Report to the Federal Energy Regulatory Commission
for activities under the Long-Term Settlement Agreement
for the 1992 calendar year
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County

Wells Hydroelectric Project

F.E.R.C. Project No. 2149

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

April 1993

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Foreword

On January 24, 1991, the Federal Energy Regulatory Commission approved a Settlement Agreement to resolve anadromous fish issues for the Wells Hydroelectric Project on the Columbia River in Washington State. The Agreement was a product of negotiations with state and federal fisheries agencies and tribes on the operations of the Wells Project (No. 2149). The F.E.R.C. directed that the licensee of the Wells Project has certain reporting responsibilities. This document fulfills portion (E)(d) of the Order requiring an annual report to be filed by April 30. This is the third annual report under the Agreement and will cover the period between January 1 to December 31, 1992.

Report to the Federal Energy Regulatory Commission
for activities under the Long-Term Settlement Agreement
for the 1992 calendar year
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County

(1) Development of Studies, Plans and Evaluations

The Public Utility District No. 1 of Douglas County (District) worked closely with fisheries agencies and tribes to carry out various studies and obligations specified in the Agreement. These included the evaluation of the juvenile bypass, various monitoring studies and operation plans.

1.1 Annual Bypass System Operations Plan for 1992

The Long-Term Settlement Agreement calls for the District to provide an Annual Bypass System Operational Plan to be submitted by December. The District submitted the Annual Bypass Plan for 1992 to the Wells Coordinating Committee (WCC) for review on December 12, 1991. The Plan was revised based upon recommendations of the WCC (92-2)[1] (Appendix A).

The Bypass Team for the Wells Project makes decisions on the start and end of bypass operation during both spring and summer migration periods. The Team is made up of three members representing the agencies, tribes and the District (Agreement II.F.3). The members of the Bypass Team selected by the WCC were : Rod Woodin, Washington Department of Fisheries, Jerry Marco, Colville Confederated Tribes and Rick Klinge, Douglas County PUD (92-2).

1.2 Evaluation of the Juvenile Bypass for 1992

At the end of 1991, the District had proposed dropping the third and final year of the evaluation of the Bypass System. It was pointed out that the evaluation had exceeded operations criteria of the first two years of the evaluation and that only a very low passage efficiency would cause a failure of the three year evaluation. The WCC decided that a third year of the evaluation would be beneficial (92-1). The evaluation for the third year would be identical in sampling effort and analysis used in 1991 (92-2).

1.3 Miscellaneous Planning for the 1992 Bypass Season

The anticipated starting date of bypass operation for 1992 was April 15. This date coincided with the historical release schedule of hatchery salmon

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[1] (92-2) refers to minutes of the Wells Coordinating Committee from the second meeting in 1992. See Appendix H.

from the Winthrop National Fish Hatchery and timing of wild spring chinook in the mid-Columbia. This meant preparations for installation of bypass barriers and hydroacoustic equipment for the hydroacoustic index would need to be ready by April 1 (Agreement II.D.1.).

1.4 Fyke Netting at Wells Dam in 1992

The Wells Bypass Team initiated bypass operation when the hydroacoustic index demonstrated the presence of migrating juvenile fish. This index was also used to suspend bypass operation at the end of the spring and summer migration periods. During April and May, the index was composed primarily of salmonids migrating to the ocean. From mid-May on, the hydroacoustic index also contained detections of resident fish in the forebay that were not migrating. Fyke net sampling was used to adjust the hydroacoustic index by the percent composition of salmonids in fyke nets.

The WCC requested that operation of the fyke net be kept to a minimum (92-2). The District decreased sampling effort in 1991 and would likely follow a similar sampling pattern for 1992.

1.5 Underwater Video monitoring of adult passage at Zosel Dam

Underwater video recording adult sockeye passage has been used successful at Columbia River Dams. The advantage of video monitoring over hydroacoustic sampling is that species identification is possible. A proposal was submitted to the District by Columbia River InterTribal Fisheries Commission (CRITFC) to assess adult sockeye salmon passage with underwater video at Zosel Dam in 1992. The WCC requested to review a proposal for this work (92-1, 92-2). There was a brief snag when a contracting problem occurred between the District and CRITFC for this project (92-4). This problem was cleared up and the study proceeded on schedule (92-5).

1.6 Adult Passage Study with sockeye salmon

The District worked with National Marine Fisheries Service to conduct an Adult Sockeye Passage Study through the ladders at Wells Dam for 1992. A draft study proposal was reviewed by the WCC in 1991. Details of the study plans were discussed by the Committee (92-1, 92-2, 92-5, 92-6). This study was designed to fulfill part of the requirements of the Adult Delay/Mortality Study (Agreement III.G.1).

1.7 Project Mortality Study

The Long-Term Settlement Agreement specified the District, along with consultation from the Joint Fisheries Parties, will develop a study of juvenile mortality associated with Wells Dam by 1990 (IV, C, 5). Results from this work would adjust compensation levels of the hatchery programs. The WCC had decided not to pursue this work in 1991. In 1992 the WCC recommended that the study again be delayed (92-1). The results of the study would drive the hatchery based compensation at the new Methow Hatchery. Because of the schedule to gradually build up the Methow Program, it would be some time before any adjustment in compensation would be implemented.

1.8 Methow Trapping Facilities

The Long-Term Settlement Agreement called for adult collection facilities for spring chinook broodstock (Agreement IV.D.2.c.(3)(a)). Early in the year there was discussion of the construction schedules for the three broodstock traps. The traps on the Twisp and Chewuck Rivers were completed early in the year. The trap on the Methow River would required further planning in 1992 with an anticipated completion for 1993 trapping season. Two locations were being considered for the Methow River trap at the first of the year (92-1, 92-2). One location was several miles upstream of the hatchery. The site would call for a floating weir similar in design of the one selected on the Twisp River. The second location would be adjacent to the fish ladder at Fog Horn Irrigation Dam, located a half mile up river from the hatchery. It was emphasized that in order to assure that a trap would be available for the 1993 season, a decision would have to be made soon on the location and comments in from review of trap plans (92-2, 92-7).

The designs for all three traps would allow some passage in high flow conditions. The WCC felt that a structure that would collect 100% of the upstream migrants would not be desirable in the Methow Basin (92-2).

The District proposed for the 1992 brood, that production for the Methow River should be collected from the ladders at Wells Dam (92-1). The WCC had reservations because the plan lacked the ability to separate spring chinook destined for the upper Methow from other sub-basin populations of the Methow at Wells Dam.

The Washington Department of Fisheries submitted a Trapping Protocol for the new Methow Hatchery (92-1). The protocol had provisions for required numbers of natural escapement and minimum numbers of brood from each drainage to address concerns of genetics in hatchery settings. The District requested that the Washington Department of Fisheries provide clarification for the stringent guidelines on genetic protective measures (92-2). A revised protocol was discussed at the WCC meeting on April 17 (92-4) and adopted for the 1992 season.

1.9 Methow Spring Chinook Facilities

The Methow Hatchery was under construction through the fall of 1992. It was felt in early March that necessary components of the facility would be ready for collection and holding of broodstock (92-2). Though construction was behind schedule the WCC wanted collection of brood for the Chewuch and Twisp portions of the Methow Program. Arrangements were made with the contractor to have water systems and necessary alarms in place prior to the arrival of adult salmon. Coordination was arranged for the operation of the facility with the Washington Department of Fisheries (92-5, 92-7)

1.10 Evaluation of the hatchery facilities

The Settlement Agreement called for an evaluation of the Program or facilities built by the District (Section IV). The evaluation would look at the adequacy of the facility and operations to be able to implement the hatchery plan. The WCC formed an Evaluation sub-committee to draft a work plan for evaluating the Methow facility (92-1). At the end of the calendar year, the Draft Plan had been through two major revisions (92-2, 92-9, 92-10, 92-11).

1.11 Sockeye Salmon Enhancement

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

Sockeye salmon enhancement was the topic of several WCC meetings in 1992. The Washington Department of Fisheries developed an enhancement proposal for the 8,000 pounds of production called for in the Settlement Agreement. The proposal was circulated to the WCC for review (92-1). Members of the WCC requested that the proposal be put on hold (92-2). The Committee was hosting a sockeye workshop in March (see 1.12). It was felt that information from the workshop would be helpful for planning enhancement strategies.

After the workshop, Washington Department of Fisheries said they were ready to talk about their proposal (92-4). On May 4, the WCC met to discuss the Washington Department of Fisheries proposed sockeye pilot project (92-5). It was emphasized that a decision would need to be made soon if anything were to be done this year. The members of the Committee had several questions concerning the feasibility of the proposal, how it would be assessed, potential for spreading diseases from sockeye, and disposition of returning adults (92-6, 92-7, 92-8, 92-9, 92-10). The District indicated it had found a location at the mouth of the Okanogan River where sockeye could be reared while minimizing the potential for disease to other hatchery programs. The Committee agreed to pursue a "pre-pilot" program with the 1992 brood. This program would rear 2,000 lbs. of production at 25 fish per pound to see if sockeye could be reared to reach a suitable migrant size in 6 months of intensive culture (92-8, 92-9). An understanding was reached on who would operate the program. Both the Washington Department of Fisheries and the Colville Confederated Tribes had expressed an interest in the program. It was agreed that the Colville Tribes would operate the program under the direction of the Committee (92-10). At the end of the year, the facility was close to the point where it could receive eggs (92-11).

1.12 Okanogan Sockeye Salmon Planning

The District proposed that the WCC sponsor a workshop on sockeye salmon issues and in particular, Okanogan sockeye. There was interest in considering sockeye since the WCC was ready to embark on the sockeye salmon portion of the compensation outlined in the Settlement Agreement. A sub-committee from the WCC was selected to help with the planning (92-1).

The Workshop was held on March 5 in Seattle (92-3). Presentations were made on issues concerning Okanogan sockeye and can be divided into process, environment and enhancement options. Topics under "Process" included how sockeye fit into the Settlement Agreement, dealing with trans-boundary stocks (U.S. and Canadian governments) and enhancement in an era of the Endangered Species Act. Discussion on "Environment" included biology of the Okanogan sockeye, spawning and nursery areas and water temperatures encountered by returning adults. Discussion topics under "enhancement options" included net pens, eggs boxes and improvements to existing habitat (92-3).

The WCC had outlined several research needs that became clear through the workshop on sockeye. They were outlined in a Memo to the WCC from Bill Hevlin (dated April 2, 1992) and discussed by the Committee (92-4). Research needs included monitoring of spawning escapement, river flows and temperatures in the Okanogan during adult migration and spawning. Also felt by the Committee was information on habitat needs such as fry protection at irrigation withdrawals and information on fry emergence and the irrigation season between the spawning grounds and Lake Osoyoos. The Hevelin Memo became the focus for planning in 1992. The Committee also felt that it would be important for Canadian management entities to outline their management objectives for Okanogan sockeye. The Canadian waters are managed for kokanee, a non-anadromous (resident) form of sockeye. It was hoped that management objectives were not in conflict between these two populations of O. nerka for water, habitat or food resources.

In the area of production, the District was developing a potential hatchery site at the mouth of the Okanogan River. A well had been established and showed promise for delivering enough water for the pilot program outlined in the Settlement Agreement (92-7, 92-8, 92-11).

1.13 Okanogan Sockeye Spawning Ground Surveys

The WCC reviewed and accepted a plan to assess spawning ground escapement of Okanogan sockeye (92-6, 92-7). The WCC felt assessing escapement was important because of the significant discrepancy of counts between Wells and the spawning grounds. Efforts to collect information on adult Okanogan Sockeye in 1992 were from ladder counts at Wells, radio telemetry studies of sockeye migrating to and past Wells, video counting at Zosel Dam and spawning ground counts. Field efforts for spawning ground counts were started in September and continued into November.

1.14 1993 Bypass Operational Plan

The District submitted to the WCC, a Bypass Operational Plan for 1993, at the December 1 meeting as per Section II.F.1 of the Settlement Agreement (92-11). The plan outlined scheduled hatchery releases above Wells Dam and anticipated the starting and completion date of bypass operation (Appendix A).

1.15 1993 Adult Passage Studies

The WCC discussed an adult passage study for 1993 with spring and summer chinook (92-7, 92-8, 92-11). This study, along with the 1992 sockeye passage study would fulfill part of the requirements of the Adult Delay/Mortality Study (Agreement III.G.1). The study at Wells was to be part of a larger effort in the mid-Columbia with the other two PUDs who operate four major dams below Wells plus a study on the Snake River through the Corps of Engineers.

The District had concern with how this study would fulfill the requirements under the Agreement of a "Delay and/or Mortality Study". The study was designed to determine delays of migrating adults through fish ladder at each of the main stem projects. There was nothing in the study design that would identify the mortality issue. There was discussion in the Committee that currently there is no technology available that could be used for direct measure of delay and mortality of adults in passage up the river. The District prepared a Stipulation to be signed by the members of the Committee that the 1992 and 1993 passage studies would fulfill in part the District´s responsibility under the Agreement. Negotiations on the wording and collections of signatures were on going at the end of the year.

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Evaluation of the Juvenile Bypass for 1991

The Long-Term Settlement Agreement for the Wells Project states that the District will conduct a three year evaluation of fish passage efficiency (FPE) of the juvenile bypass system. The 1990 migration season was the first year of this evaluation. The goal for FPE of the Wells bypass was 80% for spring migration and 70% for the summer migration. The Settlement Agreement also required a certain level of statistical precision (Sec. II.H.2).

The 1991 evaluation of the spring FPE was 95.4 ±0.3% at the 90% C.I. and the summer FPE was 97.0 ±0.3% at the 90% C.I. The 1991 spring and summer bypass evaluations exceeded the FPE goal for bypass operation and statistical precision (Appendix B).

2.2 Evaluation of the Juvenile Bypass for 1992

The 1992 evaluation of the juvenile bypass at Wells was the third of a three year study of fish passage efficiency (FPE). A DRAFT copy of the 1992 evaluation was submitted to the WCC for review on December 1 (Appendix C).

During the 1992 spring evaluation, some of the sampling equipment was mis-calibrated. These data were examined by a statistician to recover lost information and determine Fish Passage Efficiency (FPE) (92-11). Through this process, three estimates of FPE were prepared for the Draft Report. All three point estimates exceeded the criteria established in the Settlement Agreement for bypass evaluation (Agreement II.H.1 & 2).

The 1992 evaluation of the spring FPE was 89.0% ±0.5% at the 90% C.I. and the summer FPE was 93.0% ±0.7% at the 90% C.I. The 1992 evaluation for both spring and summer evaluation exceeded the FPE and statistical goal.

2.3 Relative Index of juvenile salmonid migration at Wells Dam for 1992

The bypass operation was initiated by the Bypass Team as they interpreted the hydroacoustic index as suggesting the start of the spring migration. This index, along with species composition from fyke netting in turbine intake provided necessary information to start bypass operation. During the 1992 migration, the index signified the beginning of spring migration on April 16. The summer bypass was started when the index plus species composition from fyke netting indicated a high number of juvenile salmonids on June 24 (Appendix C).

2.4 Spring Chinook Spawning surveys in the Methow River Basin, 1992

This was a continuation of an ongoing effort to determine the wild escapement of spring chinook in the Methow River basin. The number of redds (nests deposited by spawning salmon) in 1992 was 741 for 127 miles of streams surveyed (Appendix G).

2.5 Video Monitoring of Adult Passage at Zosel Dam

Okanogan sockeye salmon in route to spawning areas pass Wells Dam on the Columbia and Zosel Dam, a small irrigation control dam on the Okanogan River. Escapement to the spawning grounds is sometimes half what the counts were at Wells Dam. Zosel Dam allows for another point to check the strength of the sockeye migration.

In 1992, underwater video cameras were installed at the exits of the two fish ladder to assess passage. Video recording units made recording tapes of fish passage from July through October. Passage at Zosel between these months was estimated to be between 25,172 and 42,410 sockeye. The range of values was due to expansion for "blind spots" or the effective field of view. The work showed that passage of sockeye occurred as long as water temperatures remained below 73 F. Temperatures above 73 F. showed little to no sockeye passage (appendix F).

2.6 Adult Passage Study with sockeye salmon

A goal of 100 sockeye were to be tagged with radio transmitters at the adult fish ladders at Rocky Reach Dam. These fish would then be monitored as they proceeded to the next major dam, Wells. The intent of the study was to monitor passage time through ladders at Wells Dam.

A total of 96 sockeye were tagged at the Rocky Reach ladder. Of these, 84 were tracked and passed Wells Dam. It was unclear why 12 of the tagged fish were not recorded as passing Wells. It was later discovered that some of the tags were faulty and had stopped emitting a signal. Of the fish with tags that functioned properly, it was determined that median passage time at Wells was 28 hours. Migration past Wells showed a marked delay once the fish reached the confluence of the Okanogan River. Delay was likely due to high temperatures in the Okanogan River. National Marine Fisheries Service provided a preliminary report to the WCC (92-9, 92-10, 92-11).

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

3.1 Bypass Evaluation

The evaluation of the Bypass for 1992 was the third of a three year study. A final report for the 1992 season will be available in 1993. The District will prepare a single report that will summarize the evaluation methodology and findings for the three years.

3.2 Methow River Spring Chinook Hatchery

The Agreement called for a hatchery based compensation program composed of adult collection sites; a central hatchery facility for incubation, early rearing, and adult holding and acclimation facilities for final rearing (Agreement IV). By the end of 1992, the District had completed work on all of the physical aspects of the program with the exception of one of the adult collection facilities. All work was done per criteria established in the Agreement. Also plans were circulated among the agencies and tribes for their review. Work toward the completion of the third trap, to be placed on the Methow River, was in the permit stage at the end of 1992. Anticipated completion of this project should occur in 1993.

Adult collection facilities on two of the three sub-basins of the Methow were operated and collected broodstock in 1992. There were 20 adults collected from the Chewuck and 30 collected from the Twisp Rivers. These fish were spawned at the Methow Spring Chinook Facility. The eggs were hatched and 83,000 spring chinook fry were being held at the end of the year.

3.3 Contract professional services in implementing the Settlement Agreement.

During 1991, the District contracted with Dr. Richard Whitney to serve as Studies Coordinator for the Wells Coordinating Committee. The District also contracted with Dr. John Skalski to provide statistical evaluation of methods and studies.

3.4 Juvenile and Adult Fish Passage Operations at Wells Dam

During 1992, the juvenile bypass system operated as per conditions outlined in the Agreement (II,C,D,F). The bypass operated between April 16 and June 23 (69 days) for the spring migration and between June 24 and August 3 (41 days) for the summer migration.

The adult fish ladders were operated as outlined in the Agreement (III,B,C,D,E,F). Counts at Wells Dam showed that 62,260 salmon and steelhead passed the Wells Project in 1992.

3.5 Steelhead Production at Wells Hatchery

The Agreement specified that the District will fund additional steelhead compensation of 30,000 pounds at 6 fish per pound after 1991 (IV,3,a). This additional production was accomplished at the Wells Game fish hatchery in 1992.

3.6 Other Actions toward fulfillment of the Agreement

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

(4) Explanation of Alternatives Chosen

4.1 Change in time table of adult studies

The Agreement specified that a study plan to determine the extent of adult delay and mortality at Wells Project would be initiated in 1990 with studies starting in 1991 (III, G, 1). The District funded a study of passage delay of sockeye salmon at Wells Dam in 1992. Additional research on adult passage at Wells is being planned for spring and summer chinook in 1993.

4.2 Hatchery Based Compensation

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

(1) 49,200 pounds of spring chinook yearlings at 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 hinged around the Methow Spring Chinook Hatchery. The facility was dedicated on October 2,1992. Efforts to collect broodstock are anticipated for the 1993 brood year with the first release of yearling fish in the spring of 1994.

Pursuant to the direction of the WCC, sockeye production was delayed pending the results of a study on sockeye enhancement options above the Wells Project. This report was specified as part of the Studies and Evaluations section of the Agreement (Section IV, C, 1). There was discussion this year to host a workshop specifically to deal with the issue of enhancement of Okanogan sockeye. The workshop was conducted in March of 1992 (see 1.12). After the workshop, the WCC agree to pursue a "pre-pilot" sockeye program with 2,000 pounds of production. Necessary broodstock were collected and eggs were held and hatching at the end of the year.

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

4.3 Project Mortality Study

As pointed out in Section 1.7, the WCC recommended that the Project Mortality Study not be pursued in 1992 (92-1) nor 1993 (92-11). There was no recommendations as to when this work should be done.

(5) Chronology of compliance for 1992

The chronology of compliance for 1992 is contained in items (3) and (4) above. Documentation that the Joint Fisheries Parties were consulted prior to implementation of changes is provided in the minutes of the Wells Coordinating Committee. These records are included as Appendix H.

(6) A schedule of activities for 1993

6.1 Spring Chinook Facility

Construction on the Methow Hatchery was completed in 1992. Completion of the adult collection facility on the Methow River is scheduled for September and October 1993.

6.2 Sockeye production and Adult Passage Studies.

During 1992, the WCC worked with the issues of sockeye production and adult passage studies. The Committee will continue to deal with both of these issues through 1993. The WCC 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 1993

The following schedule of activities is planned for 1993

Dec. (92)	Develop Annual Bypass System Operation Plan between District, Agencies and Tribes
March 1	Annual Bypass System Operation Plan finalized
March 1	Determine Bypass Team members for bypass season
March 1	Develop Annual Passage Monitoring Plan between District, Agencies and Tribes
April 1	Bypass barriers in place Begin monitoring juvenile migration via hydroacoustics Field work to start on Methow Hatchery Evaluation Studies
April 15	Begin radio tagging chinook at John Day Dam Begin predator index study Planning for 1993 Sockeye Enhancement Pilot Program
April 15	Anticipated start of the juvenile migration
May 1	Monitor movement of radio tagged chinook at Wells Start collecting spring chinook broodstock in Methow
July 1	Start collecting sockeye broodstock for Cassimer Bar Start video monitoring of sockeye passage at Zosel Dam
August 1	Start spawning ground surveys for spring chinook in Methow
Sept. 15	Start spawning ground surveys for sockeye in Okanogan
October	Production Plan annual review between District, Agencies and Tribes
on going	Planning sockeye enhancement strategies
on going	Planning for operations and protocols of the new Methow River Spring Chinook Facilities
on going	Planning for Methow River broodstock trap

(7) Meeting Minutes of the Wells Coordinating Committee for 1992

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. Minutes from the meetings of the WCC for 1992 are attached as Appendix H.

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Appendix I

1992 Membership list of the Wells Coordinating Committee

Ron Boyce
Oregon Department of Fish and Wildlife

Tony Eldred
Washington Department of Wildlife

Cary Feldmann
Power Purchasers

Bob Heinith
Columbia River Inter-Tribal Fisheries Commission

Bill Hevlin
National Marine Fisheries Service

Rick Klinge
Douglas County P.U.D.

Jerry Marco
Colville Confederated Tribes

Tom Scribner
Yakima Indian Nation

Craig Tuss
U.S. Fish and Wildlife Service

Rod Woodin
Washington Department of Fisheries

Dick Whitney
Wells Coordinating Committee Chairman

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ANNUAL BYPASS OPERATION PLAN

FOR

WELLS DAM; 1992 AND 1993

APPENDIX - A

WELLS HYDROELECTRIC PROJECT

JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 1992 Bypass Season

December 12, 1991

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

The Bypass System

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

Operation Criteria

The bypass will operate as per criteria specified in Section II. C. and E. of the Settlement Agreement. This includes operation of the bypass in partnership with adjacent turbine units, the amount of water required for bypass operation and criteria for full bypass system operation. Should criteria for fish passage efficiency specified in Section II.E. not be reached, then changes in the operation of the bypass will be made to meet criteria.

Bypass Operations Timing Criteria

The bypass will be in place as per criteria specified in Section II. D. of the Settlement Agreement. This includes placement of the bypass two weeks before predicted migration and keeping the bypass in place two weeks after the migration is complete. Bypass will be in place from April 2 through August 31.

Projected Hatchery Releases above Wells Dam

Hatchery releases for 1992 above Wells Dam are as follows,

Facility	Species	No. (thous)	Dates
Winthrop (USFW)	Spr Chinook	1000	4/15
Twisp (WDF)	Sum Chinook	400	5/15
Similikameen (WDF)	Sum Chinook	500	5/15
Wells (WDW)	Sum Steelhead	550	4/15 - 5/15

Starting Dates and Ending Dates

Starting and closure of the bypass system is a decision that is reached by the Bypass Team. A hydroacoustic index of fish in the Wells forebay is used to show the start and completion of the spring and summer migration. Collection of the hydroacoustic index will start on April 2 and run through August 31. Preseason dates used for bypass operation for spring migration are April 15 to May 30. Preseason dates used for summer migration are July 1 to August 30.

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

December 9, 1992

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

The Bypass System

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

Operation Criteria

The bypass will operate as per criteria specified in Section II. C. and E. of the Settlement Agreement. This includes operation of the bypass in partnership with adjacent turbine units, the amount of water required for bypass operation and criteria for full bypass system operation.

Bypass Operations Timing Criteria

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

Projected Hatchery Releases above Wells Dam

Hatchery releases for 1993 above Wells Dam are as follows:

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

Starting Dates and Ending Dates

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

EVALUATION OF THE SMOLT BYPASS SYSTEM

AT

WELLS DAM IN 1991

APPENDIX - B

Evaluation of the Smolt Bypass System at Wells Dam in 1991

Final Report

Sponsored by:

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April 8, 1992

EXECUTIVE SUMMARY

In 1991 we used hydroacoustics to evaluate the smolt bypass system at Wells Dam on the Columbia River. The evaluation, sponsored by Douglas County Public Utility District (DCPUD), took place in spring (April 14 to May 24) and summer (July 8 to 22). The 1991 evaluation was the second of a three-year program to substantiate 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 (dated October 1990). The agreement also included criteria for precision which guided development of the sampling design. The primary objective of the 1991 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.) To form the bypass, 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 past 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 spring and summer evaluations : 1990, 1991, and 1992.

In 1991, 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 24 of 30 turbine intake locations. Transducers (6°) were deployed at 5 of 5 bypass intake locations (S2, S4, S6, S8, and S10). 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 1991 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. In 1991, daily bypass flow averaged 6.1% of total project discharge. Overall, the mid-Columbia River had relatively high flows in spring and summer 1991.

DCPUD sampled for species composition with a fyke net in Turbine Intake 4C during the month of May. Samples were taken inside Turbine Intake 8C for the rest of the season. Net data were collected at least weekly from May 16 to August 28. The fyke net effort in 1991 was curtailed to reduce juvenile salmon mortality during the spring out-migration. The data showed that as compared to previous years primarily chinook, steelhead and sockeye were present through the end of May. During June, other non-target species dominated the catch, although chinook were present as well. Whitefish became evident during July. Zero age chinook dominated the catch during July and the first half of August. The latter half of August showed increasing numbers of non-target species.

The 1991 hydroacoustic run timing data from the forebay transducers showed the usual year to year trends. The outmigration begins with a large peak of spring chinook due to the Winthrop hatchery release. In mid- and late May, the wild sockeye migration from Lake Osoyoos moves past the dam. Passage rates are low throughout June. In July the summer chinook outmigration begins and continues through mid-August. In the latter part of August, passage rates are high and variable primarily due to non-target species.

Horizontal distribution data for 1991 again showed highest passage rates at the west and east ends of the dam. Nighttime passage rates were higher than daytime during the spring. Daytime passage rates were higher than nighttime during the summer.

Estimated total project bypass efficiency for the 40-day spring study was 95.0% +/- 0.43% at the 90% confidence level. Daily efficiencies for spring ranged from 73% to 99%. Estimated total project bypass efficiency for the summer study was 97.0% +/- 0.29% at the 90% confidence level. Daily efficiencies for summer ranged from 96% to 99%.

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.

- Valerie Stark, Mike Nealson, and Andy Wilson for collecting the hydroacoustic data.

- J. Skalski and D. Ouellette for developing the statistical tools.

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1.0 INTRODUCTION

1.1 Objective

In 1991, we used hydroacoustics to evaluate the smolt bypass system at Wells Dam on the Columbia River. The evaluation, sponsored by Douglas County Public Utility District (DCPUD), took place in spring (April 14 to May 24) and summer (July 8 to 22). The 1991 evaluation was the second of a three-year program to substantiate 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 (dated October 1990). The agreement also included criteria for precision which guided development of the sampling design. This year marked the most intensive sampling effort to date. The primary objective of the 1991 evaluation was to estimate **total project bypass efficiency.**

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 past 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. Parties to the settlement agreement and DCPUD agreed to evaluate total bypass efficiency from 1990 to 1992.

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.

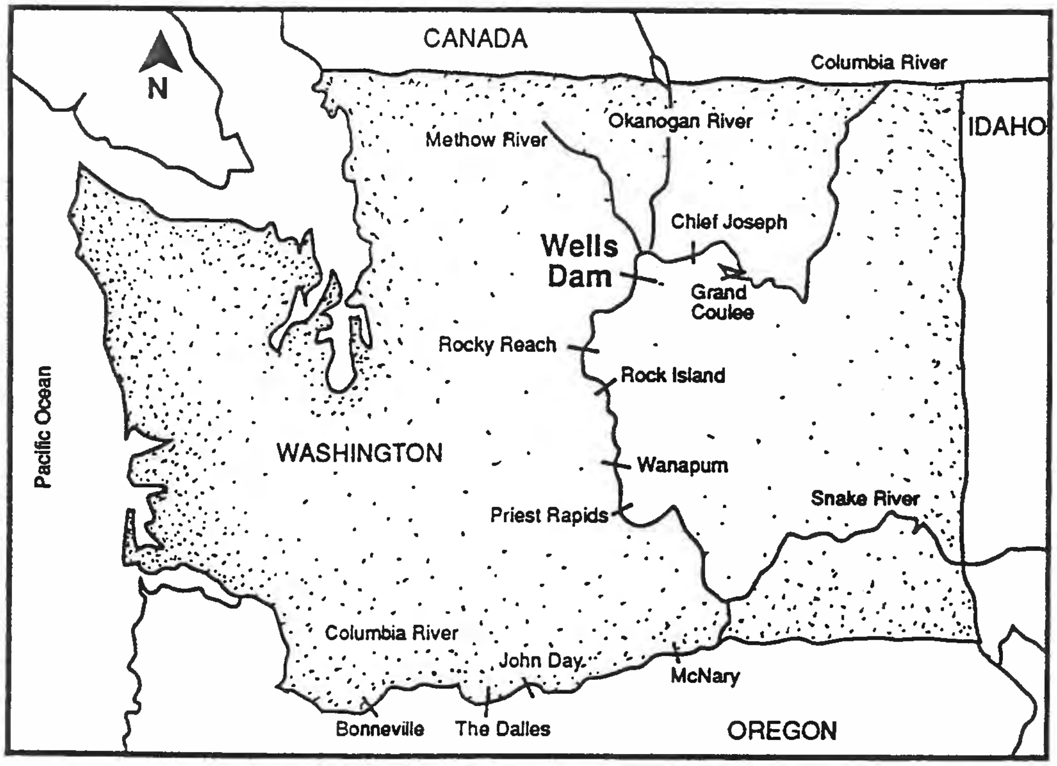

Figure 1. Location of Wells Dam on the Columbia River.

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

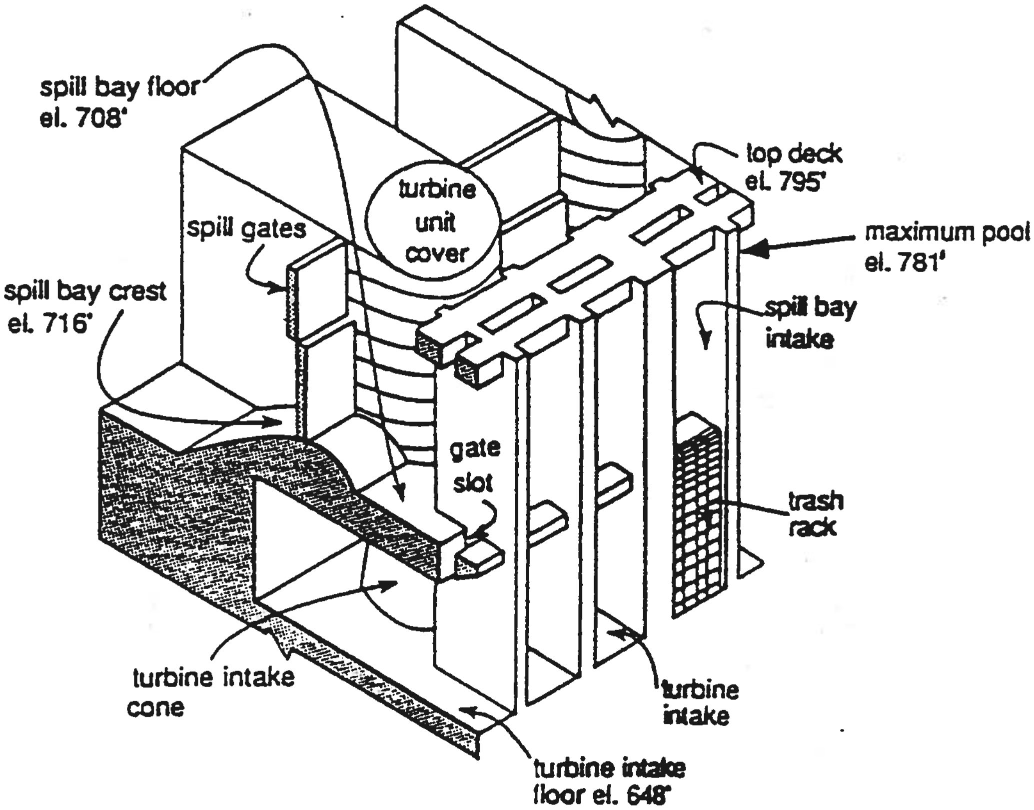

Figure 2. Three-dimensional view of Wells Dam hydrocombine with spill intakes directly above turbine intakes.

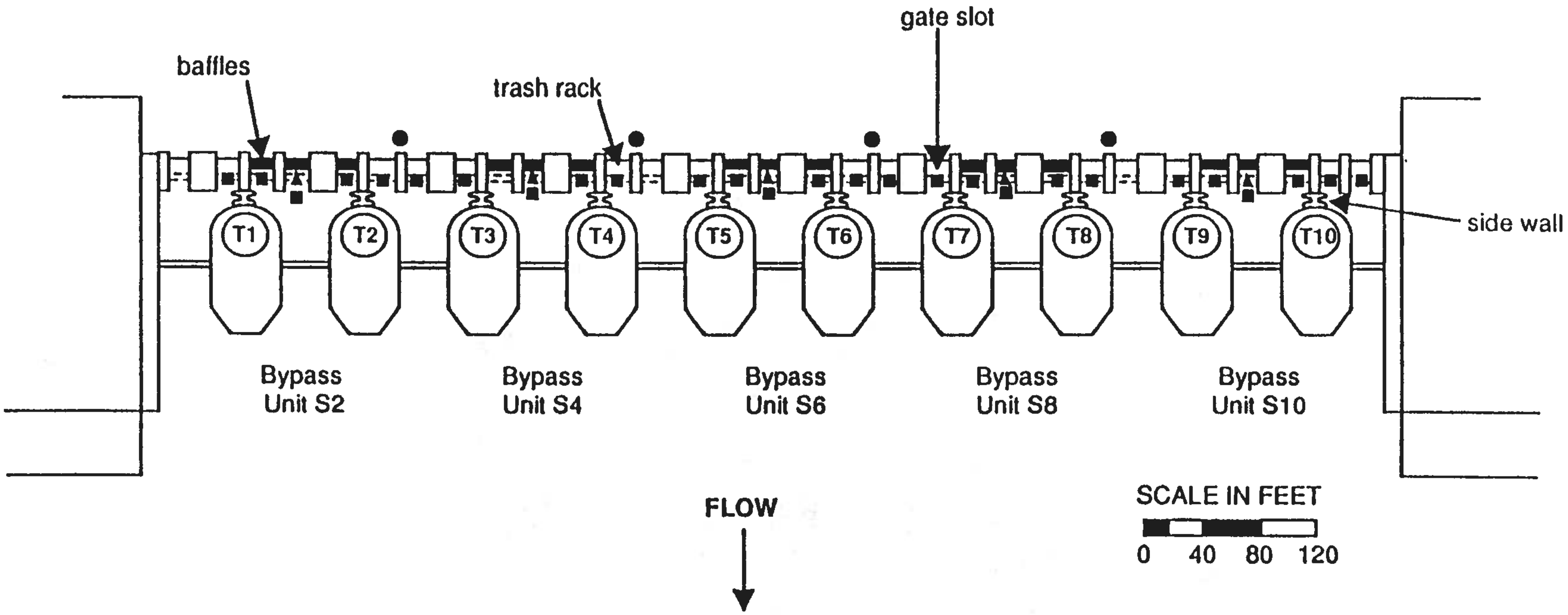

Figure 3. Plan view showing the five bypass units and the locations of forebay transducers (●), turbine intake transducers (■), and bypass slot transducers (▲) at Wells Dam in 1991.

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 past 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 that began in 1990.

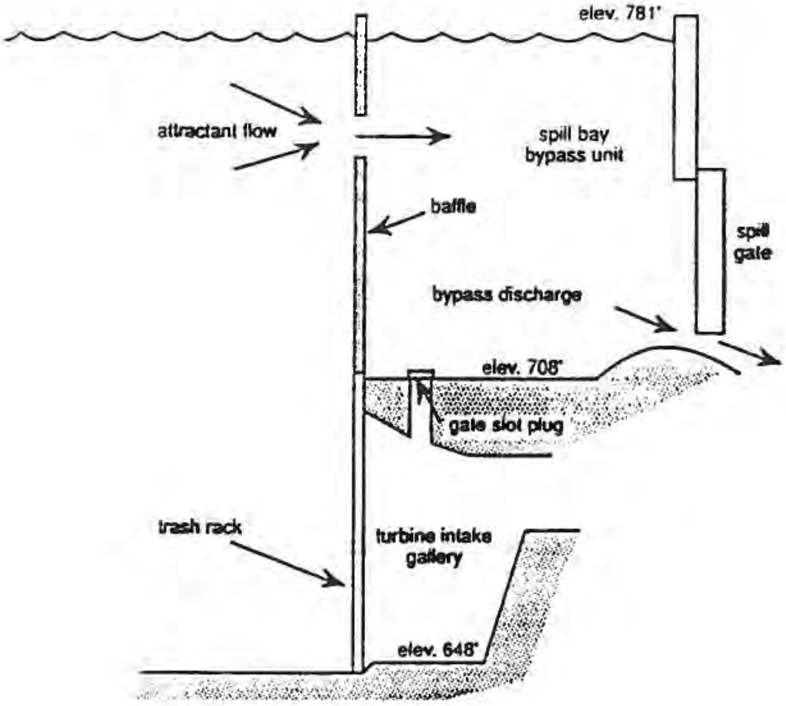

Figure 4. Side view of a bypass unit at Wells Dam showing a horizontal baffle opening and attractant flow.

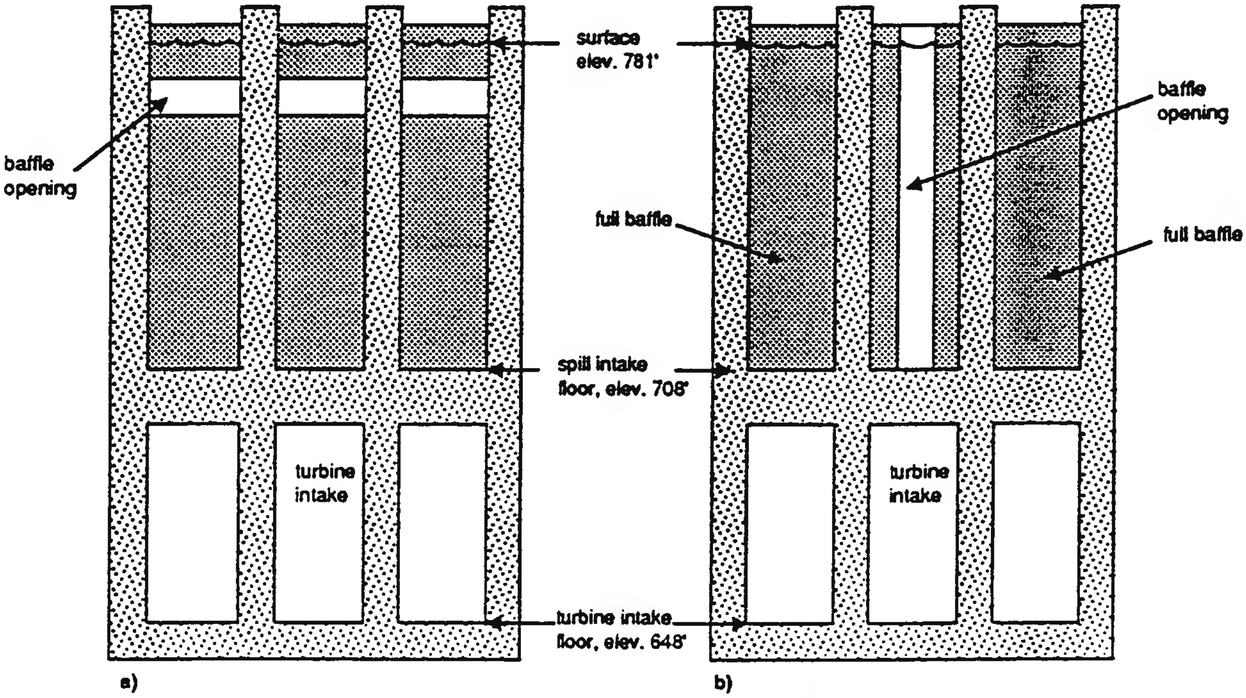

Figure 5. The upstream side (front view) of a bypass unit at Wells Dam with (a) horizontal baffle opening and (b) vertical baffle opening.

2.0 METHODS

2.1 General Hydroacoustics

We used fixed-location hydroacoustic techniques for monitoring smolt passage at Wells Dam in 1991. 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 transducers 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 units S2, S4, S6, S8, and S10 (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 10 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, 24 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 10 pps. At least two of three intakes at each turbine unit were sampled. The sampled intakes were selected randomly. At four turbine units (Units 1, 2, 5, and 10), all three intakes were sampled; Units 1 and

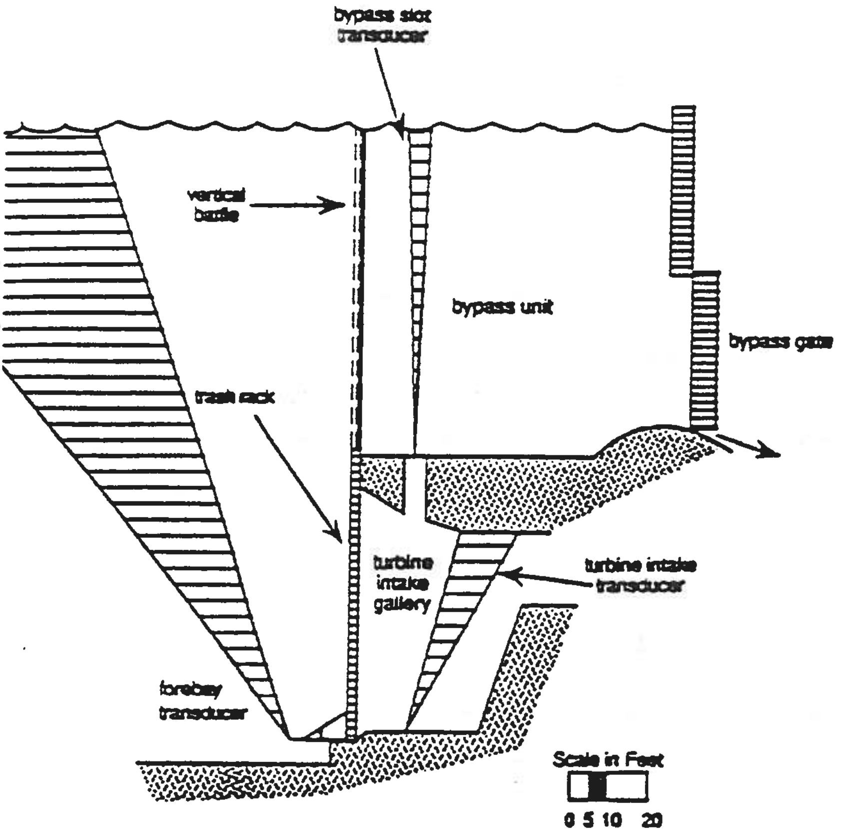

Figure 6. Side view of a bypass unit at Wells Dam showing 1991 transducer sampling areas.

Table 2. Turbine intake sampling locations at Wells Dam in 1991. (NS = Not sampled)

	DATES SAMPLED			DATES SAMPLED	
LOCATION	Spring	Summer	LOCATION	Spring	Summer
1A	4/14-5/24	7/08-7/22	6A	4/16-5/02	NS
1B	4/14-5/24	7/08-7/22	6B	4/14-5/24	7/08-7/22
1C	4/14-5/24	7/08-7/22	6C	4/14-5/24	7/08-7/22
2A	4/14-5/24	7/08-7/22	7A	4/14-5/24	7/08-7/22
2B	4/14-5/24	7/08-7/22	7B	4/16-5/02	NS
2C	4/14-5/24	7/08-7/22	7C	4/14-5/24	7/08-7/22
3A	4/14-5/24	7/08-7/22	8A	4/14-5/24	7/08-7/22
3B	NS	NS	8B	4/14-5/24	7/08-7/22
3C	4/14-5/24	7/08-7/22	8C	NS	NS
4A	4/14-5/24	7/08-7/22	9A	4/14-5/24	7/08-7/22
4B	4/14-5/24	7/08-7/22	9B	4/16-5/02	NS
4C	NS	NS	9C	4/14-5/24	7/08-7/22
5A	4/14-5/24	7/08-7/22	10A	5/03-5/24	7/08-7/22
5B	4/14-5/24	7/08-7/22	10B	5/03-5/24	7/08-7/22
5C	4/14-5/24	7/08-7/22	10C	5/03-5/24	7/08-7/22

2 were selected because previous data showed relatively high fish passage rates. Given extra transducers at Units 1 and 2, we chose Units 5 and 10 to gain the most complete east-west coverage. The turbine intake transducers sampled fish passage into 24 of 30 turbine intakes. During the spring Unit 10 was out of service until May 3. The transducers deployed in Unit 10 were moved to Units 6, 7, and 9 when Unit 10 went out of service. Unit 10 was back in service for the entire summer study period. 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 14 to May 24) and summer (July 8 to July 22) bypass studies, we did not sample the forebay. During the bypass studies, we used data from the bypass intake 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 March 29th to August 31st.

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

Day = 0600 h - 2000 h (Date X)

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

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 10 minutes an hour for 24 hours per day during the spring and summer sampling periods. Typically, five 2-minute samples were collected each hour for each transducer location in turbine. Six 2-minute samples were collected each hour at the bypass transducer locations. The hourly sampling sequence was systematic. A new randomized sequence was selected at the start of every study day.

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 10 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 describing passage distributions in 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 B = total project bypass efficiency

y = fish passage in bypass, and

x = fish passage in turbine.

$$CI(B) = B +/- z * \quad var(B)$$

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 algorithms for estimating total bypass and turbine passage and the confidence interval were determined by Dr. Skalski (Skalski and Ouellette, 1990).

2.5 Fyke Net Methods

During 1991, DCPUD collected species composition data using fyke nets. Data was collected from inside Turbine Intake 4C during the month of May. Only four nets were fished during the month of May. Data was collected from inside Turbine Intake 8C for the rest of the season, using seven nets. Net data were collected at least once per week from May 16th to August 28th. Fyke netting was started later in 1991 in order to reduce juvenile salmon mortality during the spring out-migration. Sampling usually lasted eight hours. Sample hours were from 2200h to 0600h. The entire cross-sectional area of the turbine could be sampled by the array of three nets across by seven nets down. During 1991 only the center column of nets was fished. Each net opening was 7.16 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 1991, project discharge at Wells Dam was higher than the 15-yr average (Table 3). Overall, the mid-Columbia had relatively high flows during spring and summer 1991. Because of the high flows, power generation was usually at its maximum during the bypass evaluation. Unit 10 was not sampled from April 15 to May 3 as it was off line for maintenance.

Table 3. Project discharge (kcfs) for Wells Dam during April through August, 1991. Source: G. Donabauer (DCPUD).

	PROJECT DISCHARGE (kcfs)				
	April	May	June	July	August
Min. daily average	96.8	57.4	69.6	37.0	21.1
Max. daily average	213.3	285.6	234.3	220.2	208.4
Avg. hourly discharge	169.9	177.8	175.6	146.7	132.7
15-year average	113.0	132.1	135.2	113.6	96.8
% 15-year average	150	135	130	129	137

Bypass operations for smolt passage at Wells Dam in 1991 were similar to those in previous years. DCPUD operated the bypass daily from April 11 to June 6, and from July 5 to August 19, 1991. 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 were a total of 75 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. The entire bypass opening is 24 feet wide. Four of the six 4-foot wide plates are removed from the barrier to provide a 16-foot vertical slot in the center of the opening. 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. Top spill was used for bypass flow at bypass units S2 and S10. Flows at these bypass units varied according to forebay pool elevation. During 1991, daily bypass flow at Wells Dam averaged 6.1% 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 1991 releases of hatchery-raised salmonids above Wells Dam are given in Table 4. About 2.9 million fish were released in the drainage above Wells Dam in 1991. Wild stocks of sockeye also migrate downstream past 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 River (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 1991. Sources: B. Wallien (USFWS) and S. Miller (WDG).

SPECIES	RELEASE SITE	MILES FROM WELLS DAM	DATE	NUMBER
spring chinook	Winthrop (yearling)	50	4/11	1,055,056
	Winthrop (zero age)	50	5/29	417,864
summer chinook (yearling) (volitional release)	Twisp	38	5/1-5/31	420,000
	Similkameen RM 2	86	5/1-5/31	352,600
summer steelhead	Methow RM 10	16	4/22-5/6	343,432
	Methow RM 1	7	4/23-5/8	144,135
	Okanogan RM 28	43	4/24-4/30	72,830
	Similkameen RM 6	90	4/22-5/2	90,320
	Omak Cr. RM 7	43	5/7	6290
				Total = 2,902,527

The 1991 fyke net catch data from Wells Dam are tabulated in Table 5 and graphed in Figures 7A, 7B, and 8. Fyke net effort was greatly reduced this year as compared to previous years to minimize juvenile salmon mortality. Fyke netting began on May 16, after it was believed that the majority of the spring out-migration had passed Wells Dam. Catch numbers were low and showed less than 50% salmon species (Figure 8 and Table 5). On May 23, there was a large peak of chinook salmon (Figure 7A), but sockeye were also present, constituting about 25% of the catch (Table 5). From May 30 until the end of August, the chinook catch accounted for more than 94% of all salmon caught. During the month of June, the catch consisted primarily of other non-target species (Figure 7B). However, chinook were also present during June. This may be due to an unusually late chinook (zero age) release from the Winthrop hatchery at the end of May (Table 4). No whitefish were caught until the beginning of July (Table 5 and Figure 7B). Large numbers of chinook were caught from mid-July through mid-August (Figure 7A). Zero age chinook were prevalent on July 25 and dominated the catch through August 15. The catch during this period ranged from 83% to 99% chinook-0's. From mid-August through the end of the study, August 31, the catch consisted mainly of non-target species.

The 1991 fyke net data again show a spring and summer period dominated by salmonid species. Whitefish were present throughout July. The catch from July 25 to August 15 was primarily zero-age chinook. Overall, chinook constituted the vast majority of all salmon caught. "Other" fish that were caught in the fyke net included bullhead (*Ictalurus spp.*), carp (*Cyprinus spp.*), chiselmouth (*Acrocheilus spp.*), dace (*Chrosomus spp.*) lamprey (*Entosphenus spp.*), peamouth (*Mylocheilus spp.*), sculpin (*Cottus spp.*), shiner (*Notropis spp.*), squawfish (*Ptychocheilus spp.*), sucker (*Catostomus spp.*), and walleye (*Stizostedion spp.*).

Table 5. Number and proportion of chinook, steelhead, sockeye and other non-salmonid species caught in the fyke nets at Wells Dam in spring and summer 1991. Data are expressed in number of fish per hour and proportion. Source R. Klinge (DCPUD).

	Oncorhynchus Species						Non-Salmonid Species					
	Chinook		Sockeye		Steelhead		Whitefish		Other		All non-salm.	
Date	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.
May - 16	0.9	0.19	1.1	0.25	0.0	0.00	0.0	0.00	2.5	0.56	2.5	0.56
23	10.9	0.62	4.3	0.24	0.4	0.02	0.0	0.00	2.0	0.11	2.0	0.11
30	3.9	0.89	0.1	0.03	0.0	0.00	0.0	0.00	0.4	0.09	0.4	0.09
June - 6	1.8	0.37	0.0	0.00	0.0	0.00	0.0	0.00	3.0	0.63	3.0	0.63
13	2.5	0.29	0.0	0.00	0.0	0.00	0.0	0.00	6.1	0.71	6.1	0.71
20	1.6	0.17	0.0	0.00	0.0	0.00	0.0	0.00	7.8	0.83	7.8	0.83
27	1.0	0.32	0.0	0.00	0.0	0.00	0.0	0.00	2.1	0.68	2.1	0.68
July - 3	1.6	0.48	0.0	0.00	0.0	0.00	0.5	0.15	1.3	0.37	1.8	0.52
11	7.4	0.72	0.0	0.00	0.0	0.00	0.6	0.06	2.3	0.22	2.9	0.28
18	6.6	0.76	0.0	0.00	0.0	0.00	1.3	0.14	0.9	0.10	2.1	0.24
25	17.1	0.94	0.0	0.00	0.0	0.00	0.3	0.01	0.9	0.05	1.1	0.06
August - 1	12.3	0.90	0.0	0.00	0.1	0.01	0.5	0.04	0.8	0.06	1.3	0.09
8	9.5	0.89	0.0	0.00	0.0	0.00	0.3	0.02	0.9	0.08	1.1	0.11
15	2.4	0.83	0.0	0.00	0.0	0.00	0.1	0.04	0.4	0.13	0.5	0.17
19	0.0	0.00	0.0	0.00	0.0	0.00	0.1	1.00	0.0	0.00	0.1	1.00
22	1.3	0.53	0.1	0.05	0.0	0.00	0.0	0.00	1.0	0.42	1.0	0.42
28	0.5	0.03	0.0	0.00	0.0	0.00	0.0	0.00	14.5	0.97	14.5	0.97

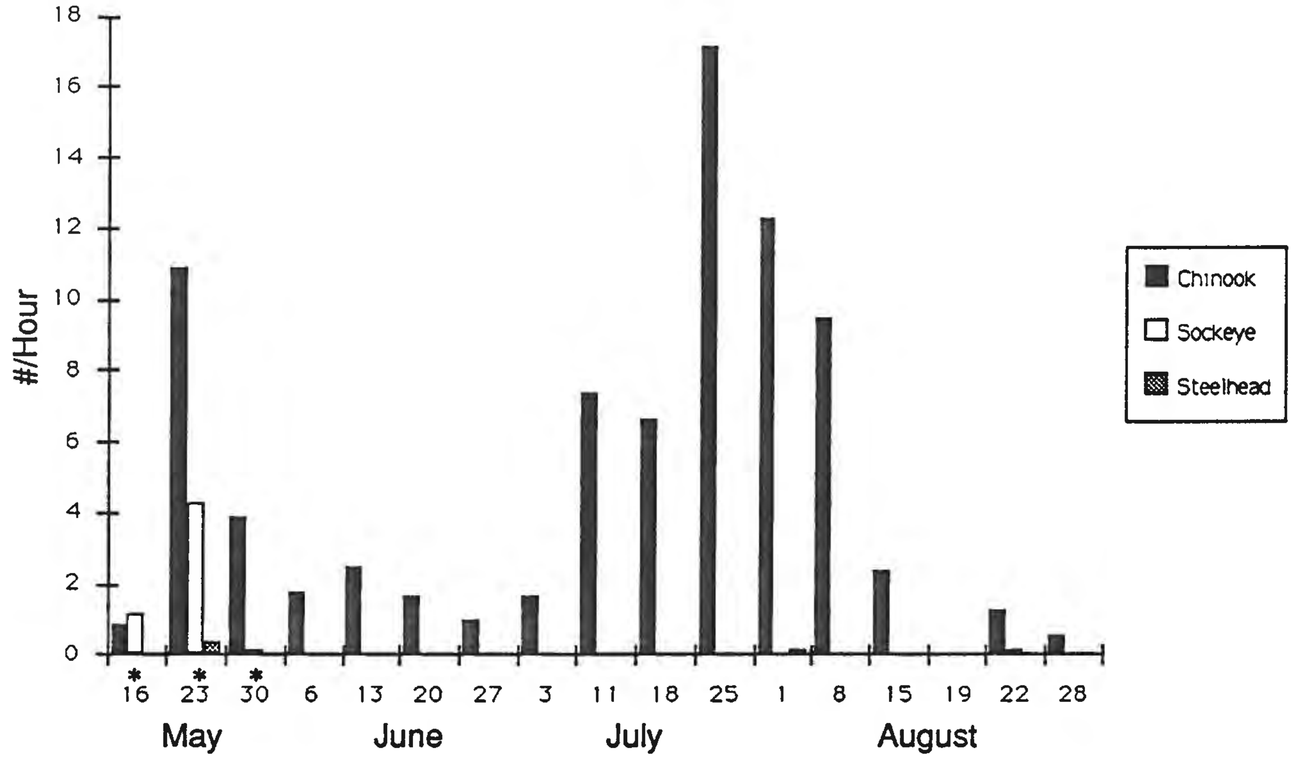

Figure 7A. Catch per hour of chinook (zero-age and yearlings combined), sockeye, and steelhead in the fyke nets at Wells Dam from May 16 to August 28, 1991. (* - Only four nets fished.)

