131232	16.34	8.40	274	0.175	113.3	10.7	417	0.9	13
51497	131302	15.07	8.34	263	0.168	110.9	10.8	419	2.0	13
51497	131337	12.49	8.30	260	0.166	103.7	10.7	422	4.0	13
51497	131430	11.95	8.31	266	0.17	103.3	10.8	420	6.1	12.9
51497	131456	11.44	8.27	267	0.171	100.5	10.6	422	8.0	12.9
51497	131531	10.87	8.21	269	0.172	95.5	10.2	423	10.0	12.8
51497	131606	10.05	8.13	272	0.174	88.2	9.6	426	12.0	12.8
51497	131640	9.45	8.07	275	0.176	84.1	9.3	427	14.0	12.8
51497	131724	8.97	8.01	276	0.177	79.9	8.9	429	16.0	12.7
51497	131822	8.53	7.96	277	0.178	76.9	8.7	430	18.1	12.7
51497	131909	8.38	7.94	278	0.178	76.1	8.6	430	20.0	12.7
51497	131945	8.17	7.94	278	0.178	77.2	8.8	429	22.0	12.6
51497	132022	7.91	7.88	280	0.179	71.3	8.2	431	24.0	12.6
51497	132037	7.91	7.86	280	0.179	68.5	7.9	431	24.7	12.6
Annotation at 051497 133944 : HALF										
51497	135353	16.76	8.42	271	0.174	114.0	10.7	401	0.5	13.2
51497	135405	15.17	8.43	270	0.173	113.2	11.0	402	1.0	13.2
51497	135434	14.30	8.37	264	0.169	110.8	11.0	404	2.0	13.1
51497	135457	13.05	8.35	262	0.168	108.9	11.1	405	3.8	13.1
51497	135515	12.20	8.31	264	0.169	105.3	10.9	407	6.0	13.1
51497	135541	11.44	8.27	269	0.172	98.6	10.4	408	8.1	13
51497	135602	10.93	8.22	269	0.172	95.4	10.2	410	10.1	13
51497	135619	10.93	8.20	269	0.172	94.2	10.1	410	10.1	13
51497	135643	10.51	8.16	272	0.174	91.2	9.8	411	12.1	13
51497	135712	9.35	8.10	275	0.176	84.8	9.4	413	14.1	12.9
51497	135747	8.81	8.04	276	0.177	81.3	9.1	415	16.1	12.9
51497	135823	8.40	7.99	278	0.178	77.0	8.7	417	18.0	12.9
51497	135901	8.35	7.95	279	0.178	75.6	8.6	417	20.1	12.8
51497	135919	8.25	7.93	279	0.178	74.7	8.5	417	22.1	12.8
51497	135933	8.22	7.92	279	0.178	73.8	8.4	417	22.6	12.8
Annotation at 051497 140553 : SCB										
51497	140907	17.46	8.43	276	0.177	114.2	10.6	399	0.5	13.3
51497	140927	17.21	8.43	275	0.176	113.5	10.6	399	1.0	13.3
51497	140957	14.67	8.46	274	0.175	113.2	11.1	399	2.1	13.2
51497	141035	12.66	8.41	266	0.17	107.9	11.1	401	4.1	13.2
51497	141112	12.23	8.40	270	0.173	106.4	11.0	401	6.1	13.1
51497	141134	11.90	8.36	270	0.173	104.2	10.9	402	8.0	13
51497	141206	11.16	8.26	272	0.174	96.0	10.2	405	9.9	13
51497	141243	9.95	8.12	273	0.175	85.3	9.3	410	12.1	13
51497	141412	9.99	8.05	273	0.175	84.4	9.2	410	12.1	12.9
51497	141443	9.30	8.01	275	0.176	80.7	9.0	412	14.0	12.9
51497	141510	8.73	7.95	280	0.179	75.0	8.4	415	16.0	12.8
Annotation at 051497 142156 : RV OUT										
51497	142648	17.01	8.49	274	0.175	116.5	10.9	413	0.4	13.2
51497	142716	17.28	8.49	276	0.177	115.7	10.7	411	0.5	13.2
51497	142728	17.08	8.50	276	0.176	115.3	10.8	410	0.5	13.2
Recovery finished at 051497 211838										

Appendix 11. Hydrolab Multiprobe Results 1997
19-Jun-97

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	TDS Kmg/l	DO %Sat	DO mg/l	Depth meters	Batt volts
Annotation at 061897 095927 : RV IN									
Variable or Calibration changed at 061897 100239									
61897	100321	18.77	8.41	235	0.15	97.90	8.82	0.5	13.2
61897	100335	18.77	8.40	235	0.15	98.00	8.83	0.5	13.2
Annotation at 061897 101508 : NO BASIN									
61897	101656	19.41	8.33	232	0.148	95.90	8.52	0.5	13.2
61897	101715	19.13	8.31	231	0.148	95.40	8.53	1.1	13.2
61897	101739	19.03	8.28	231	0.148	95.10	8.52	2.1	13.1
61897	101822	18.77	8.26	230	0.147	95.50	8.60	4.0	13.1
61897	101843	18.62	8.24	229	0.147	95.10	8.59	6.0	13.1
61897	101923	18.16	8.21	229	0.147	93.10	8.49	8.0	13
61897	102005	16.92	8.15	228	0.146	90.20	8.44	10.0	13
61897	102026	14.52	8.11	230	0.147	86.20	8.49	12.0	13
61897	102100	13.48	8.06	232	0.148	84.30	8.49	14.0	12.9
61897	102122	12.08	8.02	238	0.152	82.50	8.58	16.0	12.9
61897	102159	10.98	7.99	244	0.156	81.20	8.66	18.0	12.9
61897	102300	9.27	7.94	253	0.162	79.30	8.80	19.9	12.8
61897	102344	8.24	7.91	258	0.165	77.20	8.78	21.9	12.8
61897	102424	7.99	7.89	260	0.166	76.30	8.73	23.8	12.7
61897	102506	7.66	7.87	260	0.166	75.10	8.66	26.0	12.7
61897	102553	7.61	7.86	261	0.167	74.70	8.63	27.9	12.7
61897	102637	7.42	7.84	263	0.168	74.40	8.63	30.1	12.6
61897	102717	7.33	7.84	262	0.168	74.10	8.62	31.9	12.6
61897	102752	7.30	7.83	262	0.168	73.80	8.59	34.0	12.7
61897	102817	7.22	7.82	262	0.168	73.50	8.58	36.0	12.6
61897	102857	7.11	7.81	264	0.169	72.20	8.45	38.1	12.4
61897	102945	7.06	7.80	264	0.169	72.20	8.45	40.1	12.5
61897	103037	7.04	7.79	264	0.169	71.90	8.43	42.1	12.5
61897	103054	6.99	7.79	265	0.169	71.90	8.43	44.0	12.5
61897	103125	6.94	7.79	265	0.169	71.80	8.43	45.9	12.4
61897	103155	6.88	7.78	265	0.169	71.60	8.43	47.9	12.4
61897	103212	6.89	7.78	265	0.169	71.60	8.42	50.0	12.4
Annotation at 061897 110159 : CEN									
61897	110308	18.79	8.25	230	0.147	96.60	8.70	0.4	13.3
61897	110335	18.59	8.24	229	0.147	95.90	8.67	1.0	13.2
61897	110402	18.45	8.22	229	0.147	95.50	8.66	2.0	13.2
61897	110429	18.38	8.20	230	0.147	94.40	8.57	3.9	13.1
61897	110446	18.33	8.19	229	0.147	94.40	8.58	6.0	13.1
61897	110506	18.25	8.18	229	0.147	94.10	8.56	8.0	13.1
61897	110533	18.19	8.17	230	0.147	93.10	8.48	10.0	13
61897	110555	18.18	8.16	230	0.147	93.00	8.47	12.0	13
61897	110639	18.18	8.16	230	0.147	92.90	8.46	14.1	13
61897	110701	18.18	8.16	230	0.147	92.70	8.45	16.0	12.9
61897	110719	17.89	8.13	231	0.148	88.00	8.07	18.0	12.9
61897	110739	16.99	8.07	234	0.15	79.30	7.41	18.5	12.9
Annotation at 061897 111526 : BOUN									
61897	111558	20.24	8.33	235	0.15	99.80	8.73	0.5	13.3
61897	111629	19.98	8.35	235	0.15	100.10	8.80	0.9	13.2
61897	111649	19.86	8.34	235	0.15	99.50	8.77	2.0	13.2
61897	111709	19.69	8.32	235	0.151	98.70	8.73	4.0	13.2
61897	111730	19.22	8.27	236	0.151	96.50	8.61	6.0	13.1
61897	111745	17.40	8.19	239	0.153	88.30	8.18	8.0	13.1
61897	111812	15.37	8.05	247	0.158	75.60	7.31	10.0	13.1
61897	111826	12.95	7.98	262	0.168	66.40	6.77	12.0	13
61897	111916	11.95	7.85	267	0.171	50.40	5.25	14.1	13
61897	111952	11.39	7.80	270	0.173	45.70	4.83	16.0	13
61897	112024	11.08	7.75	272	0.174	43.90	4.67	18.0	12.9
61897	112058	10.89	7.72	273	0.174	43.30	4.62	20.0	12.9
61897	112129	10.25	7.69	275	0.176	38.40	4.17	22.0	13
Annotation at 061897 114056 : HALF									
61897	114144	20.59	8.31	236	0.151	100.40	8.72	0.5	13.3
61897	114214	20.00	8.34	235	0.151	100.50	8.83	1.0	13.2
61897	114238	19.75	8.34	235	0.151	100.00	8.83	2.0	13.2
61897	114335	19.48	8.32	235	0.15	97.90	8.69	4.0	13.1
61897	114416	18.62	8.25	238	0.152	95.10	8.59	6.0	13.1
61897	114507	16.69	8.10	242	0.155	83.20	7.82	8.0	13
61897	114557	15.15	7.96	249	0.159	71.40	6.93	9.9	12.9
61897	114636	13.86	7.88	255	0.163	62.10	6.20	12.0	12.9
61897	114751	11.95	7.77	267	0.171	48.50	5.06	14.0	12.8
61897	114829	11.29	7.72	271	0.174	42.10	4.45	16.1	12.8
61897	114927	10.61	7.66	274	0.175	36.10	3.88	18.0	12.7
61897	114956	10.36	7.64	276	0.176	34.80	3.76	20.0	12.7
61897	115011	10.35	7.62	276	0.176	33.80	3.66	21.4	12.7
Annotation at 061897 115444 : SCB									
61897	115550	20.54	8.30	235	0.151	100.10	8.70	0.5	13.3
61897	115617	19.86	8.33	235	0.151	99.40	8.76	1.0	13.2
61897	115644	19.48	8.33	235	0.15	98.90	8.78	2.0	13.2
61897	115710	19.00	8.31	238	0.152	97.60	8.75	4.0	13.1
61897	115748	17.60	8.19	240	0.154	89.70	8.27	6.0	13.1
61897	115815	17.41	8.14	241	0.154	88.40	8.19	7.9	13.1
61897	115838	17.38	8.13	241	0.154	88.00	8.16	8.1	13
61897	115924	15.42	8.00	248	0.159	74.20	7.17	10.1	13
61897	120009	13.63	7.87	258	0.165	58.20	5.85	12.0	12.9
61897	120056	11.93	7.75	268	0.172	38.90	4.06	14.0	12.9
61897	120138	11.61	7.68	270	0.173	34.30	3.60	16.0	12.8
61897	120146	11.59	7.67	271	0.174	34.00	3.58	16.3	12.8
Annotation at 061897 121308 : RV OUT									
61897	121342	19.05	8.28	238	0.152	99.00	8.86	0.6	13.3
61897	121354	19.08	8.3	238	0.152	98.70	8.84	0.6	13.3
Recovery finished at 061897 205739									

Appendix 11. Hydrolab Multiprobe Results 1997
14-Jul-97

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	TDS Kmg/l	DO %Sat	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 071497 095635 : RV IN										
Variable or Calibration changed at 071497 095742										
71497	95826	19.81	8.32	241	0.154	99.8	8.8	327	0.2	14.9
71497	95837	19.81	8.32	241	0.154	99.8	8.8	326	0.2	14.9
71497	95850	19.82	8.32	242	0.155	99.8	8.8	326	0.2	14.9
Annotation at 071497 101106 : NO. BASIN										
71497	101248	20.59	8.41	237	0.152	103.3	9.0	368	0.4	14.8
71497	101339	20.34	8.42	238	0.152	103.7	9.1	363	1.0	14.9
71497	101408	20.08	8.41	237	0.151	103.6	9.1	362	2.1	14.8
71497	101436	19.44	8.35	238	0.152	100.1	8.9	364	4.1	14.8
71497	101511	18.84	8.30	239	0.153	96.6	8.7	364	6.0	14.8
71497	101615	18.26	8.19	237	0.152	90.8	8.3	365	8.0	14.8
71497	101644	18.06	8.16	238	0.152	90.4	8.3	365	10.1	14.8
71497	101722	17.36	8.10	235	0.15	86.3	8.0	367	12.0	14.8
71497	101806	15.72	8.00	235	0.15	79.3	7.6	371	14.1	14.8
71497	101844	12.72	7.93	240	0.154	74.1	7.6	374	16.0	14.8
71497	101914	10.16	7.89	253	0.162	71.0	7.7	377	18.1	14.8
71497	101936	8.73	7.85	260	0.166	69.1	7.8	379	20.0	14.8
71497	101947	8.71	7.84	260	0.167	68.6	7.7	379	19.9	14.8
71497	102013	8.29	7.81	262	0.168	67.9	7.7	380	22.0	14.8
71497	102033	8.12	7.79	262	0.168	67.3	7.7	380	24.0	14.8
71497	102129	8.02	7.75	262	0.168	66.2	7.6	380	26.0	14.8
71497	102200	7.89	7.72	263	0.168	65.5	7.5	380	27.9	14.8
71497	102239	7.83	7.71	263	0.168	64.8	7.5	380	30.0	14.8
71497	102329	7.78	7.68	263	0.168	63.8	7.3	380	31.8	14.8
71497	102410	7.68	7.66	263	0.168	63.0	7.3	380	34.0	14.8
71497	102444	7.68	7.65	264	0.169	63.0	7.3	380	36.1	14.8
71497	102545	7.66	7.64	264	0.169	63.1	7.3	380	37.9	14.8
71497	102619	7.63	7.63	263	0.168	62.4	7.2	379	40.0	14.8
71497	102709	7.63	7.62	264	0.169	61.7	7.1	379	42.1	14.8
71497	102748	7.61	7.62	264	0.169	61.9	7.2	379	44.1	14.8
71497	102818	7.56	7.61	264	0.169	62.5	7.2	378	46.1	14.8
71497	102854	7.48	7.62	264	0.169	62.9	7.3	378	48.1	14.8
71497	102913	7.45	7.62	264	0.169	63.0	7.3	378	50.0	14.7
Annotation at 071497 105421 : CEN. BAS.										
71497	110544	20.94	8.38	242	0.155	102.3	8.8	390	0.6	14.8
71497	110642	20.67	8.37	240	0.153	101.8	8.8	387	1.0	14.8
71497	110722	19.96	8.36	237	0.152	99.5	8.8	386	2.1	14.8
71497	110759	19.75	8.32	238	0.151	97.6	8.6	386	4.0	14.8
71497	110812	19.60	8.29	236	0.151	96.3	8.5	387	6.1	14.8
71497	110849	19.55	8.27	233	0.149	94.2	8.4	388	8.0	14.7
71497	110912	19.53	8.26	236	0.151	93.9	8.3	385	10.0	14.7
71497	111003	19.51	8.25	230	0.147	93.0	8.3	384	12.0	14.8
71497	111033	19.38	8.22	243	0.155	90.7	8.1	384	14.1	14.8
71497	111104	19.31	8.18	243	0.156	88.1	7.9	384	16.0	14.8
71497	111116	19.13	8.17	236	0.151	87.2	7.8	387	17.6	14.8
Annotation at 071497 111143 : BOUN. PT.										
Annotation at 071497 112159 : BP										
71497	112307	23.08	8.53	243	0.155	106.2	8.8	368	0.5	14.8
71497	112334	22.38	8.53	242	0.155	107.5	9.0	366	0.9	14.7
71497	112404	21.92	8.54	241	0.154	108.3	9.2	365	2.0	14.8
71497	112444	19.89	8.41	236	0.151	99.5	8.8	370	4.0	14.7
71497	112506	19.72	8.43	242	0.155	100.8	8.9	368	6.0	14.8
71497	112622	19.56	8.34	236	0.151	95.8	8.5	369	7.0	14.8
71497	112658	19.03	8.22	242	0.155	84.8	7.6	373	8.0	14.8
71497	112813	17.92	7.94	243	0.156	63.3	5.8	381	9.0	14.8
71497	112901	15.58	7.76	251	0.161	39.6	3.8	389	10.0	14.8
71497	113019	14.50	7.64	262	0.168	31.3	3.1	391	11.1	14.8
71497	113106	13.89	7.60	267	0.171	25.3	2.5	392	12.0	14.7
71497	113155	13.46	7.55	268	0.172	20.9	2.1	394	13.0	14.8
71497	113247	12.98	7.50	264	0.169	16.2	1.7	394	14.0	14.7
71497	113332	12.74	7.49	259	0.166	15.6	1.6	394	15.1	14.7
71497	113437	12.52	7.46	267	0.171	13.5	1.4	394	16.0	14.7
71497	113534	12.29	7.44	264	0.169	10.8	1.1	395	17.1	14.8
71497	113623	12.10	7.42	263	0.168	9.3	1.0	395	18.0	14.8
71497	113703	11.97	7.41	265	0.17	8.4	0.9	394	19.0	14.8
71497	113729	11.74	7.41	280	0.179	6.9	0.7	395	20.0	14.6
71497	113819	11.54	7.39	270	0.173	4.4	0.5	395	21.0	14.8
71497	113847	11.10	7.38	279	0.179	3.3	0.4	395	22.1	14.8
71497	113859	10.90	7.38	285	0.183	3.3	0.4	387	22.7	14.8
Annotation at 071497 120632 : HALF										
71497	120705	22.67	8.47	240	0.154	106.6	8.9	349	0.5	14.8
71497	120736	22.21	8.49	240	0.153	106.2	8.9	348	1.0	14.8
71497	120803	21.55	8.50	240	0.154	105.8	9.0	348	2.1	14.8
71497	120835	19.86	8.44	239	0.153	100.0	8.8	350	4.0	14.8
71497	120922	19.43	8.34	239	0.153	92.3	8.2	353	6.0	14.8
71497	121016	18.72	8.10	239	0.153	76.7	6.9	361	8.0	14.8
71497	121102	17.43	7.91	245	0.157	58.6	5.4	367	10.0	14.7
71497	121212	14.57	7.70	260	0.167	30.8	3.0	375	11.9	14.8
71497	121304	12.80	7.60	271	0.173	16.5	1.7	380	14.0	14.8
71497	121353	12.38	7.54	277	0.177	13.2	1.4	381	16.1	14.8
71497	121511	12.08	7.49	277	0.177	7.3	0.8	382	17.9	14.8
71497	121545	12.00	7.47	275	0.176	6.2	0.7	382	20.0	14.7
71497	121616	11.87	7.46	277	0.177	5.8	0.6	382	22.0	14.7
71497	121654	11.80	7.44	275	0.176	5.1	0.5	382	23.8	14.8
71497	121710	11.74	7.46	272	0.174	4.7	0.5	330	24.7	14.8
Annotation at 071497 121720 : SCB										
71497	122254	22.28	8.45	240	0.154	105.9	8.9	319	0.6	14.8
71497	122328	21.53	8.50	240	0.153	105.3	9.0	318	0.9	14.8
71497	122402	20.90	8.50	241	0.154	104.5	9.0	319	2.0	14.7
71497	122436	19.81	8.44	237	0.152	99.8	8.8	321	4.1	14.8
71497	122527	19.34	8.29	237	0.152	90.5	8.1	326	6.1	14.7
71497	122610	19.10	8.15	242	0.155	81.4	7.3	330	8.0	14.7
71497	122712	17.94	7.90	249	0.159	50.4	4.6	339	10.0	14.8
71497	122819	13.51	7.67	267	0.171	17.7	1.8	352	12.0	14.8
71497	122914	12.31	7.58	278	0.178	8.5	0.9	355	14.0	14.8
71497	122921	12.33	7.55	276	0.177	8.4	0.9	355	14.1	14.7
Annotation at 071497 122940 : RV. OUT										
71497	125056	21.22	8.52	240	0.154	105.2	9.0	334	0.6	14.7
71497	125115	21.22	8.53	240	0.154	105.1	9.0	333	0.6	14.7
71497	125128	21.22	8.53	240	0.154	105.2	9.0	333	0.6	14.7

