Report to the Federal Energy Regulatory Commission
for activities under the Long-Term Settlement Agreement
for the 1993 calendar year
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County

# 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, Washington 98802-4497

April, 1994

DOC # 34234

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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 fulfills portion (E)(d) of the Order requiring an annual report to be filed by April 30. This is the ~~third~~ 4th annual report under the Agreement and will cover the period between January 1 to December 31, 1993.

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## (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 the evaluation of adult passage at Wells Dam, various monitoring studies and operation plans.

### 1.1 Annual Bypass System Operations Plan for 1993

The Settlement Agreement calls for the District to provide an Annual Bypass System Operational Plan to members of the Wells Coordinating Committee (WCC) by December each year. The District submitted the Annual Bypass Plan for 1993 to the WCC for review on December 8, 1992. The WCC accepted the Plan (93-2)[1] (Appendix A). Bill Hevlin (National Marine Fisheries Service; NMFS) requested that the bypass provide additional protection to early migrating fish (93-2). The spring and summer migration is monitored by hydroacoustics at Wells. The level of hydroacoustic detections responds proportionally to the magnitude of the salmonid migration. B. Hevlin requested that the bypass operate when the hydroacoustic index reached 100. The matter was to be left up to the bypass team.

The Bypass Team for the Wells Project makes decisions on the start and end of bypass operation during both spring and summer migration periods. Representatives from the agencies, tribes and District make up the team (Agreement II.F.3). Members selected for the team in 1993 were Bill Hevlin (NMFS), Bob Heinith (Columbia River Inter-Tribal Fisheries Commission; CRITFC) and Rick Klinge (District) (93-2).

### 1.2 Juvenile Bypass Evaluation

The evaluation of the bypass system in 1990 through 1992 showed the bypass met and exceed the criteria established for fish passage efficiency under the Settlement Agreement. John Skalski, contract Statistician, prepared a final report combining the three years for a single point estimate of fish passage efficiency (93-2). Fish passage efficiency of 89% was calculated for both the spring and summer migrations (WCC 93-4; Appendix B).

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[1] (93-2) refers to minutes of the Wells Coordinating Committee from the second meeting in 1993. See Appendix H.

1.3 Predator Index Study for the mid-Columbia

The Washington Department of Wildlife and U.S. Fish & Wildlife Service presented a proposal to the mid-Columbia PUD's (Chelan, Douglas and Grant) to conduct a predator index study in five reservoirs including Wells. The WCC reviewed the study. The WCC discussed the study early in the year (93-2). The District, funded this effort for investigations in the Wells reservoir for the 1993 field season. Study results are expected by spring of 1994.

1.4 Miscellaneous Planning for the 1993 Bypass Season

The anticipated starting date of bypass operation for 1993 was April 15. This date coincided with the historical release schedule of hatchery salmon from the Winthrop National Fish Hatchery and timing of wild spring chinook in the mid-Columbia. This meant preparations for installation of bypass barriers and hydroacoustic equipment for the hydroacoustic index would need to be ready by April 1 (Agreement II.D.1.).

Bill Hevlin told the WCC (Memo 3/19/1993) that the operation of the bypass from 1990 - 1992 had not provided protection for early naturally produced spring chinook. He recommended a change in bypass operation based upon the level of hydroacoustic index used to interpret the start of the migration (93-2). The Bypass Team adopted these recommendations in the operation of the bypass for 1993.

1.5 Underwater Video monitoring of adult passage at Zosel Dam

Underwater video recording of adult sockeye passage has been successfully used at Columbia River Dams. The advantage of video monitoring over hydroacoustic sampling is that species identification is possible. Columbia River Inter-Tribal Fisheries Commission (CRITFC) submitted a proposal to the District to assess adult sockeye salmon passage with underwater video at Zosel Dam in 1993. The WCC requested to review the proposal for this work (93-1, 93-2). A feature to this proposal was to tag 600 sockeye for identification as they passed Zosel Dam (93-3). Tags with different colors for each week of the migration at Wells, would be recorded as fish passed Zosel Dam. Also recovery of carcasses with tags on the spawning grounds would provide information on success in reaching spawning grounds. CRITFC expressed interest in assessing success to spawning of the early portion of the migration. The WCC requested the number of tags be reduced to 200 tags. The WCC wanted to see an emphasis placed on the early potion of the run for movement up to Zosel Dam (93-3). CRITFC revised it's study proposal per recommendation of the WCC. The study was done during the calendar year with a report due in 1994.

1.6 Adult Passage Studies

The District worked with National Marine Fisheries Service to conduct an adult spring and summer chinook passage study through the ladders at Wells Dam for 1993. This study was part of a system wide project to assess passage at dams in the mid-Columbia and the Snake River. The WCC reviewed a draft study proposal 1992. The WCC discussed details of the study (93-1, 93-2, 93-4, 93-5, 93-6).

The Settlement Agreement calls for an Adult Delay/Mortality Study to be conducted by 1990 (Agreement III.G.1). The WCC agreed adult mortality cannot be associated with anyone incident (ie. resultant from Wells Dam) since there are likely multiple effects (effects from other dams, fishing gear damage, warm river temperatures, etc.) that would be cumulative. A delay study, on the other hand, may be done by radio telemetry. The District asked the WCC to clarify this change in fulfilling an obligation to III.G.1. A stipulation was circulated, language agreed to and signed by the parties to the Settlement Agreement. The District submitted this document to F.E.R.C. (93-1; Appendix C). The WCC felt the 1992 sockeye passage study plus the 1993 study with spring chinook would identify passage problems at Wells.

### 1.7 Project Mortality Study

The Settlement Agreement specified the District, along with consultation from the Joint Fisheries Parties, 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 had decided not to pursue this work in 1991 and 1992. The WCC decided to postpone this study again for 1993 (WCC 93-1).

### 1.8 Methow Trapping Facilities

The Settlement Agreement calls for adult collection facilities for spring chinook broodstock (Agreement IV.D.2.c.(3)(a)). Traps on the Twisp and Chewuck Rivers were completed in 1992. The District made modifications to the Twisp trap to encourage fish to find the trap entrance (93-2). The WCC suggested improvements to trap efficiency WCC (93-4, 93-6, 93-7). The District agreed to change the entrance to "V"-trap as per recommendation (93-8). Some erosion to Fulton Irrigation Dam on the Chewuck required repair. The WCC hoped that modifications to the adult ladder and trap may be done simultaneously (93-6). The District proposed that investigations of fish behavior first be conducted before significant changes be made at Fulton dam fishway. Planning for these studies was underway at the end of the year.

The trap on the Methow River was approved for construction by agency engineers. The project is part of a rehabilitation to an existing fish ladder and irrigation dam. Necessary permits were being solicited. The Okanogan Wilderness League (OWL) had requested to the State Shoreline Board that the shoreline permit be withheld for further review. The WCC discussed how to approach the objection (WCC 93-4). The delay in the process has put construction back at least a year (93-6).

The Washington Department of Fisheries submitted a Trapping Protocol for the Methow Hatchery (93-2; 93-3). The protocol had provisions for required numbers of natural escapement and minimum numbers of brood from each drainage to address concerns of genetics in hatchery settings. The WCC did not care to see 100% collection of adults from traps (93-3) and that 33% or 50% is a desirable level of collection. Tom Scribner (Yakama Indian Nation)(92-3) and Bob Heinith (CRITFC) requested that brood collection minimize harassment to native spawners (93-4). Also there was a request that 24 hour monitoring be made at the brood collection traps. A 24 hour sentry was employed at the Twisp trap to minimize possible injury of adult salmon on the floating pickets.

Due to the lack of collection trap on the Methow, there was discussion how brood would be collected for this part of the program. The WCC resisted a proposal to gaff fish from spawning grounds (93-5). The WCC later decided that fish returning to the hatchery outfall channel would be used for brood (93-5). These fish were progeny of both hatchery and wild spawners (93-7).

## 1.9 Evaluation of the hatchery facilities

The Settlement Agreement calls for an evaluation of the program or facilities built by the District (Section IV). The evaluation would look at the adequacy of the facility and operations to be able to implement the hatchery plan. The Evaluation sub-committee worked toward a draft plan (93-1, 93-2, 93-7). Rod Woodin (WDF) felt the plan needed to be in place (93-4, 93-9). The plan would be helpful for addressing required under Endangered Species Act for listed stocks in the Columbia River (93-4). The District funded investigations for baseline information to understand potential impacts to native population from the program. The District had shown an interest in providing a revised draft document and continues to work on this document (93-6). There was a question of the appropriateness of the evaluation of the facility being done by the agency operating the hatchery. An independent contractor has been used to oversee other evaluation programs to lend veracity to the evaluation process (93-7).

## 1.10 Sockeye Salmon Enhancement

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

The WCC agreed to pursue a "pre-pilot" program with 1992 brood. This program would rear 2,000 lbs. of production at 25 fish per pound to see if the Cassimer Bar facility was a suitable environment for the growth required for sockeye to reach a zero age smolt. Water temperatures have been recorded at 54° - 55°F., which were felt to be favorable for the growth needed from the fish. The "pre-pilot" showed the sockeye will grow rapidly, though the fish did not reach the desired size before summer. These fish were released in Lake Osoyoos in late May, 1993. Enough 1993 brood would be collected to allow for the full 8,000 pounds as part of the first of the three years of production and evaluation. The Colville Confederated Tribes distributed a sockeye brood collection and disease protocol to the WCC (93-4; 93-5; 93-6).

1.11 Okanogan Sockeye Salmon Planning

Bob Heinith (CRITFC) had submitted a draft plan for enhancement of Okanogan sockeye (93-1). The plan had several areas of research that would require some ranking for possible funding (93-1). Comments were received (93-2). The WCC felt the plan needed to be more specific and identify problems and opportunities. The trans-boundary stock status (migrating into Canada) made working with this population more difficult than most fish runs and created complexity of jurisdictions (93-8). A report prepared by Dr. Jack Rensel for the net-pens in Lake Osoyoos would be helpful for understanding limitations of the lake environment (Appendix D). Klinge and Feldmann continue to revise the plan (93-8, 93-9).

1.12 Okanogan Sockeye Spawning Ground Surveys

The WCC reviewed draft requests for proposals (RFPs) to assess spawning ground escapement of Okanogan sockeye (93-1). The WCC felt assessing escapement was important because of the significant discrepancy of counts between Wells and the spawning grounds. Proposals were solicited and a contractor selected (93-7).

1.13 Okanogan Sockeye Fry Emergence Study

The WCC discussed the possibility of a study of fry emergency timing of Okanogan sockeye (93-1, 93-7). The purpose of this project would be monitor emergence timing of sockeye from spawning gravels in the Okanogan down to Lake Osoyoos. The WCC developed the RFP. No proposals were received for the 1993 spring migration. The WCC wanted to see the work done in 1994 (93-7; 93-8; 93-9). The WCC worked toward development and distribution of a RFP before the end of the year for work in 1994. The thrust of the study would be timing on the fry migration and possible impact from irrigation operations (93-8).

1.14 1994 Bypass Operational Plan

The District submitted to the WCC, a Bypass Operational Plan for 1994, at the December 1 meeting as per Section II.F.1 of the Settlement Agreement (93-9). The plan outlined scheduled hatchery releases above Wells Dam and anticipated the starting and completion date of bypass operation (Appendix E).

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Spring Chinook Spawning Surveys in the Methow River Basin

The Yakama Indian Nation has conducted spawning ground surveys in the Methow basin for spring chinook since 1988. The information on abundance and distribution of spawners will be important for the evaluation of the Methow Supplementation facility. The YIN submitted a final report to the WCC (93-1).

The report showed for the three basins, there were 19%, 25%, and 45% of escapement to the basin that spawned in the Twisp, Chewuck and Methow Rivers respectively. The remaining 11% returned to the National Hatchery.

Spawning ground counts in 1993 were 617 redds for 127 miles of streams surveyed (93-7; Appendix F). It was speculated that the adult traps have caused a re-distribution of spawners in the area (93-8). This situation was observed at broodstock traps from other supplementation projects (93-8).

### 2.2 Okanogan Sockeye Spawning Ground Surveys

Sockeye surveys in 1993 were conducted by Parametrix. Escapement at Wells Dam was 28,038 sockeye. Estimated escapement to the spawning grounds was 21,505 (93-9; Appendix G). Part of the work at Zosel Dam in 1993 was to follow migration of sockeye tagged in the early migration (see Section 1.5 and 2.4). Inspections of 11,000 sockeye carcasses on the spawning grounds only produced 2 of the 200 tags placed on sockeye at Wells. The WCC also discussed the possibility of sockeye redds being de-watered prior to the full incubation period. The provincial government in British Columbia regulates flows in the Okanogan River that may be detrimental to incubating sockeye eggs (93-8). The committee agreed to explore this situation further.

### 2.3 Adult Passage Study with sockeye salmon

National Marine Fisheries Service conducted a telemetry study with sockeye salmon in 1992 to understand passage issues at Wells Dam. The report for this work was due by spring 1993. The report was delayed because of complications of work schedule through the year (93-6; 93-7, 93-8, 93-9).

### 2.4 Video Monitoring of Adult Passage at Zosel Dam

The Columbia River Inter-Tribal Fisheries Commission presented results from monitoring efforts at Zosel Dam with underwater video records. Video equipment recorded sockeye passage at Zosel Dam in route to spawning grounds in the Okanogan River. It was hoped that video records would confirm pre-spawn mortality of sockeye before passage at Zosel. Records of passage at Wells and counts on the spawning grounds shows as much as 50% of the adult that pass Wells never successfully spawn.

Video tapes did not record total escapement because of a limited effective field of view at the exit of the ladder. The report presented a range of escapement. The study did reveal that sockeye passed Zosel when temperatures dropped below 73°F. The scientific literature indicated these temperatures are lethal for adult salmonids (93-1, 93-2).

A similar effort was done in 1993. Flows were significantly higher than the previous year. Consequently, spill gates at Zosel Dam were open and the sockeye chose to ascend spill. There were only 144 sockeye picked up on video tape (93-7). None of the 200 tagged fish to assess migration success of early sockeye were seen on the recordings at Zosel Dam.

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

3.1 Methow River Spring Chinook Facility

The Settlement Agreement called for a hatchery based compensation program for spring chinook composed of adult collection sites; a central hatchery facility for incubation, early rearing, and adult holding and acclimation facilities for final rearing (Agreement IV). Hatchery personnel reared progeny from 1992 broodstock in all sections of the facility (93-2).

Hatchery personnel operated brood collection facilities on two of the three sub-basins of the Methow in 1992. A trap was scheduled for work on the Methow River at Fog Horn Dam in 1993. Due to concern from a local environmental group about the project, construction was placed on hold until permits could be obtained. The WCC recommended brood could be collected in the hatchery outfall channel (93-5; 93-6) instead of the adult collection facility.

3.2 Cassimer Bar Sockeye Hatchery

The Settlement Agreement call for a pilot effort to enhance Okanogan sockeye for three years at 8,000 pounds of production (IV.A.3.(a)(2)). This effort would also have an evaluation to gauge the success of the program. Brood were collected at Wells Dam in 1992 for a limited "pre-pilot" evaluation of 2,000 pounds of production. Fish were held, spawned and eggs incubated at the Methow Hatchery and transferred to the Cassimer Bar sockeye facility, at the mouth of the Okanogan River (93-1, 93-2). This limited production demonstrated sockeye do grow very rapidly at the Cassimer Bar facility. The fish did not reach desired size at 25 fpp in six months.

The Colville Tribes (CCT) collected adult sockeye at Wells for the first of a three year evaluation of 8,000 pounds of production (93-7, 93-8). Fish were screened for bacterial and viral diseases. Eggs from 1993 brood were being incubated at Cassimer Bar through the end of the year.

3.3 Contract professional services in implementing the Settlement Agreement.

During 1993, the District contracted with Dr. Richard Whitney to serve as Studies Coordinator for the Wells Coordinating Committee. The District also contracted with Dr. John Skalski to provide statistical evaluation of methods and studies.

3.4 Juvenile and Adult Fish Passage Operations at Wells Dam

During 1993, the juvenile bypass system operated as per conditions outlined in the Settlement Agreement (II,C,D,F). The bypass operated between April 14 and June 8 (55 days) for the spring migration and between June 22 and August 12 (57 days) for the summer migration (93-6; 93-7).

The adult fish ladders operated as outlined in the Settlement Agreement (III,B,C,D,E,F). A fisheries researcher noticed that a grate in the East ladder, where attraction water is introduced, was damaged and required repair. The grate was detached from the wall of the fish way near the entrance. The District appraised the WCC of the situation. The District took the ladder out of service and corrected the problem in a week.

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. During the early fall, part of the steelhead production at Wells contracted a parasite that destroyed the eyes. Between 185,000 and 195,000 steelhead at 13 fpp were deemed blind and had to be destroyed (93-7, 93-8)). It is difficult to anticipate the number of fish available for planting in the spring of 1994, as this will be effected by the severity of additional mortality from aviary predators and disease.

3.6 Function of the Wells Coordinating Committee

Bob Heinith (CRITFC) felt the District had circumvented the WCC by awarding a study contract without committee review of the proposals (93-7). The District solicited input from the WCC in the develop of the request for proposals (RFP). The study in question had received two proposals which were true to the objectives of the RFP. The District promised to work closer with the committee to receive input for study plans and recommendations.

The District objected to the communication outside the committee prior to an opportunity to fully air an issue. This occurred with the August 20, 1993 correspondence from Bob Heinith where attorneys, the Administrative Law Judge and FERC were copied before the issue had a chance to be resolved in the committee (93-7). The WCC is equipped and prepared to handle issues concerning anadromous fish studies and protection without notification of outside parties. Mr. Heinith agreed to strive for better communication and that the situation would not happen again (93-7).

3.7 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 Change in time table of adult studies

The Settlement Agreement specified that a study plan to determine the extent of adult delay and mortality at Wells Project would be initiated in

1990 with studies starting in 1991 (III, G, 1). The District funded a study of passage delay of sockeye salmon at Wells Dam in 1992. Additional passage research on adult spring and summer chinook was conducted in 1993.

### 4.2 Hatchery Based Compensation

Section IV of the Settlement Agreement dealt with determining a "Production Plan" to be agreed to by the Joint Fisheries Parties and reviewed annually. This plan came in four phases, starting with Phase I in 1991 (Section IV, A, 3 a). The compensation elements for 1992 are as follows,

(1) 49,200 pounds of spring chinook yearlings at 15/pound
(2) 8,000 pounds of sockeye juveniles at 25/pound
(3) 30,000 pounds of steelhead smolts at 6/pound

The spring chinook program hinged around the Methow Spring Chinook Hatchery. The facility was dedicated on October 2, 1992. Broodstock were collect in 1993 brood year with the first release of yearling fish in the spring of 1994.

Pursuant to the direction of the WCC, sockeye production was delayed pending the results of a study on sockeye enhancement options above the Wells Project. This report was specified as part of the Studies and Evaluations section of the Settlement Agreement (Section IV, C, 1). The District built a pilot hatchery that was operating by 1993. Fish from 1992 and 1993 brood were raised in this facility.

The hatchery based compensation for the additional 30,000 pounds of steelhead was met along with the original steelhead mitigative responsibility for the Wells Project (Section 3.6).

### 4.3 Project Mortality Study

As pointed out in Section 1.7, the WCC recommended that the Project Mortality Study not be pursued in 1993 (93-1). The issue came up toward the end of the year (93-7, 93-8). The results of this study will drive the level of the compensation. The compensation program is currently in the early stages. The study is not needed to adjust compensation for the immediate future (93-7). A problem with proceeding with the work is the availability of test fish. There was discussion about conducting the work in 1995 (93-8).

### (5) Chronology of compliance for 1993

Items (3) and (4) above contain chronology of compliance in 1993. 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 H.

## (6) A schedule of activities for 1994

### 6.1 Spring Chinook Facility

Construction on the Methow Hatchery was completed in 1992. Completion of the adult collection facility on the Methow River is pending a hearing in May 1994. Adult traps on the Twisp and Chewuck Rivers will be evaluated for passage problems from spring chinook with radio transmitters from May through September 1994.

### 6.2 Operational Activities for 1994

The following schedule of activities is planned for 1994

| | |
|---|---|
| Dec. (93) | 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 27 | Bypass barriers in place<br>Begin monitoring juvenile migration via hydroacoustics<br>Field work to start on Methow Hatchery Evaluation Studies |
| April 15 | Have sockeye net pens in Lake Osoyoos |
| April 15 | Anticipated start of the juvenile migration |
| May 1 | Start radio tag spring chinook in route to Methow Basin at Wells |
| May 21 | Start collecting spring chinook broodstock in Methow |
| July 1 | Start collecting sockeye broodstock for Cassimer Bar |
| August 1 | Start spawning ground surveys for spring chinook in Methow |
| Sept. 15 | Start spawning ground surveys for sockeye in Okanogan |
| October | Production Plan annual review between District, Agencies and Tribes |
| on going | Planning sockeye enhancement strategies |
| on going | Planning for operations and protocols of the Methow River Spring Chinook Facilities |
| on going | Planning for Methow River broodstock trap |

## (7) Meeting Minutes of the Wells Coordinating Committee for 1993

The Wells Project was removed from the mid-Columbia proceedings on January 29, 1991 as the Settlement Agreement between the Fisheries Agencies and Tribes was approved by F.E.R.C. Minutes from the meetings of the WCC for 1992 are attached as Appendix H.

# TABLE OF APPENDICES

**WELLS HYDROELECTRIC PROJECT**

**JUVENILE BYPASS SYSTEM OPERATIONS PLAN**

**FOR THE 1993 BYPASS SEASON**

# APPENDIX - A

# WELLS HYDROELECTRIC PROJECT
# JUVENILE BYPASS SYSTEM OPERATIONS PLAN
# for the 1993 Bypass Season

December 9, 1992

Section II. F. 1 of the Wells Long Term Settlement Agreement specifies that an Annual Operations Plan for the Bypass will be submitted by Douglas County P.U.D. to the Wells Coordinating Committee by December prior to the spring migration. This plan will be reviewed and approved by the Coordinating Committee by March 1.

## The Bypass System

The P.U.D. will install five bypass baffles in spill gates of the Wells Project. The operation of the bypass will be per criteria outlined in the Settlement Agreement.

## Operation Criteria

The bypass will operate as per criteria specified in Section II. C. and E. of the Settlement Agreement. This 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 as per criteria specified in Section II. D. of he Settlement Agreement. This includes placement of the bypass two weeks before predicted migration and keeping the bypass in place two weeks after the migration is complete. Bypass will be in place from April 1 through August 31.

## Projected Hatchery Releases above Wells Dam

Hatchery releases for 1993 above Wells Dam are as follows:

| Facility | Species | No. (thous.) | Dates |
|---|---|---|---|
| Winthrop (USFW) | Spr. Chinook | 920 | 4/15 |
| Twisp (WDF) | Sum. Chinook | 420 | 5/15 |
| Similikameen (WDF) | Sum. Chinook | 600 | 5/15 |
| Wells (WDW) | Sum Steelhead | 550 | 4/15-5/15 |

## Starting Dates and Ending Dates

Starting and closure of the bypass system is a decision that is reached by the Bypass Team. A hydroacoustic index of fish in the Wells forebay is used to show the start and completion of the spring and summer migration. Collection of the hydroacoustic index will start on April 1 and run through August 31. Preseason dates used for bypass operation for spring migration are April 15 to May 30. Preseason dates used for summer migration are July 1 to August 30.

# SUMMARY OF 3-YEAR BYPASS

# EFFICIENCY STUDY AT WELLS DAM

# PREPARED FOR P.U.D. NO. 1 OF DOUGLAS COUNTY

BY DR. JOHN R. SKALSKI

## APPENDIX - B

# SUMMARY OF 3-YEAR BYPASS EFFICIENCY STUDY AT WELLS DAM

to

**P.U.D. No. 1 of Douglas County**
**1151 Valley Mall Parkway**
**East Wenatchee, WA 98802-4497**

from

John R. Skalski
Center for Quantitative Science
School of Fisheries
University of Washington
Seattle, WA 98117

18 March, 1993

### *Introduction*

Estimates of bypass efficiently were obtained for Spring and Summer seasons for the years 1990-1992 (Table 1). Based on these annual estimates of bypass efficiency, analyses were performed to determine whether the bypass system meets the bypass performance criteria stated in the Wells Settlement Agreement. Section IIE.2 of the Agreement states "Bypass operations... 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." Annual reports have shown the criteria are generally met during the specific years of study 1990-1992 (Table 1: exception being Spring of 1990). However, the purpose of these analyses is to determine whether bypass efficiency can be expected to fulfill these criteria in general. In other words, can the bypass system be expected to meet the performance criteria in future years.

To make inferences to future years, we must assume the river flow conditions during 1990-1992 are a random sample of anticipated hydrologic conditions on the Columbia River, and the observed bypass efficiencies (Table 1) are a random sample of possible annual values.

### *Methods*

The performance criteria specified in the Settlement Agreement can be translated into sets of hypotheses. For the Spring season, the hypotheses of interest are

$$H_0: \quad \mu_\beta \leq .80 \qquad (1)$$

against

$$H_A: \quad \mu_\beta > .80.$$

The null hypothesis $(H_0)$ states mean Spring bypass efficiency $(\mu_\beta)$ is less than or equal to .80 (i.e., 80%) against the alternative hypothesis $(H_A)$ that mean bypass efficiency is greater than .80 (i.e., 80%). For the Summer season the set of hypotheses to be tested are

$$H_0: \quad \mu_\beta \leq .70 \tag{2}$$

against

$$H_A: \quad \mu_\beta > .70.$$

The null hypothesis (1) and (2) state the bypass performance is not achieved. To conclude the bypass system meets settlement requirements, these null hypotheses (1) and (2) must be rejected based on the data collected in 1990-1992.

The statistic used to test the null hypothesis (1) and (2) is a 1-sample t-test of the form

$$t_2 = \frac{\hat{\bar{\beta}} - \theta}{\sqrt{s_\beta^2/n}} \tag{3}$$

where

$t_2 =$ $t$ - statistic with 2 degrees of freedom,

$\theta =$ specified bypass performance (i.e., .80 or .70),

$n =$ number of replicate years of study (i.e., $n = 3$ ),

$\bar{\hat{\beta}} = \sum_{i=1}^{n} \hat{\beta}_i/n$ = average estimate.

The test statistic (3) can also be inverted to provide confidence intervals for mean bypass efficiency ($\mu_\beta$).

***Results***

Based on the Spring 1990-1992 data, null hypothesis (1) is rejected ($P$ = .0465), concluding the mean bypass efficiency is significantly greater than 80%. A 90% confidence interval about mean Spring bypass efficiency can be expressed as

$$CI(.8039 < \mu_\beta < .9847) = .90.$$

For the Summer season, null hypothesis (2) is rejected ($P$ = .0477), concluding mean bypass efficiency is significantly greater than 70%. A 90% confidence interval about mean Summer bypass efficiency can be expressed as

$$CI(.7052 < \mu_{\beta} < 1.0) = .90.$$

Consequently, statistical analyses demonstrate both Spring and Summer performance criteria were achieved (i.e., .80 and .70, respectively).

*Discussion*

Similar results are obtained using log-transformed bypass estimates. Using log-transformed estimates to achieve approximate normality of the data, null hypotheses (1) and (2) are still rejected ($P < .05$). Consequently, results are not dependent on the choice of scaled use in the data analysis.

*Table 1.* Summary of bypass efficiency estimates ($\hat{\beta}_i$) for Spring and Summer seasons 1990-1992.

| Season | Year | $\hat{\beta}_i$ | $SE(\hat{\beta}_i)$ | 90% *CI* |
|---|---|---|---|---|
| Spring | 1992 | .890 | .0030 | .884 - .896 |
| | 1991 | .950 | .0026 | .945 - .955 |
| | 1990 | .843 | .0409 | .763 - .923 |
| Summer | 1992 | .934 | .0045 | .925 - .943 |
| | 1991 | .970 | .0018 | .967 - .973 |
| | 1990 | .765 | .0243 | .717 - .813 |

\jrs\wells

# ADDITIONAL SUMMARIES OF 3-YEAR BYPASS EFFICIENCY STUDY AT WELLS DAM

to

**P.U.D. No. 1 of Douglas County**
**1151 Valley Mall Parkway**
**East Wenatchee, WA 98802-4497**

from

John R. Skalski
Center for Quantitative Science
School of Fisheries
University of Washington
Seattle, WA 98117

30 March 1993

*Introduction*

The nature of a 3-year overall estimate of bypass efficiency depends on the type of inference being sought. If the desire is to quote the single best estimate of bypass efficiency for the years 1990-1992, then a weighted average is appropriate. The weighting would be proportional to the certainty of the annual point estimates. On the other hand, if the desire is to make inferences to annual efficiencies in general, then an arithmetic average is appropriate. The point estimates, standard errors, and associated confidence intervals differ depending on analysis approach and desired inference.

The following sections describe the statistical methods and results associated with the two alternative approaches to data summarization. The report dated 18 March 1993: Skalski, uses an arithmetic average to make inferences to bypass efficiency in general, and is a supplement to this report.

*Weighted Average 1990-1992*

Assuming the three annual estimates of bypass efficiency are samples from a common process, the overall estimate is a weighted average of the separate estimates. The weights are the inverses of the variance estimates. In this manner, estimates with greater precision (i.e., smaller variance) are given greater weight in the overall estimate. Table 1 reports the annual estimates of bypass efficiency for Spring and Summer seasons, along with variances and associated weights.

The weighted average is defined as

$$\hat{\beta}_w = \frac{\sum_{i=1}^{3} w_i \hat{\beta}_i}{\sum_{i=1}^{3} w_i}$$

where

$\hat{\beta}_i$ = estimate of bypass efficiency for the $i$th year $(i = 1, \cdots, 3)$,

$w_i = \frac{1}{\hat{Var}(\hat{\beta}_i)}$ = weight for the $i$th bypass efficiency estimate,

$\hat{Var}(\hat{\beta}_i)$ = estimated sampling variance for the $i$th bypass efficiency estimate.

*Table 1* Seasonal estimates of bypass efficiency, estimated variance and associated weights ($w_i$).

| Season | Year | $\hat{\beta}_i$ | $\hat{Var}(\hat{\beta}_i)$ | $w_i$ |
|---|---|---|---|---|
| Spring | 1992 | .890 | .0000092 | 108,241.0 |
| | 1991 | .950 | .0000068 | 146,350.7 |
| | 1990 | .843 | .00167 | 600.3 |
| Summer | 1992 | .934 | .000020 | 49,416.1 |
| | 1991 | .970 | .0000031 | 321,762.8 |
| | 1990 | .765 | .00059 | 1,691.3 |

Treating the variance estimates as constants, the variance of the overall estimate of bypass efficiency is found to be

$$\hat{Var}(\hat{\beta}_w) = Var\left[\frac{\sum_{i=1}^{3} w_i\hat{\beta}_i}{\sum_{i=1}^{3} w_i}\right]$$

$$= \frac{\sum_{i=1}^{3} w_i^2\,\hat{Var}(\hat{\beta}_i)}{\left(\sum_{i=1}^{3} w_i\right)^2}$$

$$\hat{Var}(\hat{\beta}_w) = \left(\sum_{i=1}^{3} \frac{1}{\hat{Var}(\hat{\beta}_i)}\right)^{-1} .$$

The standard error of the overall estimate is the square root of the variance estimate. Confidence intervals are based on a $Z$ - distribution using the formula

$$\hat{\beta}_w \quad \pm \quad Z_{1-\alpha} SE(\hat{\beta}_w) \quad .$$

Summary of study results are based on weighted averages are presented in Table 2.

*Table 2* Weighted averages of seasonal bypass efficiency along with standard errors and 90% interval estimates.

| Season | $\hat{\beta}_w$ | $SE(\hat{\beta}_w)$ | 90% *C. I.* |
|---|---|---|---|
| Spring | .924 | .0020 | .921 - .927 |
| Summer | .964 | .0016 | .961 - .967 |

***Arithmetic Average 1990-1992***

Assuming river flow conditions during 1990-1992 are a random sample of anticipated hydrologic conditions, and the observed bypass efficiencies (Table 1) are a random sample of possible annual values, inferences to average performance across all years can be obtained. The variability in annual bypass efficiency estimates is estimated with 2 degrees of freedom (i.e., $n-1$ ), and confidence intervals based on a Student's $t$-distribution.

The overall estimate of bypass efficiency is estimated as

$$\overset{\wedge}{\overline{\beta}} = \sum_{i=1}^{3} \hat{\beta}_i / 3$$

with variance

$$\hat{\text{Var}}\left(\overset{\wedge}{\overline{\beta}}\right) = \frac{\sum_{i=1}^{3}\left(\hat{\beta}_i - \overset{\wedge}{\overline{\beta}}\right)^2}{2(3)} \quad .$$

The standard error is computed as the square-root of the variance estimate, and confidence intervals calculated according to the formula

$$\hat{\beta} \pm t_{2,1-\alpha} SE\left(\hat{\beta}\right).$$

Table 3 summarizes the average estimates of bypass efficiency for 1990-1992.

*Table 3* Averages of seasonal bypass efficiency along with standard errors and 90% interval estimates.

| Season | $\hat{\beta}$ | $SE\left(\hat{\beta}\right)$ | 90% *C. I.* |
|---|---|---|---|
| Spring | .894 | .0310 | .804 - .985 |
| Summer | .890 | .0632 | .705 - 1.0 |

### *Discussion*

Because the intent of the study was to assure adequate performance of the bypass system over time, the statistical analysis based on arithmetic means and Student's *t*-distribution is a more realistic expectation of future performance. Furthermore, the weighted average assumes a stationary process, but annual fluctuations in flows likely resulted in additional variability not explained by measurement error alone. Hence the arithmetic mean appears most appropriate.

\jrs\bypass

# STIPULATION TO MODIFY ADULT FISH PASSAGE STUDIES CALLED FOR IN THE WELLS HYDROELECTRIC PROJECT SETTLEMENT AGREEMENT

**APPENDIX - C**

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

## STIPULATION TO MODIFY ADULT FISH PASSAGE STUDIES CALLED FOR IN THE WELLS HYDROELECTRIC PROJECT SETTLEMENT AGREEMENT

The parties to the Wells Hydroelectric Project Settlement Agreement ("Settlement Agreement") dated October 1, 1990, and approved by the Federal Energy Regulatory Commission ("Commission") by order dated January 24, 1991 (Public Utility District No. 1 of Douglas County, Washington, 54 FERC ¶61, 056), hereby unanimously agree to modify the studies of adult salmon delay and mortality at the Wells Hydroelectric Project called for by Subsection III.G. of the Settlement Agreement. Section (E)(c) of the Commission's Order Approving Settlement Agreement requires Commission approval of all changes in study plans. The Settlement Agreement also denotes in Subsection V.A. that all study designs and modifications to study designs will be subject to agreement by all parties.

Subsection IV.A.3.(c)(2) of the Settlement Agreement provides for adjustment of hatchery-based compensation requirements to reflect any unavoidable adult losses identified by the studies conducted under Subsection III.G.

Technical representatives of the parties on the Wells Project Coordinating Committee (Subsection V.A., page 34) have unanimously agreed that it is infeasible to study the adult mortality of salmon at the Wells Hydroelectric Project at this time. Members of the Committee further agree that a comprehensive adult passage study would provide valuable information about any adult passage problems. An adult passage study, using radio telemetry, has been designed by the Committee and by the Rock Island and Mid-Columbia Coordinating Committees. The study would investigate adult passage through all non-federal projects in the Mid-Columbia, from Priest Rapids through Wells.

Public Utility District No. 1 of Douglas County, Washington ("Douglas") shall participate in and fund its share of an adult passage study in the Mid-Columbia using radio telemetry as outlined in the April 30, 1992, Request for Proposals (RFP), a copy of which is attached as Appendix A to this Stipulation. This proposed 1993 study using spring and summer chinook, the completed 1992 study using sockeye at the Wells Project, and a Wells Coordinating Committee-approved steelhead passage study in 1994, comprise the adult passage study program at the Wells Project. If the Wells Coordinating Committee determines that the results of the studies in 1992 and 1993 demonstrate that there are not unacceptable delays and/or losses at the Wells Project, and that the 1994 steelhead passage study demonstrates that there are not unacceptable losses at the Wells Project, then Douglas' obligations under Sections III.G and IV.A.3(c)(2) shall be deemed satisfied and discharged in full. If the adult passage study program identifies delays and/or losses for sockeye and/or chinook salmon and/or losses for steelhead which the Coordinating Committee deems unacceptable, Douglas will comply with the provisions of Section III.G.2 of the Settlement Agreement. If the Coordinating Committee determines that there are unavoidable and unmitigated adult losses, there will be an adjustment to the compensation requirement as provided in Section IV.A.3(c)(2). Estimates of the level(s) of adult losses will be made by the Coordinating Committee as provided in Section IV.A.3(c)(2).

By affixing their signatures on the signature pages attached hereto, the undersigned are certifying that they are authorized to consent to this agreement on behalf of the party they represent.

Douglas agrees to file a copy of this stipulation with the Commission and to request Commission approval of the modification. All parties to the Settlement Agreement respectfully request an expedited FERC approval of the modification set forth in this stipulation.

Dated this 7th day of April, 1993.

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Exhibit A

Appendix A

Radio Telemetry Studies of Adult Salmonid Passage at Mid-Columbia Hydroelectric Projects

Study Outline

Description: The passage of spring and summer chinook salmon adults through the Mid-Columbia dams and reservoirs will be studied by radio tracking of tagged fish. The purposes of the study are to determine the length of time tagged fish take to pass each project and reservoir, the routes fish use to find fishway entrances, and to account for discrepancies in fish counts between dams. The study is expected to last at least two years, with the first year devoted to monitoring fish movements in response to the usual range of project and fishway operating conditions. Contingent on first year study results, the second year of study may include tests of fish passage under specific project or fishway operating conditions.

Objectives: Determine the date and time of arrival at each project's tailrace, entry into the fishway, arrival at intermediate points, and exit from the fishway. Determine the rates of fallout (number of times a fish may move in and out of fishway entrances before ascending and exiting the fishway) and fallback (fish that ascend and exit a fishway, only to return to the tailrace via the powerhouse or spillway). Determine the eventual fate (arrival at next project's tailrace, reservoir sighting or tributary turnoff) of tagged fish after passing or falling back over each project. Determine the proportion of fish using each fishway entrance (or group of entrances) at the projects.

Specified Equipment and Methodology: The radio tags and receiving equipment will be the Digitally Encoded Radio Telemetry System, manufactured by Lotek Engineering Inc. The tags will include motion sensors. Fish will be collected and tagged at John Day Dam. An adult fish trap will be provided apart from this contract. The number of spring and summer chinook tagged will be sufficient to ensure arrival of a minimum of 100 tagged fish of both runs combined at Wells Dam (average 5% of spring chinook and average 20% of summer chinook passing John Day Dam). Mobile surveys will be done to locate fish in reservoirs between Mid-Columbia dams once per week. Fixed antennas will be placed as needed to record fish arrival at the locations stated in the objectives.

Reporting Requirements: The contractor will prepare weekly summaries of tag detections at each hydroelectric project, including preliminary analysis to determine elapsed time between detection of fish in the tailrace and exit from fishway to forebay (mean, range and standard deviation), proportion of fish using each major entrance, incidence of multiple entry into lower fishway (fallout), incidence of fallback, and incidence of fish detected in fishway that are not detected exiting the fishway. A preliminary data report summarizing all Columbia River detections and tributary turnoff will be submitted by October 15. A draft annual report will be submitted by December 1.

Appendix A

Outline of Specific Tasks

I. Determine tag needs and logistics.
   A. Determine number of fish to tag of each species and tag size. Procure tags.
   B. Finalize trapping/tagging site with USCOE. Execute contract for use of trapping facilities.
   C. Line up tagging equipment, personnel, support services, etc.
   D. Execute the tagging program.

II. Determine tag tracking needs and logistics.
   A. For each dam, develop the fixed antenna array needed to track tagged fish movements in the project tailrace, at fishway entrances, within the fishway and exiting the fishway. Determine the number of receivers and data loggers needed for the antenna array.
   B. For each reservoir and the reach below Priest Rapids Dam, determine the access route and equipment needed to pick up tagged fish location with mobile equipment once per week. Determine number and type of mobile units needed.
   C. For each tributary and perhaps selected reservoir sites, develop the fixed antenna and receiver array needed. Determine the number of receivers and data loggers needed.
   D. Procure receivers, data loggers, antennas, housings and power supplies, rental of motor vehicles, boats, and flight services. Install and test tracking equipment.

III. Determine personnel needs.
   A. Determine number of people needed on-site for maintenance of equipment, downloading of data, mobile survey work, and data organization and preliminary processing.
   B. Determine the supervisory structure, data processing requirements, support staff, and people responsible for reporting the results.
   C. Procure personnel, necessary office space and supplies. Execute the adult passage study and reporting.

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

Michael Doneen
Commissioner, President

Commissioner, Secretary

Commissioner Davis, Absence excused
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

FOR PACIFIC POWER & LIGHT COMPANY:

FOR THE WASHINGTON WATER POWER COMPANY:

FOR THE PORTLAND GENERAL ELECTRIC
COMPANY:

FOR THE WASHINGTON DEPARTMENT OF
FISHERIES:

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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Commissioner

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Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

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FOR PACIFIC POWER & LIGHT COMPANY:

Brian D. Sickels
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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR THE PORTLAND GENERAL ELECTRIC
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FISHERIES:

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OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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FOR PACIFIC POWER & LIGHT COMPANY:

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR THE PORTLAND GENERAL ELECTRIC
COMPANY:

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FOR THE WASHINGTON DEPARTMENT OF
FISHERIES:

Judith M. Merchant
____________________________________

FOR THE WASHINGTON DEPARTMENT OF WILDLIFE:

[signature]
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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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FOR THE CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION:

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FOR THE WASHINGTON DEPARTMENT OF WILDLIFE:

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FOR THE OREGON DEPARTMENT OF FISH AND WILDLIFE:

[signature], Chief of Fisheries

FOR THE NATIONAL MARINE FISHERIES SERVICE:

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FOR THE U.S. FISH & WILDLIFE SERVICE:

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FOR THE NATIONAL MARINE FISHERIES SERVICE:

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FOR THE U.S. FISH & WILDLIFE SERVICE:

Marvin L Plenert
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FOR THE CONFEDERATED TRIBES AND BANDS OF THE YAKIMA INDIAN NATION:

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FOR THE CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION:

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FOR THE OREGON DEPARTMENT OF FISH AND WILDLIFE:

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FOR THE NATIONAL MARINE FISHERIES SERVICE:

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FOR THE U.S. FISH & WILDLIFE SERVICE:

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FOR THE OREGON DEPARTMENT OF FISH AND WILDLIFE:

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FOR THE NATIONAL MARINE FISHERIES SERVICE:

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FOR THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION:

Dale L. [signature]
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**SOCKEYE SALMON ENHANCEMENT IN**

**LAKE OSOYOOS WITH NET PENS**

**PREPARED FOR P.U.D. NO. 1 OF DOUGLAS COUNTY**

**BY JACK RENSEL, Ph D.**

**APPENDIX - D**

FINAL REPORT

# SOCKEYE SALMON ENHANCEMENT IN LAKE OSOYOOS WITH NET PENS

PREPARED FOR THE

DOUGLAS COUNTY PUBLIC UTILITY DISTRICT
EAST WENATCHEE, WASHINGTON

SEPTEMBER 23, 1993

PREPARED BY:

JACK RENSEL, Ph D.

RENSEL ASSOCIATES
4209 234TH NE STREET
ARLINGTON, WASHINGTON 98223

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# EXECUTIVE SUMMARY

The natural run of sockeye salmon (*Oncorhynchus nerka*) to the Okanogan River and Lake Osoyoos is the largest remaining run of the species in Columbia River system, but run sizes have been declining steadily since 1984. Relatively large size of salmon smolts migrating from the lake indicates that existing habitat is underutilized, and more juvenile fish could be accommodated. The Wells Dam Settlement Agreement discusses the use of net pens in Lake Osoyoos to increase the native run of sockeye, as a temporary measure while habitat restoration in the subbasin is planned. Pen operation would be funded by the Douglas County Public Utility District. This report provides an assessment of site selection, existing hydrographic conditions and effects of net-pen operation.

Phase one of the proposed project would use small net-pens (i.e., floating cages) for approximately 8 weeks each spring to rear 200,000 juvenile salmon from 4 grams weight to release at 20 grams. If successful, phase two would release 375,000 fish annually. The purpose of this report is to provide information about the aquatic effects of the proposed project, and to survey existing literature and data about the limnology of Lake Osoyoos. After considering a number of factors, a site southeast of Smith Point was selected as the best alternative site for the temporary net pens.

Lake Osoyoos is divided into two major and one minor basins. Only part of the southerly (shallow) basin lies within the U.S. The middle and northern (deepest) basins are in British Columbia. Historical data and anecdotal evidence suggest that water quality in the lake has been declining due to land-use practices including loss of riparian habitat, filling of wetlands and similar actions in the Okanogan Valley drainage system.

Lake Osoyoos is vertically stratified in the summer with elevated surface water temperatures. Deeper waters are much cooler, but have severely reduced oxygen content due to microbial degradation of organic matter (e.g., decaying plankton). At present the lake is considered mesotrophic (moderately enriched), and nitrogen supply apparently limits phytoplankton growth during the summer, while phosphorus may be more important during the fall. Nitrogen and phosphorus supply appear to be balanced during the proposed salmon rearing period. Limited and somewhat out of date evidence suggests that the annual cycle of phytoplankton production begins in the spring with diatom blooms, followed by blue-green algae and microflagellate dominance in the summer, returning to diatoms again in the fall. The extent and duration of blue-green algal blooms, which can be noxious or harmful, is a measure of the eutrophication.

The effects of the proposed project were quantitatively estimated by analyzing the amount and elemental components of the fish feed to be used, coupled with a knowledge of fish physiology and the fate of waste products from prior studies. The major element of waste material loss will be due to elemental carbon (C), with much less dissolved nitrogen (N), in the form of ammonia and urea. Phosphorus (P) loss will be even smaller, because there is very little (<0.8 to 1.6%) in fish feed.

Elemental carbon loss is estimated to be 522 kg/yr and solids will account for 33% of the (dry) weight of the feed, including the uneaten portion. It is estimated that the proposed net-pens would produce about 38.1 kg/yr (84 lbs) of dissolved phosphorus (P) each year. For comparison, the natural flux of total P at the outlet is estimated to be 14,575 kg/yr (32,065 lbs) and there is a large, but unknown amount of P entering the lake that is retained in sediments. Dissolved nitrogen losses will total approximately 202.9 kg /yr. The natural flux of nitrogen in and out of the lake is unknown, but likely is much greater than that of phosphorus.

Because of the timing of the above dissolved waste losses (April and May, except small portions leaching from sediments), it is probable that some of the N and P will become incorporated into the spring diatom bloom and the remainder will be advected out of the lake into the Okanogan River. Peak monthly discharge of the river occurs in June, shortly after fish from the net pens are to be released. The background N:P ratio in the lake is nearly neutral during the rearing season, suggesting that neither N nor P are relatively more scarce. The estimated waste N:P ratio is similar, suggesting no preferential uptake by the phytoplankton.

Using a simple deposition model, it is estimated that waste feed will be deposited in a 37 x 37 m area and waste fish feces will sink more slowly and be found in an area 48 x 48 m beneath the net-pens. Because of the very low loading density of the fish in the pens, the bottom will fully recover within at least a year (and probably only 6 months) to the pre-fish rearing condition in terms of organic carbon decay. Carbon deposition is estimated to average 0.27 kg C/m$^2$/yr. Existing carbon content of the sediments at the proposed site in the south basin is much lower than the content of sediments in the north basin.

Aquatic macrophytes, including Eurasian watermilfoil, will not be affected by the proposed salmon net-pens because these plants take all of their P and most of their N from sediments, not from the water column. The proposed project is too remote from shallow water areas to have any effect on the plants.

The mesotrophic conditions in Lake Osoyoos apparently result in a rich supply of zooplankton prey for juvenile sockeye forage, but conversely, each summer the available habitat is restricted and the fish are sandwiched between elevated surface water temperatures and low dissolved oxygen concentrations in deep water. Re-interpretation of existing juvenile sockeye distribution data in this report tentatively indicates that water temperature may be relatively more important than dissolved oxygen in controlling the fish's vertical migration. There remains, however, several data gaps regarding both the limnology of the lake and the life history of the juvenile sockeye.

Recommendations for monitoring of water column and benthic effects of the proposed net pens are included, as are some approaches to further limnological and sockeye salmon research.

## **Summary of Compliance with State of Washington *Recommended Guidelines***

The following checklist is provided to aid reviewers in assessing the proposed net-pen site relative to the *Recommended Guidelines for Sizing and Siting Delayed Release Net Pens* with regard to depth and velocity and the *Recommended Interim Guidelines for the Management of Salmon Net-pen Culture in Puget Sound* for all other topics.

1) Depth/Velocity requirements: The project was designed to meet area loading limitations designed to prevent accumulation of waste materials on the bottom beneath and adjacent to the fish pens.

2) Critical aquatic organisms habitat buffer: The area immediately beneath and around the proposed site is not a critical habitat for fish, birds or invertebrates.

3) Bird and mammal habitats of special significance: There are no known bird nesting areas or special mammal habitat at, or adjacent to the proposed sites.

4) Annual production limitation - nutrient loading: There are presently no limitations on fish culture in the Lake Osoyoos. This report reviews existing nutrient data and discusses probable effect of the salmon enhancement project on water and sediment quality.

5) Wet feed type restriction: the project will not utilize wet feed.

6) Predator control restrictions: applicant will comply, see state programmatic EIS: *Fish Culture in Floating Net-pens* (WDF 1990).

7) Antifouling guidelines: Applicant will comply, antifoulants are not needed for the short-term rearing to be conducted in Lake Osoyoos.

8) Antibiotics restrictions: Applicant will comply and only use U.S. FDA approved antibiotics and only in the case of certified disease outbreak.

9) Transfer of fish requirements: Applicant will comply.

10) Operations plan submittal to Wash. Dept. of Natural Resources: Not applicable.

11) Site characterization survey: No formal studies were required, but the applicant has sponsored this study. The applicant will conduct further studies before and after net pen installation (additional benthic sampling), but before fish transport.

12) Benthic baseline survey: Preliminary bottom sampling has been completed and indicates a probable lack of macro-infauna, making visual surveys inappropriate.

13) Annual monitoring requirements: Applicant will conduct special studies as per recommendations included in this report.

# TABLE OF CONTENTS

## LIST OF TABLES



## ACKNOWLEDGEMENT

Assistance in field surveys was provided by Mr. Wayne Marsh. In addition to data collected in this study, water quality data was provided by the Washington Department of Ecology (routine and special monitoring), via citizen volunteer programs and Ms. Julie Rector. E.V. Jensen of B.C. Environment provided data from the north basin of Lake Osoyoos.

## LIST OF FIGURES

(Located after References Cited)

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## 1.0 INTRODUCTION

The natural run of sockeye salmon (*Oncorhynchus nerka*) to the Okanogan River and Lake Osoyoos is the largest remaining run of the species in Columbia River system, but run sizes have been declining steadily since 1984 (Columbia Basin System Planning 1991). These fish utilize the Okanogan River and Lake Osoyoos in north-central Washington State and south central British Columbia (Figs. 1 and 2). Although optimum spawning escapement and carrying capacity of the lake for juvenile sockeye salmon is not known with certainty, the relatively large smolt migrating out of the lake indicates that existing habitat is underutilized (Pratt et al. 1991).

The Wells Dam Settlement Agreement discusses the use of net pens in Lake Osoyoos to increase the native run of sockeye, as a temporary measure while habitat restoration in the subbasin is planned. Pen operation would be funded by the Douglas County Public Utility District. This report provides an assessment of site selection, existing hydrographic conditions and the effects of net-pen operation in the lake.

Small net-pens would be placed in the lake each spring and removed by early summer. Native sockeye salmon, previously reared in a separate hatchery facility, would be moved to the net-pens in mid March. They will be fed a commercially available pelleted diet and released after approximately 8 weeks after increasing their weight by a factor of four, hence the term "delayed-release" enhancement to describe the project.

Salmon net-pens have high benefit/cost ratios due to their simplicity, relatively low capital costs and ease of operation compared to traditional upland hatchery facilities (Senn et al. 1984). Net-pens are particularly well suited to small-scale salmon enhancement projects for these reasons and because of their portability. In western Washington and coastal areas elsewhere in temperate regions, commercial net-pen aquaculture of salmon has increased in recent years along with controversy and conflict over site selection and environmental impact. Much of this controversy is rooted in fears about effects on visual or noise aesthetics and effects on upland property values (Fridley 1992), but challenges to permit applications often focus on water quality aspects instead.

Since the 1970s, there have been hundreds of scientific studies, reports and commissions investigating salmon net-pens here and abroad. The State of Washington commissioned an extensive review of the literature and studies that were published as a Programmatic Environmental Impact Statement (WDF 1990). At this point in 1993, the primary environmental impacts on sediment and water column ecology are fairly well defined, and no longer subject to questioning by concerned scientists. Persistently low worldwide prices for salmon have virtually ended all new commercial net-pen site development in the western US. and British Columbia. To no surprise, most of the controversy over siting salmon net-pens has abated. There are other issues involving commercial salmon net-pens that remain controversial (e.g., effects of introduced species of salmon), but for the most part these do not involve salmon net-pens used for native stock enhancement. Because of their small size, temporary nature and public benefit goals, delayed-release net-pens are considered categorically different from commercial facilities (Kolb 1991).

## Report Objectives and Organization

This primary purpose of this report is to provide information about estimated environmental effects of small-scale salmon net-pens proposed for Lake Osoyoos in Okanogan County, Washington. Although it is possible simply to follow siting criteria of the Washington Department of Fisheries for delayed release net-pens, this report provides far more information on the proposed site, the amount and fate of waste products and the limnology of Lake Osoyoos.

Secondarily, the report provides background information about Lake Osoyoos water quality from previous studies and reports as a backdrop for estimating the effects of the pens. These data aid in gauging the potential success of the enhancement project and in characterizing the habitat that juvenile sockeye salmon must utilize. Water temperature and dissolved oxygen concentrations in the summer are particularly important in this regard, the former influenced by land-use practices and climate, the latter directly influenced by the nutrient loading of the lake.

Third, the report reviews existing data regarding phytoplankton and zooplankton that inhabit the lake and briefly reviews the scant information regarding life history of juvenile sockeye salmon use of the lake. Although information and available time were limited for the second and third objectives, some insight was obtained and associated data gaps were resolved.

This report begins with background information about the native sockeye salmon, and selection and location of alternative net-pens sites. The following sections deal with methods used to evaluate physical characteristics of the sites, and general topics regarding biological needs of salmon, environmental criteria used by agencies, and morphology and limnology of the lake. Although the project is not expected to have a measurable effect on algal stocks in the lake, the next chapters provide information on phytoplankton, zooplankton and macrophytes (aquatic weeds) to help the non-professional reviewer gain perspective on these components of the lake ecosystem and the factors that control their growth.

After the physical characteristics of the sites are examined, the projected effects of the net-pen project are estimated based on the amount of feed used, its composition and the known metabolism and physiology of salmon. The report concludes with selection of the preferred site, recommendations for environmental monitoring and mitigation as well as general recommendations regarding data gaps for all the topics discussed.

## 1.1 Overview of Native Sockeye Salmon Stock

Lake Osoyoos has two major basins and one minor intervening basin. The north and middle basins are entirely within British Columbia and the south basin straddles the U.S./Canadian international border (Figs. 1 and 2). Although a small sockeye salmon population was native to the mainstem Okanogan River lakes prior to 1939, it was supplemented with 19,795 adult fish of the Arrow Lake, Canada stock when Grand Coulee Dam eliminated upstream migration in the mainstem Columbia River in 1939 and 1940. Allen and Meekin (1980) review the literature regarding transplants to Lake Osoyoos and Lake Wenatchee and reported that the adults survived the transplants, but unfortunately the efforts resulted in lowest returning runs on record.

Sockeye salmon and kokanee (lake-resident sockeye) are native to the Okanogan River mainstem lakes, but the historical distribution of returns and rearing juveniles is unknown. At present, blockage of upstream migration at Lake Vaseux restricts fish from repopulating the upper lakes and and all of the juvenile rearing must occur in Lake Osoyoos. It is possible that the juveniles utilized the generally cooler headwater lakes (Stockner and Northcote 1974), although I could find no evidence of this in the literature. Similarly, available data that could be used to reconstruct historical run sizes estimates are difficult to decipher and likely inaccurate compared to the Lake Wenatchee component of the middle Columbia sockeye population (Allen and Meekin 1980).

Sockeye salmon typically are found, sometimes in amazing abundance, in cooler lakes than Lake Osoyoos, that often are considered oligotrophic (nutrient poor). It has been suggested that nutrient and thermal "pollution" limit sockeye salmon production of Lake Osoyoos during the summer, and indeed the limited data on juvenile distribution lends credence to this contention (Allen and Meekin 1980). Data reviewed herein shows that Lake Osoyoos is presently mesotrophic (moderately enriched), which leads to abundant zooplankton production and relatively large sockeye smolt size. Many sockeye salmon lakes apparently have inadequate food resources for their fish, which is one factor limiting the growth and survival of juvenile sockeye in many lake systems in Alaska and British Columbia (e.g., Parsons et al. 1973). In reviewing data from the middle Columbia River and Lake Osoyoos, Pratt et al. (1991) found no evidence of density dependent (food limited) growth when examining a range of 0.4 to 2.0 million smolts produced. The prevalence of larger, age 1 smolts from the Okanogan also suggested that habitat was not saturated with juvenile and pre-smolt sockeye salmon and hence their is a need to increase spawning habitat, and survival of eggs or artificially propagate juvenile fish.

Use of salmon net-pens for rearing and release of native stocks of juvenile sockeye may be viewed as a research tool, as well as a production tool, that may aid in exploring the complexities that potentially limit the sockeye and kokanee of Lake Osoyoos. Once delayed-release programs are established, tag/recapture, extended rearing at low density and other means can be used to further understanding of the basic life history features of the juvenile sockeye salmon (e.g., Rensel et al. 1988 for coho salmon). This sort of active, experimental research will likely yield more measurable benefits compared to a merely descriptive, monitoring approach in a habitat already as adversely perturbed by human actions as Lake Osoyoos.

### 1.2 Selection of Alternative Sites

The candidate net-pen siting areas were considered to be protected areas near the east and west sides of the south basin of Lake Osoyoos. These areas were evaluated with several criteria in mind including the following. First, water depth should be sufficient to allow the net-pens to hang unimpeded above the bottom. Second, as much depth as possible is desirable without placing the net-pen structure in the open areas of the lake that are subject to extensive wind fetch (unless the pens can be placed over an area of persistently higher dissolved oxygen near the bottom, more on this later). Third, the net-pen site should be located as far from shore as possible, to minimize intrusion on upland owner's use and aesthetic enjoyment of the shoreline and to optimize current velocity from wind and internal lake sources. An exception to this would be placement of a net-pen near an uninhabited shoreline to provide a visual backdrop and screening for viewers in other directions (EDAW and $CH_2M$ Hill 1986). On criteria 1 and 3, any potential sites on the west side or near the middle of the lake were rejected, leaving the areas along the east side for consideration.

Next I more closely evaluated the effects of wind exposure, as discussed in the next section. The prevailing air flow through the Methow and Okanogan sub basins is from the northwest and west from spring to fall (WDW 1990). Winds in the Okanogan Valley generally follow the orographic features, i.e., they are channeled by the surrounding hills and mountains. With rare exception, the wind direction is from the north or south (D. Coe, pers. comm., 2/28/93, Tonasket WA). Winds during my field sampling period in October 1992 were exclusively from the south to south south-west, generally less than 10 mph and will likely be similar in velocity to winds occurring during the proposed mid-March to mid-May fish rearing period (DeHarpporte 1983).

### 1.3 Location of Alternative Sites

The first alternative site on the east side of the lake was located in the southeast section of the southern basin of Lake Osoyoos, southeast of a point of land known as Smith Point on the USGS's 7.5 minute Oroville quadrangle map (Fig. 2). This first site will be referred to as the "Smith Cove" site, because of its proximity to Smith Point, although there is no official designation of the area as a cove by that name. Through sextant triangulation to multiple known building locations shown on the quadrangle map, the location of site one was found to be 119° 26' 4" W longitude and 48° 57' 55.4" N latitude. The nearest shoreline is about 1113.05' (340 m) to the north (Fig. 2), which was also formally surveyed on August 21, 1992.

The second alternative site is located nearly true north of the Smith Cove site in an area officially known as Grubbs Cove, a prominent bight in the eastern shoreline of Lake Osoyoos. This cove is much larger in proportion than Smith Cove, but is shallower near shore. Accordingly a site was located offshore about 360 m from the north shore to find maximum depth while still seeking protection of Grubbs Point from northerly winds. This site was determined to be at 119° 26' 8.4" W longitude and 48° 59' 0.8" N latitude.

Water depths at both sites were measured during field work in late October 1992 and found to be 46 feet (14 m) at both sites. Judging from water marks on the bulkhead at the nearby Washington State Park, the water surface elevation was relatively normal. This was confirmed with data from the B.C. Hydrology Branch, showing the elevation to be approximately 911.2'.

Potential wind wave exposure was estimated by using fetch analyses methods for shallow water that utilize the longest distance relative to storm winds that could occur from the south (US Army Corps of Engineers 1984). I chose this direction because both sites are more protected from the north, although prevailing northwesterly winds occur during the spring through fall (WDW 1990). I arbitrarily selected a sustained wind speed of 25 MPH (11.2 m/sec) and found that the resulting wind waves would be "fetch limited", i.e., the duration of sustained wind does not matter as long as it exceeds about 1 hour and the height of the waves would peak at a certain limit despite the duration of winds.

The Smith Cove site (maximum fetch of about 1.6 km to the south lake shore) afforded the best protection from winds from the north. Significant wave height (i.e., the average height of the one-third highest wave) is estimated to be 0.25 m with a wave period of 1.5 seconds. (Wave period is the time taken for a wave crest to travel a distance equal to one wavelength.) Because relatively adequate depth was found nearer to the shore, the danger of wind waves refracting around Smith Point would be minimized. The Grubbs Cove site was less protected from north winds because of the distance offshore that allows waves to refract around the point of land immediately north of the study site. In the event of south winds, it was also much less protected than the Smith Cove site (fetch of approx. 3.7 km). Under the same wind conditions discussed above, the significant wave height could be 0.37 m with a period of 2 seconds.

As discussed above, visual aesthetics were considered in both cases. Neither site was located immediately adjacent to, or within the primary direct view shed of a shoreline residence. The Grubbs Cove site, however, was within the primary view shed of a few non-lake-shore homes located about 0.3 mile from the lake. The Smith Cove site had an uninhabited shoreline nearest to it, which is judged an aesthetic advantage, allowing the facility to blend into the background more readily than if it was located further offshore (EDAW and $CH_2M$ Hill 1986). Because of the relatively small size and annually short-term nature of the net-pen operation, no sustained and substantially adverse aesthetic effect would be likely.

## 2.0 METHODS

Data was collected at two alternative net-pen sites on three days in October 1992. Current velocity was monitored with a Scientific Instruments Co. Price AA meter fitted with a Swoffer 2100 optical sensor and custom, digital time averaging display. In general, the meter was lowered to 1, 5 and 10 meters for collection of velocity data for 2 minute intervals after the effects of lowering the meter had passed. The survey boat was tied to a temporary buoy and anchor arrangement, and a trailing parachute drogue or anchor was used to stabilize the boat and prevent drifting.