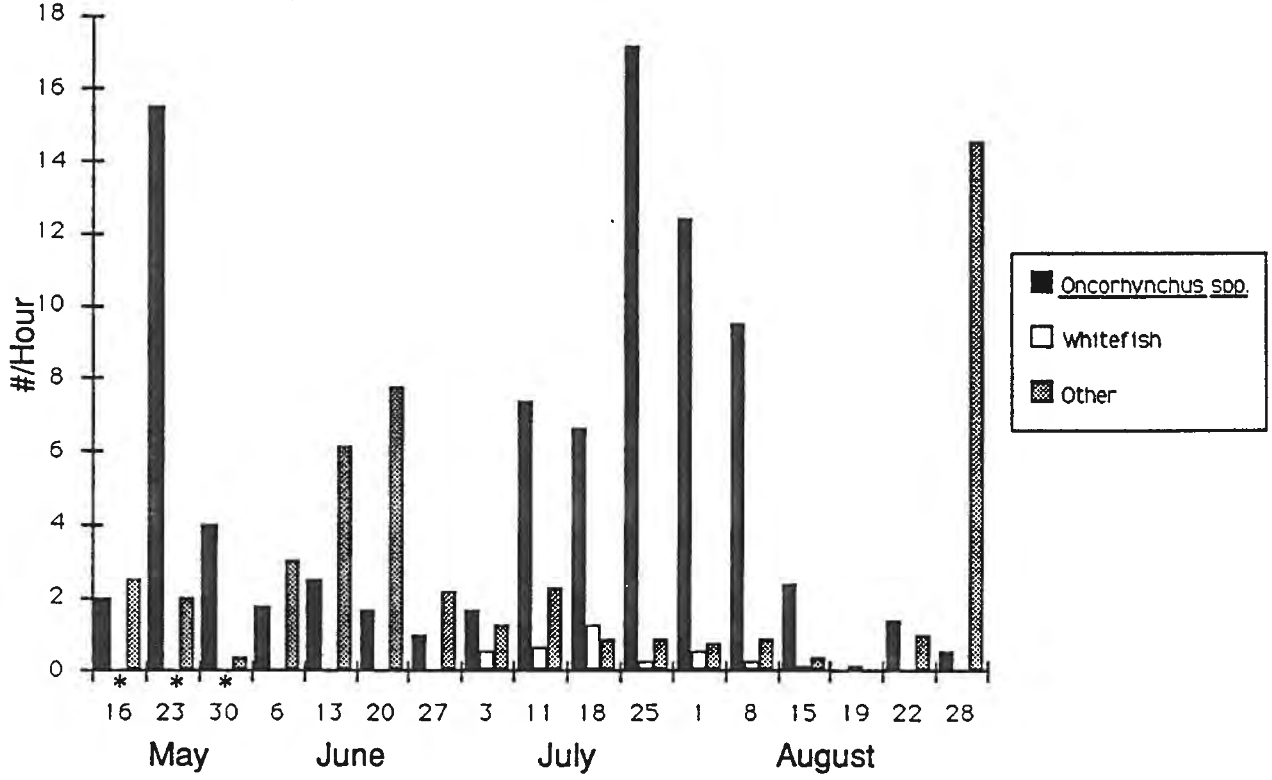

Figure 7B. Catch per hour of *Oncorhynchus spp.*, whitefish, and "other" species in the fyke nets at Wells Dam from May 16 to August 28, 1991. (* - Only four nets fished.)

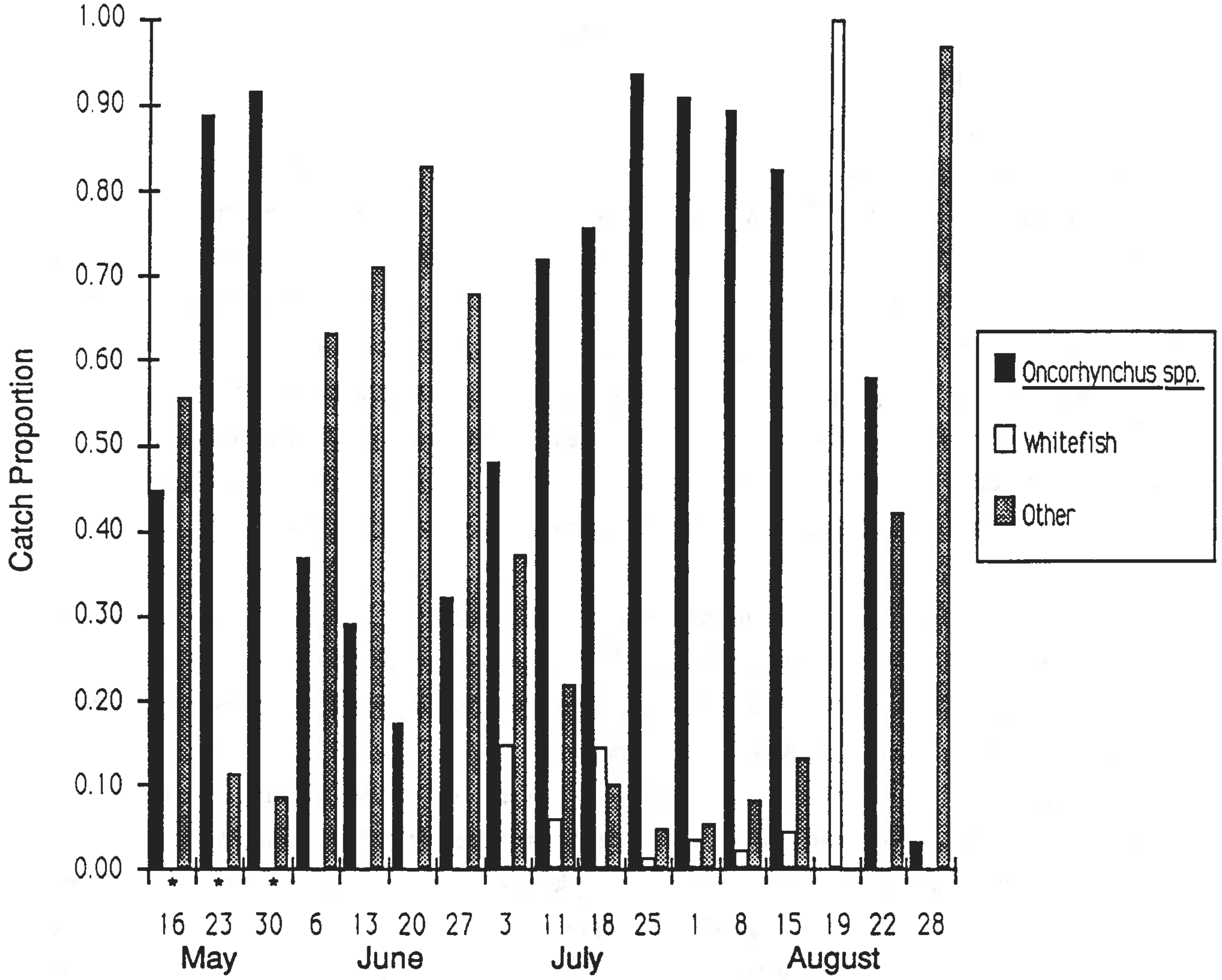

Figure 8. Proportions of the total catch from fyke net samples at Turbine Intake 4C and Turbine Intake 8C at Wells Dam in 1991, May 16 to August 28. (* - Sample taken at Turbine Intake 4C.)

3.1.3 Run Timing

The daily "sub-index" of run timing (mean #/8hr/location) from March 29 to August 31, 1991 is presented in Figures 9, 10, and 11. The run timing index was calculated using forebay data for all days except during the bypass evaluations when the run timing index was calculated using bypass slot data.

As in past studies, passage was generally low in early April (Figure 9). Passage rates increased dramatically on April 13 with the arrival of chinook from the Winthrop hatchery release. The release occurred on April 11 (Table 4). No fyke netting was done during the first month of the bypass evaluation. Fyke netting began on May 16. Passage rates were generally high during the latter part of April but dropped quickly after April 30 to the lowest passage rate of the spring bypass evaluation on May 2 (Figure 10). After May 2, passage rates gradually increased and there was a large peak on May 14. Passage rates remain high through May 21. The fyke net catch from May 23 was 88% chinook, sockeye, and steelhead (Table 5). As in previous years (Kudera et al. 1990) lowest passage rates occurred during late May and early June (Figure 9).

Passage rates began to steadily increase on June 27 and into the summer bypass evaluation period. The fyke net catches from July 3 through August 15 contained between 48% and 94% chinook salmon (Table 5). The summer bypass evaluation showed generally higher passage rates than the spring evaluation. There was a distinct peak on July 12 (Figure 11). The fyke catch of July 11 was 72% chinook (Table 5). Lowest passage of the summer evaluation occurred on July 14. There was another peak on July 16. Passage rates remained relatively constant from July 17 to July 21 and then began to rise dramatically. The fyke data from July 25 and August 1 showed zero-age chinook constituting 86% and 99% of the catch respectively. This was also when the highest fyke net catch rates of the season occurred (Table 5). There was another large peak on August 8 (Figure 9). The fyke catch from August 8 was 89% summer chinook The passage rates remained high and variable through the end of the study period primarily due to increasing numbers of other non-target species. The fyke catch on August 28 was 97% "other" species.

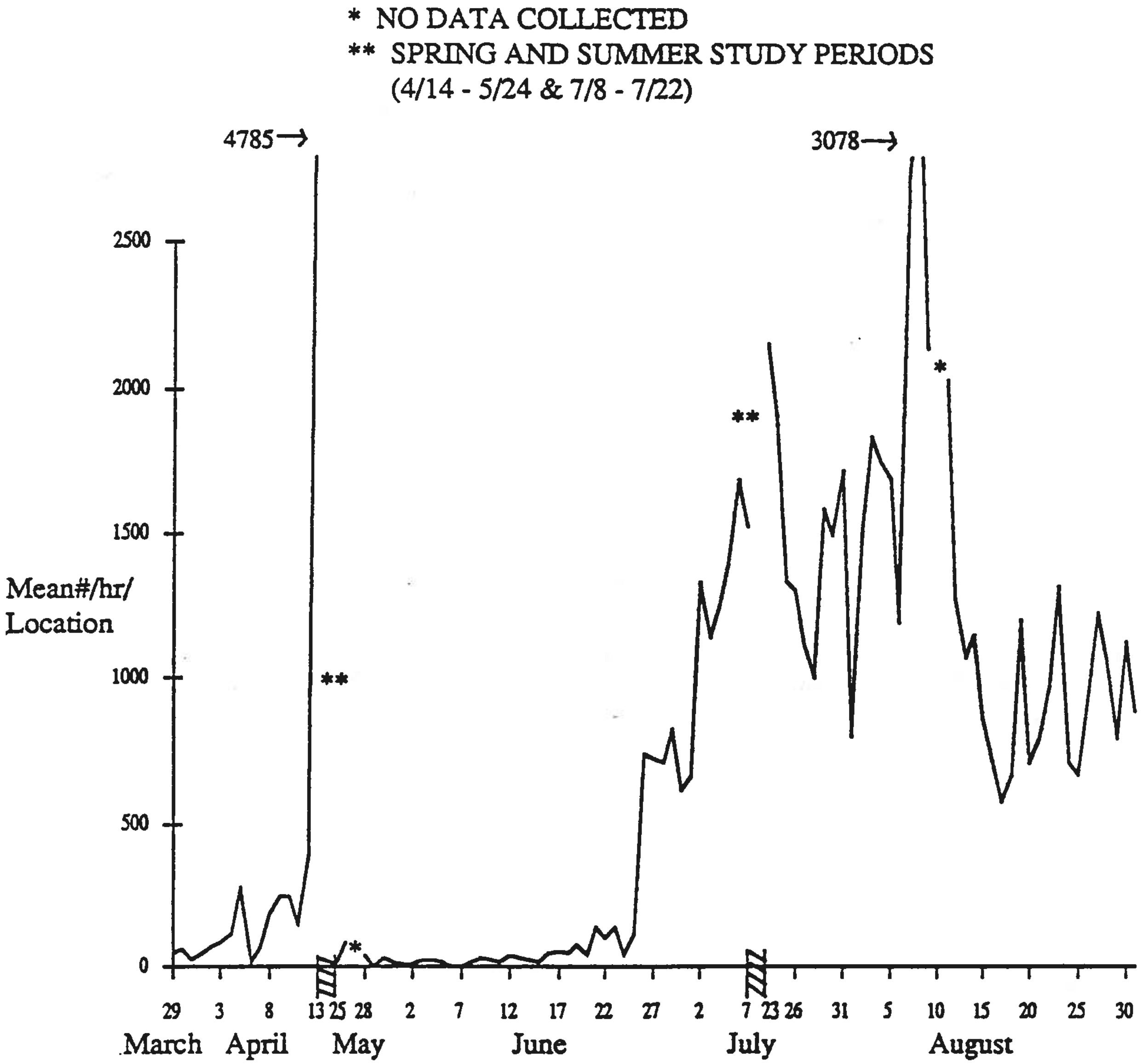

Figure 9. Daily fish passage indices (mean #/8hr/location) for day (1300- 1700h) and night (2200- 0200h) combined at Wells Dam forebay between March 29 and April 13, May 25 through July 7, and July 23 through August 31, 1991.

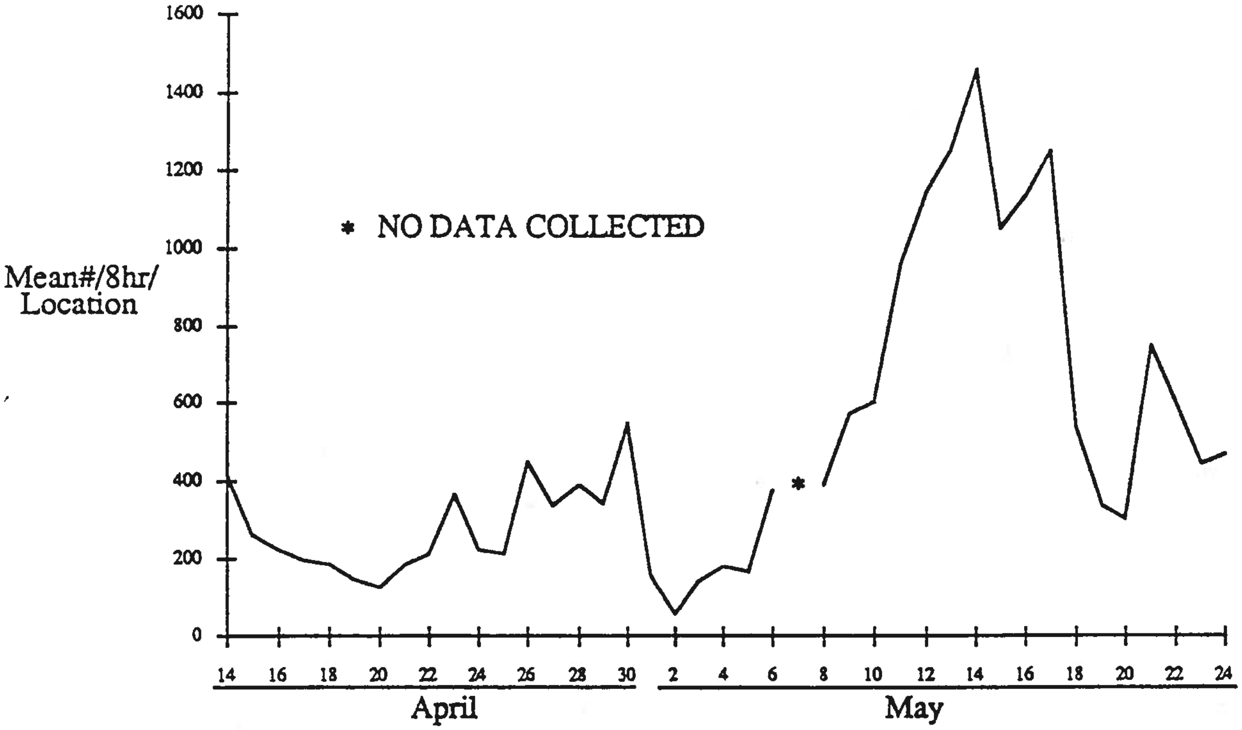

Figure 10. Daily fish passage indices (mean #/8hr/location) for day (1300- 1700h) and night (2200- 0200h) combined using bypass slot data at Wells Dam between April 14 and May 24, 1991.

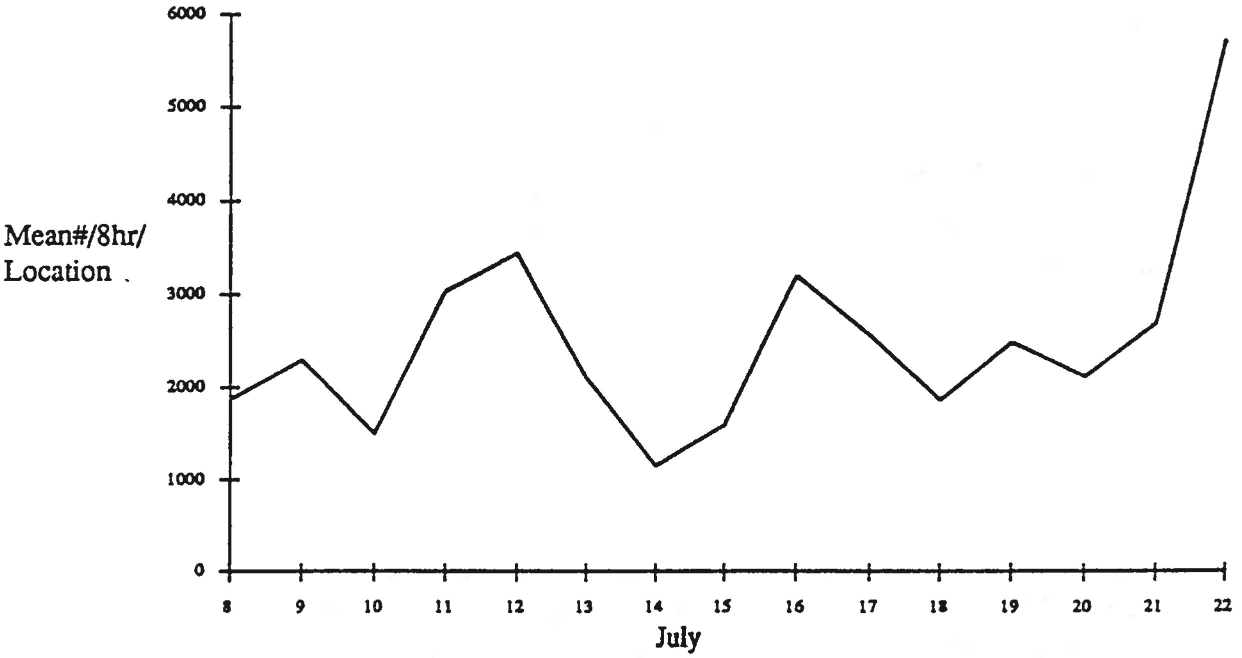

Figure 11. Daily fish passage indices (mean #/8hr/location) for day (1300- 1700h) and night (2200- 0200h) combined using bypass slot data at Wells Dam between July 8 and July 22, 1991.

3.2 Estimated Total Project Bypass Efficiency

Estimated total project bypass efficiency in spring 1991 was 95.0% +/- 0.43% at the 90% confidence level. Daily bypass ratios for spring are given in Figure 12. Daily bypass efficiencies ranged from 73% to 99%. As in 1990, bypass efficiencies were generally higher during the latter part of the spring evaluation. Both April 14 and April 18 had the lowest bypass efficiency of about 73%. The highest efficiency (99%) occurred on May 12.

Estimated total project bypass efficiency in summer 1991 was 97.0% +/- 0.29% at the 90% confidence level. Daily bypass ratios for the summer evaluation are given in Figure 13. Daily bypass efficiencies ranged from 96% to 99%. Bypass efficiencies were higher during the summer than in the spring. Bypass efficiencies were generally higher at the beginning of the summer study. The lowest efficiency (about 96%) occurred on the last day of the evaluation, July 22. The highest efficiency (99%) occurred on July 21.

To summarize, the estimates of **total project bypass efficiency** at Wells Dam in 1991 were:

Spring	95.0% +/- 0.43% at the 90% confidence level
Summer	97.0% +/- 0.29% at the 90% confidence level

The estimate of total project bypass efficiency compares fish passage in bypass flow with passage in bypass plus turbine flow. This estimate assumed that the ability to acoustically detect fish at each location was equivalent . To confirm this assumption, we did an analysis of relative detectability as was done during the bypass development . (BioSonics 1984). The methods of this analysis are described in Appendix E. The analysis showed that detectabilities between transducers at bypass slot and turbine intake locations under different environmental conditions were equivalent.

Bypass efficiencies were high in 1991. This may have been due to a lesser number of juvenile sockeye migrating past the dam, although data apparently do not exist to support or refute this hypothesis. Fyke net results in past years showed that sockeye were distributed deeper in the water column than other juvenile migrants, hence possibly lowering bypass efficiency. Also, the 1990 bypass efficiencies may have been conservative. The forced spill in 1990 did not allow for complete sampling of all spill bay bypass openings. Some fish undoubtedly passed the dam in this unsampled spill. During 1991, little forced spill occurred during the spring and summer studies.

The confidence intervals were tight because most of the daily bypass efficiencies were very close to one. It is a statistical phenomenon that as the point estimate of a proportion gets close to zero or one, the confidence interval gets smaller (J. Skalski, personal communication). Also, greater sampling effort, i.e. more transducers and smaller sampling intervals than 1990 reduced confidence interval size. The results of the bypass evaluations from 1990 and 1991 show yearly variability.

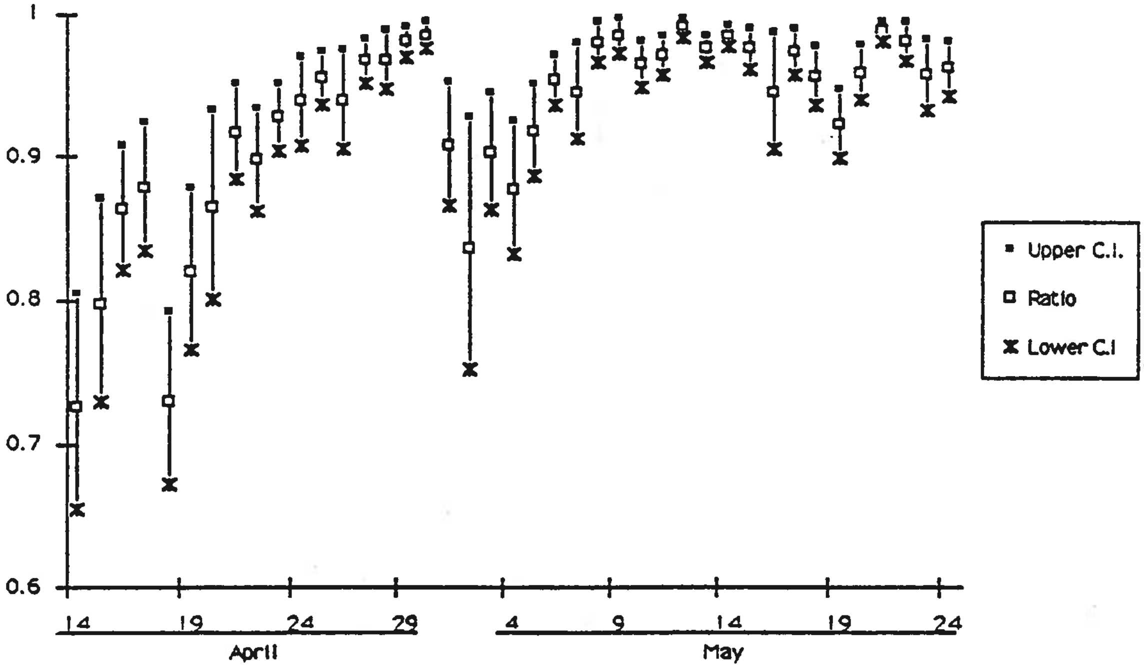

Figure 12. Daily bypass efficiency estimates for spring (April 14 to May 24) at Wells Dam, 1991. Ratios are expressed for 90% confidence levels.

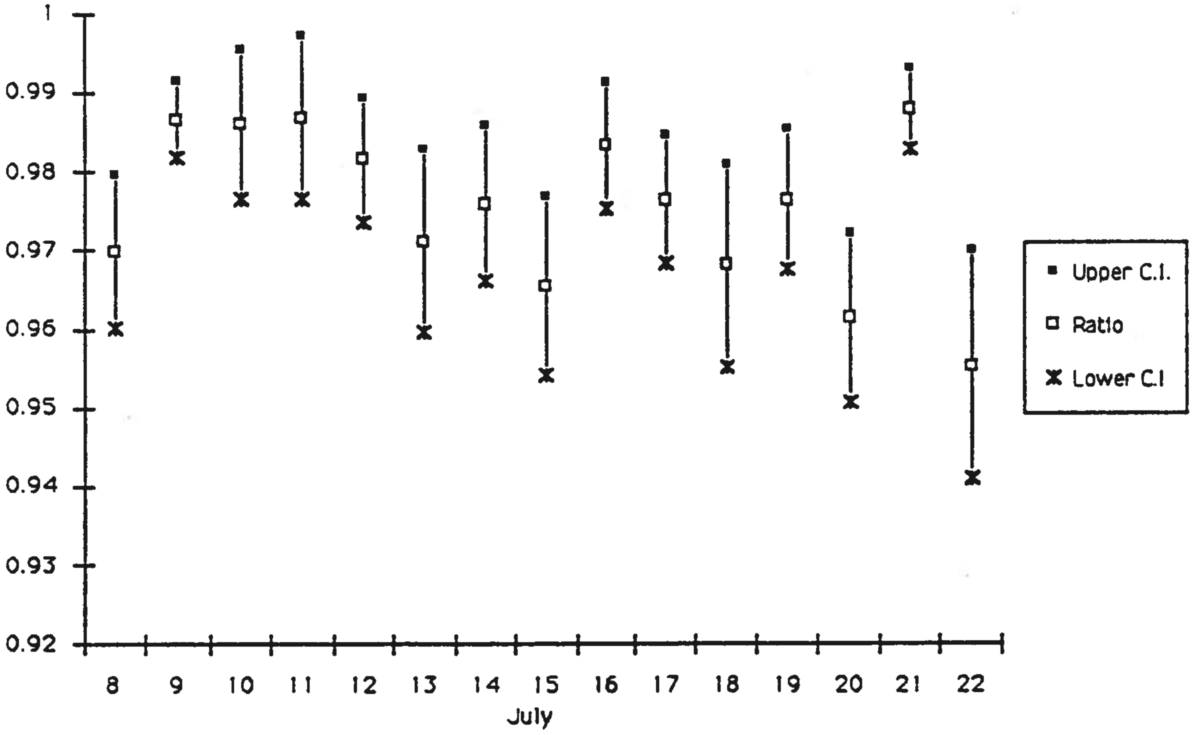

Figure 13. Daily bypass efficiency estimates for summer (July 8 to July 22) at Wells Dam, 1991. Ratios are expressed for 90% confidence levels.

4.0 SUMMARY

(1) Total project bypass efficiency was estimated using hydroacoustic techniques during spring (April 14 to May 24) and summer (July 8 to July 22) study periods at Wells Dam in 1991.

(2) Species composition data were collected using fyke net methods from May 16 to August 28, 1991. Run timing data were collected using hydroacoustic methods from March 29 to August 31, 1991.

(3) Chinook and sockeye salmon and steelhead trout juveniles were predominant during the spring study. Passage rates were lowest during June. Zero-age chinook were predominant from mid-July through mid-August. Whitefish were present in noticeable numbers in July. Other non-target species were predominant through the end of August.

(4) Estimated total project bypass efficiency for the 40-day spring study was 95.0% ± 0.43% at the 90% confidence level.

(5) Estimated total project bypass efficiency for the 15-day summer study was 97.0% ± 0.29% 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 1991 required three BioSonics systems. Each system (Figure A1) consisted of the following components: high-frequency transducers (420 kHz) with cable, an echo sounder/multiplexer, 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 1991 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 1991.

MODEL NO. AND EQUIPMENT	MANUFACTURER	SERIAL NO.
Model 101 (420 kHz) Echo Sounder	BioSonics, Inc.	101-81-010 101-81-031
Model 1005 (420 kHz) Echo Sounder/Multiplexer		1005-91-001 1005-91-002 1005-91-003
Model 151 MPX/EQ Multiplexer/Equalizer	BioSonics, Inc.	151-83-006
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

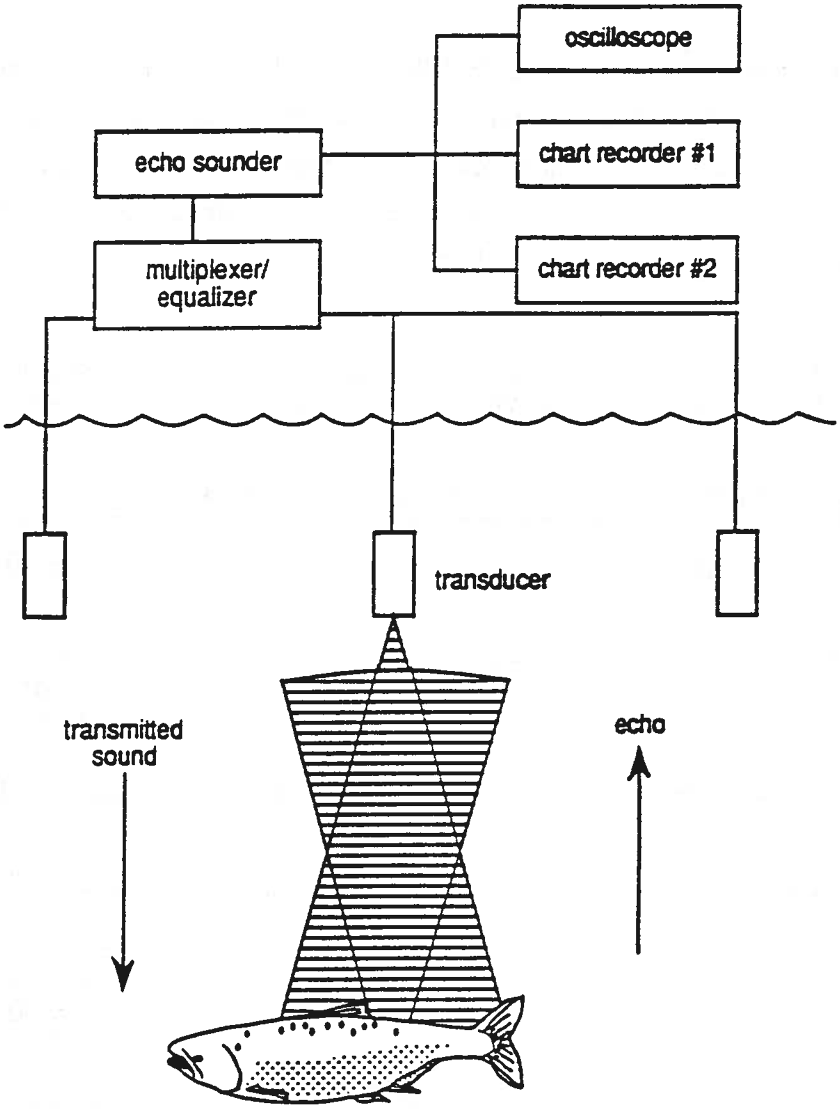

Figure A1. Block diagram of hydroacoustic data collection system used at Wells Dam in 1991.

Table A2. Hydroacoustic system parameters used for studies at Wells Dam in 1991.

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 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 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 -54 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 Biosonics engineer checked the performance of the Model 1005 Sounder/Multiplexer at the end of the spring 1991 study. He discovered an error in the TVG circuit of the receiver boards of all three Model 1005's used. The TVG was slightly under-amplifying the signals. The amount of error was exactly the same on all systems. Thus, although fish detectability was lower than it should have been, it was equivalent for all systems. The ratio of bypass efficiency in spring was not affected by this problem. The TVG was corrected for the summer study.

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 -54 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. During 1991, less than 1% of the data were excluded due to excessive noise.

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, and 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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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 ($Var(\hat{B}\,|\,B)$) and estimated variance ($\hat{V}(\hat{B}\,|\,B)$) 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

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

$$Var(\hat{Z}) = \frac{N^2}{n}\left(1-\frac{n}{N}\right)S_{z_i}^2 + \frac{N^2}{n}\overline{Var(\hat{z}_i \mid z_i)} \qquad (1)$$

where

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

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

$$V\hat{a}r(\hat{Z}) = \frac{N^2}{n}\left(1-\frac{n}{N}\right)s_{z_i}^2$$

where

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

This estimate of the variance has the expected value

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

Hence, the empirical variance, $s_{z_i}^2$, 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 $(Var(\hat{z}_i|z_i))$ 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 $(g = 1, 2, ..., l_{ijk})$ in the kth hour $(k = 1, 2, ..., 24)$ at the jth bypass $(j = 1, 2, ..., 5)$ on the ith day $(i = 1, 2, ..., D)$,

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

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

Then the estimate of total bypass passage (Y) is

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

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

$$Var(\hat{Y} \mid Y) = \sum_{i=1}^{D}\sum_{j=1}^{3}\sum_{k=1}^{24}\left[L_{ijk}^{2}\left(1-\frac{l_{ijk}}{L_{ijk}}\right)\frac{S_{y_{ijk}}^{2}}{l_{ijk}}\right] . \tag{4}$$

and where

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

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

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

and where

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

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

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

or

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

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

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

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, $\hat{Var}(\hat{B} \mid B)$, 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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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

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

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

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

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

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

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

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

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

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

where

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

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

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

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

$$Cov(\hat{X},\hat{Y}) = E_{s_1}[0]+Cov_{s_1}\left[\cdot\sum_{k=1}^{D} X_k \cdot \sum_{k=1}^{D} Y_k\right]$$

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

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

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

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

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

Assuming approximate normality,

$$\begin{aligned} P\left(\frac{-\epsilon}{\sqrt{Var(\hat{B})}}<Z<\frac{\epsilon}{\sqrt{Var(\hat{B})}}\right) &= 1-\alpha \\ P\left(Z<\frac{-\epsilon}{\sqrt{Var(\hat{B})}}\right) &= \frac{\alpha}{2} \\ \Phi\left(\frac{-\epsilon}{\sqrt{Var(\hat{B})}}\right) &= \frac{\alpha}{2} \end{aligned}$$

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

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

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

APPENDIX C

HORIZONTAL AND DIEL DISTRIBUTION RESULTS

C.1 Horizontal Distributions

As in previous years, the horizontal distribution data from the bypass slots during the spring study (April 14 to May 24) showed greater passage at the west end of the dam (Figure C1). Nighttime passage rates were higher than daytime passage rates. The highest passage rate occurred at bypass unit S6. Next highest passage occurred at S2, followed closely by S4. Slot passage was lowest at S10.

Turbine horizontal distribution data from spring showed highest passage rates at 10C (Figure C2). Units 1 and 6 also had high passage rates. The lowest passage rates occurred at Units 4 and 5. Data from turbine intakes also showed generally higher nighttime passage than daytime. Passage rates in turbine were much lower than in bypass slots.

As in spring, summer (July 8 to July 22) bypass slot passage rates are higher towards the west end of the dam (Figure C3). Again, bypass unit S6 showed the highest rates of all. The lowest passage rate occurs at S10. S2, S4, S6, and S8 had higher daytime passage rates than nighttime. S10 had a slightly higher nightime passage rate. Passage rates overall were higher during the summer than in the spring

As was the case with bypass slot data, passage rates in turbine during summer were higher during the daytime hours than during nighttime (Figure C4). The highest rates occurred at Units 2 and 9. The highest rate of all occurred at 2B. Unit 10 showed the third highest passage rate. The lowest passage rate was at Unit 5 again. Passage rates overall were higher in summer than in spring.

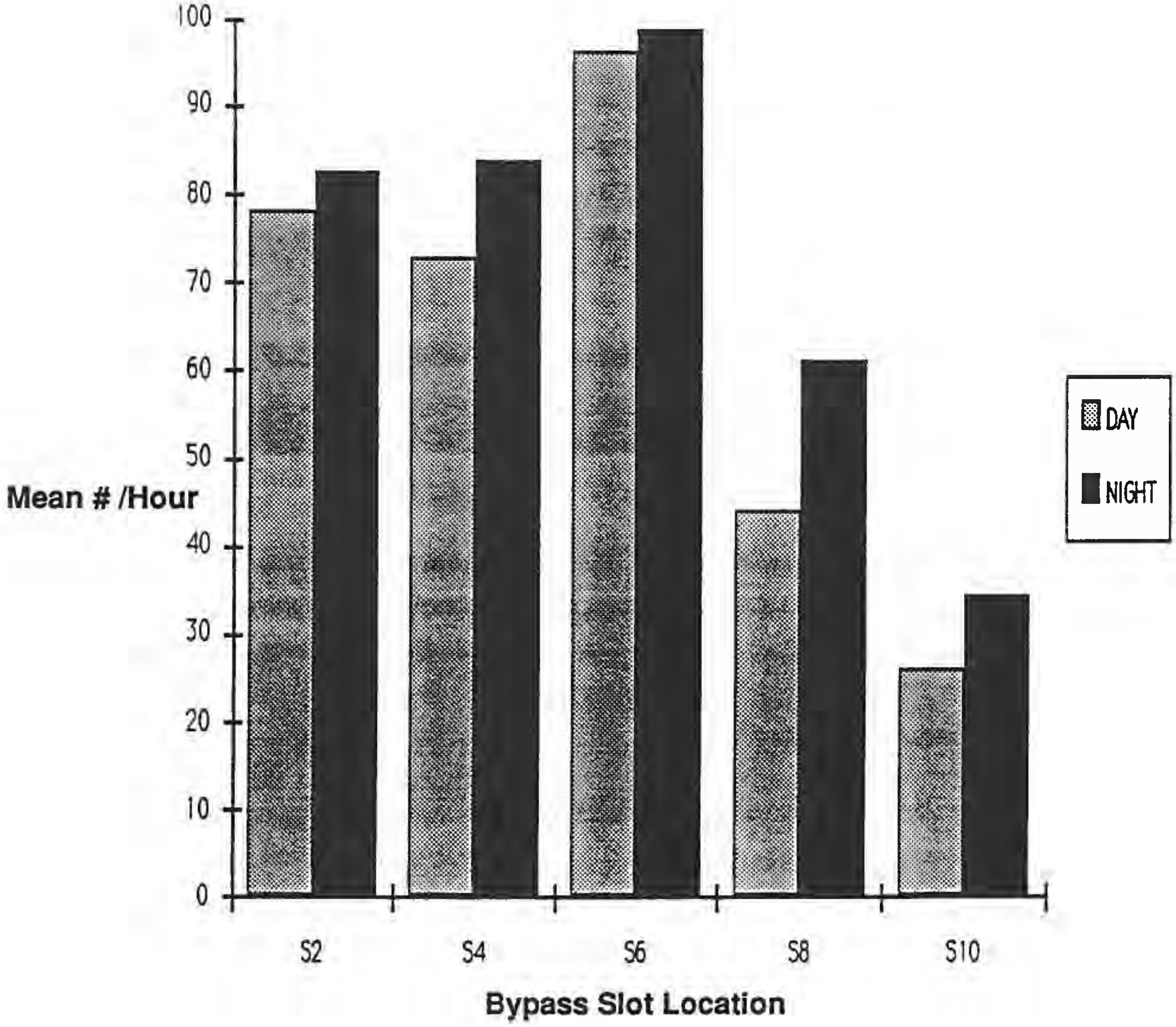


Figure C1. Horizontal distribution of bypass slot indices (mean#/1hr/location) for day and night separately at Wells Dam between April 14 and May 24, 1991.

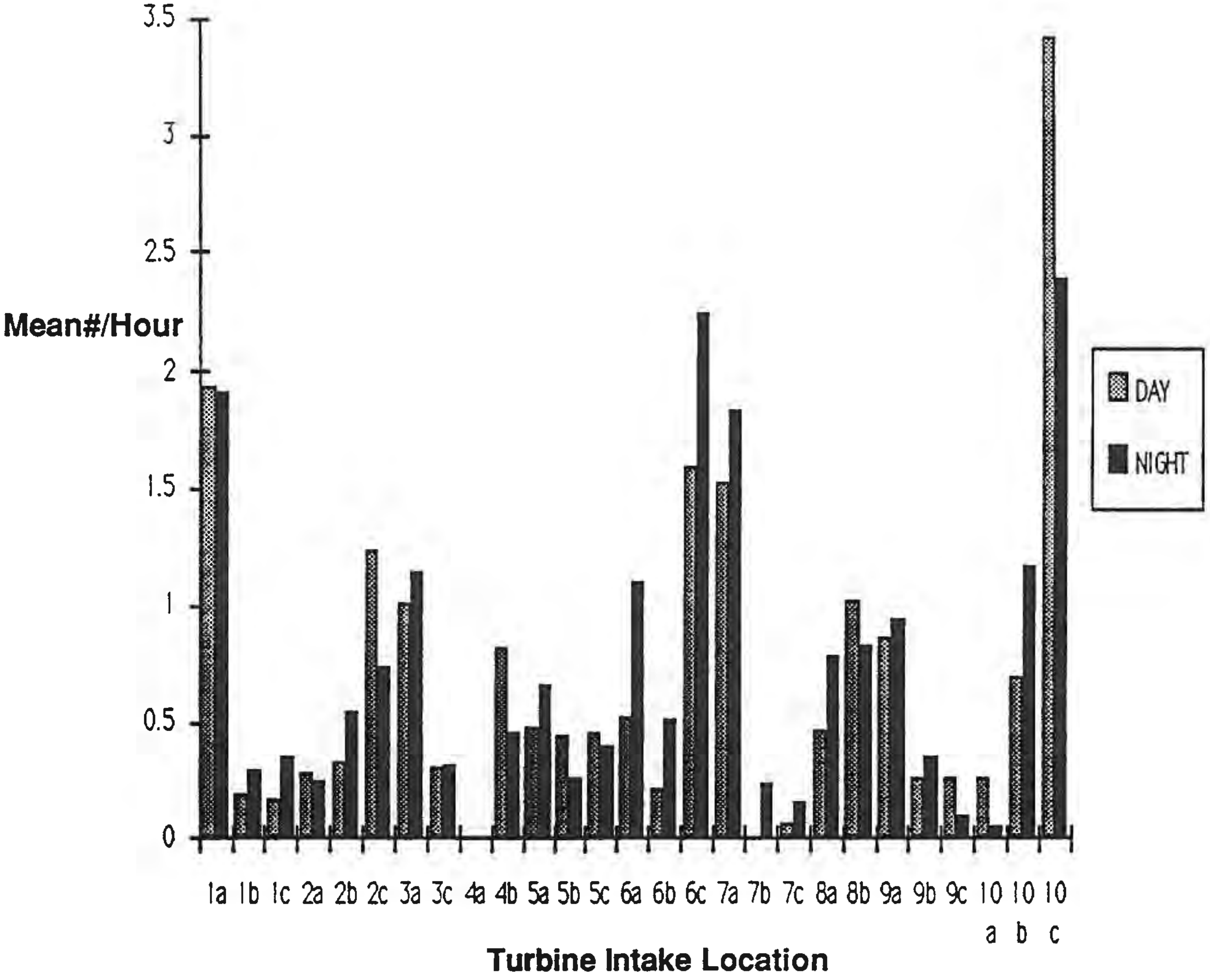


Figure C2. Horizontal distribution of turbine passage indices (mean#/1 hr/location) for day and night separately at Wells Dam between April 14 and May 24, 1991.

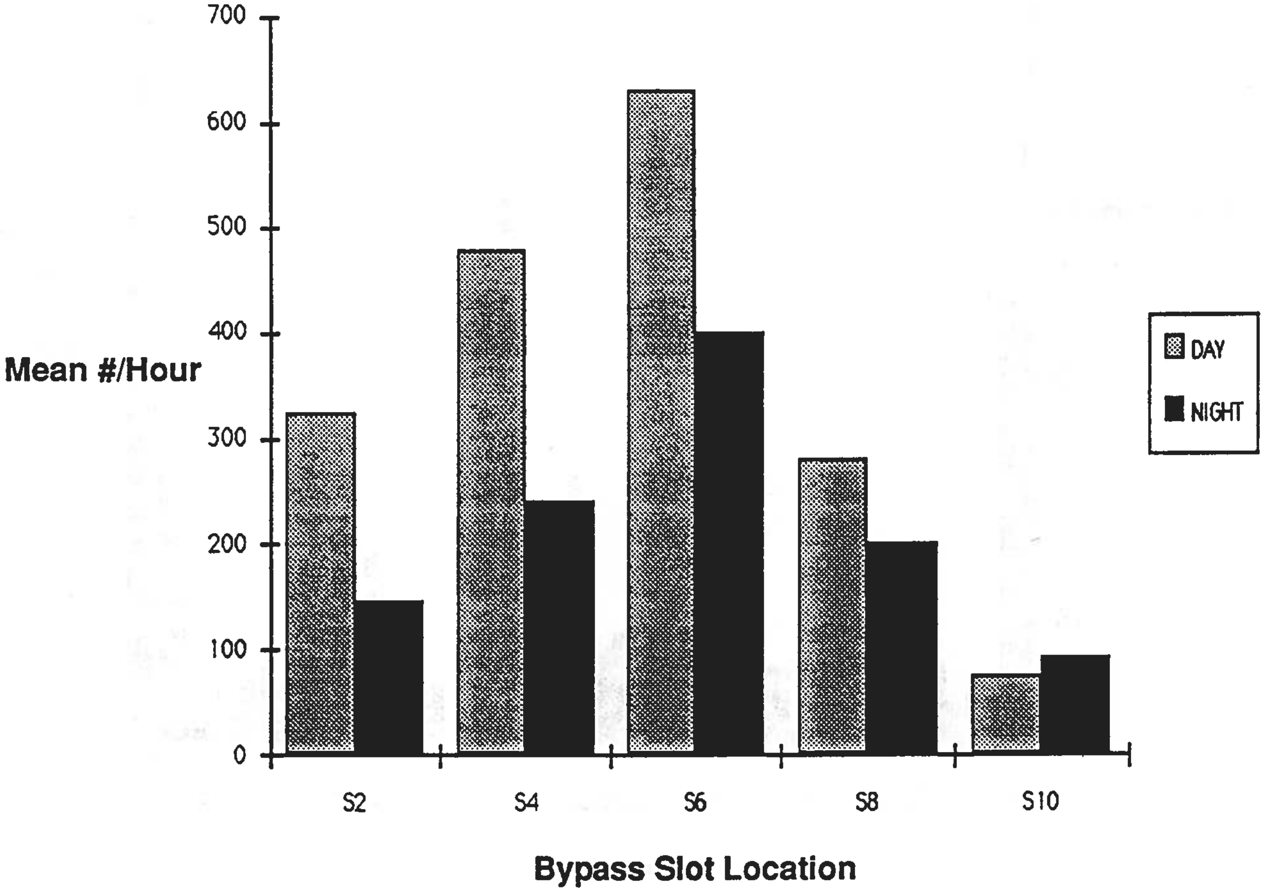


Figure C3. Horizontal distribution of bypass slot indices (mean #/1 hr/location) for day and night separately at Wells Dam between July 8 and July 22, 1991.

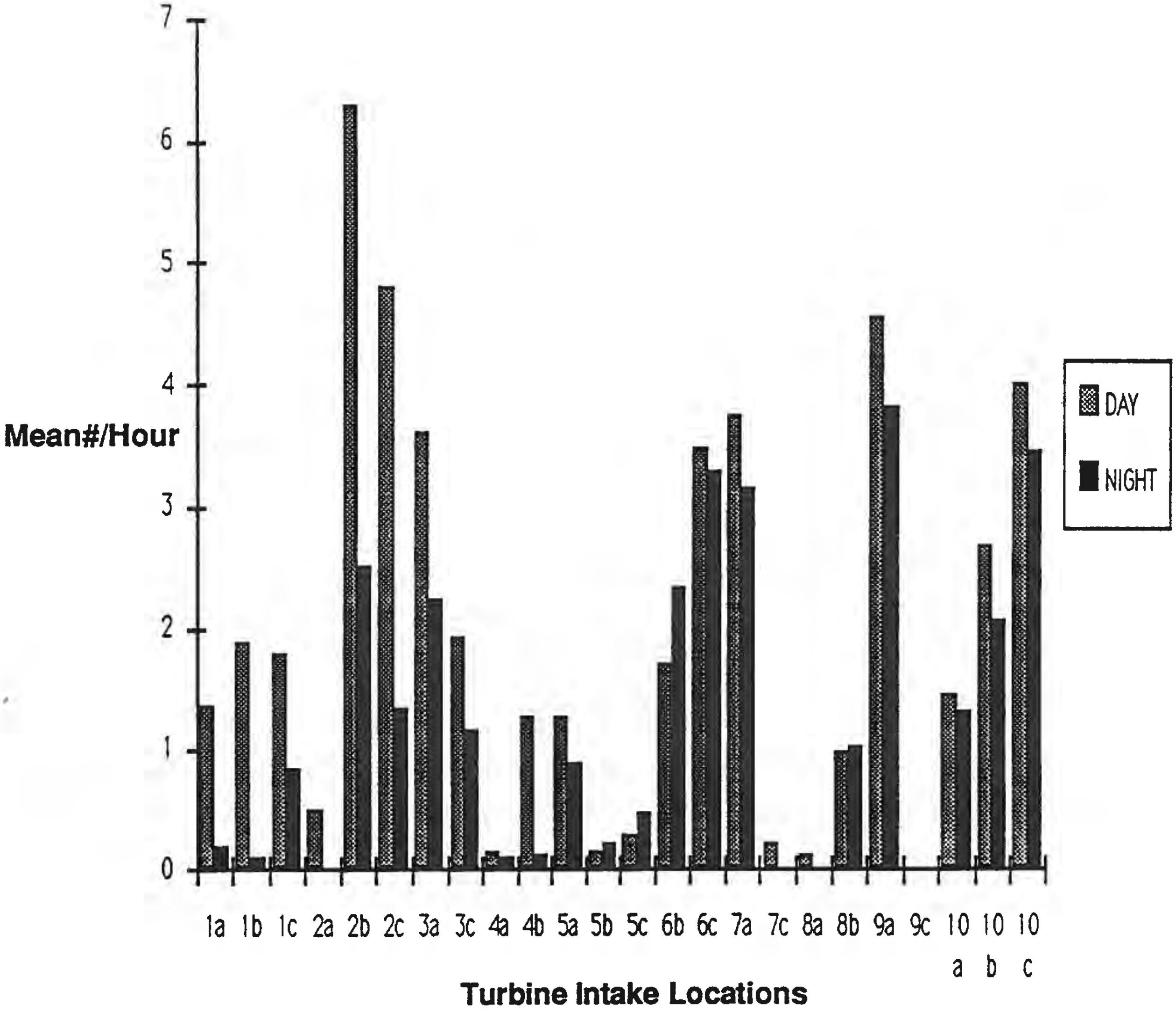


Figure C4. Horizontal distribution of turbine passage indices (mean #/1 hr/location) for day and night separately at Wells Dam between July 8 and July 22, 1991.

C.2 Diel Distributions

The diel distribution data for the bypass slots during spring (April 14 to May 24) show highest passage during the morning hours, 0500h to 1000h (Figure C5). Passage rates were also generally high between 2300h and 0100h hours. Highest passage occurred at 0700h. After 1000h, passage rates dropped to their lowest rate at 1800h.

The turbine diel distribution also show generally higher passage rates between 0000h and 1100h (Figure C6). Highest passage occured at 0800h. Overall, passage rates were much lower in turbine than in the bypass slots. After 1100h passage rates steadily declined to the lowest rate, which occurred at 1500h. Passage rates remained highly variable throughout the evening and nighttime hours.

Bypass slot data for the summer study (July 8 to July 22) are similar to last year's data. There was higher passage during daytime hours with peak passage occurring at 1000h (Figure C7). Passage rates overall were much higher than in the spring. Passage rates were lowest between 2300h and 0500h. The lowest passage occurred at 0500h.

Turbine diel distribution data show similar high daytime passage (Figure C8). Passage rates were relatively high between 0700h and 1500h. The highest passage rate occurred at 1000h. Passage rates were lowest between 0000h and 0400h. The lowest passage occurred at 0100h. As in the spring turbine data, passage rates were highly variable during the evening and nighttime hours (Figures C6 and C8).

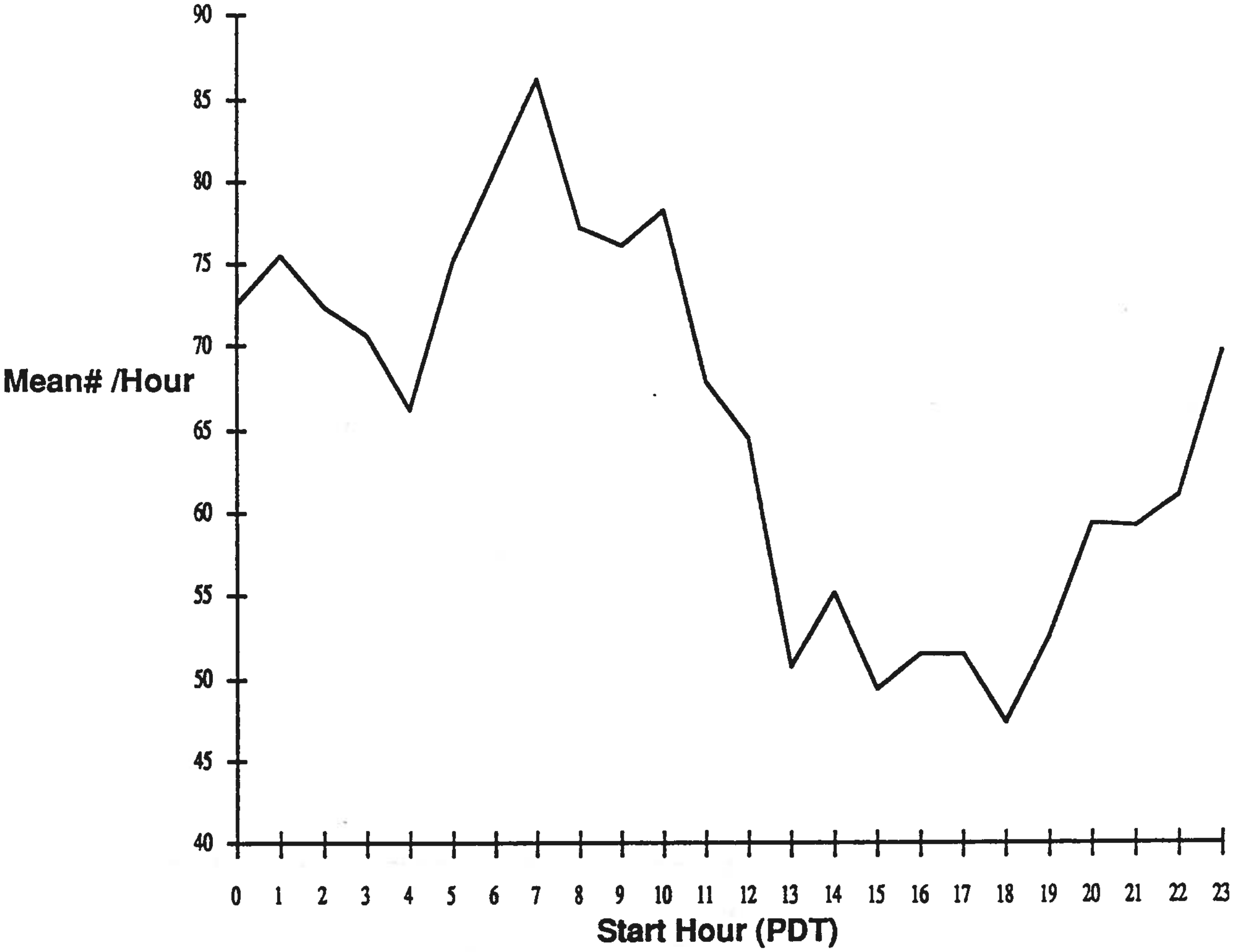


Figure C5. Diel distribution of bypass slot indices (mean #/hr/location) at Wells Dam between April 14 and May 24, 1991.

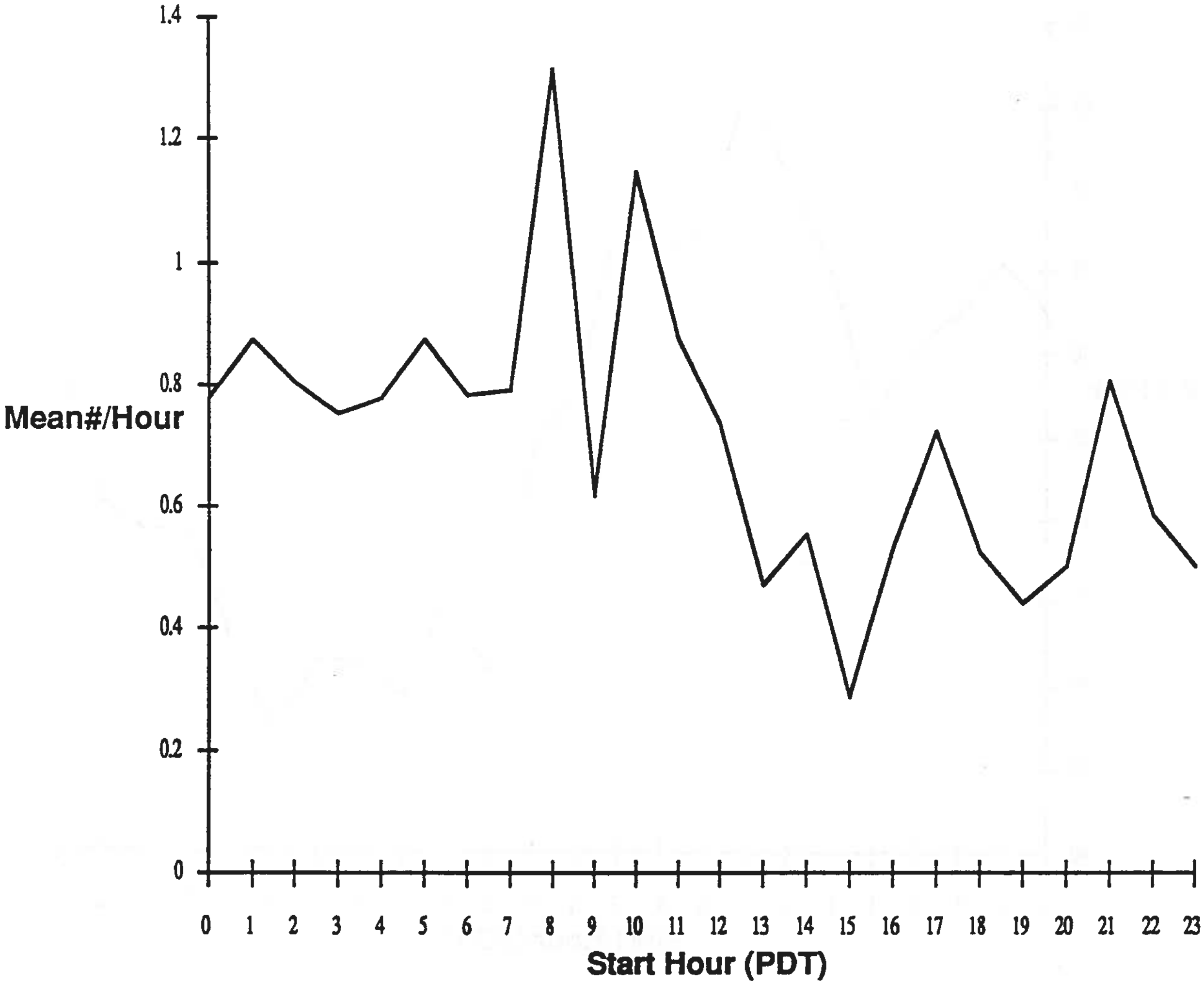


Figure C6. Diel distribution of turbine indices (mean #/1hr/location) at Wells Dam between April 14 and May 24, 1991.

