Report to the Federal Energy Regulatory Commission for activities under the Long Term Settlement Agreement for the 1990 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
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June 1991

DOC # 34310

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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 first annual report under the new Agreement and will cover the period between January 1, 1990 to April 30, 1991. While the Settlement Agreement was not signed by the fisheries agencies and tribes until the fall of 1990, many of the conditions outlined in the Agreement were being implemented by the P.U.D. throughout 1990.

Report to the Federal Energy Regulatory Commission
for activities under the Long Term Settlement Agreement
for the 1990 calendar year
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County

(1) Development of Studies, Plans and Evaluations

The PUD worked closely with fisheries agencies and tribes to carry out various studies and obligations specified in the Agreement. These included the evaluation of the juvenile bypass, various monitoring studies and operation plans.

1.1 Evaluation of the Juvenile Bypass for 1990

A plan for the first year of a three year evaluation of fish passage efficiency (FPE) at the Wells juvenile bypass was developed by BioSonics and submitted to the PUD. The plan was forwarded for review to the fisheries agencies and tribes. The PUD's contract Statistician, Dr. John Skalski reviewed the study design to insure that the level of statistical significance outlined in the Settlement Agreement could be reached. The study was also reviewed by two other statisticians, one from a tribal interest and one from the fisheries agencies. The study proposal was incorporated into the Methods of the Final Report of the Evaluation of the Smolt Bypass System at Wells Dam in 1990 (see Appendix A). The plan was approved by the mid-Columbia Coordinating Committee.

1.2 Evaluation of Juvenile Sockeye Passage at Zosel Dam 1990

The juvenile bypass at the Wells Dam provides protection for migrating salmonids from the Methow and Okanogan/Similkameen River Basins. The last group of spring migrants to reach the Wells Project are Okanogan sockeye. These fish migrate out of Lake Osoyoos down the Okanogan River and into the Columbia River. Wells Dam is the first hydroelectric project these migrants reach in route to the ocean.

A study to determine the timing of these juvenile sockeye as they leave Lake Osoyoos was initiated in 1990 (see Appendix B). Hydroacoustic equipment was placed at Zosel Dam, a flow control dam at the outlet of Lake Osoyoos. Two underwater transducers were deployed in the forebay of Zosel to collect a relative index of fish passage at this dam. This information would be useful for operation of the bypass system at the Wells Project in determining the time and magnitude of sockeye migration out of lake Osoyoos. The study was approved by the mid-Columbia Coordinating Committee

1.3 Bypass Operation Plans for 1991 Bypass Season

At the December 20, 1990 meeting of the Wells Coordinating Committee, the PUD proposed a Bypass Plan for the 1991 Bypass season (See Appendix D). The plan was identical to the operations during the 1990 bypass season. There were no changes recommended by the Committee for operation of the bypass or the function of the bypass team.

1.4 Evaluation of the Juvenile Bypass for 1991

The PUD submitted the 1991 Bypass Evaluation plan to the members of the Wells Coordinating Committee on March 5, 1991. This plan was changed to improve the statistical evaluation of the data. There was also an option to add two five day extensions to the 30 day evaluation of the spring bypass season (a 35 or 40 day evaluation). This was proposed to insure that the evaluation would encompass an early hatchery release of spring chinook and the expected timing of juvenile sockeye to the Wells Project (see Appendix C).

1.5 Bypass Operation in Association with Top spill vs. Bottom Spill

The PUD proposed a study that would compare differences in survival of juvenile steelhead that passed through two different spill gates (Appendix E). The study was sent out to the Wells Coordinating Committee and discussed at the April 3 and April 10 meetings of the Coordinating Committee. The juvenile bypass at Wells uses five spill gates during bypass operation. Two of these gates are capable of utilizing either top or bottom spill, the other three are only bottom spill gates. The study was designed to see if there was a significant difference in survival (>10%) between fish released through top spill compared to fish released through bottom spill. Two groups of 2,200 thousand steelhead were to be PIT tagged (Passive Internal Transponder) and released at Wells through top spill or bottom spill. Detection of tagged fish would be at the bypass collection gallery at McNary Dam, 223.6 miles down stream of the Wells Project.

Based upon the recommendations of the Coordination Committee, the PUD did not initiate the study for the 1991 season. Anticipated high flows during the juvenile migration would reduce the collection efficiency of the bypass at McNary and result in a low recovery of tagged steelhead.

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Evaluation of the Juvenile Bypass for 1990

This was the first of a three year evaluation of the Fish Passage Efficiency (FPE) of the juvenile bypass at Wells (see Appendix A). Hydro-acoustic equipment was placed in turbine intakes as well as in spill bays that are associated with the bypass barriers in order to detect passage of juvenile salmonids. By comparing the numbers of fish using spill flow in association with the bypass with numbers of total detected migrants gives FPE.

The Settlement Agreement specifies a goal FPE for the Wells Bypass of 80% for spring migration and 70% for the summer migration. The Agreement also requires an evaluation precision of the bypass FPE to be ±5.0% FPE at the 95% confidence interval (C.I.). If the FPE is greater than 85% for the spring migration and greater than 75% for the summer migration, then the evaluation precision is relaxed to ±10% at the 90% C.I. (Appendix J, Section II.H.2).

The 1990 evaluation of the spring FPE was 84.3% ±8.0% at the 95% C.I. and the summer FPE was 76.5% ±4.0% at the 95% C.I. The 1990 spring bypass exceeded the FPE goal but the evaluation fell short of the desired accuracy.

2.2 Relative Index of juvenile salmonid migration at Wells Dam for 1990

The operation of the juvenile bypass at Wells requires water to spill through five spill bays. The bypass spill starts when an index of juvenile fish abundance at the dam rises to a point and the members of the Bypass Team determine the spring migration has started. This index, along with species composition from fyke netting within turbine intake bays provide necessary information to start bypass operation for the spring and summer migration of juvenile salmonids. During the 1990 migration, the index climbed to a level to start the bypass on April 17 for spring migration. The summer bypass was started when the index plus species composition from fyke netting indicated a high number of juvenile salmonids in front of Wells on July 8 (see Appendix A, pages D1 and D2 for Hydroacoustic Index and page 15 for species composition from fyke net sampling).

2.3 Evaluation of Juvenile Sockeye Passage at Zosel Dam 1990

An effort to collect a relative index of emigration of sockeye from Lake Osoyoos was conducted in 1990 (see Appendix B). Hydroacoustic sampling took place between April 26 and May 24. A high index was seen early in the monitoring. Due to high flows out of the Okanogan River, flow control structures were opened that were not equip with hydroacoustic transducers. The index did show that there was high passage of sockeye out of Osoyoos in late April.

2.4 Spring Chinook Spawning surveys in the Methow River Basin, 1990

This was the second year of a five year study to survey spring chinook spawning in the Methow River (see Appendix F). The number of redds (nests deposited by spawning salmon) in 1990 was 502 for 133 miles of streams surveyed. The assessment of spring chinook escapement may be artificially low due in part to a delay of the migration of this run of chinook. High flows in the Columbia River are felt to be the reason for the delay.

2.5 Sockeye Salmon Enhancement Potential Above Wells Dam

Chapman and Associates prepared a report for PUD that investigates the potential for sockeye enhancement above Wells Dam (see Appendix G). The study showed that the Okanogan drainage with associated Lake Osoyoos was the best candidate for sockeye enhancement. High temperature problems pose a serious obstacle to adult migration to spawning areas. River temperatures during the migration of adult sockeye in the Okanogan River approach lethal levels for salmon and trout. The report suggests several possible avenues for enhancement including holding adults in cooler water, improving spawning substrate and pen rearing fish in Lake Osoyoos. The Agreement specifies that the PUD would fund this study in 1990.

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

3.1 Bypass Evaluation

As was mentioned in Section 2.1, the evaluation of the juvenile bypass in 1990 was just shy of meeting the necessary statistical precision as outlined in the Settlement Agreement. The District's contract statistician, Dr. John Skalski recommended that additional hydroacoustic sampling would help to lower the variance around the point estimate. The 1991 Evaluation will have an additional four hydroacoustic transducers. Also additional time of the evaluation for the spring juvenile migration was made available should the spring migration extend beyond the 30 day evaluation period as outlined in the Agreement.

3.2 Annual Bypass Action Plans and FPE Evaluation Plan

Plans for operation of the Bypass during the 1991 Bypass season were distributed to members of the Wells Coordinating Committee in March 1991. The bypass will be operated in accordance to criteria established in the Settlement Agreement. Dr. John Skalski provided the evaluation methods for the 1991 Bypass to the members of the Wells Coordinating Committee. Changes in the 1990 evaluation were made to increase the precision of the point estimate for FPE. Statisticians from the fisheries agencies and tribes felt the changes would provide the necessary accuracy for the evaluation.

3.3 Methow River Spring Chinook Hatchery

The plans for the Methow Spring Chinook hatchery, as specified under the Agreement, were reviewed and agreed to by the agencies and tribes. Acquisition of property and necessary permits for construction were being obtained through the close of the calendar year. Necessary water rights and permits had been acquired by the end of 1990. The PUD advertised and sent out plans for the hatchery to solicit construction bids on the project. The low bid for $5,533,222 was awarded to Dyad Construction of Woodinville, Washington.

3.4 Contract professional services in implementing the Settlement Agreement.

During 1990, Douglas PUD contracted with the University of Washington College of Fisheries for the services of Dr. Richard Whitney as Studies Coordinator for the Mid-Columbia Coordinating Committee. The PUD also contracted with Dr. John Skalski to provide review of methods in determining FPE from the bypass evaluation and other studies. Both of these individuals were retained for services during 1991.

(4) Explanation of Alternatives Chosen

4.1 Change in time table of adult studies

The Agreement specifies that a study plan to determine the extent of adult delay and mortality at Wells would be initiated in 1990 with studies starting in 1991 (Appendix J, Section III, G, 1). Members of the Wells Coordinating Committee felt that adequate time to formulate these plans in order to implement studies for 1991 was not possible. Discussions on adult delay and mortality studies for the Wells Project are expected to take place in the early fall of 1991.

4.2 Hatchery Based Compensation

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

(1) 49,200 pounds of spring chinook yearlings at about 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 hinges around the Methow Spring Chinook hatchery that is being constructed in 1991. The facility will be completed by March 1992.

A study on sockeye enhancement options above the Wells Project was prepared for the PUD as part of the Studies and Evaluations section of the Agreement (Appendix J, Section IV, C, 1). The Wells Coordinating Committee is making plans to discuss this study and other information on sockeye in the fall of 1991.

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

4.3 The Wells Project Juvenile Mortality Study

The Agreement specifies that the PUD will plan for a juvenile mortality study in 1990 to be implemented in 1991 (Appendix J, Section IV, C, 5). The PUD submitted a proposed study to the Wells Coordinating Committee in the Spring of 1991 to look at survival of steelhead smolts that pass the Wells Project through Top Spill verses Bottom Spill. This study was to be initiated during the 1991 spring migration of salmonids past Wells. The Wells Coordinating Committee recommended that the study not be conducted until full discussion on how juvenile survival studies could be accomplished. The Wells Coordinating Committee is making plans to discuss juvenile mortality studies in the fall of 1991.

(5) Chronology of compliance for 1991

The chronology of compliance for 1990 is contained in items (3) and (4) above. Documents that the Joint Fisheries Parties were consulted prior to implementation of changes is provided in the minutes of the mid-Columbia Coordinating Committee and the Wells Coordinating Committee. These records are included as Appendix H.

(6) A schedule of activities for 1991

6.1 Spring Chinook Hatchery

Construction on the Methow Hatchery will begin in May, 1991 with a projected completion date of December 1991. The bid for the contract was awarded to Dyad Construction for the price of $5,533,222. Their projected work schedule is as follows,

```
                        |---------------- 1991 -----------------| - 1992
                        Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec  Jan
Ground preparation           xxxx
Work on satellite ponds          xxxxxxxxxxxxxxx
Hatchery Building                    xxxxxxxxxxxxxxxxxxxxxxxxxxxxx
Hatchery residence                 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
Hatchery raceways                      xxxxxxxxxxxxxxxxx
```

6.2 Bypass evaluation

During 1991, the proposed schedule for the second year of bypass evaluation is as follows,

Hydroacoustic equipment set up at Wells	March
Monitoring forebay of Wells	March 25 - April 10
Spring bypass season	April 10 - May 20
Fyke netting of turbine bay	May 15 - Aug 30
Summer bypass season	July 1 - July 20
Data analysis and report writing	August - November
Draft report circulated for comments	December - January 92
Final Report out	March 1992

6.3 Sockeye production and Adult Passage Studies.

The Wells Coordinating Committee did not have the opportunity to adequately deal with the issue of sockeye production and adult passage studies. The Committee will deal with both of these issues in the fall of 1991. Through this process will develop a list of recommended studies and actions plus a time table to implement various elements of the Settlement Agreement.

6.4 Operational Activities for 1991

The following schedule of activities is planned for 1991

December	Develops Annual Bypass System Operation Plan between PUD, Agencies & 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 PUD, Agencies & Tribes
April 1	Bypass system in place Begin monitoring juvenile migration
April 15	Anticipated start of the juvenile migration
October	Production plan annual review between PUD, Agencies & Tribes

(7) Meeting Minutes of the Mid-Columbia Coordinating Committee for 1990 and the Wells Coordinating Committee to March 31, 1991

The Wells Project was removed from the mid-Columbia proceedings on January 29, 1991 as the Long Term Settlement Agreement between the Fisheries Agencies and Tribes was approved by F.E.R.C. Until that time, discussion of the Wells Project and points of the Agreement were done through the mid-Columbia Coordinating Committee. Minutes from those meetings for 1990 are attached as Appendix H. Meetings under the Wells Coordinating Committee are also listed up through March 31, 1991.

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EVALUATION OF THE SMOLT BYPASS SYSTEM AT WELLS DAM IN 1990

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Evaluation of the Smolt Bypass System at Wells Dam in 1990

Final Report

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EXECUTIVE SUMMARY

In 1990, we used hydroacoustics to evaluate the smolt bypass system at Wells Dam on the Columbia River. The evaluation, sponsored by Douglas County PUD (DCPUD), took place in spring (April 19 to May 18) and summer (July 9 to 24). The 1990 evaluation was the first of a three-year program to substantiate the efficiency of Wells' bypass system. Fisheries agencies and DCPUD agreed to a three-year evaluation period as part of the Wells Settlement Agreement. The agreement also included criteria for precision which guided development of the sampling design. The primary objective of the 1990 evaluation was to estimate **total project bypass efficiency**.

The bypass concept at Wells Dam is based on Wells' hydrocombine structure. (A hydrocombine is a dam with the spillway located directly above the turbine intakes. Wells is the only dam constructed like this in North America.) Baffles are placed in the spill intakes to create attractant flow for downstream migrant smolts. Once entrained in this attractant flow, smolts enter the bypass and migrate through the dam in bypass flow instead of turbine flow. Data show that a relatively small amount of flow properly baffled is more effective at bypassing smolts than is a large amount of flow that is not baffled.

Annual bypass evaluations using hydroacoustic sampling methods and rigorous experimental designs were critical to the development of an efficient bypass at Wells Dam. A prototype bypass was first installed and tested in 1983 at one spillbay of the dam. The 1983 study showed that smolt passage in bypass flow was greater with baffles in place than without. In 1984, 1985, and 1986, the bypass passage rates for various baffle configurations (underflow, overflow, vertical slot, etc.) were compared. The configuration that passed statistically significantly more fish than the others, all other factors being equal, was deemed the "best." The data showed that the vertical slot and underflow configurations were the best. In 1986, two bypass sections were installed and tests conducted to determine if operating an adjacent bypass section increased passage at the original bypass section; it did not. In 1987, more bypass sections were installed and the study objective was to determine the most effective locations for bypass sections across the dam; the middle and west sections had higher passage than the east section. In 1988 and 1989, detailed data on specific characteristics of the bypass were evaluated to fine-tune the system. The bypass will be officially completed after review and acceptance of total project bypass efficiency data from three years of evaluation beginning in 1990.

In 1990, we used fixed-location hydroacoustic techniques to estimate total project bypass efficiency. Transducers (15°) were deployed at 4 of 10 forebay locations (T2, T4, T6, and T8) and

20 of 30 turbine intake locations (Table 2). Transducers (6°) were deployed at 5 of 5 bypass intake locations (1C, 3C, 5C, 7C, and 9C). The number of transducers and sampling design were based on statistical analysis of previous data from Wells. This analysis was performed in winter 1989/90 and presented in the study plan for the 1990 evaluation.

Total project bypass efficiency (B) was estimated by first estimating total passage in bypass flow (Y) and total passage in turbine flow (X) separately. Total passage in turbine was obtained by extrapolating from sampled intakes into non-sampled intakes. Then the ratio B=Y/(X+Y) and confidence interval were calculated.

The bypass system at Wells Dam in 1990 was operated as in previous years. That is, if the daily flow forecast was greater than 140 kcfs, all 5 bypass units were opened. If the forecast was less than 140 kcfs, only bypass units above operating turbines (one or both of the turbines associated with a bypass unit) were opened. Daily bypass flow averaged 5.8% of total project discharge. Overall, the mid-Columbia River had relatively high water in spring and summer 1990.

DCPUD sampled for species composition with a fyke net in Turbine Intake 4C at least weekly from April 5th to August 30th, 1990. The 1990 fyke net data showed that chinook, sockeye, and steelhead dominated the catch from late April to mid-May. Then, in early and mid-June, there was a decline in the numbers of salmonids and an increase in whitefish and other non-targeted fish. In early July the summer chinook outmigration began. It lasted until mid-August.

The 1990 hydroacoustic run timing data from the forebay transducers show that during the five-month monitoring program the spring and summer outmigrations were reasonably distinct. The outmigration began with spring chinook, as usual, then was influenced by the steelhead releases in late April and early May. In mid- and late May, the natural run of sockeye from Lake Osoyoos moved through the dam. Passage rates were low in mid-June, increased in late June and were relatively high and variable throughout the summer.

Estimated total project bypass efficiency for the 30-day spring study was 84.3% $\pm$ 8.0% at the 95% confidence level. During the 30-day study, however, the coefficient of variation (CV = standard deviation divided by mean) was 30.4% for the bypass, which is abnormally high. The CV for turbine passage during spring was only 4.3%. There was one day (April 25) that had extremely high passage in bypass. The ratio for this day was 99% $\pm$ 2%. With this data point excluded from analysis, the bypass CV is 1.2%. The CV for bypass passage was expected to be less than that for turbine passage because 5 of 5 bypass units were sampled and only 20 of 27 turbine intakes were sampled. (Three intakes were not available because of turbine runner

replacement.) For a 29-day spring study, excluding April 25th, total project efficiency was 77.9% ± 1.5% at the 95% confidence level. Thus, although estimated total efficiency is lower if the date with extremely high passage in bypass is excluded, the confidence interval is much tighter. Estimated total project bypass efficiency for the summer study was 76.5% ± 4.0% at the 90% confidence level.

To summarize, the estimates of **Total Project Bypass Efficiency** at Wells Dam in 1990 were:

Spring	84.3% ± 8.0% at 95% confidence level
Summer	76.5% ± 4.0% at 90% confidence level

ACKNOWLEDGEMENTS

The hydroacoustic studies at Wells Dam are the product of much hard and excellent work by many people. We sincerely thank:

- Douglas County PUD staff at Wells Dam and East Wenatchee for their guidance, cooperation, and assistance. They also provided the dam operations data, the fyke net data, and much logistical support. Without DCPUD staff, this project could not have been done.
- J. Skalski for pre-study sampling design analyses which were incorporated into the study plan.
- Phil Mundy and Ben Sanford for reviewing the sampling design.
- Alex Birmingham, Paul Salomone, Mike Spong, and Jim Thorne for collecting the hydroacoustic data.
- Paul Salomone for post-study data processing.
- J. Skalski and D. Ouellette for developing the statistical tools.
- L. Stone for graphics and word processing.

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1.0 INTRODUCTION

1.1 Objective

In 1990, we used hydroacoustics to evaluate the smolt bypass system at Wells Dam on the Columbia River. The evaluation, sponsored by Douglas County PUD (DCPUD), took place in spring (April 19 to May 18) and summer (July 9 to 24). The 1990 evaluation was the first of a three-year program to substantiate the efficiency of Wells' bypass system. Fisheries agencies and DCPUD agreed to a three-year evaluation period as part of the Wells Settlement Agreement. The agreement also included criteria for precision which guided development of the sampling design. The primary objective of the 1990 evaluation was to estimate **total project bypass efficiency.**

The 1990 study was the first of a three-year program to evaluate the efficiency of Wells' bypass system. Fisheries agencies, tribes, and DCPUD agreed to a three-year evaluation period as part of the Wells Settlement Agreement. The agreement also included criteria for precision which guided development of the sampling design.

1.2 Background

Wells Dam (Figure 1 and Table 1) is the first dam that over two million smolts must pass during annual outmigrations to the Pacific Ocean. DCPUD is responsible for protecting anadromous fish that migrate through Wells Dam because of Federal Energy Regulatory Commission (FERC) license conditions. The type and amount of protection is formally agreed upon by DCPUD, fisheries agencies, and tribes. Between 1980 and 1989, inclusive, provisions in FERC settlement agreements have guided the development of the smolt bypass system at Wells Dam. From 1990 to 1992, the agencies and DCPUD agreed to evaluate total bypass efficiency.

Wells Dam was designed as a hydrocombine (Figure 2) to reduce the area of concrete structures founded on rock (Patrick 1970). The spill bay and turbine intake floors are 73 ft and 133 ft from the surface, respectively. The dam has ten turbines and eleven spill bays (Figure 3). All eleven spillbays are equipped with bottom spill gates, but only Bays 2 and 10 have surface gates which can be opened to accommodate top spill. Each turbine has three intakes and, except for Bays 1 and 11, each spill bay has three intakes. Water enters the bypass intakes above water entering the turbine intakes because of the hydrocombine design.

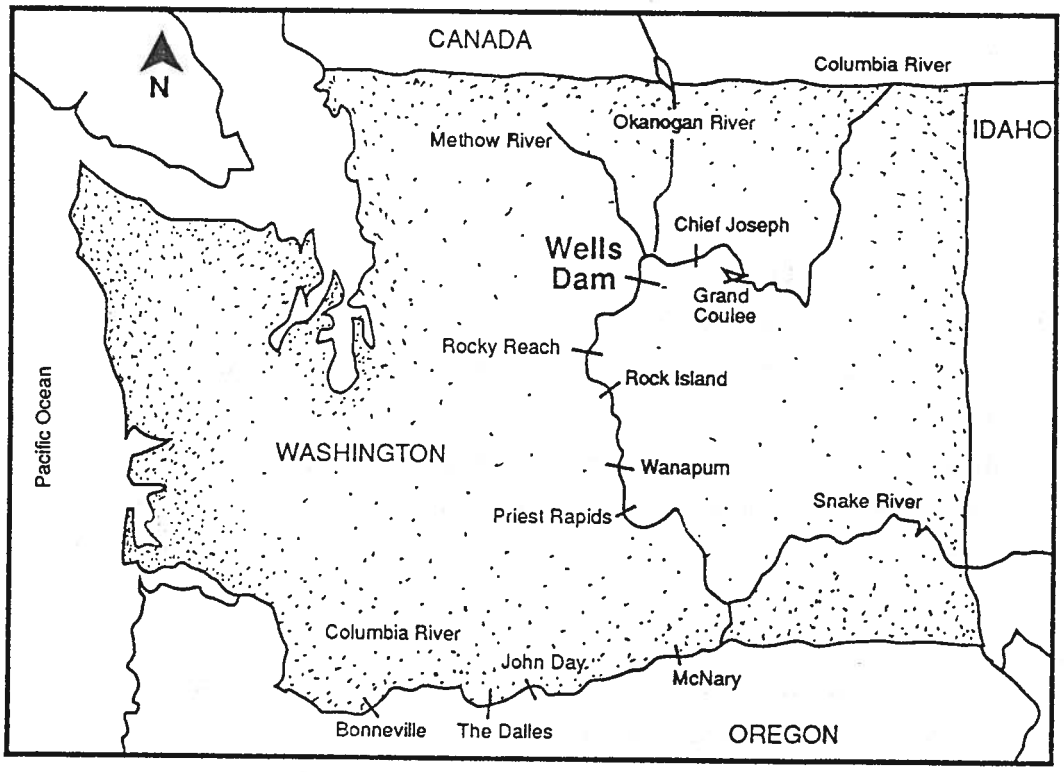

Figure 1. Location of Wells Dam on the Columbia River.

Table 1. Descriptive data for Wells Dam for reservoir elevation 779 ft Mean Sea Level (MSL). (In 1984, the reservoir was raised to 781 ft MSL.)

River Mile at Dam Site	515.8
Drainage Area	85,300 sq mi
Historical Flood (1894)	657 kcfs
Spillway Design Flood	1,180 kcfs
Gross Head (maximum)	74.5 ft
Reservoir Storage Capacity	300,000 acre-ft
Reservoir Length	30 mi
Dam Length (overall)	4,460 ft
Hydrocombine Length	1,130 ft
Hydrocombine Height	185 ft
Generating Units	10
Type of Turbine	Kaplan
Maximum Capability	820,000 kw

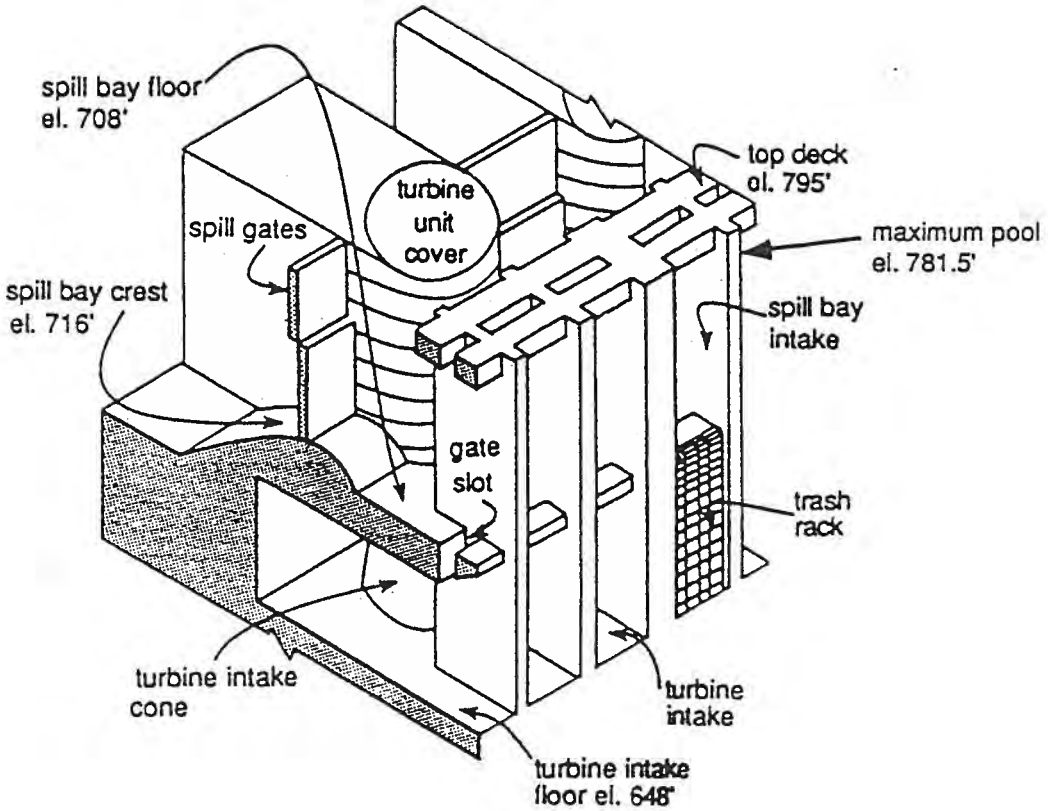

Figure 2. Three-dimensional view of Wells Dam hydrocombine with spill intakes directly above turbine intakes.

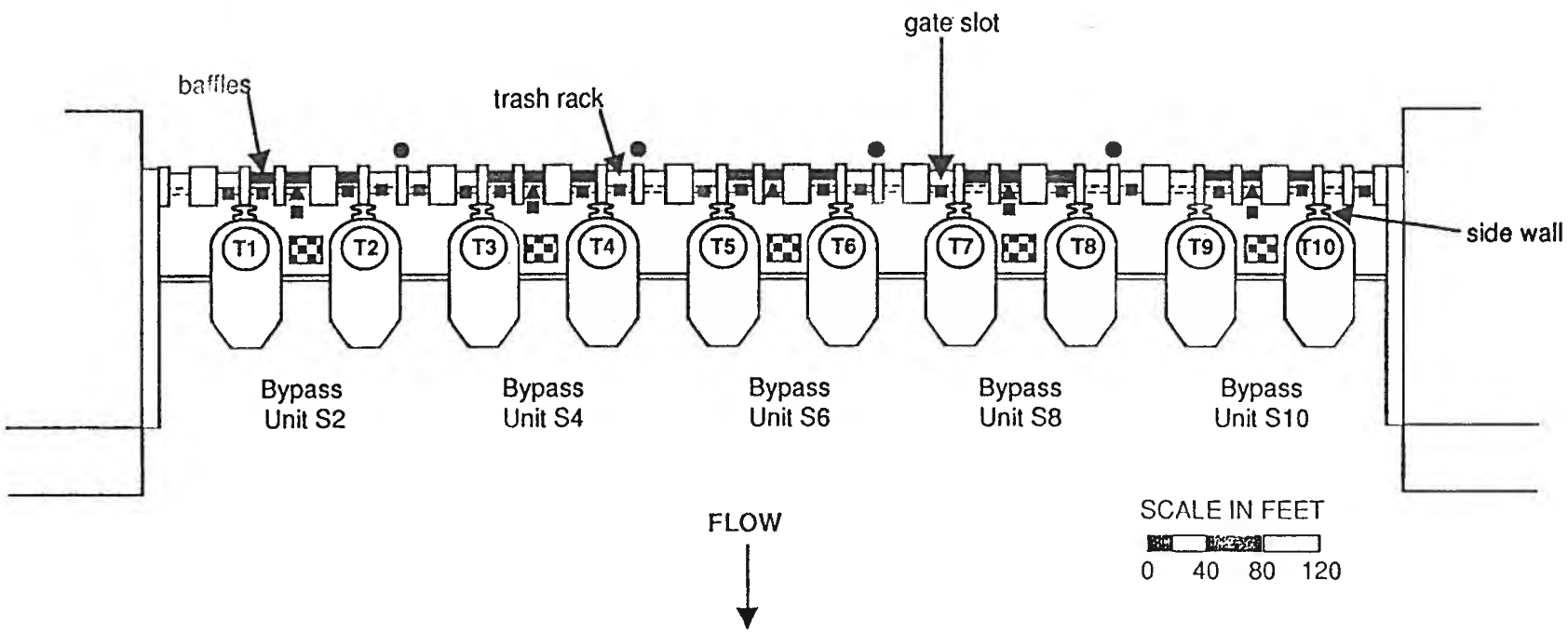

Figure 3. Plan view showing the five bypass units and the locations of forebay transducers (●), turbine intake transducers (■), bypass slot transducers (▲), and spill bay bypass transducers (⊠) at Wells Dam in 1990.

The smolt bypass system is based on spill intake baffles which increase flow velocities to attract smolts into the bypass. Once entrained in this attractant flow, smolts enter the bypass and migrate through the dam in bypass flow instead of turbine flow. A relatively small amount of flow, properly baffled, is equally or more effective at bypassing smolts than is a large amount of flow that is not baffled.

The smolt bypass system at Wells Dam has five individual bypass units (Figure 3). A bypass unit is formed by modifying a spill bay with sidewalls, gate slot plugs, and baffles (Figures 3 and 4). Side walls installed between the pier noses and the turbine pit walls on each side of a spill bay prevent water from flowing between adjacent spill bays, thereby increasing the effect of the intake baffles on forebay flows. Gate slot plugs prevent flow between turbine intakes and the bypass unit. Baffles anchored in the trash rack guides in the spill intakes increase flow velocity into the bypass units. The baffle opening can be oriented horizontally (Figure 5a) or vertically (Figure 5b) in 4-ft increments of height or width. The horizontal opening can be placed anywhere in the water column of the bypass unit intakes. The vertical opening is placed in the center intake of the three intakes. The baffles are the most important feature in the design of the smolt bypass system at Wells Dam. After many years of testing, a vertical slot baffle opening was selected.

During the 1980's, annual bypass evaluations using hydroacoustic sampling methods and rigorous experimental designs were critical to the development of an efficient bypass at Wells Dam. A prototype bypass was first installed and tested in 1983 at one spillbay of the dam. The 1983 study showed that smolt passage in bypass flow was greater with baffles in place than without. In 1984, 1985 and 1986, the bypass passage rates for 13 different baffle configurations (underflow, overflow, vertical slots, etc.) were compared. The configuration that passed statistically significantly more fish than the others, all other factors being equal, was deemed the "best." The data showed that the vertical slot and underflow configurations worked best. In 1986, two bypass sections were installed and tests conducted to determine if operating an adjacent bypass section increased passage at the original bypass section; it did not. In 1987, more bypass sections were installed and the study objective was to determine the most effective locations for bypass sections across the dam; the middle and west sections had higher passage than the east section. In 1988 and 1989, detailed data on specific characteristics of the bypass were evaluated to fine-tune the system. The bypass will be officially completed after review and acceptance of total project bypass efficiency data from three years of monitoring beginning in 1990.

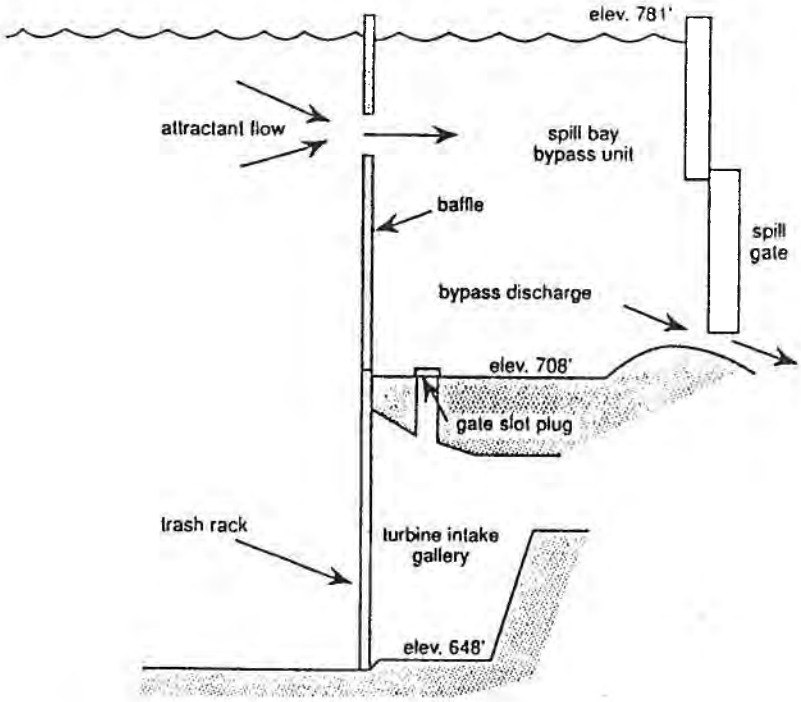

Figure 4. Side view of a bypass unit at Wells Dam showing a horizontal baffle opening and attractant flow.

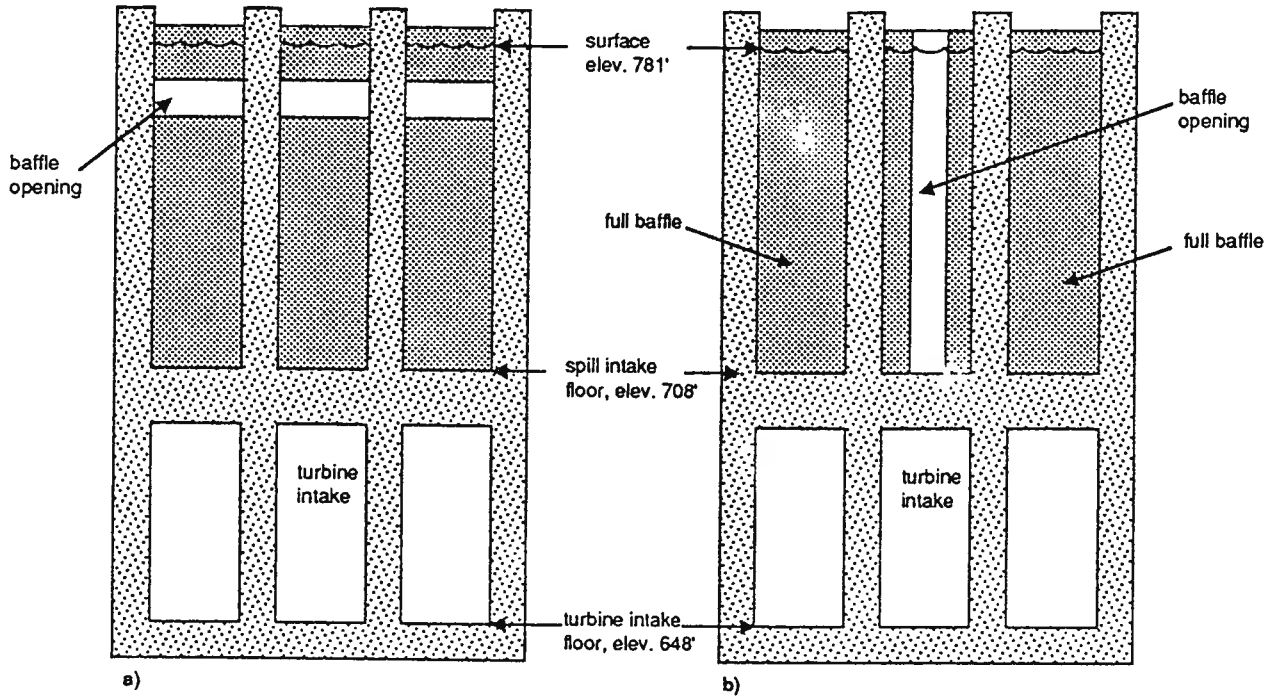

Figure 5. The upstream side (front view) of a bypass unit at Wells Dam with (a) horizontal baffle opening and (b) vertical baffle opening.

2.0 METHODS

2.1 General Hydroacoustics

We used fixed-location hydroacoustic techniques for monitoring smolt passage at Wells Dam in 1990. The techniques were similar to those used in 1989 (Kudera *et al.* 1990) and are explained by Thorne and Johnson (In Press). The following methods are described in detail in Appendix A: (1) operating BioSonics hydroacoustic systems; (2) acquiring data from echograms; and (3) reducing data and calculating the primary statistics. Specific details of transducer locations and orientations, sampling design, and statistical methods are presented below.

2.2 Transducer Locations and Orientations

Transducers were deployed in the forebay, bypass intake slots, and turbine intake galleries. To monitor run timing, transducers (nominal beam width 15°) sampled fish passage in the forebay in front of Turbine Units 2, 4, 6, and 8 (Figure 3). We deployed the forebay transducers at the bottom of the pier nose between the B- and C-slots of the designated units, about 130 ft deep. They were aimed up about 28° off the face of the dam (Figure 6). The forebay had ranges from 118 to 127 feet so a low pulse rate of 4 pulses per second (pps) was used. The forebay data were used to generate a daily index of fish passage before and after the spring and summer bypass studies; the forebay was not sampled during the bypass evaluation.

For the bypass evaluation, five transducers (nominal beam width 6°) were placed in bypass intake slots: 1C, 3C, 5C, 7C, and 9C (Figures 3 and 6). The bypass slot transducers were deployed in the gate slot immediately downstream of the vertical baffle opening in the C-slots of the designated bypass. This location is at the center of a bypass spillbay. These transducers rested at the bottom of the bypass and were aimed straight up toward the surface (Figure 6). The range in the bypass slots was approximately 65 feet so a higher pulse rate of 12 pps was used. The bypass slot transducers sampled fish passage into all five bypass intakes of the smolt bypass system.

Also for the bypass evaluation, 20 transducers (nominal beam width 15°) were deployed in turbine intake galleries (Table 2 and Figure 3). These transducers were mounted on the bottom and aimed upward about 10° downstream (Figure 6). The pulse rate was 12 pps. At least two of three intakes at each turbine unit were sampled. The sampled intakes were selected randomly. At two turbine units (Units 1 and 2), all three intakes were sampled; these two units

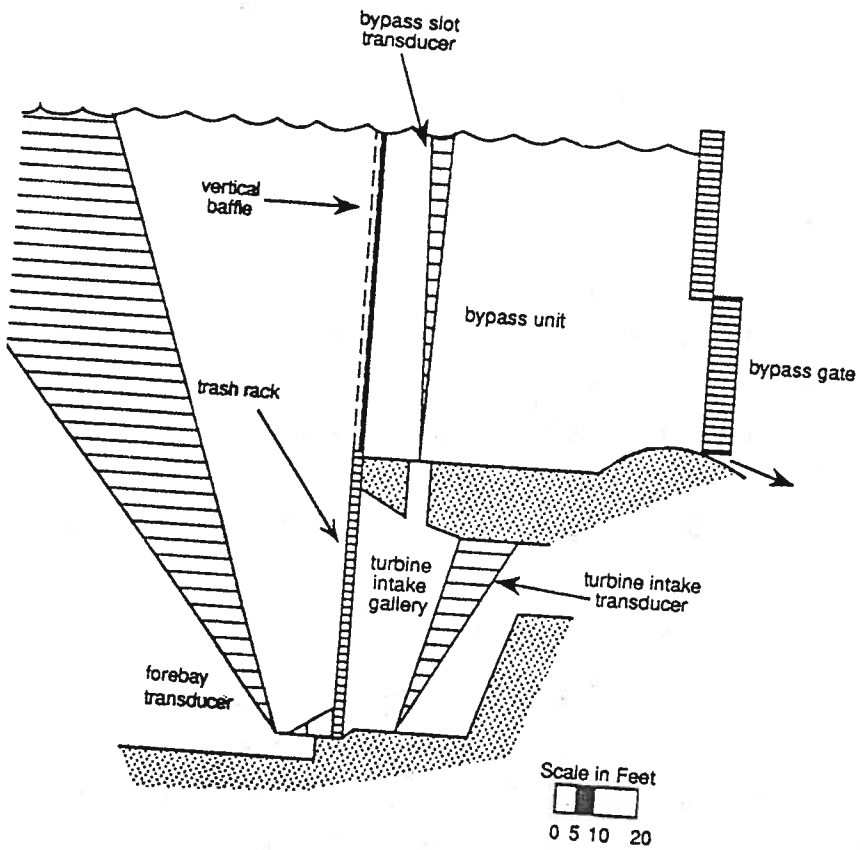

Figure 6. Side view of a bypass unit at Wells Dam showing 1990 transducer sampling areas.

Table 2. Turbine intake sampling locations at Wells Dam in 1990.

LOCATION	DATES SAMPLED Spring	Summer
1A	4/19-5/18	7/09-7/24
1B	4/19-5/18	7/09-7/24
1C	5/04-5/18	7/09-7/24
2A	4/19-5/18	7/09-7/24
2B	4/19-5/18	7/09-7/24
2C	4/19-5/18	7/09-7/24
3A	4/19-5/04	NS
3B	4/19-5/18	7/09-7/24
3C	4/19-5/18	7/09-7/24
4A	4/19-5/18	7/09-7/24
4B	4/19-5/18	7/09-7/24
4C	NS	NS
5A	5/03-5/18	7/09-7/24
5B	5/03-5/18	7/09-7/24
5C	NS	NS

LOCATION	DATES SAMPLED Spring	Summer
6A	4/19-5/18	7/09-7/24
6B	4/19-5/18	7/09-7/24
6C	NS	NS
7A	4/19-5/01	NS
7B	NS	NS
7C	4/19-5/01	NS
8A	4/19-5/18	7/09-7/24
8B	NS	NS
8C	4/19-5/18	7/09-7/24
9A	NS	NS
9B	4/19-5/18	7/09-7/24
9C	4/19-5/18	7/09-7/24
10A	4/19-5/18	7/09-7/24
10B	NS	NS
10C	4/19-5/18	7/09-7/24

were selected because previous data showed relatively high fish passage rates. The turbine intake transducers sampled fish passage into 20 of 27 turbine intakes. (At any given time during the study, three intakes were not available because of turbine runner replacement.) During the spring Unit 5 was out of service until May 3. Unit 7 was out of service for the entire summer study period. The transducers deployed in Unit 7 were moved to Unit 5 when Unit 7 went out of service. The transducer in Turbine Intake 3A was moved to Turbine Intake 1C on May 5 to more intensively sample where preliminary data showed higher fish passage rates. The turbine intake transducers sampled fish that were not diverted into the bypass system.

2.3 Sampling Design

For monitoring run timing, one hydroacoustic system sampled smolt passage in the forebay. The system, which had one chart recorder, sampled in the forebay immediately upstream of the dam. The four forebay locations were each sampled once every hour for a minimum of 15 min at 4 pps. During the spring (April 19 to May 18) and summer (July 9 to July 24) bypass studies, we did not sample the forebay. During the bypass studies, we used data from the bypass intake slot transducers to produce a run timing index. For monitoring run timing, samples were obtained at least eight hrs/day (1300 h - 1700 h and 2200 h - 0200 h) every day from April 7 to August 31.

For both spring and summer, we defined the hours of day and night during a study day as follows:

Day = 0800 h - 2000 h (Date X) and 0600 h - 0800 h (Date X+1)

Night = 2000 h - 0600 h (Date X to Date X+1).

NOTE: This definition was based on previous studies when it was necessary to change experimental conditions each day. These changes were made by work crews starting at 0800 h. In 1991, a study day should be defined as 0600 h to 0600 h.

For evaluating the bypass, one hydroacoustic system sampled the bypass slots and two systems sampled turbine intakes. Each transducer was sampled for a minimum of 12 minutes an hour for 24 hours per day during the spring and summer sampling periods. Typically, three 4-minute samples were collected each hour for each transducer location. The hourly sampling sequence was systematic. The start location of the systematic sequence was randomized at the start of every study day (0800 h).

2.4 Statistical Methods

We determined fish passage (#/hr) at each location each hour by summing the weighted fish detections and dividing by total sample time (usually 12 minutes) at a given location within a given hour and then multiplying by 60 minutes per hour (Appendix A). The hourly passage rate estimates were the basic data for monitoring run timing and evaluating the bypass.

The run timing index from the forebay transducers was calculated by averaging passage rates over the four locations to produce a mean number per eight hrs per location. These numbers were adjusted for the percentage of non-target species present in the fyke net catch for each week. The run timing index from the bypass slot transducers was calculated by averaging passage rates over the five bypass slot locations.

Total project bypass efficiency, for spring and summer separately, was estimated by dividing total fish passage in bypass by total passage in turbine plus bypass.

$$B = y/(y+x)$$

where y = fish passage in bypass, and

x = fish passage in turbine.

$$CI(B) = B * \exp[z * (var(B)(1/B^2 + 3 * var(b)/B^4))^{.5}]$$

where $var(B) = B^2(1-B)^2[var(y)/y^2 + var(x)/x^2]$

z = 1.645 at the 90% confidence level and

z = 1.96 at the 95% confidence level

The methods were developed by Dr. John Skalski of the University of Washington and are presented in Appendix B. The algorithm for estimating the confidence interval was determined by Dr. Skalski (Skalski and Ouellette, 1990).

2.5 Fyke Net Methods

During 1990, DCPUD collected species composition data inside Turbine Intake 4C using fyke nets. Net data were collected at least once per week from April 5 to August 30, 1990. Sampling usually lasted eight hours. For the first three months of the study, sampling was done

only at night. During July and August, day and night samples were collected. The entire cross-sectional area of the turbine could be sampled by the array of three nets across by seven nets down. During 1990 only the center column of seven nets was fished. Each net opening was 7 ft wide and 6.75 ft high. Each net was 13 ft long with 3/8 inch stretch mesh and 1/4 inch mesh cod end. In spring and summer, all captured fish were counted, examined for marks and a subset was measured. The fish were categorized as follows: yearling chinook, zero-age chinook, sockeye, steelhead, whitefish, and other. Fish counts were divided by sample time to produce number passing per unit time.

3.0 RESULTS

3.1 Ancillary Data

3.1.1 Project Discharge and Dam Operations

From April through August 1990, project discharge at Wells Dam was higher than the 15-yr average (Table 3). Overall, the mid-Columbia had relatively high water during spring and summer 1990. Because of the high amount of water, power generation was usually at its maximum during the bypass evaluation. One turbine unit, however, was always off line due to turbine runner replacement.

Table 3. Project discharge (kcfs) for Wells Dam during April through August, 1990. Source: T. Roberts (DCPUD).

	PROJECT DISCHARGE (kcfs)				
	April	May	June	July	August
Min. daily average	72.3	89.4	157.9	92.8	52.3
Max. daily average	186.1	189.5	254.6	186.5	156.4
Avg. hourly discharge	138.7	144.1	208.5	145.3	111.3
15-year average	110.5	132.1	133.9	115.1	100.1
% 15-year average	125	109	156	126	111

Bypass operations for smolt passage at Wells Dam in 1990 were similar to those in previous years. By agreement of the Mid-Columbia Coordinating Committee, bypass flow replaced interim spill. DCPUD operated the bypass daily from April 17 to June 6, and from July 6 to August 15, 1990. The number of bypass units that were operated depended on the daily flow forecast from Chief Joseph Dam. If the flow forecast was greater than or equal to 140 kcfs, all five bypass units were opened for that 24-hr period. There was a total of 22 days during which all bypass units were open due to inflow estimates. If the forecast was less than 140 kcfs, only those bypass units above a pair of turbines, with one or both operating, were opened (Tom Hook, DCPUD, personal communication). Each bypass unit is associated with two turbines (Bypass Unit S2 with Turbines 1 and 2; Bypass Unit S4 with Turbines 3 and 4; etc.). Therefore, if one or both turbines of a pair were on-line, then the bypass unit was opened. If both units were off-line,

then the bypass unit was closed. From August 6 to August 15, bypass operation was limited to dusk through dawn operation (2000 h -0600 h). Minimum bypass flows (kcfs) were: S2 = 1.6 to 2.1; S4 = 2.2; S6 = 2.2; S8 = 2.2; and S10 = 1.6 to 2.1. During 1990, daily bypass flow at Wells Dam averaged 5.8% of total project discharge.

3.1.2 Species Composition

The principle salmonid species migrating past Wells Dam in spring are: chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*O. mykiss*), and sockeye salmon (*O. nerka*). Spring chinook are raised and released at the U.S. Fish and Wildlife Service hatchery at Winthrop, 50 miles upstream from Wells. Steelhead are raised at the Wells hatchery and transported to upstream release sites. The quantities, dates, and locations of the spring 1990 releases of hatchery-raised salmonids above Wells Dam are given in Table 4. About 1.8 million fish were released in the drainage above Wells Dam in 1990. Wild stocks of sockeye also migrate downstream through Wells Dam. These salmon migrate out of Lake Osoyoos, about 100 miles upstream from Wells. In spring and summer, wild chinook that reproduce in the Okanogan and Methow drainages (zero-age chinook) migrate downstream through the Mid-Columbia (Figure 1).

Table 4. Species, locations, distances from Wells, dates, and sizes of releases of hatchery-raised juvenile salmonids upstream of Wells Dam in spring 1990. Sources: B. Wallien (USFWS) and S. Miller (WDG).

SPECIES	RELEASE SITE	MILES FROM WELLS DAM	DATE	NUMBER
spring chinook	Winthrop	50	4/17	1,121,395
summer steelhead	Methow RM 27	33	4/27-5/2	163,089
	Methow RM 10	16	4/30-5/9	294,150
	Methow RM 1	7	5/3-5/4	30,000
	Okanogan RM 26	41	5/1-5/3	57,900
	Okanogan RM 5	21	5/4-5/7	40,500
	Similkameen RM 6	90	4/18-4/25	97,494
	Twisp RM 6	46	4/30-5/1	28,500
	Chewuch RM 8	58	4/23	28,800
				Total = 1,861,828

The 1990 fyke net catch data from Wells Dam are tabulated in Table 5 and graphed in Figures 7A, 7B, and 8. Catches from April 5 and April 12 were low and consisted mainly of chinook salmon with only one steelhead present in each catch. On April 19 the catch increased dramatically due to the chinook release from Winthrop on April 17 (Figure 7A and Table 4). The catch from April 19 to May 16 ranged between 96% and 100% chinook, sockeye, and steelhead (Figure 8). There were large numbers of steelhead present in the catches of May 3 and May 10 (Figure 7A). On May 16, a large peak of sockeye occurred. From the end of May through the end of June, whitefish and other non-target species increased in catch proportion (Figure 8). From May 24 to June 28 the catch proportion of whitefish and "other" species ranged from 54% to 90% of the total catch (Table 5). Zero-age chinook began to appear in greater numbers on July 5 (Figure 7A). Between July 5 and August 9 the proportion of chinook in the fyke net catch ranged from 71% to 95% for the night samples (Table 5). Very low numbers of salmon were caught during daytime sampling in July and August (Figure 7B). From mid-August until the end of the study (August 31) the catch consisted mainly of non-target species (Figure 8).

The 1990 fyke net data show the consistent year-to-year trend of a spring period (April 5 to May 16) dominated by chinook, sockeye, and steelhead. Zero-age chinook dominated the catch from July 5 through August 9 (Figure 7A). Whitefish increased in number in late May and were present in noticeable numbers throughout the summer (Figure 8). "Other" fish that were caught in the fyke net included bullhead, carp, chiselmouth, dace, lamprey, peamouth, sculpin, shiner spp., squawfish, sucker, and walleye.

Table 5. Number and proportion of chinook, steelhead and other non-salmonid species caught in the fyke nets at Wells Dam in spring and summer 1990. Data are expressed in number of fish per hour and proportion. Source J. McGee (DCPUD).

		Oncorhynchus Species						Non-Salmonid Species					
	Day/	Chinook		Sockeye		Steelhead		Whitefish		Other		All non-salmonids	
Date	Night	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.
4/05	N	9.6	0.99	0.0	0.00	0.1	0.01	0.0	0.00	0.0	0.00	0.0	0.00
4/12	N	1.4	0.92	0.0	0.00	0.1	0.08	0.0	0.00	0.0	0.00	0.0	0.00
4/19	N	190.8	0.99	0.0	0.00	0.0	0.00	0.0	0.00	1.0	0.01	1.0	0.01
4/26	N	7.9	0.80	0.1	0.01	1.5	0.15	0.0	0.00	0.4	0.04	0.4	0.04
5/03	N	7.1	0.45	0.4	0.02	8.4	0.52	0.0	0.00	0.1	0.01	0.1	0.01
5/10	N	7.9	0.20	6.1	0.16	23.8	0.61	0.3	0.01	1.0	0.03	1.0	0.03
5/16	N	1.0	0.01	116.5	0.99	0.4	0.00	0.1	0.00	0.3	0.00	0.4	0.00
5/24	N	0.4	0.02	9.5	0.42	0.4	0.02	3.3	0.15	8.9	0.39	12.1	0.54
5/31	N	1.4	0.03	3.1	0.07	0.0	0.00	2.4	0.05	39.6	0.85	42.0	0.90
6/04	N	0.3	0.06	0.1	0.03	0.0	0.00	1.1	0.29	2.4	0.61	3.5	0.90
6/07	N	0.3	0.11	0.0	0.00	0.0	0.00	0.5	0.21	1.6	0.68	2.1	0.89
6/14	N	0.9	0.23	0.1	0.03	0.0	0.00	1.0	0.26	1.9	0.48	2.9	0.74
6/21	N	1.4	0.18	0.0	0.00	0.0	0.00	2.1	0.28	4.0	0.52	6.1	0.82
6/28	N	2.1	0.38	0.0	0.00	0.0	0.00	0.9	0.16	2.6	0.47	3.5	0.62
7/05	N	9.9	0.71	0.0	0.00	0.0	0.00	0.9	0.06	3.1	0.23	4.0	0.29
7/06	D	0.3	0.40	0.0	0.00	0.0	0.00	0.3	0.40	0.1	0.20	0.5	0.60
7/12	N	24.4	0.81	0.0	0.00	0.1	0.00	3.0	0.10	2.5	0.08	5.4	0.18
7/13	D	0.1	0.14	0.0	0.00	0.0	0.00	0.6	0.71	0.1	0.14	0.8	0.86
7/19	N	25.7	0.86	0.0	0.00	0.0	0.00	2.4	0.08	2.1	0.01	4.5	0.15
7/20	D	0.5	0.40	0.0	0.00	0.0	0.00	0.6	0.50	0.1	0.10	0.8	0.60
7/26	N	14.0	0.87	0.0	0.00	0.4	0.02	1.0	0.06	0.8	0.05	1.8	0.11
7/27	D	0.1	0.60	0.0	0.00	0.0	0.00	0.4	0.30	0.1	0.10	0.5	0.40
8/02	N	7.6	0.92	0.0	0.00	0.0	0.00	0.1	0.02	0.5	0.06	0.6	0.08
8/03	D	0.1	0.50	0.0	0.00	0.0	0.00	0.0	0.00	0.1	0.50	0.1	0.50
8/09	N	2.3	0.95	0.0	0.00	0.0	0.00	0.0	0.00	0.1	0.05	0.1	0.05
8/10	D	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.1	1.00	0.1	1.00
8/14	N	0.8	0.32	0.0	0.00	0.0	0.00	0.5	0.21	1.1	0.47	1.6	0.68
8/16	N	1.5	0.39	0.0	0.00	0.0	0.00	0.0	0.00	2.4	0.61	2.4	0.61
8/23	N	0.0	0.00	0.0	0.00	0.0	0.00	0.3	0.05	2.4	0.95	4.8	1.00
8/30	N	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	26.3	1.00	26.3	1.00

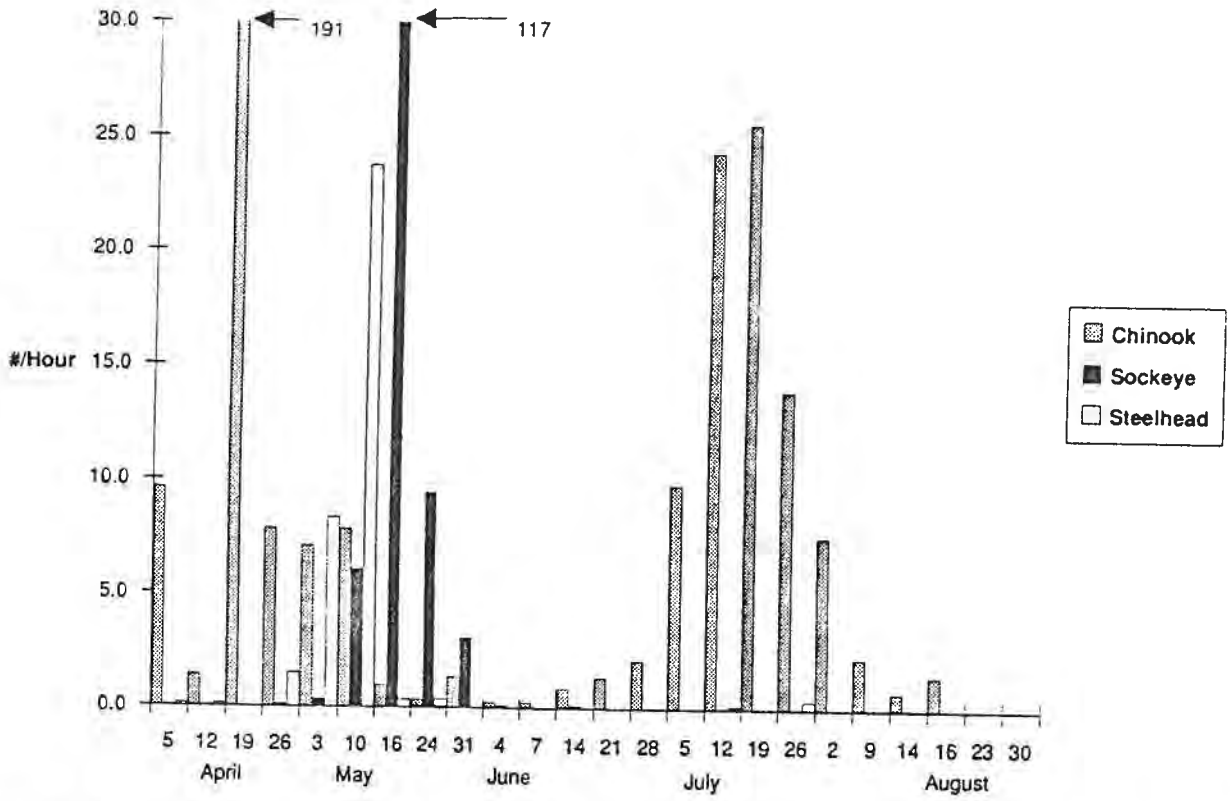

Figure 7A. Catch per hour of chinook (zero-age and yearlings combined), sockeye, and steelhead in the fyke nets at Wells Dam from April 5 to August 30, 1990, for night only.

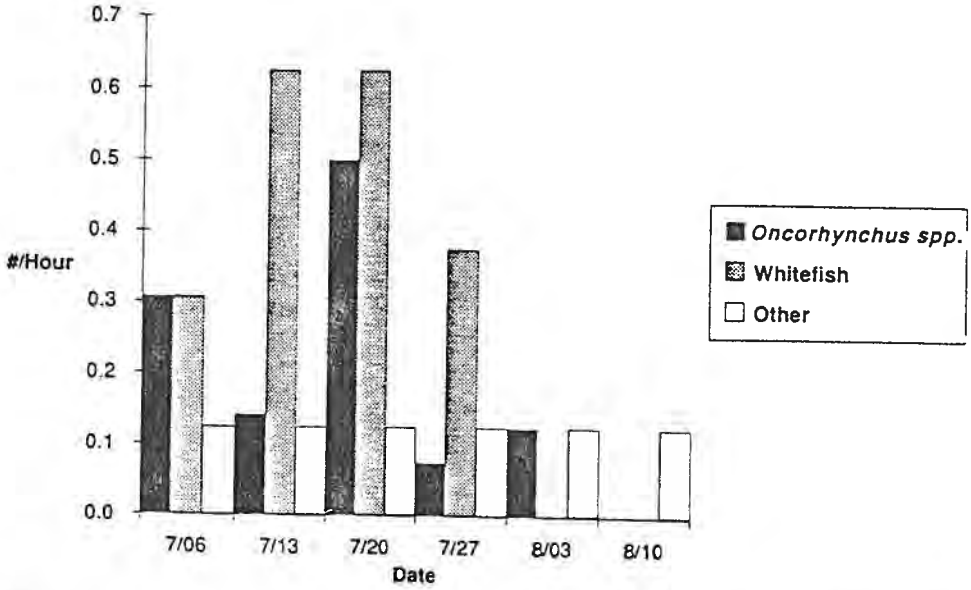

Figure 7B. Catch per hour of *Oncorhynchus spp.*, whitefish, and "other" species in the fyke nets at Wells Dam from July 6 to August 10, 1990, for day only.

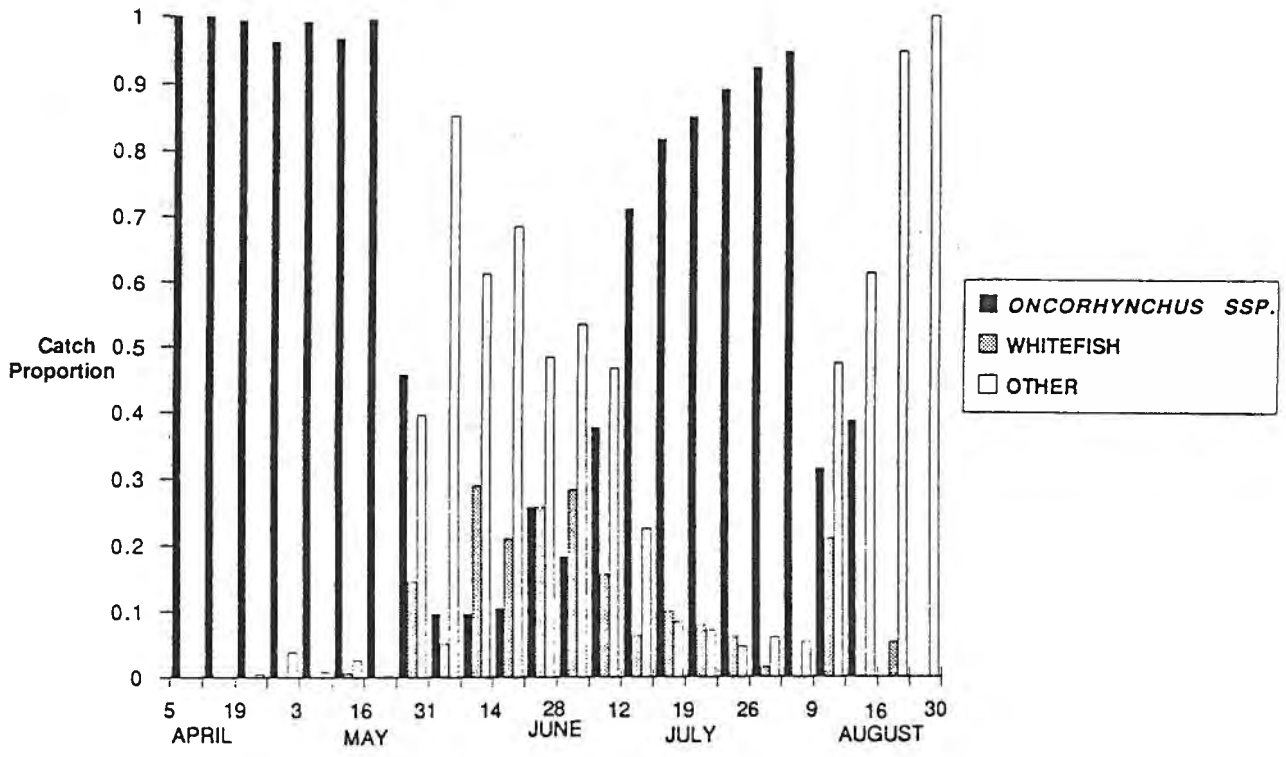

Figure 8. Proportions of the total catch from fyke net samples at Turbine Intake 4C at Wells Dam in 1990, April 5 to August 30, for night only.

3.1.3 Run Timing

The daily "sub-index" of run timing (mean #/8hr/location) from April 7 to August 31, 1990 is presented in Figures 9, 10, and 11. Recall from the methods section that run timing was calculated using forebay data for all days other than those during the spring and summer study periods. Bypass intake slot data were used to generate the run timing index during the bypass evaluation periods.

Passage was generally low in early April (Figure 9). The first peak occurred on April 16. There were significant numbers of chinook present in the fyke net catches of April 5 and April 12 (Table 5). These fish may have been produced in the wild since no 1990 hatchery fish had been released above Wells yet. The next peak occurred on April 19, two days after the chinook release at Winthrop (Figure 10 and Table 4). Passage rates remained high until April 26. Fyke net catches on April 19 and April 26 were 99% and 80% chinook salmon respectively (Table 5). There were two more peaks on May 5 and May 7 (Figure 10). There were significant numbers of steelhead in the fyke net catches of May 3 and May 10 (Figure 7A). This coincides well with the large hatchery releases of steelhead in the Methow River during late April and early May (Table 4). Another peak occurred on May 15 (Figure 10). The fyke net catch of May 16 showed that very high numbers of sockeye were present (Table 5 and Figure 7A). Passage rates then generally declined to the lowest rates of the season which occurred in mid-June. Another peak occurred on June 21 (Figure 9). This was probably a combination of whitefish and other non-target species. The fyke net catches of June 14, 21, and 28 contained between 62% and 82% whitefish and "other" (Table 5). Passage rates began to rise in late June and early July due to the beginning of the summer chinook outmigration. Passage rates remained high from July 12 to July 18 (Figure 11). The fyke net catches from this period were between 81% and 86% zero-age chinook (Table 5 and Figure 8). Very low numbers of salmon were caught during daytime sampling in July and August (Figure 7B). As in previous years (Kudera *et al.* 1990), after the end of the summer study period passage rates began to rise due to the influence of other non-target species. The highest passage rate of the season was on August 3 (Figure 9).