Drogue (i.e., drift object) tracking utilized 1 x 1 m square "windowshade" underwater nylon sails attached by thin nylon lines to surface floats of Styrofoam marked with fluorescent numbered flags. Drogue locations were estimated using an instrument grade sextant used as a horizontal angle measuring device. The sextant was used for triangulation on specific visual locations to known locations displayed on the 7.5 minute USGS Quad map, "Oroville". Plots of drogue movements were recorded on enlarged versions of the same map using an very large, engineering quality three-arm protractor. Wind speed and direction were periodically measured during current meter and drogue tracking while tethered to a buoy at each alternative site using an induction wind meter and a hand bearing compass.

Bottom sampling was conducted at alternative net-pen sites on October 22, 1992 using a 0.01 $m^2$ Van Veen grab sampler. Because of the very soft bottom at the alternative sites, 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 capped and immediately placed in zip-lock bags, placed in an ice-filled cooler and frozen later the same day. Cores were later sectioned and analyzed for total phosphate, total organic carbon and sediment grain size, for reasons explained later.

Water quality data collected in Lake Osoyoos utilized techniques recommended by EPA (1990). A Scott-Richards sampling bottle was used, as well as a YSI SCT temperature/conductivity meter and a corning checkmate DO and pH meter. Phytoplankton and zooplankton samples were collected with a phytoplankton net and the sampling bottle, preserved in 1% buffered formalin and processed by experts, as discussed below.

Water quality data was obtained from a variety of literature and governmental sources. Only very minor changes were made in nutrient data from one source (the lake outlet), after careful inspection of the data for outliers or obviously misreported data. For example, total phosphorus concentration from September 1984 was reported to be 0.170 mg/L-P (170 µg/L-P). Compared to the average concentration for that month in other years (about 0.029 mg/L-P), this appeared to be an order of magnitude (decimal point placement) error. Accordingly the data point was changed to 0.017 mg/L-P.

## 3.0 BIOLOGICAL REQUIREMENTS OF SALMON IN NET PENS

Salmon to be cultured in net-pens require adequate dissolved oxygen (>7 mg/L for good growth) and moderately cool water temperatures (<18 - 20°C, and ideally always <16°C, depending on the species and size). Additionally, they must be held at loading densities suitable to allow diffusion or transport of dissolved oxygen into the pens. Loading densities are best considered based on a combination of 1) water flow per biomass of fish and 2) a physical density index independent of flow (Rensel 1984). At relatively high loading densities, transport of dissolved nitrogenous wastes (principally ammonium+ammonia and urea) out of the cages could theoretically become an issue, but this has never been found to be a problem in densely stocked cages used for commercial culture (WDF 1990). Moreover, experience has shown that stocking density of fish in net-pens is best viewed on a sliding scale, with smaller fish requiring increased volume of water per unit weight of fish. The reasons for this are not entirely clear, but are likely a combination of physiological, behavioral and disease resistance factors. See Beveridge (1987) and Senn et al. (1984) for more information on recommended net-pen culture facilities, practices and economics.

Salmon net-pens are optimally useful when there is a modest current velocity flowing through the location, so that loading density can be increased and sedimentation effects minimized. In lakes and reservoirs, significant current velocity may be due to riverine flow or to wind stress. It is not necessary, however, to have any measurable current velocity as long as loading density is adjusted down to match the requirements of the fish for oxygen and the minimization of sedimentation effects.

To some degree fish create their own currents and flushing in net-pens as has been shown by Chacon-Torres et al. (1988). This is the reason that net-cages function well for the culture of trout in lakes that have little or no water movement during periods of calm winds. Under normal circumstances, approximately 50% of the available current velocity will flow around net-pens and the remainder will pass through them, although mesh size and configuration of the cages will greatly influence the passage of water.

Rearing of sockeye salmon in net-pens is a relatively new practice, but coho, chinook and Atlantic salmon have been reared in that manner for about 25 years. In the past, traditional sockeye salmon culture was impeded by viral disease problems and low return rates (Mullan 1986). There are numerous small net-pen projects in the Washington State and neighboring areas such as British Columbia that are operated by state, federal, tribal or sport-fishing groups in cooperation with fisheries agencies.

As a pilot project, sockeye salmon have been reared in net pens in Lake Wenatchee for outplanting to Cle Elum Lake (Flagg et al. 1991). They are also reared for enhancement of Lake Wenatchee sockeye stock by the Washington Dept. of Fisheries (WDF; K. Hooper and B. Duplaga, pers. comm. 9/92). Unlike Lake Osoyoos, Lake Wenatchee is very oligotrophic, has much cooler water temperatures, and no hypoxia of the hypolimnion. The Dept. of Fisheries net-pen site is located on the "upstream" end of the lake, near the entry of the White River. Detailed operation information discussed below was provided by Mr. Bill Duplaga, the manager of several

WDF fish culture facilities in the area. Dissolved oxygen in the area ranges from 9 to 13 mg/L during the spring to fall rearing period, and Mr. Duplaga has noted signs of stress when DO declines to 8 mg/L, although this is still considered adequate by most fish culture authorities.

Small sockeye fry are stocked in the Lake Wenatchee pens during April at approximately 3500 fish/lb (0.13 g) and are released in October at about 25 fish/lb (18 g) before ice formation on the lake. The fish are about 115 mm in fork length at release. They are fed a moist pellet (e.g., Biofeed Inc. #1 or #2) and excellent food conversion rates (FCR) are obtained, ranging from 0.8 to 1.0 (moist feed) to 1 (wet fish flesh), depending on the feed and fish size. Initially fish are fed 12-16 times a day, which diminishes to once a day when the fish are about 600 per pound (0.76 g). The goal in feeding is to get about 5% of body weight fed to the fish each day. These feeding practices appear to be appropriate for the fish, because there is little variation in the size of the fish at release (B. Duplaga, pers. comm, 10/92).

The net-pens used by WDF at Lake Wenatchee measure 20' by 20' square, constructed of galvanized steel walkways on plastic floats. When the fish are first stocked in the cages, 1/16 inch delta style, knotless nylon pens are used. Nets of sequentially larger mesh size are used over the summer until the fish are 50 per lb, when 1/4 inch mesh is needed, and 3/8" mesh may be suitable too. Fish are reared at a densities $< 0.12$ lb/ $ft^3$ (1.92 $kg/m^3$), which is very low compared to coho salmon reared in delayed release projects that utilize loading densities up to 0.5 $lb/ft^3$ (8 $kg/m^3$). Commercial culture of subadult Atlantic salmon (*Salmo salar*) in net-pens may use densities exceeding 2 $lb/ft^3$ (32 kg $m^3$), depending on water flow conditions. Even greater loading densities have successfully been used in land-based tank farms in Europe and Iceland, but oxygen is added continuously.

## 4.0 ENVIRONMENTAL CRITERIA FOR EVALUATING NET-PEN SITES

This report focuses upon key aspects of the Lake Osoyoos sockeye rearing proposal relative to the State of Washington's *Recommended Guidelines for Sizing and Siting Delayed Release Net Pens* (i.e., the "*Recommended Guidelines*", Parametrix 1990). These guidelines use a discrete settling model similar to the Gowen and Weston model (Weston and Gowen 1988) and the Parametrix (1989, 1990) model, both of which are described in the State of Washington's Programmatic Environmental Impact Statement *Fish Culture in Floating Net Pens* (WDW 1990). These models simulate the settling of particles from salmon net pens on the bottom with relatively good accuracy if the bottom profile is uniformly even (such as both alternative sites in Lake Osoyoos). The Parametrix model was altered for use in delayed release net pens sites by allowing for a period of deposition and a longer following period of no deposition corresponding to the period between crops of fish.

The model used in the *Recommended Guidelines* is based on the recognition that delayed release or enhancement net-pens are generally operated for only a small fraction of the year, and that the total fish load is small compared to commercial facilities. The *Recommended Guidelines* are designed to limit the density of fish such that no measurable accumulation of sediment will be detected on annual basis after the pen site has been unoccupied for the summer through mid-spring period. A maximum sedimentation thickness of approximately 0.1 mm (0.025 inch) is used in the *Recommended Guidelines* model, which corresponds to a maximum organic carbon accumulation of 0.05 $kg/m^2$ after laying fallow for a year. As noted above, this is well below the level of accumulation that could be measured using typical methods and equipment available today. The accumulation declines after annual release of the fish because of normal microbial decay of carbon and other elements of the waste products. An organic decay rate of 1% per day is used based on EPA (1982) literature.

The *Recommended Guidelines* were originally designed for use in salt-water locations, but there are only minor modifications necessary for applying them to freshwater; these involve estimates of maximum current velocity. There are many freshwater locations, especially large riverine systems like the middle or upper Columbia River, that are suited for salmon net-pen rearing both for the health of the fish and from the viewpoint of minimizing environmental effects (Rensel 1993). In western Washington there have been several successful salmon net pen facilities operated in freshwater lakes including a state-operated facility at Lake Aberdeen and the Tribal facility at Lake Quinault. However in lake systems, even ones with relatively large riverine flow through such as Lake Osoyoos, current velocity is typically less than in "run-of-the-river" reservoirs such as are found in the middle Columbia River.

The approach used in the present study was to empirically measure current velocities during a period of relatively low discharge of the Okanogan River that flows through Lake Osoyoos. This was coupled with measurement during periods when winds were relatively weak. Together, these conditions provide a conservative estimate of water currents likely to be encountered during the spring rearing period when river discharge is greater. Other components of the *Recommended Guidelines* are also conservatively structured, such as the use of a high feed loss coefficient of 15%.

Another set of criteria is available for evaluating salmon net pen placement. These criteria are known as "*The Interim Guidelines for Management of Salmon Net Pen Culture in Puget Sound*" (SAIC 1986). These guidelines also use depth and water velocity to recommend various levels of fish production, but they were not used herein because they were designed for commercial facilities used year-round with much higher densities and larger sized fish. In most of these facilities there is no rest period when the sediments are allowed go fallow.

A final note regarding criteria for estimating aesthetic effects of salmon net-pens. In general, only observers on the water or beach within about 2,000 feet (610m) are able to see a full sized, commercial fish farm as anything more than a thin line on the horizon (EDAW and CH2M Hill 1986). The proposed sockeye salmon rearing facility would be much smaller than a commercial sized facility, but would have similar height of perimeter railings, about 4 feet (1.2 m) above the water. Viewers at higher elevations would see relatively more of the proposed facility, but not significantly more at distances greater than 1,500 feet (450m).

## 5.0 MORPHOMETRICS OF LAKE OSOYOOS

Lake Osoyoos 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. The river flows nearly due south from Lake Osoyoos and joins the middle reaches of the Columbia River in Lake Pateros. The entire Okanogan River basin is considered a mixture of semi-arid (continental) and maritime climate, and rainfall decreases with decreasing latitude along the river valley and increases toward the Cascade Mountains crest.

Lake Osoyoos is a natural lake with outlet at river mile 79.0 that was modified by the addition of the Zosel Dam at river mile 77.4 (USGS 1985-90). The USGS operates several gauging stations in the area, but the station at river mile 77.3 below the Zosel Millpond is used by international agreement and is the basis for flow data in this report (Station 12439500).

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 north end of Lake Osoyoos, 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.

Lake Osoyoos 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 x $10^6$ $m^2$ and a volume of 397 x $10^6$ $m^3$. The north basin has a mean depth of 21 m and the south basin's average depth is 10 m. The north basin of Lake Osoyoos (maximum depth of 63 m) lies entirely in British Columbia, the south basin (max. depth of 29 m) is split between both countries. In comparison, Lake Okanogan 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.

# 6.0 LIMNOLOGY OF LAKE OSOYOOS AND IMPLICATIONS FOR SOCKEYE SALMON AND ALGAE

## 6.1 Background

Lake Osoyoos is a nutrient-rich, dimictic lake that exhibits some, but not all of the detrimental aspects of eutrophication because of relatively fast flushing rates (Stockner and Northcote 1974). The category dimictic means there are two major mixing periods in a typical year, the spring and fall turnover, with intervening periods of ice coverage in the winter and thermal stratification in the summer. Since Stockner and Northcote made the above conclusion, however, macrophyte growth has become abundant in the lake, interferring with recreational use of the lake.

The cumulative effects of poor agricultural practices in the basin have compounded for decades to produce the present state of water quality in the Okanogan Lakes. Land-use practices that have eliminated or narrowed riparian corridors, filled or drained associated wetlands, removed vegetation for weed control, overgrazed and eroded stream banks have caused thermal impacts and nutrient enrichment for many of the Okanogan Valleys lakes and streams (WDW 1990). A variety of non-point source pollutants are often implicated in the decline of aquatic environments in agricultural and mining areas, but recent EPA Priority Pollutant sampling of Lake Osoyoos indicated very low to negligible concentrations of heavy metals, pesticides and organic pollutants (Gibbons 1987). Prior studies, however, found high levels of mercury in some rainbow trout and squawfish in Lake Osoyoos as well as Skaha and Okanogan (Northcote et al. 1972).

Several sources of water quality data were utilized for this report. Stockner and Northcote (1974) provide the most complete assessment of Lake Osoyoos limnology that is readily available, although the reference is somewhat dated. Allen and Meekin (1980) provide additional information in this regard with a focus on native sockeye salmon stocks.

To supplement and update these data sources, I obtained monthly water quality data from the Department of Ecology from a station on the Okanogan River, just downstream of the Lake Osoyoos outlet near Oroville, at river mile 78.0 for the period 1960-1990. This is not the same station as the international discharge measauring station, but is upstream of Zosel Dam and the river's confluence with Tonasket Creek. These data are less useful than data collected directly in the lake, as it provides a composite view of surface and deep water during the summer stratification season, but the percentage mixture of each is unknown. Nevertheless, data from the outlet has been collected in a consistent fashion for many years and therefore provides an opportunity to evaluate trends of water quality over time. Additionally, data collected by citizen volunteers working with the Dept. of Ecology (from the south basin) as well as late winter and early fall data from the north basin (B.C. Ministry of Environment, courtesy of E.V. Jensen) were also available (although I utilized only the fall data).

This chapter begins with information about Okanogan River discharge. This is followed by a section introducing general concepts about conventional water quality parameters, first for those other than nutrients and later about the nutrient parameters. I have included limited discussion about how juvenile sockeye and algae may be influenced by these conditions and conclude with a general discussion of nutrient dynamics in the lake.

## 6.2 Discharge Characteristics of the Okanogan River

U.S. Geological Survey data from the Zosel Dam at Oroville from 1985 to 1990 was analyzed for discharge patterns from the lake (Fig. 3, USGS 1985-90). Mean monthly flow is relatively constant from September to April at about 450 KCFS, begins an abrupt increase in May, peaks in June at about 970 KCFS and slowly declines through the balance of the summer. Discharge patterns are regulated in part by upstream dams, as previously discussed. The annual mean discharge of the Okanogan River at Oroville for the 1985-1990 water years was 486 CFS. Residence time (i.e., flushing rate) of Lake Osoyoos is estimated to be about 0.7 years, which is much faster than other mainstem Okanogan Lakes except Vaseux (Stockner and Northcote 1974).

Long-term (1943-1979) mean monthly flow records for the Okanogan River at Oroville are presented by WDW (1990, page 10). These data show a mean annual discharge of 7,976 cfs and mean monthly average flows always >500 cfs (i.e., 664.6 cfs). This is significantly greater than the period of record discussed above (1985-1990), and could be due to an ongoing drought in recent years. It may also be possible that the mean monthly flows in WDW (1990) are based on data with increased sampling during periods of high flows, but there is no methodology section to indicate how the averages were derived. If flows have decreased, there is the possibility of adverse effects on salmonid populations because of slower flushing times in Lake Osoyoos. See section 6.3.1 *Water Temperature* and section 13 *General Recommendations* for further discussion of this topic.

River inflow at Oliver, B.C. and outflow at Oroville, WA and lake elevation data during my field sampling (October 1992) were provided by Mr. Robin McNeil of the B.C. River Forecast Center in Victoria B.C. Lake elevation was about 911.25 feet. and varied only a few tenths of a foot. Inflow at Oliver, B.C. averaged 10.66 $m^3/s$ (376.4 cfs, SD = 19.5) and outflow at Oroville averaged 375.9 cfs (SD = 20.8), so there was little net change in lake volume during the month. The 5 year mean discharge at Oroville (1985-1990) for October was 393 cfs. Accordingly, discharge during the sampling period of October 1992 conducted for this report was about 5% less than normal, or essentially the same as normal.

## 6.3 Water Quality and Effects on Juvenile Sockeye

Mean monthly data from the Ecology sampling station just downstream of the Lake Osoyoos outlet are presented in Table 1. This table was based on pooled data from the time period 1961-1965 and 1974-1991. Mean summer water quality data from the same station are presented in Table 2 from 1975 to 1991 (years with full reporting of summer months).

Table 1. Mean monthly water quality data from Okanogan River mile 78.0 (downstream of Lake Osoyoos outlet). Constructed from raw data of Washington Dept. of Ecology, dated 1961-65 (for non-nutrient data) and 1974-1991 for all nutrient and other types of data.

| Month | Water Temper. (C) | Dissolved Oxygen mg/L | Conduct. (µS) | pH | Unionized Ammonia mg/L-N | Ammonium +Ammonia mg/L-N | DIN mg/L-N | Ortho-P mg/L-P | Total P mg/L-P | N:P Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 1.3 | 13.7 | 289.2 | 8.1 | 0.0003 | 0.048 | 0.133 | 0.008 | 0.025 | 16.3 |
| Feb | 2.6 | 14.4 | 300.4 | 8.2 | 0.0005 | 0.043 | 0.126 | 0.010 | 0.019 | 12.5 |
| Mar | 4.8 | 14.2 | 289.3 | 8.4 | 0.0014 | 0.033 | 0.095 | 0.008 | 0.020 | 12.6 |
| April | 9.2 | 12.7 | 296.7 | 8.3 | 0.0015 | 0.027 | 0.045 | 0.007 | 0.031 | 6.6 |
| May | 13.6 | 10.8 | 289.8 | 8.4 | 0.0016 | 0.043 | 0.066 | 0.008 | 0.031 | 8.0 |
| June | 18.1 | 9.9 | 282.6 | 8.4 | 0.0010 | 0.021 | 0.038 | 0.010 | 0.017 | 3.8 |
| July | 21.2 | 9.2 | 264.5 | 8.4 | 0.0017 | 0.030 | 0.040 | 0.009 | 0.019 | 4.3 |
| Aug | 21.8 | 8.8 | 257.8 | 8.4 | 0.0036 | 0.036 | 0.054 | 0.009 | 0.024 | 6.1 |
| Sept | 19.5 | 9.4 | 264.9 | 8.4 | 0.0030 | 0.029 | 0.039 | 0.011 | 0.029 | 3.4 |
| Oct | 13.6 | 9.7 | 278.4 | 8.2 | 0.0006 | 0.031 | 0.047 | 0.010 | 0.029 | 4.7 |
| Nov | 8.1 | 11.1 | 278.9 | 8.2 | 0.0006 | 0.034 | 0.081 | 0.007 | 0.024 | 11.7 |
| Dec | 3.2 | 12.6 | 296.7 | 8.2 | 0.0006 | 0.042 | 0.115 | 0.007 | 0.032 | 17.2 |
| Mean | 11.4 | 11.4 | 282.4 | 8.3 | 0.0014 | 0.035 | 0.073 | 0.009 | 0.025 | 8.9 |
| SD | 7.3 | 2.0 | 13.4 | 0.1 | 0.0010 | 0.008 | 0.034 | 0.001 | 0.005 | 4.7 |

Table 2. Mean summer months (June - Sept.) water quality data from Okanogan River mile 78.0 (downstream of Lake Osoyoos outlet), constructed from raw data of Washington Dept. of Ecology, 1975 through 1991. 1977 was not included because no summer data were collected in that year. Missing data due to inadequate data.

| Year | Water Temper. (C) | Dissolved Oxygen mg/L | Conduct -ivity. (µS) | pH | Unionized Ammonia mg/L-N | Ammonium+ Ammonia mg/L-N | DIN mg/L-N | Ortho-P mg/L-P | Total P mg/L-P | N:P Ratio (weight) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | ---- | 8.4 | 260.0 | | ---- | ---- | ---- | 0.0001 | ---- | ---- |
| 1976 | 20.4 | 10.5 | 266.1 | 8.5 | ---- | 0.045 | ---- | 0.0001 | 0.024 | ---- |
| 1978 | 20.3 | 9.3 | 265.8 | 8.5 | ---- | 0.068 | 0.075 | 0.005 | 0.020 | 14.9 |
| 1979 | 21.1 | 8.1 | 278.0 | 8.5 | ---- | 0.018 | 0.030 | ---- | 0.010 | ---- |
| 1980 | 19.8 | 9.1 | 254.3 | 8.8 | ---- | 0.020 | 0.033 | 0.020 | 0.030 | 1.7 |
| 1981 | 18.9 | 9.1 | 265.8 | 8.4 | ---- | 0.028 | 0.048 | 0.010 | 0.010 | 4.8 |
| 1982 | 20.4 | 8.7 | 252.0 | 8.5 | ---- | 0.015 | 0.035 | 0.010 | 0.020 | 3.5 |
| 1983 | 19.6 | 9.8 | 247.0 | 8.1 | 0.001 | 0.015 | 0.035 | 0.010 | 0.018 | 3.5 |
| 1984 | 19.1 | 9.1 | 253.8 | 8.3 | 0.002 | 0.035 | 0.065 | 0.047 | 0.037 | 1.4 |
| 1985 | 20.1 | 9.5 | 295.7 | 8.3 | ---- | ---- | ---- | 0.010 | ---- | ---- |
| 1986 | 20.3 | 11.0 | 250.5 | | 0.002 | 0.037 | 0.063 | 0.010 | 0.023 | 6.3 |
| 1987 | 20.2 | 7.9 | 284.5 | 8.3 | 0.001 | 0.020 | 0.045 | 0.010 | 0.020 | 4.5 |
| 1988 | 21.3 | 9.7 | 290.5 | 8.7 | 0.001 | 0.010 | | 0.010 | 0.017 | 0.0 |
| 1989 | 19.9 | 9.0 | 324.8 | 8.7 | 0.005 | 0.030 | 0.040 | 0.010 | 0.019 | 4.0 |
| 1990 | 21.2 | 9.3 | 259.5 | 8.7 | 0.004 | 0.018 | 0.028 | 0.010 | 0.013 | 2.8 |
| 1991 | 18.9 | 9.2 | 260.5 | 8.3 | 0.002 | 0.010 | 0.020 | 0.010 | 0.014 | 2.0 |
| Mean | 20.1 | 9.3 | 269.9 | 8.5 | 0.002 | 0.026 | 0.043 | 0.013 | 0.020 | 4.5 |
| SD | 0.7 | 0.8 | 20.6 | 0.2 | 0.002 | 0.015 | 0.016 | 0.010 | 0.007 | 3.6 |

### 6.3.1 Water Temperature

Consistent water temperature data from several depths in Lake Osoyoos throughout the spring to fall period are not available, but I assembled a collection of data from different places and times that can be used to generally describe the thermal properties of the lake. Surface water temperature was monitored in Okanogan Valley Lakes six times during the spring to early fall of 1971, and maximum temperatures were about 21°C in Lake Osoyoos, with the peak occurring in August (Blanton and Nye 1972). Warmer surface water temperatures were encountered in Wood and Kalamalka Lakes, but peak values were in July. Hypolimnion waters (i.e., subsurface to the bottom) varied from about 6 to 9°C in the same time period, and were warmer than the other Okanogan River lakes.

Washington Dept. of Ecology data from the Lake Osoyoos outlet area show similar results to the preceding data, with a mean monthly maximum of 21.8°C in August and mean monthly minimum of 1.3°C in January (Table 1, Fig. 4). Water temperatures during the period of proposed sockeye salmon rearing in April and May averaged 9.2 and 13.6°C, respectively, or very suitable for juvenile salmon in general. No obvious trends in summer water temperature were evident in the lake outlet data (Table 2, Fig. 5). However, water temperatures averaged 0.5°C warmer in recent years of low mean annual flow in the Okanogan (1985-1991, mean = 20.5°C), compared to prior years (1976-1984, mean = 20.0°C, based on Table 2 data).

Data collected by citizen volunteers in cooperation with the Washington Dept. of Ecology from near the international boundary in the south basin are presented in figure 6 to illustrate surface water temperatures during the summers of 1989-1992. In general, the mean surface water temperatures were about 5°C greater than the monthly averages measured at the lake outlet. Peak water temperatures of about 26°C occurred in the August 1 to August 15 period, slightly later than maximum temperatures at the outlet station near Oroville.

Figure 7 shows vertical profiles of mean water temperature collected by Canadian workers from the north basin of Lake Osoyoos during late August and early September of 1987-1991. This figure illustrates a relatively broad thermocline that existed between about 14 to 18 m depth. Mean surface water temperature declined from about 19°C at 12 m to about 9°C at 18m. The average for these data is less than for the data collected by volunteers near the U.S. border, in the south basin. Although the north basin is likely cooler than the south basin (as shown below in figures from Allen and Meekin 1980, discussed below), some of the difference could be also due to difference in measurement techniques (CTD versus thermometer) and slight variation in what is considered "zero" depth.

Elevated water temperature in the Okanogan River below Lake Osoyoos may have a profound effect on the migration timing of adult sockeye salmon migrating upstream from the Columbia River, and in some years reduces spawner survival. In other years, e.g., 1991, the fish move in rapidly because of lower than normal water temperatures in mid summer. In that year, the water temperature was 15.5°C on June 11th at the lake outlet, compared to 18.1°C in an average June (Table 1). By July 19th, the temperature was 20.1°C compared to 21.2°C on average (but the average date of measurement was earlier), and most, if not all of the salmon had already migrated past the Zosel Dam (R. Klinge, pers. comm. 3/8/93).

### 6.3.2 Dissolved Oxygen

Dissolved oxygen (DO) is generally considered best for aquatic life if concentrations remain above 7.0 mg/L at all times. Natural waters should generally have concentrations greater than 5.0 mg/L for long periods, and never drop below 4.0 mg/L for the protection of aquatic life. Many mesotrophic and eutrophic lakes that vertically stratify during the summer have low or no DO content (hypoxia or anoxia) in the hypolimnion associated with thermal stratification, a lack of mixing or exchange with the atmosphere and microbial decomposition of organic matter. Additionally, low DO of bottom waters may contribute to the greatly elevated release of dissolved phosphorus from sediments, known as internal loading (Welch 1992).

Surface water of Lake Osoyoos are typically saturated with oxygen throughout the year, but waters below the thermocline to the bottom (hypolimnion) are hypoxic or anoxic during the summer. Williams (1973) found a minimum of 27% DO saturation in a survey in 1971. In the same study, oxygen depletion rates, which may be used as an index of primary productivity, were high in Lake Osoyoos (0.035 mg/L/day). But this was only about 1/2 of the rate seen in Wood Lake, upstream of Lake Osoyoos. More recent data indicated 0.1 to 0 mg/L DO at 12 to 22 m on August 31, 1992 at the international boundary sampling site (J. Rector, pers. comm, unpublished vertical profile data, Wash. Dept. of Ecology).

Mean monthly DO at the lake outlet varied from 8.8 to 14.4 mg/L, with a noticeable and apparently stepwise decrease toward mid-summer season (Fig. 8). It is not known if this represents decreased algal productivity, or if deep hypolimnion waters are being advected out of the lake, causing the depressed DO content. I could see no correlation with other parameters (e.g., total phosphorus) that would suggest the change in outflow water composition. No discernible trend in mean summer DO at the outlet was noted; the 1975-91 average was 9.3 mg/L (Fig. 9).

The average in-lake DO profile collected by Canadian government workers from late August or early September of 1987-1991 in the north basin of Lake Osoyoos is shown in figure 10. This data shows isopleths that match the water temperature data from the same source (fig. 7) that was previously discussed. However there was more interannual variation of water temperature at the surface and considerably more interannual variation of DO in the deeper strata of the lake.

### 6.3.3 Salmon Physiology and Behavior Relating to Dissolved Oxygen and Water Temperature

Salmonids are particularly sensitive to low ambient DO concentrations, and natural waters are oxygen-poor environments compared to the atmosphere at sea level. Review of a number of studies indicated minor and subchronic physiological effects at DO concentrations below 6.7 mg/L (SD = 2.57), equivalent to a partial pressure of 111 mm mercury (Davis 1975). Fish culture manuals typically state that salmonids are "safe" above 5 mg/L, will have reduced growth and susceptibility to disease at 3 to 5 mg/L and will die at less than 3 mg/L (Piper et al. 1982), but these are only broad generalization.

Stress on salmonids from low DO is less if the ambient water temperature is lower, because requirements for basal metabolism are less (Brett 1976). When ambient DO concentrations fall below the level required for basal metabolism, fish lose their self-righting ability and die from blood hypoxia. The exact level at which death occurs is somewhat variable depending on the species, size and age of the fish, physiological condition, prior low DO conditioning, exposure time, and very importantly, water temperature. Salmonids may be severely affected if they are subjected to prolonged exposure of DO concentrations <4.0 mg/L (Davis 1975), especially at high water temperatures, and when fish health may be compromised by pollution, disease, or other stress factors.

Strong avoidance of DO concentrations of 1.5, 3.0, and 4.5 mg/L has been noted in laboratory studies of chinook salmon at normal summer water temperatures, but not at 4.5 mg/L during cooler fall temperatures (Whitmore et al. 1960). It is also likely that salmonids do not adapt to low DO conditions, like some other species of teleost fish, but juvenile salmonids have improved ability to carry oxygen in their erythrocytes, compared to adult salmon (Heath 1987).

It is of particular interest to fishery managers and others concerned with the sockeye salmon populations of Lake Osoyoos how juvenile sockeye can survive when surface waters become too warm or the deeper waters become depleted of oxygen during the summer months. Bell (1973) states that the preferred temperature range for sockeye salmon is 11 to 14 °C and the upper lethal limit is 24.5°C, but his sources are not stated. Brett et al. (1969) studied juvenile sockeye at the Nanaimo station on Vancouver Island with regard to the effect of water temperature on food ration consumed. These authors concluded, on the basis of growth and food-conversion efficiency, that temperatures from 5 to 17°C were favorable for young sockeye, when an adequate ration (>6% body weight) was available. They also concluded that a general physiological optimum occurred in the vicinity of 15°C.

Figure 11 shows the interaction of DO and water temperature in Lake Osoyoos during late August and early September compared to what Brett et al. (1969) suggest as favorable conditions for juvenile sockeye in general. The figure shows that fish in the north basin should utilize waters from 14 m and 38 m of depth during the early September period of average years. Bell's (1973) predictions would encompass a much narrower range of depths, from 14 to 16 m depth. It is important to note that DO in the deep (hypolimnion) strata becomes progressively depleted throughout the summer, while surface water temperatures normally begin to decline by early September. This will be shown below in figures 12 through 16. Accordingly, the data shown in figure 11 represent slightly less than the peak surface water temperatures in the north basin combined with still worsening hypolimnetic DO.

Allen and Meekin (1980) sampled temperature and DO in vertical profiles throughout Lake Osoyoos in all three basins in 1972. Concurrently, they investigated the spatial distribution of juvenile sockeye salmon (and kokanee) using gill nets that extended to relatively great depths, although most of the effort was restricted to the north, deep basin. Gill nets were used in 1973 also, but no DO and water temperature results were reported. The profiles of temperature and DO from 1972 are reproduced herein as figures 12-16. It appears that 1972 had warmer than normal water temperatures, compared to late August-early September of recent years (cf figs. 7 and 14). Juvenile sockeye/kokanee catch data that corresponds to the hydrographic data are shown as Table 3. The author's total catch of sockeye in six attempts was acceptable, but not large (<100 fish). On the day of the highest catch (Oct. 2-3), most of the fish were found in the 11 - 30 m depths, in the zone of acceptable water temperature (> 13 °C) and good to unacceptable DO (9.0-2.1 mg/L).

During July, few fish were caught by Allen and Meekin in the north basin at depths shallower than 16 m, corresponding to water temperatures <14°C and DO of about 6.6 mg/L. During August, the fish were caught at depths with even lower water temperatures (<10°C) and DO probably <5.5 mg/L. Under these conditions, growth could have been slightly impaired due to physiological problems of obtaining enough oxygen, but it is possible that rich supplies of zooplankton throughout a long growing season could offset these losses.

| Date | Fishing location | Total fishing depth | Mesh size (cm) | Depth of catches (meters | O. nerka catch by age group | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $0^+$ | $1^+$ | $2^+$ | $3^+$ | Total |
| June 1-2 | station 1 | surface nets only | 1.91-5.08 | 0-3.7 | 0 | 1 | 5 | 0 | 6 |
| | | | | Total | 0 | 1 | 5 | 0 | 6 |
| July 11-12 | station 4 | surface to 34 m | 1.91 and 2.54 | 0-5 | 2 | 0 | 0 | 0 | 2 |
| | | | | 6-10 | 0 | 0 | 0 | 0 | 0 |
| | | | | 11-15 | 0 | 0 | 1 | 0 | 1 |
| | | | | 16-20 | 3 | 0 | 1 | 0 | 4 |
| | | | | 21-25 | 0 | 1 | 0 | 0 | 1 |
| | | | | 26-30 | 1 | 0 | 0 | 0 | 1 |
| | | | | 31-34 | 0 | 0 | 0 | 0 | 0 |
| | | | | Total | 6 | 1 | 2 | 0 | 9 |
| July 12-13 | station 3 | surface to 43 m | 1.91 and 2.54 | 0-5 | 0 | 0 | 1 | 0 | 1 |
| | | | | 6-10 | 0 | 0 | 0 | 0 | 0 |
| | | | | 11-15 | 0 | 0 | 0 | 0 | 0 |
| | | | | 16-20 | 4 | 0 | 0 | 0 | 4 |
| | | | | 21-25 | 2 | 2 | 0 | 0 | 4 |
| | | | | 26-30 | 1 | 0 | 0 | 0 | 1 |
| | | | | 31-35 | 0 | 0 | 0 | 0 | 0 |
| | | | | 36-40 | 0 | 0 | 0 | 0 | 0 |
| | | | | 41-43 | 0 | 0 | 0 | 0 | 0 |
| | | | | Total | 7 | 2 | 1 | 0 | 10 |
| August 9-10 | station 3 | surface to 43 m | 1.91 and 2.54 | 0-5 | 0 | 0 | 0 | 0 | 0 |
| | | | | 6-10 | 0 | 0 | 0 | 0 | 0 |
| | | | | 11-15 | 0 | 0 | 0 | 0 | 0 |
| | | | | 16-20 | 0 | 1 | 0 | 0 | 1 |
| | | | | 21-25 | 3 | 2 | 0 | 0 | 5 |
| | | | | 26-30 | 4 | 3 | 2 | 0 | 9 |
| | | | | 31-35 | 2 | 2 | 0 | 0 | 4 |
| | | | | 36-40 | 1 | 2 | 1 | 0 | 4 |
| | | | | 41-43 | 0 | 0 | 0 | 0 | 0 |
| | | | | Total | 10 | 10 | 3 | 0 | 23 |
| August 10-11 | station 7 | surface to 21 m | 1.91 and 2.54 | -- | 0 | 0 | 0 | 0 | 0 |
| | | | | Total | 0 | 0 | 0 | 0 | 0 |
| October 2-3 | station 4 | surface to 44 m | 1.91 and 2.54 | 0-5 | 2 | 0 | 0 | 0 | 2 |
| | | | | 6-10 | 1 | 0 | 0 | 0 | 1 |
| | | | | 11-15 | 6 | 0 | 0 | 0 | 6 |
| | | | | 16-20 | 3 | 2 | 0 | 0 | 5 |
| | | | | 21-25 | 11 | 2 | 2 | 0 | 15 |
| | | | | 26-30 | 4 | 3 | 3 | 0 | 10 |
| | | | | 31-35 | 1 | 1 | 1 | 0 | 3 |
| | | | | 36-40 | 0 | 0 | 0 | 0 | 0 |
| | | | | 41-44 | 0 | 0 | 0 | 0 | 0 |
| | | | | Total | 28 | 8 | 6 | 0 | 42 |

Table 3. Gill net catch of juvenile sockeye in Lake Osoyoos, 1972.
(Copied directly from Allen and Meekin, 1980)

It can be seen from Figure 13 (August 9-11, 1972) that maximum surface water temperatures exceeded the upper lethal limit for sockeye: a maximum of 25.6 °C at the south end of the lake and 25.0 °C at the north end. Water temperatures decreases with increasing depth on all dates, but so did DO concentrations until October. Uniform DO concentrations at all depths occurred in the south basin during the two October samples (Figs. 15 and 16), indicating mixing and probable complete turnover. However, the north basin was still stratified at the end of October.

Allen and Meekin's data overlap with the physiological data of Brett et al. (1969), but show a preference for much lower than the predicted physiological optimum of 15°C. This suggests that water temperature is a stronger control of vertical distribution compared to DO, relative to what Brett et al. (1969) stated were the optimum conditions of each, as discussed above. Other factors (predators, zooplankton distribution), may influence the depth distribution of juvenile sockeye in Lake Osoyoos, and there may be interannual variation that Meekin and Allen's data did not show (see section 13 *General Recommendations* for further discussion of this topic).

No juvenile sockeye salmon were caught in the south basin, although only one attempt was made on August 10-11, 1972. It is likely that naturally occurring juvenile sockeye and kokanee use this basin during the fall through spring, but no data are available from those time periods. It is assumed that fish released in the early summer from net-pens in the south basin of the lake will find their way to suitable water temperatures and DO as the summer progresses. This assumption is based on the observation that no fish kills of naturally occurring juvenile sockeye have been reported from the lake, and that DO in the hypolimnion gradually declines in the summer, allowing the fish adequate time to move up or downstream (see section 13 *General Recommendations* for further discussion of this topic).

### 6.3.4 pH

pH is a measure of hydrogen ion concentration (acid/base condition). For protection of aquatic life, 7.0 to 8.0 is best, with 5.0 to 8.5 often encountered. Acceptability depends on other factors such as the concentration of carbon dioxide, unionized ammonia, sulfides and metals concentrations. Lake Osoyoos is slightly basic, similar to the mainstem Columbia River and most other major water bodies in Eastern Washington, with monthly mean pH varying from 8.1 in the winter to 8.4 uniformly throughout the May to September period (Fig. 17). The increased pH at that time is likely due to use of carbon dioxide in the form of bicarbonate ion ($HCO_3^-$) by algae. This results in excess hydroxyl radicals ($OH^-$) and the tendency to basic or alkaline conditions. No identifiable temporal trends were evident for mean summer pH from the period 1976-1991 (Table 2, Fig. 18).

### 6.3.5 Conductivity

Specific conductivity is a measure of the capacity to carry an electrical charge, which in turn is a measure of the concentration of ions and factors related to their valence, etc. For domestic water, < 90 µmhos is considered excellent, 100 to 125 µmhos good, 125 to 150 µmhos fair and >150 µmhos is considered poor, but in areas of alkaline surface water it is often higher. In some cases (e.g., Lake Chelan, Washington) there is a correlation between conductivity with dissolved phosphorus and nitrogen concentrations of tributary streams that allows the use of conductivity as an easy surrogate for nutrient measurement (Patmont et al. 1989). Conductivity may be a useful measurement for evaluating long-term historical trends in water quality in some freshwater habitats because it has been collected for many years in basically the same manner. For example, it has been used to evaluate long-term trends in the mainstem Columbia River (Rambow and Sylvester 1967).

In Lake Osoyoos, conductivity is relatively high, but monthly averages vary only slightly from about 257 to 300 µS, peaking in the winter and spring and declining in late summer (Fig. 19). When compared with mean monthly Okanogan River discharge, there is an interesting lack of correlation that is unexplained. No identifiable temporal trends were evident for mean summer conductivity from the period 1975-1991, although elevated levels were seen in 1985, and 1987-89 (Fig. 20).

### 6.3.6 Water Transparency

Water transparency as measured by Secchi disc can be a powerful but inexpensive measure of trophic conditions in lakes and reservoirs. Lake Osoyoos has moderate to poor water transparency, compared to other lakes in the Okanogan Valley. Blanton and Ng (1972) reported a mean Secchi disc depth of 3.3 m for Lake Osoyoos from April to October 1971. This was one of the lowest average transparency, second only to Wood Lake and far less than Okanogan Lake that had a mean Secchi disc depth of 8.0 m. Stockner and Northcote (1974) mention early, meager records of lake transparency for Okanogan Valley Lakes, but do not cite specific data. They conclude that "there is no clear evidence of a progressive decrease in clarity following eutrophication though this is suggested" (by the data).

Although turbidity data from the lake outlet station were available, I chose instead to focus on water transparency data collected bimonthly during the summer from 1989 to 1992 by citizen-volunteers organized by the Dept. of Ecology (Rector 1990-1993). The data shows an annual trend of decreasing average water transparency from about 3.7 m to 1.8 m over the summer months (Fig. 21). There is no readily apparent explanation for this decrease, although it is possible that there is a steady increase in the density of blue-green algae during the same period. Many of these algae are able to adjust their buoyancy, floating to the surface during the day to compete for light and descending at night to acquire nutrients from deeper layers. The epilimnetic density of these forms could be increasing throughout the summer and Secchi disc measurements are taken during the day, in the surface waters that would be affected by their presence. Other possible covarying factors I examined (Okanogan River discharge, conductivity, etc.) did not correlate with the decreasing transparency during the summer and neither did pH at the lake outlet (Fig. 17) that remained high all summer. In many lakes and reservoirs, water transparency increases after reaching an annual minimum during a spring bloom (e.g., Lake Roosevelt in the mainstem Columbia River). See section 13 (*General Recommendations*) for a strategy to evaluate this phenomenon.

### 6.3.7 Chlorophyll *a*

Chlorophyll *a* refers to the most common photosynthetic pigment present in phytoplankton that is often used as a gross indicator of phytoplankton density. In this regard it is useful as a snapshot indicator of phytoplankton standing stock, but gives only indirect evidence regarding rates of primary productivity. There are few chlorophyll *a* data or other measures of phytoplankton productivity from Lake Osoyoos, but some data are available from the north basin (E.V. Jensen, unpublished data, 11/1992).

Late February/March (N=7) and September (N=4) chlorophyll a data taken from 0 and 1 meters during 1986 to 1992 is discussed here. The late winter chlorophyll *a* mean was 11.5 μg/L (SD = 2.8) , and the fall mean was 7.8 μg/L (SD = 1.5), and no phaeophytin (decomposition products) data were available. These few data suggest that phytoplankton productivity in the early spring was fairly high, and not much less in September. Given the Secchi disc information previously discussed, it is likely that mean summer chlorophyll *a* in Lake Osoyoos is at least 10 μg/L, which is indeed high compared to other sockeye salmon lakes reviewed by Koenings and Burkett (1987) and Stockner and Shortreed (1979).

Pratt et al. (1991) compared unpublished spring chlorophyll *a* data from Lake Osoyoos with mean summer chlorophyll *a* data of Stockner and Northcote (1974). The source of the unpublished information was not mentioned, that I will assume was from the north basin as collected by the B.C. Ministry of Environment. On cursory examination the two sources indicate a decline in concentration from 23.0 μg/L to 8.0-11.0 μg/L, which would be a very significant drop in algal production. However, these data are not comparable because of greatly different timing of collection. Stockner and Northcote's (1974) data represent the mean summer concentration and the unpublished data were single point estimates, probably from the late winter-very early spring before the spring diatom bloom begins in earnest (and likely from the same data discussed in more detail above).

Additional chlorophyll *a* data collected during the spring to fall period would be useful in defining patterns of phytoplankton productivity in Lake Osoyoos. This could be accomplished as part of a broader program discussed further in section 13, *General Recommendations*.

## 6.4 Nutrient Water Quality and Algal Dynamics

This section presents a brief primer on macronutrients, results of limited water quality sampling in the fall of 1992, and synthesis of available nutrient data from in-lake and lake-outlet monitoring stations with respect to algal dynamics in Lake Osoyoos.

### 6.4.1 Background on Macronutrients

There are two general categories of nutrients required for algal growth and metabolism, macronutrients (required in large quantities including carbon, phosphorus, nitrogen and silica for diatoms) and micronutrients (required in very small amounts, e.g., trace metals and vitamins).

This discussion focuses on two macronutrients, nitrogen and phosphorus, commonly accepted to be of major importance in aquatic environments and seasons where nutrients could possibly limit plant growth. At other times and places, factors such as cold or warm water temperature, lack of sunlight or grazing by predators may be more important in controlling the growth of algae.

Although usually not considered a macronutrient, carbon is required in large quantities by all forms of biota in the aquatic food web. At normally occurring pH, it is typically present as bicarbonate but rarely limits algal growth, except in eutrophic environments where algal blooms may deplete the supply and raise pH. Less desirable blue-green algae may dominate the phytoplankton at such times, particularly during quiescent lake conditions (Bouchard 1989 and references cited therein).

Although the accurate and routine measurement of dissolved inorganic nitrogen is limited to about the last two decades, relatively accurate phosphorus measurement has been routinely accomplished for many decades. This is fortunate because phosphorus is often considered the important limiting plant nutrient in most freshwater environments, despite evidence of short-term limitation of nitrogen in eutrophic freshwater habitats.

The reader is reminded that nutrients in natural waters are not conservative elements, i.e., physical transport, chemical changes and biological processes act to alter the form and distribution in the water column and sediments. Algal uptake and release during decay, denitrification to nitrogen gas, sedimentation of P with other solids, and advection downstream are some of the factors that cause periodic if not daily variations of macronutrient concentrations in fresh waters.

**Phosphorus**

In general, phosphorus is the most important nutrient that may, under certain conditions, limit the growth of algae in freshwater environments. Two forms of phosphorus are considered in this discussion: (dissolved) orthophosphate ($PO_4^{3-}$) and total phosphorus (herein abbreviated "TP"). Orthophosphate is that fraction generally considered available for plant uptake and assimilation, and is often a significant fraction of the total phosphorus concentration in natural waters. TP includes all forms of organic and inorganic phosphorus, both dissolved and particulate (plant matter or detritus).

In contrast to the dissolved inorganic macronutrients, the measure of total nutrients, especially total phosphorus is a very useful indicator of tropic status of fresh water systems, especially lakes. A summer mean <14 µg/L has been suggested to indicate oligotrophy, and a summer mean > 25 µg/L may be an indicator of eutrophic conditions (Porcella et al. 1980, Welch 1992). Carlson's (1977) trophic state index relates algal biomass (chlorophyll *a*) to total phosphorus and is among the most widely cited index. It also incorporates secchi disc transparency measurements.

As shown in figure 22, the range of trophic status involves a gradual shift in these measures from nutrient poor (oligotrophic TP <7-10 µg/L) to nutrient rich (hypereutrophic TP > 60 µg/L). In comparison to oligotrophic lakes, eutrophic lakes are often shallow, have a high rate of nutrient supply (internally from sediments and/or from external sources), have few species of plankton, abundant rooted macrophytes and may have depletion of hypolimnetic water (Welch 1992). Another index of lake productivity is to use the steady-state TP concentration at spring overturn. This could be accomplished using the Canadian data from the north basin. Maximum TP for temperate lakes with salmonid fish was judged to be 60 µg/L by Beveridge (1987).

**Nitrogen**

Nitrogen is generally less important than phosphorus in limiting freshwater algal production, but may be more important in eutrophic and hypereutrophic lakes where internal loading of phosphorus (i.e., sediment release) and other factors may be significant. Some species of blue-green algae are able to fix nitrogen gas, although at relatively slow rates. Several forms of nitrogen are commonly measured in aquatic environments including total nitrogen (herein "TN"), nitrate ($NO_3^-$), nitrite ($NO_2^-$), and ammonium + ammonia ($NH_4^+$ & $NH_3$).

Total nitrogen includes all forms of nitrogen, particulate and dissolved, organic (e.g., amino acids) and inorganic (e.g., nitrate, nitrite and ammonia). Nitrate is a common plant nutrient that is used a component to synthesize protein. It may be denitrified by microbial forms to nitrite and ammonia, or be generated from ammonia via nitrite through nitrification in aerobic environments. In natural waters nitrate is usually much more prevalent than nitrite or ammonia. Nitrite is also a plant nutrient in some cases, but is toxic to animal life and is rapidly oxidized to nitrite in oxygenated waters. Ammonium + ammonia, i.e., the combined amount of dissociated ammonium ion ($NH_4^+$, the ionized and non-toxic fraction) and ammonia ($NH_3$, the unionized and toxic fraction) is sometime preferentially utilized by plants compared to nitrate. The percent occurrence of either form may be calculated from the total ammonium + ammonia concentration using tables of ambient water temperature and pH at the time of sample collection (Trussel 1972). Ammonium and ammonia are much less mobile in soils (Goldman and Horne 1983) and is strongly sorbed to particulate and colloidal particles, especially in alkaline lakes with high concentrations of humic matter (Wetzel 1975). When combined, the three inorganic forms of nitrogen in aquatic environments, nitrate, nitrite and ammonium+ammonia, are often referred to as dissolved inorganic nitrogen or DIN. This is a useful measure because all three forms may be useful for algal growth and are often inter converted in the microbial loop.

**Nutrient Cycling**

A paradoxical situation exists for the dissolved inorganic macronutrients (i.e., orthophosphate, nitrate, nitrite and ammonia + ammonium) during the summer months. These nutrients are not useful measures of the state of eutrophication, because they are often rapidly taken up by algae and cycled through the food and detritus web. This is shown through the normal decreased concentrations of dissolved inorganic nutrients in the main algal growing season that often seen in the lakes and reservoirs. The primary importance of these measures in the present context is for indication of limiting nutrient status, i.e., which nutrient or nutrients are potentially limiting to algal growth when ambient concentrations decline to low or nearly undetectable concentrations.

To complicate matters, there can be an uncoupling of ambient nutrient **concentration** and nutrient **supply rate** (from recycling and sediment release) that diminishes the use of simply measuring and analyzing dissolved inorganic nutrients. This occurs when the supply of freely available dissolved inorganic nutrient declines due to biological demand, and but the recycling of it increases due to the seasonally larger size of the algal biomass. See Hecky and Kilham (1988), Rensel Associates and PTI Environmental Services (1991) and Welch (1992) for more details.

**Nitrogen to Phosphorus Ratios**

Nitrogen to phosphorus or N:P ratios (N refers to DIN, P refers to orthophosphate) ratios are potentially useful as seasonal indicators of nutrient supply and algal uptake in lakes and reservoirs with less than moderate water exchange or flushing rates. The N:P ratio, coupled with a knowledge of the actual concentration of the lesser abundant nutrient, may serve as a potential indicator of nutrient limitation, but not as an absolute measure. In areas of more active physical transport, abiotic factors such as riverine flow, wind mixing, and upwelling may significantly alter the ratio. Many nutrient budgets are controlled by advective inputs and outputs of riverine water and wind-driven circulation (Jaworski 1981; Monoget et al. 1981). Nitrification, denitrification, or both may be significant processes that alter the forms of nitrogen in some systems. The rate of exchange between pools of dissolved and particulate forms also affects nutrient availability.

A balanced N:P ratio for use by plants is about 7:1 (by physical weight, 16 to 1 for atomic weight, Redfield 1958). Over time, freshwater habitats that experience nutrient enrichment often have ratios that increase at first (indicating limited phosphorus) and later decline to less than 7 when the trophic state shifts to mesotrophic or eutrophic. Again, the index is only useful when the concentration of one or both nutrients is near to zero. When both nutrients are in excess supply, other factors may be more important in limiting plant growth, or plant growth may be at physiological maximum rates if no single factor is limiting. Actual algal growth limitation could be demonstrated through nutrient-addition bioassays, knowledge of the nutrient requirements of the dominant species, and other means, but these involve measurements that have not been conducted often enough or over a broad enough geographic range to be useful here, as discussed below.

**Units of Measurement**

At this point it is necessary to discuss the units of nutrient measurements used herein. Most of the background nutrient data utilized in this report were reported as milligrams per liter (mg/L) or micrograms per liter (µg/L = mg/L divided by 1000) of nitrogen or phosphorus in a particular compound such as nitrate or orthophosphate, respectively. It is important to note that the only the nitrogen content of each of these compounds is reported here (e.g., nitrogen within nitrate... $NO_3$-N, the suffix N referring to only the nitrogen); the weight of other atoms in the compounds (e.g., oxygen within nitrate) are not reported. Some authors are careless and may not report the suffix of the measurement units, which can lead to great confusion about the actual nutrient status of a water body. For example, the concentration of nitrogen within nitrate ($NO_3$-N) must be increased by a factor of 4.4 when converting nitrate nitrogen ($NO_3$-N) to nitrate ($NO_3$). It is not necessary to use the suffix when referring to total nitrogen or total phosphorus, as long as it is clear which nutrient is being discussed. See Welch (1992) or Rensel Associates and PTI

Environmental Services (1991) if more detailed introduction to this topics is required.

### 6.4.2 Results of Fall 1992 Water Column Sampling

Samples were collected at two alternative net-pen sites on the east side of Lake Osoyoos in October 1992 (Table 4). Secchi disc depth was 2.3 meter at both sites, and abundant numbers of zooplankton were observed in surface waters. Lack of temperature and DO stratification indicated that the lake had been mixing ("turning over") at some point in the fall prior to sampling.

Table 4. Results of October 12, 1992 sampling at two alternative net-pen sites in Lake Osoyoos.

Both Sites, October 12, 1992

| Station | Depth (m) | Nitrate mg/L-N | Nitrite mg/L-N | Ammonium + Ammonia mg/L-N | DIN mg/L-N | Ortho-P mg/L-P | N:P Ratio (by wt.) | Total P mg/L-P | Total N mg/L-N |
|---|---|---|---|---|---|---|---|---|---|
| Grubbs Cove | 1 | 0.011 | 0.001 | 0.037 | 0.049 | 0.004 | 11.3 | 0.024 | 0.504 |
| | 10 | 0.011 | 0.001 | 0.065 | 0.077 | 0.004 | 19.2 | 0.071 | 0.542 |
| Smith Cove | 1 | 0.016 | 0.001 | 0.022 | 0.038 | 0.001 | 41.3 | 0.024 | 0.496 |
| | 10 | 0.024 | 0.001 | 0.018 | 0.044 | 0.001 | 43.1 | 0.023 | 0.375 |

Grubbs Cove Only, October 12, 1992

| Depth (m) | Wat. Temp (°C) | Conduct-ivity (µM) | D. Oxygen (mg/L) | pH | Secchi Disk (m) | Chl. *a* µg/L | Phaeo-phytin | Weather Conditions |
|---|---|---|---|---|---|---|---|---|
| 1 | 14.7 | 294 | 8.1 | 8.02 | 2.3 | 10.4 | 10.56 | 2kt N wind warm and pt. cloudy |
| 5 | 14.5 | | | | | | | |
| 10 | 14.5 | 299 | 7.9 | 7.72 | | 0.63 | 0.503 | |
| 15 | 14.5 | | | | | | | |

### 6.4.3 Synthesis of Nitrogen Data from Lake Osoyoos

As discussed above, dissolved inorganic nitrogen (DIN) includes nitrate, nitrite and total ammonia (i.e., ammonium + ammonia). All of these forms are subject to quick biological cycling and all may be used by plants as nitrogen sources. Ammonium ion ($NH_4^+$) is a product of organic matter decomposition that is non-toxic and is more prevalent at cooler temperatures and lower pH levels compared to unionized ammonia.

The annual average of ammonium + ammonia concentrations at Lake Osoyoos outlet was 0.035 mg/L-N (SD = 0.008 mg/L-N), which is relatively high for natural waters (Table 1, Fig. 23). However, the average un-ionized portion is small (Trussel 1972), averaging only about 4% of the total ammonium + ammonia or 0.0014 mg/L-N on an annual basis. Ammonium + ammonia concentrations generally decline at the lake outlet during spring and summer, with the exception of May. This pattern may be caused by the enhanced flushing of the lake that occurs during these same time periods (Fig. 3), or related to the affinity of total ammonia for algal and particulate matter, previously discussed, or to other, unknown factors. Rector (1992) reported a possible decrease in ammonia nitrogen at the lake outlet during the period 1981 - 1991, but the decrease is not definite (J. Rector, pers. comm. 2/93) and is not apparent in the data examined here (Fig. 24).

Unionized ammonia ($NH_3$) is toxic to many aquatic organism and becomes more prevalent at higher pH (base conditions) and elevated water temperatures (EPA 1986). For sensitive fish such as salmonids, ammonia should not exceed 0.029 mg/L-N at a pH of 8.25 and water temperature of 20 °C for chronic (4-day) exposures. Concentrations of un-ionized ammonia are quite low at the outlet from the lake, despite the nutrient-rich conditions, with monthly means not exceeding 0.0014 mg/L-N (Table 1). The four-day chronic exposure threshold for total ammonia under the same conditions is 0.76 mg/L-N, a level never approached at any time at the lake outlet.

A comparison of mean monthly dissolved inorganic nitrogen (DIN, Fig. 25) to mean monthly ammonium + ammonia at the lake outlet (Fig. 23) shows that about 25 to 50% of the DIN may be accounted for by the ammonium + ammonia, the balance being nitrate and a small amount of nitrite (Ecology data, not shown here). The mean summer DIN concentration (Fig. 26) has a pattern similar to mean summer ammonium + ammonia (Fig. 24). DIN results are discussed below in more detail with regard to the nitrogen:phosphorus ratio.

### 6.4.4 Synthesis of Phosphorus Data for Lake Osoyoos

As previously discussed, orthophosphate is the form of phosphorus available for plant uptake and metabolism, but total phosphorus (all forms combined) is useful as an index of lake or reservoir eutrophication. Mean monthly orthophosphate at the lake outlet did not vary much, from only 0.007 to 0.011 mg/L-P over the annual cycle, with lowest values in April and highest values in September (Fig. 27). The decline in orthophosphate in spring could be due to algal uptake, but without some index of phytoplankton productivity (Secchi disk, chlorophyll *a*, or cell counts) it is difficult to explain the late summer increase.

No trends were seen in mean summer concentration of orthophosphate over the period 1978-1991 (Fig. 28), but there are major limitation with these data. However, the detection limit for orthophosphate at the lake outlet was relatively high (0.010 mg/L-P) and virtually all of the measurements from the late summer of 1988 through 1991 were labeled "k" in the data base, indicating the orthophosphate concentration was at or below detection limits of the laboratory equipment. I treated these detection limit values the same as the detection limit for this report, but that likely introduced a bias toward unrealistically high orthophosphate concentrations. Welch (1992) advises a detection limit of 0.002 mg/L-P or less for orthophosphate monitoring in lakes. Nevertheless, these data have a useful purpose; more on this below with regard to the nitrogen to phosphorus ratio.

Mean monthly total phosphorus (TP) concentrations at the lake outlet assumed a tri-modal pattern, varying from 0.017 mg/L in June to 0.032 mg/L in December, with peaks in spring and late summer and December (Fig. 27). Unlike orthophosphate, detection level concentrations of total phosphorus were rarely seen in the data base. A major peak of TP was seen in April and May, with individual data points (not shown) reaching 0.100 mg/L in some years. This spring peak was most likely related to the spring overturn and loss of vertical stratification in the water column. Stockner and Northcote (1984) discuss the overturn, and show a mean total P of 0.076 mg/L for two years of sampling somewhere in Lake Osoyoos, probably in the north Basin. Mean summer TP values were slightly less than the 0.025 mg/L (25 µg/L) index of eutrophy previously discussed. These summer averages also appeared to be gradually declining since 1985, but were still within the range of averages previously seen.

A comparison of TP with orthophosphate by monthly or summer means (Figs. 27 and 28, respectively) shows that there is too little variation of orthophosphate to show a trend. However, there are hints that the two factors are inversely related in the spring and winter, but directly related in the late summer. The cause of this relationship is unknown, but in any case, much of the phosphorus is in particulate (algal or detrital) forms throughout the year.

Finally, a better indicator of eutrophication status would be "in-lake" TP data, and fortunately there is some information from the north basin. These data for late August and September of 1983-1991 show a mean summertime total phosphorus of 0.0142 mg/L (SD = 0.004, N = 9) for surface waters or 0 or 1 m depth. This would indicated moderately low, mesotrophic conditions, based on one of the indices previously discussed. It would be useful to coordinate sampling with the Canadian workers to try to detect possible tropic differences between the north and south basin, as discussed further in section 13, *General Recommendations*.

### 6.4.5 Nitrogen to Phosphorus Ratios and Algal Growth Limitation

Nitrogen to phosphorus (N:P) ratios may serve as surrogate indicators of possible nutrient limitations, under certain conditions discussed in the introduction to this section. Monthly N:P ratios from the lake outlet (Table 1, Fig. 29) varied from about 17 in the winter (relatively low P) to lows of about 3-4 (relatively low N) during the summer. Because light and temperature may limit algal growth in the winter, the spring to fall period is of more interest in this discussion, and the winter ratios are of no significance. (Although some mesotrophic lakes in temperate, marine climates are capable of supporting blue-green algal blooms throughout the winter, e.g., American Lake in Pierce County WA.). No obvious annual trends were seen for mean summer N:P ratio at the lake outlet (Fig. 30).

Canadian surface water data for late August to early September, 1983-86 and 1989-91 (N = 7) shows a mean N:P ratio of 4.1, similar to the lake outlet station, which averaged 6.1 in August and 3.4 in September. In using these data, however, it must be noted that there was a high detection limits for nitrate+nitrite (0.020 mg/L-N), which means that the true N:P ratio may have been even lower than the calculated ratio of 4.1.

From Brower and Kendra's (1990) data, I calculated epilimnetic (dissolved) N:P ratios of 3.0 and 2.8 on June 6 and September 6, 1989, respectively, for a station in the south basin near the international border. Unlike the routine water quality data collected from the lake outlet, these data reflects a lower threshold of phosphorus detection and epilimnion orthophosphate was measured to be 0.004 mg/L-P on both dates, a relatively low concentration. They found DIN concentrations of about 0.011 - 0.012 mg/L-N, which are much lower than the average found at the outlet sampling station during the same months.

Because of the moderately low N:P ratios found at all stations (in-lake and at outlet station) during the summer, one might assume that nitrogen limitation is prevalent in the lake's euphotic zone during the summer. The nominal concentrations of both N and P were relatively low at both in-lake stations mentioned above. The outlet station had higher mean N and P values, but it was likely composed of a mixture of hypolimnetic and epilimnetic waters, as previously discussed for DO.

In summary, the N:P ratio data suggests possible nitrogen limitation of phytoplankton growth during the summer in Lake Osoyoos, but phosphorus limitation has been more likely in the early fall. This sort of seasonally fluctuating condition was not unexpected, and also occurs in the mainstem Columbia River, where somewhat similar mean monthly N:P ratios have been seen (Rensel 1989). The lack of extreme ratios in either direction (i.e., > 18 or < 3.4) for Lake Osoyoos surface water suggest that nutrient supply is not greatly imbalanced and that the lake is correctly characterized as mesotrophic, not eutrophic.

N:P ratios during the period of proposed fish rearing in April and May are virtually neutral (7), suggesting that neither nutrient is less limiting to phytoplankton growth at that time. Low concentrations of both N and P at that time suggest that DIN and orthophosphate added to the water from the net-pen fish will be rapidly utilized by the diatoms that are expected to be dominant at that time of year (as discussed below). However, flushing rates during the fish rearing period will increase rapidly due to the annual pattern of discharge from the Okanogan River. If the site is located as near as possible to the lake outlet, a significant portion of the dissolved nutrient wastes could be flushed from the lake.