Appendix 11. Hydrolab Multiprobe Results 1997

13-Aug-97 Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	TDS Kmg/l	DO %Sat	DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 081397 092146 : RV IN										
81397	92949	21.76	8.19	253	0.162	98.2	8.3	323	0.3	12.9
81397	92958	21.68	8.19	254	0.162	98.4	8.4	323	0.3	12.8
Annotation at 081397 093828 : NO. BASIN										
Variable or Calibration changed at 081397 094009										
81397	94152	22.63	8.33	251	0.161	104.8	8.7	333	0.5	13.3
81397	94221	22.53	8.32	252	0.161	103.0	8.6	332	1.1	13.1
81397	94317	22.38	8.31	252	0.161	101.8	8.5	330	2.2	13
81397	94341	22.14	8.28	252	0.161	100.3	8.5	332	4.0	13
81397	94404	21.68	8.23	252	0.161	97.2	8.3	333	6.0	13
81397	94463	21.57	8.19	252	0.161	94.6	8.1	333	8.1	12.9
81397	94517	21.39	8.17	250	0.16	93.3	8.0	333	10.1	12.9
81397	94548	20.97	8.14	248	0.159	90.8	7.8	334	12.1	12.9
81397	94614	15.77	7.98	240	0.153	67.5	6.5	347	14.0	12.8
81397	94645	13.17	7.84	244	0.156	61.6	6.2	352	16.0	12.8
81397	94709	13.25	7.78	243	0.156	61.2	6.2	353	16.0	12.8
81397	94730	11.21	7.74	250	0.16	60.3	6.4	355	17.9	12.8
81397	94752	9.20	7.71	259	0.166	59.3	6.6	356	19.9	12.7
81397	94832	8.58	7.65	261	0.167	56.9	6.4	357	22.2	12.7
81397	94944	8.42	7.59	261	0.167	55.8	6.3	357	23.9	12.8
81397	95013	8.30	7.57	262	0.167	55.6	6.3	357	25.9	12.6
81397	95034	8.25	7.56	262	0.167	55.3	6.3	357	28.0	12.6
81397	95057	8.17	7.54	262	0.167	54.8	6.3	357	30.0	12.6
81397	95115	8.07	7.53	263	0.168	54.1	6.2	357	31.9	12.6
81397	95144	8.04	7.52	263	0.168	53.0	6.1	357	34.0	12.6
81397	95239	7.99	7.50	264	0.169	52.5	6.0	356	36.0	12.5
81397	95304	7.96	7.49	263	0.168	51.8	5.9	356	38.0	12.5
81397	95413	7.92	7.46	264	0.169	51.2	5.9	356	40.1	12.5
81397	95501	7.89	7.45	265	0.169	51.0	5.9	356	42.2	12.4
81397	95543	7.89	7.44	264	0.169	50.7	5.8	356	44.0	12.4
81397	95607	7.88	7.44	265	0.169	50.5	5.8	356	46.1	12.4
81397	95628	7.83	7.43	265	0.169	50.4	5.8	356	48.0	12.4
81397	95650	7.79	7.43	265	0.169	50.3	5.8	356	49.8	12.4
Annotation at 081397 104232 : CEN.										
81397	104326	23.33	8.36	250	0.16	105.8	8.7	385	0.2	13.2
81397	104349	23.23	8.38	250	0.16	105.6	8.7	382	0.5	13.3
81397	104419	23.19	8.38	251	0.161	106.2	8.8	380	1.0	13.1
81397	104508	22.87	8.40	250	0.16	106.0	8.8	376	2.0	13
81397	104555	22.62	8.33	251	0.161	100.3	8.4	376	4.0	13
81397	104626	22.58	8.32	251	0.161	99.4	8.3	375	5.9	12.9
81397	104647	22.56	8.31	251	0.161	99.3	8.3	374	5.9	12.9
81397	104710	22.49	8.29	251	0.16	97.1	8.1	374	8.0	12.9
81397	104726	22.49	8.28	251	0.16	96.8	8.1	374	9.9	12.8
81397	104756	22.49	8.28	251	0.16	96.6	8.1	373	11.9	12.8
81397	104830	22.49	8.28	251	0.16	96.4	8.1	371	11.9	12.8
Annotation at 081397 105757 : BO. PT										
81397	105821	23.57	8.40	251	0.16	106.2	8.7	380	0.2	13.2
81397	105839	23.48	8.40	250	0.16	106.3	8.7	378	0.5	13.1
81397	105901	23.35	8.41	250	0.16	106.4	8.8	377	1.1	13.1
81397	105926	23.17	8.41	251	0.161	106.3	8.8	375	2.0	13
81397	110000	22.42	8.39	251	0.16	102.3	8.6	375	4.1	13
81397	110044	21.99	8.30	250	0.16	94.8	8.0	377	6.0	12.9
81397	110131	21.39	8.16	251	0.161	84.6	7.2	381	8.0	12.8
81397	110234	21.06	8.02	251	0.16	77.9	6.7	385	9.0	12.8
81397	110420	19.59	7.85	254	0.163	29.0	2.5	396	10.0	12.7
81397	110532	16.34	7.49	259	0.166	4.3	0.4	401	11.0	12.7
81397	110608	14.97	7.45	264	0.169	3.4	0.3	403	12.0	12.6
81397	110633	13.73	7.42	268	0.172	3.1	0.3	394	14.0	12.6
81397	110710	13.23	7.39	270	0.173	2.9	0.3	340	16.1	12.5
81397	110734	12.82	7.37	271	0.174	2.7	0.3	316	18.0	12.5
81397	110754	12.46	7.36	272	0.174	2.7	0.3	304	20.1	12.5
81397	110812	11.77	7.48	278	0.178	2.6	0.3	132	22.5	12.5
Annotation at 081397 113707 : BP NEAR SH										
81397	113743	23.79	8.42	250	0.16	109.9	9.0	290	0.5	13.3
81397	113801	23.62	8.43	251	0.16	108.1	8.9	289	1.0	13.2
81397	113825	23.28	8.43	250	0.16	107.9	8.9	288	1.6	13.2
81397	113852	23.19	8.43	251	0.161	107.9	8.9	287	2.1	13.1
Annotation at 081397 114107 : HALF										
81397	114133	23.71	8.42	251	0.161	106.7	8.7	294	0.5	13.3
81397	114157	23.56	8.43	251	0.16	107.0	8.8	293	1.0	13.2
81397	114227	23.23	8.44	251	0.161	107.8	8.9	291	2.0	13.2
81397	114309	22.80	8.40	251	0.161	103.0	8.6	292	4.0	13.1
81397	114337	22.22	8.35	250	0.16	97.4	8.2	294	6.0	13
81397	114445	21.68	8.22	251	0.16	86.9	7.4	297	7.9	12.9
81397	114528	20.69	8.00	252	0.161	68.3	5.8	306	9.0	12.9
81397	114603	18.01	7.75	256	0.164	30.2	2.8	317	10.0	12.8
81397	114646	17.01	7.62	258	0.165	12.9	1.2	322	11.0	12.8
81397	114720	14.79	7.54	265	0.17	5.0	0.5	328	12.0	12.8
81397	114755	13.61	7.49	269	0.172	3.9	0.4	308	14.0	12.7
81397	114834	13.36	7.44	270	0.173	3.2	0.3	280	15.9	12.6
81397	114906	13.03	7.42	271	0.174	3.1	0.3	261	18.0	12.7
81397	114931	12.69	7.39	272	0.174	2.9	0.3	251	20.0	12.6
81397	114948	12.59	7.38	273	0.175	2.9	0.3	248	22.0	12.6
81397	114968	12.59	7.38	273	0.175	2.9	0.3	244	22.0	12.6
Annotation at 081397 115041 : SCB										
81397	115526	23.91	8.41	250	0.16	107.1	8.7	268	0.5	13.2
81397	115544	23.71	8.41	251	0.161	106.7	8.7	268	1.1	13.2
81397	115616	23.37	8.43	250	0.16	106.1	8.7	267	2.1	13.1
81397	115639	22.51	8.41	249	0.159	101.8	8.5	268	4.0	13.1
81397	115707	22.19	8.34	249	0.16	96.7	8.1	271	6.0	13
81397	115812	21.68	8.19	251	0.16	84.9	7.2	276	8.0	12.9
81397	115843	20.57	8.01	251	0.161	68.8	6.0	284	9.0	12.9
81397	115962	18.71	7.69	257	0.164	30.5	2.8	297	10.0	12.8
81397	120012	15.93	7.62	262	0.168	13.0	1.3	300	11.0	12.8
81397	120049	14.50	7.52	267	0.171	4.6	0.5	304	12.0	12.8
81397	120136	13.33	7.46	273	0.174	3.4	0.4	277	14.0	12.7
81397	120211	12.93	7.42	272	0.174	3.0	0.3	255	16.4	12.7
Annotation at 081397 120233 : RV OUT										
81397	121115	23.42	8.40	250	0.16	106.3	8.7	304	0.3	13.5
81397	121134	23.44	8.41	250	0.16	106.6	8.8	302	1.0	14.1
81397	121143	23.44	8.42	250	0.16	106.5	8.8	300	1.0	14.1
Annotation at 081397 121915 : SMITH PT										
81397	122031	23.90	8.45	250	0.16	107.6	8.8	310	0.5	13.3
81397	122106	23.42	8.46	250	0.16	107.2	8.8	307	1.0	13.2
81397	122206	23.35	8.47	250	0.16	107.9	8.9	305	1.4	13.1
81397	122218	23.32	8.48	250	0.16	107.9	8.9	304	1.5	13.1
81397	122239	23.28	8.49	250	0.16	108.5	9.0	303	2.1	13.1
81397	122314	22.72	8.45	250	0.16	103.1	8.5	304	3.0	13

Recovery finished at 081497 113008

Appendix 11. Hydrolab Multiprobe Results 1997
17-Sep-97

Date MMDDYY	Time HHMMSS	Temp degC	pH units	SpCond uS/cm	TDS Kmg/l	DO %Sat	DO mg/l	Corrected DO mg/l	Redox mV	Depth meters	Batt volts
Annotation at 091797 094740 : RV IN											
91797	94828	16.96	8.32	262	0.168	94.7	8.9	8.9	386	0.2	14
91797	94841	17.04	8.29	262	0.168	94.9	8.9	8.9	386	0.6	14.1
Annotation at 091797 100007 : NO BASIN											
91797	100247	18.52	8.28	261	0.167	91.6	8.3	8.4	404	0.2	14.1
91797	100303	18.52	8.27	261	0.167	91.5	8.3	8.4	403	0.4	14.1
91797	100315	18.53	8.26	260	0.166	91.7	8.3	8.4	402	1.1	14.1
91797	100340	18.53	8.25	260	0.166	91.7	8.3	8.4	401	1.9	14.1
91797	100404	18.53	8.24	260	0.166	91.7	8.3	8.4	401	3.7	14.1
91797	100420	18.53	8.23	260	0.166	91.8	8.3	8.4	401	6.2	14.1
91797	100528	18.50	8.22	260	0.166	92.2	8.4	8.4	399	8.3	14.1
91797	101108	18.45	8.24	261	0.167	94.8	8.6	8.7	380	2.5	13.9
91797	101123	18.45	8.24	261	0.167	93.5	8.5	8.6	380	3.9	14.1
91797	101135	18.45	8.24	261	0.167	93.3	8.5	8.5	380	6.4	13.7
91797	101152	18.43	8.24	261	0.167	93.1	8.4	8.5	380	8.0	14.1
91797	101204	18.43	8.24	261	0.167	92.8	8.4	8.5	380	9.7	14.1
91797	101218	18.38	8.24	261	0.167	92.6	8.4	8.5	380	12.0	14
91797	101229	18.21	8.23	260	0.167	92.4	8.4	8.5	380	13.9	14.1
91797	101244	16.52	8.12	261	0.167	86.8	8.2	8.3	386	16.0	13.8
91797	101308	10.66	7.85	258	0.165	51.1	5.5	5.5	401	18.1	14.1
91797	101323	9.67	7.79	260	0.166	46.3	5.1	5.1	403	20.0	14.1
91797	101343	8.78	7.71	261	0.167	43.4	4.9	4.9	405	21.7	14.1
91797	101358	8.55	7.68	262	0.168	42.2	4.8	4.8	407	24.8	14.1
91797	101412	8.37	7.64	263	0.168	40.5	4.6	4.6	407	26.3	14.1
91797	101425	8.29	7.60	263	0.168	38.8	4.4	4.5	408	28.1	14
91797	101441	8.27	7.58	264	0.169	38.0	4.3	4.4	409	30.0	14
91797	101453	8.24	7.56	264	0.169	37.5	4.3	4.3	409	32.0	14.1
91797	101505	8.24	7.55	264	0.169	36.7	4.2	4.2	410	31.8	14
91797	101517	8.22	7.53	264	0.169	36.1	4.1	4.2	410	34.3	14.1
91797	101528	8.20	7.51	264	0.169	35.4	4.0	4.1	410	36.1	14.1
91797	101539	8.19	7.50	264	0.169	34.7	4.0	4.0	410	38.4	14.1
91797	101552	8.12	7.49	265	0.17	34.7	4.0	4.0	411	40.2	14.1
91797	101614	8.10	7.46	265	0.17	34.1	3.9	3.9	411	42.4	13.7
91797	101622	8.07	7.46	265	0.17	34.0	3.9	3.9	411	45.0	14.1
91797	101638	8.07	7.45	265	0.17	33.6	3.8	3.9	411	46.2	14.1
91797	101648	8.04	7.44	266	0.17	33.5	3.8	3.9	412	48.7	14.1
91797	101658	8.02	7.44	266	0.17	33.2	3.8	3.8	412	49.3	14.1
Annotation at 091797 110145 : CEN											
91797	110207	18.71	8.26	260	0.166	90.1	8.1	8.3	424	0.3	14.1
91797	110235	18.71	8.26	260	0.166	89.9	8.1	8.3	423	0.5	14.1
91797	110250	18.71	8.26	261	0.167	90.1	8.1	8.3	423	2.2	14.1
91797	110316	18.71	8.25	260	0.166	89.8	8.1	8.3	422	3.9	14.1
91797	110334	18.72	8.25	261	0.167	89.8	8.1	8.3	422	6.3	14.1
91797	110404	18.72	8.25	261	0.167	89.8	8.1	8.3	421	8.0	14.1
91797	110420	18.72	8.25	260	0.166	89.7	8.1	8.3	420	10.0	14.2
91797	110443	18.72	8.25	261	0.167	89.7	8.1	8.3	420	12.4	14.1
91797	110500	18.72	8.25	260	0.166	89.6	8.1	8.2	419	14.0	14.1
Annotation at 091797 111452 : BOUN PT											
91797	111548	18.96	8.26	261	0.167	89.8	8.1	8.3	430	0.2	13.9
91797	111600	18.98	8.26	261	0.167	89.7	8.1	8.3	430	0.5	14.1
91797	111614	18.98	8.26	261	0.167	89.7	8.1	8.3	429	2.0	14.2
91797	111633	18.98	8.26	261	0.167	89.7	8.1	8.3	428	4.3	14.2
91797	111654	18.98	8.26	261	0.167	89.7	8.1	8.3	427	6.2	14.1
91797	111719	18.98	8.27	261	0.167	89.7	8.1	8.3	426	6.1	14.1
91797	111741	19.00	8.27	261	0.167	89.7	8.0	8.3	426	8.1	14.2
91797	111802	18.96	8.27	261	0.167	89.4	8.0	8.3	425	10.3	14.1
91797	111813	17.08	8.08	269	0.172	83.5	7.8	8.0	436	12.4	14.1
91797	111831	14.74	7.90	273	0.175	20.4	2.0	2.1	184	14.0	14.1
91797	111849	13.69	7.77	276	0.177	9.5	1.0	1.0	99	16.0	14
91797	111915	13.45	7.68	275	0.176	6.3	0.6	0.6	58	17.9	14.1
91797	111939	13.30	7.87	275	0.176	5.0	0.5	0.5	36	19.5	14.1
91797	111953	13.00	7.95	277	0.177	4.7	0.5	0.5	26	21.4	14.2
Annotation at 091797 115257 : HALF											
91797	115321	19.03	8.19	261	0.167	88.4	7.9	8.2	300	0.1	14.1
91797	115341	19.03	8.19	261	0.167	86.5	7.8	8.0	298	0.2	14.1
91797	115352	19.03	8.20	261	0.167	86.5	7.8	8.0	297	0.7	14.1
91797	115412	19.05	8.20	261	0.167	86.5	7.8	8.0	296	2.0	14.1
91797	115430	19.05	8.20	261	0.167	86.6	7.8	8.0	295	4.3	14
91797	115453	19.05	8.21	261	0.167	86.4	7.7	8.0	294	5.9	13.8
91797	115520	19.05	8.21	261	0.167	86.3	7.7	8.0	292	8.0	14.1
91797	115531	19.05	8.21	261	0.167	86.2	7.7	8.0	292	10.2	14.1
91797	115548	16.45	7.86	271	0.173	53.1	5.0	5.2	310	12.2	14.1
91797	115606	14.69	7.77	275	0.176	13.7	1.4	1.4	94	14.3	14.2
91797	115629	14.64	7.68	276	0.176	7.3	0.7	0.7	45	14.5	14.1
Annotation at 091797 120402 : SCB											
91797	120440	19.01	8.19	261	0.167	84.8	7.6	7.9	240	0.0	14.1
91797	120501	19.03	8.19	261	0.167	84.4	7.6	7.9	238	0.4	14.1
91797	120532	19.03	8.18	261	0.167	84.2	7.5	7.8	238	1.1	14.1
91797	120546	19.03	8.18	261	0.167	84.1	7.5	7.8	237	2.0	14.1
91797	120602	19.03	8.18	261	0.167	84.1	7.5	7.8	237	2.9	14.1
91797	120612	19.03	8.18	261	0.167	84.1	7.5	7.8	238	4.3	14.1
91797	120640	19.03	8.17	261	0.167	83.3	7.5	7.8	238	6.0	14.1
91797	120657	19.00	8.15	261	0.167	82.7	7.4	7.7	239	7.9	14.1
91797	120712	18.83	8.07	262	0.168	77.4	7.0	7.2	242	9.7	14.2
91797	120728	16.81	7.89	270	0.173	60.3	5.7	5.9	219	12.3	14.1
91797	120754	14.55	7.67	276	0.176	10.4	1.0	1.1	55	14.1	14.1
91797	120809	13.79	7.68	277	0.178	7.4	0.7	0.8	35	15.6	14.1
Annotation at 091797 121536 : RV OUT											
91797	121738	18.96	8.09	261	0.167	83.9	7.5	7.8	231	0.2	14.2
91797	121752	18.98	8.10	261	0.167	83.7	7.5	7.8	230	0.6	14.1

Recovery finished at 101497 140241

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: REN001-58 PAGE 1

REPORT DATE: 05/27/97

DATE SAMPLED: ~~05/01/97~~ APRIL 97' DATE RECEIVED: ~~05/01/97~~

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM JACK RENSEL / LAKE OSOYOOS

CASE NARRATIVE

Two water samples and three sediment samples were received by the laboratory in good condition. The samples were 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 follows on subsequent pages.