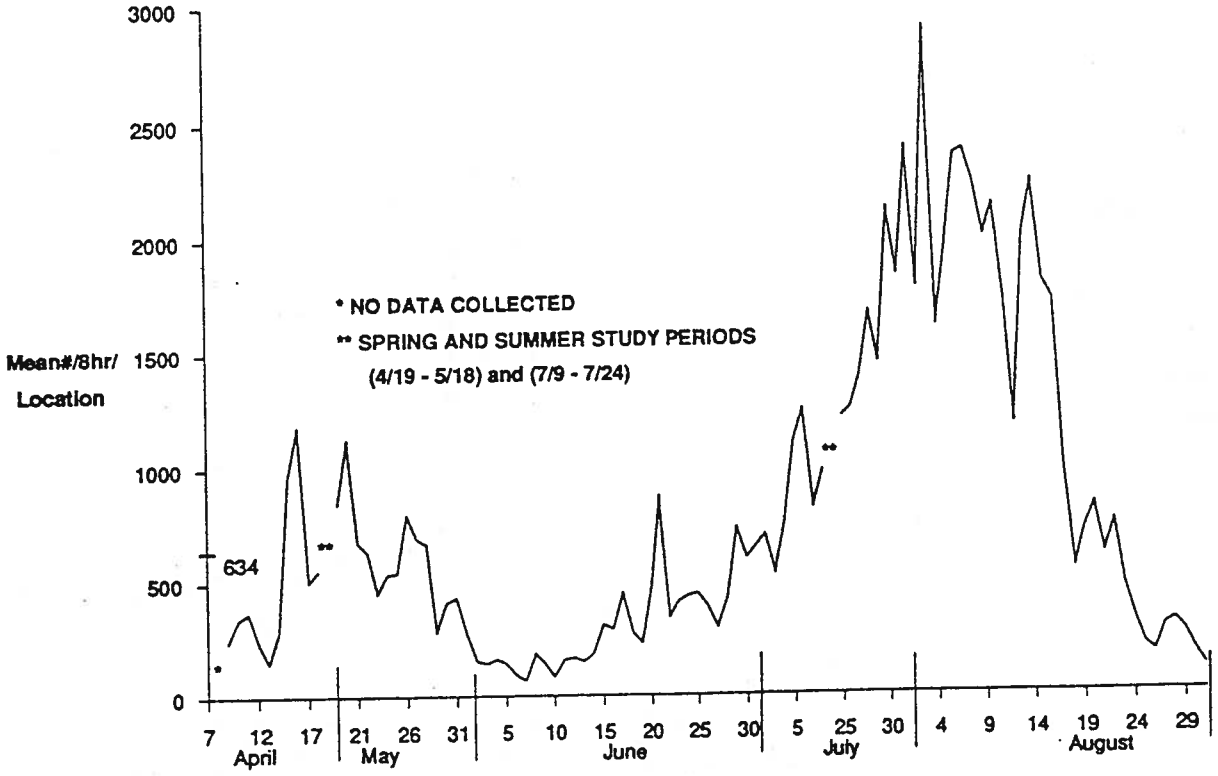

Figure 9. Daily fish passage indices (mean #/8hr/location) for day (1300 h - 1700 h) and night (2200 h - 0200 h) combined at Wells Dam forebay between April 7 and April 18, May 19 through July 8, and July 25 through August 31,1990.

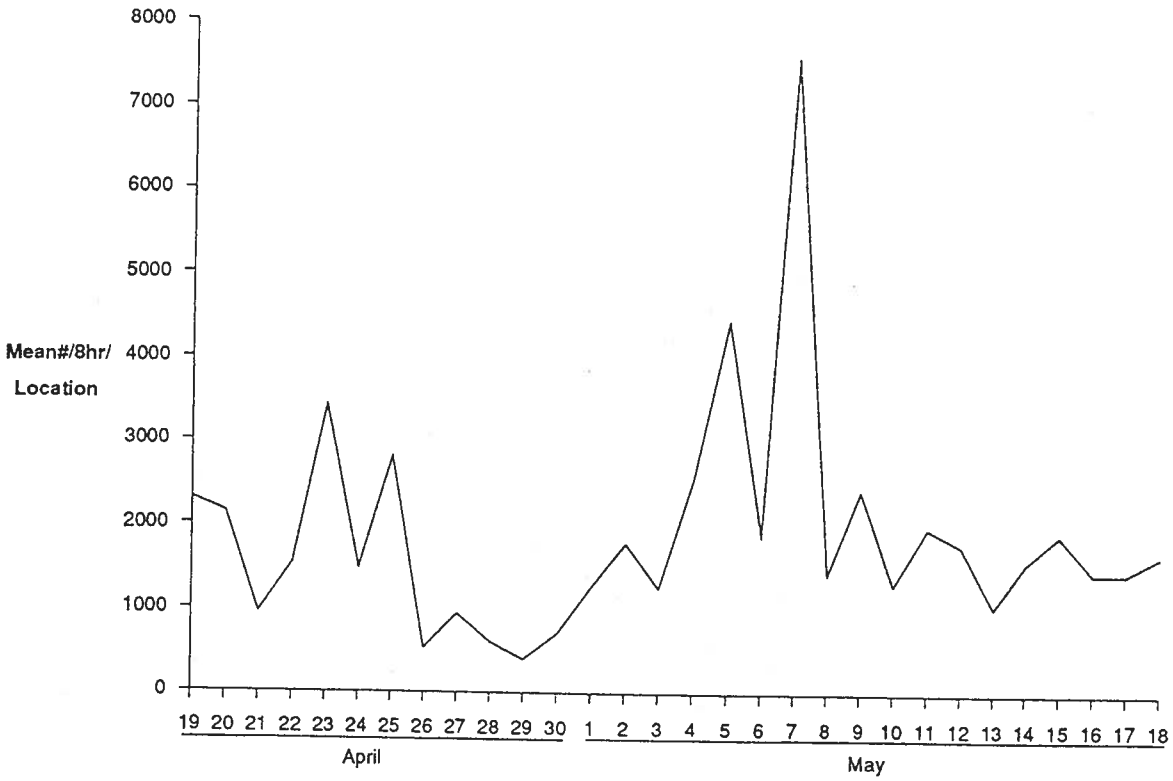

Figure 10. Daily fish passage indices (mean #/8hr/location) for day (1300 h - 1700 h) and night (2200 h - 0200 h) combined using bypass slot data at Wells Dam between April 19 and May 18, 1990.

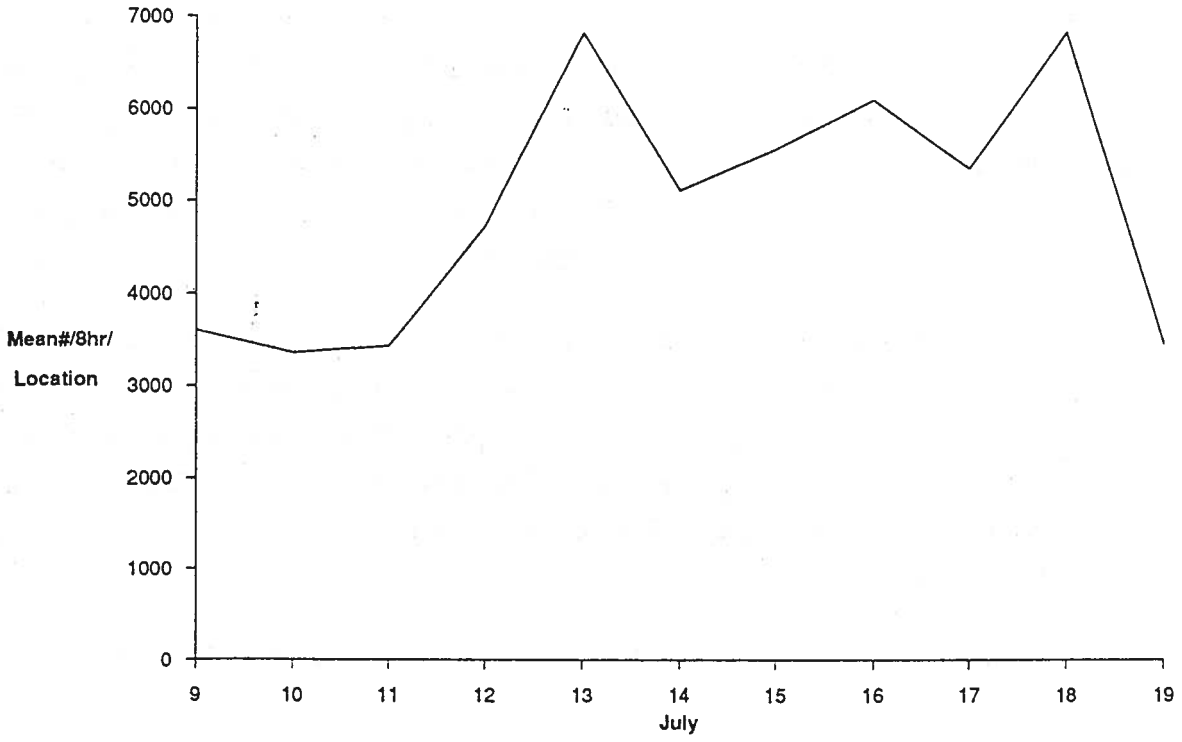

Figure 11. Daily fish passage indices (mean #/8hr/location) for day (1300 h - 1700 h) and night (2200 h - 0200 h) combined using bypass slot data at Wells Dam between July 9 and July 19, 1990.

3.2 Estimated Total Project Bypass Efficiency

Estimated total project bypass efficiency in spring 1990 was 84.3% ± 8.0% at the 95% confidence interval. Daily bypass ratios for spring are given in Figure 12. Bypass efficiency was generally lower at the beginning of the study than at the end. The lowest efficiency during the spring was 53% and occurred on April 19. The highest efficiency was 99% and occurred on April 25.

The coefficient of variation (CV = standard error divided by the mean) for the 30-day spring study was 30.4% for bypass and 4.3% for turbine passage. The bypass CV was unusually high because of the high bypass passage rates sampled on April 25, although the ratio CV and confidence interval met the criteria (Appendix C). Excluding this date, the CV for bypass for a 29-day spring study was 1.2%. Excluding April 25 bypass and turbine data, the 29-day bypass efficiency for spring was 77.8% ± 1.45% at the 95% confidence level.

Estimated total project bypass efficiency in summer 1990 was 76.5% ± 4.0% at the 90% confidence level. Thus, the bypass results for the 1990 summer study do meet the criteria. Daily bypass ratios for summer are given in Figure 13. Bypass efficiency during the summer was generally lower than during the spring. The highest rates were generally at the beginning and the end of the study period. The highest efficiency of 82% occurred on July 18. The lowest efficiency, 69%, occurred on July 14.

To summarize, the estimates of **total project bypass efficiency** at Wells Dam in 1990 were:

Spring	84.3% ± 8.0% at 95% confidence level
Summer	76.5% ± 4.0% at 90% confidence level

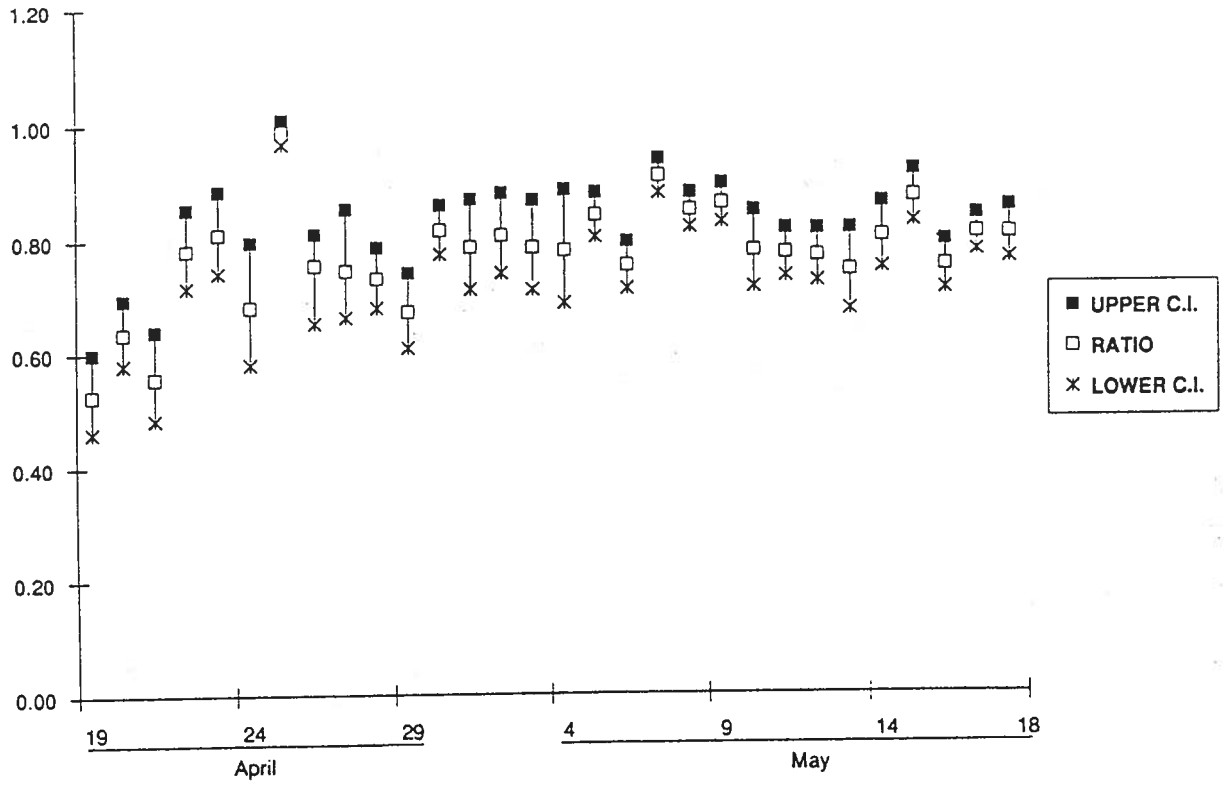

Figure 12. Daily bypass efficiency estimates for spring (April 19 to May 18) at Wells Dam, 1990. Ratios are expressed for 90% confidence levels.

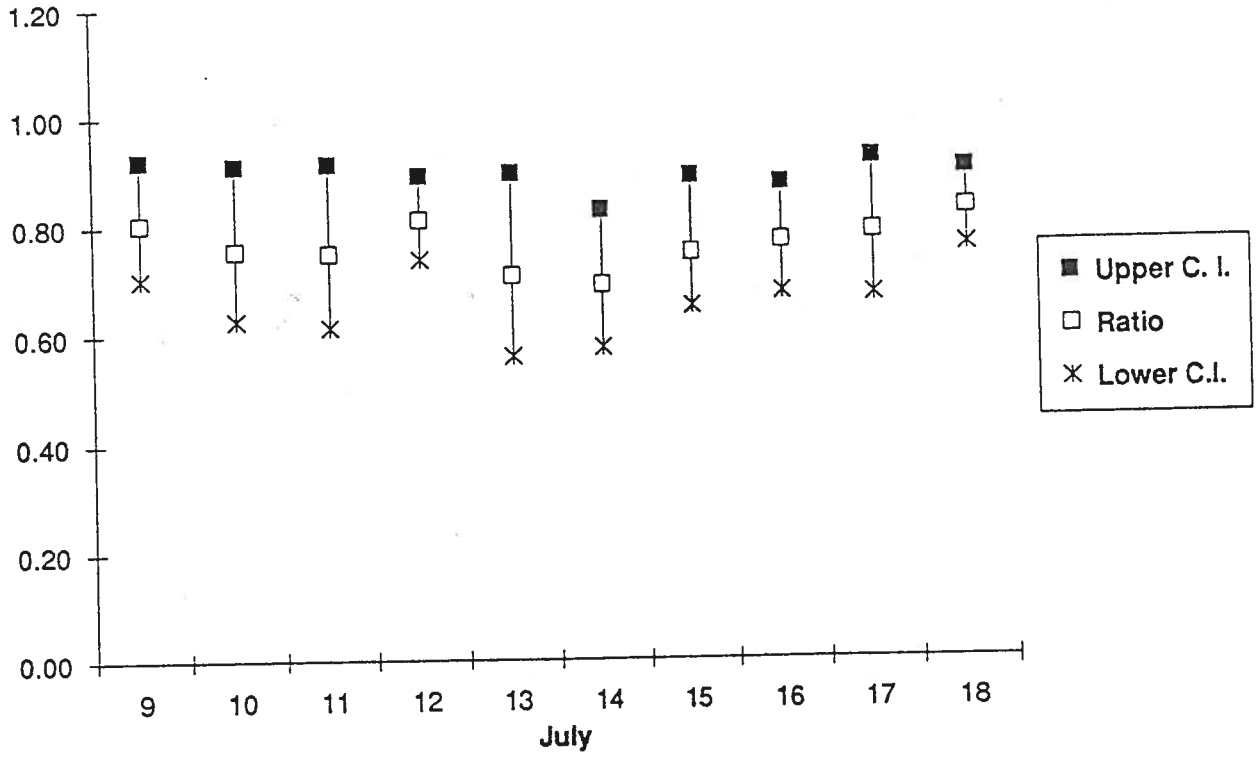

Figure 13. Daily bypass efficiency estimates for summer (July 9 to July 19) at Wells Dam, 1990. Ratios are expressed for 90% confidence levels.

4.0 CONCLUSIONS

(1) Total project bypass efficiency was estimated using hydroacoustic techniques during spring (April 19 to May 18) and summer (July 9 to 24) study periods at Wells Dam in 1990.

(2) Species composition and run timing data were collected using fyke net and hydroacoustic methods from April 5 to August 31, 1990.

(3) Chinook and sockeye salmon and steelhead trout juveniles were predominant in spring from April 15 to May 16. Zero-age chinook were predominant in July. During the periods between the spring and summer studies and after the summer study, other species such as whitefish were prevalent.

(4) Estimated total project bypass efficiency for the 30-day spring study was 84.3% ± 8.0% at the 95% confidence level. There was one day (April 25), however, that had extremely high passage in bypass. The bypass efficiency for this day was 99%. With this data point excluded from analysis, estimated total project efficiency in spring was 77.9% ± 1.5% at the 95% confidence level.

(5) Estimated total project bypass efficiency for the summer study was 76.5% ± 4.0% at the 90% confidence level.

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APPENDIX A

HYDROACOUSTIC SYSTEM, DATA ACQUISITION, AND DATA REDUCTION

APPENDIX A. Hydroacoustic System, Data Acquisition, and Data Reduction

A.1 Hydroacoustic System Equipment, Operation, and Calibration

A.1.1 Equipment Description

The hydroacoustic studies at Wells Dam in 1990 required three BioSonics systems. Each system (Figure A1) consisted of the following components: high-frequency transducers (420 kHz) with cable, an echo sounder/transceiver, a multiplexer/equalizer, one or two chart recorders, and an oscilloscope. Specific manufacturers and model numbers of the electronic equipment used are listed in Table A1. The hardware parameters used in 1990 are presented in Table A2.

Table A1. Model numbers, manufacturers, and serial numbers of electronic equipment used by BioSonics, Inc. at Wells Dam in spring and summer 1990.

MODEL NO. AND EQUIPMENT	MANUFACTURER	SERIAL NO.
Model 101 (420 kHz) Echo Sounder	BioSonics, Inc.	101-81-010 101-83-030 101-81-031
Model 151 MPX/EQ Multiplexer/Equalizer	BioSonics, Inc.	151-83-006 151-87-026 151-89-029
Model X-MPX Multiplexer	BioSonics, Inc.	MPX-81-004
Model X-EQU Equalizer	BioSonics, Inc.	EQ-82-010
Model 111 Chart Recorders	BioSonics, Inc.	111-85-004 111-86-029 111-88-038 111-88-039 111-89-048 111-90-062
Transducers	BioSonics, Inc.	Too numerous to list
Model V-423 Oscilloscope	Hitachi, Inc.	5017445

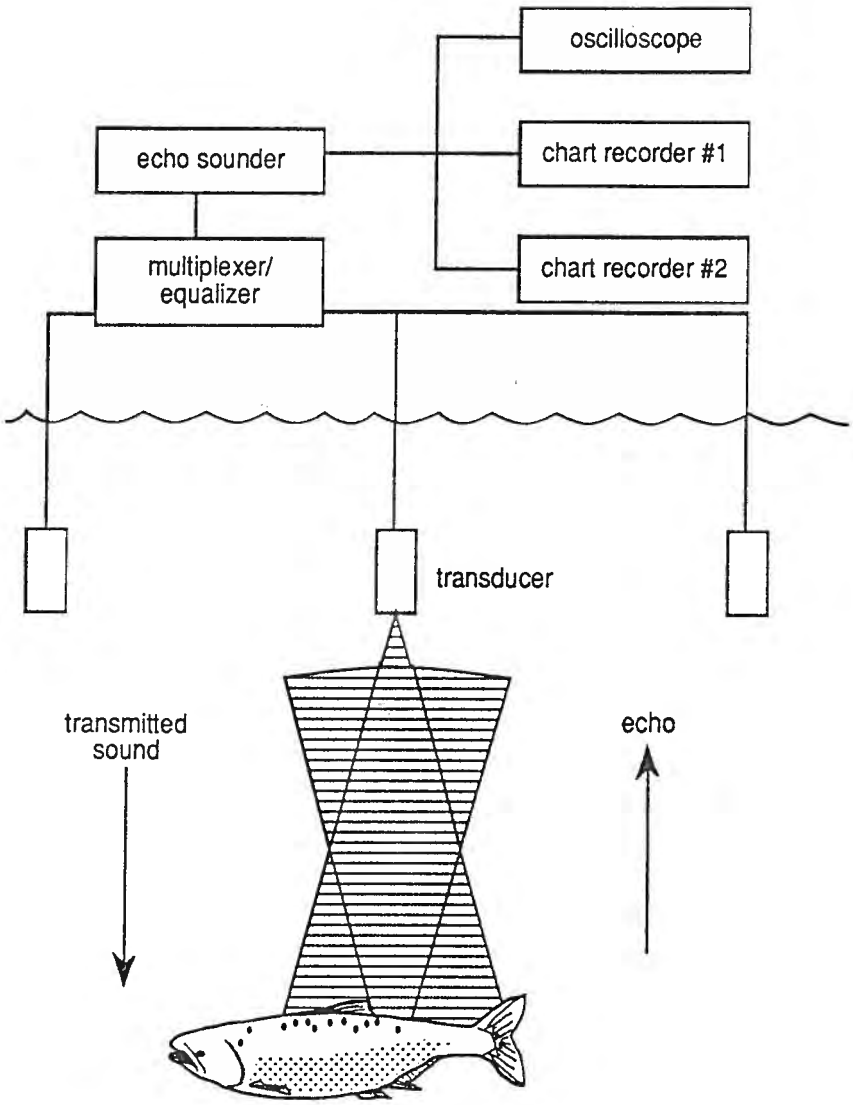

Figure A1. Block diagram of hydroacoustic data collection system used at Wells Dam in 1990.

Table A2. Hydroacoustic system parameters used for studies at Wells Dam in 1990.

ECHO SOUNDER	Transmit frequency: 420 kHz
	Transmit power: 0 dB
	Band width: 5 kHz
	Pulse width: 0.4 msec
	TVG: 40 log(R)
	Trigger source: Thermal chart recorder
	Receiver gain -6 dB
CHART RECORDERS	Threshold: 0.1 volts

A.1.2 Equipment Operation

A BioSonics hydroacoustic system works as follows. When triggered by the Model 101 Echo Sounder, a high-frequency transducer emits short sound pulses in a relatively narrow beam aimed toward an area of interest. As these sound pulses encounter fish or other targets, echoes are reflected back to the transducer which then reconverts the sound energy to electrical signals. The signals are then amplified by the echo sounder at a 40 log(R) time-varied-gain (TVG) to compensate for the loss of signal strength due to absorption and geometric spreading of the acoustic beam with distance from the transducer. Thus, equally sized targets produce the same signal amplitudes at the echo sounder receiver output regardless of their distance (range) from the transducer. The range of each target from the transducer is determined from the time it takes the sound pulse and echo return to travel that distance (velocity of sound in fresh water = 1445 m/sec).

The echo sounder relays the returning TVG-amplified signals to the chart recorder, oscilloscope, and tape recorder. The return signals are visually displayed on the oscilloscope to observe echo strength and echo duration. Returns from individual fish are recorded on the chart recorder's echograms which provide a permanent record of all targets detected throughout the study. The threshold circuit on the chart recorder is adjusted to eliminate signals less than the echo levels of interest.

The Model 151 Multiplexer/ Equalizer (MPX/EQ) permits a single echo sounder to automatically interrogate up to 16 different transducers in an operator-specified sequence. The MPX/EQ channels transmit pulses from the echo sounder to the appropriate transducers and equalizes the return signals to compensate for the different receiving sensitivities resulting from varying cable lengths and transducer characteristics.

A.1.3 System Calibration

Each acoustic system was calibrated before the study began. Calibration assured that an echo from a target of known acoustic size passing through the axis of the acoustic beam produced a specific output voltage at the echo sounder. Based on the calibration information, the adjustable print threshold on the chart recorder was set so that it would print signals from targets larger than -56 dB on the acoustic axis of the transducer. The calibration information was also used to equalize the system sensitivity (using the MPX/EQ) for each receiving channel. A system calibration at the end of the season verified that the sensitivities had remained constant throughout the study. A detailed description of the calibration of hydroacoustic systems can be found in Albers (1965) and Urich (1975).

A.2 Data Acquisition Methods

A.2.1 Migrant Detection Criteria

Echogram traces had to satisfy two criteria to be classified as fish: 1) the strength of target echoes had to exceed a predetermined threshold; and 2) the targets had to be detected by consecutive acoustic pulses (redundancy).

As stated above, the hydroacoustic systems were calibrated so that the chart recorder marked only targets with echo strengths greater than -56 dB on the acoustic axis of each transducer. This echo strength threshold was chosen so that even the smallest outmigrant salmon and steelhead returned an echo strong enough to mark the echogram.

At least four successive echoes were required for a target to be classified as a fish. Most of the observed fish were detected more than four times in succession. This high redundancy occurred because of the relatively wide beamwidths of the transducers and the high pulse repetition rates. This redundancy criterion enhanced fish detectability in the presence of background

interference. Further details of fish detection criteria for fixed-location hydroacoustics can be found in Carlson, *et al.* (1981).

Based on echogram "trace types" (i.e., the pattern of marks produced by successive detections), fish were classified as either "migrants" or "wallowers." Wallowers produced marks consistent with large resident fish milling about in the forebay. Migrant trace types exhibited change-in-range consistent with the smaller smolts. Only fish classified as migrants were included in the analyses.

A.2.2 Background Interference Level

The background interference level on the echograms of each interrogation period was rated on a scale of 1 to 5.

1 = No interference
2 = Little interference, no effect on fish trace recognition
3 = Moderate interference, no effect on fish trace recognition
4 = Excessive interference, adverse effect on fish trace recognition
5 = Black

Interrogation periods with the highest interference levels (4 and 5) were not included in data analysis. For the 1990 studies at Wells Dam, less than 4% of all interrogation periods were excluded because of excessive interference.

A.2.3 Data Entry and Storage

Microcomputers were used for data storage and analysis. Data from individual fish detections recorded on the echograms were written to computer data files using a digitizing pad and appropriate software. For each fish detected passing through the acoustic beam, a technician used the digitizing stylus to record the following:

time of entrance
time of exit
range at entrance
range at exit
trace type

The following information was recorded for each interrogation period:

date
start time of transducer interrogation
duration of transducer interrogation
transducer location
transducer depth
transducer beamwidth
transducer orientation
background interference level

A.3 Data Reduction Methods

A.3.1 Data Selection

Two criteria were used to select the data for the various analyses. First, all fish detections from interrogation periods with excessive background interference were eliminated, as explained in Appendix A.2. Second, based on trace type classification, all non-migrant fish ("wallowers") were excluded. The remaining fish detections were used in the analyses.

A.3.2 Range of Fish

For a given outmigrant, the range from the transducer (R) was the mid-point range of the echo trace as calculated by:

$$R = \frac{R_{in} + R_{out}}{2}$$

where R_{in} and R_{out} are the ranges at which the fish entered and exited the acoustic beam, respectively.

A.3.3 Weighting Factor

Since only a portion of the cross-sectional area at a sampling location was ensonified, individual fish detections were multiplied by a weighting factor to estimate the total relative number of fish passing that location at that particular range and time. To account for the cone-shaped geometry of the acoustic beam, the weighting factor was defined as the ratio of the width at the

sampling location to the width of the acoustic beam at the range of detection. (Sampling location widths were: pier nose = 90 ft; turbine intake = 22.5 ft; bypass slot = 22.5; and bypass spill bay = 46 ft). The weighting factor was:

$$W_{ij} = \frac{I_j}{2R_{ij}\mathrm{Tan}(\theta_j/2)}$$

where:

W_{ij} = weighted observation of fish (i) at location (j);

I_j = width of location (j);

θ_j = nominal beam width (degrees) of transducer at location (j);

R_{ij} = range of fish (i) from transducer at location (j).

Thus, fish detected closer to the transducer were weighted more (to represent more fish) than those detected further away. All subsequent analyses were based on these weighted fish detections.

A.3.4 Fish Passage Indices

An hourly estimate of relative fish passage (#/hr) at location (j) was computed as:

$$F_{jh} = \frac{\sum_{i=1}^{n_{jh}} W_{ijh}}{t_{jh}} \times 60$$

where:

F_{jh} = number of fish per hour at location (j) during hour (h)

W_{ijh} = weighted fish (i) at location (j) during hour (h)

t_{jh} = total number of minutes in hour (h) that location (j) was sampled

n_{jh} = total number of migrant detections at location (j) during hour (h).

APPENDIX B

STATISTICAL DESIGN FOR ESTIMATING TOTAL PROJECT BYPASS EFFICIENCY

STATISTICAL DESIGN FOR ESTIMATING TOTAL PROJECT BYPASS EFFICIENCY AT WELLS DAM IN 1990

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to

Douglas County PUD No. 1

8 June 1989

INTRODUCTION

The objective of the 1990 bypass study at Wells Dam is to estimate total project bypass efficiency (B). Using hydroacoustic techniques, estimates of B will be obtained separately for the spring and summer outmigrations. Total project bypass efficiency is defined as

$$B = \frac{Y}{Y + X}$$

where

Y = total passage of smolt through bypass facilities,

X = total passage of smolt through turbine units.

However, direct enumeration of bypass (Y) and turbine (X) passage is not feasible. Instead, estimates of passage, $\hat{Y}$ and $\hat{X}$, must be used in estimating total project bypass efficiency where

$$\hat{B} = \frac{\hat{Y}}{\hat{Y} + \hat{X}} .$$

The sampling error associated with the estimate, $\hat{B}$, includes two sources of error, the hydroacoustic measurement error and the subsampling error associated with sampling only a fraction of the total spatial and temporal dimensions of the outmigration at Wells Dam. Proper statistical analysis must account for these sources in subsequent confidence interval construction.

The objective of the statistical design and analysis of total project bypass efficiency is to provide a consistent and statistically efficient estimator ($\hat{B}$) and expressions for its variance ($Var(\hat{B} \mid B)$) and estimated variance ($\hat{V}(\hat{B} \mid B)$) which can be subsequently used in designing the survey and confidence interval construction. The form of the estimator and its variance will depend on the sampling schemes used to estimate $\hat{Y}$ and $\hat{X}$ at Wells Dam. Unlike traditional ratio estimators (Cochran 1977), estimates of Y and X will be independent because separate hydroacoustic sampling schemes will be used in monitoring bypass and turbine passage.

Using hydroacoustic data collected at Wells Dam in 1988 and 1989, the magnitude of the anticipated sampling variance associated with $\hat{B}$ can be projected. The projected estimates of $Var(\hat{B} \mid B)$ will be used to evaluate alternative sampling schemes and levels of sampling effort at Wells Dam during the studies of total project bypass efficiency in 1990. Consequently, an important aspect of the statistical design research is the prediction of sampling precision and the selection of a cost-effective, logistically feasible and precise sampling design.

HYDROACOUSTIC MEASUREMENT ERROR AND SUBSAMPLING ERROR

The basis of proposed sampling designs is a stratified random sampling scheme at a turbine slot or bypass unit on an hour-by-hour basis. In other words, the basic stratum is a "unit hour." Within that hour, only a fraction of the time will be sampled by the hydroacoustic apparatus. For example, let the hour be divided into N equal time intervals of length $60/N$ minutes. Then, if the sampling scheme monitors n of these N intervals, an unbiased estimate of total passage during that unit hour (Z) is

$$Z = \frac{N}{n} \sum_{i=1}^{n} \hat{z}_i$$

where

$\hat{z}_i$ = number of fish estimated to have passage through the unit during the ith interval by the hydroacoustic apparatus,

provided $\hat{z}_i$ is an unbiased estimate of z_i, the actual fish passage in the ith interval.

The variance of $\hat{Z}$ will consist of both subsampling error and hydroacoustic measurement error. To see how these error sources contribute to the overall variance, we can use the total variance formula

$$
\begin{aligned}
Var(\hat{Z}) &= Var_{z_i}[E(\hat{Z} \mid z_i)] + E_{z_i}[Var(\hat{Z} \mid z_i)] \\
&= Var_{z_i}\left[E\left(\frac{N}{n}\sum_{i=1}^{n} \hat{z}_i \mid z_i\right)\right] + E_{z_i}\left[Var\left(\frac{N}{n}\sum_{i=1}^{n} \hat{z}_i \mid z_i\right)\right] \\
&= Var_{z_i}\left[\frac{N}{n}\sum_{i=1}^{n} z_i\right] + E_{z_i}\left[\frac{N^2}{n^2}\sum_{i=1}^{n} Var(\hat{z}_i \mid z_i)\right] \\
&= N^2\left(1-\frac{n}{N}\right)\frac{S^2_{z_i}}{n} + \frac{N}{n}\sum_{i=1}^{N} Var(\hat{z}_i \mid z_i) \\
Var(\hat{Z}) &= \frac{N^2}{n}\left(1-\frac{n}{N}\right)S^2_{z_i} + \frac{N^2}{n}\overline{Var(\hat{z}_i \mid z_i)} \qquad (1)
\end{aligned}
$$

where

$$S^2_{z_i} = \frac{\sum_{i=1}^{N}(z_i - \bar{z})^2}{N-1} .$$

In a sample survey of fish passage, the $Var(\hat{Z})$ would be estimated by

$$\hat{Var}(\hat{Z}) = \frac{N^2}{n}\left(1-\frac{n}{N}\right)s^2_{\hat{z}_i}$$

where

$$s^2_{\hat{z}_i} = \frac{\sum_{i=1}^{n}\left(z_i - \hat{\bar{z}}\right)^2}{(n-1)} .$$

This estimate of the variance has the expected value

$$
\begin{aligned}
E\left[\frac{N^2}{n}\left(1-\frac{n}{N}\right)s^2_{\hat{z}_i}\right] &= \frac{N^2}{n}\left(1-\frac{n}{N}\right)E\left(s^2_{\hat{z}_i}\right) \\
&= \frac{N^2}{n}\left(1-\frac{n}{N}\right)S^2_{z_i} + \frac{N^2}{n}\left(1-\frac{n}{N}\right)\overline{Var(\hat{z}_i \mid z_i)} . \qquad (2)
\end{aligned}
$$

Hence, the empirical variance, $s^2_{\hat{z}_i}$, implicitly incorporates both the subsampling error and the hydroacoustic measurement error. Comparison of variance formulas (1) and (2) shows, however, the variance estimate (2) is negatively biased. The second term in formula (2) has the additional

factor of $\left(1-\frac{n}{N}\right)$ which variance formula (1) does not possess. Typically, it is believed that the measurement error $(Var(\hat{z}_i \mid z_i))$ is small relative to $S^2_{z_i}$, so the bias will be small. Furthermore, the bias is proportional to $\left(1-\frac{n}{N}\right)$, which for the Wells Dam study will be .80, close to the required 1.0 in formula (1). A conservative but always valid estimator of the true variance can be obtained by ignoring the finite population correction (i.e., $\left(1-\frac{n}{N}\right)$).

The conclusion of these computations is that we can avoid explicit measurement of hydroacoustic measurement error and still incorporate that error source in the overall variance of $\hat{B}$ and in confidence interval construction of B.

PROPOSED SAMPLING DESIGN

The sampling design has two major components which need to be considered; these are the spatial sampling of the bypass and turbine units at Wells Dam and the temporal sampling of days during the outmigration. Independent estimates of the spring bypass efficiency ($\hat{B}$) and summer bypass efficiency ($\hat{B}$) will be derived during the 1990 sampling program. The sampling designs will be the same for both seasons. Outlined below are general descriptions of the proposed sampling schemes and the statistical designs for the estimates of total project bypass efficiency (B).

Wells Dam Sampling Scheme

A. Temporal Sampling

- Sampling will be conducted every day during the designated spring and summer study periods.
- The spring period will last from 20-30 days. The period will begin shortly after the Winthrop chinook releases and will sample varying proportions of chinook, sockeye and steelhead.

- The summer period will last from 10-20 days. The sampling will begin when subyearling chinook occur in reasonable numbers in weekly fyke net catches.
- Sampling will occur 24 hours each day.
- Each "unit hour" will be sampled for a total of 12 minutes per hour.
- Within a "unit hour," a minimum of two samples will be taken. Prior data will be used to determine the benefits of allocating sampling effort, as

    a. 2 6-minute samples,

    b. 3 4-minute samples,

    c. 4 3-minute samples,

    d. 6 2-minute samples.

- Within a "unit hour," systematic sampling will be conducted. The choice of the systematic sampling sequence at a unit will be randomly assigned to each unit at the beginning of spring and summer seasons.

B. Spatial Sampling

1. Bypass Units

    - Five of the five bypass units at Wells Dam will be sampled.

2. Turbine Units

    - Ten of the ten turbine units will be sampled.
    - At each turbine unit, two of three turbine slots will be sampled randomly. The choice of turbine slots will remain constant during a season.

STATISTICAL SAMPLING DESIGN

The proposed sampling design at Wells Dam can be characterized by the separate designs for bypass units and turbine units. The results of the separate sampling schemes are then combined to provide the estimate of total project bypass efficiency (B). Below are formal descriptions of the estimators and variances for each sampling scheme.

Bypass Sampling Design

Sampling every day of the study period simplifies the statistical design and eliminates a potentially large error source (i.e., day-to-day variation) in estimating bypass passage (Y). Furthermore, by sampling at each bypass unit, the bypass-to-bypass variation is also eliminated. The resulting sampling design at the bypass units is a single stage sample using stratified sampling of "unit hours" across the dam and through time. Within a "unit hour," a systematic sample will be collected during the hour, and repeated each hour of the survey. In constructing the estimator, variance and estimated variance of the estimator, sampling will be assumed to be stratified random sampling. The consequences of assuming random sampling will be assessed using Monte Carlo simulations.

Define the following terms:

y_{ijkg} = number of fish detected in the gth sampling unit ($g = 1, 2, \ldots, l_{ijk}$) in the kth hour ($k = 1, 2, \ldots, 24$) at the jth bypass ($j = 1, 2, \ldots, 5$) on the ith day ($i = 1, 2, \ldots, D$),

L_{ijk} = number of sampling units in the kth hour ($k = 1, 2, \ldots, 24$) at the jth bypass ($j = 1, 2, \ldots, 5$) on the ith day ($i = 1, 2, \ldots, D$),

l_{ijk} = number of sampling units sampled in the kth hour ($k = 1, 2, \ldots, 24$) at the jth bypass ($j = 1, 2, \ldots, 5$) on the ith day ($i = 1, 2, \ldots, D$).

Then the estimate of total bypass passage (Y) is

$$\hat{Y} = \sum_{i=1}^{D}\sum_{j=1}^{5}\sum_{k=1}^{24}\sum_{g=1}^{l_{ijk}}\left[\frac{L_{ijk}}{l_{ijk}}y_{ijkg}\right] . \tag{3}$$

The variance of $\hat{Y}$ follows directly from stratified random sampling (Appendix A), where

$$Var(\hat{Y}\,|\,Y) = \sum_{i=1}^{D}\sum_{j=1}^{5}\sum_{k=1}^{24}\left[L_{ijk}^2\left(1-\frac{l_{ijk}}{L_{ijk}}\right)\frac{S_{y_{ijk}}^2}{l_{ijk}}\right] \tag{4}$$

and where

$$S_{y_{ijk}}^2 = \frac{\sum_{g=1}^{l_{ijk}}(y_{ijkg}-\overline{y_{ijk}})^2}{(L_{ijk}-1)} .$$

Note, the proposed sampling fraction within a "unit hour" is

$$\frac{l_{ijk}}{L_{ijk}} = \frac{12}{60} = .20 .$$

Turbine Sampling Design

The estimate of total turbine passage is based on a two-stage sampling scheme. The first stage of sampling is the selection of two of three turbine slots in each turbine unit. The second stage of the sampling design is the stratified random sampling of each "unit hour." As was the case in estimating bypass passage, in practice, a systematic sample within the "unit hour" will be used in estimating total turbine passage. The anticipated consequence of using a systematic sample in conjunction with a variance formula based on random sampling is to overestimate the true variance.

Define the following terms, where:

x_{ijklg} = number of fish detected in the gth sampling unit ($g = 1, 2, \ldots, h_{ijkl}$) in the lth hour ($l = 1, 2, \ldots, 24$) during the kth day ($k = 1, 2, \ldots, D$) in the jth slot ($j = 1, 2$) of the ith turbine unit ($i = 1, 2, \ldots, 10$),

H_{ijkl} = number of sampling units in the lth hour ($l = 1, 2, \ldots, 24$) of the kth day ($k = 1, 2, \ldots, D$) in the jth slot ($j = 1, 2$) of the ith turbine unit ($i = 1, 2, \ldots, 10$),

h_{ijkl} = number of sampling unit sampled in the lth hour ($l = 1, 2, \ldots, 24$) of the kth day ($k = 1, 2, \ldots, D$) in the jth slot ($j = 1, 2$) of the ith turbine unit ($i = 1, 2, \ldots, 10$).

Then the estimate of total turbine passage is

$$\hat{X} = \sum_{i=1}^{10}\left[\sum_{j=1}^{2}\frac{3}{2}\left[\sum_{k=1}^{D}\sum_{l=1}^{24}\sum_{g=1}^{h_{ijkl}}\left[\frac{H_{ijkl}}{h_{ijkl}}x_{ijklg}\right]\right]\right] . \tag{5}$$

Since $\hat{X}$ is based on two-stage sampling, the variance of $\hat{X}$ will consist of two variance components. The variance of $\hat{X}$ can be expressed as (Appendix B)

$$Var(\hat{X} \mid X) = \frac{3}{2}\sum_{i=1}^{10} S^2_{X_{ij}} + \frac{3}{2}\sum_{i=1}^{10}\sum_{j=1}^{3}\sum_{k=1}^{D}\sum_{l=1}^{24}\left[H^2_{ijkl}\left(1 - \frac{h_{ijkl}}{H_{ijkl}}\right)S^2_{X_{ijkl}}\right] \tag{6}$$

where

$$S^2_{X_{ij}} = \frac{\sum_{j=1}^{3}(X_{ij} - \bar{X}_i)^2}{(3-1)}$$

and where

$$S^2_{X_{ijkl}} = \frac{\sum_{g=1}^{H_{ijkl}}(x_{ijklg} - \bar{x}_{ijkl})^2}{(H_{ijkl} - 1)} .$$

Overall Sampling Design

Using the delta method (Appendix C), the overall variance of the estimate of total project bypass efficiency ($\hat{B}$) can be expressed as a function of the variances (4) and (6). The variance of $\hat{B}$ is

$$Var(\hat{B} \mid B) = B^2(1-B)^2\left[\frac{Var(\hat{Y} \mid Y)}{Y^2} + \frac{Var(\hat{X} \mid X)}{X^2}\right] \tag{7}$$

or

$$Var(\hat{B} \mid B) = B^2(1-B)^2[CV(\hat{Y})^2 + CV(\hat{X})^2] \tag{8}$$

where CV denotes the coefficient of variation. Unlike variances for typical ratio estimators, the covariance between $\hat{X}$ and $\hat{Y}$ is not incorporated in the variance of $\hat{B}$. The reason the covariance of $\hat{X}$ and $\hat{Y}$ does not enter into the variance of $\hat{B}$ is that independent sampling schemes are used to estimate $\hat{X}$ and $\hat{Y}$ and all D of D days within a bypass study are sampled.

PRECISION OF THE BYPASS STUDY

The precision of the estimate of total project bypass efficiency ($\hat{B}$) will be defined as

$$P(|\hat{B} - B| < \epsilon) = 1 - \alpha \quad . \tag{9}$$

In other words, we want the absolute difference between the estimate ($\hat{B}$) and true bypass efficiency (B) to be less than ϵ, with probability $1-\alpha$. For example, letting $\epsilon = .05$ and $\alpha = .10$, specifies a precision of

$$P(|\hat{B} - B| < .05) = .90$$

where we want the absolute error in estimating bypass efficiency to be less than 5%, 90% of the time, with the proposed sampling design. Assuming $\hat{B}$ to be approximately normally distributed, the anticipated sampling error in the Wells bypass study can be predicted by the formula (Appendix D)

$$\epsilon = Z_{1-\frac{\alpha}{2}} B(1-B)\sqrt{CV(\hat{Y})^2 + CV(\hat{X})^2} \quad . \tag{10}$$

Hence, we can investigate the precision of $\hat{B}$ by determining the precision of the proposed bypass and turbine passage estimates. Data from the 1988 and 1989 hydroacoustic studies at Wells Dam will be used to evaluate the precision of the anticipated design for 1990.

FUTURE DESIGN RESEARCH

Two aspects of the research on the study design have yet to be performed. The first aspect is the analysis of the 1988, 1989 data for purposes of predicting the precision of the 1990 total project bypass efficiency estimate. Among the outcomes of this investigation will be the determination of whether 12 min./hr. is adequate sampling within a "unit hour" and how to allocate that sampling time within the hour (e.g., two 6-min. samples versus six 2-min. samples).

The second aspect of the statistical design is the identification of the most appropriate means of confidence interval estimation of B. It is not always sufficient simply to have a point estimate, $\hat{B}$, and its variance estimate, $V\hat{a}r(\hat{B} \mid B)$, for valid and efficient confidence interval estimation. Monte Carlo studies will be performed to assure the confidence interval estimator has nominal coverage with minimum width. Another aspect of the Monte Carlo studies is to assess the effect of using systematic sampling within a "unit hour" and computing the variance based on the formula for random sampling. Wolter (1984) suggests the systematic sampling will overestimate the true variance, making the resulting confidence interval estimation conservative yet valid.

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Hansen, M. H., W. N. Hurwitz and W. G. Madow. 1953. Sample survey methods and theory. Volume II. Theory. Wiley. New York. 332 pp.

Wolter, K. M. 1984. An investigation of some estimators of variance for systematic sampling. *J. Amer. Stat. Assoc.* 79:781-790.

Appendix A

Variance of Total Bypass Passage

The single stage sampling design used in estimating total bypass passage constitutes stratified random sampling (in practice systematic). The variance of $\hat{Y}$ follows directly, where

$$Var(\hat{Y}\,|\,Y) = Var\left[\sum_{i=1}^{D}\sum_{j=1}^{5}\sum_{k=1}^{24}\sum_{g=1}^{l_{ijk}}\left[\frac{L_{ijk}}{l_{ijk}}y_{ijkg}\right]\right]$$

$$Var(\hat{Y}\,|\,Y) = \sum_{i=1}^{D}\sum_{j=1}^{5}\sum_{k=1}^{24} Var[L_{ijk}\overline{y_{ijk}}]$$

$$Var(\hat{Y}\,|\,Y) = \sum_{i=1}^{D}\sum_{j=1}^{5}\sum_{k=1}^{24}\left[L_{ijk}^2\left(1-\frac{l_{ijk}}{L_{ijk}}\right)\frac{S_{y_{ijk}}^2}{l_{ijk}}\right]$$

and where

$$S_{y_{ijk}}^2 = \frac{\sum_{g=1}^{L_{ijk}}(y_{ijkg}-\overline{y_{ijk}})^2}{(L_{ijk}-1)} \quad .$$

Appendix B

Variance of Total Turbine Passage

The estimate of total turbine passage is obtained using two-stage sampling, the first stage, the selection of two of three turbine slots per turbine unit, the second stage, the sampling within a "unit hour." Similarly, the variance of $\hat{X}$ can be found in stages

$$Var(\hat{X} \mid X) = Var_{S_1}[E_{S_2}(\hat{X} \mid S_1)] + E_{S_1}[Var_{S_2}(\hat{X} \mid S_1)] \qquad (B1)$$

and where S_1 denotes the stratified random sampling of slots within a turbine unit, and S_2 denotes the stratified random sampling within a "unit hour."

Considering the first term of the variance

$$Var_{S_1}[E_{S_2}(\hat{X} \mid S_1)] = Var_{S_1}\left[E_{S_2}\left[\sum_{i=1}^{10}\sum_{j=1}^{2}\frac{3}{2}\sum_{k=1}^{D}\sum_{l=1}^{24}\left(\sum_{g=1}^{h_{ijk}}\frac{x_{ijklg}}{h_{ijkl}}H_{ijkl}\right)\middle| S_1\right]\right]$$

$$= Var_{S_2}\left[\sum_{i=1}^{10}\sum_{j=1}^{2}\frac{3}{2}X_{ij}\right]$$

$$Var_{S_1}[E_{S_2}(\hat{X} \mid S_1)] = \sum_{i=1}^{10}\frac{9}{2}\left(1-\frac{2}{3}\right)S^2_{X_{ij}} = \frac{3}{2}\sum_{i=1}^{10}S^2_{X_{ij}} \qquad (B2)$$

where

$$S^2_{X_{ij}} = \frac{\sum_{j=1}^{3}(X_{ij}-\overline{X}_i)^2}{(3-1)} .$$

The second term of the variance is evaluated as

$$
\begin{aligned}
E_{S_1}[Var_{S_2}(\hat{X} \mid S_1)] &= E_{S_1}\left[Var_{S_2}\left[\sum_{i=1}^{10}\sum_{j=1}^{2}\frac{3}{2}\sum_{k=1}^{D}\sum_{l=1}^{24}\left(\sum_{g=1}^{h_{ijkl}} \frac{x_{ijklg}}{h_{ijkl}} H_{ijkl}\right) \middle| S_1 \right]\right] \\
&= E_{S_1}\left[\frac{9}{4}\sum_{i=1}^{10}\sum_{j=1}^{2}\sum_{k=1}^{D}\sum_{l=1}^{24}\left(\frac{H_{ijkl}^2}{h_{ijkl}}\left(1-\frac{h_{ijkl}}{H_{ijkl}}\right)S_{x_{ijkl}}^2\right)\right] \\
&= \frac{9}{4}\sum_{i=1}^{10}\frac{2}{3}\sum_{j=1}^{3}\sum_{k=1}^{D}\sum_{l=1}^{24}\left(\frac{H_{ijkl}^2}{h_{ijkl}}\left(1-\frac{h_{ijkl}}{H_{ijkl}}\right)S_{x_{ijkl}}^2\right) \\
&= \frac{3}{2}\sum_{i=1}^{10}\sum_{j=1}^{3}\sum_{k=1}^{D}\sum_{l=1}^{24}\left(\frac{H_{ijkl}^2}{h_{ijkl}}\left(1-\frac{h_{ijkl}}{H_{ijkl}}\right)S_{x_{ijkl}}^2\right) \qquad (B3)
\end{aligned}
$$

where

$$
S_{x_{ijkl}}^2 = \frac{\sum_{g=1}^{H_{ijkl}} (x_{ijklg} - \bar{x}_{ijkl})^2}{(H_{ijkl}-1)}
$$

The variance of $\hat{X}$ given by (B1) is therefore the sum of (B2) and (B3), where

$$
Var(\hat{X} \mid X) = \frac{3}{2}\sum_{i=1}^{10} S_{\bar{x}_{ij}}^2 + \frac{3}{2}\sum_{i=1}^{10}\sum_{j=1}^{3}\sum_{k=1}^{D}\sum_{l=1}^{24}\left[\frac{H_{ijkl}^2}{h_{ijkl}}\left(1-\frac{h_{ijkl}}{H_{ijkl}}\right)S_{x_{ijkl}}^2\right]
$$

Appendix C

Variance of the Estimate of Total Project Bypass Efficiency

Using the delta method, the variance of $\hat{B}$ is computed to be

$$Var\left(\frac{\hat{Y}}{\hat{Y}+\hat{X}}\right) \doteq Var(\hat{Y})\left(\frac{X^2}{(X+Y)^4)}\right)+Var(\hat{X})\left(\frac{Y^2}{(X+Y)^4}\right)-2Cov(\hat{X},\hat{Y})\left(\frac{XY}{(X+Y)^4}\right) \cdot \quad (C1)$$

However, the covariance term is shown to be zero by computing it in stages, where

$$Cov(\hat{X},\hat{Y}) = E_{S_1}[Cov_{S_2}(\hat{X},\hat{Y}\mid S_1)]+Cov_{S_1}[E_{S_2}(\hat{X}\mid S_1),E_{S_2}(\hat{Y}\mid S_1)]$$

and where S_1 denotes sampling of days during the study, and S_2 denotes sampling within a day. Evaluating the covariance

$$Cov(\hat{X},\hat{Y}) = E_{S_1}[0]+Cov_{S_1}\left[\sum_{k=1}^{D} X_k,\sum_{k=1}^{D} Y_k\right]$$

$$Cov(\hat{X},\hat{Y}) = \frac{D^2}{D}\left(1-\frac{D}{D}\right)Cov(X_k,Y_k) = 0$$

from Hansen, Hurwitz and Madow (1953: eq (1.15), page 148, Vol. 2).

The resulting variance (C1) can then be expressed as

$$Var(\hat{B}\mid B) = B^2(1-B)^2\left[\frac{Var(\hat{Y})}{Y^2}+\frac{Var(\hat{X})}{X^2}\right]$$

or

$$Var(\hat{B}\mid B) = B^2(1-B)^2[CV(\hat{Y})^2+CV(\hat{X})] \cdot$$

Appendix D

Precision of Total Project Bypass Efficiency ($\hat{B}$)

Defining precision in terms of the absolute deviation between the estimate ($\hat{B}$) and the true value of total project bypass efficiency (B), we have the probability expression

$$P(|\hat{B} - B| < \epsilon) = 1 - \alpha$$

$$P(-\epsilon < \hat{B} - B < \epsilon) = 1 - \alpha$$

$$P\left(\frac{-\epsilon}{\sqrt{Var(\hat{B})}} < \frac{\hat{B} - B}{\sqrt{Var(\hat{B})}} < \frac{\epsilon}{\sqrt{Var(\hat{B})}}\right) = 1 - \alpha \ .$$

Assuming approximate normality,

$$P\left(\frac{-\epsilon}{\sqrt{Var(\hat{B})}} < Z < \frac{\epsilon}{\sqrt{Var(\hat{B})}}\right) = 1 - \alpha$$

$$P\left(Z < \frac{-\epsilon}{\sqrt{Var(\hat{B})}}\right) = \frac{\alpha}{2}$$

$$\Phi\left(\frac{-\epsilon}{\sqrt{Var(\hat{B})}}\right) = \frac{\alpha}{2}$$

where Φ denotes the cumulative normal distribution. The error in estimation (ϵ) for a particular probability ($1 - \alpha$) of coverage (e.g., 90% implies $\alpha = .10$) can be solved as a function of the variance of $\hat{B}$ and $1 - \alpha$ where

$$\frac{-\epsilon}{\sqrt{Var(\hat{B})}} = Z_{\frac{\alpha}{2}}$$

$$\epsilon = Z_{1-\frac{\alpha}{2}} B(1 - B)\sqrt{CV(\hat{Y})^2 + CV(\hat{X})^2}$$

and can be used in evaluating the anticipated performance of the sampling program.

APPENDIX C

HORIZONTAL AND DIEL DISTRIBUTION RESULTS

APPENDIX C. Horizontal & Diel Distribution Results

C.1 Horizontal Distributions

The horizontal distribution data from the bypass slots during the spring study (April 19 to May 18) showed greater passage rates towards the west end of the dam (Figure C1). The lowest passage rate occurred at 7C. The highest rate occurred at 1C, followed by 3C, 5C, and 9C. In the middle sections of the dam, daytime passage rates were higher than nightime rates. At the east and west ends of the dam nighttime passage rates were higher.

Turbine horizontal distribution data from the spring also showed that passage rates towards the west end of the dam were generally higher (Figure C2). The highest rates occurred at Units 1 and 10. The lowest rate occurred at Unit 8. The "C"-slots showed a generally lower nighttime passage rate. Overall passage rates were much lower in the turbine intakes than in the bypass slots.

The bypass slot horizontal distribution data for the summer study (July 9 to July 24) also showed highest passage rates occurring towards the west end of the dam (Figure C3). The highest rate occurred at slot 5C, followed by 3C, 1C, and 9C. As in the spring, 7C had the lowest passage rate. The west end locations (1C, 5C, 7C) showed higher daytime passage rates. 7C and 9C had slightly higher nighttime passage rates.

As in the spring, the turbine horizontal distribution data for summer showed highest passage rates at Units 1 and 10 (Figures C2 and C4). As was the case with the bypass slot data, Unit 5 had high daytime in-turbine passage rates. Unit 2 had the next highest passage rate. The "A" and "B" slots showed generally higher daytime passage rates. Turbine passage rates were lower overall than those for the bypass slot locations.

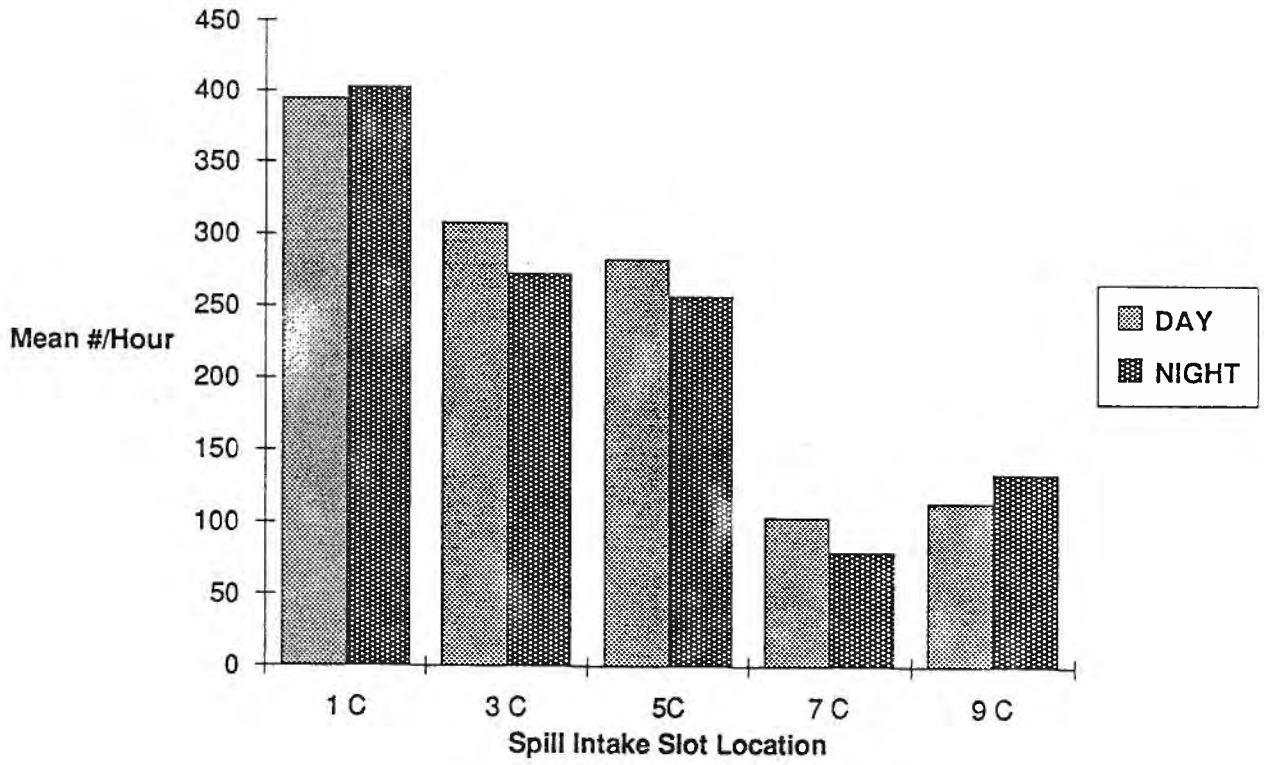

Figure C1. Horizontal distribution of slot passage indices (mean#/1hr/location) for day and night separately at Wells Dam between April 19 and May 18, 1990.

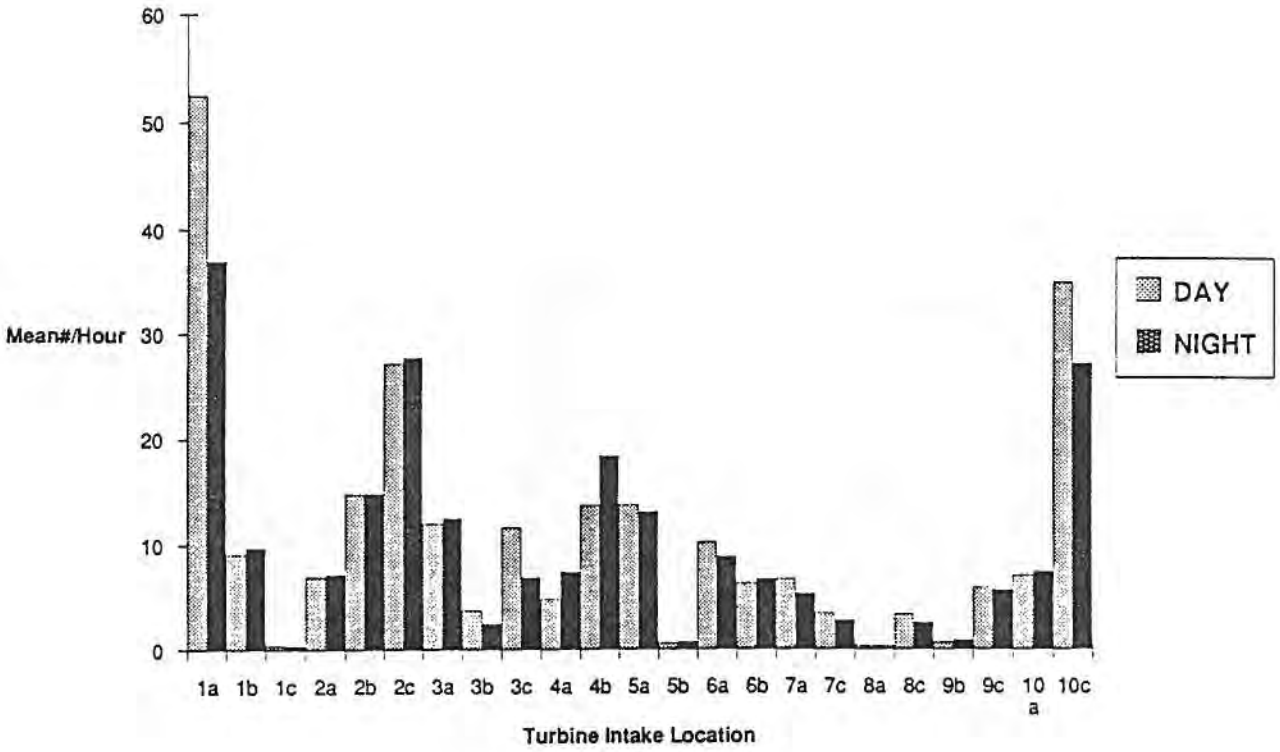

Figure C2. Horizontal distribution of turbine passage indices (mean#/1hr/location) for day and night separately at Wells Dam between April 19 and May 18, 1990.

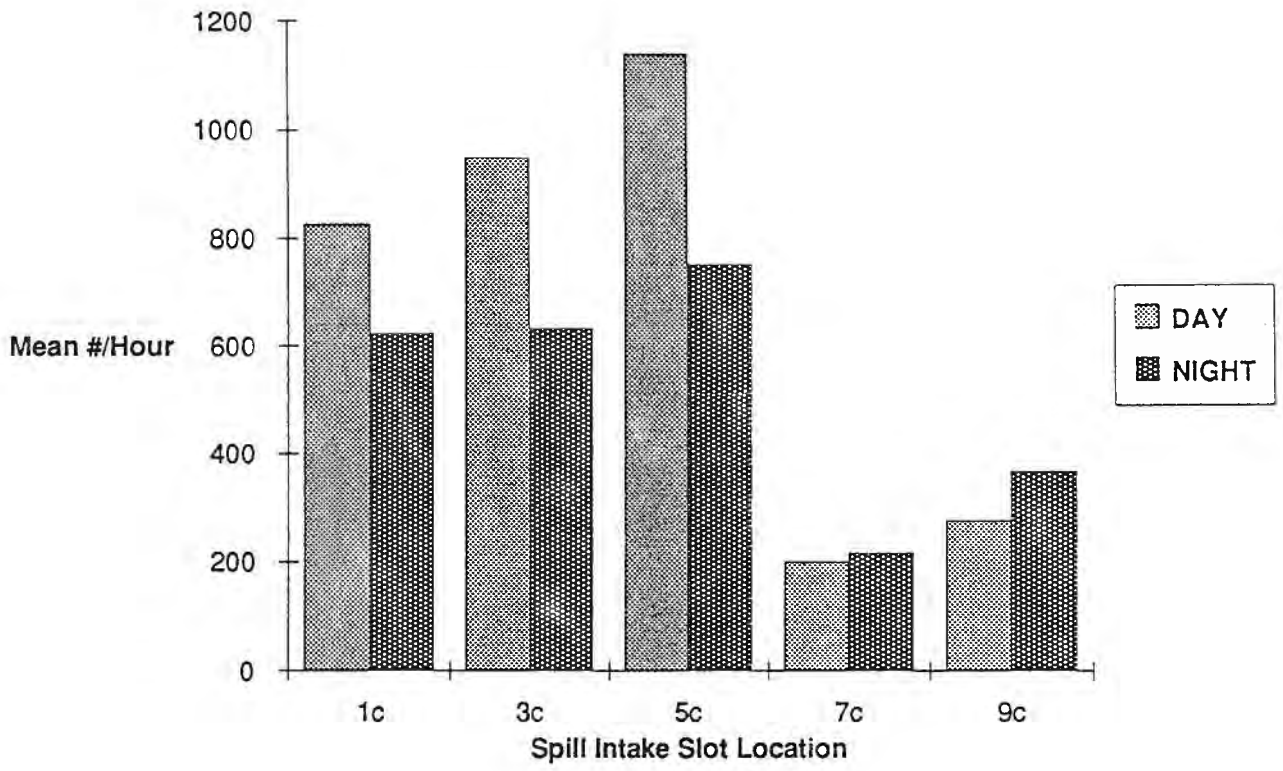

Figure C3. Horizontal distribution of slot passage indices (mean #/1hr/location) for day and night separately at Wells Dam between July 9 and July 19, 1990.