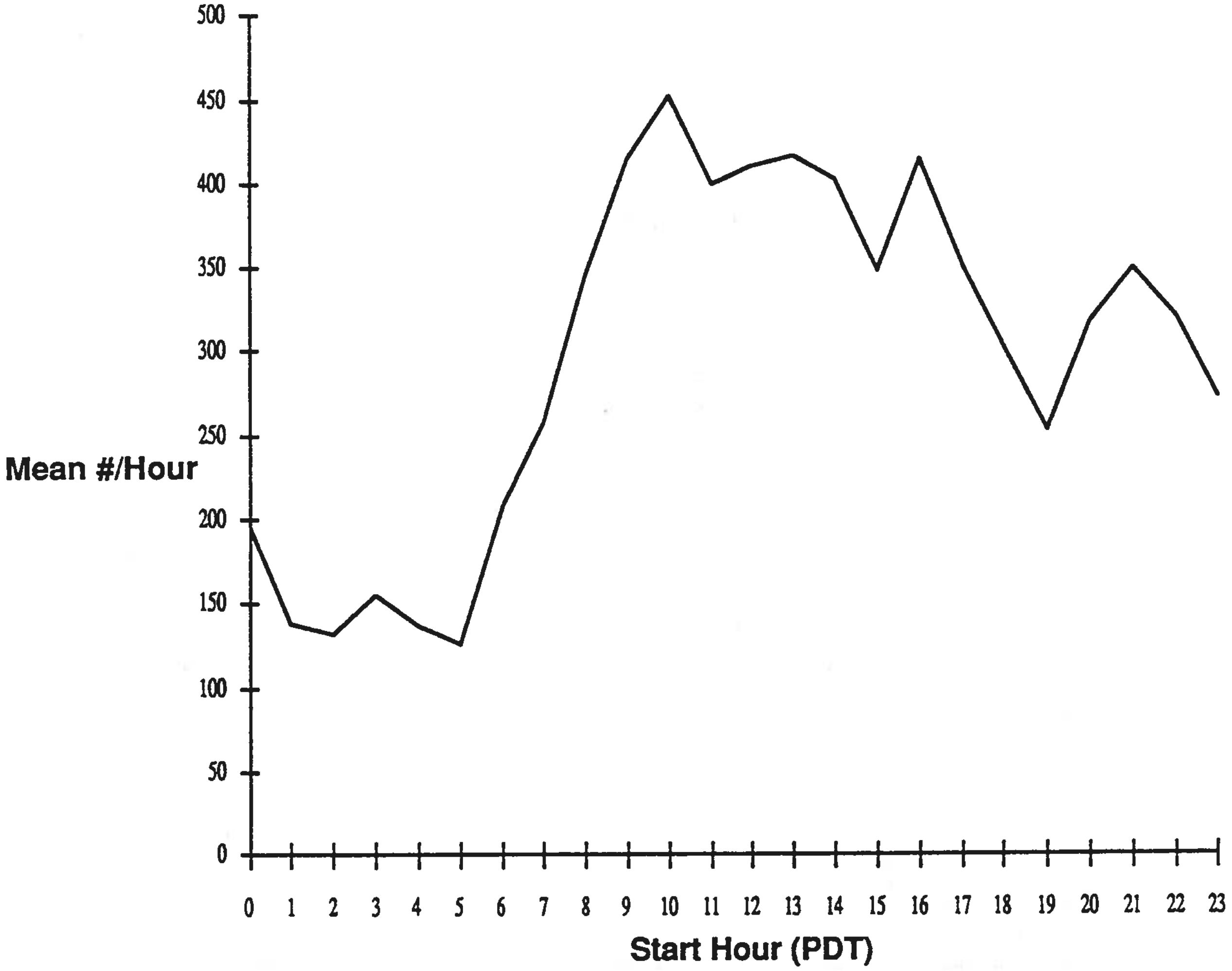


Figure C7. Diel distribution of bypass slot indices (mean #/1 hr /location) at Wells Dam between July 8 and July 22, 1991.

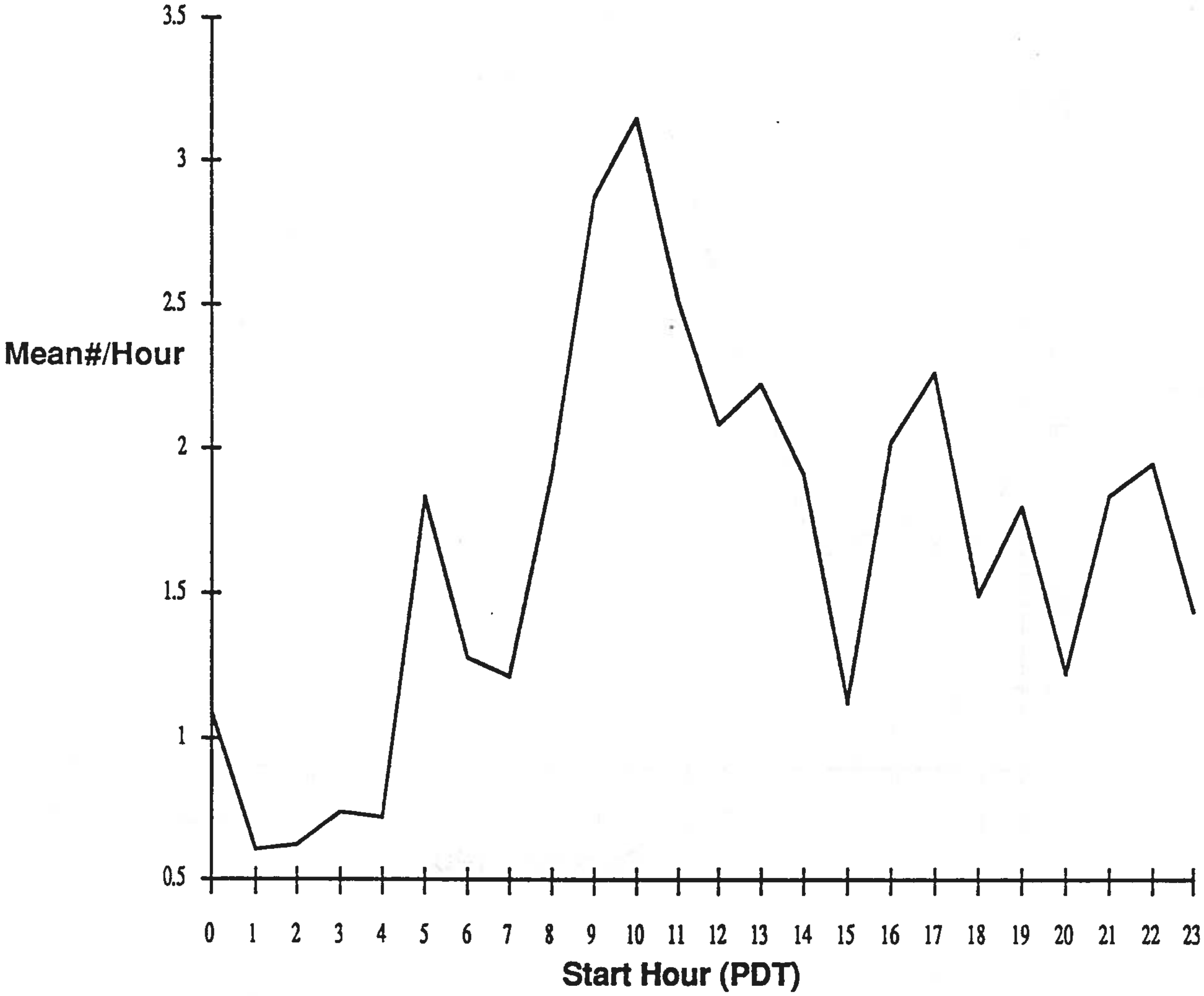


Figure C8. Diel distribution of turbine passage indices (mean #/hr/location) at Wells Dam between July 8 and July 22, 1991.

APPENDIX D

FISH PASSAGE DATA

Wells 1991 Forebay Hydroacoustic Index
Day/Night=Mean #/4hr/location
Combined=Mean #/8hr/location

	Date	Day	Night	Combined
March	29	20.1	25.6	45.8
	30	45.3	18.9	64.3
	31	15.7	7.7	23.4
April	1	35.2	15.3	50.5
	2	49.6	25.3	74.9
	3	62.3	22.6	84.9
	4	91.8	30.9	122.7
	5	86.3	194.0	280.3
	6	13.0	6.6	19.6
	7	29.3	43.7	73.0
	8	44.9	140.9	185.8
	9	122.8	131.4	254.3
	10	180.6	68.8	249.4
	11	73.0	73.7	146.7
	12	37.0	356.1	393.2
	13	198.6	4586.6	4785.2
	Spring Bypass Evaluation			
May	25	14.5	3.8	18.3
	26	0.0	90.3	90.3
	27	N/S	13.4	N/A
	28	26.5	19.0	45.5
	29	0.0	6.5	6.5
	30	21.6	8.8	30.5
	31	3.5	11.5	15.1
June	1	6.0	2.5	8.5
	2	6.2	3.0	9.2
	3	19.5	3.7	23.2
	4	9.4	17.4	26.7
	5	11.3	9.7	21.0
	6	0.0	4.8	4.8
	7	2.8	0.0	2.8
	8	3.9	18.5	22.4
	9	15.8	16.3	32.1
	10	21.1	6.7	27.7
	11	2.9	16.5	19.4
	12	22.9	16.2	39.1
	13	28.8	7.0	35.8
	14	12.6	11.5	24.1
	15	13.8	3.1	16.9
	16	39.6	19.2	48.8
	17	23.0	32.4	55.4
	18	23.4	28.9	52.3
	19	55.4	21.5	76.9

Wells 1991 Forebay Hydroacoustic Index
Day/Night=Mean #/4hr/location
Combined=Mean #/8hr/location

June	20	20.9	18.6	39.5
	21	95.4	48.9	144.4
	22	34.9	70.5	105.4
	23	33.7	110.8	144.5
	24	2.6	40.7	43.3
	25	55.4	63.2	118.6
	26	531.8	202.5	734.4
	27	116.5	603.0	719.5
	28	348.4	361.4	709.8
	29	511.9	311.8	823.8
	30	325.9	286.9	612.8
July	1	425.6	534.0	659.6
	2	441.2	891.6	1332.7
	3	550.2	587.6	1137.8
	4	939.5	309.7	1249.2
	5	1051.8	342.0	1393.8
	6	763.5	922.2	1685.7
	7	777.1	748.9	1526.0
	Summer Bypass Evaluation			
	23	977.6	1177.9	2155.4
	24	1211.0	696.0	1907.0
	25	811.0	520.5	1331.5
	26	735.5	568.7	1304.2
	27	463.2	653.5	1116.7
	28	638.9	360.8	999.7
	29	1210.3	374.7	1585.0
	30	964.3	535.3	1499.6
	31	1236.1	483.8	1719.9
August	1	554.5	245.7	800.1
	2	1029.5	483.2	1512.7
	3	937.9	894.5	1832.5
	4	1344.8	404.9	1749.7
	5	1046.4	640.2	1686.6
	6	1020.6	175.5	1196.1
	7	1636.9	1092.6	2729.5
	8	1871.7	1206.5	3078.2
	9	1528.8	606.2	2135.0
	10	N/S	673.3	N/A
	11	1161.5	865.0	2026.5
	12	410.8	860.1	1270.9
	13	503.0	568.4	1071.5
	14	511.0	653.2	1144.2
	15	341.9	516.9	858.8
	16	310.3	394.5	704.8
	17	303.3	274.4	577.8

Wells 1991 Forebay Hydroacoustic Index
Day/Night=Mean #/4hr/location
Combined=Mean #/8hr/location

August	18	414.7	254.1	668.8
	19	741.9	462.6	1204.4
	20	495.7	214.4	710.1
	21	394.2	409.4	803.5
	22	490.3	477.8	968.1
	23	978.2	341.1	1319.3
	24	465.6	244.2	709.8
	25	353.3	317.8	671.0
	26	381.1	571.6	952.7
	27	755.7	467.6	1223.3
	28	606.8	449.3	1056.1
	29	389.3	399.1	788.4
	30	778.2	349.3	1127.5
	31	505.5	380.8	886.3

Wells 1991 Study Periods Bypass Slot Run Timing

SPRING

	DATE	Mean #/8hr/location
April	14	411.881
	15	259.572
	16	221.078
	17	196.740
	18	183.743
	19	145.994
	20	127.614
	21	183.324
	22	210.881
	23	361.141
	24	219.054
	25	208.981
	26	445.098
	27	335.452
	28	388.487
	29	338.276
	30	546.357
May	1	157.038
	2	56.230
	3	138.498
	4	178.435
	5	163.298
	6	372.844
	7	No Data Collected For Day Period
	8	386.989
	9	573.203
	10	603.065
	11	963.552
	12	1145.567
	13	1247.932
	14	1459.427
	15	1051.563
	16	1135.875
	17	1249.220
	18	537.267
	19	334.367
	20	297.762
	21	749.022
	22	601.226
	23	442.714
	24	466.398

SUMMER

	DATE	Mean #/8hr/location
July	8	1857.244
	9	2295.527
	10	1489.016
	11	3039.483
	12	3445.813
	13	2090.995
	14	1145.023
	15	1576.673
	16	3206.072
	17	2544.649
	18	1851.678
	19	2475.864
	20	2110.247
	21	2685.699
	22	5707.031

WELLS 1991 SPRING BYPASS EFFICIENCY DATA

	Date	Ratio var.	Upper C.I.	Ratio	Lower C.I
April	14	0.00203	0.80438	0.72583	0.65495
	15	0.00180	0.86984	0.79652	0.72938
	16	0.00071	0.90807	0.86301	0.82020
	17	0.00074	0.92339	0.87741	0.83372
	18	0.00130	0.79140	0.72944	0.67233
	19	0.00113	0.87717	0.81984	0.76626
	20	0.00159	0.93276	0.86441	0.80107
	21	0.00042	0.95133	0.91690	0.88372
	22	0.00047	0.93371	0.89716	0.86203
	23	0.00020	0.95098	0.92739	0.90438
	24	0.00036	0.97018	0.93857	0.90798
	25	0.00013	0.97357	0.95440	0.93560
	26	0.00046	0.97488	0.93908	0.90460
	27	0.00009	0.98279	0.96696	0.95139
	28	0.00016	0.98814	0.96728	0.94685
	29	0.00004	0.99074	0.98046	0.97029
	30	0.00003	0.99479	0.98525	0.97581
May	1	0.00070	0.95234	0.90767	0.86509
	2	0.00279	0.92765	0.83553	0.75256
	3	0.00062	0.94436	0.90254	0.86258
	4	0.00081	0.92493	0.87687	0.83131
	5	0.00039	0.95095	0.91801	0.88621
	6	0.00011	0.97120	0.95345	0.93601
	7	0.00042	0.97974	0.94552	0.91249
	8	0.00008	0.99492	0.98018	0.96567
	9	0.00006	0.99671	0.98436	0.97217
	10	0.00010	0.98099	0.96467	0.94862
	11	0.00007	0.98438	0.97102	0.95785
	12	0.00002	0.99698	0.99031	0.98368
	13	0.00003	0.98515	0.97545	0.96585
	14	0.00002	0.99239	0.98494	0.97754
	15	0.00007	0.98984	0.97557	0.96150
	16	0.00061	0.98659	0.94506	0.90527
	17	0.00010	0.98967	0.97317	0.95694
	18	0.00015	0.97700	0.95636	0.93616
	19	0.00022	0.94790	0.92291	0.89857
	20	0.00014	0.97883	0.95915	0.93986
	21	0.00002	0.99464	0.98797	0.98134
	22	0.00007	0.99437	0.98084	0.96750
	23	0.00024	0.98269	0.95711	0.93220
	24	0.00014	0.98139	0.96172	0.94244

WELLS 1991 SUMMER BYPASS EFFICIENCY DATA

	Date	Ratio var.	Upper C.I.	Ratio	Lower C.I
July	8	0.00003	0.97946	0.96978	0.96019
	9	0.00001	0.99139	0.98661	0.98185
	10	0.00003	0.99546	0.98601	0.97664
	11	0.00004	0.99712	0.98672	0.97643
	12	0.00002	0.98924	0.98142	0.97365
	13	0.00005	0.98289	0.97115	0.95955
	14	0.00004	0.98564	0.97583	0.96613
	15	0.00005	0.97692	0.96545	0.95412
	16	0.00002	0.99120	0.98327	0.97541
	17	0.00002	0.98449	0.97640	0.96837
	18	0.00006	0.98088	0.96799	0.95527
	19	0.00003	0.98513	0.97631	0.96757
	20	0.00004	0.97202	0.96126	0.95063
	21	0.00001	0.99304	0.98786	0.98270
	22	0.00008	0.96980	0.95524	0.94090

WELLS 1991 TURBINE HORIZONTAL DISTRIBUTION
(MEAN #/HR)

	SPRING			SUMMER	
Location	DAY	NIGHT	Location	DAY	NIGHT
1a	1.934	1.907	1a	1.345	0.201
1b	0.182	0.291	1b	1.872	0.096
1c	0.169	0.342	1c	1.782	0.838
2a	0.280	0.247	2a	0.499	0.000
2b	0.320	0.536	2b	6.277	2.523
2c	1.238	0.734	2c	4.807	1.326
3a	1.014	1.148	3a	3.609	2.253
3c	0.299	0.318	3c	1.923	1.161
4a	0.000	0.000	4a	0.149	0.103
4b	0.813	0.455	4b	1.269	0.113
5a	0.473	0.655	5a	1.264	0.869
5b	0.440	0.261	5b	0.155	0.216
5c	0.447	0.390	5c	0.274	0.463
6a	0.514	1.105	6b	1.694	2.345
6b	0.209	0.511	6c	3.478	3.296
6c	1.595	2.245	7a	3.741	3.150
7a	1.523	1.829	7c	0.224	0.000
7b	0.000	0.231	8a	0.124	0.000
7c	0.065	0.154	8b	0.971	1.012
8a	0.459	0.777	9a	4.541	3.824
8b	1.017	0.828	9c	0.000	0.000
9a	0.866	0.939	10a	1.440	1.304
9b	0.254	0.349	10b	2.682	2.055
9c	0.256	0.094	10c	4.011	3.444
10a	0.251	0.055			
10b	0.684	1.174			
10c	3.418	2.389			

WELLS 1991 BYPASS SLOT HORIZONTAL DISTRIBUTION
SPRING MEAN #/HR

	DAY	NIGHT
S2	78.060	82.378
S4	72.770	83.633
S6	96.229	98.597
S8	43.923	61.202
S10	25.920	34.310

WELLS 1991 BYPASS SLOT HORIZONTAL DISTRIBUTION
SUMMER MEAN #/HR

	DAY	NIGHT
S2	323.379	147.010
S4	476.401	239.145
S6	629.826	399.484
S8	280.349	200.520
S10	74.190	92.863

WELLS 1991 TURBINE DIEL DISTRIBUTIONS

SPRING		SUMMER	
START HOUR	MEAN #/HR	START HOUR	MEAN #/HR
0	0.778	0	1.088
1	0.872	1	0.608
2	0.803	2	0.621
3	0.751	3	0.731
4	0.778	4	0.721
5	0.872	5	1.836
6	0.783	6	1.273
7	0.791	7	1.213
8	1.312	8	1.916
9	0.615	9	2.867
10	1.144	10	3.148
11	0.874	11	2.511
12	0.735	12	2.078
13	0.468	13	2.223
14	0.551	14	1.907
15	0.289	15	1.118
16	0.531	16	2.016
17	0.720	17	2.255
18	0.523	18	1.485
19	0.439	19	1.793
20	0.499	20	1.221
21	0.802	21	1.831
22	0.583	22	1.938
23	0.501	23	1.431

WELLS 1991 BYPASS SLOT DIEL DISTRIBUTIONS

SPRING		SUMMER	
START HOUR	MEAN #/HR	START HOUR	MEAN #/HR
0	72.491	0	195.886
1	75.464	1	138.488
2	72.331	2	131.858
3	70.673	3	155.130
4	66.212	4	137.008
5	75.174	5	126.638
6	80.810	6	208.107
7	86.230	7	257.748
8	77.154	8	344.910
9	76.053	9	415.331
10	78.254	10	452.996
11	67.963	11	399.052
12	64.477	12	410.658
13	50.684	13	417.138
14	55.261	14	402.341
15	49.355	15	348.597
16	51.488	16	415.261
17	51.464	17	351.731
18	47.346	18	303.110
19	52.525	19	253.189
20	59.464	20	318.353
21	59.235	21	350.519
22	61.024	22	320.263
23	69.715	23	273.664

Wells 1991 daily bypass slot passage.
(Total Weighted Fish)

Bypass Unit Date	S2	S4	S6	S8	S10
April - 14	2479	1273	924	708	1506
15	729	848	689	1273	299
16	1054	590	683	458	301
17	1210	691	937	441	155
18	848	926	1713	475	225
19	763	759	527	530	194
20	742	483	683	498	111
21	990	838	956	774	215
22	645	827	1124	717	346
23	1345	1281	1204	829	282
24	1206	525	612	525	413
25	1216	1223	1173	520	271
26	1561	1471	1351	874	339
27	1171	1678	1543	816	299
28	1176	1804	1354	603	248
29	822	1501	3192	840	238
30	1133	2334	5522	1630	214
May - 1	111	545	2623	336	172
2	265	186	312	168	53
3	302	389	847	568	103
4	561	608	1107	295	359
5	819	746	842	494	298
6	1339	1393	2645	959	485
7	965	721	1309	450	164
8	1684	1679	2457	1051	521
9	1448	2120	2001	2180	1329
10	3258	3478	2002	1263	648
11	1591	4840	4856	1383	1066
12	1387	6064	6989	1760	1659
13	3143	5544	7037	2948	1758
14	2669	4418	6006	3007	2072
15	3220	3344	5394	2449	2055
16	4846	3441	4344	4120	2699
17	4400	3906	2740	2237	1601
18	4001	2625	1095	509	716
19	1631	811	1159	696	509
20	2983	769	998	871	489
21	5018	1583	3979	2098	529
22	3760	1554	4432	2351	602
23	3097	1436	2149	570	596
24	4558	1332	1539	1091	871

Wells 1991 daily turbine passage.
(Total Weighted Fish)
(-0- Not Sampled)

Turbine loc.	1A	1B	1C	2A	2B	2C	3A	3B	3C
Date									
April - 14	236	41	34	25	19	26	106	-0-	0
15	131	15	75	17	0	54	124	-0-	12
16	34	13	22	0	0	18	76	-0-	0
17	127	40	19	0	24	73	90	-0-	13
18	108	0	0	0	49	53	81	-0-	33
19	115	0	0	16	48	141	62	-0-	0
20	35	0	0	0	0	51	35	-0-	0
21	79	20	0	0	42	35	0	-0-	39
22	19	0	13	0	0	0	22	-0-	63
23	67	0	0	17	0	49	0	-0-	0
24	41	0	0	0	20	0	0	-0-	0
25	22	0	0	0	0	0	0	-0-	0
26	0	0	0	13	0	17	17	-0-	0
27	15	0	0	0	0	0	0	-0-	0
28	42	17	0	0	0	0	22	-0-	0
29	26	23	19	0	0	0	0	-0-	0
30	41	0	0	0	0	0	32	-0-	0
May - 1	47	0	0	0	0	16	15	-0-	0
2	61	0	0	0	0	0	33	-0-	0
3	79	0	0	0	15	0	0	-0-	0
4	94	0	0	0	13	80	30	-0-	0
5	55	0	0	0	0	0	0	-0-	31
6	60	0	0	0	0	19	18	-0-	0
7	13	0	0	0	0	0	0	-0-	0
8	0	0	0	0	0	20	0	-0-	0
9	0	18	0	0	0	0	0	-0-	0
10	29	0	0	0	0	102	32	-0-	33
11	53	0	18	0	11	0	66	-0-	31
12	0	0	0	0	15	0	49	-0-	0
13	53	0	0	47	0	19	14	-0-	0
14	26	0	0	0	6	8	0	-0-	0
15	12	0	0	0	24	50	0	-0-	21
16	0	0	0	0	0	45	32	-0-	12
17	15	0	0	0	0	0	40	-0-	0
18	24	0	19	18	0	58	0	-0-	0
19	42	0	14	53	65	33	36	-0-	13
20	13	16	0	18	13	17	0	-0-	0
21	36	0	0	16	0	19	16	-0-	0
22	0	0	0	0	30	0	0	-0-	0
23	0	0	0	18	0	0	0	-0-	0
24	14	16	0	0	0	0	0	-0-	0

Wells 1991 daily turbine passage.
(Total Weighted Fish)
(-0- Not Sampled)

Turbine loc. Date	4A	4B	4C	5A	5B	5C	6A	6B	6C
April - 14	0	32	-0-	13	39	65	-0-	18	178
15	0	0	-0-	62	26	137	-0-	0	18
16	0	22	-0-	99	17	0	0	12	62
17	0	49	-0-	0	12	0	20	41	27
18	0	62	-0-	66	99	0	40	0	77
19	0	79	-0-	0	25	15	0	53	62
20	0	0	-0-	26	37	21	0	20	49
21	0	16	-0-	0	0	0	0	0	50
22	0	0	-0-	16	43	15	12	0	48
23	0	0	-0-	45	0	0	47	36	64
24	0	38	-0-	0	0	18	0	12	37
25	0	21	-0-	24	0	0	0	0	61
26	0	24	-0-	24	0	0	0	0	36
27	0	0	-0-	0	0	0	15	25	12
28	0	38	-0-	21	11	0	0	0	0
29	0	0	-0-	0	0	0	0	0	36
30	0	0	-0-	0	0	0	28	0	12
May - 1	0	0	-0-	0	18	0	116	0	12
2	0	16	-0-	0	0	0	13	0	12
3	0	17	-0-	18	0	0	-0-	0	36
4	0	54	-0-	21	0	0	-0-	0	25
5	0	21	-0-	0	0	48	-0-	29	11
6	0	21	-0-	0	18	0	-0-	0	40
7	0	0	-0-	0	0	0	-0-	0	0
8	0	0	-0-	0	0	0	-0-	0	17
9	0	0	-0-	0	0	0	-0-	0	41
10	0	16	-0-	33	0	35	-0-	0	24
11	0	0	-0-	17	0	0	-0-	0	48
12	0	0	-0-	0	0	33	-0-	0	23
13	0	15	-0-	0	0	0	-0-	23	90
14	0	20	-0-	0	0	0	-0-	0	26
15	0	24	-0-	0	0	0	-0-	0	120
16	0	0	-0-	0	0	0	-0-	0	90
17	0	17	-0-	0	0	0	-0-	13	103
18	0	0	-0-	0	0	0	-0-	0	53
19	0	0	-0-	0	13	0	-0-	13	50
20	0	18	-0-	17	0	0	-0-	0	12
21	0	0	-0-	0	0	0	-0-	0	0
22	0	0	-0-	17	0	26	-0-	18	0
23	0	32	-0-	18	0	0	-0-	0	0
24	0	0	-0-	0	0	0	-0-	12	0

Wells 1991 daily turbine passage.
(Total Weighted Fish)
(-0- Not Sampled)

Turbine loc. Date	7A	7B	7C	8A	8B	8C	9A	9B	9C
April - 14	48	-0-	0	54	34	-0-	100	-0-	0
15	68	-0-	0	44	66	-0-	83	-0-	38
16	16	17	29	32	49	-0-	31	17	0
17	31	0	0	0	78	-0-	25	17	0
18	46	0	0	47	61	-0-	0	12	21
19	89	0	0	78	86	-0-	14	23	0
20	15	0	0	35	103	-0-	0	0	26
21	15	0	0	0	42	-0-	14	0	0
22	30	0	0	65	62	-0-	19	29	0
23	14	0	0	30	52	-0-	0	0	0
24	60	0	15	12	20	-0-	0	0	0
25	30	0	0	12	38	-0-	25	0	0
26	46	0	0	0	27	-0-	0	0	59
27	0	0	0	0	22	-0-	52	15	24
28	17	20	0	0	15	-0-	13	0	0
29	0	0	0	0	19	-0-	0	0	0
30	26	0	0	0	0	-0-	23	0	0
May - 1	14	0	0	0	0	-0-	0	0	0
2	0	0	0	18	30	-0-	13	0	0
3	0	-0-	0	0	0	-0-	0	-0-	0
4	13	-0-	0	0	13	-0-	0	-0-	0
5	46	-0-	0	32	0	-0-	0	-0-	0
6	14	-0-	0	0	0	-0-	0	-0-	0
7	0	-0-	0	0	0	-0-	28	-0-	0
8	0	-0-	0	0	0	-0-	22	-0-	0
9	49	-0-	0	0	0	-0-	16	-0-	0
10	30	-0-	0	0	0	-0-	0	-0-	0
11	32	-0-	0	0	0	-0-	0	-0-	0
12	0	-0-	0	0	0	-0-	33	-0-	0
13	63	-0-	0	0	0	-0-	37	-0-	17
14	14	-0-	0	12	0	-0-	12	-0-	0
15	85	-0-	21	0	0	-0-	12	-0-	0
16	419	-0-	16	0	38	-0-	135	-0-	0
17	100	-0-	0	25	12	-0-	25	-0-	0
18	0	-0-	0	0	0	-0-	0	-0-	0
19	31	-0-	0	13	0	-0-	13	-0-	0
20	15	-0-	0	0	13	-0-	13	-0-	0
21	27	-0-	0	27	0	-0-	0	-0-	0
22	0	-0-	0	0	12	-0-	34	-0-	0
23	96	-0-	0	42	0	-0-	44	-0-	0
24	14	-0-	19	0	27	-0-	42	-0-	0

Wells 1991 daily turbine passage
(Total Weighted Fish)
(-0- Not Sampled)

Turbine loc. Date	10A	10B	10C
April - 14	13	86	271
15	0	11	42
16	-0-	-0-	-0-
17	-0-	-0-	-0-
18	-0-	-0-	-0-
19	-0-	-0-	-0-
20	-0-	-0-	-0-
21	-0-	-0-	-0-
22	-0-	-0-	-0-
23	-0-	-0-	-0-
24	-0-	-0-	-0-
25	-0-	-0-	-0-
26	-0-	-0-	-0-
27	-0-	-0-	-0-
28	-0-	-0-	-0-
29	-0-	-0-	-0-
30	-0-	-0-	-0-
May - 1	-0-	-0-	-0-
2	-0-	-0-	-0-
3	0	0	0
4	0	0	39
5	0	63	99
6	0	0	208
7	0	0	209
8	0	0	48
9	0	0	21
10	0	15	21
11	0	34	86
12	0	19	44
13	0	21	80
14	0	38	0
15	0	58	39
16	0	75	0
17	13	0	16
18	0	12	0
19	0	0	107
20	0	0	186
21	0	18	0
22	0	31	33
23	53	0	50
24	12	0	25

Wells 1991 daily bypass slot passage
(Total Weighted Fish)

Bypass Unit Date	S2	S4	S6	S8	S10
July - 8	4350	4984	17558	3527	1274
9	8750	10862	14274	5912	1674
10	3798	3984	4551	4605	1847
11	5512	9039	17749	10534	1774
12	12344	7705	14139	6692	1941
13	5828	9198	9296	5710	2628
14	1069	4512	5776	4212	1726
15	6804	8343	7663	3435	874
16	5273	12737	15632	9607	658
17	7312	10110	11300	4580	1795
18	6861	9431	10472	2995	1079
19	9659	9118	7689	3235	3303
20	3041	7919	9852	4776	3449
21	1160	10186	14145	6971	2164
22	7906	17071	29633	11558	3233

Wells 1991 daily turbine passage
(Total Weighted Fish)
(-0- Not Sampled)

Turbine loc. Date	1A	1B	1C	2A	2B	2C	3A	3B	3C
July - 8	0	54	110	38	173	112	54	-0-	65
9	0	0	41	0	83	132	0	-0-	13
10	0	0	0	0	43	0	0	-0-	17
11	0	0	0	0	40	18	0	-0-	0
12	0	0	0	0	69	75	54	-0-	0
13	0	40	33	0	60	24	48	-0-	35
14	20	24	54	0	20	0	58	-0-	42
15	0	13	58	0	141	137	84	-0-	0
16	44	0	0	0	112	66	17	-0-	37
17	0	13	30	0	102	16	80	-0-	39
18	33	48	15	0	103	44	55	-0-	13
19	0	12	0	38	81	68	19	-0-	35
20	56	56	109	0	0	0	53	-0-	88
21	0	16	0	0	0	0	17	-0-	101
22	156	127	41	28	641	498	537	-0-	81

Turbine loc. Date	4A	4B	4C	5A	5B	5C	6A	6B	6C
July - 8	0	16	-0-	39	0	0	-0-	35	0
9	0	0	-0-	68	0	28	-0-	13	-0-
10	0	0	-0-	17	31	0	-0-	0	63
11	0	0	-0-	19	0	0	-0-	0	78
12	0	0	-0-	0	0	0	-0-	25	119
13	0	0	-0-	0	0	34	-0-	25	65
14	0	0	-0-	23	0	0	-0-	0	42
15	0	32	-0-	49	0	0	-0-	57	94
16	19	0	-0-	17	0	0	-0-	102	97
17	0	0	-0-	0	0	0	-0-	91	177
18	27	0	-0-	52	0	0	-0-	39	89
19	0	17	-0-	0	0	0	-0-	73	26
20	0	79	-0-	70	0	0	-0-	54	37
21	0	34	-0-	0	0	0	-0-	53	54
22	0	103	-0-	35	32	55	-0-	99	84

Wells 1991 daily turbine passage
(Total Weighted Fish)
(-0- Not Sampled)

Turbine loc. Date	7A	7B	7C	8A	8B	8C	9A	9B	9C
July - 8	18	-0-	0	0	0	-0-	58	-0-	0
9	62	-0-	0	0	13	-0-	13	-0-	0
10	62	-0-	0	0	0	-0-	17	-0-	0
11	192	-0-	0	0	20	-0-	33	-0-	0
12	109	-0-	0	0	19	-0-	13	-0-	0
13	117	-0-	27	13	0	-0-	172	-0-	0
14	14	-0-	0	0	27	-0-	27	-0-	0
15	92	-0-	0	0	0	-0-	27	-0-	0
16	135	-0-	0	0	39	-0-	70	-0-	0
17	85	-0-	0	0	13	-0-	40	-0-	0
18	89	-0-	0	0	15	-0-	168	-0-	0
19	76	-0-	0	0	26	-0-	81	-0-	0
20	29	-0-	0	0	63	-0-	121	-0-	0
21	0	-0-	0	0	64	-0-	271	-0-	0
22	86	-0-	16	12	47	-0-	471	-0-	0

Turbine loc. Date	10A	10B	10C
July - 8	0	0	18
9	50	49	20
10	0	0	0
11	25	0	123
12	71	190	142
13	13	119	37
14	36	48	0
15	0	29	52
16	18	0	0
17	0	0	28
18	0	24	156
19	0	71	21
20	103	24	144
21	13	236	339
22	164	73	177

APPENDIX E

RELATIVE DETECTABILITY RESULTS

APPENDIX E. Relative Detectability Results

The primary objective of the 1991 evaluation at Wells was to estimate total project bypass efficiency which compared fish passage in bypass flow with passage in turbine flow. These comparisons assumed that the ability to acoustically detect fish at each location was equivalent. To confirm this assumption, we did an analysis of the relative detectability of fish as a function of range from the transducer. The actual distribution of fish ranges was determined from the data collected at Wells during the 1991 summer study.

The relative detectability model was based on three interrelated analyses: detection angle, vertical distribution, and time in the beam. These analyses are summarized in this appendix.

The analysis showed that detectabilities between transducers at bypass slot and turbine intake locations under different environmental conditions were equivalent.

The parameters and conditions used for these analyses were:

1) Ping rate - maximized at 10 pulses/sec in bypass slots and turbine intakes.

2) Transducer beamwidth - maximized at 15° in turbine intakes and 6° in bypass slots.

3) Transducer aiming angle - aimed toward area where most fish expected.

4) Water velocity - Turbine intake velocities were measured by the Columbia River Turbine Discharge Rating Program (Figure E1). Bypass slot velocities are approximated.

Detection angle

An analysis was done to estimate the angle of the acoustic beam within which fish are detected over all transducer ranges under conditions found at Wells during 1991. Accurate relative estimates will be obtained if the angle over which targets are detected is constant for all depths analyzed.

The following equation was used to calculate actual detection angles assuming a redundancy criteria of four successive echoes for a target to be classified as a fish (Appendix A).

$$\theta_A = \sqrt{\theta_T - \left[\frac{4\ V \cos(|\theta_p + \theta_f|)}{2 r_s R}\right]^2}$$

Where: θ_A = actual detection angle over which targets exceeded the threshold four times

θ_T = the half-power beamwidth of the transducer

V = water (fish) velocity

θ_p = transducer aiming angle relative to horizontal

θ_f = angle of fish trajectory relative to horizontal

R = range

r_S = pulse rate of the acoustic system

Detection angles for the bypass slot were calculated using water velocities ranging from 3.0 to 5.0 feet/sec. Detection angles for turbine intake locations were calculated for the same range of velocities, and are equivalent to those found where the turbine was block loaded at approximately 65 MW.

This analysis showed that the actual detection angle for both bypass slot and turbine intake locations were very near the half-power beamwidth, except for ranges near the transducer at the highest measured velocity. The point where the angle of detection is constant at the highest velocity occurred at approximately 15 feet from the transducer in the turbine intakes and 35 feet from the transducer in the bypass slots (Figures E2 and E3).

Vertical Distribution

Vertical distributions of fish in spill and turbine were calculated to confirm that the targets of interest were located where the beam angle is constant and the sample volumes are largest (i.e., widest part of the beam).

Separate vertical distiribution functions were calculated for turbine intakes and bypass slots locations during the summer study 1991. Data for the turbine intake distribution included detections from all in-turbine sampling locations. Data for the bypass slot distribution included detections from all bypass locations for the first seven days of the study. Targets detected within 4 feet from the transducer were not included in this analysis.

Vertical distribution analysis showed over 90% of migrants in turbine intakes and 60% of migrants in bypass slots were found at ranges in the beam where the angle of detection is constant (Figures E4a and b).

Time in the Beam

A third investigation of detectability compared the amount of time targets were observed in the acoustic beam with an expected value calculated using the same model used for the detection angle calculation described above.

The observed time in the beam was estimated using data digitized from the echograms. Data selections were done using the classification described in Appendix A. The time and range of entrance and exit from the acoustic beam were used to determine the average range and the amount of time each target spent in the beam (time exit - time entered). These values were averaged for all singe fish detection over all depths.

The expected time in the beam was calculated using the following equation:

$$T_{exp} = \{(\Pi /4) * 2R \tan(\Phi t/2)\}/V$$

where: R = range of fish

Φ_t = half-power beamwidth

V = water (fish) velocity

For turbine intake and bypass slot data, the mean observed time in the beam was near the midpoint of the mean expected time in the beam (Table E1). Even at higher velocities where the mean expected time was less than 2 seconds, detection was possible because of the high pulse rates used (10 pulses/sec in bypass and turbine intakes).

The results were consistent and verified that detectabilities were equivalent between bypass and turbine intake sampling locations.

Table E1. Observed and expected times (sec) in the acoustic beam for various velocities (fps) in the bypass slots and turbine intakes.

Location	Estimated Velocities	Mean Time in the Beam	
		Observed	Expected
Bypass slot	1-5 fps	2.3	0.3 - 5.8
Turbine intake	1-5 fps	1.5	0.8 - 8.3

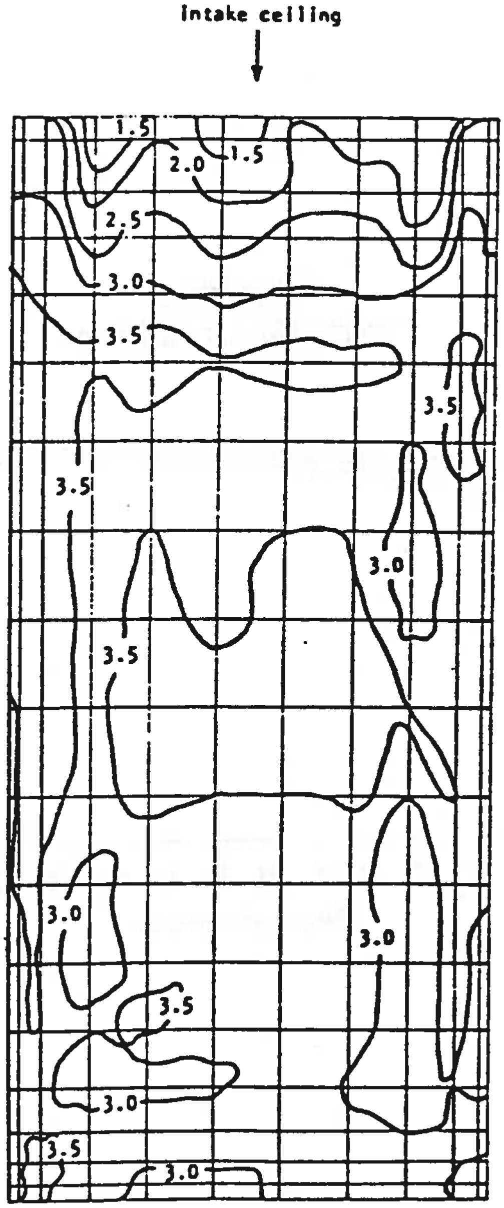


Figure E1. Current velocity profile in fps within Turbine Intake 6A at 67.4 ft gross head and 70% wicket gate opening (DCPUD 1975).

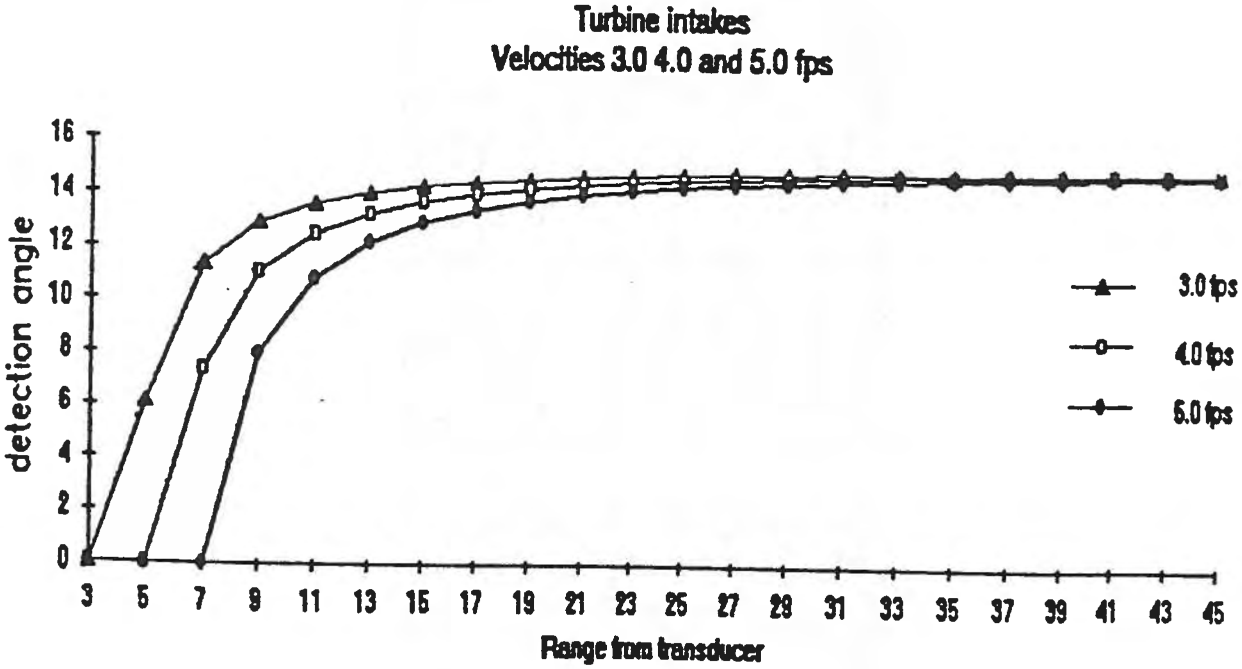


Figure E2. The effective beamwidths over all ranges from the transducer for various velocities for typical turbine intake conditions, Wells Dam 1991.

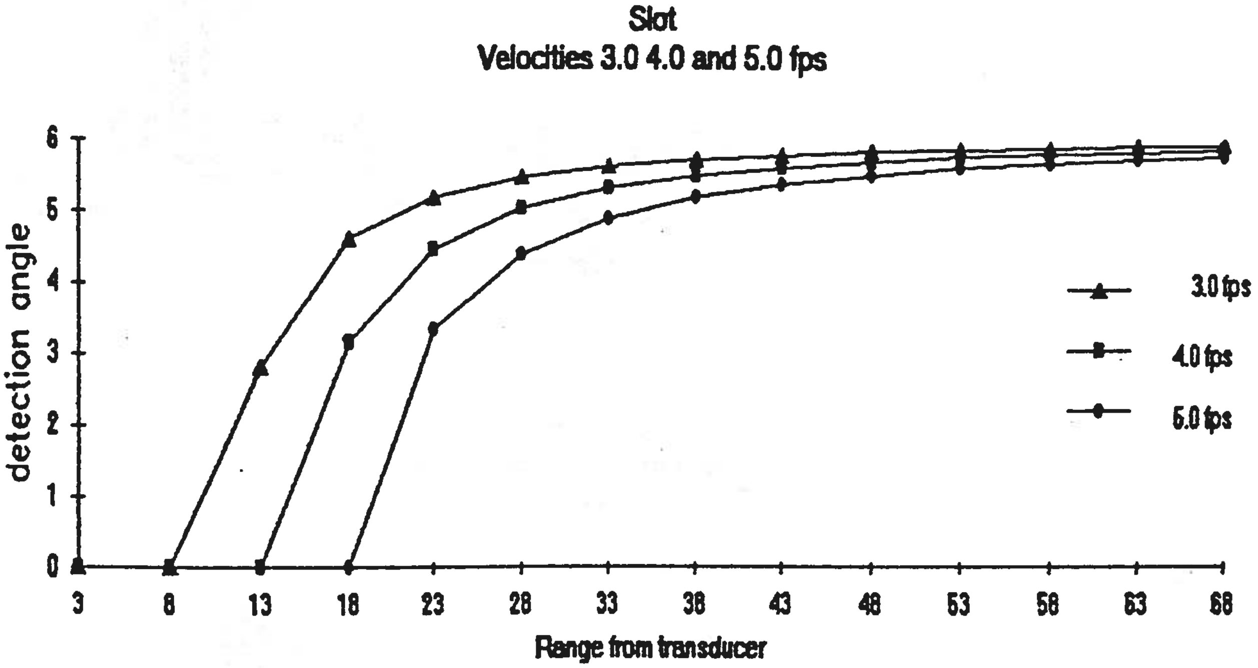
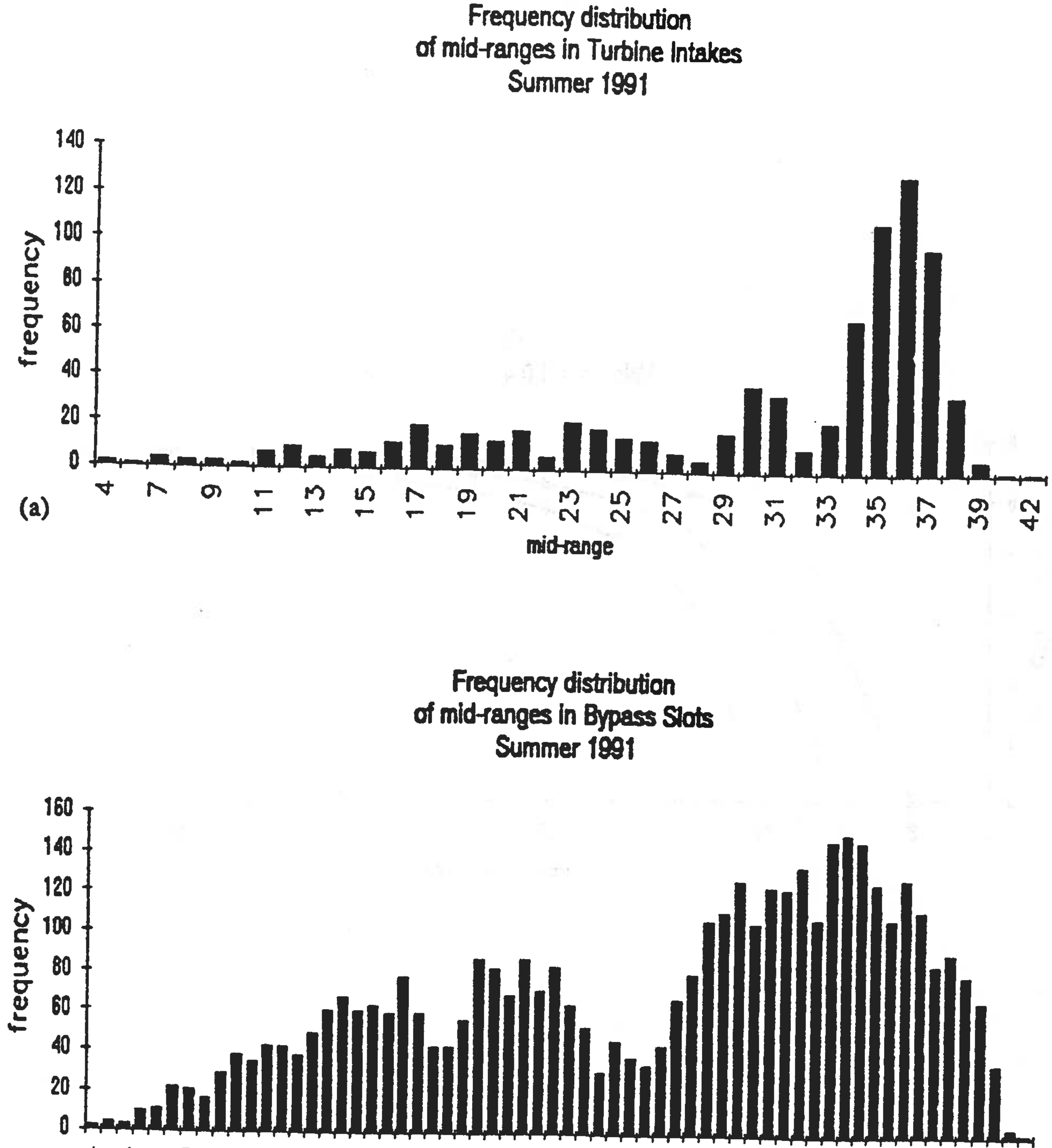


Figure E3. The effective beamwidths over all ranges from the transducer for various velocities for typical bypass slot conditions, Wells Dam 1991.



Frequency distribution of mid-ranges in Turbine Intakes Summer 1991

Frequency distribution of mid-ranges in Bypass Slots Summer 1991

Figure E4. Vertical distribution of migrants for a) turbine intakes and b) bypass slots, Wells 1991.

APPENDIX F

AGENCY COMMENTS

APPENDIX F: Agency Comments

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

Chief Executive Officer/Manager:
ELDON E. LANDIN

Public Utility District No.1 of Douglas County

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

March 10, 1992

Mr. Gary Johnson
BioSonics, Incorporated
3670 Stone Way North
Seattle, Washington 98103

Dear Gary:

At the December 12, 1991 meeting of the Wells Coordinating Committee a copy of the Draft report, Evaluation of the Smolt Bypass System at Wells Dam in 1991 was distributed to the joint fisheries parties for their review. The Wells Committee set a deadline for comments of February 12, 1992. To date I have not received any written comments on the 1991 evaluation. At the March 2, 1992 meeting of the Wells Coordinating Committee the members of the fisheries agencies and tribes assured me that there would not be any comments toward the 1991 Bypass evaluation.

Please proceed to make the final version of this report.

Sincerely,

Rick Klinge

Rick Klinge
Fisheries Biologist

EVALUATION OF THE SMOLT BYPASS SYSTEM

AT

WELLS DAM IN 1992; DRAFT REPORT

APPENDIX - C

Evaluation of the Smolt Bypass System at Wells Dam in 1992

Draft Report

Sponsored by:

Douglas County PUD
1151 North Main
East Wenatchee, WA 98802

Prepared by:

Edward A. Kudera
Colleen M. Sullivan

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

November 30, 1992

EXECUTIVE SUMMARY

In 1992 we used hydroacoustics to evaluate the smolt bypass system at Wells Dam on the Columbia River. The evaluation, sponsored by Douglas County Public Utility District (DCPUD), took place in spring (April 17 to May 26) and summer (June 26 to July 12). The 1992 evaluation was the third of a three-year program to substantiate 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 (dated October 1990). The agreement also included criteria for precision which guided development of the sampling design. The primary objective of the 1992 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.) To form the bypass, 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 past 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 spring and summer evaluations : 1990, 1991, and 1992.

In 1992, 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 24 of 30 turbine intake locations. Transducers (6°) were deployed at 5 of 5 bypass intake locations (S2, S4, S6, S8, and S10). 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 1992 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. In 1992, daily bypass flow averaged 5.8% of total project discharge. Overall, the mid-Columbia River had relatively low flows in spring and summer 1992.

DCPUD sampled for species composition with a fyke net in Turbine Intake 6C during the season. Net data were collected at least weekly from May 28 to August 12. The fyke net effort in 1992 was curtailed to reduce juvenile salmon mortality during the spring out-migration. The data showed that chinook salmon were the predominate salmonid present during the entire fyke net sample period. There were no steelhead or sockeye captured. This was probably due to the late start of the sampling period. Zero age chinook became more prevalent during the summer months. Whitefish were present in significant numbers throughout the sampling period. Net data from the latter part of July and August showed predominately non-target species.

The hydroacoustic run timing data for 1992 showed relatively low passage during early April. Passage rates rise with the arrival of hatchery raised chinook released from Winthrop. Passage rates remain high throughout May and through the beginning of June. Whitefish are strongly present throughout this period as well. Passage rates are high again in late June and early July due to the summer chinook outmigration. Passage rates in late July and August are variable and are primarily due to non-target species.

Horizontal distribution data in 1992 again showed that passage is highest at the west end of the dam. During the spring, passage is highest during the night. In the summer, daytime passage is higher. As in previous years, Unit 10 also shows high passage.

Estimated total project bypass efficiency for the 40-day spring study is presented as three numbers, a 26 day estimate using available data from all five bypass units, a 40 day estimate in which a regression model was used to estimate bypass efficiency at S2 and S4 combined for a period of missing data, and a 40 day estimate using data from bypass units S6, S8, and S10 only. The 26 day estimate for the spring study was 89.0% +/- 0.50% at the 90% confidence level. The 40 day estimate using the regression prediction for the spring study was 92.3% +/- 1.7% at the 90% confidence level. The 40 day estimate using S6, S8, and S10 data only was 86.0% +/- 0.66% at the 90% confidence level. Daily efficiencies for spring ranged from 61% to 96%. Estimated total project bypass efficiency for the summer study was 93.4% +/- 0.74% at the 90% confidence level. Daily efficiencies for summer ranged from 87% to 98%.

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.

- Valerie Stark, Ryan Weddle, Steve Anglea, and Paul Salomone for collecting the hydroacoustic data.

- J. Skalski and D. Ouellette for developing the statistical tools.

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1.0 INTRODUCTION

1.1 Objective

In 1992, we used hydroacoustics to evaluate the smolt bypass system at Wells Dam on the Columbia River. The evaluation, sponsored by Douglas County Public Utility District (DCPUD), took place in spring (April 17 to May 26) and summer (June 26 to July 12). The 1992 evaluation was the third of a three-year program to substantiate 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 (dated October 1990). The agreement also included criteria for precision which guided development of the sampling design. The primary objective of the 1992 evaluation was to estimate **total project bypass efficiency**.

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 past 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. Parties to the settlement agreement and DCPUD agreed to evaluate total bypass efficiency from 1990 to 1992.

Wells Dam was designed as a hydrocombine (Figure 2) to reduce cost, and the overall length of the structures (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.