### 6.4.6 Nutrient Addition Bioassays

Nutrient-enrichment algal bioassays were conducted in 1971 as reported by Stockner and Northcote (1974). As shown in their figure 6 (not included here, see Pratt et al. 1991 or the original reference), by far the greatest response of algal growth was when both nitrogen and phosphorus were added to Lake Osoyoos surface water. Slight increases were seen with the addition of nitrogen alone, and no increase was seen with the addition of phosphorus. It has, however, been over 20 years since this work was conducted. Methodology and accuracy of analytical methods have changed greatly. The significance of this work is unclear for the purposes of this report, because I could not find enough details about the work.

To begin to investigate this further, I collected and filtered surface water in early October (10/12/92) at Grubbs Cove. I would have preferred to conduct the work during the summer, but that was not possible in 1992. Orthophosphate concentration was very low (0.004 mg/L-P) and the background N:P ratio was 11.3, suggesting possible tendency toward phosphorus limitation (as previously reported above in Table 4). Through addition of equal molar amounts of phosphorus or nitrate. I found that phosphorus greatly enhanced algal biomass as measured by chlorophyll *a*, with a final yield of 25.7 µg/L versus 6.4 µg/L for nitrate addition and 3.2 µg/L for no additions. The nitrate addition and control flasks had actually declined in cells density from chlorophyll *a* values of about 9.0 µg/L at the beginning of the experiment, 15 days prior.

## 7.0 MACROPHYTES AND EURASIAN WATERMILFOIL

This section begins with a review of the factors controlling the growth of Eurasian watermilfoil in general, then summarizes the known status of Eurasian Watermilfoil in the Lake Osoyoos. Smith and Barko (1990) recently reviewed the ecology of the Eurasian watermilfoil (*Myriophyllum spicatum* L.), a problem species whose genus is present on all continents except Antarctica. Excessive growth of Eurasian watermilfoil has a well known and negative effect on aquatic recreation (boating, swimming and fishing), and generally is perceived as reducing the aesthetic value of affected waters.

Macrophytes, however, should not be considered an ecological problem *per se*, as they are normal components of a mesotrophic lake and aid in controlling nutrient loading by several means as described by Welch (1992b). Professor Welch notes that they: 1) provide a refuge for large zooplankton that will grow, reproduce and control phytoplankton, 2) protect and stabilize bottom sediments and phosphorus, 3) utilize nutrients released by sediments and decaying macrophytes and 4) may inhibit the growth of harmful blue-green algae by release of excretory products. Europeans consider macrophytes as far more desirable than dense phytoplankton blooms that will replace the macrophytes in eutrophic or hypereutrophic waters.

Some of the negative aspects of prolific macrophyte growth are described as follows. The drowning deaths of several swimmers have been directly linked to intense Eurasian watermilfoil infestations (WDOE 1992). The plant may clog industrial, power generating and irrigation water intakes, lower DO concentrations during fall or winter decay, clog fishways, and may even lead to increased populations of mosquitoes in some locales. In some cases growth is excessive and causes increased internal loading of the nitrogen and phosphorus in the water column due to sloughing and leaf turnover and plant decomposition at the end of a growing season (Newroth 1985, Nichols and Shaw 1986). In many cases, native populations of macrophytes are severely reduced due to milfoil competition, as has occurred in the middle reaches of the Columbia River (Chelan County Public Utility District, unpublished survey reports).

The following section is in part paraphrased from the Smith and Barko's (1990) literature review and eventually leads to a focus on the relationship of macronutrients to the ecology of Eurasian watermilfoil.

Eurasian watermilfoil is generally most common in 1 to 4 meters of water, but may be found in deeper areas ( >10 m) in some cases where water clarity is good. Indeed, macrophyte growth may actually enhance water clarity by stabilizing sediments and promoting sedimentation (Welch 1992b). Growth in depths < 1 m is not common due to a variety of factors such as wave action, water level fluctuation, and temperature extremes. Growth begins in the spring as water temperature approaches 15°C, and reproduction is by both sexual (flowering) and asexual (fragmentation). Fragmentation is thought to be by far the most important means of dispersal; stolons are responsible for spread of populations for a few meters in established locations. The plant is rooted in bottom sediments and looses its lower leaves in response to shading as it grows to nearer the surface to form a dense canopy.

Surprisingly, Eurasian watermilfoil is not considered to be unusually productive or capable of attaining high densities of biomass, even in new introductions. Table 5 presents the factors that are known to influence the growth and shape of Eurasian watermilfoil.

Table 5. Factors influencing the growth and morphology of Eurasian watermilfoil (modified after Smith and Barko 1990).

| FACTOR | INFLUENCE No. 1 | INFLUENCE No. 2 |
|---|---|---|
| Water clarity | 1. Low water clarity limits plants to shallow rooting depths and leads to canopy formation | 2. High water clarity allows milfoil growth at greater depths. |
| Water temperature | 1. Plants grow best from about 15 to approximately 35°C. | 2. Maximum growth at about 30-35°C. but growth at 10°C is better than many competitor plants. Freezing temperatures are lethal. |
| Inorganic carbon | 1. Alkaline lake waters are best, but other waters will support some growth. | |
| Macronutrients | 1. Nuisance growths restricted mostly to moderately fertile lakes, or fertile locations in less fertile lakes, but nutrient supply is apparently less important than other factors. No one has shown that P supply limits growth | 2. Nitrogen and phosphorus uptake by the roots is the most important route of entry. Cations and bicarbonate taken from water. |
| Micronutrients | 1. Growth is not likely limited by these as sediments sources are abundant. | 2. Oxygen in the water column precipitates them to the sediment. |
| Sediment | 1. Plants grow best in fine-textured inorganic sediment of intermediate density due to optimal nutrient supply. May grow in other areas, if slope and depth are not too great | 2. Plants grow poorly on highly organic substrates (>20%) and very course substrates. |
| Water movements | 1. Spread of the plant is aided by water movement. | 2. Too much water motion and high energy discourages plant growth |
| Eutrophication | 1. Populations do best in mesotrophic (moderate trophic state) waters | 2. hypereutrophic systems have phytoplankton and other algae that may outcompete watermilfoil for light. |

Mineral nutrition of Eurasian watermilfoil has been more closely studied than any other similar submerged macrophyte. Uptake of phosphorus (P) is mostly from the roots, even in flowing water systems that constantly bathe the plant in fresh sources of P. It is thought that availability of P rarely limit the growth of this plant because fine-textured sediments of lakes are generally replete with phosphorus.

For nitrogen (N) the picture is not as clear. Eurasian watermilfoil prefers ammonium-nitrogen over nitrate, as do many algal species, and may absorb it from either the sediment or the overlying water. Nitrate is only taken up from the overlying water. Sediments are usually much more replete with ammonium than the overlying water. Under some circumstances, the availability of N may limit the growth of this species.

Carbon availability has been implicated in numerous studies as important in controlling growth of Eurasian watermilfoil. Water with high dissolved inorganic carbon (DIC, e.g., bicarbonate) content is invariably a good location for this species. Therefore, alkalinity is a good measure of the growth potential of the species. Other elements (Na, K, Ca and Mg) are not considered limiting to the plant's growth, except in areas of low inorganic carbon availability.

Macrophytes such as Eurasian watermilfoil generally allow for more diverse and abundant invertebrate and fish populations compared to adjacent open-water areas (Wiley et al. 1984, Kilgore et al. 1989). Not all types of fish increase proportionately with biomass: piscivorous fish increase to maximal numbers when macrophyte biomass is moderate, then taper off. Invertebrates and forage fish, however, have been found to increase directly with macrophyte biomass throughout the range studied. For warmwater species, small fish hide in the vegetation while adult fish remain along the edges or in open channels (Engels 1988). I could find no similar information for cold-water fish such as juvenile salmon, despite the presence of large macroalgal beds in portions of the Columbia River mainstem.

Eurasian watermilfoil was first reported in Lake Osoyoos in 1976 (Pine 1983), and is thought to have spread from upstream Okanogan Lake (Newroth 1985). Dion et al. (1976) reported "very few aquatic macrophytes" during their survey of July 1974. In 1978, the area coverage of Eurasian watermilfoil was estimated to be 1 acre, and increased to 132 acres by 1980 (Dardeau 1983), and spread downstream into the mainstem Columbia River. There have been no annual or other periodic, systematic surveys of Eurasian watermilfoil in the lake. Brower and Kendra (1990) estimate that approximately 60% of the shoreline in the south basin had macrophytes (they used the term "covered with macrophytes"). In 1992 informal survey information collected by Dept. of Ecology staff suggest major declines in the species abundance in areas once infested, at least on the U.S. side of the lake (K. Hamel, pers. comm. 10/92).

## 8.0 PHYTOPLANKTON AND ZOOPLANKTON

Analysis of phytoplankton samples is important in characterizing the general trophic condition of a lake. Although phytoplankton are considered the important base of the pelagic food-web, certain forms (especially blue-green algae) can be toxic or harmful depending on their prevalence, distribution and growing conditions. Several blue-green algal species form large, filamentous webs that may be unacceptable to zooplankton grazers, since it may clog some species' filter-feeding mechanisms, or may produce toxins that are harmful to the grazers. The blue-greens are able to vertically migrate through gas-vacuole formation, which allows them to access light at the surface and nutrients at depth. They may be able to move as much as 15 m/day (E. Welch, pers. comm, 10/92).

According to Stein and Coulthard (1971), phytoplankton succession in Osoyoos Lake is marked by a spring bloom of diatoms, followed by a summer bloom of blue-green algae and microflagellates and a return to diatoms in the fall. They found *Asterionella formosa*, *Fragilaria crotonensis*, *Cyclotella comta* and *Melosira Italica* to be the principle diatom species. The dominant microflagellate was *Cryptomonas ovata* and no they made no mention of the dominant blue-green algae.

Zooplankton are important as consumers of phytoplankton and other plankton and as a food source for fish including sockeye salmon. In general, larger zooplankton are more desirable as fish forage, and this apparently applies to sockeye salmon as well. A particularly desirable zooplankton prey species would be the cladoceran *Daphnia* spp. (up to 2 mm carapace length), that may do well in eutrophic lakes, unless fish predation rates are high. Other common zooplankton species include *Bosmina* sp. (about 0.4 mm CL). Smaller species such as rotifers are probably not good prey species for sockeye salmon (LeBrasseur and Kennedy 1972).

As lakes increase in nutrient richness from mesotrophy to eutrophy, however, the mean size of zooplankton often decreases in response to changes in the food web including a shift to smaller detritus and bacteria associates with the increased phytoplankton biomass. Additionally, phytoplankton prey changes to more colonial and filamentous forms as a result of decreased $CO_2$, increased pH and enhanced vertical stratification during quiescent weather (Welch 1992 and references therein). With regard to Lake Osoyoos, this generality suggests that further eutrophication could seriously affect the sockeye population by shifting its prey composition to smaller, less desirable species. As discussed below and in section 13, *General Recommendations*, there is not enough quantitative information to evaluate if sockeye prey composition is shifting significantly to smaller zooplankton forms.

Water samples were collected for qualitative analysis of phytoplankton and zooplankton on October 12 and 22, 1992 at the Grubbs Cove site. Phytoplankton and zooplankton were generally much more abundant in the later samples, although generally the same species were present on both dates. Both blue-green algae and diatoms were present, suggesting a transition period in the lake that would be expected following seasonal overturn. The water was particularly dense with zooplankton on October 22, 1992; a dozen or so visible zooplankton were seen when I immersed my hand a few centimeters into the water regardless of my location on the lake.

The most dominant phytoplankton species were *Phormidium* sp. (a blue-green alga) and an unknown filamentous diatom. In much less abundance was *Zygnewa* sp. (filamentous green alga), *Aphanizomenon flos-aqui* (a potentially harmful blue-green alga), *Melosira* sp. (distinctive filamentous diatom found in about equal numbers to *A. flos-aqui*). Also in low abundance were two diatoms *Coscinodiscus* sp. and *Asterionella* sp. Numerous other species were present. Phytoplankton identifications were provided by Dr. Leal Dickson of the University of Washington Botany Dept. There was some uncertainty regarding these samples, due to the effects of formalin preservation and handling.

More detailed and quantitative analysis of phytoplankton and zooplankton species has been conducted by the British Columbia government for samples collected opposite Monashee Co-op. in the lake's north basin. Data were provided to me for late winter and early fall between 1989 and 1991 by E.V. Jensen, Ministry of Environment, Lands and Parks. Late February 1988 phytoplankton samples were sparsely populated by several blue-green algae including the dominant *Oscillatoria tenuis* and *Lyngybya subtilis*. Several types of diatoms especially *Asterionella* sp. were present in low numbers. In March of 1990, similarly low numbers of phytoplankton were present, with *Lyngybya subtilis* the dominant blue-green alga and *Melosira italica* the dominant but less abundant diatom. In September of 1990, the dominant blue-green alga was *Oscillatoria tenuis*, and *Anabeaena affinis* was present. About 48 other species were present in low numbers.

The most dominant zooplankton present in the October 1992, south basin samples that I collected was *Diaptomus ashlandi* (a calanoid copepod). This species was similarly most dominant on September 9, 1991 in samples collected by the B.C. Ministry of Environment in the north basin, and was present in March of the same year. Also present in modest numbers on all three occasions was *Diacyclops bicuspidatus thomasi*, a cyclopoid copepod. *Daphnia* sp., an important prey item of some fishes was present on September 1991, but not in the other samples. Other species of zooplankton were noted in the March 1991 samples including 3 species of rotifers and cladocerans (*Bosmina* sp.). Allen and Meekin (1980) report that the dominant zooplankton during their 1972-73 surveys were copepods (*Cyclops* spp. and *Diaptomus* spp.), immature copepod nauplii, and the cladoceran *Daphia* spp.

# 9.0 PHYSICAL SAMPLING RESULTS AT ALTERNATIVE NET-PEN SITES

## 9.1 Current Meter and Drogue Study

### 9.1.1 Wind Conditions and River Discharge During Sampling

In order to evaluate the suitability of a site using the State of Washington's *Recommended Guidelines*, previously discussed, it was necessary to evaluate water velocity at the alternative sites. This chapter addresses that topic by comparing conditions during sampling to average wind and river flow conditions during the proposed period of salmon net-pen rearing, previously discussed.

Wind forcing can be a major factor controlling the direction and velocity of water currents in lakes. Efforts were made to monitor wind conditions during the current meter and drogue studies. In general, winds were very light (5 MPH or less) on the first full day of sampling (October 21, 1992) but were much stronger on the second day (5-10 MPH on October 22, 1992; see Table 6). As a result, current meter monitoring was curtailed on the second day in favor of drogue studies. Greater wind velocity on that day made the small skiff move too much so that current meter readings were likely to be less accurate.

As previously noted, wind direction is usually north or south, following the orientation of the Okanogan Valley. Mean wind velocity in the valley during spring is 9.8-11 mph (DeHarpporte 1983). Gibbons et al. (1987) reported winds from the southerly direction during their April 21 to 26 sampling period of 1986 in the lake. Accordingly, sampling during October of 1992 was done during wind conditions typically encountered in the proposed sockeye salmon rearing period of April and May, although specific wind direction information was not available.

Although tributary river discharge may have little direct influence on current velocity in a large lake (Goldman and Horne 1983), it is important to consider it's possible effects during the sampling period. This can then be compared to average discharge during the proposed salmon nearing period to get a sense of possible differences in current velocity and water resident time. Water flow into Lake Osoyoos is controlled on the Canadian side of the border, but there are agreements for maintenance of minimum flows.

Daily flow data during the October 1992 sampling were provided by Mr. Robin McNeil of the River Forecast Centre of British Columbia Department of Environment, Lands and Parks. Data from several stations were available, but for our purposes data from Oroville at the outlet of Lake Osoyoos is most useful. Flows in the 20 days prior to sampling averaged 379.9 CFS. Flows during the proposed net-pen rearing months are typically similar for April (1985-1990 mean = 339 cfs) and somewhat greater during May (1985-1990 mean = 560 cfs) averaged 495 cfs. Therefore the sampling period flows were about 30% less than will occur during the actual rearing period, resulting in substantially conservative estimates of water flow from riverine input.

### 9.1.2 Current Meter Results

Current meter monitoring results are shown in Table 6 and Figure 31. In general, flows on the first sampling day were very similar at both stations and at all three depths, with nearly twice the velocity at 1 m depth and most of the water motion to the north, correlating with winds mostly from the south.

Only one initial velocity measurement was made at both sites on the second day. The stronger winds at Grubbs Cove at that time resulted in about 3 times the current velocity at all depths compared to Smith Cove.

For the purposes of the evaluating alternative net-pen sites using the *Recommended Guidelines*, the mean current velocity near the surface at the site during light wind conditions was 0.09 ft/s (2.7 cm/s). This value does not represent maximum velocity (as used by the *Recommended Guidelines*) but allows a very conservative estimate of water velocity at the site during light wind conditions likely to be encountered in the late spring rearing period (spring period 9.8-11 mph, DeHarpporte 1983). See Section 11.2 for allowable rearing density using these data.

Table 6. Lake Osoyoos current meter data and associated wind conditions during October 1992.

**Grubbs Cove**

| Date | Time | Velocity (ft/s) 1 m | 5 m | 10 m | 1-2 m Current Direction * | Wind Conditions |
|---|---|---|---|---|---|---|
| 10/21/92 | 1100 | 0.10 | 0.12 | 0.10 | Variable N to E | 5 MPH South |
| | 1210 | 0.04 | 0.06 | 0.03 | North | 5 MPH South |
| | 1400 | 0.05 | 0.0 | 0.0 | | 2 MPH South |
| | 1500 | 0.16 | 0.05 | 0.06 | North | Calm |
| | 1600 | 0.12 | 0.03 | 0.04 | North | 4 MPH South |
| | 1700 | 0.08 | 0.03 | 0.07 | | 1 MPH South |
| | Mean | 0.09 | 0.05 | 0.05 | | |
| | SD | 0.04 | 0.04 | 0.03 | | |
| 10/22/92 | 0920 | 0.19 | 0.18 | 0.20 | North | 10 MPH South |

**Smith Cove**

| Date | Time | Velocity (ft/s) 1 m | 5 m | 10 m | 1-2 m Current Direction * | Wind Conditions |
|---|---|---|---|---|---|---|
| 10/21/92 | 1130 | 0.06 | 0.05 | 0.06 | North | 3 MPH South |
| | 1300 | 0.08 | 0.03 | 0.02 | North | 5 MPH South |
| | 1415 | 0.13 | 0.04 | 0.03 | Southeast | Calm |
| | 1525 | 0.09 | 0.07 | 0.04 | Southeast | Calm |
| | 1620 | 0.10 | 0.03 | 0.04 | North | 4 - 5 MPH South |
| | Mean | 0.09 | 0.04 | 0.04 | | |
| | SD | 0.046 | 0.024 | 0.021 | | |
| 10/22/92 | 0940 | 0.06 | 0.05 | 0.06 | North | 5 MPH South |

* Based on current meter direction at 1 m and general path of drogue travel.

There have been no broad studies of current patterns in Lake Osoyoos, however, bathymetry, sediment grain size and distribution of moderately soft-sediment utilizing macrophytes may also be used as a rough indicator of current velocity. There are several macrophyte beds located on the east shore of the lake in silty sand substrate (Gibbons et al. 1987) and in each case the beds are located behind the north side of a point of land. At least two of the points (Grubbs and Smith) also have relatively deep water areas to the south of the points. These features suggest the presence of counter clockwise current patterns in the coves south of each point, that results in low current velocity and lack of scouring along the north side of each point.

### 9.1.3 Drogue Tracking Results.

Shallow (2m) and deep (10m) drogues (drift object) were released from the center of the alternative sites as explained in the methods section. The narrative will focus on one site at a time, relative to current meter results and wind conditions (Table 6).

#### Smith Cove

Drogues released at 1130 hours at the Smith Cove site on the morning of October 21, 1992 moved in a north-northwesterly direction towards Smith Point (Fig. 32). The deep drogue grounded quickly on the point after approximately 15 minutes, while the shallow drogue was still moving in that direction. A near repeat performance was obtained by drogues released at 1245 hours (Fig. 33), although both drogues quickly ran aground on the point. Winds were 3 MPH from the south during both of these releases.

By 1415, winds had ceased, and drogue released at 1440 moved in a different direction (Fig. 34). The shallow drogue moved directly north, then west along the shoreline for about 1 hour. The deep drogue maintained a similar course as had earlier releases, but the shallow drogue moved to the northeast and then southeast in a clockwise fashion. This seemed interesting, so I released another shallow drogue at 1534 and it traveled directly to the southeast (Fig. 35). The south wind began to blow about 1600, reaching 4-5 MPH by 1620 hours.

The next morning two sets of drogues were released near the Smith Cove site and due west, nearer the middle of the lake (Fig 36). All of these drogues moved quickly toward the Smith Point and the wind was measured at 5 MPH.

These limited data from Smith Cove show the importance of wind on water motion, and the residual gyre that occurred during slack winds. I did not expect to see such a close correlation between drogue tracks and wind conditions.

#### Grubbs Cove

Drogues released at 1150 hours at the Grubbs Cove station moved in near opposite directions initially, then generally to the north (Fig. 37). Wind velocity averaged about 5 MPH from the south until about 1500, when it became calm. The drogues were left in place for several hours and the shallow drogue moved toward the shore and to the west, paralleling the shore. The deep drogue moved first south and then north, but slightly towards the east. A new pair of drogues released at 1420 during calm conditions tracked quite differently (Fig. 38). The deep drogue moved to the northwest, while the shallow drogue moved to the southeast, nearly 180° different. Despite the calm conditions until about 1550, these drogues moved rapidly and were recovered after about an hour.

The next morning, two pairs of drogues were released at 0900 hours, one pair from the site and another pair from a position due west and towards the middle of the lake (Fig. 39). The wind was generally much stronger than the previous day (about 10 MPH from the south). The shallow drogue released west of the Smith Cove site moved very rapidly to the north-northeast. The deep drogue moved in a similar direction, but at a much slower rate. Both shallow and deep drogues released at the Smith Cove site moved at similar speeds to the north-north east and eventually went aground.

These limited data collected only under south wind conditions (with occasional calm periods) are similar to the Smith Cove data, but there were differences. At Smith Cove the surface and deep drogues traveled in similar directions, except during calm periods. At Grubbs Cove, drogues traveled in differing directions regardless of wind conditions. These results are important to generally corroborate the current meter findings and to give preliminary hints regarding general water circulation patterns. I would tentatively conclude that there is the possibility of a gyre (i.e., an eddy) that centers near the Grubbs Cove station, which makes that site less desirable from the standpoint of flushing. No evidence of a gyre at the Smith Cove site was found. There likely is a gyre at times in Smith Cove, but its center would be somewhere to the south of the sampling site.

## 9.2 Bottom Sampling Results

Bottom samples were collected at both alternative sites to determine sediment interstitial phosphate, total organic carbon and sediment grain (particle) size. This information is useful to characterize the sites with regards to background levels of organic loading and possibly for indirect information regarding water velocity and sedimentation. Bottom sediments may provide an index of overlying water velocity, with coarser sediments dominating in areas of greater average and maximum velocity. Results of sediment phosphate, total organic carbon and sediment size analyses are presented in tables 7 and 8 and figure 40.

Table 7. Total phosphate, total organic carbon and mean phi sediment grain size for alternative net-pen sites in Lake Osoyoos, October 1992.

| Parameter & Unit of Measure | Smith Cove | Grubbs Cove |
|---|---|---|
| Total Phosphate (mg-P/kg) | 3,500 mg/kg | 1,520 mg/kg |
| Total Organic Carbon (% C dry wt.) | 2.0% | 2.5% |
| Mean Phi Size (mm, graphically determined) | 0.05 mm | 0.035 mm |

Sediments at both alternative sites were principally silt (i.e., 0.004 to 0.625 mm; Fig. 40) with very small amounts of fine sand (0.625 to 1.0 mm) and clay (<0.004 mm). The mean sediment (phi) size was slightly greater at Smith Cove, which may suggest slightly greater maximum water currents. Total organic carbon (TOC) was similar at both sites (2 to 2.5%) and was less than expected. Data reported by Canadians (Stockner and Northcote 1974) from the north basin of the lake were nearly 4% TOC in surface sediments. Besides the likely difference in depths of sampling, the north basin could have higher productivity and organic carbon sedimentation rates because of the nutrient-rich plume of the Okanogan River. A similar situation occurs in Lake Roosevelt in the mainstem Columbia River, where maximum primary productivity is in the middle reaches and related to industrial discharges of N and P upstream (Stober et al. 1982, Welch et al. 1992). Total phosphate was much greater at the Smith Cove site, but total carbon is a better and more standard measure of organic deposition, and the laboratory that analyzed the samples rarely does phosphate samples.

The general appearance of the sediment at both sites was surprising to this author. It was a uniform, medium dark gray with no sulfur smell or obvious redox (RPD) layer. A light brownish layer was noted at the very surface of the sediment. Because of the apparent mesotrophic state of the lake, I expected that there would be a dark to black reducing layer in the near-surface sediments, but none was found. The prolonged summer period of hypolimnetic hypoxia would also be expected to contribute to the reducing layer, as anaerobic decomposition is much slower than in aerobic conditions.

# Lake Osoyoos
## Sediment Grain Size Distribution

Sample ID: CO91A Grubb Cove — 34 % SOLIDS

| Sieve Size --> | No. 4: | No. 10: | No. 20 | No. 40 | No. 60 | No. 140 | No. 200 | No. 230 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Finer than Phi Size --> | | | | | | | | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Balance |
| Grain Size --> | > 4750 microns | 4750-2000 microns | 2000-850 microns | 850-425 microns | 425-250 microns | 250-106 microns | 106-75 microns | 75-62.5 microns | 62.5-31.2 microns | 31.2-15.6 microns | 15.6-7.8 microns | 7.8-3.9 microns | 3.9-1.9 microns | 1.9-0.9 microns | <0.9 microns | |
| Percent Passing (%) --> | 100 | 99 | 98 | 95 | 91 | 74 | 65 | 61 | 43 | 25 | 13 | 7 | 4 | 3 | 2 | 2 |
| ractional Percent (%) --> | 0 | 1 | 1 | 3 | 4 | 17 | 9 | 4 | 18 | 18 | 12 | 6 | 3 | 1 | 1 | |

Sample ID: CO91B Smith Cove — 34 % SOLIDS

| Sieve Size --> | No. 4: | No. 10: | No. 20 | No. 40 | No. 60 | No. 140 | No. 200 | No. 230 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Finer than Phi Size --> | | | | | | | | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Balance |
| Grain Size --> | > 4750 microns | 4750-2000 microns | 2000-850 microns | 850-425 microns | 425-250 microns | 250-106 microns | 106-75 microns | 75-62.5 microns | 62.5-31.2 microns | 31.2-15.6 microns | 15.6-7.8 microns | 7.8-3.9 microns | 3.9-1.9 microns | 1.9-0.9 microns | <0.9 microns | |
| Percent Passing (%) --> | 94 | 94 | 91 | 88 | 85 | 71 | 59 | 53 | 28 | 15 | 7 | 3 | 1 | 0 | 0 | 0 |
| Fractional Percent (%) --> | 6 | 0 | 3 | 3 | 3 | 14 | 12 | 6 | 25 | 13 | 8 | 4 | 2 | 1 | 0 | |

Table 8. Sediment grain size distribution (tabular) from alternative net-pen sites in the south basin of Lake Osoyoos in October 1992.

# 10.0 PROJECTED EFFECTS OF NET-PEN REARING ON LAKE OSOYOOS

## 10.1 Background

This chapter presents the technical information and calculations used to estimate the total amount of waste produced from the proposed net-pens in Lake Osoyoos. On a broader basis, effects of salmon net-pens have been extensively researched and are summarized in several reports and publications (Weston 1986, Gowen and Bradbury 1987, Tetra Tech unpublished, Cross 1990, Rensel 1990, WDF 1990).

## 10.2 Fish Production Strategy and Timing

The proposed project is planned to be implemented in two phases. Phase one is a three-year program with an anticipated annual release of approximately 200,000 juvenile sockeye (8,000 lbs). If phase one is successful, phase two would have annual fish releases of 375,000 (15,000 lbs; R. Klinge, pers. comm. 11/92).

The projected timing of net-pen rearing is Mid-March to mid-May. Sockeye fingerling will be stocked in the pens at approximately 90 fish per lb (4.5 g) and will be released at approximately 25 fish per lb (18.4 g). I selected a feed rate of three percent of body weight and a food conversion ratio (FCR) of 1.5 to 1, which is conservatively less than what is achievable, based on the literature and the experience at rearing pens in Lake Wenatchee. As discussed above, sockeye salmon grown in Lake Wenatchee net-pens regularly achieve an FCR of <1.0. Higher rates of feeding and lower FCR are certainly possible for the Lake Osoyoos project, but for conservative planning purposes I have selected easily achievable and conservative goals.

Growth rate of the sockeye salmon is projected in Table 9. Using these values it is shown that fish can be released after 61 days cultivation in the net-pens, preferably before the first of June. Because of the relatively rich secondary production of Lake Osoyoos, fish should be released in mid-May depending on water temperature (i.e., avoiding high surface water temperatures) and when abundance of desirable zooplankton is acceptable. Estimated daily loading is shown in Table 10, assuming a daily mortality rate of 0.04 percent per day and a feed rate of 3% body weight.

Table 9. Sockeye Salmon Growth Rate Spreadsheet.
FCR = 1.5:1, Feed Rate = 0.03 x BW per day.
Daily Factor = Fish Weight x FCR x Feed Rate

| Day | Fish Weight (g) | Daily Factor | Day | Fish Weight (g) | Daily Factor |
|---|---|---|---|---|---|
| 1 | 4.5 | 0.11 | 31 | 9.17 | 0.22 |
| 2 | 4.61 | 0.11 | 32 | 9.39 | 0.23 |
| 3 | 4.72 | 0.11 | 33 | 9.61 | 0.23 |
| 4 | 4.83 | 0.12 | 34 | 9.84 | 0.24 |
| 5 | 4.95 | 0.12 | 35 | 10.08 | 0.24 |
| 6 | 5.07 | 0.12 | 36 | 10.32 | 0.25 |
| 7 | 5.19 | 0.12 | 37 | 10.57 | 0.25 |
| 8 | 5.31 | 0.13 | 38 | 10.82 | 0.26 |
| 9 | 5.44 | 0.13 | 39 | 11.08 | 0.27 |
| 10 | 5.57 | 0.13 | 40 | 11.35 | 0.27 |
| 11 | 5.70 | 0.14 | 41 | 11.62 | 0.28 |
| 12 | 5.84 | 0.14 | 42 | 11.90 | 0.29 |
| 13 | 5.98 | 0.14 | 43 | 12.18 | 0.29 |
| 14 | 6.13 | 0.15 | 44 | 12.48 | 0.30 |
| 15 | 6.27 | 0.15 | 45 | 12.78 | 0.31 |
| 16 | 6.42 | 0.15 | 46 | 13.08 | 0.31 |
| 17 | 6.58 | 0.16 | 47 | 13.40 | 0.32 |
| 18 | 6.73 | 0.16 | 48 | 13.72 | 0.33 |
| 19 | 6.90 | 0.17 | 49 | 14.05 | 0.34 |
| 20 | 7.06 | 0.17 | 50 | 14.39 | 0.35 |
| 21 | 7.23 | 0.17 | 51 | 14.73 | 0.35 |
| 22 | 7.40 | 0.18 | 52 | 15.08 | 0.36 |
| 23 | 7.58 | 0.18 | 53 | 15.45 | 0.37 |
| 24 | 7.76 | 0.19 | 54 | 15.82 | 0.38 |
| 25 | 7.95 | 0.19 | 55 | 16.20 | 0.39 |
| 26 | 8.14 | 0.20 | 56 | 16.58 | 0.40 |
| 27 | 8.34 | 0.20 | 57 | 16.98 | 0.41 |
| 28 | 8.54 | 0.20 | 58 | 17.39 | 0.42 |
| 29 | 8.74 | 0.21 | 59 | 17.81 | 0.43 |
| 30 | 8.95 | 0.21 | 60 | 18.24 | 0.44 |
| | | | 61 | 18.40 | 0.44 |

Table 10. Estimated daily loading and feed use of sockeye salmon in net pens. See text for assumptions and factors utilized.

| Day | Mean Weight (g) | Number of Fish | Total Weight (kg) | Feed Use (kg) | Day | Mean Weight (g) | Number of Fish | Total Weight (kg) | Feed Use (kg) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.5 | 204,530 | 920.4 | 33 | 31 | 9.17 | 202,414 | 1,855.5 | 66 |
| 2 | 4.61 | 204,448 | 942.1 | 33 | 32 | 9.39 | 202,333 | 1,899.2 | 67 |
| 3 | 4.72 | 204,366 | 964.3 | 34 | 33 | 9.61 | 202,252 | 1,944.0 | 69 |
| 4 | 4.83 | 204,284 | 987.1 | 35 | 34 | 9.84 | 202,171 | 1,989.9 | 70 |
| 5 | 4.95 | 204,203 | 1010.4 | 36 | 35 | 10.08 | 202,090 | 2,036.8 | 72 |
| 6 | 5.07 | 204,121 | 1034.2 | 37 | 36 | 10.32 | 202,010 | 2,084.9 | 74 |
| 7 | 5.19 | 204,039 | 1058.6 | 37 | 37 | 10.57 | 201,929 | 2,134.1 | 76 |
| 8 | 5.31 | 203,958 | 1083.6 | 38 | 38 | 10.82 | 201,848 | 2,184.4 | 77 |
| 9 | 5.44 | 203,876 | 1109.1 | 39 | 39 | 11.08 | 201,767 | 2,235.9 | 79 |
| 10 | 5.57 | 203,795 | 1135.3 | 40 | 40 | 11.35 | 201,687 | 2,288.7 | 81 |
| 11 | 5.70 | 203,713 | 1162.1 | 41 | 41 | 11.62 | 201,606 | 2,342.7 | 83 |
| 12 | 5.84 | 203,632 | 1189.5 | 42 | 42 | 11.90 | 201,525 | 2,398.0 | 85 |
| 13 | 5.98 | 203,550 | 1217.5 | 43 | 43 | 12.18 | 201,445 | 2,454.5 | 87 |
| 14 | 6.13 | 203,469 | 1246.3 | 44 | 44 | 12.48 | 201,364 | 2,512.4 | 89 |
| 15 | 6.27 | 203,388 | 1275.7 | 45 | 45 | 12.78 | 201,284 | 2,571.7 | 91 |
| 16 | 6.42 | 203,306 | 1305.8 | 46 | 46 | 13.08 | 201,203 | 2,632.4 | 93 |
| 17 | 6.58 | 203,225 | 1336.6 | 47 | 47 | 13.40 | 201,123 | 2,694.5 | 95 |
| 18 | 6.73 | 203,144 | 1368.1 | 48 | 48 | 13.72 | 201,042 | 2,758.0 | 98 |
| 19 | 6.90 | 203,063 | 1400.4 | 50 | 49 | 14.05 | 200,962 | 2,823.1 | 100 |
| 20 | 7.06 | 202,981 | 1433.4 | 51 | 50 | 14.39 | 200,882 | 2,889.7 | 102 |
| 21 | 7.23 | 202,900 | 1467.2 | 52 | 51 | 14.73 | 200,801 | 2,957.9 | 105 |
| 22 | 7.40 | 202,819 | 1501.8 | 53 | 52 | 15.08 | 200,721 | 3,027.6 | 107 |
| 23 | 7.58 | 202,738 | 1537.3 | 54 | 53 | 15.45 | 200,641 | 3,099.1 | 110 |
| 24 | 7.76 | 202,657 | 1573.5 | 55 | 54 | 15.82 | 200,561 | 3,172.2 | 112 |
| 25 | 7.95 | 202,576 | 1610.6 | 56 | 55 | 16.20 | 200,480 | 3,247.0 | 115 |
| 26 | 8.14 | 202,495 | 1648.6 | 57 | 56 | 16.58 | 200,400 | 3,323.6 | 118 |
| 27 | 8.34 | 202,414 | 1687.5 | 58 | 57 | 16.98 | 200,320 | 3,402.0 | 120 |
| 28 | 8.54 | 202,333 | 1727.3 | 59 | 58 | 17.39 | 200,240 | 3,482.3 | 123 |
| 29 | 8.74 | 202,252 | 1768.1 | 60 | 59 | 17.81 | 200,160 | 3,564.4 | 126 |
| 30 | 8.95 | 202,171 | 1809.8 | 61 | 60 | 18.24 | 200,080 | 3,648.5 | 47 |
| | | | | | 61 | 18.40 | 200,000 | 3,680.0 | 39 |

| SUMMARY | Ingested by Fish | | Ingested + Feed Loss | |
|---|---|---|---|---|
| | Kilograms | Pounds | Kilograms | Pounds |
| Feed use in March= | 578 | 1,272 | 607 | 1,335 |
| Feed use in April = | 1,973 | 4,340 | 2,071 | 4,557 |
| Feed use in May = | 1,610 | 3,543 | 1,691 | 3,720 |
| Total annual feed use = | 4,161 | 9,155 | 4,369 | 9,613 |
| Net Fish Growth = | 2,760 | 6,071 | | |
| Average FCR = | 1.51 | | | |

In phase one of the project, a total of 6,071 lbs (2,760 kg) of growth will be accumulated by the fish as the initial biomass is 2,025 lbs (920.4 kg) and the estimate release biomass is projected to be approximately 8,096 lbs (3,680 kg). Using a food conversion ratio1.5 to 1, a total of 9,115 lbs feed (4,161 kg) will be consumed by the fish in phase one. Assuming a loss of 5% of the feed, the total feed required will be 9,613 lbs (4,369 lbs), although the calendar month maximum use will be less than 5,000 lbs. (2,273 kg) obviating the need for a national pollution discharge elimination system (NPDES) permit.

The effects of phase one production can be described in terms of the components of the dissolved and solid wastes: phosphorus, nitrogen, carbon dioxide, oxygen consumption and area distribution of waste feed and fish feces. Phase two production effects can be estimated by approximately doubling the results discussed below.

Feed composition: Salmon feed is composed of the components shown in table 11. In addition, vitamins are sometimes added to the diet.

Table 11. Components of fish feed: proximate and elemental analyses.

| Proximate Analysis Component | Percent By weight |
|---|---|
| Water content | 10.0 |
| Ash | 10.0 |
| Carbohydrates | 25.0 |
| Fat | 10.0 |
| Protein | 44.0 |
| Fiber | 1.0 |
| Total ---> | 100.0% |

Elemental analysis shows that fish food consists of:

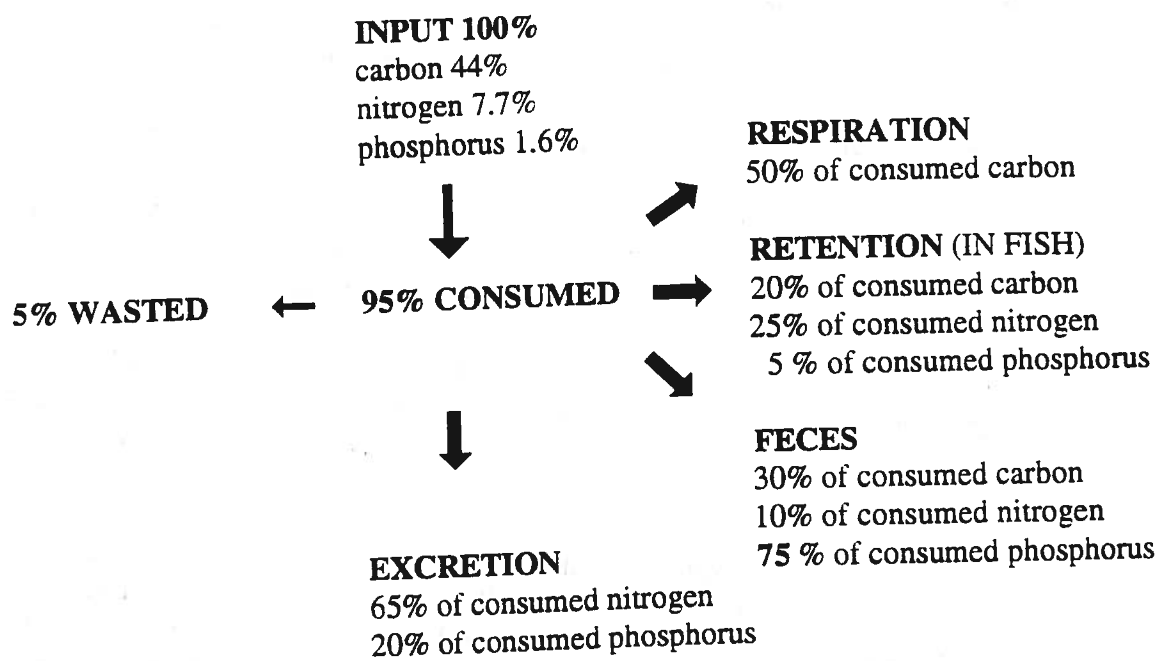
1. Carbon 44.0%
2. Nitrogen 7.7%
3. Phosphorus 1.0 - 1.6%
4. Hydrogen and oxygen (water) 10.0%
5. ash, sulfur and minerals (e.g., calcium, potassium, sodium), metals (e.g., iron, zinc, manganese) hydrogen, oxygen, etc as part of carbohydrates, fats and proteins and vitamins compose the balance.

Sources: Nos. 1 and 2 from Gowen and Bradbury (1987) but may vary to 55%;
No. 3 from Ketola (1975) and Holby and Hall (1991)
Nos. 4 and 5 from various feed manufacture's and other literature

## 10.3 Phosphorus, Nitrogen and Carbon Production

Table 12 illustrates the flux of feed elements through a salmon net-pen system. The components are discussed in more detail below.

Table 12. Distribution of feed elements from the a generalized fish farm (modified from Gowen and Bradbury 1987, by changing percent consumed and adding P data from Pettersson 1988).




### 10.3.1 Phosphorus Production

Fish food contains little phosphorus compared to carbon or nitrogen, typically a maximum of 1.6% (Ketola 1975) and as little as 0.6 - 0.8% is actually required by the salmon (Beveridge 1987). Approximately 66-84% of the phosphorus waste material will be in particulate (solid) form and be part of the waste feed and feces that settles to the bottom.

By contrast, fish excretion will only have about 20% of the consumed P (see studies reviewed by Weston 1986 and WDF 1990). Philips et al. (1985) found that 45% to 55% of the waste phosphorus was buried in the sediments near the net pens. Even greater sedimentation rates are likely for Lake Osoyoos, with its relatively weak currents, perhaps as much as 90%.

The only detailed study of salmon wastes in a freshwater reservoir in Washington state showed that 63% of the total waste P was deposited beneath or near the pens, and 37% was removed by flushing (Taylor 1990). The findings were similar to the literature averages discussed above. This study also showed that most of the dissolved inorganic phosphorus produced by the fish was rapidly sorbed onto particulate matter within 30 minutes to 1 hour, resulting in increased total P but no measurable increase in orthophosphate at the lake's outlet dam. This study is applicable to the Lake Osoyoos situation because it occurred in Lake Aberdeen, an artificial reservoir with fast flushing rate of 0.002 $y^{-1}$, much faster than the rate of 0.7 $y^{-1}$ for Lake Osoyoos. Particulate matter concentration is undoubtedly higher and slower flushing rates allow for lower export rates of P from Lake Osoyoos.

For the purposes of conservative estimation, I will assume a 50% burial rate of waste P. Accordingly, the distribution of waste P for phase one of the project is as follows, based on the distribution of wastes discussed above and assumptions noted below:

Feed = 4.161 kg x 0.016 = 66.6 kg P fed to fish x 95% consumed = 63.3 kg P/ yr. consumed

Waste feed P = 66.6 kg P x 0.05 = 3.3 kg P, assume 50% buried, 50% leach back to water
Feces P = 63.3 kg P x 0.75 = 47.5 kg P with 50% buried, 50% leached back to water
Excretion P = 63.3 kg P x 0.20 = 12.7 kg P soluble P, assume orthophosphate or similar

If all the P leached back to the water column was usable plant nutrient (orthophosphate), the total annual production of P from the above estimates would be 38.1 kg. For perspective, the British Columbia town of Oliver was pumping about 1,800 kg/yr into Osoyoos Lake in the early 1970s.

A first order estimate of background flux of total P through all three basins of Lake Osoyoos can be constructed as follows. The flushing rate of all of Lake Osoyoos was determined to be 0.7/year, the mean annual outflow of 590.3 x $10^6$ $m^3$ (Stockner and Northcote 1974) and the mean total P concentration was 25 µg/L-P (0.025 mg/L-P, based on tables previously presented). Accordingly, 14,575 kg of total P are transported out of the lake each year (and undoubtedly a significant fraction is retained in the lake). For example, Welch et al. (1992) estimated that about 30% of the total P input to Lake Roosevelt is retained in sediments.

Estimated phase one net-pen production of P in Lake Osoyoos would be about 0.0026 times as much (about 3/10 of a percent) of the annual lake outflow. Because of biological use, cycling and additional burial to sediments, the actual increase in Lake Osoyoos outflow would be much less and in any event, not measurable in the total phosphorus budget of the lake.

### 10.3.2 Nitrogen Production

About 78% to 89% of the nitrogen content of salmonid metabolic wastes is in the form of soluble ammonia with lesser amounts of urea (Ackefors and Sodergren 1985, Enell 1985, Gowen et al. 1985, Merican and Phillips 1985, Phillips et al. 1985). Brett and Zala (1975) showed that fingerling sockeye (29 g average weight) produced urea at a steady rate of 2.16 mg N/kg of fish per hour (51.4 mg N/kg fish per day). Ammonia production varied over a daily cycle, peaking about 4 hours after feeding at 35 mg N/kg of fish per hour and falling to a baseline level of 8.2 mg N/kg per hour in the early morning. The average daily rate of ammonia production was 349 mg N/kg per day.

The pathway of nitrogen associated with the Lake Osoyoos sockeye salmon rearing project may be estimated as follows, starting with the nitrogen composition of feed (about 7.7%). Sediment accumulation (burial) rates of N will vary, but I will refer to the recent work of Hall et al. (1992) for an estimate of 11% leach back rate to the water column. This was at a site with more water circulation and therefore less sedimentation beneath the cages than will occur in Lake Osoyoos.

Feed = 4.161 kg x 0.077 = 320.4 kg N fed to fish x 95% consumed = 304.3 kg/yr. consumed

Waste feed = 320.4 kg N x 0.05 = 16.0 kg N assume 89% buried, 11% leached to water column
Feces = 304.3 kg N x 0.10 = 30.4 kg N with 89% buried, 11% leached to water column
Excretion = 304.3 kg N x 0.65 = 197.8 kg soluble N, assume all ammonia and urea

Total dissolved inorganic nitrogen entering water column directly or through leach-back process = waste feed (1.8 kg) + feces (3.3 kg) + excretion (197.8 kg) = 202.9 kg N/yr.

It is not possible to compare the total soluble N production of 202 kg/yr from the proposed net-pens to natural flux through the lake because there are few data for total N. The dissolved inorganic forms (nitrate, nitrite and ammonia-ammonium) are cycled through biological and physical states, negating their use in this regard.

As a result of the net-pen program, the amount of nutrient from decomposing adult sockeye carcasses will be diminished in the Okanogan River. This will reduce the amount nitrogen loading in the lake to a minor degree, and is only an inadvertant and temporary effect of the net-pen program. At 2,000 eggs per spawner, a 0.5 to 1 male to female removal rate, and survival of 50% from egg to planting in the net pens (304,500 eggs initially), there will be a need for 152 females and 76 males for phase one of the program. This is total of 228 adult salmon, with an average assumed weight of 2.2 kg (5 lbs), and a total weight of 502 kg (1,140 lbs). Salmon are approximately 7 - 9% protein, of which about 16% is elemental nitrogen (Brett et al. 1969) for a total of 1.3% of the salmon being composed of elemental nitrogen. Therefore, approximately 6.5 kg (14.3 lbs) of nitrogen would not be introduced to the river and lake system if the carcasses were removed for the net-pen project, and the total net increase of N in the system would be 202.9-6.5 = 196.4 kg/yr. Ultimately it is more desirable to restore adquate fish habitat conditions in the Okanogan River, and allow all the returning fish spawn naturally.

### 10.3.3 Solids and Carbon Production

By definition, total solids include suspended solids (portion retained on a fine filter) and settleable solids (portion that settles out in an Imhoff cone over a one hour period. APHA 1985). Calculation of total solids production from fish farms depends greatly on the assumed food conversion ratio (FCR). This was previously discussed and conservatively set at 1.5 ("dry" feed, with 10% moisture) to 1.0 (wet fish weight, 70% moisture, see Parker 1987). The method of determining solids production is shown in Table 13 and is patterned after Weston (1986) and Gowen and Bradbury (1987) and may be used for any unit (kg or lbs) of feed provided. Other methods (e.g., Liao 1970) yield similar results.

Table 13. Flow chart of solid waste production from salmon net-pens, from a generalized fish farm (modified from Gowen and Bradbury 1987 and Weston 1986).

**INPUT 1.5 kg fish feed**
90% dry solids, → 10% water = 0.15 kg

↓

1.35 kg dry fish feed

↓

95% consumed → 5% waste = 0.07 kg dry wt.
1.28 kg dry wt.

↙ ↘

33% fish feces
0.42 kg dry wt

66% fish flesh + respiration loss of carbon to $CO_2$
1.0 kg wet wt. or 0.86 kg dry wt.

Total solids = food waste (0.07 kg) + fish feces (0.42 kg) = 0.49 kg or 33% of feed provided

Phase one production will use 9,155 lbs (4,161 kg) of feed annually, resulting in the production of 3,021 lbs (1,370 kg) of dry waste solids. Conservatively assuming that all of the solids will be deposited beneath the net-pens within an area of 1,369 $m^2$ (as described below), this amounts to a deposition of about 1 $kg/m^2$ of bottom area.

The carbon content of feed is about 44%, and losses may be partitioned as follows (modified from Gowen and Bradbury 1987):

4,161 kg of feed supplied x 0.44 = 1,831 kg C fed to fish

Waste feed C = 1,830 kg C x 0.05 = 92 kg C
Feces C = 1,830 kg C x 0.95 = 1,738.5 kg C x 0.30 = 522 kg C
Respiration C = 1,830 kg C x 0.95 = 1,738.5 kg C x 0.50 = 869 kg C as carbon dioxide
Retention C = 1,830 kg C x 0.95 = 1,738.5 kg C x 0.20 = 348 kg C as fish flesh

Total waste carbon to the bottom will be waste feed (92 kg C) + feces (522 kg C) = 614 kg C.

Respired carbon will enter the water as bicarbonate or carbon dioxide after crossing the gill epithelium. In either case it will likely enter the bicarbonate pool that helps buffer the water from pH changes, or will escape to the atmosphere as carbon dioxide depending on air/water transfer coefficients that vary with wave turbulence and temperature.

The above exercise shows that most of the carbon is lost to respiration, followed by losses as waste feed and feces, with the least incorporated into fish tissue. Based on estimates in the next section, 614 kg waste carbon will be distributed over an area of 2,264 $m^2$, assuming minimal current velocity similar to that found in the October 1992 sampling. This amounts to an average deposition of 0.27 kg $C/m^2/yr$ on the affected bottom area (about 30 to 60 times less than a commercial net-pen system, see Weston and Gowen 1988).

The deposition rate of carbon (a rate function) can be converted into a steady state accumulation estimate by accounting for the decay of organic matter. The actual rate of decay of the fish feces and waste feed on the bottom of Lake Osoyoos is unknown. However, at a steady state, the rate of decay equals the rate of deposition and the time rate of change of material on the bottom equals zero. The decay of organic material is considered a first order reaction, determined by a reaction rate coefficient. A reaction rate of 0.01/day is assumed, as recommended by US. EPA (1982). Because the net-pens will only be operated a maximum of 60 days/yr, the bottom will have more than ample time to recover in terms of carbon breakdown, even accounting for the period of epilimnetic hypoxia that occurs during summer months.

## 10.4 Modeling Area of Deposition

Waste fish food (non-floating variety) settles much quicker than fish feces. Most if not all of the waste feed will settle directly to the bottom beneath or within a few meters of the proposed net-pen facility. The actual deposition area of uneaten food may be estimated by use of equation 7.1 (from Tetra Tech unpublished). The formula accounts for the area under the pens and the distribution in four separate directions from the pens depending on the current vectors assumed. An approximate sinking rate for the size of feed to be used at the proposed net-pens would be 4 cm/sec, based on Stoke's fall velocity and tables prepared by Tetra Tech (unpublished). Current resuspension would occur at roughly 20 cm/sec, which may never occur at the proposed site.

Assuming a mean current velocity of 2.7 cm/sec (see section 9.2), and an average depth of 14 m, and a normal distribution of currents around the compass rose, the following calculation would apply:

$$A_f = [\, LW + (2ut)L + (2ut)W + uut^2 ]$$

where $A_f$ = area of deposition in $m^2$, the unknown in this equation
$L$ = length of all four net pens combined in m = 24 m
$W$ = width of all four net pens combined in m = 24 m
$u$ = mean current velocity in m/sec = 0.027 m/sec (may be altered for L or W sides)
$t = (H/W_f) = 282.5$
$H$ = depth of water beneath the bottom of the cages in m = 11.3 m (cage depth 2.7 m)
$W_f$ = sinking velocity of uneaten food in m/sec = 0.04 m/sec

Application of the equation to the Lake Osoyoos sites show that virtually all of the waste feed will settle beneath the cages and to a distance no more than 3.5 m from the cages, within an area 37 m x 37 m (1,366 $m^2$).

Fish feces are less dense than waste feed and settle more slowly through the water column (but fish feces do indeed sink, and will **not** be transported to nearby beaches). Using the same approach as above (equation 7.1), and assuming a fecal settling rate of 2 cm/sec (50% of Weston and Gowen 1988; Cross et al. 1990 that were both for subadults and 75% of Rensel unpublished data from 50 gram fish), the area of waste feces deposition would be 2,264 $m^2$ or 48 m by 48 m. Waste feces, therefore, will not spread greater than 24 m from the proposed net-pens.

### 10.5 Biological Effects

Possible biological effects of the proposed net-pens on algae and sediments are discussed here. These are much more difficult to forecast than the nutrient loading estimates discussed above, but some general conclusions can be drawn. First, because of the location and timing of the proposed project, measurable effects of the net-pens will be limited to the south basin of the lake. As previously shown, mean monthly flow through the lake increases greatly in May and peaks in June (Fig. 3), allowing for expedited flushing of the lake and any soluble or suspended particulate wastes resulting from net-pen rearing.

Benthic effects of the proposed net-pens should be non-detectable a year after the pens have operated, based on the loading rates and distribution of wastes discussed above. From the preliminary grab sampling efforts I made, it appears that few invertebrates inhabit, although meiofauna are likely present. The benthic effects are the easiest to monitor, and that is proposed below in section 13 *Monitoring Recommendations*.

The biological effects of the net-pens on the water column are expected to be minimal, and will certainly be harder to quantify in any event. During the proposed period of operation the spring diatom bloom will likely in progress, wind-driven vertical mixing in the lake is probably still active (there are no data from the lake for this period), nitrogen concentrations are at annual maximum and N:P ratios are near normal (7:1, Table 1). Given these conditions, the small amounts of dissolved N and P released from the net-pen fish will likely be rapidly taken up by the diatoms. The estimated N:P ratio of the dissolved wastes (5.3) is similar to the receiving waters, suggesting no preferential uptake by the phytoplankton.

As previously discussed, it is possible that soluble phosphate will leach from fish feces and uneaten feed, and possibly contribute to phytoplankton production. Because fish food and fish waste has little phosphorus, and flushing rates increase dramatically each year near the end of the fish rearing cycle, the pens will not contribute substantially to the phytoplankton productivity in Lake Osoyoos. In the worse case that they do contribute, at least it will be for diatom production, not blue-green algae which are less desirable species dominating later in the year. The exact distribution of nutrient incorporation could be predicted if more elaborate physical and biological modeling was conducted (e.g., Kiefer and Atkinson 1988), but given the small size of the proposed facility that would be unreasonable. No anticipated effects are forecast for macrophytes, because the area of waste deposition is well below the surface, euphotic zone.

# 11.0 PREFERRED SITE SELECTION

## 11.1 Comparison and final site selection

Table 14 is a comparison of site attributes for the two. final alternative sites. After considering these and other factors, the Smith Cove site is preferable in all but the category of measured current velocity. I discounted this factor because of the possible presence of a small scale gyre (eddy) at that site which would tend to reduce far-field dispersion. In any event, the current velocity is not a fish cultural factor because of the very low loading rates of fish to be used. The flushing rate of dissolved wastes from the Smith Cove site will likely be much faster than the average for the entire lake (0.7 yr.) because of the close proximity to the lake outlet (Beveridge 1987).

Table 14. Comparison of alternative net-pen sites for environmental and fish cultural factors. A + indicates preference of one site over the other.

| Factor or Effect | Smith Cove | Grubbs Cove |
|---|---|---|
| Current velocity (for benefit of fish) | similar to less velocity | similar to stronger (due to more wind fetch) + |
| Depth | same | same |
| Exposure to Wind Waves | much better + | much worse |
| Water Column Effects | less - near lake outlet + | more - further from outlet |
| Visual Presence | similar to less, will blend with nearby shore better + | similar to more noticeable, as it is further from shore |
| Logistics/fuel use, etc. | better + | worse |
| Sediment Effects (no score on this, see text) | similar, may be more concentrated but background sedimentation rate is lower | similar, may be more dispersed because of stronger currents but higher carbon content suggests greater background sedimentation rate |
| Sediment carbon content and grain size | similar to lower C content and larger grain size (suggests greater max. current velocity + | similar to higher C content and smaller grain size suggests lower maximum current velocity |
| Overall Score a/ (1 = poor, best = 7) | + 5 | + 1 |

## 11.2 Rearing Density and *Recommended Guidelines* criteria

The State of Washington's *Recommended Guidelines for Sizing and Siting Delayed Release Net Pens* (Parametrix 1990) are discussed here, relative to site-specific conditions at the proposed net-pen site. The *Recommended Guidelines* provides water depth and velocity criteria for specific densities of fish production at proposed net-pen sites that if followed, minimize or eliminate any measurable long-term sediment effect beneath or near net pens.

Figure 41 shows the set of curves depicting the maximum allowable fish density per meter square for a rearing period of 120 days. The Lake Osoyoos facility will only operate for <1/2 that period, hence the use of this figure builds in a large safety margin that will help deal with the period of epilimnetic hypoxia that likely exists during the summer months at the proposed site. Additionally, the guidelines were apparently developed for use with coho salmon, which are typically reared to a weight of 10 per lb (45g) in marine net-pens. The sockeye salmon will be less than 1/2 as large, about (20g) at release, hence building in a further margin of safety with regard to minimizing benthic impacts. A third conservative factor is that the estimated current velocity was based on averages during mild weather and wind conditions, and the *Recommended Guidelines* use maximum velocity, which would be considerably greater at the sampling locations in Lake Osoyoos.

For phase one, the maximum loading of fish is planned to be 200,080 fish @ 24.6 fish/lb (average of 18.4 grams) at the end of the annual rearing cycle for production of 8,119 lbs of fish. Given the average current velocity during sampling in October 1992 (2.97 cm/s), and a depth of about 35 feet beneath the bottom of the proposed cages, the allowable density would be about 600 fish/$m^2$ (Fig. 41). Accordingly, for phase one a total of 333 $m^2$ (200,000 fish divided by 600 fish/$m^2$) of rearing surface area is needed. The only commercially available net-pens of high quality construction available on the local market have an inside size of 12 x 12 m and four of these units assembled in a single square shape would have an effective rearing area of 576 $m^2$. Using 3 meter deep nets, this amounts to about 1,728 $m^3$ (61,024 $ft^3$ ) of rearing volume.

The total biomass on day 44 will be approximately 3,690.3 kg and the volumetric loading density will therefore average 2.13 kg per $m^3$ (or 0.13 lbs per $ft^3$). This is nearly identical to the density used in the successful Lake Wenatchee program and is much less than used for coho salmon of similar size are routinely reared to 0.5 lbs/$ft^3$ in delayed-release net-pen facilities. Larger salmon of all species may be reared at much higher densities (up to 32 kg $m^3$ ) as long as water currents are sufficient or oxygenation is provided. However, a prime consideration in siting net pens in Lake Osoyoos should be to minimize benthic or water column effects, while maximizing quality of the cultured fish.

## 12.0 MONITORING RECOMMENDATIONS

Although small-scale delayed release programs such as the proposed net-pens for Lake Osoyoos typically are not required to collect environmental impact data, it seems reasonable to collect data in this case because of the mesotrophic conditions not encountered in other similar projects. Monitoring should include sediment and water column measurements for at least a few years until trends, if any, become apparent.

Monitoring of sediments is recommended for total carbon, phosphorus and grain-size analysis. Because of the soft sediments at the proposed site, it would be easy to collect bottom samples using a small Van Veen or similar grab sampler. Core samples for sediment chemistry may be extracted from the undisturbed top of the samples, and visually inspected for the presence of a reducing layer. The cores should be chilled in ice and frozen within 12 hours for laboratory analysis. In the laboratory, samples should be sectioned so that only the surface layer of the sediment is analyzed.

Bottom samples should also be taken for infauna analysis. A 1.0 or 0.5 mm screen can be used to remove invertebrates for preservation and later enumeration. Based on my preliminary inspection, I would not expect to find much in this regard. Bottom samples for sediment chemistry and infauna analysis should be collected from 1) beneath the middle of the net-pen cages, 2) at the perimeter of the cages, and 3) at a reference station at least 50 m from the cages, but with similar depth and sediment composition. Initial sampling should be conducted after the cages are in place, but before the fish are stocked. The bottom is likely to be very homogeneous in the area of the proposed site, but placement of a permanent buoy to facilitate relocating the pens each year is recommended. In this manner the area of impact will remain the same and worst-case analysis of benthic effects can be conducted. After the first year of full operation, it would be reasonable to collect cores for carbon analysis immediately after the rearing period is completed. In the following year and at all other times, sampling should be in the spring, before fish are stocked. If there is difficulty relocating the pens to the same, exact spot each year, it is recommended that samples be taken after the completion of a rearing season.

Water quality sampling should involve measurement of several parameters at the proposed site in a vertical profile. Water temperature and DO measurements should be collected daily with a probe or CTD, as well as Secchi disc reading from the north side of the pens, in the same location and at approximately the same time.

At least once during the rearing season, preferably in the last weeks of rearing, DIN samples should be taken inside the middle of the cages at a depth corresponding to 1) the average depth of the pens or 2) the average depth of the fish cultured in the pens. Samples should be take twice during the day, once before feeding and another about 5 hours after the day's first feeding. This will allow an estimate of minimum (basal) and maximum nitrogen production (see Brett and Zala 1975). If wind-driven currents exist, an estimate of the rate of flow should be made using a sensitive current meter or drift objects placed up and downstream of the net-pens. Water samples should be taken up and downstream of the pens for analysis of DIN if current velocity is measurable. Wind speed and direction should be monitored for at least an hour before sampling.

Chlorophyll *a* measurements are recommended within and near the net pens if Secchi disc measurements are significantly less near the cages.

After the completion of rearing each season, a report should be prepared documenting fish production and feed used, fish stocking density, fish survival and results of the water quality testing discussed above. The report should provide estimates of nitrogen production, by integrating under a curve similar to that shown by Brett and Zala (1975, their figures 1 and 3).

# 13. GENERAL RECOMMENDATIONS

Recommendations for further study and action are grouped together by category including limnological, juvenile fish, and environmental mitigation. These recommendations are not to be confused with the recommended monitoring of environmental impacts discussed above. Those measures are fully adequate to detect and begin to quantify environmental effects of the cages.