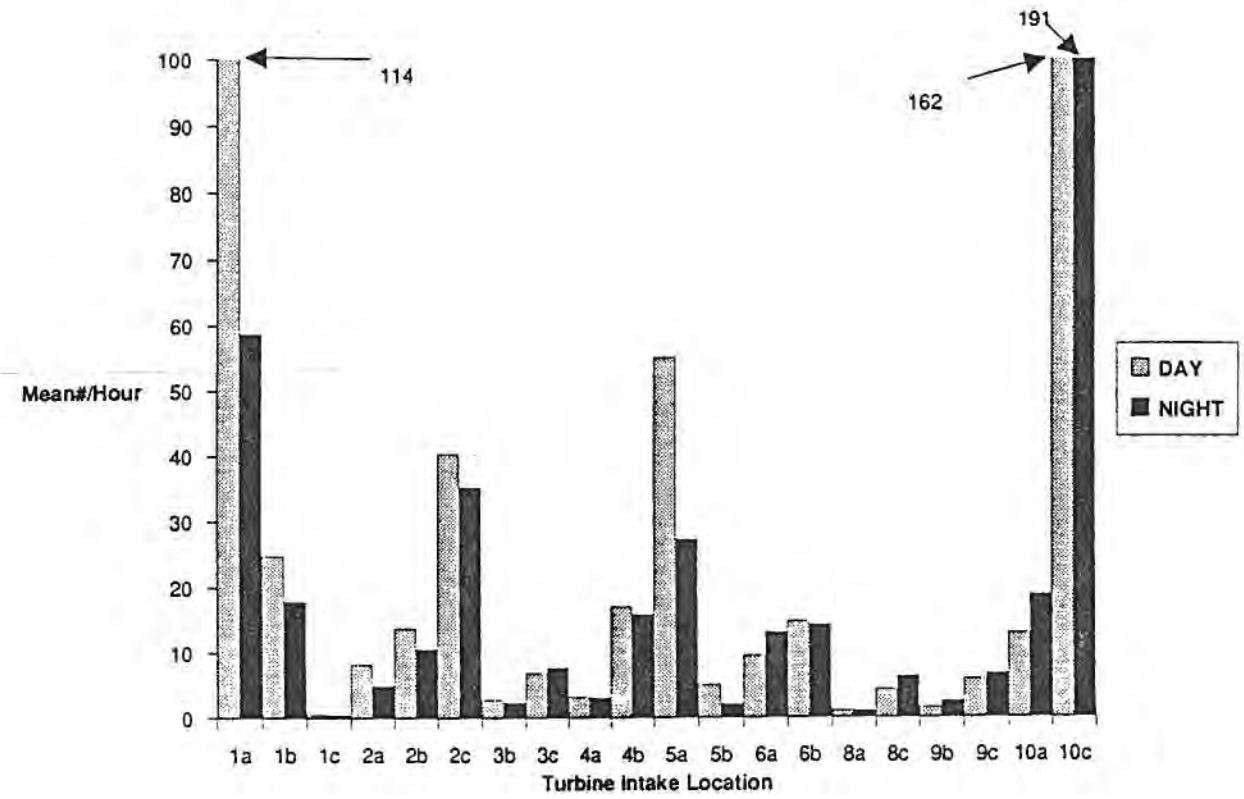

Figure C4. Horizontal distribution of turbine passage indices (mean #/1hr/location) for day and night separately at Wells Dam between July 9 and July 24, 1990.

C.2 Diel Distributions

The diel distribution data for the bypass slots during spring (April 19 to May 18) showed that variable high passage rates occurred during daylight hours (Figure C5). Passage rates declined during the late evening hours (1700 h - 1900 h) and then rose to the highest passage rate, which occurred at 2200 h. Passage rates then declined to the lowest rate at 0100 h. Passage rates were lowest during the early morning hours (0100 h - 0700 h).

The turbine intake diel distribution data also showed generally higher passage rates during the day (Figure C6). The lowest passage rate occurred at 0200 h. There was then a general increase in passage rates until the peak occurred at 1100 h. Passage rates then declined but remained relatively high until 1600 h. As in the bypass slots, passage rates were generally lower between 1700 h and 1900 h.

The summer (July 9 to July 24) bypass slot data again showed highest passage rates during daylight hours (Figure C7). Passage was lowest at 0300 h. There was then a gradual rise until peak passage occurred at 1000 h. Passage rates remained relatively high until 1800 h. The rates then declined until 2200 h.

As in the bypass slots, passage rates for the turbine locations were highest during daylight hours (Figure C8). The highest rate occurred at 1200 h. The lowest rate occurred at 0200 h. The passage rates between 1400 h and 0600 h were relatively constant, with another slight peak at 2200 h. Again, passage rates in turbine were far lower than those in the bypass slots.

For both the diel and horizontal distributions, overall passage rates were higher during the summer study period than during the spring study.

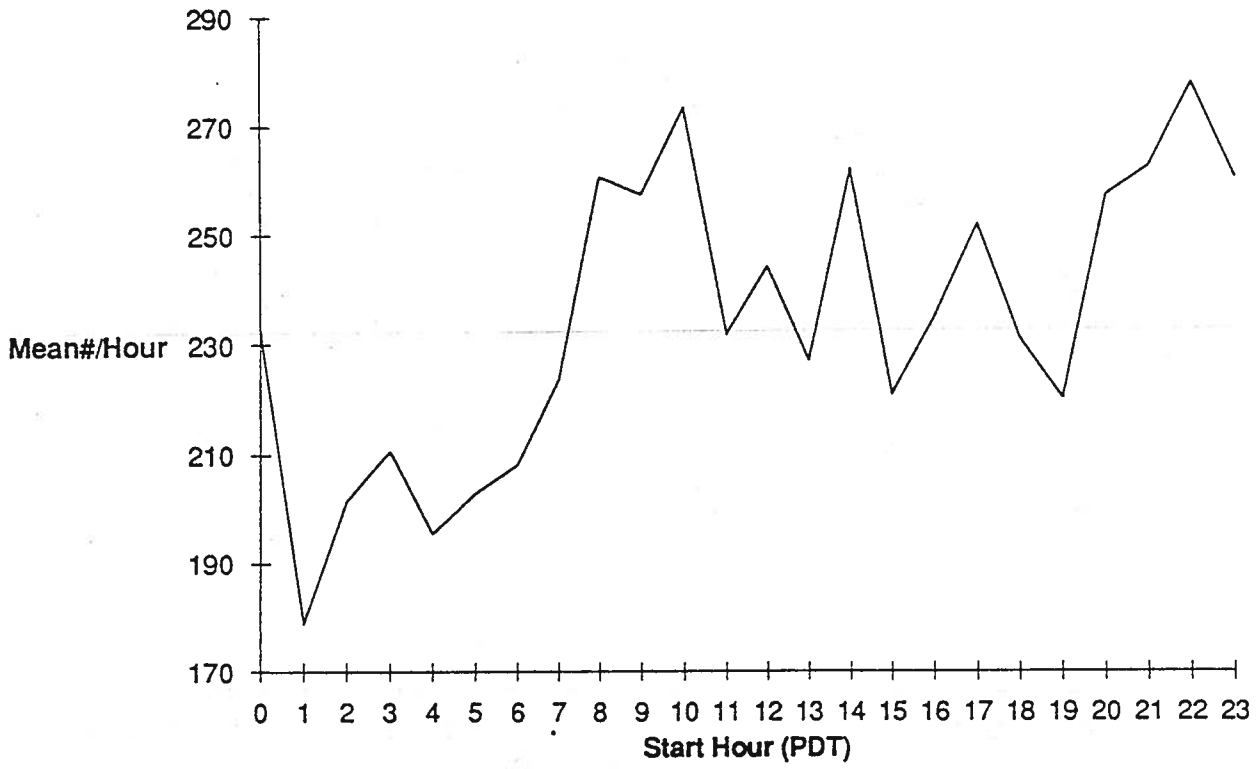

Figure C5. Diel distribution of slot passage indices (mean #/1hr/location) at Wells Dam between April 19 and May 18, 1990.

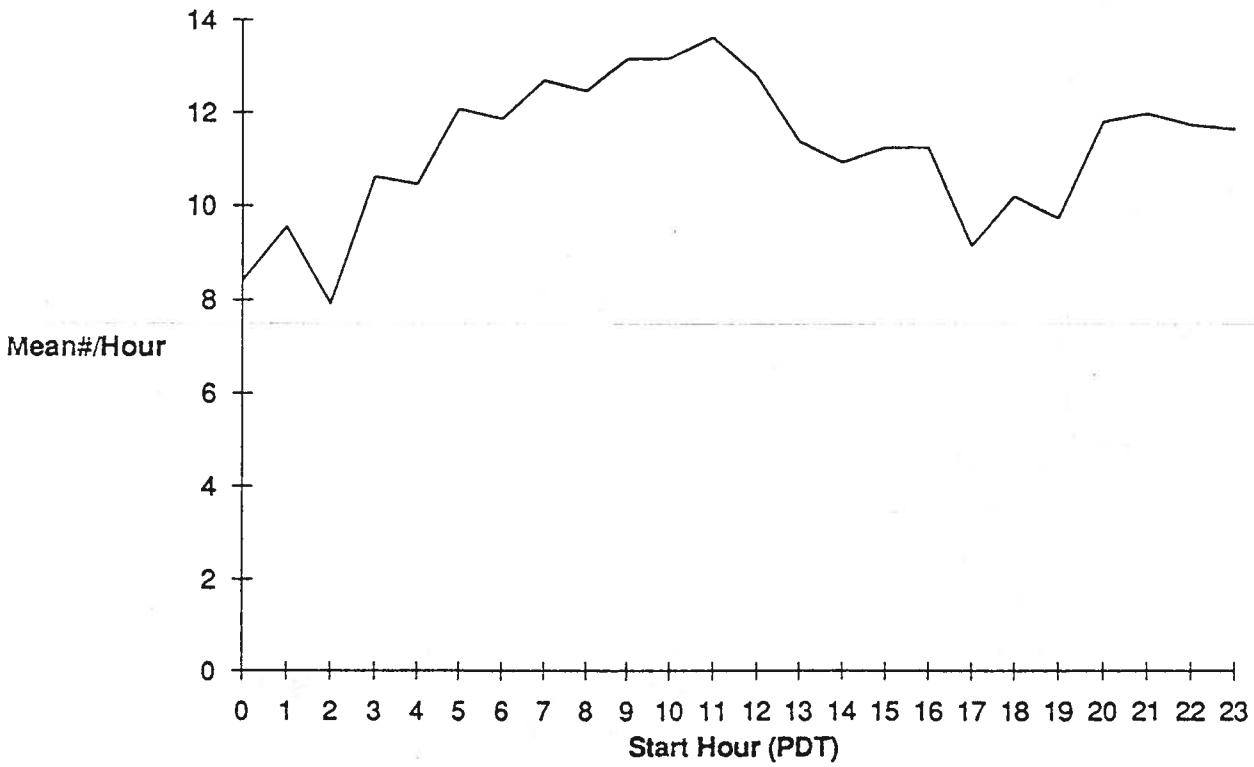

Figure C6. Diel distribution of turbine passage indices (mean #/1hr/location) at Wells Dam between April 19 and May 18, 1990.

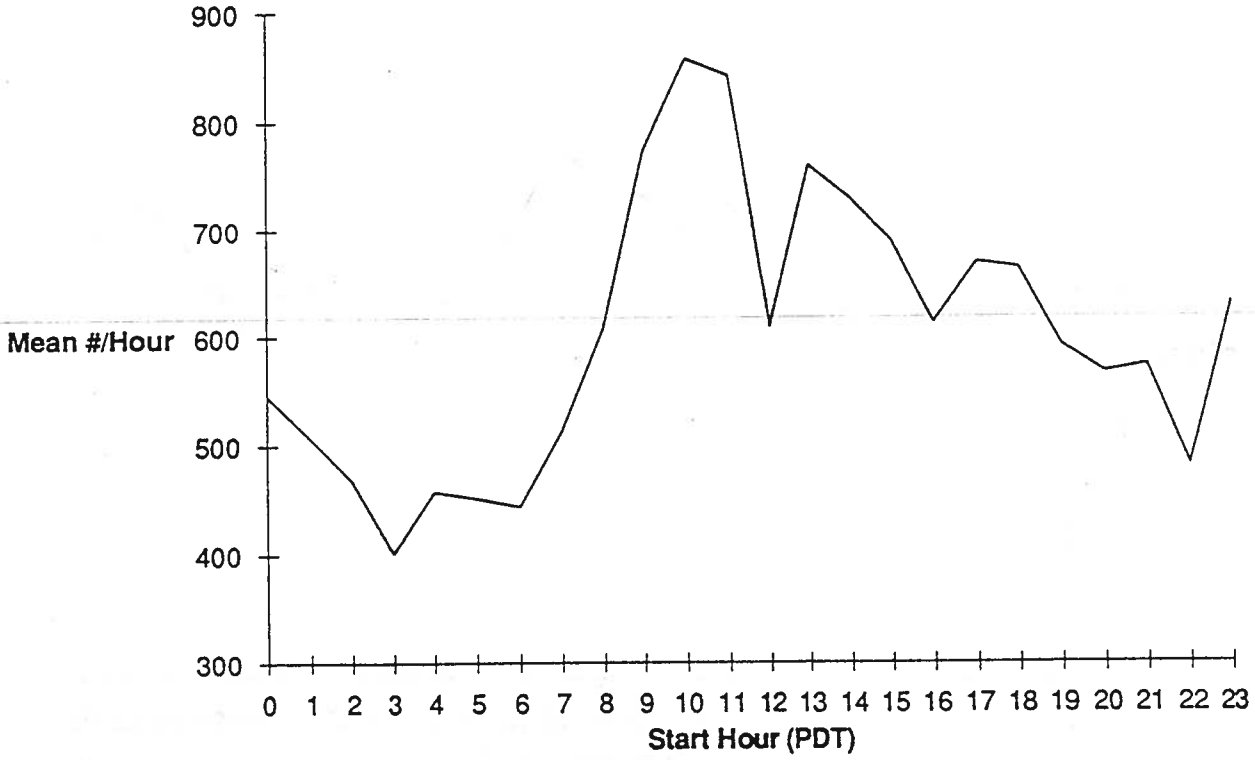

Figure C7. Diel distribution of slot passage indices (mean #/1hr/location) at Wells Dam between July 9 and July 19, 1990.

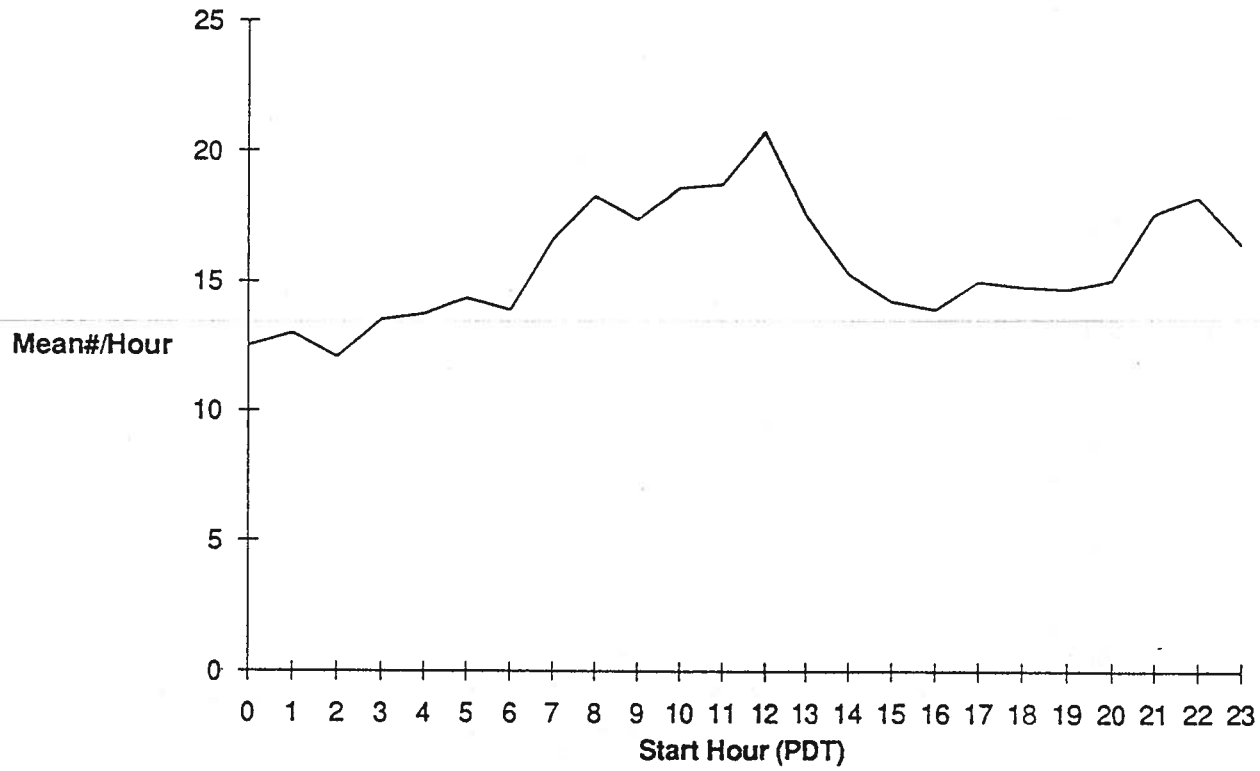

Figure C8. Diel distribution of turbine passage indices (mean #/1hr/location) at Wells Dam between July 9 and July 24, 1990.

APPENDIX D

FISH PASSAGE DATA

APPENDIX D. Fish Passage Data

WELLS DAM FOREBAY HYDROACOUSTIC INDEX
1990

	DATE	MEAN #/8 HR/LOCATION DAY	NIGHT	COMBINED	
April	7	417	217	634	
	8	NO DATA COLLECTED			
	9	122	116	239	
	10	122	217	339	
	11	178	192	370	
	12	109	126	236	
	13	49	97	146	
	14	176	108	283	
	15	448	512	960	
	16	379	807	1186	
	17	324	178	502	
	18	173	378	551	
		BYPASS EVALUATION			
May	19	240	605	846	
	20	138	989	1128	
	21	399	278	676	
	22	99	534	633	
	23	218	230	449	
	24	146	390	536	
	25	151	391	542	
	26	41	758	799	
	27	152	538	690	
	28	200	466	666	
	29	160	117	277	
	30	160	249	410	
	31	141	291	432	
June	1 *	107	163	270	*
	2 *	104	47	151	*NO T2 DATA COLLECTED
	3 *	85	57	140	*
	4	55	105	160	
	5	61	79	140	
	6	51	39	90	
	7	36	29	65	
	8	80	106	185	
	9	71	69	140	
	10	26	53	79	
	11	78	77	155	
	12	68	97	164	
	13	47	104	148	
	14	102	79	181	
	15	109	199	309	
	16	101	186	287	
	17	119	333	452	
	18	127	147	273	
	19	131	135	226	
	20	144	328	472	
	21	172	705	876	
	22	47	293	340	
	23	63	348	412	
	24	263	173	436	
	25	91	357	448	
	26	138	251	389	
	27	118	174	292	
	28	262	163	425	
	29	242	494	736	
	30	254	346	599	

WELLS DAM FOREBAY HYDROACOUSTIC INDEX
1990

	DATE	MEAN #/8 HR/LOCATION DAY	NIGHT	COMBINED
July	1	288	363	651
	2	255	488	703
	3	146	383	529
	4	285	468	752
	5	428	684	1112
	6	423	828	1251
	7	177	638	815
	8	299	684	983
		BYPASS EVALUATION		
	25	735	478	1213
	26	880	372	1252
	27	782	608	1390
	28	1141	536	1677
	29	674	775	1449
	30	1376	756	2132
	31	1153	684	1837
August	1	1731	666	2397
	2	1033	748	1781
	3	1599	1312	2911
	4	854	755	1609
	5	1397	571	1968
	6	1451	910	2361
	7	1358	1026	2384
	8	1072	1168	2240
	9	1092	912	2004
	10	1033	1110	2143
	11	867	874	1741
	12	334	843	1177
	13	862	1148	2010
	14	1432	813	2245
	15	1035	771	1806
	16	994	730	1724
	17	744	239	982
	18	217	326	543
	19	385	330	715
	20	407	418	825
	21	464	142	606
	22	491	259	750
	23	142	330	472
	24	154	175	322
	25	132	72	204
	26	62	104	166
	27	162	123	285
	28	174	136	310
	29	146	113	259
	30	120	56	176
	31	56	48	104

Wells 1990 Study Periods Run Timing

	SPRING			SUMMER	
	DATE	Mean #/8hr/location		DATE	Mean #/8hr/location
	19	2309.153	July	9	3605.891
	20	2138.762		10	3350.332
	21	952.743		11	3432.103
April	22	1538.939		12	4725.418
	23	3433.595		13	6828.106
	24	1472.464		14	5117.422
	25	2816.421		15	5565.642
	26	533.548		16	6102.154
	27	946.636		17	5351.98
	28	610.704		18	6833.601
	29	404.914		19	3454.016
	30	718.377		20	1093.029
	1	1273.352			
	2	1791.739			
	3	1257.21			
	4	2569.183			
	5	4463.141			
	6	1870.937			
	7	7597.808			
May	8	1420.551			
	9	2430.4			
	10	1300.336			
	11	1981.585			
	12	1771.326			
	13	1038.334			
	14	1563.674			
	15	1906.176			
	16	1441.71			
	17	1443.143			
	18	1655.434			

WELLS 1990 BYPASS EFFICIENCY DATA

	Date	Ratio var.	Upper C.I.	Ratio	Lower C. I.
April	19	0.00172	0.59972	0.52606	0.46145
	20	0.00118	0.69370	0.63425	0.57989
	21	0.00216	0.63835	0.55552	0.48343
	22	0.00180	0.85387	0.78062	0.71366
	23	0.00189	0.88415	0.80894	0.74013
	24	0.00419	0.79547	0.67845	0.57864
	25	0.00016	1.00649	0.98561	0.96515
	26	0.00231	0.80976	0.75272	0.65040
	27	0.00276	0.85340	0.74305	0.66090
	28	0.00108	0.78597	0.72961	0.67729
	29	0.00161	0.74010	0.67034	0.60716
	30	0.00069	0.85946	0.81512	0.77307
May	1	0.00230	0.86852	0.78501	0.70953
	2	0.00181	0.87910	0.80574	0.73849
	3	0.00227	0.86692	0.78395	0.70892
	4	0.00360	0.88450	0.77830	0.68485
	5	0.00054	0.87913	0.84001	0.80263
	6	0.00066	0.79476	0.75105	0.70975
	7	0.00032	0.93759	0.90753	0.87843
	8	0.00033	0.87927	0.84899	0.81975
	9	0.00042	0.89507	0.86075	0.82775
	10	0.00167	0.84775	0.77718	0.71249
	11	0.00069	0.81731	0.77293	0.73096
	12	0.00080	0.81595	0.76792	0.72271
	13	0.00190	0.81724	0.74148	0.67274
	14	0.00123	0.86291	0.80290	0.74706
	15	0.00073	0.91793	0.87218	0.82871
	16	0.00070	0.79543	0.75069	0.70847
	17	0.00038	0.84097	0.80814	0.77659
	18	0.00078	0.85500	0.80769	0.76299

	Date	Ratio var.	Upper C. I.	Ratio	Lower C.I.
	9	0.00424	0.92078	0.80495	0.70370
July	10	0.00720	0.91040	0.75386	0.62624
	11	0.00785	0.91251	0.74784	0.61289
	12	0.00211	0.88960	0.80999	0.73750
	13	0.00986	0.89494	0.70722	0.55887
	14	0.00559	0.82596	0.68865	0.57417
	15	0.00583	0.88583	0.74673	0.64927
	16	0.00355	0.87219	0.76666	0.67389
	17	0.00554	0.91774	0.78323	0.66843
	18	0.00178	0.89758	0.82478	0.75789

WELLS 1990 TURBINE HORIZONTAL DISTRIBUTION
(MEAN #/HR)

SPRING Location	Day	Night
1a	52.51346	37.07815
1b	9.174458	9.798657
1c	0.441124	0.415163
2a	6.960445	7.275392
2b	14.81756	14.90514
2c	27.20461	27.7839
3a	12.07515	12.6003
3b	3.799929	2.522599
3c	11.68811	6.954522
4a	4.85051	7.458688
4b	13.78755	18.4116
5a	13.83962	13.18322
5b	0.619614	0.772644
6a	10.3092	8.972811
6b	6.31249	6.772419
7a	6.734731	5.369828
7c	3.498141	2.806808
8a	0.344301	0.377511
8c	3.393753	2.60435
9b	0.692182	0.904875
9c	5.925926	5.666849
10a	7.102214	7.434932
10c	34.94109	27.20164

SUMMER Location	Day	Night
1a	114.1024	58.77659
1b	24.76373	17.96186
1c	0.519828	0.440415
2a	8.190396	5.001823
2b	13.79182	10.6148
2c	40.38445	35.32332
3b	2.790103	2.329952
3c	6.908094	7.731758
4a	3.252117	3.225583
4b	17.1182	16.00998
5a	55.19104	27.41519
5b	5.098664	2.147429
6a	9.570066	13.21482
6b	14.87812	14.35062
8a	1.106333	0.9904
8c	4.318771	6.303814
9b	1.515016	2.533474
9c	5.889639	6.693461
10a	12.99864	18.8735
10c	161.9515	190.6883

WELLS 1990 SLOT HORIZONTAL DISTRIBUTION
SPRING MEAN #/HR

SLOT	DAY	NIGHT	COMBINED
1 C	394.9282	402.9726	398.3255
3 C	307.7809	273.1739	293.3291
5C	282.8525	257.7123	272.5204
7 C	103.7669	80.45155	94.00011
9 C	114.1171	134.367	122.5899

SLOT HORIZONTAL DISTRIBUTION
SUMMER MEAN #/HR

SLOT LOCATION	DAY	NIGHT	COMBINED
1c	826	623	741
3c	948	632	814
5c	1139	751	980
7c	200	217	207
9c	276	367	314

WELLS 1990 TURBINE DIEL DISTRIBUTIONS

SPRING START HOUR	MEAN #/HR	SUMMER START HOUR	MEAN #/HR
0	8.415485	0	12.50679
1	9.55389	1	12.99204
2	7.911116	2	12.07108
3	10.6107	3	13.5258
4	10.44543	4	13.72867
5	12.07459	5	14.34442
6	11.84891	6	13.89417
7	12.68869	7	16.61282
8	12.46306	8	18.27759
9	13.14488	9	17.38088
10	13.16772	10	18.59447
11	13.62068	11	18.74533
12	12.79502	12	20.77358
13	11.36954	13	17.61139
14	10.91398	14	15.30781
15	11.23778	15	14.22762
16	11.23473	16	13.9213
17	9.139967	17	15.00411
18	10.18212	18	14.78851
19	9.719609	19	14.70263
20	11.79284	20	15.04621
21	11.96046	21	17.61477
22	11.71164	22	18.24567
23	11.62496	23	16.45293

WELLS 1990 SLOT DIEL DISTRIBUTION

SPRING START HR	MEAN #/HR	SUMMER START HOUR	MEAN #/HR
0	232.826	0	545.15
1	178.8807	1	506.43
2	201.4395	2	468.07
3	210.6345	3	401.02
4	195.5815	4	457.83
5	202.9509	5	452.12
6	208.2384	6	444.45
7	223.6593	7	513.10
8	260.6907	8	607.75
9	257.3849	9	773.94
10	273.5074	10	857.57
11	231.7502	11	842.41
12	244.3002	12	609.50
13	227.1204	13	760.79
14	262.3545	14	730.03
15	220.986	15	690.47
16	234.968	16	613.70
17	252.2909	17	670.45
18	231.1722	18	664.88
19	220.2819	19	593.28
20	257.6218	20	568.01
21	262.8626	21	575.06
22	278.2303	22	482.88
23	260.7409	23	632.47

APPENDIX E

AGENCY COMMENTS AND BIOSONICS' RESPONSES

APPENDIX E. Agency Comments and BioSonics' Responses

E.1 Introduction

Written comments on the November 28, 1990 draft report were received from Washington Department of Fisheries and National Marine Fisheries Service. Those letters are reproduced on the following pages. BioSonics' responses to these comments follow the two letters.

E.2 Agency Comments

See pages E2 through E7.

Joseph R. Blum
Director

STATE OF WASHINGTON

DEPARTMENT OF FISHERIES

115 General Administration Building, M.S. AX-11 • Olympia, Washington 98504 • (206) 753-6600 • (SCAN) 234-6600

February 19, 1991

BioSonics
Gary Johnson, Manager, Technical Services
3670 Stone Way North
Seattle, Washington 98103

Dear Gary:

We have reviewed the document titled "Evaluation of the Smolt Bypass System at Wells Dam in 1990" and have the following comments and recommendations. Most of these we have discussed already, but there are a few additional suggestions.

Executive Summary, Para 3; and Page 2, Para 3:
CLARIFICATION: It would be helpful if the "best" configuration, determined from the 1984-86 studies, was mentioned here.

Executive Summary, Page 2, Para 1
TYPO: "These analysis were..." should be "These analyses were..." or "This analysis was...".

Executive Summary, Page 2, Para 2:
CLARIFICATION: The formula should read "B = Y/(X+Y)".

Table of Contents, Appendices, C.:
TYPO: "Destribution" should be "Distribution".

Page 8, Para 1: CLARIFICATION: There are two sentences that refer to how many intakes were unavailable because of turbine runner replacement. One refers to two intakes and the other refers to three. Which is correct?

Page 10, Para 2: CLARIFICATION: Some explanation would be helpful to me as to why a study day is defined as running from 8AM-8AM instead of 6AM-6AM? i.e. Why do day hours run 12 hours one day and 2 hours the next?

Page 14, Para 1: TYPO: "...through the end of June__, whitefish and..."

Page 18, Para 2: SUGGESTION: The phrase "Fyke catches" is used a great deal here. While the meaning is clear, my opinion is that "Fyke net catches.." is more appropriate. This would hold for the entire document.

Page 24, Para (3): TYPO: I think "predominate" should be "predominant".

Figure C.2: TYPO: "seperately" should be "separately".

Thank you for the opportunity to comment. If you have questions or need further information please call me at (206) 753-2546.

Sincerely,

Cynthia A. Wilson

Cynthia A. Wilson
Fish Biologist
Habitat Management Division

cw

cc: Rick Klinge, Douglas County PUD
Rod Woodin

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
911 NE 11th Avenue - Room 620
PORTLAND, OREGON 97232
503/230-5400 FAX 503/230-5435

FEB 01 1991
DOUGLAS COUNTY P.U.D.

Rick
RK

January 30, 1991 F/NWR5

NOTED
FEB 01 1991
R.W.K.

Mr. Rick Klinge
PUD No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, Wa. 98802-4497

Dear Mr. Klinge:

We recently received a draft report titled "Evaluation of the Smolt Bypass System at Wells Dam in 1990". We have reviewed this document and have received comments from the National Marine Fisheries Service (NMFS) scientific staff familiar with hydroacoustic technology. The comments of Bill Karp, NMFS Alaska Fisheries Science Center, are enclosed. We have no further comment at this time.

Sincerely,

Brian J. Brown

Brian Brown
NMFS Representative
Mid-Columbia Coordinating Committee

Enclosure with RK

cc: Dr. Richard Whitney

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Alaska Fisheries Science Center
Resource Assessment and
Conservation Engineering Division
7600 Sand Point Way Northeast
BIN C15700, Building 4
Seattle, Washington, 98115-0070

January 17, 1991 F/AKC1:WK

MEMORANDUM FOR: F/NWR5 - Bill Hevlin

FROM: F/AKC1 - Bill Karp WK

SUBJECT: Review of Draft Report on 1990 Acoustic Studies at Wells Dam

I have reviewed the report and would like to offer the following comments and suggestions.

General

The report reviews the study methods and results well but treats important technical aspects superficially. The data appear to support the interpretations presented in the report but I recommend that more detailed presentations and analyses be provided in future reports. **Particular attention should be paid to calibration procedures and results and other potential sources of bias.** I also recommend that a 90-day review period be incorporated into the report evaluation process.

Executive summary

1 The equation at the end of the second paragraph on the second page should read: B=Y/(X+Y).. This error should be corrected elsewhere in the text.

2 Care should be taken to qualify terms correctly. For example, "Total bypass efficiency " should read "Estimated total bypass efficiency".

Other issues will be addressed in my comments regarding other sections; responses may require modification of the executive summary.

1.0 Introduction
1.1 Objective

3 Second Paragraph. The term "substantiate" is inappropriate; I hope the objective was to evaluate!

DEPARTMENT OF COMMERCE
RECEIVED
2 2 1991
F/NWR5
MARINE FISHERIES SERVICE

1.2 Background

This section is written with the assumption that the reader has a great deal of knowledge about dam operations and fish passage. (4) It would be helpful if the background section could be expanded, especially with regards to the description of the baffle system and its effects, and the long term study objectives.

2.0 Methods
2.2 Transducer Locations and Orientations

First Paragraph. The definition of transducer beamwidth is inadequate. Further technical information should be provided for (5) each transducer and beam patterns should also be available. Since forebay data were based on a slower pulse rate than data collected elsewhere, how did this effect relative detectibility? Was this evaluated?

Paragraph 1, page 8. The report states that "At least two of three intakes at each turbine were sampled...". Was there any (6) investigation of horizontal effects across the intakes of each turbine? What was the potential bias introduced by this approach?

2.3 Sampling Design

The definition of day length is rather surprising. Since the principal reason for assigning day and night periods would be to (7) allow the effects of daylight and darkness to be evaluated, I would have expected the definition to be based on the actual day length for each calendar date.

2.4 Statistical Methods

This section and the supporting appendices are detailed and (8) thorough. The statistical approaches described address issues relating to precision thoroughly but do not deal with bias. Many aspects of the study incorporate potential sources of bias.

3.0 Results
3.2 Total Project Bypass Efficiency

What was unusual about April 25? Where there any notable environmental or operational conditions? How did conditions on (9) that day compare with the two unusually high efficiency dates in May? Are the anomalies somehow related to sample sizes? Anomalous results can often provide useful insights and should be investigated carefully. Why is it appropriate to exclude specific results from the analysis?

(10) Why are the spring and summer bypass efficiency estimates presented with different confidence intervals?

(11) Confidence intervals should be plotted around the passage index

estimates in figures 10 and 11.

4.0 Conclusions

(12) "were predominate" should read "were predominant".

Appendix 1.

The section on equipment performance and calibration is rather
(13) brief. I suggest that future reports provide detailed pre- and post-study calibration results and a discussion of the effects of breakdowns or changes in performance on study results.

Appendix 2.
A.2.1 Migrant Detection Criteria

After reading the first two paragraphs of this section the reader is left with the sense that target strength and echo strength are
(14) interchangeable terms. In fact, the term "target strength" is used incorrectly. Since the data collection and interpretation methods employed at Wells Dam did not provide target strength measurements, detection thresholds must have been based on echo strength criteria.

The rationale for using a criterion of "four successive echoes" for classifying a target as a fish is not provided. The
(15) contractor should discuss this rationale and explain why the criterion remains constant regardless of range, pulse repetition rate, or fish target strength.

A.2.2 Background Interference Level

The scale used for rating background interference level should be described. The times and dates of excluded data collection
(16) periods should also be provided. Is data collected at intermediate interference levels of reduced quality, and what is the effect of this on the results?

Appendix D Raw Data

This appendix does not provide raw data. I think it would be useful if raw data tables (in the form of individual hourly
(17) counts, perhaps broken down by range intervals) were provided in future reports. Averaging over long time periods may make it easier to tabulate the results but does not permit the reader to examine the them closely.

E.3 BioSonics' Responses

E.3.1 WDF Comments

All changes made as requested.

E.3.2 NMFS Comments

(1) Change made as requested.

(2) IBID

(3) IBID

(4) We are currently working on scientific publications which will have an expanded description of the baffle system and its effects, and long term study objectives. We will incorporate this major addition into future reports.

(5) Beamwidths were changed from "15 deg" to "nominal beamwidth 15 deg". Beam pattern plots for all 35 transducers used in this study are available from BioSonics for those interested; 35 pages of beam pattern plots is excessive for this report.

The forebay data were not used in estimating total project bypass efficiency. Relative detectability of spill bay bypass and turbine intake transducers was documented by BioSonics in 1985 ("Hydroacoustic Studies of Downstream Migrant Salmon and Steelhead at Wells Dam in Spring 1984," report to DCPUD, 44 pp).

(6) The horizontal distribution across an intake has been investigated using fyke nets. The data show that passage rates are <u>not</u> significantly different ($P < .05$) between the east, middle and west thirds of the sampled intake. These data validate the extrapolation procedure used for turbine transducers.

(7) The definition of a 24-hour period was based on previous studies when it was necessary to change experimental conditions each day. These changes were made by work crews starting at 0800 h. In 1991, a study-day should be from 0600 h to 0600 h. The appropriate edits have been made to the report.

(8) There are several sources of bias in fish passage studies at dams. These were documented by Thorne in 1987 (Chapter 4 "Sources of Error" in "Hydroacoustic Evaluation of the Spill Program for Fish Passage at John Day Dam in 1987," report to US Army Corps of Engineers, Portland District). They include target strength/calibration and pattern recognition. Dr. Thorne is currently a technical advisor for the hydroacoustic studies at Wells Dam.

(a) Changes in target strength during hydroacoustic studies at Wells Dam during spring can occur as the predominant species changes from chinook to steelhead to sockeye. Steelhead are the largest outmigrants but they are predominant only for a week or so in early May (e.g., see Table 5 of this report). Bias in the data due to fish size changes, however, is minimized because the system is set up with the effective transducer beam width at the -3 dB level of the beam pattern and able to detect a -50 dB target at this level. A chinook or sockeye target is about -48 dB (BioSonics, unpublished data). As the mean target strength gets larger, for example from steelhead, the beam pattern drops off rapidly, therefore there are not drastic changes in the effective beam width.

(b) Differences in transducer orientation relative to fish passage may also affect the effective transducer beam width. We eliminated this effect by aiming transducers up in both bypass and turbine intake locations.

(c) Differences in target strength due to differences in species composition between the fish passing through the bypass and those passing through turbine intakes would affect the effective beam width. Fyke net data taken concurrently in the bypass and turbine intakes do not show any differences in species composition (DCPUD, unpublished data).

(d) Another source of bias is from calibration. Changes in calibration can occur but we check for these with pre- and post-season measurements. If discrepancies are discovered, data from that transducer are discarded.

(e) Differences in transducer depth may also affect transducer performance and hence the calibration values. We minimized this effect by deploying the transducers for bypass and turbine sampling at depths as similar to each other as possible. Bypass and turbine intake transducers were placed at elevations 708 ft and 648 ft, respectively.

(f) Bias due to pattern recognition was minimized by having one person primarily responsible for "marking" the fish traces on the echograms. During the 1990 evaluation, that person was E. Kudera.

(9) We did not notice any unusual environmental or operational conditions for April 25, 1990. The high passage rate in bypass was not due to species composition because other dates with high efficiency estimates (e.g. May 7 and May 15) had different species prevalent. Flows were generally high throughout the study, but we did not examine flows for those particular dates.

We did not exclude any results from the analysis; we presented the results with and without data from April 25 so that readers could draw their own conclusions.

(10) The spring and summer bypass efficiency estimates are presented with different confidence intervals because that was what the Settlement Agreement called for. The parties may have felt that summer passage is naturally more variable than spring passage and, thus, felt a looser confidence interval (larger confidence level) would be appropriate.

(11) This is a good point. Unfortunately, we do not have this information. We will include confidence intervals around "sub-index" data for future studies.

(12) Change made as requested.

(13) See Response No. 7.

(14) Change made as requested.

(15) This comment concerns the fact that at least four consecutive echoes were required for a target to be classified as a fish, regardless of range, pulse repetition rate, and target strength. These are all important factors that can affect detectability. The important point in this study, however, is that detectability between bypass and turbine transducers be equivalent and consistent, which it was.

(16) Change made as requested. Data affected by noise were not included in the analysis.

(17) The title of the appendix has been changed from "Raw Data" to "Fish Passage Data." A table with passage estimates and variances for each date of the study for each sampling location has been added to the report.

HYDROACOUSTIC EVALUATION OF JUVENILE SOCKEYE PASSAGE AT ZOSEL DAM ON THE OKANOGAN RIVER IN 1990

APPENDIX - B

Hydroacoustic Evaluation of Juvenile Sockeye Passage at Zosel Dam on the Okanogan River in 1990

Draft Report

Prepared for:
Douglas County PUD
1151 North Main
East Wenatchee, WA 98802

Prepared by:
Michael S. Spong
Gary E. Johnson
and
Colleen M. Sullivan

BioSonics, Inc.
3670 Stone Way N.
Seattle, WA 98103

February 18, 1991

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ACKNOWLEDGEMENTS

The hydroacoustic studies at Zosel Dam were the result of the cumulative efforts of the following people to whom we extend sincere appreciation:

- Douglas County PUD staff at Wells Dam and East Wenatchee for logistical assistance and incomparable cooperation.

- E. Kudera for technical and methodological information.

- J.J. Dawson and T. Brooks for Echo Signal Processor software support and technical information.

- L. Stone for graphics.

- D. Teghtmeyer for word processing.

1.0 INTRODUCTION

1.1 Background and Objectives

Lake Osoyoos supports a wild run of sockeye salmon (*Oncorhynchus nerka*). Juveniles migrate downstream out of the lake in April and May and adults migrate upstream into the lake in late August and early September. The outmigration exits Lake Osoyoos at Zosel Dam and then enters the Okanogan River, which empties into the Columbia River. The first hydroelectric project these fish must pass is Wells Dam (Figure 1). Douglas County Public Utility District (DCPUD) operates a smolt bypass system at Wells Dam during the spring outmigration of steelhead, chinook salmon, and Lake Osoyoos sockeye salmon. The hydroacoustic monitoring index calculated at Wells Dam, which shows the decline in passage rates as the spring outmigration ends, can help operate the bypass efficiently. The sockeye outmigration usually completes the total spring outmigration of steelhead and salmon at Wells Dam. Because the timing of the sockeye outmigration is unpredictable, we used hydroacoustic methods to meet our main objective: monitor the outmigration of juvenile sockeye at Zosel Dam. Gaining a greater understanding of the migrations of sockeye passing through Zosel Dam is important because these fish are wild and one of the few sockeye runs remaining in the Columbia Basin.

The juvenile outmigration at Zosel Dam was first sampled in 1989 (Kudera *et al.* 1990). This study showed that hydroacoustics could be used to generate an index of outmigration timing. Adults were not sampled in 1989. In 1990, however, a secondary objective was to assess the feasibility of using hydroacoustic techniques to count adult sockeye migrating through Zosel Dam during summer. Transducers were installed in each fishway to monitor the adult migration during August 1990. Due to excessive flows, spill occurred throughout the adult migration period. Visual observations indicated that the majority of the adults utilized the spill flow and not the fishways. Because of these high flows too few fish were detected in the fishways to determine general trends for the adult migration. The methods and results of the spring study of juvenile sockeye only are presented in this report.

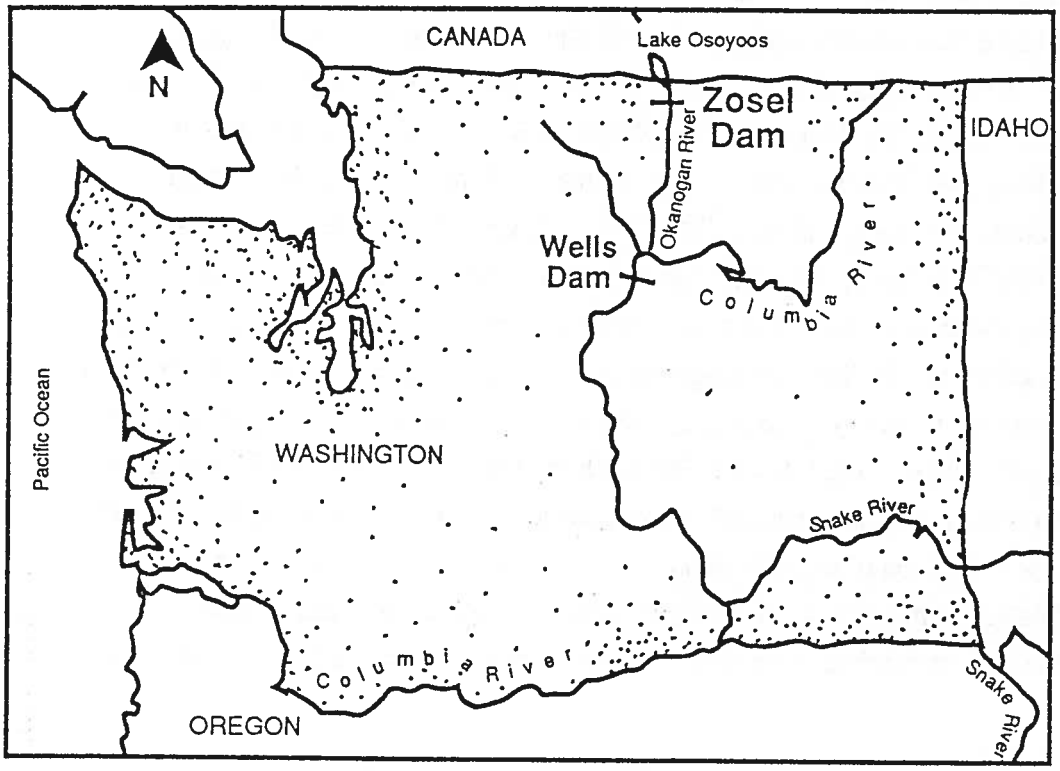

Figure 1. Location of Zosel Dam on the Okanogan River.

1.2 Study Site Description

Zosel Dam, completed in 1987, controls surface elevation and outflow from Lake Osoyoos. The purpose of the dam is strictly to control lake elevation. There are no hydroelectric generating facilities at the dam. The dam is owned by Washington State Department of Ecology and is operated by the Oroville-Tonasket Irrigation District. Washington Department of Fisheries (WDF) is in charge of operations for passing sockeye through Zosel Dam.

Zosel Dam has four spillbays located on the west side of the river and an overflow weir on the east side (Figure 2). Fishways for adult passage are located on each side of the spillway. The forebay is approximately 5-10 feet deep, and is normally maintained at elevation 911.0 to 911.5 feet MSL during the spring outmigration.

In April 1990, WDF installed a weir at Spillbay 1. The weir was a modified stoplog with a tapered 1 foot notch cut in the top of the stoplog. This was done to provide attractant flow and also conserve water. Because of high flows, the weir was removed on May 3, prior to hydroacoustic monitoring at Spillbay 1. The special weir was replaced by the emergency gate repair mechanism used in 1989.

Because of high flows during May the emergency gate repair mechanism consisted of two 18 inch stoplogs set in the stoplog guides just upstream of the vertical lift gates and two 18 foot stoplogs set in guides just downstream of the vertical lift gates (Figures 4 and 5). This allows water to spill over the top over the downstream stoplog and into the tailrace at elevation 906.0 ft. The vertical lift gate was pulled almost completly out of the water and was there to provide some riffling between the stoplogs. This configuration was used at Spillbays 1 and 4 from May 4 to May 26.

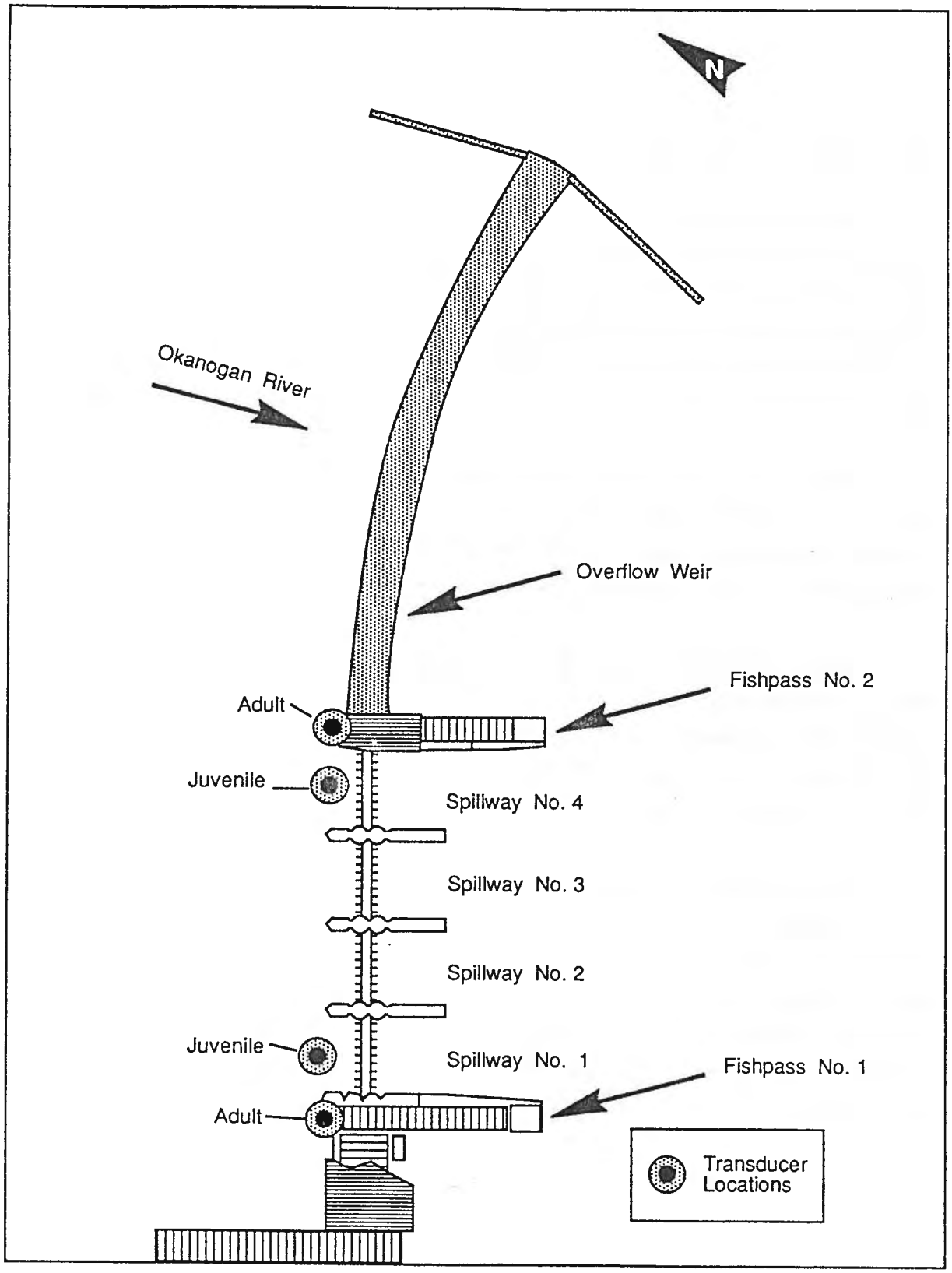

Figure 2. Plan view of Zosel Dam.

2.0 METHODS

2.1 General Hydroacoustics

A BioSonics remote hydroacoustic data collection system was used to collect fish passage data at Zosel Dam. This system consists of a Model 105 echosounder, a transducer with cable, a Model 151 multiplexer/equalizer, a Model 111 Thermal Chart Recorder, a Hitatchi Oscilloscope, and a Model 281 Echo Signal Processor (Figure 3). Manufacturers and model numbers of equipment used at Zosel Dam in 1990 are presented in Table 1.

The hydroacoustic system was acoustically calibrated before the study. During calibration, the source levels, receiving sensitivities and beam patterns of the transducers were measured. System parameters are presented in Table 2. Hydroacoustic system operation and calibration are explained in Appendix A.

2.3 Echo Signal Processing

The voltages from fish echoes detected by the echo sounder were routed to a BioSonics Model 281 Echo Signal Processor (ESP). This processor includes a circuit board installed inside a IBM AT compatible computer. Each detected echo was compared to a voltage threshold and to a standard shape before acceptance. Those echoes that pass the user selected criteria were written to the computer's hard disk. Each day a new data file containing 24 one-hour periods was created. Once each day at a preselected time, the processing computer halted the digitizing process and reset itself to create a new data file. This usually occured near midnight.

Table 1. Hydroacoustic equipment used at Zosel Dam, spring 1990.

Model Number	Manufacturer	Serial Number
Portable Echo Sounder Model 105	BioSonics, Inc.	105-85-009
Multiplexer/Equalizer Model 151	BioSonics, Inc.	151-83-006
Thermal Chart Recorder Model 111	BioSonics, Inc.	111-88-039
Transducer 15deg / attached 500' cable	BioSonics, Inc.	141-88-510
6 deg transducers		06-420-059&063
Oscilloscope Model V-422	Hitachi, Inc.	5017445
DeskPro 386 w/ 4832HT2H0776	Compaq,Inc.	
Echo Signal Processor Model 281	BioSonics, Inc.	281-89-039

Table 2. Hydroacoustic system parameters used at Zosel Dam, spring 1990.

Model 105 Portable Echo Sounder and Model 281 ESP

Transmit Frequency:	420 kHz	
Transmit Power:	0 dB	
Band Width:	5 kHz	
Pulse Width	0.5 msec	
Time-Varied-Gain	40 logR	
Trigger Source	105 Sounder	
Receiver Gain	0 dB	
Pulse Rate	10 pulses/sec	
Max Ping Gap	3 Pings	
Tracking Window	5 Meters	
Minimum Tracking Range	0.2 Meters	
Beam Pattern Threshold	-20.0 dB	
	MIN	MAX
Average Slope	-50.0	+50.0
Average Target Strength	-70.0 dB	-10.0 dB

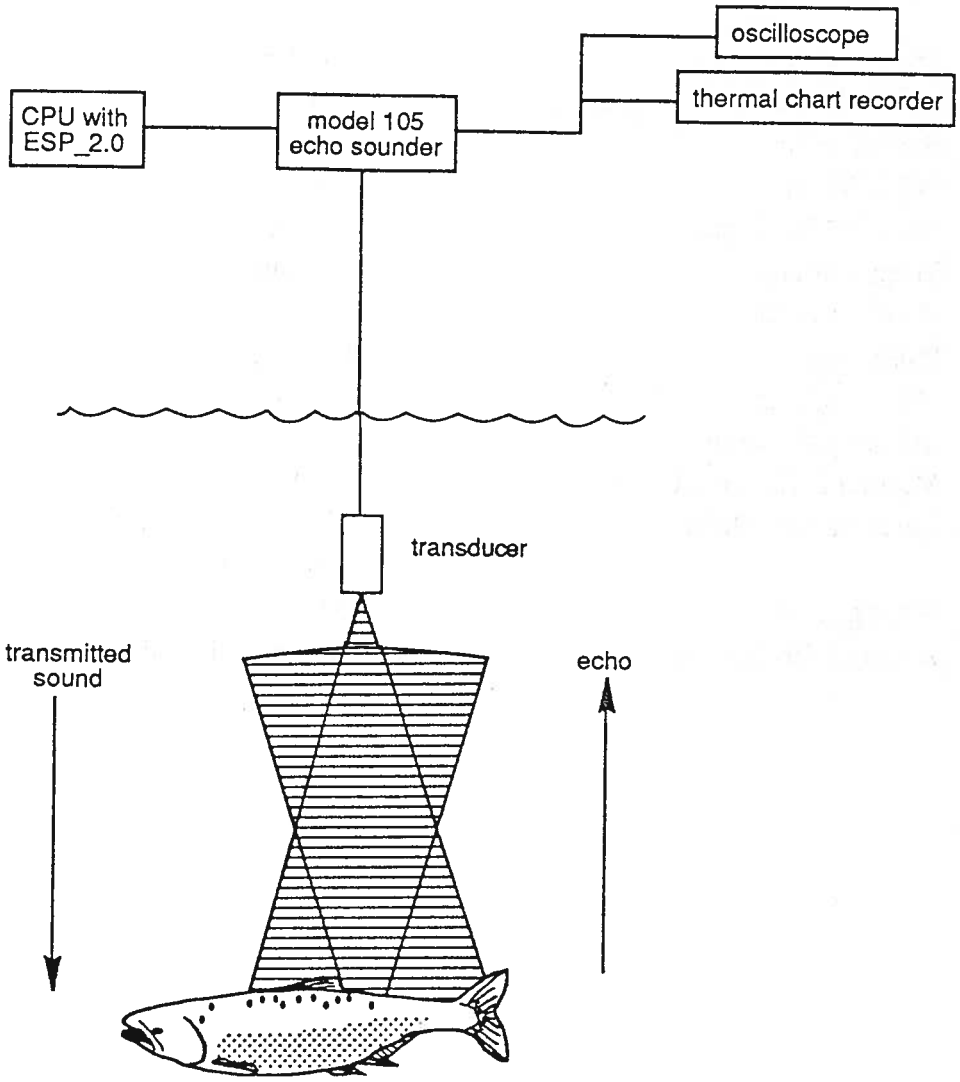

Figure 3. Schematic of hydroacoustic system used at Zosel Dam in 1990.

2.4 Transducer Locations and Orientations

One 15 degree single beam transducer was used for the the spring study. During spring, the transducer initially was deployed on a floating mount just below the surface in the forebay of Spillbay 4. This transducer was aimed downward at an angle 10 degrees upstream (Figures 2 and 4). The Spillbay 4 transducer location was used during April 26 to May 2. At the request of WDF, the transducer was moved to Spillbay 1 on May 4 and remained there for the duration of the outmigration. The transducer was mounted at the bottom of the forebay about 6 feet deep. It was aimed up, 10° downstream (Figure 5).

2.5 Sampling Design

Data collection occurred from April 26 through May 24, 1990. Data were not collected on May 2 and 3, because we redeployed the transducer and changed the configuration of stoplogs at Spillbay 1. We originally planned to extend the sampling period to May 31, but exceptionally high water flows necessitated the removal of the transducer. The single transducer was sampled 24 hours per day except for May 2 and 3. The pulse rate was set at 10 pulses per second.

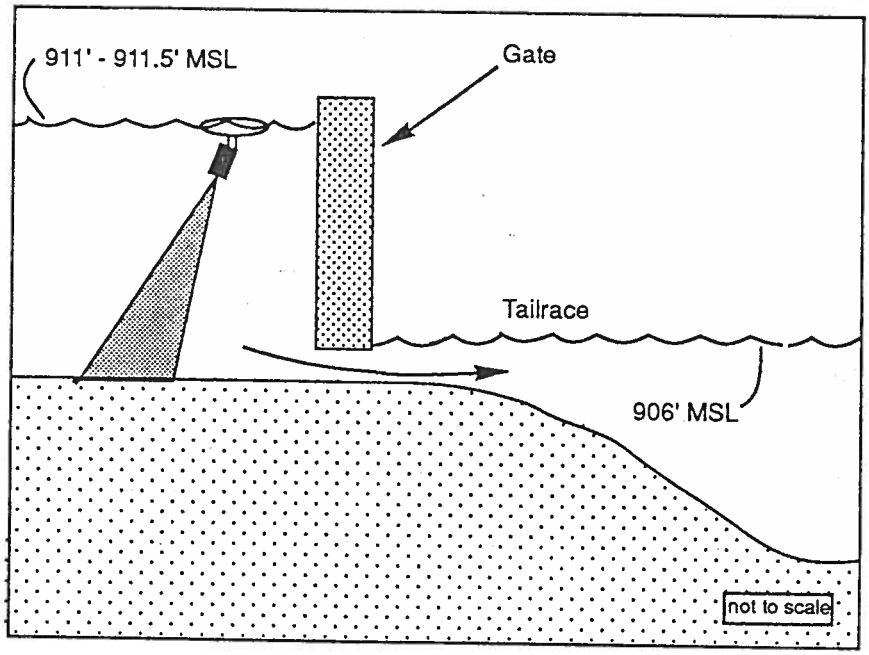

Figure 4. Side view of Spillbay 4 showing down-looking transducer.

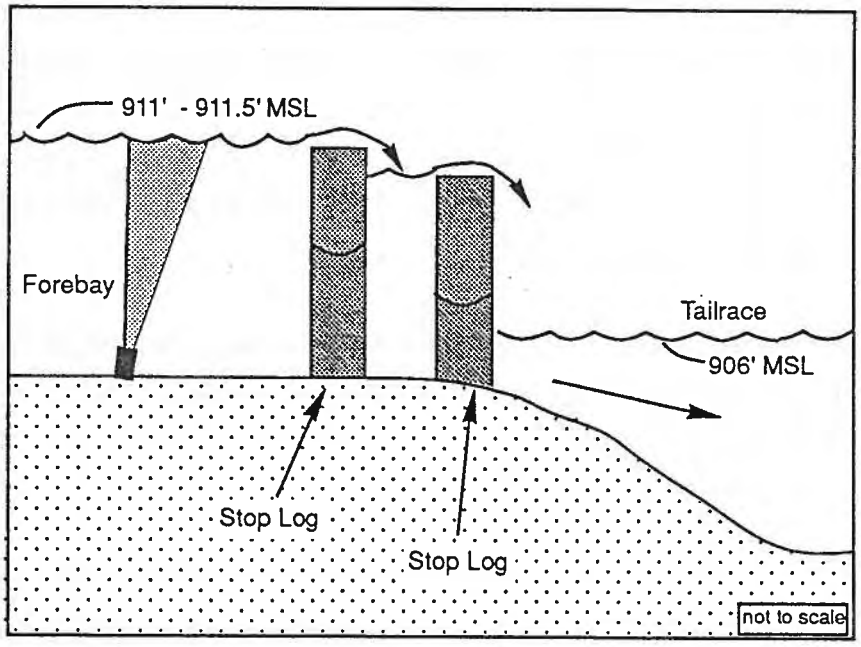

Figure 5. Side view of Spillbay 1 showing up-looking transducer.

2.6 Data Analysis

Hourly fish passage was estimated by totalling tracked fish targets. This real time tracking process is based on the ping number and range of each individual echo. For each fish tracked by this process, the following parameters are measured and written to disk: mean target strength, mean range, date and time of detection, direction of travel, fish velocity, and time in the beam. The criteria used to estimate targets in the ESP_2.0 were: (1) target echoes had to exceed minimum threshold, and (2) targets had to be detected by a minimum number of consecutive echoes. Fish targets were not weighted for beam spreading because of the short sample ranges, nor were they extrapolated for unsampled area. Relative hourly passage rate estimates were averaged over each day of the study to produce the run timing curve. Diel distributions were estimated by averaging the passage rates for a given hour over the study period.

The pulse width criteria for selecting valid echoes were set very wide (maximum 1.2 msec at 1/2 amplitude) to collect data from multiple, overlapping targets. Remember, we were indexing run timing, not making an absolute count. The hydroacoustic data provide a relative index of fish passage at Zosel Dam.

The target tracking and filtering process is efficient in removing spurious detections returned from bubbles and debris. Most debris would be neutrally buoyant if it was in the acoustic sound field. The majority of neutrally buoyant debris will have a very low acoustic reflectivity, since it has about the same density as water. Therefore, debris can usually be excluded because of low target strength.

During the spring study at Zosel Dam in 1990, hydroacoustic data were supplemented with extensive visual observations.

3.0 RESULTS

3.1 Project Discharge and Dam Operations

In Table 3 we present daily flow rates and gate apertures with the dates and times of change during spring 1990 at Zosel Dam. (The last two flow discharge entries in Table 3, are possibly larger than actual, due to high water backing up into the area where the metering station is located.) Estimated daily total flow (in cfs) are presented in Figure 6. Total daily flow ranged from 246 to 375 cfs for most of the study. On May 23 & 24, flow was 853 to 760 cfs, respectively. During spring 1990, flows at Zosel Dam were higher than normal.

Table 3. Dates and gate heights for spill at Zosel Dam, April 26 through May 24, 1990.

Date	Gate 1 Top Spill	Gate 2 /----------	Gate 3 Bottom Spill	Gate 4 ----------\	Flow Ttl CFS	Time of Change
26-Apr	12.0"	Closed	Closed	9.5"	375	1330
27-Apr	12.0"	Closed	Closed	8.0"	375	1440
28-Apr	12.0"	Closed	Closed	8.0"	335	*
29-Apr	12.0"	Closed	Closed	6.8"	300	1331
30-Apr	12.0"	Closed	Closed	6.0"	\	0825
30-Apr	12.0"	Closed	Closed	6.5"	270	1345
1-May	12.0"	Closed	Closed	6.5"	285	*
2-May	12.0"	Closed	Closed	6.5"	285	*
3-May	12.0"	Closed	Closed	6.5"	285	*
4-May	12.0"	1.0"	2.5"	2.0"	285	1500
5-May	12.0"	1.0"	2.5"	2.0"	290	*
6-May	12.0"	1.0"	2.5"	2.0"	289	*
7-May	12.0"	2.0"	2.5"	2.0"	\	1246
7-May	12.0"	10.0"	2.5"	2.0"	\	1610
7-May	12.0"	6.5"	2.5"	T spill12.0"	310	1900
8-May	12.0"	Closed	2.5"	12.0"	\	0745
8-May	12.0"	2.0"	2.0"	12.0"	277	1345
9-May	12.0"	Closed	2.0"	12.0"	320	0745
10-May	12.0"	Closed	Closed	12.0"	265	0815

11-May	12.0"	Closed	Closed	12.0"	265	*
12-May	12.0"	Closed	Closed	12.0"	260	*
13-May	12.0"	Closed	Closed	12.0"	250	*
14-May	12.0"	Closed	Closed	12.0"	255	*
15-May	12.0"	Closed	Closed	12.0"	265	*
16-May	12.0"	Closed	Closed	12.0"	260	*
17-May	12.0"	2.5"	Closed	12.0"	270	1400
18-May	12.0"	2.5"	Closed	12.0"	246	*
19-May	12.0"	Closed	Closed	12.0"	355	1420
20-May	12.0"	1.5"	Closed	12.0"	275	1835
21-May	12.0"	1.5"	Closed	12.0"	315	*
22-May	12.0"	2.5"	Closed	12.0"	360	1115
23-May	12.0"	3.0"	24.0"	12.0"	\	0830
23-May	12.0"	3.0"	3.0"	12.0"	\	1540
23-May	12.0"	3.0"	15.0"	12.0"	\	1610
23-May	12.0"	3.0"	13.5"	12.0"	853	2200
24-May	12.0"	3.0"	13.5"	12.0"	760	1200

(*) indicates no logged change in spillgate settings.

(\) indicates multiple spillgate adjustments during one day, last entry is total daily discharge.

Lake Osoyoos discharge data is acquired daily at 1300H, and was provided by courtesy, United States Department of Interior, Department of the Geological Survey.