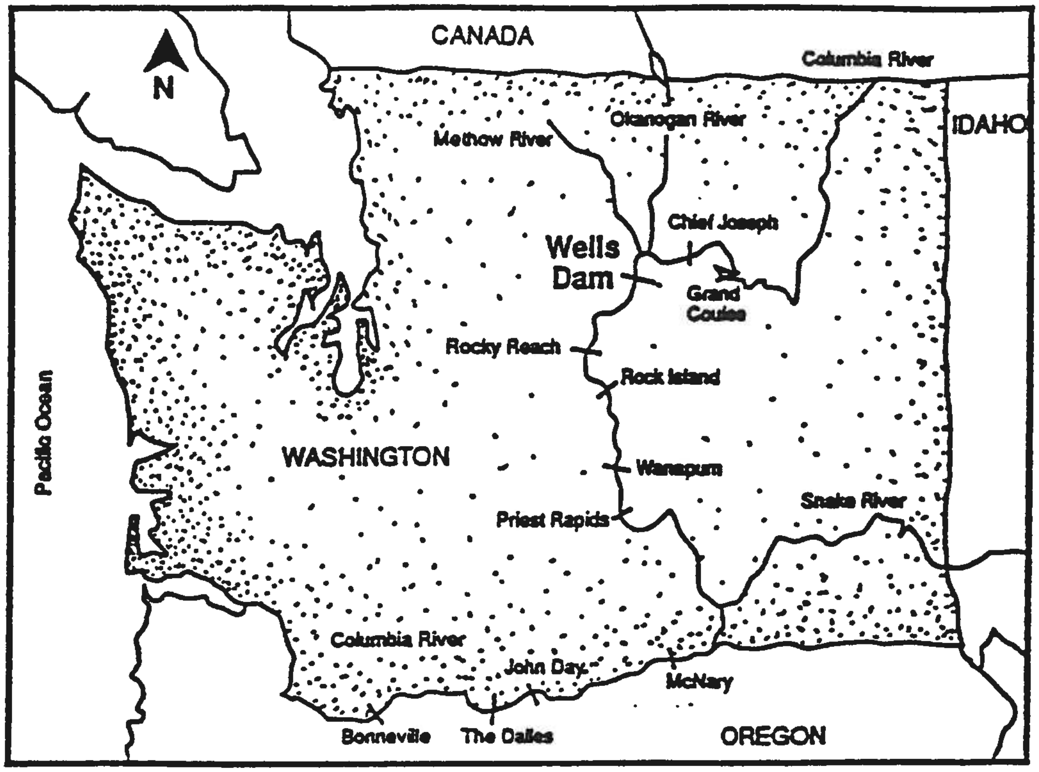

Figure 1. Location of Wells Dam on the Columbia River.

Table 1. Descriptive data for Wells Dam for reservoir elevation 781 ft Mean Sea Level (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)	78 ft
Reservoir Storage Capacity	330,000 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

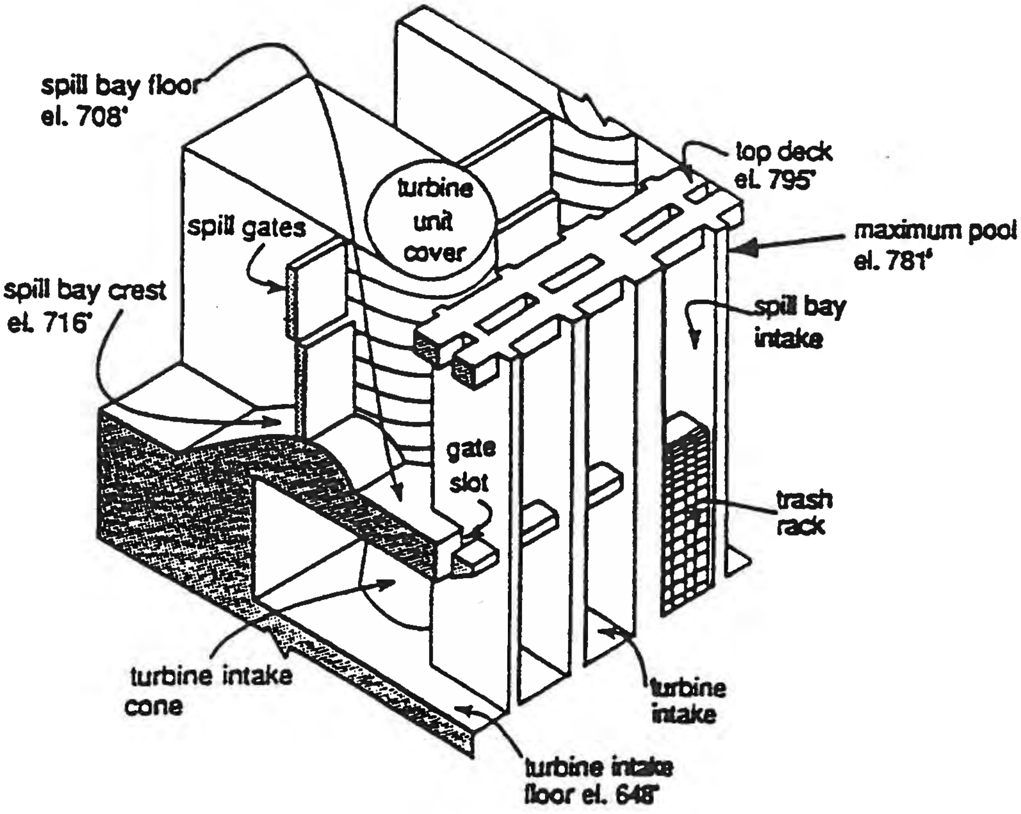

Figure 2. Three-dimensional view of Wells Dam hydrocombine with spill intakes directly above turbine intakes.

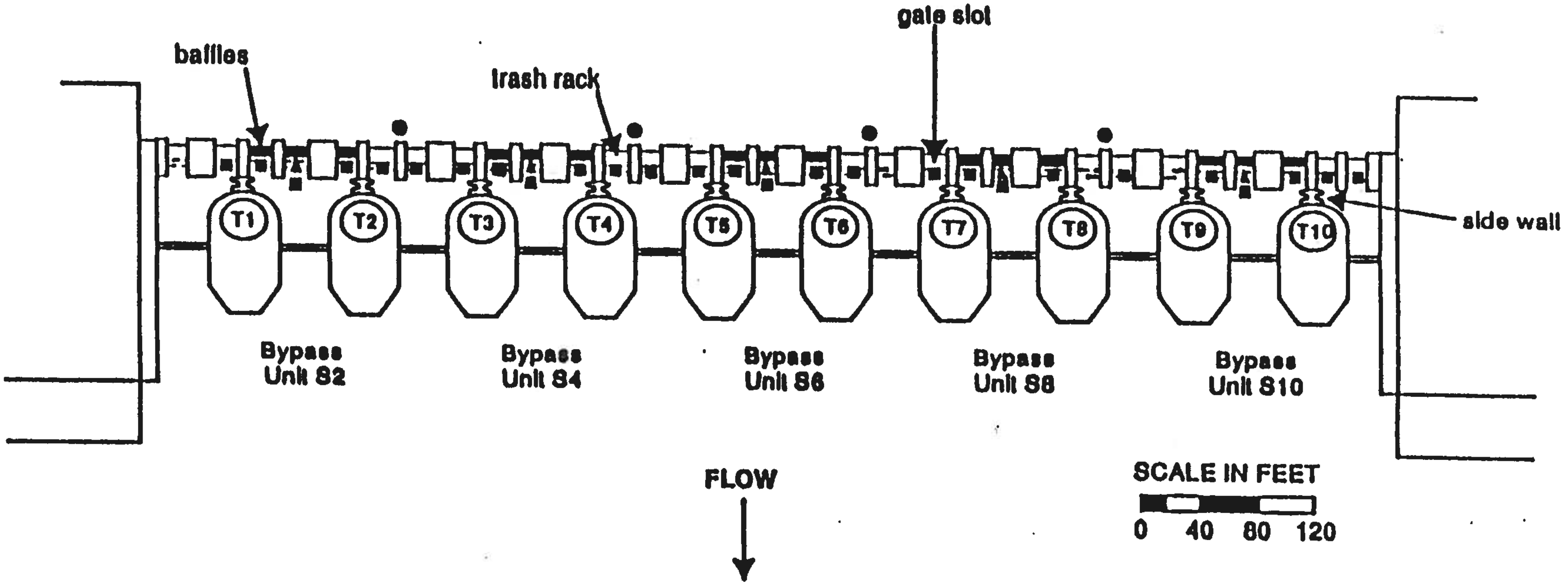

Figure 3. Plan view showing the five bypass units and the locations of forebay transducers (●), turbine intake transducers (■), and bypass slot transducers (▲) at Wells Dam in 1992.

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 past 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 bypass 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 intakes. The 16ft wide vertical opening is located in the center intake of the three bypass unit 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 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 worked best. A detailed description of the development of the bypass system can be found in Johnson, Sullivan and Erho (1992). 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 that began in 1990.

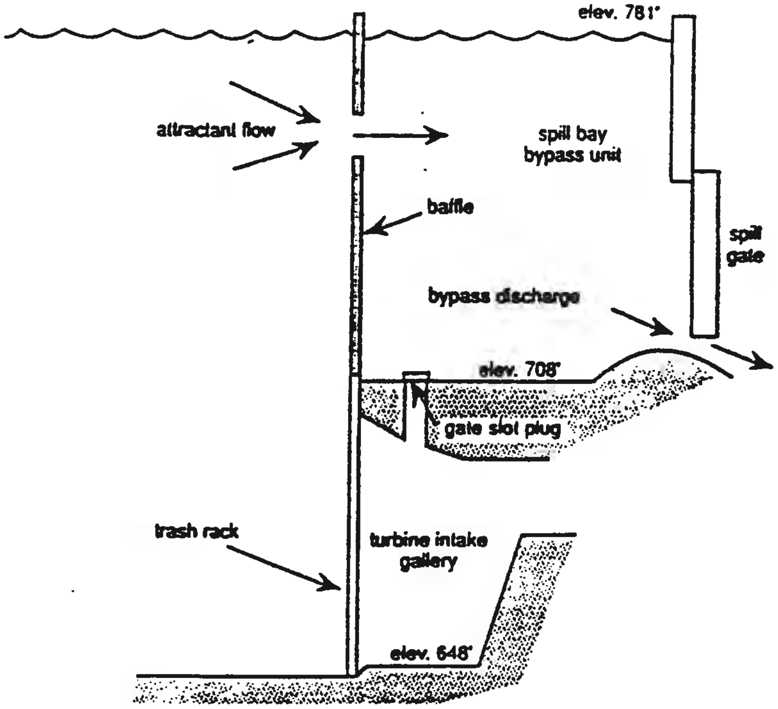

Figure 4. Side view of a bypass unit at Wells Dam showing a horizontal baffle opening and attractant flow.

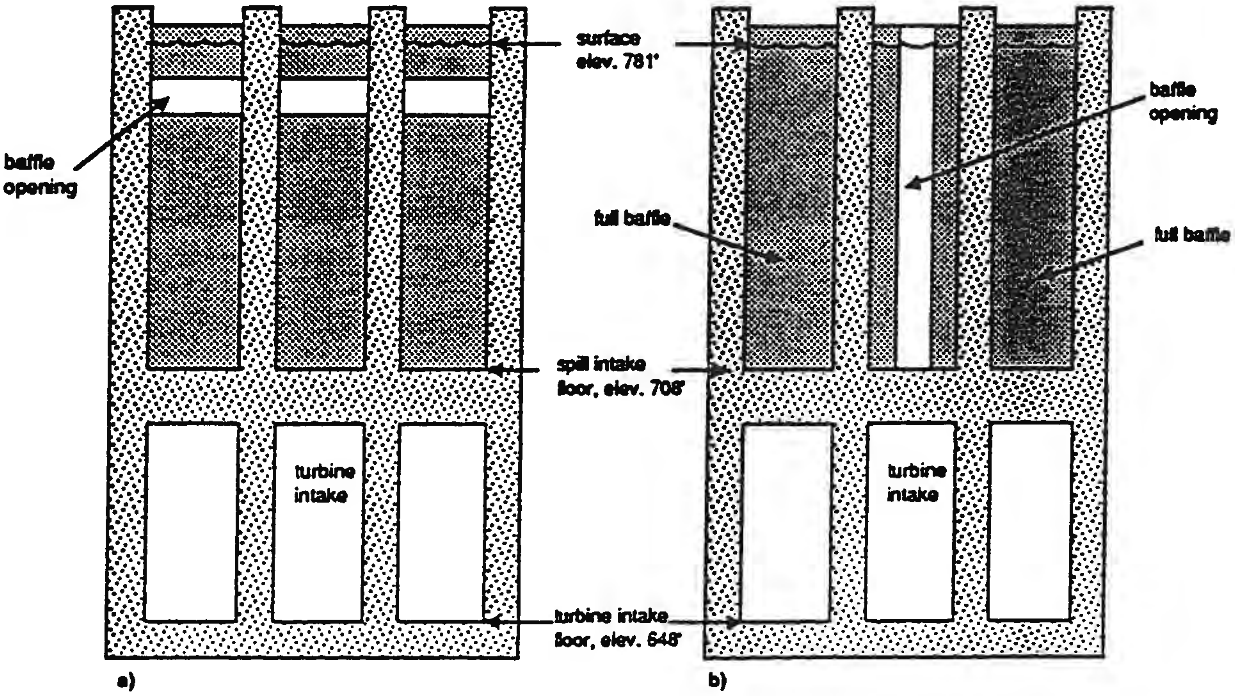

Figure 5. The upstream side (front view) of a bypass unit at Wells Dam with (a) horizontal baffle opening and (b) vertical baffle opening.

2.0 METHODS

2.1 General Hydroacoustics

We used fixed-location hydroacoustic techniques for monitoring smolt passage at Wells Dam in 1992. 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 120 ft deep. They were aimed up about 28° off the face of the dam (Figure 6). The forebay transducers 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 units S2, S4, S6, S8, and S10 (Figures 3 and 6). The bypass transducers were deployed in the gate slot immediately downstream of the vertical baffle opening in the center slot of the designated bypass. These transducers rested at the bottom of the bypass intake and were aimed straight up toward the surface (Figure 6). The range in the bypass was approximately 65 feet so a higher pulse rate of 10 pps was used. The bypass transducers sampled fish passage at the intakes of all five bypasses of the smolt bypass system.

Also for the bypass evaluation, 24 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 10 pps. The turbine intake transducers sampled fish passage into 24 of 30 turbine intakes. At least two of three intakes at each turbine unit were sampled. The sampled intakes were selected randomly.

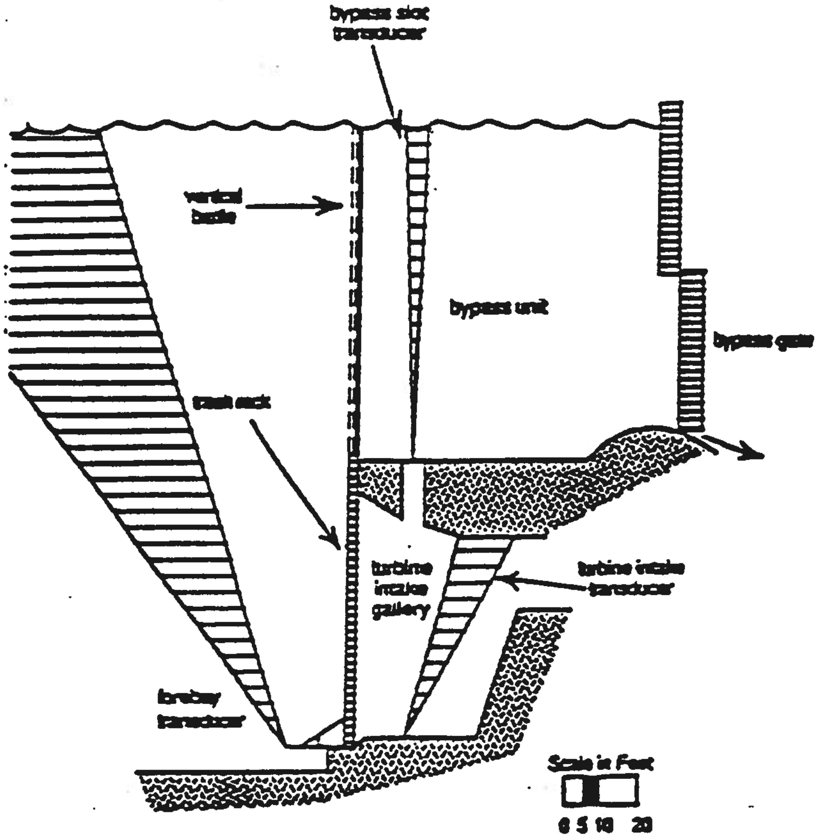

Figure 6. Side view of a bypass unit at Wells Dam showing 1992 transducer sampling areas.

Table 2. Turbine intake sampling locations at Wells Dam in 1992. (NS = Not sampled)

	Dates Sampled			Dates Sampled	
Location	Spring	Summer	Location	Spring	Summer
1A	4/17-4/27	NS	6A	4/17-5/26	6/26-7/12
1B	4/17-4/27	6/26-7/12	6B	4/17-5/26	6/26-7/12
1C	4/17-4/27	6/26-7/12	6C	NS	NS
2A	4/27-5/26	6/26-7/12	7A	4/17-5/26	6/26-7/12
2B	4/27-5/26	6/26-7/12	7B	4/17-5/26	6/26-7/12
2C	4/27-5/26	NS	7C	4/17-5/26	6/26-7/12
3A	4/17-5/26	6/26-7/12	8A	4/17-5/26	6/26-7/12
3B	4/17-5/26	6/26-7/12	8B	NS	NS
3C	4/17-5/26	6/26-7/12	8C	4/17-5/26	6/26-7/12
4A	4/17-5/26	6/26-7/12	9A	NS	NS
4B	4/17-5/26	6/26-7/12	9B	4/17-5/26	6/26-7/12
4C	4/17-5/26	NS	9C	4/17-5/26	6/26-7/12
5A	4/17-5/26	6/26-7/12	10A	4/17-5/26	6/26-7/12
5B	4/17-5/26	6/26-7/12	10B	4/17-5/26	6/26-7/12
5C	4/17-5/26	6/26-7/12	10C	4/17-5/26	6/26-7/12

During the spring evaluation, six turbine units were sampled at all three intakes. Three turbine units were sampled at two of three intakes. Unit 2 was unavailable until April 24. The transducers deployed at Unit 1 were moved to Unit 2 when Unit 1 went out of service on April 27. During the summer bypass evaluation all turbine units were available. 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 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 17 to May 26) and summer (June 26 to July 12) bypass evaluations, we did not sample the forebay. During the bypass evaluations, we used data from the bypass intake 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 2nd to August 17th.

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

Day = 0600 h - 2000 h (Date X)

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

For evaluating the bypass, one hydroacoustic system sampled the bypass intakes and two systems sampled turbine intakes. Each transducer was sampled for a minimum of 10 minutes an hour for 24 hours per day during the spring and summer sampling periods. Four 2.5 minute samples were collected each hour for each transducer location in turbine. Six 2-minute samples were collected each hour at the bypass transducer locations. The hourly sampling sequence was systematic. A new randomized sequence was selected at the start of every study day. Because of changes in dam operations due to low flows our systematic sampling sequence interrogated transducers at bypasses and turbines that were not operating. The methods used to incorporate bypass and turbine operations data are presented in Appendix A. This was the first year during the three year bypass evaluation that all bypasses and monitored turbines were not fully operational during the evaluation period.

2.4 Statistical Methods

We determined fish passage (#/hr) at each location each hour by summing the weighted fish detections observed while the bypass or turbine unit was operating and dividing by total sample time (usually 10 minutes) at an operating location within a given hour when the bypass or turbine unit was operating and then multiplying by 60 minutes per hour (Appendix A). The hourly passage rate estimates were the basic data for monitoring run timing and describing passage distributions in 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. Unlike data collected in the bypass and turbine units, the forebay data were not adjusted for changes in dam operations. These numbers were adjusted for the percentage of non-target species present in the fyke net catch for each week fyke netting occurred. The run timing index from the bypass slot transducers was calculated by averaging passage rates over the five bypass locations.

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

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

where B = total project bypass efficiency

y = fish passage in bypass, and

x = fish passage in turbine.

$$CI\ (B) = B +/- Z * \sqrt{\text{var}\ (B)}$$

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

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 algorithms for estimating total bypass and turbine passage and the confidence interval were determined by Dr. Skalski (Skalski and Ouellette, 1990).

From May 8 through May 21 the chart recorder monitoring Turbine Units 1 and 3 had an incorrect threshold setting effectively removing all but the largest fish. Because Bypass Unit S2 is paired with Turbines 1 and 2 and Bypass Unit S4 is paired with Turbines 3 and 4 we were not able to directly calculate bypass unit efficiencies for S2 and S4 during this two week period. A regression estimate was calculated using the 26 days when data from all five bypass units were available. A significant correlation was found between S2+S4, and S6+S8+S10 ($r = 0.52$). The regression model used the following equation: $Y_i = .782525 + .169542(X_i)$ where Y_i = bypass efficiency at S2+S4 and X_i = bypass efficiency at S6+S8+S10. This equation was used to predict ratios at S2 and S4 from ratios at S6+S8+S10 for the 14 days of missing data.

2.5 Fyke Net Methods

During 1992, DCPUD collected species composition data using fyke nets. Data was collected from inside Turbine Intake 6C usually using the center column of seven nets. On May 28, June 4, and June 11 four nets were used (two top and two bottom), and on June 16 three nets were used (one top and two bottom). Net data were collected at least once per week from May 28th to August 12th. Fyke netting began later in 1992 to reduce juvenile salmon mortality during the spring out-migration. Sampling usually lasted nine hours. Sample hours were from 2200h to 0700h. The entire cross-sectional area of the turbine could be sampled by the array of three nets across by seven nets down. During 1992 only the center column of nets was fished. Each net opening was 7.16 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 1992, project discharge at Wells Dam was lower than the 15-yr average (Table 3). Overall, the mid-Columbia had relatively low flows during spring and summer 1992. Unit 2 was not sampled for the first week of the spring evaluation as it was unavailable. Unit 1 was not sampled from April 27 to May 26 as it was unavailable.

Table 3. Project discharge (kcfs) for Wells Dam, April through August, 1992. Source: G. Donabauer (DCPUD).

	PROJECT DISCHARGE (kcfs)				
	April	May	June	July	August
Min. daily average	33.2	62.4	31.5	38.3	33.0
Max. daily average	153.3	155.2	157.0	147.1	118.0
Avg. hourly discharge	96.7	107.1	117.3	98.7	85.0
15-year average	115.1	133.2	138.1	115.5	97.4
% 15-year average	84	80	85	85	87

Bypass operations for smolt passage at Wells Dam in 1992 were similar to those in previous years. DCPUD operated the bypass daily from April 16 to July 27, 1992. 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 were a total of 25 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. The entire bypass opening is 24 feet wide. Four of the six 4-foot wide plates are removed from the barrier to provide a 16-foot vertical slot in the center of the opening. 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. Top spill was used for bypass flow at bypass units S2 and S10. Flows at these bypass units varied according to forebay pool elevation. During 1992, 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. Summer chinook reared at the Eastbank hatchery were moved to ponds on the Similkameen and Twisp rivers for volitional release. The quantities, dates, and locations of the spring 1992 releases of hatchery-raised salmonids above Wells Dam are given in Table 4. About 2.1 million fish were released in the drainage above Wells Dam in 1992. Wild stocks of sockeye also migrate downstream past 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 River (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 1992. Sources: B. Wallien (USFWS), S. Miller (WDG) and D. Rapplejay (WDF).

SPECIES	RELEASE SITE	MILES FROM WELLS DAM	DATE	NUMBER
spring chinook	Winthrop (yearling)	50	4/15	624,771
summer chinook	Similkameen RM 2	86	5/1-5/19	542,000
(volitional release)	Twisp	38	5/1-5/19	391,650
summer steelhead	Methow RM 10	16	4/20-5/1	395,350
	Okanogan RM 28	43	4/23-4/27	66,645
	Similkameen RM 6	90	4/14-4/22	47,215
	Omak Cr. RM 5	41	4/30	5400
				Total = 2,073,031

The 1992 fyke net catch data from Wells Dam are tabulated in Table 5 and graphed in Figures 7 and 8. Fyke netting during 1992 did not begin until after the spring bypass evaluation period ended. This was done in order to minimize juvenile salmon mortality during peak out-migration. There were no sockeye or steelhead caught in the fyke net during the entire sampling season. The first fyke net sample was collected on May 28. The catch level was relatively high and showed 56% chinook (Figure 8 and Table 5). Whitefish were present in substantial numbers throughout June (Table 5 and Figure 7). Between May 28 and July 1 the proportion of whitefish present in the catch ranged between 22% and 44% (Figure 8). There was a large peak on June 9, with the highest salmonid catch rate of the entire season (Figure 7). Chinook remained the most prevalent species throughout June. Length frequency data showed Chinook - 0's became more prevalent during July. From July 14 to August 4 chinook - 0's composed between 74% and 100% of all salmonids caught. After the middle of July, non-target species became more prevalent. Between July 16 and August 6 the catch consisted of between 50% and 88% non-target species (Table 5 and Figure 8). The last fyke net sample was taken on August 12 and was comprised of only non-target species.

The 1992 fyke net data again show a spring and summer period dominated by salmonid species. Chinook 1's were prevalent during the spring and chinook - 0's became prevalent during the middle of July. Whitefish were present throughout the fyke net sampling period. Chinook salmon constituted the entire salmonid catch. "Other" fish that were caught in the fyke net included bullhead (*Ictalurus spp.*), carp (*Cyprinus spp.*), chiselmouth (*Acrocheilus spp.*), dace (*Chrosomus spp.*) lamprey (*Entosphenus spp.*), peamouth (*Mylocheilus spp.*), sculpin (*Cottus spp.*), shiner (*Notropis spp.*), squawfish (*Ptychocheilus spp.*), sucker (*Catostomus spp.*), and walleye (*Stizostedion spp.*).

Table 5. Number and proportion of chinook (zero age and yearling combined), steelhead, sockeye and non-salmonid species caught in the fyke nets at Wells Dam in spring and summer 1992. Data are expressed in number of fish per hour and proportion. Source: R. Klinge (DCPUD).

	Oncorhyncus Species						Non-Salmonid Species					
	Chinook		Sockeye		Steelhead		Whitefish		Other		All non-salm.	
Date	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.	#/hr	Prop.
May - 28	4.9	0.56	0.0	0.00	0.0	0.00	2.6	0.29	0.33	0.14	2.90	0.43
June - 4	5.4	0.54	0.0	0.00	0.0	0.00	4.2	0.42	0.33	0.03	4.56	0.46
9	29.8	0.75	0.0	0.00	0.0	0.00	8.7	0.22	1.00	0.03	9.67	0.25
11	5.0	0.49	0.0	0.00	0.0	0.00	4.0	0.39	1.22	0.12	5.22	0.51
16	1.9	0.46	0.0	0.00	0.0	0.00	1.3	0.32	4.11	0.22	5.44	0.54
18	4.4	0.47	0.0	0.00	0.0	0.00	4.1	0.44	0.89	0.09	5.00	0.53
23	7.6	0.50	0.0	0.00	0.0	0.00	5.9	0.39	1.67	0.11	7.56	0.50
July - 1	5.0	0.35	0.0	0.00	0.0	0.00	6.1	0.42	3.33	0.23	9.44	0.65
9	9.8	0.79	0.0	0.00	0.0	0.00	1.3	0.11	1.33	0.11	2.67	0.21
16	2.6	0.50	0.0	0.00	0.0	0.00	0.4	0.09	2.11	0.41	2.56	0.50
23	2.0	0.32	0.0	0.00	0.0	0.00	1.3	0.21	2.89	0.46	4.22	0.68
30	1.3	0.32	0.0	0.00	0.0	0.00	0.6	0.14	2.22	0.54	2.78	0.68
August - 6	0.2	0.13	0.0	0.00	0.0	0.00	0.3	0.19	1.22	0.69	1.56	0.88
12	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.89	1.00	0.89	1.00

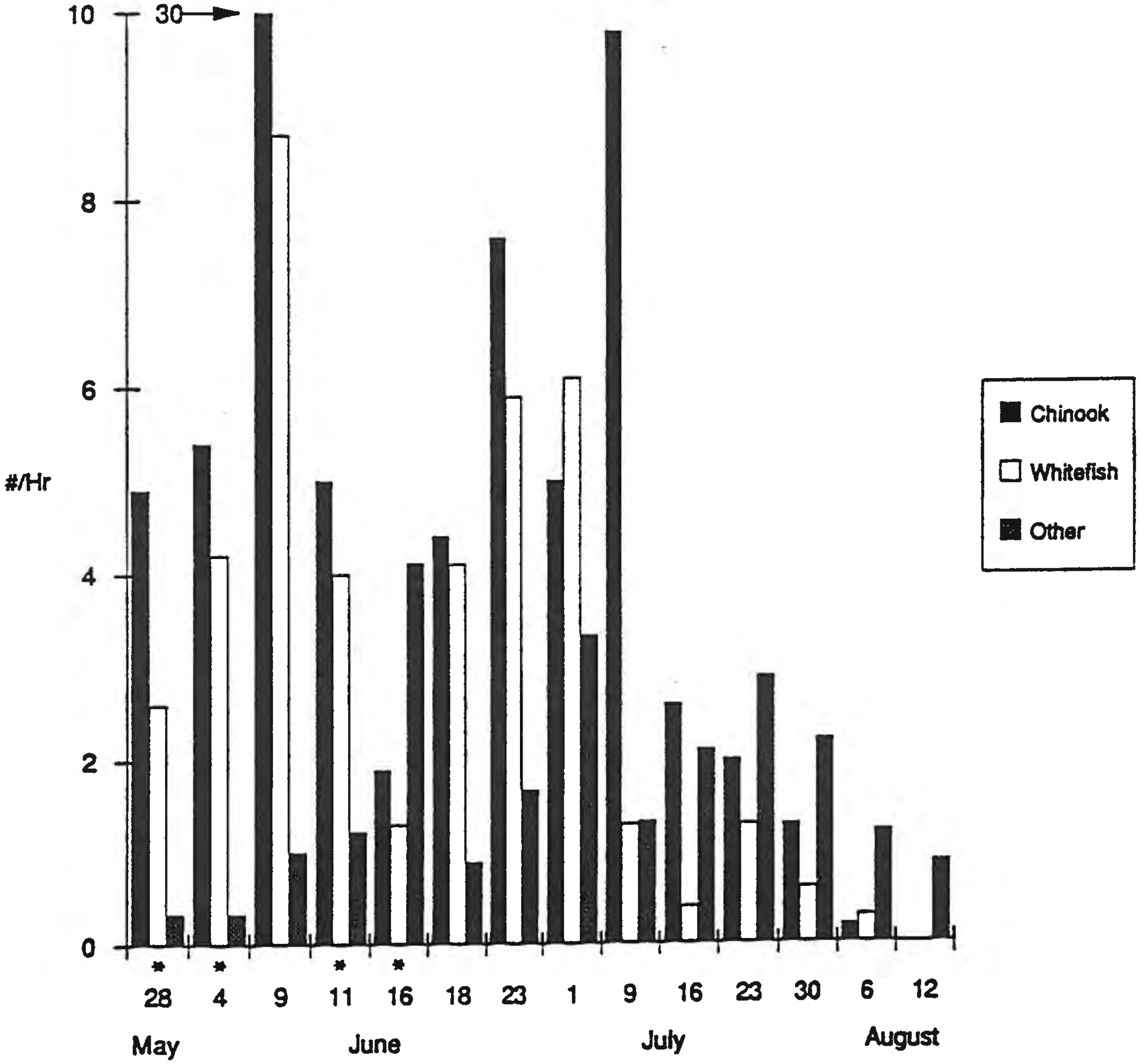

Figure 7. Catch per hour of *Oncorhynchus spp.*(Chinook zero-age and yearling combined), whitefish, and "other" species in the fyke nets at Wells Dam from May 28 to August 12, 1992. (* - Only four nets fished.)

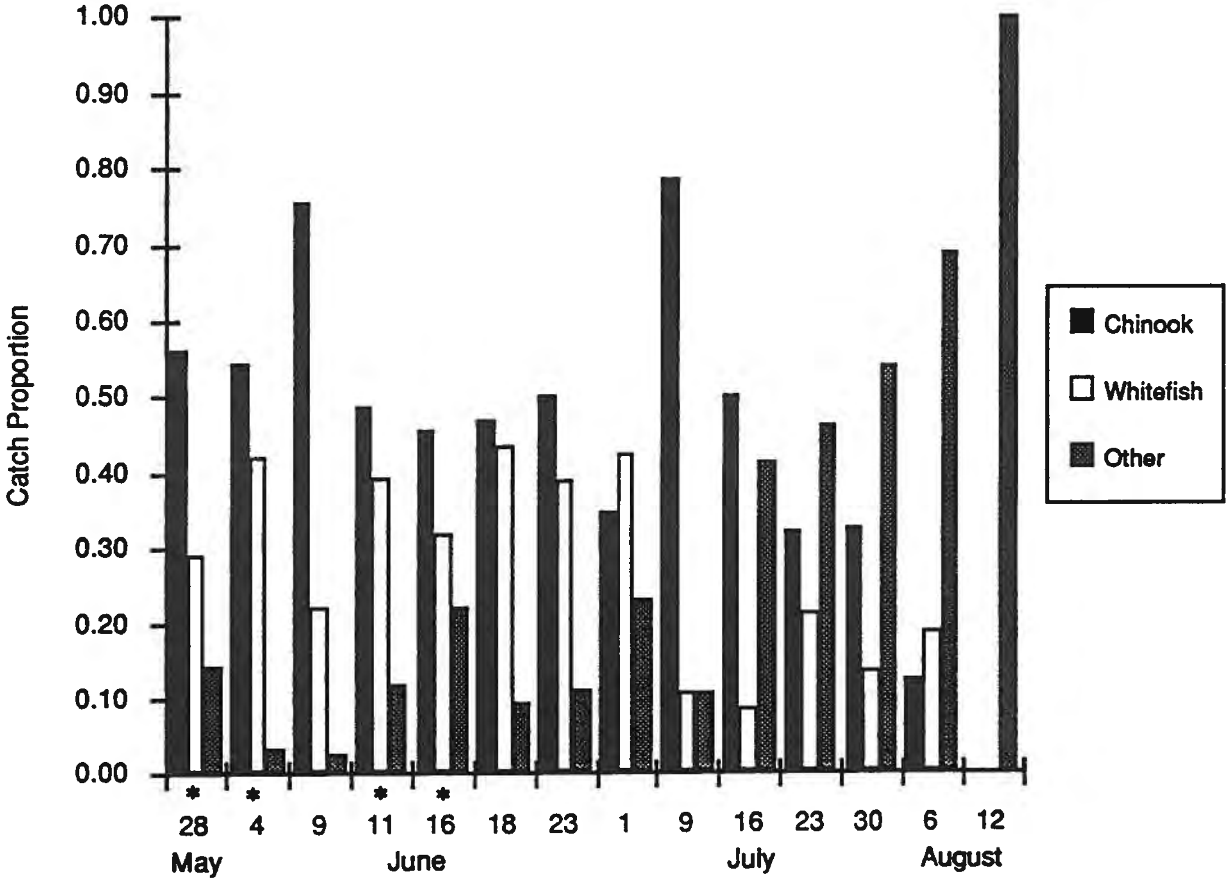

Figure 8. Proportions of the total catch of *Oncorhynchus spp.*, whitefish, and "other" species in the fyke net samples at Turbine Intake 8C at Wells Dam during 1992, May 28 to August 12. (* - Only four nets fished.)

3.1.3 Run Timing

The daily "sub-index" of run timing (mean #/8hr/location) from April 2 to August 17, 1992 is presented in Figures 9, 10, and 11. The run timing index was calculated using forebay data for all days except during the bypass evaluations when the run timing index was calculated using bypass intake data.

Passage rates were relatively low in early April (Figure 9). Passage rates began to rise steadily with the arrival of spring chinook smolts from the Winthrop hatchery. These smolts were released at Winthrop on April 15 (Table 4). No fyke netting was done during the entire spring bypass evaluation. Overall, passage rates during the bypass evaluation were relatively high and variable (Figure 10). The last week of April showed a dramatic rise in passage. After the peak on April 27, passage rates dropped to the lowest rates of the spring season. Lowest passage of the spring evaluation occurred on May 6. Passage rates remained highly variable through the first half of May. Passage rates began to climb steadily on May 18 until reaching the highest passage rate of the spring on May 25. The first fyke net sample of the year was collected on May 28 and the catch consisted of 56% chinook and 29% whitefish (Table 5).

Passage rates remained relatively high during June (Figure 9). The highest forebay passage rate occurred on June 9. The fyke net catch from June 9 consisted of 75% chinook salmon (Table 5). This sample had the highest catch rate of the entire fyke net sampling period. In contrast to last year (Kudera et al. 1991) there were substantial numbers of whitefish present throughout June (Figure 8). The catches between June 9 and June 23 consisted of between 22% and 44% whitefish (Table 5). Passage rates during the summer evaluation were higher than the spring although these passage rates derived from bypass transducers are not adjusted for species composition (Figures 10 and 11). Passage rates began to decline on June 30 to the lowest rate of the summer study which occurred on July 3 . The fyke catch from July 1 was 35% chinook and 65% non-target species (Table 5). Passage rates began to rise again on July 8 until they peak at the highest rate of the summer which occurred on July 9 (Figure 11). The fyke catch from July 9 was 79% chinook. Passage rates dropped towards the end of the summer study period. The fyke catch from July 16 was only 50% chinook (Table 5). Passage rates remained relatively low from the latter part of July through the middle of August (Figure 9).There were increasing numbers of other non-target species during this time. The proportion of chinook caught between July 23 and August 6 ranged between 13% and 32%. Passage rates rose again during the latter part of the study primarily due to non-target species. The last fyke sample was taken on August 12 and consisted of 100% "other" species.

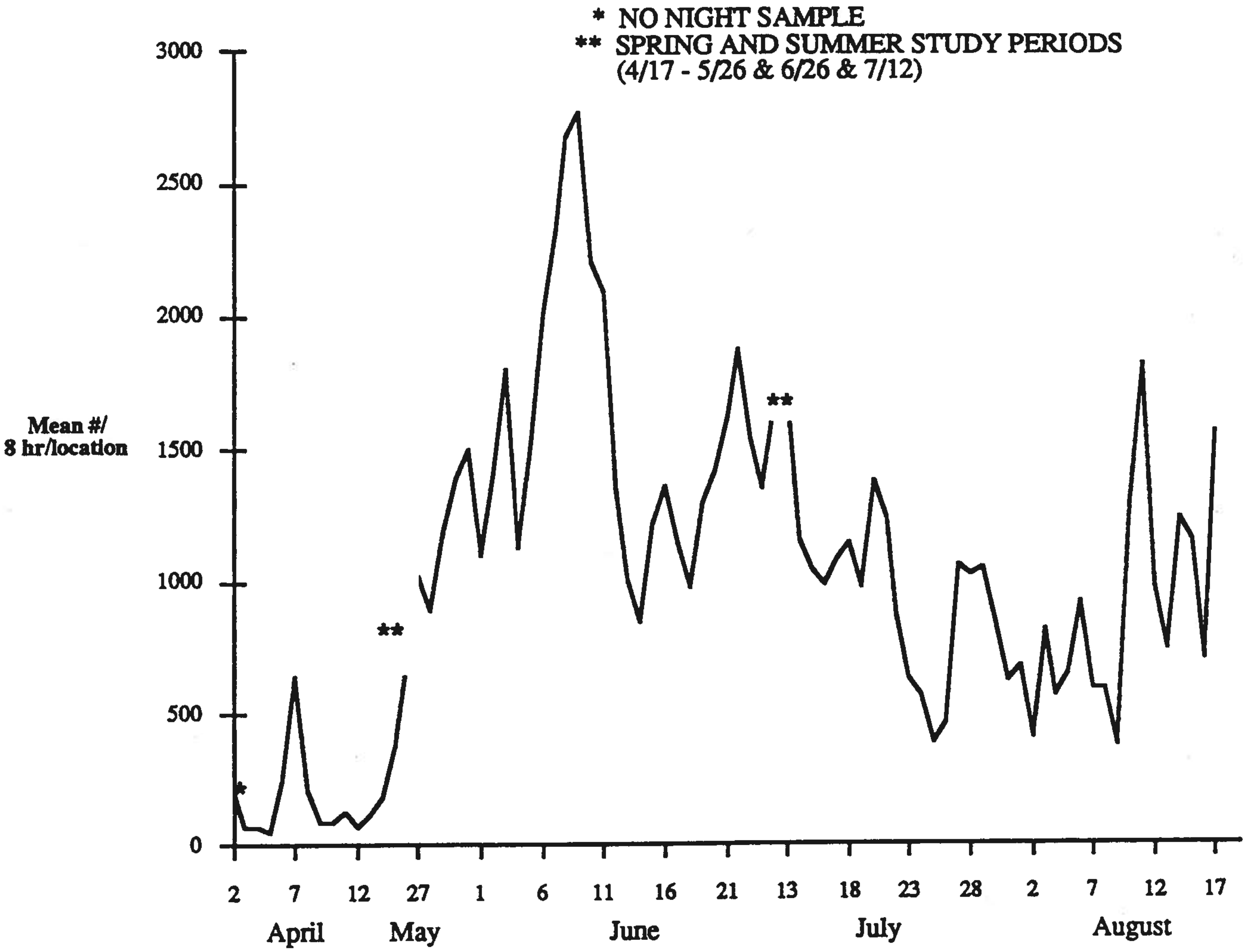

Figure 9. Daily fish passage indices (mean #/8 hr/location) for day (1300 h - 1700 h) and night (2200 h - 0200 h) combined at Wells Dam forebay between April 2 and April 16, May 27 through June 25, and July 13 through August 17, 1992.

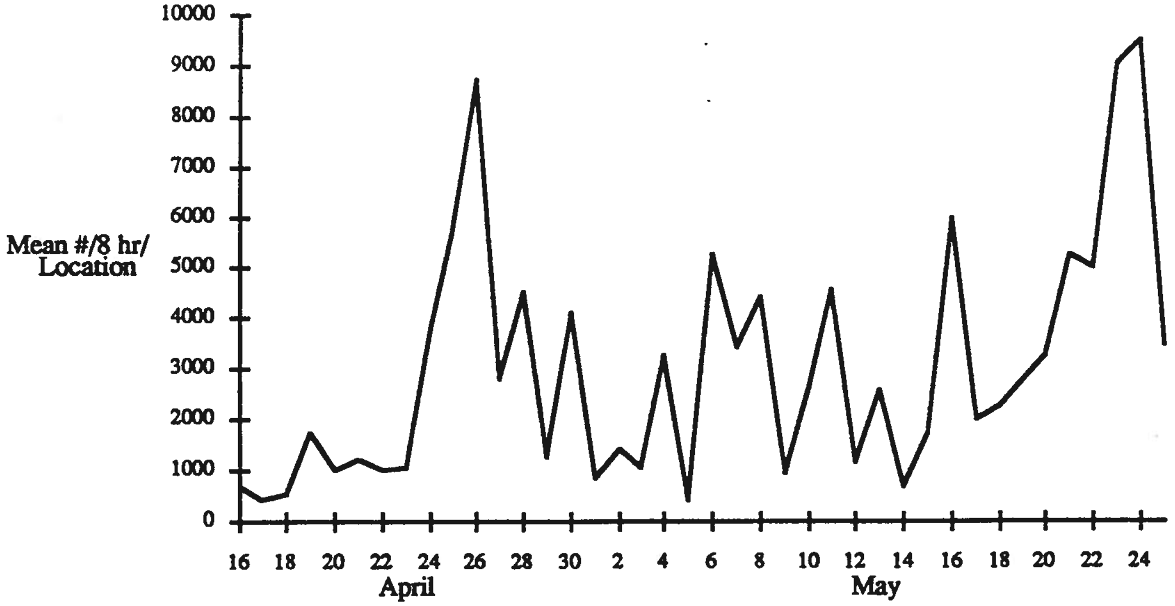

Figure 10. Daily fish passage indices (mean #/8 hr/location) for day (1300 h - 1700 h) and night (2200 h - 0200 h) combined using bypass slot data at Wells Dam between April 17 and May 26, 1992.

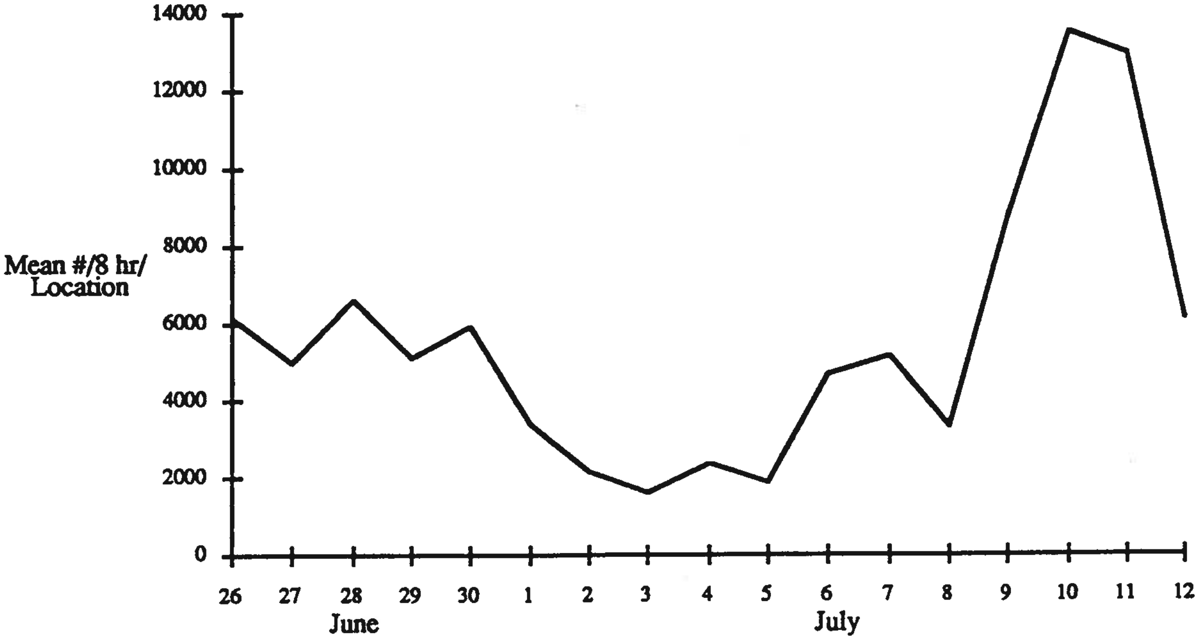

Figure 11. Daily fish passage indices (mean #/8 hr/location) for day (1300 h - 1700 h) and night (2200 h - 0200 h) combined using bypass slot data at Wells Dam between June 26 and July 12, 1992.

3.2 Estimated Total Project Bypass Efficiency

Estimated total project bypass efficiency in spring for 1992 is presented as three separate estimates due to missing data at some turbine locations. The three estimates are derived from (1) a 26 day estimate using data available from all five bypass units, (2) a 40 day estimate for all five bypasses in which a regression model was used to predict the efficiency at S2 and S4 for the period of missing data, and (3) a 40 day estimate of bypass efficiency using only units S6, S8, and S10 . First, the 26 day estimate for all five bypass units combined was 89.0% +/- 0.50% at the 90% confidence level. For the 26 days of complete data Bypass Units S2 and S4 have the highest composite bypass efficiencies (Appendix D pg. 4). The 26 day composite ratio for S2 and S4 combined was 94%. The 26 day composite ratio for S6, S8, and S10 combined was 84%. The daily composite ratios for all five bypass units combined over the 26 days are higher than those of S6, S8, and S10 only (Figure 16). Second, the 40 day estimate using the regression prediction to adjust for the missing S2 and S4 data was 92.3% +/- 1.7% at the 90% confidence level. The overall predicted bypass efficiency for S2 and S4 combined for the entire 40 day period is 92%. Third, the 40 day estimate using S6, S8, and S10 only was 86.0% +/- 0.66%. Daily bypass ratios for spring are given in Figure 12. Daily bypass efficiencies ranged from 61% to 96%. The horizontal distribution of the bypass unit ratios during the spring show highest efficiencies occurred at the west end of the dam (Figure 14). The lowest efficiency occurred at Bypass Unit S8. As in 1990 and 1991, bypass efficiencies were generally higher during the latter part of the spring evaluation.

Estimated total project bypass efficiency in summer 1992 was 93.4% +/- 0.74% at the 90% confidence level. Daily bypass ratios for the summer evaluation are given in Figure 13. Daily bypass efficiencies ranged from 87% to 98%. Bypass efficiencies were higher during the summer than in the spring. As in the spring, the horizontal distribution of the bypass ratios during the summer showed highest efficiencies at the west end of the dam (Figure 15). Again, Bypass Unit S8 shows the lowest efficiency. Bypass efficiencies were generally higher at the end of the summer study. The lowest efficiency (about 87%) occurred on July 5. The last week of the study averaged 96%.

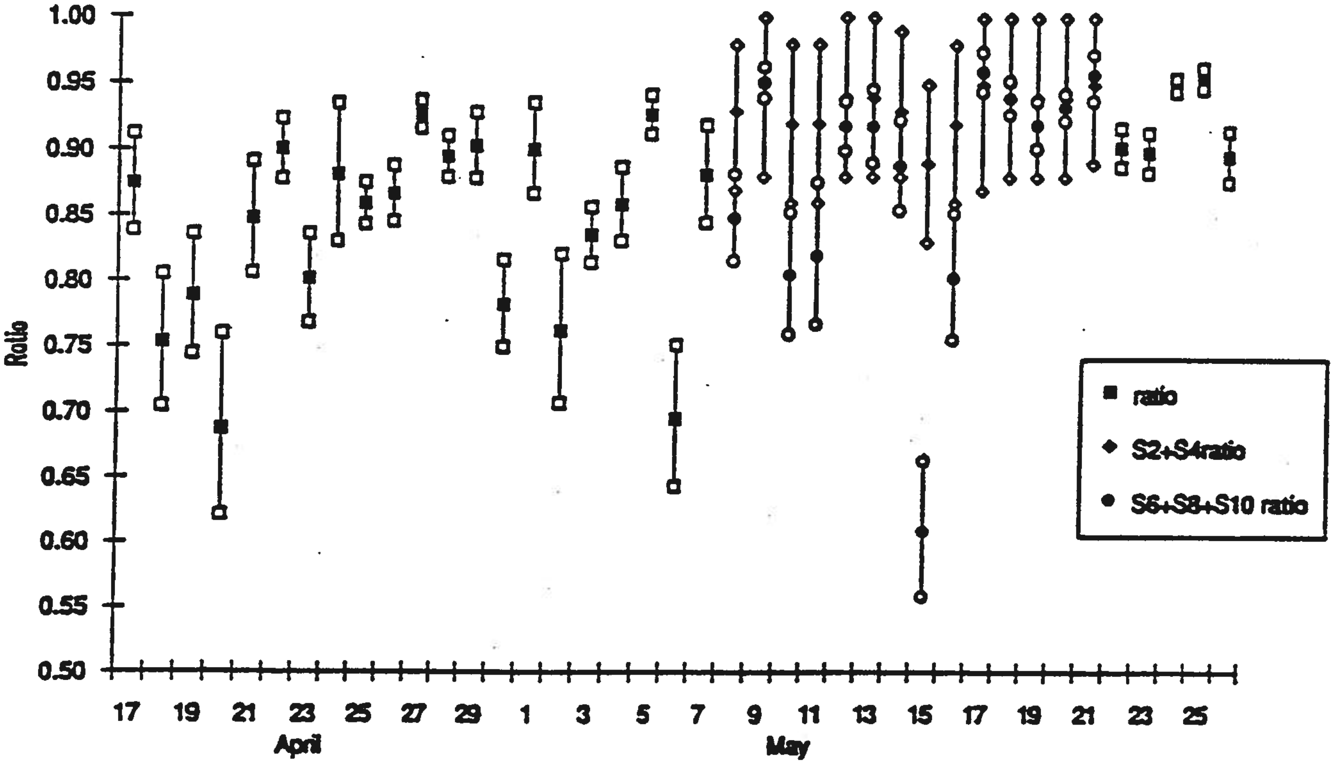

Figure 12. Daily bypass efficiency estimates for spring (April 17 to May 26) at Wells Dam, 1992. Ratios are expressed for 90% confidence levels. For the missing data period, May 8 to 21, two bypass efficiency estimates are presented. The S2+S4 ratio (derived from the fitted regression model of estimated passage at the two westernmost bypasses), and the S6+S8+S10 ratio (derived from passage estimates at the three easternmost bypasses).

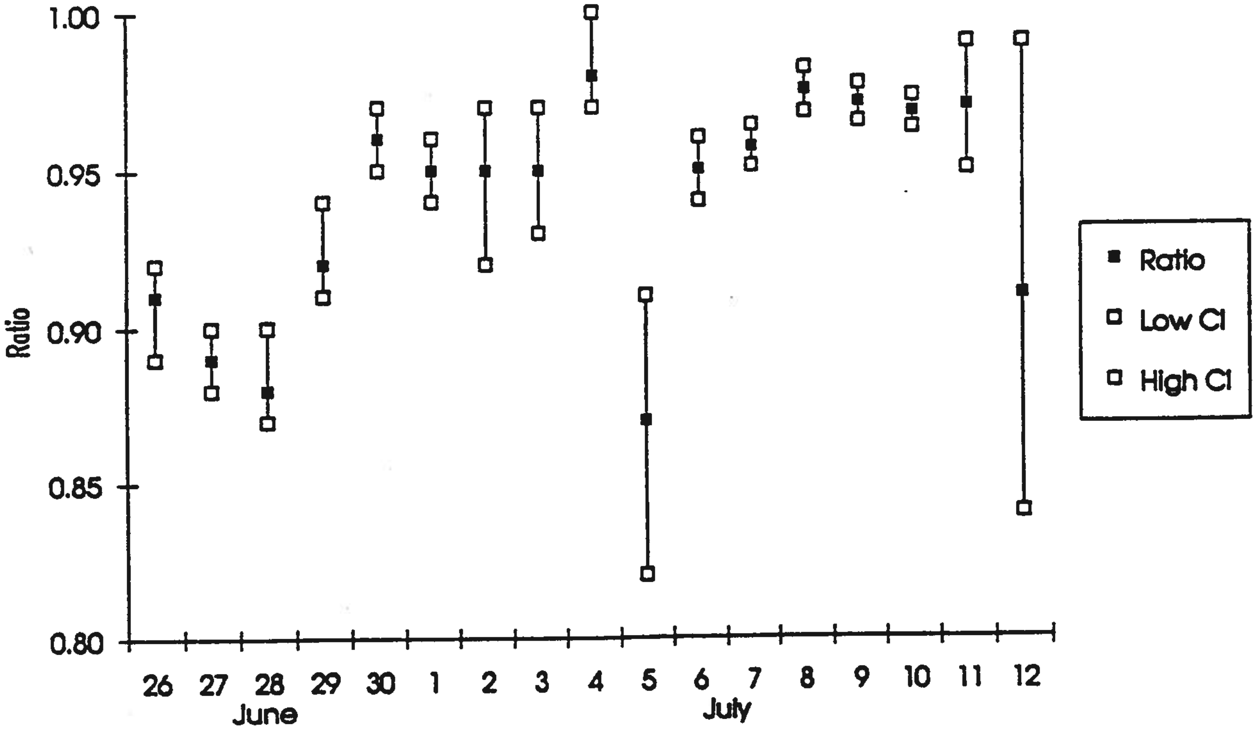

Figure 13. Daily bypass efficiency estimates for summer (June 26 to July 12) at Wells Dam, 1992. Ratios are expressed for 90% confidence levels.

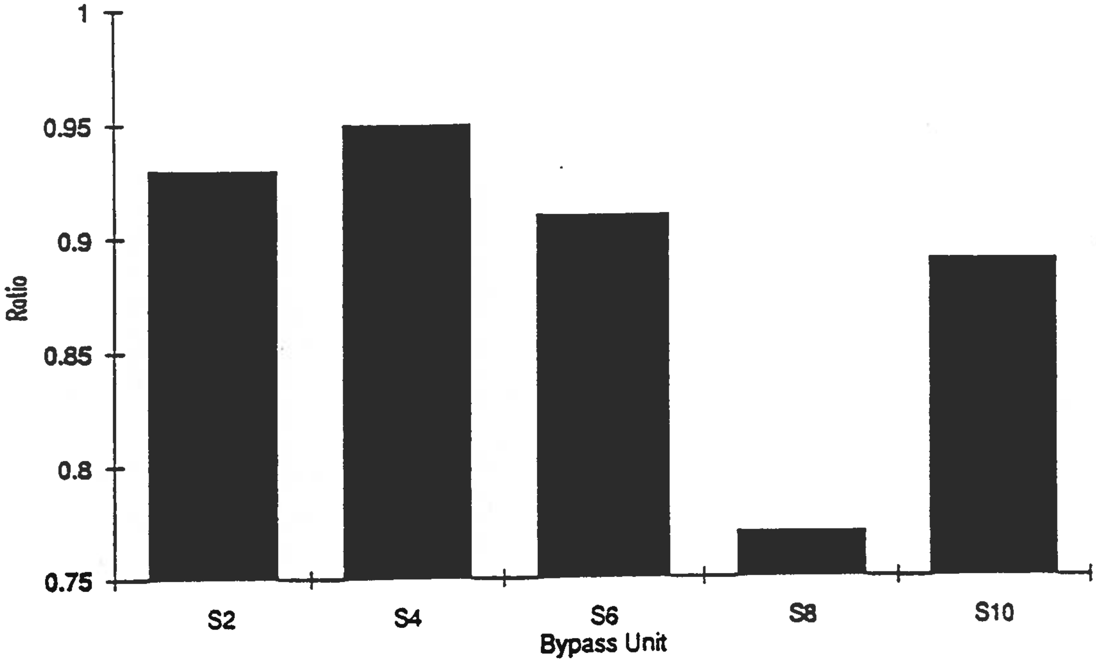

Figure 14. Horizontal distribution of composite bypass efficiencies for each bypass unit during spring (April 17 to May 26) at Wells Dam, 1992.