**Limnological Study:**

Ecology Monitoring Station:

It is recommended that the Washington Department of Ecology consider temporarily adding a new monthly monitoring station in the lake and operate both the lake station and the outlet station for a few years to establish correlations between the two sites for specific water quality parameters. Water sampled at the outlet station is some distance downstream in the Okanogan River from the lake and is likely composed of a mixture of hypolimnetic and epilimnetic waters, as previously discussed for DO and nutrients. It is far less useful than in lake monitoring, similar to sampling the tailrace of a dam rather than collecting data from the reservoir of interest. The Department of Ecology has numerous fresh and salt water sampling locations and the cost of adding a station is estimated to be only $2,000/year (B. Hopkins, pers. comm., 1/93).

In-Lake Monitoring: Base Level

In lieu of changing the Ecology monitoring station, it would be useful for the PUD to work with and expand the existing program of water quality sampling conducted by citizen volunteers as coordinated by the Department of Ecology. The cooperation could take several paths, but at a minimum should include coordination of sampling days, sharing of some equipment and calibration efforts, inclusion of nutrients and chlorophyll *a* samples at least once a month in the summer and begin the sampling earlier in the spring (April). Sampling should continue near the volunteer citizen's sampling location at the international border, and at the net-pen site.

Similarly, coordination with Canadian sampling efforts should be proposed, by sampling on the same days and exchanging protocols for increasing the likelihood of compatible data. The Canadian effort is obviously a very professional and detailed approach, and the value of their information is high. In particular the collection and analysis of phyto- and zooplankton data should be encouraged and closely reviewed.

In-Lake Monitoring: Expanded Level

A greatly expanded water quality sampling program in the south basin of Lake Osoyoos would have the goal of documenting interannual and long-term changes in nutrient composition and water temperature. The south basin of the lake is shallower than the north basin, and appears to mix quicker in the fall. It may has less of a DO problem in the fall, but no data were available to compare the onset of stratification and DO depression in the spring, and only limited data were available for the summer.

Water quality samples for an expanded level of monitoring should be collected bimonthly during the April to October period and include vertical profiles of at least the following parameters: water temperature, dissolved and total phosphorus and nitrogen, chlorophyll *a*, Secchi disc transparency, conductivity, and pH. Once vertical stratification is established, there is no need to take more than one set of nutrient samples in the hypolimnion and the epilimnion, but temperature and DO should be monitored at close intervals of depth. Samples for zooplankton and phytoplankton analyses should be collected too, using water bottles or plankton nets of the appropriate kind and size.

Of particular interest in all basins of the lake would be the collection of vertical profiles of DO and water temperature, that would help clarify the areas of the lake suitable for sockeye salmon use. This approach was used by Allen and Meekin (1980), but they had few DO measurements and their data were for one year only. The Canadian data were useful in this regard, but it was collected only in late August or September and again in the late winter.

One goal of an expanded monitoring program would be to collect concurrent Secchi disc, chlorophyll *a*, total phosphorus and phytoplankton/zooplankton samples in the south basin to explore the reasons for the decline in water transparency that occurs each summer. The timing of sampling could be coordinated with the Canadians (at a minimum in their late winter and late summer-early fall). This type of sampling could help determine if productivity declines from north to south in the lake's basins, as has been hypothesized in this report and suggested by earlier workers (Coulthard and Stein 1969).

A water budget should be developed for Lake Osoyoos to track inflows, evaporation and outflows, which could then be used to develop a nutrient budget for phosphorus (EPA 1990). The budget would start with estimates of average inflow P from the Okanogan River and estimates of sedimentation rates in the lake. These data, along with existing outflow P data, could be used to estimate retention coefficients in the lake.

Finally, it may be possible to use published and unpublished data from fishery agencies to construct a review of long-term changes in zooplankton populations relative to sockeye salmon use in the lake. For example, Allen and Meekin (1980) apparently had more zooplankton data than was shown in their report. Similarly, the Canadians probably have additional data, both recent and certainly from the early 1970s or before.

Miscellaneous:

In order to understand the relationships between water quality in the lake and Okanogan River discharge, the long-term discharge record at Oroville of the Okanogan River should be examined to see if there has been recent, significant declines in annual discharge. This possibility was detected by comparison of monthly means of 1943-1979 calculated in WDW (1990; mean of 665 cfs) to 1985-1990 mean data (486 cfs) summarized in this report. If correct, this is a huge reduction in flow (27%) and could have profound effects on Lake Osoyoos and all phases of sockeye salmon life history in the lake and river. Reduced discharge could be due to recent drought conditions, increased evaporation related to land-use and agricultural withdrawals, short-term climate cycles known to exist in the Pacific Northwest or errors in data analysis. This is an easily achievable task, but was beyond the scope of the present report.

**Juvenile Fish Study:**

Some possible approaches to broadening life history knowledge about juvenile sockeye in Lake Osoyoos are as follows:

There were no data regarding juvenile sockeye use of the south basin, i.e., timing of use, depths utilized, relationship of water temperature and DO to fish distribution, etc. This work could involve acoustic sampling or tag/recapture gill netting of juvenile fish from the net-pens. If water temperatures are greater than normal during release of the juvenile sockeye from the net pens, it may be prudent to sample the lake outlet area or at Zosel Dam for early downstream migration. Because water temperatures increase slowly in the lake's surface and dissolved oxygen in the hypolimnion decreases slowly all summer, the net-pen fish should be able to find their way to the north basin to survive the poorer water quality conditions of the late summer. Some insight into the vertical distribution of juvenile sockeye could be gained by holding a small number of fish in vertically-elongated net-pens after the bulk of the fish had been released. Sampling could be accomplished by acoustics as simple as the digital depth sounders that have fish detection modes. These fish could also be sampled for gut-content analysis to study their feeding preferences.

Allen and Meekin's (1980) general assertion that salmon enhancement should be directed at lakes other than Osoyoos should be examined in an objective fashion, through the use of empirical carrying capacity estimates. There is a need to explore the actual carrying capacity of the lake for sockeye smolt production, to scope the "floor and ceiling" of smolts needed for maximizing use of the lake for natural rearing and to estimate adult escapement goals (WDW 1990). This effort should be matched with a modest effort to monitor water quality in the lake, especially DO, temperature profiles and local weather information. In part this could be accomplished in cooperation with the volunteer citizen's monitoring program, coordinated by the Department of Ecology if all parties agreed.

**Mitigating the Possible Effects of Net-Pen**

To minimize fish feed loss (which is "nutrient hot"), manual feeding should be conducted and automatic feeders avoided unless a fail safe system can be designed. The use of manual feeding should not be a major problem, because the fish require less frequent feeding at the sizes to be reared in the net pens. It allows the staff to customize delivery of the feed to the fish for each feeding, and experience shows that salmon feeding rates change with changing environmental conditions such as weather (light and temperature) and various stress factors.

To further minimize fish feed loss, the feed should be of a slow sinking variety to allow the fish to have time to find and consume it. Floating feed (i.e., feed that first floats and then slowly sinks) is available also, and may be used depending on the amount of surface drift experienced during the rearing period.

Fish feed could include defluorinated rock phosphate to reduce the solubility of P wastes from the fish (Ketola 1982. Asgard et al. 1988). Total P should be analyzed and held to a minimal level. Beveridge (1987) reviewed the dietary requirements of salmon and other fish and found that salmon require <0.8% P in their diets, while many fish feeds have about 1.6% p content.

It is remotely possible that there is a location in the south basin of the lake where outflow to the Okanogan River causes mixing of surface and bottom waters and eliminates the hypoxic conditions that occur in the hypolimnion during summer months. Depending on the depth and possible conflict with boat use from the state park, such a site could be investigated as another alternative rearing area. Stronger current flow, less anaerobic conditions on the bottom and transport of dissolved wastes directly to the river are desirable features of such a site.

To minimize visual effects of the net-pens, the system should be equipped with light gray or black colored floats, not the orange floats sometimes used in marine net-pens.

For navigation, the net-pens should be clearly marked with directionally oriented lights as per Coast Guard recommendations.

**Habitat Work**

Although beyond the scope of this report, a long-term alternative that would benefit the sockeye salmon stock more than the use of net-pens would be to improve upstream habitat and reduce nutrient loading to minimal levels. Re-establishment of riparian shade, cover and wetland areas on the Okanogan River and reducing point and non-point sources of N and P would go far to reverse the apparent degradation of Lake Osoyoos habitat. Because most of the watershed in British Columbia, this is out of immediate US control. Although there most certainly have been measures pursued in recent years by Canadian and B.C. agencies and environmentalists, there is a need for renewed commitment to improving the nutrient and thermal properties of the watershed.

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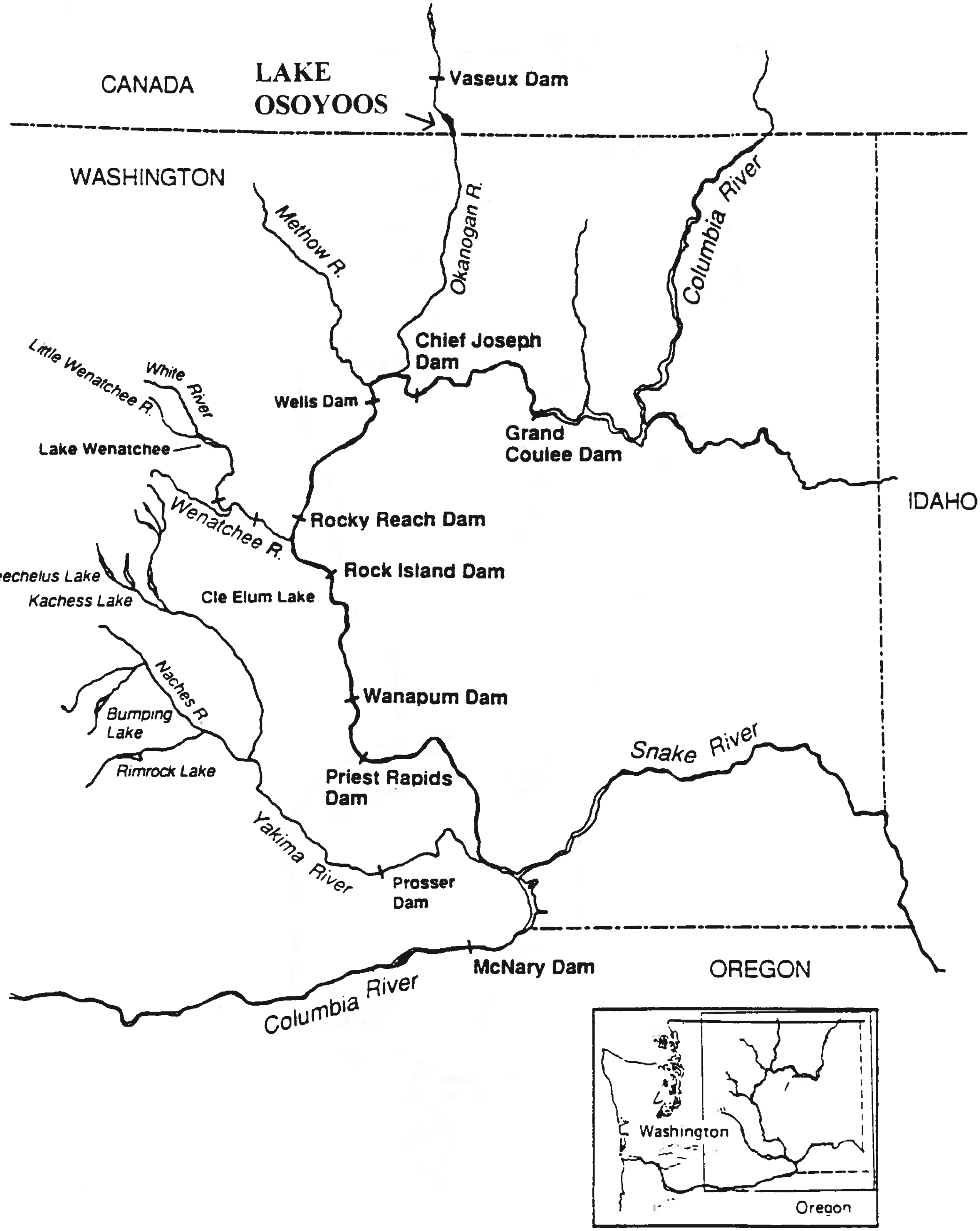


Figure 1. Vicinity map of eastern Washington state. major rivers and dams (after Flagg et al. 1991)

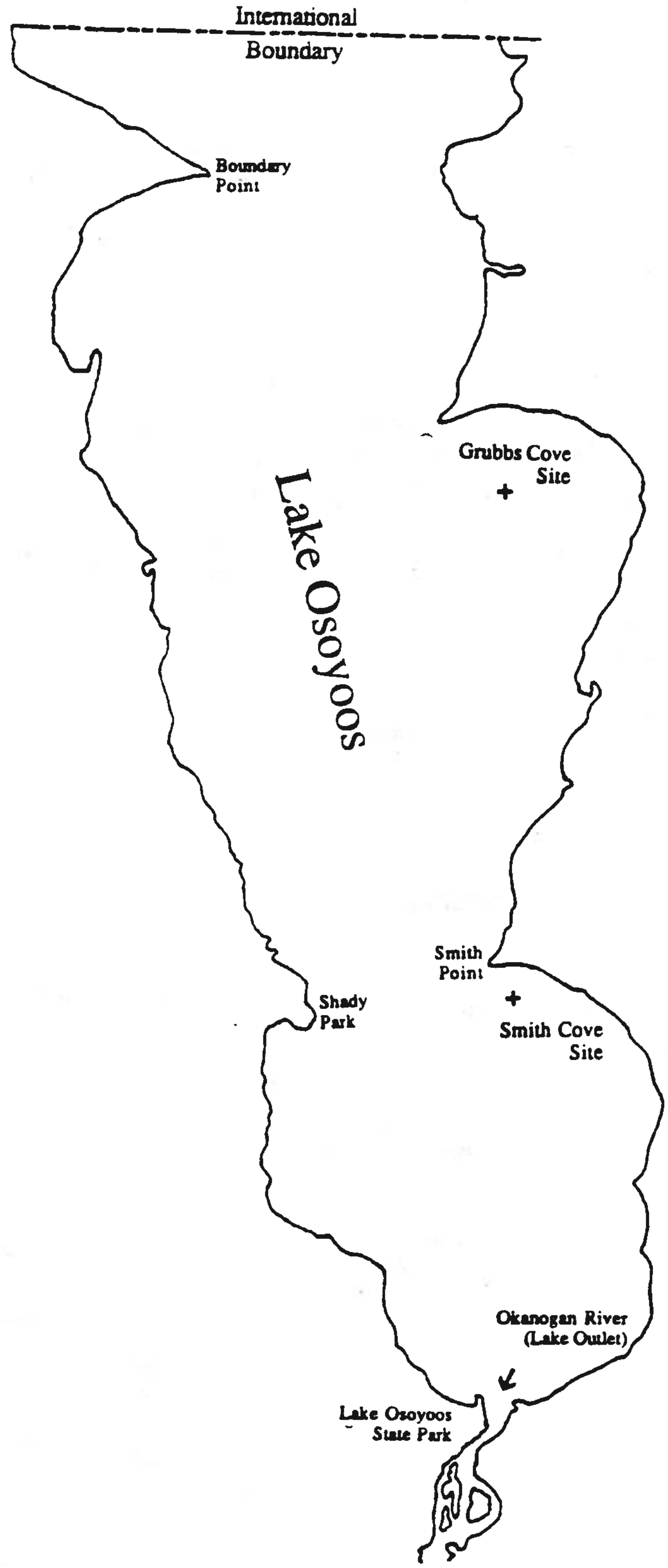


Figure 2. Location map of alternative net-pen sites in the south basin of Lake Osoyoos.

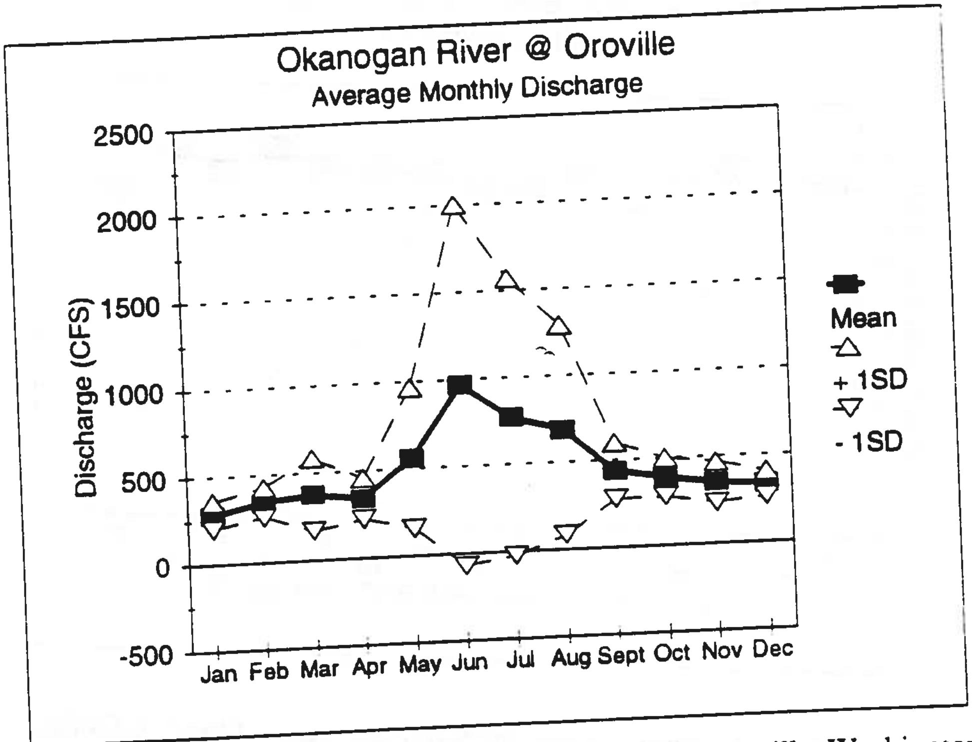


Figure 3. Mean monthly discharge of Okanogan River at Oroville, Washington, during water years 1985-1990 near the outlet of Lake Osoyoos.

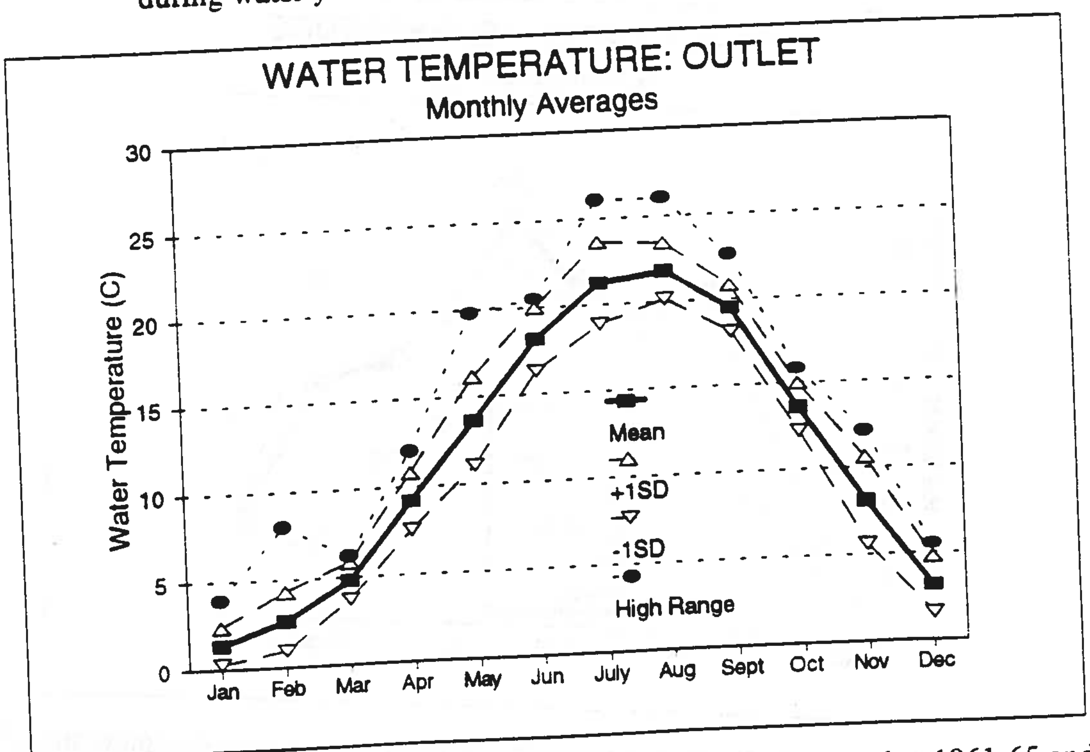


Figure 4. Mean monthly water temperature at Lake Osoyoos Outlet, 1961-65 and 1976-91.

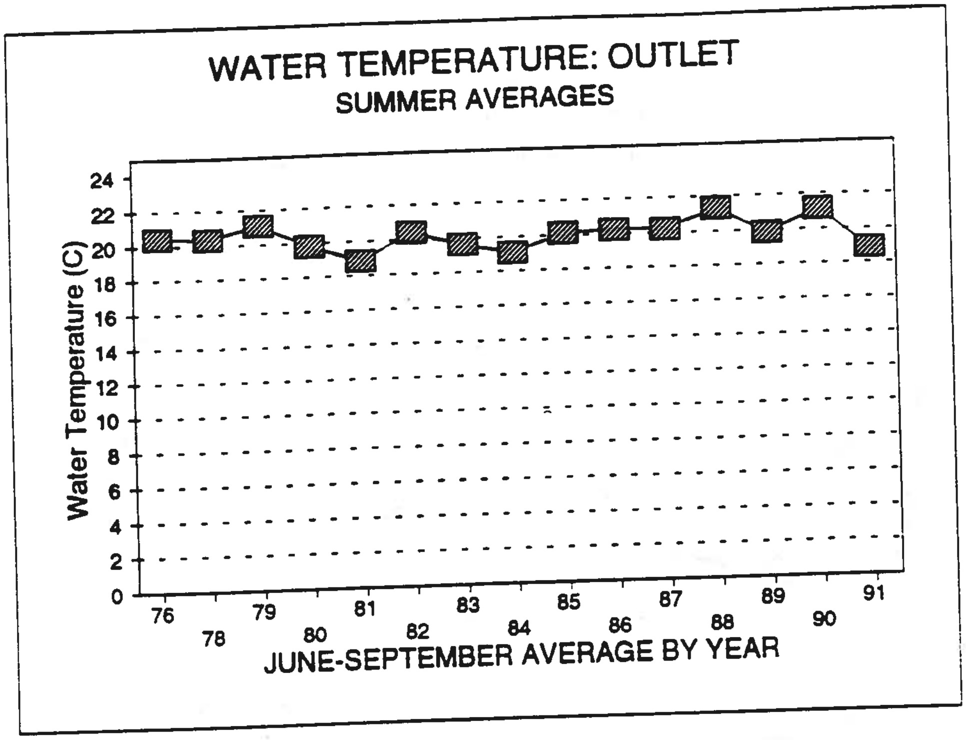


Figure 5. Mean June-September water temperatures at Lake Osoyoos Outlet, 1976-91.

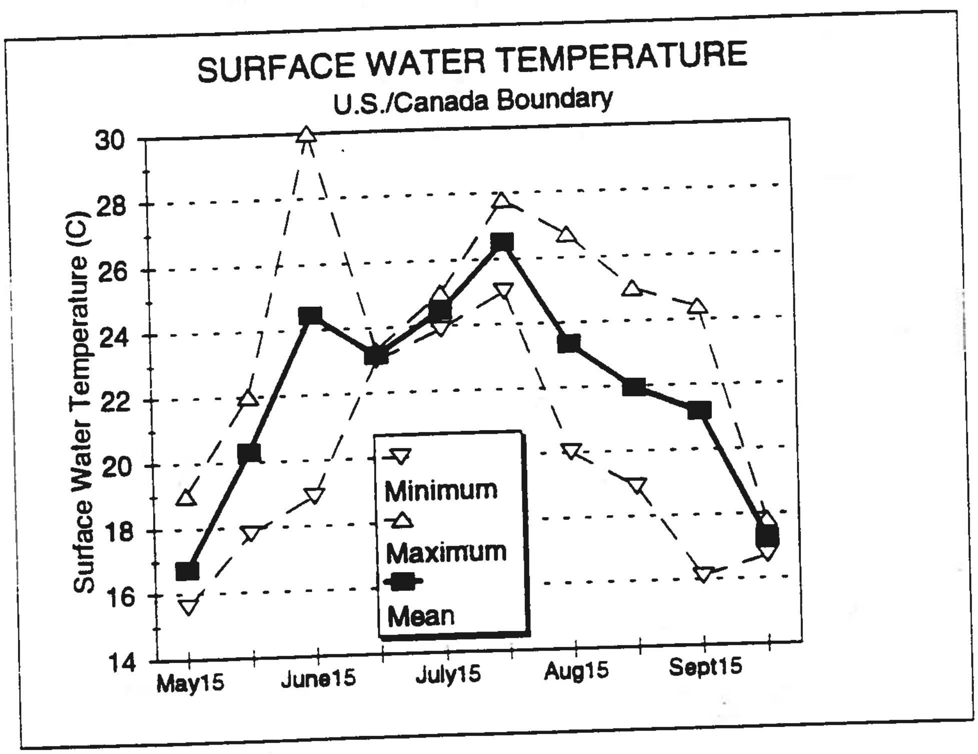


Figure 6. Mean bimonthly water temperatures from surface near the international boundary in the south basin of Lake Osoyoos, 1989-1992.

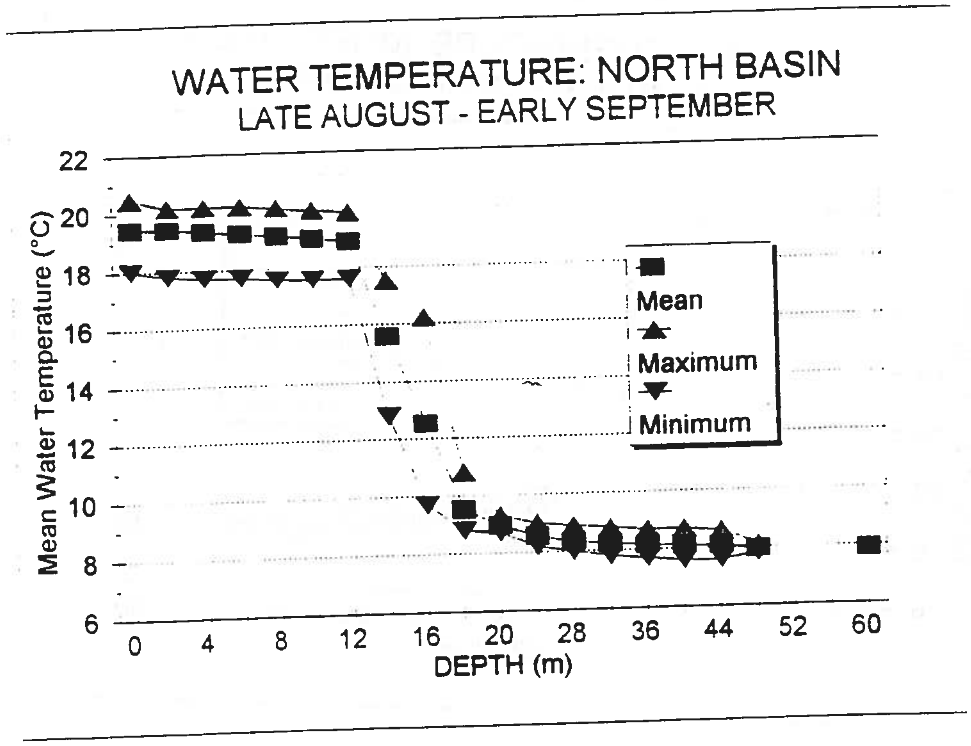


Figure 7. Vertical profiles of mean, minimum and maximum water temperature in north basin, Lake Osoyoos, late August to early September, 1987-91.

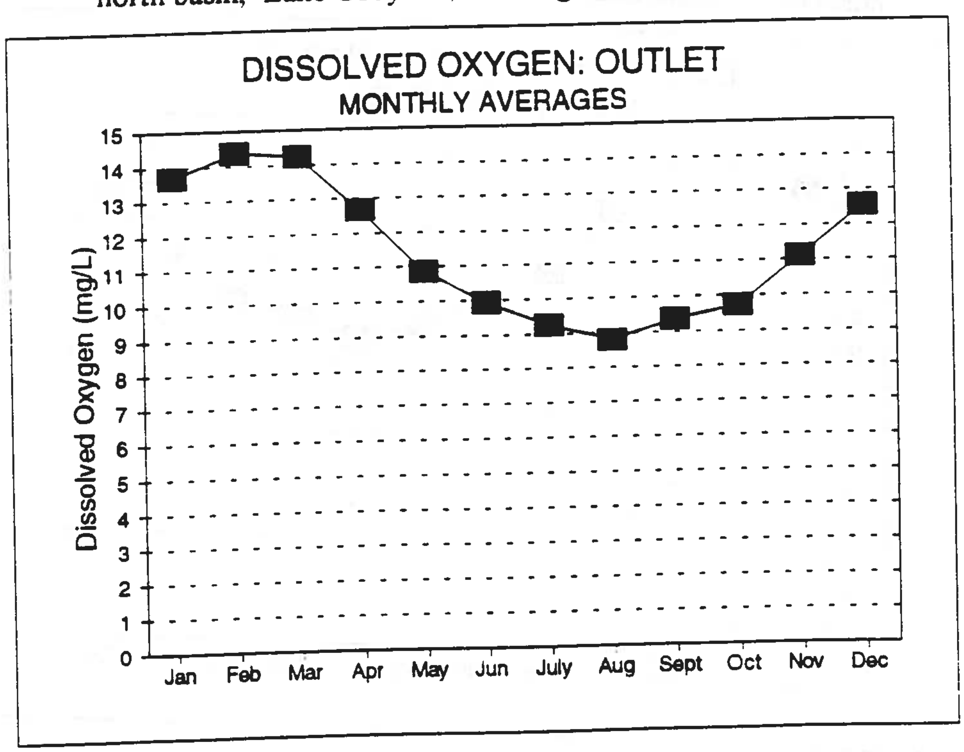


Figure 8. Mean monthly dissolved oxygen concentration at Lake Osoyoos Outlet, 1961-65 and 1974-1991.

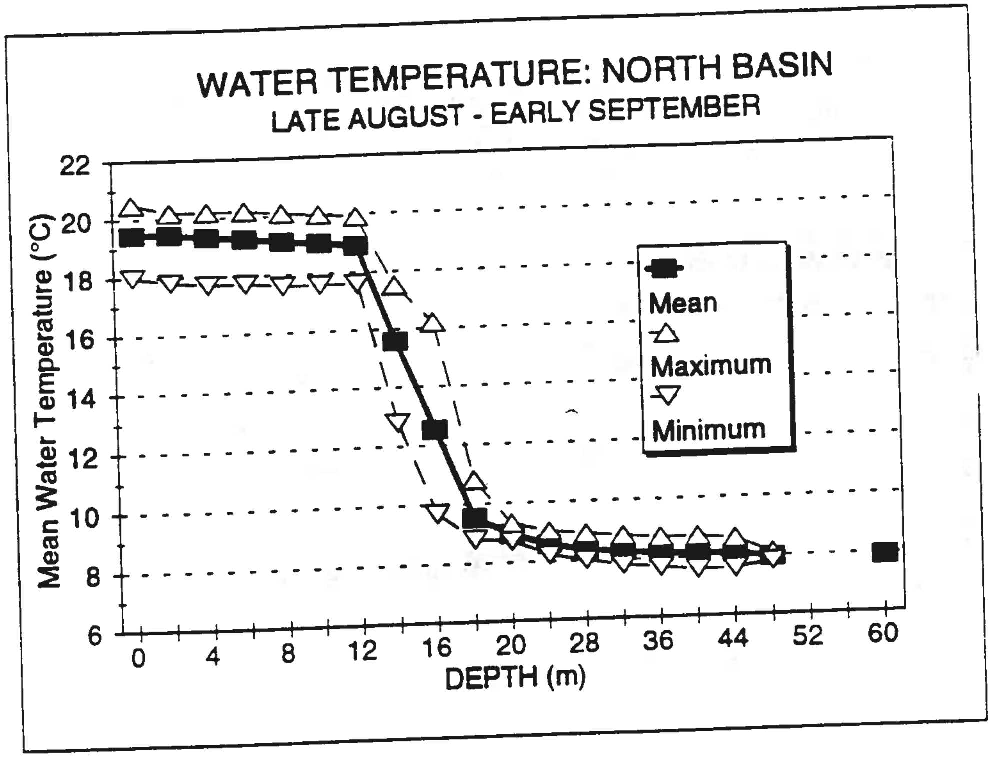


Figure 7. Vertical profiles of mean, minimum and maximum water temperature in north basin, Lake Osoyoos, late August to early September, 1987-91.

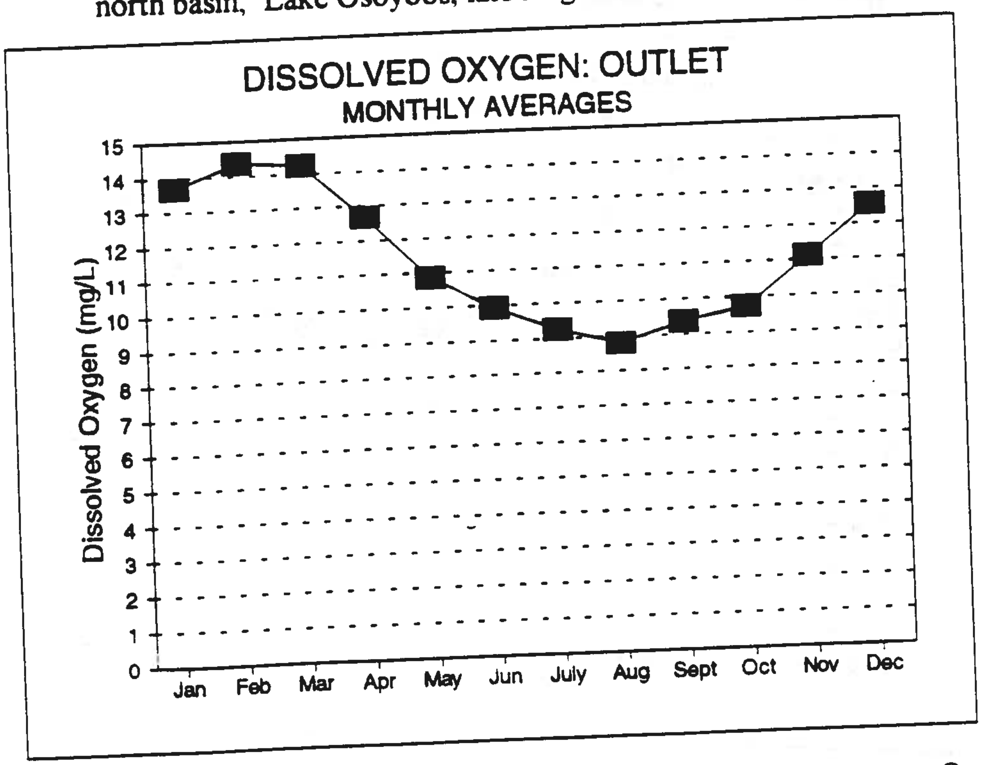


Figure 8. Mean monthly dissolved oxygen concentration at Lake Osoyoos Outlet, 1961-65 and 1974-1991.

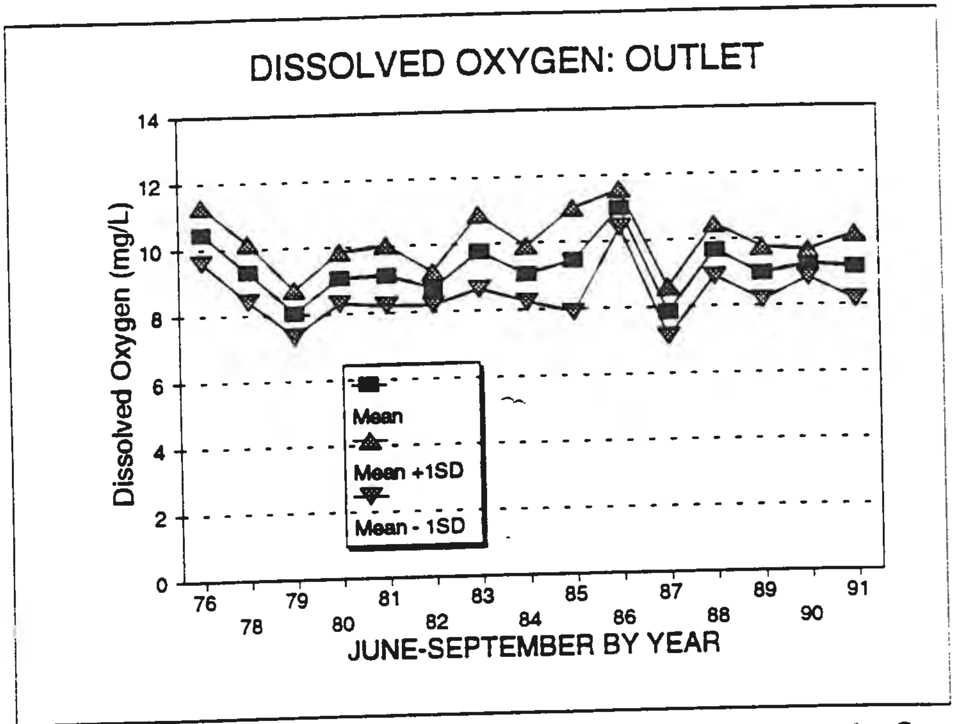


Figure 9. Mean June-September dissolved oxygen concentration at Lake Osoyoos outlet from 1976 to 1991.

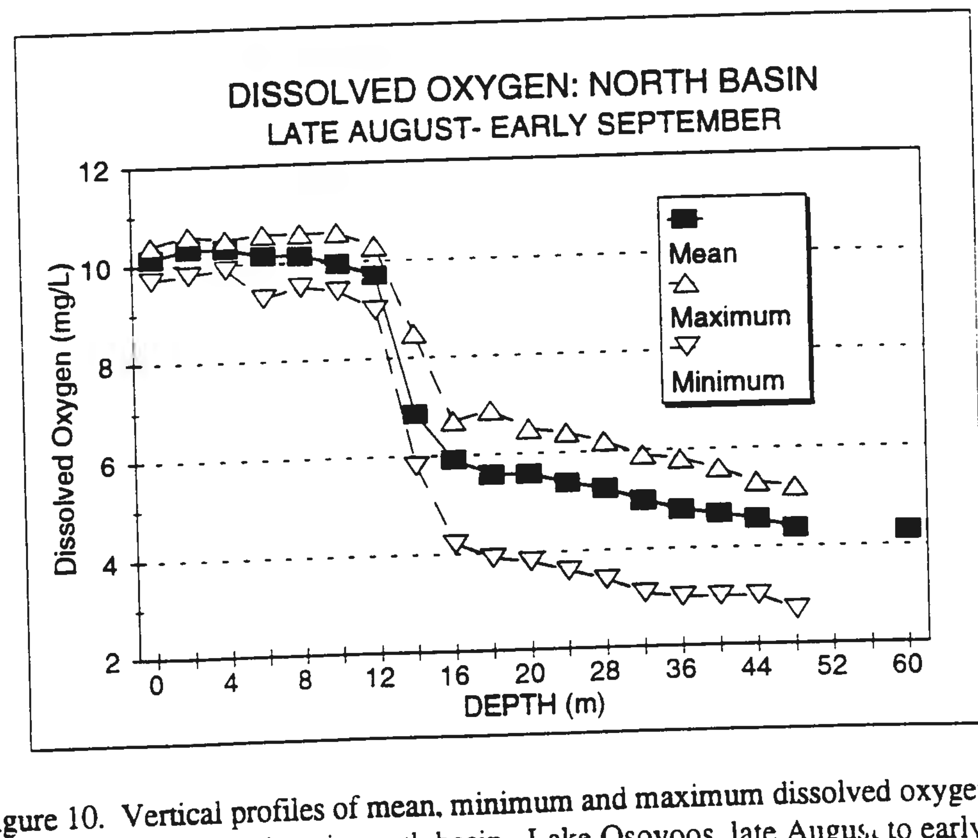


Figure 10. Vertical profiles of mean, minimum and maximum dissolved oxygen concentrations in north basin, Lake Osoyoos, late August to early September, 1987-91.

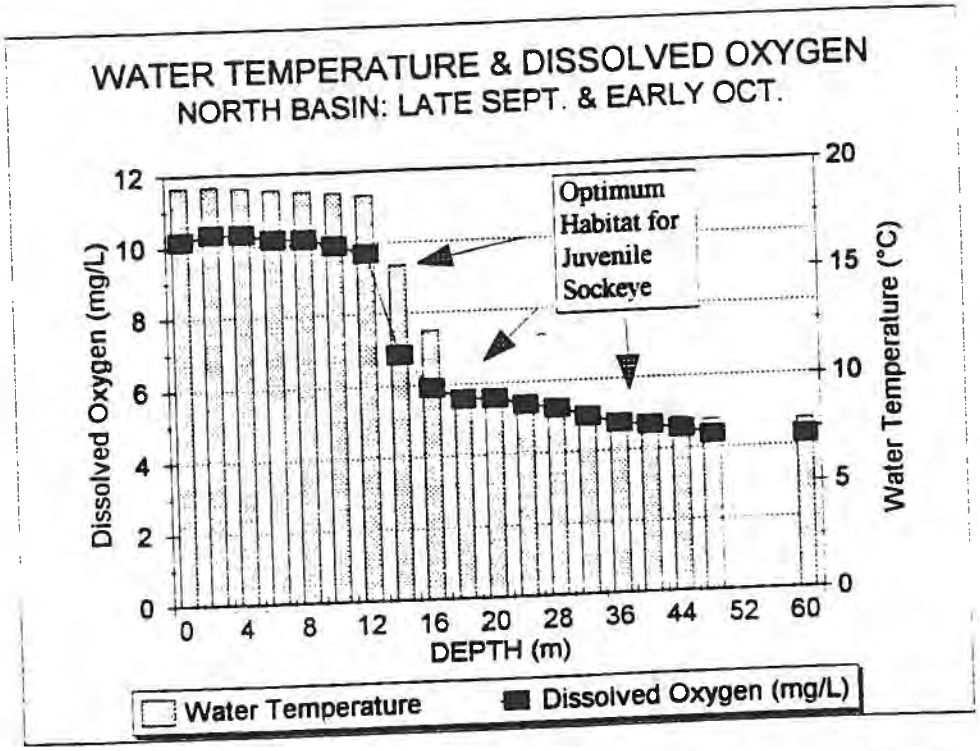


Figure 11. Vertical profiles of mean water temperature and mean dissolved oxygen concentrations in north basin, Lake Osoyoos, late August to early September, 1987-91. Optimum rearing habitat designation based laboratory work of Brett et al. (1969).

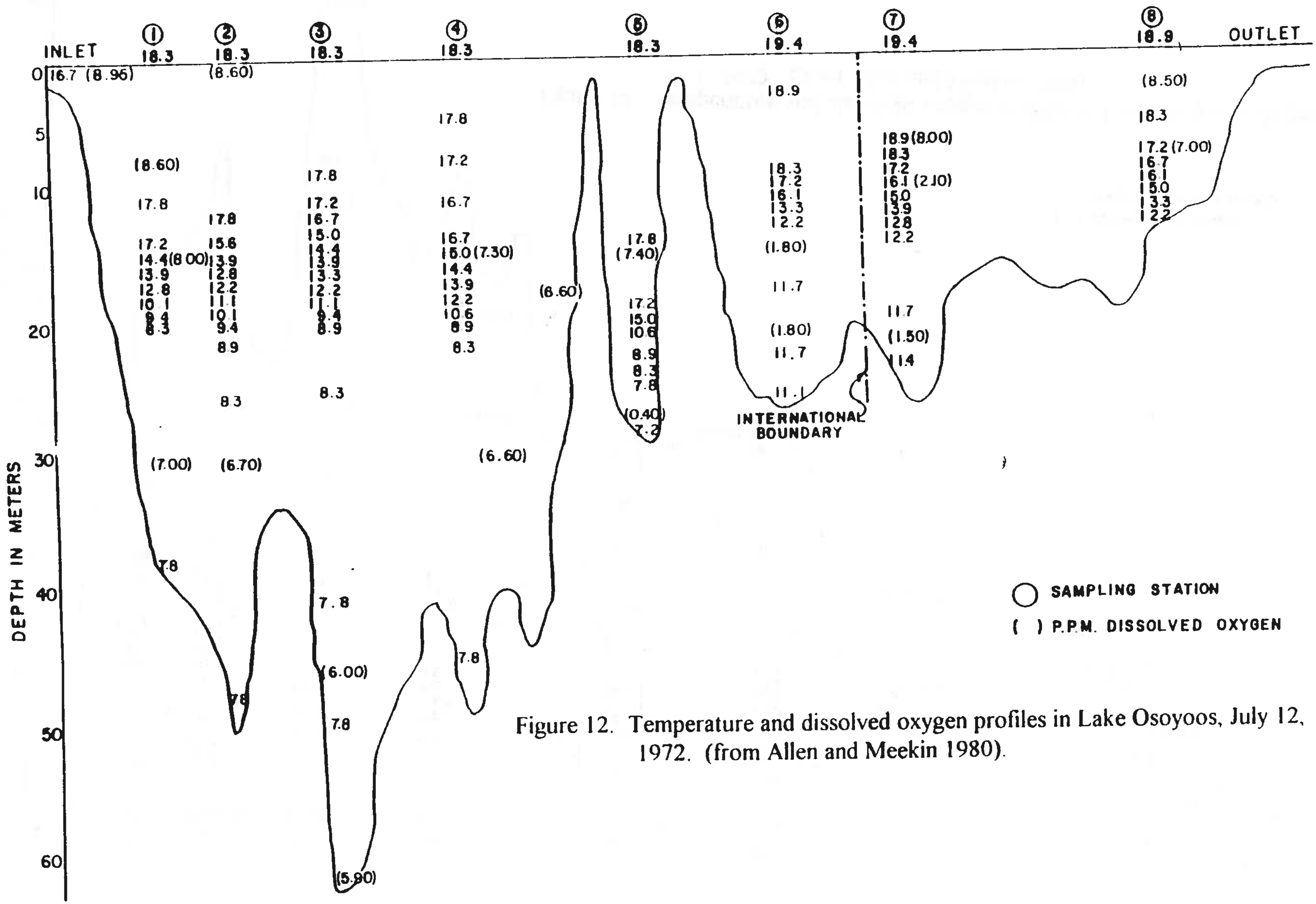


Figure 12. Temperature and dissolved oxygen profiles in Lake Osoyoos, July 12, 1972. (from Allen and Meekin 1980).

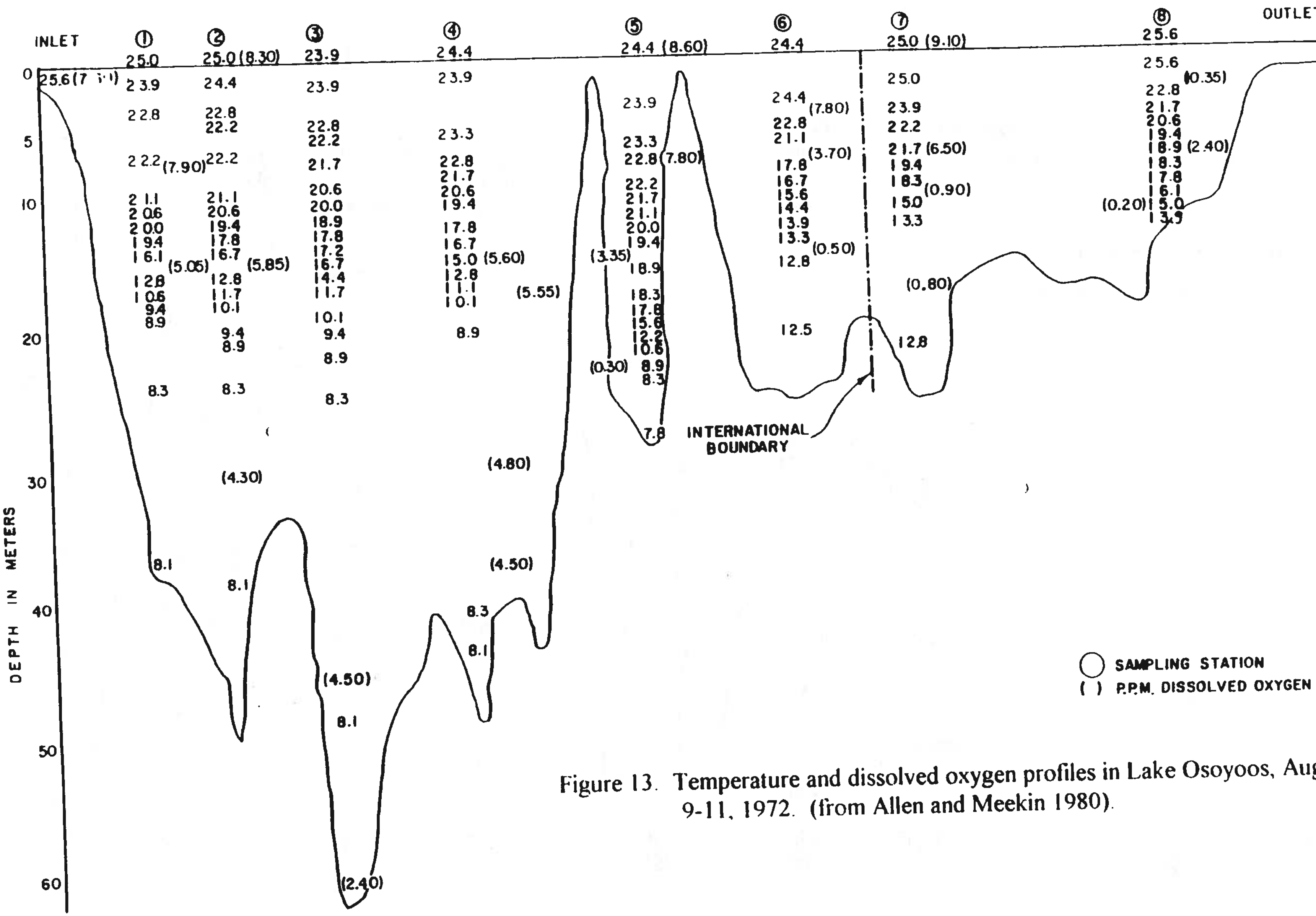


Figure 13. Temperature and dissolved oxygen profiles in Lake Osoyoos, August 9-11, 1972. (from Allen and Meekin 1980).

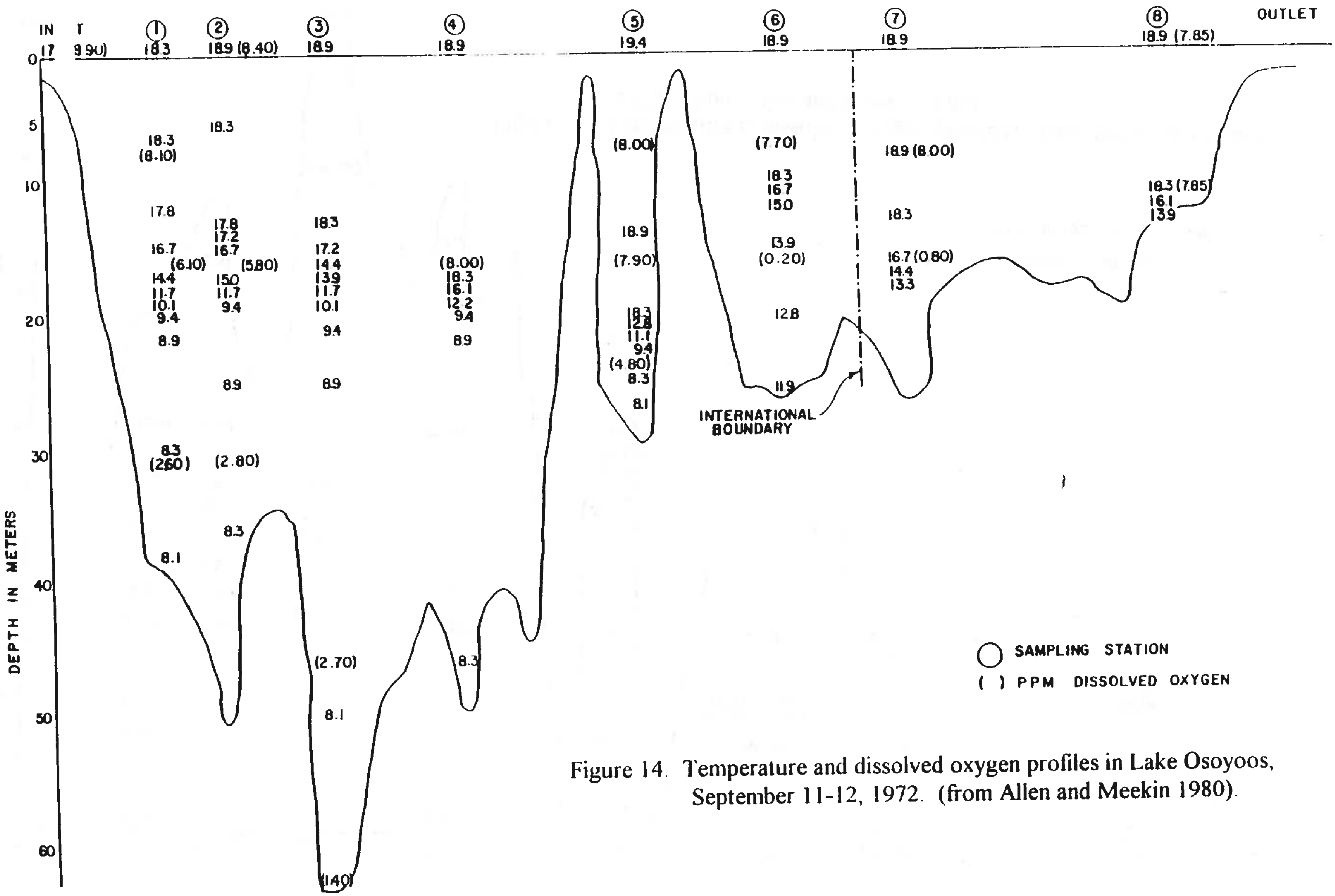


Figure 14. Temperature and dissolved oxygen profiles in Lake Osoyoos, September 11-12, 1972. (from Allen and Meekin 1980).

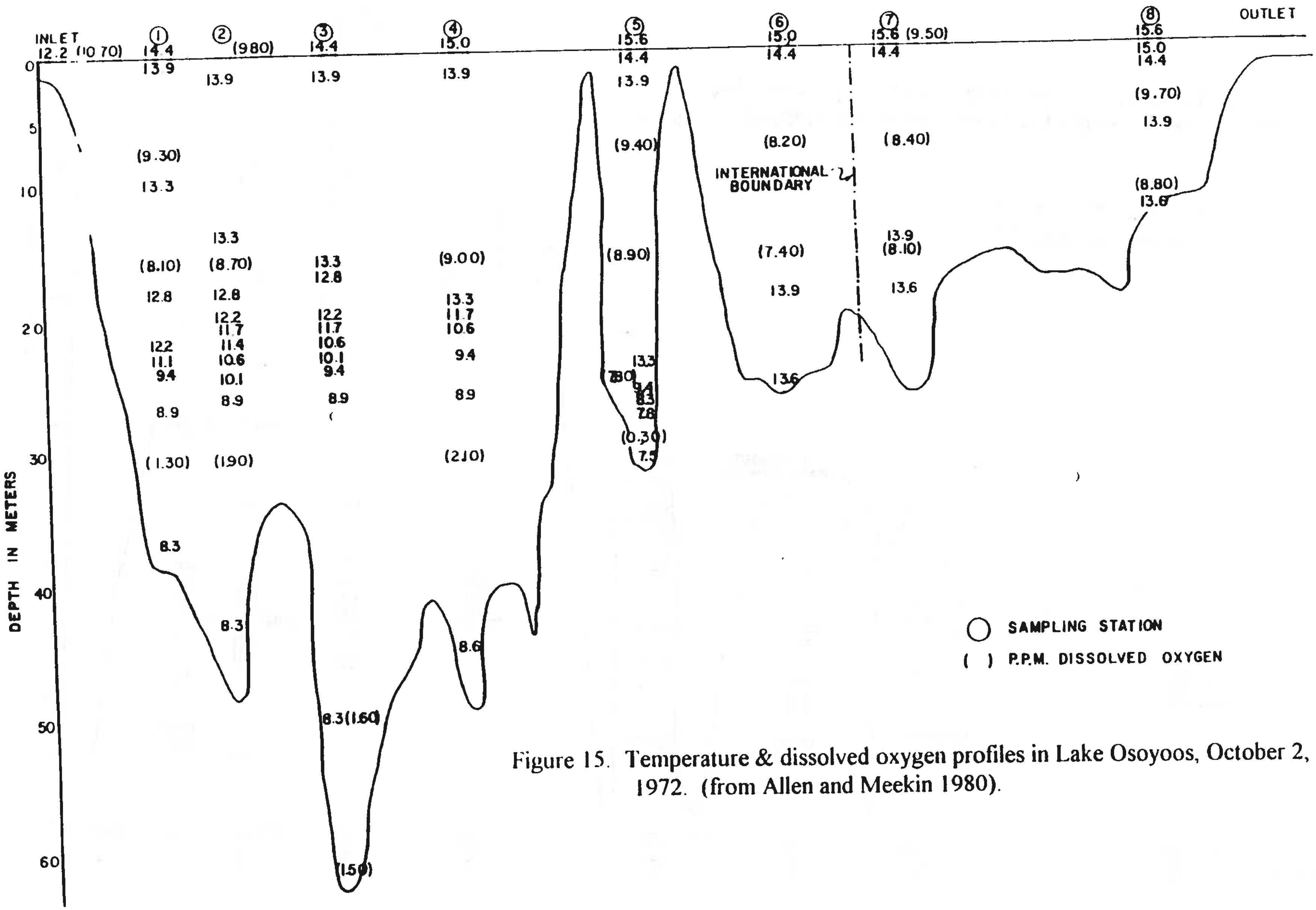


Figure 15. Temperature & dissolved oxygen profiles in Lake Osoyoos, October 2, 1972. (from Allen and Meekin 1980).

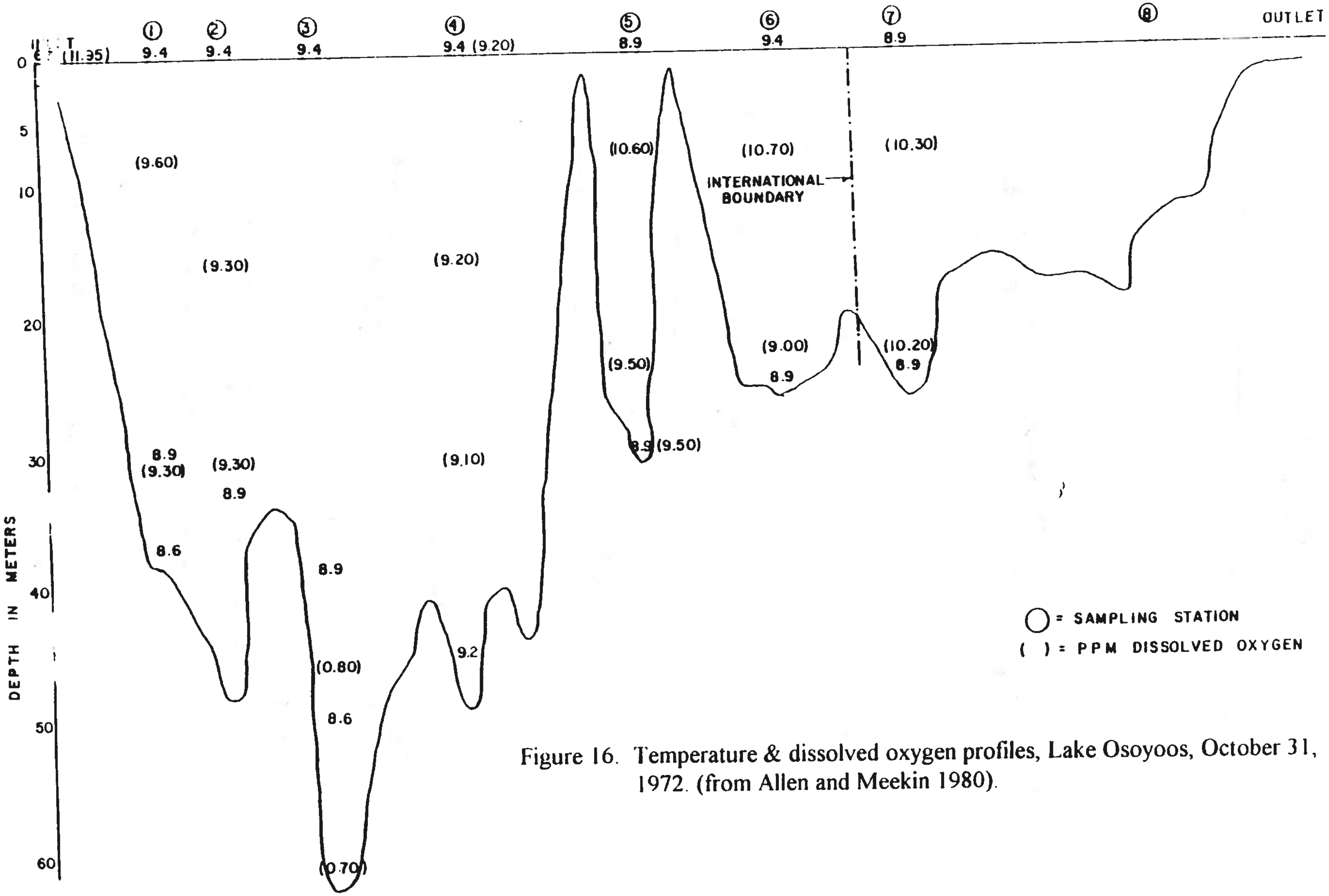


Figure 16. Temperature & dissolved oxygen profiles, Lake Osoyoos, October 31, 1972. (from Allen and Meekin 1980).

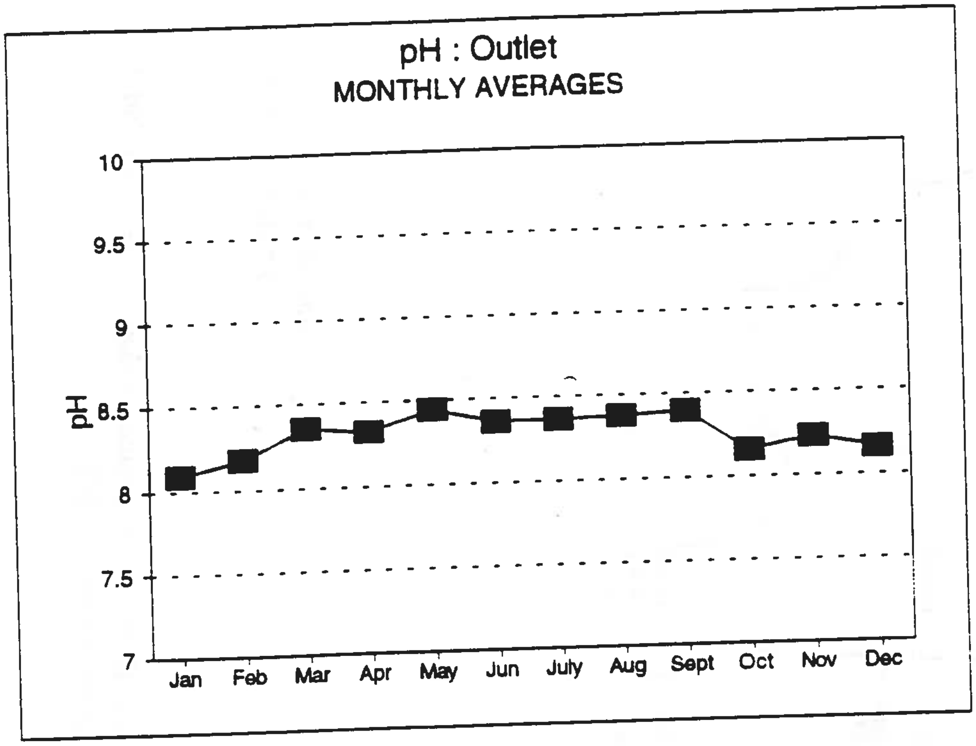


Figure 17. Mean monthly pH at Lake Osoyoos Outlet, 1961-65 and 1974-1991.