SAMPLE DATA

SAMPLE ID	TOT IRON (mg/l)	TOC (%)
NORTH BASIN 50M	0.074	
SOUTH BASIN 14M	0.024	
#1 CENTER OF PENS		4.49%
#2 NE CORNER OF PENS		3.89%
#3 50M N OF PENS		3.84%

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QA/QC DATA

QC PARAMETER	TOT IRON (mg/l)	TOC (%)
METHOD	EPA 200.7	EPA 415.1
DATE ANALYZED	05/15/97	05/23/97
DETECTION LIMIT	0.010	0.015
DUPLICATE		
SAMPLE ID	SOUTH BASIN 14M	#1 CENTER OF PENS
ORIGINAL	0.024	4.49%
DUPLICATE	0.024	4.00%
RPD	0.00%	11.54%
SPIKE SAMPLE		
SAMPLE ID	SOUTH BASIN 14M	
ORIGINAL	0.024	
SPIKED SAMPLE	0.987	
SPIKE ADDED	1.00	
% RECOVERY	96.30%	NA
QC CHECK		
FOUND	0.986	2.08%
TRUE	1.00	2.00%
% RECOVERY	98.63%	104.31%
BLANK	<0.010	<0.015%

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

MINUTES OF THE WELLS COORDINATING COMMITTEE FOR 1997

APPENDIX J

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
9 JANUARY 1997

Agreements Reached:

1. The committee approved the squawfish studies proposed by Douglas PUD with the understanding that Chelan and Douglas PUD's will develop a proposal for a joint squawfish assessment in 1997 for committee review prior to the next coordinating committee meeting.

I. GENERAL MID-COLUMBIA ISSUES

A. Sockeye Adult Radio Telemetry Studies

Heinith reported on the discussion he had recently with John Ferguson where he had requested, on behalf of the tribes, that the 200 radio tags provided for a planned lamprey study be diverted to the sockeye study to increase the number of radio tags available for sockeye to 800. The committee agreed they had no problem with using the lamprey tags for sockeye since the lamprey study was not a PUD study. Heinith said he would talk to Ferguson about the switch since the tribes would like to see additional sockeye tagged. Bickford pointed out that 800 radio tagged sockeye could result in excess tag detection's at Wells Dam over what is needed to accomplish the objectives of the passage study. Heinith asked Bickford if the additional detection's would present a problem in data handling. Bickford said he thought they would be able to process the additional tag detection's.

Bickford said they would like to assess delay resulting from the summer chinook brood stock collection efforts on the east ladder at Wells Dam. To accomplish that objective would be desirable to standardize the trapping protocol in terms of the days of the week that trapping would take place. Brown said this issue will be raised with hatchery personnel at Wells Hatchery so they understand that due to other study requirements, they should stick with an established trapping protocol.

B. DFOP Document

Hevlin raised a question regarding the status of the DFOP document. He said they had finalized and update of the DFOP with Douglas PUD for the Wells Project and he thought this had been done with Chelan PUD for Rocky Reach and Rock Island. He wasn't sure if this had been done for Wanapum and Priest Rapids. Hevlin said he would like to see the DFOP document finalized. Klinge requested that the draft document be sent to the committee to refresh everyone's memory. Hevlin said he would ask Larry Basham from the Fish Passage Center to provide the draft document to the committee so everyone could review the document for their respective projects. He asked the committee members to provide comments back to he or Larry Basham so the document can be finalized.

C. Steelhead Spawning Protocol

Brown reported that steelhead spawning commenced on January 18. Twenty one females were spawned. For fish health purposes a portion of the spawned males were sacrificed so that viral screening could take place. Brown said the early spawned eggs are destined for the Ringold Program via Lyons Ferry Hatchery. The decision to sacrifice the males was made to allow viral assessment prior to transfer of the eggs to Lyons Ferry Hatchery.

Brown said the protocol had gone out for committee review as his best shot at how the program might be modified to address potential ESA concerns and possible listing action by NMFS. The protocol relies heavily on the use of gonadotropin to accelerate maturation of the wild broodstock collected. This would allow W x H crosses as called for in the protocol. Without use of gonadotropin hatchery brood stock would be spawned before the wild brood stock is ripe. Brown said they are running into trouble finding a legal source of gonadotropin(i.e. an FDA approved supplier) since the previous supplier had gone into receivership recently. Scribner said the protocol represents a snapshot of a steelhead management plan which causes him some concern. With the small number of wild brood stock collected, if it isn't possible to integrate the wild and hatchery components it would result in a genetic bottleneck and low effective population size if only WxW crosses were allowed.

II. WELLS DAM

A. Okanogan Sockeye Decision Tree

Klinge reviewed previous discussions on Okanogan sockeye. He reiterated Douglas PUD's position that they are unwilling to provide further support for the existing sockeye program. He said they feel they have met the requirements for a sockeye pilot program as spelled out in the Wells Settlement Agreement and would like to see a permanent decision made on the direction the program should go in the future. Hevlin said he feels the Cassimer Bar facility should be maintained in operation and if Canadian opposition persists when the fish are ready to be released, they could be release in another location. Woodin said he feels there has been encouraging information gained to date in terms of handling adults and rearing juveniles at the Cassimer Bar facility. He feels that there should be an attempt made to build on the positive results to date. Marco agreed that it doesn't make sense to drop sockeye at this time and try to start up again at a later date. Klinge said he would like to clarify, for committee understanding, what Douglas PUD's position is relative to the Okanogan sockeye effort. They are not opposed to sockeye enhancement per se, but, they feel the existing pilot program lacks merit biologically and politically given the Canadian opposition. The committee agreed to appoint a sub-committee to develop an alternative sockeye strategy for 1997 by the next committee meeting. The sub-committee, consisting of Feldmann, Marco, Cates, Heinith, and Klinge will get together or conference call on January 21, 1997.

B. Squawfish Radio Telemetry Study

Bickford summarized the proposed squawfish radio telemetry study for the Wells Project. Heinith asked about possible incidental catch of salmonids. Bickford replied that it was unlikely salmonids would be taken incidentally while squawfish were being collected for radio tagging. Woodin asked if the radio telemetry study could be expanded to include the Chelan PUD projects so that a broader area could be assessed. He asked if Chelan PUD would participate in the proposed study. Hays stated that with all the activities they will be involved in they could not

participate fully in the squawfish radio telemetry study in 1997. He said that they could provide some incidental radio tracking in association with the radio telemetry studies at their projects. He said they would plan to participate in the tagging and population assessment which takes advantage of fish captured in the planned squawfish derby. Woodin said he was pleased to see an expanded effort to develop valid population estimates for squawfish. The committee approved the proposed squawfish studies proposed by Douglas PUD. Chelan and Douglas PUD's will develop a proposal for a joint squawfish assessment study in 1997 prior to the next committee meeting.

Hevlin inquired about collection of data on radio tagged steelhead if these are included in the adult radio telemetry studies planned by the Corps of Engineers in 1997. It was pointed out that to monitor steelhead adults it would take a much longer period of monitoring than is currently planned.

C. Steelhead Broodstock Collection Protocol

Hevlin expressed the need to develop a steelhead broodstock collection protocol which would be responsive to ESA concerns in the event steelhead are placed on the Threatened or Endangered List. Discussion continued on broodstock collection considerations that should be taken into account in development of a steelhead protocol. These discussions will continue at future coordinating committee meetings.

The next Wells Coordinating Committee meeting will be February 13, 1997.

ATTENDANCE LIST

Name	Representing
Cary Feldmann	Puget Sound Power and Light Company
Steve Hays	Chelan County Public Utility District
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Tom Scribner	Yakama Indian Nation
Jerry Marco	Colville Confederated Tribes
Jon Hansen	Colville Confederated Tribes
Bob Heinith	Confederated Tribes of the Umatilla Indian Reservation
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Stuart Hammond	Grant County Public Utility District
Chris Carlson	Grant County Public Utility District
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
13 FEBRUARY 1997

Agreements Reached:
1..

I. GENERAL MID-COLUMBIA ISSUES

A. Spring Chinook Brood Stock Collection Protocol

Brown reviewed the draft spring chinook brood stock collection protocol for the Methow Basin and the Chiwawa River and discussed the supporting rationale. For the Methow Basin the draft protocol calls for trapping marked hatchery adult returns three days per week at Wells Dam in addition to trapping operations at each of the tributary traps. In addition, since so few Twisp River fish are likely to be collected from the Twisp River adult trap, the proposed protocol calls for the use of the 1993 "captive brood stock" being held at the Methow Hatchery in the spawning population.

For the Chiwawa spring chinook program, the proposed protocol calls for trapping three days per week at Tumwater Dam in addition to collection at the Chiwawa weir. Brown said the large runoff expected in 1997 may result in few adults being collected at the Chiwawa weir and the Tumwater Dam effort should assure collection of some brood stock.

Brown explained that the proposed protocol represents his best shot at a brood stock collection plan that would be responsive to the realities which will be faced in 1997 and this protocol has not been reviewed internally. He would like to have committee comments as soon as possible so that suggested modifications can be considered prior to internal review. Brown directed the chairman to transmit a copy of the draft protocol to committee members Heinith and Scribner and to Mike Cuenco of the Columbia River Inter Tribal Fish Commission for their review since they were not present at this meeting.

B. PATH Process and Reports

The chairman informed the committee that he had been contacted by a representative of the PATH process and asked to inform the committee of the documents prepared by PATH and that if they wished to obtain copies of those documents they could request them from PATH representatives.

II. WELLS DAM

A. Dissolved Gas Monitoring

Klinge stated that he had distributed a proposed plan for dissolved gas monitoring at Wells Dam including Wells tailrace. The tailrace monitoring would be done on a weekly basis with additional monitoring selected to coincide with larger spill volumes. The proposed tailrace

monitoring plan would not utilize fixed monitors but would be done from a boat at two sites, one located approximately 1000 feet downstream from the dam and the other at a site yet to be selected approximately one to two miles farther downstream. Monitoring would take place from mid-March through June.

Lorz asked how the monitoring information would be distributed. Klinge said the data would be provided on at least a weekly basis while the forebay information would be transmitted on a daily basis (six readings per day) using the CHROMS system as done in the past. Klinge said it would be possible to have the tailrace information put on the DART system for electronic retrieval.

Woodin asked if the tailrace data would be from transects. Klinge replied that they would be collecting transect information and would probably report the average.

B. Okanogan Sockeye

Klinge said he had sent out a memo to the committee dated February 2, summarizing the meeting of the sub-committee on Okanogan sockeye. The sub-committee came up with two strategies depending upon whether or not the provincial government in British Columbia accepted the concept of net pen rearing of sockeye in Lake Osoyoos. Woodin asked if the preferred alternative I-B, would be possible under existing environmental conditions and if it wasn't possible that there could be variations on I-B that would be worth considering. He said holding fish in a hatchery through the warm summer months and using net pens for a shorter term in late summer and early fall for release in the lake might be a viable option. He went on to say that in an HCP concept it wouldn't be out of the question to consider rearing fish at a different hatchery with cooler water temperatures to arrive at an acceptable size fish for release into Lake Osoyoos net pens following the summer warm water period. Chiwawa acclimation ponds using Chiwawa River water and the Rocky Reach Annex were mentioned as hatcheries with cooler water temperature regimes. Klinge said option II-1-A-i is the preferred option if provincial support for Lake Osoyoos net pens is not received. Woodin asked if this proposal assumes the same level of production as the last several years. Klinge said it would be a continuation of the pilot program at 8,000 pounds of production.

Woodin stated that if the plan is to release fish into the Columbia River, they should be held to yearling size before release. Klinge and Feldmann said it would be difficult to hold the fish to yearling size due to the water temperatures at the area hatcheries. Woodin said, if that is the case, a large proportion of the fish should be released in the southern basin of Lake Osoyoos as fry. It was pointed out that part of the premises discussed at the sub-committee meeting requires provincial acceptance before fish are released in the Okanogan River system. Woodin said when we move away from Okanogan system releases he feels it would be a waste of time and resources to release anything but yearlings.

The committee agreed that the option of net pen rearing of sockeye in Lake Rufus Woods for release as yearlings below Chief Joseph Dam or from Cassimer Bar Hatchery should be explored. Klinge said he, Marco, and the rest of the sockeye sub-committee would look at that option since the committee wasn't enthusiastic about alternative II-1-A-i. Woodin stated that he has some interest in option I-3-B (transport of adults), especially since the escapement to the spawning grounds was so dismal in 1996, even with a good water year. Klinge stated that although Bruce Shepard, B.C. Environment, expressed some support for the concept of adult

sockeye transport to avoid the thermal barrier in the Okanogan River, Douglas County PUD was unable to get a permit to transport adult sockeye into Canada.

The next meeting of the Wells Coordinating Committee will be March 21, 1997 at Sea/Tac.

ATTENDANCE LIST

Name	Representing
Cary Feldmann	Puget Sound Power and Light Company
Steve Hays	Chelan County Public Utility District
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Jerry Marco	Colville Confederated Tribes
Tom Lorz	Columbia River Inter Tribal Fish Commission
Rick Klinge	Douglas County Public Utility District
Stuart Hammond	Grant County Public Utility District
Stephen Brown	Grant County Public Utility District
Chris Carlson	Grant County Public Utility District
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
13 MARCH 1997

Agreements Reached:
1..

I. GENERAL MID-COLUMBIA ISSUES

A. Spill Representatives for 1997

Spill representatives for 1997 were established by the committee as follows:

1. Priest Rapids/Wanapum	Bob Heinith and Rod Woodin (Joint Fisheries Parties) Chris Carlson (Grant County PUD)
2. Rock Island/Rocky Reach	Bill Hevlin and Tom Scribner or Dale Bambrick (JFP) Robert McDonald (Chelan County PUD)
3. Wells	Jerry Marco and Brian Cates (JFP) Rick Klinge (Douglas County PUD)

B. Steelhead Egg Take-1997

Woodin reported that several IPN positive female steelhead had shown up during routine viral screening following spawning at Wells Hatchery. Ordinarily, when a fish which is spawned tests positive for IHN or IPN the eggs from that fish are destroyed. This has been done for fish from the Wells Hatchery brood collection that tested positive. The problem this year is due to the fish held and spawned at Wells Hatchery that were collected from Priest Rapids and the Wenatchee River as part of an attempt to develop a Wenatchee River brood stock. The 1996/97 spawning protocol allowed for live spawning of males in case one to one matings were not possible due to uneven sex ratios. Since IPN was discovered in several females there is a possibility that some of the live spawned males could ultimately test positive. Therefore, the 115,000 eggs collected from matings involving live spawned males are quarantined until all males have undergone viral testing. If no males are found to be positive, then the eggs could be released for transfer to Eastbank Hatchery for the Wenatchee River program. Subsequent to the discovery of the IPN positive females, no fish have been live spawned. Therefore, as the remaining fish which had been live spawned are killed, they will be tested for viruses. Brown will be monitoring the situation and will report back to the committee as the results become known.

C. Spring Chinook Brood Stock Collection Protocol

Woodin reported on internal discussions within WDF&W recently which reconfirmed that agencies commitment to separation of spring chinook sub-stocks in the Wenatchee and Methow Basins. Brown will likely be submitting a new protocol so WDF&W is not seeking approval of the plan previously submitted.

Woodin stated that WDF&W is currently leaning toward the use of a captive broodstock program for spring chinook. This could effect the number of eggs that might be collected for the

next several years due to concerns on capacity if juveniles are collected for captive broodstock use.

There was discussion concerning broodstock collection in the Twisp and Chewuch Rivers. The pro's and con's of installation of the floating weir on the Twisp River were debated. Klinge pointed out that it was very likely, given the large run-off expected this spring, the weir would not last through the spring freshet. Since results of previous trapping efforts on the Twisp River have had limited success, even during years with low spring freshets, he questioned the wisdom of installing the weir this year. Woodin said it appears this is a technical issue between the PUD and the hatchery staff. Klinge acknowledged the desire to collect Twisp River broodstock but pointed out that it was unlikely that they would be successful in a year when the snowpack was at 140% of normal and there was the added concern regarding the potential loss of the weir if it was installed this year. The committee decided to inform the hatchery crew that the weir should not be installed in the Twisp River this spring.

Heinith said the tribes had concerns about the proposed brood stock protocol, particularly as they relate to sub-stock issues. They have been in contact with Tom Cooney, WDF&W, to set up a meeting to attempt to develop an acceptable protocol.

D. Mid-Columbia Flows

Heinith reported that there have been rather heated discussions regarding flow management in the mid-Columbia which call for flows dropping to about 90 kcfs in the first week in April. Woodin pointed out that there is also a potential for reduced flows from Grand Coulee in May resulting from Snake River runoff concerns. Heinith said there will be a conference call with the Implementation Planning Team to discuss these concerns.