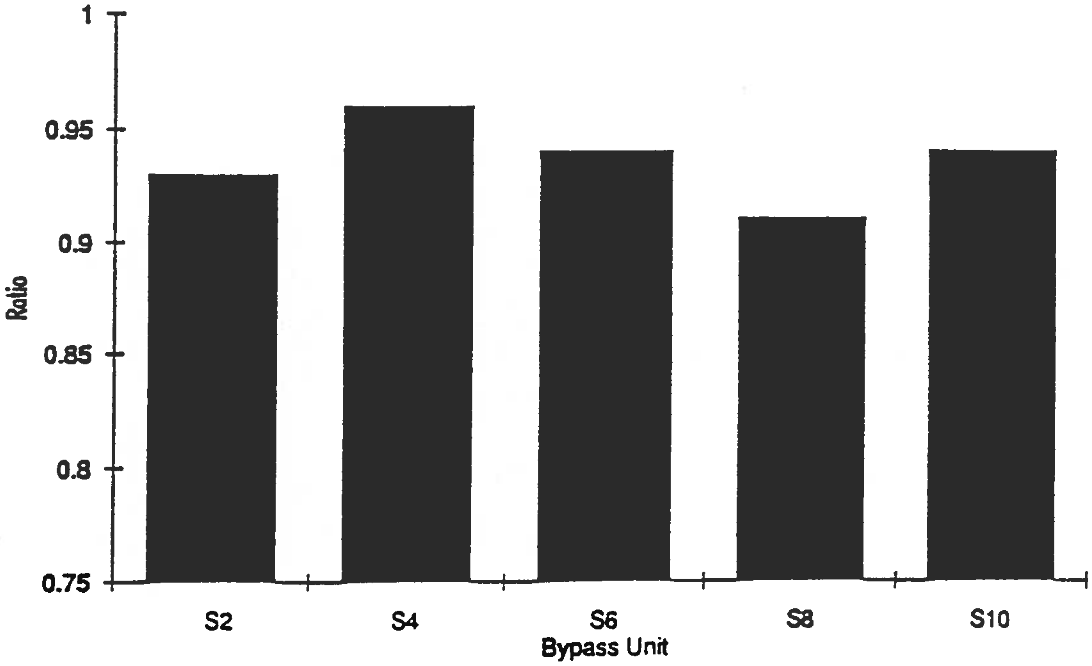

Figure 15. Horizontal distribution of composite bypass efficiencies for each bypass unit during summer (June 26 to July 12) at Wells Dam, 1992.

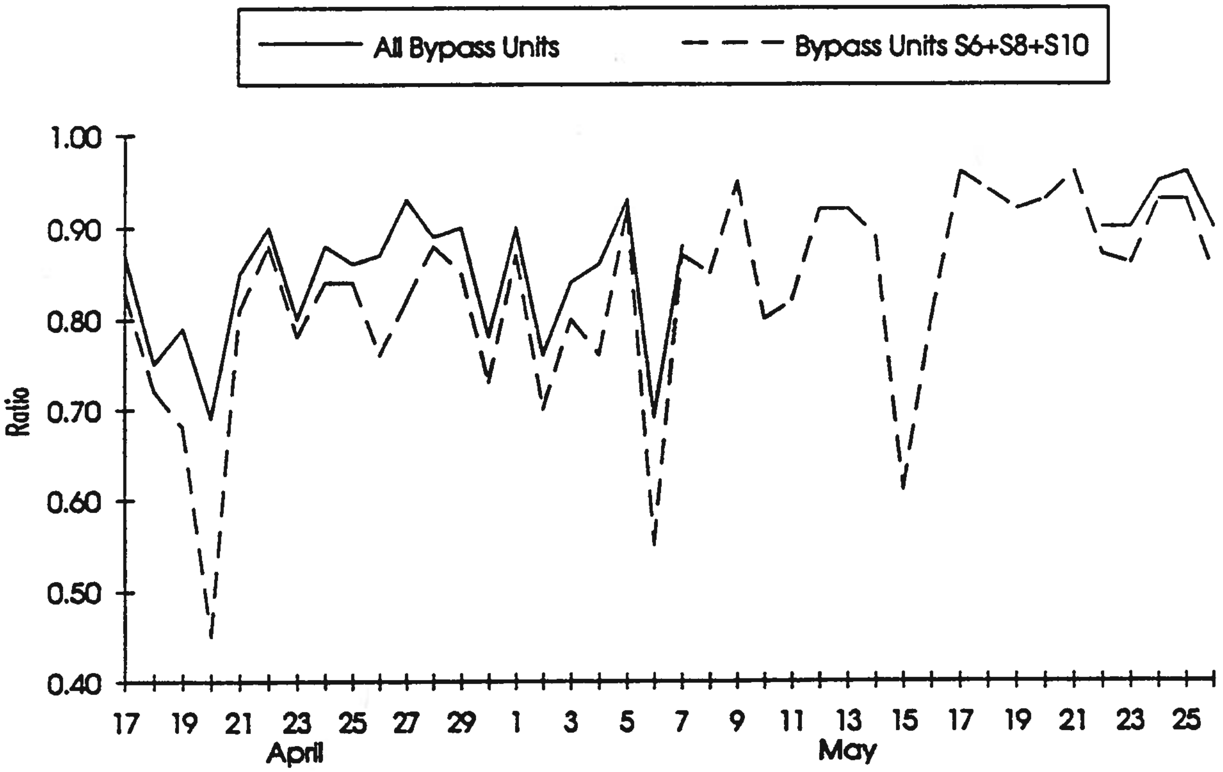

Figure 16. Comparison of daily composite bypass ratios from all five bypass units and S6, S8, and S10 only during the 26 days of sampling at all five bypass units.

4.0 SUMMARY

(1) Total project bypass efficiency was estimated using hydroacoustic techniques during spring (April 17 to May 26) and summer (June 26 to July 12) study periods at Wells Dam in 1992.

(2) Species composition data were collected using fyke net methods from May 28 to August 12, 1992. Run timing data were collected using hydroacoustic methods from April 2 to August 17, 1992.

(3) Chinook salmon juveniles and whitefish were predominant during the spring period. Passage rates were lowest during April. Passage rates were highest during the beginning of June. Yearling chinook were predominant during the spring. Zero-age chinook were predominant from mid-July through mid-August. Whitefish were present in noticeable numbers throughout the study period. Other non-target species were predominant through the end of the sampling in August.

(4) Estimated total project bypass efficiency for the 40-day spring study was:

26 day, all five bypass units - 89.0% +/- 0.50% at the 90% confidence level

40 day, all five bypass units using a regression prediction for efficiency to adjust for the missing data at S2 and S4 - 92.3% +/- 1.7% at the 90% confidence level

40 day, bypass units S6, S8, and S10 only - 86.0% +/- 0.66% at the 90% confidence level.

(5) Estimated total project bypass efficiency for the 17-day summer study was 93.0% ± 0.74% 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 1992 required three BioSonics systems. Each system (Figure A1) consisted of the following components: high-frequency transducers (420 kHz) with cable, an echo sounder/multiplexer, 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 1992 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 1992.

MODEL NO. AND EQUIPMENT	MANUFACTURER	SERIAL NO.
Model 101 (420 kHz) Echo Sounder	BioSonics, Inc.	101-81-010 101-81-031
Model 1005 (420 kHz) Echo Sounder/Multiplexer		1005-91-001 1005-91-002 1005-91-003
Model 151 MPX/EQ Multiplexer/Equalizer	BioSonics, Inc.	151-83-006
Model 111 Chart Recorders	BioSonics, Inc.	111-85-004 111-85-014 111-88-038 111-88-039 111-86-029 111-90-067
Transducers	BioSonics, Inc.	Too numerous to list
Model V-423 Oscilloscope	Hitachi, Inc.	5017445

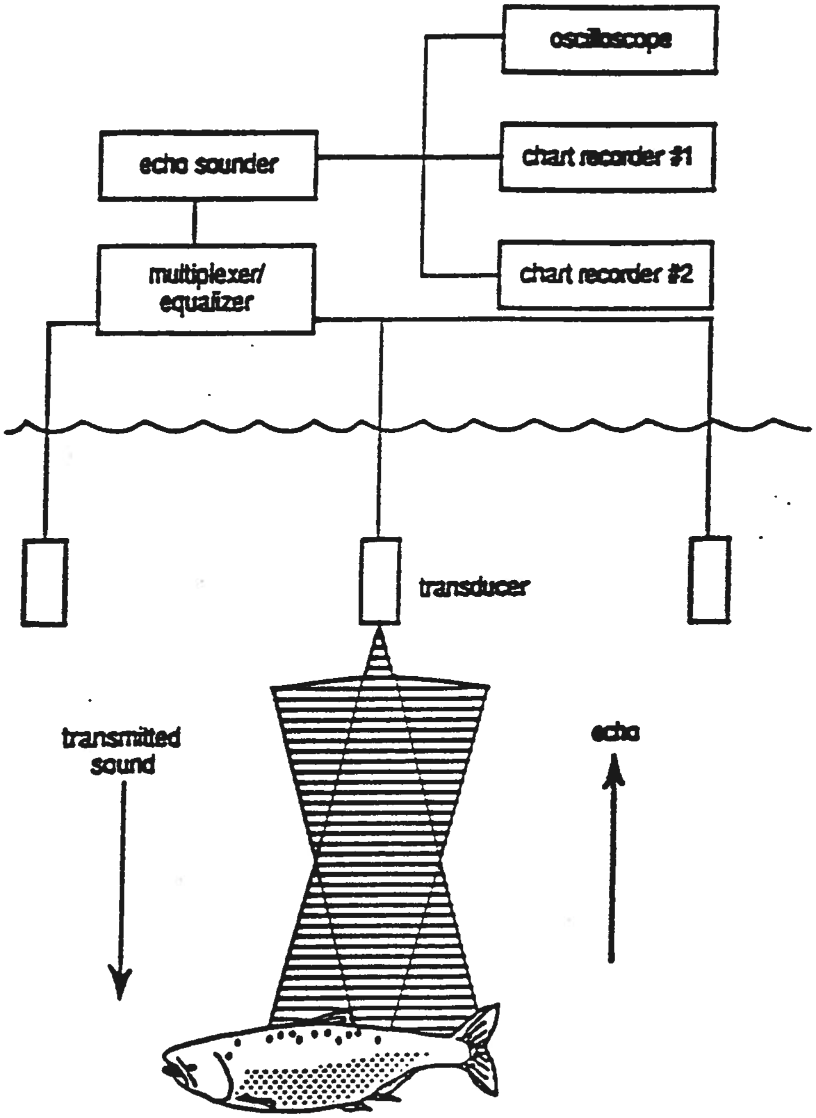

Figure A1. Block diagram of hydroacoustic data collection system used at Wells Dam in 1992.

Table A2. Hydroacoustic system parameters used for studies at Wells Dam in 1992.

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 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 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 -54 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 -54 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.

A.2.3 Dam Operations Data Acquisition

Operations data were received from the control room at Wells Dam. Turbine on/off periods were obtained from electronic copies of Microsoft EXCEL spreadsheets. Turbine operational status (time on, time off, unavailable) at each unit was recorded to the nearest one tenth of an hour (6 minute intervals). Bypass spillbay on/off periods were obtained from the spill gate height log sheet. Time on or off for each bypass spillbay was entered to Microsoft EXCEL spreadsheets to the nearest one quarter of an hour (15 minute intervals). These data were reformatted and converted to R:BASE format for inclusion in the data analysis database.

Because each bypass spillbay is associated with two turbine units (Bypass Spillbay 2 with Turbine Units 1 and 2; etc.), the turbine and spill combined operations data were coded as the flow conditions that existed at each of the five bypass units during a sampling interrogation. These conditions were:

1. Bypass operating and both of the associated turbine units operating.

2. Bypass operating and one of the associated turbine units operating.

3. Bypass not operating and both of the associated turbine units not operating.

A.2.4 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, and 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

Three 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. Third, for all analyses except the run timing index, when the bypass or turbine unit at the sampling location was not operating, all detections and sample times 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

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

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 *i*th interval by the hydroacoustic apparatus,

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

The variance of 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

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

where

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

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

$$V\hat{a}r(\hat{Z}) = \frac{N^2}{n}\left(1-\frac{n}{N}\right)s_{z_i}^2$$

where

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

This estimate of the variance has the expected value

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

Hence, the empirical variance, $s_{z_i}^2$, 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 ($Var(\hat{z}_i | z_i)$) 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

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

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

$$Var(\hat{Y}|Y) = \sum_{i=1}^{D}\sum_{j=1}^{3}\sum_{k=1}^{24}\left[L_{ijk}^{2}\left(1-\frac{l_{ijk}}{L_{ijk}}\right)\frac{S_{y_{ijk}}^{2}}{l_{ijk}}\right] \qquad (4)$$

and where

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

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

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

and where

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

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

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

or

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

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)

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

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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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

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

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

$$Var(\hat{X}\,|\,X) = Var_{s_1}[E_{s_2}(\hat{X}\,|\,S_1)] + E_{s_1}[Var_{s_2}(\hat{X}\,|\,S_1)] \quad . \tag{B1}$$

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

$$Var_{s_1}[E_{s_2}(\hat{X}\,|\,S_1)] = Var_{s_1}\left[E_{s_2}\left[\sum_{i=1}^{10}\sum_{j=1}^{2}\frac{3}{2}\sum_{k=1}^{D}\sum_{l=1}^{24}\left(\sum_{g=1}^{h_{ijkl}}\frac{x_{ijklg}}{h_{ijkl}}H_{ijkl}\right)\middle|\,S_1\right]\right].$$

$$= Var_{s_2}\left[\sum_{i=1}^{10}\sum_{j=1}^{2}\frac{3}{2}X_{ij}\right]$$

$$Var_{s_1}[E_{s_2}(\hat{X}\,|\,S_1)] = \sum_{i=1}^{10}\frac{9}{2}\left(1-\frac{2}{3}\right)S^2_{X_{ij}} = \frac{3}{2}\sum_{i=1}^{10}S^2_{X_{ij}} \tag{B2}$$

where

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

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

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

Appendix C

Variance of the Estimate of Total Project Bypass Efficiency

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

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

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

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

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

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

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

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

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

Assuming approximate normality,

$$
\begin{aligned}
P\left(\frac{-\epsilon}{\sqrt{Var(\hat{B})}}<Z<\frac{\epsilon}{\sqrt{Var(\hat{B})}}\right) &= 1-\alpha \\
P\left(Z<\frac{-\epsilon}{\sqrt{Var(\hat{B})}}\right) &= \frac{\alpha}{2} \\
\Phi\left(\frac{-\epsilon}{\sqrt{Var(\hat{B})}}\right) &= \frac{\alpha}{2}
\end{aligned}
$$

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

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

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

APPENDIX C

HORIZONTAL AND DIEL DISTRIBUTION RESULTS

C.1 Horizontal Distributions

During spring (April 17 to May 26) 1992, as in previous years, bypass horizontal distributions showed greatest passage occurred at the west half of the dam (Figure C1). Except for bypass unit S4, passage rates were higher during the night than day. Overall passage was highest at S4, followed closely by S6. Lowest passage occurred at S10.

As with the bypass, turbine horizontal distribution during the spring showed overall higher passage rates during the night (Figure C2). Turbine intake 7A had the highest passage rates of the spring. Turbine intakes 1A, 2C, 4C, and 10C had relatively high passage rates as well. Turbine intakes 1B, 3C, and 4A had low passage rates. Turbine passage rates were far lower overall than bypass passage rates.

The summer (June 26 to July 12) bypass horizontal distribution data is similar to the spring (Figure C3). Highest overall passage occurred at bypass unit S4. Bypass unit S6 showed next highest passage. Lowest passage was at bypass unit S10. As in previous years, daytime passage rates during the summer are higher than nightime. All bypass locations show higher passage rates in summer than the spring (Figures C1 and C3).

As in the spring, summer turbine horizontal distribution showed highest passage at turbine intake 7A (Figure C4). Units 1 and 5 overall showed high passage. Turbine intake 10C also showed high passage. As with the bypass, turbine passage is higher in summer than the spring. Turbine intake 4A again showed very low passage. Daytime passage was higher overall than nightime.

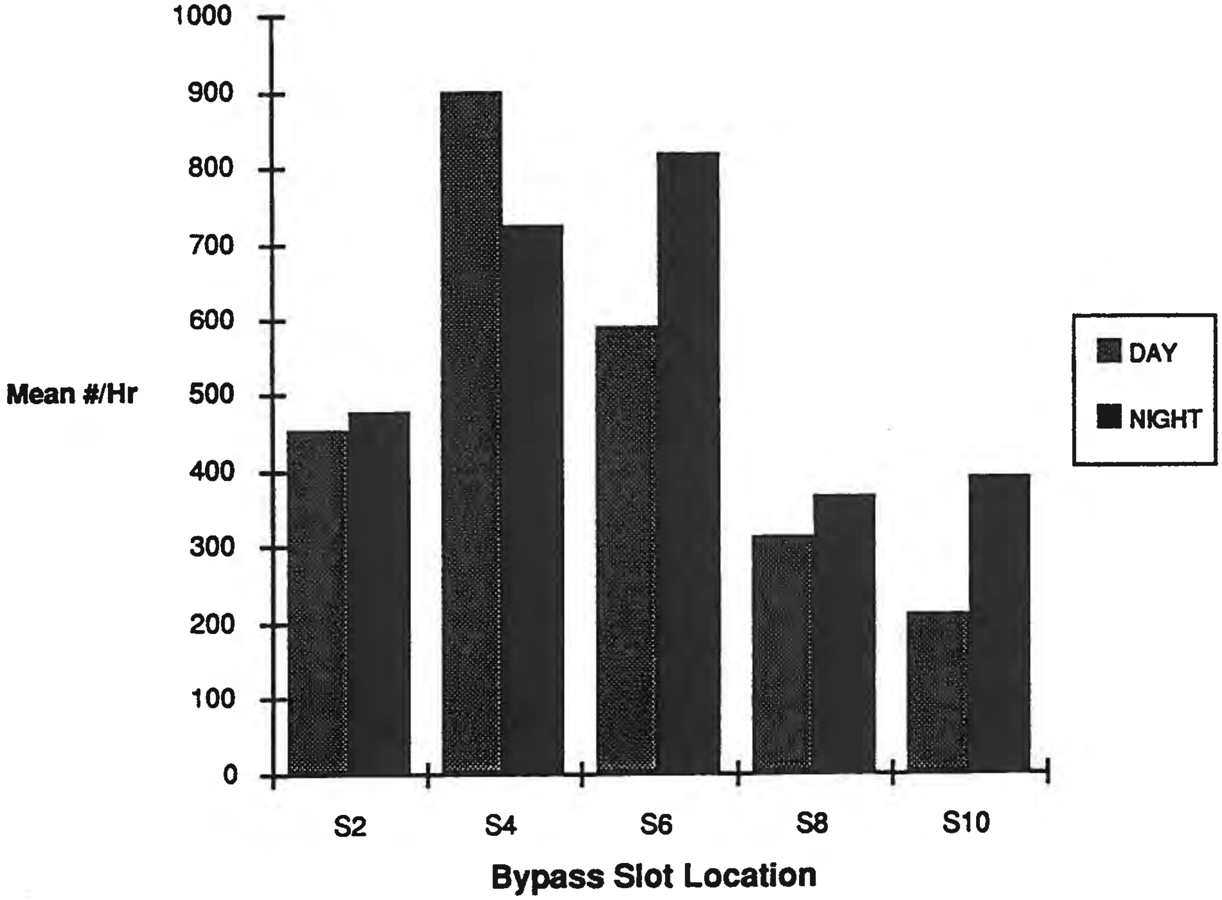


Figure C1. Horizontal distribution of bypass slot indices (mean #/1 hr/location) for day and night separately at Wells Dam between April 17 and May 26, 1992.

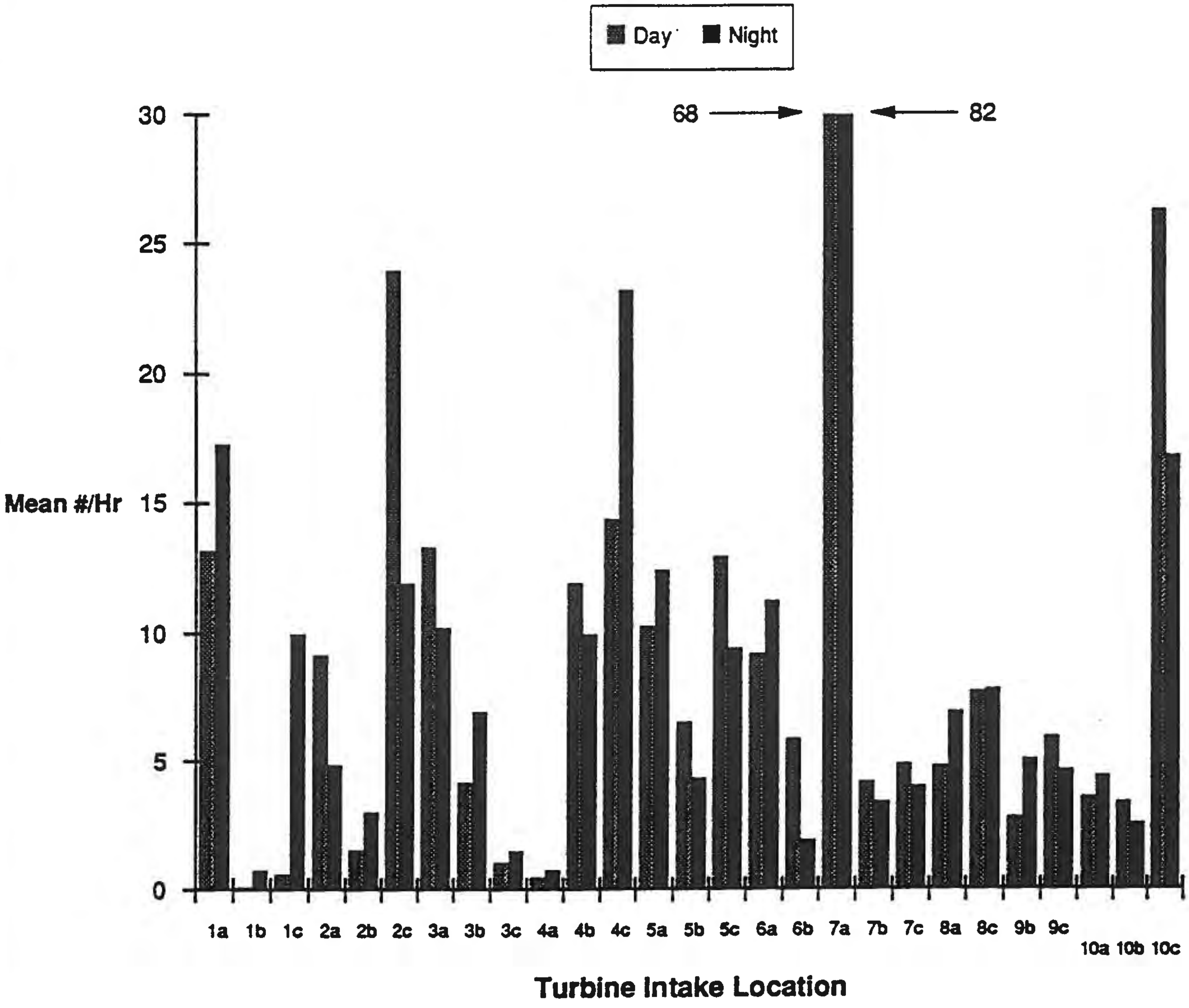


Figure C2. Horizontal distribution of turbine passage indices (mean #/1 hr/location) for day and night separately at Wells Dam between April 17 and May 26, 1992.

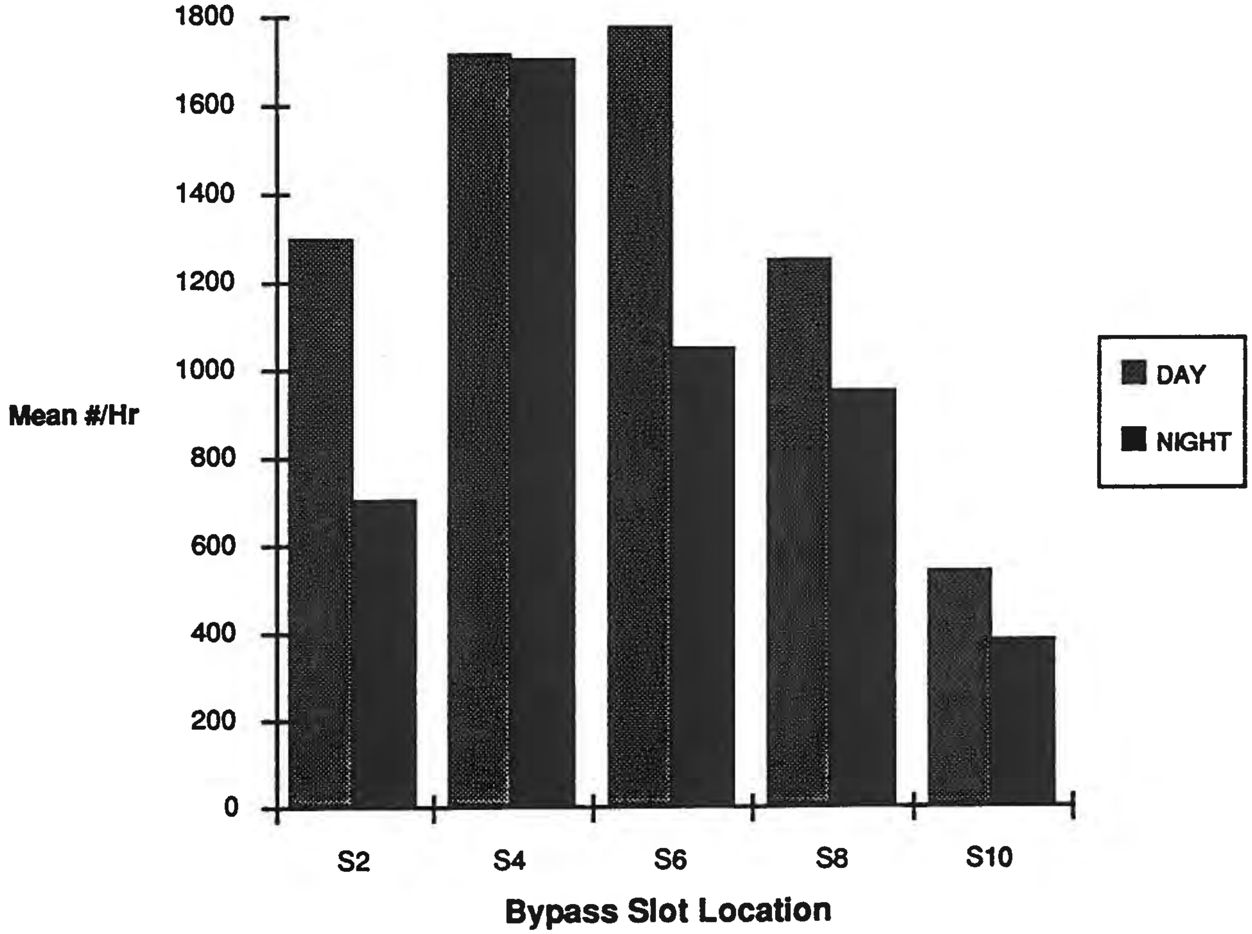


Figure C3. Horizontal distribution of bypass slot indices (mean #/1 hr/location) for day and night separately at Wells Dam between June 26 and July 12, 1992.

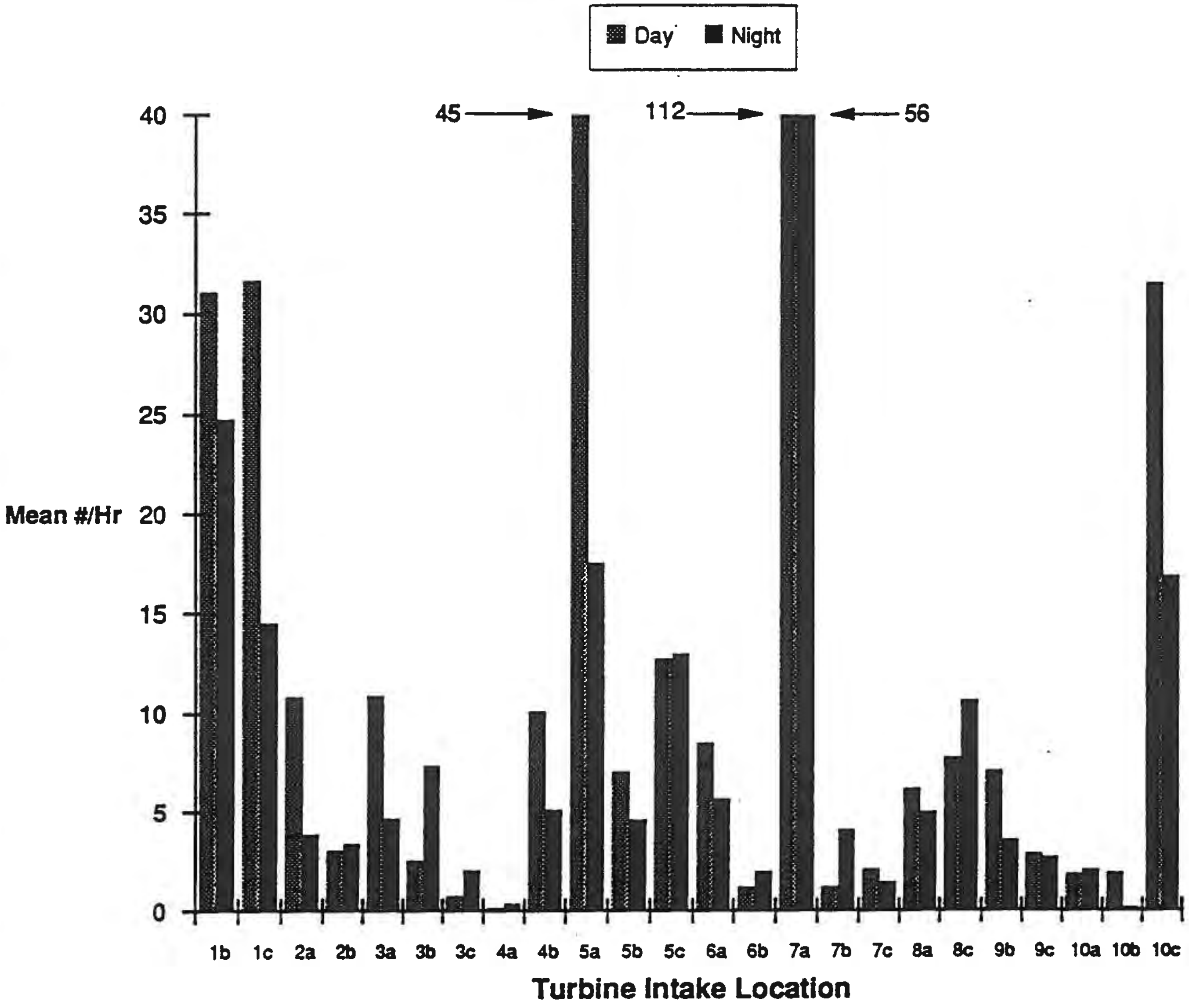


Figure C4. Horizontal distribution of turbine passage indices (mean #/1 hr/location) for day and night separately at Wells Dam between June 26 and July 12, 1992.

C.2 Diel Distributions

Diel distribution for the bypass during the spring study (April 17 to May 26) showed relatively constant passage rates (Figure C5). Highest passage occurred between 2000h and 2300h. Lowest passage occurred at 1500h. A separate peak in passage occurred at 0700h. This peak was only slightly lower than the highest passage rate.

Diel distribution for the turbines during spring showed lowest passage between 0100h and 0500h (Figure C6). Passage rates remained relatively constant during daylight hours. As with the bypass, highest passage occurred between 2000h and 2300h with peak passage at 2100h. Overall, turbine passage was much lower than bypass passage.

Diel distribution for the bypass during the summer study (June 26 to July 12) showed highest passage rates during daylight hours (Figure C7). Overall, passage rates were higher during the summer than the spring. This was consistent with the horizontal distribution. Peak passage occurred at 1200h. As was the case in previous years, lowest passage occurred between 2300h and 0500h.

Diel distribution for the turbines during summer again showed highest passage during daylight hours (Figure C8). Peak passage in turbine also occured at 1200h. Lowest passage occured between 0000h and 0600h. There is a second lower peak which occurred at 1800h. Overall, passage rates were higher during the summer than the spring.

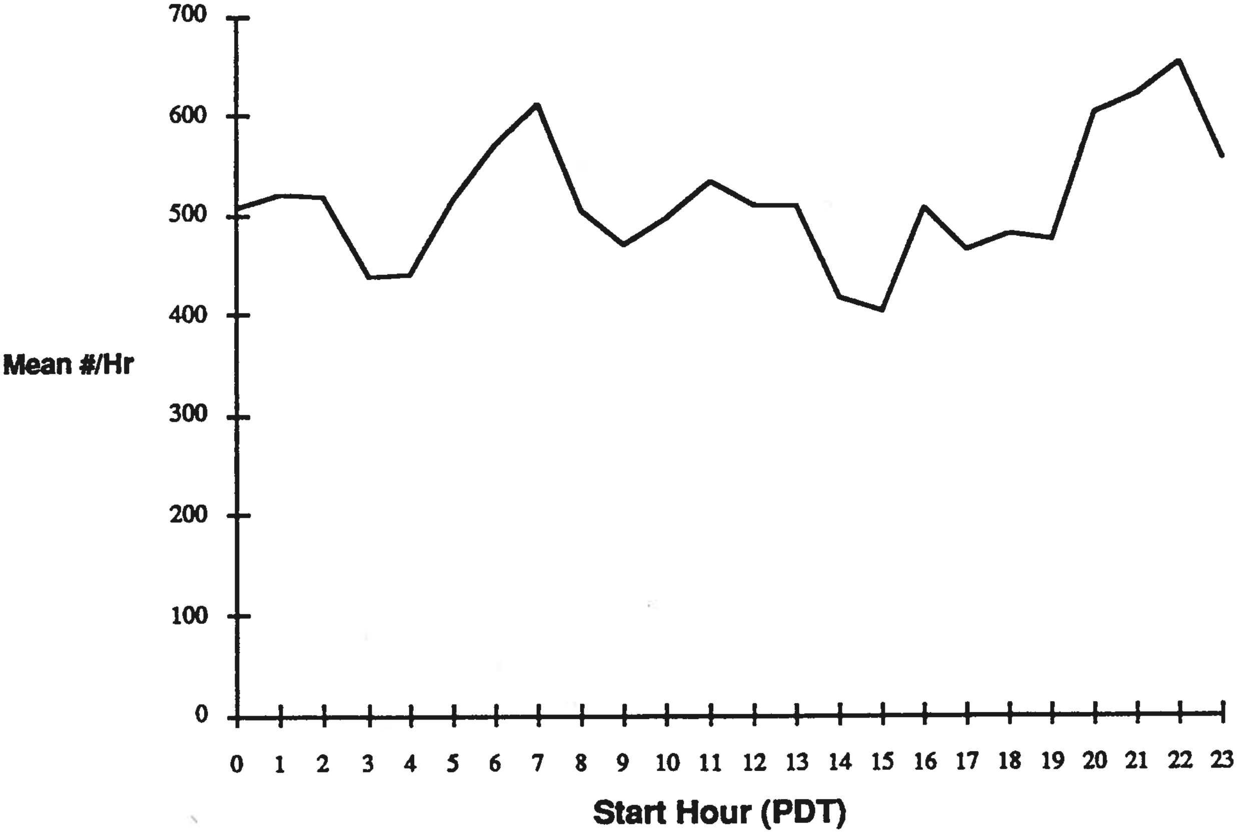


Figure C5. Diel distribution of bypass slot indices (mean #/1 hr/location) at Wells Dam between April 17 and May 26, 1992.

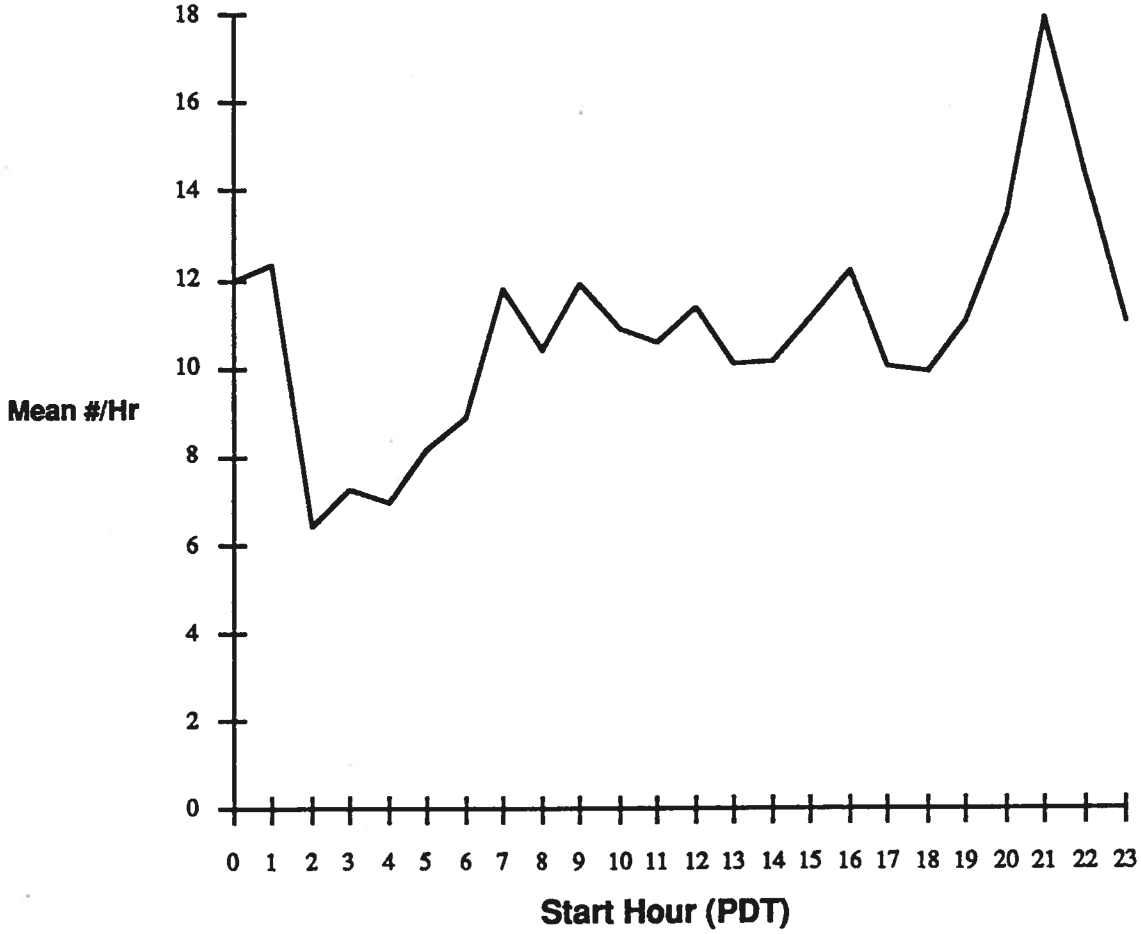


Figure C6. Diel distribution of turbine passage indices (mean #/1 hr/location) at Wells Dam between April 17 and May 26, 1992.

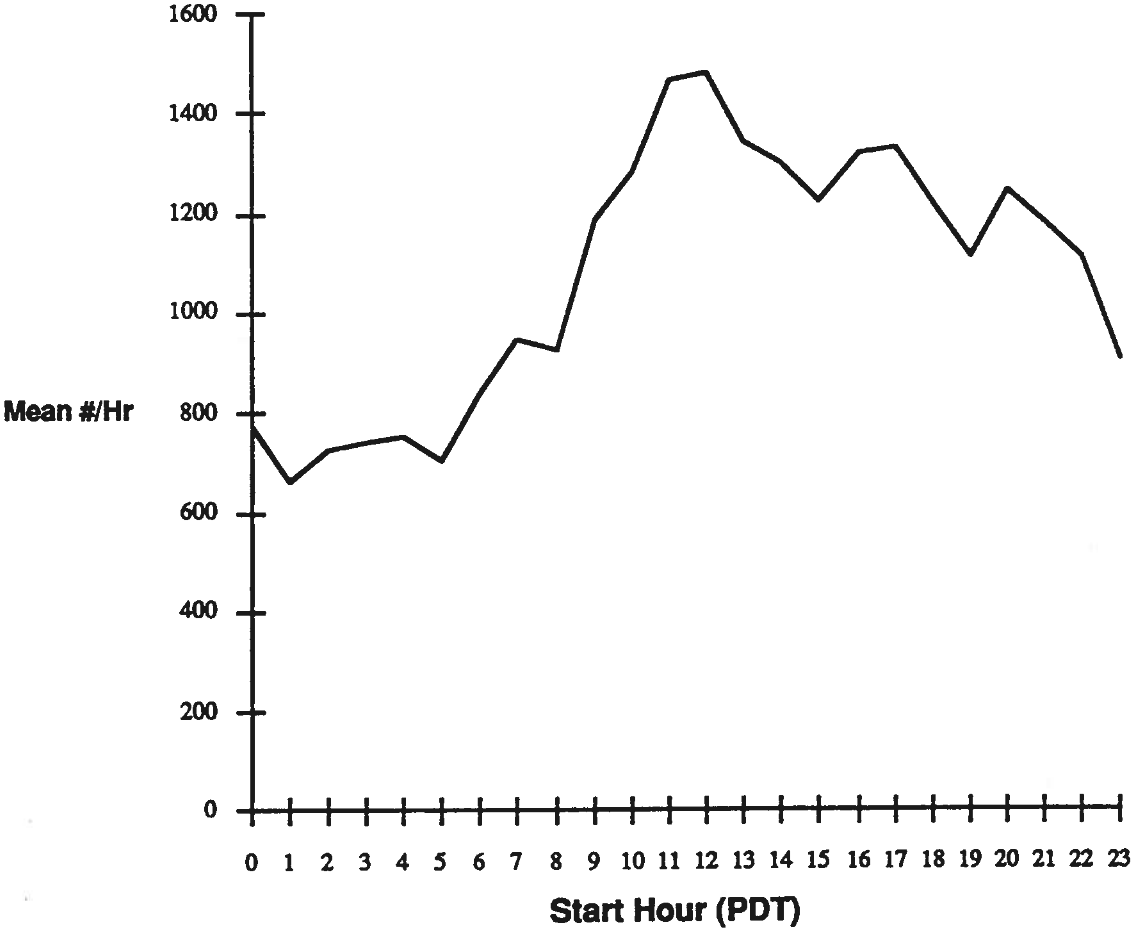


Figure C7. Diel distribution of bypass slot indices (mean #/1 hr/location) at Wells Dam between June 26 and July 12, 1992.

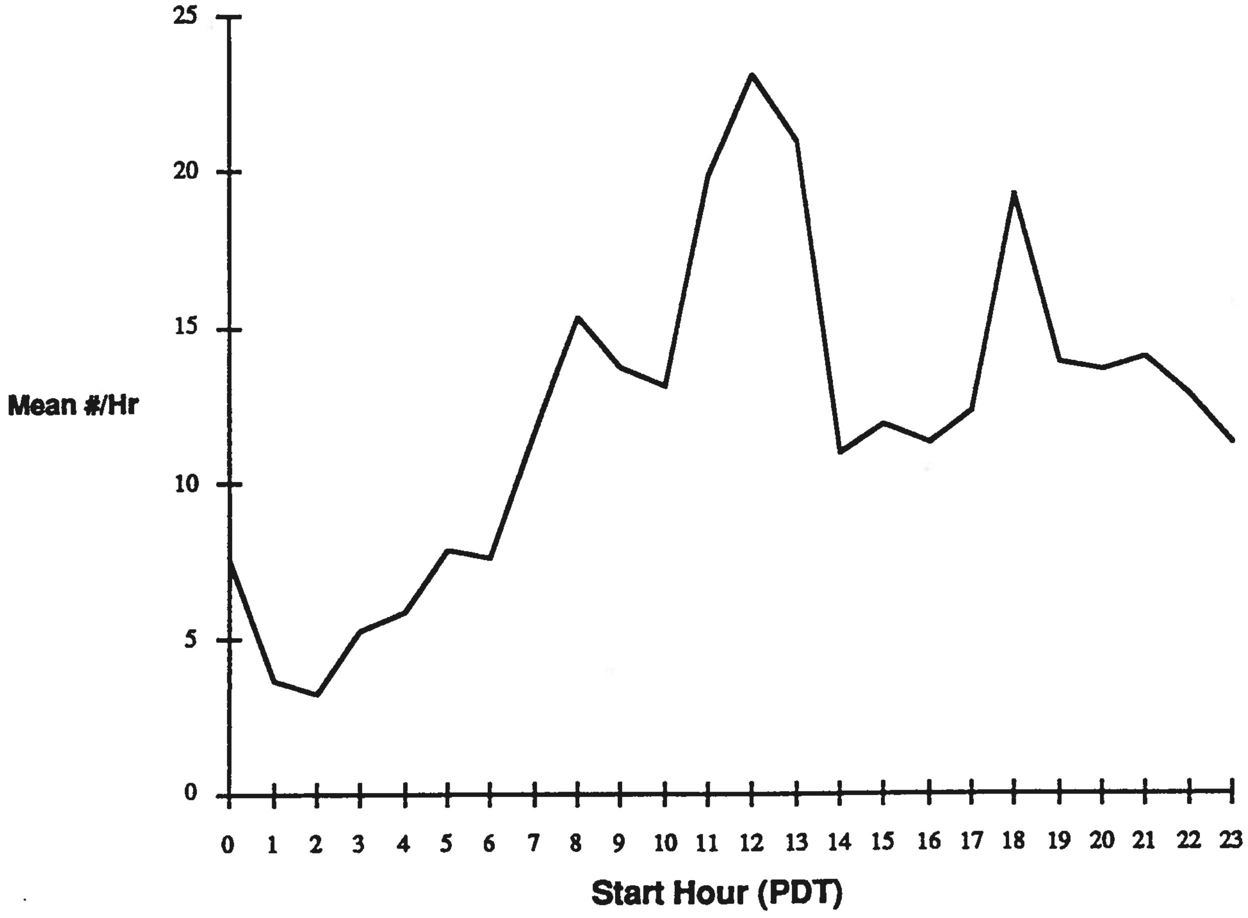


Figure C8. Diel distribution of turbine passage indices (mean #/1 hr/location) at Wells Dam between June 26 and July 12, 1992.

APPENDIX D

FISH PASSAGE DATA

Wells 1992 Forebay Hydroacoustic Index
Day/Night=Mean #/4hr/location
Combined=Mean #/8hr/location

	Date	Day	Night	Combined
April	2	205.7	N/A	N/A
	3	55.9	11.8	67.7
	4	43.4	29.0	72.4
	5	20.8	32.5	53.3
	6	188.5	58.2	246.7
	7	82.0	562.6	644.6
	8	61.2	154.1	215.3
	9	61.8	31.2	93.0
	10	69.7	23.4	93.1
	11	84.5	42.4	126.9
	12	47.0	23.9	70.9
	13	66.2	47.8	114.0
	14	61.0	122.3	183.3
	15	154.6	228.4	383.0
	16	417.1	247.2	664.3
	Spring Bypass Evaluation			
May	27	184.3	845.3	1029.6
	28	269.2	623.1	892.3
	29	217.3	963.9	1181.2
	30	268.4	1126.8	1395.2
	31	330.0	1172.4	1502.4
June	1	492.5	608.0	1100.5
	2	550.4	861.0	1411.4
	3	436.5	1369.2	1805.7
	4	330.4	800.1	1130.5
	5	284.5	1233.4	1517.9
	6	482.5	1539.4	2021.9
	7	634.2	1690.5	2324.7
	8	798.2	1876.8	2675.0
	9	1043.8	1724.2	2768.0
	10	799.3	1404.2	2203.5
	11	717.4	1375.5	2092.9
	12	384.4	965.7	1350.1
	13	283.9	727.7	1011.6
	14	326.2	522.7	848.9
	15	489.0	737.5	1226.5
	16	549.5	808.8	1358.3
	17	439.2	705.4	1144.6
	18	530.9	446.0	976.9
	19	970.7	322.5	1293.2
	20	756.3	661.0	1417.3
	21	631.8	995.1	1626.9
	22	704.4	1170.2	1874.6
	23	630.5	914.1	1544.6

Wells 1992 Forebay Hydroacoustic Index
Day/Night=Mean #/4hr/location
Combined=Mean #/8hr/location

	Date	Day	Night	Combined
June	24	607.1	744.6	1351.7
	25	823.4	864.9	1688.3
	Summer Bypass Evaluation			
July	13	1020.6	702.2	1722.8
	14	626.6	530.9	1157.5
	15	694.7	347.7	1042.4
	16	404.9	581.8	986.7
	17	675.1	403.2	1078.3
	18	449.4	700.6	1150.0
	19	413.6	565.8	979.4
	20	626.2	751.9	1378.1
	21	770.2	473.2	1243.4
	22	491.8	386.4	878.2
	23	363.9	268.5	632.4
	24	349.1	219.3	568.4
	25	216.2	171.6	387.8
	26	237.2	231.0	468.2
	27	960.8	103.6	1064.4
	28	756.4	265.9	1022.3
	29	703.2	349.8	1053.0
	30	534.5	313.3	847.8
	31	306.6	316.9	623.5
August	1	385.8	295.2	681.0
	2	245.2	164.7	409.9
	3	574.7	243.7	818.4
	4	386.6	181.1	567.7
	5	365.6	283.9	649.5
	6	541.3	384.6	925.9
	7	457.4	137.6	595.0
	8	464.9	125.2	590.1
	9	163.7	216.8	380.5
	10	1128.1	173.6	1301.7
	11	1097.4	719.7	1817.1
	12	805.6	171.2	976.8
	13	615.2	133.1	748.3
	14	944.5	300.1	1244.6
	15	605.8	551.5	1157.3
	16	304.0	402.8	706.8
	17	1273.0	299.9	1572.9

Wells 1992 Study Periods Bypass Slot Run Timing

SPRING

	DATE	Mean #/8hr/location
April	16	729.358
	17	451.734
	18	529.232
	19	1772.759
	20	1026.401
	21	1226.451
	22	1041.460
	23	1066.577
	24	3834.358
	25	5687.322
	26	8786.000
	27	2796.058
	28	4552.198
	29	1275.585
	30	4112.305
May	1	856.433
	2	1455.165
	3	1065.784
	4	3292.006
	5	452.328
	6	5288.118
	7	3472.210
	8	4424.880
	9	988.214
	10	2666.878
	11	4625.739
	12	1168.159
	13	2611.235
	14	716.653
	15	1756.143
	16	6039.008
	17	2016.227
	18	2281.949
	19	2760.612
	20	3288.561
	21	5305.070
	22	5021.118
	23	9098.333
	24	9556.305
	25	3497.887

SUMMER

	DATE	Mean #/8hr/location
June	26	6152.908
	27	4973.565
	28	6640.617
	29	5083.678
	30	5912.906
July	1	3359.632
	2	2136.813
	3	1614.973
	4	2377.206
	5	1873.98
	6	4707.076
	7	5154.117
	8	3330.337
	9	8761.300
	10	13553.07
	11	13003.24
	12	6178.325

Wells Spring 1992 Bypass Efficiencies

<table>
<tr><th>Date</th><th>Ratio</th><th>Lower C.I.</th><th>Upper C.I.</th><th>S2+S4 Ratio</th><th>Lower C.I.</th><th>Upper C.I.</th><th>S6+S8+S10 Ratio</th><th>Lower C.I.</th><th>Upper C.I.</th></tr>
<tr><td>April 17</td><td>0.87</td><td>0.84</td><td>0.91</td><td>|0.94|</td><td>0.90</td><td>0.98</td><td>{0.83}</td><td>0.79</td><td>0.88</td></tr>
<tr><td>18</td><td>0.75</td><td>0.70</td><td>0.80</td><td>N/O</td><td>N/O</td><td>N/O</td><td>{0.72}</td><td>0.66</td><td>0.78</td></tr>
<tr><td>19</td><td>0.79</td><td>0.74</td><td>0.84</td><td>N/O</td><td>N/O</td><td>N/O</td><td>{0.68}</td><td>0.61</td><td>0.75</td></tr>
<tr><td>20</td><td>0.69</td><td>0.62</td><td>0.76</td><td>|0.91|</td><td>0.89</td><td>0.94</td><td>{0.42}</td><td>0.34</td><td>0.52</td></tr>
<tr><td>21</td><td>0.85</td><td>0.81</td><td>0.89</td><td>|0.89|</td><td>0.85</td><td>0.92</td><td>{0.81}</td><td>0.75</td><td>0.89</td></tr>
<tr><td>22</td><td>0.90</td><td>0.88</td><td>0.92</td><td>|0.94|</td><td>0.92</td><td>0.97</td><td>{0.88}</td><td>0.84</td><td>0.91</td></tr>
<tr><td>23</td><td>0.80</td><td>0.77</td><td>0.84</td><td>|0.83|</td><td>0.78</td><td>0.89</td><td>{0.78}</td><td>0.74</td><td>0.82</td></tr>
<tr><td>24</td><td>0.88</td><td>0.83</td><td>0.93</td><td>|0.93|</td><td>0.91</td><td>0.96</td><td>{0.84}</td><td>0.76</td><td>0.93</td></tr>
<tr><td>25</td><td>0.86</td><td>0.84</td><td>0.88</td><td>N/O</td><td>N/O</td><td>N/O</td><td>{0.84}</td><td>0.82</td><td>0.86</td></tr>
<tr><td>26</td><td>0.87</td><td>0.85</td><td>0.89</td><td>N/O</td><td>N/O</td><td>N/O</td><td>{0.76}</td><td>0.71</td><td>0.81</td></tr>
<tr><td>27</td><td>0.93</td><td>0.92</td><td>0.94</td><td>|0.97|</td><td>0.96</td><td>0.98</td><td>{0.82}</td><td>0.79</td><td>0.84</td></tr>
<tr><td>28</td><td>0.89</td><td>0.88</td><td>0.91</td><td>|0.92|</td><td>0.90</td><td>0.94</td><td>{0.88}</td><td>0.86</td><td>0.90</td></tr>
<tr><td>29</td><td>0.90</td><td>0.88</td><td>0.93</td><td>|0.94|</td><td>0.93</td><td>0.95</td><td>{0.85}</td><td>0.80</td><td>0.90</td></tr>
<tr><td>30</td><td>0.78</td><td>0.75</td><td>0.82</td><td>|0.87|</td><td>0.84</td><td>0.90</td><td>{0.73}</td><td>0.68</td><td>0.78</td></tr>
<tr><td>May 1</td><td>0.90</td><td>0.87</td><td>0.94</td><td>|0.94|</td><td>0.93</td><td>0.96</td><td>{0.87}</td><td>0.81</td><td>0.93</td></tr>
<tr><td>2</td><td>0.76</td><td>0.71</td><td>0.82</td><td>|0.85|</td><td>0.81</td><td>0.89</td><td>{0.70}</td><td>0.61</td><td>0.79</td></tr>
<tr><td>3</td><td>0.84</td><td>0.81</td><td>0.86</td><td>|0.89|</td><td>0.87</td><td>0.92</td><td>{0.80}</td><td>0.78</td><td>0.83</td></tr>
<tr><td>4</td><td>0.86</td><td>0.83</td><td>0.89</td><td>|0.95|</td><td>0.94</td><td>0.97</td><td>{0.76}</td><td>0.71</td><td>0.81</td></tr>
<tr><td>5</td><td>0.93</td><td>0.91</td><td>0.94</td><td>|0.94|</td><td>0.92</td><td>0.95</td><td>{0.92}</td><td>0.89</td><td>0.94</td></tr>
<tr><td>6</td><td>0.69</td><td>0.64</td><td>0.75</td><td>|0.87|</td><td>0.84</td><td>0.91</td><td>{0.55}</td><td>0.48</td><td>0.63</td></tr>
<tr><td>7</td><td>0.88</td><td>0.85</td><td>0.92</td><td>|0.90|</td><td>0.88</td><td>0.91</td><td>{0.87}</td><td>0.82</td><td>0.93</td></tr>
<tr><td>8</td><td></td><td></td><td></td><td>(0.93)</td><td>0.87</td><td>0.98</td><td>{0.85}</td><td>0.82</td><td>0.88</td></tr>
<tr><td>9</td><td></td><td></td><td></td><td>(0.94)</td><td>0.88</td><td>1.00</td><td>{0.95}</td><td>0.94</td><td>0.96</td></tr>
<tr><td>10</td><td></td><td></td><td></td><td>(0.92)</td><td>0.86</td><td>0.98</td><td>{0.80}</td><td>0.76</td><td>0.85</td></tr>
<tr><td>11</td><td></td><td></td><td></td><td>(0.92)</td><td>0.86</td><td>0.98</td><td>{0.82}</td><td>0.77</td><td>0.88</td></tr>
<tr><td>12</td><td></td><td></td><td></td><td>(0.94)</td><td>0.88</td><td>1.00</td><td>{0.92}</td><td>0.90</td><td>0.94</td></tr>
<tr><td>13</td><td></td><td></td><td></td><td>(0.94)</td><td>0.88</td><td>1.00</td><td>{0.92}</td><td>0.89</td><td>0.95</td></tr>
<tr><td>14</td><td></td><td></td><td></td><td>(0.93)</td><td>0.88</td><td>0.99</td><td>{0.89}</td><td>0.85</td><td>0.92</td></tr>
<tr><td>15</td><td></td><td></td><td></td><td>(0.89)</td><td>0.83</td><td>0.95</td><td>{0.61}</td><td>0.56</td><td>0.66</td></tr>
<tr><td>16</td><td></td><td></td><td></td><td>(0.92)</td><td>0.86</td><td>0.98</td><td>{0.80}</td><td>0.76</td><td>0.85</td></tr>
<tr><td>17</td><td></td><td></td><td></td><td>(0.95)</td><td>0.87</td><td>1.00</td><td>{0.96}</td><td>0.94</td><td>0.97</td></tr>
<tr><td>18</td><td></td><td></td><td></td><td>(0.94)</td><td>0.88</td><td>1.00</td><td>{0.94}</td><td>0.93</td><td>0.95</td></tr>
<tr><td>19</td><td></td><td></td><td></td><td>(0.94)</td><td>0.88</td><td>1.00</td><td>{0.92}</td><td>0.90</td><td>0.94</td></tr>
<tr><td>20</td><td></td><td></td><td></td><td>(0.94)</td><td>0.88</td><td>1.00</td><td>{0.93}</td><td>0.92</td><td>0.94</td></tr>
<tr><td>21</td><td></td><td></td><td></td><td>(0.95)</td><td>0.89</td><td>1.00</td><td>{0.96}</td><td>0.94</td><td>0.97</td></tr>
<tr><td>22</td><td>0.90</td><td>0.89</td><td>0.92</td><td>|0.96|</td><td>0.95</td><td>0.97</td><td>{0.87}</td><td>0.85</td><td>0.89</td></tr>
<tr><td>23</td><td>0.90</td><td>0.88</td><td>0.91</td><td>|0.94|</td><td>0.92</td><td>0.95</td><td>{0.86}</td><td>0.84</td><td>0.89</td></tr>
<tr><td>24</td><td>0.95</td><td>0.94</td><td>0.96</td><td>|0.96|</td><td>0.95</td><td>0.97</td><td>{0.93}</td><td>0.90</td><td>0.96</td></tr>
<tr><td>25</td><td>0.96</td><td>0.95</td><td>0.96</td><td>|0.96|</td><td>0.96</td><td>0.97</td><td>{0.93}</td><td>0.90</td><td>0.96</td></tr>
<tr><td>26</td><td>0.90</td><td>0.88</td><td>0.92</td><td>|0.93|</td><td>0.92</td><td>0.95</td><td>{0.85}</td><td>0.83</td><td>0.87</td></tr>
</table>