Closed = no water through this location

853 = may be influenced (increased) by high water entering downstream from Zosel

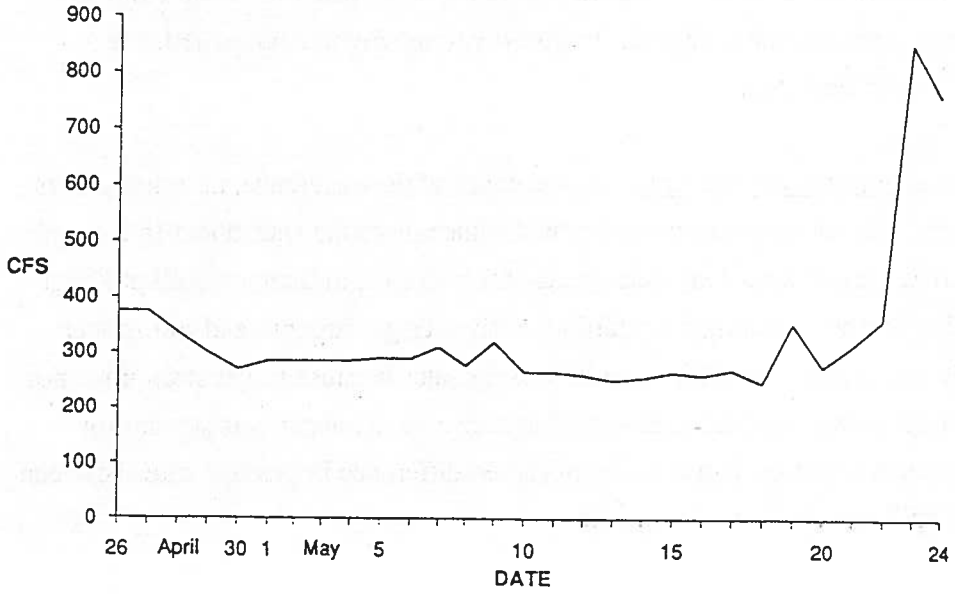

Figure 6. Estimated discharge at Zosel Dam in spring 1990.

3.2. Run Timing

On April 26 when hydroacoustic monitoring started, the sockeye outmigration was already in progress. The first peak occurred on April 27, 28, and 29 (Figure 7). Another peak occurred on May 16, with a decline in daily numbers to the termination of the study on May 24 (Figure 7). Hourly results for each day of the study are presented in Appendix B.

There were higher passage rates in early May when Spillbay 4 bottom spill was sampled with a downlooking transducer than in mid to late May when Spillbay 1 top spill was sampled with an uplooking transducer. In investigating why this happened, the following factors should be noted:

(1) If acoustic detectability was the cause of the difference, all other things being equal, we might expect greater passage rates for the uplooking transducer in top spill because water velocity inside a spillbay was greater for bottom spill than top spill at Zosel Dam in 1990. Other factors affecting detectability such as target strength and transducer depth are probably not causing the difference in passage rates because target strength is not significantly different between dorsal and ventral aspects and the water was so shallow. Acoustic detectability was not the cause of the observed difference in passage rates between Spillbay 4 bottom spill and Spillbay 1 top spill.

(2) Juvenile sockeye behavior to school and actively avoid top spill was much more pronounced at Spillbay 1 than at Spillbay 4 apparently because of the slower water velocities. Thus, we might expect higher counts at Spillbay 1 because the same fish might have been counted more than once.

(3) Other targets, such as squawfish and carp, could cause counts to be higher at one place than other. Because of the conditions noted in Item (2), however, more non-target fish were present at Spillbay 1 than Spillbay 4.

Therefore, the difference in passage rates was observed because there were probably more juvenile sockeye migrating out of Lake Osoyoos early in the study at Spillbay 4 than later in the study at Spillbay 1.

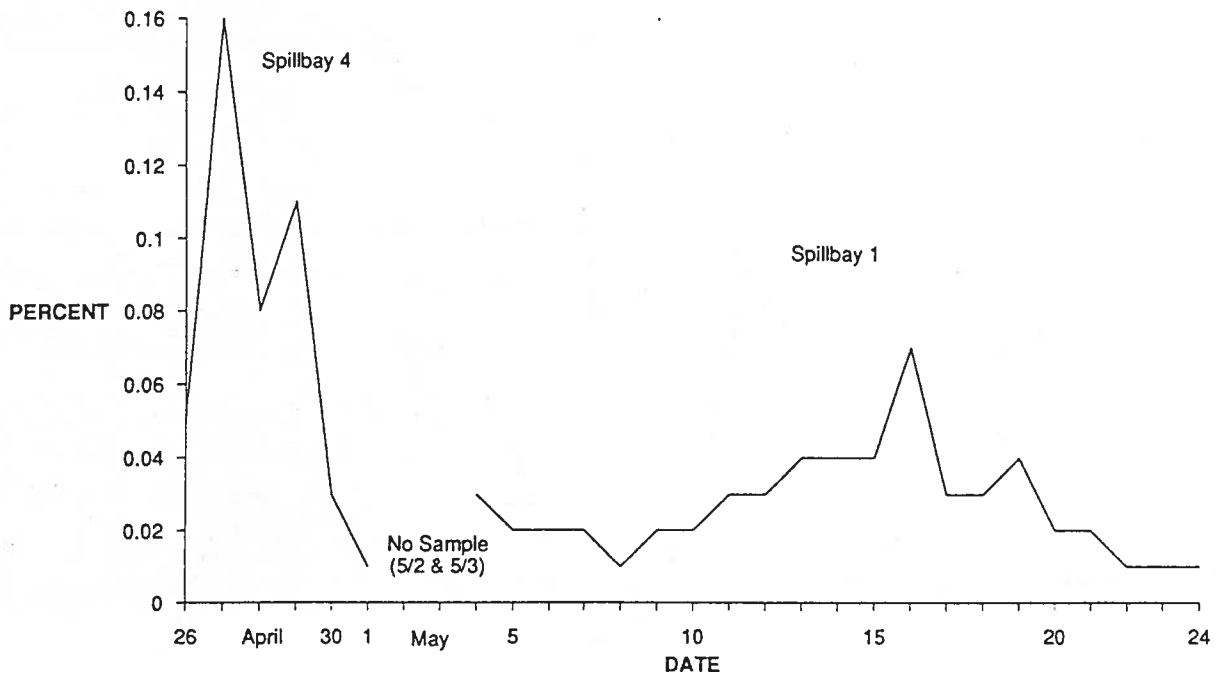

Figure 7. Run timing curve for outmigrant sockeye at Zosel Dam in spring 1990.

3.3 Diel Distribution

The diel distribution show higher numbers of fish passing during the early to mid morning and mid afternoon hours (Figure 8). These data are consistent with those collected for sockeye at Wells Dam (Johnson and Sullivan 1985) and data from previous hydroacoustic studies at Zosel Dam (Kudera *et al.* 1990). Sockeye smolt diel behavior is apparently different than that of other salmon, such as chinook, which have higher passage during nighttime than daytime hours (Thorne & Johnson, In Press).

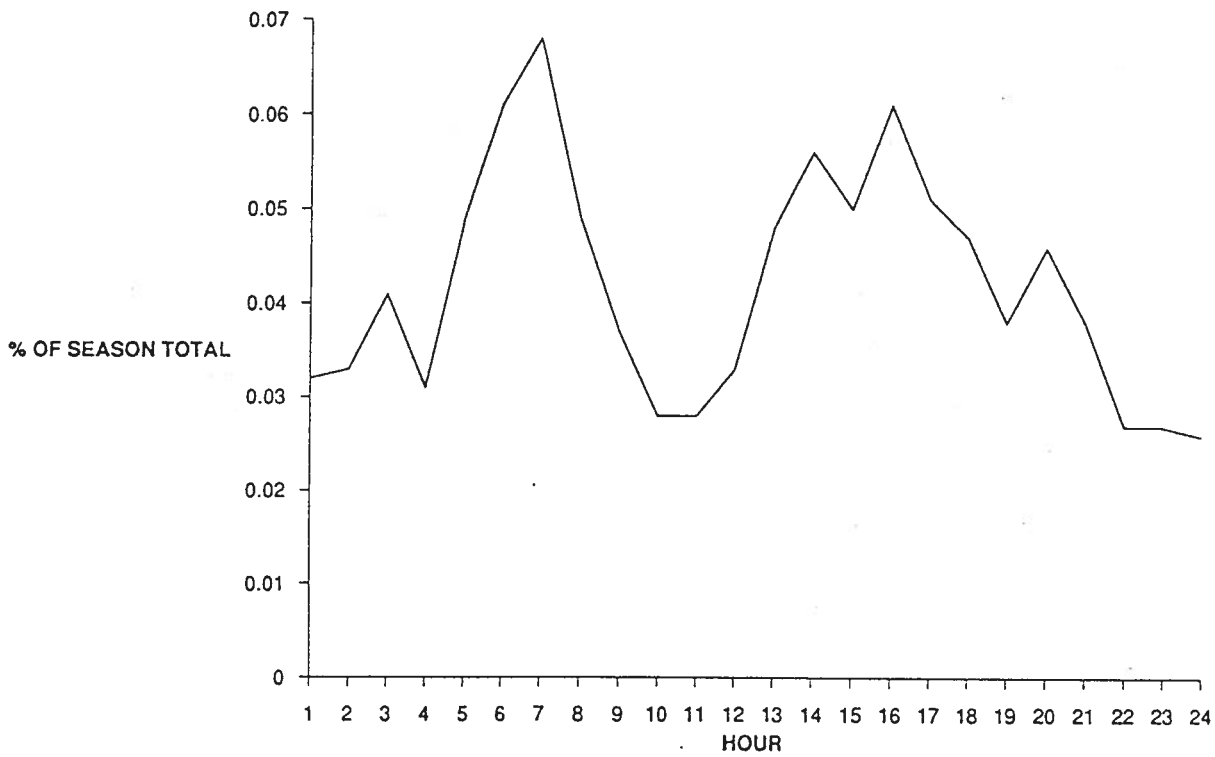

Figure 8. Diel distribution for outmigrants at Zosel Dam in spring 1990.

4.0 CONCLUSIONS AND RECOMMENDATIONS

(1) The juvenile sockeye outmigration at Zosel Dam was monitored using hydroacoustic techniques. During April 26 to May 2, fish were sampled at Spillbay 4 bottom spill using a down-looking transducer. During May 4 to May 26, fish were sampled at Spillbay 1 top spill using an up-looking transducer.

(2) For the 1990 outmigration, WDF had a weir installed at Spillbay 1 to enhance juvenile sockeye passage there. This weir, which was a modified stoplog, had an aperture to facilitate near surface passage of fish. Because of high flows, however, other spill gates were opened and much more water flowed through Zosel Dam at these gates than at Spillbay 1's special weir.

(3) WDF and BioSonics observed that fish were not noticeably attracted to the weir at Spillbay 1. Therefore, WDF had the weir removed and the emergency gate repair mechanism used in 1989 was put in place. This occurred on May 3 and 4 during which time we moved the transducer from Spillbay 4 to Spillbay 1.

(4) Juvenile sockeye were present in noticeable numbers when the study began on April 26, 1990. The run timing curve shows highest passage in late April. There was also a minor peak on May 16. Passage rates had declined to their lowest level of the study on May 24 when sampling ended.

(5) The diel distribution shows more juvenile sockeye passing through Zosel Dam during daytime than nighttime.

(6) Future spring studies should *sample more than one bay simultaneously and start sooner* in April (April 10 may be appropriate).

5.0 REFERENCES

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APPENDIX A: Hydroacoustic System Operation

A.1 Equipment Operation

A BioSonics hydroacoustic system works as follows. When triggered by the Model 101 Echo Sounder, a high-frequency transducer emits short sound pulses in a relatively narrow beam aimed toward an area of interest. As these sound pulses encounter fish or other targets, echoes are reflected back to the transducer which then reconverts the sound energy to electrical signals. The signals are then amplified by the echo sounder at a 40 log(R) time-varied-gain (TVG) to compensate for the loss of signal strength due to absorption and geometric spreading of the acoustic beam with distance from the transducer. Thus, equally sized targets produced the same signal amplitudes at the echo sounder receiver output regardless of their distance (range) from the transducer. The range of each target from the transducer is determined from the time it takes the sound pulse and echo return to travel that distance (velocity of sound in freshwater = 1445 m/sec).

The echo sounder relays the returning TVG-amplified signals to the chart recorder, oscilloscope, and tape recorder (the tape recorder was not used in the Zosel studies). The return signals are visually displayed on the oscilloscope to observe echo strength and echo duration. Returns from individual fish are recorded on the chart recorder's echograms which provide a permanent record of all targets detected throughout the study. The threshold circuit on the chart recorder is adjusted to eliminate signals less than the echo levels of interest.

The Model 151 Multiplexer/ Equalizer (MPX/EQ) permits a single echo sounder to automatically interrogate up to 16 different transducers in an operator-specified sequence. The MPX/EQ channels transmit pulses from the echo sounder to the appropriate transducers and equalizes the return signals to compensate for the differing receiving sensitivities resulting from varying cable lengths and transducer characteristics. (the multiplexer was not used during spring 1990 at Zosel; it was used during summer.)

A.2 System Calibration

Each acoustic system was calibrated before the study began. Calibration assured that an echo from a target of known acoustic size passing through the axis of the acoustic beam produced a specific output voltage at the echo sounder. Based on the calibration information, the adjustable print threshold on the chart recorder was set so that it would print signals from targets larger than -56 dB for the juvenile study and -42 dB for the adult study. The calibration information was also used to equalize (using the MPX/EQ) the system sensitivity for each receiving channel. A system calibration at the end of the season verified that the sensitivities had remained constant throughout the study. A detailed description of the calibration of hydroacoustic systems can be found in Urich (1975).

APPENDIX B

Hourly Fish Passage for April 26 - May 24, 1990

Table B-1. Hourly fish passage, April 26 - May 24, 1990, Zosel Dam.

DATE	HOUR																								TOTAL
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
26-Apr-90	0	*	*	*	*	*	*	*	*	*	*	*	75	157	229	270	394	107	131	249	249	695	659	143	3358
27-Apr-90	147	317	449	227	1263	1277	1287	1219	889	135	141	179	135	117	259	763	641	117	131	149	411	141	211	711	11316
28-Apr-90	935	949	1013	101	*	*	*	*	*	*	*	29	89	173	229	103	183	115	129	779	123	109	139	103	5301
29-Apr-90	143	115	339	873	975	1005	949	433	127	113	257	151	107	107	129	619	417	377	113	101	389	75	73	83	8070
30-Apr-90	53	61	65	87	75	81	97	99	91	91	97	101	101	265	117	125	89	73	73	89	51	31	31	37	2090
1-May-90	35	41	35	45	43	69	77	59	71	69	73	102	79	58	*	*	*	*	*	*	*	*	*	*	856
2-May-90	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3-May-90	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
4-May-90	*	*	*	*	*	*	*	*	*	37	95	29	68	101	546	306	169	213	197	175	147	35	27	31	2176
5-May-90	54	39	45	29	39	177	91	67	71	73	65	55	59	59	59	65	87	111	83	67	51	33	29	41	1559
6-May-90	54	31	35	39	49	63	57	63	53	55	83	103	87	63	75	73	59	59	35	45	53	51	43	37	1365
7-May-90	50	41	77	37	39	77	69	63	81	77	53	57	89	75	65	55	51	45	43	45	41	41	47	33	1351
8-May-90	50	25	29	25	33	41	53	39	35	41	51	43	47	43	47	43	55	73	65	65	49	31	35	31	1049
9-May-90	56	31	35	31	33	71	83	73	55	63	53	61	101	121	105	79	65	59	57	39	39	29	25	31	1395
10-May-90	54	33	35	27	27	31	45	33	37	45	68	67	87	67	91	103	81	83	93	81	63	29	29	31	1340
11-May-90	50	27	31	33	37	73	53	45	41	67	61	81	81	107	107	141	237	153	91	75	83	39	29	33	1785
12-May-90	79	45	37	45	81	109	103	87	107	73	55	90	148	37	101	149	99	115	205	87	57	29	37	31	2006
13-May-90	31	31	33	33	33	53	63	83	93	87	95	403	427	663	127	79	71	81	71	43	47	29	27	29	2732
14-May-90	33	33	29	35	31	47	61	51	45	51	47	93	121	147	283	219	119	427	163	187	147	43	33	29	2474
15-May-90	33	33	35	31	49	145	327	223	93	207	127	115	109	107	139	105	89	273	179	215	91	45	29	35	2834
16-May-90	35	33	27	33	57	167	365	103	99	103	107	121	809	1093	359	453	89	185	231	99	79	33	45	49	4774
17-May-90	39	31	33	39	47	151	367	117	123	109	79	79	93	95	71	89	87	63	79	63	73	39	29	31	2026
18-May-90	37	33	37	41	47	99	129	125	97	105	115	107	251	119	99	81	103	235	143	61	71	31	29	29	2224
19-May-90	31	31	35	31	59	101	91	127	129	289	111	121	159	117	177	111	125	237	283	103	65	39	25	37	2634
20-May-90	29	31	56	31	45	67	115	83	63	53	51	61	69	69	65	71	61	91	109	117	67	49	33	33	1519
21-May-90	29	27	33	29	49	65	63	67	77	73	77	77	77	99	75	67	65	63	99	205	127	37	29	31	1640
22-May-90	29	29	27	33	37	47	39	41	41	41	45	65	63	53	45	53	51	39	41	51	53	31	27	33	1014
23-May-90	31	29	29	29	35	61	47	41	47	53	47	47	53	55	43	43	45	45	39	37	41	41	43	35	1016
24-May-90	33	35	35	35	35	31	33	41	39	31	35	25	*	*	*	*	*	*	*	*	*	*	*	*	408

* = not sampled

PROPOSAL FOR
HYDROACOUSTIC EVALUATION
OF THE SMOLT BYPASS SYSTEM
AT WELLS DAM IN SPRING AND SUMMER 1991
AND MONITORING AT ZOSEL DAM IN SPRING 1991

APPENDIX - C

Proposal for Hydroacoustic Evaluation of the Smolt Bypass System at Wells Dam in Spring and Summer 1991 and Monitoring at Zosel Dam in Spring 1991

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March 15, 1991

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Proposal for Hydroacoustic Evaluation of the Smolt Bypass System at Wells Dam and Monitoring at Zosel Dam in 1991

1.0 INTRODUCTION

1.1 Objective and Format

We propose to use hydroacoustic techniques to evaluate the smolt bypass system at Wells Dam in 1991. The fish of interest include the spring downstream migration of chinook, steelhead, and sockeye and the summer downstream migration of chinook. The main objective of the study will be to estimate total project smolt bypass efficiency.

This proposal also includes monitoring at Wells Dam during periods when the bypass is not being evaluated between March 29 and August 31, 1991 and monitoring at Zosel Dam from April 10 to May 31, 1991. Monitoring data help in deciding when to open and close the bypass. Thus, secondary study objectives are to monitor run timing at Wells and Zosel dams.

The proposal is formatted as follows: the smolt bypass system's development and operations for 1991 are presented in Section 2.0; detailed methods on the bypass evaluation are presented in Section 3.0. Run timing monitoring for Wells and Zosel dams are proposed in Sections 4.0 and 5.0, respectively. Project tasks are in Section 6.0 and the cost proposal is in Section 7.0

2.0 THE SMOLT BYPASS SYSTEM AT WELLS DAM

2.1 Bypass Concept and Development

A smolt bypass system has been developed and installed at Wells Dam on the Columbia River. The bypass system at Wells uses baffles in spill intakes to create attractant flow and ultimately divert downstream migrants around turbines and through spill. This bypass concept is Douglas County PUD's (DCPUD) long-term solution to improving smolt survival at Wells Dam. As stated in the Settlement Agreement, 1991 will be the second year of a 3-year evaluation to substantiate the effectiveness of the smolt bypass system at Wells Dam.

The bypass concept at Wells Dam is based on Wells' hydrocombine structure. (A hydrocombine is a dam with the spillway located directly above the turbine intakes. Wells is the only dam constructed like this in North America.) Baffles are placed in the spill intakes to increase flow velocities in the forebay, thereby creating attractant flow for downstream migrant smolts. Once entrained in this attractant flow, smolts enter the bypass and migrate through the dam in bypass flow instead of turbine flow. Data show that a relatively small amount of flow properly baffled is more effective at bypassing smolts than is a large amount of flow that is not baffled.

Annual bypass evaluations using hydroacoustics were critical to the development of an efficient bypass at Wells Dam. A prototype bypass was first installed and tested in 1983 at one section (one spillbay of eleven in the spillway) of the dam. This study showed that smolt passage in bypass flow was greater with baffles in place than without. In 1984, 1985, and 1986, the bypass passage rates for various baffle configurations (underflow, overflow, vertical slot, etc.) were compared. The configuration that passed statistically significantly more fish than the others, all other factors being equal, was deemed the "best". In 1986, two bypass sections were installed and tests conducted to determine if operating an adjacent bypass section increased passage at the original bypass section; it did not. In 1987, more bypass sections were installed and the study objective was to determine the most effective locations for bypass sections across the dam; the middle and west sections had higher passage than the east section. In 1988 and 1989, detailed data on specific characteristics of the bypass were evaluated to fine-tune the system and the vertical slot was chosen as the preferred configuration because it was among the best at bypassing

smolts. Although the underflow configuaration was statistically equivalent with vertical slot, underflow occurs much nearer the turbine intakes than vertical slot flow, thus the latter was chosen. Bypass efficiency was estimated by sampling inside turbine intake galleries and inside the bypass. The bypass will be officially completed after review and acceptance of total project bypass efficiency data from three years of evaluation beginning in 1990.

In 1990, total project smolt bypass efficiency was estimated for the first time. Transducers were placed in all 5 bypass units and in at least 2 of 3 intakes in all 9 turbine units (the tenth turbine unit was off-line for runner replacement.) The results were: spring 84% +/- 8% at the 95% confidence level and summer 77% +/- 4% at the 90% confidence level.

2.2 Bypass System Configuration and Operation in 1991

In 1991 DCPUD plans to use the same baffle configuration as in 1990; vertical slot baffle with an opening 16 ft wide. This configuration will be in place at all five bypass units throughout the study. Gate slot plugs will be placed in the three head gate slots corresponding to each of the five bypass units. The spill level will be approximately 2200 cfs per bypass unit.

Complete bypass units are located at Spill Bays 2, 4, 6, 8, and 10. Each bypass unit includes a bypass spill bay, the turbine beneath it, and an adjacent turbine beneath an unmodified spill bay. For example, Bypass Spill Bay 2 is associated with Turbines 1 and 2.

Daily bypass operations will depend on the flow forecast for Chief Joseph Dam. If flows are expected above 140 kcfs, all five bypass units will be opened. If flows are below this level then only bypass bays above operating turbines of a turbine pair will be opened. Thus, in general, bypass operations will be similar to those in 1988, 1989, and 1990.

3.0 BYPASS EVALUATION METHODS

3.1 Species Composition

DCPUD will place an array of fyke nets in a turbine intake to sample for species composition. Net sampling will occur weekly throughout the study period. DCPUD will employ the same fyke net methods that were used in previous studies. BioSonics will analyze and present the fyke net data in their report on the smolt bypass evaluation.

3.2 Transducer Locations and Orientations

The 1991 bypass evaluation will be based on hydroacoustic data collected from the entire dam, both turbine intakes and bypass bays. Transducers will be placed inside five of five bypass slots (bypass spill bays will not be sampled). The bypass slot transducers will sample smolt passage in bypass flow. Transducers will be placed in 10 of 10 turbine units. Transducers will be placed inside 2 turbine intakes of 3 intakes at each of 6 units. Transducers will be placed in all 3 turbine intakes of the 4 remaining units (Table 1). The total number of turbine intakes sampled will be greater in 1991 than in 1990 because the unit that was down in 1990 will be on-line in 1991. Transducer orientations will be the same as those used in the 1990 spring and summer studies. Turbine and bypass transducers will be used to estimate total project bypass efficiency.

Table 1: Intake slots for sampling in spring and summer 1991. Locations randomly chosen.

Unit	Intakes	Unit	Intakes
1	ABC	6	BC
2	ABC	7	AC
3	AC	8	AB
4	AB	9	AC
5	ABC	10	ABC

3.3 Hydroacoustic Systems

Three hydroacoustic systems will be needed in 1991 (Table 2). Systems 1 and 2 will be used to sample the turbine intakes. Each system will sample 12 separate turbine intakes for 10 minutes per hour at 16 pings per second. Each system will require two Thermal Chart Recorders and one Echo Signal Processor.

The third system will sample the 5 bypass openings (S2, S4, S6, S8, and S10) for 12 minutes per hour at 12 pings per second. This system will require one thermal chart recorder.

There will be a 5 day mini-study done at the beginning of the spring season to determine if the allocation of sampling effort in-turbine is satisfactory. That is, we will examine the data for turbine units with extremely variable passage rates between intakes and if such exist we may redeploy transducers from other turbine units. A meeting between Dr. Skalski, DCPUD, and BioSonics will be held soon after the first five days of the study to decide if redeployment is necessary.

For all systems, each bypass bay transducer will be sampled for four 3-minute intervals for a total of 12 minutes per hour. Each turbine intake transducer will be sampled for four 2.5-minute intervals for a total of 10 minutes per hour. Each transducer will be sampled randomly without replacement in a given hour.

Table 2: Hydroacoustic systems for the bypass evaluation at Wells Dam in 1991.

System	Location	Sounder/MUX	Xducers	ESP	Chart Rec
1	Turbine	1	12	1	2
2	Turbine	1	12	1	2
3	Bypass	1	5	1	1

3.4 Sampling Schedule

The 1991 spring bypass evaluation at Wells Dam will begin shortly after the spring chinook are released from the Winthrop hatchery, April 11, 1991. The spring study will last for a minimum of 30 days with the option to sample up to 35 or 40 days. The Wells Bypass Team (Rick Klinge DCPUD, Cindy Wilson WDF, and Jerry Marco Colville Tribe) will decide when to end the 1991 spring study.

The 1991 summer study will begin when subyearling chinook occur in reasonable numbers in the weekly fyke net catches. The summer study will last for 15 days.

During both the spring and summer studies, hydroacoustic sampling for all three systems will occur 24 hours per day for 7 days per week. If a turbine unit is off-line for an extended period of time for maintenance, transducers there will not be sampled; thus, sample time at other locations will increase proportionately.

3.5 Data Analysis Methods

The mean number of smolts passing each sampling location each hour will be estimated using the same methods as were used in the 1990 spring and summer studies. The primary data will be obtained from chart recordings.

The ratio of the mean number of smolts passing in bypass flow to the mean for bypass plus turbine flow for the dam as a whole will be used to meet the objective of determining the effectiveness of the total smolt bypass system at Wells. We will use the same basic data analysis methods as we used in previous studies. The statistical determination of sample effort and prediction of total project bypass efficiency was made in 1990 (Skalski, J.R. and D.A. Ouellette. 1990. Statistical Methods For Estimating Total Project Bypass Efficiency At Wells Dam In 1990 Using Stratified Random Sampling. Report to Douglas County Public Utility Department. 24 pages). These results are still applicable but, in addition, Dr. Skalski is performing a similar analysis from 1990 data for the 1991 study. That analysis is forthcoming.

4.0 RUN TIMING MONITORING AT WELLS DAM

Run timing data from Wells Dam is usually helpful in deciding when to close the bypass at the end of the spring outmigration and when to open the bypass for the summer outmigration. This decision will be made by thge Wells Bypass Team. The historical data set for run timing at Wells Dam extends annually from 1981 to present.

We propose to monitor run timing in the forebay during periods when we are not evaluating the bypass between March 29 and August 31, 1991. As in previous years, monitoring will take place in the forebay using pier nose transudcers located 130 ft deep and aimed up about 27 degrees off the face of the dam. Sampling will take place 8 hours per day (1300-1700 and 2200-0200 h). Data from these transducers will produce a "sub-index" of run timing (mean number fish per 8 hr per location). The sub-index data will be reported the following day it was collected.

5.0 RUN TIMING MONITORING AT ZOSEL DAM

Run timing data from Zosel Dam should be especially important for deciding when to end the 1991 spring evaluation. The 30-day spring study at Wells Dam is scheduled to begin April 11 but, because the wild sockeye outmigration from Lake Osoyoos may not be completed by May 4, the bypass at Wells Dam will probably operate into mid May until the sockeye outmigration is complete. In 1990, run timing at Zosel Dam peaked in late April and in mid-May. It had fallen off precipitously by May 22. At Wells Dam the 1990 fyke data show that: sockeye dominated the catch on May 16; sockeye were present in noticable numbers on May 24 (10 fish per hour; 42% of total catch); and sockeye were present in low numbers on May 31, 1990.

A transducer will be placed in Spill Bay 1 and aimed upward, just as in previous years. Data will be collected 24 hours from about April 10 until May 31. Data will be automatically processed by the Echo Signal Processor. A relative index of passage at Zosel Dam will be reported by BioSonics to DCPUD according to the following schedule: April 19, April 26, May 3, May 10, May 13, and daily thereafter until the sockeye outmigration ends, but no later than May 31. A summary report of the study at Zosel Dam will be provided by November 30, 1991.

6.0 PROJECT TASKS

Task 1: Preparation

Activity 1.1 Perform sampling design analyses
1.2 Calibrate hydroacoustic gear.
1.3 Train technicians.
1.4 Deploy transducers and cables.
1.5 Design multiplexer sequences.
1.6 Lease trailers, vehicles, and housing.
1.7 Test equipment in field.
1.8 Review data acquisition and database management software and test hardware.

Task 2: Data Collection

Activity 2.1 Monitor hydroacoustic systems.
2.2 Review echograms and mark fish.
2.3 Enter dam operations data.
2.4 Perform quality-control checks.

Task 3: Data Analysis and Reporting

Activity 3.1 Edit data.
3.2 Select applicable data.
3.3 Estimate mean passage rates and ratios.
3.4 Prepare draft report by October 31, 1991.

7.0 Cost Proposal

BioSonics Quote No. 1200, March 15, 1991, Douglas County PUD.

Budget Summary

1991 Bypass Evaluation (Spring and Summer 1991)

Labor and Overhead	$202,189
Travel	45,725
Supplies	15,700
Non-BioSonics Lease	3,500
BioSonics Lease	37,324
Calibration	2,000
Fee	40,067
Total	$346,505

Extension of 1991 Spring Study (per 5-day period)

Labor and Overhead	$7,459
Travel	0
Supplies	1,500
Non-BioSonics Lease	0
BioSonics Lease	0
Calibration	0
Fee	1,344
Total	$10,303

Run Timing Monitoring at Wells Dam in Spring and Summer 1991

Included with bypass evaluation.	
Total	$0

Run Timing Monitoring at Zosel Dam in Spring 1991

Labor and Overhead	$12,473
Travel	280
Supplies	150
Non-BioSonics Lease	0
BioSonics Lease	7,560
Calibration	200
Fee	1,935
Total	$22,598

1991 BYPASS OPERATING PLAN

APPENDIX - D

1991 Bypass Plan
for the Wells Dam

December 1990

The Settlement Agreement entered into on October 1, 1990 between Douglas County P.U.D. and the Joint Fisheries Parties members requires that an Annual Bypass Plan be presented to the Wells Coordination Committee by December before each Bypass season (Section II.F.1). This plan outlines the operation of the bypass system for the coming juvenile salmonid migration season.

The 1991 bypass plan for the Wells Project is as follows.

1. The bypass will be in place two weeks prior to the preseason forecasted beginning of the juvenile migration and will be removed two weeks after the end of the juvenile migration period.

2. The PUD will operate 5 bypass baffles at the Wells Project to meet criteria set out in subsections II.C,D, and E. of the Settlement Agreement.

3. No turbine will operate during the migration period unless an adjacent bypass system is operating.

4. The 5 bypass systems bays will be numbers 2, 4, 6, 8, and 10. Operations of the turbines will be in pairs with associated bypass bays, as follows.

Turbines Operated	Bypass Bay 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

5. At least one bypass will be operate continuously throughout the juvenile migration period up to August 1.

6. The bypass and spillgates will be operated in configuration K of the 1987 bypass system report (bottom spill, 1 foot spill gate opening, 2.2kcfs, vertical baffle opening.

7. When Chief Joseph Dam Uncoordinated Discharge Estimate is equal to or greater than 140kcfs for the following day, all 5 bypass bays will operate continuously for 24 hours.

8. When Chief Joseph Uncoordinated Discharge Estimate is less than 140kcfs, bypass system operation will be as follows.

Number of Turbines	Minimum Number Bypass Bays Operating
0 - 2	1
3 or 4	2
5 or 6	3
7 or 8	4
9 or 10	5

9. Monitoring the fish run will begin when bypass baffles are in place and will end when baffles are removed.

10. Bypass will be available to operate continuously 24 hours per day during the juvenile migration period.

11. Bypass operation as described are intended to provide fish passage efficiency (FPE) of at least 80% for the juvenile spring migration and FPE of at least 70% for the juvenile summer migration.

12. Members of the Bypass Team (Settlement Agreement Section II.F.2), will be designated by March 1, before the Bypass Season.

Supplement to the
1991 Bypass Plan
for the Wells Dam

In addition to the 1991 Wells Bypass Plan, the following supplemental plan will be in effect as agreed to by the Bypass Team members.

1. The anticipated bypass operation season will be from April 15 to August 15.

2. Operation of the bypass from August 1 to August 15 will be adjusted from a 24 hour schedule to operating between 2200 to 0600.

1991 Annual Passage Monitoring Plan for the Wells Dam

The Settlement Agreement entered into on October 1, 1990 between Douglas County P.U.D. and the Joint Fisheries Party members requires that an Annual Passage Monitoring Plan to be presented before the Bypass season to the Coordinating members (II.G.1). This plan is to outline the anticipated abundance of juvenile salmonids for the upcoming bypass season and how monitoring of bypass efficiency will be achieved.

1. Hydroacustic sampling of the forebay, bypass intake slots, and turbine intake galleries will monitor movement of fish during the smolt migratory season.

2. Monitoring of run timing will be done by 15° transducers placed in the forebay in front of Turbine Units 2, 4, 6 and 8 at a depth of 130 feet. The transducers will be aimed at 28° off the face of the dam.

3. Sampling of run timing will be preempted during the spring bypass operation. Monitoring of run timing will begin at the end of the spring studies and continue until the start of summer bypass operation.

4. Bypass evaluation will be sampled by 6° transducers placed in intake slots 1C, 3C, 5C, 7C, and 9C. These locations are at the center of the five bypass spillways.

5. Fish that pass through turbines will be monitored by 15° transducers placed in twenty turbine intakes galleries. For each of the ten units, two transducers will randomly be placed among the three intake galleries.

6. A series of fyke nets will be deployed in one turbine intake to collect fish for the purpose of determining species composition. Sampling will be one night a week between April and June. In July and August, alternating sampling of day and night will be conducted each week.

7. Weekly reports of activities surrounding Bypass operation will be made available to members of the Bypass Team.

Supplement to the
1991 Annual Passage Monitoring Plan
for the Wells Dam

In addition to the 1991 Annual Passage Monitoring Plan, the following Supplemental Monitoring Plan will be in effect as agreed to by the Bypass team members.

1. Monitoring of the run timing for the spring migration will start on April 1.

2. Douglas P.U.D. will contact the National Hatchery at Winthrop on timing of releases of spring chinook smolts from the National Hatchery at Winthrop. A rise in the numbers of fish in the run timing index will trigger the start of the spring bypass season. When numbers of spring migrants reach _____, the spring bypass season will be finished.

3. The start of the summer migrant season will be monitored as numbers of fish from the timing studies and the fyke net monitoring show an increase in target fish. Expected date for the start of the summer migration monitoring period will be July 10.

4. The anticipated bypass operation season will be from April 15 to May 20 for spring migrants and from July 10 to August 25 for summer migrants.

A COMPARISON OF SMOLT SURVIVAL BETWEEN BYPASS OPERATION IN ASSOCIATION WITH TOP SPILL AND BOTTOM SPILL AT THE WELLS HYDROELECTRIC PROJECT

STUDY PROPOSAL

RICK KLINGE, FISHERIES BIOLOGIST
P. U. D. NO. 1 OF DOUGLAS COUNTY

APRIL, 1991

APPENDIX - E

A Comparison of Smolt Survival between Bypass Operation in Association with Top Spill and Bottom Spill at the Wells Hydroelectric Project

Study Proposal

Rick Klinge, Fisheries Biologist
P.U.D. No.1 of Douglas County

April 1991

Through the mid-Columbia proceedings in the early 1980's, fisheries agencies and tribes requested of the Federal Energy Regulatory Commission that the operators of the mid-Columbia hydroelectric projects mitigate for ongoing loss of juvenile migrating salmonids. As part of this mitigation Douglas County Public Utility District (DCPUD) developed a bypass system to keep migrating salmonids away from the turbines at the Wells Dam. Preliminary evaluation of the bypass has shown that the system successfully passes a high percent of the migrants that reach the project. The Long Term Settlement Agreement of the Wells Project with the fisheries agencies and tribes requires that DCPUD evaluate the bypass system determining fish passage efficiency (FPE). The bypass at Wells is currently in the second year of a three year evaluation.

The juvenile bypass is made up of a series of barriers and slotted barriers placed across the intake bays of the spill gates. Operators at the project spill water creating velocities through the slotted barriers attracting migrating fish and allowing them to pass through the project without

encountering the turbines. The eleven spill gates at Wells are vertical split-leaf design which operate by raising the lower leaf to discharge water. Spill gates 2 and 10 have been designed to also allow spill from the surface to the reservoir up to a maximum capacity of approximately 2.2 kcfs each.

The Wells Settlement Agreement in Section II.C.5 stipulates that DCPUD will compare the effectiveness of top spill verses bottom spill. One aspect of effectiveness is survival of the smolts passing through the Wells Bypass System via each route. DCPUD asked BioMark to develop a proposal for PIT tagging steelhead from the Wells Hatchery. DCPUD will release these steelhead through top spill of spillway number 2 and bottom spill of spillway number 4 based on a study design prepared by John Skalski. The precision of the study was designed to detect a 10% difference between the two groups of fish[1].

Section IV.C.5 of the Settlement Agreement specifies that DCPUD is to conduct a study in 1991 on project survival. We cannot conduct a project survival study this year. However, we believe that our study will provide valuable information which will help to design a survival study in the future for the Wells Dam.

Methods

BioMark will mark two groups of steelhead smolts with PIT tags and hold them for 24 hours at the Wells Game Hatchery. The fish will be released from the deck of the dam through plastic flexible pipe into the spill bay where

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[1] See Skalski, John 1991. Sample Size Calculations for a Pit -Tag Study at Wells Dam in 1991. MS, March 4; Seattle, WA AND Skalski, John 1991. Supplementary Sample Size Calculations for 1991 Pit-Tag Study. MS, March 11; Seattle, WA.

water velocities will insure their passage through appropriate spill. Top spill will be through spillgate 2 and bottom spill through spillgate 4. A release size of 2,200 steelhead per group will give a desired precision to ascertain a 10% difference in survival between the two groups of fish. Both groups of marked steelhead will be released as close in time to each other as possible. Detection of survival will be made through PIT tag detectors at the McNary Dam. BioMark has been contracted by DCPUD to mark the fish and coordinate tag recovery data from the Pacific States Marine Fisheries Commission.

Sample Size Calculations
for a PIT-Tag Study at Wells Dam in 1991

To

Douglas County PUD

From

John R. Skalski
Center for Quantitative Science, HR-20
University of Washington
Seattle, WA 98195

March 4, 1991

Introduction

A paired release of PIT-tagged fish is proposed at Wells Dam to evaluate the relative survival rates of steelhead through two alternate routes in the dam. A 10% difference in survival between groups is considered important to detect and is the basis for subsequent sample size calculations. The steelhead will be released simultaneously at Wells Dam with the smolt detected at the decoder facilities at McNary Dam. This paired release-recapture study is the simplest of sampling protocol discussed in Burnham et al. (1987) and is similar to the survival studies conducted at Bonneville Power House #2 in recent years.

An important assumption of the study (a complete list of assumptions can be found in Burnham et al. 1987, pp. 51-52) is complete mixing of the fish of the two release groups below Wells Dam. A test of mixing will be performed by comparing the pattern of daily recoveries of the smolt at McNary Dam. The test of complete mixing will be performed using a test of homogeneity for an K x 2 contingency table. Validity of the survival estimate is predicated upon this assumption of complete mixing being true and the confirmation by the test of homogeneity.

Methods

The survival rate (S_T) associated with the passage of the treatment group through Wells Dam is estimated by the expression (Appendix A):

$$\hat{S}_T = \frac{\left(\frac{y_.}{R_T}\right)}{\left(\frac{x_.}{R_C}\right)}$$

where

R_C = number of control fish released,

R_T = number of treatment fish released,

$y.$ = total number of treatment fish recovered at McNary Dam,

$x.$ = total number of control fish recovered at McNary Dam.

The estimate of treatment survival $(\hat{S}_T)$ or the treatment mortality rate $(1-\hat{S}_T)$ has an associated sampling variance of:

$$Var(\hat{S}_T \mid S_T) = \frac{S_T(1-S_T P.)}{R_T P.} + \frac{S_T^2(1-P.)}{R_C P.}$$

where $P.$ = probability control fish survive and are detected at McNary Dam.

Sample size calculations are therefore based on "guesstimates" of the anticipated values of S_T and $P.$ encountered during the PIT-tag study.

The required number of the PIT-tagged fish to be released at Wells Dam also is dependent upon the desired precision of the study. For purposes of this study, precision will be defined by the expression:

$$P(|\hat{S}_T - S_T| < \epsilon) = 1-\alpha \quad .$$

In other words, we want the different between the estimate and the true value $(\hat{S}_T - S_T)$ to be less than or equal to $\pm\epsilon$, $(1-\alpha)$ 100% of the time. For example, if one wanted a precision of ±5%, 90% of the time, precision would be expressed as:

$$P(|\hat{S}_T - S_T| < 0.05) = 0.90 \quad .$$

In subsequent sample size calculations, we assumed sample sizes are equal for both control and treatment groups (i.e., $R_C = R_T = R$).

In a 1987 PIT-tag study, Scott McCutcheon estimated the average recovery rate of PIT-tagged fish at McNary Dam from release at Priest Rapids Dam to be 0.406 (values 0.358, 0.416, and 0.445) for steelhead under no flow spill conditions at the recovery site. Recovery rates will decrease under spill conditions at McNary Dam. Assuming a survival rate of steelhead smolt between Wells and Priest Rapids of ~0.6, the anticipated rate of recovery of PIT-tagged fish from Wells to McNary Dam is about $P_{\cdot} = 0.24$. Subsequent sample size calculations used a range of $P_{\cdot} = 0.2$ to 0.3.

Results

Two approaches to sample size calculations were used in evaluating the study design. The first approach was to determine the anticipated precision that might be expected with a total release size of 3000 PIT-tagged fish (i.e., $R_C = R_T = 1500$) (Table 1). With 1500 fish per group, the differential survival (i.e., S_T projected to be 0.90) can be estimated with a precision of ±0.086, 90% of the time if recovery rates at McNary are 30%. Should recovery rates drop to 20%, the precision drops to ±0.112, 90% of the time. Hence, it appears 3000 fish is about at the minimum release size; for ideally, you would want $\epsilon < 0.10$ $(= 1 - S_T)$ mortality rate considered important to detect.

As an alternative approach, the release size (R) required to have a precision of $\pm\epsilon$, $(1-\alpha)$ 100% of the time was also calculated (Table 2). For instance, to have a precision of ± 0.05, 90% of the time, $R = 7502$ or a total release of 15,000 PIT-tagged fish is necessary. Inspection of Table 2 indicates very large sample sizes are needed for high levels of precision.

From the sample size calculations (Table 2), I would recommend that during this preliminary study, a minimum release of 3712 fish be used (i.e., $R_C = R_T = 1876$). At this release size, under unfavorable conditions (i.e., $P. = 0.2$), the study has a precision of $\epsilon = 0.10$, 90% of the time. In this situation, ϵ equals the mortality rate of 0.10 considered important to detect. In other words, at $(1-S_T) = 0.10$, we can expect a 90% confidence interval to be $CI(0 < 1-S_T < 0.20) = 0.90$. Hence, 90% of the time with $R_C + R_T = 3712$, we will be able to detect the presence of mortality $(1-S_T) \geq 0.10$ if it exists.

Should the 1991 study confirm a potential problem, subsequent studies in 1992 and beyond would use greater sample sizes to more precisely estimate $1-S_T$. As a final warning, if there is appreciable spill at McNary Dam, the above sample sizes would be underestimates.

Table 1. Anticipated precision of the dual release-recapture study at Wells Dam when sample sizes are $R_C = R_T =$ 1500 fish when $S_T = 0.90$ and $P. = 0.2, 0.3$ at $1 - \alpha = 0.90, 0.95$.

$R_T = R_C$	$P.$	$1 - \alpha$	ϵ
1500	0.2	0.90	0.112
1500	0.3	0.90	0.086
1500	0.2	0.95	0.133
1500	0.3	0.95	0.102

Table 2. Predicted sample sizes $(R_C = R_T)$ required to have a precision of $\epsilon = 0.02, 0.05, 0.10$ at $1 - \alpha = 0.90, 0.95$, when $S_T = 0.90$ and $P. = 0.2, 0.3$.

ϵ	$1 - \alpha$	$P.$	$R_C = R_T$	$R_C + R_T$
0.02	0.90	0.20	46882	93764
0.05	0.90	0.20	7502	15004
0.10	0.90	0.20	1876	3712
0.02	0.90	0.30	27602	55204
0.05	0.90	0.30	4417	8834
0.10	0.90	0.30	1105	2210
0.02	0.95	0.20	66556	133112
0.05	0.95	0.20	10649	21298
0.10	0.95	0.20	2663	5326
0.02	0.95	0.30	39185	78370
0.05	0.95	0.30	6270	12540
0.10	0.95	0.30	1568	3136

Literature Cited

Burnham, K. P., D. R. Anderson, G. C. White, C. Brownie, and K. H. Pollock. 1987. Design and analysis method for fish survival experiments based on release-recapture. *Amer. Fish. Soc. Monograph* 5. 437 pp.

Appendix A

Statistical basis for the survival estimate $\hat{S}_T$, or analogously $1 - \hat{S}_T$ (differential mortality between release groups) is maximum likelihood estimation. The major assumptions of the estimation scheme are:

1. The probability of mortality through the treatment channel $(1 - S_T)$ is independent of subsequent downstream mortality.
2. Survival of control and treatment groups from below Wells Dam to the recovery site at McNary Dam on day $i(S_i, i = 1, \ldots, K)$ is the same.
3. Daily probabilities of recovery $p_i(i = 1, \ldots, K)$ are the same for control and treatment groups.
4. Fates of the PIT-tagged fish are independent of one another.

Using these assumptions, a likelihood model can be constructed where:

$$L\left(\underset{\sim}{x}_i, \underset{\sim}{y}_i \mid R_C, R_T, S_T, \underset{\sim}{S}_i, \underset{\sim}{p}_i\right) =$$

$$\binom{R_C}{\underset{\sim}{x}_i, R_C - x.}(p_1 S_1)^{x_1}(p_2 S_2)^{x_2}\ldots(p_K S_K)^{x_K}\left(1 - \sum_{i=1}^{K} p_i S_i\right)^{R_C - x.}$$

$$\cdot\binom{R_T}{\underset{\sim}{y}_i, R_T - y.}(S_T p_1 S_1)^{y_1}(S_T p_2 S_2)^{y_2}\ldots(S_T p_K S_K)^{y_K}$$

$$\cdot\left(1 - \sum_{i=1}^{K} p_i S_i S_T\right)^{R_T - y.}$$

and where

R_C = number of control fish released,

R_T = number of treatment fish released,

x_i = number of control fish recovered in day $i (i = 1, \ldots, K)$,

y_i = number of treatment fish recovered on day $i (i = 1, \ldots, K)$,

$x.$ = total number of control fish recovered,

$y.$ = total number of treatment fish recovered.

Note p_i and S_i are not separately estimable; hence, denote $P_i = p_i S_i$. The likelihood function can then be written as:

$$L\left(\underset{\sim}{x_i}, \underset{1}{y_i} \mid R_C, R_T, \underset{\sim}{P_i}, S_T\right) = \binom{R_C}{\underset{\sim}{x_i}, R_C - x.} \prod_{i=1}^{K} P_i^{x_i} \left(1 - \sum_{i=1}^{K} P_i\right)^{R_C - x.}$$

$$\cdot \binom{R_T}{\underset{\sim}{y_i}, R_T - y.} S_T^{y.} \prod_{i=1}^{K} P_i^{y_i} \left(1 - S_T \sum_{i=1}^{K} P_i\right)^{R_T - y.} .$$

The maximum likelihood estimates of S_T from the above likelihood is:

$$\hat{S}_T = \left(\frac{y.}{R_T}\right) / \left(\frac{x.}{R_C}\right)$$

with the associated variance

$$Var(\hat{S}_T) = \frac{S_T\left(1 - S_T \sum_{i=1}^{K} P_i\right)}{R_T \sum_{i=1}^{K} P_i} + \frac{S_T^2\left(1 - \sum_{i=1}^{K} P_i\right)}{R_C \sum_{i=1}^{K} P_i}$$

$$= \frac{S_T(1 - S_T P.)}{R_T P.} + \frac{S_T^2(1 - P.)}{R_C P.}$$

and variance estimator

$$\hat{Var}(\hat{S}_T) = \hat{S}_T^2 \left[\frac{1}{y.} - \frac{1}{R_T} + \frac{1}{x.} - \frac{1}{R_C}\right] .$$

The assumption of equal downriver survival and recapture probabilities for control and treatment releases is predicated upon the assumption of complete mixing of the release groups. The condition of complete mixing can be tested using an K x 2 contingency table and a chi-square test of homogeneity. The contingency table is constructed as follows:

Day	Control	Treatment	
1	x_1	y_1	$x_1 + y_1$
2	x_2	y_2	$x_2 + y_2$
3	x_3	y_3	$x_3 + y_3$
.	.	.	.
.	.	.	.
.	.	.	.
K	x_K	y_K	$x_K + y_K$
	$x.$	$y.$	$x. + y.$

The chi-square test of homogeneity has K-1 degrees of freedom.

Supplementary Sample Size Calculations

for 1991 PIT-tag Study

To

Douglas County PUD

From

John R. Skalski
Center for Quantitative Science, HR-20
University of Washington
Seattle, WA 98195

March 11, 1991

The proposed PIT-tag study will use a total release of $R_C + R_T = 4400$ fish or each group will have a sample size of $R = R_C = R_T = 2200$. The anticipated precision of the survival study using $R = 2200$ is summarized in Table 1 below.

Table 1. Projected precision (ϵ) for the PIT-tag study when $1 - S_T = 0.10$, $P_. = 0.20, 0.30$, and $1 - \alpha = 0.90, 0.95$.

Release Size (R)	$(1-\alpha)$	$P_.$	ϵ
2200	0.90	0.20	0.0720
	0.90	0.30	0.0552
	0.95	0.20	0.0786
	0.95	0.30	0.0603

SPRING CHINOOK SPAWNING GROUND SURVEYS OF THE METHOW RIVER BASIN 1990

BY
SCOTT A. EDSON
YAKIMA INDIAN NATION
FISHERIES RESOURCE MANAGEMENT
NOVEMBER, 1990

APPENDIX - F

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1.0 ACKNOWLEDGEMENTS

A special thanks to Virgil Lewis Sr., Sandy A. Pinkham and Seymour L. Billy of the Yakima Indian Nation. Their many long hours in the field and conscientious work made this study successful. Tom Scribner gave advice and support throughout the project and for proofreading this report. Michael S. Kohn provided helpful suggestions, and assisted with computer graphics and relevant information. Thanks too, to Bill Walline, Scott Hamelberg and the crew of the Winthrop National Fish Hatchery for their advice, ideas and comparative data. Louiza Umtuch and Carol S. Heemsah typed this manuscript, and to Tammy Swan performed scale analysis.

Several other individuals not mentioned gave information and assistance regarding these surveys.

Funding for this project was provided through the Wells Dam Agreement by the Douglas County Public Utility District.

2.0 ABSTRACT

The purpose of this study was to collect comprehensive spawning ground data on spring chinook (Oncorhynchus tshawytscha) throughout the Methow River Basin. The baseline data developed from this study will be used to assist outplanting from the proposed Methow Valley Spring Chinook Hatchery and associated satellite facilities.

The surveys covered approximately 133 river miles and located 502 redds. The Methow River itself had 194 redds (39%), and the Chewuck, Twisp and Lost Rivers had 158, 113 and 33 redds (31%, 23% and 7%), respectively. The four remaining redds were found in Gold Creek and Early Winters Creek.

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 hatchery and acclimation facilities. Similar to the Eastbank Production Program (Rock Island Settlement Agreement), this compensation will be based on supplementing natural stocks of spring chinook, steelhead and sockeye in the mid-Columbia River tributaries.

The Douglas County P.U.D. contract provided for the gathering of comprehensive spawning ground data on spring chinook in all spawning habitat within the Methow River Basin. This study will allow fisheries agencies, tribes, and Douglas County P.U.D. to assess the status of spring chinook populations within the basin. The information will also aid in developing an outplanting strategy for the proposed 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.

Before 1987, spring chinook spawning ground surveys were conducted annually by the Washington Department of Fisheries (W.D.F.) and consisted of a single mid-September count of established index reaches (Fig. 1). Those surveys provided information on spawning trends but did not allow for shifts in spawning location or timing. While recording redd counts in the W.D.F. index reaches, we expanded our surveys upstream and downstream from these areas, making redd counts in 42 separate reaches which were judged to be accessible and contain useable spawning habitat. We also surveyed most of the reaches more than once in order to determine spawning timing. The Confederated Tribes of the Colville Reservation were contracted by the Chelan County P.U.D. to perform the 1990 summer chinook spawning ground surveys in the Okanogan Basin (which is comprised of the Okanogan and Similkameen Rivers) and the Methow Basin. Chelan County P.U.D. conducted the spring and summer chinook surveys in the Wenatchee Basin.

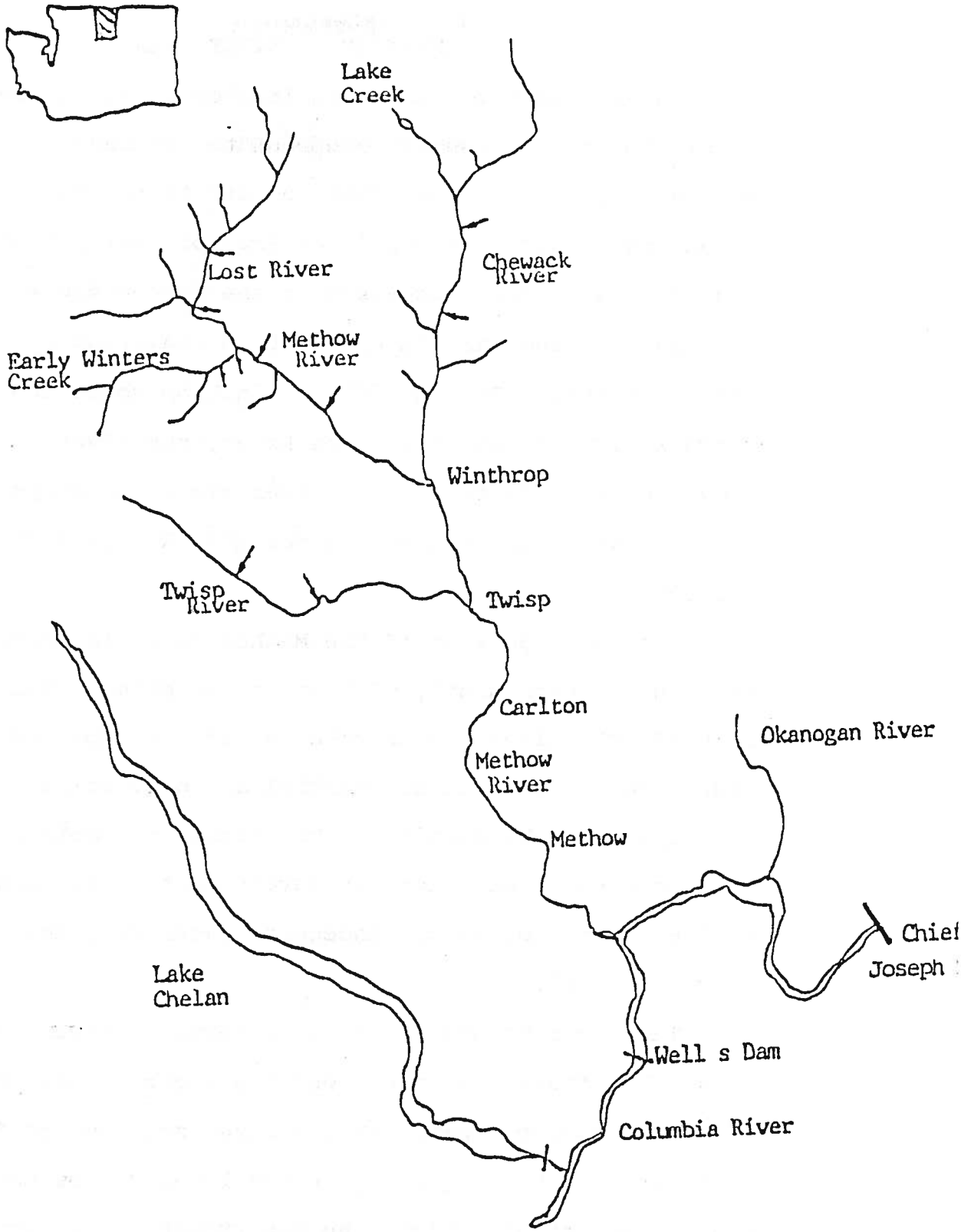

Figure 1. Methow River Basin. Arrows indicate spring chinook index areas.

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.1). 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 Chewuck 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.

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 river and some of its tributaries. Water quality in the lower Methow Basin nonetheless remains high; the Department of Ecology gives the lower Methow River an AA rating.

Spawning runs to the Methow River have been impacted by fishing and by 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 once again during the Grand Coulee Fish Maintenance Project (1939-43) when all adult salmon were captured downstream from the Methow River at Rock Island Dam.

Chinook production at Winthrop Hatchery began in 1943. Most of the releases between 1943 and 1962 were spring chinook. No chinook were released from 1963 through 1975. Since 1976, spring chinook originating from the Methow River, Icicle Creek and the Little White Salmon, Wind and Cowlitz Rivers, and summer chinook from the Methow River and Wells Dam have been released in the Methow River. The current Winthrop Hatchery program calls for annual production of 1,000,000 spring chinook smolts and no summer chinook.

5.0 METHODS

Forty of the 42 survey reaches were surveyed on foot; a raft was used on the Methow River downstream from the Winthrop Bridge. Spring chinook redds were flagged on the bank and numbered, and their distance from the bank was also recorded on the flag to avoid recounting or missing any redds on subsequent surveys. Near campgrounds, flags from earlier surveys were occasionally missing. When this occurred, we counted all redds in the reach with missing flags and subtracted previous counts to determine the number of new redds. The number of redds, live fish, and carcasses in each reach were recorded. The frequency of redd counts in a given reach depended on spawning activity. In general, the expanded areas were surveyed less frequently than the index reaches.

The sex and mideye-hypural length of each recovered carcass was recorded, and egg retention in female fish was also checked. Scale samples were taken and carcasses were checked for jaw tags and adipose clips. Caudal fins were removed from carcasses before they were returned to the water so they would not be counted on subsequent trips.

6.0 RESULTS

6.1 Spawning Ground Surveys

Spring chinook spawning ground surveys in the Methow River Basin were conducted from July 30 to September 28th, 1990. Our goals were to determine locations, timing and magnitude of spring chinook spawning throughout all the utilized habitat within the Methow Basin. Summer chinook surveys in 1990 were the combined responsibilities of the Confederated Tribes of the Colville Reservation (Methow and Okanogan Basins) and Chelan County Public Utility District (Wenatchee Basin). Chelan County P.U.D. also did the spring chinook surveys in the Wenatchee Basin.

Spring chinook began spawning in the upper Chewuck River in the last week of July. In the upper Methow, Twisp and Lost Rivers, spawning was first noted by mid-August. Spawning activity peaked near the end of August in most reaches, and was completed by late September.

The surveys covered approximately 133 river miles and located 502 redds. The 1990 redd counts were the lowest since extensive surveys began in 1987. Among the major tributaries listed in Table 1, the highest count was 194 redds in the Methow River itself. Eighty (41%) of these redds were found in the six-mile index reach between Mazama Bridge and Weeman Bridge. Of the

Table 1. Spring chinook redd count summary for the Methow River Basin in 1990. Redd counts are broken down into three sections: above, below, and within the index areas.

River	Index	Above Redds (%)	Index Redds (%)	Below Redds (%)	Total Redds (%)
Lost River	Eureka Cr. - Mouth	0 (0.0)	33 (100.0)	N/A	33 (6.6)
Early Winters Creek	Upper Fish Screen-Mouth	0 (0.0)	1 (100.0)	N/A	1 (0.2)
Methow River	Mazama Br.-Weeman Br.	26 (13.4)	80 (41.2)	88 (45.4)	194 (38.7)
Chewuck River	Camp 4 C.G. - Falls Cr.C.G.	34 (21.5)	61 (38.6)	63 (39.9)	158 (31.5)
Twisp River	Mystery Br.-Buttermilk Br.	13 (11.5)	77 (68.1)	23 (20.4)	113 (22.5)
Gold Creek		N/A	N/A	N/A	3 (0.6)
Basin Total					502

remaining 114 redds, 26 (13%) were above the index reach and 88 (45%) were below it. The Chewuck River had 158 redds; 61 (38%) were in the index reach, 34 (22%) were above the index and 63 (40%) below the index. The Twisp River had 113 redds, with 13 (12%) above the index, 77 (68%) within the index and 23 (20%) below. All 33 redds deposited in the Lost River were located in the 4-mile index reach between Eureka Creek and the mouth.

The Chewuck, Twisp and Lost Rivers had 158, 113 and 33 redds respectively. Three redds were found in Gold Creek, while Early Winters Creek had only one redd. No redds were observed in Lake, Wolf or Cedar Creeks. Libby Creek, a new area of investigation, had no spawning.

Table 2 shows redd density in reaches of the Methow River and five tributaries. Table 3 compares 1990 redd counts with those from 1987, the year extensive surveys began, through 1989. Table 4 focuses on index reaches, listing index counts since 1962.

The 1990 count of spring chinook over Wells Dam (Table 5) was 927 adults, less than half the 1980-89 average of 2582 fish. After subtraction of Winthrop Hatchery returns, the 1990 natural spawning escapement of 806 was 80 percent and 61 percent smaller than escapements of the parent brood which returned in 1985 and 1986. However, because of a delayed spring chinook migration in 1990, as many as 1000 of the migrants counted as summer chinook may actually have been spring chinook (J. McGee, Douglas County P.U.D., personal comm., 1990). This hypothesis is supported by the fact that, in contrast to the dam count, the total spring chinook redd count did

Table 2. Number of spring chinook redds observed in each Methow Basin survey reach, length of each reach and numbers of redds per mile. Asterisks identify index reaches.

Reach	Redds	Miles	Redds/ Mile
Lost River			
* Eureka Cr - Lost R. Br. (3.9 - 0.5)	31	3.4	9.1
* Lost R. Br. - Conf. (0.5 - 0.0)	2	0.5	4.0
Early Winters Creek			
Klipchuck C.G. - Hwy Br. (4.0 - 2.0)	0	2.0	0.0
* Hwy Br. - Mouth (2.0 - 0.0)	1	2.0	0.5
Methow River			
Lost R. Conf. - Mazama Br. (73.0 - 65.4)	26	7.6	3.4
* Mazama Br. - Weeman Br. (65.4 - 59.7)	80	5.7	14.0
Weeman Br. - Winthrop Br. (59.7 - 49.8)	74	9.9	7.5
Winthrop Br. - Twisp Br. (49.8 - 39.4)	7	10.4	0.7
Twisp Br. - Carlton Br. (39.4 - 27.2)	7	12.2	0.6
Chewuck River			
Lake Cr. - 20 Mile Br. (23.4 - 20.4)	18	3.0	6.0
* 20 Mile Br. - Falls Cr. C.G. (20.4 - 13.6)	61	6.8	9.0
Falls Cr. C.G. - Chewuck Br. (13.6 - 7.9)	42	5.7	7.4
Chewuck Br. - Conf. (7.9 - 0.0)	21	7.9	2.7
Twisp River			
South Cr. - Mystery Br. (24.4 - 20.4)	12	4.0	3.0
* Mystery Br. - Buttermilk Br. (20.4 - 12.7)	77	7.7	10.0
Buttermilk Br. - Little Br. (12.7 - 9.0)	19	3.7	5.1
Little Br. Cr - Conf. (9.0 - 0.0)	4	9.0	0.4

Table 3. Spring chinook redd counts in five major subbasins within the Methow Basin, 1990-1987. Asterisks identify index reaches.

Reach	Number of Redds 1990	1989	1988	1987
Lost River				
* Eureka Cr - Lost R. Br. (3.9 - 0.5)	31	53	N/A	N/A
* Lost R. Br. - Conf. (0.5 - 0.0)	2	4	N/A	N/A
	33	57	53	56
Early Winters Creek				
Klipchuck C.G. - Hwy Br. (4.0 - 2.0)	0	5	17	13
* Hwy Br. - Mouth (2.0 - 0.0)	1	6	0	1
	1	11	17	14
Methow River				
Lost R. Conf. - Mazama Br. (73.0 - 65.4)	26	9	52	32
* Mazama Br. - Weeman Br. (65.4 - 590.7)	80	60	75	75
Weeman Br. - Winthrop Br. (59.7 - 49.8)	74	37		
Winthrop Br. - Twisp Br. (49.8 - 39.4)	7	2	135	147
Twisp Br. - Carlton Br. (39.4 - 27.2)	7	2	N/A	N/A
	194	110	262	254
Chewuck River				
Lake Cr. - 20 Mile Br. (23.4 - 20.4)	18	21	51	38
* 20 Mile Br. - Falls Cr CG (20.4 - 13.6)	61	44	55	77
Falls Cr. CG - Chewuck Br. (13.6 - 7.9)	42	52	96	73
Chewuck Br. - Conf. (7.9 - 0.0)	21	42	N/A	N/A
	142	159	202	188
Twisp River				
South Cr. - Mystery Br (24.4 - 20.4)	12	28	45	41
* Mystery Br - Buttermilk Br (20.4 - 12.7)	77	100	111	79
Buttermilk Br - Little Br (12.7 - 9.0)	19	41	43	41
Little Br. Cr. - Conf. (9.0 - 0.0)	4	10	N/A	N/A
	112	179	199	161
Basin Totals	482	516	733	673

Table 4. Historical Spring Chinook index redd counts for Methow Basin from 1962-1989.

Spawning Year	Lost River: Eureka Cr. To Lost R. Br.	Lost River: Lost R. Cr. To Mouth	Chewack River: Camp Four to Chewack C.G.	Chewack River: Chewack C.G. to Falls Cr. C.G.	Twisp River	Methow River	Early Winters
1962	104	N.S.	9	49	203	187	N.S.
1963	35	N.S.	N.S.	78	132	110	N.S.
1964	98	N.S.	N.S.	176	311	127	N.S.
1965	86		N.S.	34	138	111	N.S.
1966	271		N.S.	91	257	233	N.S.
1967	80	22	N.S.	N.S.	135	140	N.S.
1968	35	2	30.	N.S.	190	92	1
1969	49	11	17	32	123	57	3
1970	101	N.S.	14	32	75	150	1
1971	61	9	10	23	97	113	6
1972	58	11	97		97	65	N.S.
1973	65	5	47	42	247	95	1
1974	11	N.S.	22	30	129	49	3
1975	59	N.S.	N.S.	98	177	39	2
1976	12	N.S.	N.S.	22	53	34	N.S.
1977	14		N.S.	107	174	65	0
1978	50	N.S.	87	59	265	67	4
1979	23	3	18	13	40	12	0
1980	13	4	8	14	27	25	0
1981	20	5	1	6	24	39	2
1982	29	4	2	8	17	56	0
1983	18	4	6	29	58	63	1
1984	54	6	24	15	48	43	3
1985	5		93	34	95	23	6
1986	48	N.S.	34		38	63	3
1987	52 56	4	23 77	54	79	75	1
1988	53 53	0	40 55	15	111	75	0
1989	53	4	12	32	100	60	6

Table 5. Spring chinook counts at Wells Dam from 1967 through 1990.