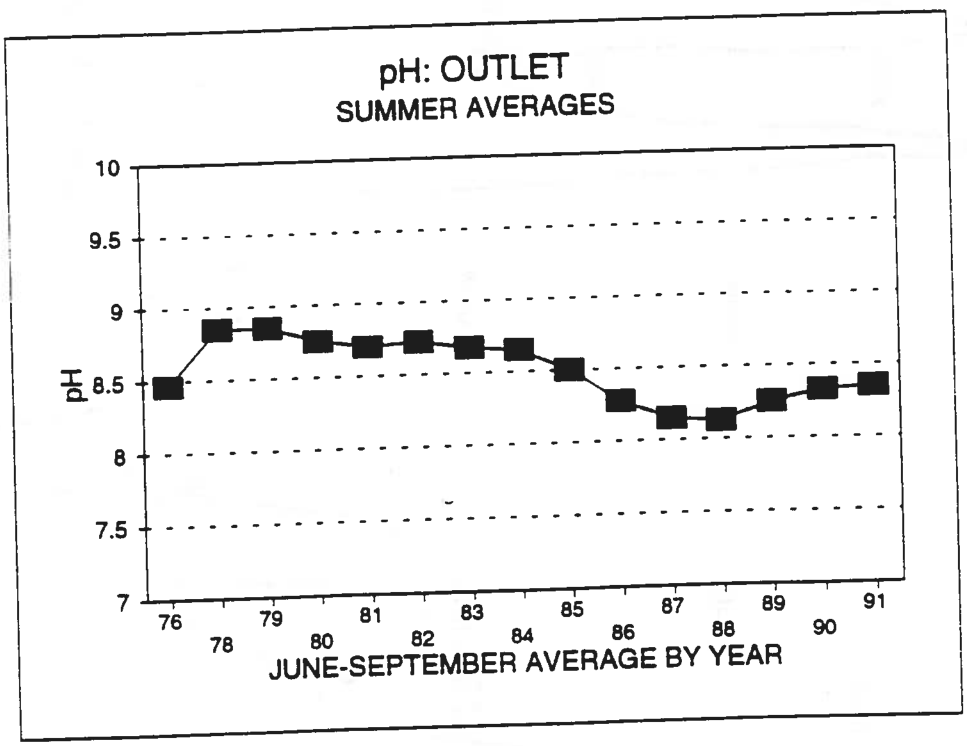


Figure 18. Mean June-September pH at Lake Osoyoos outlet, 1976-1991.

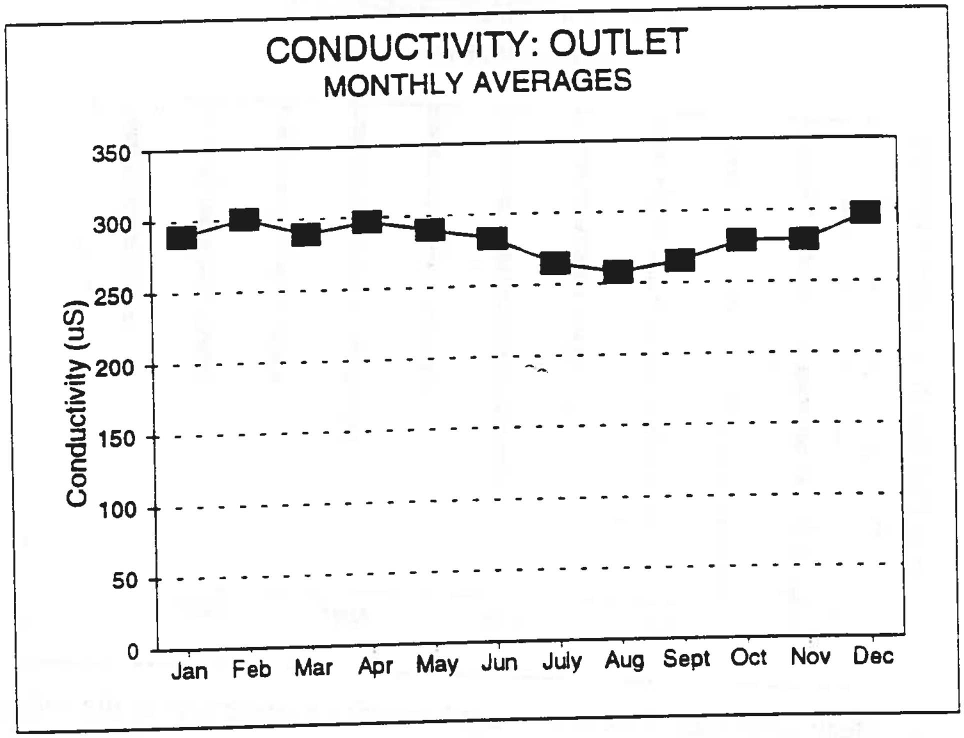


Figure 19. Mean monthly specific conductivity at Lake Osoyoos outlet, 1961-65 and 1975-91.

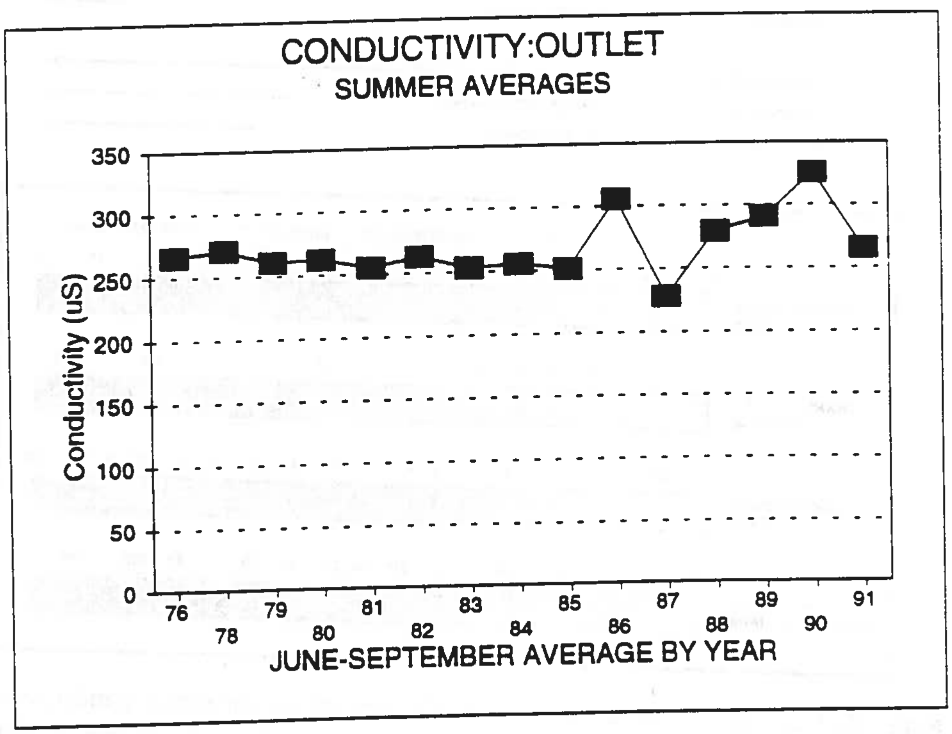


Figure 20. Mean June-September conductivity at Lake Osoyoos outlet, 1975-91.

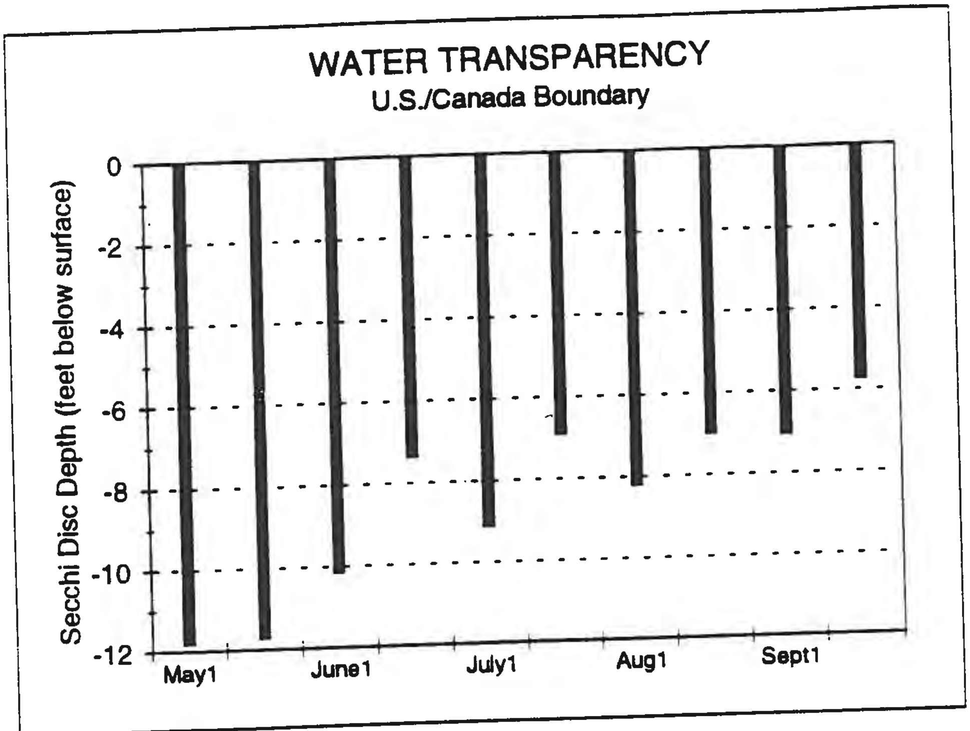


Figure 21. Mean bimonthly Secchi disc depth (water transparency) in the south basin of Lake Osoyoos near the international boundary, 1989-1992.

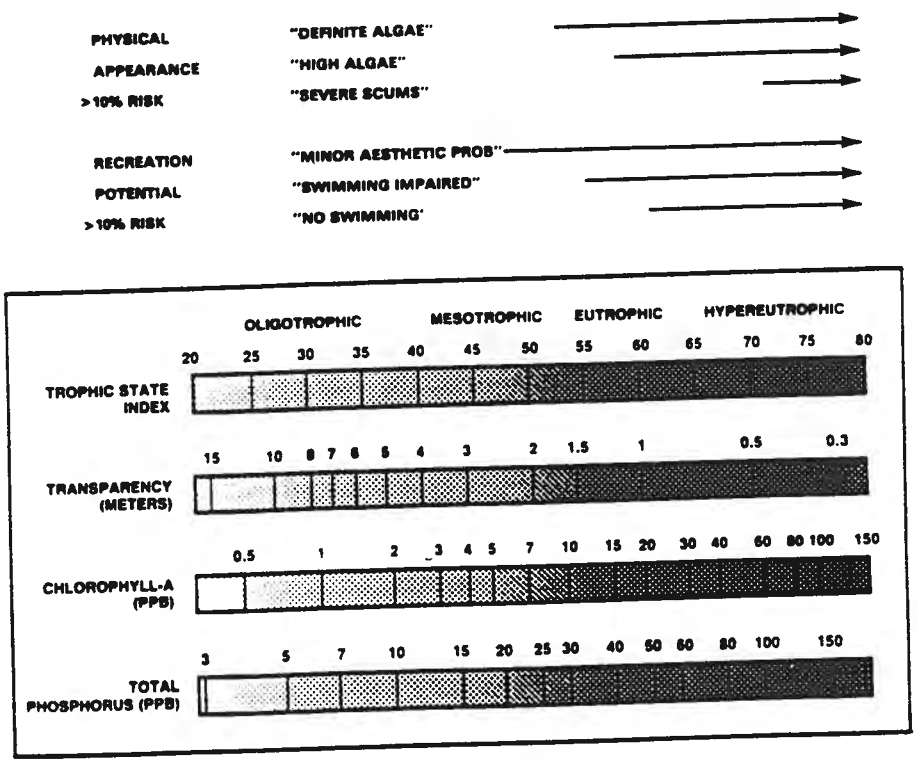


Figure 22. Carlson's trophic index related to perceived nuisance conditions. Length of arrows indicate range over which a greater than 10 percent probability exists that users will perceive a problem. From EPA 1990.

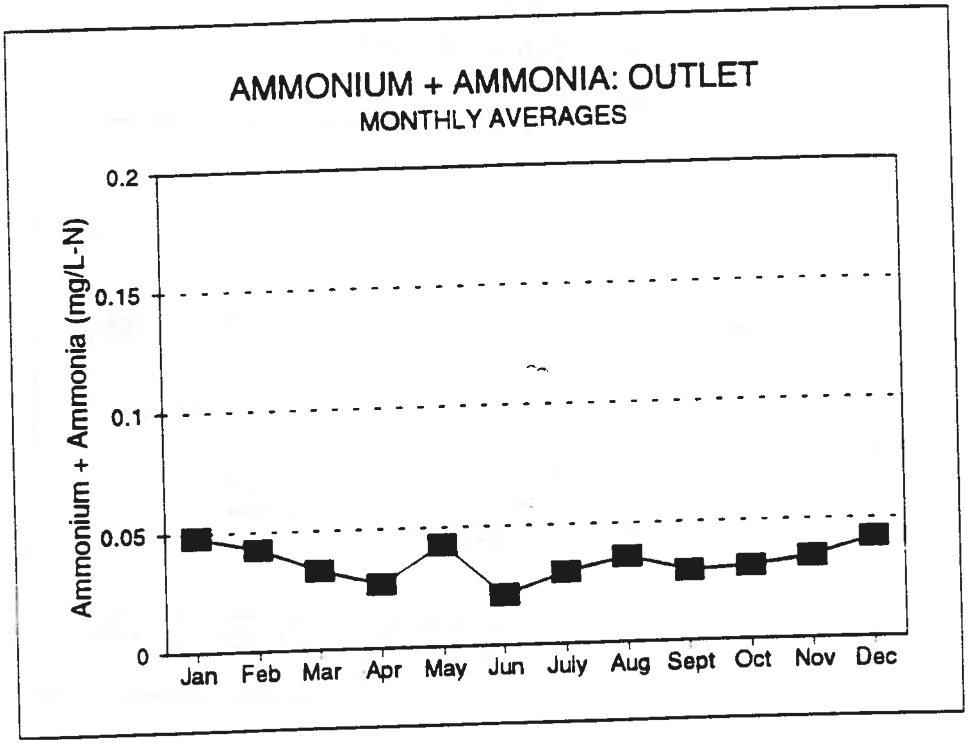


Figure 23. Mean monthly ammonium and ammonia at Lake Osoyoos Outlet, 1976-1991.

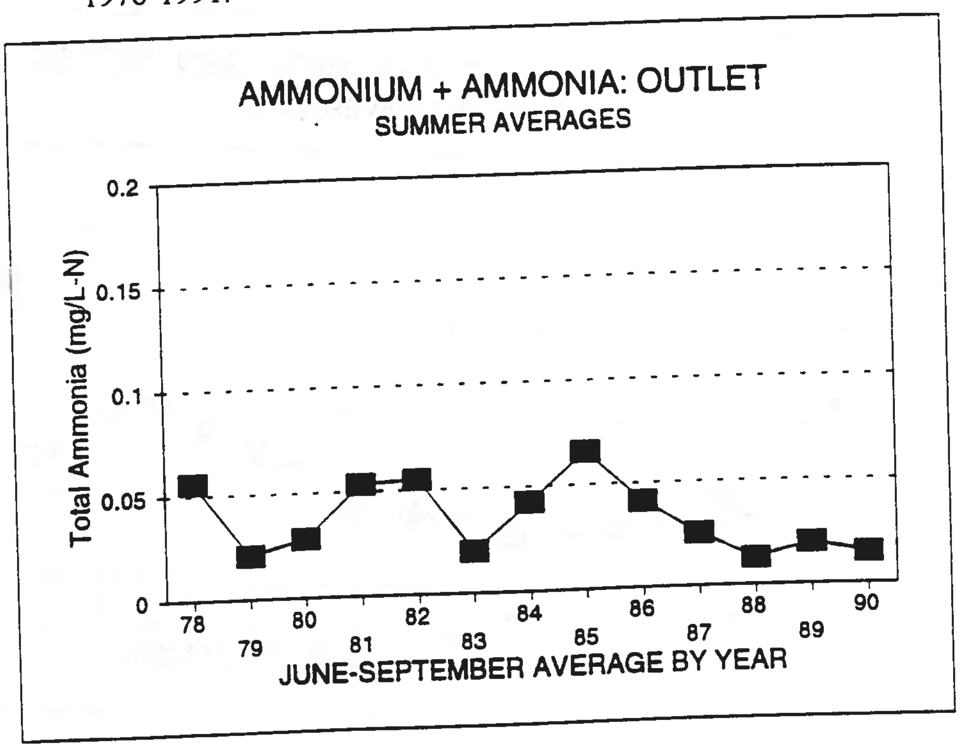


Figure 24. Mean June-September ammonium + ammonia at Lake Osoyoos outlet, 1978-1990.

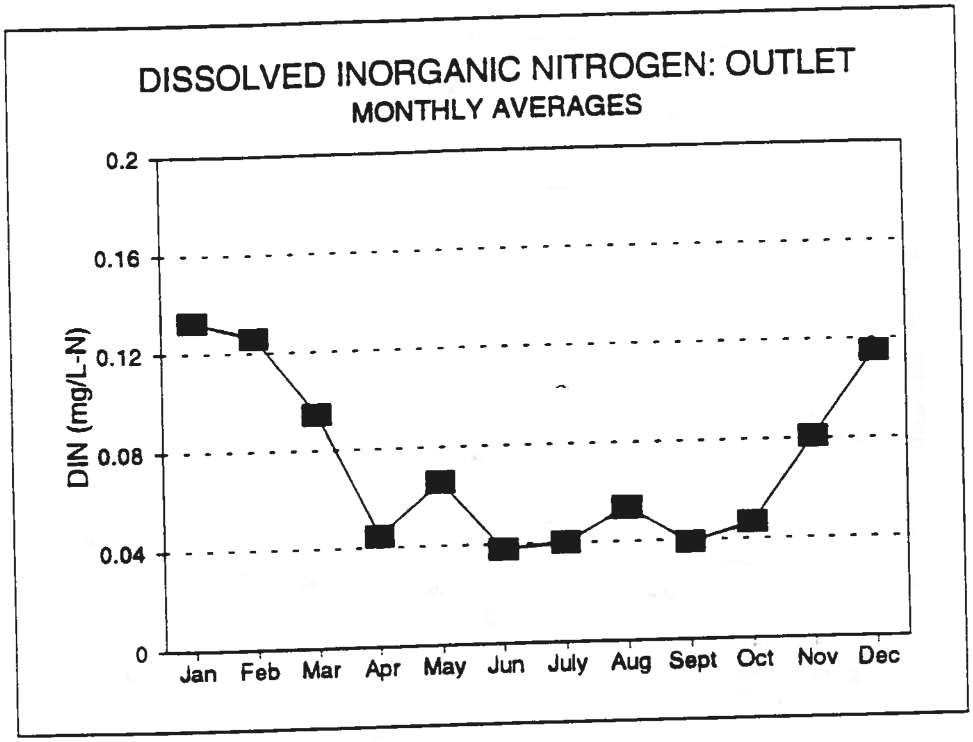


Figure 25. Mean monthly dissolved inorganic nitrogen at Lake Osoyoos outlet, 1978-1991.

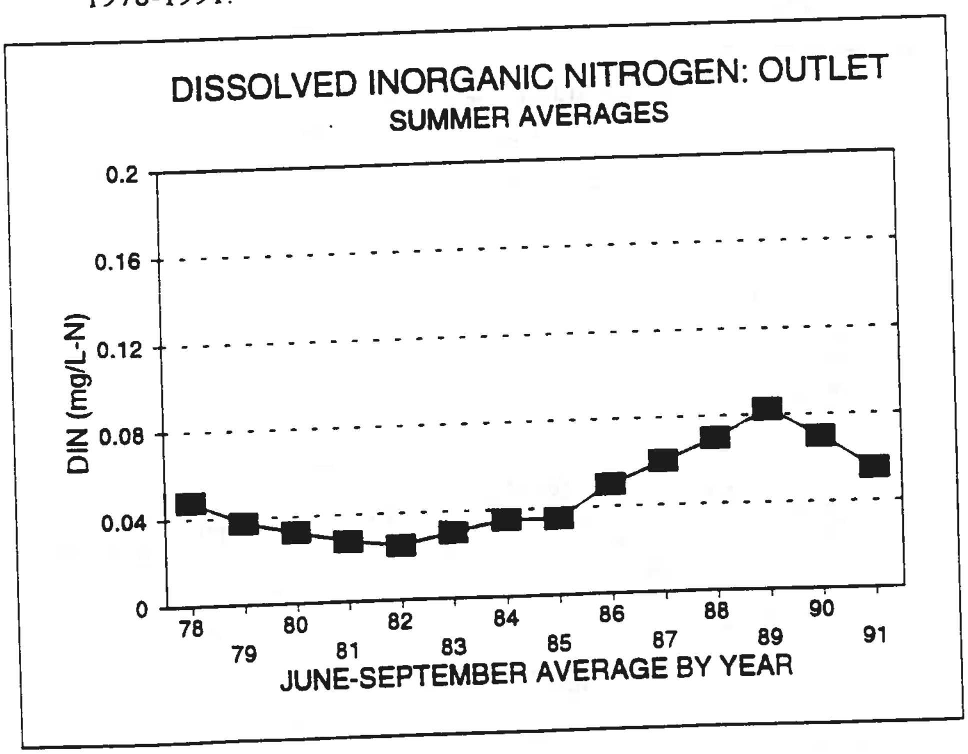


Figure 26. Mean June-September dissolved inorganic nitrogen at Lake Osoyoos Outlet, 1978-1991.

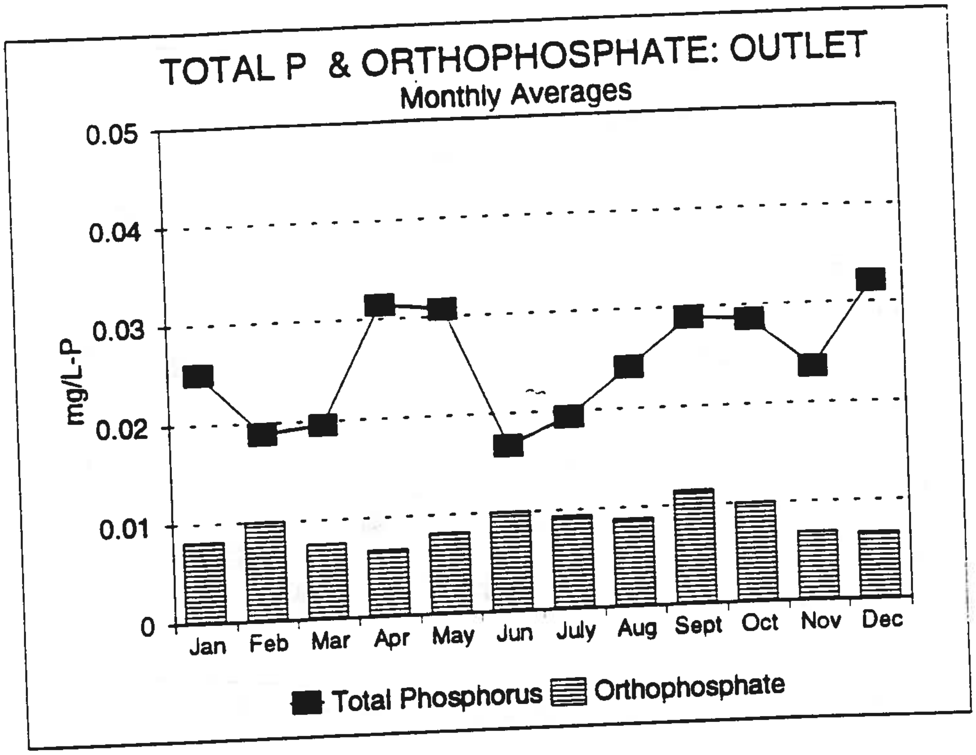


Figure 27. Mean monthly total phophorus and orthophosphate at Lake Osoyoos outlet 1976-1991.

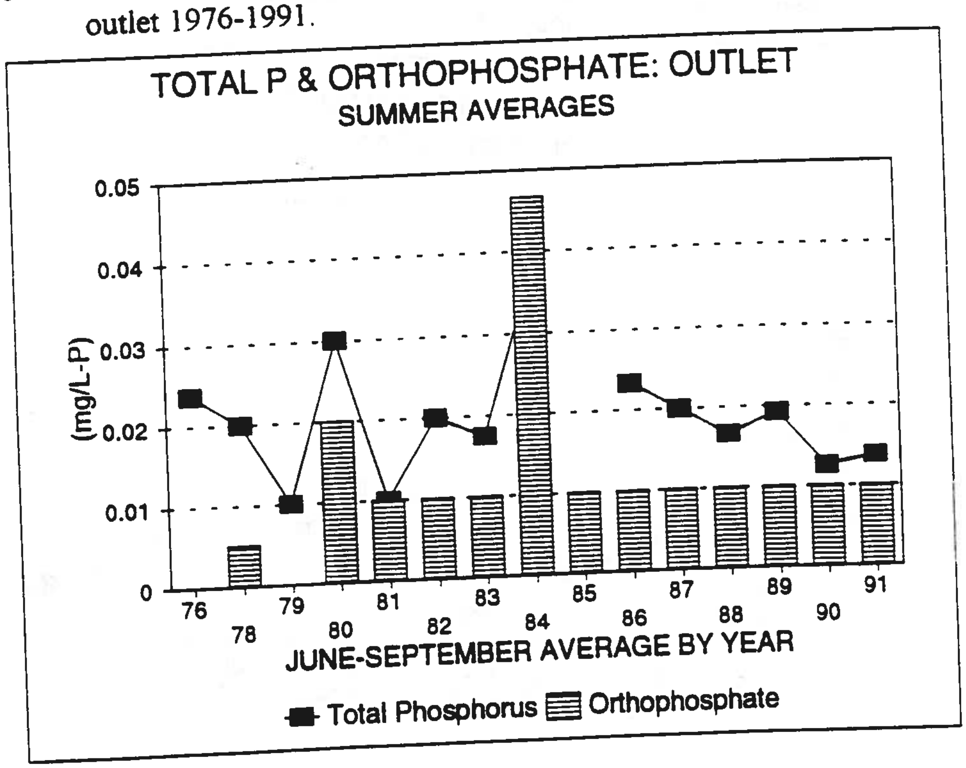


Figure 28. Mean June-September total phosphorus and orthophosphate at Lake Osoyoos outlet, 1976-1991. See text about orthophosphate data problems.

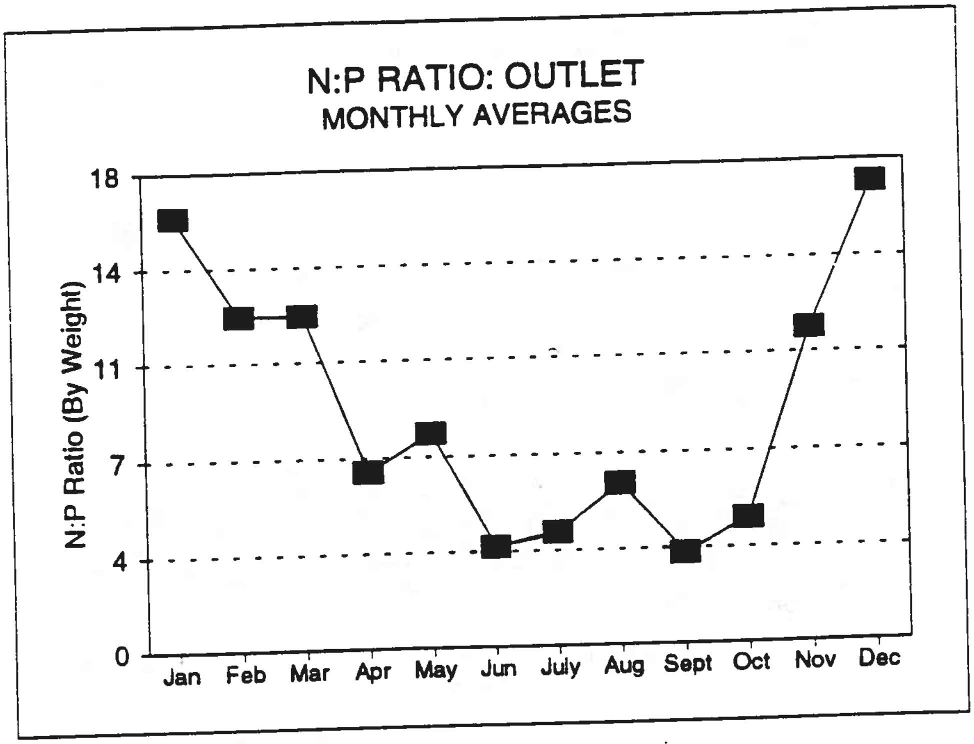


Figure 29. Mean monthly (dissolved) nitrogen to phosphorus ratio at Lake Osoyoos outlet, 1980-1991.

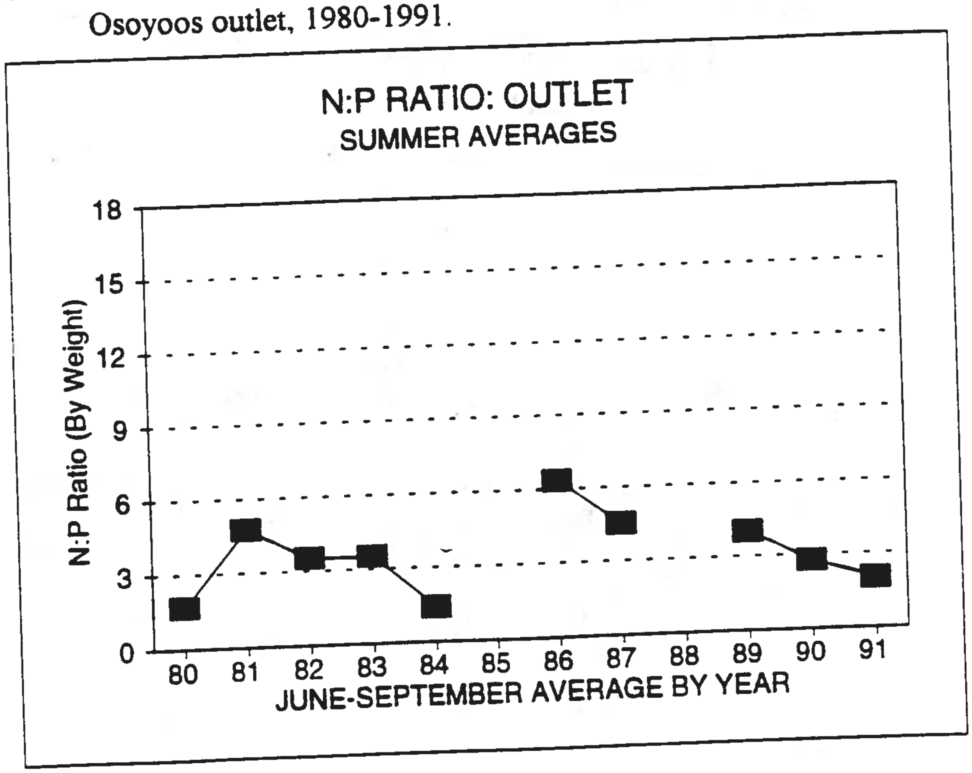


Figure 30. Mean June-Sep tember nitrogen to phosphorus ratio at Lake Osoyoos outlet, 1980-1991.

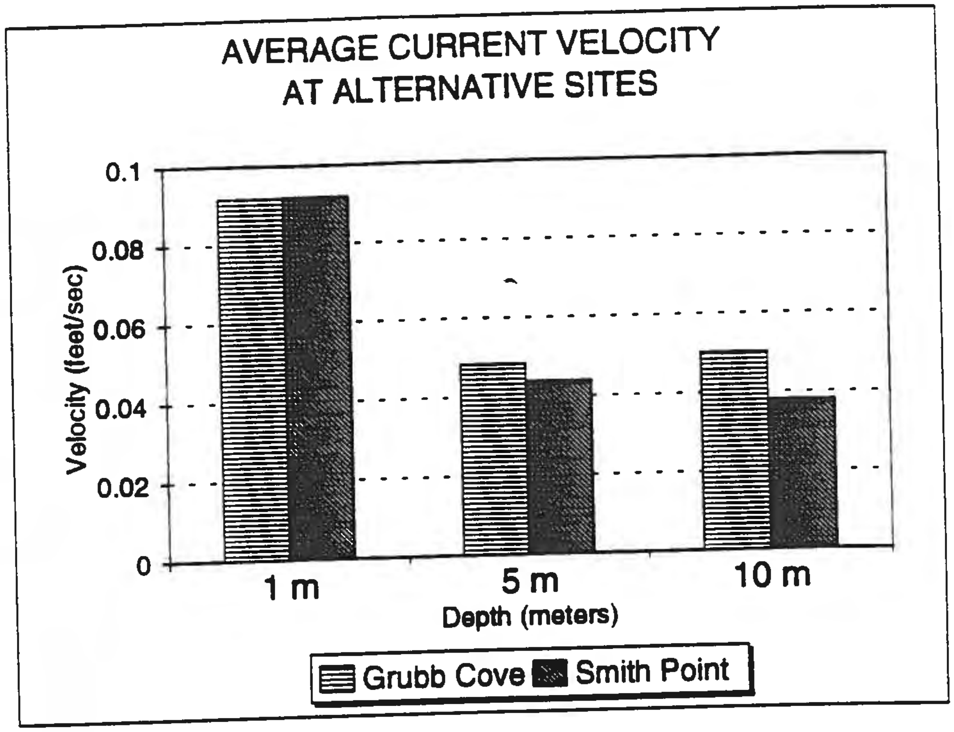


Figure 31. Average current velocity at 3 depths for two alternative net-pen sites in the south basin of Lake Osoyoos.

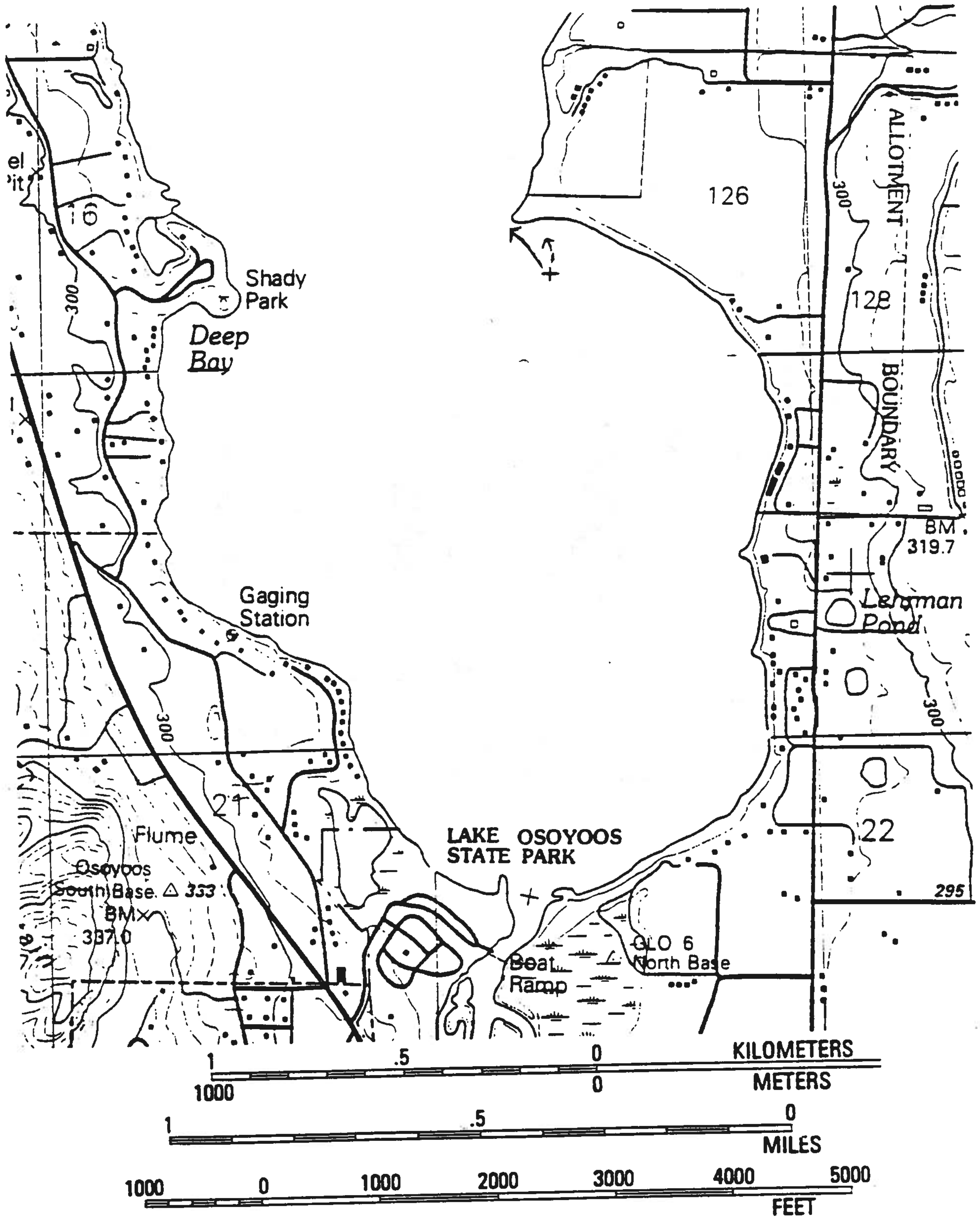


Figure 32. Plot of drogue paths from Smith Cove site, released at 1130 hours on 10/21/92. Dashed line represents shallow drogue, solid line indicates deep drogue. Wind 3 MPH from south.

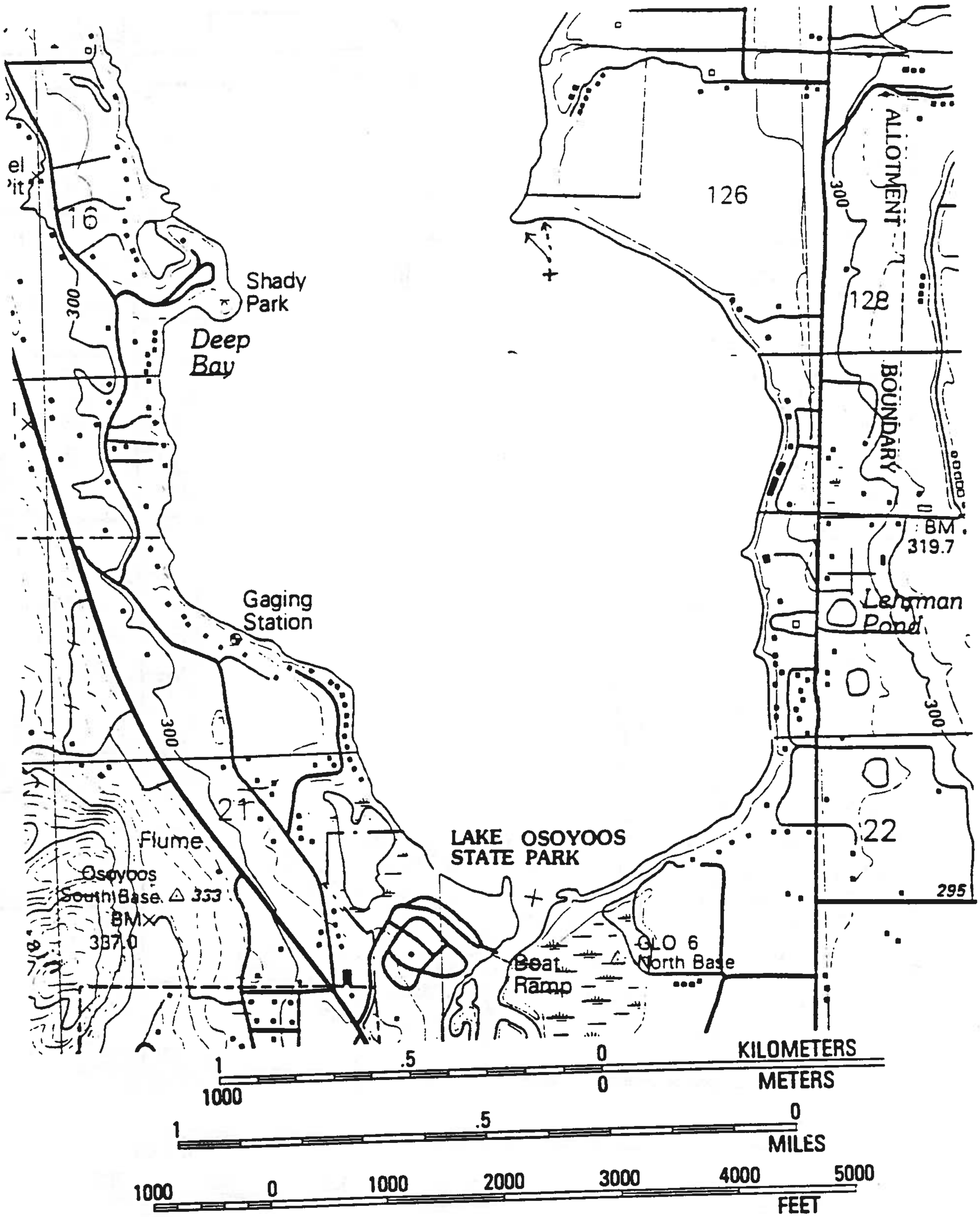


Figure 33. Plot of drogue paths from Smith Cove site, released at 1245 hours on 10/21/92. Dashed line represents shallow drogue, solid line indicates deep drogue. Wind 5 MPH from south.

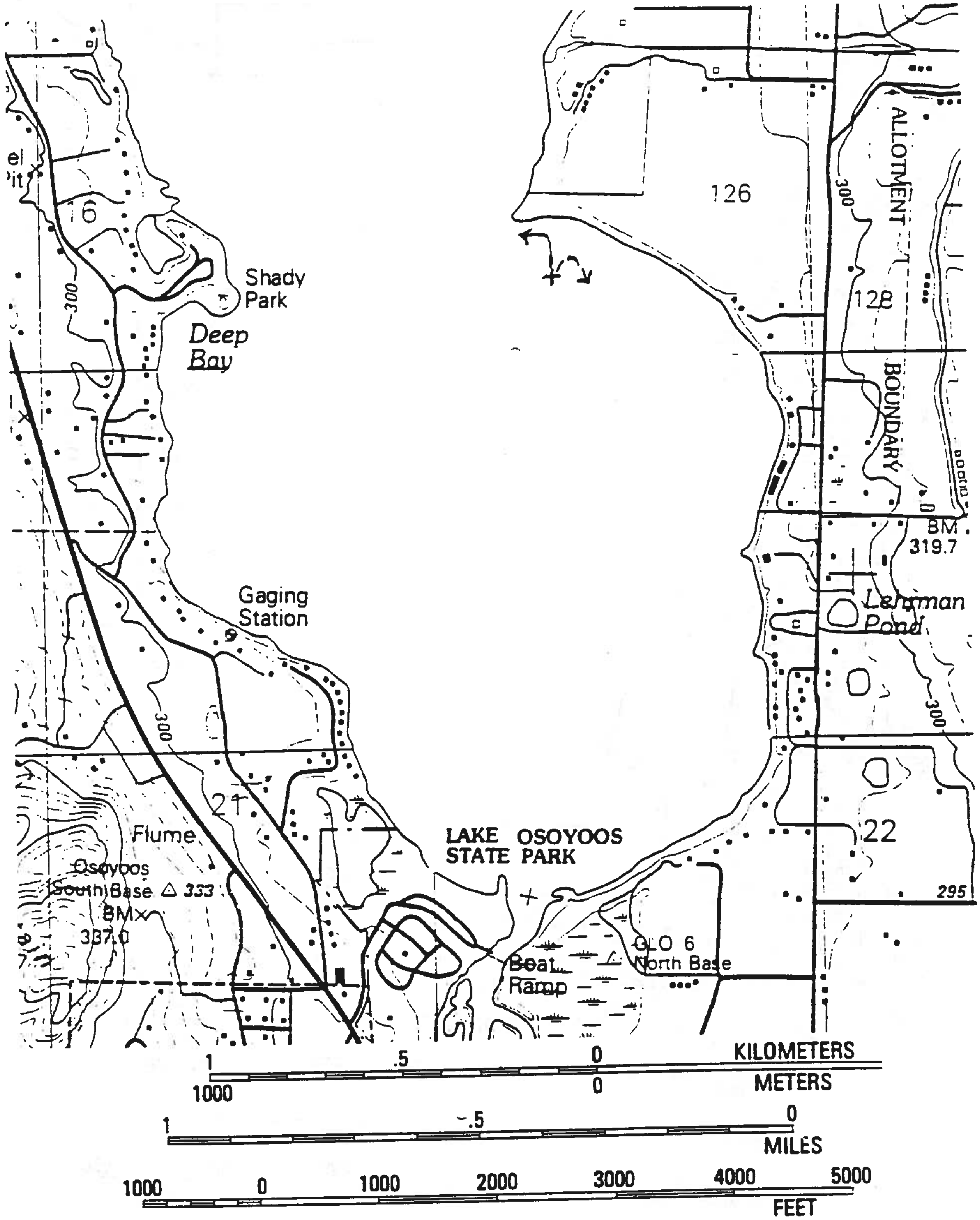


Figure 34. Plot of drogue paths from Smith Cove site, released at 1440 hours on 10/21/92. Dashed line represents shallow drogue, solid line indicates deep drogue. No wind.

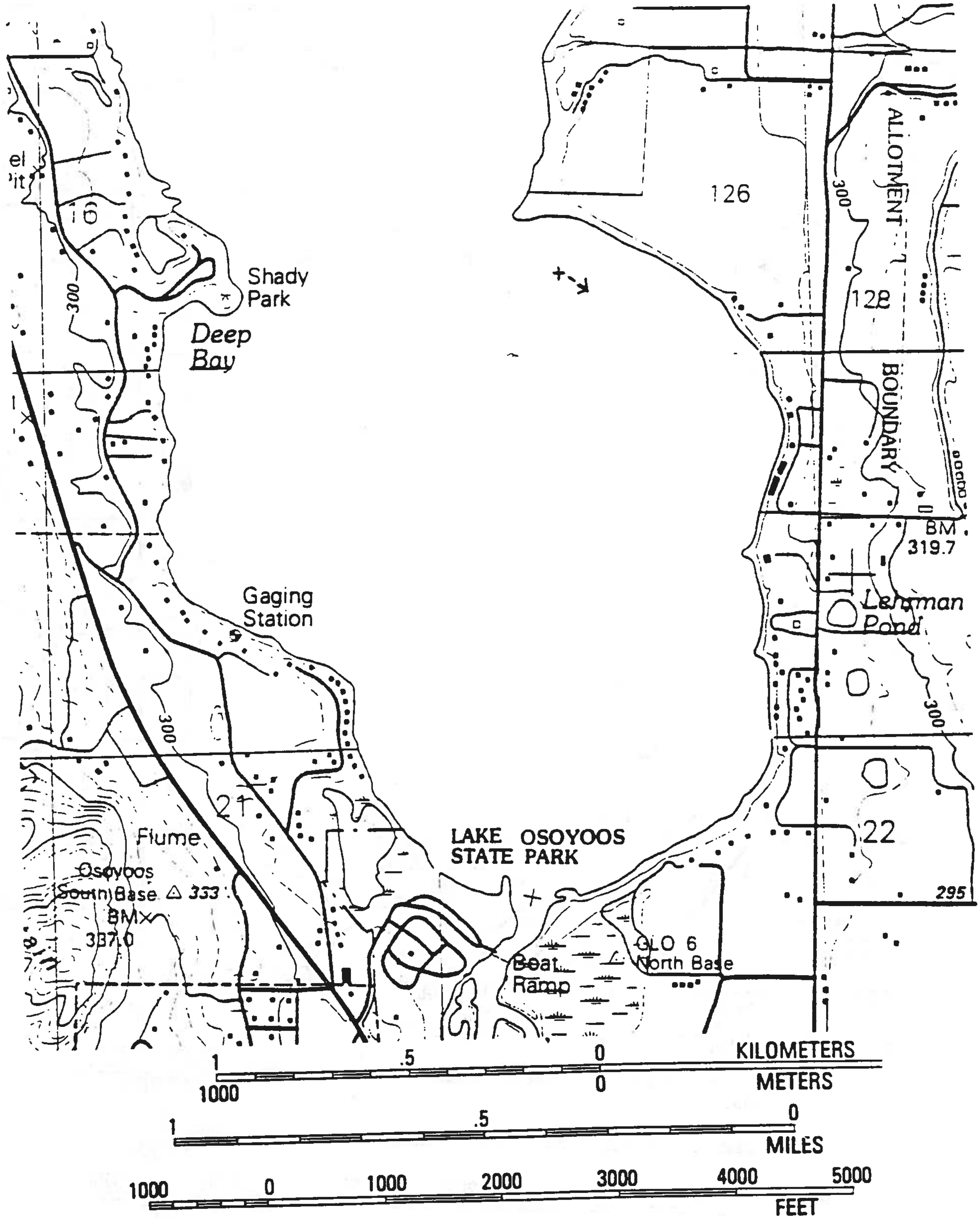


Figure 35. Plot of drogue paths from Smith Cove site, released at 1534 hours on 10/21/92. Dashed line represents shallow drogue, solid line indicates deep drogue. Wind calm to 4-5 MPH from south.

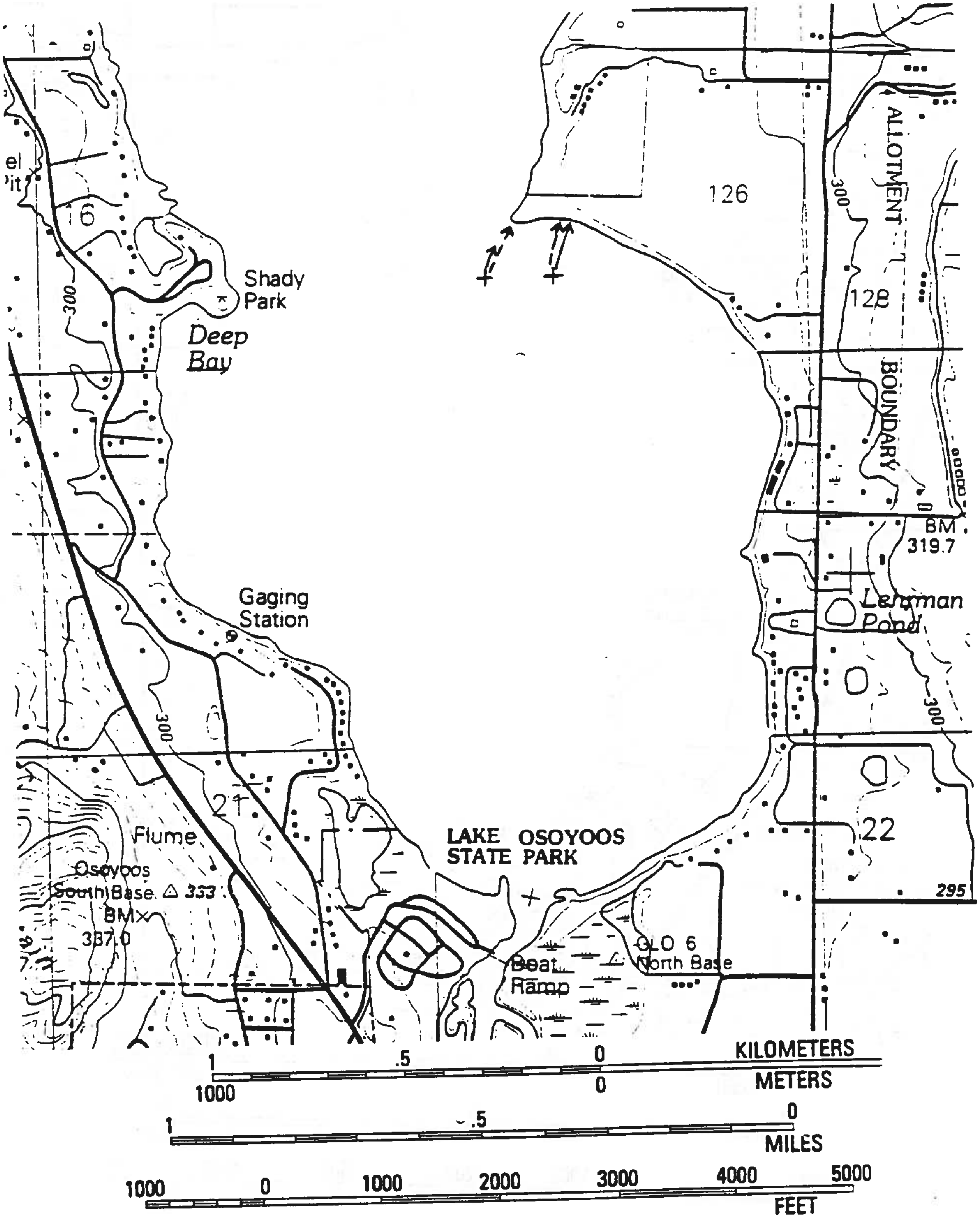


Figure 36. Plot of drogue paths from Smith Cove site, released at 0855 hours on 10/22/92. Dashed line represents shallow drogue, solid line indicates deep drogue. Wind was 5 MPH from south.

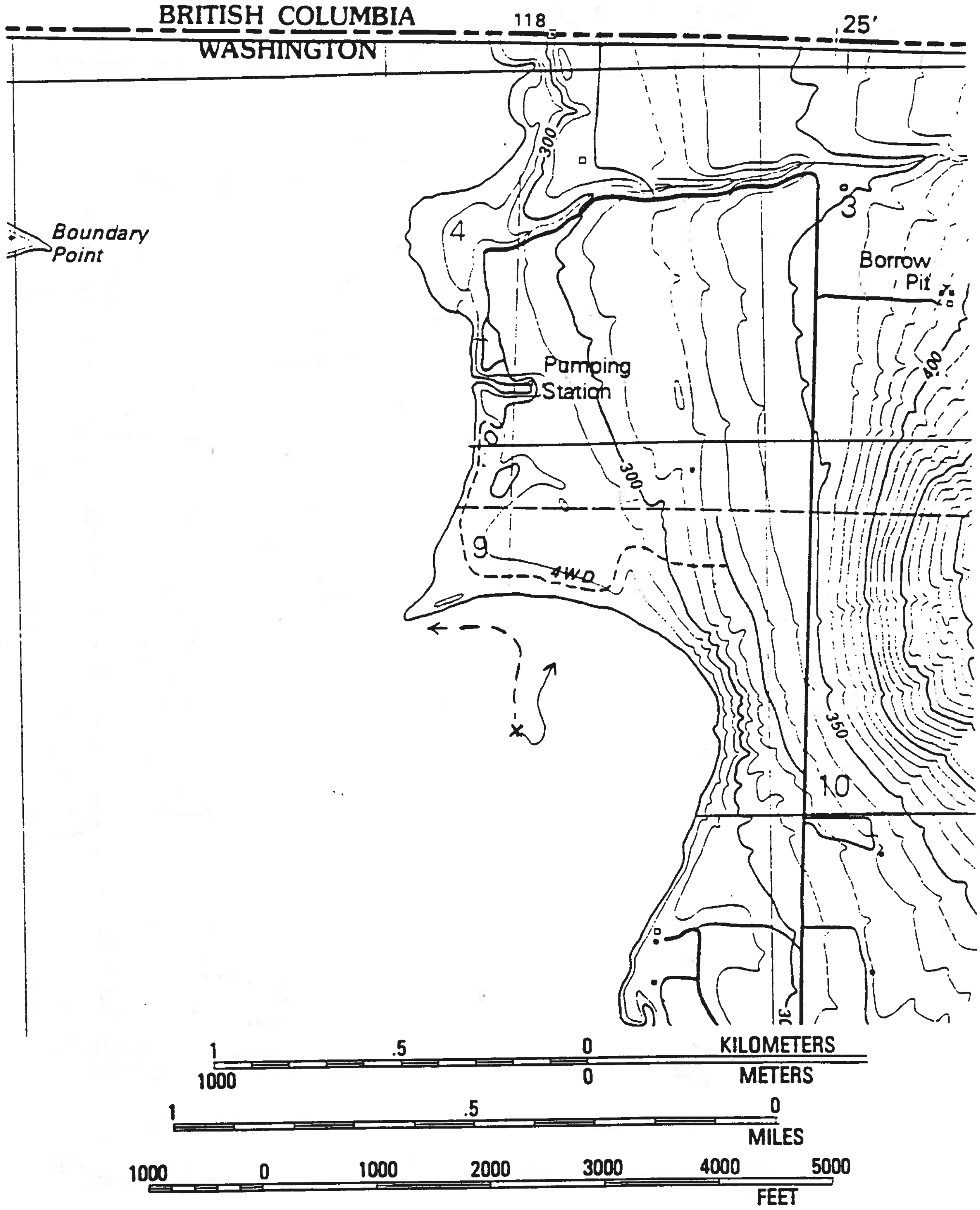


Figure 37. Plot of drogue paths from Grubb Cove site, released at 1100 hours on 10/21/92. Dashed line represents shallow drogue, solid line indicates deep drogue. Wind was 0-5 MPH from south.

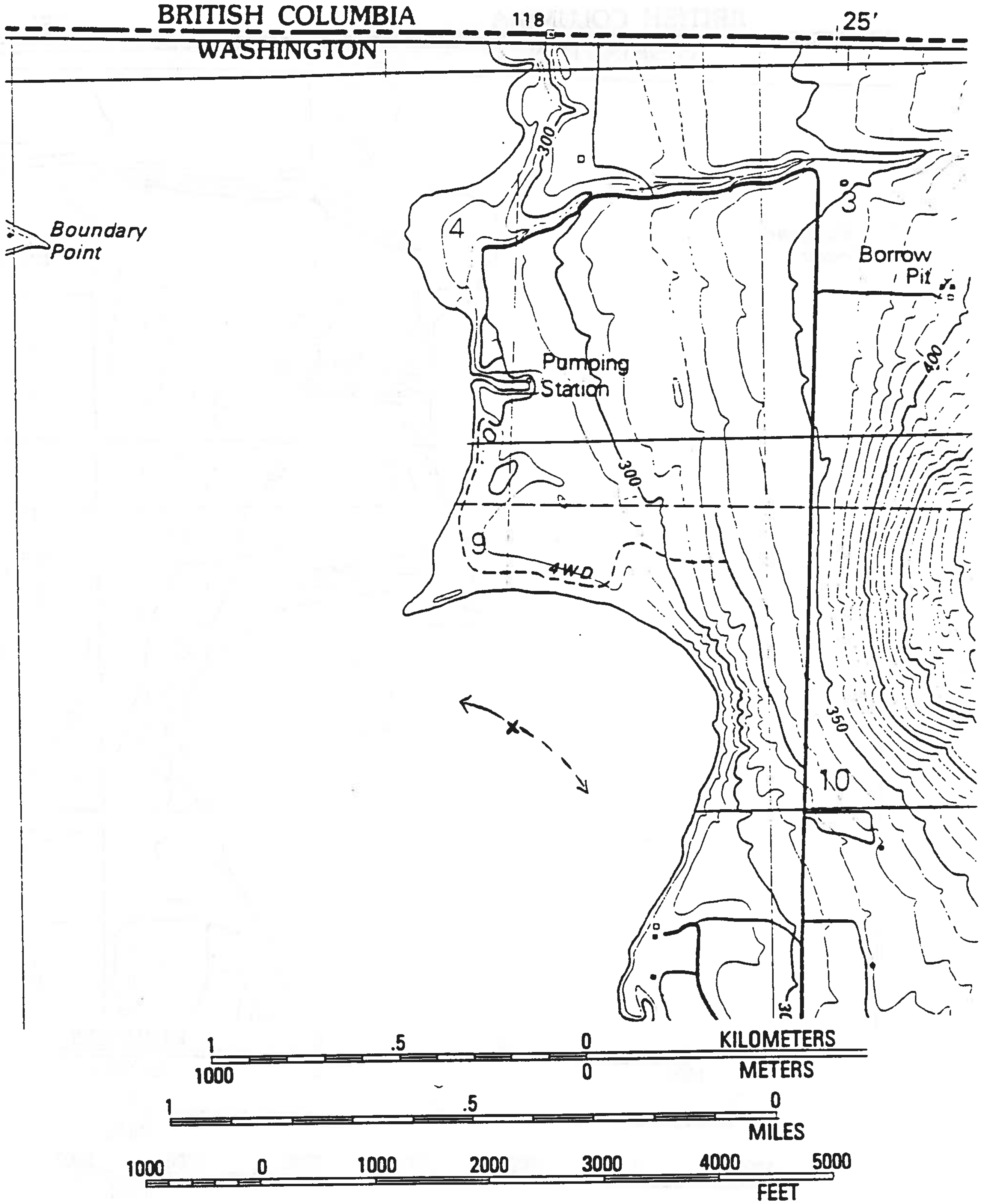


Figure 38. Plot of drogue paths from Grubb Cove site, released at 1428 hours on 10/21/92. Dashed line represents shallow drogue, solid line indicates deep drogue. No wind.