( ) derived from the fitted regression model of estimated passage at S2 and S4

| | derived from passage estimates at S2 and S4 only

{ } derived from passage estimates at S6, S8 and S10 only

N/O = bypass not operating

Wells 1992 Summer Bypass Efficiency Data

Date	Ratio	Lower CI	Upper CI
June - 26	0.91	0.89	0.92
27	0.89	0.88	0.90
28	0.88	0.87	0.90
29	0.92	0.91	0.94
30	0.96	0.95	0.97
July - 1	0.95	0.94	0.96
2	0.95	0.92	0.97
3	0.95	0.93	0.97
4	0.98	0.97	1.00
5	0.87	0.82	0.91
6	0.95	0.94	0.96
7	0.96	0.95	0.96
8	0.97	0.97	0.98
9	0.97	0.97	0.98
10	0.97	0.96	0.97
11	0.97	0.95	0.99
12	0.91	0.84	0.99

Wells Spring 1992 Horizontal Distribution of Bypass Efficiencies

	S2			S4			S6		
Date	Ratio	Lower CI	Upper CI	Ratio	Lower CI	Upper CI	Ratio	Lower CI	Upper CI
April - 17	0.88	0.74	1.00	0.94	0.91	0.98	0.97	0.93	1.00
18	Bypass Not Operating			0.84	0.77	0.91	0.81	0.65	1.00
19	Bypass Not Operating			0.92	0.89	0.96	0.48	0.35	0.68
20	Bypass Not Operating			0.93	0.90	0.95	0.67	0.59	0.77
21	0.88	0.76	1.00	0.89	0.85	0.92	0.87	0.77	0.97
22	0.95	0.91	0.99	0.94	0.91	0.97	0.86	0.81	0.90
23	0.81	0.72	0.91	0.84	0.78	0.90	0.82	0.77	0.87
24	0.50	0.35	0.71	0.95	0.93	0.98	0.90	0.85	0.95
25	Bypass Not Operating			0.90	0.87	0.92	0.94	0.91	0.98
26	Bypass Not Operating			0.95	0.94	0.97	0.84	0.69	1.00
27	0.75	0.65	0.87	0.97	0.97	0.98	0.93	0.91	0.95
28	0.93	0.91	0.96	0.92	0.89	0.94	0.90	0.87	0.94
29	0.93	0.90	0.95	0.95	0.93	0.96	0.78	0.66	0.93
30	0.75	0.62	0.91	0.88	0.85	0.91	0.75	0.66	0.84
May - 1	0.71	0.51	0.98	0.95	0.94	0.97	0.85	0.70	1.00
2	0.84	0.73	0.96	0.85	0.81	0.90	0.51	0.30	0.86
3	0.76	0.67	0.86	0.93	0.90	0.95	0.90	0.85	0.96
4	0.97	0.95	0.98	0.94	0.92	0.96	0.93	0.90	0.96
5	0.92	0.89	0.95	0.95	0.93	0.96	0.96	0.94	0.98
6	0.91	0.87	0.96	0.85	0.81	0.90	0.69	0.54	0.88
7	0.87	0.82	0.92	0.90	0.89	0.92	0.87	0.75	1.00
8	***0.93***	***0.87***	***0.98***	*<< Regression estimate*			0.89	0.81	0.98
9	***0.94***	***0.88***	***1.00***	*of S2 and S4*			0.95	0.93	0.98
10	***0.92***	***0.86***	***0.98***	*combined*			0.90	0.84	0.95
11	***0.92***	***0.86***	***0.98***				0.77	0.61	0.98
12	***0.94***	***0.88***	***1.00***				0.95	0.90	1.00
13	***0.94***	***0.88***	***1.00***				0.93	0.87	1.00
14	***0.93***	***0.88***	***0.99***				0.91	0.85	0.98
15	***0.89***	***0.83***	***0.95***				0.80	0.72	0.89
16	***0.92***	***0.86***	***0.98***				0.90	0.82	0.99
17	***0.95***	***0.87***	***1.00***				0.97	0.95	0.99
18	***0.94***	***0.88***	***1.00***				0.95	0.93	0.97
19	***0.94***	***0.88***	***1.00***				0.97	0.95	0.98
20	***0.94***	***0.88***	***1.00***				0.98	0.97	0.98
21	***0.95***	***0.89***	***1.00***				0.99	0.99	1.00
22	0.95	0.93	0.97	0.97	0.95	0.98	0.93	0.91	0.96
23	0.68	0.56	0.82	0.96	0.95	0.97	0.96	0.93	0.99
24	0.75	0.65	0.87	0.97	0.96	0.98	0.96	0.91	1.00
25	0.89	0.88	0.91	0.98	0.97	0.98	0.96	0.92	0.99
26	0.91	0.88	0.94	0.95	0.93	0.97	0.90	0.88	0.92

Wells Spring 1992 Horizontal Distribution of Bypass Efficiencies

	S8			S10		
Date	Ratio	Lower CI	Upper CI	Ratio	Lower CI	Upper CI
April - 17	0.78	0.70	0.87	0.74	0.62	0.87
18	0.69	0.57	0.83	0.71	0.64	0.79
19	0.54	0.36	0.79	0.76	0.69	0.84
20	0.42	0.33	0.54	0.28	0.16	0.48
21	0.79	0.69	0.89	0.69	0.48	0.99
22	0.89	0.82	0.96	0.90	0.84	0.96
23	0.73	0.66	0.80	0.81	0.70	0.93
24	0.57	0.38	0.86	0.95	0.92	0.98
25	0.80	0.77	0.83	0.80	0.76	0.83
26	0.68	0.62	0.75	0.92	0.87	0.97
27	0.74	0.69	0.79	0.81	0.75	0.87
28	0.78	0.73	0.84	0.96	0.94	0.98
29	0.81	0.77	0.86	0.93	0.91	0.95
30	0.72	0.66	0.78	0.71	0.63	0.81
May - 1	0.84	0.80	0.88	0.93	0.91	0.95
2	0.64	0.57	0.72	0.80	0.67	0.95
3	0.69	0.63	0.75	0.85	0.82	0.88
4	0.69	0.62	0.78	0.60	0.49	0.75
5	0.87	0.83	0.91	0.88	0.79	0.97
6	0.39	0.31	0.49	0.52	0.42	0.63
7	0.90	0.87	0.93	0.86	0.82	0.89
8	0.86	0.83	0.89	0.79	0.73	0.85
9	0.94	0.92	0.97	0.95	0.94	0.97
10	0.45	0.35	0.58	0.91	0.88	0.94
11	0.78	0.73	0.84	0.87	0.81	0.95
12	0.94	0.80	0.87	0.98	0.97	0.99
13	0.94	0.91	0.97	0.87	0.82	0.92
14	0.78	0.71	0.85	0.97	0.94	1.00
15	0.37	0.32	0.44	0.84	0.76	0.93
16	0.65	0.57	0.73	0.93	0.86	1.00
17	0.94	0.92	0.97	0.97	0.94	1.00
18	0.99	0.98	1.00	0.87	0.84	0.91
19	0.83	0.79	0.88	0.93	0.89	0.98
20	0.84	0.81	0.87	0.95	0.93	0.97
21	0.92	0.89	0.95	0.84	0.71	0.99
22	0.66	0.60	0.72	0.93	0.91	0.96
23	0.66	0.61	0.72	0.91	0.89	0.94
24	0.75	0.64	0.89	0.96	0.92	1.00
25	0.80	0.72	0.89	0.97	0.96	0.99
26	0.77	0.72	0.82	0.89	0.85	0.94

Wells Summer 1992 Horizontal Distribution of Bypass Efficiencies

	S2			S4			S6		
Date	Ratio	Lower CI	Upper CI	Ratio	Lower CI	Upper CI	Ratio	Lower CI	Upper CI
June - 26	0.91	0.83	1.00	0.97	0.95	0.99	0.93	0.92	0.94
27	0.84	0.72	0.99	0.95	0.93	0.97	0.93	0.91	0.94
28	0.85	0.72	0.99	0.97	0.94	1.00	0.92	0.89	0.94
29	0.98	0.96	0.99	0.92	0.87	0.98	0.94	0.92	0.95
30	0.94	0.90	0.98	0.98	0.97	1.00	0.94	0.92	0.97
July - 1	0.95	0.94	0.97	0.97	0.94	0.99	0.95	0.94	0.97
2	0.97	0.95	0.99	0.87	0.80	0.95	0.97	0.95	0.99
3	0.95	0.93	0.97	Not Operating			Not Operating		
4	0.96	0.91	1.00	Not Operating			Not Operating		
5	0.88	0.82	0.95	Not Operating			Not Operating		
6	Corrupted Data			0.99	0.97	1.00	Not Operating		
7	0.94	0.91	0.97	Not Operating			0.98	0.97	0.99
8	0.97	0.94	1.00	0.97	0.95	0.99	0.96	0.92	1.00
9	0.98	0.96	1.00	0.97	0.96	0.99	Not Operating		
10	0.93	0.85	1.00	0.98	0.97	0.99	0.97	0.95	0.98
11	Not Operating			0.97	0.94	1.00	Not Operating		
12	Not Operating			0.90	0.80	1.00	Not Operating		

	S8			S10		
Date	Ratio	Lower CI	Upper CI	Ratio	Lower CI	Upper CI
June - 26	0.79	0.74	0.84	0.80	0.70	0.92
27	0.76	0.73	0.80	0.82	0.76	0.89
28	0.84	0.81	0.87	0.88	0.80	0.98
29	0.86	0.83	0.90	0.91	0.86	0.97
30	0.94	0.92	0.96	0.97	0.95	0.98
July - 1	0.82	0.72	0.94	0.96	0.94	0.98
2	Not Operating			0.91	0.85	0.98
3	0.94	0.89	1.00	0.97	0.96	0.98
4	Not Operating			0.99	0.99	1.00
5	Not Operating			0.83	0.79	0.88
6	0.96	0.93	0.99	0.94	0.92	0.95
7	Not Operating			0.93	0.92	0.95
8	0.98	0.96	0.99	0.98	0.97	0.99
9	0.97	0.96	0.98	0.92	0.88	0.96
10	0.96	0.95	0.98	0.92	0.89	0.95
11	0.98	0.97	1.00	0.96	0.95	0.97
12	0.94	0.91	0.98	0.93	0.88	0.98

WELLS 1992 TURBINE HORIZONTAL DISTRIBUTION
(MEAN #/HR)

	SPRING	
Location	DAY	NIGHT
1a	13.15	17.27
1b	0.09	0.75
1c	0.60	9.97
2a	9.16	4.86
2b	1.54	3.00
2c	23.96	11.90
3a	13.27	10.21
3b	4.16	6.93
3c	1.04	1.49
4a	0.47	0.75
4b	11.90	9.96
4c	14.36	23.22
5a	10.26	12.42
5b	6.53	4.32
5c	12.90	9.42
6a	9.19	11.25
6b	5.87	1.90
7a	68.42	82.26
7b	4.19	3.39
7c	4.88	4.01
8a	4.78	6.91
8c	7.71	7.83
9b	2.80	5.07
9c	5.93	4.64
10a	3.58	4.43
10b	3.37	2.54
10c	26.40	16.85

	SUMMER	
Location	DAY	NIGHT
1b.	31.05	24.78
1c	31.64	14.54
2a	10.83	3.84
2b	3.03	3.37
3a	10.89	4.66
3b	2.51	7.35
3c	0.73	2.04
4a	0.15	0.36
4b	10.10	5.10
5a	45.33	17.52
5b	7.03	4.61
5c	12.74	13.02
6a	8.51	5.68
6b	1.18	1.98
7a	112.40	56.10
7b	1.20	4.10
7c	2.09	1.45
8a	6.18	4.99
8c	7.73	10.66
9b	7.10	3.56
9c	2.87	2.67
10a	1.83	2.06
10b	1.89	0.15
10c	31.56	16.88

WELLS 1992 BYPASS SLOT HORIZONTAL DISTRIBUTION
SPRING MEAN #/HR

	DAY	NIGHT
S2	451.62	475.89
S4	900.26	724.17
S6	589.54	819.22
S8	311.18	366.16
S10	209.98	390.03

WELLS 1992 BYPASS SLOT HORIZONTAL DISTRIBUTION
SUMMER MEAN #/HR

	DAY	NIGHT
S2	1294.68	707.08
S4	1716.31	1698.54
S6	1773.72	1045.84
S8	1248.30	949.04
S10	543.76	383.45

WELLS 1992 TURBINE DIEL DISTRIBUTIONS

SPRING		SUMMER	
START HOUR	MEAN#/HR	START HOUR	MEAN#/HR
0	11.950	0	7.602
1	12.317	1	3.646
2	6.415	2	3.216
3	7.273	3	5.321
4	6.957	4	5.856
5	8.201	5	7.880
6	8.913	6	7.637
7	11.795	7	11.665
8	10.427	8	15.339
9	11.895	9	13.733
10	10.909	10	13.134
11	10.589	11	19.884
12	11.356	12	23.141
13	10.113	13	20.951
14	10.180	14	10.948
15	11.146	15	11.927
16	12.192	16	11.307
17	10.052	17	12.291
18	9.918	18	19.245
19	11.097	19	13.845
20	13.501	20	13.588
21	17.970	21	14.001
22	14.353	22	12.827
23	11.097	23	11.260

WELLS 1992 BYPASS SLOT DIEL DISTRIBUTIONS

SPRING		SUMMER	
START HOUR	MEAN#/HR	START HOUR	MEAN#/HR
0	506.721	0	774.982
1	521.953	1	660.745
2	518.644	2	726.014
3	438.638	3	743.310
4	439.692	4	755.418
5	514.527	5	702.906
6	570.830	6	836.695
7	611.704	7	945.689
8	503.691	8	923.088
9	469.395	9	1188.173
10	497.630	10	1283.676
11	533.796	11	1468.317
12	509.498	12	1484.343
13	511.102	13	1344.063
14	416.352	14	1298.205
15	404.641	15	1227.092
16	508.049	16	1322.663
17	463.795	17	1330.773
18	479.710	18	1218.297
19	475.503	19	1113.954
20	603.480	20	1249.195
21	620.694	21	1182.097
22	655.155	22	1110.039
23	559.286	23	910.338

Wells 1992 Spring Slot Passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Bypass Unit Date	S2	S4	S6	S8	S10
Apr-17	338	4132	2632	1907	1568
18	0	2398	1542	1317	2981
19	-0-	4695	1317	809	3698
20	2740	9865	2044	1609	1444
21	973	5994	3850	2202	811
22	1651	3183	5301	2432	2734
23	946	5426	3565	3851	2103
24	260	10001	2837	2530	7121
25	-0-	18691	11651	16470	5157
26	16643	45168	8080	13235	5512
27	895	80120	11189	12531	3270
28	5075	19115	12384	11827	10332
29	16515	35550	13046	8804	15440
30	1435	11101	8064	6631	2897
May-01	719	21172	9510	10105	7450
2	539	5521	1451	2366	3723
3	2116	7290	3282	4322	7491
4	5309	6897	4176	2469	2018
5	9768	15081	10563	5928	3880
6	3065	5852	4332	1956	752
7	7318	24438	26935	11937	14844
8	4899	14443	9908	12446	8291
9	-0-	31062	7616	9966	16074
10	381	6995	4003	1291	4903
11	4074	6169	4901	6156	8093
12	7473	9388	13376	11857	10766
13	9200	12793	9745	7683	5804
14	9597	9079	8649	5825	7241
15	5141	4279	2426	2822	4540
16	1016	10406	4853	4214	3599
17	14655	28771	13537	12549	9000
18	4723	10589	17159	8553	4855
19	9446	8732	10635	5503	6100
20	18228	12029	28365	11287	8148
21	7990	9606	22156	8004	3234
22	11178	22472	38913	9134	7380
23	3728	43513	27801	10789	6236
24	1201	70627	21820	5377	22255
25	19257	92118	21495	6178	9354
26	7378	11479	13169	8322	3031

Wells 1992 spring turbine passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Turbine loc.	1A	1B	1C	2A	2B	2C	3A	3B	3C
Date									
Apr-17	117	0	0	-0-	-0-	-0-	0	0	52
18	0	0	0	-0-	-0-	-0-	22	79	0
19	0	0	0	-0-	-0-	-0-	22	79	0
20	360	0	0	-0-	-0-	-0-	115	74	0
21	117	0	48	-0-	-0-	-0-	21	0	25
22	94	0	50	-0-	-0-	-0-	42	0	0
23	291	13	0	-0-	-0-	-0-	193	112	0
24	232	44	38	-0-	-0-	-0-	63	218	0
25	35	0	0	-0-	-0-	-0-	676	189	65
26	2309	32	945	-0-	-0-	-0-	1067	406	127
27	-0-	-0-	-0-	173	41	156	613	530	156
28	-0-	-0-	-0-	184	14	250	365	327	26
29	-0-	-0-	-0-	254	69	696	550	189	74
30	-0-	-0-	-0-	72	88	193	373	0	27
May-01	-0-	-0-	-0-	0	50	220	238	170	13
2	-0-	-0-	-0-	60	0	231	215	189	0
3	-0-	-0-	-0-	76	28	416	128	0	0
4	-0-	-0-	-0-	91	14	164	109	0	0
5	-0-	-0-	-0-	17	56	617	107	0	0
6	-0-	-0-	-0-	78	69	189	187	0	0
7	-0-	-0-	-0-	236	111	328	275	33	34
8	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
9	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
10	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
11	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
12	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
13	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
14	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
15	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
16	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
17	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
18	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
19	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
20	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
21	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
22	-0-	-0-	-0-	143	21	202	316	64	0
23	-0-	-0-	-0-	344	158	377	318	69	0
24	-0-	-0-	-0-	290	43	55	275	210	88
25	-0-	-0-	-0-	377	29	2107	1019	137	28
26	-0-	-0-	-0-	276	0	686	21	167	34

Wells 1992 spring turbine passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Turbine loc. Date	4A	4B	4C	5A	5B	5C	6A	6B	6C
Apr-17	0	46	79	0	19	35	38	0	-0-
18	0	216	106	17	16	190	43	95	-0-
19	0	100	65	40	30	769	81	59	-0-
20	0	225	321	64	42	355	164	132	-0-
21	0	29	155	18	66	284	192	24	-0-
22	0	59	367	141	143	453	85	0	-0-
23	0	321	398	177	249	594	46	0	-0-
24	0	60	162	81	82	178	39	0	-0-
25	0	534	939	147	184	336	299	0	-0-
26	0	236	194	97	48	95	167	54	-0-
27	124	468	173	413	269	251	167	-0-	-0-
28	116	447	443	422	452	644	203	-0-	-0-
29	76	559	745	322	506	973	495	0	-0-
30	27	543	949	450	747	739	687	-0-	-0-
May-01	44	99	308	138	47	340	789	-0-	-0-
2	0	235	1052	63	85	96	300	-0-	-0-
3	0	179	359	139	21	58	46	0	-0-
4	0	179	219	158	34	127	113	31	-0-
5	0	145	441	105	92	196	75	-0-	-0-
6	0	141	441	412	204	450	548	-0-	-0-
7	73	263	1260	484	166	356	808	-0-	-0-
8	0	200	831	214	175	260	546	-0-	-0-
9	0	494	676	113	35	293	0	-0-	-0-
10	0	472	607	150	154	0	115	-0-	-0-
11	0	371	473	73	61	334	274	15	-0-
12	0	176	71	57	33	52	86	146	-0-
13	0	107	178	29	63	152	229	0	-0-
14	0	230	373	397	93	121	259	52	-0-
15	0	270	294	237	107	251	80	-0-	-0-
16	0	232	64	42	40	115	203	0	-0-
17	0	277	98	100	88	19	153	0	-0-
18	0	164	126	213	0	51	42	0	-0-
19	0	14	193	434	15	58	0	52	-0-
20	0	57	353	462	13	67	209	151	-0-
21	0	70	327	43	84	68	165	0	-0-
22	0	281	209	1684	204	307	426	-0-	-0-
23	0	641	1107	392	120	65	445	0	-0-
24	0	364	447	332	85	52	579	0	-0-
25	72	464	401	233	73	84	188	160	-0-
26	0	164	395	754	31	314	55	0	-0-

Wells 1992 spring turbine passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Turbine loc.	7A	7B	7C	8A	8B	8C	9A	9B	9C
Date									
Apr-17	462	25	22	0	-0-	67	-0-	23	84
18	527	139	127	0	-0-	47	-0-	69	314
19	309	73	330	0	-0-	13	-0-	139	185
20	571	130	832	143	-0-	554	-0-	434	1014
21	432	25	105	0	-0-	76	-0-	85	194
22	373	80	18	52	-0-	0	-0-	161	127
23	1026	293	171	100	-0-	34	-0-	24	47
24	365	114	24	72	-0-	117	-0-	0	0
25	3970	135	105	226	-0-	386	-0-	100	77
26	6852	143	72	139	-0-	359	-0-	170	90
27	3668	108	181	302	-0-	421	-0-	84	20
28	1660	77	148	360	-0-	438	-0-	55	0
29	1252	228	238	315	-0-	168	-0-	196	218
30	2253	189	378	292	-0-	224	-0-	223	74
May-01	1000	143	214	285	-0-	65	-0-	81	63
2	1415	175	152	62	-0-	118	-0-	92	401
3	1518	21	37	177	-0-	145	-0-	105	54
4	950	0	34	26	-0-	80	-0-	38	0
5	727	0	40	90	-0-	59	-0-	0	73
6	1930	78	85	165	-0-	89	-0-	0	54
7	1084	74	44	110	-0-	176	-0-	101	291
8	1271	275	15	140	-0-	177	-0-	123	0
9	369	75	0	0	-0-	64	-0-	0	32
10	1425	59	29	152	-0-	0	-0-	48	28
11	2265	160	61	226	-0-	198	-0-	49	304
12	1856	0	53	100	-0-	163	-0-	0	0
13	699	46	137	57	-0-	41	-0-	55	61
14	877	0	71	178	-0-	213	-0-	192	0
15	3339	122	191	105	-0-	461	-0-	183	63
16	2208	0	20	168	-0-	61	-0-	69	61
17	686	17	60	119	-0-	105	-0-	0	0
18	1160	98	35	68	-0-	272	-0-	75	41
19	941	38	16	136	-0-	220	-0-	22	114
20	1942	98	0	194	-0-	403	-0-	0	0
21	933	0	0	28	-0-	93	-0-	0	0
22	3961	71	55	197	-0-	167	-0-	138	87
23	7066	68	0	220	-0-	91	-0-	78	116
24	1541	19	15	41	-0-	284	-0-	108	0
25	738	81	0	30	-0-	345	-0-	97	0
26	2702	46	49	114	-0-	133	-0-	50	92

Wells 1992 spring turbine passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Turbine loc. Date	10A	10B	10C
Apr-17	21	0	791
18	163	62	996
19	112	18	372
20	604	30	467
21	172	0	0
22	23	0	29
23	62	30	0
24	126	0	679
25	25	73	1386
26	188	0	323
27	125	25	458
28	147	22	383
29	145	86	688
30	120	51	632
May-01	138	118	424
2	42	161	148
3	78	90	1183
4	23	107	1116
5	122	115	245
6	97	47	643
7	45	372	2183
8	45	243	1617
9	0	230	683
10	17	153	463
11	193	95	1023
12	39	0	238
13	98	116	78
14	65	98	55
15	12	53	383
16	19	30	112
17	107	0	133
18	125	17	243
19	22	48	108
20	0	96	729
21	30	15	243
22	25	56	378
23	44	12	293
24	27	34	339
25	61	0	232
26	95	0	215

Wells 1992 summer slot passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Bypass Unit Date	S2	S4	S6	S8	S10
Jun-26	16747	16788	34374	15330	2468
27	15082	12903	31689	10621	2655
28	6006	16194	37327	45217	8170
29	14385	7371	23400	16056	5396
30	12930	18018	17165	14767	11174
Jul-01	17151	8941	39256	4066	4365
2	10672	1743	15487	-0-	8486
3	14356	3783	-0-	1465	16534
4	8670	-0-	-0-	-0-	16384
5	19263	-0-	-0-	-0-	10893
6	42947	3358	-0-	18486	11041
7	41360	-0-	24475	156	15103
8	23998	6358	8310	7450	13461
9	58736	23093	-0-	35536	15874
10	24599	79466	30242	27931	12026
11	-0-	119840	-0-	41727	13393
12	511	70396	-0-	26258	6752

Wells 1992 summer turbine passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Turbine loc. Date	1A	1B	1C	2A	2B	2C	3A	3B	3C
Jun-26	-0-	1174	400	36	30	-0-	269	0	0
27	-0-	1659	407	121	104	-0-	181	165	32
28	-0-	851	339	13	26	-0-	153	114	49
29	-0-	62	263	113	57	-0-	109	181	48
30	-0-	323	200	29	111	-0-	190	0	66
Jul-01	-0-	135	444	90	78	-0-	220	0	0
2	-0-	98	179	63	28	-0-	181	155	0
3	-0-	260	100	64	70	-0-	43	0	0
4	-0-	352	0	48	16	-0-	-0-	-0-	-0-
5	-0-	270	880	388	26	-0-	-0-	-0-	-0-
6	-0-	284	3750	876	47	-0-	37	0	0
7	-0-	1177	880	566	270	-0-	0	0	0
8	-0-	806	55	77	36	-0-	181	37	0
9	-0-	905	147	111	59	-0-	120	52	57
10	-0-	1322	156	39	78	-0-	383	343	136
11	-0-	-0-	-0-	-0-	-0-	-0-	502	482	52
12	-0-	-0-	-0-	0	-0-	-0-	281	30	0

Turbine loc. Date	4A	4B	4C	5A	5B	5C	6A	6B	6C
Jun-26	0	179	-0-	1309	155	320	452	136	-0-
27	0	233	-0-	1802	185	365	363	49	-0-
28	0	391	-0-	1850	657	924	347	18	-0-
29	0	399	-0-	869	182	642	86	35	-0-
30	0	26	-0-	301	37	65	39	38	-0-
Jul-01	0	120	-0-	1724	159	211	195	0	-0-
2	0	0	-0-	89	35	98	92	81	-0-
3	0	0	-0-	0	37	30	151	0	-0-
4	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
5	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
6	0	0	-0-	0	14	0	37	0	-0-
7	47	26	-0-	211	156	215	327	55	-0-
8	0	0	-0-	72	0	333	81	0	-0-
9	28	152	-0-	0	0	30	0	0	-0-
10	0	387	-0-	1377	58	236	0	0	-0-
11	0	231	-0-	-0-	-0-	-0-	-0-	-0-	-0-
12	0	396	-0-	0	-0-	0	0	0	-0-

Wells 1992 summer turbine passage
(Total Weighted Fish/Hr)
(-0- Not Sampled)

Turbine loc.	7A	7B	7C	8A	8B	8C	9A	9B	9C
Date									
Jun-26	5353	66	0	276	-0-	162	-0-	156	107
27	3454	190	18	139	-0-	177	-0-	77	113
28	9312	-0-	252	1050	-0-	941	-0-	317	-0-
29	3450	0	0	100	-0-	102	-0-	137	0
30	500	105	17	58	-0-	167	-0-	49	56
Jul-01	1117	39	16	0	-0-	0	-0-	19	22
2	95	42	0	0	-0-	0	-0-	68	0
3	38	0	37	15	-0-	0	-0-	18	34
4		-0-	-0-	-0-	-0-	-0-	-0-	153	0
5	-0-	-0-	-0-	-0-	-0-	-0-	-0-	220	0
6	479	97	16	40	-0-	283	-0-	50	84
7	39	16	84	0	-0-	80	-0-	164	124
8	233	0	0	0	-0-	18	-0-	22	107
9	1141	86	21	114	-0-	182	-0-	338	28
10	1321	21	117	0	-0-	116	-0-	167	32
11	948	14	0	13	-0-	304	-0-	87	71
12	1727	0	20	53	-0-	384	-0-	0	26

Turbine loc.	10A	10B	10C
Date			
Jun-26	22	0	63
27	19	15	406
28	14	34	623
29	63	0	269
30	46	0	300
Jul-01	29	57	136
2	72	0	496
3	60	60	558
4	0	12	164
5	0	60	1618
6	0	0	760
7	104	116	1049
8	0	0	320
9	124	0	873
10	100	62	792
11	22	15	556
12	0	0	350

FYKE NETTING

AT

WELLS DAM IN 1992

APPENDIX - D

Fyke Netting at Wells Dam, 1992

Rick Klinge, Fisheries Biologist
Douglas County Public Utility District No. 1
East Wenatchee, Washington

December 1992

During the spring and summer months, the Wells Hydroelectric Project operates a bypass system to protect migrating salmonids (smolts) in route to the Pacific Ocean. The bypass at Wells takes advantage of the unique hydrocombine design of the dam. Conventional dams on the Columbia have separate areas for spill and power generation. The hydrocombine design has intake for the spill gates located directly above the turbine intakes. Five of the eleven spill bay intakes at Wells have been partially constricted, leaving a vertical opening or slot sixteen feet wide and approximately seventy feet deep (Figure 2). Spill gates opened one foot provides the necessary water velocities at the vertical slot sufficient to attract, guide and safely pass smolts. The bypass and its operations at Wells have been developed under the consultation of Joint Fisheries Parties comprised of various State and Federal fisheries agencies and tribe.

The evaluation of the bypass system in 1992 was the third year of a three year evaluation of fish passage efficiency (FPE). The evaluation was made via hydroacoustic sampling of fish passing Wells. Calculations are made of the numbers of fish migrating through bypass spill and through turbines flow. The percent of the fish that use the bypass is called fish passage efficiency (FPE).

While the hydroacoustic sampling shows the presence of fish, the fyke netting verifies what species are present. Several years of hydroacoustic and fyke net sampling have shown the migration of three species of salmonids at Wells occurs over several months. The migration is divided into two distinct periods; a spring migration and a summer migration. Earliest migrants are spring chinook, followed by steelhead and sockeye. Summer chinook smolts start their migration around the first week in July. Fish from both the spring and summer periods are composed of hatchery and wild migrants.

Hydroacoustic Index of Fish Passage

Hydroacoustic monitoring of presence of fish began on April 2. Four transducers sampled the Wells forebay for presence of fish. A day index samples between 1:00 PM and 5:00 PM and an evening index sampled between 10:00 PM and 2:00 AM. Index values are used to start bypass operation. Fyke netting a turbine intake provided species composition of the fish detected by hydroacoustic equipment.

The hydroacoustic index of the forebay showed a moderate rise and drop the first week of April with a peak reached on April 7. The index climbed again on April 14, 15 and 16. The bypass operation was initiated on April 16 at 8:00 P.M. in anticipation of the arrival of spring chinook from the Winthrop National Hatchery at Wells (Figure 3). The collection of this index was interrupted because of the need to use hydroacoustic equipment for the spring evaluation of the bypass system. The index was resumed on May 27. The index was at a moderately high level at the beginning of the month of June in 1992. In previous years the index would be low in June marking the completion of the spring migration. The index would build in July as summer chinook migrants reach the dam. In 1992, the index remained high and climbed to a peak on June 9. Fyke net samples helped adjust the index to reflect the status of migrating salmonids. Non-salmonids (ie, minnows, squawfish, and suckers) also are moving in the reservoir and affect the hydroacoustic index. The adjusted index is used to determine the start and end of the summer bypass season. Spring bypass season ended on June 23 at 6:00 A.M.

Summer bypass operations were initiated on June 23 at 10:00 P.M. when the index signified the presence of chinook migrants. An evaluation of the bypass for the summer migration was initiate on June 25 and ran for fifteen days. The summer bypass operations were closed on August 3 when the adjusted index showed the migration of juvenile summer chinook was finished.

Fyke Netting

Fyke netting collected fish between 10 P.M. and 7 A.M. the following morning. Sampling was done with 3/8 inch mesh fyke nets (7 feet by 6 feet) with 1/4 inch mesh cod end. Seven fyke nets in a column were attached to a metal frame that was lowered into a turbine gate slot. Turbine bay 6C was selected for fyke net in 1992. Sampling effort was reduced when there was a likelihood of collecting more than 200 salmonids. The effort was reduced by decrease the number of nets. An additional step to reduce sampling mortality was to delayed fyke netting from early April to mid May.

Fyke netting was started on May 27 and continued weekly through August 12. The catch and amount of effort is on Table 1. Catches were greatest for chinook yearlings on June 8. Adipose fin clipped yearling chinook were saved for later coded wire tag recovery and tag identification. A total of 291 adipose clipped yearling chinook were captured. Adipose clipped fish made up 59% of the yearling chinook captured in the fyke nets. Zero aged chinook (0′s) contributed the highest catches in mid- June. The absence of both sockeye and steelhead in this years fyke net catches is unusual. The absence of sockeye and steelhead may be partially due the fact that fyke netting started late in the spring migration at the end of the migration of these fish. This years sockeye were progeny of the 1990 return of Okanogan sockeye. That year less than 7,597 adult sockeye were counted at Wells Dam in route to spawning areas. The 10 year average (1983-1992) return size of this population is 36,378. The 1990 return was the second smallest return of sockeye since adult counts have been made in the fish ladders since 1967.

Table 1. Fyke net results from Wells Dam, 1992.

Date	No. Nets	Total Salmonids	---Chinook--		Sock	Sthd	non-salmonid	Percent Salmonid
			1+	0's				
May 27	4	44	43	1	0	0	34	61%
June 3	4	49	48	1	0	0	41	55%
June 8	7	268	253	15	0	0	87	77%
June 10	3	45	37	8	0	0	47	53%
June 15	4	17	6	11	0	0	20	50%
June 17	7	40	18	22	0	0	85	50%
June 22	7	68	14	54	0	0	68	54%
June 30	7	45	12	33	0	0	85	41%
July 8	7	88	57	31	0	0	24	82%
July 15	7	23	6	17	0	0	23	51%
July 22	7	18	0	18	0	0	38	39%
July 29	7	12	0	12	0	0	25	33%
Aug 5	7	2	0	2	0	0	14	14%
Aug 12	7	0	0	0	0	0	8	7%*
		Totals	494	225	0	0	599	

Note: Non-salmonids include lamprey ammocoete which will are not detected by hydroacoustic equipment. The lamprey numbers are excluded from the calculations of pecent salmonids since this number adjusts the hydroacoustic index.

* Percent salmonids for Aug 12 was averaged between Aug 5 and Aug 12.

Figure 1. Location of Wells Dam

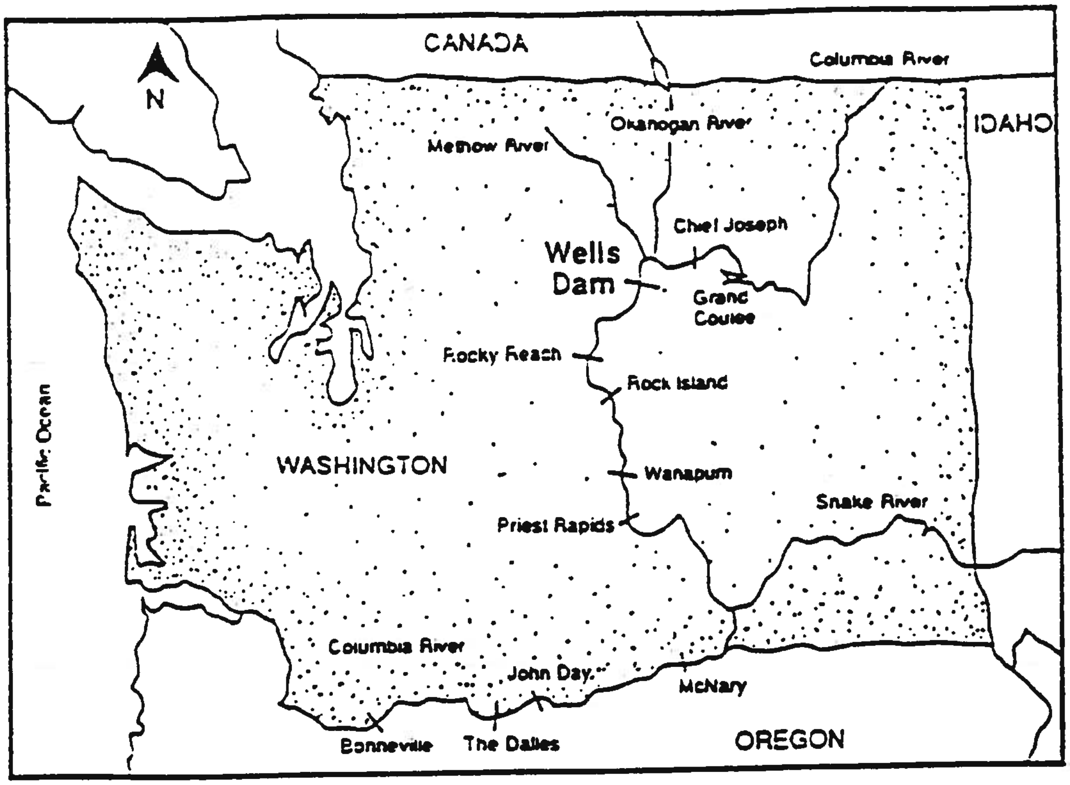
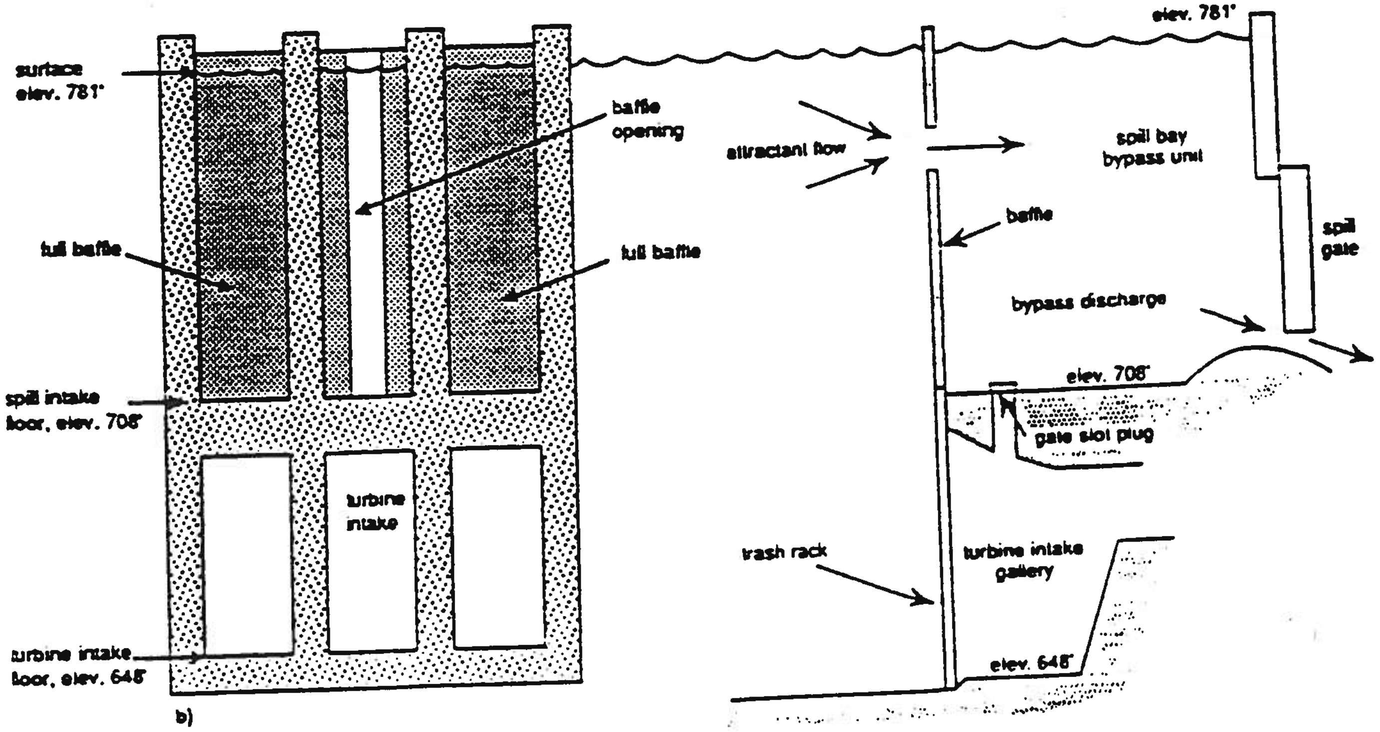


Figure 2. Head on and side view of bypass system and turbine intake at Wells Dam.



HYDROACOUSTIC EVALUATION OF ADULT SOCKEYE SALMON PASSAGE AT ZOSEL DAM IN 1991;

DRAFT REPORT

APPENDIX - E

Hydroacoustic Evaluation of Adult Sockeye Salmon Passage at Zosel Dam in 1991

Draft Report

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January 28, 1991

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1.0 INTRODUCTION

1.1 Background

A natural stock of sockeye salmon (*Oncorhynchus nerka*) migrates up the Columbia River to the Okanogan River to spawning grounds above Lake Osoyoos. Enumeration of Okanagon sockeye historically has been conducted at Rocky Reach and Wells dams (Duree 1991). These fish also pass through Zosel Dam near the outlet of Lake Osoyoos. Zosel Dam is a convenient location to count migrant sockeye because of its proximity to the spawning grounds and its structure includes fishways. Gaining a greater understanding of adult Okanogan sockeye migration timing and magnitude is important because these fish reproduce in the wild and are one of the few sockeye stocks remaining in the Columbia Basin (Pratt *et al.* 1991).

1.2 Objectives

From August 20 to October 20, 1991, a scientific hydroacoustic system was deployed at Zosel Dam. Because hydroacoustic techniques had not been used at Zosel Dam previously to count adult sockeye, a two-phased study was performed. In Phase 1, the objective was to determine if acoustic techniques would work. If acoustics would work, then the objective of Phase 2 was to estimate the following features of the adult sockeye upmigration past Zosel Dam:

- Run size
- Daily counts (run timing)
- Diel distribution
- Horizontal distribution

1.3 Study Site Description

Zosel Dam is located on the Okanagon River at Oroville, Washington (Figure 1). It is approximately two miles downstream from the outlet of Lake Osoyoos and 20 miles downstream from the Okanagon sockeye spawning grounds. There are no major rivers between the dam and the spawning grounds.

Construction of the dam was completed in 1987. It was built to replace a wood and concrete dam which dated back to 1927. The original dam created a log storage pond for the adjacent lumber yard. The present dam functions solely to regulate the water level of Lake Osoyoos. Zosel Dam is owned by the Washington State Department of Ecology and operated by the Oroville-Tonasket Irrigation District (OTID).

Zosel Dam has four spillgates, two fishways (east and west), and an overflow weir (Figure 2). The spillgates are 29 feet wide. Each fishway has one upstream exit and two downstream entrances. The upstream exits on the face of the dam are oriented toward the river bank. The two downstream entrances differ in size and orientation to the river. The larger entrance is located at the end of the fishway with the exiting water flowing in the same direction as that of the river. This opening is approximately one foot wide and extends from the dam sill to the deck of the fishway. A smaller entrance (1.5 by 2 ft) is located in the inner wall of each fishway. The smaller entrances have gates to regulate flow. During the study, when fishway sidegates were completely open, the upper edge of the entrance was just below the surface of tailrace water. The fishways are located adjacent to each end of the spillway.

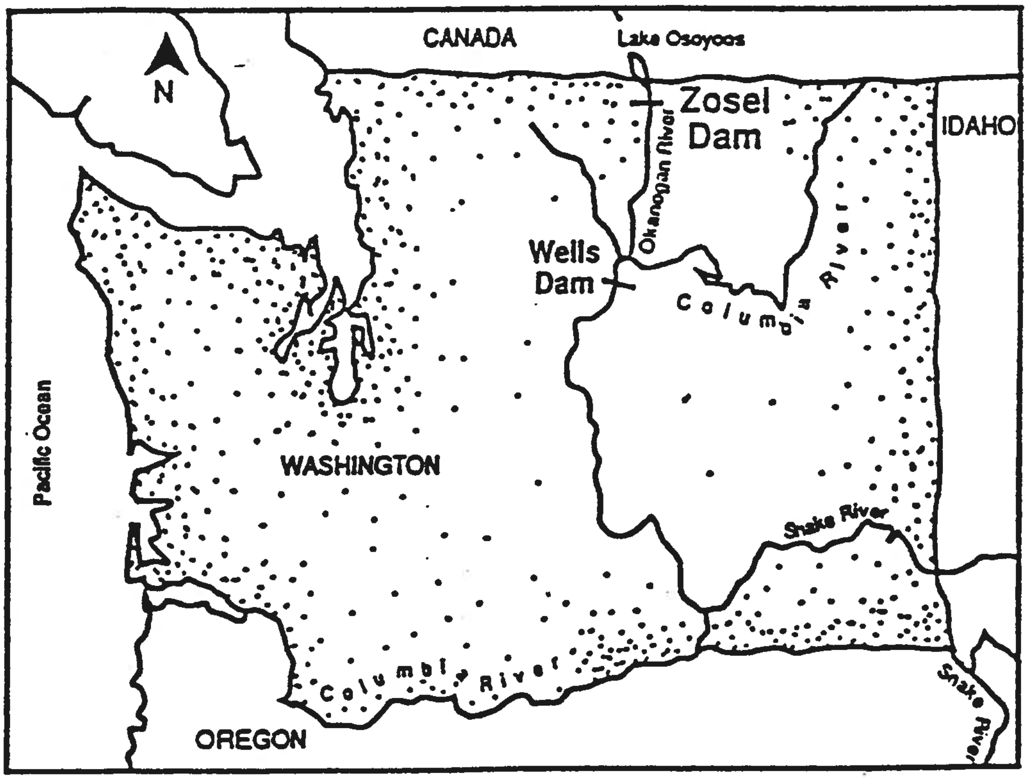

Figure 1. Location of Zosel Dam on the Okanagon River.

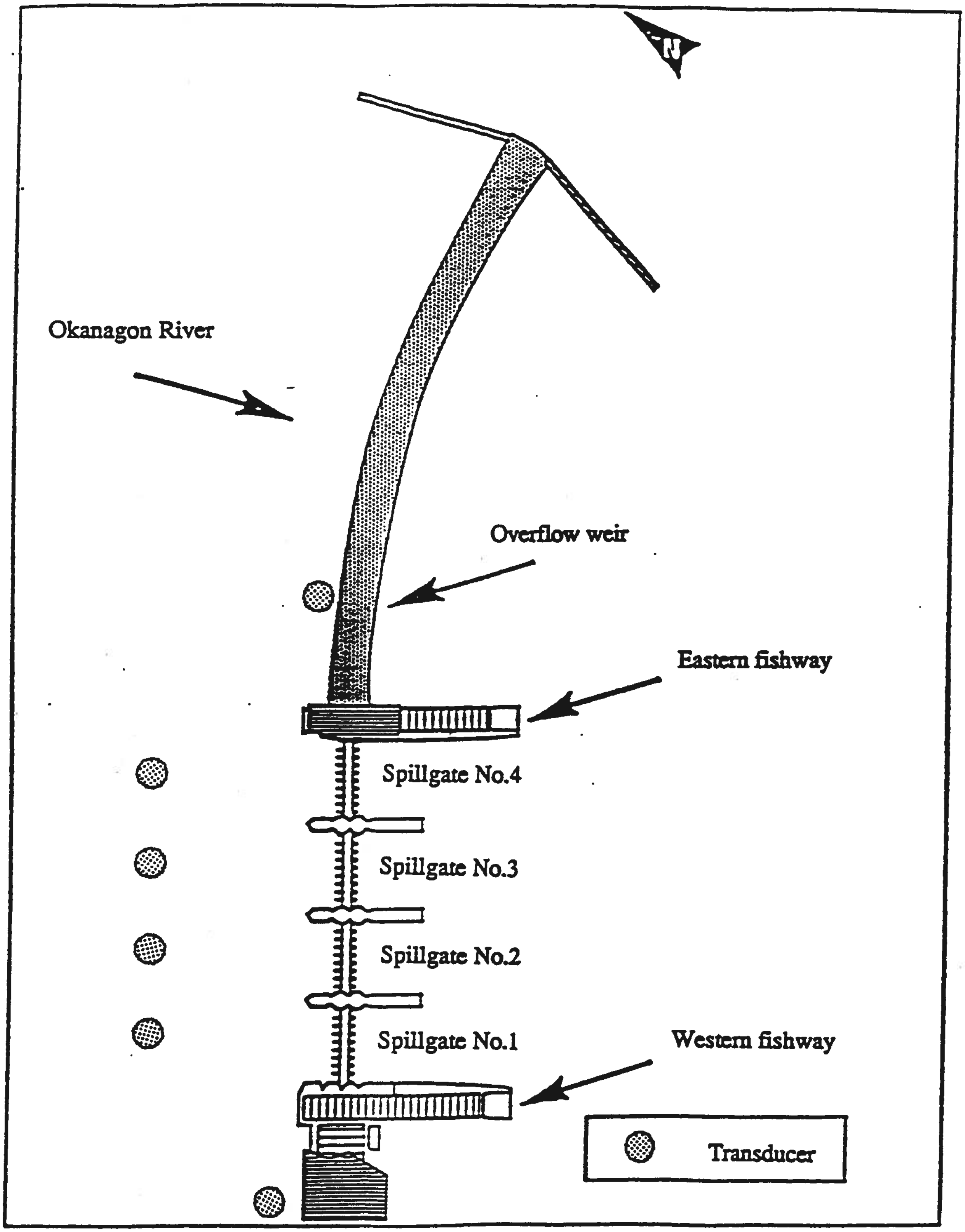

Figure 2. Plan view showing locations of transducers at Zosel Dam in 1991.

2.0 METHODS

2.1 General Approach

We used a phased approach for this study. In Phase 1, we deployed a hydroacoustic system and assessed its ability to detect adult sockeye. In Phase 2, we monitored passage of adult sockeye salmon at Zosel Dam.

During routine monitoring in Phase 2, we used hydroacoustic techniques coupled with extensive visual observations and temperature data. We observed sockeye and resident fish visually from the deck of the dam. We also utilized a temporary viewing background that was placed immediately outside of the western fishway. This white plastic background was monitored at times during daylight and darkness. And, by snorkeling in the forebay and tailrace, we observed fish from underwater. We also made qualitative surveys of sockeye salmon at the spawning grounds to confirm that sockeye had passed Zosel Dam. Grant County PUD (GCPUD) did quantitative surveys of the spawning grounds. Douglas County PUD (DCPUD) collected temperature data at Wells Dam, Okanogan River Mile 6, and Zosel Dam forebay. Visual observations and temperature data coupled with the hydroacoustic counts provided a comprehensive study approach.

2.2 Hydroacoustic Methods

We used fixed-location hydroacoustic techniques to monitor adult passage at Zosel Dam in 1991. The techniques used were similar to those employed at Wells Dam (Kudera *et al.* 1991) and are explained by Thorne and Johnson (1992). Operation of BioSonics hydroacoustic systems, reduction of data, and calculation of primary statistics are detailed in Appendix A.

2.2.1 Hydroacoustic System

The BioSonics scientific hydroacoustic system (Figure 3) consisted of: ES2000 Sounder/Multiplexer; transducers; cables; Model 281 Echo Signal Processor (ESP); Model 111 Thermal Chart Recorder; Compaq 386 computer; and Hitachi oscilloscope. We deployed 4X15 deg elliptical and 6 deg circular transducers. The voltages from the ES2000 Sounder were processed in real-time by the Model 281 ESP. The data files created by the ESP were analyzed after the field season.

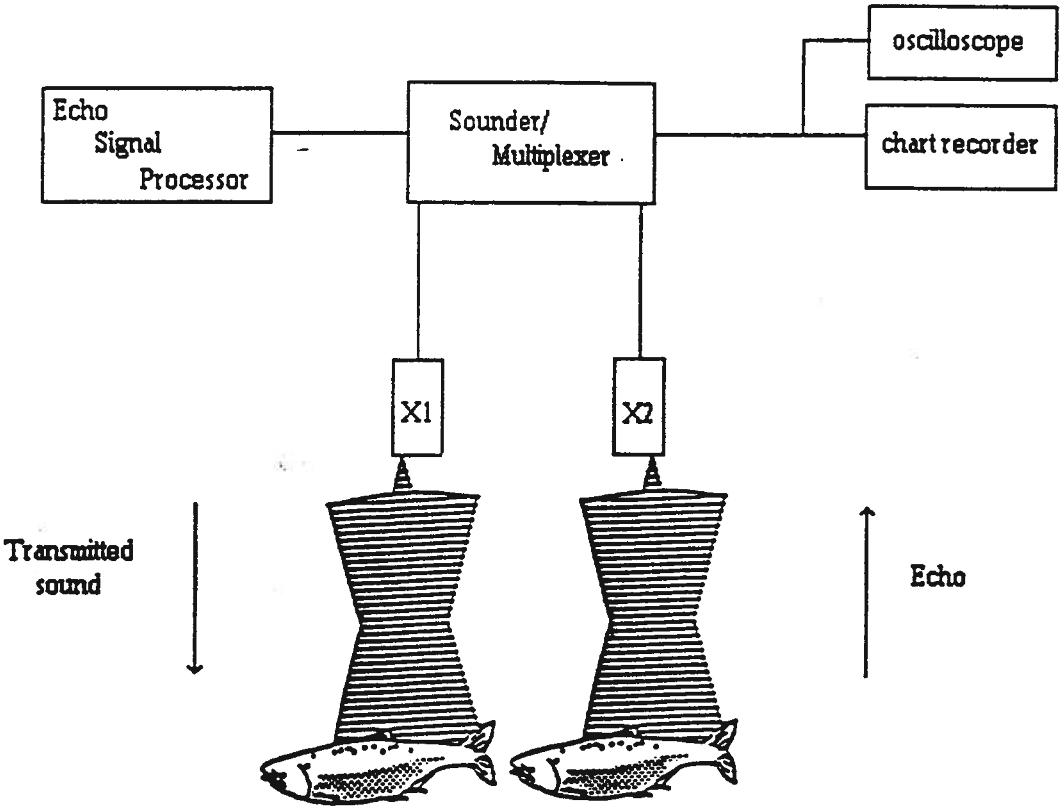

Figure 3. Block diagram of hydroacoustic data collection system used at Zosel Dam between August 31 and October 20, 1991.

2.2.2 Transducer Locations and Orientations

To monitor sockeye salmon passage through Zosel Dam, all dam openings (two fishways and four spillgates) were equipped with hydroacoustic equipment. This was done to ensure that any changes in dam operation, during the study, would not adversely affect data collection. Transducers were deployed in the forebay of the dam to monitor passage in the spillway and on the dam face to monitor passage at the fishway exits.

In the forebay, four transducers (4X15 deg) were mounted about 1 ft deep on the bottom of floats which were attached to a nylon line stretching across the forebay approximately 50 ft from the dam. The forebay transducers were aimed downstream, 5 deg down from the surface, toward the spillgate openings. To enable these transducers to achieve the correct range, a large amount of milfoil had to be manually removed from the forebay. It was necessary to deploy transducers to sample the spillgates because adult sockeye were seen passing Zosel Dam via the spillway during high flows in 1990 (BioSonics 1991).

Our strategy for sampling the fishways was to position the acoustic beam to detect fish as they exited the fishway (Figures 2, 4, and 5). At the western fishway, a transducer (6 deg) was fastened to a pole-mount and bolted onto the forebay wall 9 meters from the fishway exit (Figure 5a). The transducer was aimed at an angle of 0 deg relative to the surface and downstream toward the exit. At the eastern fishway, a transducer (6 deg) was attached to a pole-mount and bolted onto the overflow weir 9 meters from the fishway exit (Figure 5b). The transducer was aimed at an angle of 0 deg relative to the surface and slightly upstream from the face of the overflow weir. Both fishway transducers were aimed in such a way to give change in range information for discriminating upstream moving fish from downstream moving fish (Figure 6).