Year	Counts	
	Adults	Jacks
1967	541	616
1968	4,086	845
1969	3,048	551
1970	2,092	578
1971	2,535	633
1972	3,368	248
1973	2,505	507
1974	3,199	221
1975	2,096	129
1976	1,510	1,249
1977	3,976	235
1978	3,532	83
1979	971	132
1980	941	241
1981	1,367	98
1982	2,270	131
1983	2,726	143
1984	3,066	214
1985	5,151	116
1986	2,896	65
1987	2,272	74
1988	2,844	96
1989	1,633	87
1990	927	12

not decline drastically in 1990 (Table 3).

Sockeye have been reported spawning in small numbers within the summer chinook reaches in the Methow River (see for example Kohn, 1989). In 1990, sockeye were seen in the Methow River upstream from the Winthrop Bridge, but no spawning was observed.

6.2 Carcass Recovery

Of the 62 female spring chinook carcasses examined in the Methow Basin, 59 were fully spent and three had not spawned. No jaw tags or adipose clips were seen in 1990. Figure 2 shows length-frequencies for the basin as a whole, and histograms for individual Methow tributaries are presented in Appendix Figure A.1. The lengths of 4- and 5-year-old spring chinook overlapped from 65 through 71 cm. This is a broader overlap than that found by Kohn (1989) but has an identical midpoint. Nine fish were 3 years old, and all were less than 60 cm long. One two-year-old jack was collected in 1990.

Fewer carcasses were recovered than might have been expected in the areas of heavier spawning concentration, apparently due to foraging. Several black bears were sighted in and near these areas.

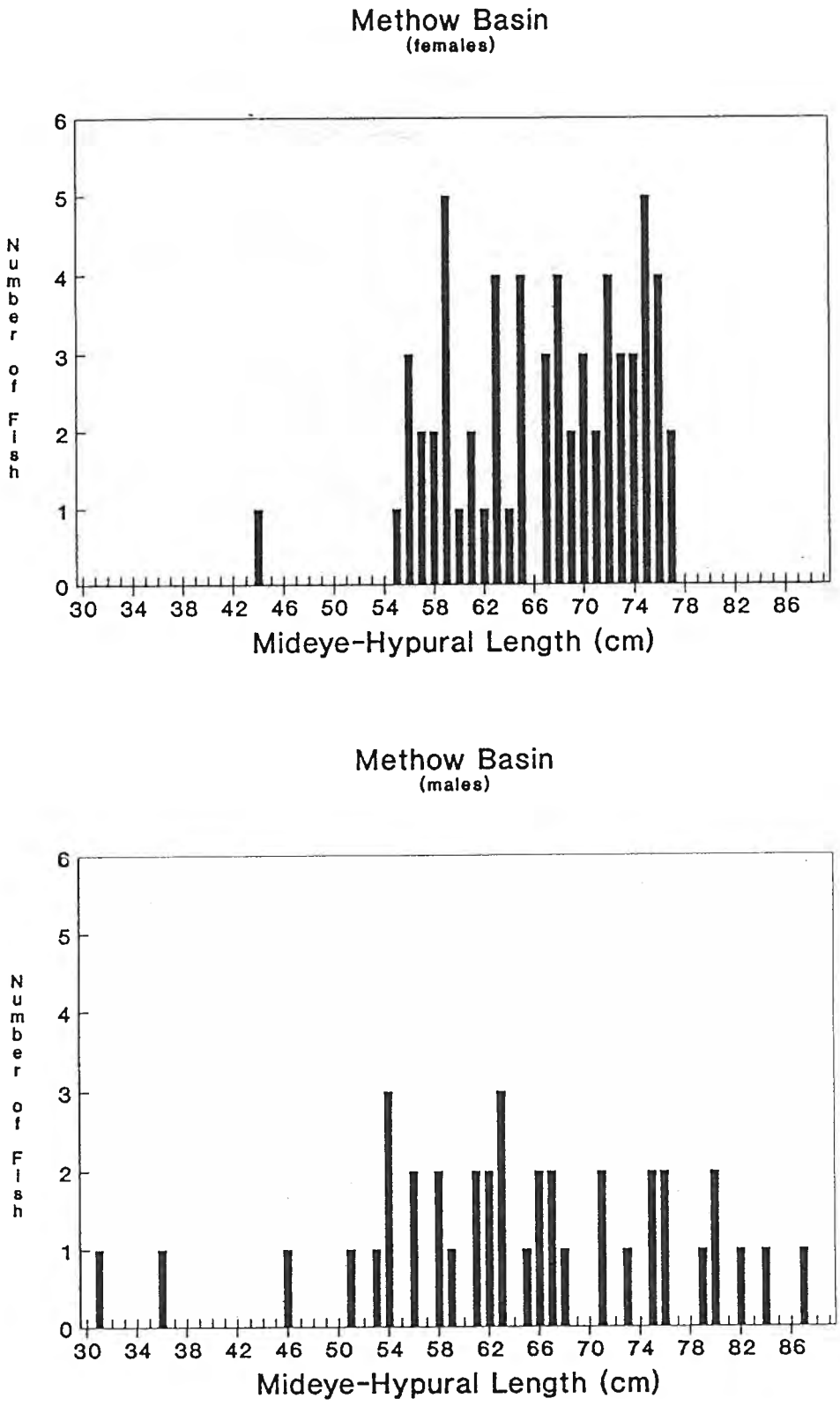

Figure 2. Length-frequencies of spring chinook in the Methow Basin. All females under 65 cm and all males under 69 cm were 3 or 4 years old; all females over 70 cm and all males over 71 cm were 5 years old.

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Table A-1. Individual spring chinook surveys in the Methow Basin, 1990.

River and Reach	Date	Redds	Live	Dead	Temp Range
<u>Lost River</u>					
Hurricane Cr. - Eureka Cr.	9/25	0	0	0	44-49
*Eureka Cr.- Lost R. Br.	8/14	9	8	1	51-58
	9/07	22	3	9	46-54
*Lost River Br. - Mouth	8/17	0	0	0	50-52
	9/13	2	0	1	52-54
<u>Early Winters Creek</u>					
Falls - Klipchuck C.G.	9/14	0	0	0	45-46
Klipchuck C.G. - Hwy. Br.	8/03 S	0	0	0	46-48
	8/14	0	0	0	50-60
*Hwy. Br. - Mouth	8/03 S	0	0	0	46-48
	8/14	0	0	0	50-60
	8/27	1	2	0	46-46
<u>Methow River</u>					
Lost River Mouth - Gate C	8/13	0	0	0	57-58
	8/27	11	7	1	55-55
Gate Cr. - Mazama Br.	8/13	1	0	0	54-60
	8/17 S	0	1	0	53-53
	8/20	1	0	0	53-59
	8/27	13	8	1	54-55
*Mazama Br. - Rd. Barrier	8/03	0	0	0	45-46
	8/09	0	0	1	54-56
	8/17 S	1	0	0	53-53
	8/28	13	17	0	50-57
	9/04	10	6	1	51-54
*Rd. Barrier - Weeman Br.	8/03	0	0	0	45-46
	8/09	0	2	0	48-61
	8/17 S	1	0	0	48-48
	8/28	41	22	0	46-57
	9/04	14	10	3	47-57

Table A-1 (cont'd). Individual spring chinook surveys in the Methow Basin, 1990.

River and Reach	Date	Redds	Live	Dead	Temp Range
Methow River (cont'd).					
Weeman Br. - Heath Spgs.	8/28	20	12	0	59-60
	9/10	47	10	17	51-57
Heath Spgs. - Winthrop Br.	8/20 S	0	0	1	51-52
	9/10	7	2	5	49-54
Winthrop Br. - Twisp Br.	9/17	7	1	3	52-60
Twisp Br. - Carlton Br.	9/26	7	5	0	55-59
Chewuck River					
Falls - 30 Mile Br.	9/18	0	0	0	46-48
Thirty Mile Br. - Backwater	7/30 S	0	2	0	53-53
	8/06	0	5	2	54-54
(Dibbie Springs Area)	8/10	10	5	2	53-53
	8/16	5	4	0	56-56
	8/21 S	1	4	2	53-54
Lake Cr. - Twenty Mile Br.	9/05	18	5	4	49-58
*Twenty Mile Br. Chewack C.G.	8/07	0	0	0	52-58
	8/21	1	1	0	58-60
	8/29	7	8	0	55-59
	9/05	17	15	1	52-60
*Chewack C.G. - Falls Cr.	8/07	0	3	0	60-63
	8/21	3	5	0	58-60
	8/29 S	0	0	0	N/A
	9/05	33	25	4	49-59
Falls Cr. - Halfway Point	8/29 S	0	0	0	N/A
	8/11	17	6	8	50/60
Half Way Point - Chewack Br.	8/11	25	6	11	46-56
Chewack Br. - Halfway Point	9/11	2	0	0	51-56
Halfway Point - Mouth	9/13	19	7	6	48-58

Table A-1 (cont'd). Individual spring chinook surveys in the Methow Basin, 1990.

River and Reach	Date	Redds	Live	Dead	Temp Range
Twisp River					
Roads End C.G.-South Cr. Br	8/15 S	0	0	0	49-52
	8/19	1	0	0	43-47
South Cr. - Mystery Br.	8/15	7	9	0	52-55
	8/22	5	3	2	50-51
*Mystery Br. - War Cr. Br.	8/08	0	1	0	47-55
	8/22	13	5	0	49-54
	9/06	18	1	10	44-56
*War Cr. Br. - Buttermilk Br	8/08	2	2	0	49-54
	8/15	15	27	1	54-59
	8/23	19	29	5	48-52
	9/06	10	4	11	46-55
Buttermilk Br.-Little Br.Cr	8/23	5	1	0	52-59
	9/06	14	7	1	48-55
Little Br. Cr. - Newby Br.	8/23	0	1	0	56-60
	9/12	2	0	0	50-56
Newby Br. - Christianson Br	9/12	1	0	0	50-57
Christianson Br. - Mouth	9/12	1	0	2	52-60
Lake Creek					
Lake - Halfway Point	9/24	0	0	0	58-54
Halfway Point - Parking Lot	9/24	0	0	0	54-53
Parking Lot - Mouth	8/06	0	0	0	N/A
	9/24	0	0	0	46-52
Gold Creek					
Foggy Dew Cr. - N. Fork Br.	8/02	0	0	0	58-59
	8/30	2	1	0	50-54
1 Mile Up S. Fork - Forks	8/02	0	0	0	51-55
	9/26	0	0	0	47-48
N. Fork Br. - Mouth	9/06	1	0	0	59-59

Table A-1 (cont'd). Individual spring chinook surveys in the Methow Basin, 1990.

River and Reach	Date	Redds	Live	Dead	Temp Range
Wolf Creek					
1.5 Miles Above Div - Div	8/31	0	0	0	54-54
	9/13	0	0	0	52-55
Diversion - Bridge	8/20	0	0	0	56-59
Bridge - Mouth	8/20	0	0	0	59-59
Cedar Creek					
Mile 0.25 - Mouth	8/27	0	0	0	43-46
Libby Creek					
Mile 3 - Mouth	9/27	0	0	0	48-49

S: Spot check only.
N/D: No data.
*: Index areas.

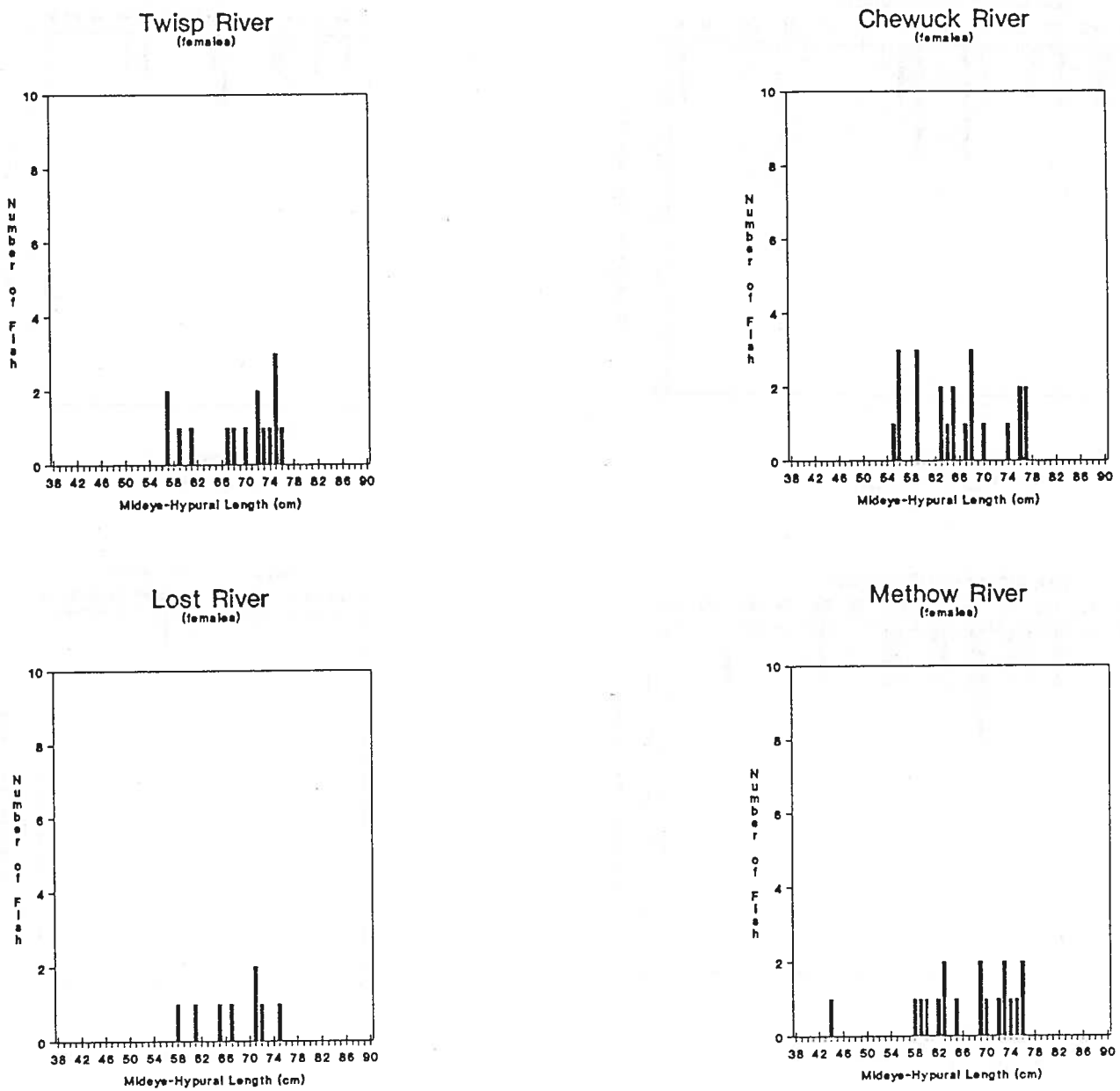

Figure A-1. Length-frequencies of spring chinook females in four subbasins of the Methow Basin.

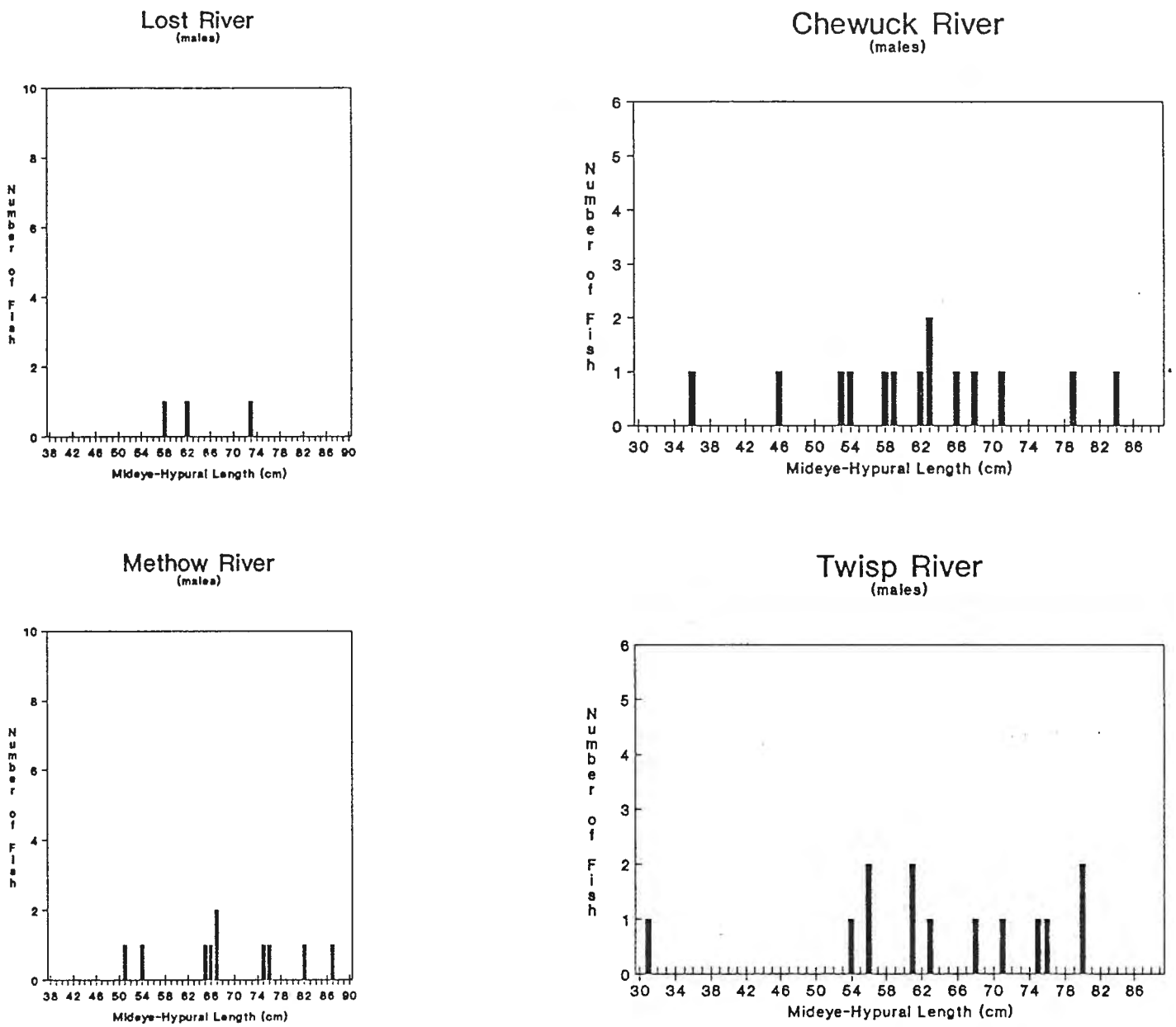

Figure A-2.. Length-frequencies of spring chinook males in four subbasins of the Methow Basin.

POTENTIAL TO ENHANCE SOCKEYE SALMON UPSTREAM FROM WELLS DAM

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FOR
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EAST WENATCHEE, WASHINGTON
JANUARY 4, 1991

APPENDIX - G

POTENTIAL TO ENHANCE SOCKEYE SALMON UPSTREAM FROM WELLS DAM

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EXECUTIVE SUMMARY

We examined the potential to enhance the natural production of sockeye salmon in the Okanogan River system. We present a brief review of Okanogan sockeye life history, system capacity compared to smolt production, and a series of enhancement alternatives. We considered any waterways that sockeye could reach from the Columbia River between Wells pool and Chief Joseph Dam.

Many of the waterways above Wells have either spawning or rearing space, but not both. The Methow River has spawning but not rearing space. There is no evidence of spawning in Wells pool. Fry from the lower Okanogan River and Methow River <u>might</u> conceivably rear in Wells pool, but limited zooplankton there makes successful rearing unlikely.

The Okanogan/Lake Osoyoos system provides space for sockeye spawning and rearing. Full use of the rearing potential in Lake Osoyoos could provide more sockeye smolts than any other natural production alternative. The lake now supports sockeye, and we believe could support many additional fry. It is the only lake in the area accessible to natural fry production. It is also the only lake permitting smolt emigration into Wells Pool without transportation.

Lake Osoyoos should support 4.0 million smolts without evidence of density dependent growth. Recent smolt production estimates were about 0.5 million. We suspect the spawning space already available in the Okanogan River is not fully seeded. Egg survival rates are unknown. Potential production estimates based on lake area, on the ratio of spawning area to lake area, and on euphotic zone volume, imply that additional fry could rear in Lake Osoyoos. We recommend alternatives to increase fry recruitment to the lake.

It is not possible to select the most cost effective approach without additional data. We suggest modest investigations directed toward selecting appropriate enhancement programs. We recommend evaluations of spawning substrate quality and methods of increasing egg to fry survival. Enhancement programs that minimize interference with sockeye life history will probably be more cost-effective than hatchery programs.

If available spawning gravels provide effective incubation areas any one, or a combination, of the following could increase production: eliminate all harvest; hold adults in cooler water; transport adults from Wells to Lake Osoyoos after evaluation of water temperatures and dissolved oxygen.

It is possible to hold adult sockeye in net pens successfully at other sites; however, the limnology of Lake

Osoyoos does not favor such a program. We doubt that adult sockeye could be successfully held for long periods in net pens within Wells pool, based on past experiences holding adult salmon in Columbia River waters.

Other potentially successful methods of increasing production from spawning areas include: gravel cleansing, provision of new high-quality spawning space, or use of streamside and lake incubators. Fry recruitment to the lake could increase with hatchery programs. Any approach involving egg incubation, will probably require egg segregation, disease testing, destroying infected eggs, and precautions such as egg treatments.

Drought conditions may reduce the rearing space in Lake Osoyoos. It is not possible to determine the effect of the 1987-88 drought on Okanogan smolt production from the data available. The smolt monitoring program at Rock Island does not detect annual changes in growth rate typical of sockeye populations. The program would not have detected density dependent growth in Lake Osoyoos in 1987-88.

Smolt production should be the evaluation standard for the natural production of Okanogan sockeye upstream from Wells Dam. Future smolt monitoring should include estimates of both smolt numbers and smolt size in the Okanogan system. It will be difficult to detect small changes in the number of Okanogan sockeye smolts, because of limited baseline data. An index such as increased smolt production per spawner, or the presence of smaller smolts (indicating approach of carrying capacity) leaving Lake Osoyoos might provide a measure of success.

It will be very difficult to monitor enhancement programs. Programs emphasizing natural production do not lend themselves to evaluations requiring marked fish. Instead improvements would not be evident without large changes in the population, that result in density dependent growth. Hatchery facilities do not enhance natural production, and often create severe mixed-stock harvest management problems. If natural production is the objective, we recommend avoiding hatcheries. However, if it is important to monitor the success of a fixed number of fish for mitigation, hatcheries offer opportunities to mark fish for monitoring purposes.

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INTRODUCTION

Douglas County Public Utility District (DCPUD) requested an examination of the potential to enhance natural production of sockeye stocks upstream from Wells Dam. Waters available for natural sockeye production are:

1) the main Columbia River between Wells Dam and Chief Joseph Dam
2) the Methow River Basin
3) the Okanogan[1] River Basin.

The Okanogan River Basin arises in British Columbia, flows south through a series of lakes and enters the USA as the southern basin of Lake Osoyoos (Appendix A).

This document reviews the use of these waters by sockeye. In addition, we predict natural production potential and suggest enhancement programs. We note biological and social constraints of each enhancement program.

In general, data available do not provide a basis to evaluate enhancement programs. Therefore we review data needs for enhancement proposals. We outline data deficiencies that influence reliable program selection and refinement. Providing monitoring programs is beyond the scope of this project, but their cost could influence any enhancement program selected.

SOCKEYE USE OF THE STUDY AREA

Sockeye salmon spawned and reared in the Wenatchee, Okanogan, and the upper Columbia River basins of the mid and upper Columbia River Basin[2]. These populations lie near the

---

[1] There are two accepted spellings; Okanogan in the United States, and Okanagan in Canada.

[2] The upper Columbia River Basin is defined as areas upstream from Chief Joseph Dam; while the mid Columbia refers to the main stem of the Columbia, and its tributaries between the confluence of the Snake, up stream to Chief Joseph Dam.

southern limit of inland sockeye distribution[3]. Before the construction of Grand Coulee Dam about 85% of the sockeye production in the mid and upper Columbia River Basin was probably from the Kettle River Basin (Mullan 1986).

Natural production in the Okanogan system cannot sustain the historic production of both the Okanogan River and upper Columbia River sockeye stocks. Federal mitigation relocated the upper Columbia River stocks into other basins with the Grand Coulee Fish Maintenance Project (1939-1960). The program trapped sockeye at Rock Island and released them into the Wenatchee, Okanogan, Entiat and Methow Rivers (Mullan 1986). Today a few sockeye spawn in the Methow River. Since pre-project estimates of sockeye production in the Okanogan are not available, it is difficult to evaluate the success of the Grand Coulee Fish Maintenance Project, or its influence on the gene pool and productivity of the Okanogan stock.

We speculate that the early years of the Grand Coulee Fish Maintenance Project accelerated a rebuilding of the Okanogan stock. Irrigation and storage for irrigation were in place in the Okanogan as early as 1915 (Fisheries Service, Environment Canada 1973). It is likely that only a small population remained after the drought of the late 1920's and early 1930's. The mean monthly flows for the incubation period 1930-31 and 1931-32 were 8-25 cfs and 6-48 cfs[4] respectively in the Okanogan River at Okanogan Falls (Walker 1956). Progeny from these eggs should have returned to the Okanogan in 1933 and 1934 if the stock had a life history similar to fish in the basin today.

It is unlikely that the original stock of sockeye, adapted to the Okanogan basin, dominates the gene pool today. The Okanogan stock was a minor proportion of the Columbia River sockeye collected at Rock Island. The release of mixed stocks, and their progeny, into the Okanogan probably increased genetic diversity while diluting endemic stocks. Enhancement projects

---

[3] The only regions farther south than the Columbia River with records of sockeye populations include coastal streams along the Oregon Coast to the Klamath River of northern California (Scott and Crossman 1973). Today the southern limit of the range is the Columbia River basin (French et al. 1976).

[4] Typical flows for the incubation period from 1916-1953 were between 200 and 600 cfs.

were discontinued in the 1950's[5] (Appendix B). Progeny of naturally-produced fish by 1964-66[6] made up all spawning sockeye in the Okanogan.

During the 25 years of Okanogan stock manipulation (1939-1964), the Columbia River hydropower system continued to develop. During the past 25 years (1965-1990) sockeye research or management included manipulation of harvest, monitoring of adults at Columbia River dams, juvenile transportation evaluations, smolt monitoring at Columbia River dams and flow monitoring during emigration. Allen and Meekin (1980) and Mullan (1986) represent the primary rigorous evaluations of Okanogan stocks.

About 30-120 thousand sockeye from the Okanogan system returned annually to the Columbia River during the past 25 years. Only a small proportion of the fish are seen on the spawning grounds (Appendix B).

Limited habitat is available for natural sockeye production upstream from Wells Dam. Yet 28-91% of the Columbia River sockeye production originates from the Okanogan (Appendix B). The Okanogan River is the only waterway with both spawning and lake rearing habitat accessible to the main stem of the mid-Columbia upstream from Wells Dam.

Habitat in the Okanogan River Basin is atypical of lake/river systems that sustain sockeye populations. Epilimnetic temperatures, lake productivity, hypolimnetic oxygen levels, and potential predation in the Okanogan basin may not favor sockeye production. Yet the population persists. We contend the sockeye population in the Okanogan exists at the fringe of its biological limits. It may lack the population resilience of stocks described in the literature. It is not the purpose of this document to develop this argument, but these ideas influence our evaluation.

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[5] there were two smolt releases in the 1950's, (1953 and 1958); the 1949 smolt release was the last release in the continuous program of the 1940's

[6] dominance of natural production occurred sooner, due to intermittent enhancement programs; smolts planted in 1958 should have returned in 1960-1961 to spawn and their progeny returned in 1964-1966.

GENERAL LIFE HISTORY

Adult sockeye destined for the spawning grounds of the mid-Columbia enter the Columbia River as early as late May. By early July about half of the run has passed Bonneville Dam.

Sockeye of Okanogan origin begin their upstream migration later than fish of the Wenatchee Basin, based on scale analysis (J. Fryer, Columbia River Intertribal Fisheries Commission, CRITFIC, Personal Communications). By July 10, 1989, about half the sockeye moving past Bonneville were Okanogan stock.

The sockeye pass upstream promptly, arriving at Priest Rapids about two weeks after crossing Bonneville Dam (Howell et al. 1985). After passing Rock Island Dam, the fish arrive at Rocky Reach within 4-5 days (Major and Mighell 1966). Within an additional 3-5 days sockeye reach Zosel Dam on the Okanogan River (Major and Mighell 1966). Passage time to Zosel Dam increases when water temperatures in the Okanogan River rise over 70 F (Major and Mighell 1966).

Okanogan sockeye begin to arrive at Wells Dam by mid-June (unpublished data 1982-89 Wells Dam counts). About half of the run has passed Wells Dam by mid-July. A few sockeye continue to cross Wells Dam into September, and in some years October.

Sockeye enter the Okanogan River and reach Lake Osoyoos as early as mid-late July; most fish reach the lake in August (Major and Mighell 1966). In some years adult sockeye delay in the Columbia River instead of entering the Okanogan River. Major and Mighell (1966) report that a thermal barrier (water temperatures of 20-21 C and greater) in the Okanogan River inhibits sockeye passage. Allen and Meekin (1980) document delays of up to a month.

Delayed adult sockeye movement may reduce the reproductive potential of the run (Major and Mighell 1966). High temperatures increase the rate of energy consumption, incidence of disease, and may directly kill fish (Major and Mighell 1966). Bouck et al. (1975) found 22 C was directly lethal within four days to Columbia River sockeye. At 20 C adult sockeye mortality was high

because disease incidence rose. When fish were held at 20 C, 50 percent died within one week, and all fish died within 24 days (Bouck et al. 1975).

Reconstruction of Zosel Dam in both 1948 and 1987 aided adult fish passage. After 1948, adult sockeye could pass upstream without the fish ladder at some flows (Major and Mighell 1966).

After reaching Lake Osoyoos, the adult fish remain in the lake for up to a month (Fisheries Department, Environment Canada 1973). Migration upstream to the spawning grounds in Canada usually begins in mid-September as river temperatures cool (Major and Mighell 1966). At least one observer reports two runs of sockeye into the Canadian regions of the Okanogan River; one in July, and one again in September (B. Kurtz, Personal Communication, Ministry of the Environment, Salmon Arm, British Columbia).

Sockeye spawn in September and October, most actively October 10-20 (Allen and Meekin 1980). Allen and Meekin report pre-spawning mortality as 20 percent in the early 1970's, attributing it to high water temperatures.

Most (70-80%) of the Okanogan run spawns in the 9 miles of unchannelized river between McIntyre Dam[7] (below Vaseux Lake) and the community of Oliver, B.C. (Allen and Meekin 1980). During spawning the regulated river flow is 350-500 cfs (IJC operating procedures 1982).

In some years, other fish spawn in the channelized portion of the river and along the lake shore. Few spawners use the 7 miles[8] channelized in 1957. It is a deep, straight channel with 13 drop structures (Fisheries Department Environment Canada 1973). Sediment, periphyton and macrophytes collect and grow in the substrate located along the upstream side of the structures, reducing the quality of the available spawning substrate (Kohn 1987, Kohn 1988). Allen and Meekin (1980) report limited (4%)

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[7] constructed in 1954

[8] this region of river was a 14 mile meandering section of river

lake shore spawning in 1971. Sockeye may spawn in deeper waters than those visible to aerial observers.

Incubation flows may be as low as approximately 175 cfs. We could not locate the report describing the determination of the suitability of incubation flows. The wetted perimeter changes little as flows drop from 350 to 175 cfs (C. Bull, Ministry of the Environment, Personal Communication).

Egg survival in different regions of the spawning area was variable (Allen and Meekin 1980). Of the eggs and sac fry recovered during March and April of 1972, 2-86% were alive (Allen and Meekin 1980).

Sockeye fry may emerge in March and April in the Okanogan system. Allen and Meekin report finding live eggs as late as March 22, 1972, and live fry on March 22 and April 26, 1972. May trapping in the Canadian section of the Okanogan River did not yield sockeye fry in the early 1970's (Allen and Meekin 1980). Variation of emergence timing should be minor because upstream lakes moderate water temperatures.

Minimum flows vary from year to year during March and April, the period when fry probably emigrate to Lake Osoyoos. Between 1982 and 1988 USGS minimum flow records show between 126-2140 cfs at Okanogan Falls (McGavock et al. 1989, 1988, 1987, 1986, 1985; USGS 1984, 1983). This variation in flow must influence fry arrival time, fry distribution in the lake, and the early spring limnology of the lake.

Canadian resource management requires screening at the numerous irrigation withdrawal sites along the river (Department of Fisheries and Oceans, undated mimeo). Screening practices could influence fry recruitment if we assume: the Canadian irrigation season begins in April (the same month as the irrigation season in the United States) and; fry emerge in April. Even with adequate screens, the impingement of fry in dead macrophyte beds, sloughing downriver as flows increase, could reduce fry survival.

Fry enter the lake at the north end, into the longest and

deepest of the three basins. Early distribution in the lake is not well documented. There is some evidence that in 1983 they remained close to the shore as late as June, instead of moving to pelagic areas (Biosonics 1983b). They rear in the nutrient-rich environment of Lake Osoyoos for one year.

Lake Osoyoos provides a rich rearing environment. Chorlophyll 'a' concentrations, a typical index of lake productivity, were high (23 ug/l) in the early 1970's (Stockner and Shortreed 1979). This represents approximately 10 times the chlorophyll 'a' concentrations reported for other sockeye lakes (Table 1). In recent years (1984-1988) spring concentrations of Chlorophyll 'a' were 8-12 ug/l (unpublished data); these values are still considered high in comparison to other sockeye lakes. The richness of the lake is evident in comparison with other sockeye lakes (Table 1).

Predators, warm temperatures and anoxic waters provide hazards. Eighteen species of fish inhabit the lake, and many are potential sockeye predators. Water temperatures rise early in the year, reaching 18 C at the surface of the lake as early as May (Allen and Meekin 1980). In August surface temperatures reach 25 C and the hypolimnion is anoxic (Allen and Meekin 1980). The entire euphotic zone, as well as the remaining water column within 10 meters of the water surface, was more than 20 C during August of 1972 (Allen and Meekin 1980). Oxygen levels were 5-6 mg/l at about 15 meters. Below 30 meters oxygen concentrations were less than 5 mg/l, and often less than 3 mg/l (Allen and Meekin 1980).

In the spring of 1982 and 1983 approximately 0.4 and 0.6 million fish left Lake Osoyoos. Smolt size has been relatively consistent (110 mm) since the 1960's (Table 2). Smolts of this size survive ocean life better than larger or smaller smolts (Peterman 1981). Smolt weight was approximately 13 grams during the early 1970's (Allen and Meekin 1980). About 95% of the 1985-87 smolts were one year old[9] (Swartzberg and Fryer 1989; Swartzberg and Fryer 1988; Fryer, CRITFIC, personal communication).

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[9] assumes the composition of the freshwater ages of adult sockeye returning to the Okanogan are representative of the composition of ages of emigrating smolts

Table 1. Primary production (chlorophyll 'a') of various sockeye lakes.

Lake	Reference	Chlorophyll 'a' (ug/l)
Okanogan Lakes		
Osoyoos		
1970-71	Stockner and Northcote 1974	23.0
1982-88	Unpublished data	8.0 - 11.0
Skaha	Stockner and Northcote 1974	31.0
Sockeye Lakes Around the World		
Karluk	1 Koenings & Burkett 1987	2.5
Hidden	1 " "	1.6
Tokum	1 " "	0.8
Leisure	1 " "	0.4
Eshamy	1 " "	1.1
Larson	1 " "	1.0
Upper Russian	1 " "	1.9
Falls	1 " "	0.9
Hugh Smith	1 " "	2.0
McDonald	1 " "	1.0
Packers	1 " "	3.3
Cresent	1 " "	1.1
Tustumera	1 " "	1.3
Alistar	2 Stockner & Shortreed 1979	2.7
Bear	2 " "	1.5 - 2.0
Fred Wright	2 " "	1.8
Kiltope	2 " "	0.6
Lowe	2 " "	1.2
Meziadan	2 " "	1.3 - 1.5
Manice	2 " "	0.7 - 0.8
Nimpkish	2 " "	0.7 - 0.9
Owikeno	2 " "	0.9 - 1.9
Simpson	2 " "	1.1
Stephens	2 " "	1.4
Swan	2 " "	0.9
Woss	2 " "	0.8

Table 2. Average ranges in length (mm) of sockeye smolts originating from the Okanogan River Basin based on collections in Lake Osoyoos, the Okanogan River or Wells Pool 1957-1983.

Smolt year	Citation	Location smolts measured	Length avg.	min.	max.	sample size
1957	Allen and Meekin (1980)	Lake Osoyoos[a]	96	75	144	365
1958	Allen and Meekin (1980)	Lake Osoyoos[a]	103	75	139	407
1972	Allen and Meekin (1980)	Lake Osoyoos	106	85	124	122
1973	Allen and Meekin (1980)	Lake Osoyoos	112	90	134	360
1974	Allen and Meekin (1980)	Lake Osoyoos	111	100	124	22
1977	Unpublished	Rocky Reach	115	90	148	174
1977	Unpublished	Rocky Reach	117	100	150	269
1978	Unpublished	Wells Pool	109	86	125	45
1981	Weitkamp & Nuener (1981)	Okanogan R.	128	84	151	1,385
1981	Parametrix 1981	Okanogan R.	128	84	243	1,398
1981	Parametrix 1981	Wells Pool	131	99	275	246
1982	Unpublished		110	76	147	3,418
1982	McGee and Truscott (1982)	Okanogan R.	114	75	232	6,994
1982	McGee and Truscott (1982)	Wells Pool	136	53	187	432
1983	McGee et al. (1983)	Okanogan R.	105	84	123	3,884
1983	McGee et al. (1983)	Wells Pool	106	75	290	1,086
1987	Peven (1987b)	Rocky Reach	116	70	219	170
1988	Peven (1989)	Rock Island	113	54	190	915
1989	Peven (1989)	Rock Island	108	66	220[b]	563

[a] Assumes Lake Osoyoos - Allen and Meekin (1980) cite unpublished NMFS data.

[b] Assumes all from after May 5 are Lake Osoyoos fish

Sockeye smolts move downstream in the Okanogan River from April 9 to May 30 and perhaps longer (McGee and Truscott 1982). Sockeye migrate in two peaks in the United States portion of the Okanogan; a few days during the third week of April, and a few days during the middle of May (Wietkamp and Neuner 1981; McGee and Truscott 1982; McGee et al. 1983).

During smolt emigration the minimum flows out of Lake Osoyoos vary despite flow regulation. Between 1982 and 1988 minimum flows out of Lake Osoyoos ranged from 75 to 2,140 cfs at Oroville (1.7 miles downstream from Lake Osoyoos)[10]. Records of the USGS show mean outflows of 163-2,870 cfs for the same period. Smolts did not seem to find their way over Zosel Dam during the very low flows of May 1987 (B. Zook, WDF, personal communication).

The Similkameen River enters the Okanogan River about 3 km downstream from Zosel Dam. Spring flows from the Similkameen may flow upstream to Zosel Dam, creating a large backwater area. The backwater, with upstream currents, could delay smolts until Similkameen flows subside. We were unable to confirm or disallow a cause-and-effect relationship between smolt movement and the Similkameen flow stage.

The Similkameen River and several other smaller tributaries enter the Okanogan, resulting in April and May minimum flows of 561-4,640 cfs (1982-88) at Mallott, WA (McGavock et al. 1989, 1988, 1987, 1986, 1985; USGS 1984, 1983).

The irrigation season in the State of Washington begins in April[11]. Pumped river water enters closed, pressurized systems. Most of the water is withdrawn from the river by 18 stations operated by the Oroville-Tonasket Irrigation District and are adequately screened (J. Easterbrooks, WDF, personal

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[10] Tonasket Creek enters the river between the lake and Oroville rarely contributing as much as 30 cfs. During most years spring flows at Tonasket Creek were 10-23 cfs.

[11] an April 1987 survey by WDF indicated that 71% of the pump stations were operational in April (J. Easterbrooks WDF personal communications)

communications). WDF estimates that the remaining 229[12] pumping stations do not have adequate screening (J. Easterbrooks, WDF, personal communications).

Juvenile sockeye may arrive in Wells pool one day[13] after passing Zosel Dam on the Okanogan River (McGee et al. 1983). April-June or July sockeye smolts are in Wells pool or passing Wells Dam (Olson 1984; McGee and Truscott 1982; McGee et al. 1983; McGee 1984). Sockeye smolts were more abundant in the middle of May than at other times during April or May (McGee and Truscott 1982; McGee et al. 1983).

The relative abundance (CPUE) of sockeye smolts passing downstream past Wells Dam begins increasing in late April (Table 3 adapted from Olson 1984, and Figure 1). The number of sockeye smolts passing Wells Dam usually declines by June (McGee et al. 1983; McGee 1984; Olson 1984). Estimates of the mortality of Columbia River (Okanogan and Wenatchee stocks combined) sockeye smolts through the hydroelectric system to the estuary range between 15% and 20% per dam (Wahle et al. 1979).

Most sockeye smolts (Okanogan and Wenatchee stocks combined) move through the estuary during May and early June (Dawley et al. 1984). A few sockeye smolts can be found in the estuary until late July (Dawley et al. 1984). We know very little about their ocean distribution, but assume they migrate promptly to the North Pacific. Tagging on the high seas indicates that at least a few Columbia River sockeye use areas west of 150 W and north of 48 N (French et al. 1976).

Data on ocean growth and survival for Columbia River sockeye stocks are sparse. Estimates of smolt to adult survival presented in Mullan (1986) provide an indication of the combined mortality of downstream passage, estuary and ocean life mortality. He estimates 0.6-4.6% survival for Okanogan stocks.

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12 Does not include the Oroville Tonasket Irrigation District

13 the peak downstream migrant count at Zosel dam was one day prior to the peak sockeye purse seine catch in Wells pool

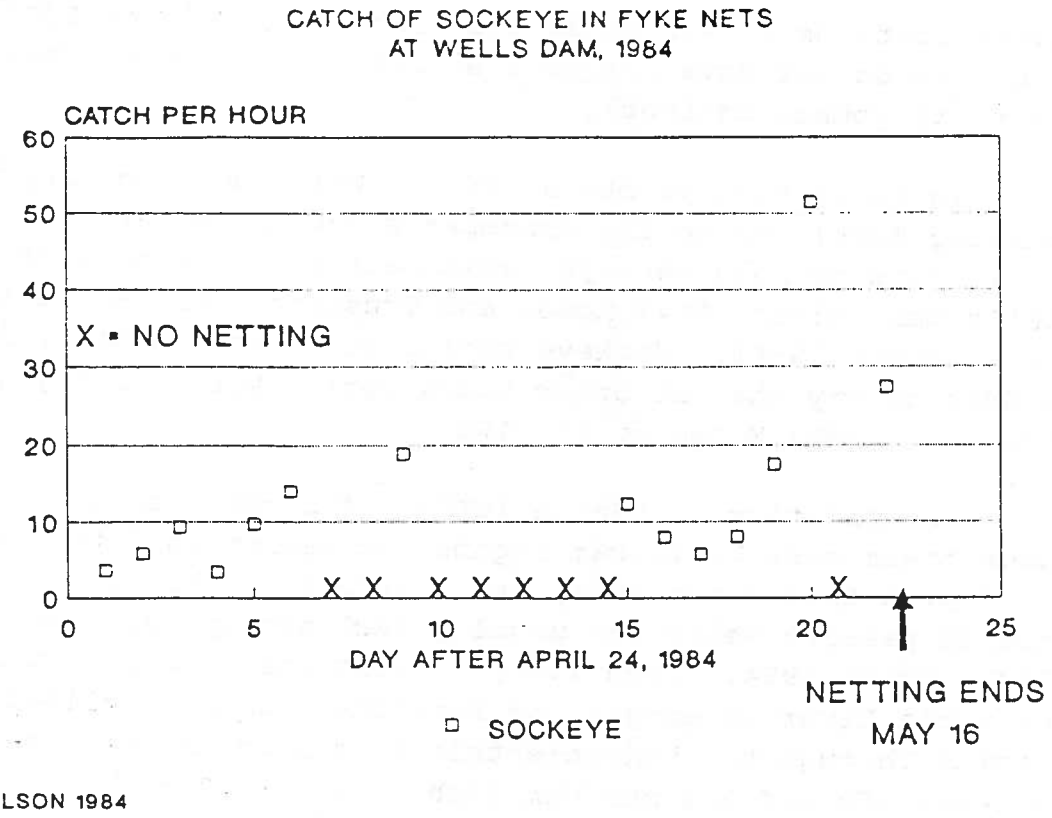


Figure 1. Sockeye smolts caught in Fyke nets per hour in turbine intakes at Wells Dam (Olson 1984).

Table 3. Catch per unit effort (CPUE) of sockeye smolts at Wells Dam as adapted from Olson 1984.

Date	Number Observed	Total Time (hours)[a]	CPUE[b] (fish/hour)
4/25	15	4.2	3.6
4/26	23	4.0	5.8
4/27	67	7.2	9.3
4/28	24	7.0	3.4
4/29	97	10.0	9.7
4/30	140	10.0	14.0
5/03	188	10.0	18.8
5/09	155	12.6	12.3
5/10	110	14.0	7.9
5/11	89	15.5	5.7
5/12	124	15.5	8.0
5/13	271	15.5	17.5
5/14	347	6.8	51.4
5/16	75	2.8	27.3

a. Rounded to nearest tenth of an hour for the table, but more accurate numbers were used for CPUE caculations.

b. Rounded to nearest tenth.

The literature on smolt-to-adult survival shows that the size of sockeye smolts influences ocean survival but not adult size (Ricker 1982). Peterman (1981) reports the highest ocean survival for 110 mm sockeye smolts. Ocean conditions are primarily responsible for adult size (Ricker 1982). Juvenile sockeye density and water temperature may also influence adult size (Ricker 1982). Peterman (1984) reports a 10-22% decrease in adult sockeye body size, due to density-dependent marine growth during the first 16 months of marine life in the Gulf of Alaska. Ricker (1982) reports that cooler ocean temperatures result in larger adult sockeye. He suggests that sockeye seek cool ocean temperatures. If ocean waters warm, the sockeye move north (Ricker 1982). Global warming trends predicted by some scientists could influence the marine distribution of sockeye in the North Pacific as well as utility of freshwater rearing habitats for sockeye.

Eggers (1980) suggests that enhancement may upset the temporal and spatial aspects of migration and ocean rearing; fish size, not species, determines feeding niche of Pacific salmon. Peterman (1984) speculates that juvenile pink and chum salmon use the same ocean areas as juvenile sockeye, but does not discuss their influence on sockeye growth. It seems reasonable that the declining survival of sockeye smolts over 120 mm is in some way linked to ocean feeding competition. Large size should decrease vulnerability to predators.

As Columbia River sockeye begin their return, regulated fisheries within the 200 mile limit do not appear to harvest them. We assume ocean harvest is negligible. We have no data that permit evaluation of effects of high-seas squid fisheries on Columbia River sockeye.

ESTIMATED POTENTIAL

We considered sockeye enhancement opportunities upstream from Wells Dam. Before recommending enhancement projects we attempted to determine the production bottleneck. We looked for:

1) evidence of density-dependent growth or survival; and,

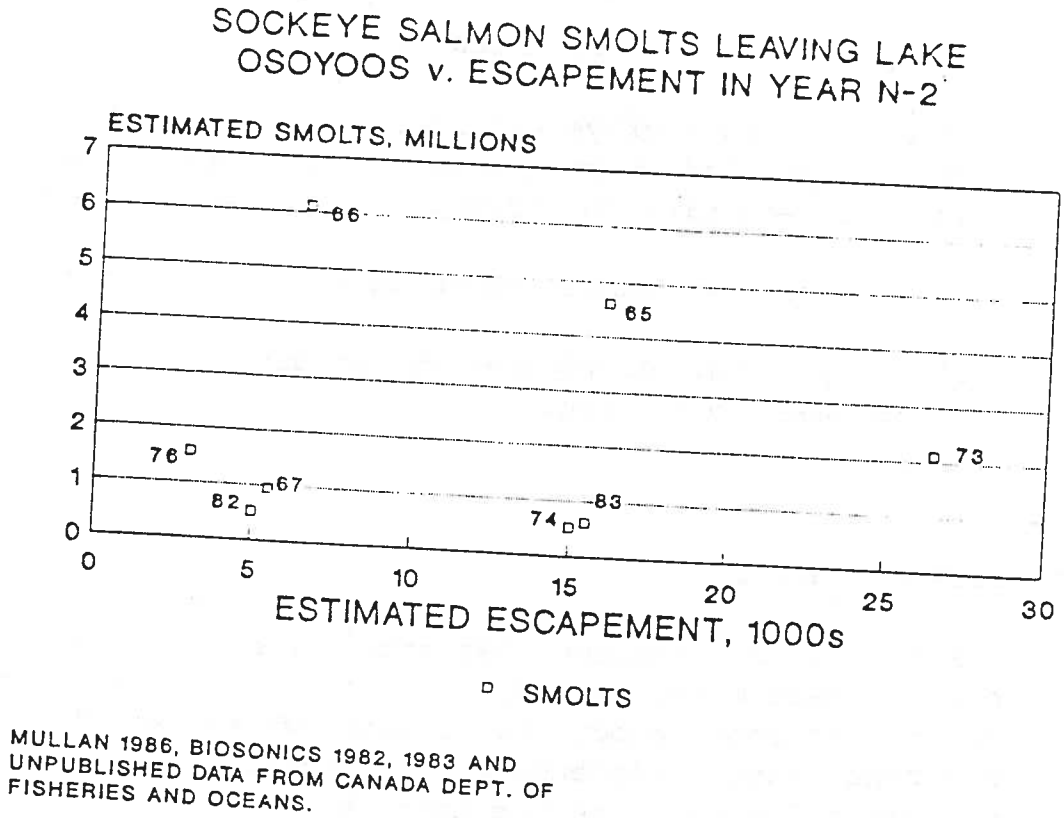
2) comparisons of theoretical production based on space and actual production.

DENSITY DEPENDENCE

Mullan (1986) provides estimates of egg to smolt survival. We plotted escapement and egg to smolt survival for the data available and found a potential, although not statistically significant, density-dependent relationship (Figure 2). This relationship incorporates two major areas of interest: (1) egg to fry survival through the period of fry recruitment to the lake, and, (2) fry to smolt survival, or lake residence. We infer the relative success of these two periods of early sockeye life from limited in-basin data and models in the literature.

A comparison between the estimated number of smolts and the average length of smolts in Lake Osoyoos (Table 4; Figure 3) provides no evidence of density dependent growth. The average size of smolts did not change whether there were 2.1 or 0.4 million.

Koenings and Burkett (1987) provide a theoretical smolt size threshold to infer if a sockeye population is "spawning limited" (which includes escapement, spawning space, spawning habitat quality or egg-to-fry survival) or "rearing limited" by the capacity of the lake rearing environment. They contend that a smolt population composed of more than 85% age 1 fish that are larger than 60-65 mm and 2 grams is "spawning limited". In this case juvenile sockeye growth would not depend on fish density. If the juvenile sockeye saturated the available habitat in a rearing lake then the "rearing limited" lake, they contend, would



MULLAN 1986, BIOSONICS 1982, 1983 AND UNPUBLISHED DATA FROM CANADA DEPT. OF FISHERIES AND OCEANS.

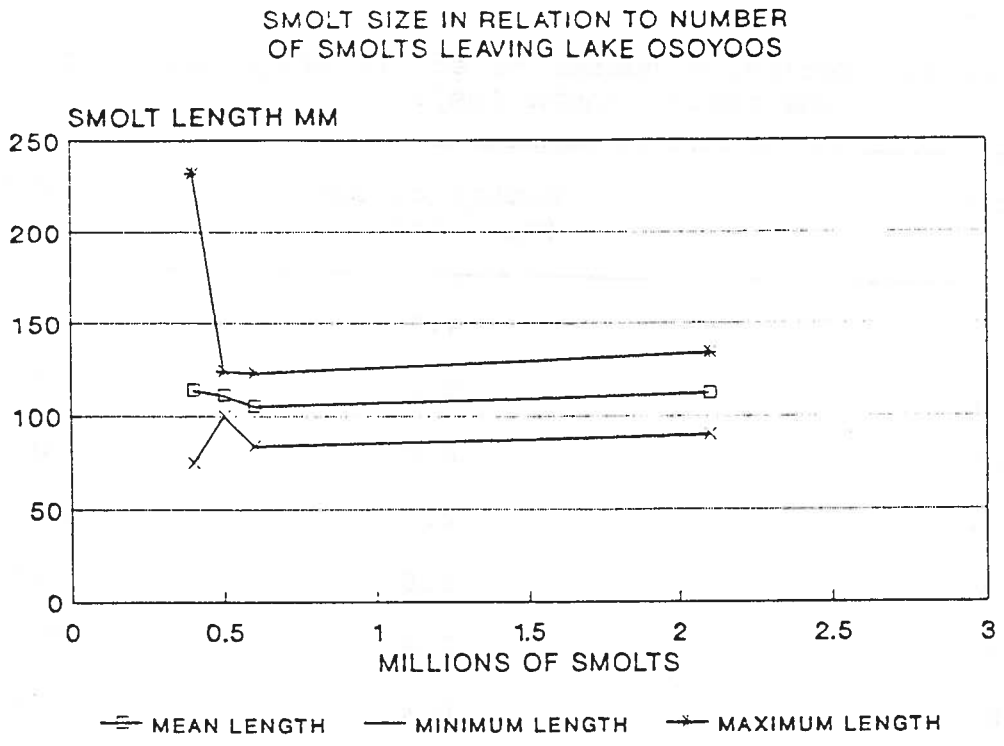
Figure 2. Estimated escapement to the spawning grounds in the Okanogan River upstream from Lake Osoyoos (spawning ground counts) and the resulting estimated smolt production from Lake Osoyoos two years later.

Table 4. Estimated number of smolts emigrating from Lake Osoyoos and their length (mm).

Smolt year	Number of smolts[a] (millions)	Length[b] (mm)
1965	4.6	ND
1966	6.1	ND
1967	0.9	ND
1973	2.1	112 (90-134)
1974	0.5	111 (100-124)
1976	1.6	ND
1982	0.4	114 (75-232)
1983	0.6	105 (84-123)

[a]. Source: Mullan (1986) for 1965-67 and 1973-76; Biosonics (1983a) for 1982; Biosonics (1983b) for 1983.

[b]. Allen and Meekin (1980) for 1973-74; McGee & Truscott (1982) for 1982; McGee et al. (1983) for 1983.



SEE TABLE 4 FOR SOURCES

Figure 3. Sockeye smolt size in relation to estimated numbers of smolts in Lake Osoyoos.

produce a higher proportion of older-age smolts, and less than 85% of the smolt population would be age 1. The age 1 fish in their "rearing limited" systems would likely be less than 60-65 mm and 2 grams.

Based on Koenings and Burkett (1987), we conclude that the smolt size (105-115 mm)[14] and age composition (>95% age 1 smolts) of Lake Osoyoos smolts do <u>not</u> indicate saturation of available rearing space in the lake.

Over 95% of the smolts in 1985-87 were probably age 1 fish[15], based on the freshwater age of adult sockeye returning to the Okanogan (Table 5). Historical data describing the freshwater age of Okanogan sockeye were not found, precluding an evaluation of this variable over time.

One might argue that Koenings and Burkett model Alaskan lakes that may tend to produce smaller smolts because they are cold and have a shorter growing period than Lake Osoyoos. Koenings and Burkett (1987) also examined historic records for Cultus Lake age 1 smolts. Although this lake tends to produce large age 1 smolts, in 1929 and 1941 the age 1 smolts approached the threshold size that Koenings and Burkett (1987) used as evidence of a lake at rearing capacity. Looking at a wide range of sockeye lakes, we find that the Lake Osoyoos smolts[16] are larger than most age 1 sockeye smolts (Tables 4 and 6).

We conclude that survival from egg deposition to fry recruitment is density dependent, but lake rearing is not, based on the limited data available. Our evidence is:

1) the density dependent relationship between escapement and smolts produced,
2) the lack of density-dependent growth in the lake, and,
3) classification of Lake Osoyoos smolt populations into the Koenings and Burkett (1987) 'spawning limited' category.

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[14] available data on average length of smolts in the 1980's ; see Table 2.

[15] assuming there is no difference in the marine mortality rates of an age/1 and age/2 smolts.

[16] the effective smolts were over 90% age/1 in the mid 1980's

Table 5. Freshwater age of adult sockeye destined for the Okanogan River Basin.

Run Year	% Age 1	Citation
1987	97%	Swartzberg & Fryer 1988
1988	98%	Swartzberg & Fryer 1989
1989	95%	J. Fryer, CRITFIC, personal communication

Table 6. Comparison of length at age 1 for sockeye smolts from various lakes, adapted from Burgner (1987).

Lake	Length (mm)	
	Average	Range
Lake Washington	125	120-129
Cultus	82	68-94
Chilko	82	75-101
Fraser	90	---
Shuswap	74	---
Babine	79	75-83
Ouikeno	60	59-61
Great Central	69	64-78
Falls	67	---
Summett	92	---
Eshamy	75	73-77
Larson	77	---
Hidden	143	---
Big	132	---
Russian	84	---
Kenai	62	---
Crescent	69	68-69
Kasilof	70	68-73
Packers	83	74-96
Tustumena	70	68-73
Karluk (R1)	111	100-122
Karluk (R2)	107	102-110
Karluk (R3)	102	96-112
Red	85	---
Frazer	135	113-163
Little Ketoi	64	43-75
Ruth	104	88-119
Wood River	83	71-91
Illiamna	88	80-98
Nakpek	100	91-113
Rechapof	103	99-107
Wagasher	91	81-97
Danlee	116	106-133
Tokam	65	63-67

SPACE

Spawning

Fewer spawners reached the spawning grounds during the 1980s[17] than the estimated capacity of the spawning area. Canadian biologists and WDF estimated the region between McIntyre Dam and the community of Oliver could support 35,000 spawners at 325 cfs[18] (Fisheries Service Environment Canada and WDF 1973). Each year the Canadian Department of Fisheries and Oceans estimates the spawning escapement in this same region to derive a spawning escapement index. Only the 1984 escapement approached spawning capacity with an escapement of 37,500 sockeye.

Ellis and McNeil (1979) estimate about 0.15 ha of spawning saturates about 1.0 km^2 of rearing area. The Okanogan/Osoyoos system has 0.48-0.70 ha of spawning space[19]: 1 km^2 of rearing space. Their technique would indicate that there is adequate spawning space in the Okanogan system. If escapement filled all the spawning area available, juvenile sockeye growth should then be density dependent in Lake Osoyoos.

Sediment, periphyton and milfoil degrade spawning habitat, particularly in the channelized portion of the Okanogan River. The net effect of deteriorating spawning habitat would be to reduce egg to fry survival and therefore reduce fry recruitment to the lake.

We conclude that:

1) The spawning space available is not fully seeded most years.

2) Sedimentation, periphyton and macrophyte growth may reduce egg survival.

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17 Estimated by the Canadian Department of Fisheries and Oceans.

18 The minimum flow for the spawning period. Flows may be up to 425 cfs, but generally are not.

19 this refers to the region between McIntyre Dam and the community of Oliver, where approximately 80% of the spawning occurs (Allen and Meekin 1980). Some additional spawning area may be available downstream, or in the lake but its use is minor. Recently WDF has estimated up to 50% of the spawning occurs downstream from Oliver and the VDS 13. The Canadian Department of Fisheries and Oceans indicates in their field notes that they do not agree with, and see no evidence for this estimate (unpublished data)

Rearing

Johnson (1965) reviewed sockeye smolt production in productive and unproductive systems and found that sockeye growth rates vary with productivity. He found a common threshold of 2,000-5,000 smolts produced per ha of lake surface area. His evaluation included the eutrophic Lake Dalnee in the USSR as well as oligotrophic and mesotrophic systems. Lake Osoyoos, (according to Johnson 1965) should be able to produce between 4.6-11.5 million smolts (Table 7).

Some researchers may find these arguments insufficient and prefer to argue for a rearing habitat limitation. Relatively high epilimnion temperatures, anoxic hypolimnion and eutrophication of Lake Osoyoos may not offer optimum rearing habitat. To account for potential changes in the rearing environment, we recalculated smolt capacity based on the euphotic volume of the lake.

Koenings and Burkett (1987) provide a method to estimate euphotic zone volume, relating it to sockeye smolt numbers. We used it to estimate the smolt capacity of Lake Osoyoos as 2.9-7.1 million smolts (Table 8).

In 1964, Mullan (1986) shows[20] 6.1 million smolts in Lake Osoyoos. This estimate is within the range estimates of both the euphotic zone volume method (Koenings and Burkett 1987) and the surface area method (Johnson 1965). The large 1966 Columbia River sockeye run (169,000) tends to support Mullan's smolt estimates.

The worst case might eliminate usable habitat in the central and southern basins of the lake due to high temperatures and anoxic waters. In the early 1970's Allen and Meekin (1980) reported waters at the south end of the lake within 10 meters of the surface with dissolved oxygen concentrations of 2 mg/l and water temperatures of 18.9 C. This was the extreme, but it makes

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[20] page 100 of Mullan 1986

? ppm ?

Table 7. Estimated number of smolts that should be produced in Lake Osoyoos, each basin of the lake, Skaha Lake, and Vaseux Lake based on the common threshold of 2,000-5,000 sockeye/ha described by Johnson (1965).

	Surface Area (ha)	Estimated Smolt Capacity (Millions) @ 2,000/ha	@ 5,000/ha
Lake Osoyoos	2,300	4.6	11.5
North Basin	991	2.0	5.0
Central Basin	541	1.1	2.7
South Basin	795	1.6	4.0
Skaha Lake	2,010	4.0	10.1
Vaseux Lake	275	0.6	1.4

Table 8. Smolt production estimates based on euphotic volume

	North Basin	Central Basin	South Basin	Osoyoos Total
Surface Area[a] (km2)	9.91	5.14	7.95	23.0
Secchi Depth[b] (m)	5	5	5	5
Euphotic Depth[c] (m)				
Maximum	13.5	13.5	13.5	13.5
Minimum	5.4	5.4	5.4	5.4
Euphotic Volume ($10^6 m^3$)				
Maximum	133.8	69.4	107.3	310.5
Minimum	53.5	27.8	42.9	124.2
Estimated Number of Smolts[d] (millions)				
Maximum	3.1	1.6	2.5	7.1
Minimum	2.1	0.6	1.0	2.9
Estimated Biomass[e] (kg)				
Maximum	10,837	5,621	8,693	25,151
Minimum	4,335	2,248	3,477	10,060

[a] Stockner and Northcote 1978

[b] Unpublished data (Ministry of the Environment, Penticton)

[c] Euphotic depth = secchi x 2.7 (Cole 1975)

[d] EV units x 23,000 smolts (Koenings and Burkett 1987)

[e] EV units x 81 kg (Koenings and Burkett 1987)

the point that juvenile sockeye may not be able to use the entire lake area. If we eliminate the southern two basins from the rearing area and recalculate the potential capacity of the lake, we find the northern basin alone could support 1.2-3.1 million smolts based on Koenings and Burkett (1987) or 2.0-5.0 million smolts based on Johnson (1965).

The 1982 and 1983 estimates of 0.4 and 0.6 million smolts did not approach even the numeric capacity of the northern basin of Lake Osoyoos. In 1976 the smolt estimate was 2.1 million, a number within the estimated production of the northern basin. We cannot find evidence of approaching or reaching a threshold density of smolts, as smolt size was similar in the 1976, 1982, and 1983 smolt populations.

THE EXCEPTION

We agree that in most years Lake Osoyoos could support more fry. However, there may be notable exceptions. During drought years international water management agreements permit additional storage in, and additional releases from Lake Osoyoos. Such agreements may: (1) reducing the opportunity for smolts to emigrate in the spring of drought years, increasing the density of juvenile sockeye in the lake, and (2) reduce available rearing space by reducing the elevation of the lake a total of 2.5 feet during the summer, or 1.5 feet more than during a normal flow year. Water temperatures in Lake Osoyoos are already higher than reported for most sockeye lakes. During a drought, temperatures could be even higher, especially if water retention time increases. The high temperatures in Lake Osoyoos may reduce the energy available for growth, particularly if an oxygenated cold water refuge is unavailable. It seems logical the size of Lake Osoyoos smolts would decline under drought conditions. We were unable to locate the average length of smolts during 1987, 1988 and 1989 to check this line of reasoning.

ALTERNATIVES INCREASING FRY RECRUITMENT

SITUATION

It is reasonable to expect inconsistent success from any project enhancing natural sockeye production[20] upstream from Wells Dam. The most likely strategies for successful enhancement involve the Okanogan River and Lake Osoyoos. If natural production alternatives are prohibitive for social or biological reasons, we suggest several opportunities incorporating aquaculture technologies.

Our analysis suggests sockeye fry rarely saturate the available rearing space in Lake Osoyoos. The lake currently produces about 0.5 million smolts. A conservative estimate of potential production is 4 million smolts. At smolt populations up to 2.1 million, no evidence appeared for density-dependent growth.

We speculate that smolt production could increase if more fry reach the open waters of the lake. The rearing space in Lake Osoyoos can support additional sockeye (about 4-8x recent estimates), so we consider it unnecessary to look elsewhere in the basin for rearing space. Fry production can increase with: 1) additional spawners, or 2) increased egg survival, or 3) increased survival from emergence to fry recruitment to the open waters of the lake. If we assume the spawner capacity estimates from the 1970s are correct, recent escapements do not fully seed the available spawning space. However, the escapements available may produce more fish if we can increase survival between egg deposition and the beginning of pelagic residence.

We cannot project the number of fry that would result in density-dependent growth (rearing limitation) without additional data. Until we see density-dependent growth, we will not be able to determine the actual rearing capacity of Lake Osoyoos.

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[20] The composite production originating upstream from Wells and downstream from Chief Joseph Dam will be referred to as 'Okanogan' or 'Lake Osoyoos' production.

Inadequate Escapement

Canadian biologists estimated that the available spawning space would support about 35,000 sockeye spawners, in the early 1970s. The egg to smolt survival would have to be about 10% to produce 4 million smolts (assuming a 50:50 sex ratio and an average fecundity of 2,250 egg/female). Ten percent egg to smolt survival would be an excellent survival rate (Table 9). Ten percent is within the range of survival estimates reported by Mullan (1986); but is higher than the median (4-7%) values he presents.

Spawning escapements[21] rarely approach 35,000 fish, the number that may fully seed[22] the available spawning space (Table 10; Figure 4). During the past 20 years spawning escapements estimate were typically 5,000-15,000 fish (Table 11; Figure 4; Appendix B). There were a few exceptional years with spawning escapements of 27-38,000 fish (Table 11). Survival estimates and smolt production estimates are not available for the progeny of the large 1984 spawning run.

Low Incubation Survival

In 1973-74 Allen and Meekin (1980) evaluated incubation survival in the Okanogan River. They concluded that egg survival in the Okanogan was low in comparison to the Wenatchee system (Allen and Meekin 1980). Yet the median egg to smolt survival was similar for the Wenatchee (6%) and Okanogan (4-7%) systems (Mullan 1986). Increasing egg survival in the Okanogan may increase fry and smolt production.

There are no recent reviews of spawning habitat quality, or egg survival in the Okanogan River. We did not find data describing the annual sediment load of the river system. The series of lakes along the river may act as settling ponds, but

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21 Based on spawning ground counts

22 Allen and Meekin (1980)

Table 9. Reported rates of survival during the early life history of sockeye salmon.