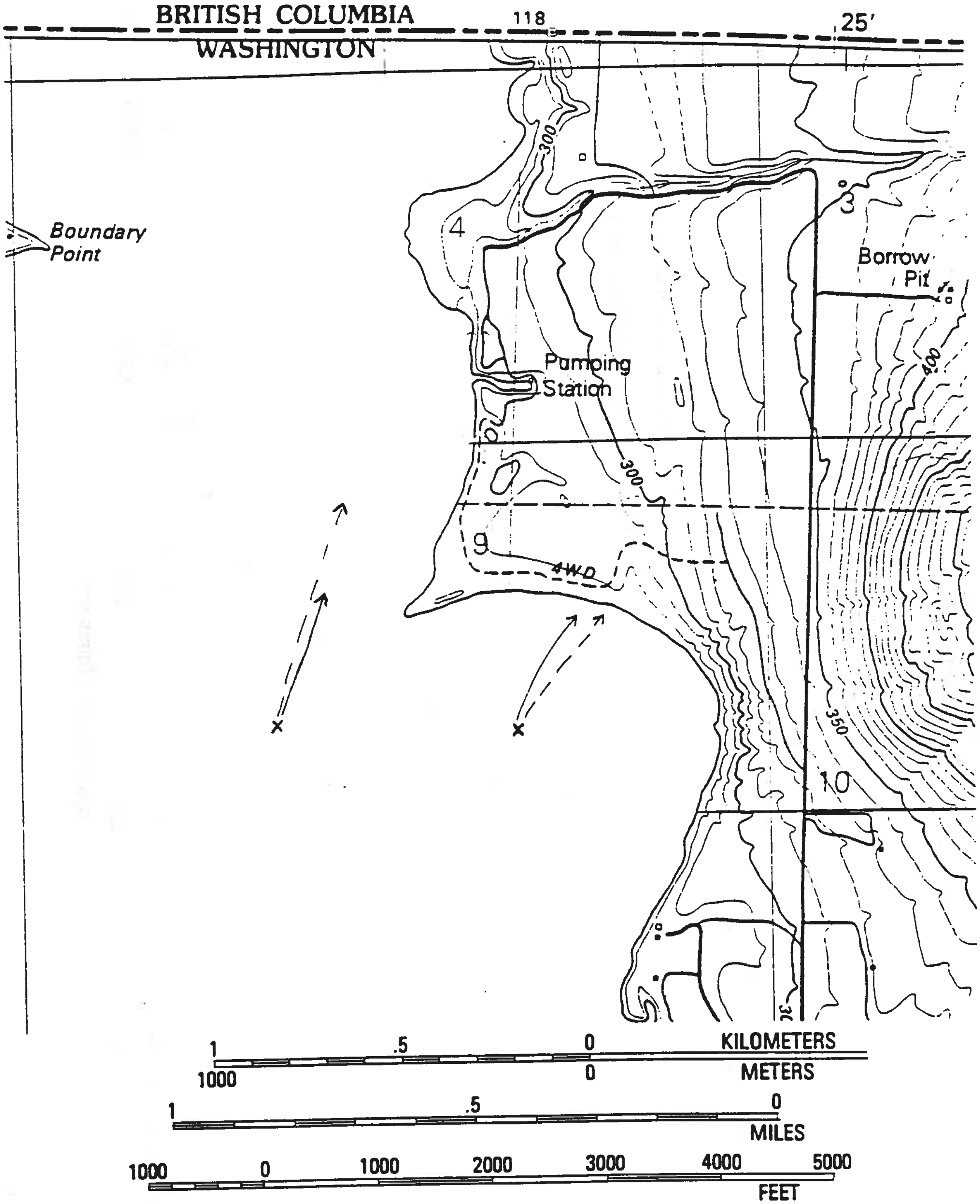


Figure 39. Plot of drogue paths from Grubb Cove site, released at 0900 hours on 10/22/92. Dashed line represents shallow drogue, solid line indicates deep drogue.

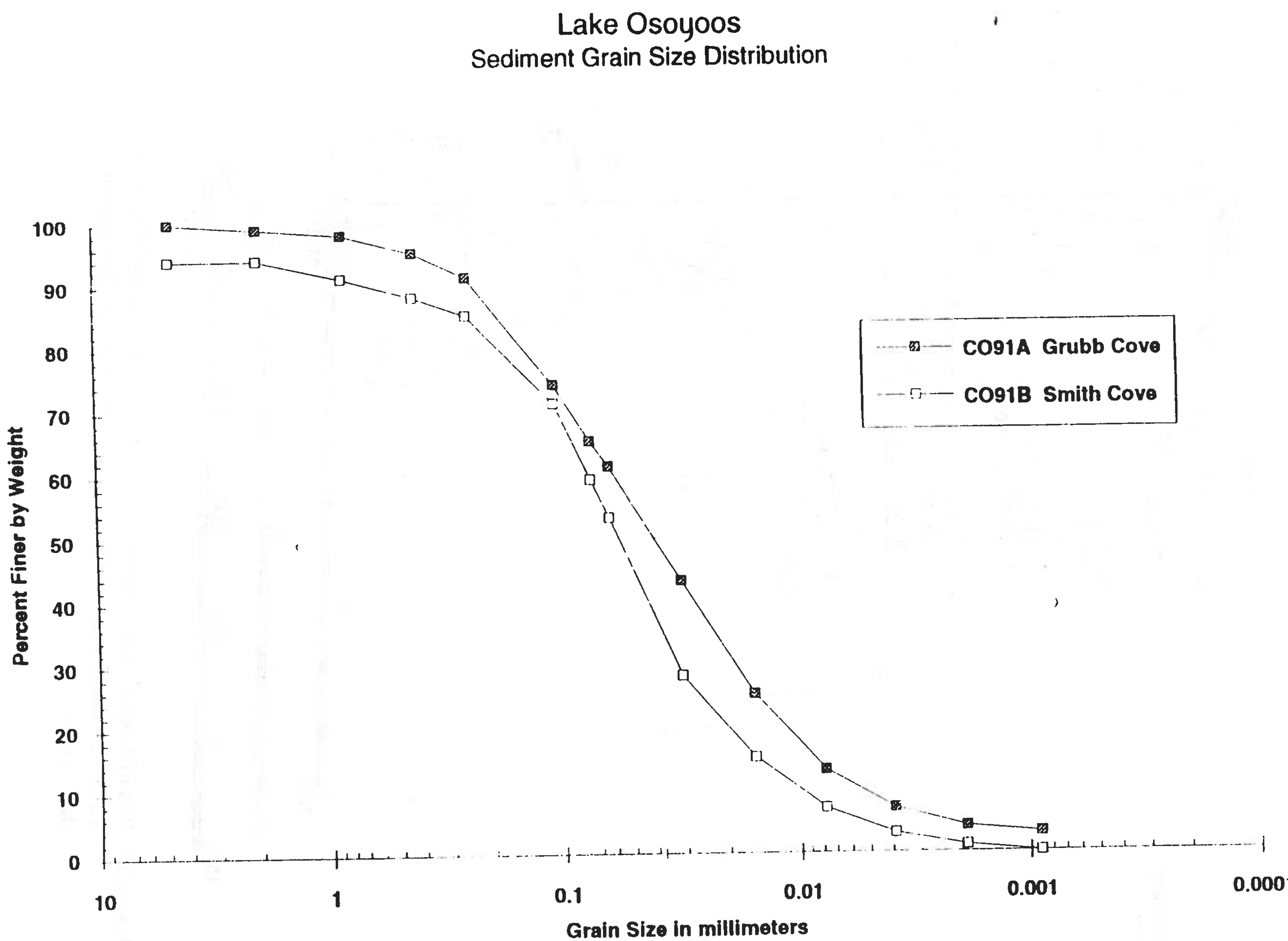


Figure 40. Sediment grain size distribution (graphic) from alternative net-pen sites in the south basin of Lake Osoyoos in October 1992.

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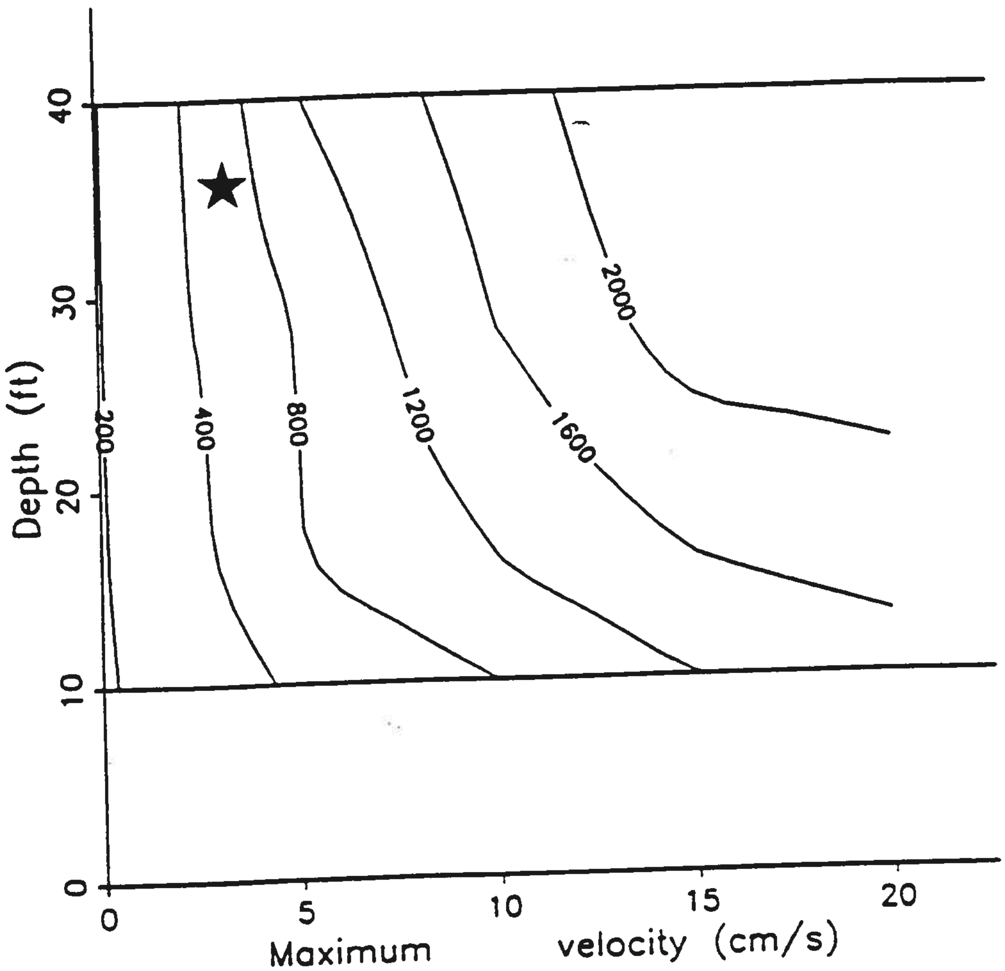


Figure 41. Maximum allowable fish density (fish/m$^2$) for net-pens used 120 days/yr with star representing the proposed project in Lake Osoyoos (adapted from *Recommended Guidelines*, Parametrix 1990).

Note that the proposed project will be utilized for less than 60 days/yr, the fish will be much smaller at release (20g) than this figure was designed to accommodate (45g), and I used average current velocity, not maximum velocity. All of these factors provide a wide margin of safety to protect the benthic environment.

**WELLS HYDROELECTRIC PROJECT**

**JUVENILE BYPASS SYSTEM OPERATIONS PLAN**

**FOR THE 1994 BYPASS SEASON**

**APPENDIX - E**

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 1994 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 1994 above Wells Dam are as follows:

| Facility | Species | No. (thos.) | Dates |
|---|---|---|---|
| Winthrop (USFWS) | Spr. Chinook | 920 | 4/15 |
| Methow (WDF) | Spr. Chinook | 77 | 4/15 |
| Carlton (WDF) | Sum. Chinook | 400 | 4/15 |
| Similikameen (WDF) | Sum. Chinook | 560 | 4/15 |
| Lake Osoyoos (CCT) | Sockeye | 200 | 5/15 |
| Wells (WDW) | Sum. steelhead | 400 | 4/20 |

Starting Dates and Ending Dates

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

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

**SPRING CHINOOK SPAWNING GROUND SURVEYS**

**OF THE METHOW RIVER BASIN**

**1993**

**APPENDIX - F**

# SPRING CHINOOK SPAWNING GROUND SURVEYS

# OF THE METHOW RIVER BASIN

# 1993

BY

THOMAS SCRIBNER

THOMAS K. MEEKIN

JOEL HUBBLE

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YAKIMA INDIAN NATION

FISHERIES RESOURCE MANAGEMENT

DECEMBER, 1993

**DRAFT REPORT**

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# 1.0 ACKNOWLEDGEMENTS

Special thanks are due to fisheries technicians Sandy Pinkham, Evans Lewis, Paul Wahpat, and Robert Cruz for their dedicated effort and conscientious performance during the spring chinook surveys. Lee Carlson provided the computer graphics. All personnel are employees of the Fisheries Resource Management Division of the Yakima Indian Nation.

Funding for the surveys was provided through the Wells Dam Agreement by the Public Utility District No. 1 of Douglas County.

# 2.0 ABSTRACT

The purpose of these surveys was to collect comprehensive data regarding timing, location, and magnitude of spring chinook (Oncorhynchus tshawytscha) spawning throughout the Methow River Basin. The baseline data developed from this study will be useful in stratgizing outplanting from the Methow Valley Spring Chinook Hatchery and associated satellite facilities that commenced operations in May, 1992.

The Methow River Basin spring chinook escapement as measured at Wells Dam was 2,444 fish of which 1,546 were available for spawning after hatchery returns and broodstock trapping.

Spring chinook surveys were conducted from July 27 through September 22. The surveys covered approximately 127 river miles and located a total of 617 redds. The Methow River had 290 redds (47.0%) and the Chewuch, Lost and Twisp Rivers had 83, 51 and 192 redds (13.5%, 8.4% and 31.1%) respectively. An additional 1 redd (0.1%) was located in Early Winters Creek. Redds were not found in Lake, Wolf and Gold creeks.

A total of 217 carcasses were examined. The male to female ratio was 1.0 to 1.7, and 92.6% of the females were spawned successfully. The fish per redd ratio was 2.5 to 1.

The change in spawning distribution between the lower Methow and Chewuch rivers appears to be attributable to an increased number of hatchery fish in the 1993 run that "overshot" the WNFH and spawned in the lower Methow River.

Stream flows decreased rapidly after spawning and by late November an estimated 48 redds were dewatered in the upper Methow River and 4 were exposed in the upper Twisp River.

Broodstock trapping for the Methow Valley Hatchery continued for the second year on the Twisp and Chewuch Rivers. A total of 46 Twisp River Fish and 110 Chewuch River chinook were retained as broodstock. An additional 99 Methow River fish entered the hatchery discharge stream and were trapped as broodstock. Total egg take was 520,000.

# 3.0 INTRODUCTION

A mitigation/compensation agreement between state and federal fisheries agencies, Indian tribes and Douglas County Public Utility District was finalized in July, 1990. One of the stipulations of this agreement is for Douglas County P.U.D. to compensate for losses at their Wells Dam Hydroelectric Project with a central fish hatchery and associated acclimation facilities. This compensation is based on supplementing natural stocks of spring chinook, steelhead and sockeye in the Methow and Okanogan River Basins, upstream from Wells Dam. The Methow Valley Spring Chinook Hatchery, located on the Methow River near Winthrop, WA., commenced broodstock trapping on May 15, 1992 in the Twisp and Chewuch rivers. The hatchery goal is to release 750,000 migrants into the Methow Basin. However, hatchery guidelines allow for a maximum broodstock take of approximately 30%[1] of escapement in each respective watershed to ensured adequate of wild spawners. Thus the number of eggs taken for the hatchery each year is dependent upon the size of the Methow River Basin escapement.

The Douglas County P.U.D. contract provides for the collection of comprehensive spawning ground data for spring chinook in all spawning habitat within the Methow River Basin. Data from these surveys, in conjunction with the Wells Dam counts, will assist fisheries agencies, tribes and Douglas County P.U.D. to assess the status of spring chinook populations within the basin. The data will be useful in developing an outplanting strategy for the Methow Valley Spring Chinook Hatchery and associated satellite facilities. The Methow Valley hatchery's production plan and enhancement program is intended to complement the Northwest Power Planning Council's system planning process for the Columbia River Basin.

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[1] The percentage of broodstock taken each year varies around this 30% figure depending upon the projected run size.

Salmon spawning runs to the Methow River have been impacted by fishing and hydroelectric development (see Bryant and Parkhurst, 1950 and Mullan, 1987). In 1915, Washington Water Power Co. constructed an impassable hydroelectric dam at Pateros near the mouth of the Methow River. Records from 1928 and 1929 indicate that some chinook were netted below the dam and released above it, but by the time the dam was removed in 1930, the Methow River chinook run had been nearly exterminated.

In 1935, the Methow River and its tributaries were estimated to have a run of 200 to 400 spring chinook. The run was placed in jeopardy during the Grand Coulee Fish Maintenance Project (1939-43) when all adult salmon were captured downstream from the Methow River at Rock Island Dam.

The first extensive spring chinook spawning ground surveys of the Methow River Basin were conducted from 1954-1960 (French and Wahle, 1965). The Chewuch and upper Methow rivers were found to be the most important spring chinook spawning areas.

Beginning in 1961, the Washington Department of Fisheries (WDF) established index areas in the Methow River Basin and performed the spring chinook surveys through 1986 (Meekin, 1991).

The Douglas County Public Utility District assumed responsibility for funding the surveys beginning in 1987. The surveys have been conducted by the Yakima Indian Nation since that time.

The Methow River spring chinook run passes Wells Dam and enters the basin during May and June usually peaking after mid-May. The fish enter the Methow River Basin coincidental with the spring run-off which enables them to pass the irrigation diversion dams. Spawning commences in early August in the upper areas of the Methow and its tributaries and continues through mid to late September in the lower reaches of the basin rivers.

Hatchery production of salmon for release into the Methow River commenced at the Winthrop National Fish Hatchery in 1943. Spring chinook, coho, and sockeye salmon smolts were released through 1962. From 1963 through 1975 salmon were not reared at the hatchery. Beginning in 1976, spring chinook salmon became the prime focus of the hatchery. Since 1976, spring chinook broodstock from either the Methow River, Icicle Creek, White Salmon, Wind or Carson rivers have been reared and released from the hatchery. Numbers released have ranged from 270,000 in 1976 to 1,200,000 in 1985. Releases averaged approximately one million per year and were usually released in mid-April at an average weight ranging from 12 to 15 fish per pound.

From 1977 through 1979 and again in 1983 summer chinook were reared and released from the hatchery. Releases ranged from 250,000 to 600,000 smolts.

The current Winthrop National Hatchery production program is to produce one million spring chinook smolts annually. The 1991 brood year spring chinook release was 950,623 smolts at 17.3 per pound on April 15, 1993[2]. Of this number a total of 861,290 was Leavenworth hatchery stock and 89,333 were Methow hatchery stock.

As previously mentioned the Methow Valley Hatchery initiated broodstock collection in 1992. The smolts will be released during the spring of 1994 into their "source" streams, the Twisp and Chewuch rivers.

The 1993 Methow Valley Hatchery smolt production goals for each run, Methow, Twisp and Chewuch rivers, were 250,000 fish for release as yearlings at 15 fish per pound.

---

[2] Hatchery data is personal communication from W. Wallein, Winthrop Hatchery Manager.

The objectives of the spring chinook spawning ground surveys were to determine: 1) spawn timing, 2) redd location and distribution pattern within each river system, 3) magnitude of spawning and 4) the age/length composition of each spawning population.
to 1987, spring chinook spawning ground surveys were conducted annually by the WDF and usually consisted of a single count of established index areas (Figure 2). These counts were usually made during or immediately after the peak of spawning in late August or early September.

These index surveys, in conjunction with the Wells Dam counts, provided information on spawning trends but did not provide data regarding any changes of timing, location or overall magnitude of spawning. Therefore, it became necessary to initiate the surveys earlier, by late July, in order to obtain time of spawning. In addition, to determine location, as in 1987-1992, the expanded surveys were continued to check all areas of the Methow River Basin where spring chinook spawning might occur. The surveys ended only after it was determined that all spawning was complete.

For purposes of continuity and comparison separate redd counts in the WDF index areas were continued during the 1993 surveys (Figure 1 and Table 1).

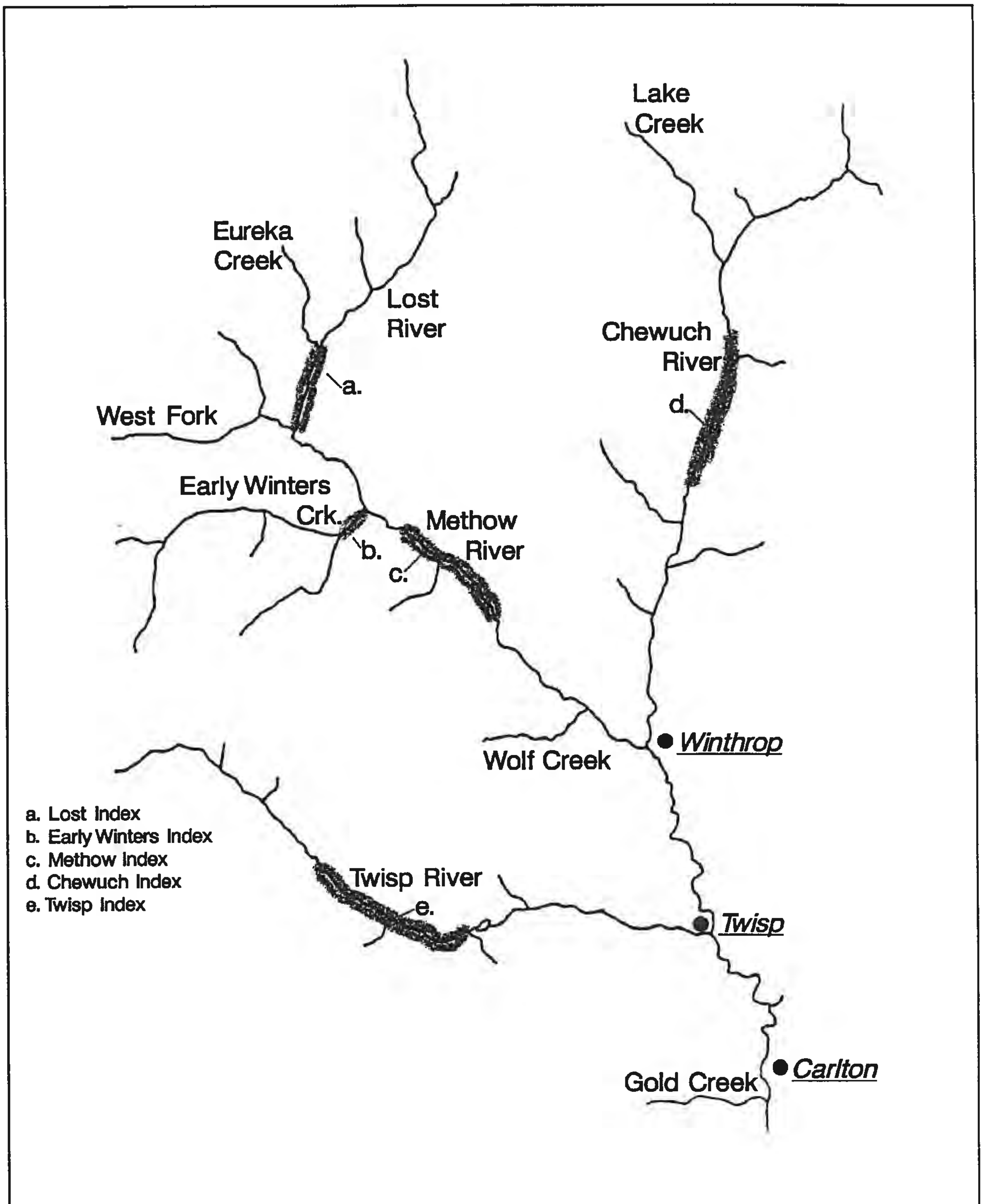


**Figure 1.** Upper Methow River Basin. Shaded sections indicate spring chinook spawning index reaches.

## 4.0 DESCRIPTION OF STUDY AREA

The Methow River Basin is located in north-central Washington on the eastern slope of the Cascade Mountains (Fig.2). The river and its tributaries lie in Okanogan County and drain an area of nearly 1800 square miles. The headwaters of the Methow River are located near the cascade crest at an elevation of more than 6000 feet. At the city of Winthrop, where the Chewuch River joins the Methow River, the river elevation is 1745 feet. The river elevation drops to 779 feet where the Methow and Columbia rivers meet at Pateros, WA.

The upper portion of the Methow Basin is heavily forested, predominantly with ponderosa pine. This area is used extensively for recreation and is experiencing significant growth in residential and commercial development. The Washington Department of Ecology has even proposed limitations on development in the upper Methow Basin because of inadequate water supplies (Perrow, 1990).

The lower Methow Valley is a fertile agricultural area. The fruits and crops which are grown here place heavy irrigation demands on the Methow River and its tributaries. Water quality in the lower Methow Basin nonetheless remains high with the Department of Ecology giving it a AA rating.

Though development is uncertain at this time, private developers have proposed a major winter/summer recreational development in the upper valley. Impacts of this development on anadromous fish are potentially high because of the limited water resources in the basin. Several reaches of the Methow mainstem, from the Lost River confluence downstream to Foghorn Dam and some areas of its tributaries presently dewater naturally during low to moderate flow years.

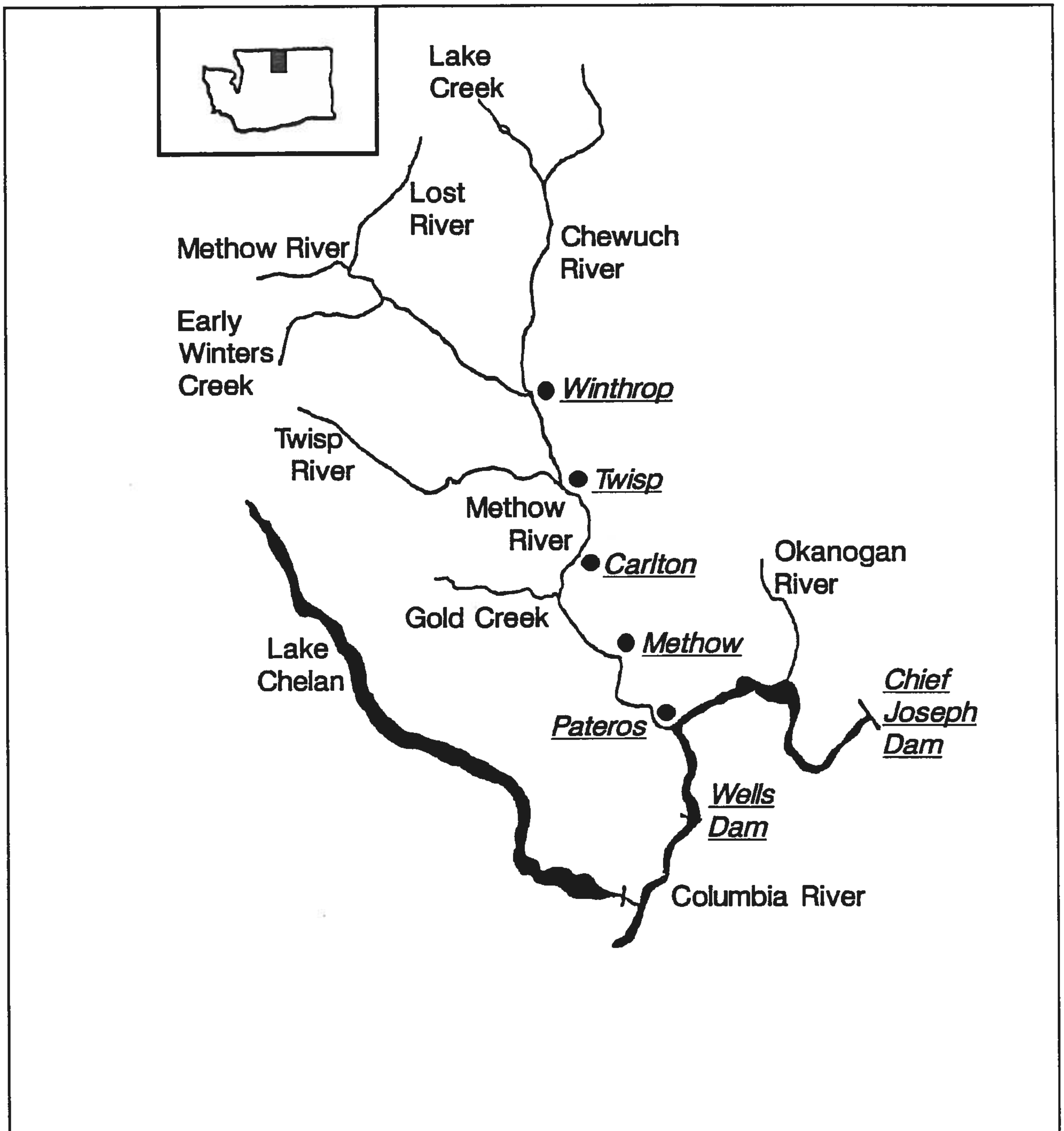


**Figure 2.** Methow River Basin location map.

# 5.0 METHODS

The Methow River and its tributaries were divided into specific spawning reaches. The surveys were conducted by walking and/or rafting when there were sufficient flows. More surveys were made by rafting during 1993 than in previous years.

Surveys of known spawning reaches in each tributary were usually conducted weekly as time permitted. As in 1987-92, the surveys included all accessible reaches of the Methow River and its tributaries available to spawners. Some survey reaches, usually those in the upper reaches, contain minimal spawning habitat and were not surveyed on a weekly basis. However, these reaches were surveyed at least once with the survey conducted during or after peak spawning had occurred. As spawning progressed in the upper reaches and fewer redds were observed, the surveys concentrated on the lower reaches. To ensure redd count consistency, the same surveyor was usually assigned, when possible, to the same river reaches for each weekly survey.

To avoid recounting or missing any spring chinook redds. All redds were flagged on the river bank with surveyors tape, dated and numbered. The approximate location of the redd to the nearest bank was also noted on the tape. The flag color was changed each week. All live spawners were counted during each survey. If fish were observed on a flagged redd, during subsequent weekly surveys they were recounted.

Carcasses were recovered and checked for tags, fin clips, sex and spawning success. Scales and post-eye to hypural plate lengths were recorded for age/length analysis. Scales were also analyzed to determine the incidence of hatchery spawners.

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

The total number of spring chinook available for spawning in the Methow River Basin was calculated by subtracting from the Wells Dam count the number of chinook returning to the two Methow River Basin hatcheries, plus those trapped for broodstock at the Twisp River weir and the Fulton Dam fish ladder on the Chewuch River.

# 6.0 RESULTS AND DISCUSSION

## 6.1 Spring Chinook Run Size

The 1993 Wells Dam spring chinook count was 2,444 fish (Table 2). This was an increase of xx% over the 1989 parent year run of 1,720 and a decrease of 13% from the 1981-1990 average run size of 2,804 fish.

## 6.2 Winthrop National Fish Hatchery (WNFH) Returns[3]

Spring chinook voluntarily entered the hatchery ladder and holding pond commencing about mid-May, peaked in early June and entered sporadically after mid-June. A total of 646 chinook were trapped (Table 2). Spawning occurred during the period August 18-30 with a total egg-take of 1,340,700.

The final chinook count was 263 (40.7%) males and 383 (59.2%) females for a male to female ratio of 1.0:1.5.

## 6.3 Methow Valley Spring Chinook Hatchery Broodstock Trapping[4]

Trapping for broodstock commenced on May 11 at the Twisp River weir and terminated on August 21. Only one fish was trapped during May. Beginning on June 1, adult chinook entered the trap sporadically with the peak daily catch of 5 fish occurring on July 30. A total of 70 fish were trapped, one in May, 35 in June, 20 in July and 14 in August. Only one mortality occurred prior to spawning. A total of 70 fish were trapped, of these 26 females and 16 males, were transported to the hatchery for broodstock (Table 2). The

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[3] Personal communication from W. Wallein, Winthrop National Fish Hatchery Manager.

[4] Personal communication from B. Jateff, Methow Valley Spring Chinook Hatchery Manager.

remaining 28 fish were released upstream. Broodstock pre-spawning mortality was two females. Spawning occurred during the period August 2-25 resulting in a total egg-take of 92,000.

Broodstock collection at Fulton Dam on the Chewuch River was initiated on May 31 and terminated on August 23. A total of 186 adult chinook were trapped in 1993 compared with 33 fish trapped in 1992. In 1993 a total of 110 adult chinook were retained for broodstock and the remainder released upstream (Table 2). These broodstock fish were comprised of 56 females and 54 males. The peak day of trapping was June 1 when 26 chinook entered the trap. Five fish were trapped in May, 137 in June, 23 in July and 21 in August. Prespawning mortality was 2 females and 5 males. Spawning occurred from August 2 to September 7 with a total egg-take of 232,000.

A total of 99 fish (Table 2), 50 females and 49 males entered the discharge stream and were collected for broodstock at the Methow Valley Spring Chinook Hatchery. Twenty-one fish were collected in June, 17 in July and 61 in August. Pre-spawning mortality was 2 males. Spawning occurred between July 26 and September 1 resulting in an egg-take of 196,000.

6.4 Methow River Basin Flows

Stream discharge measured at the Pateros gauge (USGS) showed an increase over the 1992 stream discharge during the period of spring chinook upstream migration (Appendix Table I). Stream discharge in the upper Methow River near Mazama was less than in 1992, but increased slightly at Winthrop (Appendix Tables IV and V). Chewuch River discharge decreased during May and June, however stream discharge increased minimally on the Twisp River (Appendix Tables IV and V). Stream discharge in all areas declined during September and October.

## 6.5 Spawning Ground Surveys

### 6.5.1 Introduction

Spawning ground surveys commenced on July 27 and continued through September 22. A final survey of the upper Methow River was made in late November to determine number of dewatered redds. A total of 127 rm were surveyed. Spawning usually occurred first in the upper reaches of each watershed and later in the lower reaches.

Because of the broodstock trapping on the Chewuch and Twisp rivers, several surveys were made in late July and August downstream from the trapping sites to determine if adult fish were being delayed or blocked in their upstream migration.

### 6.5.2 Generalized Spawning Distribution

The relationship of redd counts within each of the three river's index area to that of the redd counts upstream to and downstream from the index area is presented in Table 13. The highest number of redds were located within the index areas, except for the Methow River. In the Methow River the majority of redds were located downstream from the index area. When compared with the cumulative index area spawning in all areas encompassing the six previous years, a change in spawning distribution is not observed (Table 14).

Table 4 shows the spawning distribution within the Methow River Basin since the expanded surveys were initiated in 1987. As previously mentioned, the Methow River contained the highest portion (47.0%) of redds ever recorded in its basin, while the Chewuck River had a record low (13.5%). The Twisp River which received the lowest portion of the run in 1992, increased in 1993 probably because of improved adult passage past the weir.

### 6.5.3 Methow River

The first redd was counted in the Lost River confluence to Gate Creek reach (section 2) on July 29 (Table 3). The greatest concentration of spawning (96 redds or 33.1% of the total) occurred in the Weeman Bridge to Highway 20 "along river" reach (section 6), a total of 5.3 rm. Within the index areas, sections 5 (Mazama Bridge to Weemam Bridge) and 6, 92 redds (31.7%) were counted.

Peak spawning was from August 16 to August 26 with 190 redds or 65.5% of the 290 total counted during this period (Table 3). Spawning occurred in all sections from the West Fork Ballard Campground to the diversion dam. Redds were not found between the diversion dam to Carlton Bridge (sections 11 and 12).

The Methow River redd count was 290 or 47% of the total basin count of 617 (Table 4). This was the second highest count since the expanded surveys were initiated in 1987, and significantly greater than the mean of 37.5% of the total basin redds (Table 4). There is no definitive reason or explanation for the greater percentage of redds observed in the Methow River in 1993. It has been suggested that adult passage was in some manner impaired at Fulton Dam. However, there was no significant changes in either how broodstock was collected at Fulton Dam or in the physical structure of the dam itself between 1992 and 1993 (pers. comm. Jateff, 1993). A more plausible explanation is that the increased redd count resulted from WNFH origin spawners. The redd count in the Methow River increased primarily between the Weeman Bridge downstream to the Winthrop Bridge. It appears that hatchery origin fish "overshot" the WNFH and spawned in the reaches immediately upstream to the hatchery. The high number of WNFH fish that entered the Methow Valley Spring Chinook Hatchery (pers. comm. Jateff, 1993), which is located upstream to the WNFH, indicates WNFH fish were "overshooting" the hatchery. Fifty-five percent of the carcasses in this reach were of hatchery origin, 33% were wild and 12% were unidentifiable, based on scale data (per. comm. Sneva, 1993). The estimated mean run composition for the years 1981-90 was 23.3% hatchery and 76.7% wild. The mean run size past Wells Dam for the same period was 2,804 fish. In 1993 the run size was 2,444 fish and the run composition was 27.5% hatchery and 72.5% wild. Thus it's plausible that the number of additional hatchery fish comprising the run this year could account for the increased redd count.

Exposed and dewatered redds were not observed in the upper Methow River in late September. The mean river discharge in the upper Methow River was 34 cfs (Mazama USGS gauge station) in September 1993, as opposed to 15 cfs during 1992 when redds were exposed (Appendix Table II). However, during October 1993 flows had decreased to 3 cfs in the upper river. A survey of the river on November 18, 1993 revealed only minimal flow from about a mile downstream from the Lost River confluence to Gate Creek. A total of 21 of 32 redds were dewatered in section 2. From Gate Creek downstream to Early Winters Creek (section 3) the river was completely dry and all 15 redds in this section were judged to be dewatered. Minimal flows from Early Winters Creek were sufficient to maintain water flow over the 11 redds in section 4, downstream to the Mazama Bridge. Low flows downstream from the Mazama Bridge to the road barrier revealed an additional 12 redds exposed in section 5.

In summary, in the Methow River, one mile downstream from the Lost River confluence to Boulder Creek there was a total of 48 dewatered redds. A further decrease in river discharge during the winter months could seriously affect the survival of the 80 redds located in section 5 that were not dewatered during November.

Continuous stream flow in the Methow River downstream from the Weeman Bridge is usually sufficient to maintain adequate flow over the redds (Appendix Table III).

Stream discharge data that became available after the 1992 report was written indicates that there was no flow in the upper Methow River recorded at Mazama from November 1992 through March 1993 (Appendix Table II). If assumed that all 135 redds located in sections 2-[redacted] in 1992 were dewatered, 40% of the 336 redds located in these sections were potentially at risk of being lost. This may have a significant negative effect on the returning adults in 1996.

#### 6.5.4 Chewuch River

The first redd was observed on August 3 in the Falls Creek Campground to Eight-Mile Ranch (section 11) (Table 5). Peak spawning occurred between September 2-8, with 33 redds counted or 39.8% of the total redds deposited in the watershed (Table 5). No new redds were counted after the September 8 survey.

No redds were located from the "falls" to Thirty-Mile Bridge (section 1) and the "roadside camp" to Lake Creek Campground (sections 3 and 4 ). This attributed to the poor spawning habitat that exists in these sections. The redds were distributed throughout the remainder of the river with 14 redds (16.9%) between Buck Creek to Camp Four (section 6) and 19 redds between Chewuck Campground to "mile 6" (section 9). The index area from Camp Four to Falls Creek Campground (sections 7-10), contained 35 redds or 42.2% of the watershed total. Only five redds (6.0%) were located in the lower river between the Chewuch River road bridge and the confluence ( sections 14 and 15), as compared with 23 redds (28.8%) in 1993.

Discharge through the Fulton Dam fish ladder during 1993 was about three times greater ([redacted] during 1992. More fish were trapped during 1993, but fish were also observed passing over the dam. However, the Chewuch River count totaled only 83 redds, the lowest count since expanded surveys were initiated in 1987. Only 13.5% of the Methow River Basin redd count was in the Chewuch

River. The percent of total Methow River Basin redds in the Chewuch River between 1987-92 has ranged from 25.0% up to 36.4% with an mean of 28.6% (Table 4). This apparent change in the proportions of redds between the Chewuck and Methow rivers was previously discussed above.

### 6.5.5 Lost River

The initial survey was made on August 2 with three redds being counted (Table 6). Peak spawning occurred between August xx-19 with a count of 31 redds. Eight additional redds were located on August 26 and nine new redds were found on August 30. No new redds were found on September 16, the final survey.

Since 1987, the Lost River redd counts have ranged from 6.4% up to 11.0% of the total Methow River Basin count (Table 4). This year's redd count of 51 comprised 8.3% of the basin total.

### 6.5.6 Twisp River

Surveys were initiated on July 28 and continued through September 23. Surveys were made downstream from the weir on July 28 and August 4 to determine if chinook were blocked by the weir, but no live fish were observed.

The first redds were observed between South Creek Bridge to Poplar Flats Campground (section 3) and "cabin on left" Bank Road to Buttermilk Bridge (section 7) on July 28 (Table 7). A total of 173 redds or 90% of the total 192 redds were constructed between August 4-25. The index area, between Mystery Bridge to Buttermilk Bridge (sections 5-7), contained 108 (56%) of the total redds in the Twisp River. Poor spawning habitat between "road end" campground to South Creek Bridge (sections 1 and 2), between Little Creek to the fish weir (sections 10 and 11) and between the Twisp River Bridge to the confluence (section 15) account for the absence of spawning in these sections.

Twenty-nine redds (15.1%) of the 192 total were located from the weir at rm 6.1 downstream to the Twisp River road bridge (sections 12-14). Eight of the 29 redds were constructed immediately below the weir. Forty redds were found in these sections in 1992 after construction of the weir. The spawning gravel in this area is marginal. For the past years of 1988-91 a total of only 10 redds were found in these sections. Though down from 1992, the location of 29 redds compared to the mean of 2.5 redds per year for the years 1988-91 suggests the weir may still be impeding upstream migration.

Only 2 redds were found in the Methow Valley Irrigation Canal between the headgate and the fish screen. Gravel in the canal is ideal for spawning and the canal is watered throughout the year.

Escapement to the Twisp River was the second highest count since 1988 when 199 redds were counted. This comprised 31.1% of the Methow River Basin total, as compared with 19.0% in 1992 and the six year mean of 26.3% (Table 4).

Low flows in the upper Twisp in sections 3 and 4 resulted in de-watering of 4 redds on September 9. Additional surveys of these sections were not conducted after this date.

### 6.5.7 Other Tributaries

One redd was found in Early Winters Creek on September 13 (Table 8). Redds were not located in Lake, Gold, or Wolf creeks (Tables 9, 10, 11).

6.6 Water temperatures

Water temperatures were taken at the beginning and end of all surveys and are summarized in Tables 3 and 5-11. Water temperatures in all areas exceeded 60° F only for a few days.

6.7 Carcasses Recovery

During the surveys, 217 carcasses, 81 males and 136 females, were examined (Appendix Table VI). Of the 136 females examined, 126 (92.6%) were completely spawned, 2 (1.5%) were partially spawned with 500 plus eggs remaining, and 8 (5.9%) were unspawned. Several of the unspawned fish had been killed by poachers (evidence?). From 1987 through 1992, the percentages of completely spawned females were 89%, 90%, 88%, 95%, 90% and 92%, respectively (Kohn, 1987, 1988, 1989; Edson, 1990; and Meekin, 1991, 1992).

Three (3.7%) of the 81 male carcasses examined were classified as green. The male to female ratio was 1.0 to 1.7. For the past years of 1987-1992 the male to female ratios have been 1 to 1.33; 1 to 2; 1 to 1.9; 1 to 1.6; 1 to 1.6; 1 to 1.6 and 1 to 1.6, respectively. This seems to indicate a constant bias towards the recovery of female carcasses, as one would expect more males in the spawning population due to the jacks.

SCALE DATA- Joel has this data worked up. It's written on the title page (i think) of the most recent rough draft. I hope it's on my desk.

The incidence of hatchery origin fish, based on scale pattern, comprised, as expected, 39% (44 fish) of the Methow River spawners. Two fish (15%) from the Lost River, one (2%) from the Twisp River and one (3%) from the Chewuch River were also judged to be of hatchery origin.[5]

One NMFS radio tag was recovered from the Twisp River (section 7) on August 25 and two from the Chewuch River (sections 8 & 9) on September 9. Two adipose clipped carcasses were also recovered, one on the Twisp River in section 5 on September 2 and one on the Methow River in section 6 on September 7.

## 6.8 Fish Per Redd

Based on the number of adults past Wells Dam and the total number of redds counted in the Methow River Basin, the fish per redd ratio was estimated at 2.5 to 1 (Table 12).

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[5]Personal communication from John Sneva, WDF.

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# 9.0 APPENDIX TABLES

Table 1. Historical spring chinook index redd counts for the Methow River basin, 1962-1993.

| Spawning Year | Methow River | Chewuch River | | Lost River | | Twisp River | Early Winters Creek |
|---|---|---|---|---|---|---|---|
| | Mazama Br. to Weeman Br. | Camp Four to Chewuch C.G. | Chewuch C.G. to Falls Cr. C.G. | Eureka Cr. to Lost R. Br. | Lost R. Br. to Mouth | Mystery Br. to Buttermilk Br. | Diversion Dam to Mouth |
| 1962 | 187 | 9 | 49 | 104 | NS | 203 | NS |
| 1963 | 110 | NS | 78 | 35 | NS | 132 | NS |
| 1964 | 127 | NS | 176 | 98 | NS | 211 | NS |
| 1965 | 111 | NS | 34 | 86 | | 138 | NS |
| 1966 | 233 | NS | 91 | 271 | | 257 | NS |
| 1967 | 140 | NS | NS | 80 | 22 | 135 | NS |
| 1968 | 92 | 30 | NS | 35 | 2 | 190 | 1 |
| 1969 | 57 | 17 | 32 | 49 | 11 | 123 | 3 |
| 1970 | 150 | 14 | 32 | 101 | NS | 75 | 1 |
| 1971 | 113 | 10 | 23 | 61 | 9 | 97 | 6 |
| 1972 | 65 | 97 | | 58 | 11 | 97 | NS |
| 1973 | 95 | 47 | 42 | 65 | 5 | 247 | 1 |
| 1974 | 49 | 22 | 30 | 11 | NS | 129 | 3 |
| 1975 | 39 | NS | 98 | 59 | NS | 177 | 2 |
| 1976 | 34 | NS | 22 | 12 | NS | 53 | NS |
| 1977 | 65 | NS | 107 | 14 | | 174 | 0 |
| 1978 | 67 | 87 | 59 | 50 | NS | 265 | 4 |
| 1979 | 12 | 18 | 13 | 23 | 3 | 40 | 0 |
| 1980 | 25 | 8 | 14 | 13 | 4 | 27 | 0 |
| 1981 | 39 | 1 | 6 | 20 | 5 | 24 | 2 |
| 1982 | 56 | 2 | 8 | 29 | 4 | 17 | 0 |
| 1983 | 63 | 6 | 29 | 18 | 4 | 58 | 1 |
| 1984 | 43 | 24 | 15 | 54 | 6 | 48 | 3 |
| 1985 | 23 | 93 | 34 | 5 | | 95 | 6 |
| 1986 | 63 | 34 | | 48 | NS | 38 | 3 |
| 1987 | 75 | 23 | 54 | 52 | 4 | 79 | 1 |
| 1988 | 75 | 40 | 15 | 53 | 0 | 111 | 0 |
| 1989 | 60 | 12 | 32 | 53 | 4 | 100 | 6 |
| 1990 | 80 | 61 | | 33 | | 77 | 1 |
| 1991 | 31 | 14 | 16 | 16 | 0 | 40 | 0 |
| 1992 | 90 | 22 | 55 | 71 | 2 | 73 | 2 |
| 1993 | | | | | | | |

NS - No Survey

Table 2. Spring chinook counts at Wells Dam, number of fish returning to the Winthrop Hatchery, number trapped for the Methow Valley Hatchery and total fish available for spawning in the Methow Basin, 1967-1993.

| Year | Wells Dam Counts[1] | | Total | Winthrop Hatchery[2] | Methow Valley Hatchery[3] | | | | Methow Valley Spawners (est) |
|---|---|---|---|---|---|---|---|---|---|
| | Adults | Jacks | | | Twisp River | | Methow River | Chewuch River | |
| | | | | | Live | Morts | | | |
| 1967 | 541 | 616 | 1157 | | | | | | 1157 |
| 1968 | 4086 | 845 | 4931 | | | | | | 4931 |
| 1969 | 3048 | 551 | 3599 | | | | | | 3599 |
| 1970 | 2092 | 578 | 2670 | | | | | | 2670 |
| 1971 | 2535 | 633 | 3168 | | | | | | 3168 |
| 1972 | 3368 | 248 | 3616 | | | | | | 3616 |
| 1973 | 2505 | 507 | 3012 | | | | | | 3012 |
| 1974 | 3199 | 221 | 3420 | | | | | | 3420 |
| 1975 | 2096 | 129 | 2225 | | | | | | 2225 |
| 1976 | 1510 | 1249 | 2759 | | | | | | 2759 |
| 1977 | 3976 | 235 | 4211 | | | | | | 4211 |
| 1978 | 3532 | 83 | 3615 | 38 | | | | | 3577 |
| 1979 | 971 | 132 | 1103 | 102 | | | | | 1001 |
| 1980 | 941 | 241 | 1182 | 155 | | | | | 1027 |
| 1970-1980 (avg)[4] | | | 2831 | | | | | | 2801 |
| 1981 | 1367 | 98 | 1465 | 399 | | | | | 1066 |
| 1982 | 2270 | 131 | 4252 | 601 | | | | | 3651 |
| 1983 | 2726 | 143 | 2869 | 755 | | | | | 2114 |
| 1984 | 3066 | 214 | 3280 | 510 | | | | | 2770 |
| 1985 | 5151 | 116 | 5267 | 1201 | | | | | 4066 |
| 1986 | 2896 | 65 | 2961 | 836 | | | | | 2125 |
| 1987 | 2272 | 74 | 2346 | 594 | | | | | 1752 |
| 1988 | 2844 | 96 | 2940 | 1327 | | | | | 1613 |
| 1989 | 1633 | 87 | 1720 | 195 | | | | | 1525 |
| 1990 | 927 | 12 | 939 | 121 | | | | | 818 |
| 1981-1990 (avg)[4] | | | 2804 | 654 | | | | | 2150 |
| 1991 | 682 | 100 | 782 | 92 | | | | | 690 |
| 1992 | 1596 | 27 | 1623[5] | 331 | 30 | 10 | | 20 | 1232 |
| 1993 | 2422 | 22 | 2444[6] | 646 | 42 | 1 | 99 | 110 | 1546 |

1 Personal communication from R. Klinge, Douglas County PUD.

2 Personal communication from W. Wallein, Winthrop National Hatchery Manager.

3 Personal communication from B. Jateff, Methow Valley Hatchery Manager.

4 Not a moving average.

5 An additional 107 adults and 4 jacks were counted by video during "non-counting" hours.

6 An additional 197 adults and 6 jacks were counted by video during "non-counting" hours.

Table 3. Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Methow River, 1993

| RIVER SECTION | ROAD MILES | SURVEY DATES AND REDD COUNTS | | | | | | | | | TOTALS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7/29 | 8/2 | 8/9 | 8/16,17 | 8/23,24,26 | 8/30,31 | 9/7 | 9/13,15 | 9/21,22 | NUMBER | PER CENT |
| 1. W.Fork Ballard C.G. to Lost R. Confl. | 2.2 | | | 1 | | 0 | | | | | 1 | 0.3 |
| 2. Lost R. Confl. to Gate Creek | 2.5 | 1 | 1 | 11 | 9 | 9 | 1 | | 0 | | 32 | 11.0 |
| 3. Gate Creek to Early Winter Creek | 1.3 | 0 | 1 | 1 | 12 | 1 | 0 | | 0 | | 15 | 5.2 |
| 4. Early Winters Cr. to Mazama Bridge | 1.9 | 0 | 0 | 5 | 4 | 2 | 0 | | 0 | | 11 | 3.8 |
| 5. Mazama Bridge to Road Barrier to Weeman Br. | 5.2 | 0 | 2 | 17 | 12 | 40 | 13 | 8 | 0 | | 92 | 31.7 |
| 6. Weeman Bridge to Hiway 20 along river | 5.3 | | 2 | 5 | 35 | 49 | 5 | 0 | | | 96 | 33.1 |
| 7. Highway 20 along river to Wolf Creek | 1.1 | | 0 | 2 | 0 | 2 | 0 | 0 | | | 4 | 1.4 |
| 8. Wolf Creek to Diversion Dam | 1.5 | | | 0 | 1 | 7 | 5 | | 0 | | 13 | 4.5 |
| 9. Diversion Dam to Winthrop Bridge | 1.3 | | | 3 | 4 | 3 | 1 | | 0 | | 11 | 3.8 |
| 10. Winthrop Bridge to Diversion Dam | 5.0 | | | | | | | | 14 | 1 | 15 | 5.2 |
| 11. Diversion Dam to Twisp Bridge | 4.1 | | | | | | | | 0 | 0 | 0 | 0 |
| 12. Twisp Bridge to Carlton Bridge | 10.5 | | | | | | | | 0 | 0 | 0 | 0 |
| TOTALS | 41.9 | 1 | 6 | 45 | 77 | 113 | 25 | 8 | 14 | 1 | 290 | 100% |
| Temperature Range (F) | | 50-54 | 49-59 | 51-59 | 49-61 | 47-56 | 51-57 | 56-60 | 48-59 | 45-54 | | |

Table 4. Number and percent of redds found in the Methow River and tributaries, based on expanded surveys, 1987-1993.

| Year | Methow River | | Chewuch River | | Lost River | | Twisp River | | Early Winters Cr. | | Gold Cr. | | Lake Cr. | | Wolf Cr. | | Totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Redds | Per Cent | Redds | Per Cent | Redds | Per Cent | Redds | Per Cent | Redds | Per Cent | Redds | Per Cent | Redds | Per Cent | Redds | Per Cent | Redds | Per Cent |
| 1987 | 254 | 37.4 | 188 | 27.6 | 56 | 8.2 | 161 | 23.7 | 14 | 2.1 | 3 | 0.4 | 4 | 0.6 | 0 | 0 | 680 | 100 |
| 1988 | 262 | 35.1 | 202 | 27.1 | 53 | 7.1 | 199 | 26.7 | 17 | 2.3 | 4 | 0.5 | 9 | 01.2 | 0 | 0 | 746 | 100 |
| 1989 | 110 | 21.2 | 160 | 30.8 | 57 | 11.0 | 179 | 34.4 | 11 | 2.0 | 3 | 0.6 | 0 | 00 | 0 | 0 | 520 | 100 |
| 1990 | 194 | 38.6 | 158 | 31.5 | 33 | 6.6 | 113 | 22.5 | 1 | 0.2 | 3 | 0.6 | 0 | 00 | 0 | 0 | 502 | 100 |
| 1991 | 74 | 29.6 | 91 | 36.4 | 16 | 6.4 | 69 | 27.6 | 0 | 0 | 0 | 0 | 0 | 00 | 0 | 0 | 250 | 100 |
| 1992 | 336 | 45.3 | 185 | 25.0 | 73 | 9.9 | 141 | 19.0 | 3 | 0.4 | 0 | 0 | 3 | 0.4 | 0 | 0 | 741 | 100 |
| 1993 | 290 | 47 | 83 | 13.5 | 51 | 8.3 | 192 | 31.1 | 1 | 0.1 | 0 | 0 | 0 | 00 | 0 | 0 | 617 | 100 |
| 1987-1993 Avg | 217 | 37.5 | 152 | 26.3 | 48 | 8.4 | 151 | 26.0 | 7 | 1.2 | 2 | 0.3 | 2 | 0.4 | 0 | 0 | 4056 | 100 |

Table 5. 1993 Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Chewuck River.

| RIVER SECTION | ROAD MILES | SURVEY DATES AND NUMBER OF REDDS | | | | | | | | | TOTALS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7/27 | 8/3 | 8/9,10 | 8/16,17,19 | 8/24,26 | 9/1 | 9/8 | 9/14,15 | 9/20 | NUMBER | PERCENT |
| 1. Falls to Thirty Mile Bridge | 3.4 | | | | | | | | | 0 | 0 | 0 |
| 2. Thirty Mile Bridge to Roadside Camp | 2.5 | 0[1] | 0[1] | 5[1] | 3[1] | 0[1] | | | | 0 | 8 | 9.6 |
| 3. Roadside Camp to Andrews Creek | 3.4 | | | | | | | | | 0 | 0 | 0 |
| 4. Andrews Creek to Lake Creek C.G. | 2.4 | | | | | | | | | 0 | 0 | 0 |
| 5. Lake Cr. C.G. to Buck Cr. | 2.0 | 0 | | | 1 | | | 0 | 0 | | 1 | 1.2 |
| 6. Buck Creek to Camp 4 | 1.2 | 0 | 0 | 3 | 2 | 1 | 5 | 3 | 0 | | 14 | 16.9 |
| 7. Camp 4 to Roadside Camp | 1.2 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | | 3 | 3.6 |
| 8. Roadside Camp to Chewuch C.G. | 1.6 | 0 | 0 | 4 | 0 | 0 | 1 | 5 | 0 | | 10 | 12.1 |
| 9. Chewuch C.G. to Mile 6 | 1.9 | 0 | 0 | 0 | 0 | 0 | 6 | 13 | 0 | | 19 | 22.9 |
| 10. Mile 6 to Falls Cr.C.G. | 1.4 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | | 3 | 3.6 |
| 11. Falls Creek C.G. to Eight Mile Ranch | 2.9 | 0 | 1 | 0 | 2 | 0 | 4 | 5 | 0 | | 12 | 14.5 |
| 12. Eight Mile Ranch to Memorial Br. Piers | 1.5 | 0 | 0 | 0 | 0 | 4 | 1 | 3 | 0 | | 8 | 9.6 |
| 13. Memorial Br. Piers to Chewuch R. Rd.Bridge | 0.9 | 0 | | 0 | | 0 | | | 0 | | 0 | 0 |
| 14. River Rd. Bridge to 1/2 Way Point | 3.3 | | 0 | 0 | 0 | 0 | 2 | 0 | | | 2 | 2.4 |
| 15. 1/2 Way Point to Mouth | 3.4 | | 0 | 0 | 0 | 1 | 2 | 0 | | | 3 | 3.6 |
| Totals | 33.0 | 0 | 1 | 12 | 9 | 6 | 22 | 33 | 0 | 0 | 83 | 100% |
| Temperature Range (F) | | 48-58 | 60-64 | 52-58 | 50-60 | 46-54 | 50-57 | 48-61 | 45-53 | 41-43 | | |

[1] Dibble Springs area only.

Table 6. Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Lost River 1993.

| River Section | Miles (est.) | Survey Dates and Number of Redds | | | | | Totals | |
|---|---|---|---|---|---|---|---|---|
| | | August | | | | September | Number | Percent |
| | | 2 | 19 | 26 | 30 | 16 | | |
| 1. Sunset Cr. to Eureka Cr. | 2.0 | | | | | 0 | 0 | |
| 2. Eureka Cr. to Bridge | 4.0 | 3 | 31 | 8 | 9 | 0 | 51 | 100 |
| 3. Bridge to Methow River | 0.5 | 0 | | 0 | 0 | | 0 | |
| Totals | 6.5 | 03 | 31 | 8 | 9 | 0 | 51 | 100 |
| Temperature range (°F) | | 49 - 55 | 50 - 51 | 46 - 51 | 50 - 51 | 46 - 50 | | |

Table 7. Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Twisp, 1993.

| RIVER SECTION | ROAD MILES | SURVEY DATES AND NUMBER OF REDDS | | | | | | | | | TOTALS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 7/28 | 8/4 | 8/11 | 8/18 | 8/25 | 9/1,2 | 9/9 | 9/15 | 9/23 | NUMBER | PERCENT |
| 1. Road End C.G. up for 2 miles. | 2.0 | | | | | | | | | 0 | 0 | 0 |
| 2. Road End C.G. to South Creek Bridge | 3.1 | | | | | | | | | 0 | 0 | 0 |
| 3. South Creek Br. to Poplar Flats C.G. | 2.0 | 1 | 5 | 11 | 1 | 0 | 0 | 0[2] | | | 18 | 9.4 |
| 4. Poplar Flats C.G. to Mystery Br. | 2.0 | 0 | 14 | 7 | 1 | 0 | 0 | 0[3] | | | 22 | 11.5 |
| 5. Mystery Br. to War Cr. | 4.4 | 0 | | | 1 | | | 0 | | | 38 | 19.8 |
| 6. War Cr. Br. to cabin on left Bark Rd. | 2.2 | 0 | 3 | 5 | 11 | 5 | 1 | 0 | | | 25 | 13.0 |
| 7. Cabin to Buttermilk Bridge | .5 | 3 | 9 | 10 | 7 | 11 | 5 | 0 | | | 45 | 23.4 |
| 8. Buttermilk Br. to Br. with gate. | 0.7 | 0 | 0 | 1 | 2 | 0 | 0 | | | | 3 | 1.6 |
| 9. Br. with gate to Little Br. Cr. | 2.0 | 0 | 1 | 0 | 11 | 0 | 0 | | | | 12 | 6.3 |
| 10. Little Br. Cr. to Newby Br. | 1.3 | 0 | 0 | | | | | | | | 0 | 0 |
| 11. Newby Br. to Fish Weir | 1.2 | 0 | 0 | | | | | | | | 0 | 0 |
| 12. Fish Weir to Wooden Br. | 1.0 | 0 | 0 | | | 17 | 2 | 0 | | | 19 | 9.9 |
| 13. Wooden Br. to Poor Man Br. | 1.3 | 0 | 0 | | | 0 | 2 | 0 | | | 2 | 1.0 |
| 14. Poor Man Br. to Twisp River Rd. Br. | 2.4 | 0 | 0 | | | 8[1] | 0 | | | | 8 | 4.1 |
| 15. Twisp River Rd. Br.to Mouth | 1.2 | 0 | | | | | | 0 | | | 0 | 0 |
| Totals | 29.3 | 7 | 38 | 48 | 38 | 49 | 12 | 0 | 0 | 0 | 192 | 100% |
| Temperature Range (F) | | 48-64 | 49-63 | 49-58 | 50-57 | 44-62 | 50-60 | 49-56 | - | 41-46 | | |

[1] 2 redds in Methow Valley Canal
[2] 3 redds dewatered
[3] 1 redd dewatered

Table 8. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Early Winters Creek, 1993.

| Creek Section | Road Miles | August | | Sept. | Totals | |
|---|---|---|---|---|---|---|
| | | 5 | 25 | 13 | Number | Percent |
| 1. Klipchuck C.G. to Early Winters Br. | 0.9 | 0 | 0 sc | 0 | 0 | |
| 2. Early Winters Br. (C.G. Rd.) to Highway 20 Br. | 1.3 | 0 | 0 sc | 0 | 0 | |
| 3. Highway Br. to Diversion Dam (EWCG) | 1.5 | 0 | 0 sc | 1 | 1 | |
| 4. Diversion Dam to Highway 20 Br. | 0.2 | 0 | | 0 | 0 | |
| 5. Highway Br. to Mouth | 0.5 | | | 0 | 0 | |
| Totals | 4.4 | 0 | 0 | 1 | 1 | 100 |
| Temperature range (°F) | | 48-58 | 47-48 | 45-49 | | |

sc = Spot Check

Table 9. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Lake Creek, 1993.

| Creek Section | Road Miles | Sep. 14 | Totals | |
|---|---|---|---|---|
| | | | Number | Percent |
| 1. Lake to Halfway Point | 1.5 | N.S. | | |
| 2. Halfway Point to Parking lot | 1.5 | N.S. | | |
| 3. Parking lot to Mouth | 2.2 | 0 | 3 | 100 |
| Totals | 5.2 | 0 | 3 | 100 |
| Temperature range (°F) | | 47-48 | | |

N.S. = No Survey

Table 10. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Gold Creek, 1993.

| Creek Section | Road Miles | Survey Dates and Number of Redds | | | | |
|---|---|---|---|---|---|---|
| | | July 29 | Aug. 18 | Sept. 21 | Totals | |
| | | | | | Number | Percent |
| 1. Foggy Dew C.G. to North Fork Br. | 2.4 | 0 | 0 | 0 | 0 | |
| 2. N. Fork Bridge to S. Fork Road Br. | 1.8 | 0 | 0 | 0 | 0 | |
| 3. S. Fork Rd. Br. to Gold Cr. Rd. Br. | 1.1 | 0 | 0 | 0 | 0 | |
| 4. Gold Cr. Rd. Br. to Mouth | 0.1 | 0 | 0 | 0 | 0 | |
| Totals | 5.4 | 0 | 0 | 0 | 0 | |
| Temperature range (°F) | | 53-60 | 51-61 | 46-49 | | |

Table 11. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Wolf Creek, 1993.

| Creek Section | Road Miles | Survey Dates and Number of Redds | | | | |
|---|---|---|---|---|---|---|
| | | Aug. 5 | Aug. 26 | Sept. 23 | Totals | |
| | | | | | Number | Percent |
| 1. Diversion Dam to First Br. | 0.2 | 0 | 0 | 0 | 0 | |
| 2. Bridge to mouth | 1.0 | 0 | 0 | 0 | 0 | |
| Totals | 1.2 | 0 | 0 | 0 | 0 | |
| Temperature range (°F) | | 54-57 | | 52-60 | 52-60 | |

Note: Three carcasses were reported in Wolf Creek by WDF.