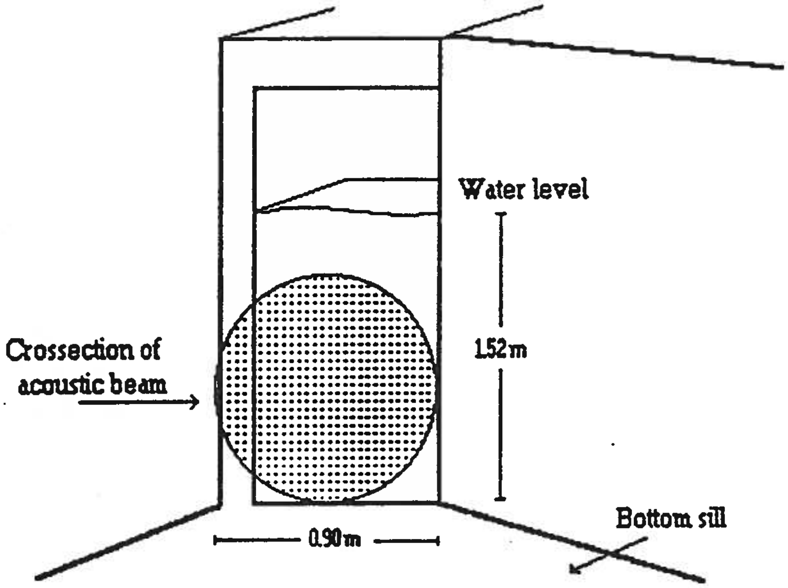

Figure 4. Front view of western fishway opening, showing ensonified cross-section (drawing not to scale).

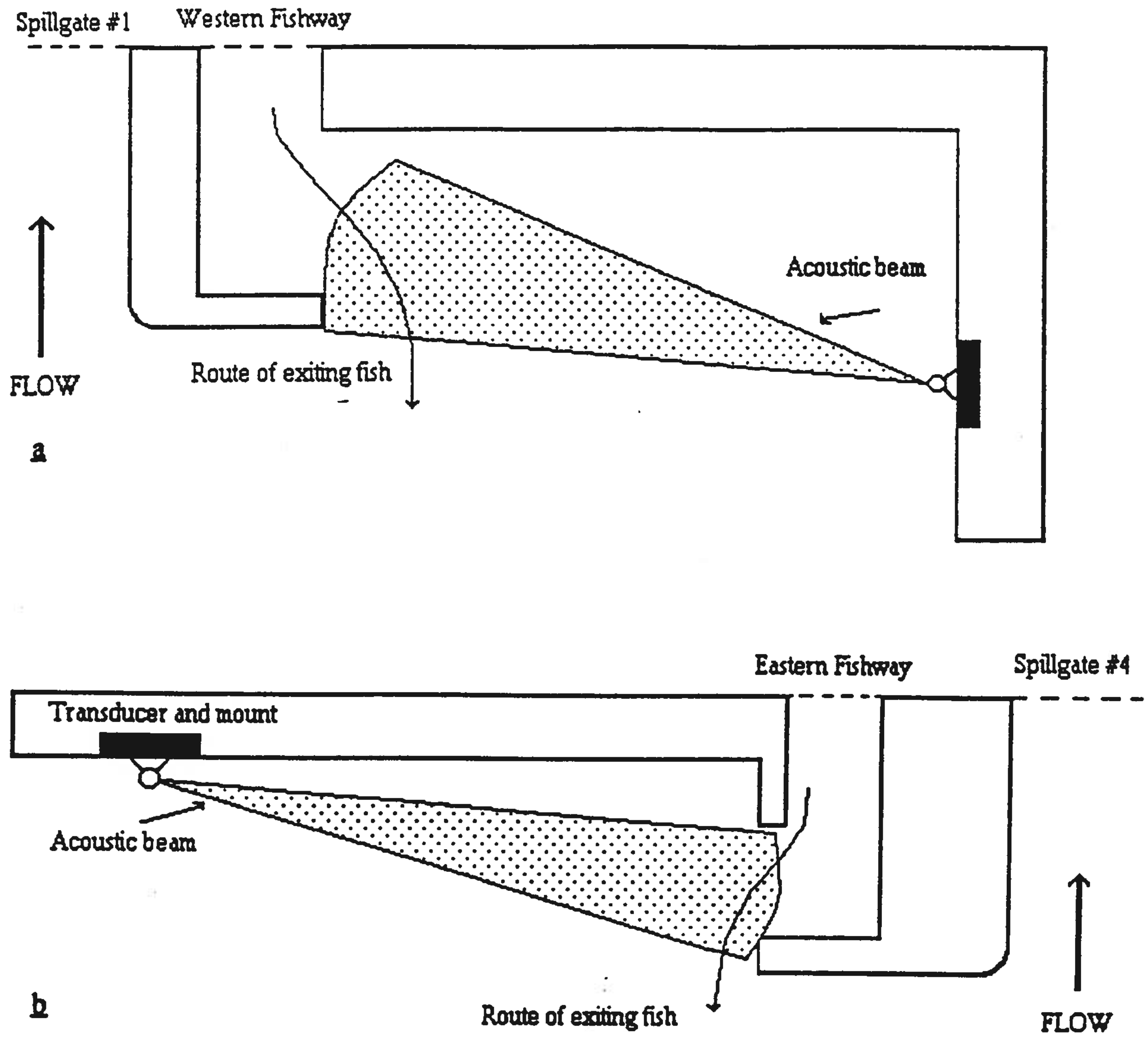

Figure 5. Topview of western and eastern fishways, showing appoximate beam angles and travel direction of exiting fish (drawing not to scale. (a=Western Fishway, b=Eastern fishway).

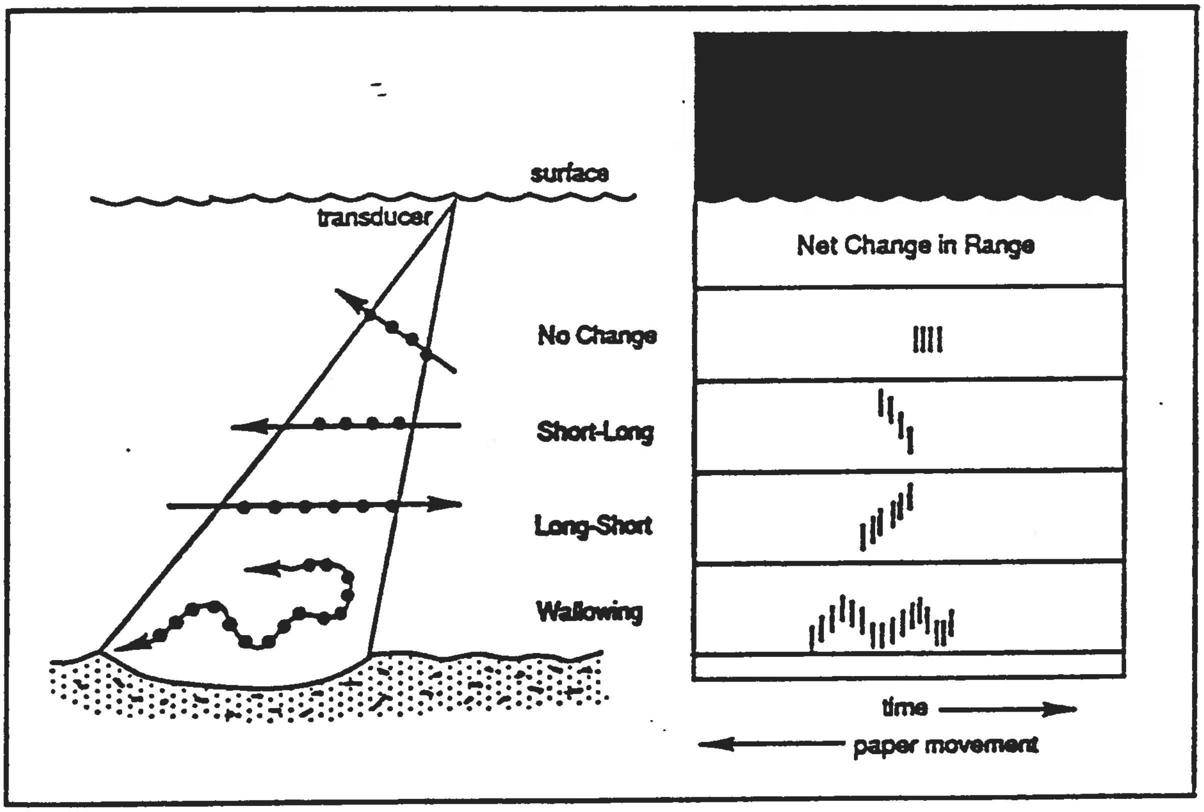

Figure 6. Fish behavior in the acoustic beam of a transducer (left) results in distinct traces on the chart recorder, or echogram (right). The change in range on the echogram traces indicates changing distances of the fish from the transducer. Arrows indicate the path ensonifications, or "pings," each leaving a mark on the echogram.

2.2.3 Sampling Design

Samples were collected 60 min per hour, 24 hours per day from August 31 to October 20, 1991. There were, however, minor stoppages in sampling due to unforeseen complications such as broken cables caused by foraging muskrats.

The hydroacoustic system was programmed to monitor one transducer for a given period of time (5 to 15 min per interrogation), and then switch to the next transducer in the sequence. At the beginning of the study, both fishways and the western-most spillgate (Spillgate No. 1) were included in the sampling sequence (Table 1). All other spillway gates were closed at this time and remained closed throughout the study. Because more fish were seen in the area of the western spillgate and fishway, starting on September 6 , the western fishway was sampled more intensively than any other location (Table 1). After careful analysis of acoustic and visual information, it was determined that there was no passage of salmon through Spillgate No. 1, so on September 20 we removed this transducer from the sampling sequence. Only information acquired from the fishway transducers was used in the data analysis.

Table 1. Sample minutes per location per hour and dates of changes in sampling design for the hydroacoustic study at Zosel Dam in summer 1991. (X1=western fishway, X2=eastern fishway, X3=westernmost spillgate).

Date of Change	Time of Change	X1	X2	X3
8/30/91	0000	20	20	20
9/06/91	0930	30	15	15
9/16/91	1440	30	10	20
9/17/91	0220	30	15	15
9/17/91	1800	30	15	15
9/18/91	0900	30	30	----
9/18/91	1600	30	15	15
9/20/91	1110	40	20	----
10/06/91	1420	35	25	----
10/20/91	2359	35	25	----

2.2.4 Data Analysis

The ESP was programmed with location specific parameters for tracking adult sockeye salmon moving through the ensonified areas. These parameters were determined after extensive visual and electronic observation of fish movement. The selection criteria used to track salmon and eliminate non-target traces, while data was initially collected, consisted of four primary parameters:

- Absolute concentration of echoes.
- Concentration of echoes by range.
- Absolute number of echoes from the target.
- Tracked target trajectory through the acoustic beam.

Refer to the Appendix A.2.2 for definition of these and other system parameters. Data for each individual tracked fish were written to computer file automatically. Data files were generated for each day of the study.

To account for unsampled time and cross-sectional area of a fishway exit, each raw tracked fish count was multiplied by a weighting coefficient (Appendix A.3). The basic data set then became hourly weighted fish counts for each day for each fishway during the study. These values were then used to meet the objectives of the study as follows:

- Run size = sum of the daily total passage estimates during the study.
- Daily counts (run timing) = sum of hourly passage estimates for both fishways combined for each day of the study separately.
- Diel distribution = average hourly passage estimates for each of 24 hours separately for both fishways combined during the entire study.
- Horizontal distribution = average hourly passage rate estimates for each fishway separately during the entire study.

3.0 RESULTS

3.1 Dam Operations

There were minor adjustments in spillgate height and sidegate openings during the 1991 study (Table 2). The western most spillgate was the only gate used during the study period for lake level management. During the study, water level was maintained at an average elevation of 911.37 ft MSL, resulting in a water depth of 5 feet over the upstream sill of the dam. On September 17 and 18, Spillgate No. 1 was closed to allow construction of a spawning area downstream from the dam. The western fishway sidegate was completely open during the study period, while the eastern sidegate was not opened until September 11, 1991.

Table 2. Changes in spillgate height at Zosel Dam between August 30 and October 20, 1991. During this period, only the western most spillgate (No. 1) was open; all others were completely closed. Source: T. Scott (OTID).

Date of Change	Time of Change	Gate Height (in.)	CFS
8/31/91	1902	9.0	274
9/01/91	0745	7.5	345
9/06/91	1051	6.0	301
9/11/91	1300	6.5	284
9/13/91	1500	7.5	309
9/14/91	1705	8.5	339
9/16/91	2000	10.0	484
9/17/91	0800	0.0	349
9/18/91	2005	8.0	195
9/19/91	0745	0.0	218
9/19/91	0759	6.0	218
9/19/91	1650	4.0	218
9/20/91	1300	5.0	247
10/06/91	1230	6.5	271
10/08/91	1030	9.0	336
10/11/91	0900	8.0	350
10/14/91	1400	7.0	325
10/18/91	0954	6.0	285

3.2 Environmental Information

River water temperature data from thermistors located at Wells Dam pool, Okanagon River Mile 6, and the log boom in the forebay of Zosel Dam show that temperatures exceeded 22 deg C in the Okanogan in mid-late August (Figure 7). Temperature data from the Zosel Dam thermistor, reflects the flushing of warm surface waters from Lake Osoyoos into the Okanagon River. Prolonged temperatures above 22 deg C may be lethal for adult sockeye (Bouck *et al.* 1975). The temperature data will be discussed in Section 4.0 in context with the run timing data.

3.3 Visual Observations

3.3.1 Resident Fish

Due to the similarity in size of some resident fish and the migrating adult sockeye, concern was expressed about misinterpreting resident fish as salmon. To assess this potential problem, we visually observed fish and their behavior in the acoustic sampling area. We saw the following resident fish at Zosel Dam in summer 1991: carp (*Cyprinus spp.*), squawfish (*Ptychocheilus spp.*), bass (*Micropterus spp.*), yellow perch (*Perca flavescens*), sunfish (*Lepomis spp.*), and suckers (*Catostomus spp.*). We found that the angle of the sun upon the river influenced greatly the ability to see any fish in the water; optimal lighting conditions occurred between 1300 and 1700 hours.

Some resident fish were observed in the area of the fishways. One small squawfish was observed maintaining position in the eastern fishway opening. Smallmouth bass and yellow perch were seen in schools near the opening of the western fishway. Suckers were frequently seen in the area of the western fishway exit scouring the algae-covered walls and bottom sill. But, because the suckers and squawfish were relatively stationary, the ESP excluded them from the data file. The only observed incidence of a resident fish actively exiting a fishway was a carp at the western fishway. Based on our extensive visual observations, upstream movement of resident fish in the fishways was considered negligible when we calculated sockeye passage rates.

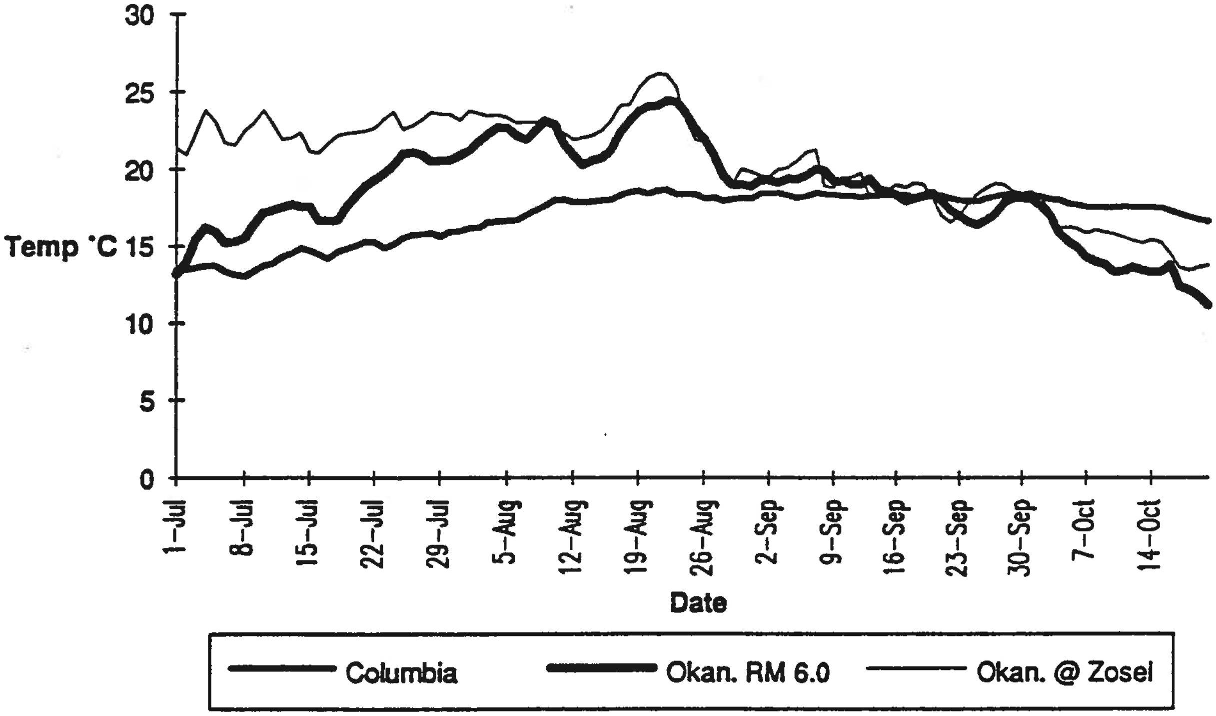

Figure 7. Temperature at three gauges along the Columbia and Okanagon rivers, between July 1 and October 20, 1991. Source: R. Klinge (DCPUD).

3.3.2 Sockeye Salmon Observations

The first known observation of adult sockeye salmon in 1991 around Zosel Dam was made by a worker at the lumber yard next to the dam. The employee reportedly saw an adult sockeye salmon below the dam during the first week of August, 1991. Later in August after the acoustic system was installed, the system operator saw a salmon catapulting itself toward the western most spillgate (No. 1). We observed sockeye salmon exhibiting upstream migrant behavior, such as jumping at the spillgate or maintaining a position on the sill behind the spillgate, repeatedly in the first two weeks of the data collection period (August 31 to September 14, 1991). The greatest number of adult sockeye salmon were visually observed between September 12th and 14th, 1991. During this period, schools of 20 to 30 salmon were seen in the tailrace. After this time, however, this activity was not seen. We did continue to see salmon milling near the surface of the water, but they were not exhibiting the pronounced upstream migrant behavior to the degree that we witnessed earlier. During the remainder of the study, we saw variable numbers of sockeye salmon in the tailrace. At no time during the course of the study period did the water above or below the dam appear to be teaming with adult sockeye salmon.

Salmon were seen near entrances to the fishways. Observations of fish movement was aided by the white plastic background in the western fishway, but relatively low numbers of salmon during the study made it extremely difficult to see salmon passing on a regular basis. An adult salmon, however, was seen exiting the western fishway on August 29, 1991. This was the only sighting of an exiting salmon.

At Wells Dam on the Columbia River, sockeye salmon were seen between July 1 and October 10 (Figure 8). The greatest single day passage occurred on July 26 when 2,301 sockeye passed Wells Dam. A total of 27,492 sockeye salmon passed through Wells Dam (R. Klinge, Douglas County PUD, pers. comm.).

At the spawning grounds above Oliver, B.C. we observed sockeye salmon during our informal surveys on October 6 and later dates. Our final survey on October 20 revealed that salmon were still present in the spawning grounds. The post-spawn count at the spawning grounds above Zosel Dam was 7,830 sockeye salmon (C. Carlson, Grant County PUD, pers. comm.). It was estimated that an addtional 2,000 sockeye salmon remained on the spawning grounds at the conclusion of the spawning ground survey. These salmon had not yet spawned and therefore were not included in final count.

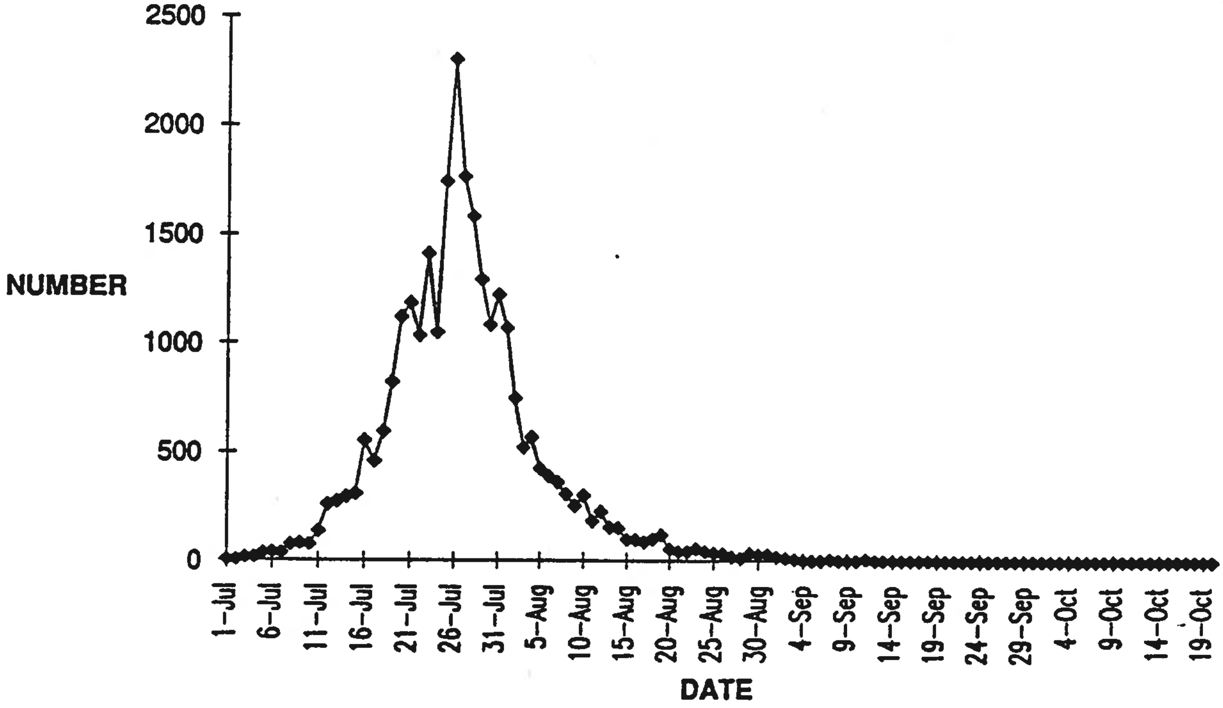

Figure 8. Daily counts of sockeye salmon passage at Wells Dam between July 1 and October 20, 1991. Source: R. Klinge (DCPUD).

3.4 Hydroacoustic Data

3.4.1 Phase 1 Feasibility

After the hydroacoustic system was deployed, we found that migrant salmon could be sampled exiting the fishways. Our detectability tests were successful; we saw active migrant traces on the echograms and in the computer files (Figure 9). Thus, we decided to proceed with routine monitoring.

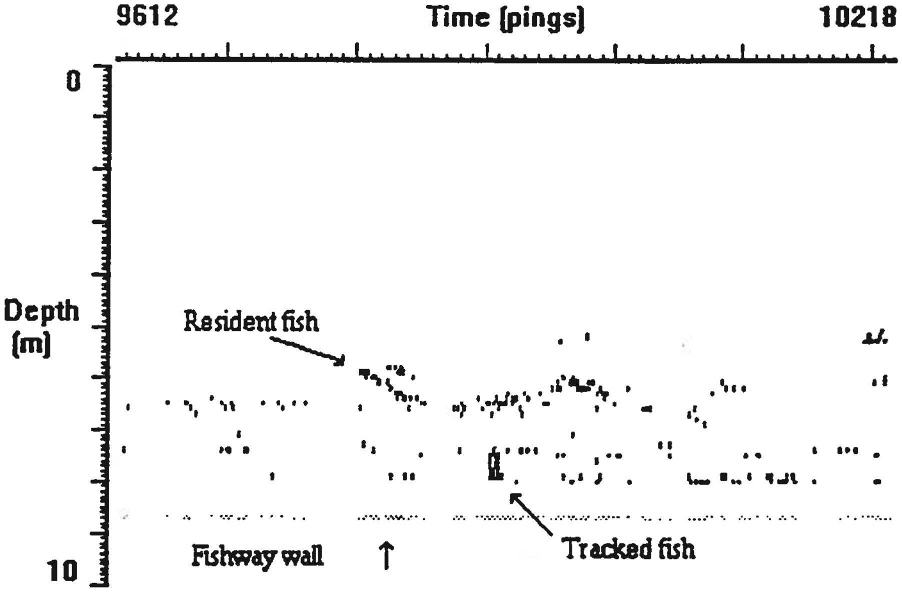

Figure 9. Computered generated echogram of tracked fish exiting Western fishway on August 27, 1991. Fish is exhibiting long to short trace type. (Note: refer to Figure 4. for model trace types)

3.4.2 Run Size

Between August 31 and October 20, 1991, we estimate that 1,336 adult sockeye salmon passed through Zosel Dam. The total number of sockeye salmon we counted at Zosel Dam was considerably lower than that observed at either Wells Dam or the spawning grounds. Thus, we believe that most Okanogan sockeye seen at the spawning grounds passed through Zosel Dam before the hydroacoustic study began.

3.4.3 Daily Counts

The run-timing curve shows the greatest passage occurring during the beginning of the study with a gradual decrease over time (Figure 9). Peak daily passage, during the study period, was on September 6, 1991 when 96 salmon were detected passing through the dam via the fishways. Since the study apparently was conducted after sockeye passage had peaked, it is not surprising that the data show a steady decrease in daily counts instead of a unimodal peak associated with the beginning and ending of a migration. Both run size and daily count data are consistent with our visual observations (Section 3.2.2).

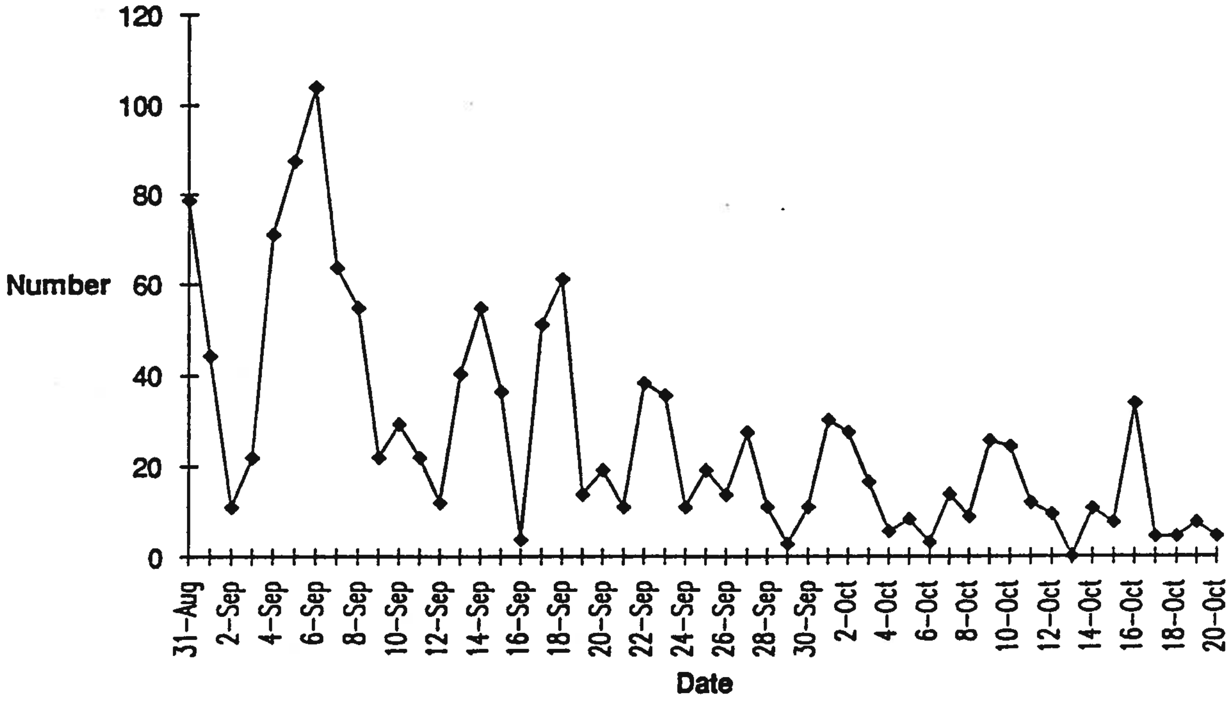

Figure 10. Daily counts of sockeye salmon through Zosel Dam between August 31 and October 20, 1991.

3.4.4 Diel Distribution

The diel distribution data show four peaks in passage (Figure 10). The two largest peaks occurred at sunrise and sunset. These two peaks indicate crepuscular activity within the upstream migrant sockeye. Other peaks were in daytime and nighttime hours. Sockeye passage occurred during all hours of the day.

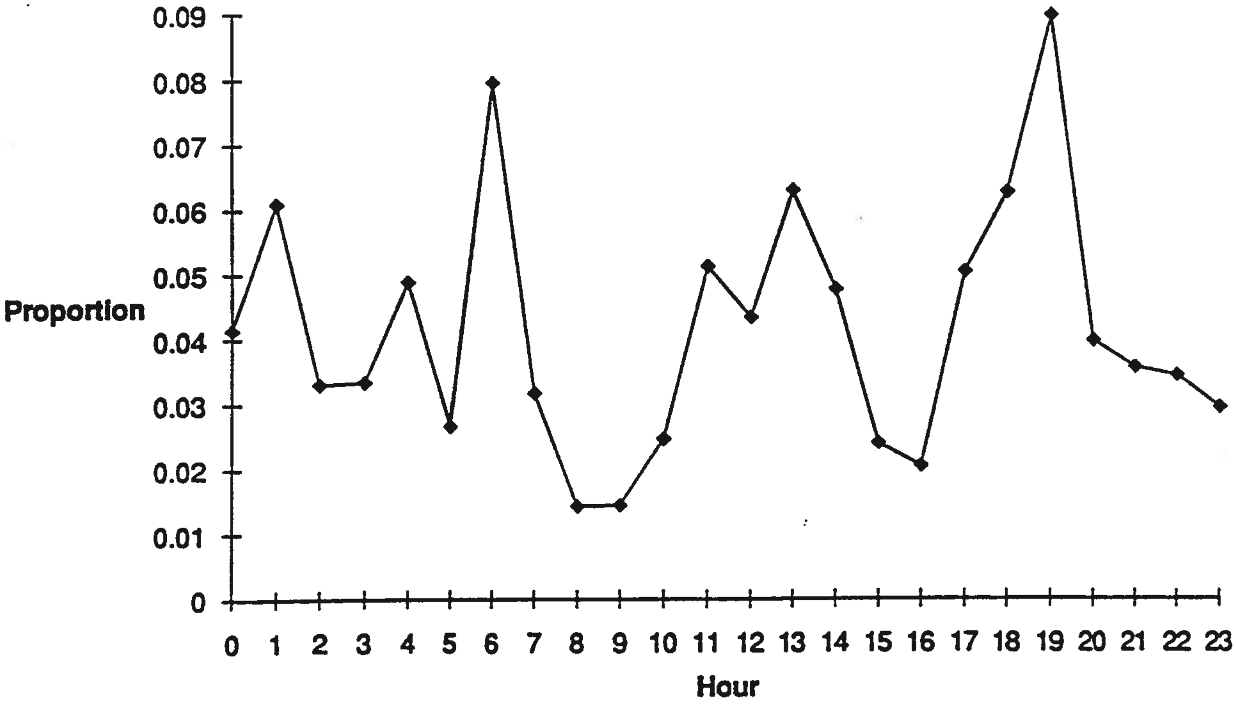

Figure 11. Diel distribution of sockeye salmon through Zosel Dam between August 31 and October 20, 1991.

3.4.5 Horizontal Distribution

The horizontal distribution data show a marked difference in passage between the two fishways (Figure 11). Four times as many sockeye used the western fishway than the eastern fishway. This was most likely due to the operation of only the western-most spillgate during the study. During snorkeling, salmon were observed throughout the stilling basin, with the majority being seen swimming in and out of the tailrace of Spillgate No.1. Recall that only in the area immediately downstream of the western spillgate were salmon seen catapulting out of the water, or maintaining a position on the dam sill. The fishway adjacent to western spillgate was also the only location were an adult sockeye salmon was observed passing through the dam structure.

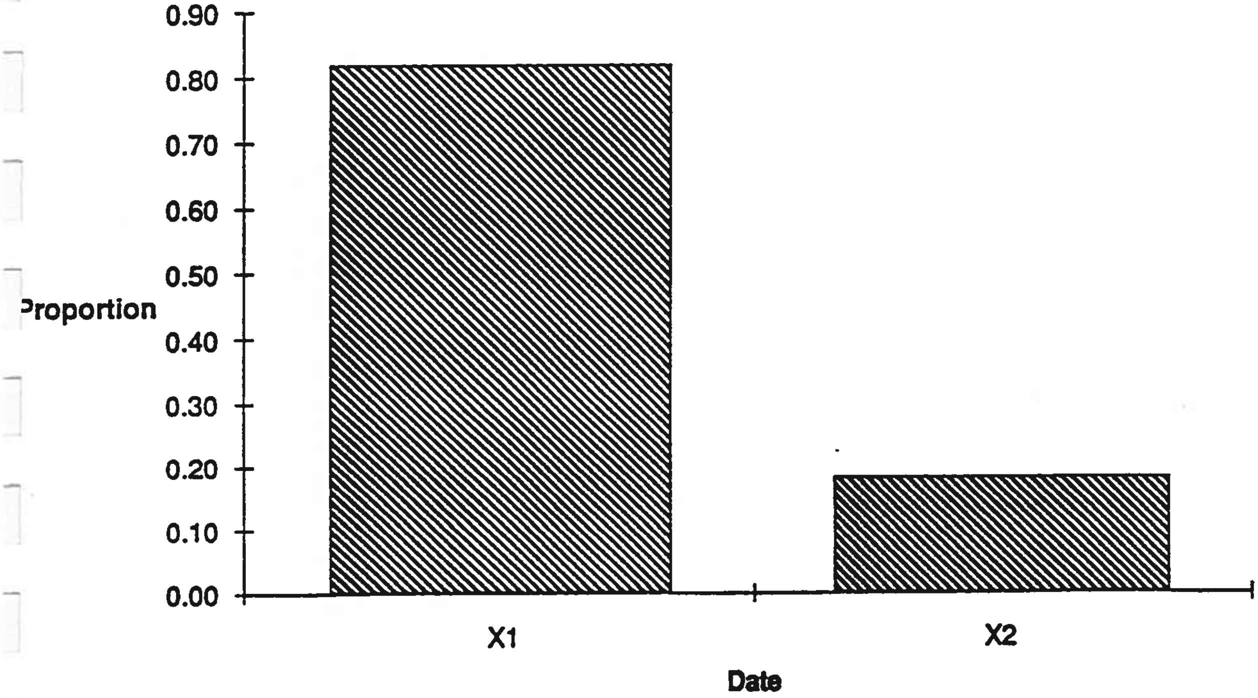

Figure 12. Horizontal distribution of sockeye salmon through Zosel Dam between August 31 and October 20, 1991.

4.0 DISCUSSION OF TEMPERATURE BARRIER HYPOTHESIS

Duree (1991) indicated a thermal barrier at the confluence of the Columbia and Okanagon rivers may delay sockeye passage and possibly cause sockeye mortality with prolonged exposure to the higher temperatures. Bouck et al. (1975) found that four days of exposure to 22 °C water was lethal to Columbia River sockeye. On July 1, 1991, the date of the first sighting of sockeye at Wells Dam, temperatures recorded in the Wells Dam pool and those at the six mile mark of the Okanagon River were both below 22 °C (Figures 7 and 8). On July 26, when sockeye passage through Wells Dam, the temperature at Okanagon R.M. 6.0 was greater than that in the Columbia main stem, but still did not exceed 22 °C. The riverine temperature at the six mile mark did not exceed 22 °C until after the peak of the sockeye run had passed through Wells Dam (Figure 7 and 8).

Allen and Meekin (1980) reported that rarely are half the fish seen as Wells Dam accounted for on the spawning grounds. The difference between the numbers of salmon counted at the spawning grounds and at Wells Dam may be due to either pre-spawning mortality or lake spawning sockeye. Allen and Meekin (1980) indicated that there may be a limited amount of lake shore spawning. A question that arises is: if pre-spawning mortality accounts for the majority of the difference between the counts done at Wells Dam and those done at the spawning grounds, then when and where does the mortality occur. The hydroacoustic study at Zosel Dam in 1991 shows that the majority of the salmon had passed before August 31. And, visual observations at Zosel Dam before that date indicate that they had passed before August 18. An absolute estimate of passage at Zosel Dam during the entire migration period, would provide useful data for examining the temperature barrier hypothesis.

To assess at the possibility of a thermal barrier more thoroughly, it may be prudent to monitor sockeye passage and riverine temperature and also tagged fish at more than one location. By taking these steps, the progress of migrating salmon could be documented, along with water temperatures. This added information could be used to look at possible differences in sockeye counts between Wells Dam and those at the spawning grounds.

5.0 SUMMARY and RECOMMENDATIONS

(1) We demonstrated that hydroacoustic techniques could be used to count adult sockeye salmon exiting the fishways at Zosel Dam.

(2) We counted sockeye at Zosel Dam from August 31 to October 20, 1991. Total run size during the study period was 1,336 adult sockeye.

(3) We visually and electronically observed sockeye salmon at Zosel Dam at the beginning of the study. During the study, daily counts were greatest during the first week of September. Counts decreased steadily over the remainder of the study period.

(4) The diel distribution of sockeye passage through the dam showed more pronounced peaks at sunrise and sunset. Passage occurred during daytime and nighttime hours.

(5) Sockeye salmon showed a marked preference for the western fishway which was nearest the only open spillgate (No. 1).

(6) Resident fish were observed visually in the area of the fishway exits and in the tailrace. Because of extensive visual observations and the parameters used to process the acoustic data, we determined that resident fish did not compromise the acoustic data.

(7) The total number of fish determined to have passed through Zosel Dam (1,336) was considerably less than would be expected, given the number of salmon enumerated at in the spawning grounds (about 7,000). This is due to the majority of the salmon passing through Zosel Dam before our study began.

(8) Use of dual beam transducers to monitor passage of adults will allow Target Strengths to be calculated, and consequently fish length.

(9) Radio tag study of adults passing through Wells Dam, and into the Okanagon River.

(10) Study period should begin shortly after sockeye are observed at Wells Dam and extend into October. This would allow ample time for enumerating the majority of the migrating population.

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

A.1 Hydroacoustic System Equipment, Operation and Calibration

A.1.1 Equipment Description

The remote hydroacoustic system at Zosel Dam in 1991 consisted of the following components: a Model 1005 Portable Sounder/Multiplexer, transducers with cable, a Model 281 Echo Signal Processor (ESP), a Model 111 Thermal Chart Recorder, an IBM AT compatible computer, and a Hitachi Oscilloscope (Figure A1). Specific manufacturers and model numbers of the electronic components used are listed in Table A1. The hardware parameters used are presented in Table A2.

Table A1. Model numbers, manufacturers, and serial numbers of electronics equipment used by BioSonics, Inc. at Zosel Dam in spring and summer of 1991.

MODEL NO. AND EQUIPMENT	MANUFACTURER	SERIAL NO.
Model ES2000 (420 kHz)	BioSonics, Inc.	1005-91-001
Model 111 Chart Recorder	BioSonics, Inc.	111-90-062
Model 281 ESP	BioSonics, Inc.	281-89-001
Transducers (6 deg)	BioSonics, Inc.	12-420-06-059 12-420-06-060
Model V-423 Oscilloscope	Hitachi, Inc.	5017445

Table A2. Hydroacoustic system parameters used for studies at Zosel Dam in 1991.

ECHO SOUNDER	Transmit frequency: 420 kHz Transmit power: 0 dB Band width: 5 kHz Pulse width: 0.4 msec

Table A2 cont.

ECHO SOUNDER	TVG: 40 log (R) Trigger source: ES2000 Receiver gain: -20 dB
CHART RECORDER	Threshold: 0.17 volts

A.1.2 Equipment Operation

A BioSonics hydroacoustic system worked as follows. When triggered by the 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/s).

The echo sounder relays the returning TVG-amplified signals to the chart recorder, oscilloscope, and system computer. 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 echogram 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 that the echo levels of interest.

The 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

The 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. The calibration information was also used to equalize the system sensitivity (using 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 Detection Criteria

Returning voltages had to meet four independent filtering criteria in order for the echo to be stored as a tracked fish:

- Strength of target echoes had to exceed a predetermined threshold.
- Absolute echoes of a particular target were not to be greater than 20 nor less than 4.
- Targets had to be detected by consecutive acoustic pulses (redundancy).
- Slope exhibited by the target had to match that which would be expected by an upstream migrating fish.

Using the calibration information, the threshold of the hydroacoustic system was set to collect targets from targets greater than -54dB on the acoustic axis of each transducer.

Those targets with negatively sloping trace types were accepted as possible adult sockeye salmon. An object moving upstream through the beam would exhibit a negative slope (Figures 4, 5 and 6). Many resident wallowers were observed visually in the area of concern as well as on the paper echogram. Absolute number of echoes in beam and the slope criteria were used to reduce the likelihood that one of these fish would be counted as an upstream migrating salmon.

A.2.2 Fish Filter Definitions

Echo Concentration - Ping Concentration measures variability of targets over time, which is represented by the horizontal plane, of x-axis.

The following equation is used to determine Ping Concentration:

$$\text{Ping Concentration} = \frac{\text{Total \# of echoes in tracked fish}}{[(\text{Exit Ping \#}) - (\text{Entrance Ping \#})] + 1}$$

Values are in decimals, with 1.000 representing a perfect concentration of targets, and 0.000 meaning that there are gaps between all targets in that tracked fish.

This filter is very effective for eliminating noisy data. Ping Concentration values of 0.9 or greater will eliminate all but best tracked fish.

Range Concentration - The Range Concentration is a filter option that allows you to specify how close in range (or depth) the targets from a tracked fish must be in relation to each other. In other words, this is a measure of how well each target matched its expected range along a fish's trajectory.

Values are in decimals, with 0.000 representing a perfect match between targets and their expected ranges and 1.000 meaning the targets are scattered about.

This filter is very effective for eliminating noisy data. Range Concentration values of less than 0.1 will discard all but the best tracked fish.

Absolute Echoes in Fish - This filter option is used to exclude fish that are spending either too little or too much time in the beam. The system operator specifies the minimum and maximum number of absolute echoes expected from an individual fish. The settings will depend on the pulse rate of your echo sounder and the approximate speed of the fish through the acoustic beam.

The values you enter for the filter options are also very dependent on the nature of the survey site. At high ping rates (those greater than 10 pings/sec) and with swift currents, you may expect fish to be ensonified 4 to 10 times.

Average Slope - When target tracking is taking place, the slope (or trajectory) of a tracked target is continuously calculated and updated with each successive ping. The slope is calculated using the formula:

$y = mx + b$

where the y-axis is the target's range from the transducer (in meters), and the x-axis is the ping number. Slope is expressed in meters/ping. For example, a slope of 0.1 meters/ping means that a fish is moving away from the transducer at a rate of 0.1 m per ping.

A.2.3 Data Entry and Storage

Microcomputers were used for date storage and analysis. Data from individual tracked fish was written to a database file using BioSonics post processing software. The following information was recorded for each tracked fish: time of detection, date, transducer location, entrance range, exit range, number of absolute echoes in beam, target slope, and average TS value (-dB).

A.3 Data Reduction Methods

A.3.1 Data Selection

Three additional criteria were used to select data for analysis:

- Targets had to have an average TS value greater than -48dB and less than 20dB.
- Absolute number of echoes had to range between four and ten.
- Entrance range of target had to be less than 8.3 meters and greater than 7.8 meters.

Target strength criteria is based on lengths of previous classes of migrating salmon as determined by the sampling efforts of Columbia River Inter-Tribal Fish Commission (Schwartzberg and Fryer 1990). Absolute number of echoes was based on sustained speed of adult sockeye salmon, as determined by Brett (1965). By restricting the range of acceptable targets, fish observed to school in front of the fishway opening would not be included.

A.3.2 Weighting Factor

The weighting factor applied to the generated data, corrected for area of opening not sampled and also the time during the hour that a unit was not active.

The area not sampled was calculated by comparing the area of the cross-section of the formed at the range of the fishway opening, using a nominal beam pattern of 6 deg as a standard, to the area of the opening that was underwater (Figure 4). The only sightings of fish, two, showed both fish in the bottom portion of the opening. With the use of a calibration tool, it was determined that this area was infact being sampled, but due to the unpredictable nature of fish, the entire opening was considered as available for passage.

Using the transducer information from above, the amount of time that a location was being monitored was calculated, and fish counts from these times and locations were corrected for time not sampled.

THE FEASIBILITY OF ESTIMATING SOCKEYE SALMON ESCAPEMENT
AT
ZOSEL DAM, WASHINGTON
USING UNDERWATER VIDEO TECHNOLOGY;
DRAFT REPORT

APPENDIX - F

The Feasibility of Estimating Sockeye Salmon Escapement at Zosel Dam Using Underwater Video Technology

Annual Progress Report

by

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Andrew Wand

Alicia Porter

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for

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December 31, 1992

Columbia River Inter-Tribal Fish Commission

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Abstract

In 1991 a study to test the feasibility of recording and enumerating sockeye salmon (*Oncorhynchus nerka*) using underwater video technology at Zosel Dam was initiated. This report covers the second year of the study. Video technology has, over the last few years, become a proven technique for estimating escapement of Pacific Salmon.

Video cameras enclosed in watertight housings were attached to fish counting chambers and placed in the water column at the two fish ladder exits at Zosel Dam located at rkm 127 on the Okanogan River. Continuous 72hr timelapse recordings were made from June 24 through October 18, 1992. Sockeye salmon escapement was estimated to be between 25,172 and 42,410. This range encompasses point estimates of escapement made at Wells Dam and at the spawning grounds. The mean date of passage was August 2 with a standard deviation of 24.2 days.

Sockeye salmon migratory timing had a tri-modal distribution and seemed to be affected by water temperature. When water temperature decreased over a few days and reached a temperature less than 73F, sockeye salmon passage increased. When water temperatures were stable or increasing, few sockeye salmon crossed Zosel Dam. Most sockeye salmon passage occurred at night. Approximately 93% of the sockeye salmon observed crossed Zosel Dam between 2000 and 0600 hours.

We recommend that future studies be conducted to refine this fish counting technique

and further investigate the effects of the thermal barrier that forms in the Okanogan River.

Acknowledgements

We thank the following individuals for their contribution to this project: Bob Heinith, Jeff Fryer, Dave Pederson, and Phil Mundy from the Columbia River Inter-Tribal Fish Commission; Rick Klinge from Public Utility District No. 1 of Douglas County; and Dennis Burton and Tom Scott from the Oroville-Tonasket Irrigation District.

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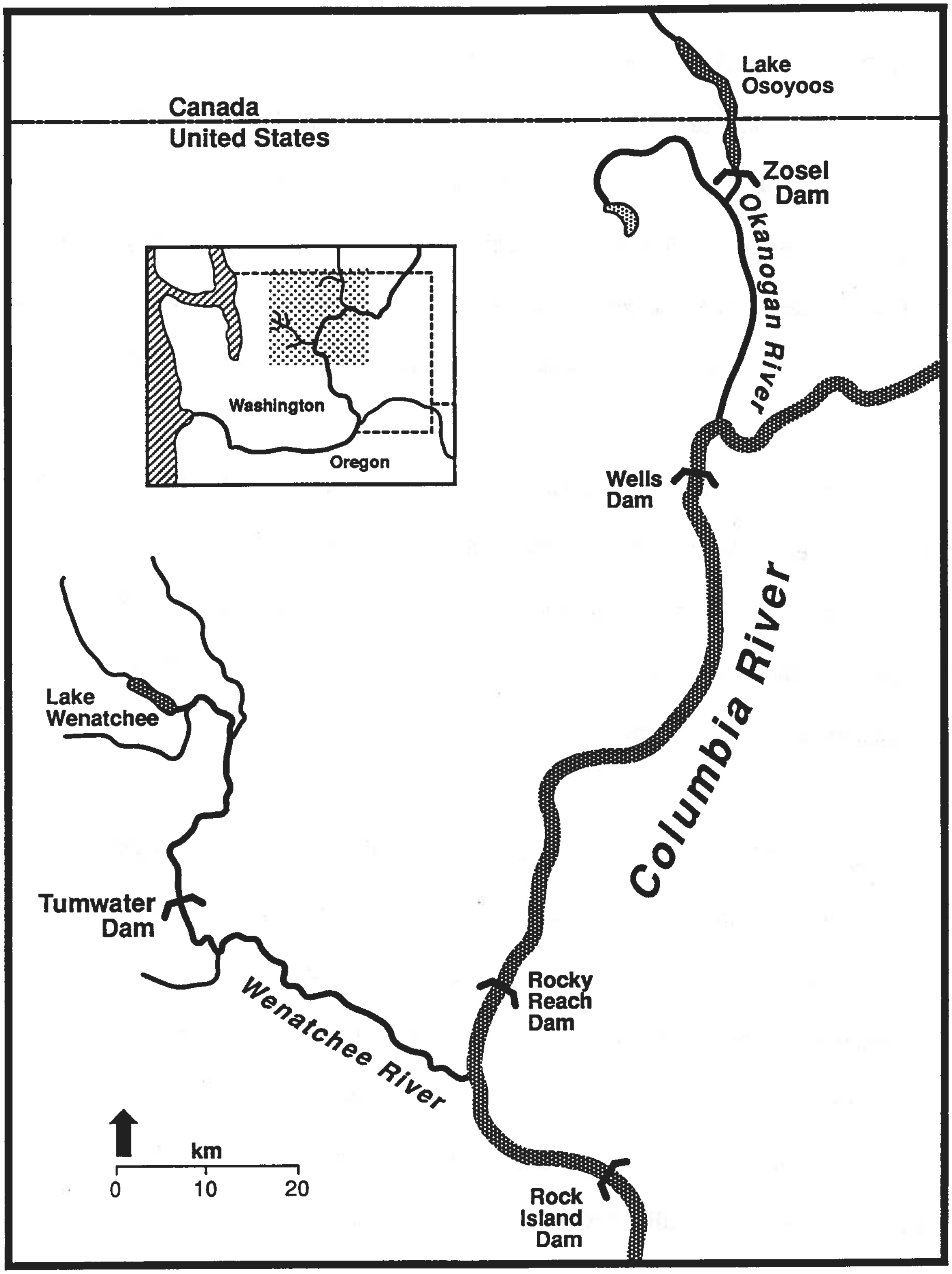
Introduction

Prior to dam construction in the Columbia River Basin, sockeye salmon (*Oncorhynchus nerka*) were found in at least eight different lake systems (NPPC 1986). The largest population of sockeye salmon was the Arrow Lakes stock, located in the upper Columbia River in Canada (Anonymous 1938). Following the construction of Grand Coulee Dam, sockeye salmon bound for the Arrow Lakes were trapped and moved to hatcheries and the Wenatchee and Okanogan rivers as part of the Grand Coulee Relocation Program (Fish and Hanavan 1948).

Currently, only two major stocks of sockeye salmon exist in the Columbia River Basin (Allen and Meekin 1980). These include the Lake Wenatchee stock that migrates up the Wenatchee River and the Lake Osoyoos stock that migrates up the Okanogan River (Figure 1). The habitat for the Okanogan stock has been reduced to only Lake Osoyoos and about 15 miles of the Okanogan River upstream of Lake Osoyoos (Allen and Meekin 1980).

Major and Mighell (1966) reported that a thermal barrier in the Okanogan River between Zosel Dam and the confluence created a barrier to sockeye salmon migration. Major and Mighell (1966) further quantified the thermal barrier as occurring during periods of rising or stable water temperatures above 70F. Below 70F, the sockeye salmon migration was not affected. Decreased survival of Okanagon sockeye salmon has been attributed to the elevated water temperatures in the Okanagon River (Major and Mighell 1966, Allen and Meekin 1980). Because this potential mortality agent is located upstream of Wells Dam (rkm 829), sockeye

Figure 1. Map of the Okanogan and Wenatchee river basins showing the location of Zosel Dam and Lake Osoyoos.



salmon counts at Wells Dam are not good estimates of escapement.

Over the last few years, attempts to count sockeye salmon at Zosel Dam have been made using hydroacoustic systems (Anglea and Johnson 1991). The transducers were located at the exits of the adult fish ladders. Escapement estimates were based on echo signal processing. Adult sockeye salmon counts made were biased for at least two reasons: 1) many rough fish, of sizes similar to adult sockeye salmon, are present in the exits of the fish ladders and, 2) fish were observed to pass under the spillway gates when they were open. These fish were undetected with hydroacoustics as a result of the location of the transducers. Using time-lapse video tape to record, document, and enumerate salmon passage at fish ladders has been proven to be effective at several locations (Hatch and Schwartzberg 1990, Hatch and Schwartzberg 1991, Hatch et al. 1992, Hatch et al. in prep.) Because of the management need to have accurate sockeye salmon counts at Zosel Dam, a feasibility study was designed to determine if an underwater video system could be used to count fish at the exits of the fish ladders (Hatch et al. 1991). This report covers the second year of that study with the objective of not only determining if it is feasible to use underwater video systems to count fish, but also to attempt to produce a sockeye salmon escapement estimate at Zosel Dam.

Methods

Study Area

Zosel Dam is located on the Okanogan River approximately one mile downstream of Lake Osoyoos in northcentral Washington state. Zosel Dam provides control of the level of Lake Osoyoos, and does not contain power generation facilities. The present dam structure was built in 1987 by the Washington State Department of Ecology and is operated by the Oroville-Tonasket Irrigation District. Zosel Dam has two pool and weir type adult fish ladders and four spillway gates (Figure 2). The average water levels in the forebay and tailrace areas are 911 and 906 MSL.

Study Design

This study utilized video tape equipment in the Super Video Home System (SVHS) format. Two fish counting chambers constructed from aluminum were placed at the fish ladder exits in the forebay at Zosel Dam. The fish counting chambers had a 4ft cubical opening that allowed for unobstructed fish passage (Figure 3). These fish counting chambers provided a platform to mount video cameras, underwater lights, and a removable white backboard. Table (1) includes specifications of all video equipment used.

Video cameras were enclosed in watertight aluminum housings measuring 10in by 10in by 18in. One end of the housing was super strong super scratch resistant plexiglass. The camera housings were attached to the fish counting chambers in the center of the upstream wall

Figure 2. Plan view of Zosel Dam showing the location of the fish ladders, spillway gates, and underwater fish counting stations.

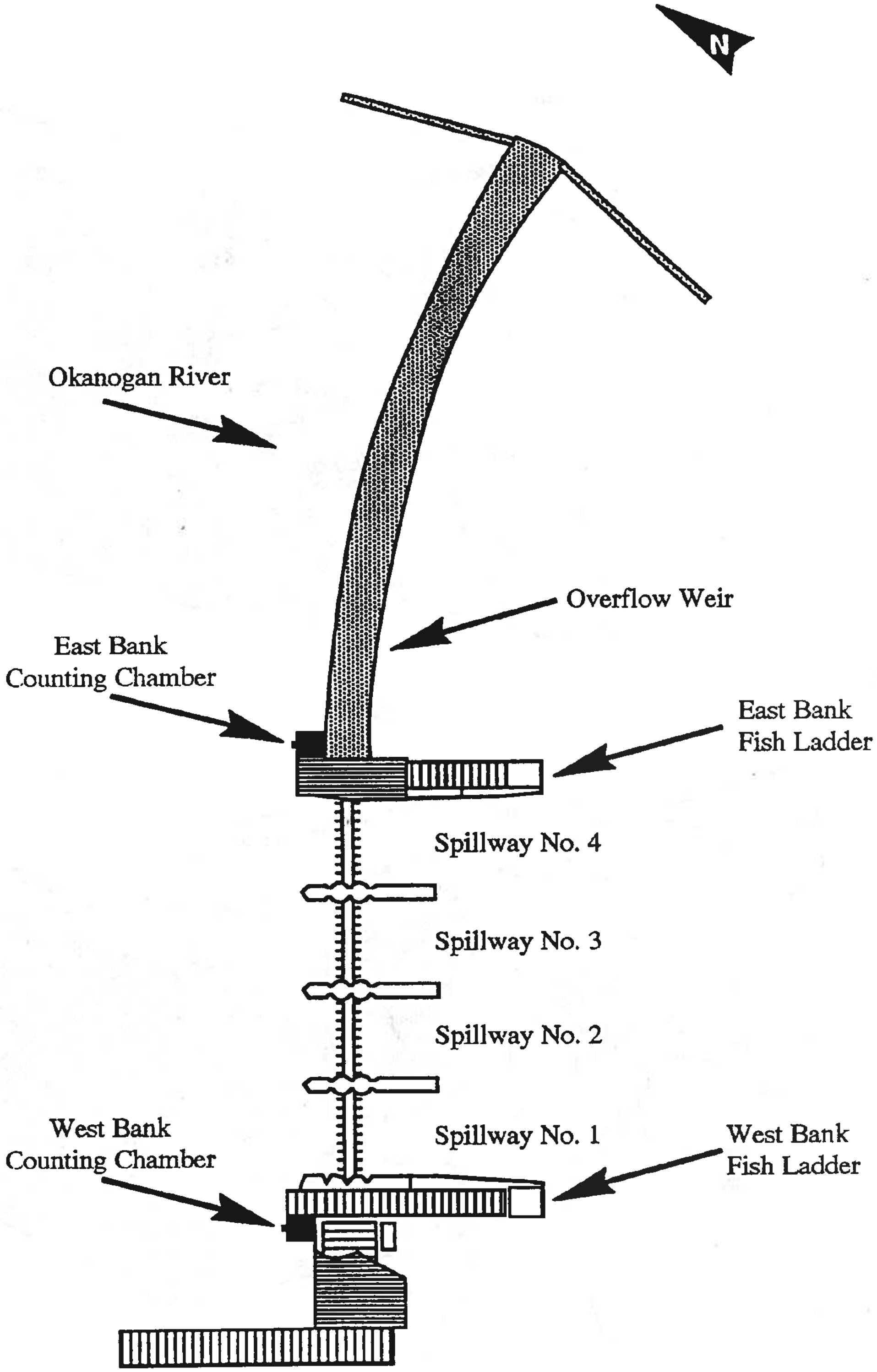
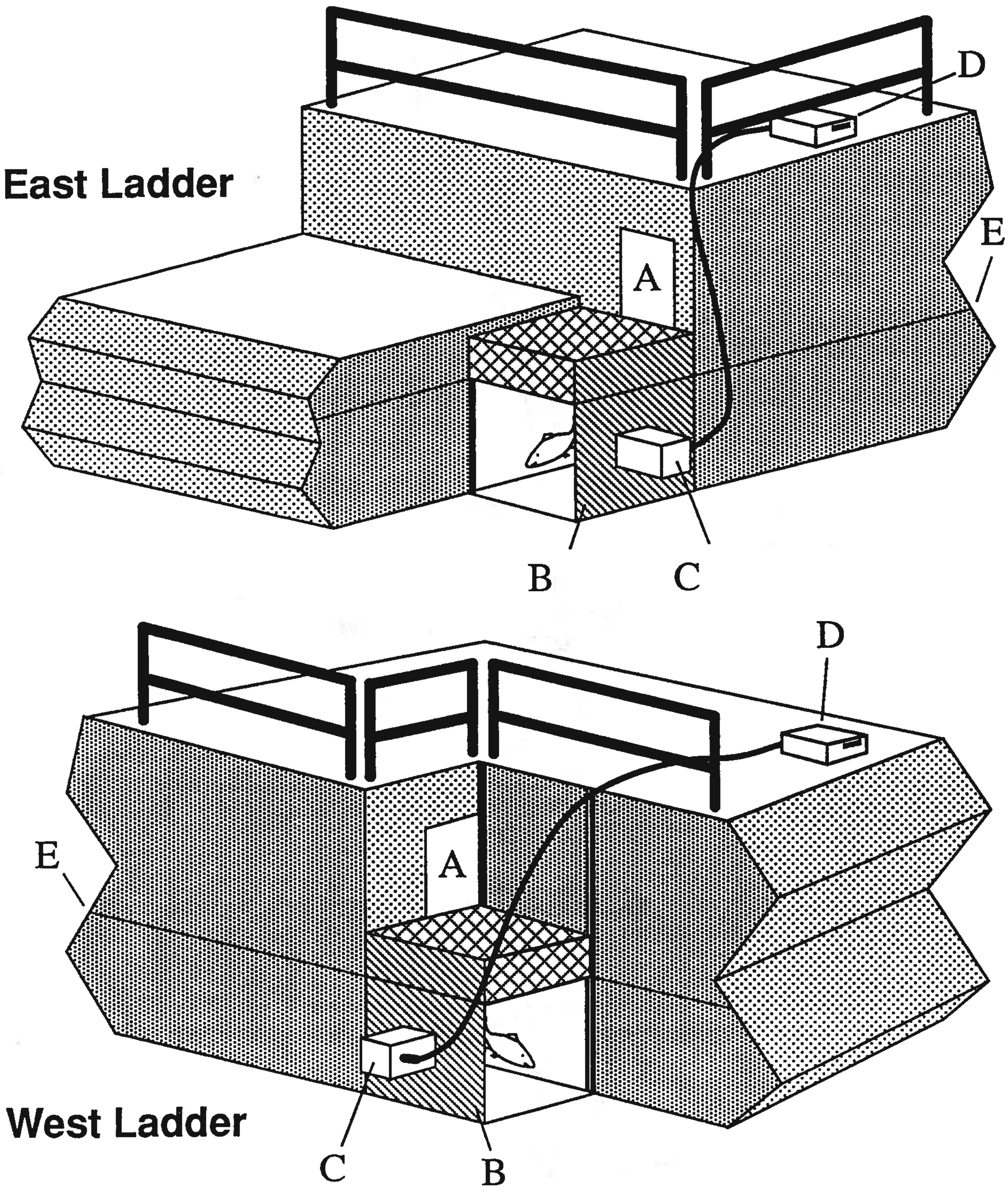


Figure 3. **Diagram of the east and west bank fish counting stations installed at Zosel Dam. A) Fish ladder exit. B) Fish counting chamber. C) Underwater camera housing. D) Video tape recorder. E) Water level.**



of the chamber (Figure 3).