Citation	Survival		
	egg to fry	fry to smolt	egg to smolt
Allen and Meekin 1980	0.021-0.84	---	---
Ellis and McNeil 1979	0.66-0.14	0.09	---
Ellis and McNeil 1979	0.85	---	---
Ellis and McNeil 2979	0.70-0.12	---	---
Bowles 1984[a]	0.09	0.07-0.47	0.21
Bowles 1984[b]	0.45	---	---
Bowles 1984[c]	0.67	---	---
Bjorn et al. 1968	---	---	0.01
Burgner et al. 1969	0.50	0.70-0.28	---
Foerster 1968	---	0.53	0.08
McDonald and Hume 1984	0.40	0.07-0.50	---
McDonald and Hume 1984	0.20	---	---
Kyle et al. 1988	0.10	---	---
Personal Communications[d]	0.16-0.45	0.20-0.50	---

[a] Citations from other evaluations

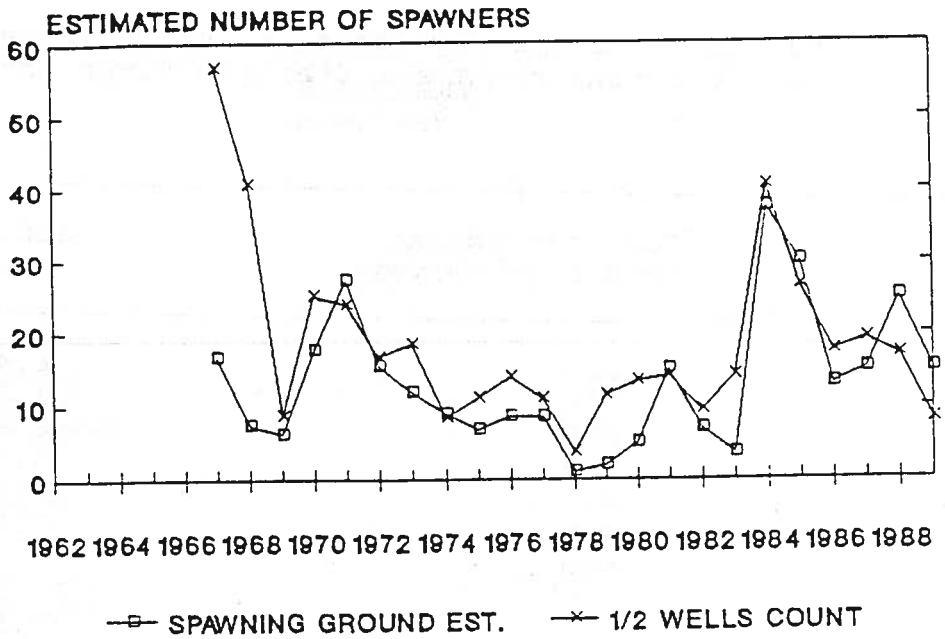
[b] Mean used in the model - for tributary spawning sites

[c] Reported incubation survival of sockeye eggs along lake shoal areas.

[d] Values reported at the Cedar River spawning channel workshop 1990

Table 10. Estimated spawning area, rearing area and ratio of spawning to rearing area for the Okanogan River McIntyre Dam to Oliver) and Lake Osoyoos at two minimum flows during the spawning period, based on Ellis and McNeil (1979).

Flow (cfs)	Spawning Area (ha)	Rearing Area (km2)	Ratio (ha/km2)
325	11	23	.48
425	16	23	.70



SEE APPENDIX B AND MULLAN (1986)

Figure 4. Estimated adult sockeye escapement based on the WDF estimator of half the Wells count (Wells Count) and the Okanogan River spawning surveys.

Table 11. Subsistence harvest by Canadian Indian tribes and the spawning ground count for Okanogan River sockeye salmon 1977-1989.

Year	Canadian Indian Food Fish Harvest	Spawning Ground Count
1977	800	8,475
1978	175	1,050
1979	2,000	2,000
1980	1,000	5,000
1981	500	15,000
1982	400	7,000
1983	500	3,500
1984	2,250[a]	37,500
1985	750	30,000
1986	1,000	13,000
1987	---	15,000b
1988	---	25,000
1989	---	15,000

[a] Raw data sheets show 2,500

[b] File attachment states WDF estimate is 35,000 for total run, but Canadian Department of Fisheries and Oceans does not agree. They state only 2-3 dozen additional fish were found in the channelized area and question if 20,000 spawned in the lake.

the agricultural use of the area could still contribute sediment locally. McIntyre Dam controls flushing flows; impoundments along the Okanogan operate to limit flooding. Annual flushing flows or large spawning populations can disturb and clean the river substrate. Without this annual cleaning, small amounts of sediment probably accumulate in the Okanogan River channel. It is reasonable to speculate that egg survival and spawning habitat quality are declining.

Low Survival from Emergence to Pelagic Residence

Fry migration into Lake Osoyoos may be hazardous. Predatory fish in the river and the lake must take sockeye fry. Fry may become entangled in sloughing weeds in the river and impinged on irrigation pump screens. If adult Okanogan fish carry IHNV, fry with IHNV usually die during migration or the first few weeks in the lake (Data presented at the Cedar Creek Spawning Channel Workshop January 1990).

OBJECTIVES OF ENHANCEMENT

We assume the objectives of enhancement are:

1. enhance natural production without physical manipulation of the fish (or)
2. enhance natural production with minimal manipulation (or)
3. enhance natural production with significant manipulation, ie. a hatchery.

PRELIMINARY EVALUATIONS

Two years of biological investigations will be necessary to select the method of enhancement most likely to succeed with the least manipulation by man. The first year, pilot evaluations should focus on the physical parameters of the enhancement site. Potential incubation sites include 3 parts of the Okanogan River,

the spawning channel at Wells and the waters of Lake Osoyoos. A preliminary evaluation of each incubation site could define its potential utility. The second year a prototype experimental project (biological evaluation) would be useful. A matrix of biological investigations, for each group of enhancement alternatives is available in Appendix D.

We examined sockeye enhancement alternatives using the conservative criteria in Table 12. Some of the literature presents slightly higher survival rates for various development stages than we have used here. However, we feel the selected criteria will provide a reasonable estimate of production potential.

ALTERNATIVES

I. Increase potential escapement

One option is to ban sockeye harvest in the Columbia River Basin until escapement to the Canadian spawning grounds exceeds 35,000-90,000 fish. Perhaps a short, early harvest window could be designed to take Wenatchee sockeye (Preliminary information from CRITFIC implies a difference in the upstream timing of the two mid Columbia sockeye stocks). An escapement of 35,000-90,000 sockeye at Wells Dam is insufficient. Pre-spawning mortality occurs and is probably high (no empirical estimates available). Allen and Meekin (1980) rarely accounted for half the fish crossing Wells dam on the spawning grounds. Canadian expanded spawning ground estimates have been about half of the Wells Dam count (Table 11; Figure 4; Appendix B). We suggest adult escapement monitoring at Zosel Dam (a manned counting station) rather than using Wells Dam counts. Additional studies should seek estimates of survival between Zosel Dam and the spawning grounds.

The social desire to harvest sockeye may make this alternative unrealistic.

Table 12. Assumptions used for sockeye enhancement estimates.

Biological parameter	Estimate
Spawning capacity =	35,000 adults
Spawn ratio =	1:1
Pre-spawn mortality =	20%
Spawning habitat =	0.48 - 0.70 ha
Fecundity =	2,250
Egg take =	October 1
TU/inch of fish growth=	20
Degree days =	900 to eye, 1,200 to hatch, 1,800 to swim-up
Groundwater temperature =	54-63 F
Max. groundwater flow =	1000 gpm
Egg to smolt survival =	4 - 7% natural
Egg to fry survival =	25% natural, 50% baskets, 65-70% tray
Fry to smolt survival =	30% natural, 65% hatchery
Smolt to adult survival =	0.6 - 4.6%
Max. Lake smolt production= (Lake Osoyoos est. capacity)	4,000,000
Average smolt size =	110 mm
Smolt passage period =	late April to mid-June

II. Increase production from available escapement

We recommend an evaluation of spawning habitat to assess if incubation survival is low. If egg to emergence survival is about 25-30%, incubation survival is probably not the problem in the Okanogan. However, if survival rates are considerably less, consider options in section II and III.

II a. Cleaning Okanogan River substrate

This alternative would aim at increasing survival from egg deposition to fry emergence. Gravel cleansing temporarily degrades water quality in the river therefore it will be necessary to develop a cooperative agreement with Canadian authorities. This project could be quite expensive or cheap. To clean several miles of stream a mechanized approach might prove practical. Large hydraulic cleaning units could remove some of the sediment from the river channel. A less expensive approach is the use of volunteer labor (the interested public), and several small hydraulic pumps. The pumps force water into the gravel, agitating it and dislodging sediment and debris. Sediment and debris remain in the river channel with this method. Each approach suspends sediment and dislodges macrophytes, altering water quality downstream. Floating macrophytes could impinge on the screens of pump irrigation withdrawal systems. Canadian regulations require discharge permits. Cleaning gravel could produce an aesthetically disagreeable sediment plume in Lake Osoyoos. Since cleaning would probably be done in the summer[23], the sediment and macrophytes would discharge into the lake during the recreational season.

Despite the potential problems with gravel cleaning in the upper river, the method might provide a durable habitat improvement. There have not been efforts to purge the system in

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[23] river flow is low and the eggs of sockeye or other stream spawning species would not be affected.

the past. The river was channelized in 1957. In 1964, seven years later, about 6.1 million smolts left the Osoyoos system (Mullan 1986). In 1976, almost 20 years later, 2.1 million smolts left Lake Osoyoos. Recent yield has been about 0.5 million smolts.

It seems reasonable that the cleansed gravel would remain relatively clean for several years. Less organic material enters the system today than 15 years ago. The water quality in Skaha and Osoyoos Lakes has improved since 1976, with new sewage treatment and disposal programs. Okanogan, Skaha and Vaseux Lakes all act as stilling basins for suspended materials. The reduction of new inputs, and these stilling basins should prevent rapid sedimentation and macrophyte invasion in the spawning area.

II b. Increase available spawning area

According to our calculations, adult sockeye are not saturating the spawning space available in the Okanogan system today. Additional spawning space will not increase production unless: (1) adult sockeye are available and choose to use the added space, or (2) if the gravel quality of added areas exceeds that of existing spawning areas.

Although we do not recommend seeking additional spawning space, laddering McIntyre Dam and Skaha Dam may increase the available spawning area. There are three small reaches of the Okanogan River: (1) between Vaseux Dam and Vaseux Lake, (2) Vaseux Lake and Skaha Lake, and (3) Skaha Lake and the impoundment at the outlet of Okanogan Lake (Appendix A).

If additional spawning areas prove necessary, it may be possible to develop a cooperative agreement with Canada to ladder McIntyre Dam and possibly the Skaha Lake impoundment. This would allow adult sockeye the opportunity to use additional spawning space in the river upstream from McIntyre Dam, Vaseux Lake, and Skaha Lake. This technique also offers additional rearing space in Skaha Lake. Canadian research planted about 2.7 million kokanee in Skaha lake from 1981-1986 (Appendix C). The kokanee grew well in the lake (Parkinson, in prep), but did not return to

the creel (Bull, 1987).

The drawbacks of this option include potentially low survival as sockeye fry pass through Vaseux Lake. The use of Vaseux Lake for rearing is unlikely to be as successful as rearing in Lake Osoyoos. Vaseux Lake is a shallow basin; summer water quality can be poor. Canadian management plans, presently view Vaseux Lake as a warm-water fishery. Warm-water species are potential predators on juvenile sockeye. Trout and kokanee are not regularly planted in Vaseux Lake because of poor water quality.

III. Increase production with minimal manipulation

III a. Hold adults in cooler water

Trapping and either holding or transporting adults to cooler waters may reduce pre-spawning mortality, and increase effective escapement. It may be possible to increase pre-spawning survival by holding adults in cool water until Okanogan River temperatures drop in the fall. Alternatively managers could trap adults at Wells and perhaps transport them directly to Lake Osoyoos. In the lake the adults could seek preferred water temperatures. The drawback is finding a location for release with adequate water quality at the surface. This technique would likely require international permits to transport adult sockeye to the northern basin of the lake.

Another alternative for holding adult sockeye in Lake Osoyoos would be the use of a floating culture facility similar to those used in Alaska. Facilities fashioned on pontoons could pump cool waters below the thermocline (in the northern basin) to the water's surface and through a heat exchanger to cool the warm surface waters. The temperature control options of this method are very desirable. However this method probably requires an American facility in Canadian waters, as well as the transport of live adult fish over an international border.

A similar concept might work in Wells Pool with a chiller instead of a heat exchanger on a floating culture facility. This alternative would eliminate the international regulation issues associated with holding adults in the northern basin of Lake Osoyoos.

DCPUD developed a ground water source near the mouth of the Okanogan River. Continuous pumping for one year yielded a cool (53-64 F) water supply of about 1,000 gpm. Holding sockeye in a deep pond fed by ground water may reduce pre-spawning mortality. Holding adults is difficult in waters warmer than 17-18 C (60 F). Even with a groundwater source a chiller may be necessary during part of the summer.

Disease such as columnaris may result in excessive pre-spawning mortalities. It is unlikely that (IHNV) is directly responsible for pre-spawning mortality, but holding situations may increase disease transition between adults, and juvenile mortality (Keith Johnson personal communication). A pilot program should evaluate the relative success of holding adult fish in any cool water situation.

III b. Restore the Wells spawning channel

This option would increase available spawning area. The Wells spawning channel was originally constructed for chinook. At first the channel worked well, then juvenile chinook yield declined sharply (Mike Erho, DCPUD, personal communications). Perhaps an annual maintenance program would result in consistent fry yields.

All successful sockeye spawning channels in Canada are cleansed regularly. Annual cleaning is not uncommon. Some channels require cleaning once every 2-3 years.

To estimate the potential success of using the Wells channel preliminary activities include: substrate evaluation in the channel, cleaning the channel, replacement of gravel if necessary, and a biological testing period.

This method would increase quality spawning space for sockeye, but requires human intervention at several stages.

Adult sockeye collected at Wells Dam could be held in the Wells Channel until spawning. The fish would presumably spawn naturally. As fry migrate from the channel, an inclined plane trap could collect them for transport to Lake Osoyoos. Fry releases into the aquatic vegetation along the shore of the lake may increase early survival (Jaenicke et al. 1987).

Holding sockeye to maturity in the Wells channel may prove impractical because of disease. Holding areas may enhance disease, causing pre-spawning mortality. A pilot program should reveal whether holding conditions result in severe losses.

Unfortunately it will be difficult to attribute a relative increase or decrease in disease to any holding facility. We do not feel the extensive investigation required to quantify increases or decreases in pre-spawning mortality due to disease will be cost effective. Instead pilot programs should look at several holding sites, and select the most successful.

III c. Incubate eggs in hanging baskets.

Hanging egg baskets successfully incubate both sockeye and lake trout in lakes (Haddix 1986). Haddix (1986) reports sockeye egg survival[24] in hanging baskets of 73% (52-94%). These baskets offer relatively low-cost artificial incubation. In addition the fry emerge directly into the lake bypassing many of the hazards of fry migration.

The baskets are incubator trays with a screen top. The top screen is large enough to let the fry escape. The baskets are suspended in a lake for the incubation period. Egg survival depends upon basket placement in relation to current, and on sedimentation within the lake. Other potential considerations for basket placement include:

24 fertilized eggs to emergent fry

(1) the fry 'release[25] site,

(2) spring flow patterns in relation to emergence time that do not flush fry from the lake, particularly in the south end of the lake, and

(3) water temperatures in the lake, compared to inter-gravel temperatures and the associated time of hatch.

Lake Osoyoos is a logical location for egg basket incubation. If there are not suitable basket sites in U.S. waters, then a cooperative agreement with Canadian fisheries authorities is necessary. Fish transportation and planting permits across international borders are sometimes difficult to obtain.

Adult sockeye collected at Wells Dam would be held until artificially spawned. The fertilized eggs would be taken to Lake Osoyoos for incubation. Egg baskets, like those described in Appendix E, provide an incubation site. Basket locations should allow for flow over the eggs, but minimize sediment deposition in the basket. Treatment of fertilized eggs with iodiform (100 ppm for 10 minutes) may provide some interruption of vertical disease transmission.

Preliminary research programs should include:

(a) location of suitable sites for basket incubation;

(b) fall temperature and oxygen monitoring will determine the appropriate time to place eggs in the lake;

(c) temperature regimes in the lake during the incubation period to project the timing of emergence;

(d) zooplankton composition in the lake during the projected emergence period.

Adults could be held in the Wells Channel, and conceivably

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25 Fry actually leave the incubation baskets volitionally.

in net pens (eg. Wells Pool). They might be held in floating tanks in Lake Osoyoos. they might better be held in ground water (see III a). To minimize pre-spawning mortality, managers should maintain low densities of adults in any holding facility.

Net pens would be inexpensive and require little maintenance. Additional net pens can easily reduce fish density or increase adult holding capacity. However water temperature control would be difficult or impossible.

Adults can be spawned near net pens. Carcass disposal options may offset program costs. For instance Wisconsin's Sea Grant Program is test marketing an odorless garden mulch product made from fish. One midwest electrical utility facilitated the development of a commercial venture that sells frozen blocks of ground fish carcasses as bait (chum material) to commercial fishermen in Florida. Marketing mechanisms for carcass disposal programs exist. Lake Osoyoos is an unusually productive sockeye lake, and removal of a portion of the carcass "fertilization" may be desirable.

III d. Incubate eggs in streamside hatch boxes

Streamside hatch boxes are inexpensive to install and maintain (Robertson and Holder 1987). Fry emigrate directly from the hatch box, as they would from stream gravel.

Adult sockeye collection at Wells, adult holding space, artificial spawning and egg transport permits will be necessary. If eggs must incubate before disease certification, egg facilities must be available. We recommend iodiform treatment of fertilized eggs to minimize effective vertical transmission of disease.

This method requires the legal right to divert a small amount of water from the Okanogan during the period of lowest flows. Although hatch boxes require a relatively small amount of water, it is unlikely that new water rights will be obtainable. Irrigation, as well as Okanogan Lake kokanee spawning and incubation needs determine the operation of the Okanogan River.

Winter water management is particularly important to kokanee incubating in the shoreline regions of Okanogan Lake. Use of any water in the basin would require a cooperative agreement with several Canadian agencies and approval of the International Joint Commission.

Table 13 shows our calculations for both basket and box incubation. We assumed the loading rate could be similar for both systems. However, basket incubation is the more likely alternative unless additional studies indicate that tributary water quality and quantity is adequate. Use of baskets or box incubation should provide improved egg to fry survival (even though we used conservative parameters). Fifty four units (baskets or boxes) would fully seed[26] the lake without recruits from natural spawning.

III e. Eyeing Station.

Heath trays or streamside incubators are suitable egg incubation facilities. Sockeye eggs held to the eyed stage can continue development in baskets or boxes. At swim-up, fry leave the baskets or boxes by themselves. Table 14 shows our computations for the number of incubators and other facilities required to meet lake rearing capacity. We also show flow and cost estimates.

Pilot programs are necessary to evaluate the horizontal transmission problems commonly associated with IHNV, a common viral disease. Since some vertical transition of IHNV occurs, we recommend iodiform treatment of eggs, realizing it does not eliminate the more common horizontal transition. In addition, we recommend as much egg segregation as possible, with no more than five pairs of parents per egg lot. We recognize that some Alaska programs will incubate eggs of both IHNV negative and eggs with low titers (detectable levels of 10^3-10^5); however we recommend use of only IHNV negative eggs, as they will be transported over an international border.

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[26] Full seeding refers to the estimated number of sockeye fry that could rear in the lake before density influences growth.

Table 13. Estimates of sockeye production and cost of production using basket/box incubation to supplement Lake Osoyoos sockeye salmon production.

Variable	Estimate
Fish production:	
24,000 spawners @ 2250 eggs =	27,000,000 eggs
Incubation survival (egg to fry) = 50% =	13,500,000 fry
Rearing survival (fry to smolt) = 30% =	4,050,000 smolts
Smolt to adult return required = (@ 20% pre-spawn mortality)	0.74%
Basket/box loading density =	500,000 eggs /unit
Units required =	54
Cost:	
Capital investment	> $100,000
O&M	> $225,000/yr

Table 14. Estimates of fish production and cost of an eyeing station to supplement Lake Osoyoos sockeye.

Variable	Estimate
Fish production:	
24,000 Spawners @ 2250 eggs =	27,000,000
Incubation survival (70% to eyed eggs) =	18,900,000 transfer eggs
Basket/box egg to fry survival (72%) =	13,608,000 fry
Rearing survival (30% fry to smolt) =	4,082,400 smolts
Smolt to adult return required = (assuming 20% pre-spawn mortality)	0.73%
Heath tray incubation = (assuming 16-tray stacks @ 7200 eggs/tray)	234
Flow required = (assuming 1 gpm/stack)	0.5 cfs
Basket/Box units = (assuming 500,000 eggs/unit)	38
Cost:	
Capital investment	> $800,000
O&M	$300,000/Yr.

III f. Other spawning channels.

This is not a feasible alternative for the Okanogan because spawning channels require large volumes of water. It is unlikely additional water would be available during this low flow period (see history of water law in the basin Appendix F). Channels are expensive to construct and expensive to maintain. A recent review by Canadian biologists rejected spawning channels in the Okanogan for kokanee enhancement because channels require too much water (Bull 1987).

IV HATCHERY OPTION

We do not recommend the use of a hatchery system, unless there is no other alternative. Hatcheries are expensive, and have a history of declining benefit over time. Hatchery programs may cause loss of genetic variability and reduce viability of wild stocks over time. One advantage of a hatchery program is the ability to mark pre-smolt sockeye for an evaluation program. We provide criteria for a sockeye salmon hatchery, which may prove useful as managers consider other alternatives.

Table 15 shows our calculations for a sockeye hatchery with a production goal of 4,000,000 smolts. Use of a full scale hatchery reduces the escapement requirements for run maintenance. However, hatchery production depends on suitable hatchery water.

We assume barrel incubation will be as successful for sockeye as it has for kokanee. Heath tray incubation requires greater flow and space.

We used groundwater temperatures obtained at a site upstream from Wells Dam to calculate rates of egg development (unpublished data, DCPUD). Eggs will reach the eyed stage on about October 31, and hatch November 11 (Table 16). Alevins should reach swim-up about December 4. Sockeye will reach smolt size for out-migration by May 1. Consequently, full hatchery production would circumvent lake rearing. Hatchery-reared smolts would be

Table 15. Estimated needs and production at various life stages to produce 4 million smolts, or the estimated capacity of Lake Osoyoos.

Variable	Estimate
Fish production	
8,500 spawners @ 2250 egg=	9,562,500 eggs
Incubation survival (65% egg to fry)=	6,215,625 fry
Rearing survival (65% fry to smolt)=	4,040,156 smolts
Adult Holding Requirements	
3.7 lbs /fish=	31,450 lbs
Holding Density =	5.25 lbs/ft^3/pond
Pond Volume =	6,000 ft^3
Number of Ponds = (@10ft x 40 ft x 3 ft deep)	5 @ 1,200 ft^3/pond
Total Flow Required =	1.7 cfs @ 1 turnover/hr
Incubation	
Number Incubators = (@ 270,000 eggs/incubator)	24
Incubator Type =	2 ft diameter, upwelling incubator, 2/rearing pond
Flow Required = (20 gpm/incubator = 480 gpm)	1 cfs
Early Rearing	
Pond Capacity = (6,215,625 fry @ 1100/lb.)	5,650 lbs.
Loading Density =	0.5 lb./ft^3
Pond Volume =	11,300 ft^3
Number of Ponds = (@ 480 ft^3 /pond) (each pond 4 ft x 40 ft x 3 ft deep)	24
Total Flow Required for all ponds= (@ 2 turnover/hr, 1-pass)	6.3 cfs
Final Rearing	
Pond Capacity = 4,040, 156 smolts @ 35/lb =	115,433 lbs
Loading Density =	0.5 lb/ft^3
Pond Volume =	58,000 ft^3
Number of Ponds = (@ 2400 ft^3/pond) (10ft x 80 ft x 3 ft deep)	24
Flow Required = (@ 2 turnovers /hr, 3-pass)	11 cfs
Total Flow Required = (approximately 10 cfs of groundwater with/2-5 wells)	20 cfs
Smolt to adult return required = (@ 20% pre-spawn mortality)	0.26%

Table 15. Continued

Variable	Estimate
Facility Requirements	
Early Rearing Tanks	
Final Rearing Raceways	
Adult Trap	
Feed & Equipment Storage	
Spawning Shed	
Office & Utility	
Effluent Settling Ponds	
Road & Fencing	
Vehicles	
Residences	
Vehicle Storage	
Pumps	
Shop	
Head Tanks	
Barrel Incubators	
3-5 Acres of Land	
Capitol Cost >	$2.5 Million
O&M Cost >	$475,000 /year.

Table 16. Predicted sockeye development and growth rates[a] using groundwater as calculated for water temperatures of groundwater at Cassimer Bar.

Month	Groundwater average Temp (F)	Degree days	Thermal units	Accumulative Growth rate	Fish/ pound	Development stage	Date
Estimates with 1988-89 data							
Oct	65[b]	33	26.4	Incubation	-	Eyed	Oct 27
Nov	59	27	20.4	Incubation	-	Hatch	Nov 11
Dec	56	24	17.4	0.87	3,500	All-Feeding	Nov 28
Jan	55	23	16.4	1.69	581	-	-
Feb	56	24	17.4	2.56	172	-	-
Mar	54	22	15.4	3.33	77	-	-
Apr	54	22	15.4	4.10	41	-	-
May	55	23	16.4	4.92	24	Smolt	May 1
Estimates with 1989-90 data							
Oct	56	24	17.4	Incubation	-	Eyed	Oct 31
Nov	56	24	17.4	Incubation	-	Hatch	Nov 7
Dec	57	25	18.6	0.93	3,500	All-Feeding	Dec 4
Jan	55	23	16.4	1.75	531	-	-
Feb	53	21	14.4	2.47	190	-	-
Mar	53	21	14.4	3.19	88	-	-
Apr	55	23	16.4	4.01	44	-	-
May	55	23	16.4	4.83	25	Smolt	May 1

[a] All calculations assume optimum conditions

b October temperatures recorded during first year of pumping (1988) were much higher than those recorded in 1989 (DCPUD unpublished data)

available to migrate in May, one year before their naturally spawned cohorts.

LESS PROMISING ALTERNATIVES

We reviewed other possible sockeye enhancement alternatives suggested by committee members. The following programs provide potentially minor enhancement opportunities compared to reaching the estimated capacity of sockeye production within the habitat already available.

Readers should keep in mind that water allocation in the basin is controversial, and there are other popular sport fishing opportunities and recreational uses in the region. Agriculture, recreation, and international water law compromises that will lead to additional water for sockeye are unlikely.

METHOW RIVER

Although sockeye spawn in the Methow River Basin, they represent less than 0.5% of the spawners above Wells Dam (Appendix B; Mullan 1986; Kohn 1988; Kohn 1987). The Methow "population" of riverine spawners may be progeny from the Methow River or represent strays.

Wells pool would be a logical rearing area for fry from the Methow. There are no data to confirm or refute sockeye rearing in Wells pool. Low zooplankton populations make successful and extensive sockeye rearing unlikely (Mullan 1986). Jaenicke et al. (1987) found juvenile sockeye using chironomids, which Mullan et al. (1986) indicates are abundant in Wells Pool. We conclude sockeye rearing might be possible, but extensive success unlikely.

WELLS POOL

Operation of Grand Coulee influences both water temperatures and the aquatic invertebrate population of Wells Pool. River water is warmer in fall and winter and colder in spring and summer (Mullan et al. 1986). Summer temperatures at Wells Dam do not exceed 18 C (65 F; McGee, Douglas County PUD, Personal

Communication). Water temperature regimes in the mid-Columbia modified both primary and secondary production (Mullan et al. 1986).

Mullan et al. (1986) describes the primary production of the mid-Columbia pools as dominated by detritus, sessile algae, and macrophytes. Diatoms dominate the phytoplankton community. The peak of phytoplankton abundance is April-June with a lesser bloom September to October. Zooplankton are scarce, except in backwaters. The benthic community is within the range of reservoir fluctuation. Where benthos exist, it primarily consists of chironomids and oligochaetes (Mullan et al. 1986).

Mullan et al. (1986) speculate that more nutrients are available today than before impoundment, yet describe the impoundments as similar to unproductive oligotrophic lakes, with low Chlorophyll 'a' concentrations. Reservoirs often act as nutrient sinks; for example the storage reservoirs of the Clark Fork River in the upper Columbia watershed act as phosphorous sinks (Johnson 1989). These upstream projects could actually reduce nutrient load, instead of increasing it.

Today fishes dependent upon periphyton remain or increase while those dependent upon detritus, plankton and zooplankton are generally absent in the mid-Columbia reservoirs (Mullan et al. 1986). It is logical to assume juvenile sockeye that depend on zooplankton foods, would not successfully rear in large numbers.

It has been speculated, but seems unlikely, that Wells pool may be used for sockeye rearing today. An argument for use of the Wells pool stems from the recurring use of the Methow River by spawning sockeye despite the lack of rearing habitat. The zooplankton data available to date for Wells pool do not seem to indicate an abundance of appropriate foods for juvenile sockeye, unless they adapt to use of chironomids as Jaenicke et al. (1987) report for some Alaskan lakes. This seems unlikely, as chironomid use seems to correspond with the presence of aquatic macrophytes (Jaenicke et al. 1987).

Despite low water retention times in Lake Rufus Woods, the kokanee must be finding some zooplankton (or using chironomids).

One explanation could be these fish are sustained on the seston from Lake Roosevelt. It seems unlikely that sufficient seston of Lake Roosevelt origin is still available for juvenile sockeye in the Wells pool.

Unlike the other reservoirs in the mid-Columbia, Wells pool maintains centrarchid populations. For instance, there is a fishery for smallmouth bass. Mullan et al. (1986) suggest this unique centrachid population exists due to the warm waters of the Okanogan River entering an otherwise 'cool' mid-Columbia.

This warmer water, while favoring smallmouth bass, does not necessarily enhance sockeye production and survival. Bouck et al. (1975) examined the survival of adult sockeye held in Columbia River waters between 10 - 22 C. They found 22 C lethal to sockeye by predisposing the fish to disease. The Okanogan River is frequently 22 C, hot enough to discourage sockeye passage into their natal river until temperatures begin to decline in the fall.

PALMER LAKE

Alternative 1

Palmer Lake is located on a high water channel of the Similkameen River upstream from Enloe Dam. The lake receives water year round from a small headwater stream, and seasonally from the Similkameen River. Populations of centrarchids dominate lake sport fish populations, which WDW actively manages.

We did not find O. nerka planting records, but were told of planting programs by several agency employees. Although WDF mentioned a discontinued sockeye planting program, we could not locate the description of the program and its results. There are reports of kokanee in Palmer Lake, but the populations do not provide a substantial fishery.

We found limited limnological data for Palmer Lake. Summer surface temperatures reach 24 C (70 F), and these temperatures extend down to about 8 meters (Langless 1990 DRAFT).

Palmer Lake fills with water from the Similkameen River during high spring flows. The direction of flow changes in the channel between the lake and the river as spring flow subside. By early summer water flows out of (instead of into) Palmer Lake. An impoundment increases the natural water level in Palmer Lake, and controls flow out of the lake. Plans exist for increasing the volume of the lake with a higher impoundment and delaying outflow (Langless 1990 DRAFT).

If juvenile sockeye successfully reared in Palmer Lake, it is unlikely they would successfully pass downstream in the spring as smolts. They would have to voluntarily swim upstream, against the current in the spring to reach the Similkameen. Then their behavior would need to change, allowing them to pass downstream. Later smolts would find less water for passage in the main Columbia River, based on the past use of the water budget.

In the event that sockeye could rear in Palmer Lake, smolt, and successfully return to the Similkameen as adults, they would not be able to pass upstream of Enloe Dam without transportation. If kokanee spawn successfully in the lake, there may be some suitable habitat for sockeye spawning. However we could not confirm the presence of suitable spawning habitat in Palmer Lake or the inlet to the lake.

Alternative 2

The subbasin planning process of the Northwest Power Council proposed using Palmer Lake waters to cool the Similkameen and Okanogan Rivers (Langless 1990 DRAFT). Since surface waters are warm, the plan proposed to siphon cool waters from deep in the lake. Two factors made this alternative unrealistic: 1) the cost of such a siphon is prohibitive, 2) the water law in the state of Washington does not allow water storage specifically for fisheries when there are competing consumptive uses (Langless 1990 DRAFT).

OTHER SMALL LAKES

There are several other small lakes in the region. Most are small irrigation reservoirs, with outlet flows used for irrigation. Lakes that retain water year-round are alkaline and managed for Lahontan cutthroat trout fisheries. None of the lakes maintain outflows throughout the adult sockeye migratory period, preventing natural spawning migrations. We were unable to confirm the presence of suitable sockeye spawning areas associated with any of these lakes. We were unable to confirm suitable sockeye rearing space in any of these lakes.

CANADIAN WATERWAYS

There are two regions in Canada that are presently unavailable to Okanogan sockeye: (1) The upper Okanogan River Basin from the headwaters to the outlet of Okanogan Lake and (2) the region from the impounded outlet of Okanogan Lake to Vaseux Dam, discussed previously in this document.

It is unlikely that the upper Okanogan River/Lake Basin will become available to sockeye. Okanogan Lake supports an economically important kokanee population, generating regional income from recreational opportunities. Water management in the basin considers the kokanee population, acknowledging its economic importance to the region. In contrast, sockeye offer little to Canadian nationals.

Columbia River sockeye carry IHNV, a disease infecting both kokanee and sockeye populations. It is unlikely that Canadian authorities would agree to sockeye passage into Okanogan Lake, on the basis of disease alone.

There is no reason to think that increased production of Okanogan sockeye would benefit Canadians. American harvest allocation in the Columbia River provides for the harvest of additional fish in the U.S. instead of Canada. Management agreements in U.S. v Oregon clearly permit the harvest of sockeye

if more than 75,000 cross Bonneville Dam (assuming 75,000 fish results in 65,000 at Priest Rapids [27]). This harvest allocation procedure potentially limits escapement to the Okanogan and the success of any enhancement program.

Native American tribes in Canada that could have ceremonial and subsistence interests in the Okanogan sockeye, do not have the political influence to generate national interest in U.S. harvest allocation issues affecting sockeye escapement into the Canadian portion of the Okanogan.

LAKE CHELAN

The outlet from Lake Chelan enters the Columbia River downstream from Wells Dam, and therefore lie beyond the scope of this study.

WATER BUDGET AND OTHER COLUMBIA RIVER PASSAGE ISSUES.

All Columbia River passage issues influence Okanogan sockeye at or downstream from Wells Dam, and were therefore beyond the scope of this study. Water budget allocations and management require consultation of regional fisheries scientists operating in both technical and political capacities, and beyond the scope of DCPUD management.

EXPLOITATION

Harvest allocations in marine and freshwater environment are negotiated, beyond the scope of this study, and beyond the sole control of DCPUD. However, the success of any natural production program selected in the basin could improve with additional escapement (as previously discussed in several sections of this report).

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[27] with an interdam mortality rate of 4%, or less than half the inter dam mortality rate currently used by the NWPPC

CONCLUSIONS

The data available suggest it is possible to increase Okanogan sockeye production if more fry reach the productive pelagic regions of Lake Osoyoos. The data provide an incomplete picture of current conditions in the Okanogan River and Lake Osoyoos. We offer several enhancement strategies. We do not select one strategy above all others. Instead we recommend modest and focused biological investigations to refine the selection of an enhancement strategy.

Other sites upstream from Wells Dam are less likely to provide successful enhancement opportunities. The Methow, Similkameen and lower Okanogan rivers provide limited spawning without rearing space. Other small lakes in the region, and the Wells Pool, are less suitable than Lake Osoyoos for rearing juvenile sockeye. Since rearing space does not seem to be the issue, we did not focus on these waters.

We did not develop evaluation programs for each enhancement strategy. We feel that smolt emigration is an appropriate evaluation standard as it addresses sockeye production upstream from Wells Dam. The use of a later stage of life for an evaluation standard for program success inappropriately involves the population at sites downstream from Wells Dam, and outside the scope of this study. An optimum smolt size might be set in the enhancement program goal and used as a standard for success. Peterman (1981) suggests sockeye smolts 100-120 mm survive ocean life better than smaller or larger fish.

We recommend development of a consistent smolt monitoring technique. Baseline data should provide both an estimate and a bound on the error of the estimate. Past estimates are of limited use. Estimates of smolt size did not temporally correspond with hydroacoustic estimates of smolt yield. Trapping data did not include information on trap efficiency and hence could not be used to estimate smolt yield. Some combination of standardized trapping and hydroacoustic estimates might provide appropriate annual estimates of smolt yield.

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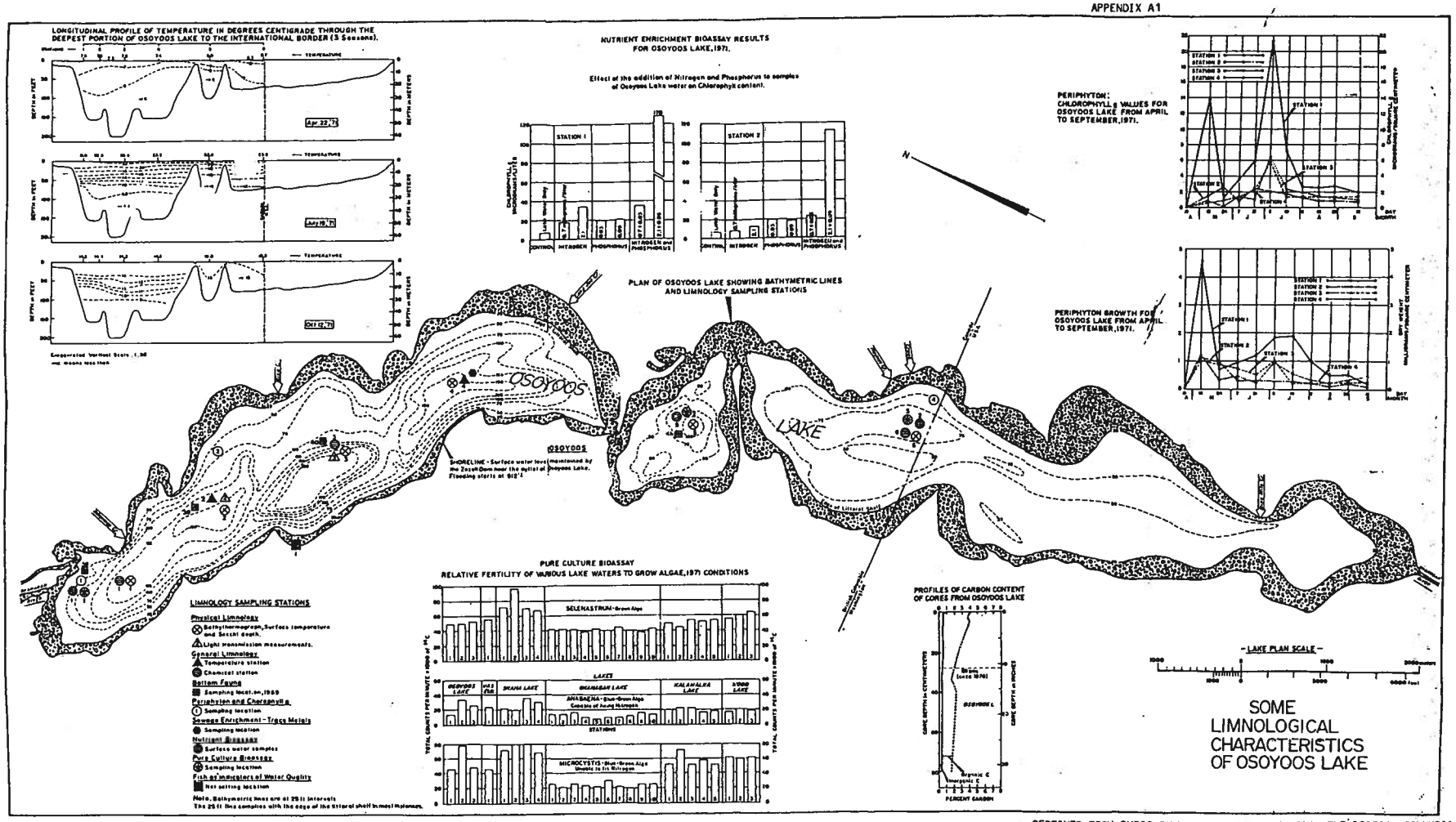
APPENDIX A

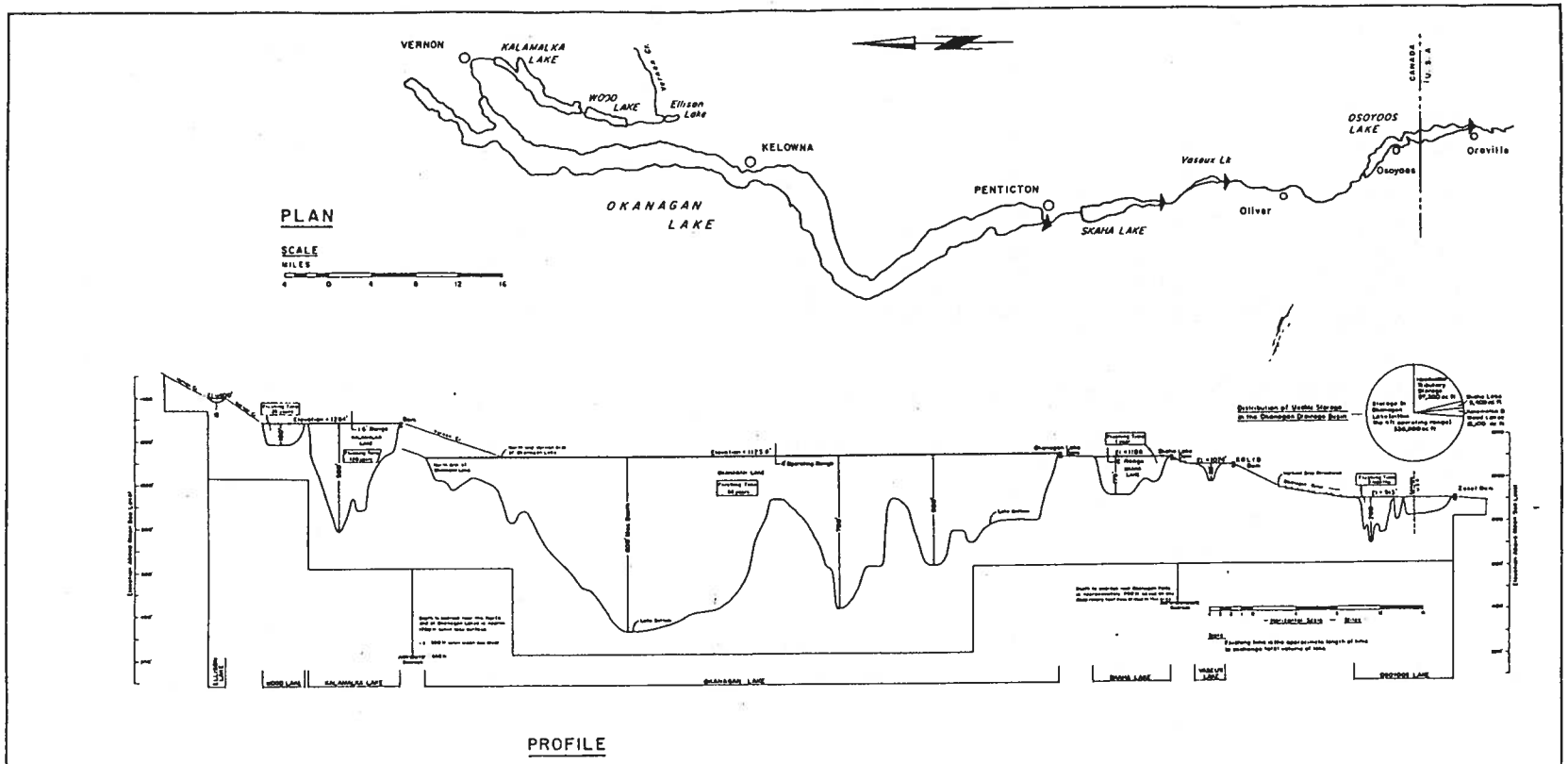
MAPS

APPENDIX A1



RECEIVED FROM CHRIS BULL - MINISTRY OF ENVIRONMENT-BRITISH COLUMBIA

APPENDIX A2



PLAN AND PROFILE of OKANAGAN MAIN VALLEY LAKES

RECEIVED FROM CHRIS BULL - MINISTRY OF ENVIRONMENT
BRITISH COLUMBIA

APPENDIX B

RAW DATA DESCRIBING SOCKEYE POPULATIONS UPSTREAM FROM WELLS DAM

Appendix B1. Estimated sockeye spawning escapement (based on spawning ground counts and the WDF method of 1/2 the Wells Dam count), and number of adults returning to the Columbia destined for the Okanogan River Basin, Washington.

Year of adult return	Estimated production of Okanogan origin [a,b]	Wells Dam count	Estimated spawning escapement [d,e]	
			from 1/2 Wells ct.	from ground observation
1926				nil
1927				nil
1928				------
1929				nil
1930				light
1931				nil
1932				nil
1933				light
1934				300-500
1935				nil
1936				1-50
1939				10,104 [f]
1940				9,691 [f,g]
1942				[g]
1943				[g]
1946				[g]
1947	172,700			6,027
1948	72,600			7,175
1949	35,100			133
1950	------			500
1951	163,600			5,602
1952	247,500			10,360
1953	236,100			15,165
1954	126,900			7,233
1955	158,200			19,320
1956	143,400			16,067
1957	87,600			8,533
1958	196,100			10,628
1959	217,400			20,847
1960	85,000			3,421
1961	36,800			691
1962	12,800			1,969
1963	36,500			---
1964	47,500			6,286
1965	40,300			5,462
1966	132,000			44,865
1967	150,000	113,232	55,616	16,786
1968	116,000	81,530	40,765	7,440
1969	39,800	17,352	8,676	6,235
1970	72,000	50,667	25,334	17,810
1971	104,100	48,172	24,086	26,728
1972	75,600	33,398	16,699	14,796
1973	43,400	37,178	18,589	6,328
1974	26,800	16,716	8,358	3,080
1975	29,200	22,286	11,143	6,684

Appendix B1. (continued).

Year of adult return	Estimated production of Okanogan origin [a,b]	Wells Dam count	Estimated spawning escapement [d,e]	
			from 1/2 Wells ct.	from ground observation
1976	32,900	27,619	13,810	8,535
1977 c.1	28,100	21,973	10,986	4,870
1978	10,100	7,458	3,729	420
1979	29,800	22,655	11,327	839
1980 c.2	29,900	26,573	13,286	5,000
1981 c.3	30,600	28,234	14,117	
1982 c.4	21,100	19,005	9,502	
1983	30,300	27,925	13,962	
1984	108,500	81,054	40,527	
1985	103,900	53,170	26,585	
1986	39,600	34,876	17,438	
1987	84,500	39,948	19,974	
1988	------	33,980	16,990	
1989	------	15,895	7,948	

[a] Estimates from 1926-1936 from Fisheries Service of Environment Canada (1973). Table 1;

[b] Estimates of sockeye run origin Mullan (1986) page 93

[c.1] Estimate from Mullan (1986), and similar within 100 fish to Pratt and Chapman (1989)

[c.2] Estimate from Mullan (1986); Pratt and Chapman (1989) estimate 28,300

[c.3] Estimate from Mullan (1986); Pratt and Chapman (1989) estimate 36,200

[c.4] Production estimated by Pratt and Chapman (1989)

[d] Estimates of escapement 1947-1980 from Mullan (1986) page 83

[e] Canadian Department of Fisheries and Oceans annual spawning ground counts

[f] Estimates for 1939 and 1940 are adults released in Osoyoos Lake; numbers derived from Table 2. Fisheries Service of Environment Canada (1973).

[g] Fingerlings planted in Lake Osoyoos and back calculated to estimate number of additional spawners

Potential to Enhance Sockeye Salmon Upstream From Wells Dam

- p.5 Has anyone checked out the two runs. Spawn mid Sept & Oct.
- p.6 Lake shore spawning limited?
- p.10 Two groups of juvenile migrants.
- p.20 FW age of fish @ 1.- is 95% or more
- p.22 Between McIntyre Dam - Oliver could support 35K spawners.
- p.26 T in Osoyoos is already higher than most sockeye lakes. Lack of cold water refuge areas will decline # smolts.
- p.33 Will we initiate the investigations outlined here?
- p.34 What is status of Zosel dam County CRITFC?
- p.39 Plans for DCPUD ground well @ mouth of Okanogan R.

Appendix B2 Proportion of run destined for Okanogan as estimated by dam counts at Rock Island and Rocky Reach (1962-1989). Adapted from unpublished data from Dell, Grant County PUD, 1-30-90.

Year of adult sockeye return	Adult Sockeye Dam Counts Rock Island[a]	Rocky Reach[b]	% of Run crossing Rocky Reach
1965	42,380	31,735	75
1966	164,547	129,557	79
1967	119,765	109,434	91
1968	104,790	91,376	87
1969	37,965	70,374	54
1970	74,904	57,251	76
1971	71,438	49,838	70
1972	43,467	26,978	62
1973	68,732	48,856	71
1974	33,859	20,976	62
1975	53,405	76,925	50
1976	35,407	27,205	77
1977	90,262	25,648	28
1978	14,748	8,157	55
1979	50,485	28,747	57
1980	52,658	29,906	57
1981	47,139	30,649	65
1982	41,111	17,379	42
1983	86,424	26,079	30
1984	109,074	73,290	67
1985	103,230	54,077	52
1986	49,789	32,912	66
1987	70,673	41,115	58
1988	49,159	34,090	69
1989	37,360	16,176	43

a. Sockeye crossing Rock Island are a mixed stock originating from the Wenatchee River and Okanogan River Basin.

b. Sockeye crossing Rocky Reach are primarily Okanagon fish, though some turn occurs to the Entiat and Methow.

Table B3. Rocky Reach and Wells Dam counts (in thousands) and an estimated percent mortality or turn off. [a]

Year	Rocky Reach (Thousands)	Wells (Thousands)	% Mortality
1967	109.4	110.0	-----[b]
1968	91.4	81.4	11
1969	20.4	17.3	15
1970	57.2	50.3	12
1971	49.8	48.3	3
1972	27.0	33.1	-----
1973	48.9	38.1	22
1974	21.0	16.6	21
1975	26.9	22.2	18
1976	27.2	27.6	-----
1977	25.6	22.0	14
1978	8.2	7.3	11
1979	28.7	26.7	7
1980	29.9	26.5	11
1981	30.6	28.0	8
1982	17.4	18.7	-----
1983	26.1	27.9	-----
1984	73.3	81.1	-----
1985	54.1	53.2	2
1986	32.9	34.9	-----
1987	41.1	40.0	3
1988	34.1	34.0	0
1989	16.2	15.9	2

[a] A few Entiat fish turn off between Rocky Reach and Wells Dam, but their numbers are small enough to have little effect on these estimates of loss or mortality.

[b] Chronic problems exist with the comparison of counts at these two dams: mortalities were not calculated when more fish seen at Wells than Rocky Reach.

Appendix B4. Summary of sockeye planting records for Lake Osoyoos as presented by Mullan (1986).

Brood Year	Egg Source	Number Release	Place Release	Size @ Release	Date Released	% Returning as adults
1939	wild	10,104	Osoyoos	adult	-----	----
1939	Okan R.	15,932	Osoyoos	-----	4&5/41	0.43
1940	wild	9,691	Osoyoos	adult		
1940	Rock Is.	370,420	Osoyoos	87.5/lb	5/42	0.15
1940	Rock Is.	50,040	Osoyoos	95.0/lb	11/41	2.66
1940	Rock Is.	25,000	Osoyoos	80.0/lb*	5/42	0.15
1940	Rock Is.	519,256	Osoyoos	95.0/lb	11/41	2.66
1941	?	84,000	Osoyoos	117.0/lb	/42	--
1942	Rock Is.	31,264	Osoyoos	52.0/lb	3/44	0.20
1942		36,400	Osoyoos	52.0/lb	3/44	0.20
1942	Rock Is.	33,864	Osoyoos	117.0/lb	10/43	1.87
1942		84,456	Osoyoos	117.0/lb	10/43	1.87
1942		534,204	Osoyoos	90.0/lb	10/43	1.87
1943		577,227	Osoyoos	90.0/lb	10/44	1.87
1943		510,911	Osoyoos	106.0/lb	10/44	1.87
1946	Methow	337,590	Osoyoos	95.0/lb	4/47	ND
1948	Methow	524,400	Osoyoos	45.9/lb	9/49	ND
1952	L.Wenatchee	79,040	C.R.@Pateros	159.0/lb	?/53	ND
1957	L.Wenatchee	627,460	Osoyoos	32.0/lb	?/58	ND
1957	L.Wenatchee	466,678	Osoyoos	26.0/lb	?/58	ND

from Mullan (1986); pages 16-17;18-19.

* could be 87.5/lb

APPENDIX C

KOKANEE RELEASED INTO SKAHA AND OKANOGAN LAKES

Table C1. Kokanee (in thousands) released to Skaha Lake from Bull (1987) page 16.

Year	Number released (thousands)	Dates at release	Size (grams)
1981	118	July 17-July 20	0.2-1.0
1982	536	May 1-June 21	1.3-2.5
1983	548	May 6-June 29	1.6-4.5
1984	458	May 2-July 30	2.8-4.6
1985	411	May 30-July 15	0.5-3.7
1986	600	April 21-June 3	1.1-3.0
Total	2,671		

Table C2. Kokanee releases into Okanogan Lake (Bull 1987)

Year	Number (Thousands)	Size @ Release (Partial count in thousands)
1978	210.0	fry (60.0) eggs (150.0)
1979	1145.0	fry (42.0) eggs (1103)
1980	93	fry (@ 0.25 gm)
1981	900	eyed eggs
1982	374	fry
1983	62	fry (@ 1.6 gm)
1984	----	
1985	50	swim up fry
1986	1328	swim up fry (50) eggs (390) fry (888; @ 0.2-2.8 gm)
1987	1238	fry (@ 1.5 gm)

APPENDIX D

SELECTING ENHANCEMENT STRATEGIES AND DESIGNING EVALUATION AND MONITORING PROGRAMS

APPENDIX D

SELECTING ENHANCEMENT STRATEGIES AND DESIGNING EVALUATION AND MONITORING PROGRAMS

Selecting an Enhancement Strategy

We recommend exhausting natural production enhancement possibilities before use of intensive aquaculture facilities. We believe selecting the most cost-effective enhancement of natural production requires an understanding of early survival, since we assume there is additional sockeye rearing space and food in Lake Osoyoos. A series of pilot programs would provide the required information, but require time. Any alternative described might provide an immediate attempt to increase production, without cost-effective criteria.

Any enhancement effort selected would test the fry capacity of Lake Osoyoos to a degree. We recommend monitoring the relationship between smolt production and size for some evidence of approaching density dependent growth with any enhancement effort.

Evaluation and Monitoring

Evaluation and monitoring of the additional yield of naturally produced sockeye smolts is difficult. Additional fish production resulting from enhancement measures cannot be identified for subsequent recovery. Only a discrete period of survival, or component of an enhancement program, can be tested. Attributing small increases in smolt yields to enhanced natural production is not possible. Smolt yield evaluations before-and-after in management-scale enhancement programs might be feasible.

Enhancement with hatchery practices, although less desirable in many respects than promotion of wild/natural production, permits marking fish with half-tag coded wire tags (CWT). Enhancement assessed on a component basis is possible with recoveries of marked smolts and adults.

Although assessment of enhancement success is not within the scope of our evaluation of sockeye potential upstream from Wells Dam, we offer the following suggestions for evaluation and monitoring. No recommended order of priority is attached to numbering. We emphasize that several evaluations in the categories A to C below could proceed at the same time, and are not mutually exclusive.

Evaluation of measures designed to stimulate natural yield

A. Measures with minimal interference:

1. Increased escapement.
   a. Monitor adult escapement at Zosel Dam.
   b. Radio-tag 200 adults for each of two years to assess pre- spawning mortality and assess spawning distributions to find any formerly unidentified areas (eg. deep-water sites).

2. Increased production from escapements.
   a. Assess intragravel temperatures.
   b. Assess gravel composition in spawned and unspawned gravels.
   c. Assess dissolved oxygen in redds.
   d. Hydraulically sample pre-hatch egg survivals.
   e. Measure a-d after gravel cleansing. May be done in parallel on test and control areas.
   f. Expand [e] if successful and repeat as needed, based on monitoring.

3. Best management practices.
   a. Adopt [e] on extended basis if successful, monitor, repeat as needed.

B. Measures with modest interference:

1. Increased pre-spawning survival.
   a. Assess adult survival and egg viability after adult maturation in groundwater.
   b. Assess adult survival and egg viability after holding in tanks chilled by heat exchange with hypolimnetic water or chillers.
   c. Assess adult survival and egg viability after holding in Wells spawning channel.
   d. Expand [a], [b], [c] in accord with success.

2. Increased incubation survival.
   a. Using fertilized eggs from adults from B.1., assess survival and timing to emergent fry in hanging baskets in Lake Osoyoos.
   b. Monitor lake temperatures, benthic plants, fines deposition associated with 2.a.
   c. Using fertilized eggs from adults from B.1., assess survival and timing to emergent fry in streamside hatch boxes.
   d. Using fertilized eggs from adults from B.1., assess survival and timing to eyed stage in Heath incubators. [Eyed eggs may prove more suitable for use in hanging baskets or hatch boxes if emergence timing proves

unsuitable in terms of lake temperature or availability of vegetation for cover.]

e. Expand most successful elements [a-d] sufficiently to provide management level tests. Evaluation must consist primarily of monitoring of component survivals. Hydroacoustic assessment of pre-smolt abundance may be useful, as may scoop trapping at outlet with appropriate efficiency assessment.

3. Best management practices.
   a. Use best combination of measures.
   b. Monitor success with hydroacoustics and scoop trapping with known efficiency.

C. Measures with extensive interference.

1. Partial rearing size.
   a. Using fertilized eggs from adults from B.1., assess egg survival in groundwater incubation to swim-up.
   b. Monitor disease incidence.
   c. Determine survival and growth to partial rearing. [Partial rearing here means to sizes sufficient to permit insertion of half CWTs or PIT tags. Fingerlings should be retained and fed for two weeks minimum after tagging so that disease incidence from tagging can be reduced with antibiotics.]
   d. Test survival to smolt stage of rearing to two sizes; minimum size for CWT insertion, and a larger size.

2. Release of partially reared fish.
   a. Test release locations/times by releasing test CWT groups to (1) pelagic waters; (2) benthic vegetation; (3) net pen for feeding and subsequent release in pelagic waters just before surface of Lake Osoyoos reaches about 58 degrees F.
   b. Scoop trap lake outlet to recover samples of CWTs. Sacrifice to assess codes.

3. Smolt rearing.
   a. Using fertilized eggs from adults from B.1., assess survival from egg to smolt in hatchery rearing.
   b. Assess best time/size for smolt release.

4. Best management practice.
   a. Expand successful elements in C.1-3 sufficiently to provide enough adult returns for evaluation.
   b. Monitor production level efforts with smolt output and/or adult return. Smolt evaluation may demand annual trapping with trap efficiency assessment. Hydroacoustic assessment of pre-smolts may prove useful if partial rearing is used rather than smolt release.

APPENDIX E

DESCRIPTION OF HANGING BASKET INCUBATORS

(QUOTE FROM HADDIX 1986)

The "incubation boxes" used were constructed from Washington pond trays which were previously used in FRED hatchery incubation units.

These trays consist of a 15" x 30 1/2" aluminum frame with 1/4" mesh vexar netting. The trays are used as a top and bottom of a sandwich of plastic saddles. The bottom tray was also lined with #12 nylon Screen. The nylon screen prevented alevins from migrating down and out of the "box" after they hatch.

Eggs were placed evenly over the saddle substrate of each layer approximately 3500 eggs per layer.

The individual trays were stacked in a "jig" frame to hold them in place, with a 3" piece of wood 2" x 2" at each corner to act as spacers between each layer. Four trays were placed in each unit and strapped together with plastic banding tape (Figure 1).

The unit with four egg trays was 15 1/2 x 30 1/2 x 15" and held approximately 14,000 eggs. Any number of trays could be stacked in this manner with 5 1/2" added for each tray and spacer. Anything over 10 trays would be difficult to handle.

APPENDIX F

INTERNATIONAL WATER MANAGEMENT IN THE OKANOGAN

1867-1965 as Described by Quinn (1965)

1867 British North American Act-describes the role of the provincial and federal Canadian entities with respect to water management (Quinn 1965).

Irrigated agriculture dominated the economy of the Okanogan Valley as early as the turn of the century

1909 Boundary Waters Treaty Article III provides for an International Joint Commission to review and make decisions about waters crossing the international border (Quinn 1965).

The drought of 1928-1931 prompted an increased interest in irrigation storage in Canada and the US.

1930's Construction of Grand Coulee Dam.

By 1935 snowpack monitoring and annual run off forecasting procedures were established.

1939 Grand Coulee Dam closed.

1939-1943 Sockeye destined for basins upstream from Grand Coulee, Osoyoos and Wenatchee were trapped at Rock Island Dam and transported to Wenatchee and Lake Osoyoos.

Flooding in 1942 and 1948 destroyed many of the orchards and homes in the Okanogan valley and flood control projects became a priority for the region.

Negotiations for hydroelectric development in the upper Columbia River watershed prompted a review of water uses in the Okanogan.

1943 State of Washington requested the IJC review the restrictive effect of Zosel Dam on Lake Osoyoos; this was prompted by a flood of the area.

1944 the International Joint Commission established the International Columbia River Engineering Board to examine water development in the Columbia River basin

1946 International Joint Commission Order (Sept 12,1946) approving the alteration of Zosel Dam and establishing the International Osoyoos Lake Board of Control.

1946 The International Joint Engineering Board proposes a flood control project that requires the channelization and excavation of the Okanogan River channel upstream from Lake Osoyoos.

1948 the U.S. proposed the Shakers Bend project on the Similkameen River.

1949 Agreement that Canadians would only divert freshett flows in the Similkameen for new irrigation.

By 1949 it was clear that additional water development for irrigation would endanger the sockeye production in the Okanogan. The US objected to the proposed Okanogan Flood Control Project (which included channelization of the river in Canada) on the basis of the sockeye spawning habitat. At the time sockeye populations were low, and fisheries concerns, particularly those of the Indian tribes in Canada eliminated the Okanogan from consideration for hydroelectric development.

1951 Canadian rejection of the American suggestion for fish ladders permitting access to Okanogan Lake.

1952 U.S. Public Law 577 authorizes financial assistance from Chief Joseph power revenues to irrigate lands in the Okanogan valley IF there is an agreement with Canada to store Similkameen waters over Canadian lands.

1953 Canada Water Conservation and Assistance Act

1954 The Okanogan Flood Control Project compromised by leaving one of the 23 miles of river planned for channelization in to 17 miles of river for sockeye spawning and the 3 foot drop structures would only be one foot drop structures.

1955 International River Improvements Act requires federal authorization of anything affecting flows on a river crossing the international order.

_____ Prairie Farm Rehabilitation Administration has subsidized with federal dollars flood relief and control activities in the basin.

1958 British Columbia Provincial Water Act.

1959 The Okanogan Basin studies were complete and the effect of the IJC was to prevent additional storage and use of water in Canada.

APPENDIX F (continued)

WATER MANAGEMENT AGREEMENTS OF THE 1980's

1980 The Province of British Columbia and the State of Washington cooperative plan for Osoyoos Lake levels and trans-border flows (Oct 1980). Agreement concerning criteria for operation of a new control structure at Zosel Dam, the lake outlet.

1982 Okanogan Lake and River operation plan (February 1982) updating the July 1976 operating plan.

1982 International Joint Commission Order of approval for the operation and construction of a new Zosel Dam (Dec. 1982).

1985 Supplementary order (Oct 1985) verifying the reconstruction of Zosel Dam and issued raised by Chief Baptist of the Osoyoos Indian Band.

1987 International Joint Commission Order of Approval for the construction of Zosel Dam (April 1987).

1987 The Province of British Columbia and the State of Washington Memorandum of Understanding concerning the operating plan for Zosel Dam, and Lake Osoyoos water levels (Sept 1987)

1988 Memorandum of Understanding between Washington Departments of Ecology, Fisheries and Wildlife and the Colville Indian tribe related to the operation of Zosel Dam (March 1988)

1989 Addendum to the Memorandum of Understanding between Washington Departments of Ecology, Fisheries and Wildlife and the Colville Indian tribe related to the operation of Zosel Dam. Establishes coordination of flows and sockeye smolt emigration (Sept. 20, 1989)

NOTES FROM THE
MID-COLUMBIA COORDINATING COMMITTEE
AND THE
WELLS COORDINATING COMMITTEE
CONCERNING THE WELLS PROJECT

APPENDIX - H

MEMORANDUM

MID-COL 90-1

TO: Hon. Stephen L. Grossman, Administrative Law Judge

FROM: Richard R. Whitney, Mid-Columbia Coordinator

DATE: March 19, 1990

SUBJECT: Summary of Meeting of February 22, 1990

Agreements Reached

1. There will be another negotiating session on the Rocky Reach extension at a meeting on March 19, 1990.
2. The parties have agreed that there should be provision for additional years of testing of a prototype bypass device at Rocky Reach.
3. There will be a comment period until March 9, 1990 for draft study plans submitted by Grant County PUD.
4. Douglas County PUD will submit draft study plans for evaluation of fish guidance efficiency at Wells Dam, and for recovery of marked fish from the study of accelerated smoltification of spring chinook in the next week to 10 days.
5. The next meeting of the Mid-Columbia Coordinating Committee will be 10:00 A.M., March 19, 1990 at the West Coast Sea-Tac Hotel.

The meeting was convened at 10;00 a.m. February 22, 1990 at the West Coast Sea-Tac Hotel. The agenda followed was include in the meeting announcement mailed to the full mailing list on February 14, 1990. Those in attendance are listed on the attached roster. The Coordinating Committee meeting was preceded at 9:00 A.M. by a negotiating session on the Rocky Reach extension of the Stipulation.

I. Chelan County PUD. Rocky Reach Agreement and Study Plan.

Dick Nason provided a report on the status of the installation of the new prototype bypass at Rocky Reach Dam. The extension of the curtain wall has been built and is being painted. The material for the bar screen is ordered. The vertical barrier screen is being built. Everything is on schedule for placement in the intake slot by March 31, 1990. The next step is assembly of the parts. They will borrow the apparatus from Grant PUD to release fish at specified depths in the gatewell. There will be a new gatewell dipper, all steel in construction, which will expedite the dipping process as it should sink more rapidly. Transducers are being placed for the hydroacoustic study of fish distribution and reaction to the prototype. It was pointed out that the study plan was approved last fall, but that it did not include description of the horizontal distribution of fish across the powerhouse as HTI is now proposing. The committee requested that Chelan submit a study plan that includes this modification for approval by the committee.

There was a discussion of the design and operation of the new gatewell dipper. It will include on the upper edge a brush designed to clean the VBS as the dipper is brought to the surface. Concern was expressed that trash would be entering the receiving tank along with the fish. It was suggested that some mechanism be provided at the upper lip

of the device to retain the trash and keep it from dropping into the fish container at the bottom. Nason said it would be modified in some way so that either the brushes can be removed during fish dipping and replaced for a subsequent cleaning operation, or a way would be found to separate the fish from trash.