E. Replacement Spill

Hevlin said he would like to develop a mid-Columbia position on replacement spill priorities for 1997. This would help to assure mid-Columbia input to replacement spill decisions which the Technical Management Team will be dealing with. Woodin pointed out the need to consider changing priorities during the season depending upon whether we are addressing juvenile passage improvements or reduction in TDG. Hevlin said it would be desirable to have consultations during the season to consider changes in priority. The committee agreed to make the following recommendations to the TMT for allocation of replacement spill:

April 1-15	Wells, Rock Island, Rocky Reach, Priest Rapids, and Wanapum
April 15-	Priest Rapids, Rock Island or Wells, Rocky Reach, and Wanapum

II. WELLS DAM

A. Okanogan River Sockeye Holding Study

A proposed study plan to address Okanogan sockeye pre-spawning mortality was distributed to the committee by Bickford's memo dated February 22, 1997. The study was proposed by Douglas PUD and Washington Department of Fisheries and Wildlife. Heinith stated that his group has major problems with the proposed study. He questioned whether there would bea way of determining success on the spawning grounds. Klinge and Bickford said that they will be attempting to recover tags on the spawning grounds and assessing pre-spawning mortality, egg retention, etc. Klinge said he feels it is important to conduct the study this year since the sockeye

run the next two years is expected to be extremely low and it may be desireable to do everything we can to assist those runs to survive to the spawning grounds. Marco said that he had concerns regarding chemical treatment of the fish during the holding period and possible FDA problems with those fish being taken in the tribal fishery following release. He said he would be checking with John Morrison concerning this potential problem and will get back to Klinge and Bickford when he has had a chance to talk to Morrison. Heinith said he would notify the chairman on March 19, 1997 after he has had opportunity for further discussion with his people. Bickford said that for the study to proceed in 1997 they would have to order the radio tags by March 21.

B. Okanogan River Sockeye Program

Klinge called on Marco to update the committee on progress with the 1996 brood rearing program. Marco reported that they were a little behind last year due to a problem that developed with an unidentified bacteria which caused them to take the fish off feed for several days for treatment. The water heaters are operating and fish marking will begin next week. Klinge said they are moving the net pens to Lake Osoyoos so they will be ready when the fish are moved.

The proposal developed by the ad hoc sockeye committee for the 1997 brood was not met with much enthusiasm by the committee at the last meeting. Woodin had expressed the opinion that he would prefer to see a yearling program if fish are to be released into the Columbia River. The problem with a yearling program, stated Klinge, is finding a hatchery with a suitable water supply. With the water temperature at the Cassimer Bar Hatchery, sockeye would reach an undesirable size if reared to the yearling stage.Marco then distributed a proposal he had developed for a 1997 brood program wherein eggs would be incubated using chilled water. Upon hatching the fish would be reared in the hatchery until about October when they would be moved to net pens in the Wells Reservoir. Included in this proposal would be the use of one half of the production for an accelerated fingerling release from the Cassimer Bar Hatchery into the Wells Reservoir. Klinge said he will be working with Marco to try to develop a "fleshed-out" proposal for committee review prior to the next coordinating committee meeting.

C. Water Releases From Lake Okanogan

Klinge reported on a conversation he had with Bruce Shepard, B.C. Ministry of the Environment, where he was informed of the Provinces concern regarding the high snow pack this year and the predicted high flows this spring. The Province is in the process of drafting Lake Okanogan by increasing discharge from the normal 350 to 700 cfs to about 1200 cfs. This operation has impacted shoreline spawning kokanee in Lake Okanogan and fry traps fished below the sockeye spawning area between Lake Osoyoos and McIntyre Dam have confirmed that pre-emergent nerkid fry are being flushed out of the gravel downstream. The Province plans to ramp the flows up to 1700 to 1800 cfs and possibly as high as 2100 cfs to reduce the level of Lake Okanogan further. Klinge said flows in excess of 1100 cfs result in eggs or fry being scoured out of the gravel. Shepherd estimated as many as 500,000 fry may have been lost as a result of this operation. Both kokanee and sockeye are effected by this operation. The committee discussed the ramifications of the reported operations at Lake Okanogan and determined that shifting the net pens from the southern basin of Lake Osoyoos to the northern basin, for rearing 1996 brood sockeye currently being held at the Cassimer Bar Hatchery, would be an appropriate measure to mitigate losses resulting from the 1997 operations. Woodin said he would see that this message is relayed to the appropriate Canadian parties.

Klinge distributed a letter received from Richard Larsen, Department of Fisheries and Oceans in Canada, which references the formation of an ad hoc Okanogan Basin Technical Working Group to address questions regarding Canadian interests in the Okanogan Basin. In the letter Larsen said they would be addressing the question of net pen rearing of sockeye in the north basin of Lake Osoyoos.

D. Wells Bypass Activities-1997

Kling distributed a bypass plan for 1997. He identified two changes from the operating plan previous discussed. These are changes in the beginning of hydroacoustic run monitoring from March 27 to March 15 and an ending date of September 15 rather than August 29.

Bickford stated that fyke netting would be done four times between March 19 and April 10 and again in August. Hevlin remarked that the fyke netting should not take place whenever the hydroacoustic index is above 150 as discussed in HCP meetings. Bickford and Hevlin will coordinate the ending date for the spring fyke net sampling.

E. Radio Telemetry Studies

Bickford reported that preparations are presently underway for the adult passage study at Wells Dam. They expect to be through with the necessary installation of equipment in the Wells ladders by April 15. Bickford reported that they are interested in adding a monitoring site between the north and south basins of Lake Osoyoos if they can locate the necessary equipment. Cates said to contact his office since they have two monitors which they might be able to make available. Bickford also mentioned the desireablility of monitoring for radio tagged chinook at the mouth of the Methow River.

F. Squawfish Program

Bickford reported on calculations of sample size necessary to get reasonable estimates of the squawfish population. He distributed a draft squawfish cencus study. He said to produce reliable information would require 600 to 1000 tagged squawfish. The only feasible way to apply that many tags would be through the use of electro shocking. If the committee isn't comfortable with the use of electro shocking in the late June, early July timeframe, it wouldn't be feasible to do the study in 1997. Hevlin said he has reviewed proposals for taking listed species as by-catch for a study of this nature in the past and there is usually a requirement to estimate by-catch and and inseason accounting of actual by-catch. Hevlin said Bickford should contact Bovorskas at his office to request copies of permits for like studies. Woodin suggested that Bickford also contact Foster and Williams, WDF&W, to see what concerns they might have with the use of electro shocking in that time frame. The squawfish derby, which would provide the tag recovery effort for the calculation of the population estimates, is set to take place July 12-13. Bickford said he would check with Bovorskas, Foster, and Williams and develop an impact assessment and electro shocking protocol for committee review.

The next meeting of the Wells Coordinating Committee will in Wenatchee on April 30-May 1 and will include site visits.

ATTENDANCE LIST

Name	Representing
Cary Feldmann	Puget Sound Power and Light Company
Steve Hays	Chelan County Public Utility District
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Jerry Marco	Colville Confederated Tribes
Bob Heinith	Columbia River Inter Tribal Fish Commission
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Stuart Hammond	Grant County Public Utility District
Stephen Brown	Grant County Public Utility District
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
APRIL 30-MAY 1, 1997

Agreements Reached:
1..

I. GENERAL MID-COLUMBIA ISSUES

(none)

II. WELLS DAM

A. Okanogan Sockeye

Klinge reported that there had been discussions of development of options for 1997 brood year Okanogan sockeye. He and Marco hope to have something available in a couple weeks. He also said there had been no word from Canada concerning there position on Okanogan sockeye enhancement.

Klinge said the 1996 brood sockeye had been moved from Cassimer Bar to the net pens in Lake Osoyoos. The move went well and although the fish were small (about 130/pound) they looked good.

Hevlin asked Klinge if he would report on the Okanogan water management meeting last week. Klinge said the water management group is expecting high flows in the Okanogan this year and, in preparation, they had been drawing down the level of Lake Okanogan for flood control. Bruce Shepard reported that those actions had resulted in a reported loss of 30% of the shoreline spawned kokanee in Lake Okanogan. He also estimated that 10 to 15% of the sockeye and kokanee which spawned below McIntyre Dam were lost because of scouring of redds.

Marco remarked that they were concerned that the screw trap smolt emigration sampling below Zosel Dam would be effected as the Similkameen River flow increases. Peven said they had made arrangements with the Okanogan River screw trap crew to receive 900 fish for PIT tag evaluation of the Rocky Reach surface collector. They expect to receive 300 fish early in the migration, 300 during the middle portion of the migration, and 300 late in the season.

B. Bypass Operations and Hydroacoustic Index

Klinge presented a graph which showed the hydroacoustic index beginning March 13. He pointed out the apparent peak in the index around the end of March and said that fyke netting on March 30 and April 2 produced very few fish and only one salmonid.

C. Monitoring for Total Dissolved Gas

Klinge reported that the TDG reading in the Wells forebay was about 122%. They recently received another instrument which allows them to take transects of TDG in the Wells tailrace. The first transect was run recently and indicated TDG below Wells of 127 to 128%, an increase of approximately 4 to 5%. Woodin remarked that this information was contrary to what had previously been believed about the effect of spill, at Wells Dam, on TDG.

D. Adult Radio Telemetry Study

Bickford reported on preparations for the adult radio telemetry study at Wells Dam. He said they have added monitoring stations at the Methow, and Okanogan Rivers for chinook salmon and between the north and south basins of Lake Osoyoos for sockeye salmon. In addition, they will be flying over the area looking for tags and will be checking Lake Osoyoos by boat in an attempt to locate sockeye holding areas.

E. Squawfish Assessment

Bickford reported on plans for squawfish studies in 1997. He said they plan to begin tagging squawfish on in early July. The squawfish derby, which will provide the recoveries for development of the population estimate, will be held on July 12-13. Bickford said they plan to use electro shocking to capture squawfish for tagging. Bickford discussed the risk assessment that he developed for incidental take of salmonids, during the electro fishing effort, as part of the permitting process. Woodin questioned several of the assumptions used by Bickford but acknowledged that the impact would likely be small. He stated that he would like to see the reservoir area between Wells Dam and the mouth of the Methow avoided during the electro fishing effort. Bavarskas asked Bickford how the risk assessment would be effected by the increased spring chinook run over the projected run size. Bickford said the risk assessment is conservative and the incidental take of spring chinook so low that even if the run size was doubled or quadrupled there would still be minimal effect. He went on to say that with sockeye they do project an incidental take. Steelhead numbers would be practically non-existent during the time when electro fishing would take place. Bickford said he would like to set an impact level (i.e. number of salmonids encountered) that could be agreed upon that would cause the electro fishing effort to be terminated when that level is reached. Hevlin asked Bickford if he could develop that impact level since he was in a better position to set a level than NMFS. Woodin said he would hate to see a level set for just spring chinook since they could encounter other species such as kokanee, resident rainbow trout, walleye, etc. Bickford agreed to take other species of interest into consideration when developing an impact level.

Bickford told the committee that he needs a decision soon so that necessary arrangements can be made in time to conduct the census this year. Although there was support for the proposed study at the meeting, the committee agreed to meet by conference call next week to make a decision on the study since all parties with an interest were not present at the meeting.

Klinge stated that he feels it is important for the committee to make decisions, in committee, after the matter has been thoroughly discussed and not have committee members leave the meeting and make decisions, in some cases killing desirable studies, as a result of in-house discussion. He said this occurs despite the fact that study proposals are circulated well in advance of the meetings. There was strong committee support for timely decision on matters under consideration by the committee.

F. Spring Chinook Brood Stock Collection Protocol

Brown summarized for the committee the essential elements of the current spring chinook brood stock collection protocol. There will be no tributary collection of spring chinook in the Methow Basin. There will be an evaluation of the Foghorn trap to check the potential for future collection at that site. Also, volunteers to the Methow and Winthrop Hatcheries will be collected. Natural spawning will be stressed as the highest priority for the 1997 brood spring chinook.

ATTENDANCE LIST

Name	Representing
Cary Feldmann	Puget Sound Energy
Steve Hays	Chelan County Public Utility District
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Jerry Marco	Colville Confederated Tribes
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Tom Lorz	Columbia River Intertribal Fisheries Commission
Bill Hevlin	National Marine Fisheries Service
Diana Bavarskas	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Lee Bernheisel	Okanogan Wilderness League
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
JUNE 25, 1997

Agreements Reached:

1. The committee agreed to meet by conference call on July 3 to develop consensus on the release strategy for the 1996 juvenile sockeye released under provisions of the Wells Settlement Agreement.

I. GENERAL MID-COLUMBIA ISSUES

A. Steelhead Management

Brown said the management of steelhead is moving in the direction of the Habitat Conservation Plan discussions which call for sub-basin management with collection of brood stock at Wells Dam for the Methow, Okanogan, and Entiat Rivers and collection at Dryden and Tumwater Dams for the Wenatchee River.

II. WELLS DAM

A. Okanogan Sockeye

Klinge said there hasn't been a clear decision on how the 1997 brood sockeye would be handled except that the progeny would not go back to Lake Osoyoos unless the Canadian position was changed in support of the sockeye program. Klinge reported that Douglas PUD had been discussing, with the operator, the possibility of rearing sockeye in the commercial net pens in Lake Rufus Woods behind Chief Joseph Dam. This would avoid the uncertainty of securing permits for a new net pen operation in other locations considered. The operator expressed concerns regarding possible disease transmission and would require that the fish taken to his net pens be virus free. He also said the fish should be screened for BKD and be from low titer parents. Klinge suggested that the fish from high titer parents could be reared at Cassimer Bar for zero age release. Scribner asked where the fish would be released and when Klinge explained they would be released at Chief Joseph Dam, Scribner asked if the fish were being reared for a fishery. Klinge responded by saying that they were. Heinith and Scribner questioned this action. Scribner asked if this had been discussed previously and Klinge said the possibility had been discussed previously but, at this time, he was asking for formal committee approval before the brood stock was collected. Scribner objected to the release of the progeny at Chief Joseph because of possible precedent for harvest management considerations. Scribner said this could set a precedent that could be very troublesome. He said he would have to discuss this proposal with his policy people.

The committee discussed other potential options for release of the progeny of fish from the 1997 brood that might be reared in commercial net pens in Lake Rufus Woods. Scribner said he didn't mind net pen rearing in Rufus Woods, it was the release site that caused the problem. He said releasing sockeye in a non-production area was especially troublesome. Releasing fish in the Methow River was mentioned as a possibility since there is a small population that spawns between Twisp and Winthrop each year. Woodin and Brown objected to release of sockeye in the

Methow River given the importance of the Methow for upper Columbia steelhead production and the susceptibility of steelhead to viral outbreaks.

Klinge reminded the committee that brood stock collection was scheduled to start within the next two weeks and some decision is necessary to go ahead with the collections as scheduled. Scribner said he wasn't objecting to the rearing proposal but an alternate release site would have to be found. He said he would take the matter back to his policy people and should have a decision on the matter in a couple days. The committee agreed to proceed with the collection of brood stock and rearing the progeny as proposed in commercial net pens in Lake Rufus Woods. Alternate release sites will be evaluated and the committee will work toward developing consensus on an acceptable alternate release site.

Discussion continued on issues that were troublesome for committee members including Canadian opposition, non-Okanogan release sites, and the Methow River as a release site. The committee agreed to meet, by conference call, at 9 AM on Thursday, July 3 to try to resolve the release site question.

B. Sockeye Holding Study

Klinge reported that he had been contacted by Bill Green, Canadian Columbia River Intertribal Fisheries Commission, concerning his interest in the sockeye adult holding study that had been proposed earlier in the year. Klinge proposed the same study that had previously been proposed, and not pursued due to lack of committee consensus, with the exception that the sixty radio tags needed would have to come from the tags Douglas PUD provided to lower Columbia River sockeye passage study. Had the study received consensus when originally proposed, there would have been time to order the tags from the manufacturer. Klinge asked Heinith if he had any concerns about going ahead with the study, at this time, given Bill Green's support. Heinith remarked that he had not talked to Bill Green recently but he thought the study Green supported involved use of Floy tags rather than radio tags. He went on to say that the was also concerned about reducing the number of tags available for the sockeye passage study. Bickford pointed out that the sockeye run in 1998 is expected to be very small and it was desirable to know if the study provides a means to increase adult survival. Heinith questioned whether the study conducted under 1997 conditions (high runoff) would provide useful information for more normal conditions. Feldman stated that it may be important to assess the efficacy of the holding study options to have that tool available for use when river conditions are bad or numbers are critically low.

Heinith asked if there would be an attempt to monitor fish on the spawning grounds to check spawning success. Bickford said they would be flying the complete watershed to locate tags and had budgeted for follow-up with intensive ground surveys. Klinge suggested that if Heinith was not in a position to go along with the study, at this time, the matter could be discussed during the July 3 conference call. The committee agreed to seek consensus during the conference call on July 3. Marco said that his earlier concern regarding prophylactic treatment of the study fish and the potential for those fish to later be caught by tribal fishermen, is no longer a concern and that he was supportive of the study.

C. Bypass Operations

Klinge reported that the Wells Bypass Team has determined that the spring migration is officially over.

D. Wells Project Pilot Survival Study

Bickford reviewed plans for a Wells Project pilot survival study in 1998. They have determined that approximately 14,000 fish would be required or more if a greater level of precision is desired. They plan to use yearling fish and are considering several species including summer chinook and steelhead. Bickford emphasized that this will be a pilot study which would provide information on downstream recovery rates which would aid in planning for a full-blown survival study in the future based on observed recovery rates at downstream locations. Cates asked Bickford which species they were planning to use. Bickford said they were considering yearling summer chinook, steelhead, and/or sockeye. Peven cautioned against the use of sockeye due to known low recovery rates for that species at downstream recovery sites. Hevlin asked when Bickford would have a proposal available for review. Bickford said it was being reviewed and should be available for distribution to the committee within two weeks. Hevlin said Chelan PUD may be interested in "piggy-backing" a Rock Island study onto the study Bickford was developing. Peven said they were working on the matter and when they got something together he would pass it on to the committee for review.

E. Total Dissolved Gas

Klinge reviewed their efforts to monitor TDG at Wells Dam. They have had TDG levels from 110 to 130% in the forebay and have had difficulty monitoring in the tailrace. The data collected to date suggests an increase of approximately 6% when spill is greater than 160 kcfs. They have ordered additional equipment to get a better handle on the effects of spill at Wells Dam on TDG. They hope to be able to develop hourly data in the future.

Hevlin asked if anyone at Douglas PUD was working on a TDG abatement plan. Klinge said no one at Douglas was working on such a plan, at this time. Bickford pointed out that they were trying to develop better information to assess the issue at Wells Dam. Woodin said Douglas PUD should be considering re-creating spill conditions experienced to date when they develop tailrace monitoring capability.

F. Squawfish Radio Telemetry Study

Bickford said fish are showing a strong preference for rock substrate. They are holding in the hatchery outfall and making forays out into the tailrace and then returning to the outfall. The fish are nearing sexual maturity but spawning appears to be a little way off. Bickford said they will be tagging the remainder of the reservoir allotment as soon as possible.