Table 12. Number of spring chinook per redd in the Methow River basin, 1987-1993.

| Year | Estimated spring chinook spawners | Total redd count | Fish per redd |
|---|---|---|---|
| 1987 | 1752 | 680 | 2.58 |
| 1988 | 1613 | 746 | 2.16 |
| 1989 | 1525 | 520 | 2.93 |
| 1990 | 818 | 502 | 1.63 |
| 1991 | 690 | 250 | 2.76 |
| 1992 | 1232 | 741 | 1.66 |
| 1993 | 1546 | 617 | 2.51 |

Table 13. Spring chinook redd count summary, number and percentages for the Methow River basin, 1993, (redd counts are divided into three sections: above, below, and within the index areas).

| River | Index Area | Above | Index | Below | Total |
|---|---|---|---|---|---|
| | | Redds (%) | Redds (%) | Redds (%) | Redds (%) |
| Methow | Mazama Br. to Weeman Br. | 59 (20.4) | 92 (31.7) | 139 (47.9) | 290 (100) |
| Chewuch | Camp 4 C.G. to Falls Cr. C.G. | 23 (27.7) | 35 (42.2) | 25 (30.1) | 83 (100) |
| Lost | Eureka Cr. to Mouth | 0 (0) | 51 ((100) | 0 (0) | 51 (100) |
| Twisp | Mystery Br. to Buttermilk Br. | 40 (20.8) | 108 (56.3) | 44 (22.9) | 192 (100) |
| Early Winters | Fish screens to Mouth | 0 (0) | 1 (100) | 0 (0) | 1 (100) |
| Basin Total | | 122 (19.8) | 287 (46.5) | 208 (33.7) | 617 (100) |

Table 14. Distribution of redds in relation to the index areas in the Methow basin 1987-1993.

| Year | Above Index area | | Index area | | Below Index area | | Total redds |
|---|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent | |
| 1987 | 124 | 18.4 | 288 | 42.8 | 261 | 38.8 | 673[1] |
| 1988 | 165 | 22.5 | 294 | 40.1 | 274 | 37.4 | 733[2] |
| 1989 | 69 | 13.3 | 262 | 50.7 | 186 | 36.0 | 517[3] |
| 1990 | 73 | 14.6 | 252 | 50.5 | 174 | 34.9 | 499[4] |
| 1991 | 47 | 18.8 | 117 | 46.8 | 86 | 34.4 | 250 |
| 1992 | 96 | 13.0 | 315 | 42.7 | 327 | 44.3 | 738[5] |
| 1993 | 122 | 19.8 | 287 | 46.5 | 208 | 37.7 | 617 |

1 An additional 7 redds were in Lake and Gold Creeks for a basin total of 680.
2 An additional 13 redds were in Lake and Gold Creeks for a basin total of 746.
3 An additional 3 redds were in Gold Creek for a basin total of 520.
4 An additional 3 redds were in Gold Creek for a basin total of 502.
5 An additional 3 redds were in Lake Creek for a basin total of 741.

Appendix Table I. Mean monthly flows (cfs) of the Methow River at Pateros, WA., 1987-1993.

| Month | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
| JAN | 275 | 344 | 350 | 399 | 549 | 313 | 263 |
| FEB | 308 | 272 | 333 | 342 | 547 | 356 | 280 |
| MAR | 495 | 321 | 399 | 496 | 682 | 1012 | 273 |
| APR | 1673 | 1821 | 1704 | 2498 | 1667 | 1784 | 366 |
| MAY | 5862 | 4285 | 4215 | 3132 | 5688 | 3682 | 4781 |
| JUN | 2750 | 3962 | 4526 | 5452 | 6866 | 2576 | 2597 |
| JUL | 906 | 1290 | 1107 | 2049 | 4185 | 1308 | 1294 |
| AUG | 374 | 413 | 439 | 644 | 1079 | 508 | 921 |
| SEP | 255 | 262 | 291 | 411 | 447 | 306 | 439 |
| OCT | 294 | 373 | 340 | 433 | 366 | 332 | |
| NOV | 294 | 424 | 482 | 1327 | 373 | 339 | |
| DEC | 297 | 340 | 529 | 789 | 346 | 305 | |

Appendix Table II. Mean monthly flows (cfs) of the Methow River abopve Goat Creek near Mazamas, WA., 1990-1993.

| Month | Year | | | |
|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 |
| JAN | | | 0 | 0 |
| FEB | | | 2 | 0 |
| MAR | | | 405 | 0 |
| APR | | | 823 | 19 |
| MAY | | 2439 | 1780 | 1414 |
| JUN | | 2876 | 1250 | 1058 |
| JUL | | 1945 | 438 | 395 |
| AUG | | 391 | 118 | 225 |
| SEP | | 74 | 15 | 34 |
| OCT | | 11 | 0.6 | 3 |
| NOV | | 12 | 0 | |
| DEC | | 2 | 0 | |

Appendix Table III. Mean monthly flows (cfs) of the Methow River at Winthrop, WA., 1989-1993.

| Month | Year | | | | |
|---|---|---|---|---|---|
| | 1989 | 1990 | 1991 | 1992 | 1993 |
| JAN | | 247 | 330 | 213 | 197 |
| FEB | | 215 | 374 | 251 | 179 |
| MAR | | 354 | 473 | 873 | 184 |
| APR | | 1858 | 1274 | 1570 | 245 |
| MAY | | 2358 | 4265 | 3165 | 4091 |
| JUN | | 4099 | 5264 | 2066 | 1988 |
| JUL | | 1407 | 2944 | 1028 | 1067 |
| AUG | | 467 | 737 | 390 | 781 |
| SEP | | 265 | 297 | 204 | 319 |
| OCT | | 263 | 236 | 219 | |
| NOV | | 915 | 244 | 225 | |
| DEC | 337 | 506 | 223 | 201 | |

Appendix Table IV. Mean monthly flows (cfs) of the Chewuch River, as estimated from the Methow River, Goat Creek, and Winthrop flows, 1991-1993.

| Month | Year | | |
|---|---|---|---|
| | 1991 | 1992 | 1993 |
| JAN | | 213 | 40 |
| FEB | | 249 | 49 |
| MAR | | 468 | 49 |
| APR | | 747 | 79 |
| MAY | 1835 | 1385 | 1264 |
| JUN | 2388 | 816 | 654 |
| JUL | 999 | 590 | 479 |
| AUG | 346 | 272 | 354 |
| SEP | 223 | 189 | 130 |
| OCT | 225 | 72 | |
| NOV | 233 | 74 | |
| DEC | 221 | 44 | |

Appendix Table V. Mean monthly flows (cfs) of the Twisp River at Twisp, WA., 1989-1993.

| Month | Year | | | | |
|---|---|---|---|---|---|
| | 1989 | 1990 | 1991 | 1992 | 1993 |
| JAN | | 64 | 131 | 53 | 34 |
| FEB | | 55 | 122 | 65 | 38 |
| MAR | | 97 | 164 | 179 | 45 |
| APR | | 528 | 381 | 303 | 84 |
| MAY | | 563 | 1171 | 659 | 936 |
| JUN | | 933 | 1291 | 515 | 504 |
| JUL | | 367 | 859 | 159 | 175 |
| AUG | | 94 | 174 | 51 | 94 |
| SEP | 34 | 46 | 53 | 24 | 36 |
| OCT | 96 | 71 | 53 | 33 | 45 |
| NOV | 92 | 350 | 58 | 43 | |
| DEC | | 177 | 53 | 46 | |

Appendix Table VI. Number of live spring chinook counted and carcasses examined by week, 1993.

| Week Ending | Methow River | | | Chewuch River | | | Lost River | | | Twisp River | | | Early Winters Cr. | | | Lake Creek | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Live | Carcasses | | Live | Carcasses | | Live | Carcasses | | Live | Carcasses | | Live | Carcasses | | Live | Carcasses | | Live | Carcasses | |
| | | M | F | | M | F | | M | F | | M | F | | M | F | | M | F | | M | F |
| 7/31 | 4 | 0 | 0 | 1 | 0 | 0 | | | | 6 | 1 | 0 | | | | | | | 11 | 1 | 0 |
| 8/7 | 18 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 18 | 1 | 0 | 0 | 0 | 0 | | | | 40 | 1 | 0 |
| 8/14 | 73 | 2[1] | 3[2] | 16 | 1 | 3[3] | | | | 25 | 0 | 2 | | | | | | | 114 | 3 | 8 |
| 8/21 | 142 | 4 | 3 | 19[4] | 0 | 1[4] | 24 | 1 | 2 | 38 | 1 | 8[5] | | | | | | | 223 | 6 | 14 |
| 8/28 | 175 | 21 | 19 | 48 | 3 | 2 | 12 | 2 | 5 | 56 | 7 | 3 | 0 | 0 | 1 | | | | 291 | 33 | 30 |
| 9/4 | 52 | 16 | 36 | 40 | 7 | 6 | 13 | 1 | 2 | 14 | 3 | 13 | | | | | | | 119 | 27 | 57 |
| 9/11 | 9 | 2 | 11 | 6 | 6 | 9 | | | | 0 | 0 | 4 | | | | | | | 15 | 8 | 4 |
| 9/18 | 2 | 2 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 3 |
| 9/25 | 0 | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0 | 0 | | | | | | | 0 | 0 | 0 |
| Totals | 475 | 47 | 73 | 132 | 17 | 23 | 51 | 4 | 9 | 157 | 13 | 30 | 0 | 0 | 1 | 0 | 0 | 0 | 815 | 81 | 136 |

[1] Green male.
[2] Unspawned females.
[3] Two unspawned females.
[4] One partially spawned female.
[5] One unspawned female.

Note: 30 unidentified carcasses in Methow River, 8 in Chewuck River, 12 in Twisp River and 3 in Wolf Creek. Live fish were not found in Gold and Wolf Creeks.

**1993 OKANOGAN RIVER**

**SOCKEYE SALMON SPAWNING GROUND**

**POPULATION STUDY**

**PREPARED BY**

**PARAMETRIX, INCORPORATED**

**APPENDIX - G**

Draft Report

# 1993 Okanogan River Sockeye Salmon Spawning Ground Population Study

Public Utility District No. 1 of Douglas County

December 1993

Parametrix, Inc.

# 1993 OKANOGAN RIVER SOCKEYE SALMON SPAWNING GROUND POPULATION STUDY

## DRAFT REPORT

Prepared for

**PUBLIC UTILITY DISTRICT NO. 1 OF DOUGLAS COUNTY**
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December 1993

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# INTRODUCTION

This report describes a mark-recovery study conducted in the fall of 1993 to estimate adult sockeye salmon escapement to spawning grounds in the upper Okanogan River in British Columbia. This study was funded by the Public Utility District No. 1 of Douglas County.

Spawner escapement estimates have traditionally been derived from ladder counts at Wells Dam on the mainstem Columbia, and counts made during annual spawning ground surveys. However, counts at Wells Dam and counts on the main spawning grounds above Lake Osoyoos (Figure 1) have differed significantly in past years. One explanation for the count discrepancy is that only limited efforts have been made to assess sockeye escapement on the spawning grounds. Annual spawner surveys have been conducted by the Fisheries Service of Environment Canada and the Washington Department of Fisheries since the 1940's, but these surveys have been of a short duration and timed to coincide only with peak spawning activity. Their primary value is for assessing relative changes in spawner escapement from year to year.

Another factor in the spawner count discrepancies is the periodic occurrence of a thermal barrier in the Okanogan River between Zosel Dam and the confluence with the Columbia River. The elevated water temperature appears to function as a barrier to adult sockeye migration (Major and Mighell 1966) and has been associated with decreased survival of Okanogan Sockeye (Major and Mighell 1966; Allen and Meekin 1980).

In 1992, the District funded an intensive spawning ground survey designed to enumerate adult sockeye escapement and collect information on various biological and spawning habitat parameters. Also in 1992, the U.S. National Marine Fisheries Service conducted a radio telemetry study to track migration of adult sockeye. Additionally, the Columbia River Inter-Tribal Fisheries Commission conducted a feasibility study on the use of underwater video to count sockeye passage at Zosel Dam in 1992 and 1993.

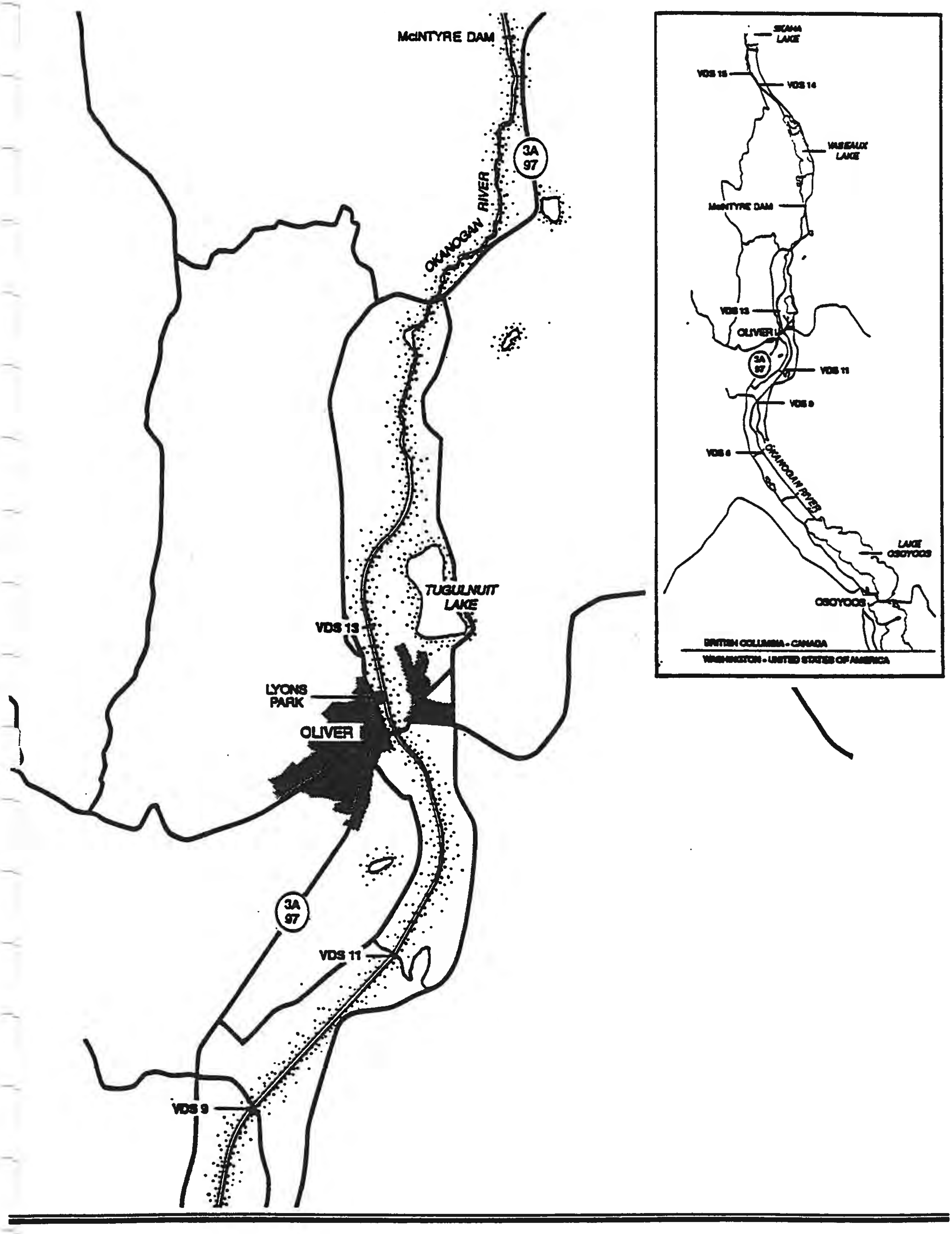



**Figure 1.**
**Map of the Okanogan River Sockeye Spawning Area**

# METHODS

An estimate of sockeye escapement was made by evaluating the recruitment of carcasses with a multiple mark-recovery method. The assumption was that this would provide a more accurate estimate of escapement compared to live counts.

## SURVEYS

Weekly spawning ground surveys were conducted between McIntyre Dam (RM 104.5) and Lyons Park, Oliver, B.C. (RM 100) (see Figure 1). This section of the river included the main spawning habitat above Lake Osoyoos. In addition to surveys of the main spawning reaches, the section of river between Lyons Park and VDS 6 was surveyed as time allowed. This lower section of river has been extensively channelized and relatively little spawning was expected to occur there. During the first week of the survey a section of the river above Vaseaux Lake, near VDS 14 and VDS 15, was checked for evidence of sockeye spawning. This was done to determine if any early arriving sockeye had escaped past McIntyre Dam during a period of high flow in September, prior to the spawning period. All surveys were conducted during three-day sample periods (units) for a total of five weeks beginning October 11 and ending November 10, 1993.

Surveys were conducted by raft and on foot using a four-man crew. The crew was split into 2 two-man crews that each examined one-half of the river (i.e., left bank and right bank). In addition, all side channels and tributaries were inspected. The crew used extendable aluminum gaffs to retrieve sockeye carcasses for examination, marking, or removal from the population.

Unmarked carcasses were first sexed and then marked by using a hole-punch that produced a single, quarter-inch diameter hole in the operculum. Separate, easily identifiable mark-groups were produced by making one, two, three, or four holes in one of the opercles. A different mark was used for each of the four weeks of carcass tagging. To further reduce the chance of misidentifying a marked carcass, the weekly mark-groups alternated between the right and left sides of the fish. After marking, the fish were placed back in the location where they had been found.

The numbers of fish marked varied by week and was dependent on the numbers of carcasses observed. The first week nearly all carcasses were marked. During subsequent weeks, approximately one out of every ten fish encountered was marked.

Marked carcasses that were recovered were identified by mark-group (the week it was marked) and sex. All recoveries were then removed from the population by cutting off the tail with a machete. All unmarked fish that were not to be marked were sexed, counted, and also removed from the population by cutting the tail.

As a part of the survey, all carcasses were examined for tags which had been attached by the Columbia River Inter-Tribal Fisheries Commission (Inter-Tribe). Originally, 200 fish had been tagged at Wells Dam by Inter-Tribe. A one-inch square patch of skin and scales was removed from each of these tagged fish that was recovered. The samples were sent to Intertribe along with the tag and information on the date and location where they were recovered.

In addition to the mark-recovery study, estimates of average egg retention per female were obtained by examining a subsample of spawned-out females and counting the remaining eggs. Subsamples were taken at the beginning, middle and end of the spawning period to examine time trends. A minimum of 20 fish were examined for each sample.

Average daily river discharge was obtained from the B.C. Ministry of Environment and average daily water temperatures at Zosel Dam were obtained from Douglas County PUD.

## ANALYSIS

The multiple mark-recovery analysis model used in this study was provided by the Washington Department of Fisheries (WDF) which has used it to estimate escapement of fall chinook salmon (DeVore personal communication 1993). The carcass mark-recovery model was originally developed by G. Paulik of the University of Washington and is based on the Seber-Jolly multiple mark-recapture model (Seber 1965; Jolly 1965).

This method of estimating the population depends on the following:

- There must be knowledge as to when the carcasses are first present on the spawning ground.
- There are at least five marking and sampling periods during the spawning season.
- The marking and sampling periods are spread throughout the spawning season.
- The lapse of time between the first and second sampling periods is approximately equal to the interval between the initial occurrence of spawners and the first sampling period. (The time lapse between the subsequent sampling periods need not be equal).
- All recovered carcasses are either marked and returned to the stream or are removed from the population.
- Tags of the same type are used throughout the sampling period. The tag must be inconspicuous and not change the probability of recovery.

As with any multiple mark-recovery method where there is both immigration and emigration, the validity of the WDF model relies on the following assumptions:

- All marks are permanent, and are identified correctly upon recovery.

- Once marked and returned to the location where it was found, a marked carcass has the same probability of being recovered in a subsequent sampling period as an unmarked fish.

- It is assumed that both new and older carcasses will be marked so that a differential rate of carcasses loss (between older and newer fish) does not bias the population estimates.

The WDF-Paulik model was obtained as a spreadsheet and the calculations were performed by input of weekly mark and recovery data (sample period i). The variables are defined as follows:

Input Variables:

$T_i$ = Number of marks released

$C_i$ = Total carcasses examined

$R_{i.}$ = Number of marks recovered in $C_i$

$R_{.i}$ = Number of marks recovered from $T_i$

$Z_i$ = Number of carcasses marked before the $i^{th}$ sample period and recovered after the $i^{th}$ sample period

Output Variables:

$M_i$ = 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 total spawning population estimate is the sum of the estimated $D_i$'s, the number of fish dying during each time interval.

Estimates for $M_i$, $f_i$, $N_i$, $u_i$, $D_i$, $B_i$, $s_i$ can all be calculated from the mark-recovery data using the model with the exception of $D_5$, $B_5$, and $s_5$, as these would be estimates for the interval following sample period five.

To calculate an estimate of $N_1$, and subsequently $B_1$ and $D_1$, where there is no mark-recovery data, it is necessary to assume that the probability of recovering a carcass in sample period one is the same as the probability of recovery in the second period ($u_1 = u_2$). Likewise, the estimate calculated for $u_4$ is the same estimate used for $u_5$.

# RESULTS

## MARK-RECOVERY SURVEY (MCINTYRE DAM TO LYONS PARK)

Results from the weekly mark and mark recovery effort are presented in Table 1.

**Table 1. Summary of 1993 carcass marking and recovery data from the Okanogan River between McIntyre Dam and Lyons Park.**

| Sample Period | Week | Number Removed | Number Marked | Mark Recoveries (by period) 2 | 3 | 4 | 5 | Total | % Recovery |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 11-Oct | 22 | 254 | 44 | 11 | 3 | 0 | 58 | 22.8% |
| 2 | 18-Oct | 1588 | 264 | | 90 | 19 | 1 | 110 | 41.7% |
| 3 | 25-Oct | 3726 | 433 | | | 148 | 28 | 176 | 40.6% |
| 4 | 1-Nov | 1707 | 151 | | | | 44 | 44 | 29.1% |
| 5 | 8-Nov | 1137 | 0 | | | | | — | — |
| Total | | 8180 | 1102 | | | | | 388 | 35.2% |

Note: Adding the number removed, marked and recovered equals the total number of fish handled for any sample period.

During the first sample period nearly all of the carcasses were marked because few carcasses were encountered. The peak of the die-off occurred between the second and third periods. In the second through fourth sample periods approximately one out of every nine carcasses (average) was marked.

The mark recovery results in Table 1 show the second and third period mark groups had the highest recovery rates, respectively, followed by the fourth and first period marks.

The survey made above Vaseaux Lake during the first week showed that at least 38 adult sockeye were able to get past McIntyre Dam during the high flow period. Thirty live fish were observed near VDS 14 and eight fish near VDS 15. It appeared some of the fish were guarding redds. No sockeye were seen above this area, although suitable spawning habitat was available.

The results of the spreadsheet calculations and the spawner population estimate for the main spawning area is presented in Table 2.

**Table 2.** Values used to calculate the 1993 sockeye spawning population in the Okanogan River between McIntyre Dam and Lyons Park.

| Period (i) | $T_i$ | $Z_i$ | $R_i$ | $R_{.i}$ | $C_i$ | $M_i$ | $f_i$ | $N_i$ | $s_i$ | $u_i$ | $B_i$ | $D_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | 486.76 | 880.65 |
| 1 | 254 | 0 | 0 | 58 | 276 | 0.00 | 0.0000 | 486.76 | 0.3055 | 0.5670 | 3201.86 | 5792.80 |
| 2 | 264 | 14 | 44 | 110 | 1896 | 77.60 | 0.0232 | 3343.85 | 0.5295 | 0.5670 | 5740.20 | 7888.35 |
| 3 | 433 | 23 | 101 | 176 | 4260 | 157.59 | 0.0237 | 6646.66 | 0.5505 | 0.6409 | 1662.99 | 2241.33 |
| 4 | 151 | 29 | 170 | 44 | 2028 | 269.52 | 0.0838 | 3215.25 | 0.4620 | 0.6037 | 1300.13 | 1912.82 |
| 5 | 0 | 0 | 73 | 0 | 1210 | 115.74 | 0.0603 | 1918.37 | | 0.6037 | | |
| | | | | | | | | | | | Total spawners = | 18,716 |

## LYONS PARK TO VDS 6

Carcass counts between Lyons Park and VDS 6 were made during separate surveys in sample periods four and five. The river reach between the park and VDS 9 was surveyed during week four, and the area between VDS 9 and VDS 6 was covered in week five. Therefore, in these areas insufficient data are available to calculate an estimate with the method listed above. To account for the loss of carcasses in this area during the previous weeks of the spawning season, an expansion method was applied. The total carcass count for the reach between Lyons Park and VDS 6 (1,343) was multiplied by the ratio of the mark-recovery population estimate for the upper area (18,716), and divided by the total number of carcasses counted in the upper area (9,282). This method resulted in a population estimate of 2,710 fish for the lower area.

## 1993 SPAWNER ESCAPEMENT

A total spawner escapement estimate of 21,505 (Table 3) was produced by summing the mark-recovery estimate for the main spawning area, the expansion estimate for the lower reach, and counts of live fish (43 total) from both areas in week five. The live fish counted above Vaseaux Lake are included in the total escapement estimate.

## ALTERNATIVE METHOD

In comparison to the estimate derived from the method described above, an alternative escapement estimate was calculated by including the carcass counts from the area between Lyons Park and VDS 6 in the mark-recovery model. The counts for week four and week five were

**Table 3. Total sockeye spawner escapement estimate to the upper Okanogan River, 1993.**

| Method | Dam to Lyons Park | Lyons Park to VDS 6 | Above Vaseaux Lake | Total |
|---|---|---|---|---|
| Mark-recovery | 18,716 | -- | -- | 18,716 |
| Dead counts | -- | 2708* | -- | 2708 |
| Live counts | 41 | 2** | 38 | 81 |
| Escapement | 18,758 | 2710 | 38 | 21,505 |

*Carcass expansion estimate
**Only live counts between VDS 9 and VDS 6

included individually. The carcass population estimate with this alternative method was 21,343 fish. With the live counts for weeks one and five (as described above), the total escapement estimate was 21,424.

Although the two population estimates vary by less than 100 fish, the first method is considered to be more accurate because it treats the carcass counts from below Lyons Park as a separate population. No carcasses were marked, nor were any marked carcasses recovered in the lower section. The counts made during weeks four and five were an accumulation of carcasses over the entire spawning period, rather than only one week, as in the main spawning area. Therefore, carcasses that washed out, or otherwise disappeared during the previous four or five weeks would not be represented in the same proportion as the weekly losses determined from the mark-recovery data in the upper section. The net result of the alternative method is an underestimate of the spawner population for the lower section.

## EGG RETENTION

The results of the three egg retention samples from the beginning, middle and end of the spawning period are presented below (Table 4). The categories are based on an average fecundity of 2000 eggs per female and are the same categories used in the 1992 Okanogan River sockeye spawner survey (Hansen 1993). All of the females examined were found between McIntyre Dam and Lyons park.

Of the 70 females sampled, 90 percent were completely spawned, 8.6 percent were partially spawned, and 1.4 percent were unspawned.

**Table 4.** **Results of egg retention samples from the beginning, middle, and end of the spawning period.**

| | | | Eggs Remaining | | |
|---|---|---|---|---|---|
| Sample Period | Week | n | 0-5% (completely spawned) | 6-76% (partially spawned) | 77-100% (unspawned) |
| 1 | 11-Oct | 27 | 24 | 3 | 0 |
| 3 | 25-Oct | 21 | 20 | 0 | 1 |
| 5 | 8-Nov | 22 | 19 | 3 | 0 |
| Total | | 70 | 63 | 6 | 1 |

## SEX RATIO

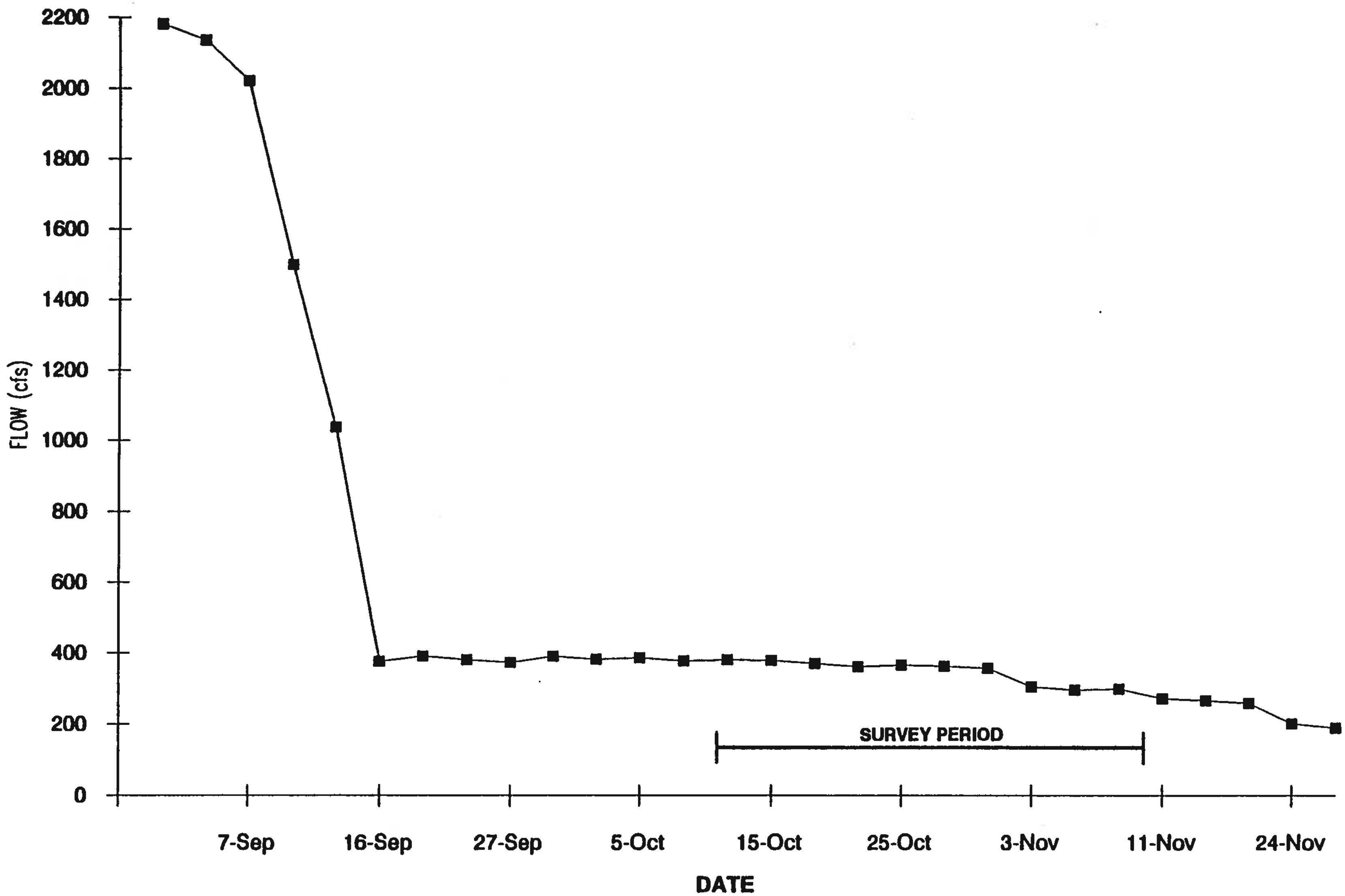
Sex ratios in the carcass population from fish examined during each sample period and all sample periods combined are presented in Table 5.

**Table 5.** **Sex ratios in the carcass population for each sample period.**

| | | | Percent | |
|---|---|---|---|---|
| Sample Period | Week | n | Female | Male |
| 1 | 11-Oct | 276 | 59.1 | 40.9 |
| 2 | 18-Oct | 1,852 | 49.8 | 50.2 |
| 3 | 25-Oct | 4,159 | 54.6 | 45.4 |
| 4 | 1-Nov | 2,709 | 57.5 | 42.5 |
| 5 | 8-Nov | 1,629 | 58.8 | 41.2 |
| All periods | | 10,625 | 55.3 | 44.7 |

## WATER CONDITIONS

Okanogan River flow data (mean daily flow) for the period from September 1 to November 30, 1993 is presented in Figure 2. Flow was recorded at the Road No. 18 crossing, approximately 1 mile upstream of Lake Osoyoos. During the survey period flow varied from approximately 380 to 270 cfs.




Source: B.C. Ministry of Environment 1993

**Figure 2.**
**Okanogan River Average Daily Flow, September Through November, 1993**

## DISCUSSION

### ASSUMPTIONS

The accuracy of the escapement estimate is dependent upon the validity of the mark-recovery model for this application. The model has been used successfully by WDF for estimating spawner escapement of fall chinook (DeVore personal communication 1993). In those applications, WDF marked every fish encountered, rather than marking a subset. In 1992, this method was used by the Colville Confederated Tribes to produce one of three estimates of sockeye escapement to the upper Okanogan River and the estimate obtained agreed with the estimates from the other two methods (Hansen 1993). The 1992 effort was reportedly the first time the WDF spreadsheet model was used to estimate sockeye escapement.

It is believed that all of the assumptions of the WDF-Paulik mark-recovery method were met in the current study. The following discussion addresses each assumption.

- There must be knowledge as to when the carcasses are first present on the spawning ground.

The Okanogan River sockeye typically begin spawning during the first half of October. Therefore, the survey was timed to coincide with the post-spawning die-off of the earliest spawners. Based on the number of carcasses observed in the first sampling period, sampling was initiated at the proper time.

- There are at least five marking and sampling periods during the spawning season.

A total of five weekly marking and sampling surveys were conducted during the 1993 spawning period.

- The marking and sampling periods are spread throughout the spawning season.

From the results of the first and last sample periods, it appears the five-week survey encompassed essentially the entire spawning period.

- The lapse of time between the first and second sampling periods is approximately equal to the interval between the initial occurrence of spawners and the first sampling period. (The time lapse between the subsequent sampling periods need not be equal).

From the low numbers of carcasses observed during the first week of the survey, it appears the fish were just beginning to die in significant numbers. The majority of these fish appeared to have died within the previous week. Therefore, the lapse of time between the first and second sampling periods was approximately equal to the time between the initial occurrence of fish and the first survey.

- All recovered carcasses are either marked and returned to the stream or are removed from the population.

This assumption was met throughout the five-week survey.

- Tags of the same type are used throughout the sampling period. The tag must be inconspicuous and not change the probability of recovery.

The use of the hole-punch method for marking carcasses was a success. Since the marks were visible only upon close inspection, the marks would not have changed the probability of recovery.

- All marks are permanent, and are identified correctly upon recovery.

The marks were inconspicuous, permanent, and easily identifiable. The only mark loss would have occurred with the removal of all or part of the operculum that was marked. During the course of the survey few carcasses were encountered with the head missing or a missing operculum, even though a significant number of carcasses indicated signs of predation or scavenging. It was almost always the soft tissue and not the hard, bony parts that were eaten. Even decomposed carcasses retained their marks as long as the head remained.

- Once marked and returned to the location where it was found, a marked carcass has the same probability of being recovered in a subsequent sampling period as an unmarked fish.

Based on the marking method and the placement of newly marked carcasses in the original location, there is no reason to expect this assumption was not met.

- It is assumed that both new and older carcasses will be marked so that a differential rate of carcasses loss (between older and newer fish) does not bias the population estimates.

Sampling included both new and older carcasses in the mark group during each marking period to minimize the potential for bias.

## POTENTIAL SOURCES OF ERROR

Like the Seber-Jolly model on which it is based, the WDF-Paulik mark-recovery model does not calculate an estimate of error because all mark recoveries are given as their exact expected values in the formulas. According to Ricker (1975), approximate variances can be calculated for $N_i$, $S_i$, and $B_i$ for the Seber-Jolly method by treating the marks and recoveries as Poisson variables, each with a variance equal to itself. However, the Poisson assumption is only valid for samples in which $N_i$ is much larger than $C_i$ (100 times or more) (Ricker 1975). In this study, the results of the WDF-Paulik model show that $N_i$ was only 1.8 times larger than $C_i$ in sample period one, which was the largest difference of any sample period. The estimate of $D_i$ was 21 times as large as $C_i$. Therefore, this method of estimating error is not appropriate for the 1993 population estimate.

The potential sources of error in the population estimate are discussed below.

There was a lower rate of tag recovery in the first and last period mark groups (23% and 29%, respectively) compared with the second and third period mark groups (approximately 41%) (see Table 1). According to the model, the lower the recovery rate for a mark group in the sample period following release, the higher the carcass population estimate for that interval. Since most of the carcasses found in the first period were used as marks, a potential for bias existed in the time following release because there was a much greater chance that a predator (or some other factor) would remove a carcass that was marked rather than unmarked. Thus, the relatively low recovery rate of the first mark group in the second sample period -approximately 17% as compared to 30% or more for the period following the other three mark groups- may have produced an inflated estimate, although the estimate for this period is only 880 fish. Therefore, the effect of any bias on the total estimate would be small.

The relatively low recovery rate of the week four marks may also have resulted in a biased carcass estimate. However, because there was only one period in which to recover these marks, this bias is inherent in the model. The only way to reduce the bias in the overall estimate is to increase the number of sampling periods and mark groups. However, based on the declining number of fish at this point in the survey, it was not considered necessary as such bias would have little effect on the total estimate.

The focus of the effort was on the main spawning area between McIntyre Dam and Lyons Park. Due to the large number of carcasses in this area, the lower portions of the river (below Lyons Park) were not included as part of the weekly mark-recovery survey. Carcass counts were made below the park only as time allowed during weeks four and five. Consequently, the total accumulated carcass count for this area is probably lower than if weekly surveys had been conducted. It is very likely that additional carcasses would have been found between the park and VDS 9 if this area had been surveyed again in the last sample period. Therefore the expanded population estimate from the park to VDS 6 is probably conservative. The effect on the overall population estimate is considered to be small, however, because of the relatively few fish observed there as compared to the main spawning areas in the upper reaches. Previous studies have also shown that the lower area typically represents only a small proportion of the run (Hansen 1993; Allen and Meekin 1980).

## COMPARISON TO 1992 ESCAPEMENT ESTIMATE

Using the same procedure and the same WDF spreadsheet model in 1992, Hansen (1993) reported a sockeye spawner population estimate of 22,587 fish. As a comparison, two other population estimates for 1992 were presented based on total counts of dead fish (20,202) and peak counts of live and dead fish (21,276). Hansen concluded that the estimate from the carcass marking method was higher than the other two estimates largely due to its ability to calculate loss from flushing. It was also reported that a small number of tags were shed (no figures were reported) and that this probably resulted in a conservative population estimate.

The 1992 spawning ground escapement estimate of 22,587 was approximately 54% of the total adult sockeye count at Wells Dam (Hansen 1993). This escapement figure was within the range of escapement estimates reported by Allen and Meekin (1980) between 1969 and 1974 (Table 6). The 1992 video survey estimated sockeye escapement at Zosel Dam to be between 25,172 and 42,410 fish (Hatch et al 1992). Because Zosel Dam is located below Lake Osoyoos and the spawning grounds, the spawning ground escapement would be expected to be lower.

**Table 6. Sockeye counts at Wells Dam and Okanogan River spawning grounds.**

| Year | Wells Dam Count | Estimated Okanogan River Escapement [1] | Total Spawning Ground Counts [2, 3] | Percent Escapement to Spawning Area |
|---|---|---|---|---|
| 1969 | 17,281 | 16,971 | 6,595 | 38.9 |
| 1970 | 50,218 | 49,478 | 18,600 | 37.7 |
| 1971 | 48,255 | 47,055 | 27,438 | 58.3 |
| 1972 | 32,404 | 31,904 | 15,463 | 48.5 |
| 1973 | 37,146 | 35,146 | 11,868 | 33.8 |
| 1974 | 17,000 | 16,500 | 8,870 | 53.8 |

Source: Allen and Meekin 1980

[1] After the Colville tribal fishery
[2] Including the Canadian tribal fishery
[3] Based on live counts and redd counts

## COMPARISON OF 1993 ESTIMATE TO 1993 WELLS DAM COUNT

The 1993 spawning ground escapement estimate of 21,505 sockeye is approximately 70% of the Wells Dam count of 30,860 (Klinge personal communication 1993). This difference is considerably lower than in previous years when the average difference between the Wells counts and spawning ground counts has been roughly 50%. One hypothesis is that the higher proportion is related to lower than normal temperatures and higher flows.

Water temperature data for the Okanogan River was available from Zosel Dam between July 9 and September 3, 1993 (Figure 3). Compared to water temperatures recorded at the dam during the same period in 1992, the 1993 temperatures averaged approximately 6.3°F cooler in July, and 2.4°F cooler in August. However, average water temperatures were slightly warmer (1.3°F) during the last ten days of August in 1993 than in 1992.

Sockeye migration past Zosel Dam showed a tri-modal distribution in 1992, corresponding with a drop in water temperature (Hatch et al. 1992). The results of the video survey indicated that sockeye passage increased as water temperatures decreased over several days, falling below 73°F. It appeared that during periods of stable water temperature or increasing temperature, fish passage was inhibited.

Based on the water temperature data for 1993, it is possible that a thermal barrier formed in the Okanogan River during the first week of August when average daily temperatures reached 73°F and above for five days. Temperatures declined through August until increasing near the end of the third week.

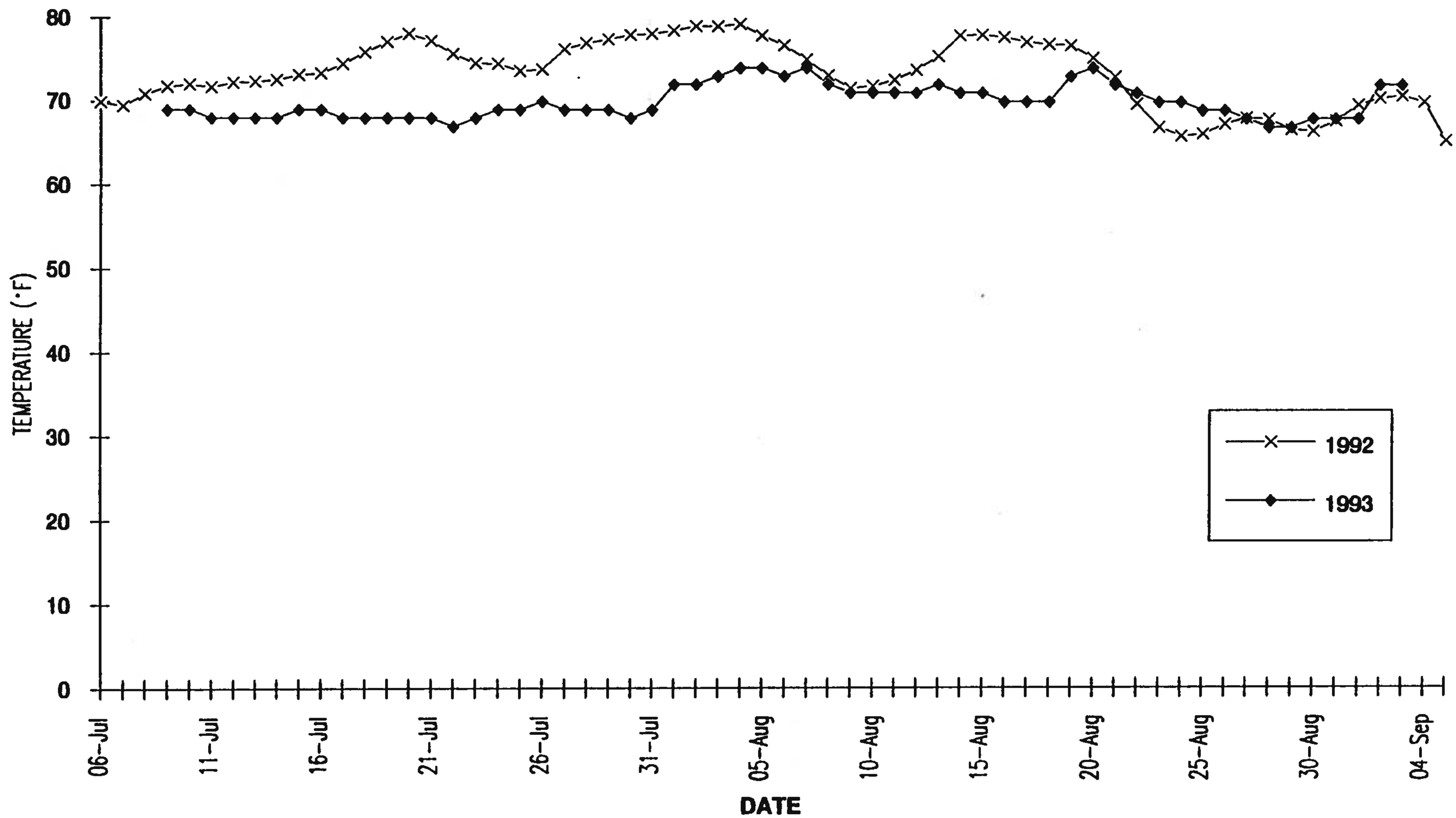
Although the numbers of fish counted at Wells Dam in 1993 was below the 10-year average of 36,422 (Fish Passage Center 1993), a larger proportion of the fish reached the spawning grounds than in previous years.

## EGG RETENTION

The results of the egg retention samples (see Table 4) indicate that spawning was successful for the majority of females. Although the sample sizes were small, it appears that spawning success was greater in 1993 than in 1992. In 1992, 148 females were examined for egg retention. Of the fish sampled, 73.6% were completely spawned, 25.7% were partially spawned, and 0.7% were unspawned (Hansen 1993). In 1993, the figures were 90%, 8.6%, and 1.4%, respectively. The higher spawning success in 1993 may be a result of lower water temperatures.

## SEX RATIO

In 1993, 55.3% of all carcasses examined were females (see Table 5). This ratio is based on approximately one half of the estimated total escapement. Based on a sample size of 406 fish in 1992 (approximately 2% of the total escapement), 42.2% of the fish on the spawning grounds were females (Hansen 1993).




Source: Douglas County PUD 1993

**Figure 3.**
**Okanogan River Average Daily Water Temperature at Zosel Dam for the Period July 9 through September 3, 1992 and 1993**

Spawning ground surveys by Allen and Meekin (1980) from 1971 to 1973 also showed variation in the sex ratio of the spawning population. Based on a subsample of the caracass population, the sex ratio ranged from 40.2% female in 1972 to 55.6% female in 1971.

## CONCLUSIONS AND RECOMMENDATIONS

The method is concluded to yield a reliable estimate of the spawning population. This conclusion is based on the numbers of carcasses marked, the numbers of carcasses examined, and the high confidence that the assumptions of the method were met.

The results of the study indicate that carcasses appeared on the spawning beds primarily between sampling period one and two, and between period two and three (see Table 2). Although the method does not allow preparation of a confidence interval for the population, the actual, but incalculable variance of the estimate would be reduced by adding more sampling effort in the time frame between periods one and three given the distribution of fish observed in 1993. Conducting a third sampling session during that two-week period would reduce the variance. Alternately, the variance could be reduced by using the same amount of effort, but allocating it to optimally reduce variance. Three sample units could be conducted during the first two weeks with the two remaining units conducted during the last three weeks of the spawning period.

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**WELLS PROJECT COORDINATING COMMITTEE**

**MEETING MINUTES FOR 1993**

**APPENDIX - H**

# WELLS PROJECT COORDINATING COMMITTEE
MEETING JANUARY 15, 1993
SUMMARY[1]

**Agreements Reached**

1. The committee asked Bob Heinith to further refine an overall study plan for sockeye enhancement, with objectives and sub-objectives identified. Comments should be sent to him by February 1, 1993.

2. The committee agreed that the spring chinook held at the Methow Hatchery should be transferred to the acclimation pond on the Methow.

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The committee met the afternoon of January 15, 1993 at the West Coast Sea-Tac Hotel. The agenda was mailed by Rick Klinge on January 4, 1993. Those in attendance are listed on the attached roster.

I. Joint Studies.

A. Predator Indexing. Klinge summarized the situation, explaining that a contract was being negotiated with the Washington Department of Wildlife for the study. It should be in place by February 1, 1993.

B. Status of spring/summer chinook telemetry study.

1. **Wells Stipulation.** Klinge noted that representatives of the fisheries parties had signed a revised version of the Stipulation. However, Douglas P.U.D. had some suggested changes in wording and asked if the committee could agree to them. The committee members pointed out that once the attorneys became involved, the biologists no longer had the authority to agree to any changes in wording. It would be necessary to have the attorneys review any changes. Klinge indicated that Douglas County P.U.D. would therefore go along with the wording as it existed in order to be able to proceed with contracting for the study in a timely manner. The radiotelemetry study should go to the P.U.D. Commission for approval at their January 23 meeting. He understands Grant P.U.D. commissioners will have it at the same time.

Ron Boyce observed that there will be some marked steelhead in the system in 1993 as a result of marking being done by Ted Bjornn for Snake River studies. He thought a study plan should be developed. The discussion led to a conclusion that some early steelhead would be observed during the chinook study by Lowell, but an extended period of monitoring would be required to cover the migration of steelhead. Any data should be sent to Bjornn for inclusion in his report.

II. Progress Reports on Wells Studies

A. Klinge distributed a report on the spring chinook spawning ground survey in the Methow River in 1992. 45% of the spawning was observed in the Methow, 25% in the Chewack, 19% in the Twisp, and 10% in the Lost River. Low water caused a redistribution of fish downstream, relative to

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1. Prepared by R. Whitney

other years.

B. **Adult Passage at Zosel Dam Using Video.** Bob Heinith distributed a report from CRITFC by **Doug Hatch**, Andrew Wand, Alicia Porter, and Matthew Schwartzberg. Passage occurs with decreasing water temperature, mainly at night from 10:00 P.M. to 6:00 A.M. At the Tumwater facility, on the other hand, movement is primarily during the day. There were 47,000 sockeye counted at Wells Dam. The upper range of the estimate at Zosel is 42,000. There was some spillway usage by fish that would not have been counted. Klinge said that next time they could monitor the spillway as well, with transducers placed by Biosonics, Inc. He would like to have one year of complete counts, and would like to do it this year. Heinith said that Doug Hatch would like to come and make a presentation to the committee at the next meeting.

C. Accelerated Smoltification of Spring Chinook. Klinge distributed a final report by Bob Sullivan on the study of accelerated smoltification of spring chinook in 1988 and 1989. [Note. The report contains no information on adult returns.]

D. Methow Hatchery Evaluation. A subcommittee is still developing agreement on an evaluation plan. Klinge reported that Bob Bugert and Jim Shackley of Washington Department of Fisheries are working with him on it, as is Tom Scribner of the Yakima Indian Nation. Although the plan has not yet been agreed upon, Douglas P.U.D. will proceed with trapping to get information that will certainly be part of the plan.

E. Okanogan Sockeye Enhancement Plan. The committee had asked Bob Heinith to draft a plan. He had mailed out a draft, which the committee discussed. Heinith hoped to prioritize some of the elements so that the work could proceed this year. Ron Boyce recommended that there be more action oriented items as distinguished from research oriented. Klinge noted with respect to the section in the draft calling for limnological studies that Jack Rensel had located data in Canada that he is using in his analysis of potential sites for a net pen operation. The Canadians have funds to collect the data, but not to analyze it. Jack will make some recommendations for future need for information related to sockeye enhancement. Rod Woodin suggested that the plan should have objectives for enhancement and sub-objectives. The plan needs to be more specific. Boyce said the plan should identify problems and opportunities. The committee decided to provide a time for written comments on Heinith's draft until February 1, 1993. Heinith will revise it based on the input. In the meantime, it was decided to proceed with some projects that the committee already recognizes as being needed.

F. Draft RFP's for 1993. Klinge reviewed the fact that at the last meeting the committee had agreed not to do the pit tag study of juvenile survival at Wells Dam in 1993, but to postpone decisions on other studies. Klinge now had RFP's for the study using video to estimate passage of sockeye at Zosel Dam, the spring chinook spawning survey, and the Okanogan spawning survey. He is planning to put these out for bid immediately, unless there are objections. There were none raised. There is also an interest in the estimation of the numbers of sockeye fry emerging into Lake Osoyoos. This proposal will be discussed later.

G. Okanogan Sockeye Enhancement. Klinge reported that the sockeye eggs hatched January 4 after 71 days of incubation. The opportunity to move them at the eyed egg stage was missed. They will be held at the hatchery until they reach the swim-up stage, which will probably be mid-March. Things are ready to receive them at the Cassimer Bar facility. The alarm system is being worked on. It will be in place by the time the fish arrive.

H. Other. Klinge called attention to a memo from Kathy Hopper of Washington Department of Fisheries, reporting on the operations at the Methow Hatchery. At the Twisp facility they have 36,000 fish on hand. At the Chewack they have 46,000 fish. The committee will receive a monthly report from her.

Woodin reported that surplus spring chinook were transferred from the Winthrop National Fish Hatchery to the Methow Hatchery to be sure that there were going to be fish raised there this year. Then sufficient numbers of adult summers were taken to eliminate the need for them. Mike Erho had suggested moving the spring chinook to the acclimation pond on the Methow. The committee agreed that was the most desirable proceedure, assuming the Winthrop Hatchery manager agrees. Klinge will check with the manager.

Klinge distributed a report on fyke netting at Wells Dam in 1992.

Meeting Summary of December 1, 1992 Meeting. Bill Hevlin provided a comment on the summary.

Next Meeting. The committee decided to wait until an agenda develops before scheduling another meeting.

ATTENDANCE ROSTER
WELLS PROJECT COORDINATING COMMITTEE
MEETING JANUARY 15, 1992

| Name | Representing |
|---|---|
| Rick Klinge | Douglas County P.U.D. |
| Ron Boyce | Oregon Department of Fish and Wildlife |
| Bob Heinith | Columbia River Intertribal Fish Commission |
| Rod Woodin | Washington Department of Fisheries |
| Tom Scribner | Yakima Indian Nation |
| Tony Eldred | Washington Department of Wildlife |
| Cary Feldman | Power Purchasers |
| Bill Hevlin | National Marine Fisheries Service |
| Richard Whitney | Chairman |

# WELLS PROJECT COORDINATING COMMITTEE
## MEETING MARCH 24, 1993
## SUMMARY[1]

**Agreements Reached**

1. The committee approved the bypass system operation plan for Wells Dam submitted by Douglas County P.U.D.

2. The bypass team for 1993 will consist of Rick Klinge, Bill Hevlin and Bob Heinith. Jerry Marco will be an alternate. Klinge will send to the bypass representatives a copy of Biosonics review of index monitoring at Wells Dam.

3. The proposed protocol for collection of chinook adults on the Methow will be reviewed by the committee and approved no later than May 1.

4. The committee agreed there should be counts of adults at the fish ladder 24 hours a day again in 1993. They asked for the counts to be made available to the coordinator.

5. There will be a site visit May 5, 6, and 7, 1993. The committee would like to see Dryden Dam, Rock Island intake screen, the Chewawa Weir, Wanapum Dam orifice test, the adult passage study, and for those able to include it, Cassimer Bar.

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The meeting was held at 11:00 A.M. in the West Coast Sea-Tac Hotel. The agenda was mailed by Rick Klinge on February 23, 1993. Those in attendance are listed on the attached roster.

I. 1993 Bypass Operation

A. **Bypass operation plan**. Klinge noted that Douglas P.U.D. had mailed out the bypass operation plan in December. The Settlement Agreement calls for it to be approved in March each year. Since December he has added the dates of April 15 and April 1 as the probable starting date for bypass operation and the date for commencement of monitoring respectively. Hevlin called attention to the memo he had sent out in which he called for bypass operation to begin when the index count reaches 100. Klinge responded that he felt that number was quite low and would not represent the beginning of the spring outmigration. In the past the team has looked for some indication of an upward trend in the numbers that would indicate movement of a significant body of fish as distinguished from small numbers that probably trickle through year-round. There was a discussion of criteria that might be used to decide when to begin bypass operation. It was decided to leave the matter to the bypass team.

B. **Bypass Team**. Members of the bypass team in 1993 are Rick Klinge, Bill Hevlin, and Bob Heinith. Jerry Marco will be an alternate. Klinge has

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1. Prepared by R. Whitney

a report from Biosonics that reviews the index counts they have obtained over the years. He will send copies to the bypass team members. Woodin noted that there will be potential for additional information on fish movement from the trap on the Methow.

C. **Acceptance of Bypass System by the Committee.** Klinge reported that he is asking Biosonics to provide a comprehensive final report. He wants to provide a single point estimate for bypass efficiency. The report in hand from John Skalski simply addresses the question whether the bypass meets the minimum criterion specified in the Settlement Agreement, which is a different question. Some of the committee expressed an interest in seeing a range of probable values of bypass efficiency. Klinge will talk to Skalski about providing both a point estimate and a range.

**II. Okanogan Sockeye.**

A. **Reports of 1992 Studies by Columbia River Intertribal Fish Commission.** Jeff Fryer reported on his sampling of sockeye in the mid-Columbia in 1992. Copies of a written report, "Identification of Columbia Basin Sockeye Salmon Stocks Using Scale pattern Analysis in 1992", by Fryer and Schwartzberg were distributed. They also provided copies of two reports on chinook, "Identifying Hatchery and Naturally Spawning Stocks of Columbia Basin Summer Chinook Salmon Using Scale pattern Analysis in 1992 and Age and length Composition of Columbia Basin Spring and Summer Chinook Salmon at Bonneville Dam in 1992." by the same authors. They found differences in age structure of sockeye sampled at Tumwater Dam versus those collected at Wells Dam. Lake Wenatchee has a higher percentage of sockeye of age 1.3 than Lake Osoyoos. The Wenatchee stock appears at Bonneville Dam somewhat earlier than the Osoyoos. At Bonneville 37% of the sockeye are Lake Wenatchee fish and 63% are Lake Osoyoos fish. Sockeye found in the Methow River are similar to Lake Wenatchee fish in age distribution.

Doug Hatch reported on the sockeye adult counting at Zosel Dam. They installed TV cameras on the east and west sides of the dam. They estimated 42,500 adult sockeye passed the dam between June and September. They continued the counts in October but observed no passage after September. Three peaks in passage were observed. The peaks correspond with drops in temperature. There appears to be an upper threshold, as no fish were counted above 73 degrees. The highest counts were at night, which is contrary to observations elsewhere. Apparently this also relates to water temperature. They would like to mark some fish in 1993 to track individuals. They would mark perhaps 100 per week for 4 weeks out of those handled at Wells Dam. Woodin would like to see a detailed study plan for the tagging, with objectives spelled out and a recovery plan. Klinge has received a proposal from CRITFC in response to the RFP for adult counting at Zosel Dam in 1993. He will send copies out to committee members. Shcwartzberg noted that the information has potential for recommendations on river management. Hevlin reported that he had attended a DOE meeting in Wenatchee on the subject of flow management and has notes he will share if others are interested.

B. **Studies Scheduled for 1993.** Klinge reported that RFP's are out. He has not talked to Jerry Marco and does not know the status of the fry trapping proposal. Other RFP's are the same as last year. The spill gates at Zosel Dam will be monitored hydroacoustically. Lowell Steuhrenberg's report will be available in draft by the end of April. Jack Rensel's report on water quality in relation to the sockeye net pens in Lake Osoyoos will be ready in two weeks.

With respect to reporting of completed projects, Heinith suggested that there might be a uniform due date for reports. Klinge thought that would not be practical because of the different durations of some of the projects. However, he recognized the problem that exists and will examine the due dates for reports specified in contracts and work with the contractors to obtain conformity.

C. **Response to Bob Heinith's Draft Plan of December 29, 1992.** Heinith reported that he has comments only from Hevlin. The committee agreed there was a need for the plan in order to become proactive. We need to get moving. Scribner commented that the plan should be developed as an umbrella. It should not be considered to be a proposal, but an outline. The need is to prioritize portions of it, based on the committee's judgement of likely payoffs in production. Heinith suggested proceeding with development of the framework and prioritizing later, after it is put together. Klinge observed that some of the elements might have national and some international aspects. He asked whether the plan should be designed just for the committee, or should it be larger in scope to these other aspects. The discussion led to the conclusion that members should provide their input to Heinith, and he should revise the draft based on the discussion. The question is how to select projects with the highest potential for payoff. This brought forward the need to specify goals in order to identify appropriate payoffs. Scribner said that from the tribe's point of view the goal should be to increase harvest in the lower river. Heinith will continue work. He observed that he might need a consultant at a later date, to help develop the prioritization procedure.

III. **Methow Operations for 1993.**

A. **Update on 1992 Brood Production.** Bob Bugert reported on the status of production at the Methow Hatchery. At the Twisp facility there has been less than 5 % loss. At the Chiwack it has been even less, and was due mainly to blank eggs. They were short on males during spawning. One of the females spawned was marked. The mark later identified her as being from the Lookingglass Hatchery. This puts them in a quandary as to what to do with her offspring, 2800 fry. Bugert asked the question whether it makes sense to take these extreme measures to purify stocks when mark recoveries show that there is straying. Since not all hatchery fish are marked, an unknown number of fish from other areas have probably been included in the spawning as well. There was a discussion of the question of what to do with the 2800 fry. Destroying them was considered. However, it was recognized that destroying them would be to discard the male contribution of genes from what was probably Methow stock. The decision was to ask the National Fish hatchery at Winthrop whether they would take the fish. Craig Tuss will make the inquiry and check with Washington Department of Fisheries as well. This solution led to a discussion of the fact that the objectives of the two hatchery programs are not compatible. The National Fish Hatchery makes no effort to segregate stocks and brings eggs from the Leavenworth Hatchery, while the WDF Hatchery, funded by Douglas P.U.D. goes to extreme lengths to segregate stocks. They are side-by-side. Bugert will meet with managers of the Leavenworth complex to resolve the issue.

B. **Draft Trap Protocol for 1993.** Bugert reported that the chinook hatched at Leavenworth have been transferred to the Methow acclimation pond and are scheduled for volitional release. He distributed a March 23 draft of a spring chinook hatchery brood stock collection protocol. He estimated that if they had collected all the fish that were trapped they could have gotten 30% of the run. He is concerned about taking a sample that might be too small, because it could include a biased sample of genes available and remove them from the population. If they are not able to collect enough fish in the trap, they would like to go on the spawning grounds to collect fish. Hevlin asked if they were certain that fish are getting past the weir. Bugert is certain. This year Douglas County P.U.D. will fund a sentry to observe fish bypassing the trap. Bugert asked the committee to approve the protocol for collection by May 1.

C. **Status of Traps.** Klinge reviewed the status of the Foghorn modifications of the ladder and trap. A permit hearing is scheduled for April 5. If bids are accepted this summer, the Fish and Wildlife Service will have it built this fall. The work at the Twisp trap will be completed in the next 2 weeks. A channel is being excavated to lead fish toward the trap entrance. At the Chewack there will be a flow control structure.