There was a discussion of the conduit at the dam for fish diverted by the bypass. The best location appears at this time to be in front of the dam on the curtain wall. It depends on the ultimate location of the bypass. If the bypass is placed so that the trash racks must be hung on the face of the dam then it will not be possible to place the conduit there. Chelan has done some preliminary evaluation, but it would be premature to try to be more specific at this time. Chelan will have a proposal or a set of options available by August, 1990 assuming the tests of the prototype this spring are successful or promising.

The parties have made progress in negotiations related to a long-term agreement at Rocky Reach. Agreement has been reached that it is appropriate to provide an additional number of years for testing of a prototype fish bypass at the project. The parties scheduled a further negotiating session for 9:00 A.M. March 19, 1990 at the West Coast Sea-Tac Hotel.

II. Grant County PUD. Study Plans.

Due to foggy conditions, Don Zeigler's flight out of Moses Lake was canceled, and he was unable to be present. However, a set of study plans had been mailed out to the committee members. The chairman was able to discuss a method of proceeding with him by telephone. The committee was not ready for a full discussion because they had not yet had time for an adequate review. It was decided to proceed with a general discussion in order to provide where appropriate some initial guidance to Grant PUD for revision of the plans. Comments and suggestions received were then forwarded to Zeigler by the chairman in a telephone conversation February 26, 1990.

1. Recovery of Marked Fish From Transportation Study.

The committee recommended that the section on recovery of fish from the study of accelerated smoltification of spring chinook be separated from the recovery of transported fish. Although there should be some recoveries of fish from the accelerated smoltification study, it is not clear how many might be expected. Rod expressed concern about the operating schedule for the trap and the possibility that chinook might be delayed in their transit through the fish ladder when perhaps very few recoveries might be expected. It was suggested that both for the transportation study and the accelerated smoltification study, it would be desirable to develop some kind of a numerical estimate of the numbers of fish expected to return, the potential differences in return rate anticipated, and from those numbers determine an appropriate sampling rate that would make it possible to statistically detect the differences.

2. Alternative Anesthetics Study.

The suggestion was made that it probably would not be necessary to design this as a full-blown study. A literature search and/or discussions with hatchery managers would probably bring the desired information on alternatives to MS-222. It was mentioned that CO_2 is used at Bonneville and Spring Creek as well as several other locations. Stephanie reported that she understood it may be hard to get the right concentration of CO_2 in the water. Rod mentioned reports of damage to eggs from use of electricity. There is a high potential of damage to fish, and danger to the opera-

tors.

3. **Proposal to Hydroacoustically Evaluate the In-Turbine Diversion Screen and the Bypass Effectiveness of the Sluiceway at Wanapum Dam in 1990.**

There was a brief discussion of the part of the study having to do with horizontal distribution of fish near the sluiceway. There was a question about how far away fish might be affected or attracted to the flow. But the committee was not prepared to discuss this proposal in detail.

4. **1990 Prototype Evaluation, Wanapum Dam Fish Guidance Screen.**

There was a feeling that the evaluation criteria are very general. A question was raised about the basis of the theoretical fish guidance efficiency referred to on p. 3. [Fyke netting studies of vertical distribution of fish in the intakes compared to the expected depth of operation of the screen.] A comment was made that it would be desirable to specify decision points for going forward or not with further tests during the spring season depending on early results. It would be desirable to agree to specific criteria in advance of the season. Although the expectation is that it will perform as well as the bypass tested at Priest Rapids, the question is what do we do if it doesn't?

5. **Continued Evaluation of the Priest Rapids Prototype System.**

It was noted that the study would focus on a comparison of descaling rates in the prototype bypasses at Priest Rapids and Wanapum. A question was raised about whether the information would be useful. A question was asked about what level of difference is expected. Considering that expected difference, what sample size would be required to show a difference or to convince us there is no difference?

With respect to these draft study plans, the committee agreed to provide written comments to Don Zeigler by March 9, 1990. The committee would like to see revisions prior to their next meeting.

III. Other

1. Douglas County PUD Status Report.

Mike Erho provided a report on Wells Dam. (A) Turbine replacement continues. The 9th turbine has been replaced. The 10th will be completed by July. This means one unit will be down during the spring outmigration. (B) A new set of flow barriers was ordered last fall. These will be installed in time for the spring outmigration. With these in place all five sets will be the same. (C) John Skalski of the University of Washington has been working on a study plan for evaluation of the bypass. Skalski has sent it to Phil Mundy for review. The Coordinating Committee considers that Skalski, Mundy and Sandford (NMFS) are a working group that is developing the study plan for use in evaluating the bypass this spring. Hydroacoustic measures will be used. Biosonics will follow the protocol in the plan. It calls for placement of transducers at 2 of the 3 intake slots for each unit in addition to transducers for each spillbay. (D) The long-term agreement for Wells Dam is still on hold. They have a draft agreement with the US Fish and Wildlife Service for an option to make water available for certain purposes out of the water right for the Winthrop hatchery. Those purposes would include filling the pond, which had been a concern of Washington Department of Ecology. The long-term agreement will be finalized when the water right agreement is finalized. Karen Pratt of Don Chapman Associates is working on a plan for sockeye enhancement, which is part of the long-term agreement. Douglas PUD has

determined that the Corps of Engineers does not require a permit for the intake and outfall. They have calculated the probable constituents in the outfall of the acclimation facilities, and concluded that they will not need an NPDS permit. But they are going through the process of application in order to obtain a ruling and satisfy Washington Department of Ecology. At the end of March they will interview firms to design facilities. They will go for construction bonds in August. Design will take place in the fall, begin construction in winter, and finish in the spring. There was a question about the fish ladder trap at Wells Dam. Erho responded that funds are not available for the work, which they had hoped to do this winter. They have a design, and a cost estimate of about $500,000.

2. **Accelerated Smoltification of Spring Chinook.**
The committee recommended development of a specific study plan for recovery of adults expected to return from the accelerated smolts released in the first year of the study. Mike Erho will provide a proposal in the next week or 10 days. He reported that there are now 120,000 juveniles at Wells hatchery that are 102 per pound. This is about the same size as last year, so it appear we will not achieve our objective of getting the fish to 20 per pound at release in the spring. The reason is that they were not sent to Wells as early as planned, due to a question whether the Leavenworth hatchery would be able to spare them after all the screening for IHN and BKD was completed at Leavenworth. They were held until it was clear that Leavenworth would satisfy their production needs.

3. **Monitoring Nitrogen Levels in the Mid-Columbia.**
Mike Erho commented that the PUD's had again been requested to install nitrogen monitoring equipment at their projects, and to transmit the data to the Corps of Engineersduring the period of the spring outmigration. He questioned whether these data are actually necessary or useful under present conditions. Douglas County PUD will cooperate as in the past and provide the data, but he would like to know what purpose they serve.

4. **The committee agreed to meet again on March 19, 1990 at 10:00 A.M. at the West Coast Sea-Tac Hotel.** The agenda will include review of Grant PUD's study plans and the Wells Dam bypass evaluation and plan for the adult recovery in the accelerated smoltification study. The meeting will be preceded by a negotiating session on the Rocky Reach extension.

MID-COLUMBIA COORDINATING COMMITTEE
Meeting February 22, 1990

ATTENDANCE ROSTER

NAME	REPRESENTING
Ron Boyce	Oregon Dept. Fish and Wildlife
Stephanie Burchfield	Col. River Intertribal Fish Comm.
Dennis Rohr	Mid-Columbia PUD's
Bob Clubb	Power Purchasers
Mike Erho	Douglas County PUD
Frank Young	Oregon Dept. Fish and Wildlife
Bob Vreeland	Natl. Marine Fisheries Service
John Williams	Natl. Marine Fisheries Service
Tom Scribner	Yakima Indian Nation
Rod Woodin	Washington Dept. of Fisheries
Jerry Marco	Colville Tribe
Tony Eldred	Washington Dept of Wildlife
Tracey Steig	Hydroacoustic Technology Inc.
Don Clark	Portland General Electric
Willard Fields	Chelan County PUD
Dick Nason	Chelan County PUD
Dick Whitney	The Committee

MEMORANDUM

MID-COL 90-2

TO: Honorable Stephen L. Grossman,
Administrative Law Judge, FERC

FROM: Richard R. Whitney, Chairman,
Mid-Columbia Coordinating Committee

DATE: May 21, 1990

SUBJECT: Summary of Mid-Columbia Coordinating Committee Meeting of March 19, 1990

Agreements Reached

1. The Designated Representatives for Spill are as follows:
   For Wells Dam - Rod Woodin, Jerry Marco and Mike Erho
   For Rocky Reach Dam - Rod Woodin, Jerry Marco and Steve Hays
   For Wanapum and Priest Rapids Dams - Bob Vreeland, Tony Eldred and Stuart Hammond.

2. The Coordinating Committee approved the study plan for hydroacoustic monitoring of the horizontal distribution of fish at Rocky Reach Dam.

3. The Coordinating Committee approved the study plan for evaluation of the prototype bypass at Wanapum Dam, with the understanding that there would be consultation during the season to determine whether there are significant problems and if so to decide whether to continue testing or to modify the configuration before further testing.

4. With respect to the recovery of adults in the study of early smoltification of Spring chinook, the committee asked Grant PUD to prepare an analysis to show how many adults from the study might be expected to be seen in the coded wire trap at Priest Rapids to help determine whether it would be worthwhile to operate it for that purpose. Don Weitkamp was assigned to produce the analysis, and to distribute it to the committee by FAX on or before April 5, 1990. A telephone conference call was scheduled for April 9, 1990 at 9:00 A.M. for the committee to review the analysis. Chelan PUD will provide a plan for carcass recovery at the meeting of the committee in May.

5. The Coordinating Committee approved the study plan for operation of the coded wire trap for the purpose of recovery of sockeye from the transportation study.

6. The Coordinating Committee approved the study plan for continued evaluation of the prototype bypass at Priest Rapids Dam.

7. The Coordinating Committee approved the study plan for evaluation of the prototype bypass at Wells Dam, with the understanding that the committee will discuss further the criteria to be used for startup in the summer.

8. The Coordinating Committee agreed the next meeting will be May 10, 1990 in Wenatchee, to be coordinated with a site visit May 9 and 10, 1990.

The meeting was convened at 9:30 A.M. March 19, 1990 at the West Coast Sea-Tac Hotel. The agenda followed was the one included in the meeting announcement mailed to the full mailing list on March 12, 1990. Those in attendance are listed on the attached roster. The meeting was preceded by a negotiating session of the parties to the interim agreement on Rocky Reach. The interim agreement calls for the parties to engage in negotitations to attempt to reach a long-term agreement. The parties feel that they have satisfied that condition of the interim agreement by conducting negotiations. However, it appears that it will not be possible in the near future to reach a long-term agreement. The parties probably will proceed under the annual renewal clause of the interim agreement.

1. Chelan County PUD.

Horizontal Distribution of Fish. Dick Nason reviewed the study plan for hydroacoustic monitoring to determine horizontal distribution of smolts at Rocky Reach Dam. The study plan for evaluation of the prototype bypass was approved by the committee last fall, but it did not include a provision for study of the horizontal distribution of fish which is included in the present study plan. The committee approved the study plan as presented. A copy is attached for reference. Nason reported that Chelan PUD is on schedule for testing of the prototype bypass in 1990. The pieces are in place.

2. Grant County PUD.

Progress Report. Don Zeigler provided a progress report for the Wanapum Dam bypass. Equipment will be delivered March 27, 1990. It includes the diversion screen, the barrier screen and the extractor. The trash racks are on site. The unit is scheduled to run April 1, 1990. At Priest Rapids the unit with the bypass is down and will not be up until May 5, 1990 at the earliest.

Prototype Bypass Evaluation at Wanapum Dam. Zeigler reviewed the study plan for evaluation of the bypass at Wanapum Dam. The study plan was revised and issued March 12, 1990. The plan was somewhat misleading in that it apparently gave the impression that the configuration of the bypass apparatus might be modified during the season. In fact, Grant County has proceeded with confidence that the prototype will operate satisfactorily because it is adapted and improved from design of the bypass tested at Priest Rapids Dam. Therefore there is no provision for modification of the design during the season. There was a discussion of possible steps that might be taken. A question was raised whether, if problems are encountered, velocities might be reduced by backing off on the unit. This, it was thought might save some time in modeling later. The point was made that a velocity problem would probably show up as descaling. It was suggested that the portion of the study dealing with descaling would detect the problem and attempt to find the place in the system where it occurs. Modifying velocities at given locations becomes a mathematical problem. Zeigler pointed out that if a problem is encountered there would not be time during the season to make any modifications in the design and get the apparatus back in the water before the season would be over. There was a discussion of impingement. A concern was expressed that impinged fish are washed off as the screen is brought to the surface of the gatewell. It was also noted that the backwash created as the unit is shut down will wash impinged fish off the screen before they can be observed. Descaling is probably the best measure of impingement that is available. The committee expressed concern that the study

should incorporate a decision point where it could be terminated if the bypass is obviously not working satisfactorily. Don Zeigler responded that Grant County PUD would be in communication with the committee during the season. If a problem is observed, there would be a consultation on what the next step should be. With that understanding, the committee approved the study plan for evaluation of the bypass at Wanapum Dam. A copy of the plan is attached.

Transportation Study - Mark Recoveries in Priest Rapids Trap. There was a discussion of the question whether it would be productive to operate the coded wire trap for recovery of adults marked as part of the study of early smoltification of Spring Chinook. The committee asked for an analysis to show how many recoveries might be expected. Grant PUD assigned Don Weitkamp to develop the analysis for distribution to the committee by FAX on April 5, 1990. The committee agreed to discuss the analysis by telephone conference call at 9:00 A.M. April 9, 1990. Those to be included in the conference call are; Rod Woodin. Don Zeigler, Mike Erho, Bob Vreeland, Don Weitkamp, and Dick Whitney. Dick Nason will provide a study plan for recovery of carcasses of adults prior to the next meeting of the committee.

There was a discussion of the part of the study plan dealing with recovery of sockeye from the transportation study. Rod Woodin asked for a target date for the final report on transportation. It ought to be possible to decide on an appropriate cutoff date for mark recoveries and to schedule the final report accordingly. Zeigler will talk to NMFS people who have the data on mark recoveries. Reading of the marks is the slowest part of the process. He will have a statement on the date for the final report at the May meeting of the committee. The committee then approved the study plan for operation of the coded wire trap. A copy of the plan is attached.

Evaluation of Priest Rapids Bypass. Rod Woodin expressed an interest in seeing the bypass operated seven days a week in a salvage mode rather than placed in a study plan. Zeigler responded that this has not been done before. On week-ends it has been pulled up and dogged off in the gatewell. There were high numbers of fish in the gatewell one year when it was dipped on Monday. Typically, low flows on week-ends have kept the numbers low. Use of caution in dipping on Mondays, and care in not overloading the container would avoid loss of fish. A concern was also expressed that data on descaling should be collected for the fish in the sample on Monday, but that the data should not be included in the analysis of descaling caused by the bypass. After further discussion, the study plan was approved by the committee. A copy is attached.

Hydroacoustic Evaluation of the Bypass at Wanapum and of the Effectiveness of the Sluiceway in Passing Fish. After full discussion the committee approved the study plan as submitted February 2, 1990. a copy is attached.

3. Douglas County PUD.

Bypass Evaluation Mike Erho presented a report on how the study plan for evaluation of the bypass at Wells Dam was developed. John Skalski of the University of Washington developed a draft proposal which was reviewed by the others in the statistical working group consisting of Phil Mundy and Ben Sandford. The plan was distributed to the committee

March 5, 1990. A question was raised about the criteria to be used for starting the summer study. Erho responded that Douglas County PUD has looked at Fyke net data to be used to correct the hydroacoustic index. In particular, it is necessary to adjust the index for species composition in the summer when many non-salmonid species are present at times. By the time of the summer study they hope to have an adjusted index available. The committee approved the study plan with the understanding that they will discuss further the criteria for a summer start. A copy of the study plan is attached.

Progress Report on Long-Term Agreement. Mike Erho reported that the long-term agreement has been held up awaiting a decision by Washington Department of Ecology on the water right needed to operate facilities for compensation. Douglas County PUD has a hydraulic permit from the state for construction on the Methow River. The Corps of Engineers has found that permits are not required under Corps authority. An agreement is near with the Fish and Wildlife Service for the temporary emergency use of their water right should it become necessary. The statewide requirements for obtaining hatchery discharge permits have a 60-day period for comments. Douiglas PUD submitted their application February 28, 1990. Douglas PUD met with the Yakima office of DOE to provide information on the expected discharge from the 3 acclimation facilities. Douglas feels that a permit should not be required, since the weight of fish and the volume of food do not come up to the criteria needed for a permit. Apparently, DOE is concerned about the potential discharge load at the time the fish would be released. Rod Sakrison pointed out that DOE did not have statewide criteria until Monday of this week. The Regional Offices are now implementing these. Douglas County PUD feels that they could proceed if they were issued a water right for the acclimation facilities. They would then assume that a permit would be issued for the hatchery. There was a discussion of the water right situation. It appeared at one time that the problem was being solved. It now appears that DOE may feel that water rights on the Methow are such a sensitive issue, particularly because the agency has established a period until June 30, 1990 during which the general matter of water rights there will be under study. Rod Sakrison pointed out that it would be difficult for DOE to issue a new water right at a time when a study is under way to develop a plan for water use in the Methow Basin. The point was made that all concerned would probably recognize that the hatchery and acclimation ponds are non-consumptive uses that should not affect or be affected by such a plan. It was pointed out that the same problem is affecting implementation of the Rock Island Agreement and has a potential of impacting agreements for all three PUD's. Mike Erho pointed out that Douglas PUD will need a decision on the water right no later than July 1, 1990 in order to meet deadlines for issuing construction bonds. If the decision is no, there would be an effect on all three PUD's because they are combined in the allocation of tax free bonds at the state level. This could lead to serious problems in construction of bypass as well as implementation of compensation plans.

4. Other.

Next Meeting. At the February 22, 1990 meeting, the committee agreed to schedule a site visit in May, 1990. The committee agreed to adjust the dates of that visit to May 9 and 10, 1990. The tentative plan will be to visit Wanapum Dam first on May 9, 1990, followed by Priest Rapids Dam. The group will then travel to Wenatchee and reconvene on May 10, 1990 at Rocky Reach Dam for a meeting that would include progress

reports, then move to Wells Dam. Rock Island would be a included for those interested. The PUD's asked Dennis Rohr to coordinate and develop the itinerary.

Designated Representatives for Spill. The committee discussed the matter of appointing designated representatives for spill and named the following;

For Wells Dam - Rod Woodin, Jerry Marco and Mike Erho
For Rocky Reach Dam - Rod Woodin, Jerry Marco and Steve Hays
For Wanapum and Priest Rapids Dams - Bob Vreeland, Tony Eldred and Stuart Hammond

Adjournment. The meeting adjourned at 12:30 P.M..

MID-COLUMBIA COORDINATING COMMITTEE
Meeting March 19, 1990

ATTENDANCE ROSTER

NAME	REPRESENTING
Dennis Rohr	Mid-Columbia PUD's
Dick Nason	Chelan County PUD
Don Zeigler	Grant County PUD
Tony Eldred	Washington Department of Wildlife
Tom Scribner	Yakima Indian Nation
John Williams	NMFS
Jerry Marco	Colville Confederated Tribes
Ron Boyce	Oregon Department of Fish and Wildlife
Rod Woodin	Washington Department of Wildlife
Bob Vreeland	NMFS
Bob Clubb	Power Purchasers
Don Weitkamp	Parametrix
Dick Whitney	Committee
Mike Erho	Douglas County PUD
Labh Sachdev	Seattle City Light
Rod Sakrison	Washington Department of Ecology

MEMORANDUM Mid-Col 90-4

TO: Honorable Stephen L. Grossman,
Administrative Law Judge, FERC

FROM: Richard R. Whitney,
Coordinator, Mid-Columbia Coordinating Committee

DATE: May 14, 1990

SUBJECT: Summary of Mid-Columbia Coordinating Committee Meeting of May 10, 1990

The meeting was convened at 8:00 A.M. May 10, 1990 in the Commission Room at Chelan County P.U.D.. The agenda followed, along with the announcement of the site visit, was mailed to the full mailing list on April 30, 1990. The agenda consisted of progress reports on the 1990 studies. Those in attendance are listed on the attached roster.

1. **Wells Dam** - Mike Erho reported that evaluation of the bypass was underway at Wells Dam. John Skalski had visited the project and made a recommendation to improve the estimate of guidance. There will be two transducers in one turbine intake, which he thinks will reduce the variance of the estimate.

Zosel Dam - Erho reported that Biosonics began monitoring at Zosel Dam about the first of May to track the outmigration of sockeye. The outmigration seems earlier than usual.

Long-term Agreement - Erho reported that Douglas County P.U.D. had met with Washington Department of Ecology. DOE said they would now process the water rights application. The water right should be issued by the end of May. On the basis of this, a meeting is being set up later in May to finalize the long term agreement. Douglas County P.U.D. has selected FishPro to design the fish facilities on the Methow.

2. **Rocky Reach Dam** - Steve Hays reviewed the 1990 testing program. Descaling is within normal bounds. Fish guidance is low. The study has shifted to how fish react to the resistance of the deflector. There is not enough flow up the gatewell. There is a fine point of balance with interruption of flow into the intake and flow up the gatewell. There have been 10 fish guidance efficiency tests to date this year. With the B-6-A bar screen in place, fish guidance efficiency has been low. A perforated backing plate with 33% porosity (same as last year) was placed behind the bar screen and FGE was a little less than last year. Chelan P.U.D. then removed the B-6-A screen material and replaced it with the B-9 material that was used last year. Today will be the first test for that configuration. They noted an increase in descaling with the perforated plate in place. It might be that it concentrated the fish near the bottom of the vertical barrier screen. It could be that a balanced flow vertical barrier screen is required.

Chuck Peven discussed the measurements of fish guidance efficiency and descaling. The vertical barrier screen is impinging fish. There were 400 dead fish counted when the gatewell was emptied prior to a test. The hydroacoustic data show that when the unit is shut down fish move out through the trash rack. Analysis of hydracoustics shows fish under the

dipping basket when it is raised. After the perforated plate was installed there were not as many fish holding at the screen. They were apparently forced up into the gatewell. Without the plate, fish were holding behind the fender wall. Zeigler asked if Chelan had modeled a configuration with the screen lowered further in the intake. Nason responded that they had taken a long, hard look at their modeling in general. Their review of the Rock Island data in connection with development of screens at the first powerhouse showed that installation of a screen in one slot increases the flow in the other slots by as much as 25%. Considering this fact, Chelan P.U.D. plans, after the fish tests are completed this season, to conduct current meter tests at Rocky Reach Dam in slots B and C with and without the fyke nets in place in slot A. They will also measure gatewell flow above the screen. This will be done in the interval between May 29 and June 15, on weekdays.
He reported that at the Rock Island bypass sampler the numbers of sockeye are down compared to earlier counts. They are pit tagging 3,000 each of chinook and steelhead there and attempting to tag equal numbers of wild and hatchery fish.

3. **Wanapum Dam** - Don Zeigler reported that Grant Count P.U.D. started evaluation of the diversion screen on April 23, 1990. Initially, they had problems with the wind and with the lifting beam. They began with a load using 16,000cfs in the unit. They pulled the screen with the unit running and found 2-300 fish impinged. Some were steelhead. They never saw steelhead impinged at Priest Rapids. The following week they reduced the flow to 15,000cfs in the unit. Impingement amounted to 3.5% and descaling 21%. Most of the impinged fish were yearling chinook. Then they reduced the flow further to 14,500cfs. Impingement was reduced to almost zero. Yesterday there were about 900 fish in the extractor and only two were impinged. Descaling was estimated as 6% for chinook and 30% for sockeye. Fish guidance efficiency yesterday was 61.5%. They will get another measure of FGE today and one Friday. They will measure the efficiency of the extractor by releasing marked fish at known depths. After that the committee can talk about the next step. Grant P.U.D. feels that there is a need to proof the model at Priest Rapids with measurements on site. We had thought that Wanapum and Priest Rapids were quite similar in terms of their intake and gatewell systems. But we are finding out that there are significant differences. For example, the center line of the turbine runners at Wanapum Dam is 10 feet lower than at Priest Rapids. So, although the dams are about the same height there is more effective head at Wanapum Dam. One result is that there appears to be more flow up the gatewell at Wanapum with the diversion screen in place than was expected based on experience at Priest Rapids Dam.

4. **Priest Rapids Dam** - Zeigler reported that the unit with the screen will come on line between May 15 and 23, 1990. Grant P.U.D. still hopes to get some descaling measurements before the season is over.
With regard to the transportation studies, they expect to have a final report 6-7 months after the last tags are returned. That will be in late 1992. The report for 1989 will be out in March 1991.

MID-COLUMBIA COORDINATING COMMITTEE

MEETING May 14, 1990

ATTENDANCE ROSTER

NAME	REPRESENTING
Rod Woodin	Washington Department of Fisheries
Tracey Steig	Hydroacoustic Technology Inc.
Phil Mundy	Col. River Intertribal Fish Comm.
Mike Cuenco	Col. River Intertribal Fsih Comm.
Don Zeigler	Grant County P.U.D.
Bob Vreeland	Natl. Marine Fish. Serv.
Roy Beaty	Col. River Intertribal Fish Comm.
Ron Boyce	Oregon Dept. of Fish and Wildlife
Mike Erho	Douglas County P.U.D.
Bob Clubb	Power Purchasers
Jim Ruff	N.W. Power Planning Council
Dick Nason	Chelan County P.U.D.
Steve Hays	Chelan County P.U.D.
Chuck Peven	Chelan County P.U.D.
Dick Whitney	Coordinating Committee

MEMORANDUM Mid-Col 90-6

TO: Honorable Stephen L. Grossman,
Administrative Law Judge, FERC

FROM: Richard R. Whitney, Chairman
Mid-Columbia Coordinating Committee

DATE: September 24,1990

SUBJECT: Summary of Mid-Columbia Coordinating Committee Meeting of September 12, 1990

The meeting was convened at 9:00 A.M. September 12, 1990 in the Phoenix D Ballroom of the Radisson Hotel near Sea-Tac. The agenda followed was mailed to the full mailing list along with the announcement of the meeting on August 23, 1990. Those in attendance are listed on the attached roster.

Agreements Reached.

1. There was a discussion about the fact that with the signing of the long-term agreement over measures to be taken at Wells Dam, that project will no longer be included in the mid-Columbia proceeding. However, there will be a joint committee for decision making whose membership will be the same as the Coordinating Committee and the same as the Rock Island Committee. It was agreed that it is important to separate the discussions under the mid-Columbia FERC proceedings from the Wells and Rock Island discussions, but that it also will be desirable to combine the time and place of the meetings in some way, and to record the agreements reached. The parties will need to discuss this further and agree on a means of accomplishing it.

2. Chelan P.U.D. will distribute next week a draft for extension of the Rocky Reach Agreement, along with a study outline for a revised prototype for testing in 1991. Continued work to develop an orifice and conduit system will be included.

3. Grant County P.U.D. will distribute to those requesting it an outline of the model test schedule along with the schematics for the orifice and conduit system being studied for Wanapum Dam.

4. The committee agreed to meet again at 9:00 A.M. on November 8, 1990 at Sea-Tac.

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1. Douglas County P.U.D. - Progress Report

Mike Erho has retired as biologist for Douglas County P.U.D.. Rick Klinge is the new biologist. Erho is being retained as a consultant by Douglas County P.U.D., particularly for assistance with development of the facilities called for in the Wells Agreement. Klinge called on him for a report. All parties have signed the Wells Agreement except the Umatilla Tribe and Douglas County P.U.D.. They expect the tribe to sign soon. Douglas County will sign when everyone else has done so. It will then be forwarded to FERC. One of the terms in the agreement calls for dismissal by FERC of the portion of the mid-Columbia Proceedings that apply to Wells

Dam. Meanwhile Douglas County P.U.D. has been going forward as though the agreement were signed. They sold bonds in August that will be used to finance construction of fish production facilities called for in the agreement. FISHPRO have been retained to design the facilities. They will complete a conceptual design today. Copies will be available for those requesting them. Roy Beaty asked for one on behalf of the Intertribal Fish Commission and Gerry Marco for the Colville Tribe.

The bypass and monitoring information from Wells Dam was reviewed. A written summary was distributed. Copies are available on request from Douglas County P.U.D.. This is the first year of bypass evaluation as called for in the Wells Agreement. The study was completed in the spring but the data have not yet been reduced to a report.

Douglas P.U.D. also contracted with Don Chapman and Associates for a study of the potential for enhancement of sockeye above Wells Dam. This study is called for in the Wells Agreement. A report is available in draft form.

Biosonics conducted an evaluation of the feasibility of developing an index of outmigration of sockeye from Lake Osoyoos at Zosel Dam. Unfortunately, they were set up to monitor at the fish ladder, and most of the fish seem to have left by way of the spillway. It is unusual for the spillway to be open during the outmigration.

2. Chelan County P.U.D. - Rocky Reach Dam

Dick Nason reviewed the past experience in studying prototypes for screen systems to divert fish away from the turbine intakes at Rocky Reach Dam. The design tested in 1990 attempted to avoid some problems identified in the 1989 testing. These problems were plugging of the vertical barrier screen by debris as the season progressed, and escape of the fish under the fender wall. In 1990 the fender wall was extended downward and vertically mounted bar screen was substituted for mesh in the vertical barrier screen. The result was lower fish guidance efficiency than in 1989. Eldon Rickman made current meter measurements in the gatewell. The results are described in a report "1990 Rocky Reach Currentmeter Test Results", copies of which are available on request from Chelan County P.U.D.. Jeff Mettler was called upon to summarize the results. It was found that with the diversion screen (B6A mesh) and fyke nets in place the flow through the test slot (A slot) was reduced 20.54%. The fyke nets alone reduced the flow by 12%. Velocities and volumes of flow are similarly affected. The model has been modified to include the B and C slots. Model studies will be conducted to measure the effects of installing similar equipment in the B and C slots.

Tracy Steig was called upon for a report on the hydroacoustic monitoring at Rocky Reach. He distributed a set of draft figures showing the vertical distribution of fish corresponding with the various configurations tested in 1990. It appears that the fender wall is driving fish deeper in the water column.

Dick Nason suggested that in 1991 Chelan P.U.D. test a configuration similar to that tested in 1989. The fender wall extension would be removed and a balanced flow vertical barrier screen installed instead of the single porosity VBS that was used in 1990. If the agencies and tribes agree with the concept, he would propose that the Rocky Reach Stipulation be extended for another year to cover 1991 tests. Modeling will be completed by mid-

November or the first of December. He asked Hassan how much time would be required to construct a new prototype. His answer was that it would depend on the magnitude of the changes required. However, it appears that Chelan's Central Maintenance Department could accomplish the changes internally without the need to go out for bid. This would save time. There was an extended discussion of the results of the current measurements and the model studies. The model studies will be used to determine what sort of inserts might be required in slots B and C to bring the intake flows back to approximately $^1/_3$ per slot. The question was raised whether a prototype could be installed in slot B and/or C which would accomplish that purpose. Chelan's response was that it could not be ready in time for testing in 1991. If all goes well, Chelan would construct a prototype for testing in the C slot as soon as possible. A question was raised whether it will be necessary to test a prototype in each slot. If so, full installation might require 30 years. Chelan responded that they have proposed a long-term agreement for Rocky Reach. The parties do not appear to be ready for a long-term agreement, since the solution is not yet in sight. Chelan's proposal for next year would be to install solid plates at the levels required in slots B and C to balance the flow. Model studies could show the probable effects of screens in all three slots. It was pointed out that redistributing the horizontal flow would not necessarily solve the problem of the deeper distribution of the fish observed with the prototype in place in 1990. Removal of the fender wall extension is designed to restore the vertical distribution of fish to that observed in the fyke net studies conducted prior to prototype testing.

The agreement reached in 1990 called for conceptual development of an orifice system and bypass at Rocky Reach Dam. Hassan Makarechian of Stone and Webster was called upon. He reported that the bypass system might be located in several places. He distributed some preliminary drawings and discussed them. Bob Pearce of NMFS provided some hydraulic criteria that were used in developing the options. Brian Brown of NMFS asked to be provided with a copy of the criteria as used. Hassan will send these directly to Bob Pearce. There is further work to be done in developing the concepts. Which path to follow depends on findings in the prototype tests. For example, if the final screen design puts the screen in the downstream gateslot, then problems are different than if it is in the front slot. It was suggested that further work on the conduit system should be included in any agreement reached.

Nason said he will obtain a time-frame estimate from Washington State University for completion of model studies. Chelan P.U.D. will develop an action plan for 1991 which he will distribute next week along with a draft agreement for 1991.

3. Grant Count P.U.D. - Progress REport

A. Descaling Studies at Wanapum Dam - Summer 1990. Don Zeigler reported that measurement of descaling brought discouraging results in the early spring. However, they later determined that some of the descaling was occurring in the extraction device. The crowder door, which is operated hydraulically, normally operates in a position $^2/_3$ open. But the system had evidently lost pressure and the door had been deployed incorrectly. The purpose of the door was to reduce turbulence and give the fish quieter water in which to rest prior to their extraction from the gatewell. This device will not be present in the production system. He suggested that the

concept should perhaps be reconsidered for the tests of the prototype. Stuart Hammond distributed tables of data from the test during the spring of 1990. These showed fish guidance efficiency, impingement, and descaling rates. Copies are available on request from Grant County P.U.D.. Impingement was measured at 1 to 5.7%.

Zeigler said that the feeling at Grant P.U.D. is that if they can duplicate the Priest Rapids conditions at Wanapum, and they are optimistic that they can do so, we will see the same descaling and impingment rates at Wanapum. He pointed out that due to shutdown of unit 1 and reduced loading of units 2 and 3 at Wanapum Dam during the spring outmigration in 1990 there was probably angled flow past unit 4, the test unit. This probably affected the vertical distribution of fish in the intake at unit 4. They will attempt to obtain straight-through flow next spring. Unit 3 had been scheduled for routine rehabilitation in March, 1991, but Grant will delay until after the spring outmigration. They will also recheck the theoretical fish guidance efficiency as it might be affected by patterns of spill or other factors.

B. Model Results. Orifice Tests for Bypass System. Zeigler reported that the model tests had first focused on a John Day-type system. Obviously, there is not space available to duplicate the system, but that type will be adapted to Wanapum Dam. It is a pressurized conduit or tunnel and has a single orifice in each gatewell. He called upon Dr. Odgaard of the University of Iowa, Institute of Hydraulic Research. Dr. Odgaard described the model and the tests conducted with orifices of two configurations. The first used an orifice similar to that at John Day Dam. A 12 inch diameter orifice was modeled. It was noted that sharp changes in diameter of the orifice where it was adapted to the entrance into the tunnel caused extreme turbulence which at times shot water back into the gatewell. Use of an orifice with a tapered opening smoothed the flow. Don Weitkamp showed video tapes of fish in transit through the orifices and into the tunnel. Passage of fish in the second configuration was straighter and smoother than in the first. There are several options to test before the model is modified. One important factor is to determine the head loss characteristics of the options, which is a crucial design criterion. There was a question whether a McNary-type system could be adapted at Wanapum Dam. Zeigler responded that it would not be possible. In order to achieve the necessary velocities at the intake screen we need to be in the downstream gatewell. To accomplish a McNary-type system would require crossing over into the upstream gatewell or onto the face of the dam, neither of which would be feasible. Zeigler will send out a schedule for the model tests along with the schematics to those requesting them.

A major proposal which Grant P.U.D. is considering is to construct a full scale model of the orifice system either at Priest Rapids or Wanapum in order to observe the behavior of fish in the system. This would make possible tests of the model with fish of the correct size. A study could be carried out in 1992, at the same time as the prototype screen tests and generate a lot more information than could be obtained from the small scale models. Grant P.U.D. would be interested in Agency and Tribal comments on this idea.

C. Transportaion. - Coded Wire Trap Recoveries, 1990. Zeigler distributed a preliminary summary of the returns to the coded wire trap in 1990 of adults that were released in 1987 and 1988 as part of the study of

transportation. A copy of the table is attached. Zeigler noted that the data show that fish moved by truck returned at a higher rate than those moved by barge. This is probably associated with the fact that fish moved by truck were subject to less handling.

D. Other. Bruce Ransom of Hydroacoustic Technology Inc. was called upon for a report on the evaluation of the effectiveness of the sluiceway at Wanapum Dam in passing fish. He reported that during the spring outmigration, 6% of the fish passed the project in 1% of the flow, which is what the sluiceway used. In 1989 there were 9% of the fish in 1% of the flow. Considering only night-time observations, there were 24% of the fish in 29% of the flow. As a rule there were higher spill volumes at night than in the day. HTI also studied the vertical and horizontal distribution of fish across the dam at Wanapum. The results were similar to those in the past. Monitoring at the prototype intake screen showed fish velocities were slower with the screen in place than when it was absent. The fish were also lower in the water column. A draft report will be available around October 1, 1990.

4. Other.

The committee agreed to meet again at 9:00 A.M. Tuesday, November 8, 1990 at Sea-Tac.

ATTENDANCE ROSTER
Mid-Columbia Coordinating Committee
Meeting September 12, 1990

Name	Representing
Roy Beaty	Columbia River Intertribal Fish Commission
Bruce Ransom	Hydroacoustic Technology Inc. (Grant P.U.D.)
Brian Brown	Natl. Marine Fisheries Service
Ron Boyce	Oregon Dept. of Fish and Wildlife
John Williams	Natl. Marine Fisheries Service
Jerry Marco	Colville Tribe
Tracey Steig	Hydroacoustic Technology Inc. (Chelan P.U.D.)
Steve Hays	Chelan P.U.D.
Dick Nason	Chelan P.U.D.
Bob Clubb	Power Purchasers
Mike Erho	Douglas P.U.D.
Rick Klinge	Douglas P.U.D.
Stuart Hammond	Grant P.U.D.
Don Zeigler	Grant P.U.D.
Hassan Makarechian	Stone and Webster (Chelan P.U.D.)
Eldon Rickman	Chelan P.U.D.
Charlie McKee	Chelan P.U.D.
Jeff Mettler	Chelan P.U.D.
Rod Woodin	Washington Dept. of Fisheries
Stephen R. Brown	Grant P.U.D.
Jacob Odgaard	Iowa Inst. Hydraulic Res. (Grant P.U.D.)
Don Weitkamp	Parametrix (Grant P.U.D.)
Dick Whitney	Committee

1990 PRIEST RAPIDS DAM CODED WIRE TAG TRAP RETURNS

Preliminary Summary
Sockeye

1987 Release Group

	Control	Barge	Truck
Number Released	24,490	24,505	24,175
Number Recaptured- 1988/89	57	123	184
- 1990	9	17	20
- Total	66	140	204
Percent Recaptured (Total)	0.27	0.57	0.84

Ratio - Barge:Truck:Control 2.11 : 3.11 : 1

1988 Release Group

	Control	Barge	Truck
Number Released	18,078	10,770	17,931
Number Recaptured- 1989	1	0	0
- 1990	84	67	128
- Total	85	67	128
Percent Recaptured (Total)	0.47	0.62	0.71

Ratio - Barge:Truck:Control 1.32 : 1.51 : 1

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(Updated 9/10/90)

MEMORANDUM MID-COL 90-7

To: Honorable Stephen L. Grossman,
Administrative Law Judge, FERC

From: Richard R. Whitney, Chairman
mid-Columbia Coordinating Committee

Date: December 7, 1990

Subject: Summary of the Mid-Columbia Coordinating Committee Meeting of November 8, 1990

The meeting was convened at 9:00 A.M. in the Skol Room at Sea-Tac. The agenda followed was mailed to the full mailing list along with the announcement of the meeting on October 30, 1990. Those in attendance are listed on the attached roster.

Agreements Reached

1. Meetings of the Wells Coordinating Committee and the Rock Island Coordinating Committee will be scheduled when possible in conjunction with the mid-Columbia Coordinating Committee meetings. However, decisions or agreements reached in the two former will be reported under headings separated from the mid-Columbia meetings in any reports that are issued. They will be sent to different lists.

2. The parties are developing a long-term agreement for bypass development at Rocky Reach Dam. In the meantime, Chelan P.U.D. is proceeding with model studies as though an agreement were in place. However, they will not be able to go beyond mid-January without a signed agreement.

3. Grant County P.U.D. will distribute prior to the next meeting a study plan for a full scale gatewell/bypass test facility. Grant P.U.D. would like to have input on the idea from the agencies and tribes prior to the next meeting.

4. The mid-Columbia projects have operated their fish facilities under DFOP. The agencies and tribes would like to expand this operating plan to include emergency action plans. The P.U.D.'s appointed Rick Klinge, Douglas County P.U.D., Steve Hays, Chelan County P.U.D., and Mike Dell, Grant County P.U.D. to work with the agencies and tribes in the development of this plan.

I. Wells Dam

A. Progress Report on Implementation of Long-Term Agreement. Rick Klinge reported that Douglas County P.U.D. has a draft report on the hydroacoustic evaluation of the bypass at Wells Dam in the spring of 1990. Dr. John Skalski is analyzing the data. It will be ready for distribution soon.

He called on Mike Erho for a report on facilities that are part of the long-term agreement. He reported that the hatchery design is coming

along. Washington Department of Fisheries is working with FISHPRO on it. They are on schedule. Within a month they should be ready for final review of the design. They will convene a meeting of the Wells Coordinating Committee before the first of the year to finalize the design.

The work on new fish facilities has been separated into phases. Phase I is the work to install a trap in the left bank fish ladder, which will begin after January 1, 1990. This will require shutting down the ladder from now to mid-April. Phase II involves everything from the false weir in the ladder to the holding facility for fish. More design work is needed on these. Fabrication and installation are involved. Final design of the hatchery is included in Phase II. No work in the ladder is required in Phase II so scheduling is not a problem. Everything should be on line by mid-summer next year. Mike has some concerns about the operation of the trap and how it might affect natural and wild runs of salmon. He will address this subject in the Wells Coordinating Committee.

Don Chapman and Associates have completed a draft report on feasibility of enhancing the run of sockeye in Lake Osoyoos. It should be ready to distribute by November 20, 1990.

The Settlement Agreement has been signed by all the parties and sent to FERC with an Offer of Settlement. When FERC adopts it, it will be finalized.

B. How to Record Agreements Reached Outside of the Mid-Columbia Proceedings. At the September meeting this item was suggested for the agenda at this meeting. There was a discussion of the desirability from the point of view of the P.U.D.'s of separating the discussions under the mid-Columbia Proceeding from discussions of the Wells Coordinating Committee and the Rock Island Coordinating Committee. The reason that it is desirable to separate them is that the mid-Columbia Proceeding represents a law suit having an interim settlement. Douglas County P.U.D. and Chelan County P.U.D. have negotiated permanent settlements of this law suit for Wells Dam and Rock Island Dam respectively, so they are no longer parties to the law suit, with respect to those projects. The committee agreed that insofar as possible, in the interest of efficiency, meetings of the Wells Coordinating Committee and the Rock Island Coordinating Committee will be set in conjunction with meetings of the mid-Columbia Coordinating Committee. Reports will be made under different headings, and sent to different lists. The Study Coordinator was asked to maintain a reporting system that would serve both functions.

II. Rocky Reach Dam

A. Extension of Agreement into 1991. Dick Nason reported that he had sent out a memo on October 31, 1990 that apparently crossed in the mail a memo from Brian Brown on the same subject. They had talked on the phone and agreed that a longer term agreement on prototype development at Rocky Reach would be appropriate. In 1991, Chelan P.U.D. is proposing that the prototype be tested in the upstream trashrack slot. Flow reduction will be measured. They will also look at the potential for screening the downstream slot as an option. Rex Elder favors the downstream slot because velocities are higher there. The new Vertical Barrier Screen is narrower, which makes less restriction and should give higher velocities up the gatewell. They need model studies. Chelan is willing to test prototypes in both locations

in 1992 , simultaneously, if the model studies are favorable. But if modeling results are not favorable, they would abandon one or both options in 1992. This is outlined in the proposal submitted by Nason in his memo of October 31, 1990. Slot A would be available for downstream slot tests if the upstream slot is shown to be unworkable. There would be no problem testing in the A slot, using a longer screen, etc. for fine tuning. That would be in 1993. Eldon Rickman reported that modeling should be completed in the summer of 1991 and design would begin immediately. Nason said that Chelan will continue to model as though they had an agreement in place, but they cannot go past item 6 on the schedule he provided in his October 1, 1990 memo. That would include all of the anticipated modeling. Chelan will need a signed agreement by mid-January. He referred to a draft of the revised Stipulation. Paragraphs 1 and 2 contain a schedule. He proposed inserting this schedule or a modification of it to extend through three spring outmigration periods.

A question was raised about how long it would take to install a full system once a design is developed. Eldon replied that it might take four to five years. Nason suggested it is probably too early to say because it might depend on what the option looks like. Zeigler added that at Wanapum Dam Grant P.U.D. has determined that the bypass system should be installed and on line as a first step and then proceed systematically with installation of screens across the dam.

The agencies and tribes planned to meet to discuss Chelan's proposed agreement. Nason suggested that following that meeting there be a telephone conference call to agree on its provisions. It could be FAXed to Jim Vasille, who could put it together in a legal framework and forward it to Lori Bodi.

Brian Brown suggested that if the parties can agree on a schedule they might also look ahead to a discussion on compensation. Nason said he had no problem agreeing to discuss it, but did not want the agreement to contain any additional provision for compensation.

III. Wanapum Dam.

A. Progress With Model Studies. Don Zeigler began with a discussion of the proposal for a full scale model. Grant P.U.D. would propose to replace the prototype screen test in 1992 with this full sized facility to study orifice bypass efficiency. He referred to it as the "Isolated Test Facility" (ITF). Grant P.U.D. is confident that they can make the prototype screen work in 1991. He distributed a figure showing configurations of the orifices tested in the model. The model study schedule is shown at the bottom of the page. He met yesterday with Bob Pearce and Randy Lee to review the model studies. Bob Pearce responded that the video tape was revealing. It shows that it is desirable to develop another orifice design for the benefit of the fish and to reduce head loss. Zeigler requested input to an agreement on the direction the orifice tests should take. The model test schedule fits with the prototype tests. He suggested that agency and tribal input be coordinated through Bob Pearce. Bob Pearce noted that they are going through the same kind of process at The Dalles. He made some specific suggestions for testing in the model, emphasizing the desirability of testing the base configuration along with the new designs.

Zeigler then moved on to a discussion of Grant P.U.D.'s proposal for the

ITF. In order to measure orifice passage efficiency (OPE), Grant P.U.D. is considering construction of a full-size test facility, probably to be located where the fish sorting facility was at Wanapum Dam. Such a facility could test the effects on fish movement out of the gatewells of such things as changes in pool elevation, changes in unit operation, etc.. It could be operated year-round, making possible more adjustments than if tests were conducted in the dam itself. It would imitate a full sized gatewell, 50 to 60 feet high in an enclosed building. Water would be taken from the forebay. The schedule would be close to the same as the prototype. OPE is difficult to measure because fish would have to be marked and this might affect their behavior. John Williams of NMFS is concerned about the differences in behavior likely to be encountered between fish obtained for such tests compared to fish actually in transit down stream. The result might be to reject some ideas that might be effective in prototype tests at the dam. Zeigler saiid Weitkamp will attempt to address these problems and others in a written study plan which Grant has asked him to prepare. Brian Brown indicated that the information would be useful, but that accumulation of fish in gatewells has not been a problem to date. Zeigler responded that if Grant could duplicate the system at John Day they would agree to proceed. However, there are great enough differences that Grant would like to conduct some tests. For example, the orifices will be submerged lower in the gatewells than anywhere else in the basin. The pool elevation at Wanapum fluctuates significantly, while it is rather stable at John Day. The proposed gallery is a lot smaller than John Day. Related hydraulic conditions are different. There is no room at Wanapum to enlarge the flume. Committee members asked to see the Weitkamp writeup. Zeigler expected to distribute it in about a week along with some drawings from Sverdrup.

B. Progress With Prototype Development. Plans for 1991. Zeigler distributed a handout showing a schedule for the ITF which also showed current meter measurements at the turbine intakes and gatewells at Wanapum and Priest Rapids Dams in November and December. A copy is attached. Information from these measurements will go into the model studies. A question was raised about how soon there would be more than one screen at Wanapum Dam. Zeigler answered that Grant P.U.D. will not prototype more than one screen, they will go right into a production schedule after the tests next year.

A question was raised about what is being proposed to improve FGE in the prototype in 1991. Zeigler said Grant will maintain load on unit 1. Units 2,3,4,5, and 6 will be block loaded at 70 megawatts. They expect the improvement in flow patterns across the dam to improve fish guidance efficiency. The model studies were done at 90 megawatts.

C. Transportation Studies. Progress Report. Zeigler reported that to date, there were recovered 5348 carcasses in spawning ground surveys. From these they recovered 139 snouts, representing fish marked with coded wire tags, and 37 jaw tagged fish, representing marked fish that had been observed previously as adults moving upstream at the coded wire trap. Data from the coded wire trap had previously been distributed to the committee.

IV. Other.

Ron Boyce introduced the subject of development of a joint fishery parties/PUD operating plan for the mid-Columbia. The agencies and tribes

have developed an annual operating plan for projects on the Columbia River. The P.U.D.'s have followed it in the past, under DFOP. He asked whether the P.U.D.'s would like to assign someone to work with them on this. Douglas County P.U.D. assigned Rick Klinge, Chelan County P.U.D. assigned Steve Hays, and Grant County P.U.D. assigned Mike Dell.

The committee agreed to meet again on Friday December 7, 1990 at Sea-Tac. The agenda should include the schedule for Rocky Reach Dam, a progress report from John Williams on fish behavior studies he has done for Chelan P.U.D., and the Wanapum model studies.

ATTENDANCE ROSTER
Mid-Columbia Coordinating Committee
Meeting November 8, 1990

Name	Representing
Dennis Rohr	mid-Columbia P.U.D.'s
Charlie McKee	Chelan County P.U.D.
Dick Nason	Chelan County P.U.D.
Bob Clubb	Power Purchasers
Steve Hays	Chelan County P.U.D.
Elvin Quiring	Grant County P.U.D.
Don Zeigler	Grant County P.U.D.
Brian Brown	Natl. Marine Fisheries Service
Frank Young	Oregon Dept. of Fish and Wildlife
Don Clark	Portland General Electric
Mike Erho	Douglas County P.U.D.
Roy Beaty	Col. River Intertribal Fish Comm.
Rod Woodin	Washington Department of Fisheries
Bob Pearce	Natl. Marine Fisheries Service
Rick Klinge	Douglas County P.U.D.
Ron Boyce	Oregon Dept. of Fish and Wildlife
John Williams	Natl. Marine Fisheries Service
Tony Eldred	Washington Dept. of Wildlife
Eldon Rickman	Chelan County P.U.D.
Dick Whitney	Committee

Wells Coordinating Committee
Notes from December 20, 1990 meeting

A meeting of the Wells Coordinating Committee was held on December 20, 1990 in the Executive Room of the Sea-Tac Airport at 10:00 AM. Meeting notice were sent out on December 4. Since this was the first meeting of the newly formed Wells Coordinating Committee, notices were sent to the Mid-Columbia Coordinating Committee membership.

I. Methow River Spring Chinook Hatchery

Final review of plans for the Methow Spring Chinook hatchery were presented by FishPro. Attached is a copy of their notes.

II. Discussion of the Wells Bypass

A. Review of BioSonics Draft report of the 1990 Bypass

Rick Klinge touched on the highlights of the Draft report prepared by BioSonics for the 1990 Bypass season. FPE for spring bypass was 84.3% ±8.0% at the 95% C.I. This met bypass performance criteria but did not meet the evaluation criteria goal of 85% ±5% at the 95% C.I. as stated in the Wells Settlement Agreement. A peripheral data point on April 25 had a FPE of 99% that caused a spread on the C.I. plus raised the point estimate. Without this data point, FPE for 1990 spring bypass is 77.9% ±1.5%. Rod Woodin suggested that for 1991, no changes be made in operations for spring bypass. If the evaluation criteria goal is not met the second year, then changes in bypass operation may be recommended.

For summer bypass, 1990 FPE was 76.5% ±4.0% at the 90% C.I. This meets both the bypass performance criteria and the evaluation criteria set out in the Wells Settlement Agreement.

There was some discussion as to what effect project spill has had on the operation of the bypass. In 1990, water was spilled over Wells 17 of the 32 days of spring bypass and 6 of 15 days of summer bypass operation. The point estimate for 1990 was felt to be conservative since there was no means to quantify passage of top spill for downstream migrants.

B. 1991 Bypass Plan

Rick Klinge distributed a draft of the 1991 Bypass Plan and a draft of the 1991 Annual Passage Monitoring Plan for review. These plans are identical to 1990 operations.

Prior to the 1991 Bypass season, these plans will need to be finalized, a Bypass Team will need to be selected and a 1991 Evaluation Plan will need to be drafted and agreed to. Various agencies are still reviewing procedures for evaluation of the

1990 Bypass Report.

III. Sockeye Enhancement Potentials above Wells Dam

Mike Erho, Consultant for Douglas P.U.D. mentioned that the sockeye report is still being prepared by Don Chapman. Completion is expected to be around the middle of January.

IV. Methow River Spring Chinook escapement for 1990.

A brief presentation was made from the Yakima Indian Nation report on the wild escapement of spring chinook in the Methow River. A total of 502 redds were located throughout the Methow, Chewack and Twisp basins. Of the 101 carcasses recovered, no tags, marks or fin clips were found. Tom Scribner, Biologist for the Yakima Tribe mentioned that unusual high flow conditions persisted in 1990 that may have delayed the run. Delayed spring chinook over Wells Dam after June 28 would have been counted as summers. This was reflected by the ratio of redds to fish which was notable different than previous years.

V. Miscellaneous

A. Progress on the Wells Eastbank Fish Trap

(1) Phase I.

Rick Klinge reported that the low bid for work on Phase 1 was $388,500. Work on Phase I should start the first week of January 1991. The work is scheduled for completion in the ladder by April 1 and miscellaneous out of the ladder work by May 1.

(2) Phase II

A meeting has been scheduled on January 9 with NMFS and the Columbia River Inter-Tribal Fisheries Commission to discuss the Eastbank ladder trap. Phase II construction will include the fish sorting flume, lifting frame, in-deck holding tank and lift basket. Final drawing will be generated from comments made in this meeting. Mike Erho expressed the concern of Douglas P.U.D. that this fish trap be used only to supplement the trap on the right side of the river.

B. Next meeting

The Next Wells Coordinating Committee will be scheduled with the Mid-Columbia Coordinating Committee. A notice of time and location will be announced.

FISH PRO, INC.
3780 S.E. State Highway 160, Port Orchard, WA 98366 (206) 871-2727

Meeting Minutes

Date: December 20, 1990

Subject: Methow Valley Spring Chinook Enhancement Program
Hatchery Facilities and Acclimation Ponds

Location: Seattle Tacoma Airport - Executive Conference Room

Attendance:

Mike Erho	Douglas County PUD No. 1 (District)
Charles Robins	District
Rick Klinge	District
Kathy Hopper	Washington Department of Fisheries (WDF)
Bill Hopley	WDF
Rod Woodin	WDF
Tom Scribner	Yakima Tribe
Jerry Marco	Colville Tribe
Bob Clubb	Power Purchasers
Dennis Rohr	Mid Columbia PUD's
Bill Hevlin	NMFS
Ed Donahue	FishPro, Inc. (FPI)
Mike McGowan	FPI
Sharon Sawdey	FPI
Ken Ferjancic	FPI (partial attendance)

This meeting was held as the last formal presentation for the hatchery design phase for the above referenced project. The following constitutes the non-verbatum minutes of the meeting.

I. An overview of the project was presented
   A. Due to weather related delivery problems, renderings of the project could not be presented at this meeting.
      1. Renderings will be sent to the District's office.
   B. The first phase of the project includes the main hatchery complex near Winthrop and two acclimation ponds (Twisp and Chewack).
   C. The design of the adult collection facilities is now underway.
      1. It appears that Sverdrup Corporation will be involved with the design of the Foghorn Ditch diversion for USFWS. FishPro will develop the trapping facilities for the Methow which will be a part of the overall USFWS diversion project.

D. The driller for the production wells has been given an extension to after the first of January to start drilling three wells on the hatchery property.
   1. The drilling of the production wells is to be completed by March 22, 1991.
   2. The District will furnish the production well pumps.

II. Design features relative to civil engineering were discussed.

A. The overall site plan for the hatchery was reviewed.
   1. There was discussion regarding potential impacts on the photoperiod by the raceway covers.
      a) Flexibility to address this has been provided through the possible later use of removable end panels.
   2. There was discussion regarding visitor access
      a) The facility features are such that there are minimum elements of design included in the design to attract visitors.
      b) Only minimal facilities (a small parking area across the Foghorn ditch from the hatchery) are being provided to accommodate visitors. Handicapped parking can be provided adjacent to the hatchery.
      c) The adult holding area is secured with both fencing and an intruder detection system.

B. The acclimation pond design proposed for the Twisp and Chewack sites were reviewed.
   1. It was emphasized that there would be no power provided to either of these sites.
   2. There was some discussion about the need for alarms at the sites.
      a) WDF felt that with the attention these ponds would receive when in use, no alarms would be necessary.
   3. It was noted that the ponds and the hatchery would be bid as one package while the adult collection facilities would be bid as a separate package later in the year.

III. Specific components of the hatchery facility were reviewed noting the following.

A. Start tanks in the hatchery building will be plumbed with an overhead supply loop with drops to each tank.
B. Formalin treatment will involve mixing of the solution in the chemical room, transfer to a pump located in another room, then injection into the headers for the isolation and vertical stack incubation.
C. Monitoring of hatchery systems will be done with a FishPro designed, industrial quality system.
D. There was a question regarding who would be doing the mechanical and electrical maintenance for the facility.
   1. It was indicated that this would most likely be contracted by WDF to a local Elec./Mech. Contractor.

E. Water temperature will be monitored at the headtank and at the surface water intake.

F. The design for the adult raceways includes covered spawning areas.
   1. Each spawning area is equipped with two drains
      a) One drain will allow blood and other high BOD effluent to be directed to the domestic sewage disposal system.
      b) Wash down effluent from the area will be directed to the clarifier.
   2. It was noted that there was room to add a fourth adult raceway to the site in the future, if ever required.
   3. The raceways will have 1 foot of freeboard, 2 feet high vinyl skirts on the sides and downstream end, a jump barrier at the upstream end, and surface sprayers.

G. Operation of the clarifier was reviewed.

H. Operation of the deicing system at the surface water intake on the Foghorn ditch was reviewed.
   1. It was noted that the design of the screens for all surface water intakes are based on square panels. This is done to allow rotation of the screen (bars parallel to the flow or perpendicular to the flow) to the position which gives the best performance.
   2. Provisions should be made to allow future delivery of well water to the surface water intake.

I. The USFWS will be informed of the opportunity to obtain borrow for raising the levee along Foghorn ditch (off the hatchery property) from the excavation necessary for hatchery construction.

IV. Structural components for the facilities were reviewed.

A. All facilities off the property will be fenced except those facilities where an existing irrigation structure is being modified.

B. A staff gage will be added at the pond outlets to record the depth of water going over the overflow weirs.

C. It was noted that water is introduced into the Twisp and Chewack ponds via a pipe header while at the hatchery it was done with an upwell (for both surface and groundwater).

D. The Twisp and Chewack ponds are provided with security and otter fencing around the ponds.
   1. The hatchery pond is not provided with otter fencing.

E. There was some discussion on acclimation pond capacity being designed for exactly 15, 000 lbs.
   1. It was noted that this was based on fairly conservative criteria as follows:
      a) Required volume was based on 0.75 lb/sq.ft.
      b) Volume of the pond was calculated based only on the area defined by the interior toe of slope.
      c) It may be theoretically possible that the hatchery pond could accommodate an additional 5,000 lbs. (This will be verified for Rod Woodin by FishPro.)

F. Smolt release from the ponds will be monitored by a WDF supplied and installed counter.
G. The pond water supply systems are designed to accommodate bypassing flow during times of release.

V. Piping systems for the hatchery were reviewed noting the following:
A. The hatchery building will only be supplied with well water. However, a blind flange will be provided for future surface water supply usage.
B. Three connection points along each side of the rearing pond, down the center of the production raceways and along one side of the adult raceways will be provided for connection to the vacuum system.
C. Freeze proof, or otherwise drainable, yard hydrants will be provided at various locations on the hatchery site.
D. Water supply lines have been designed to provide up to 3 feet of bury depth.
1. It was noted that a 2 foot minimum is the usual frost depth design for the area.
E. A separate chemical waste drain and treatment system has been provided which will allow for 24 hour detention for laboratory and disinfection room waste flows prior to discharge to the hatchery drainfield.

VI. Alarm systems for the hatchery were reviewed
A. There were no discussion items related to alarms.

VII. General discussion items
A. A question was raised regarding how the discharge of well water downstream of the hatchery was going to be viewed by DOE.
1. It was noted that the concept had been presented to and was accepted by DOE.
a) One benefit of the existing discharge scenario is the biological cleaning of the effluent as it is conveyed through the outfall ditch.
b) It was indicated that WDF may need to monitor smolt movement in the outfall ditch.
2. It was indicated that there is no change in how hatchery use of surface water will be handled relative to minimum instream flows of the Methow.
B. The issue to provide for use of surface water in the hatchery building was discussed.
1. Based on the timing of the water demands for hatchery building operations it was determined that temperature of the groundwater should not be problem.
a) If surface water is desired in the future WDF can plumb in a surface water supply through provisions in this design.
2. The need to supply surface water to the hatchery building as a backup to the groundwater supply was discussed.

a) It was determined that WDF could pump from the surface water sump by the headtank into the headtank.
b) WDF will need to supply the hatchery with a gasoline-powered pump with hose for this purpose.
c) It was calculated that the storage volume in the headtank would provide approximately 2 hours of water supply for incubation and 0.5 hours of water supply for the full hatchery building demand (assuming no other demand) - this was felt to provide adequate time to install the pump system.

C. The groundwater supply system was reviewed noting that each well would be equipped with a meter for manual reading; digital readouts will be provided for aeration tower inflow, hatchery building, and surface water flow rates.

D. Timing of the construction was discussed.
1. It was noted that it was currently anticipated that hatchery construction should be substantially completed by the end of 1991.
a) Trapping facilities should be in place shortly after that.
b) It was indicated that, should the need arise, adults from the Chewack could possibly be held at the Wells facility.
c) There was some concern expressed about the timing of USFWS design and construction of the trapping facilities and associated improvement at the Foghorn diversion.

E. The weir and trap installed by Chelan PUD at the Chiwawa site was discussed.
1. It was indicated that a similar installation was anticipated for the Twisp trap site.
a) It was felt that the Twisp site presented better flow conditions than the Chiwawa site (the site for the Chiwawa weir had been given). The flow conditions at the Chiwawa site had been such that the weir had to be tilted to the upper limit of recommended operational configuration.
b) The Twisp weir will be configured to provide better attraction flow at the trap.
c) The Twisp trapping site is located at approximately river mile 9.2.

F. It was proposed that one additional truck be purchased for facility operations
1. This truck will be used with the two trucks at Wells for hauling fish.
a) This seemed to be acceptable to WDF.

G. It was noted that the fish transfer bag should be ready for trial sometime towards the end of January.
1. The District volunteered to assist in fabrication through their Wells shop.
a) FishPro is to provide sketches and materials.

H. Concrete tints for the raceways were discussed.
1. It appeared that Davis Color's "Kahlua" would be the preferred tinting.
2. FishPro will obtain samples of this material from Salmon Bay for WDF bioassay purposes.

a) A complete breakdown of the chemical composition of the pigment (ferric oxide) will also be furnished.

I. The project sign was discussed

1. WDF will send an example of their decal for inclusion on the project signs.

a) WDF noted that project signs normally include their decal at the same level as the entity doing the construction (such as was done by Chelan PUD).

The meeting was adjourned at approximately 12:30 p.m.

Please advise of any additions or corrections.

Submitted by,

Michael J. McGowan, P.E.

Reviewed by,

Edward E. Donahue, P.E.

cc: Attendees
Mr. Glen Aurdahl, Sverdrup

1991 Bypass Plan
for the Wells Dam

December 1990

The Settlement Agreement entered into on October 1, 1990 between Douglas County P.U.D. and the Joint Fisheries Parties members requires that an Annual Bypass Plan be presented to the Wells Coordination Committee by December before each Bypass season (Section II.F.1). This plan outlines the operation of the bypass system for the coming juvenile salmonid migration season.

The 1991 bypass plan for the Wells Project is as follows.

1. The bypass will be in place two weeks prior to the preseason forecasted beginning of the juvenile migration and will be removed two weeks after the end of the juvenile migration period.

2. The PUD will operate 5 bypass baffles at the Wells Project to meet criteria set out in subsections II.C,D, and E. of the Settlement Agreement.

3. No turbine will operate during the migration period unless an adjacent bypass system is operating.

4. The 5 bypass systems bays will be numbers 2, 4, 6, 8, and 10. Operations of the turbines will be in pairs with associated bypass bays, as follows.

Turbines Operated	Bypass Bay 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

5. At least one bypass will be operate continuously throughout the juvenile migration period up to August 1.

6. The bypass and spillgates will be operated in configuration K of the 1987 bypass system report (bottom spill, 1 foot spill gate opening, 2.2kcfs, vertical baffle opening.

7. When Chief Joseph Dam Uncoordinated Discharge Estimate is equal to or greater than 140kcfs for the following day, all 5 bypass bays will operate continuously for 24 hours.

8. When Chief Joseph Uncoordinated Discharge Estimate is less than 140kcfs, bypass system operation will be as follows.

Number of Turbines	Minimum Number Bypass Bays Operating
0 - 2	1
3 or 4	2
5 or 6	3
7 or 8	4
9 or 10	5

9. Monitoring the fish run will begin when bypass baffles are in place and will end when baffles are removed.

10. Bypass will be available to operate continuously 24 hours per day during the juvenile migration period.

11. Bypass operation as described are intended to provide fish passage efficiency (FPE) of at least 80% for the juvenile spring migration and FPE of at least 70% for the juvenile summer migration.

12. Members of the Bypass Team (Settlement Agreement Section II.F.2), will be designated by March 1, before the Bypass Season.

Supplement to the
1991 Bypass Plan
for the Wells Dam

In addition to the 1991 Wells Bypass Plan, the following supplemental plan will be in effect as agreed to by the Bypass Team members.

1. The anticipated bypass operation season will be from April 15 to August 15.

2. Operation of the bypass from August 1 to August 15 will be adjusted from a 24 hour schedule to operating between 2200 to 0600.

1991 Annual Passage Monitoring Plan for the Wells Dam

The Settlement Agreement entered into on October 1, 1990 between Douglas County P.U.D. and the Joint Fisheries Party members requires that an Annual Passage Monitoring Plan to be presented before the Bypass season to the Coordinating members (II.G.1). This plan is to outline the anticipated abundance of juvenile salmonids for the upcoming bypass season and how monitoring of bypass efficiency will be achieved.

1. Hydroacustic sampling of the forebay, bypass intake slots, and turbine intake galleries will monitor movement of fish during the smolt migratory season.

2. Monitoring of run timing will be done by 15° transducers placed in the forebay in front of Turbine Units 2, 4, 6 and 8 at a depth of 130 feet. The transducers will be aimed at 28° off the face of the dam.