G. Adult Passage Study

Bickford reported that the first radio tagged spring chinook this year has been recorded at Wells Dam. This fish entered the east bank ladder, left the ladder and traveled to the west bank ladder where it then left and returned back to the east bank ladder and passed over the dam.

H. Spring Chinook Brood Stock Collection

Scribner asked Brown how he proposed to separate adipose clipped spring chinook from adipose clipped summer chinook adults during the extended collection period proposed in Brown's June 23 memo to the coordinating committee. Brown said that WDFW is reasonably

confident of their ability to distinguish between spring and summer chinook adults on the basis of their morphological characteristics at the time of capture. This confidence was reinforced in 1996 when fish identified as summer chinook during spring chinook trapping, did not ripen in the same time frame as the spring chinook collected.

No date was set for the next Wells Coordinating Committee meeting.

ATTENDANCE LIST

Name	Representing
Cary Feldmann	Puget Sound Energy
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Chris Carlson	Grant County PUD
Tom Scribner	Yakama Indian Nation
Jerry Marco	Colville Confederated Tribes
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Bob Heinith	Columbia River Intertribal Fisheries Commission
Tom Lorz	Columbia River Intertribal Fisheries Commission
Bill Hevlin	National Marine Fisheries Service
Diana Bavarskas	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Larry Swenson	National Marine Fisheries Service
Steve Rainey	National Marine Fisheries Service
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
CONFERENCE CALL SUMMARY
JULY 3, 1997

Agreements Reached:

1.. The committee agreed to proceed with the proposed 1997 brood sockeye program. There was committee consensus for release of the fish in the estuary at the mouth of the Okanogan River.

I. WELLS DAM

A. Okanogan Sockeye-1997 Brood

Klinge reviewed the discussion which took place at the June 26, 1997 Wells Coordinating Committee meeting concerning the proposed Okanogan sockeye program for the 1997 brood year. At the June 26, 1997 Wells Coordinating Committee meeting Scribner had expressed a need to discuss the sockeye proposal with his policy level people and would get back to the committee with their position. Scribner said that they were not opposed to collection of broodstock in 1997 or rearing the progeny in Lake Rufus Woods net pens. The preference of the agency and tribal committee members would be to release the fish in the North Basin of Lake Osoyoos, but Scribner said they recognized the difficulty Douglas PUD had with that option given the lack of general support by some of the Canadian entities. He went on to say that their second choice of release locations would be below Zosel Dam. Since this site is not acceptable to Douglas PUD, at this time, an alternative site is needed. Scribner mentioned two sites that had been mentioned as third or fourth alternatives. One, the Cassimer Bar Hatchery outfall had been mentioned at the June 26th meeting. A second possibility is the Okanogan River estuary in the vicinity of Cassimer Bar. Scribner expressed his preference for the estuary site if Lake Osoyoos or Zosel Dam releases are not possible due to various concerns. Woodin asked if acceptable access to this area is available. Klinge said there were several points of access. Potential use of net pens at this site were mentioned which would allow a brief recovery period for the fish from the effects of loading and transport of fish from the Lake Rufus Woods net pens. The committee felt that this would be advantageous.

The committee agreed to the release of the progeny of the 1997 brood sockeye at the Okanogan River estuary.

Woodin asked if the committee also felt this alternate release site would be suitable for release of any sub-yearling fish which might be released in 1998. There was no committee opposition to the release of sub-yearling sockeye at the alternate release site in 1998.

Woodin reported on the recent counts of sockeye at Priest Rapids and said that the total count at Bonneville Dam is now around 27,000 fish with good numbers still passing.

CONFERENCE CALL PARTICIPANTS

Name	Representing
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Tom Scribner	Yakama Indian Nation
Diana Bavarskas	National Marine Fisheries Service
Rick Westerhoff	National Marine Fisheries Service
Jerry Marco	Colville Confederated Tribes
Mike Erho	The Committee

WELLS 97-7

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
September 8, 1997

Agreements Reached:

1. Pending confirmation from Woodin, the committee agreed to support the change from 16 hour count reporting to 24 hour count reporting at Wells Dam beginning in 1998.

I. GENERAL MID-COLUMBIA ISSUES

A. Project Survival Studies

Bickford reviewed the draft pilot survival study proposal which he had faxed to the committee on September 3. He stated that the primary goals of the 1998 study is to assess recovery rates at the recovery locations, Rocky Reach, McNary, and John Day. In addition, they will be testing the concept of single release methodology in the mid-Columbia. Because Wells is not a recovery dam it will be necessary to use a modified single release methodology instead of the single release methodology. Bickford responded to a request for clarification regarding the difference between single release and modified single release methodology by giving a short explanation of the difference. Woodin asked about the sample sizes listed in table one of Skalski's sample size calculations attachment to the study proposal. Bickford said these were conservative estimates. He explained the derivation of the numbers shown in table one.

Hays reported that they are not as far along in the planning process as Bickford. He said they had met with the NMFS people at the Montlake Lab to get information for planning purposes. They came up with similar information as that presented by Bickford. Their plans are different than the Douglas PUD plans outlined by Bickford in that Chelan PUD is not interested in a pilot study since they have a good deal of information on PIT tag recoveries at down river recovery locations. Bickford discussed Douglas's position regarding use of hatchery yearling chinook as surrogates for in-river migrants. He said if they were allowed to use in-river migrants they would be willing to go directly to a full blown study. He pointed out that on the Snake River, up to 60% of the tags released from Dworshak Hatchery don't make it to Lower Granite Dam while fish collected as in-river migrants only suffer four to five percent mortality to Lower Granite. Woodin pointed out that in the mid-Columbia most of the yearling chinook are hatchery fish so he didn't see much difference between hatchery fish per se whether they're collected in-river or released from acclimation ponds. Hays pointed out the questions they have wrestled with concerning which fish to use for survival studies. Woodin asked Bickford if he has seriously considered the logistics of collecting fish in-river for tagging. Peven pointed out that Douglas PUD had done some in-river migrant sampling in past years and following a Winthrop Hatchery release large numbers of fish were collected. Bickford said his two alternate proposals were as follows:

1) Active in-river migrants (N=16,000) would be collected from either Rocky Reach surface collector and gatewell system or from smolt traps downstream of tributary acclimation ponds or major hatcheries.

2) Hatchery yearling summer chinook (N=16,000 or more) that have volitionally passed through the mile long rearing channel at Wells Hatchery would be used along with a smaller release (N=1500) of in-river migrants. This would allow evaluation of hatchery versus in-river migrant travel time and tag detection rates.

Woodin suggested that Bickford consider using one group of fish from the Carlton Acclimation Pond, tagged at the outlet of the pond, in coordination with in-river collection of the same fish as they migrate down the Methow River. This would allow use of the same basic group as 1) hatchery tagged and 2) in-river tagged. Bickford acknowledged that this scenario had some merit since it would be much easier to use 40,000 hatchery fish for the full blown, high precision study envisioned for the future.

Hevlin asked when the Chelan PUD/Douglas PUD efforts would come together. Hays said it probably wouldn't come together unless everyone was satisfied with a plus or minus 15% precision study. He went on to say that a study, as envisioned by Douglas PUD, might be appropriate for a comparative study of in-river versus hatchery tagged fish.

The committee agreed that additional information and coordination is necessary before a final decision ,on the studies, can be made. Woodin stated his position that it should be possible to go directly to a survival study without doing a pilot study as proposed by Douglas PUD. He said he could see merit in a study that compared in-river migrants to hatchery surrogates. Bickford asked for clarification on what additional information is necessary for the committee to make a decision. The committee members were interested in the question of which fish would make the most appropriate test animals.

Hevlin asked if we were sure that there would be adequate tag detection capability at John Day Dam in 1998. Hays said that conversation with John Williams, NMFS, assured him that BPA was moving ahead with installation of necessary equipment for 1998.

Bickford asked the committee if anyone was violently opposed to a pilot survival study in 1998. Woodin said that he wasn't opposed to a pilot study but he would encourage the parties to do a full blown study instead of a pilot study.

B. Spring Chinook Captive Brood Consideration

Woodin expressed WDFW's interest in collecting eyed eggs from 1997 spring chinook spawning to investigate the feasibility of instituting a captive brood program in the future for Twisp River, White River, and Nason Creek spawners. He stressed that WDFW is not asking for approval of a captive brood program at this time. They are interested in assessing the feasibility at this time. They are realizing some success with a chinook captive brood program on the Dungeness River and have experienced people they would bring over to train people in the use of equipment and techniques for the captive brood programs. Hays said they feel this would be a WDFW prerogative and they are open to discuss the use of hatchery facilities for such a program. Klinge said Douglas PUD has worked closely with WDFW and the Yakama Tribe, in the past, and he doesn't want to be out of step with either entity. He urged coordination of the proposed effort between WDFW and the Yakama Tribe.

II. WELLS DAM

A. 1997 Bypass Operations

Klinge reported on the operation of the Wells Juvenile Bypass operations for 1997. Hydroacoustic monitoring began on March 13 and the bypass was put into operation on April 7. The bypass was in operation for 79 days during the spring migration. Klinge pointed out that there were many days of forced spill at the Wells Project in 1997 due to the extremely high runoff. Peak discharge for the year occurred on June 12 at 396.7 kcfs. During the summer migration the runoff dropped so there was less forced spill and most of the spill at the Wells Project was bypass spill. Between the spring and summer migrations there were nine days when bypass operations were suspended. During that period there were five days of 24 hour forced spill and four days when there was some forced spill.

Klinge stated that fish presence, as indicated by early (late March) hydroacoustic monitoring, was not confirmed by fyke net samples. Hevlin asked Klinge if there was any explanation for what might have been passing during the early peak in the hydroacoustic index. Klinge mentioned that BioSonics is looking into the matter and will try to determine what might have been passing during that period. They are also looking into the possibility of using uplooking and downlooking transducers in the future to increase reliability of the monitoring effort.

Heinith asked for verification of the number of salmonids that were collected during the fyke net species verification. Klinge said those activities are not intended to collected large numbers of salmonids and they are pleased that only nine chinook juveniles were collected during the eight fyke net samples.

Heinith asked Klinge how much of the forced spill at Wells Dam was a result of immediate replacement spill. Klinge showed which portion of total project discharge was represented by immediate replacement spill on the figure which he handed out. He acknowledged that he wasn't sure what the actual percentage was.

B. Video Counting

Klinge stated that Douglas PUD has, for the past several years, counted fish passing Wells Dam using video recording. This allows them to count 24 hours per day even though they only report the 16 hour count. He pointed out that Chelan PUD reports the 24 hour counts at Rock Island and Rocky Reach. Since up to 15% of the sockeye and steelhead may pass during the eight hour VCR count period this compounds the Rocky Reach/Wells count discrepancy. Heinith stated that the Corps of Engineers reports 24 hour counts and Carlson reported that Grant PUD reports 16 hour counts for Priest Rapids. Klinge asked if the committee would support the change from 16 hour count reporting to 24 hour count reporting beginning in 1998, even though it would mean the historical passage comparison would have to be modified. Woodin said he wanted to check with his people to see if this would present any problems in dealing with historical records. Pending confirmation from Woodin, the other committee members agreed to support the change from 16 hour count reporting to 24 hour count reporting at Wells Dam beginning in 1998.

C. Wells Dam Adult Passage Study

Bickford reported that enough radio tagged summer chinook were detected at Wells Dam in 1997 to use these fish for the passage study. Total radio tagged fish detected at Wells Dam this year were as follows: sockeye-230, summer chinook-90, spring chinook-9, 1997 brood year steelhead-6, 1996 brood year steelhead-5. Of the 230 sockeye tags, 108 were on the right ladder

and 122 were on the left ladder. Only five tagged sockeye were fallbacks. Of the tagged fish listed above, 54 summer chinook, five spring chinook, three 1997 steelhead, and 4 1996 steelhead passed above Wells Dam. Bickford said the majority of the tagged spring chinook were missed since monitoring didn't begin until June 25th. Brown questioned the information on 1996 brood tagged steelhead and wondered where those fish might have been staying during the year. Bickford said he also question the validity of the 1996 brood steelhead tag detections and contacted the contractors for the Corps of Engineers who applied the 1996 brood year steelhead tag. They confirmed that the tag frequencies detected at Wells in 1997 were, in fact, applied to steelhead in 1996.

Bickford reported that two tagged sockeye were detected in the lower Methow River but they did not continue up the Methow. Some of the tagged sockeye immediately traveled up the Okanogan after passing Wells Dam while those passing Wells later held at the mouth of the Okanogan. A storm front which passed through the area in late August resulted in a six degree C. reduction in water temperature and about 200 fish holding at the Okanogan mouth immediately passed upstream. Summer chinook also were holding at the mouth of the Okanogan and they also passed upstream when the water temperature dropped. Bickford said all signs indicate a low mortality through the Okanogan River into Lake Osoyoos.

Hevlin asked Bickford if he had an estimate of the number of sockeye that made it to Lake Osoyoos. Bickford said that based on a tagged to untagged ratio of 1:106, he estimates about 21,000 fish reached the lake. Hays asked if there would be additional flights over the Okanogan Basin. Bickford said there would be at least three more flights. They have flying about once per week in an attempt to pinpoint where the sockeye are holding. Most have been holding in the north basin of Lake Osoyoos where the Okanogan River enters the lake with one little pod in 80 feet of water in the south basin.

Bickford said there were eight treatments and controls for the ladder evaluation at Wells. Woodin observed that passage at Wells apparently didn't take very long. Bickford remarked that it took about a day for sockeye to pass Wells Dam and slightly longer for summer chinook. Passage from Bonneville Dam to Wells Dam took about the same length of time for sockeye and summer chinook.

D. Sockeye Holding Study

Bickford reported that the tagged sockeye being held at the Cassimer Bar Hatchery, for the holding study, were released on September 5. The release site was approximately two miles above the confluence of the Okanogan and Columbia Rivers. Hevlin asked how the fish held. Bickford said the fish held real well but they experienced severe problems with the antennas which snagged on the perforated plate at the outlet of the holding pond. They had to re-tag or tag new fish about four times during the holding period. He pointed out that there are two types of antennas used for radio tags and the ones used in the holding study were stiff ones which were more susceptible to snagging. Klinge stated that it was disappointing to find out there were more appropriate tags available to use than those supplied for the holding study this year. Heinith asked Bickford if they will be doing surveys on the spawning grounds this year. Bickford said they will be working with Bill Green and his people to attempt to recover as many tags as possible from the spawning grounds.

Heinith asked if there is any word yet on what kind of flow regime will be used for releases of water from Lake Okanogan during the spawning period. There was discussion

concerning the importance of adequate flow provisions given the good survival of sockeye to the spawning grounds this year. Hevlin asked if a conference call could be set up to try to find out what flow provisions are expected this fall. Klinge said he would set up a conference call for addressing the flow question. Bickford pointed out that the system is managed for lake spawning kokanee. Lake Okanogan is being drafted so that kokanee redds won't be de-watered later in the year. There is also concern regarding the possible scouring of redds in the river if Lake Okanogan has to be drafted for flood control. Hevlin asked if there were any results from the discussion of possible mitigation of nerkid impacts resulting from the scouring of redds in the spring of 1997. No one had any information on any mitigative action for nerkid losses this spring.

Bickford asked what kind of water regime the committee was interested in seeing. There was discussion of possible scenarios that would benefit sockeye. Bickford pointed out that there are conflicts among the various interests (sockeye/kokanee) and the water managers are caught in the middle. Woodin pointed out that following Vernita Bar philosophy i.e. sacrifice a little spawning habitat for protection of available spawning, would be worth considering.

E. Total Dissolved Gas

Klinge reported that spill in excess of 150 kcfs, at Wells Dam, resulted in an increase of about 6% in the level of TDG. When they are only operating the bypass, TDG was within the WDOE variance. Klinge stated that they had previously understood that fixed location monitoring stations presented lots of problems. With the new equipment that is available they are now planning to install a tailrace monitoring station approximately two miles downstream of Wells Dam and will report TDG information on an hourly basis. Heinith asked if Douglas PUD was looking into a long-term gas abatement plan. Klinge said they first had to collect more information to understand how spill at Wells Dam effects TDG.

No date was set for the next Wells Coordinating Committee meeting.

ATTENDANCE LIST

Name	Representing
Cary Feldmann	Puget Sound Energy
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Jerry Marco	Colville Confederated Tribes
Rick Klinge	Douglas County Public Utility District
Shane Bickford	Douglas County Public Utility District
Chris Carlson	Grant County Public Utility District
Kevin Kumagai	HTI (Grant County PUD Contractor)
Bruce Ransom	HTI (Grant County PUD Contractor)
Bob Heinith	Columbia River Intertribal Fisheries Commission
Bill Hevlin	National Marine Fisheries Service
Diana Bavarskas (by phone)	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Larry Swensen	National Marine Fisheries Service
Steve Hays	Chelan County Public Utility District
Lee Bernheisel	Okanogan Wilderness League
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
CONFERENCE CALL SUMMARY
October 16, 1997

Agreements Reached:
1. The committee members participating on the conference call agreed to support the proposed Wells Project Pilot Survival Study as presented by Bickford at the September 8, 1997 Wells Coordinating Committee meeting.

I. WELLS PROJECT PILOT SURVIVAL STUDY

Bickford reviewed the proposed Wells Pilot Survival Study discussed previously at the September 8, 1997 Wells Coordinating Committee meeting. He explained that with the assumptions used they project estimated survival precision of plus or minus 10% at the 90% confidence level. Douglas PUD wants to make sure the detection capability of the system is up and running and the assumptions used are valid before committing the funds necessary to execute a full-blown survival study. He also explained that they want to assess the efficacy of using hatchery fish as surrogates for in-river migrants as test animals. Woodin asked how many in-river migrants they planned to use in the proposed pilot study to investigate the question of hatchery fish as surrogates. Bickford said that initially they were planning to use approximately 1500 in-river migrants along with the 16,000, to 20,000 volitionally released hatchery fish to address the question of surrogacy. However, both Skalski and Giorgi have advised them to double the number of in-river migrants to provide more reliable data. Woodin asked Bickford what his "game plan" was for collecting the desired number of in-river migrants. Bickford explained that they were planning to use two or three screw traps in the Methow River and would target those fish volitionally exiting the Carlton Acclimation Pond. He went on to say that they would tag the fish collected and transport them to a net pen or floating raceway at the mouth of the Methow. The fish would be held for a day or so prior to release to allow recovery from the handling/tagging process. Woodin asked how they would deal with the hatchery fish being released during the spring that could also end up in the screw traps. Bickford said they were aware of the need to deal with those releases and would be talking to the hatchery managers to make sure they were aware of the trapping effort that would be taking place and to make sure that they were aware of the release schedules at the various hatcheries.