D. **Evaluation Draft Plan and Tasks.** Douglas P.U.D. has the draft and is working on it. The tasks identified as necessary will be undertaken before the agreement is in place. there will be trapping in the Chewack to establish base line measurements. They will obtain information on parr densities and fall outmigration of zero-age fish. There was a discussion of the questions remaining to be resolved. A subcommittee has been working on the evaluation plan. Klinge will send copies to the committee members for their information. Scribner reported on the smolt trap on the Chewack, which should be in place on Monday. It will be used to monitor smolts until the end of may or first of June when the outmigration is over. They will provide in-season reports. They will work with the Forest Service habitat assessment team to make fisheries production estimates. The idea is to produce estimates of standing crop similar to the approach being used in the Chiwawa River. They will continue those measurements until the river is iced up or there is no more fish movement. They will also do spawning ground surveys. Tom Meekin will return to do that work. To keep the committee informed, it was agreed that Scribner and Heinith would send Whitney a fax with the trap counts weekly for inclusion in the weekly report.

Bugert distributed a report with autopsy reports on 20 fish taken during outmigration. Organosomatic indices will be determined for smolts out of the three supplementation projects. DNA analyses will also be conducted.

**IV. Cassimer Bar Pilot Hatchery.**

A. **Status of the Facility.** The facility is fully operational. Changes are being made in the alarm system.

B. **Status of the Fish.** Klinge reported that the sockeye are at the facility and doing well. Personnel from the trout hatchery are taking care of them at the moment, but the tribe is hiring new people to do the job. On March 10 the fish were 2600 to the pound. Yesterday they were 1400 to the pound. They are being fed 8 times a day and are growing rapidly. The Fish and Wildlife Service pathologist has been checking them regularly. There has been no sign of IHN.

C. **Proposed 1993 Brood and Operations.** We need to hear from Jerry Marco as to his plans.

D. **Lake Osoyoos Net Pens.** We are expecting to receive a report from

Jack Rensel in the near future.

**V. Status of mid-Columbia Studies.**

**A. 1993 Spring/Summer Chinook Telemetry Study.** A coordination meeting is scheduled at Chelan P.U.D. tomorrow. Lowell Steuhrenberg is staffing up. The John Day trap is ready. We need the Section 10 permit.

**B. Predator Indexing.** Washington Department of Wildlife is getting equipment. They will start April 15 at Wells Dam. Poe would like to reduce spill at times to sample up against the Dam for an hour. There seems to be no problem with that.

**VI. Miscellaneous**

**A. Various Reports From Douglas P.U.D..** Klinge reviewed 24-hour fish ladder counts at Wells Dam in 1992. There was a higher than expected count during the night hours. Klinge will send the counts to the chair and others who want them. Hevlin asked Klinge to provide the data to the other P.U.D. biologists. The 24-hour counts may be especially important this year, during the adult passage study.

**B. Comment Period on Draft Reports.** Klinge reminded the committee that the deadline date for comments on the 1992 spring chinook spawning ground report and the Zosel Dam video passage study was March 15, 1993.

**C. Site Visit.** The committee decided to make a site visit May 5, 6, and 7, 1993. They would like to see the NMFS adult passage study, the Chiwawa weir, the Dryden ladder and trap, Rock Island intake screen, and Wanapum Dam orifice and FGE tests.

ATTENDANCE ROSTER
WELLS PROJECT COORDINATING COMMITTEE
Meeting March 24, 1993

| Name | Representing |
| --- | --- |
| Tony Eldred | Washington Department of Wildlife |
| Cary Feldman | Power Purchasers |
| Matthew Schwartzberg | Columbia River Intertribal Fish Commission |
| Craig Tuss | U.S. Fish and Wildlife Service |
| Bob Heinith | Columbia River Intertribal Fish Commission |
| Colleen Sullivan | Biosonics, Inc. |
| Rick Klinge | Douglas County P.U.D. |
| Rod Woodin | Washington Department of Fisheries |
| Bob Bugert | Washington Department of Fisheries |
| Doug Hatch | Columbia River Intertribal Fish Commission |
| Jeff Fryer | Columbia River Intertribal Fish Commission |
| Dick Whitney | The Committee |

Wells 93-3

# WELLS PROJECT COORDINATING COMMITTEE
## MEETING APRIL 16, 1993
## SUMMARY[1]

Agreements Reached

1. CRITFC would revise Task 6 of their proposed Sockeye Salmon Escapement at Zosel Dam study to tagging up to 200 sockeye during the first two weeks of the migration at Wells Dam.

2. WDF would resubmit a DRAFT Trapping Protocol for the Methow Complex to include suggested changes from the committee.

3. An in-season trapping sub-committee was formed to guide with brood collection decisions from the Twisp, Chewuch and Methow River sub-basins.

A conference call was called scheduled for the Wells Coordinating Committee for Friday, April 16, 1993 at 2:00 PM. An agenda was FAXed to the committee on April 14. Those in attendance are listed on the attached sheet to notes.

I. Video Monitoring at Zosel Dam

CRITFC Faxed to the WCC (4/14/93) a copy of a study they would like to pursue in addition to the video monitoring of sockeye passage scheduled for Zosel Dam in 1993. The proposal had four basic Tasks.

**Task** 1 required design modification and changes made to counting chambers used at Zosel Dam to improve video sampling of sockeye passage.
**Task** 2 required installation of chambers and cameras.
**Task** 3 is the sampling schedule for video monitoring
**Task** 4 tags 600 sockeye at Wells Dam over a period of five weeks. Tag color will change each week. Tags will be recorded by video image at Zosel Dam.
**Task** 5 Provide monthly reports from June through February
**Task** 6 Provide Progress Report by December 1 with final by March 1

Bob Heinith said that this project will help determine the timing and passage of sockeye to Zosel Dam after they leave Wells. This information was not available from the 1992 Sockeye Passage Delay Study using sockeye. A late start on tagging sockeye plus technical problems with tags precluded this information. Through another study on spawning ground escapement, tags could be recovered to estimate spawning success by week of fish passing Wells.

Rod Woodin said WDF has had difficulty at McNary with tag identification from video images. Colors are not very distinct. Rod also had diffi-

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[1] Prepared by R. Klinge

culty understanding how the information may be used. Doug Hatch said that they were able to identify tags in 1992 at Lower Granite.

Bill Hevlin recommended that the study be scaled down in 1993 to a total of 200 tags. If the program shows success, then increase the number of tags out for 1994. Klinge said the District will not be funding the Zosel video work in 1994. If the program is felt to have merit, funding would have to come from another source. Heinith emphasized the desire to collect information on the early portion of the sockeye run at Wells. Heinith proposed to place out no more than 200 tags during the first two weeks of the migration. This would allow for some information to be collected on the early portion of the sockeye run. The WCC agreed to the modification of Task 4 as proposed by CRITFC.

II. Methow Complex Brood Collection Protocol

Bob Bugert had submitted to the WCC a DRAFT Trapping Protocol for 1993, dated March 23, 1993. The protocol discussed goal collection numbers from the traps at the Twisp and Chewuch Rivers. Also a proposed collection of brood from spawning areas from the Methow River.

Bill Hevlin said he would not be able to support collection of 100% of the fish collected from the Twisp trap. He recommended that the plan start out at 33% and build to 50% after it could be shown that fish were jumping the trap. The WCC felt that a sub-committee to deal with the 1993 protocol should be established to put together a plan. Those on the committee were Bob Bugert, Tom Scribner, Bill Hevlin and Rick Klinge. This group will act to adjust the percent of fish collected from the traps during the brood collection.

Klinge asked that once fish are collected from the traps and held at the hatchery, that they not be returned to the river. Adjustments in the proportion collected from the traps should be made in order to not exceed the 33% of escapement goal for brood. escapement at the trap would be a combination of counts into the trap plus those fish that jump the floating panels. A 24 hour sentry will be posted to asses jumping activity at the weir. Night counts will be made by infra-red cameras. Hevlin was opposed to gaffing as a means to collect brood. Scribner had concerns with gaffing from his observations on the Chiwawa in 1992, though said was uncommitted at this point. Tom Scribner felt that a portable collection facility may be incorporated in the Methow this year for broodstock. Klinge felt that some limited gaffing should be allowed for the Methow portion of the program. A response from the sub-committee concerning the gaffing issue will be issued to WDF before June 1.

III. Other issues

A. 1993 Brood Collection Protocol for Okanogan sockeye
Rod Woodin asked when we would see a Brood Collection Plan for the 1993 Sockeye program. Jerry Marco mentioned this is currently underway and should be ready for distribution soon.

B. Methow Juvenile Smolt Plan
Rod Woodin requested that the Yakima Tribe provide the WCC a copy of

their work plan for the 1993 smolt out migration on the Chewuch River. Scribner will make this available to the WCC soon.

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Wells Coordinating Committee (93-3)
Meeting April 16, 1993
Attendance Sheet

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|---|---|
| Tony Eldrid | Washington Department of Wildlife |
| Cary Feldmann | Puget Power |
| Bob Heinith | Columbia River Inter-Tribal Fisheries Commission |
| Jeff Fryer | Columbia River Inter-Tribal Fisheries Commission |
| Doug Hatch | Columbia River Inter-Tribal Fisheries Commission |
| Matt Schwatzberg | Columbia River Inter-Tribal Fisheries Commission |
| Bill Hevlin | National Marine Fisheries Service |
| Jerry Marco | Colville Confederated Tribes |
| Tom Scribner | Yakima Indian Nation |
| Rod Woodin | Washington Department of Fisheries |
| Bob Bugert | Washington Department of Fisheries |
| Rick Klinge | Douglas County PUD |

# WELLS PROJECT COORDINATING COMMITTEE
## MEETING MAY 27, 1993
## SUMMARY[1]

**Agreements Reached**

1. The committee agreed to participate in a telephone conference call at 10:00 A.M. Tuesday June 1, 1993 to discuss further the protocol for collection of sockeye brood stock for the Cassimer Bar study.

2. Several committee members expressed their desire that no spring chinook brood stock be taken off the spawning grounds in the Methow this year. Because there is no trap there, this effectively means there will be no supplementation program this year.

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The meeting was held in conjunction with the meeting of the mid-Columbia Coordinating Committee meeting at the West Coast Sea-Tac Hotel on May 27, 1993. Those in attendance are listed on the attached roster. The agenda followed was mailed to the committee on May 17, 1993.

I. 1993 Bypass Operation

A. Bypass Operation to Date in 1993. Rick Klinge reported that the bypass began operation, as agreed by the designated representatives, on April 14 and was reduced to night-time only operation on April 16. On April 18 it was put into full 24 hour operation and has continued in that mode.

B. Criteria for Termination of Spring Operation. Klinge expressed concern about the difficulty the designated representatives were experiencing in agreeing on criteria for deciding when to discontinue operation of the bypass for the spring period. He wanted to take a sample of fish with fyke nets to determine species composition of juveniles passing the project. The other representatives did not agree because they thought it was still too early. They wanted to wait one more week to avoid sacrificing more fish. No sample was taken. He asked for help from the committee. Woodin suggested using a combination of the hydroacoustic index to measure relative abundance and fyke netting to determine species composition as in the past. However, he feels it is innappropriate for the committee to become involved at this time. He suggested the dispute resolution section of the Settlement Agreement be used if the representatives cannot agree. There were some methods suggested for analysis of run timing, such as cumulative plots of the hydrocaoustic index, that might help the representatives reach a decision.

II. Methow Operations for 1993

A. Update on 1992 Brood Production. Klinge said that we should soon be getting the reports from Bob Jateff, the hatchery manager.

B. Draft Trap Protocol for 1993. The committee decided to deal with this matter in the ad hoc committee on brood stock protocol. Hevlin pointed

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1. Prepared by R. Whitney

out that the traps on the Chewack and and Twisp need changes. The efficiency of the weir on the Twisp needs to be reassessed. There is a concern that there should be an ability to trap throughout the run in order to avoid possible undesirable genetic effects. He realizes that Steve Rainey had advised the committee early in the process that there was no known way of operating a trap that would be acceptable to the public and/or agencies in the high flows seen in these tributaries. However, perhaps there have been improvements in technology, such as the rubber dam at Dryden, and the improved weir on the Chiwawa that will accomplish what is desired. At the Chewack there was a breech in the dam and the upper end of the takeoff for the irrigation ditch, which should be repaired. There is also a need for better attraction water at the Denil there. He referred to his memo to the committee that included suggestions on these points. Woodin, pointed out that it seems likely fish can negotiate the dam itself, so additional attraction water at the ladder would probably not make any difference.

III. Cassimer Bar Pilot Project Hatchery. Jerry Marco reported that Lake Osoyoos is warming up and the sockeye need to be introduced. They expect to release them in the next day or two. He distributed a proposal for a brood stock protocol for collecting adult sockeye in the period between July 8 and August 16. That interval on the average encompasses 80% of the duration of the run. The proposal is to take the fish at Wells Dam in the Eastbank trap. Rod Woodin expressed appreciation for the opportunity to review the protocol. He suggested that there be discussion about connecting the whole program. This is a pilot effort and the primary question is can the desired size of 25 fish/lb be achieved? Jerry replied that the fish being released will be close to that size. In future they will have 4 more weeks of rearing at Cassimer. The release date hinges on when the limnology of the lake dictates the temperature limit has been reached for sockeye. Woodin asked for clarification on where the adults would be held. There is a facility at Cassimer where they could be held. There was discussion of the temperatures expected there and whether they might be comparable to those experienced this year. Jerry was asked to provide some additional written description dealing with those matters. The committee agreed to talk further on the subject during the telephone conference call on Tuesday June 1.

IV. Eastbank Ladder at Wells Dam. Klinge described the problem that had been discovered by Lowell Stuehrenberg's crew early this spring as they installed receivers for the radiotelemetric study of adult passage. The diffusion grating had fallen into the ladder. He distributed a written summary of steps taken by Douglas P.U.D. to repair the system. A copy is attached here.

He said that Douglas P.U.D. will take down both ladders annually for inspection. Every second year they will shut down and clean the ladder. They will initiate a training session for the operating crew, who are new at the job. They hope to avoid such problems in the future. Woodin noted that he thinks that at some of the other mid-Columbia projects operators inspect the ladder daily. Hevlin suggested bringing Larry Basham up to help train personnel.

V. Miscellaneous.

A. **Draft 1992 Okanogan Sockeye Spawning Ground Surveys**, Klinge said that this draft report is in the mill and should be distributed soon.

B. Draft Sockeye Salmon Enhancement with Net Pens in Lake Osoyoos. Copies of the report prepared by Jack Rensel had been mailed to the committee. Klinge feels that the report is very thorough. It should expedite the issuance of permits.

C. Other.

OWL. Klinge had sent copies of correspondence from OWL expressing conern about the supplementation plan for chinook in the Methow. Scribner said that Dale Bambrick of the Yakima Nation knew the people and would talk to them about the situation. Woodin said WDF would draft a letter in response and have the committee look at it before it goes to OWL.

Bypass Evaluation. Klinge distributed a draft report by John Skalski that is a supplement to the one he previously provided. This one addresses a different question than the first one. This one addresses the question of what can be expected from the bypass in future operations in terms of its passage effectiveness.

Plan for Evaluation of Hatchery/Supplementation Program. Woodin called attention to the need to have in a place an evaluation plan that is signed, sealed and delivered. Klinge responded that Douglas P.U.D. has the draft and has discussed some problems with Bugert. Although there is no agreement in place, Douglas P.U.D. is proceeding with some things that undoubtedly will be needed. The evaluation subcommittee has agreed that these should go ahead. Woodin expressed the opinion that there is no good basis for proceeding without an overall plan. Furthermore the ESA process requires documentation that there will be an evaluation of measures that are taken.

VII. Discussion on Supplementation Program (Heinith Memo). Bob Heinith had sent a memo containing recommendations on the Methow supplementation issue. These were discussed by the committee. (1) Heinith recommended no gaffing, netting or other harrassment of adults on the spawning grounds. Scribner said that this issue has attracted a lot of attention in his agency. The final decision was in agreement with the recommendation. He noted that there might be a special case that should be dealt with on an individual basis by the ad hoc sub committee on brood stock protocol. An example might be the taking of an individual male that might be found in a location separated from actively spawning fish. He is a member of the ad hoc committee and will work through that group. Klinge noted that this means there will be no spring chinook taken from the Methow this year, since there is no trap in place. Woodin said all of us have concerns of various sorts, if not with respect to direct effects then with respect to collateral effects. There is some risk involved no matter what we do - even if we do nothing.

(2) Heinith recommended 24 hour monitoring of tributary traps. Klinge said that is being done on the Twisp. Scribner pointed out that from the looks of the photographs Rick had shown, fish would not be using the ladder at Fulton Dam so there would be little point in monitoring the trap, which is in the ladder. Probably increased observations would be warranted. He will talk to Joel Hubbell about communicating with Bob Jateff if they see fish in the trap.

(3) There should be immediate correction of known trap deficiencies. (e.g. The Chewack Trap). Klinge asked Scribner if the trap was damaged. He

replied that it was not damaged. There was a large rock at the base of the dam that moved during the high flow period. It has blocked the attraction water to the Denil. Apparently Heinith is referring to the memo of Hevlin. Klinge said that Douglas P.U.D. would look at the situation as soon as possible. They probably will not be able to get in the stream to move rocks around for some time. The possible need for a hydraulic permit was discussed. Since it would be an emergency repair, perhaps a permit would not be required. Woodin commented that repairs or changes made should depend on the results of this years work. The whole program in the Methow might require identification of alternatives.

(4) Not concentrating take of adult broodstock at tributary traps at one time. The committee agreed this matter is dealt wiith in the protocols that are developed. The ad hoc committee is taking this factor into account.

ATTENDANCE ROSTER
Wells Project Coordinating Committee
Meeting May 27, 1993

| Name | Representing |
| --- | --- |
| Jerry Marco | Colville Tribes |
| Lowell Stuehrenberg | National Marine Fisheries Service |
| John Loch | Washington Department of Wildlife |
| Rod Woodin | Washington Department of Fisheries |
| Bill Hevlin | National Marine Fisheries Servie |
| Brian Cates | U.S. Fish and Wildlife Service |
| Tom Scribner | Yakima Indian Nation |
| Richard Whitney | The Committee |
| Rick Klinge | Douglas P.U.D. |

# WELLS PROJECT COORDINATING COMMITTEE
# MEETING JUNE 1, 1993
# SUMMARY[1]

**Agreements Reached**

1. The committee approved with some modifications, the protocols for collection of brood stock for the supplementation projects. The committee agreed there should be no gaffing, netting or other taking of brood stock from the spawning grounds.

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The meeting was held by telephone conference call at 10:00 A.M. June 1, 1993, as agreed at the May 27, 1993 meeting. Participating were Rick Klinge, Douglas P.U.D.; Cary Feldman, Power Purchasers;, Jerry Marco, Colville Confederated Tribes; Bill Hevlin, NMFS; Brian Cates, USF&WS; Rod Woodin, WDF; Bob Bugert, WDF; Tony Eldred, WDW; Tom Scribner, Yakima Indian Nation; and Richard Whitney, Chair.

Protocol for Collection of Brood Stock

Wells Summer Chinook. Scribner expressed concern about the low percentage of the run being used for brood stock. However, he will deal with that problem in the ad hoc trapping group. Bob Bugert said the proposal is to collect marked fish in the east ladder at Wells Dam to estimate stray rates and develop an estimate of contribution of hatchery fish. They will read the coded wire tags prior to fertilization in order to eliminate strays. They want to have an external mark on Carlton and Similkameen releases so that strays at Wells can be more readily identified. The alternative would be to pass all the fish upstream. After discussion it was decided that such strays are part of the natural process so they should not be excluded. It was decided they would not sort to exclude marked fish. Bugert will keep people advised of developments. The hatchery crew wants to be able to collect the fish on one day out of the week, if this proves to be possible, rather than spread the catch over the entire week. It was recommended that the collection of sockeye should take place at the same time and also in one day if possible.

Cassimer Bar. Jerry Marco expressed concern that there might be more prespawning mortality for adult sockeye this year than last year because the water temperature will probably be warmer at Cassimer Bar. It is 54 F at Cassimer Bar. He thinks it was cooler at the Methow Hatchery last year. There was a discussion as to whether additional brood stock should be taken to allow for that possibility. It was pointed out that last year, due to the preponderance of females in the collection, excess eggs were taken. The same might occur this year. The protocol specified collection of sockeye 3 days in the week. The committee agreed that an effort should be made to collect the sockeye and chinook at the same time in 1 day per week. Jerry Marco said they would proceed by taking 60 fish per day rather than the 20 specified in the protocol. There will thus be a total of 5 trapping days over 5 weeks.

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1. Prepared by R. Whitney

Methow Spring Chinook. Klinge said he favored supplementing the collection of brood stock from the spawning grounds by gaffing or some other method. Scribner said his agency is opposed to that out of concern that spawning fish would be disturbed. Jerry Marco said the Colvilles are also opposed to it. It was noted that Heinith had raised a similar concern. Klinge indicated that if brood stock are not collected in that way, there will be no Methow Program this year. Douglas P.U.D. is not exerting pressure just to fill the hatchery, but wants to fulfill its obligations. The P.U.D. would like to have some communication on this matter from those who are concerned. Scribner indicated that there might be some flexibility depending on circumstances. For example, it might be acceptable to take an isolated male or two if they could be found away from primary spawning areas. He will provide input to assist in making decisions through the ad hoc trapping group as the season progresses . [This group was formed by Klinge in a memo to the committee.] Marco agreed to that procedure. Woodin pointed out that the probability of successfuly collecting the brood stock under these conditions is practically nil. Hevlin suggested that down the road better traps and weirs might provide the solution to this problem. Bugert noted that there are adult chinook that spawn in the outfall to the hatchery. There could be 3 to 5 adults captured from that location. The committee agreed those fish should be used for brood stock. Bugert said he would revise the protocol to eliminate the collection of brood stock on the spawning grounds.

# WELLS PROJECT COORDINATING COMMITTEE
MEETING JUNE 1, 1993
SUMMARY[1]

**Agreements Reached**

1. The committee appointed Washington Department of Fisheries and Douglas County P.U.D. representatives to work with the Fulton Irrigation District to plan for the renovation of the takeoff for the canal at Fulton Dam. NMFS will be consulted.

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The meeting was held following the meeting of the mid-Columbia Coordinating Committee at 12:30 P.M. June 30, 1993 in the Tacoma Room at the West Coast Sea-Tac Hotel. Those in attendance are listed on the attached roster. The agenda followed was mailed to the full mailing list on June 22, 1993.

I. Status of Joint mid-Columbia Studies.

A. Radiotelemetry study of spring and summer chinook. Progress in this jointly funded study is reported in the mid-Columbia Coordinating Committee meeting summary.

B. Predator indexing. Progress in this jointly funded study is reported in the mid-Columbia Coordinating Committee meeting summary.

II. 1993 Bypass operation.

A. Spring bypass operation. Klinge summarized the schedule for bypass operation as agreed upon by the designated representatives during the spring outmigration. Operation began April 14 based on a rise in the hydroacoustic index and the anticipated arrival of hatchery chinook and extended for 55 days. Operation of the bypass used 6.5% of the river flow in spill. There was no inadvertent spill, but some energy transfer spill did take place as BPA made efforts at their projects to reduce nitrogen supersaturation.

B. Summer bypass operation. Klinge reported that the summer period of operation began June 22 after a two week break.

III. Methow operations for 1993.

A. Update on 1993 brood trapping. Klinge distributed a written report from Bob Jateff, the hatchery manager. There are "mystery fish", 22 chinook that have come to the hatchery effluent water. The mystery is what their origin and destination might be. No returning fish are expected yet from any releases there. As agreed at the previous meeting, these fish will be used as brood stock.

Rod Woodin presented a memo from Bob Bugert in which he discussed modifications of the Fulton Dam. The left bank of the tailrace, the canal, and the dam itself were severely eroded during the spring runoff. The Fulton Irrigation District will need to repair their canal and intake structure. There is a need to coordinate that work with repair of the dam and modification of the adult trap. The committee appointed representatives

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1. Prepared by R. Whitney

from Douglas P.U.D., and Washington Department of Fisheries to work with the Fulton Irrigation District to plan for renovation of the canal and perhaps the dam. Hevlin asked that NMFS be kept informed and consulted on the fishway.

B. Hatchery evaluation progress. Klinge said that Douglas P.U.D. has the draft and will respond to the subcommittee by early August. The problem has been to find time to review it, not that the P.U.D. has a particular objection to it. Meantime, the P.U.D. is funding the things that are basic to the evaluation. The ensuing discussion emphasized the need for an agreed upon plan at an early date. Klinge agreed it is time to move ahead.

C. Status of Foghorn trap process. Klinge reviewed the situation on the trap. OWL has appealed the decision on the permit. A prehearing conference was set for July 22. The P.U.D. requested that it be set forward to July 8. The HPA time window for construction is limited. There is in place a cooperative agreement between the P.U.D. and the Fish and Wildlife Service. The Fish and Wildlife Service has a contractor lined up to do the work. Their estimate from a minority contractor is $1.2 million. The agreed upon cost is $0.5 million. It does not seem likely that any work will take place this year. It probably will be delayed a year.

D. Other. The committee discussed possible modification of the Twisp weir to follow the design used at the Chiwawa. There was a discussion of the pros and cons. One of the panels at the Twisp weir was out of alignment, having lost its buoyancy. Hevlin noted the advantage of the Chiwawa design with hydraulic arms that raise the pickets, rather than depend on floats. Klinge thought that the Twisp weir might prove to be satisfactory for its purpose.

Sockeye. Jerry Marco reported that when they take the spawners they plan to test for IHN. They will isolate the lots of eggs and be prepared to take some steps if any of the tests come back positive. However, they have limited space for fry. When it becomes necessary to pond the fish they will not have enough space to continue to separate the lots. They propose to test the juveniles too. If the juveniles are free of infection, they will be able to combine the lots. He asked for committee approval. Woodin responded that at Eastbank they disinfect the eggs. They once took eggs from females that tested positive, but the fry did not test positive. He noted that if any fry at Cassimer Bar test positive they should follow the state-wide protocol and destroy that group. The committee agreed to the plan, with that understanding.

Radiotelemetry Study in 1992. Klinge observed that the committee does not yet have a report from NMFS on the radiotelemetry study of sockeye at and above Wells Dam in 1992. He realizes that Lowell and his staff have been spending a lot of time in preparation and execution of the chinook study this year, and that the sockeye report has been temporarily pushed to the back burner.

ATTENDANCE ROSTER
Wells project Coordinating Committee

Meeting June 30, 1993

| Name | Representing |
| --- | --- |
| Rick Klinge | Douglas County P.U.D. |
| Cary Feldman | Power Purchasers |
| Bob Heinith | Columbia River Intertribal Fish Commission |
| Jerry Marco | Colville Confederated Tribes |
| Bill Hevlin | National Marine Fisheries Service |
| Rod Woodin | Washington Department of Fisheries |
| Richard Whitney | Chair |

# WELLS PROJECT COORDINATING COMMITTEE
# MEETING OCTOBER 12, 1993
# SUMMARY[1]

**Agreements Reached**

1. There was a difference of opinion over the appropriateness of the process used by Douglas County P.U.D. in which a contract for a spawning ground survey was awarded. Douglas P.U.D. felt that since the committee had reviewed the request for proposals and there were only two proposals submitted in response to the request, Douglas P.U.D. was free to award to either of the two based upon Douglas' criteria. Bob Heinith of the Columbia River Intertribal Fish Commission felt that the committee should have been asked to review the specific study proposals submitted by the respondents, and provide technical comments and recommendations. It was agreed that in the future, the committee will have the opportunity to review and rank the responses to RFP's, but that Douglas P.U.D. retains the right to award the contract for the work to one of those ranked, based on appropriate criteria.

2. The committee agreed to continue to work on a long-range sockeye enhancement plan. Members will provide to Bob Heinith suggestions and comments on a draft of a plan he prepared in December, 1992 for discussion at the next meeting.

3. Douglas County P.U.D. will send to the members copies of a table prepared by John Skalski last year that indicate the numbers of pit tagged fish required to be released based on expected recovery rates at McNary Dam for various levels of precision in estimating project mortality or turbine mortality at Wells Dam.

4. The committee agreed to meet again November 15, 1993 at Sea-Tac.

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The meeting was held in conjunction with the meeting of the mid-Columbia Coordinating Committee meeting at the West Coast Sea-Tac Hotel on October 12, 1993. Those in attendance are listed on the attached roster. The agenda followed was mailed to the committee on September 17, 1993.

## I. Status of 1993 Operations

A. **Bypass Operation.** Rick Klinge distributed copies of a summary of 1993 bypass operations, showing hydroacoustic index counts and the bypass operating schedule, as agreed upon by the bypass team. Klinge noted that an index count of 100 was used as a basis for the decision to begin operation of the bypass. Heinith noted that the number 100 was arbitrary. It may differ from year to year, depending on run strength and other factors. Hevlin observed that the purpose in going with the 100 number was to have the bypass operating when the major segment of the outmigration began,

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1. Prepared by R. Whitney

rather than wait to see it begin and then start the bypass. Operation began on a part-time basis until the numbers increased. Klinge will provide a bypass operating plan for 1994 at the next meeting.

B. **Hatchery Operations.** Rod Woodin provided from Bob Jatef, a summary of July and August operations at the Methow Hatchery. Rick Klinge also provided a handout from Heather Bartlett, the September Methow hatchery evaluation report. Bob Bugert provided a handout, a copy of a report to Kathy Hopper expressing his concerns about the source of broodstock for the spring chinook at the Methow Hatchery. He observed that there are a large number of unmarked spring chinook returning to the Methow from releases out of the Winthrop National Fish Hatchery. The plan for the Methow Hatchery is to collect wild (unmarked) spring chinook from the mainstem for broodstock and to allow hatchery fish to proceed upstream. Realistically, they collect a mixture of wild and hatchery fish. Hatchery fish occur in all of the tributary stocks, namely the Chewack, and Twisp. He recommends that the Winthrop and Methow hatchery stocks be treated as one stock, that they take no foreign gametes from now on. (i.e. from Leavenworth Hatchery, which was a source of eggs for the Winthrop Hatchery for many years.), and that development of the upstream trap at the Foghorn diversion be deferred. There was a discussion of the 7 recommendations in Bugert's proposal. Klinge reminded the committee that as originally planned, the Methow program would take no $F_1$ fish through the hatchery. They would use only wild stock. Bugert asked the members to consider whether this is a change in the program brought about by inability to identify wild fish. He is in favor of using fish of the Winthrop stock for this year and specifically of using volunteers into the hatchery channel. He also favors pulling back on the Foghorn project until this issue is resolved. He feels the committee should investigate the possibility of releasing fish further upstream to encourage broader distribution of spawning. Woodin feels that we need a better understanding of what is being produced naturally upstream. Bugert suggested that electrophoretic studies of fish upstream and of Winthrop fish might shed some light on the question whether there are some differences that ought to be preserved. He indicated there appears to be some difference between the Winthrop chinook and those in the Twisp. Scribner feels that we need more information on those upstream fish, such as their spawning time and other phenotypic characteristics. The committee decided to study the proposal in Bugert's memo and to make a decision at the next meeting.

Tony Eldred reported that one pond of steelhead at Wells Hatchery has become severely infected with eye flukes. The other two ponds have a milde infestation. There are 150,000 to 200,000 fish in the affected pond. The extent of predation on these fish may determine whether WDW can meet the objective for release. The problem stems from the fact that normally the ponds dry out during the summer, which kills the snails that are the intermediate host of the parasite. However, due to the wet, cool period in early summer this year, the ponds retained puddles that were refugia for the snails.

C. **Cassimer Bar**. Rick Klinge reported that the Colvilles are collecting sockeye at the right bank fish ladder at Wells Dam. There have been 211 adults collected in 4 weeks. Prespawning mortality has reduced the number by 23. last Wednesday they spawned 3 females.

D. **Adult Trapping**. Hevlin referred to a memo in which he proposed modification of the Twisp weir. The memo is to be regarded as a starting point for discussions on ways to increase trapping efficiency. Klinge said he wants to study the matter and discuss it further at the next meeting. Woodin noted that WDF would like some modification of the Chewack trap as well.

E. **Spawning Ground Surveys**. Scribner provided a summary of the spawning ground survey. There were 617 total redds in the basin, of which 83 were in the Chewack, and 290 were in the mainstem. The number in the mainstem is high relative to past experience. It appears the situation might be similar to that in the Chiwawa where fish blocked by the weir have moved into other areas to spawn. Hevlin noted that there did not appear to be any such displacement last year. Brian Cates observed that part of the explanation for the higher mainstem numbers could be that the Winthrop Hatchery had a higher return than usual.

Bob Heinith referred to his letter of August 20, 1993 to Rick Klinge in which he expressed concern about the process used to award the contract for spawning ground surveys in 1993. He felt that Douglas County P.U.D. had not obtained adequate input from the committee prior to awarding the contract, as is specified in the Wells Project Settlement Agreement. Specifically, he felt that the committee should have had the opportunity to review the individual proposals prior to the award. Bob Clubb responded for Douglas County P.U.D. with a letter to the chairman of the Wells Project Coordinating committee dated September 3, 1993 in which he questioned Heinith's interpretation of the situation. Klinge observed that the committee had reviewed the request for proposals on the spawning ground survey prior to its being sent out to prospective contractors. Only two proposals were received, one from the Colville Tribe and one from Parametrix Inc. In his view, the two were similar except as to cost. He felt that, under the circumstances, committee review was not necessary. However, he apologized for not advising the committee of that conclusion. Klinge said that from his point of view the Colville's did a good, professional job last year. They have produced a draft report. The award to Parametrix was made based on the lower cost. He understands the interest of the committee in seeing the specific proposals. He will distribute copies. He will do a better job of keeping the committee informed in the future. Bob Clubb agreed that Douglas P.U.D. will allow the committee to review specific proposals received, but that Douglas P.U.D. had to reserve the right to make the final decision on award of contracts. Hevlin said he liked the process that was used last year where the names were removed from the proposals and the committee rated them. Whitney acknowledged that as chair, he had a responsibility to be certain that the committee is informed as to actions that are taken. He will do better in the future as well.

Bob Clubb emphasized that communication within the committee is the proper procedure to follow when problems or differences arise. He pointed out that Heinith had sent copies of his letter to the Manager of Douglas County P.U.D., to Douglas County P.U.D.'s attorney and attorneys for the other parties, as well as to Judge Grossman. The Manager felt obliged to share it with the P.U.D. commissioners who became concerned. They feel the P.U.D. will have to respond in some way. In particular, they feel that it was a breech of the terms of the Settlement Agreement for Heinith to communicate directly with FERC, rather than using the Wells Project Coordinating Committee or provisions for dispute resolution in the Settlement Agreement.

[The chair has been unable to obtain agreement on the following sentence. The chair's original version read as follows: "Heinith acknowledged that his approach had been irregular". Bob Heinith's recollection is that he "..acknowledged his approach had been direct because of his concern over the process and said it will not occur again in the future." Douglas County P.U.D. representatives agreed with the chair's first version.] The committee members agreed to strive for better communication in the future.

F. **Adult Sockeye Passage Study in 1992.** Klinge reported that the Intertribal Fish Commission had conducted a passage study using video cameras at Zosel Dam. The flows were higher than last year. They reached as high as 2,000 cfs. As a result the spill gates were out of the water during the migration. In the period July 8 to August 14 only 144 sockeye were seen. Biosonics are also analyzing their data from the spillway area. River conditions were unfavorable for counting the fish this year.

Lowell Steuhrenberg said his staff is working on the report of the radio tracking study of sockeye in 1992. He expects to have a draft available in November.

G. **Other.** Hevlin said he would like to see some sampling at the drop structures on the Canadian side of the border to see when sockeye might move into the lake. The information obtained would also help the Canadians decide when the irrigation removals might begin. Klinge said he would have something for the committee to review at the next meeting.

**2. Status of Future Operations**

A. **Sockeye Plan.** Bob Heinith distributed copies of the draft plan he had circulated in December, 1992. He had received comments from Hevlin and no others. The committee agreed to provide comments prior to the next meeting and to discuss the plan further at that time. The committee agrees there is a need for such a plan.

Hevlin asked whether it would be possible to mark all sockeye released from enhancement operations in order to be able to identify them when they return. Klinge recommended that the Colvilles look into it. Woodin reminded the committee that there is a need for a production plan for the 1993 brood. There has been a siting study, but he is not aware of a decision made on where to put the net pens. Klinge said that the draft report had been available for the 60 day period for comment. Since no comments had been received, Douglas P.U.D. is proceeding with the location recommended by the consultant, Smith Cove. The consultant is working with Okanogan County to obtain the permits. The P.U.D. is working to obtain access to the site.

B. **Hatchery Evaluation.** Klinge said that the evaluation subcommittee had met. They are reassessing what has been done to date in developing the evaluation plan. They have another meeting scheduled this month. Bob Bugert has been asked to draft an outline for the group to discuss. They are looking at new approaches. They began with the idea of using Chelan's evaluation plan as a guide. However, they have decided that the only part of it that is applicable is the part dealing with performance within the facility. They also found that the Snake River Compensation Plan was not an appropriate model to follow.

Bob Clubb raised the point that when it comes to the actual evaluation, Douglas P.U.D.'s commissioners are questioning whether Washington Department of Fisheries are in a good position to evaluate their own facility. There might be an appearance of conflict of interest. Bob Bugert responded that Chelan P.U.D. had raised the same point. Chelan has various consultants doing parts of the evaluation. They will then have an independent contractor conduct the actual evaluation based on the data collected. Clubb asked the committee to be aware of the potential problem in the case of Douglas County P.U.D. and to consider ways to provide for an outside review, to avoid the potential for an appearance of a conflict of interest. Bugert offered to send committee members a copy of his response to Chelan when they expressed concerns along these lines. Clubb thought that would be helpful.

C. **Bypass Operating Plan for 1994**. Klinge said that he would have a draft operating plan ready for discussion at the next meeting.

D. **Other**. Hevlin wondered whether it was time to proceed with the project mortality study referred to in the Settlement Agreement. There was a discussion of the distinction between a turbine mortality study and a project mortality study. If the committee has accepted the results of the bypass evaluation, there is little room for turbine mortality, and the main components of the project mortality would be reservoir and tailrace mortality. Woodin observed that the Settlement Agreement specifies that the purpose of the study is to adjust the level of compensation if necessary. We don't have the existing compensation package fully underway as yet, so it seems to him to be premature to try to attempt fine tuning of the package. He felt it would be useful for the committee to review the tables that were prepared by John Skalski some time ago when the committee was considering a study using pit-tagged fish. The tables showed the number of fish that would have to be pit-tagged at Wells in order to achieve expected recoveries of specified numbers at McNary Dam. These would give the committee a feeling for the scope of the study. Klinge said he would find the tables and send copies out to the committee members.

**Evaluation of the Bypass**. Klinge reported that Biosonics and Skalski are preparing a final report on the bypass evaluation that will combine all three years into a single estimate. This will be available for distribution soon.

**Proposals**. Heinith asked what RFP's are coming out. Klinge said he would have to check his list. He will mail the information to the committee in the near future.

**Next Meeting**. The committee agreed to meet again on November 15, 1993 at Sea-Tac in conjunction with the meeting of the mid-Columbia Coordinating Committee.

ATTENDANCE ROSTER
WELLS PROJECT COORDINATING COMMITTEE

MEETING OCTOBER 12, 1993

| Name | Representing |
|---|---|
| Rick Klinge | Douglas County P.U.D |
| Bob Clubb | Douglas County P.U.D. |
| Cary feldman | Power Purchasers |
| Brian Cates | U.S. Fish and Wildlife Service |
| Bill Hevlin | National Marine Fisheries Service |
| Al Giorgi | Don Chapman Consultants |
| Tony Eldred | Washington Department of Wildlife |
| Labh Sachdev | Seattle City Light |
| Rod Woodin | Washington Department of Fisheries |
| Tom Scribner | Yakima Indian Nation |
| Bob Heinith | Columbia River intertribal Fish Commission |
| Richard Whitney | The Committee |
| Lowell Steuhrenberg | National Marine Fisheries Service |
| Bob Iwamoto | National Marine Fisheries Service |
| George Swan | National Marine Fisheries Service |

# WELLS PROJECT COORDINATING COMMITTEE
## MEETING NOVEMBER 15, 1993
## SUMMARY[1]

**Agreements Reached**

1. Rick Klinge and Cary Feldman will revise the draft sockeye enhancement plan and resubmit it to the committee.

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The meeting was held at 1:00 P.M. November 15, 1993 at the West Coast Sea-Tac Hotel, following the meeting of the mid-Columbia Coordinating Committee. The agenda was mailed to the full mailing list on November 2, 1993. Those in attendance are listed on the attached roster.

I. Status of studies

A. 1992 Sockeye Telemetry Study. The chair reported that he had learned that Lowell Stuehrenberg has prepared a draft report that is being reviewed and edited within NMFS for release soon.

B. 1993 Passage Studies at Zosel Dam. Rick Klinge reported that intertribe is putting together a report on their work. However, it will only point out that the spillway was not used to any great extent by adult sockeye migrants, due to the fact that the spillway was in almost continual operation, and fish could easily pass by that route. Perhaps 200 fish used the ladder. Biosonics attempted to monitor the spillbay with hydroacoustics. Their report is due by the end of this month. The information from both will possibly be useful in accounting for any count discrepancy between Wells Dam and Zosel Dam.

C. Spawning Ground Surveys. Klinge reviewed the work that is being done. Hevlin said it appears the weirs are delaying or diverting fish. Scribner agreed. One of the objectives of the weir is to block fish and the one at Chiwawa does that very well. However, it appears to have diverted the fish to other areas. Scribner noted that experience in the Yakima shows that fish behave differently once they reach the terminal areas compared to their behavior in the mainstem. He pointed to the ESA concerns that will require demonstrating that the benefits of weirs outweigh the drawbacks. Klinge said that the P.U.D. would support that concept. Hevlin called attention to the fact that the rule would apply to new construction as contrasted to existing facilities. He also observed that a situation such as at the Twisp weir where many fish get past the weir, might be an acceptable alternative. Feldman noted that the Chiwawa weir is well designed in this respect in that it can be lowered to permit fish to pass. Klinge went on to report that there had been 30,000 sockeye counted at Wells Dam. There have been 10,000 carcasses recovered. Weekly population estimates have been possible. Parametrix is doing the survey. They will look for spaghetti tags. So far, they have recovered 2 of 200 tags. The first tagging took

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1. Prepared by R. Whitney

place on July 20. The tags will be sent to Intertribe. Jerry Marco asked about the distribution of spawners. Klinge said that few had been observed above McIntyre Dam. Flow in the Okanogan was reduced on October 1. Jerry Marco circulated photographs of the river before and after the flow was reduced, showing exposure of some redds. Hevlin said that he understood flows were going to be maintained in the fall in order to delay shutdown until sometime in November. Klinge said Parametrix will have a report available by the end of the year.

Scribner reported that the Bureau of Reclamation had done a study for the Fulton Irrigation District in which they suggest that use of wells instead of the irrigation ditch would reduce the water use by half.

D. 1994 RFP's. Klinge said that he had sent out draft RFP's to the committee on October 19 relating to the sockeye emergence study and the Okanogan spawning ground survey. The purpose of the first is to understand the timing of fry as they move into the lake. Hevlin said he had talked to Bruce Shepard and learned that B.C. has a new agreement with the tribes on sockeye enhancement. They would be interested in doing the work. Klinge observed that the Colville Tribe is interested as well. He has not yet sent out the RFP to contractors. He wants committee input first. Heinith suggested that for sampling, the river be stratified into zones to measure timing in each. He feels that 2 months is plenty of time between submission of a draft report and completion of the final. Heinith provided some written comments on the RFP for the sockeye spawning ground survey. Klinge said he would take them into account in revising the RFP. Woodin suggested that the sampling be just upstream of the irrigation diversions to avoid entrainment. He feels that the methodology should be developed by the contractor after the committee sets the objectives. If we want an estimate of total outmigration numbers we should set some boundaries to the precision we want. Hevlin commented that he was not sure we need an estimate of the total numbers. Marco and Scribner pointed to some advantages of having a total estimate. Marco pointed out that it is difficult to get total numbers, whereas the timing objective is not so difficult. Rick expressed an interest in first obtaining an estimate of timing. Perhaps timing could be related to temperature. We could approach this in steps, year by year. This year we might get timing information. Then next year do the same and look at the feasibility of obtaining a quantitative estimate.. Woodin asked whether if it happens that irrigation removals occur at the same time as emergence would there be samples taken in the irrigation ditches? Klinge said yes, there would be. Hevlin said that irrigators are licensed to remove water after April 1, but they don't normally do so until May 1. There are more than 200 withdrawal locations. The committee felt that the RFP was ready to be issude to prospective contractors. However, Klinge said he will modify the RFP according to the comments and redistribute it next week to give the committee another chance to modify it. After it is isuued he will advise the committee on proposals and study plans received in response.

E. Project Mortality Study. Klinge had distributed copies of the analysis by John Skalski on the number of fish required to be marked for various levels of precision in the estimate. He noted that the committee will need to decide what level of precision would be adequate and which stock or stocks would be used for the study. Woodin reviewed the provisions of the settlement Agreement that call for such a study in order to adjust the compensation program if necessary. The program agreed upon was based on an assumption of 4% mortality at the project and 10% in the reservoir. It could be adjusted in either direction. Klinge observed that the best estimate of project mortality would now be 1%, using the average fish guidance of 89% developed by hydroacoustics. The committee discussed the Skalski report and the questions raised by Klinge. Woodin noted that the biggest complication to a study would be producing test fish and what the effects would be on the compensation package. Tough decisions are involved. He asked whether the committee could provide some feeling for the level of precision required for the estimate, so that the numbers of fish required could be determined. The members were not yet prepared to propose a figure. Scribner pointed out that the major questions have to do with the level of precision required, the stock or stocks to use, and other questions, such as where would the test fish be released? Woodin suggested that they might accept yearling summer chinook as the test animals, but the question is how do we get the fish, as well as the question where do you release them? Heinith thought that fish from the Similkameen would be the best test animals. Cary pointed out that the purely technical question is what stock or mix of stocks would provide the best estimate of overall or average survival in the reservoir. Klinge agreed that yearling chinook might be more appropriate, as the "middle of the road" stock. On the other hand perhaps sockeye could be used.

Klinge then asked what would happen if the study is not conducted? He suggested that the parties might negotiate the compensation package without the study. He suggested that the discussion be continued at the next meeting. Lots of groundwork will be required. We need to know next summer if a study is to be conducted in 1995.

II. Bypass Operating Plan for 1994. Klinge submitted a draft bypass operating plan for 1994. It is in the same format as in the past. There was a discussion. Hevlin said he will require some convincing that fyke netting is needed early in the run, because he does not feel it is necessarily a good sample of what is present when the sample is so small. When more fish are present later on, it is alright. Klinge pointed out that as soon as chinook appear in the samples the fyke netting has been discontinued. The designated representatives have further work to do on this matter.

III. Hatchery Update

A. Wells Salmon Hatchery. Bob Bugert was called upon for a report on Wells hatchery operations. Rod Woodin distributed a report from Heather Bartlett on the 1992 and 1993 brood. They have a good complement of eggs on hand.

B. Steelhead Hatchery. Klinge reported, as a follow-up of the report provided at the last meeting, that WDW had decided to destroy the 185,000 fish in the one pond that was badly infected with eye fluke. Tony Eldred reported that he had talked to Jerry Friday. He said that they had enough fish remaining to meet the program if they do not experience heavy losses to birds. Klinge said they would not let that problem with eye flukes occur again. They will take action on snails if the ponds don't dry up during the summer.

C. Methow Supplementation Facility

1. Production. The report is referred to above.

2. Evaluation Plan. Klinge said that momentum has developed in the production of the evaluation plan, and that the work group is proceeding.

Hevlin asked about the Twisp trap and its modification. Klinge said they will move the "V" back further into the live box. NMFS had recommended changes in attraction flows. Klinge said they had reviewed the situation and are recommending that the trap be operated as designed. There was plywood placed on the weir to assist sttranded adults in getting back into the water. It should be removed and a 24 hour watch placed on duty to take care of fish that are stranded. That was the plan last year, but it was not carried out. Hevlin expressed appreciation that the P.U.D. is willing to work on the problem. He suggested that a small work group meet to develop a configuration for the trap and related matters. Klinge agreed.

Scribner offered information on the outmigration in the Chewack. He reported that they had been counting about 10 fish per day moving downstream. last week it increased to 25-30 fish per day. Woodin reported that they are trapping on the Chiwawa River.

D. Cassimer Bar Sockeye Facility

1. Status of fish. Jerry Marco reported that the Colvilles will do the last spawning this week. They recorded some incidence of IHN in adults. They have isolated the fish. There are still 20 or 30 fish that have not been examined. The pathologist, John Miller, recommended that the affected fish be destroyed. This would amount to 8-12% of the station take of eggs. Jerry's feeling is that they should go ahead as the study is a test of their ability to rear the fish. They are not equipped for a true isolation of infected eggs or fry, although committee members pointed out that there are two trailers, which provides the potential for better isolation than can be practiced at most hatcheries. There was a discussion of the pros and cons of destroying eggs. It was observed that uninfected eggs have been derived from infected adults. Scribner advised testing the juveniles.

Jerry also reported a high level of prespawning mortality due to BKD. Water temperature was 57 degrees.

Woodin asked Jerry to keep the committee advised as to what is done. His concern was that if eggs are destroyed there might not be enough remaining to provide a good test of the ability to rear fish at that facility. He noted that progeny of IHN positive adults at the Eastbank hatchery were taken to Lake Wenatchee.

Jerry summarized that the program is continuing as laid out in the protocol. He will have more information next time. They are proposing a ventral fin clip on the juveniles. Scribner suggested CWT's. The Yakima Tribe has portable equipment for applying the CWT's and would loan it.

Klinge reported that Jack Rensel is working with Okanogan County in obtaining permits for the net pens in Lake Osoyoos. The process is going well.

IV. Miscellaneous

A. Okanogan Sockeye Plan. Klinge had mailed to the members his comments on the draft sockeye plan. His primary concern was that the problem with sockeye is complex and involves many entities besides those represented on the Wells Committee. There is a question whether we can effectively proceed without their involvement. The committee discussed his comments. Woodin observed that the index of abundance of outmigrant sockeye at McNary Dam in 1993 was one of the highest ever seen. Heinith thought we will see interest from other groups in the use of the Okanogan as a donor stock for endangered stocks. Klinge made the suggestion that there might be an annual, informal meeting of people interested in the Okanogan stock. Hevlin observed that we have struggled to develop a planning document. A year ago we had a preliminary plan. Then we held a workshop. Following that, Heinith wrote a draft of a plan. Klinge's comments seem to drop the committee approach and change the emphasis of a plan. The chair observed that due to the complexity of the life history of salmon it is not unusual for entities to find that they do not have full jurisdiction over a stock. One solution in developing management plans has been for the involved entities to agree to work together to influence decisions of the outside entities where possible. Perhaps that could be done here, utilizing the annual informal meeting suggested by Klinge. An encouraging factor is that we know that representatives of some outside interests, such as the B.C. Government are interested in input the Wells Committee might provide on effects of flow on exposure of redds in the Okanogan River. We know the B.C. Tribes are interested in sockeye and that the B.C. Government might modify its position on sockeye enhancement in response to that interest. Hevlin asked Klinge how he would change the words in the plan to incorporate his ideas and concerns. Klinge and Feldman agreed to work together to develop some wording in the draft that would address Klinge's concerns.

B. Other.

Next Meeting. The committee agreed to meet again on December 21 at Sea-Tac, in conjunction with the meeting of the mid-Columbia Coordinating Committee.

ATTENDANCE ROSTER
WELLS PROJECT COORDINATING COMMITTEE
MEETING NOVEMBER 15, 1993

| Name | Representing |
|---|---|
| Cary Feldman | Power Purchasers |
| Brian Cates | USFWS |
| Jerry Marco | Colville Confederated Tribes |
| Tom Scribner | Yakima Indian Nation |
| Bill Hevlin | National Marine Fisheries Service |
| Tony Eldred | Washington Department of Wildlife |
| Bob Heinith | Columbia River Intertribal Fish Commission |
| Rod Woodin | Washington Department of Fisheries |
| Dick Whitney | The Committee |

# WELLS PROJECT COORDINATING COMMITTEE
# MEETING DECEMBER 21, 1993
# SUMMARY[1]

**Agreements Reached**

1. The committee approved the RFP prepared by Douglas P.U.D. for studying sockeye emergence in the Okanogan River in 1994. Douglas P.U.D. will distribute copies of the responses in one package to the committee members.

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The Wells Project Coordinating Committee met on December 21, 1993 at the West Coast Sea-Tac Hotel, following the meeting of the mid-Columbia Coordinating Committee. The agenda followed was mailed to the full mailing list prior to the meeting.

I. Status of Studies

A. 1992 Sockeye Telemetry Study. Klinge reported that he had talked to Bob Iwamoto of NMFS and learned that Lowell Steuhrenberg has prepared a draft report that is being edited within NMFS. It should be out in January, 1994.

B. 1994 RFP's. Klinge provided two handouts, one the RFP for study of sockeye emergence and the other for spawning ground surveys in the Okanogan River in 1994. He made note of the suggestion Heinith had made last time that the emergence sampling be stratified in an attempt to quantify the estimates. He does not think it is feasible to quantify the estimate. Timing is the most important variable to measure. The contractor can let us know, based on observations whether quantification might be feasible. That RFP is identical to the one issued last year. The committee approved the RFP for study of emergence. Klinge said that the RFP will be sent out to potential bidders tomorrow. They will allow 30 days for response. After the deadline, a package consisting of the responses will be distributed to the committee for review and recommendations.

With respect to the RFP for spawning ground surveys, Heinith raised a question about lake shore spawning that could not be answered with certainty in the group, although several thought it was not a significant element. The suggestion was made that information from the radiotelemtry study might be useful in designing the spawning ground survey. The RFP for a spawning ground survey was tabled until the next meeting. Heinith expressed a wish that these RFP's had been mailed out ahead of the meeting.

C. Decision on Project Mortality Study. Scribner asked for an opportunity to caucus among the agency and tribal representatives. Klinge said that the District might see value in obtaining the number, as called for in the Settlement Agreement. Scribner asked whether the purpose would be to reduce the compensation package. Klinge responded that was not the reason. They simply want to know what the options might be. After a short discussion the matter was tabled. it was pointed out that the committee needs to

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1. Prepared by R. Whitney

decide by spring 1994 if a study is to be conducted in 1995.

II. Bypass Operating Plan for 1994. Klinge said he would like to see rather extensive early sampling with fyke nets. They do not have early information in the past, before about mid-April. Scribner asked the designated represn- tatives to resolve theri differences. Hevlin suggested perhaps fyke netting in three units, rather than one, as in the past. After discussion of some alternatives, it appeared some accommodation of the concerns of all parties could be reached. Klinge suggested that when Larry Basham and Bill Hevlin come to visit Douglas P.U.D. they can get together and work out the details.

III. Hatchery Update

A. Wells and Methow Salmon Hatcheries. Klinge distributed copies of reports prepared by Heather Bartlett of WDF, covering the Wells and Methow hatcheries. He called attention to the fact that the monthly loss of fish had been zero.

B. Evaluation Plan. Klinge reported that the Evaluation Working Group had a telephone conference call on December 10. They have met regularly. In the December 10 conference call, the Yakima representative suggested moving the Chewack fish to an underseeded area to be determined later. They have two meetings scheduled after the first of the year. The process is underway. They also discussed evaluating fish behavior as fish approach the adult traps for brood collection on the Chewack and Methow rivers. Klinge is comfortable that the P.U.D. has expertise in-house to set up electronic sensors and antennae to be able to record behavior of radio-tagged fish around the trap. We will know at the next meeting what we should do in this connection.

Woodin reminded the committee that there is a need for an overall evaluation plan with objectives in order to be able to proceed logically with studies. Klinge responded that the plan is evolving as they work out the details. Bugert added that they have been side-tracked by immediate concerns. They will now get back on course. Woodin went on to encourage the working group to make available what they have agreed to at this point, leaving unresolved issues open. The latter could even be specified. The committee agreed that high priority should be given to this effort.

C. Cassimer Bar Sockeye Facility. Klinge distributed copies of Jerry Marco's report, since Jerry had to leave. Klinge observed that Jerry's evaluation is based on a measurement of relative contribution to the outmigration. This raises a question in Klinge's mind about the objective of the sockeye project. Is the objective to contribute to the catch or is it to add to the number of sockeye in the basin? Woodin commented that the objective at this early stage is simply to see whether zero age smolts can be reared to a size where they will survive and contribute to the outmigration. Jerry has asked for comments and suggestions on the plan. Committee members should address Jerry directly.

IV. Miscellaneous

A. Okanogan Sockeye Plan (Klinge and Feldman). Klinge reported that he and Feldman are working on a draft revision per the assignment they were given at the last meeting. It should be ready next time.

B. Other. Hevlin raised a question about the report that Douglas

P.U.D. had conducted a study of survival in top spill versus bottom spill at Wells Dam in 1993. He wondered why the committee had not been informed that the study was being done. Klinge recollected that the subject had come up in the context of Dick Nason proposing the Rocky Reach study. At that time he mentioned that Douglas P.U.D. was interested in a study of top spill versus bottom spill, as had previously been proposed to the committee. Klinge's recollection is that one committee member said "go for it", and there were no objections. The whole effort consisted of 100 fish. He would not call it a study. They were looking for gross effects on the fish. They saw none. He said there is no report and will be none. Douglas P.U.D. does not want the information misused or even attributed to them.

Next meeting. The committee agreed to meet again on January 27, 1994 at Sea-Tac in conjunction with the meeting of the mid-Columbia Coordinating committee.

ATTENDANCE ROSTER
WELLS PROJECT COORDINATING COMMITTEE
Meeting December 21, 1993

| Name | Representing |
| --- | --- |
| Cary Feldman | Power Purchasers |
| Bill Hevlin | National Marine Fisheries Service |
| Brian Cates | U.S. Fish and Wildlife Service |
| Rick Klinge | Douglas County P.U.D. |
| Tony Eldred | Washington Department of Wildlife |
| Bob Heinith | Columbia River Intertribal Fish Commission |
| Tom Scribner | Yakima Indian Nation |
| Bob Bugert | Washington Department of Fisheries |
| Rod Woodin | Washington Department of Fisheries |
| Richard Whitney | The Committee |

**APPENDIX I**

**1993**

**MEMBERSHIP LIST OF THE**

**WELLS COORDINATING COMMITTEE**

**APPENDIX I**

# APPENDIX

## 1993 MEMBERSHIP LIST

## OF

## WELLS COORDINATING COMMITTEE

Mr. Ron Boyce
Oregon Department of Fish and Wildlife

Mr. Tony Eldred
Washington Department of Wildlife

Mr. Carey Feldmann
Puget Power Company

Mr. Bob Heinith
Columbia River Inter-Tribal Fisheries Commission

Mr. Bill Hevlin
National Marine Fisheries Service

Mr. Rick Klinge
Public Utility District No. 1 of Douglas County

Mr. Jerry Marco
Colville Confederated Tribes

Mr. Craig Tuss
U. S. Fish and Wildlife Service

Mr. Tom Scribner
Yakima Indian Nation

Dr. Richard R. Whitney
Wells Coordinating Committee Chairman

Mr. Rod Woodin
Washington Department of Fisheries

**SETTLEMENT AGREEMENT**

**APPENDIX J**

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 <u>de novo</u> 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. <u>PRODUCTION PLAN</u>

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, <u>Coordinating Committee</u>.

(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 x V x 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 x L x 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.

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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

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(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. <u>SUPPORT FOR RELICENSE</u>

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. <u>REGULATORY APPROVAL</u>

### A. <u>FERC ORDERS</u>

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. <u>PERFORMANCE CONTINGENT ON APPROVAL</u>

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

15,000 lbs. of Summer Chinook @ 10/lb.

6,500 lbs. of Summer Chinook at 40/lb.

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:

<u>Phase IIA</u>

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Sockeye @ 25/lb.

OR

<u>Phase IIB</u>

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/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:

$$\bar{A}ys = \frac{Ay + Ay-1 + Ay-2 + Ay-3 + Ay-4}{5}$$

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.

$$\overline{HSys} = \frac{HSy + HSy{-}1 + HSy{-}2 + HSy{-}3 + HSy{-}4}{5}$$

4. Total smolts (by species):

$$\bar{S}ys = Kys \times \bar{A}ys + \overline{HSys}$$

5. Grand Total = Sum of all species:

$$Sgt = \bar{S}sp + \bar{S}su + \bar{S}so + \bar{.}..$$

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 $\overline{A}y$ $= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$

$= \frac{3000 + 2200 + 3100 + 5000 + 2900}{5}$

$= 3240$

Summer Chinook $\overline{A}y$ $= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$

$= \frac{2400 + 2800 + 3700 + 4000 + 4700}{5}$

$= 3520$

Sockeye $\overline{A}y$ $= \frac{Ay \div Ay\text{-}1 \div Ay\text{-}2 \div Ay\text{-}3 \div Ay\text{-}5}{5}$

$= \frac{40{,}000 \div 20{,}000 + 35{,}000 + 15{,}000 + 30{,}000}{5}$

$= 28{,}000$

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 = (1,500,000 + 1,100,000 + 1,000,000 + 950,000 + 950,000) / 5

= 1,100,000

Methow Hatchery = (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 Prey
Commissioner

Michael Dezellem
Commissioner

T. James Davis
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

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FOR PACIFIC POWER & LIGHT COMPANY:

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

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FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

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FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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Commissioner

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Commissioner

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OF WILDLIFE:

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OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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Commissioner

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Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

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FOR PACIFIC POWER & LIGHT COMPANY:

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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OF FISHERIES:

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FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

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FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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Commissioner

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Commissioner

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Commissioner

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

[signature] 6/11/90
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FOR THE WASHINGTON DEPARTMENT
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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FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

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FOR THE OREGON DEPARTMENT OF
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OF THE COLVILLE RESERVATION:

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FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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Marvin L. Plenert, Regional Director
FOR THE U.S. FISH & WILDLIFE SERVICE

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FOR THE CONFEDERATED TRIBES AND BANDS
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FOR THE U.S. FISH & WILDLIFE SERVICE:

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OF THE COLVILLE RESERVATION:

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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FISHERIES SERVICE:

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FOR THE U.S. FISH & WILDLIFE SERVICE:

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FOR THE CONFEDERATED TRIBES AND BANDS
OF THE YAKIMA INDIAN NATION:

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FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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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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
OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

____________________________________

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

Chief Executive Officer/Manager:
ELDON E. LANDIN

Public Utility District No.1 of Douglas County

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

April 27, 1994

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

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

Dear Ms. Cashell:

In accordance with paragraph E of the order approving Settlement Agreement issued January 24, 1991, we submit the enclosed annual report of activities related to our settlement agreement for the Wells Project. A copy of the January 24, 1991 order is enclosed for your reference.

As directed by the order, the annual report addresses activities during the previous year. This third annual report covers activities performed in 1993 and planned for 1994.

Very truly yours,

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

nvh

Enclosures

c: (with report, but not appendices)

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

bc: Mr. Eldon Landin
Mr. William Dobbins
Mr. Ken Pflueger
Mr. Mike Erho
Mr. Rick Klinge

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 ) Project No. 2149-002
of Douglas County, Washington ) 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

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1/ 6 FERC ¶ 61,210 (1979).

2/ 45 FERC ¶ 61,401 (1988).

3/ 46 FERC ¶ 61,033 (1989).





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

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

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

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

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

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

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

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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.

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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.

<u>The Commission orders</u>:

(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/ <u>See</u> 45 FERC at p. 62,260 and 46 FERC at p. 61,198.



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

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

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

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

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

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

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

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

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

By the Commission.

( S E A L )

Lois D. Cashell,
Secretary.

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

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104558
P-2149
KEN A. PFLUEGER CHIEF ENGIN.
PUD #1 OF DOUGLAS COUNTY (WA)
1151 VALLEY MALL PARKWAY

EAST WENATCHEE, WA 98802