3. Sampling of run timing will be preempted during the spring bypass operation. Monitoring of run timing will begin at the end of the spring studies and continue until the start of summer bypass operation.

4. Bypass evaluation will be sampled by 6° transducers placed in intake slots 1C, 3C, 5C, 7C, and 9C. These locations are at the center of the five bypass spillways.

5. Fish that pass through turbines will be monitored by 15° transducers placed in twenty turbine intakes galleries. For each of the ten units, two transducers will randomly be placed among the three intake galleries.

6. A series of fyke nets will be deployed in one turbine intake to collect fish for the purpose of determining species composition. Sampling will be one night a week between April and June. In July and August, alternating sampling of day and night will be conducted each week.

7. Weekly reports of activities surrounding Bypass operation will be made available to members of the Bypass Team.

Supplement to the
1991 Annual Passage Monitoring Plan
for the Wells Dam

In addition to the 1991 Annual Passage Monitoring Plan, the following Supplemental Monitoring Plan will be in effect as agreed to by the Bypass team members.

1. Monitoring of the run timing for the spring migration will start on April 1.

2. Douglas P.U.D. will contact the National Hatchery at Winthrop on timing of releases of spring chinook smolts from the National Hatchery at Winthrop. A rise in the numbers of fish in the run timing index will trigger the start of the spring bypass season. When numbers of spring migrants reach _____, the spring bypass season will be finished.

3. The start of the summer migrant season will be monitored as numbers of fish from the timing studies and the fyke net monitoring show an increase in target fish. Expected date for the start of the summer migration monitoring period will be July 10.

4. The anticipated bypass operation season will be from April 15 to May 20 for spring migrants and from July 10 to August 25 for summer migrants.

MEMORANDUM

TO: Wells Project Coordinating Committee

DATE: April 29, 1991

FROM: Richard Whitney, Neutral Third Party

SUBJECT: Summary of Meeting by Telephone Conference Call, April 15, 1991

Agreements Reached

1. Due to high expected flows and resulting spill at McNary Dam, which would reduce the expected number of marked fish that would be recovered, the committee decided not to pursue the study of relative spill survival in top vs bottom spill at Wells Dam in 1991.

2. The committee agreed that because they had made a decision to conduct an additional bypass evaluation in 1991, the studies of survival of juveniles passing the project should be postponed until 1992.

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At the April 3, 1991 meeting of the Wells Project Coordinating Committee, Douglas County P.U.D. presented a proposal for a study of relative survival of fish passing through top spill and bottom spill at Wells Dam. The committee asked for further clarification of the study plan. Douglas P.U.D. prepared some additional information and asked the committee to meet by telephone conference call to discuss it. The Conference call was arranged for 1:30 P.M. April 15, 1991. Participating were Rick Klinge and Mike Erho for Douglas County P.U.D.; Ron Boyce, Oregon Department of Fish and Wildlife; Tom Scribner, Yakima Indian Nation; Bill Hevlin, National Marine Fisheries Service; Tony Eldred, Washington Department of Wildlife; Gerry Marco, Colville Confederated Tribes; Rod Woodin Washington Department of Fisheries; and Dick Whitney, Neutral Third Party.

Rick Klinge said that Douglas County P.U.D. would like to go ahead with the study. He had faxed out to the committee members a "decision tree" showing the possible outcomes of the study and the related responses by Douglas County P.U.D.. Erho pointed out that information on recovery rate of these fish at McNary Dam would be useful later in the designing of the study of overall project survival which is called for in the Settlement Agreement. Concerns were expressed about the effects of expected high flow and spill on the recovery rate at McNary Dam, about the wide difference that would have to occur in survival in order for the study to detect it, and about the short time interval available between tagging and release of the fish. Discussion of these factors led to a conclusion in the committee that this is not a good year in which to conduct a study to measure recovery rate at McNary Dam because

expected high levels of spill will probably reduce the recovery rate to a point where the data will not be useful. Douglas P.U.D. will withdraw the study plan for this year.

Rod Woodin suggested that Washington Department of Fisheries would be willing to sign a joint statement to the effect that because the committee had agreed upon an additional year of measuring fish passage efficiency to include 1991, it would be appropriate to delay the measurement of juvenile survival at the project. The Settlement Agreement calls for a study of survival to begin in 1991. He feels that it should be delayed until 1992. The committee agreed with this suggestion and asked Douglas P.U.D. to draft a statement that could be signed, or to consult with their attorney to get his advice on how to proceed. It was suggested that the members of the committee could document the fact that they are in agreement on the issue, and that this might suffice for the purposes of satisfying FERC that the parties are adhering to the Settlement Agreement.

It was agreed that the next step in dealing with measurement of survival should be a meeting of the Wells Project Coordinating Committee to develop criteria for the study of overall survival at the project.

MEMORANDUM

TO: Wells Project Coordinating Committee

FROM: Dick Whitney, Neutral Third Party

DATE: April 26, 1991

SUBJECT: Summary of Meeting of April 3, 1991

AGREEMENTS REACHED:

1. Douglas County P.U.D. agreed to provide, if needed, an additional period for ~~operation~~ evaluation of the bypass in the spring beyond the 30 day period of the evaluation, up to a total of 40 days.

2. Biosonics will report weekly on the hydroacoustic index at Zosel Dam until May 14, 1991, after which they will report daily.

3. The committee agreed that there was no need for special monitoring of the fish released from the Similkameen or Twisp facilities through fyke netting or other methods at Wells.

4. The committee asked Douglas County P.U.D. to develop further information on the proposed study plan for determining whether there might be a difference in survival of fish passing through top spill compared to bottom spill at Wells Dam.

5. Washington Department of Fisheries has comments on the report of Don Chapman and Associates on feasibility of enhancement of sockeye salmon. They will forward to Rick Klinge for distribution to the rest of the committee.

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The committee met at 1:00 P.M. April 3, 1991 in the Small Auditorium at Sea-Tac. The agenda followed was mailed to the committee on March 27, 1991 by Rick Klinge. Those in attendance are listed on the attached roster.

I. Final Report for 1990 Bypass Season. Rick Klinge reported that a draft report by Biosonics on the bypass evaluation was distributed, and comments were received from Washington Department of Fisheries and the National Marine Fisheries Service. The comments will be taken into account in the final version. The final version should be out in about one week. Klinge called upon Gary Johnson of Biosonics, who gave a brief summary of the report, of the comments received, and of Biosonics response.

II. Status of 1991 Bypass Season.

A. Review of 1991 Evaluation Methodology. Klinge called upon Gary Johnson of Biosonics, Inc. and John Skalski of the University of Washington. Increased sampling at the turbine intakes should reduce the variance of the estimate of fish passage efficiency by

a factor of 10, according to Skalski's calculations. There will be transducers in 24 of the 30 turbine intake slots, meaning that 4 units will have all three slots sampled. The units chosen were the ones with high numbers of fish last year. Gary Johnson indicated that Biosonics would look at the first 5 days of data and decide whether to move transducers or make other adjustments. Skalski had consulted the other members of the statistical working group, Ben Sandford, John Williams, and Phil Mundy, and they are in agreement on the study plan.

B. Current Status of Bypass Operation. Klinge reported that Douglas P.U.D. began hydroacoustic monitoring of fish abundance at Wells Dam on March 29, 1991. Abundance has been low to date. Douglas P.U.D. have met the requirement in the Settlement Agreement for a two week monitoring period prior to the arrival of major numbers of fish at the project. There is a 30 day period set for the bypass evaluation. Klinge proposed that after that time the bypass team should decide what stage the sockeye migration has reached. Douglas P.U.D. are willing, if necessary, to add a 5 day period of ~~operation~~ evaluation ~~for~~ to include late arriving smolts, if the team agrees it should be done. Again, Douglas P.U.D. are willing to add a still further 5 day period, if the team agrees it is necessary, to protect late arriving smolts, up to a total ~~operating~~ evaluation period of 40 days.

C. 1991 Smolt Monitoring at Zosel Dam. Klinge reported that Biosonics intends to monitor with a single transducer at spillbay 1 from April 24 to May 31, 1991. They will consult with the irrigation district to be sure that is the best location. Biosonics will report the monitoring numbers weekly from April 24 to May 14, at which time the numbers will be reported daily until May 31, 1991.

D. Operation of the Fyke Net. Klinge reviewed the decision made during the conference call on March 1, 1991 not to take samples with the fyke net until about May 15, 1991 when it will be desirable to obtain information on sockeye abundance at the project. Klinge is now wondering whether the committee might want to reconsider this decision, considering that it might be useful to collect information on fish being released from the Similkameen and Twisp facilities. The committee decided that fyke netting would not collect information that would be useful, and decided against it.

E. Summer Bypass Operation. Klinge said there is a 15 day period outlined in the Settlement Agreement for summer bypass operation. He will check with the designated representatives to decide jointly on the schedule for beginning summer bypass operation.

F. Projected Flows for 1991. Klinge reported that flows are projected to be 120% of normal during the period of the juvenile outmigration. By June or July, flows might reach 250 Kcfs in the

mid-Columbia. If it exceeds that, it might be necessary to remove one of the bypass baffles, according to FERC operating criteria for the project. They would be removed from spillbay 6. If this happens, it might affect the evaluation of the bypass.

III. Top Spill - Bottom Spill Evaluation

A. The Need as Outlined in the Settlement Agreement. Klinge referred to the Settlement Agreeement at Section II C 5, page 10, where there is a statement, "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." He also referred to Section IV C 5, which calls for a Wells Project juvenile mortality/survival study to begin in 1991. Douglas P.U.D. is proposing to get a start on these by undertaking a study of comparative survival in top vs bottom spill in 1991. He called upon John Skalski to describe the proposed study plan. There would be 4,400 steelhead marked with pit tags. Half would be released into an area in the spillbay where they would have to go through top spill and the other half released into bottom spill. Recoveries would be made at McNary Dam where facilities exist for detecting pit tags. Skalski had asked Klinge to specify a difference he would like to be able to detect between top and bottom spill. On the basis of his response, that he would like to be able to detect a difference of 10%, Skalski had come up with the number of tags that would need to be recovered at McNary Dam, and from that number an estimate of the number that would need to be released, thus the 4,400 number. He assumed a 20-30% recovery rate at McNary Dam, based on experience of others. This assumes no spill at McNary. If there is spill, the recovery rate would be lower.

There was a discussion in the committee about whether the study is necessary. The agency and tribal representatives suggested a paper exercise to try some numbers for relative survival and see what these might lead to in terms of differences in total survival of fish passing the project. A further analysis of data already at hand might provide the information that is desired. Particular concerns were expressed about the assumed recovery rate at McNary and the wide difference in rate of survival in the two routes that would be necessary before it could be detected in the study. Rick Klinge agreed to work further on the proposal and get back to the committee.

IV. Okanogan Sockeye.

A. Don Chapman Report on Enhancement Possibilities Above Wells Dam. There was a discussion of the Chapman report. Agency and tribal representatives would have preferred to see a draft report before it was finalized. Washington Department of Fisheries has some comments on the report which they will send to Rick Klinge. Klinge will circulate these to the committee.

B. Adult Counting Facility at Zosel Dam. The Columbia River Intertribal Fish Commission has assessed the adult passage with a

video camera at Tumwater Dam. They have submitted a proposal to Douglas County P.U.D. to do the same sort of monitoring at Zosel Dam. Douglas P.U.D. will look into it.

V. Progress on the Methow Hatchery.

A. Contract Bid Award. Klinge reported that 6 contractors bid on the Methow hatchery construction job. Low bidder was DYAD Construction Co. of Woodi
nville, WA, at $5.5 million. Most of the other bids were close, and were near the designers estimate. They will break ground in May. All permits are in hand. The wells are sunk and being developed.

B. Change of Adult Weir Location on the Twisp River. Klinge reported that FishPro had become concerned about the location of the adult weir on the Twisp River. Access was by way of a privately owned bridge with limited weight capacity. They advised moving it to the area where the acclimation ponds are located. Douglas P.U.D. approved this change in the plan. Klinge had talked to Kathy Hopper of WDF. The committee suggested that Klinge consult with the fish committee if further changes of that sort should be required.

C. Comments From Yakima Tribe on Security. The Yakima Tribe had expressed some concerns about security around the acclimation ponds. Douglas P.U.D. will talk to Kathy Hopper of WDF about addressing this problem.

VI. Miscellaneous

A. Progress on the Wells Eastbank Ladder. The ladder is being modified to include a trap. Phase I of construction is completed. The ladder was watered up last Monday, April 1, 1991. Installation of the Denil fish pass and the sorting flumes will be next in Phase II. Douglas P.U.D. has received comments from the agencies on the design. Rod Woodin suggested that Klinge should send a copy of the revised plans to Bob Pearce of NMFS to show how his concerns have been addressed.

WELLS PROJECT COORDINATING COMMITTEE
MEETING APRIL 3, 1991 AT SEA-TAC
ATTENDANCE ROSTER

Name	Representing
Rick Klinge	Douglas County P.U.D.
Bob Clubb	Power Purchasers
Rod Woodin	Washington Department of Fisheries
Gerry Marco	Colville Confederated Tribes
Frank Young	Oregon Department of Fish and Wildlife
Ron Boyce	Oregon Department of Fish and Wildlife
Bill Hevlin	National Marine Fisheries Service
Tony Eldred	Washington Department of Wildlife
Bob Heinith	Columbia River Intertribal Fish Commission
Tom Scribner	Yakima Indian Nation
Richard Whitney	Neutral Third Party
Gary Johnson	Biosonics, Inc.
John Skalski	Consultant
Donn Park	Consultant

To: Wells Project Coordinating Committee WELLS 91-1

From: Richard R. Whitney

Subject: Summary of Meeting of March 1, 1991

INTRODUCTION

The committee learned only recently (letter of February 19, 1991 from Dan Diggs) that the scheduled release date for chinook at the Winthrop and Entiat Hatcheries of the U.S. Fish and Wildlife Service will be April 4, 1991, which is two weeks earlier than in previous years. Rick Klinge became concerned about the short time available to organize a plan for operations during the 1991 outmigration period. There were two items of critical importance, appointment of the bypass team as called for in the settlement agreement, and review of the study plan for evaluation of the bypass in 1991. He asked me to arrange a meeting of the Wells Project Coordinating Committee. In the process of consulting with the members of the committee on a schedule for such a meeting, the idea emerged that the two items could be dealt with most efficiently by telephone, thereby avoiding the need for an in-person meeting. Accordingly, a telephone conference call was arranged at 8:15 A.M. March 1, 1991. Those participating were Rick Klinge, amd Jim McGee, Douglas County P.U.D.; Rod Woodin, Washington Department of Fisheries; Bill Hevlin, National Marine Fisheries Service; Bob Heinith, Columbia River Intertribal Fisheries Commission; Gerry Marco, Colville Confederated Tribes, and Richard Whitney.

Agreements Reached

1. Bypass Team. The representatives appointed to the bypass team are as follows:

   Rick Klinge, Douglas County P.U.D.
   Gerry Marco, Tribes
   Cindy Wilson, Agencies (Alternate Rod Woodin)

2. Bypass Evaluation Study Plan. Klinge reported that John Skalski had recommended modification of the study plan for bypass evaluation that was used last year. The committee agreed to appoint a working group to develop an agreed upon study plan to be recommended to the committee as soon as possible. The committee appointed the following members of the working group: Dr. John Skalski, Ben Sanford (NMFS), John Williams (NMFS), and Phil Mundy (Col. River Intertribal Fish Comm.). Klinge will ask Skalski to put his proposal in writing as soon as possible for the others to review, and then arrange a meeting or consultation to develop the agreed upon plan and report back to the committee.

3. Monitoring of Fish Runs. The settlement agreement calls for monitoring to begin two weeks prior to the preseason forecasted beginning of juvenile migration. Klinge reported that the early releases from Winthrop Hatchery will create some problems in meeting this schedule. Biosonics will do their best. However, the installation of transducers for monitoring must be coordinated with installation of the bypass. They feel that they can have it in place by April 1, 1991, but not two weeks in advance of the probable beginning of juvenile migration. It was agreed that transducers should be placed in the forebay as was done last year. These could be used to develop an

index of migration to assist in the decision as to when to start the bypass, and then to decide when to start the evaluation.

A question was raised whether it would be possible to arrange a break in the 30 day bypass evaluation period if it develops that there is a bimodal distribution in fish migration. Klinge will ask the statistical team to review that possibility and make a recommendation.

It was agreed that fyke net samples to determine species composition of migrants early in the spring could be dispensed with. The committee is now confident that the early fish will be salmonids. Later in the spring, other fish enter the picture. At that time fyke netting would be useful.

4. Beginning of Bypass Operation. The committee discussed criteria that might be used for deciding when to begin bypass operation. Klinge would like to discuss that further after he has more information.

5. Next Meeting. The committee agreed to meet again by telephone conference call at 9:00 A.M. March 11. The agenda will include a progress report from Biosonics on installation of transducers for the bypass evaluation, and criteria to be used for deciding on a starting date for bypass operation.

MEMORANDUM

To: Wells Project Coordinating Committee

WELLS 91-2

From: Richard R. Whitney

Date: March 11, 1991

Subject: Your review of enclosed draft summary of meeting of March 11, 1991 by April 3, 1991, the date of the next scheduled meeting.

Enclosed please find the subject draft meeting summary. If I don't hear from you by April 3, 1991, the date of the next scheduled meeting I will assume you have no corrections or comments and will develop a final version that will be included in the annual report to FERC, per the terms of the settlement agreement.

1. The meeting was held at 8:30 A.M. March 11, 1991, by telephone conference call as agreed at the previous meeting. Those participating were Rick Klinge and Mike Erho, Douglas County P.U.D.; Bill Hevlin, NMFS; Rod Woodin, Washington Department of Fisheries; Bob Heinith, Columbia River Intertribal Fisheries Commission; Tom Scribner, Yakima Tribe; Gerry Marco, Colville Confederated Tribes; and Dick Whitney. The purpose of the meeting was to receive progress reports on installation of the bypass and the hydroacoustic monitoring equipment, and on the revised study plan for evaluation of the prototype.

2. Progress in Monitoring. Rick Klinge reported that Biosonics have placed 15 of 20 transducers in their positions for evaluation of the bypass. Douglas County P.U.D. expects to have no problem in meeting the April 4 readiness date, which is the scheduled date for release of fish from the Winthrop Hatchery. However, they might have a problem being ready two weeks ahead of April 4, which would be March 18, 1991. In any case they expect to be ready to monitor for one week before the scheduled release. As soon as monitoring numbers are available they will be sent by Rick Klinge to Gerry Marco and Cindy Wilson. Those three are the representatives who will make the decision as to when to begin operation and evaluation of the bypass. Fyke netting will be delayed until May 15, 1991.

3. Hatchery Release Schedule. There was a discussion of the early hatchery release. Whitney reported that his information from the Fish and Wildlife Service was that there are chronic disease problems that develop in April at Entiat and Winthrop hatcheries, which led this year to recommendations by the hatchery managers for release around the first of April. The committee is not certain that these fish will move down stream right away. They might hold in the river for a while. There are marked groups that will be followed by the Fish Passage Center. Woodin pointed out that fish from the Similkameen facility will be released volitionally, starting around the first of April. These fish might affect the timing of peaks of migration as well.

4. Bypass Evaluation. Klinge reported that he had asked John Skalski to revise the study plam for evaluation of the bypass and to consult with the working group appointed at the previous meeting. Skalski will mail out the

revised plan today. He will attempt to reach the working group members next week and report back to Klinge as soon as he can. Hevlin will notify John Williams so that he will be prepared for a meeting next week. The Wells Project Coordinating Committee agreed that if the working group can agree on a plan, they will accept it. In that case Klinge should notify the Coordinating Committee by memo with a copy of the study plan. If the working group cannot agree, the Coordinating Committee will meet again to decide what to do.

Klinge had been asked to inquire about the possibility of splitting the 30 day evaluation period in the event that a bimodal distribution occurs in the outmigration period. He asked Skalski who advised against that. It would be better to enlarge the 30 day evaluation period, he thought. Douglas County P.U.D. is considering that possibility. Biosonics continue to work on a new random sampler for the hydroacoustic evaluation, but it might not be ready in time. If not, they will go with the same plan as used last year. The Committee agreed that the plan used last year was satisfactory, and could be used if the new one can not be developed in time.

MEMBERSHIP LIST OF THE WELLS COORDINATING COMMITTEE

APPENDIX - I

Appendix I.
Membership list of the Wells Coordinating Committee

Ron Boyce
Oregon Department of Fish and Wildlife

Bob Clubb
Power Purchasers

Tony Eldred
Washington Department of Wildlife

Bob Heinith
Columbia River Inter-Tribal Fisheries Commission

Bill Hevlin
National Marine Fisheries Service

Rick Klinge
Douglas County P.U.D.

Jerry Marco
Colville Indian Tribes

Tom Scribner
Yakima Indian Nation

Rod Woodin
Washington Department of Fisheries

Dick Whitney
Committee Note Taker

THE LONG TERM SETTLEMENT AGREEMENT FOR THE WELLS HYDROELECTRIC PROJECT

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 de novo review of any decision under the expedited review process. All such appeals shall be in accordance with the FERC's Rules of Practice and Procedure.

5. The Parties may agree to refer any issue subject to expedited review to a third party Decisionmaker other than someone within FERC for processing pursuant to this subsection or as otherwise agreed by the Parties.

E. EFFECTIVE DATES

1. Except as otherwise specified in this subsection I.E, this Agreement shall become effective upon the issuance of a final order by the FERC approving this Agreement.

2. Notwithstanding subsection I.E.1 above, the Parties will immediately upon execution of this Agreement, implement the provisions of the Agreement that do not require formal FERC approval.

3. The Parties agree to immediately seek interim approval by the FERC of Section IV of this Agreement in order to implement construction of hatchery facilities.

II. JUVENILE FISH PASSAGE

A. GENERAL SCOPE OF JUVENILE PASSAGE MEASURES

1. Subject to the schedules, criteria, and conditions in this Agreement, the PUD will fund the installation, operation, maintenance, and evaluation of juvenile fish bypass systems and measures at the Wells Project. Bypass systems and measures are those intended to attract and route juvenile salmonids past operating powerhouse generating units.

2. All facilities under this Agreement shall be designed and constructed using quality materials and then current engineering standards for the purpose of obtaining a high quality product designed to require low maintenance and have a long useful life.

B. BYPASS SYSTEM

The PUD will continue to implement a program of controlled spill using five (5) bypass baffles at the Wells Project to meet the criteria set out in subsections II.C, D, and E.

C. NORMAL BYPASS OPERATIONS CRITERIA

1. No turbine will be operated during the juvenile migration period unless the adjacent bypass system is operating according to the following criteria.

2. The five (5) bypass system bays will be Nos. 2, 4, 6, 8, and 10. Operation of the turbines will be in pairs with the associated bypass system bays, as follows:

Turbines Operated	Bypass Bays Operated
1 and/or 2	2
3 and/or 4	4
5 and/or 6	6
7 and/or 8	8
9 and/or 10	10

(For example, if turbines 1, 5, and 6 are operating, bypass systems 2 and 6 will be operating.)

3. At least one bypass will be operating continuously throughout the juvenile migration period, even if no turbines are operating.

4. The bypass systems and spillgates will be operated in configuration K of the 1987 bypass system report (bottom spill, 1 foot spill gate opening, 2,200 cfs, vertical baffle opening) for all bypass system bays.

5. If top spill is shown to be as effective as bottom spill in bypass bays 2 and 10, then top spill will be allowed in these bays.

6. If the Chief Joseph Dam Uncoordinated Discharge Estimate is 140,000 cubic feet per second (140 Kcfs) or greater for the following day, all five bypass systems will be operated continuously for 24 hours regardless of turbine unit operation.

7. If the Chief Joseph Dam Uncoordinated Discharge Estimate is less than 140 Kcfs, bypass system operation will be as follows:

Number Turbines Operating	Minimum Number Bypass Systems Operating
10	5
9	5
8	4
7	4
6	3
5	3
4	2
3	2
2	1
1	1
0	1

D. BYPASS OPERATIONS TIMING CRITERIA

1. Bypass systems will be in place at least two (2) weeks prior to preseason forecasted beginning of juvenile migration.

2. Bypass systems will remain in place for at least two (2) weeks after the juvenile migration period ends.

3. Monitoring of fish runs will begin when bypass baffles are in place and will end when the baffles are removed.

4. Bypass systems will be available to operate continuously, 24 hours per day, during the juvenile migration period.

E. BYPASS PERFORMANCE CRITERIA

1. At a minimum, bypass system operations will be provided as described in subsections II.B, C, and D for the entire juvenile migration period as defined in the annual operations plan under subsection II.F, and subject to the provisions of subsection II.F.3.

2. Bypass operations as described in subsections II.B, C, and D are intended to provide fish passage efficiency (FPE) of at least eighty percent (80%) for the juvenile spring migration, and FPE of at least seventy percent (70%) for the juvenile summer migration. For purposes of this Agreement, FPE is expressed by the following formula:

Where A = Sum of daily migrants successfully passed by the device during the spring or summer migration

and B = Sum of daily migrants passing through the turbine unit intakes during the same migration

$$FPE = \frac{A}{A + B} \times 100$$

3. If bypass operations under subsections II.B, C, and D do not meet the minimum FPE levels specified in subsection II.E.2, the PUD will modify those operations by implementing one or more of the following measures:

(a) Change in configuration or addition of lights or other physical changes.

(b) Change in "normal operation" under subsection II.C to operation of five bypass system bays at forecast flow of 120 Kcfs.

4. Unless and until these modifications are in place to meet the minimum FPE levels specified in subsection II.E.2, or if these modifications are not sufficient to meet the FPE levels specified therein, then the PUD will increase spillbay bypass flow up to two times normal operation (up to a total of 4.4 Kcfs) per bypass at night (1 hour before sunset to sunrise) for the period:

(a) During which 80% of the spring migration pass the Wells Project;

(b) During which 80% of the summer migration pass the Wells Project, or for 40 days, whichever is less.

5. If portions of the runs do not receive protection at the minimum FPE levels specified under subsection II.E.2, then compensation will be provided based on the difference between the minimum FPE levels specified in subsections II.E.2 and 3 and the actual FPE achieved during the evaluation provided under subsections II.H.1 and 2. The appropriate level of compensation will be calculated based on actual loss. The form of this additional compensation (i.e., fish production) will be determined by the Joint Fishery Parties in consultation with the PUD.

F. <u>ANNUAL OPERATIONS PLANS</u>

1. The PUD will develop an annual bypass systems operations plan consistent with the criteria in subsections II.B, C, D, and E in consultation with the Joint Fishery Parties by the December prior to each migration period. The plan will be reviewed and approved by the Coordinating Committee by March 1 of each year. The plan will be developed from inseason projected hatchery release

dates from facilities above Wells and previous passage monitoring data. The plan will contain predicted dates for the beginning and end of the juvenile migration period; criteria for identifying the beginning and end of the spring and summer runs; and procedures for bypass operations within the constraints of subsections II.B, C, D, and E, including dates for installation and removal of spill baffles, dates for run time monitoring, and criteria for initiation and cessation of bypass operations. If unanimous agreement cannot be reached within the Coordinating Committee regarding all items in the plan, disagreements will be resolved by expedited dispute resolution under subsection I.D.

2. A Bypass Team will be established composed of one representative each for the Party fishery agencies, the Party tribes, and the PUD.

3. Notwithstanding the provisions of subsections II.F.1 and 2 above, the Bypass Team may agree to relax the operations and performance criteria of subsections II.C and E for a period between the end of the juvenile spring migration and the beginning of the juvenile summer migration. Such a modification can only be made with the agreement of all of the members of the Bypass Team, and will be limited to one or more of the following measures:

(a) Less than continuous 24-hour operation of bypass systems.

(b) Fewer than one bypass system operated for two adjacent turbines operated.

(c) Less than 1 foot spill gate slot opening.

4. Once the annual bypass plan is adopted, decisions regarding adjustments to the plan will be made by unanimous agreement of the Bypass Team. If unanimous agreement cannot be reached, the decision on such adjustments will be by majority vote of the Bypass Team.

G. ANNUAL PASSAGE MONITORING PLAN

1. The PUD shall develop an Annual Passage Monitoring Plan, in consultation with the Joint Fishery Parties for review and approval by the Coordinating Committee by March 1 of each year. The Plan will include development of inseason indices of relative fish abundance on a daily basis and annual estimates of juvenile migrant production. Estimates of relative abundance will be used to guide bypass operations decisions under subsections II.E.4, II.F.1, II.F.3, and II.F.4. Estimates of juvenile migrant production will be used as the basis for compensation adjustments (Hatchery-Based Compensation - Phase IV) as provided in subsection IV.A.3.

H. FPE EVALUATION PLAN

1. The PUD shall develop an FPE evaluation plan, in consultation with the Joint Fishery Parties, for review and approval by the Coordinating Committee by March 1, 1990. The purpose of the plan shall be to evaluate whether minimum FPE levels set out in subsection II.E are being met. The plan will provide for evaluation beginning in 1990 and continuing for at least three consecutive years after baffles are installed and operating in accordance with this Agreement in all five (5) bypass bays. If physical or

operational changes are made to the bypass systems, additional FPE evaluation under a new or amended plan will be required to provide at least three consecutive years of evaluation after completion of the changes.

2. It is the goal of evaluations under the plan to be able to determine FPE within plus or minus five percent (5%) at the ninety-five percent (95%) confidence level. If the FPE point estimates are equal to or greater than eighty-five percent (85%) for the spring run and seventy five percent (75%) for the summer run, then the accuracy of plus or minus ten percent (10%) at the ninety percent (90%) confidence level is acceptable. If the FPE point estimate for the spring run is between eighty (80) and eighty-five (85) percent, or the FPE point estimate for the summer run is between seventy (70) and seventy-five (75) percent, the PUD will implement one of the following actions:

(a) Take the necessary steps to achieve a FPE accuracy of plus or minus five percent (5%) at the ninety-five percent (95%) confidence level, or

(b) Take steps outlined in subsection II.E.3 to increase the FPE point estimates to eighty-five percent (85%) and seventy-five percent (75%) for the spring and summer runs, respectively.

3. The PUD will fund a biometrician or statistician selected by unanimous agreement of the Coordinating Committee to review the draft plan to ensure that the plan meets the objectives of subsections II.H.1 and 2, and to review results developed under the plan.

III. ADULT FISH PASSAGE

A. GENERAL SCOPE OF ADULT PASSAGE MEASURES

The current operating and maintenance criteria for facilities for the passage of adult anadromous fish over the Wells Project Dam are specified in this Section III. Changes in these criteria must be by unanimous agreement of the Coordinating Committee.

B. WATER DEPTH CRITERIA

The water depth over the weirs of the adult fish ladder will be 1.0 to 1.2 feet.

C. ENTRANCE CRITERIA

1. Head: 1.5 feet

2. Gate Settings:

a) March 1 - November 30

	Side Wing Gate	End Wing Gate
(i) Spill less than 80 Kcfs	4 ft	6 ft
(ii) Spill greater than 80 Kcfs	Closed	8 ft

(iii) Low level fixed orifice entrance to be open whenever side gate is closed.

b) December 1 - February 28

(i) Side and end gates open 2 feet six days per week for 24-hour periods.

(ii) Side and end gates open 4 feet and 6 feet, respectively, one day per week for a 24-hour period.

D. ATTRACTION JET CRITERIA

1. Jets are located in a vertical line immediately upstream of the side wing gates.

2. Lower jet (30-inch diameter) will operate only when the low level fixed orifice entrance is open.

3. Three 24-inch diameter jets (at elevations 700, 708, and 717 msl) will each be discharging when tailwater reaches that level.

E. STAFF GAUGE AND WATER LEVEL INDICATOR CRITERIA

Staff gauge and water level indicators will:

1. Be located upstream and downstream of all entrances, and at convenient locations for viewing along ladder.

2. Be located upstream and downstream of adult fishway exit trashrack.

3. Be readable at all water levels and be kept clean.

4. Be checked against panel board water surface readings to insure proper adjustment of water level sensing equipment.

F. TRASHRACK CRITERIA

1. Visible buildups of debris will be cleaned immediately from picketed leads near counting stations, and from trashracks at adult fishway exits.

2. The staff gauges upstream and downstream of the adult fishway exit trashrack will be monitored for water surface differential, which will reflect buildup on submerged trashrack. The trashrack will be cleaned immediately if the differential reading is greater than 0.3 feet.

G. MONITORING AND EVALUATION OF ADULT PASSAGE

1. In 1990, the PUD, in consultation with the Joint Fishery Parties, will develop a study plan to determine the extent of adult

delay and mortality at the Wells Project. The study plan will be reviewed and approved in advance by the Coordinating Committee. Studies will begin in 1991 and continue for a period of time determined by the Coordinating Committee based on preliminary results.

2. If the study identifies delays and/or mortality, the operating criteria specified in this Section III will be changed to alleviate these problems. If changes in the operating criteria do not alleviate the problems, adult passage facility modifications will be made. Provided, however, that any disagreements over the appropriateness of facility modifications of $325,000 or less (1988 dollars) may be taken through the expedited dispute resolution procedure in subsection I.D. And, provided further, that any disagreements over the appropriateness of facility modifications of more than $325,000 (1988 dollars) may be resolved under the FERC Rules of Practice and Procedure at any time.

IV. HATCHERY-BASED COMPENSATION

The PUD will fund a hatchery-based compensation program (the "Program") as provided in this Section IV. The Program will include the design, construction, operation, maintenance and evaluation of facilities required to implement the elements of a production plan (the "Production Plan") as set forth in this Section. The purpose of the Program is to mitigate for fish passage losses at Wells Dam. The Program is composed of adult collection sites; a central hatchery facility for incubation, early

rearing, and adult holding; and acclimation facilities in the tributaries above Wells Dam for final rearing and release.

A. PRODUCTION PLAN

1. The Joint Fishery Parties have developed the Production Plan to define the requirements of hatchery-based compensation under this Agreement. The Production Plan describes juvenile rearing and release requirements, including species mix and target release sizes; and related broodstock requirements under subsection IV.D.

2. The Production Plan will be reviewed annually by the Joint Fishery Parties, and may be modified by the Joint Fishery Parties in consultation with the PUD. Modifications to the Production Plan may include changes to the species mix and rearing and release strategies as required to accommodate the Joint Fishery Parties' management needs. Modifications to the Production Plan will not require an increase in the rearing capability of the Program beyond that required to satisfy Phases One and Two of the Production Plan as shown in subsections IV.A.3(a) and (b) or Phases Three and Four of the Production Plan to be determined as shown in sections IV.A.3(c) and (d). The Production Plan and any modifications thereto will be consistent with guidelines and procedures developed under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program.

3. The Production Plan is comprised of four phases of hatchery-based compensation as described below. It also includes related broodstock requirements under subsection IV.D.

(a) Phase One

Phase One will begin in 1991 and will consist of the following compensation elements:

(1) 49,200 pounds of spring chinook yearlings at about 15/pound;

(2) 8,000 pounds of sockeye juveniles at about 25/pound; and

(3) 30,000 pounds of steelhead smolts at about 6/pound

(4) After 1991, space to rear additional steelhead will be provided by the PUD at Wells Hatchery, if such space is available and not needed to meet other PUD fish production responsibilities. The PUD will not be obligated to fund or supply well water to rear the fish.

(b) Phase Two

Phase Two will begin after evaluation of the Phase One Production Plan and will be restricted to the Program required by either the Phase Two A or Two B Production Plan as shown below. At the time of implementation, the Phase Two A or Phase Two B Production Plan may be modified based on other Phase One evaluations described in subsection IV.C, Studies and Evaluations, subject to the provisions of subsection IV.A.2.

(1) Phase Two A

Increase sockeye production from 8,000 pounds to 15,000 pounds of juveniles at about 25/pound.

(2) Phase Two B

(i) Eliminate sockeye production;

(ii) Add 15,000 pounds of summer chinook yearlings at

about 10/pound; and 6,500 pounds of zero-age summer chinook juveniles at about 40/pound.

(c) Phase Three

Phase Three will begin as soon as practicable following Coordinating Committee approval of the results of the Wells Project juvenile mortality/survival study or no later than the third brood year after Coordinating Committee determination of the adjustments required and will consist of the following compensation elements:

(1) Except for steelhead, which shall remain at 30,000 pounds, adjust compensation requirement to reflect the difference between the juvenile mortality rate determined by the mortality/survival study under subsection IV.C.5 and the assumed mortality rate shown in Appendix A; and

(2) Adjust compensation requirement to reflect unavoidable and unmitigated adult losses, as determined by Coordinating Committee approved estimates from studies conducted under subsection III.G, and converted to juvenile production based on adult to smolt ratio estimates as described in Appendix B.

(d) Phase Four

Phase Four will begin at such time as the Coordinating Committee approved five-year rolling average estimate of juvenile run size, estimated as described in subsection IV.C.6 and Appendix A, increases to at least 110% of the 9,034,700 estimated juvenile migrant salmon production used to establish the Phase One and Phase Two compensation levels shown in subsections IV.A.3(a) and

IV.A.3(b). Phase Four will consist of compensation adjustment, if requested by the Joint Fishery Parties, to reflect the percentage increase in juvenile run size, except for steelhead, which shall remain at 30,000 pounds. The Joint Fishery Parties, in consultation with the PUD, will determine the appropriate form of compensation (i.e., fish production) for any adjustments required in Phase Four.

B. COMPENSATION PROGRAM

1. The facilities provided in the Program will be designed, constructed, operated, maintained, and evaluated to produce the hatchery-based compensation set forth in the Production Plan.

2. If the evaluations described in subsection IV.C indicate that the Program is not meeting the production levels called for in the Production Plan, then reasonable modifications to the Program will be made.

3. The PUD will only be obligated to assure the capability of facilities provided under this Agreement to produce high quality juvenile fish at the compensation levels shown in subsection IV.A.3.

4. The Program facilities described in this Agreement are in addition to the existing mitigation program at Wells. The existing mitigation program at Wells consists of annual production of 50,000 pounds of steelhead and 56,500 pounds of summer chinook salmon. Under the 1984 Mid-Columbia Stipulation, which expired in 1989, 400,000 summer chinook at 90/pound have been reared at Wells for release into the Methow River. This production will continue until

Phase One production is initiated. Nothing in this Agreement will affect the annual production of 25,000 pounds of steelhead under the Oroville-Tonasket agreement between the PUD and the U.S. Bureau of Reclamation.

5. Facilities provided in the Program will consist of:

(a) Phase One

Phase One compensation facilities, including satellite facilities, shall be capable of rearing and releasing 57,200 pounds of salmon and 30,000 pounds of steelhead annually.

(b) Phase Two

Phase Two compensation facilities shall be capable of increased production to accommodate the Production Plan as described in subsection IV.A.3(b).

(c) Phase Three

Phase Three compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(c).

(d) Phase Four

Phase Four compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(d). Facilities for the required adjustments will be constructed by the PUD as soon as practicable and be operational no later than the third brood year following the Joint Fishery Parties request under subsection IV.A.3(d).

6. Production and acclimation facilities used in the Program shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The biological criteria and guidelines described in subsection IV.D shall apply to production and acclimation facilities used in the Program.

C. STUDIES AND EVALUATIONS

1. The PUD will develop and fund studies in 1990, approved by unanimous agreement of the Coordinating Committee, to determine:

(a) Potential for spawning and rearing sockeye in unutilized habitat in the Okanogan and Similkameen systems;

(b) Potential for establishing sockeye populations in the new habitat.

2. The PUD will fund the Joint Fishery Parties' effort to determine the success of Phase One sockeye compensation based on review of smolt production. The Joint Fishery Parties may make this determination after the evaluation of the third brood year's production.

3. The PUD will fund the Joint Fishery Parties to develop and conduct studies to evaluate the adequacy of the Program and the effectiveness and success of the Production Plan subject to the provisions of Section V, Coordinating Committee. The studies will meet standards developed for similar efforts under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program. The studies will pass the test of reasonableness with respect to cost and duration.

(a) The studies will involve marking a portion of the juvenile fish produced under subsection IV.B and will involve recoveries of juvenile and adult fish to estimate various parameters such as fish health, fishery contribution, survival, spawning time and spawning locations.

(b) The PUD will fund recovery efforts at Wells Dam and hatchery and tributary spawning areas above Wells Dam. Existing recovery operations, currently funded through different sources, will be utilized to the extent possible. Approved studies may require the PUD's participation in funding a portion of other recovery efforts.

(c) The evaluations provide data necessary to determine the success of the Program to produce the intended compensation levels and the effectiveness of the Production Plan to meet management objectives.

(d) Evaluation of the Production Plan and Program effectiveness will be initiated in Phase One for all species in the Production Plan.

(e) To the extent that the Joint Fishery Parties elect to modify the Production Plan, the PUD will fund studies to evaluate the modifications. The studies will be mutually agreeable and are intended to evaluate only the changes called for in the modification. The studies will be consistent with the provisions of Section V, Coordinating Committee.

(f) The PUD will fund an analysis of annual fish production and adult contribution to harvest and escapement to be conducted

by the Joint Fishery Parties. The analysis will be consistent with the provisions of Section V, Coordinating Committee. Draft and final reports will be provided to the Parties.

5. No later than 1990, a Wells Project juvenile mortality/survival study will be developed by the PUD in consultation with the Joint Fishery Parties and approved by unanimous agreement of the Coordinating Committee. The studies will begin in 1991, after the installation of new turbine runners at the Wells Project, for the purpose of determining juvenile losses.

6. The PUD will provide data from its ongoing, annual adult passage monitoring program that will allow the Joint Fishery Parties to compute the five-year rolling average estimate of juvenile run size which will be the basis for Phase Four compensation, as indicated in subsection IV.A.3(d). Calculation of increases in juvenile run size will be based on fish from existing mitigation programs, natural production and future compensation programs. The method of calculation will be as described in Appendices A and B.

D. PRODUCTION/ACCLIMATION FACILITIES

Production and acclimation facilities under this Section shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The following biological criteria and guidelines shall apply to production and acclimation facilities under this subsection IV.D. Criteria are not to be exceeded. Guidelines are not to be exceeded if practicable.

1. Salmon Criteria

(a) Adult Holding

(i) Density not to exceed one (1) fish per ten (10) cubic feet of space.

(ii) Flow must be at least one (1) gallon per minute per 20 pounds of fish.

(b) Juvenile Rearing

(i) Density not to exceed 0.75 pounds of fish per cubic foot of rearing space for yearling chinook to a size of 10 fish per pound. Maximum density is achieved at release date. The density through out the rearing period is proportionately lower and directly related to fish size.

(ii) Pond or raceway loading rate not to exceed 6.0 pounds of fish per gallon of water per minute inflow for yearling chinook at a size of 10 fish per pound. Maximum loading rate is achieved at release date. The loading rate throughout the rearing period is proportionately lower and directly related to fish size.

(iii) Density for sockeye juveniles in net pens not to exceed 0.33 pounds of fish per cubic foot of rearing space.

(c) Water Supply

(i) Water will be of highest quality practicably available at appropriate sites. Ground water may be required at sites. All water supplies will be pathogen free if practicable. The water source must not preclude transfer of the stocks being reared to their point of origin due to presence of fish disease organisms in the rearing water supply.

(ii) Reuse of water is not acceptable for either egg incubation or juvenile rearing.

(iii) Reuse water is acceptable for adult holding.

(iv) Effluent water from egg incubation may require treatment for fish diseases (e.g., chlorination/dechlorination).

(v) Construction of facilities must accommodate the potential to treat the juvenile rearing and adult holding water for disease pathogens.

(d) General

(i) Facilities must have the capability to maintain stock segregation from adult holding through incubation and rearing.

(ii) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(iii) Protection from mammalian and avian predators must be provided.

2. Salmon Guidelines

(a) Water Temperatures

(i) Egg incubation - no greater than 55°F nor less than 38°F.

(ii) Fry starting - 48-52°F.

(iii) Juvenile rearing - not to exceed 52°F.

(iv) Adult holding - not to exceed 55°F.

(b) Release Size, Time, and Location

(i) Yearling spring chinook - 15 fish/pound in late April.

(ii) Yearling summer chinook - 10 fish/pound in late April.

(iii) Subyearling summer chinook - 40 fish/pound in June.

(iv) Subyearling sockeye - 25 fish/pound in June.

(v) Juvenile fish will be acclimated and released in tributaries above Wells Dam.

(c) Adult Brood Stock

(i) Sufficient adults of the appropriate species and stocks will be trapped and held to meet the egg requirements for each phase of salmon production.

(ii) Fifty percent (50%) of the adults trapped will be females and it is assumed there will be

approximately eighty percent (80%) survival of eggs from trapping of females to ponding of fry.

(iii) Adult brood stock will be collected at the following sites:

a) Spring chinook - Chewack River, Methow River above Winthrop, and Twisp River above river mile 2.0.

b) Summer chinook and sockeye - at Wells Dam

(iv) Tributary brood stock collection facilities will require an annually installed rack and a semi-permanent box trap.

(v) Wells Dam brood stock collection may require a separator/sorter in the left bank fishway. The final design of the left bank trap and any modification of the right bank trap will be approved by unanimous agreement of the Coordinating Committee.

(vi) The adults will be transferred in a water-to-water system from traps to tank trucks to holding ponds.

(vii) The PUD shall provide funds for personnel to separate and sort adult fish in the right bank fishway at Wells Dam and at other required adult collection sites. All brood stock collection shall be conducted in a manner to

minimize delay of non-target species and individual fish.

3. Steelhead Criteria

The goal for this program is to use the existing facilities including well and river water, raceways, rearing ponds, house, shop, freezer, office, etc., in the manner they are being used now. Most of the following criteria and guidelines fit the existing program.

(a) Adult Holding

(i) Density not to exceed 2.5 pounds of fish per cubic foot of water.

(ii) Flow must be at least one gallon per minute for 3.3 pounds of fish.

(b) Juvenile Rearing

(i) Density: Calculated density limit not to exceed Pipers density formula: $W = D \times V \times L$ where

W = Permissible weight in pounds.

D = Density index (.25 for raceways and .03 for rearing ponds).

V = Useable volume in container in cubic feet.

L = Fish length in inches.

ii) Water flow: Calculated flow should not allow weight to exceed Pipers flow formula:

$W = F \times L \times I$ where

W = Permissible weight in pounds.

F = The loading factor from Table 1.

L = Fish length in inches.

I = Water flow in gallons per minute.

Table 1. Load factor as related to water temperature and elevation.

Water Temperature(°F)	Load Factor(lbs/in/gpm) Raceways(1)	Rearing Ponds(2)
40	2.70	3.62
41	2.61	3.53
42	2.52	3.44
43	2.43	3.35
44	2.34	3.26
45	2.25	3.17
46	2.16	3.08
47	2.07	2.99
48	1.98	2.90
49	1.89	2.81
50	1.80	2.72
51	1.73	2.65
52	1.67	2.59
53	1.61	2.53
54	1.55	2.47
55	1.50	2.42
56	1.45	2.37
57	1.41	2.33
58	1.36	2.28
59	1.32	2.24
60	1.29	2.21
61	1.25	2.17
62	1.22	2.14
63	1.18	2.10
64	1.15	2.07

1) From Piper et al. 1978
2) From Wells hatchery

(c) Water Supply

(i) Water supply to be of highest quality practicably available using ground and river water. Any disease contracted because of water source

must not stop release of fish in local watersheds.

(ii) Reuse water not acceptable for egg incubation.

(iii) Reuse water normally acceptable (unless disease problem) for adult holding.

(iv) Effluent water from egg incubation will require treatment for fish diseases.

(v) Adult holding and juvenile rearing water may have to be treated for disease pathogens.

(d) General

(i) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(ii) Protection from mammalian and avian predators must be provided.

4. Steelhead Guidelines

(a) Water Temperatures

(i) Egg incubation: 38°F to 55°F

(ii) Fry starting: 48°F to 54°F

(iii) Juvenile Rearing not to exceed 57°F

(iv) Pre-smolt not to exceed 54°F

(v) Adult holding not to exceed 54°F

(b) Release age, time, size and location

(i) Released as yearlings

(ii) April 10 to May 10 at six to the pound.

(iii) Juvenile steelhead will be released in tributaries or into the mainstem above Wells Dam.

(c) Adult Broodstock

(i) Fifty percent (50%) will be females and assume eighty percent survival of eggs to ponding of fry.

(ii) Adults will normally be trapped at the existing facilities on the right bank, however new trap at left bank may be used sometimes.

(iii) Adults will be transferred in water from traps to holding ponds.

V. WELLS PROJECT COORDINATING COMMITTEE

A. COORDINATING COMMITTEE

There shall be a Wells Project Coordinating Committee composed of one (1) technical representative of each Party to this Agreement. The Coordinating Committee shall meet whenever requested by any two (2) Parties following a minimum of ten (10) days written notice (unless waived), or pursuant to subsection I.D, and shall act only by unanimous agreement of all Parties. Any Joint Fishery Party may, at any time, elect by written notice not to participate in the Coordinating Committee. The PUD shall fund a neutral third party to record and distribute minutes of Coordinating Committee meetings.

B. USE OF COMMITTEE

The Coordinating Committee will be used as the primary means of consultation and coordination between the PUD and the Joint Fishery Parties in connection with the conduct of studies and implementation of the measures set forth in this Agreement and for dispute resolution pursuant to subsection I.D. All study designs and modifications to study designs will be subject to agreement by all Parties.

C. STUDIES AND REPORTS

1. All studies and reports prepared under this Agreement will be available to all Parties as soon as reasonably possible. Draft reports will be circulated through Coordinating Committee representatives for comment, and comments will either be addressed in order or made an appendix to the final report.

2. All studies will be conducted following accepted techniques and methodologies in use for similar studies in the Columbia Basin. All studies will be based on sound statistical design and analysis.

3. Fish passage efficiency tests will be conducted using hydroacoustic means and direct capture methods for species identification.

VI. JOINT FISHERY PARTIES' RESPONSIBILITIES

A. LIMITATION OF MID-COLUMBIA PROCEEDING

The Joint Fishery Parties agree to join with the PUD to request that the FERC terminate the Mid-Columbia proceeding insofar

as it pertains to the Wells Project. The Parties specifically agree to reserve the right to enforce the terms and conditions of this Agreement before the FERC.

B. SUPPORT FOR RELICENSE

The PUD's FERC license for the Wells Hydroelectric Project expires in 2012. The Joint Fishery Parties agree to be supportive of the PUD's new or renewal license application to the FERC, provided that the PUD has adhered to the terms and conditions of this Settlement Agreement, as well as any future terms, conditions, and obligations agreed upon by the Parties hereto or imposed upon the PUD by the FERC. To the extent that the PUD has met such terms and conditions, the Joint Fishery Parties agree that the PUD is a competent license holder with respect to its obligations to anadromous fish resources. Nothing in this paragraph shall limit or preclude any Party hereto from requesting at the time of any license renewal the provision of or supporting different, modified or additional fish protection measures and compensation; or from requiring that the fishery protection measures contained in a competing license application be included as a condition of the PUD's new license, or in the absence of such additional or modified measures in a new license, or in the absence of measures contained in a competing license application requested by the Joint Fishery Parties, from requesting that the PUD's new or renewal license application be denied.

C. STIPULATION OF ADEQUACY

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement constitutes adequate fish protection and full compensation for all fishery losses caused by the Wells Project at least until March 1, 2004. It is further stipulated that this Agreement satisfies any obligations of any Party relating to the adequacy of fish protection and compensation for fish losses caused by the Wells Project, and arising under applicable laws and regulations, including but not limited to the Federal Power Act, the Pacific Northwest Electric Power Planning and Conservation Act, and the Electric Consumers Protection Act of 1986, at least until March 1, 2004. This Agreement shall not otherwise affect the rights of any Party except as expressly covered by this Agreement.

D. FISH AND WILDLIFE PROGRAM

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement shall constitute full compliance with the applicable provisions of the Northwest Power Planning Council's 1987 Fish and Wildlife Program, at least until March 1, 2004. The Joint Fishery Parties stipulate that the PUD shall receive full credit for its hatchery production in meeting any requirements that may be established as a result of implementation of Section 203 of the Council's Program.

E. LIMITATION ON REOPENING

The Joint Fishery Parties shall not invoke or rely upon any reopener clause set forth in any license applicable to the Wells

Project for the purpose of obtaining additional fish measures or changes in project structures or operations pertaining to fishery issues until after March 1, 2004.

F. ADDITIONAL MEASURES

The Joint Fishery Parties shall refrain from contending on their own behalf or supporting any contention by other persons in any proceeding or forum that additional fish measures or changes in project structures or operations pertaining to fishery issues should be imposed at the Wells Project until after March 1, 2004.

VII. MISCELLANEOUS

A. COOPERATION

The Parties shall cooperate in conducting studies and shall provide assistance in obtaining any approvals or permits which may be required for implementation of this Agreement.

B. NOTICES

All written notices to be given pursuant to this Agreement shall be mailed by first-class mail, postage prepaid, to each Party at the address listed below or such subsequent address as a Party shall identify by written notice to all other Parties. Notices shall be deemed to be given three (3) days after the date of mailing.

C. WAIVER OF DEFAULT

Any waiver at any time by any Party hereto of any right with respect to any other Party with respect to any matter arising in

connection with this Agreement shall not be considered a waiver with respect to any subsequent default or matter.

D. ENTIRE AGREEMENT -- MODIFICATIONS

All previous communications between the Parties hereto, either verbal or written, with reference to the subject matter of this Agreement are hereby abrogated, and this Agreement duly accepted and approved, constitutes the entire agreement between the Parties hereto, and no modifications of this Agreement shall be binding upon any Party unless executed or approved in accordance with the procedures set forth in subsection I.C.

E. BENEFIT AND ASSIGNMENT

This Agreement shall be binding upon and inure to the benefit of the Parties hereto and their successors and assigns provided, no interest, right or obligation under this Agreement shall be transferred or assigned by any Party hereto to any other Party or to any third party without the written consent of all other Parties, except by a Party:

(a) To any person or entity into which or with which the Party making the assignment or transfer is merged or consolidated or to which such Party transfers substantially all of its assets; or

(b) To any person or entity that wholly owns, is wholly owned by or is wholly owned in common with the Party making the assignment or transfer.

F. FORCE MAJEURE

The PUD shall not be liable for failure to perform or for delay in performance due to any cause beyond its reasonable control. This may include, but is not limited to, fire, flood, strike or other labor disruption, act of God, act of any governmental authority or of the Joint Fishery Parties, embargo, fuel or energy unavailability, wrecks or unavoidable delays in transportation, and inability to obtain necessary labor, materials or manufacturing facilities from generally recognized sources in the applicable industry. The PUD will make all reasonable efforts to resume performance promptly once the force majeure is eliminated.

G. INFLATION CALCULATIONS

All dollars specified in this Agreement are 1988 dollars. Dollar figures shall be adjusted annually for each year after 1988 based on the "Consumer Price Index for All Urban Consumers" published by the Bureau of Labor Statistics of the U.S. Department of Labor. If this index is discontinued or becomes unavailable, a comparable index agreeable to all Parties will be substituted.

H. METHOW RIVER HATCHERY WATER SUPPLY

1. The PUD agrees to cooperate with the Washington Department of Fisheries (WDF) to secure the necessary water rights and permits for facilities to be provided under this Agreement.

2. With respect to the proposed Methow River hatchery, the Parties agree that WDF and the PUD may utilize for the proposed Methow River hatchery facility up to 7 cfs of the water right now

held by the U.S. Fish and Wildlife Service (FWS), and subject to full or partial recall by FWS for any reason. The PUD shall not obtain legal title or ownership of the FWS water right.

3. To the extent that the utilization of water does not occur or is recalled or returned to FWS, the PUD and WDF shall use their best efforts to acquire an alternative source of water that meets applicable State requirements for water rights in order to satisfy obligations under this Agreement.

4. The PUD agrees to cooperate with WDF to secure the necessary permits in order to construct and provide for the operation of the proposed Methow River hatchery. The hatchery will be designed and constructed with the capability of installing pump-back facilities for returning the flow to the point of diversion.

5. If hatchery and/or river water supply requirements dictate the need for installation of a pump-back scheme, the PUD shall install and WDF shall operate the pump-back facilities.

VIII. REGULATORY APPROVAL

A. FERC ORDERS

All Parties agree to join in the filing of an offer of settlement with the FERC based on this Agreement and to request that the FERC issue appropriate orders approving the settlement. All Parties shall refrain from seeking judicial review of the FERC orders approving this Agreement.

B. PERFORMANCE CONTINGENT ON APPROVAL

Performance of all Parties' obligations under this Agreement

is expressly made contingent on obtaining all necessary regulatory approvals, specifically including all FERC orders referred to in subsection VIII.A above, and all applicable federal, state and local permits. It is expressly agreed by all Parties that this Agreement shall be submitted to the FERC as a unit and any material modification of its terms, approval of less than the entire Agreement, or addition of material terms by the FERC shall make this Agreement voidable at the option of any Party.

C. NO PREJUDICE

All Parties stipulate that neither FERC approval nor any Party's execution of this Agreement shall constitute approval or admission of, or precedent regarding, any principle, fact or issue in the Mid-Columbia proceedings, or any other FERC proceeding, including subsequent modification proceedings under Section I.

D. EXECUTION

This Agreement may be executed in counterparts. A copy with all original executed signature pages affixed shall constitute the original Agreement. The date of execution shall be the date of the final Party's signature. Approval of this Agreement must be acknowledged by the Commissioner of Indian Affairs and the Secretary of the Interior, or their delegates, to the extent required by 25 U.S.C. § 81.

E. AUTHORITY

Each Party to this Agreement hereby represents and acknowledges that it has full legal authority to execute this Agreement and shall be fully bound by the terms hereof.

F. ACTION FOR NONCOMPLIANCE

Notwithstanding any other provision of this Agreement, any Party may seek relief arising solely from noncompliance with this Agreement by any Party; provided, all requests for specific performance of any provision of this Agreement shall be filed with the FERC pursuant to subsection I.D.

IN WITNESS WHEREOF, the Parties have executed this Agreement the day and year first written above.

APPENDIX A

JUVENILE MIGRANT LOSS ESTIMATES USED FOR COMPENSATION PLANS IN THE WELLS DAM SETTLEMENT AGREEMENT

1. Steelhead

The number of juvenile steelhead migrants killed by passage through the Wells Project reservoir and dam were not estimated for the purposes of this Settlement Agreement. As an alternative the parties have agreed to continue steelhead production programs and plans initiated under previous Mid-Columbia settlements.

2. Salmon Loss Estimates

The number of juvenile salmon migrants killed by passage through the Wells Project reservoir and dam were estimated as follows:

a. The number of juvenile migrant salmon, by species and race, entering the Wells Reservoir was estimated for natural production by applying sex ratios, egg per female data and theoretical egg to migrant survival rates to the numbers of adults passing above Wells Dam to spawn. These juvenile migrant numbers were computed annually and averaged over the passage years 1975-1984 for spring and summer chinook and averaged over the passage years 1975-1986 for sockeye. The recent average level of hatchery releases at Winthrop National Fish Hatchery were added to the spring chinook migrant estimates. The resulting estimates of average annual numbers

of juvenile migrant salmon entering Wells reservoir are:

Spring Chinook	=	1,504,400
Summer Chinook	=	2,913,300
Sockeye	=	4,617,000
Total	=	9,034,700

b. The total project mortality at Wells, including reservoir mortality, was estimated to be 14%. Applying this mortality rate to the population estimates in Item 1 above results in the following estimates of juvenile migrants killed by species:

Spring Chinook	=	210,600
Summer Chinook	=	407,900
Sockeye	=	646,400
Total loss	=	1,264,900

3. Derivation of Production Plan

a. The Phase I compensation Production Plan and Program is an initial step in production which is not intended to provide full compensation for juvenile migrant losses. The lack of full compensation is due to the experimental nature and developmental aspects of the sockeye Production Plan and Program.

b. To accommodate logistic and per-unit cost factors in Phase I development, about 225,000 (15,000 pounds) spring chinook were substituted for 231,000 sockeye.

c. Items (1) through (3) below describe the derivation of the hatchery-based compensation levels included in the body of the Agreement.

(1) Steelhead production is set at 30,000 lbs./year to continue the successful program initiated under prior Mid-Columbia Settlement Agreements.

(2) Phase I compensation includes a pilot program for hatchery production of sockeye. The sockeye production level is set to allow assessment of Program success rather than provide full compensation for the estimated juvenile losses at Wells.

(3) The Phase II Chinook/Sockeye Production Plan is sized to mitigate for estimated juvenile losses:

	Estimated Annual Losses at Wells	Annual Production Phase IIA or Phase IIB	
Spring Chinook	210,600	450,000	450,000
Summer Chinook	407,900	400,000	810,000
Sockeye	646,400	375,000	-
TOTALS	1,264,900	1,225,000	1,260,000

4. Chelan PUD/Douglas PUD Compensation Exchange

In recognition of the specific requirements for spring and summer chinook rearing facilities and the characteristics of the water supply at the PUD's proposed spring chinook rearing facility on the Methow River, the Joint Fisheries Parties, Douglas PUD and Chelan County PUD have reviewed the respective compensation

obligations of Douglas PUD as set forth in this Agreement, and Chelan County PUD under terms of the Rock Island Settlement. In consideration of biological efficiency and logistical effectiveness, the parties have agreed to adjusted compensation obligations under this agreement and the Rock Island Settlement in the following manner:

a. Douglas PUD will assume responsibility for 19,200 pounds of Methow River sub-basin spring chinook production.

b. Chelan PUD will assume responsibility for 40,000 pounds of Methow River summer chinook production.

The resulting changes in production with the Douglas-Chelan compensation exchange agreement are (number of juveniles/year):

	Douglas Production	Chelan Production
Spring Chinook	Increases 288,000	Decreases 288,000
Summer Chinook	Decreases 400,000	Increases 400,000
Sockeye	No Effect	No Effect

c. The resultant Douglas PUD annual compensation program under this agreement (Phase II Production) is:

Phase IIA

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Sockeye @ 25/lb.

OR

Phase IIB

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Summer Chinook @ 10/lb.

6,500 lbs. of Summer Chinook at 40/lb.

APPENDIX B

DETERMINATION OF RESPONSIBILITY FOR HATCHERY COMPENSATION

For each year of determination, calculate an average smolt output as follows:

1. Calculate a 5-year running average adult run (by species) for naturally spawned fish (Ays) as follows:

$$\bar{A}ys = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

Where Ay is the total adult count for each species at Wells minus the hatchery escapement for the species in year y;

Ay-1 = the same in the previous year (y-1) and so on.

2. Multiply Ays by the average expected adult to smolt production factor Kys for each species, where Kys is calculated as follows:

a. Spring Chinook:

Ksp = 0.94 (Wells Dam to spawner survival)
x 0.50 (sex ratio) x 5000 (eggs/female)
x 0.10 (av. survival to smolt) = 235

b. Summer Chinook:

Ksu = 0.94 x 0.50 x 5000 x 0.30 = 705

c. Sockeye:

$$Kso = 0.94 \times 0.50 \times 2700 \times 0.12 = 152$$

3. Add the number of hatchery smolts HSys by species, which is a running average of the same 5 years as in Ays.

$$\overline{HSys} = \frac{HSy + HSy\text{-}1 + HSy\text{-}2 + HSy\text{-}3 + HSy\text{-}4}{5}$$

4. Total smolts (by species):

$$\overline{S}ys = Kys \times \overline{A}ys + \overline{HS}ys$$

5. Grand Total = Sum of all species:

$$Sgt = \overline{S}sp + \overline{S}su + \overline{S}so + \ldots$$

6. If other salmon species or races, for which the above smolt production factors (Kys) do not apply, become established in the production areas above Wells Dam, appropriate K factors for these fish will be established by consensus of the Coordinating Committee. Juvenile migrant production will be computed for these species or races. These numbers will be included in the grand total for juvenile migrant production and the 5-year running averages.

WELLS PHASE IV THEORETICAL CALCULATION EXAMPLE

NATURAL PRODUCTION

DATA USED IN EXAMPLE CALCULATION OF NATURAL PRODUCTION

Adult Count	Ay	Ay-1	Ay-2	Ay-3	Ay-4	5 Year Average
Spring Chinook	3,000	2,200	3,100	5,000	2,900	3,240
Summer Chinook	2,400	2,800	3,700	4,000	4,700	3,520
Sockeye	40,000	20,000	35,000	15,000	30,000	28,000

Ay = Wells Count Minus Hatchery Escapement for Year Y

Ksp = Calculated Spring Chinook Smolts

Ksu = Calculated Summer Chinook Smolts

Ksoe = Calculated Sockeye Smolts

Spring Chinook $\bar{A}y$

$$= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

$$= \frac{3000 + 2200 + 3100 + 5000 + 2900}{5}$$

$$= 3240$$

Summer Chinook $\bar{A}y$

$$= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

$$= \frac{2400 + 2800 + 3700 + 4000 + 4700}{5}$$

$$= 3520$$

Sockeye $\bar{A}y$

$$= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}5}{5}$$

$$= \frac{40,000 + 20,000 + 35,000 + 15,000 + 30,000}{5}$$

$$= 28,000$$

Ksp, su, soc = Adult/redd factor x sex ratio x eggs/female x eggs to smolt survival x dam count minus hatchery return

Calculated Average Total Smolts (Natural)

Spring Chinook

$$Ksp = .94 \times .50 \times 5000 \times .10 \times 3240$$
$$= 235 \times 3240$$
$$= 761,400$$

Summer Chinook

$$Ksu = .94 \times .50 \times 5000 \times .30 \times Ay$$
$$= 705 \times 3520$$
$$= 2,481,600$$

Sockeye

$$Ksoc = .94 \times .50 \times 2700 \times .12 \times Ay$$
$$= 152 \times 28,000$$
$$= 4,263,800$$

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 950,000

$$= \frac{1,500,000 + 1,100,000 + 1,000,000 + 950,000 +}{5}$$

$$= 1,100,000$$

Methow Hatchery

$$= \frac{800,000 + 800,000 + 675,000 + 400,000 + 250,000}{5}$$

= 585,000

Twisp Accl. Pond= $\frac{400,000 + 400,000 + 400,000 + 250,000 + 200,000}{5}$

= 330,000

Sockeye Net Pens* = $\frac{200,000 + 200,000 + 200,000 + 150,000 + 100,000}{5}$

= 170,000

*Need Adjustment Factor For Survival To Migration

Average Total Hatchery Smolts

Winthrop	=	1,100,000
Methow	=	585,000
Twisp	=	330,000
Net Pens	=	170,000
		2,185,000

Average Total Hatchery/Natural Smolts
(5 Year Average for Years Y-4, Y-3, Y-2, Y-1 and Y)

Natural	=	7,779,000
Hatchery	=	2,185,000
Total	=	9,964,000

PHASE IV DETERMINATION

Base Number Smolts Used for Initial Compensation = 9,034,700

Calculated Average Natural + Hatchery Smolts in Years Y-4, Y-3, Y-2, Y-1 and Y = 9,964,000

Calculated Average Natural + Hatchery Smolts Minus Base Number Smolts = 929,300

Difference Between Base Number Smolts and Calculated Natural + Hatchery Smolts X Wells Project Mortality Rate = 929,300 X .14

= Additional Smolts Possible Under Phase IV 130,102

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

Howard Frey
Commissioner

Michael Gilmore
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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FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

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
FISH AND WILDLIFE:

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FOR THE NATIONAL MARINE
FISHERIES SERVICE:

Rolland A. Schmitten

FOR THE U.S. FISH & WILDLIFE SERVICE:

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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 U.S. FISH & WILDLIFE SERVICE:

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FOR THE CONFEDERATED TRIBES AND BANDS
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Levi George

FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES
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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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FISH AND WILDLIFE:

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FOR THE NATIONAL MARINE
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OF THE COLVILLE RESERVATION:

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