Woodin said he had no further questions and was prepared to support the proposed pilot study. Hevlin said he had several questions. Hevlin referred to the discussion of the planned survival studies that took place at the September 8 coordinating committee meeting. At that time coordination between the Chelan PUD plans for Rocky Reach and Rock Island survival studies and the Douglas PUD proposal for a Wells pilot study was encouraged. He asked Bickford if coordination was taking place. Bickford explained that he had been in almost daily contact with Chelan PUD for the last week or two. He went on to summarized some of the differences

between the Chelan and Douglas proposals. To the extent possible there will be coordination between the two proposed studies. He said that, depending upon the assumptions used in the Chelan study, the tags released under the Douglas study could be used by Chelan to augment their planned tag releases.

Hevlin said he had been alerted by someone at the Fish Passage Center to not count on full PIT tag detection capabilities at John Day Dam in 1998. Bickford said that he had also been concerned about the detection capability at John Day up until a couple weeks ago. He said he has been in contact the past several weeks with members of the Transition Team, which oversees upgrading of the PIT tag detection capabilities at the Federal Columbia River hydro system, and is now more confident of the detection capabilities which will be on-line in 1998. He understands that initial tests of the detection capabilities, using actual tagged fish, have been excellent. Bickford explained that, while it would be nice to have effective PIT tag detection capability at John Day, that isn't required for the proposed pilot study to be valid. He pointed out that John Day detection capability is much more critical for the Rocky Reach/Rock Island studies.

Hevlin and Cates said they had no further questions and were prepared to support the proposed pilot survival study.

Hammond asked Bickford what detection rate they were assuming for Rocky Reach. Bickford said that initially they understood that they could expect a detection rate of about 25%. In there planning process they have used an assumed detection rate of 15% which may be conservative but they feel that after reviewing the radio telemetry report for Rocky Reach surface collector evaluation, 15% is a realistic assumption for planning purposes.

Note: Subsequent to the October 16 conference call, Scribner was contacted and agreed to support the proposed pilot study. Prior to the conference call, Bavarskas indicated support for the proposed study. On the basis of input from coordinating committee members who participated on the conference call and subsequent verbal approval from others contacted, Douglas PUD will proceed with plans for the proposed Wells pilot survival study in 1998.

CONFERENCE CALL PARTICIPANTS

Name	Representing
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Shane Bickford	Douglas County Public Utility District
Stuart Hammond	Grant County Public Utility District
Bill Hevlin	National Marine Fisheries Service
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
November 5, 1997

Agreements Reached:

I. GENERAL MID-COLUMBIA ISSUES

A. Dissolved Gas Abatement Plans

Heinith asked if the Mid-Columbia PUD's were moving forward on a gas abatement plan. Hays responded by saying there was no coordinated PUD gas abatement plan as each PUD is addressing there own plan. McDonald said the PUD"s were continuing to monitor the Corps of Engineers gas abatement process. Hevlin said there are some within the Corps who are interested in determining mortality associated with certain Total Dissolved Gas exposure history while others in the fish community feel that what available resources should be used for is finding ways to reduce TDG. Peven said it may be desirable to do both.

B. Spring Chinook Captive Broodstock Program

Bickford reported on his conversation with Lee Bernheisel concerning captive brood stock activities in the Methow Basin. Bernheisel expressed concerns regarding mining of natural redds on the spawning grounds and collection of spring chinook broodstock at Wells Dam. He would like to have attended this coordinating committee meeting but had other commitments. Brown said Bernheisel had inquired about his possible participation in the HCP process and Brown referred him to Bob Bugert.

C. Interim Protection Plan for Steelhead--Coordination Process

There was discussion of the process for interim protection of steelhead under requirements of the ESA. It was pointed out that Chelan and Douglas PUD's have proposed interim plans being prepared which will be sent to FERC. National Marine Fisheries Service will be contacted by FERC after receipt of the proposed Interim Protection Plans and Biological Assessments and will institute consultations for development of a Biological Opinion.

II. WELLS DAM

A. Wells Project Pilot Survival Study

Bickford reviewed plans for a pilot survival study in 1998. He stated that they would be using 20,000 Wells Hatchery yearling summer chinook and will attempt to collected the fish to tag after they have been released at the upper end of the spawning channel at Wells Hatchery and allowed to migrate the length of the channel to simulate actively migrating fish. The fish will be tagged at Wells Hatchery and one half released in the tailrace below Wells Dam and the other half

at the mouth of the Methow River approximately six miles upstream of Wells Dam. In addition, they use screw trap(s) in the Methow River in an attempt to capture and tag approximately 3000 yearling chinook targeting the release of fish from the Carlton Acclimation Pond. Hevlin asked how they would estimate, for ESA permit purposes, the number of steelhead that might be taken in the trapping effort. Bickford said there wasn't any information upon which to base such an estimate so they would be making an educated guess.

Heinith asked about coordination between the proposed Douglas PUD pilot survival study and the proposed Chelan PUD survival study. Bickford said the approaches were similar but the objectives of the two studies are different. He said he feels their pilot study will enhance the Chelan study.

B. Total Dissolved Gas Monitoring for 1998

Bickford reported that the Douglas PUD plan hadn't been put together yet but, there would be real time monitoring in 1998 and the results will be transmitted to the Corps of Engineers data base on a real time basis.

C. Annual Bypass Operating Plan

Bickford said there would be a plan submitted by the next coordinating committee meeting. They have determined that they won't implement the HCP bypass operations until the HCP agreement is actually signed. Therefore, the Settlement Agreement operations will be followed in the interim. They will attempt to reconcile some hydroacoustic anomalies seen in the spring and summer in 1997. They will be meeting with Biosonics this week to discuss ways to address these anomalies.

D. Sockeye Holding Study and Ladder Passage Study

Bickford reported on the results of the sockeye holding study conducted in 1997. Problems were experienced with tag antennas snagging on perforated plate screens in the holding pond. These tags were pulled out of the fish which then required the tags to be reinserted into new fish for holding. In spite of the need to handle fish several times for checking tags and replacing those whose tags had been pulled out, the fish held quite well. When released into the lower Okanogan River to continue their migration, 47 of the 48 tagged fish released were detected passing the Monse monitoring site. Forty-four of these were detected passing Riverside and 43 detected passing Zosel Dam at the outlet of Lake Osoyoos. Forty-two fish, 87.5% of the total tags released, were subsequently detected on the spawning grounds in the Okanogan River above Lake Osoyoos.

Bickford reviewed the results of the sockeye passage study. A total of 577 sockeye was tagged at Bonneville Dam. Of these, 235 fish made it to Wells Dam and 204 were detected passing Monse, on the lower Okanogan River. One hundred ninety nine fish were detected passing Riverside and 198 detected passing Zosel Dam and entering Lake Osoyoos. Bickford said that, based on tags detected on the spawning grounds, there was 83% survival from Wells Dam to the spawning grounds. Additionally, one percent of the tagged fish were harvested in Lake Osoyoos, two percent were harvested in the Okanogan River, and one percent harvested in the Columbia River above Wells Dam. Ten tagged sockeye passed McIntyre Dam which is at the upstream end of the normal spawning area and of these, eight passed back downstream prior to spawning. Considerable spawning activity was noted in the lower one third mile of McIntyre

Creek below a migration block. They also noted eight chinook salmon on the McIntyre Creek spawning area. Bickford said it appeared that sockeye spawning was late, this year, and large numbers of fish have spawned but are still alive on the spawning grounds. Bickford said there was no evidence of sockeye spawning in Lake Osoyoos.

The next meeting of the Wells Coordinating Committee will be December 11, 1998 at the Wyndham Gardens Hotel in Sea/Tac.

ATTENDANCE LIST

Name	Representing
Cary Feldmann	Puget Sound Energy
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Steve Hays	Chelan County Public Utility District
Brian Cates	U.S. Fish and Wildlife Service
Rod Woodin	Washington Department of Fisheries and Wildlife
Larry Brown	Washington Department of Fisheries and Wildlife
Jerry Marco	Colville Confederated Tribes
Shane Bickford	Douglas County Public Utility District
Stuart Hammond	Grant County Public Utility District
Bob Heinith	Columbia River Intertribal Fisheries Commission
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Mike Erho	The Committee

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
December 11, 1997

Agreements Reached:

I. GENERAL MID-COLUMBIA ISSUES

A. Survival Studies

McDonald reported that Chelan and Douglas PUD's had determined that 400 khtz tags will be used for both studies in 1998. The ability to return detected fish to the river at McNary Dam was an important consideration in that decision. Return to the river of detected ISO tags will not be guaranteed in 1998. Heinith mentioned that there are serious problems with the new bypass facilities at John Day Dam. Bickford said it was his understanding that detection facilities have been tested at John Day but there were problems with entrainment of steelhead and fall chinook when the bypass system was watered up. Hevlin asked Bickford if he would send him a memo concerning his understanding of the problem at John Day so that he could bring the matter to the attention of the System Configuration Team.

Heinith asked what detection rate was used for McNary and John Day in planning for the survival studies considering the spill levels that may be experienced. Bickford said they stratified across a range of spill levels and have assumed the spill level will be around 20 to 40%. Heinith pointed out that a full complement of spill deflectors are expected at John Day in 1998 so the percentage spill may be higher than observed in the past.

Woodin asked if switching to 400 khtz tags would preclude detection at Rocky Reach. Peven said there could be detection of the 400 khtz tags through the two gatewell collection systems and the second surface collector if Bickford can come up with detection tunnels for installation in the 12 inch bypass pipe below the dewatering structure. Peven stressed that the surface collector evaluation would not be compromised since they plan to use 132 khtz non-ISO tags for the evaluation as they did in 1997.

Hammond asked if there would be a possibility of in-river detection as tested by NMFS in the Columbia River estuary in 1997. The committee agreed that this technology has not been refined to the degree that reasonable information could be expected if used in the 1998 studies.

Hammond informed the committee that Grant PUD had been discussing with Chelan PUD the potential for becoming involved in the 1998 survival studies using the Turtle Rock yearling chinook released by Chelan PUD below Rock Island. He pointed out that in their draft Interim Protection Plan for mid-Columbia steelhead Grant PUD proposed to conduct at least a pilot survival study, in 1998 or 1999, which would provide information needed to design a comprehensive study of Priest Rapids and Wanapum juvenile survival. He said it would only require one additional release point, below Priest Rapids, in coordination with the releases below Rock Island to provide this information for Priest Rapids and Wanapum. Hammond said a decision has not been made but he wanted to let the committee know that they were thinking of

this potential. Woodin expressed concern regarding the number of Turtle Rock yearling chinook that would have to be tagged for the study. Woodin also pointed out the fact that Chelan is proceeding with the study based on the assumption that they are actually close to the survival goal whereas Priest Rapids and Wanapum are probably not close to that goal. Hammond said he realized that if Grant PUD is seriously considering such a study for 1998, it would be necessary to provide a study plan to the committee for review. They would also have to coordinate tag orders with Chelan and Douglas.

Heinith raised tribal concerns with the Chelan study in regarding the number of fish that will be used and their belief that there would be a lower return, as adults, of the tagged fish. Peven asked if the concern was due to connection between the bypass efficiency and the survival study. Heinith said yes, it does not appear that bypass efficiency at Rocky Reach is close to the efficiency level desired. Peven pointed out that there are two considerations, one is bypass effeciency and the other is project survival. They need to know project survival to guide decisions on bypass development. Heinith said he supports the Douglas PUD approach where they are proposing a pilot study that would provide information on hatchery fish as surrogates for in-river migrants, the number of fish needed to satisfy the assumptions of the single release model, and the detection rates of PIT tagged fish at lower river detection sites. Heinith said he feels that Rock Island and especially Rocky Reach are not ready for evaluation. Peven expressed exasperation that the tribes would raise concerns regarding the proposed Chelan PUD survival studies at the "last minute". He went on to say that Chelan PUD is in the process of committing several hundred thousand dollars to the studies and the timing for ordering tags, etc. is critical. He said they would have to know by the end of next week if there is support or lack of support for the study. Heinith agreed to contact Peven by the end of the week of December 15-19 with the official tribal position and if no contact is made, the study will proceed. Heinith said that since the fish proposed for use in the survival study are mitigation fish, the tribes are concerned about the expected reduced survival to adult return for the PIT tagged fish.

II. WELLS DAM

A. 1998 Radio Telemetry Study Results

Karl English, LGL, presented a comprehensive review of the results of the 1997 sockeye radio telemetry studies. He reported that for sockeye, there was no statistically significant difference between the treatment and control fish insofar as ladder passage was concerned. He also reported that fallback was low for sockeye. The survival of sockeye to the spawning grounds was determined to be excellent in 1997. For chinook, English said the sample size was too low to determine treatment/control differences. Passage time was found to be longer on the east ladder than the west ladder and during periods of trapping compared to non-trapping periods. Fall back for chinook was higher for chinook than sockeye and may have been influenced by the fact that the Wells Hatchery is below the dam and hatchery fish could have contributed to the fallback. English pointed out that the experimental design of the ladder study, calling for changes to the test/control conditions following detection of every five radio tagged sockeye, resulted in a substantial loss of data on tagged chinook passage where some fish entered under one condition and exited the ladder under the other condition. The committee expressed appreciation for the quick availability of the study results and the comprehensive presentation.

B. Wells 1998 Bypass Operating Plan

Klinge distributed a preliminary operating plan for 1998 which should be considered a planning document. Hevlin asked if there would be changes in the monitoring plan to address the uncertainty of what the targets were during certain periods in 1997. Klinge said that BioSonics is working on a modified monitoring plan which will attempt to address these uncertainties. Hevlin asked about fyke netting plans for 1998 and Klinge said the early fyke netting indicated in the draft operating plan would be a minimal effort, to confirm the presence of salmonids, and would be completed before any steelhead migrants would be expected. Hevlin said it is important, for ESA purposes, to estimate numbers that might be captured and to include information on historical juvenile steelhead timing at Wells. Klinge reiterated that this is a planning document which will change as the season progresses.

C. Wells Fish Ladder Annual Maintenance

Klinge informed the committee that the east ladder at Wells Dam is currently un-watered and will be out of service through December if anyone would like to be there to inspect the ladder. Nordlund said he would be in the mid-Columbia next week to inspect Priest Rapids, Wanapum, and Rock Island. He said he wasn't sure if they would make it to Wells or not at that time.

D. Review of Hatchery Operations

1. Cassimer Bar Hatchery

Klinge explained that there are basically two programs at the Cassimer Bar Hatchery this year. One involves yearling production of about 60,000 fish for release in the spring of 1999 and the other involves 110,000 fish from high ELISA parents that will be released as sub-yearlings in the May of 1998. The yearling fish will be reared in net pens in Lake Rufus Woods while the sub-yearling fish will be reared at the hatchery. Klinge said there was higher pre-spawn mortality and a higher level of Biological Kidney Disease than experience previously. He pointed out that the parents of this brood year also had a high incidence of BKD.

Woodin asked where the fish would be released. Klinge said the committee had previously agreed to release the fish at the mouth of the Okanogan River. Heinith reviewed discussion that had taken place at a November sockeye workshop in British Columbia and said he would like to set up a conference call with the Canadian interests to see if the release point for the fish currently being reared at the Cassimer Bar Hatchery could be moved to the north basin of Lake Osoyoos or at least the area below Zosel Dam. The committee directed the chairman will work with Heinith to see if a conference call can be set up, prior to the holidays, to address the issue.

Woodin asked for clarification of the fish cultural program proposed for the 170,000 fish currently being held. Klinge explained that the sub-yearling group would be held at Cassimer Bar until release at an expected size of about 30 fish per pound. The fish in the net pens in Lake Rufus Woods would be held until April 1999 when they would be transported to release net pens in the lower Okanogan River.

Heinith asked Klinge what would happen regarding 1998 sockeye spawning ground surveys and the juvenile screw trap sampling in the Okanogan River. Klinge said he understands that the tribes in British Columbia are interested in being involved in the work. However, Klinge said he feels the contractor used in 1997 has done a good job and he sees no reason to consider a change. Heinith asked if the committee would have an opportunity to review the work and Klinge

responded by saying that the draft report would be out soon and the committee would have an opportunity to review the work at that time. Heinith indicated that he had heard concerns expressed, at the recent sockeye workshop in British Columbia, regarding the quality of the work done on the sockeye spawning ground surveys.

2. Methow Hatchery

Woodin reviewed the status of the spring chinook, of various brood years, currently being held at the Methow Hatchery. He reported that there are still a few non-captive, captive brood fish left from the 1993 brood year. The 1993 brood year contributed 19 females to the spawned population in 1997. The total egg take in 1997 was 224,804 Methow River, 124,954 Chewuch River, and 25,445 Twisp River, and 209,722 of unknown Methow Basin origin. There are currently 207,000 Methow River fish, 99,000 Chewuch River fish, and 79,000 Twisp River fish of the 1996 brood being reared at the Methow Hatchery for release in 1998.

Woodin reported on preliminary efforts in 1997 to establish a captive brood stock program for the Twisp River stock. During spawning ground surveys, eighteen redds were located and marked. Water temperatures were monitored to determine when the eggs would reach a level of development which would allow collection with a high degree of confidence that they would survive handling. Eggs were subsequently extracted from 15 of the 18 redds sampled using techniques used in the WDFW Dungeness River captive brood program. Approximately 70 eggs were collected from each redd. Woodin stated that there are ongoing discussions concerning where these fish would be reared. He pointed out that the captive brood program in the mid-Columbia is part of the HCP process which, as yet, has not been finalized.

3. Wells Hatchery

Woodin reviewed the status of summer chinook and steelhead at the Wells Hatchery. There are currently 357,830 summer chinook of the 1996 brood being reared for release as yearlings in the spring of 1998. For the 1997 brood year summer chinook, 592,000 eggs for the Turtle Rock accelerated chinook program and 724,640 eggs for the Turtle Rock sub-yearling program were transported to the Eastbank Complex. Eggs remaining on hand at the Wells Hatchery total 1,110,592.

Woodin reported that there are currently 535,819 steelhead, of the 1997 brood, being reared at the Wells Hatchery for release in the spring of 1998. There are 458 adult steelhead being held as brood stock with spawning scheduled to commence on January 7, 1998.

A date for the next Wells Coordinating Committee meeting was not set at the December 11 meeting but was subsequently scheduled for January 27, 1998.

ATTENDANCE LIST

Name	Representing
Robert McDonald	Chelan County Public Utility District
Chuck Peven	Chelan County Public Utility District
Thad Mosely	Chelan County Public Utility District
Rod Woodin	Washington Department of Fisheries and Wildlife
Shane Bickford	Douglas County Public Utility District

Rick Klinge	Douglas County Public Utility District
Stuart Hammond	Grant County Public Utility District
Bob Heinith	Columbia River Intertribal Fisheries Commission
Bill Hevlin	National Marine Fisheries Service
Bryan Nordlund	National Marine Fisheries Service
Karl English	LGL Limited (Douglas Contractor)
Mike Erho	The Committee

1997 MEMBERSHIP LIST OF THE WELLS COORDINATING COMMITTEE

APPENDIX K

Appendix K

1997 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
Umatilla Tribes

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 L

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. <u>ANNUAL OPERATIONS PLANS</u>

1. The PUD will develop an annual bypass systems operations plan consistent with the criteria in subsections II.B, C, D, and E in consultation with the Joint Fishery Parties by the December prior to each migration period. The plan will be reviewed and approved by the Coordinating Committee by March 1 of each year. The plan will be developed from inseason projected hatchery release

dates from facilities above Wells and previous passage monitoring data. The plan will contain predicted dates for the beginning and end of the juvenile migration period; criteria for identifying the beginning and end of the spring and summer runs; and procedures for bypass operations within the constraints of subsections II.B, C, D, and E, including dates for installation and removal of spill baffles, dates for run time monitoring, and criteria for initiation and cessation of bypass operations. If unanimous agreement cannot be reached within the Coordinating Committee regarding all items in the plan, disagreements will be resolved by expedited dispute resolution under subsection I.D.

2. A Bypass Team will be established composed of one representative each for the Party fishery agencies, the Party tribes, and the PUD.

3. Notwithstanding the provisions of subsections II.F.1 and 2 above, the Bypass Team may agree to relax the operations and performance criteria of subsections II.C and E for a period between the end of the juvenile spring migration and the beginning of the juvenile summer migration. Such a modification can only be made with the agreement of all of the members of the Bypass Team, and will be limited to one or more of the following measures:

(a) Less than continuous 24-hour operation of bypass systems.

(b) Fewer than one bypass system operated for two adjacent turbines operated.

(c) Less than 1 foot spill gate slot opening.

4. Once the annual bypass plan is adopted, decisions regarding adjustments to the plan will be made by unanimous agreement of the Bypass Team. If unanimous agreement cannot be reached, the decision on such adjustments will be by majority vote of the Bypass Team.

G. ANNUAL PASSAGE MONITORING PLAN

1. The PUD shall develop an Annual Passage Monitoring Plan, in consultation with the Joint Fishery Parties for review and approval by the Coordinating Committee by March 1 of each year. The Plan will include development of inseason indices of relative fish abundance on a daily basis and annual estimates of juvenile migrant production. Estimates of relative abundance will be used to guide bypass operations decisions under subsections II.E.4, II.F.1, II.F.3, and II.F.4. Estimates of juvenile migrant production will be used as the basis for compensation adjustments (Hatchery-Based Compensation - Phase IV) as provided in subsection IV.A.3.

H. FPE EVALUATION PLAN

1. The PUD shall develop an FPE evaluation plan, in consultation with the Joint Fishery Parties, for review and approval by the Coordinating Committee by March 1, 1990. The purpose of the plan shall be to evaluate whether minimum FPE levels set out in subsection II.E are being met. The plan will provide for evaluation beginning in 1990 and continuing for at least three consecutive years after baffles are installed and operating in accordance with this Agreement in all five (5) bypass bays. If physical or

operational changes are made to the bypass systems, additional FPE evaluation under a new or amended plan will be required to provide at least three consecutive years of evaluation after completion of the changes.

2. It is the goal of evaluations under the plan to be able to determine FPE within plus or minus five percent (5%) at the ninety-five percent (95%) confidence level. If the FPE point estimates are equal to or greater than eighty-five percent (85%) for the spring run and seventy five percent (75%) for the summer run, then the accuracy of plus or minus ten percent (10%) at the ninety percent (90%) confidence level is acceptable. If the FPE point estimate for the spring run is between eighty (80) and eighty-five (85) percent, or the FPE point estimate for the summer run is between seventy (70) and seventy-five (75) percent, the PUD will implement one of the following actions:

(a) Take the necessary steps to achieve a FPE accuracy of plus or minus five percent (5%) at the ninety-five percent (95%) confidence level, or

(b) Take steps outlined in subsection II.E.3 to increase the FPE point estimates to eighty-five percent (85%) and seventy-five percent (75%) for the spring and summer runs, respectively.

3. The PUD will fund a biometrician or statistician selected by unanimous agreement of the Coordinating Committee to review the draft plan to ensure that the plan meets the objectives of subsections II.H.1 and 2, and to review results developed under the plan.

III. ADULT FISH PASSAGE

A. GENERAL SCOPE OF ADULT PASSAGE MEASURES

The current operating and maintenance criteria for facilities for the passage of adult anadromous fish over the Wells Project Dam are specified in this Section III. Changes in these criteria must be by unanimous agreement of the Coordinating Committee.

B. WATER DEPTH CRITERIA

The water depth over the weirs of the adult fish ladder will be 1.0 to 1.2 feet.

C. ENTRANCE CRITERIA

1. Head: 1.5 feet

2. Gate Settings:

a) March 1 - November 30

		Side Wing Gate	End Wing Gate
(i)	Spill less than 80 Kcfs	4 ft	6 ft
(ii)	Spill greater than 80 Kcfs	Closed	8 ft

(iii) Low level fixed orifice entrance to be open whenever side gate is closed.

b) December 1 - February 28

(i) Side and end gates open 2 feet six days per week for 24-hour periods.

(ii) Side and end gates open 4 feet and 6 feet, respectively, one day per week for a 24-hour period.

D. ATTRACTION JET CRITERIA

1. Jets are located in a vertical line immediately upstream of the side wing gates.

2. Lower jet (30-inch diameter) will operate only when the low level fixed orifice entrance is open.

3. Three 24-inch diameter jets (at elevations 700, 708, and 717 msl) will each be discharging when tailwater reaches that level.

E. STAFF GAUGE AND WATER LEVEL INDICATOR CRITERIA

Staff gauge and water level indicators will:

1. Be located upstream and downstream of all entrances, and at convenient locations for viewing along ladder.

2. Be located upstream and downstream of adult fishway exit trashrack.

3. Be readable at all water levels and be kept clean.

4. Be checked against panel board water surface readings to insure proper adjustment of water level sensing equipment.

F. TRASHRACK CRITERIA

1. Visible buildups of debris will be cleaned immediately from picketed leads near counting stations, and from trashracks at adult fishway exits.

2. The staff gauges upstream and downstream of the adult fishway exit trashrack will be monitored for water surface differential, which will reflect buildup on submerged trashrack. The trashrack will be cleaned immediately if the differential reading is greater than 0.3 feet.

G. MONITORING AND EVALUATION OF ADULT PASSAGE

1. In 1990, the PUD, in consultation with the Joint Fishery Parties, will develop a study plan to determine the extent of adult

delay and mortality at the Wells Project. The study plan will be reviewed and approved in advance by the Coordinating Committee. Studies will begin in 1991 and continue for a period of time determined by the Coordinating Committee based on preliminary results.

2. If the study identifies delays and/or mortality, the operating criteria specified in this Section III will be changed to alleviate these problems. If changes in the operating criteria do not alleviate the problems, adult passage facility modifications will be made. Provided, however, that any disagreements over the appropriateness of facility modifications of $325,000 or less (1988 dollars) may be taken through the expedited dispute resolution procedure in subsection I.D. And, provided further, that any disagreements over the appropriateness of facility modifications of more than $325,000 (1988 dollars) may be resolved under the FERC Rules of Practice and Procedure at any time.

IV. HATCHERY-BASED COMPENSATION

The PUD will fund a hatchery-based compensation program (the "Program") as provided in this Section IV. The Program will include the design, construction, operation, maintenance and evaluation of facilities required to implement the elements of a production plan (the "Production Plan") as set forth in this Section. The purpose of the Program is to mitigate for fish passage losses at Wells Dam. The Program is composed of adult collection sites; a central hatchery facility for incubation, early

rearing, and adult holding; and acclimation facilities in the tributaries above Wells Dam for final rearing and release.

A. PRODUCTION PLAN

1. The Joint Fishery Parties have developed the Production Plan to define the requirements of hatchery-based compensation under this Agreement. The Production Plan describes juvenile rearing and release requirements, including species mix and target release sizes; and related broodstock requirements under subsection IV.D.

2. The Production Plan will be reviewed annually by the Joint Fishery Parties, and may be modified by the Joint Fishery Parties in consultation with the PUD. Modifications to the Production Plan may include changes to the species mix and rearing and release strategies as required to accommodate the Joint Fishery Parties' management needs. Modifications to the Production Plan will not require an increase in the rearing capability of the Program beyond that required to satisfy Phases One and Two of the Production Plan as shown in subsections IV.A.3(a) and (b) or Phases Three and Four of the Production Plan to be determined as shown in sections IV.A.3(c) and (d). The Production Plan and any modifications thereto will be consistent with guidelines and procedures developed under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program.

3. The Production Plan is comprised of four phases of hatchery-based compensation as described below. It also includes related broodstock requirements under subsection IV.D.

(a) Phase One

Phase One will begin in 1991 and will consist of the following compensation elements:

(1) 49,200 pounds of spring chinook yearlings at about 15/pound;

(2) 8,000 pounds of sockeye juveniles at about 25/pound; and

(3) 30,000 pounds of steelhead smolts at about 6/pound

(4) After 1991, space to rear additional steelhead will be provided by the PUD at Wells Hatchery, if such space is available and not needed to meet other PUD fish production responsibilities. The PUD will not be obligated to fund or supply well water to rear the fish.

(b) Phase Two

Phase Two will begin after evaluation of the Phase One Production Plan and will be restricted to the Program required by either the Phase Two A or Two B Production Plan as shown below. At the time of implementation, the Phase Two A or Phase Two B Production Plan may be modified based on other Phase One evaluations described in subsection IV.C, Studies and Evaluations, subject to the provisions of subsection IV.A.2.

(1) Phase Two A

Increase sockeye production from 8,000 pounds to 15,000 pounds of juveniles at about 25/pound.

(2) Phase Two B

(i) Eliminate sockeye production;

(ii) Add 15,000 pounds of summer chinook yearlings at

about 10/pound; and 6,500 pounds of zero-age summer chinook juveniles at about 40/pound.

(c) Phase Three

Phase Three will begin as soon as practicable following Coordinating Committee approval of the results of the Wells Project juvenile mortality/survival study or no later than the third brood year after Coordinating Committee determination of the adjustments required and will consist of the following compensation elements:

(1) Except for steelhead, which shall remain at 30,000 pounds, adjust compensation requirement to reflect the difference between the juvenile mortality rate determined by the mortality/survival study under subsection IV.C.5 and the assumed mortality rate shown in Appendix A; and

(2) Adjust compensation requirement to reflect unavoidable and unmitigated adult losses, as determined by Coordinating Committee approved estimates from studies conducted under subsection III.G, and converted to juvenile production based on adult to smolt ratio estimates as described in Appendix B.

(d) Phase Four

Phase Four will begin at such time as the Coordinating Committee approved five-year rolling average estimate of juvenile run size, estimated as described in subsection IV.C.6 and Appendix A, increases to at least 110% of the 9,034,700 estimated juvenile migrant salmon production used to establish the Phase One and Phase Two compensation levels shown in subsections IV.A.3(a) and

IV.A.3(b). Phase Four will consist of compensation adjustment, if requested by the Joint Fishery Parties, to reflect the percentage increase in juvenile run size, except for steelhead, which shall remain at 30,000 pounds. The Joint Fishery Parties, in consultation with the PUD, will determine the appropriate form of compensation (i.e., fish production) for any adjustments required in Phase Four.

B. COMPENSATION PROGRAM

1. The facilities provided in the Program will be designed, constructed, operated, maintained, and evaluated to produce the hatchery-based compensation set forth in the Production Plan.

2. If the evaluations described in subsection IV.C indicate that the Program is not meeting the production levels called for in the Production Plan, then reasonable modifications to the Program will be made.

3. The PUD will only be obligated to assure the capability of facilities provided under this Agreement to produce high quality juvenile fish at the compensation levels shown in subsection IV.A.3.

4. The Program facilities described in this Agreement are in addition to the existing mitigation program at Wells. The existing mitigation program at Wells consists of annual production of 50,000 pounds of steelhead and 56,500 pounds of summer chinook salmon. Under the 1984 Mid-Columbia Stipulation, which expired in 1989, 400,000 summer chinook at 90/pound have been reared at Wells for release into the Methow River. This production will continue until

Phase One production is initiated. Nothing in this Agreement will affect the annual production of 25,000 pounds of steelhead under the Oroville-Tonasket agreement between the PUD and the U.S. Bureau of Reclamation.

5. Facilities provided in the Program will consist of:

(a) Phase One

Phase One compensation facilities, including satellite facilities, shall be capable of rearing and releasing 57,200 pounds of salmon and 30,000 pounds of steelhead annually.

(b) Phase Two

Phase Two compensation facilities shall be capable of increased production to accommodate the Production Plan as described in subsection IV.A.3(b).

(c) Phase Three

Phase Three compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(c).

(d) Phase Four

Phase Four compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(d). Facilities for the required adjustments will be constructed by the PUD as soon as practicable and be operational no later than the third brood year following the Joint Fishery Parties request under subsection IV.A.3(d).

6. Production and acclimation facilities used in the Program shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The biological criteria and guidelines described in subsection IV.D shall apply to production and acclimation facilities used in the Program.

C. STUDIES AND EVALUATIONS

1. The PUD will develop and fund studies in 1990, approved by unanimous agreement of the Coordinating Committee, to determine:

(a) Potential for spawning and rearing sockeye in unutilized habitat in the Okanogan and Similkameen systems;

(b) Potential for establishing sockeye populations in the new habitat.

2. The PUD will fund the Joint Fishery Parties' effort to determine the success of Phase One sockeye compensation based on review of smolt production. The Joint Fishery Parties may make this determination after the evaluation of the third brood year's production.

3. The PUD will fund the Joint Fishery Parties to develop and conduct studies to evaluate the adequacy of the Program and the effectiveness and success of the Production Plan subject to the provisions of Section V, Coordinating Committee. The studies will meet standards developed for similar efforts under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program. The studies will pass the test of reasonableness with respect to cost and duration.

(a) The studies will involve marking a portion of the juvenile fish produced under subsection IV.B and will involve recoveries of juvenile and adult fish to estimate various parameters such as fish health, fishery contribution, survival, spawning time and spawning locations.

(b) The PUD will fund recovery efforts at Wells Dam and hatchery and tributary spawning areas above Wells Dam. Existing recovery operations, currently funded through different sources, will be utilized to the extent possible. Approved studies may require the PUD's participation in funding a portion of other recovery efforts.

(c) The evaluations provide data necessary to determine the success of the Program to produce the intended compensation levels and the effectiveness of the Production Plan to meet management objectives.

(d) Evaluation of the Production Plan and Program effectiveness will be initiated in Phase One for all species in the Production Plan.

(e) To the extent that the Joint Fishery Parties elect to modify the Production Plan, the PUD will fund studies to evaluate the modifications. The studies will be mutually agreeable and are intended to evaluate only the changes called for in the modification. The studies will be consistent with the provisions of Section V, Coordinating Committee.

(f) The PUD will fund an analysis of annual fish production and adult contribution to harvest and escapement to be conducted

by the Joint Fishery Parties. The analysis will be consistent with the provisions of Section V, Coordinating Committee. Draft and final reports will be provided to the Parties.

5. No later than 1990, a Wells Project juvenile mortality/survival study will be developed by the PUD in consultation with the Joint Fishery Parties and approved by unanimous agreement of the Coordinating Committee. The studies will begin in 1991, after the installation of new turbine runners at the Wells Project, for the purpose of determining juvenile losses.

6. The PUD will provide data from its ongoing, annual adult passage monitoring program that will allow the Joint Fishery Parties to compute the five-year rolling average estimate of juvenile run size which will be the basis for Phase Four compensation, as indicated in subsection IV.A.3(d). Calculation of increases in juvenile run size will be based on fish from existing mitigation programs, natural production and future compensation programs. The method of calculation will be as described in Appendices A and B.

D. PRODUCTION/ACCLIMATION FACILITIES

Production and acclimation facilities under this Section shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The following biological criteria and guidelines shall apply to production and acclimation facilities under this subsection IV.D. Criteria are not to be exceeded. Guidelines are not to be exceeded if practicable.

1. Salmon Criteria

(a) Adult Holding

(i) Density not to exceed one (1) fish per ten (10) cubic feet of space.

(ii) Flow must be at least one (1) gallon per minute per 20 pounds of fish.

(b) Juvenile Rearing

(i) Density not to exceed 0.75 pounds of fish per cubic foot of rearing space for yearling chinook to a size of 10 fish per pound. Maximum density is achieved at release date. The density through out the rearing period is proportionately lower and directly related to fish size.

(ii) Pond or raceway loading rate not to exceed 6.0 pounds of fish per gallon of water per minute inflow for yearling chinook at a size of 10 fish per pound. Maximum loading rate is achieved at release date. The loading rate throughout the rearing period is proportionately lower and directly related to fish size.

(iii) Density for sockeye juveniles in net pens not to exceed 0.33 pounds of fish per cubic foot of rearing space.

(c) Water Supply

(i) Water will be of highest quality practicably available at appropriate sites. Ground water may be required at sites. All water supplies will be pathogen free if practicable. The water source must not preclude transfer of the stocks being reared to their point of origin due to presence of fish disease organisms in the rearing water supply.

(ii) Reuse of water is not acceptable for either egg incubation or juvenile rearing.

(iii) Reuse water is acceptable for adult holding.

(iv) Effluent water from egg incubation may require treatment for fish diseases (e.g., chlorination/dechlorination).

(v) Construction of facilities must accommodate the potential to treat the juvenile rearing and adult holding water for disease pathogens.

(d) General

(i) Facilities must have the capability to maintain stock segregation from adult holding through incubation and rearing.

(ii) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(iii) Protection from mammalian and avian predators must be provided.

2. Salmon Guidelines

(a) Water Temperatures

(i) Egg incubation - no greater than 55°F nor less than 38°F.

(ii) Fry starting - 48-52°F.

(iii) Juvenile rearing - not to exceed 52°F.

(iv) Adult holding - not to exceed 55°F.

(b) Release Size, Time, and Location

(i) Yearling spring chinook - 15 fish/pound in late April.

(ii) Yearling summer chinook - 10 fish/pound in late April.

(iii) Subyearling summer chinook - 40 fish/pound in June.

(iv) Subyearling sockeye - 25 fish/pound in June.

(v) Juvenile fish will be acclimated and released in tributaries above Wells Dam.

(c) Adult Brood Stock

(i) Sufficient adults of the appropriate species and stocks will be trapped and held to meet the egg requirements for each phase of salmon production.

(ii) Fifty percent (50%) of the adults trapped will be females and it is assumed there will be

approximately eighty percent (80%) survival of eggs from trapping of females to ponding of fry.

(iii) Adult brood stock will be collected at the following sites:

a) Spring chinook - Chewack River, Methow River above Winthrop, and Twisp River above river mile 2.0.

b) Summer chinook and sockeye - at Wells Dam

(iv) Tributary brood stock collection facilities will require an annually installed rack and a semi-permanent box trap.

(v) Wells Dam brood stock collection may require a separator/sorter in the left bank fishway. The final design of the left bank trap and any modification of the right bank trap will be approved by unanimous agreement of the Coordinating Committee.

(vi) The adults will be transferred in a water-to-water system from traps to tank trucks to holding ponds.

(vii) The PUD shall provide funds for personnel to separate and sort adult fish in the right bank fishway at Wells Dam and at other required adult collection sites. All brood stock collection shall be conducted in a manner to

minimize delay of non-target species and individual fish.

3. Steelhead Criteria

The goal for this program is to use the existing facilities including well and river water, raceways, rearing ponds, house, shop, freezer, office, etc., in the manner they are being used now. Most of the following criteria and guidelines fit the existing program.

(a) Adult Holding

(i) Density not to exceed 2.5 pounds of fish per cubic foot of water.

(ii) Flow must be at least one gallon per minute for 3.3 pounds of fish.

(b) Juvenile Rearing

(i) Density: Calculated density limit not to exceed Pipers density formula: $W = D \times V \times L$ where

W = Permissible weight in pounds.

D = Density index (.25 for raceways and .03 for rearing ponds).

V = Useable volume in container in cubic feet.

L = Fish length in inches.

ii) Water flow: Calculated flow should not allow weight to exceed Pipers flow formula:

$W = F \times L \times I$ where

W = Permissible weight in pounds.

F = The loading factor from Table 1.

L = Fish length in inches.

I = Water flow in gallons per minute.

Table 1. Load factor as related to water temperature and elevation.

Water Temperature(°F)	Load Factor(lbs/in/gpm) Raceways(1)	Rearing Ponds(2)
40	2.70	3.62
41	2.61	3.53
42	2.52	3.44
43	2.43	3.35
44	2.34	3.26
45	2.25	3.17
46	2.16	3.08
47	2.07	2.99
48	1.98	2.90
49	1.89	2.81
50	1.80	2.72
51	1.73	2.65
52	1.67	2.59
53	1.61	2.53
54	1.55	2.47
55	1.50	2.42
56	1.45	2.37
57	1.41	2.33
58	1.36	2.28
59	1.32	2.24
60	1.29	2.21
61	1.25	2.17
62	1.22	2.14
63	1.18	2.10
64	1.15	2.07

1) From Piper et al. 1978
2) From Wells hatchery

(c) Water Supply

(i) Water supply to be of highest quality practicably available using ground and river water. Any disease contracted because of water source

must not stop release of fish in local watersheds.

(ii) Reuse water not acceptable for egg incubation.

(iii) Reuse water normally acceptable (unless disease problem) for adult holding.

(iv) Effluent water from egg incubation will require treatment for fish diseases.

(v) Adult holding and juvenile rearing water may have to be treated for disease pathogens.

(d) General

(i) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(ii) Protection from mammalian and avian predators must be provided.

4. Steelhead Guidelines

(a) Water Temperatures

(i) Egg incubation: 38°F to 55°F

(ii) Fry starting: 48°F to 54°F

(iii) Juvenile Rearing not to exceed 57°F

(iv) Pre-smolt not to exceed 54°F

(v) Adult holding not to exceed 54°F

(b) Release age, time, size and location

(i) Released as yearlings

(ii) April 10 to May 10 at six to the pound.

(iii) Juvenile steelhead will be released in tributaries or into the mainstem above Wells Dam.

(c) Adult Broodstock

(i) Fifty percent (50%) will be females and assume eighty percent survival of eggs to ponding of fry.

(ii) Adults will normally be trapped at the existing facilities on the right bank, however new trap at left bank may be used sometimes.

(iii) Adults will be transferred in water from traps to holding ponds.

V. WELLS PROJECT COORDINATING COMMITTEE

A. COORDINATING COMMITTEE

There shall be a Wells Project Coordinating Committee composed of one (1) technical representative of each Party to this Agreement. The Coordinating Committee shall meet whenever requested by any two (2) Parties following a minimum of ten (10) days written notice (unless waived), or pursuant to subsection I.D, and shall act only by unanimous agreement of all Parties. Any Joint Fishery Party may, at any time, elect by written notice not to participate in the Coordinating Committee. The PUD shall fund a neutral third party to record and distribute minutes of Coordinating Committee meetings.

B. USE OF COMMITTEE

The Coordinating Committee will be used as the primary means of consultation and coordination between the PUD and the Joint Fishery Parties in connection with the conduct of studies and implementation of the measures set forth in this Agreement and for dispute resolution pursuant to subsection I.D. All study designs and modifications to study designs will be subject to agreement by all Parties.

C. STUDIES AND REPORTS

1. All studies and reports prepared under this Agreement will be available to all Parties as soon as reasonably possible. Draft reports will be circulated through Coordinating Committee representatives for comment, and comments will either be addressed in order or made an appendix to the final report.

2. All studies will be conducted following accepted techniques and methodologies in use for similar studies in the Columbia Basin. All studies will be based on sound statistical design and analysis.

3. Fish passage efficiency tests will be conducted using hydroacoustic means and direct capture methods for species identification.

VI. JOINT FISHERY PARTIES' RESPONSIBILITIES

A. LIMITATION OF MID-COLUMBIA PROCEEDING

The Joint Fishery Parties agree to join with the PUD to request that the FERC terminate the Mid-Columbia proceeding insofar

as it pertains to the Wells Project. The Parties specifically agree to reserve the right to enforce the terms and conditions of this Agreement before the FERC.

B. SUPPORT FOR RELICENSE

The PUD's FERC license for the Wells Hydroelectric Project expires in 2012. The Joint Fishery Parties agree to be supportive of the PUD's new or renewal license application to the FERC, provided that the PUD has adhered to the terms and conditions of this Settlement Agreement, as well as any future terms, conditions, and obligations agreed upon by the Parties hereto or imposed upon the PUD by the FERC. To the extent that the PUD has met such terms and conditions, the Joint Fishery Parties agree that the PUD is a competent license holder with respect to its obligations to anadromous fish resources. Nothing in this paragraph shall limit or preclude any Party hereto from requesting at the time of any license renewal the provision of or supporting different, modified or additional fish protection measures and compensation; or from requiring that the fishery protection measures contained in a competing license application be included as a condition of the PUD's new license, or in the absence of such additional or modified measures in a new license, or in the absence of measures contained in a competing license application requested by the Joint Fishery Parties, from requesting that the PUD's new or renewal license application be denied.

C. STIPULATION OF ADEQUACY

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement constitutes adequate fish protection and full compensation for all fishery losses caused by the Wells Project at least until March 1, 2004. It is further stipulated that this Agreement satisfies any obligations of any Party relating to the adequacy of fish protection and compensation for fish losses caused by the Wells Project, and arising under applicable laws and regulations, including but not limited to the Federal Power Act, the Pacific Northwest Electric Power Planning and Conservation Act, and the Electric Consumers Protection Act of 1986, at least until March 1, 2004. This Agreement shall not otherwise affect the rights of any Party except as expressly covered by this Agreement.

D. FISH AND WILDLIFE PROGRAM

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement shall constitute full compliance with the applicable provisions of the Northwest Power Planning Council's 1987 Fish and Wildlife Program, at least until March 1, 2004. The Joint Fishery Parties stipulate that the PUD shall receive full credit for its hatchery production in meeting any requirements that may be established as a result of implementation of Section 203 of the Council's Program.

E. LIMITATION ON REOPENING

The Joint Fishery Parties shall not invoke or rely upon any reopener clause set forth in any license applicable to the Wells

Project for the purpose of obtaining additional fish measures or changes in project structures or operations pertaining to fishery issues until after March 1, 2004.

F. ADDITIONAL MEASURES

The Joint Fishery Parties shall refrain from contending on their own behalf or supporting any contention by other persons in any proceeding or forum that additional fish measures or changes in project structures or operations pertaining to fishery issues should be imposed at the Wells Project until after March 1, 2004.

VII. MISCELLANEOUS

A. COOPERATION

The Parties shall cooperate in conducting studies and shall provide assistance in obtaining any approvals or permits which may be required for implementation of this Agreement.

B. NOTICES

All written notices to be given pursuant to this Agreement shall be mailed by first-class mail, postage prepaid, to each Party at the address listed below or such subsequent address as a Party shall identify by written notice to all other Parties. Notices shall be deemed to be given three (3) days after the date of mailing.

C. WAIVER OF DEFAULT

Any waiver at any time by any Party hereto of any right with respect to any other Party with respect to any matter arising in

connection with this Agreement shall not be considered a waiver with respect to any subsequent default or matter.

D. ENTIRE AGREEMENT -- MODIFICATIONS

All previous communications between the Parties hereto, either verbal or written, with reference to the subject matter of this Agreement are hereby abrogated, and this Agreement duly accepted and approved, constitutes the entire agreement between the Parties hereto, and no modifications of this Agreement shall be binding upon any Party unless executed or approved in accordance with the procedures set forth in subsection I.C.

E. BENEFIT AND ASSIGNMENT

This Agreement shall be binding upon and inure to the benefit of the Parties hereto and their successors and assigns provided, no interest, right or obligation under this Agreement shall be transferred or assigned by any Party hereto to any other Party or to any third party without the written consent of all other Parties, except by a Party:

(a) To any person or entity into which or with which the Party making the assignment or transfer is merged or consolidated or to which such Party transfers substantially all of its assets; or

(b) To any person or entity that wholly owns, is wholly owned by or is wholly owned in common with the Party making the assignment or transfer.

F. FORCE MAJEURE

The PUD shall not be liable for failure to perform or for delay in performance due to any cause beyond its reasonable control. This may include, but is not limited to, fire, flood, strike or other labor disruption, act of God, act of any governmental authority or of the Joint Fishery Parties, embargo, fuel or energy unavailability, wrecks or unavoidable delays in transportation, and inability to obtain necessary labor, materials or manufacturing facilities from generally recognized sources in the applicable industry. The PUD will make all reasonable efforts to resume performance promptly once the force majeure is eliminated.

G. INFLATION CALCULATIONS

All dollars specified in this Agreement are 1988 dollars. Dollar figures shall be adjusted annually for each year after 1988 based on the "Consumer Price Index for All Urban Consumers" published by the Bureau of Labor Statistics of the U.S. Department of Labor. If this index is discontinued or becomes unavailable, a comparable index agreeable to all Parties will be substituted.

H. METHOW RIVER HATCHERY WATER SUPPLY

1. The PUD agrees to cooperate with the Washington Department of Fisheries (WDF) to secure the necessary water rights and permits for facilities to be provided under this Agreement.

2. With respect to the proposed Methow River hatchery, the Parties agree that WDF and the PUD may utilize for the proposed Methow River hatchery facility up to 7 cfs of the water right now

held by the U.S. Fish and Wildlife Service (FWS), and subject to full or partial recall by FWS for any reason. The PUD shall not obtain legal title or ownership of the FWS water right.

3. To the extent that the utilization of water does not occur or is recalled or returned to FWS, the PUD and WDF shall use their best efforts to acquire an alternative source of water that meets applicable State requirements for water rights in order to satisfy obligations under this Agreement.

4. The PUD agrees to cooperate with WDF to secure the necessary permits in order to construct and provide for the operation of the proposed Methow River hatchery. The hatchery will be designed and constructed with the capability of installing pump-back facilities for returning the flow to the point of diversion.

5. If hatchery and/or river water supply requirements dictate the need for installation of a pump-back scheme, the PUD shall install and WDF shall operate the pump-back facilities.

VIII. REGULATORY APPROVAL

A. FERC ORDERS

All Parties agree to join in the filing of an offer of settlement with the FERC based on this Agreement and to request that the FERC issue appropriate orders approving the settlement. All Parties shall refrain from seeking judicial review of the FERC orders approving this Agreement.

B. PERFORMANCE CONTINGENT ON APPROVAL

Performance of all Parties' obligations under this Agreement

is expressly made contingent on obtaining all necessary regulatory approvals, specifically including all FERC orders referred to in subsection VIII.A above, and all applicable federal, state and local permits. It is expressly agreed by all Parties that this Agreement shall be submitted to the FERC as a unit and any material modification of its terms, approval of less than the entire Agreement, or addition of material terms by the FERC shall make this Agreement voidable at the option of any Party.

C. NO PREJUDICE

All Parties stipulate that neither FERC approval nor any Party's execution of this Agreement shall constitute approval or admission of, or precedent regarding, any principle, fact or issue in the Mid-Columbia proceedings, or any other FERC proceeding, including subsequent modification proceedings under Section I.

D. EXECUTION

This Agreement may be executed in counterparts. A copy with all original executed signature pages affixed shall constitute the original Agreement. The date of execution shall be the date of the final Party's signature. Approval of this Agreement must be acknowledged by the Commissioner of Indian Affairs and the Secretary of the Interior, or their delegates, to the extent required by 25 U.S.C. § 81.

E. AUTHORITY

Each Party to this Agreement hereby represents and acknowledges that it has full legal authority to execute this Agreement and shall be fully bound by the terms hereof.

F. ACTION FOR NONCOMPLIANCE

Notwithstanding any other provision of this Agreement, any Party may seek relief arising solely from noncompliance with this Agreement by any Party; provided, all requests for specific performance of any provision of this Agreement shall be filed with the FERC pursuant to subsection I.D.

IN WITNESS WHEREOF, the Parties have executed this Agreement the day and year first written above.

APPENDIX A

JUVENILE MIGRANT LOSS ESTIMATES USED FOR COMPENSATION PLANS IN THE WELLS DAM SETTLEMENT AGREEMENT

1. Steelhead

The number of juvenile steelhead migrants killed by passage through the Wells Project reservoir and dam were not estimated for the purposes of this Settlement Agreement. As an alternative the parties have agreed to continue steelhead production programs and plans initiated under previous Mid-Columbia settlements.

2. Salmon Loss Estimates

The number of juvenile salmon migrants killed by passage through the Wells Project reservoir and dam were estimated as follows:

a. The number of juvenile migrant salmon, by species and race, entering the Wells Reservoir was estimated for natural production by applying sex ratios, egg per female data and theoretical egg to migrant survival rates to the numbers of adults passing above Wells Dam to spawn. These juvenile migrant numbers were computed annually and averaged over the passage years 1975-1984 for spring and summer chinook and averaged over the passage years 1975-1986 for sockeye. The recent average level of hatchery releases at Winthrop National Fish Hatchery were added to the spring chinook migrant estimates. The resulting estimates of average annual numbers

of juvenile migrant salmon entering Wells reservoir are:

Spring Chinook	=	1,504,400
Summer Chinook	=	2,913,300
Sockeye	=	4,617,000
Total	=	9,034,700

b. The total project mortality at Wells, including reservoir mortality, was estimated to be 14%. Applying this mortality rate to the population estimates in Item 1 above results in the following estimates of juvenile migrants killed by species:

Spring Chinook	=	210,600
Summer Chinook	=	407,900
Sockeye	=	646,400
Total loss	=	1,264,900

3. Derivation of Production Plan

a. The Phase I compensation Production Plan and Program is an initial step in production which is not intended to provide full compensation for juvenile migrant losses. The lack of full compensation is due to the experimental nature and developmental aspects of the sockeye Production Plan and Program.

b. To accommodate logistic and per-unit cost factors in Phase I development, about 225,000 (15,000 pounds) spring chinook were substituted for 231,000 sockeye.

c. Items (1) through (3) below describe the derivation of the hatchery-based compensation levels included in the body of the Agreement.

(1) Steelhead production is set at 30,000 lbs./year to continue the successful program initiated under prior Mid-Columbia Settlement Agreements.

(2) Phase I compensation includes a pilot program for hatchery production of sockeye. The sockeye production level is set to allow assessment of Program success rather than provide full compensation for the estimated juvenile losses at Wells.

(3) The Phase II Chinook/Sockeye Production Plan is sized to mitigate for estimated juvenile losses:

	Estimated Annual Losses at Wells	Annual Production Phase IIA or Phase IIB	
Spring Chinook	210,600	450,000	450,000
Summer Chinook	407,900	400,000	810,000
Sockeye	646,400	375,000	-
TOTALS	1,264,900	1,225,000	1,260,000

4. Chelan PUD/Douglas PUD Compensation Exchange

In recognition of the specific requirements for spring and summer chinook rearing facilities and the characteristics of the water supply at the PUD's proposed spring chinook rearing facility on the Methow River, the Joint Fisheries Parties, Douglas PUD and Chelan County PUD have reviewed the respective compensation

obligations of Douglas PUD as set forth in this Agreement, and Chelan County PUD under terms of the Rock Island Settlement. In consideration of biological efficiency and logistical effectiveness, the parties have agreed to adjusted compensation obligations under this agreement and the Rock Island Settlement in the following manner:

a. Douglas PUD will assume responsibility for 19,200 pounds of Methow River sub-basin spring chinook production.

b. Chelan PUD will assume responsibility for 40,000 pounds of Methow River summer chinook production.

The resulting changes in production with the Douglas-Chelan compensation exchange agreement are (number of juveniles/year):

	Douglas Production	Chelan Production
Spring Chinook	Increases 288,000	Decreases 288,000
Summer Chinook	Decreases 400,000	Increases 400,000
Sockeye	No Effect	No Effect

c. The resultant Douglas PUD annual compensation program under this agreement (Phase II Production) is:

Phase IIA

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Sockeye @ 25/lb.

OR

Phase IIB

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Summer Chinook @ 10/lb.

6,500 lbs. of Summer Chinook at 40/lb.

APPENDIX B

DETERMINATION OF RESPONSIBILITY FOR HATCHERY COMPENSATION

For each year of determination, calculate an average smolt output as follows:

1. Calculate a 5-year running average adult run (by species) for naturally spawned fish (Ays) as follows:

$$\bar{A}ys = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

Where Ay is the total adult count for each species at Wells minus the hatchery escapement for the species in year y;

Ay-1 = the same in the previous year (y-1) and so on.

2. Multiply Ays by the average expected adult to smolt production factor Kys for each species, where Kys is calculated as follows:

a. Spring Chinook:

Ksp = 0.94 (Wells Dam to spawner survival)
x 0.50 (sex ratio) x 5000 (eggs/female)
x 0.10 (av. survival to smolt) = 235

b. Summer Chinook:

Ksu = 0.94 x 0.50 x 5000 x 0.30 = 705

c. Sockeye:

$$Kso = 0.94 \times 0.50 \times 2700 \times 0.12 = 152$$

3. Add the number of hatchery smolts HSys by species, which is a running average of the same 5 years as in Ays.

$$\overline{HSys} = \frac{HSy + HSy\text{-}1 + HSy\text{-}2 + HSy\text{-}3 + HSy\text{-}4}{5}$$

4. Total smolts (by species):

$$\overline{S}ys = Kys \times \overline{A}ys + \overline{HS}ys$$

5. Grand Total = Sum of all species:

$$Sgt = \overline{S}sp + \overline{S}su + \overline{S}so + \ldots$$

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 Gorman
Commissioner

T. James Davis
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

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FOR PACIFIC POWER & LIGHT COMPANY:

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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OF FISHERIES:

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OF WILDLIFE:

Ray Ryan 6/11/90
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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:

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OF THE UMATILLA INDIAN RESERVATION:

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Marvin L. Plenert, Regional Director
FOR THE U.S. FISH & WILDLIFE SERVICE

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FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

Edward H. Patawa

FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

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FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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