Table 1. List of equipment used for the Zosel Dam sockeye salmon escapement estimation study in 1992.

Number Used	Item	Make	Model
2	Counting Chamber	Custom Built	
2	Video Camera	Sony	SSC-S20
2	Motorized lens	Rainbow	H6x8MEA-II
2	Motorized lens Control	Pelco	MLZ6DT
2	Video Tape Recorder	Panasonic	AG-6720
2	Underwater Camera Housing	Marine Metal Products	Custom Built
2	Waterproof Cable & Connectors	Advanced Cable & Assembly	Custom Built
2	Video Monitor	Panasonic	CV-1382Y
1	Reviewing Video Tape Recorder	Panasonic	AG-6720

Four 100 watt underwater lights were attached to the perimeter of the upstream wall of each fish counting chamber. The lights were directed toward the center of the back wall of the fish counting chambers. The back walls of the fish counting chambers were 1/8in thick sheets of aluminum painted flat white. These backboards were removable for cleaning purposes.

Two multiconductor underwater cables connected each video camera to a video tape recorder (VTR), a remote camera lens controller, and an AC power source. The VTRs recorded fish passage in time-lapse mode, which allowed 72 hours of continuous recording to be stored on a single videotape. This time-lapse mode records 1.2 video records per second, and has been shown to record enough information to precisely count sockeye salmon on the Wenatchee River (Hatch and Schwartzberg 1990) and on the Snake River (Hatch et al. in prep). In addition, the current time and date were written to every frame of the tape.

The video fish counting stations were installed on June 24, 1992 and ran continuously through October 18, 1992. Video tapes were changed every three days by personnel from the Oroville-Tonasket Irrigation District. When the tapes were changed, a routine maintenance check was also performed. This maintenance included determining if the cameras and VTRs were functioning properly, cleaning the plexiglass portion of the camera housings, cleaning the backboard, and mailing the recorded tapes to the Columbia River Inter-Tribal Fish Commission (CRITFC) office in Portland, Oregon, for analysis.

Sockeye Salmon Escapement Estimates

Video tapes were reviewed by CRITFC personnel at our laboratory in Portland, Oregon, using a VTR equipped with a jog/shuttle knob. This special control allows a reviewer to scan through a video tape, in forward or reverse, at speeds ranging from freeze frame to 7X normal speed. Sockeye salmon counts were tallied by hour and day, using the time/date stamp on the frames as a reference.

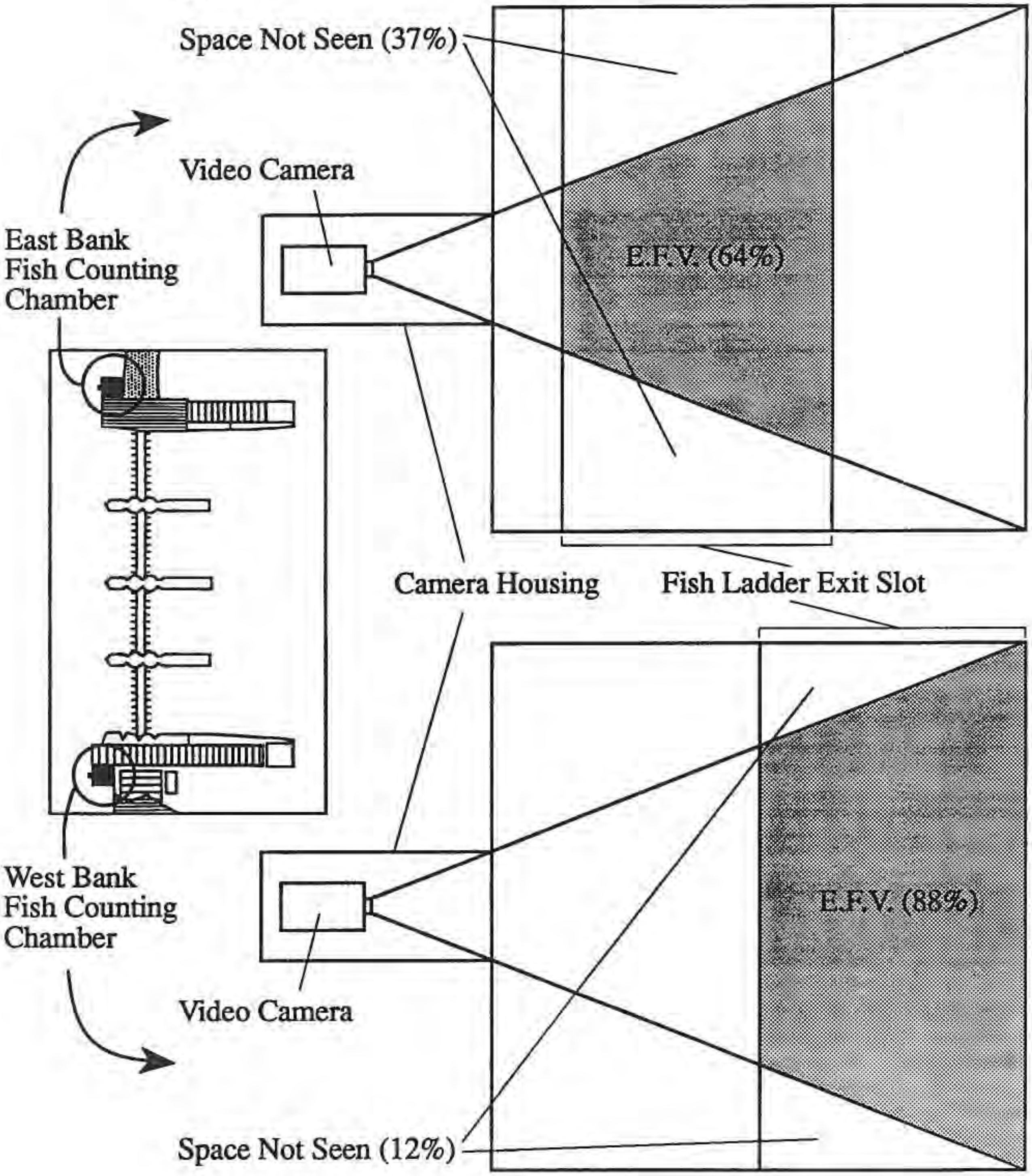
During periods of moderate to low fish passage, all fish were enumerated. During times of high-density fish passage, it was sometimes impossible to accurately count all of the salmon present. On these occasions, a high and low bound were estimated. Estimates were based on the judgement of an experienced fish counter. All estimates were made by the same individual.

Due to the structure of the counting chamber, it was possible for some fish to pass through the chamber without entering the video camera's field of view. In order to compensate for these fish, an effective field of view (EFV) was calculated for each chamber (Figure 4), and counts were expanded accordingly. This method assumes two things: that fish maintain a constant course as they exit the fish ladder, and that they are evenly distributed throughout the fish ladder exit slot. Since the two chambers were installed differently, the EFVs (and consequently the expansion factors) also differed.

A small portion of the season was not recorded, due to equipment failure, power outages, and failure to change tapes. Two tapes were also lost in the mail. The count for each missing hour was interpolated by averaging the count for the hour on the preceding and following days.

Sockeye salmon migratory timing was investigated by calculating the mean date of passage and it's associated standard deviation (Mundy 1982). Sockeye salmon passage per day was correlated to water temperature. The water temperature used was recorded bi-hourly by a thermograph located within 20 yards of the fish ladders, during the salmon migration.

Figure 4. **Cross-section of the east and west bank fish counting chambers showing the location of video cameras, fish ladder exit slots, and the effective fields of view for each system.**



Results and Discussion

Escapement Estimate

Unexpanded estimates of sockeye salmon passage at Zosel Dam were between 18,985 and 32,169. These estimates are based on actual fish counts for hours of low to moderate fish densities and low and high estimates of passage during high fish density periods. The low and high estimates during high fish density periods thus produced a range of the passage estimates instead of a point estimate. Of the 5,584 total hours of video tape that were reviewed, 273 hours contained fish passage in sufficient densities that it was necessary to estimate counts. These estimates were then expanded based on the EFV of each counting station. The EFV for the east and west counting chambers were calculated to be 64% and 88%, respectively, yielding expansion factors of 1.56 and 1.14.

By expanding the raw counts to compensate for the EFV of each counting station, we estimate that between 25,172 and 42,410 sockeye salmon escaped over Zosel Dam during the 1992 adult migration (Appendix 1). This range encompasses the preliminary estimate of 26,000 made at the spawning grounds (Jerry Marco personal communication). Our estimate is also reasonable when comparing it to the Wells Dam count of approximately 47,158 (Rick Klinge personal communication).

Between 12,042 and 21,085 sockeye passed through the west counting chamber, and between 13,130 and 21,325 sockeye passed through the east counting chamber. These numbers indicate that sockeye showed no preference for either ladder. Anglea and Johnson (1991) reported that sockeye salmon showed a 4 to 1 preference for the west fish ladder. They concluded that this preference was influenced by the exclusive use of spillway #1 during their study. During our study, gate #1 was open 41 days and gate #4 was open 74 days. Gate #1 was open for fewer days, but in most cases was opened wider than gate #4. Overall, approximately the same volume of water was spilled through both gates. Since the optimum amount of attraction water for each fish ladder is unknown, it is difficult to speculate on the effect that spill from each gate had on fish ladder preference.

During the course of this study, it was noted that some sockeye salmon migrated through open spillway gates at the dam (Dam Operations log), thereby avoiding both counting chambers. This phenomenon has also been reported in previous years (Major and Mighell 1965, Anglea and Johnson 1991). According to Major and Mighell (1965), sockeye salmon passage through the spillways was more pronounced when the gates were open at least 12 inches. During the 1992 season, spillway gates were open 12 inches or more for 75 out of 117 days (64%). Clearly, a number of fish could have crossed Zosel Dam in this manner without being counted.

Two hundred-seventy-three out of a total of 5584 hours[1], or 4.9% of all hours, were estimated with a high and low bound. It should be noted that the inability to accurately count large numbers of fish is not an inherent shortcoming of video counting. At other sites, we have recorded salmonid counts of over 1400/hour with no decrease in accuracy. (Hatch et al. 1992).

---

[1] since two counting chambers were used, the total number of hours is equal to twice the number of hours during the season.

Instead, the difficulty arose from the fact that the camera's field of view did not cover the entire counting chamber. During times of high sockeye salmon migration, fish often entered and exited the camera's field of view from the top or bottom, thereby making it impossible for the counter to track them. In addition, fish were able to approach within a few inches of the camera. When this occurred, it was possible for a single fish to cover the entire field of view and block out any other fish in the background.

Migratory Timing

The mean date of sockeye salmon passage at Zosel Dam was 8/2/92 with a standard deviation of 24.2 days. The mean date of passage at Zosel Dam is similar to the Wenatchee stock (Hatch et al. 1992), however, the Okanogan stock shows much more variation. The temporal migration distribution was tri-modal (Figure 5). The modes near the beginning and end of the migration had the greatest amplitude. This is very unusual relative to the Wenatchee sockeye salmon stock, that has demonstrated a very peaked single mode distribution in each of the last three years (Hatch et al. 1992). This unusual distribution is probably a result of a thermal barrier at the confluence of the Okanogan River (Figure 6).

Effect of Temperature on Passage

Zosel Dam fish passage counts were affected by water temperatures lagged three days. Because the water temperatures were recorded at Zosel Dam, they were lagged in the analysis to allow for water and fish travel time from the confluence. Once water temperature reached 73F, no sockeye salmon passage was recorded (Figure 7). Figure (6) shows the sockeye salmon

Figure 5. **Okanogan River sockeye salmon escapement estimates for Zosel Dam in 1992.**

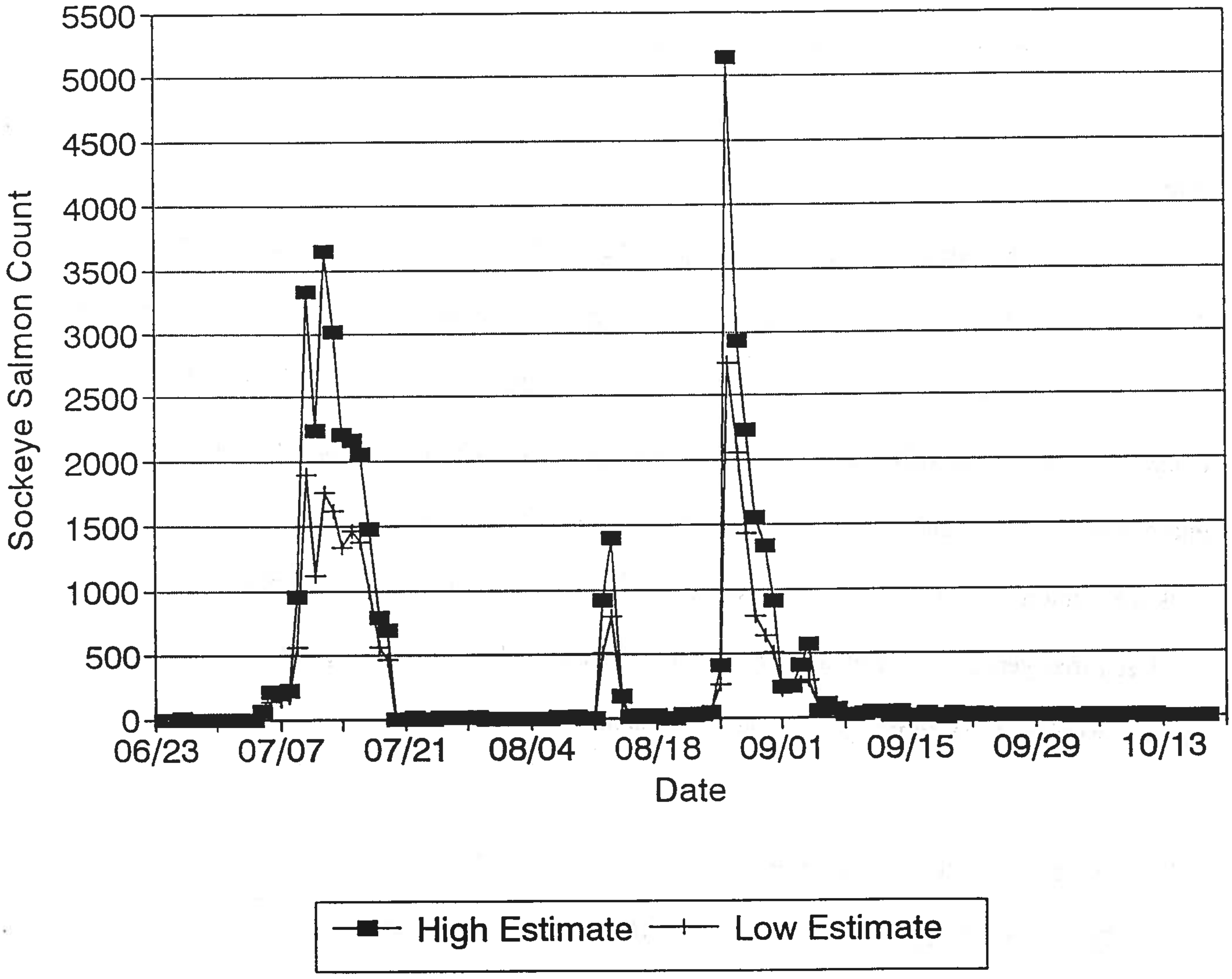


Figure 6. **Migratory timing of sockeye salmon at Zosel Dam and Okanogan River water temperatures recorded near Zosel Dam in 1992.**

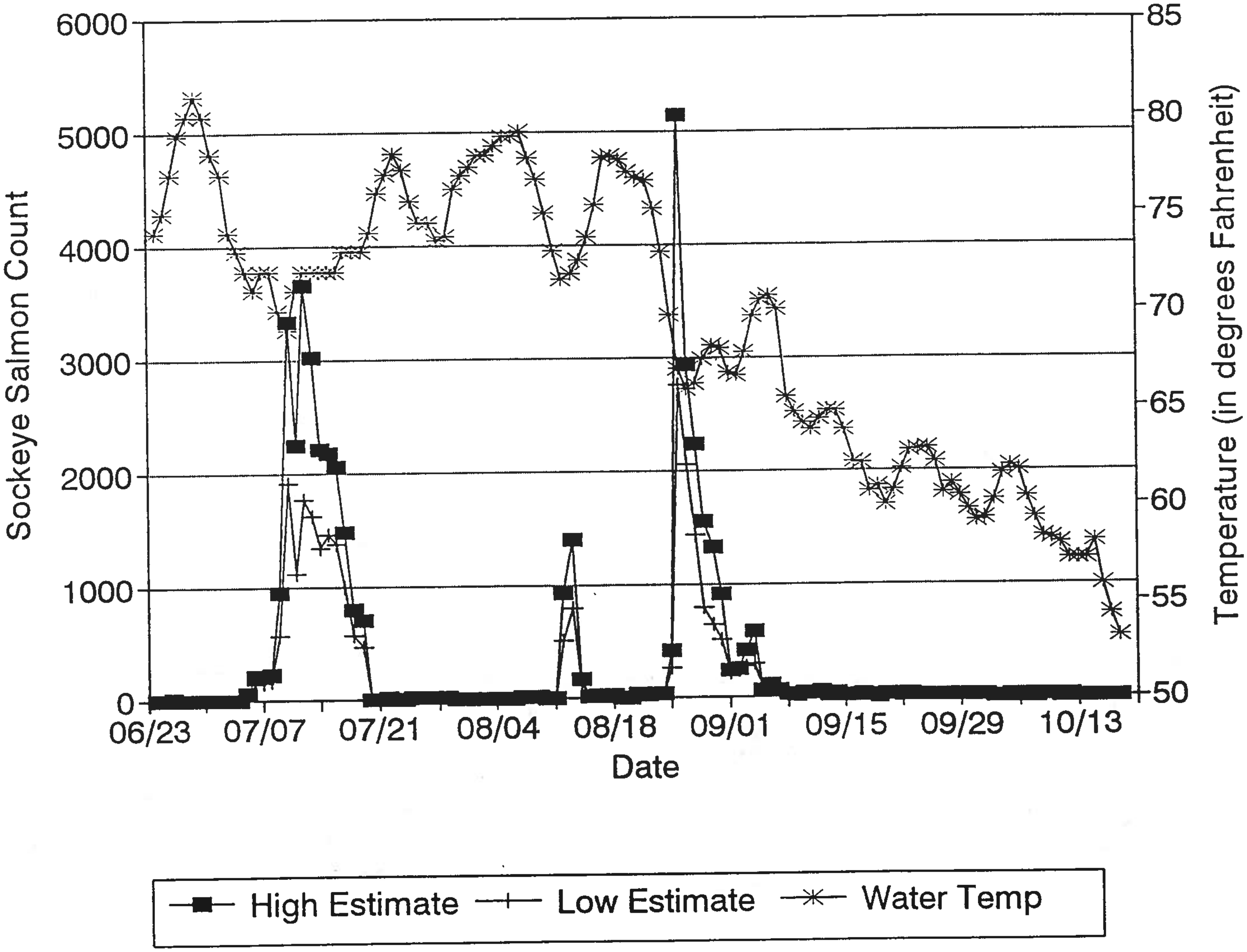
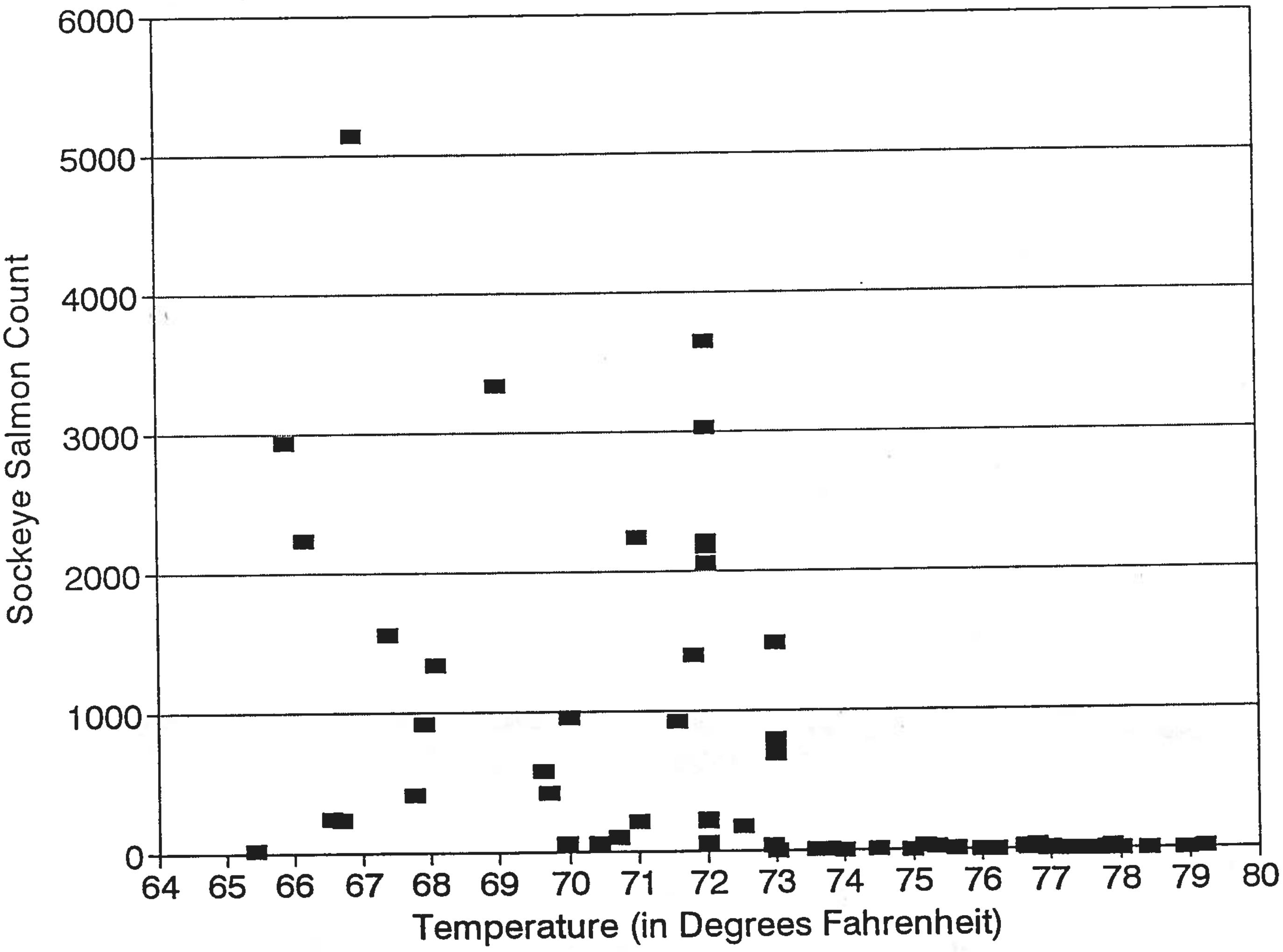


Figure 7. **Daily 1992 Zosel Dam sockeye salmon passage counts as a function of Okanogan River water temperature lagged 3 days.**

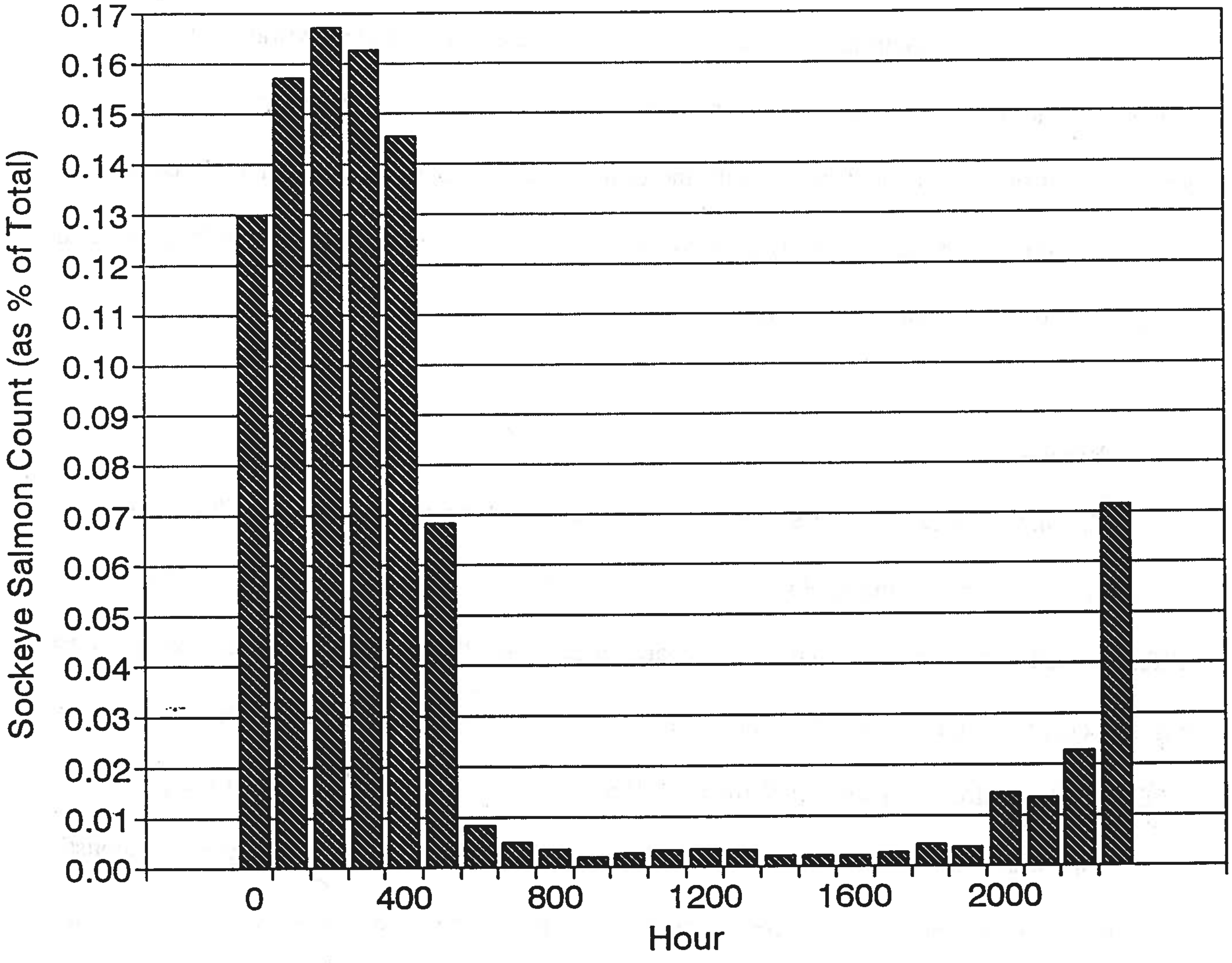


count and average daily water temperature by date. It appears that counts increase significantly following a decrease in water temperature over a period of several days. This occurred even though water temperatures remained well above 70F (Figure 6). It appears that sockeye salmon migration up the Okanogan River may be influenced by increasing flows, thereby decreasing water temperatures during the migration season. Therefore, by strategicly planning water releases in the upper Okanogan Basin, it may be possible to provide favorable fish passage conditions and reduce the mortality associated with the thermal barrier that forms at the confluence of the Okanogan River. With increasing water temperatures, counts decrease or go to zero. Major and Mighell (1965) also noticed that high temperatures impede migration, and that a sharp drop in temperature promotes passage.

Night Passage

The majority of sockeye salmon passage occurred between the hours of 2000 and 0600 (96.2% for the high estimate, 93.6% for the low estimate) (Figure 8). This is considerably different then observations at Tumwater Dam, located on the Wenatchee River, where most passage occurred during the day. Nighttime passage (2000 to 0400) has accounted for only 6.68% of the entire run from 1989 through 1991 (Hatch et al. 1992). Nighttime passage at Zosel Dam was 74.6% and 72.7% for the high and low run estimates. Using hydroacoustic estimates, Anglea and Johnson (1991) reported that sockeye salmon passage over Zosel Dam occurred during all hours of the day, with no apparent preference for particular hours. However, these estimates were not adjusted to account for rough fish. During daytime hours, we observed numerous largemouth bass *Micropterus salmoides* and chiselmouth *Acrocheilus*

Figure 8. Sockeye salmon counts as a function of time of day from Zosel Dam in 1992.



alutaceus similar in size to sockeye salmon. These fish may have been mistaken for sockeye salmon by the hydroacoustic counting system. The mechanism causing the nighttime migration is unknown, however, it may be a response to photoperiod or water temperature. Determining the causal mechanism may be a topic of future research.

Future Modifications

Several modifications should be made to the counting chambers for continuing video work. These changes should dramatically improve both the image quality of the videotapes and the accuracy of our counts.

Baffles should be placed inside the top and bottom of the counting chambers to keep fish within the camera's field of view. Fish would also be restricted to the back 2 feet of the chambers; this would prevent a fish from getting so close to the camera that it eclipses the entire field of view. With these two changes, it should be possible to give highly accurate counts of sockeye salmon passing through the fish ladders: no expansion factors would be necessary, and it should be possible to count even during times of extremely high fish passage.

An attempt should also be made to improve image quality. Additional lighting should be installed, and lights should be positioned in such a way as to optimize their output. We should also investigate the possibility of using backlighting, a technique which has worked well at other projects where water clarity is poor. Finally, it was noticed that rapid algae buildup decreased the amount of light reflected off the backboard and transmitted through the window of the camera housing. Permanent brushes should be installed to allow regular cleaning with minimum effort.

Future Studies

We recommend that future research concentrate on determining the amount of sockeye salmon passage through the spillway gates at Zosel Dam, the rate of migration and mortality between Wells and Zosel dams, and the spawning contribution of fish arriving early at the spawning grounds compared to fish arriving late.

Quantifying passage through the spillway gates at Zosel Dam will increase the precision of an escapement estimate of Okanogan sockeye salmon. This work must be conducted concurrently with counting fish exiting the fish ladders. Hopefully, a relationship between the amount that the gates are open and fish passage through the gates will be found. This relationship could then be used in future years to adjust escapement estimates that are solely based on fish ladder counts at Zosel Dam.

Determining what the migration and mortality rates are between Wells and Zosel dams and the spawning grounds could be important information for evaluating future management alternatives. If mortality is high between Wells and Zosel dams, a trap and haul program could potentially be beneficial. However, if the spawning contribution of fish arriving at the spawning grounds early is low, then any program designed to move the majority of sockeye salmon run into Lake Osoyoos early may be counterproductive. Additional arguments could be made for or against management alternatives, but to make the proper decision, determing the migration and mortality rates between Wells and Zosel dams and the spawning grounds, and the spawning contribution of fish arriving at the spawning grounds at different times is prerequisite.

In an effort to evaluate sockeye salmon passage through the spillway gates at Zosel Dam, estimate the rate of migration and mortality between Wells and Zosel dams, and evaluate the spawning contributions of fish arriving early versus late at the spawning grounds, we recommend that future research include tagging sockeye salmon at Wells Dam. Two to five hundred sockeye salmon could be trapped and tagged at Wells Dam and released. At least three tag groups based on date of passage at Wells Dam would be evaluated. The following criteria would be used to select a tag.

1. The tag must be detectable using underwater video at Zosel Dam, and it would be preferable to distinguish among different colored tags using video to evaluate different tag groups.
2. The tag must be detectable using a metal detector mounted downstream of the spillway gates at Zosel Dam in order to evaluate migration through the spillway .
3. The tag must be detectable and distinguishable among tag groups at the spawning grounds in order to permit assessment of spawning contribution of fish arriving early versus late at the spawning grounds.

Summary

1. This project demonstrated that using underwater timelapse video to fish passage at Zosel Dam was feasible.
2. Sockeye salmon escapement estimates ranged from 25,172 to 42,410; this encompassed other estimates made at Wells Dam and the spawning grounds.
3. The mean date of passage for sockeye salmon was August 2 with a standard deviation of 24.2 days.
4. Migratory timing was tri-modal and apparently affected by high water temperatures. When water temperature exceeded 73F, no passage was recorded.
5. Approximately 93% of the sockeye salmon observed crossed Zosel Dam between 2000 and 0600 hours.

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Appendix A. Daily sockeye salmon escapement estimates for 1992 at Zosel Dam, calculated using expansion factors.

Date	West High	East High	Total High	West Low	East Low	Total Low
6/24/1992	0	0	0	0	0	0
6/25/1992	0	0	0	0	0	0
6/26/1992	0	8	8	0	8	8
6/27/1992	0	0	0	0	0	0
6/28/1992	0	0	0	0	0	0
6/29/1992	0	0	0	0	0	0
6/30/1992	0	0	0	0	0	0
7/01/1992	0	0	0	0	0	0
7/02/1992	0	0	0	0	0	0
7/03/1992	0	0	0	0	0	0
7/04/1992	0	-2	-2	0	-2	-2
7/05/1992	30	28	58	30	28	58
7/06/1992	81	131	212	35	100	135
7/07/1992	177	37	214	108	37	145
7/08/1992	192	30	222	135	30	165
7/09/1992	576	374	950	302	265	567
7/10/1992	1777	1555	3332	939	970	1909
7/11/1992	1009	1234	2243	547	571	1118
7/12/1992	2037	1611	3648	971	792	1763
7/13/1992	1687	1335	3022	1028	594	1622
7/14/1992	1479	732	2211	937	404	1341
7/15/1992	858	1310	2168	573	889	1462
7/16/1992	866	1186	2052	581	796	1377
7/17/1992	506	973	1479	335	661	996
7/18/1992	684	108	792	456	108	564
7/19/1992	683	8	691	455	8	463
7/20/1992	0	-3	-3	0	-3	-3
7/21/1992	0	0	0	0	0	0
7/22/1992	2	0	2	2	0	2
7/23/1992	0	0	0	0	0	0
7/24/1992	-3	0	-3	-3	0	-3
7/25/1992	0	3	3	0	3	3
7/26/1992	1	8	9	1	8	9
7/27/1992	-54	12	-42	-54	12	-42
7/28/1992	-35	36	1	-35	36	1
7/29/1992	-1	8	7	-1	8	7
7/30/1992	0	0	0	0	0	0
7/31/1992	-1	0	-1	-1	0	-1
8/01/1992	-2	0	-2	-2	0	-2
8/02/1992	-1	0	-1	-1	0	-1
8/03/1992	0	0	0	0	0	0
8/04/1992	0	0	0	0	0	0
8/05/1992	0	0	0	0	0	0
8/06/1992	0	0	0	0	0	0
8/07/1992	0	2	2	0	2	2
8/08/1992	0	6	6	0	6	6
8/09/1992	0	2	2	0	2	2
8/10/1992	0	0	0	0	0	0
8/11/1992	8	-9	-1	-2	-9	-11
8/12/1992	325	594	919	97	407	504
8/13/1992	433	966	1399	296	498	794
8/14/1992	74	92	166	51	61	112
8/15/1992	0	8	8	0	8	8
8/16/1992	1	14	15	1	14	15
8/17/1992	1	5	6	1	5	6

Appendix A. Continued.

Date	West High	East High	Total High	West Low	East Low	Total Low
8/18/1992	14	-2	12	14	-2	12
8/19/1992	-5	-3	-8	-5	-3	-8
8/20/1992	-5	-6	-11	-5	-6	-11
8/21/1992	11	16	27	11	16	27
8/22/1992	-1	18	17	-1	18	17
8/23/1992	11	18	29	11	18	29
8/24/1992	17	18	35	17	18	35
8/25/1992	177	237	414	57	198	255
8/26/1992	1701	3441	5142	863	1889	2752
8/27/1992	1139	1792	2931	728	1324	2052
8/28/1992	899	1331	2230	430	1003	1433
8/29/1992	1285	270	1555	612	178	790
8/30/1992	648	685	1333	317	321	638
8/31/1992	492	418	910	264	239	503
9/01/1992	189	47	236	166	47	213
9/02/1992	180	62	242	180	62	242
9/03/1992	281	127	408	167	100	267
9/04/1992	415	162	577	187	108	295
9/05/1992	10	42	52	10	42	52
9/06/1992	47	53	100	47	53	100
9/07/1992	24	34	58	24	27	51
9/08/1992	5	16	21	5	16	21
9/09/1992	-1	12	11	-1	12	11
9/10/1992	3	25	28	3	25	28
9/11/1992	8	25	33	8	25	33
9/12/1992	6	34	40	6	34	40
9/13/1992	0	5	5	0	5	5
9/14/1992	8	25	33	8	25	33
9/15/1992	1	6	7	1	6	7
9/16/1992	1	5	6	1	5	6
9/17/1992	19	3	22	19	3	22
9/18/1992	6	5	11	6	5	11
9/19/1992	0	0	0	0	0	0
9/20/1992	23	0	23	23	0	23
9/21/1992	14	2	16	14	2	16
9/22/1992	7	0	7	7	0	7
9/23/1992	13	0	13	13	0	13
9/24/1992	9	0	9	9	0	9
9/25/1992	9	0	9	9	0	9
9/26/1992	10	0	10	10	0	10
9/27/1992	7	0	7	7	0	7
9/28/1992	2	0	2	2	0	2
9/29/1992	1	0	1	1	0	1
9/30/1992	2	0	2	2	0	2
10/01/1992	1	0	1	1	0	1
10/02/1992	1	0	1	1	0	1
10/03/1992	-1	0	-1	-1	0	-1
10/04/1992	0	0	0	0	0	0
10/05/1992	1	0	1	1	0	1
10/06/1992	0	0	0	0	0	0
10/07/1992	3	0	3	3	0	3
10/08/1992	0	0	0	0	0	0
10/09/1992	2	0	2	2	0	2
10/10/1992	1	0	1	1	0	1
10/11/1992	0	0	0	0	0	0
10/12/1992	5	0	5	5	0	5

Appendix A. Continued.

Date	West High	East High	Total High	West Low	East Low	Total Low
10/13/1992	0	0	0	0	0	0
10/14/1992	0	0	0	0	0	0
10/15/1992	0	0	0	0	0	0
10/16/1992	0	0	0	0	0	0
10/17/1992	0	0	0	0	0	0
10/18/1992	0	0	0	0	0	0
Total:	21085	21325	42410	12042	13130	25172

SPRING CHINOOK SPAWNING GROUND SURVEYS
OF THE
METHOW RIVER BASIN, 1992;
DRAFT REPORT

APPENDIX - G

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1.0 ACKNOWLEDGEMENTS

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

2.0 ABSTRACT

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

The Wells Dam spring chinook count of 1623 fish was the sixth lowest count on record and only 55.2% of the 1988 parent year run of 2,940 fish. A total of 1,232 fish were available for spawning.

The surveys covered approximately 127 river miles and located a total of 741 redds. The Methow River had 336 redds (45.3%) and the Chewuch, Lost and Twisp rivers had 185, 73 and 141 redds (25.0%, 9.9% and 19.0%) respectively. An additional 3 redds (0.4%) were counted in Early Winters Creek and 3 (0.4%) in Lake Creek.

Twisp River broodstock trapping for the Methow River Hatchery at River Mile 6.1 and low spring flows had an adverse effect on the total upstream migration in the Twisp River and subsequent spawning distribution. Partial reconstruction and modification of Fulton Dam at River Mile 1.1 on the Chewuch River for broodstock trapping plus low spring flows contributed to a reduced number of spawners upstream from the dam. The increased redd count in the Methow

River was a result of the Twisp and Chewuch trapping operations and low flows.

The low flows resulted in the dewatering of approximately 32 redds in the Methow River and 6 in the upper Twisp River.

3.0 INTRODUCTION

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

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

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

In 1935, the Methow River and its tributaries were estimated to have a run of 200 to 400 spring chinook. The run was placed in jeopardy 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.

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

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

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

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

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

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

The current Winthrop Hatchery production program is to produce one million spring chinook smolts annually. The 1990 brood year spring chinook releases were 417,864 zero-age juveniles at 80 per pound on May 29, 1991 and 624,771 smolts at 16 per pound on April 21, 1992[1].

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

4.0 DESCRIPTION OF STUDY AREA

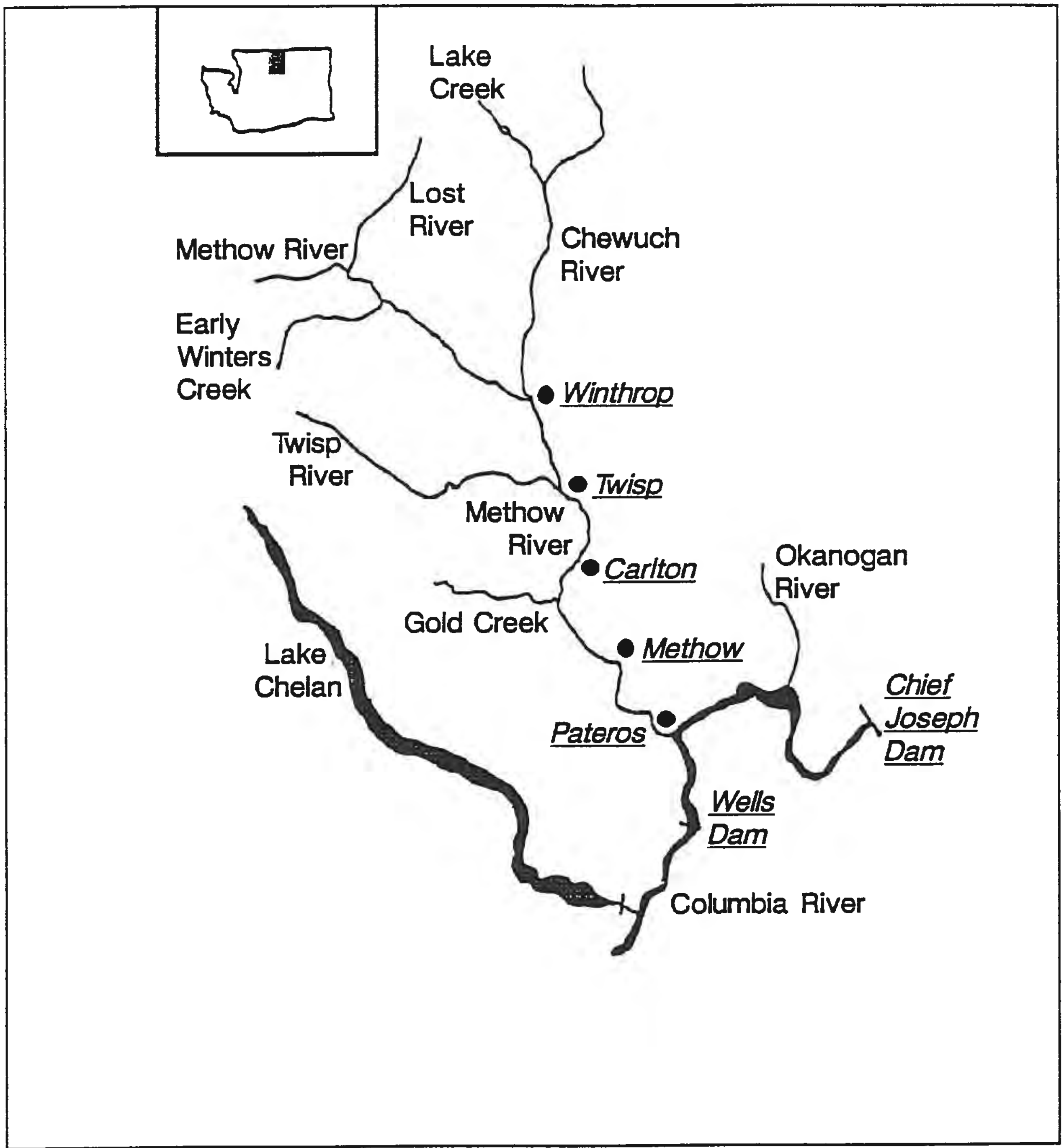

Figure 1. Methow River Basin location map.

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 Chewuch River joins the Methow River, the river elevation is 1745 feet. The river elevation drops to 779 feet where the Methow and Columbia rivers meet at Pateros, WA.

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

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

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

5.0 OBJECTIVES OF THE SPRING CHINOOK SURVEYS

The objectives of the spring chinook spawning ground surveys were to determine the timing, location, distribution and magnitude of spawning in the Methow River system.

Prior to 1987, spring chinook spawning ground surveys were conducted annually by the WDF and usually consisted of a single count of established index areas (Figure 2). These counts were usually made during or immediately after the peak of spawning in late August or early September.

These index surveys, in conjunction with the Wells Dam counts, provided information on spawning trends but did not provide data regarding any changes of timing, location or overall magnitude of spawning. Therefore, it became necessary to initiate the surveys earlier, by late July, in order to obtain time of spawning. In addition, to determine location, as in 1987-1991, the expanded surveys were continued to check all areas of the Methow Basin system where spring chinook spawning might occur. The surveys ended only after it was determined that all spawning was complete.

For purposes of continuity and comparison separate redd counts in the WDF index areas were continued during the 1992 surveys (Figure 2 and Table 1).

Additional objectives were to examine carcasses to determine success of spawning and collect length and scale samples to determine the age of the spawning population.

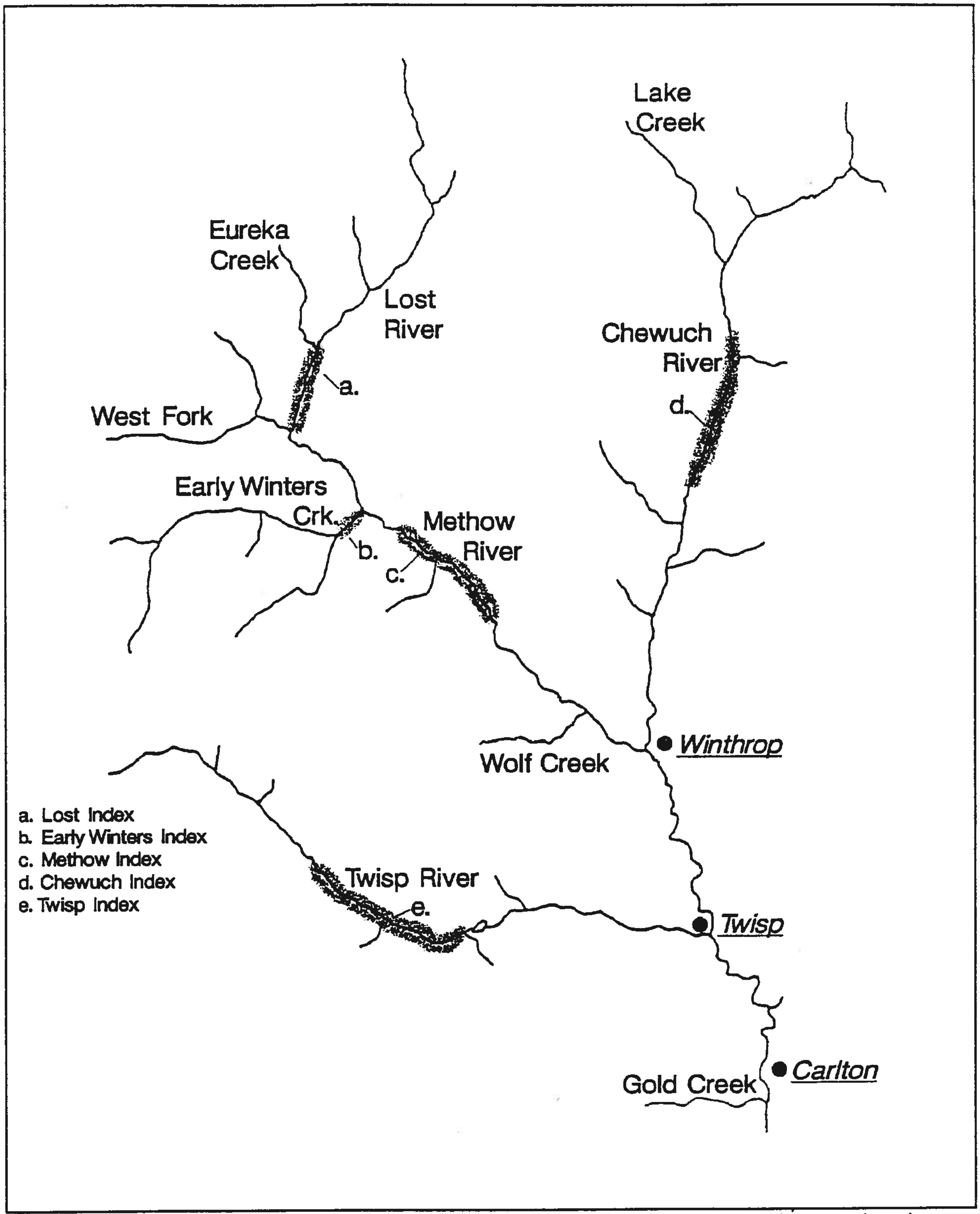

Figure 2. Upper Methow River Basin. Shaded sections indicate spring chinook spawning index reaches.

Table 1. Historical spring chinook index area redd counts for the Methow River Basin, 1962-1991.

	Methow River	Chewuch River		Lost River		Twisp River	Early Winters Creek
Spawning Year	Mazama Br. to Weeman Br.	Camp Four to Chewuch C.G.	Chewuch C.G. to Falls Cr. C.G.	Eureka Cr. to Lost R. Br.	Lost R. Br. to Mouth	Mystery Br. to Buttermilk Br.	Diversion Dam to Mouth
1962	187	9	49	104	N.S.	203	N.S.
1963	110	N.S.	78	35	N.S.	132	N.S.
1964	127	N.S.	176	98	N.S.	311	N.S.
1965	111	N.S.	34	86		138	N.S.
1966	233	N.S.	91	271		257	N.S.
1967	140	N.S.	N.S.	80	22	135	N.S.
1968	92	30	N.S.	35	2	190	1
1969	57	17	32	49	11	123	3
1970	150	14	32	101	N.S.	75	1
1971	113	10	23	61	9	97	6
1972	65	97		58	11	97	N.S.
1973	95	47	42	65	5	247	1
1974	49	22	30	11	N.S.	129	3
1975	39	N.S.	98	59	N.S.	177	2
1976	34	N.S.	22	12	N.S.	53	N.S.
1977	65	N.S.	107	14		174	0
1978	67	87	59	50	N.S.	265	4
1979	12	18	13	23	3	40	0
1980	25	8	14	13	4	27	0
1981	39	1	6	20	5	24	2
1982	56	2	8	29	4	17	0
1983	63	6	29	18	4	58	1
1984	43	24	15	54	6	48	3
1985	23	93	34	5		95	6
1986	63	34		48	N.S.	38	3
1987	75	23	54	52	4	79	1
1988	75	40	15	53	0	111	0
1989	60	12	32	53	4	100	6
1990	80	61		33		77	1
1991	31	14	16	16	0	40	0

NS - No Survey

6.0 METHODS

The Methow River and it's tributaries were divided into sections to define spawning locations and distribution. The tributaries and upper Methow River downstream to the Weeman Bridge were surveyed on foot. The Methow River from the Weeman Bridge to Winthrop and from Winthrop to Carlton was rafted when flows were sufficient but walked otherwise.

Surveys of known spawning areas in each tributary were usually conducted weekly as time permitted. As in 1987 - 1991, the surveys were expanded to cover all accessible reaches of the Methow River and its tributaries. Some expanded survey areas, usually those in the upper reaches, contained minimal spawning habitat and were not surveyed on a weekly basis. However, they were surveyed several times, when possible, with the final survey conducted during or after peak spawning had occurred. As spawning progressed in the upper reaches and fewer redds were observed, the surveys concentrated on the lower reaches. To ensure redd count consistency, the same surveyor was assigned to the same river reaches for each weekly survey.

To avoid recounting or missing any spring chinook redds they were flagged on the bank with surveyors tape, dated and numbered. The approximate location of the redd was also noted on the tape. The flag color was changed each week.

All live chinook were counted on each survey. If fish were observed on a flagged redd during subsequent weekly surveys, they were recounted. Therefore, the live fish counts are not indicative of the total number of spawning fish.

Carcasses were recovered and checked for tags, fin clips, sex and spawning success. Scales were collected and hypural lengths measured for age analysis.

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

The total number of spring chinook available for spawning in the Methow system was calculated from the Wells Dam counts, the number of fish returning to the Winthrop National Hatchery and the number of fish trapped for the Methow Valley Spring Chinook Hatchery at the Twisp River weir and the Fulton Dam Trap on the Chewuch River.

7.0 SPRING CHINOOK RUN SIZE

The 1992 Wells Dam spring chinook count of 1,623 fish was the sixth lowest count on record (Table 2). Assuming the majority of the chinook were four-year fish, the run size was only 55% of the 1988 parent year run of 2,940 and only 58% of the 1981-1990 average run size of 2,804 fish.

7.1 Winthrop National Fish Hatchery returns[2]

Spring chinook voluntarily entered the hatchery ladder and holding pond commencing about mid-May, peaked in early June and entered sporadically after mid-June. A total of 331 chinook (Table 2) were spawned during the period August 18 to September 8 for a total egg take of 945,000.

The final chinook count was 85 (25.7%) males, 10 (3.0%) jacks and 236 (71.3%) females for a male to female ratio, including jacks, of 1.0 : 2.5. Milt from 102 males was transferred from the Leavenworth National Fish Hatchery to ensure proper fertilization.

7.2 Methow Valley Spring Chinook Hatchery broodstock trapping[3]

Trapping for broodstock commenced on May 15 in the Twisp and Chewuch rivers and terminated on September 8. The 1992 egg take goal was 300,000 eggs or approximately 60 females plus sufficient males for fertilization from each river.

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

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

Table 2. Spring chinook counts at Wells Dam, number of fish returning to the Winthrop Hatchery, number trapped for the Methow Valley Hatchery and total fish available for spawning in the Methow Basin, 1967-1992.

	Wells Dam Counts \1			Winthrop \2 Hatchery	Methow Valley Hatchery\3			Methow Basin spawners
					Twisp River		Chewuch River	
Year	Adults	Jacks	Total		Live	Morts		
1967	541	616	1,157					1,157
1968	4,086	845	4,931					4,931
1969	3,048	551	3,599					3,599
1970	2,092	578	2,670					2,670
--	--	--	--					
1971	2,535	633	3,168					3,168
1972	3,368	248	3,616					3,616
1973	2,505	507	3,012					3,012
1974	3,199	221	3,420					3,420
1975	2,096	129	2,225					2,225
1976	1,510	1,249	2,759					2,759
1977	3,976	235	4,211					4,211
1978	3,532	83	3,615	38				3,577
1979	971	132	1,103	102				1,001
1980	941	241	1,182	155				1,027
1970-1980(Avg)\4			2,831	---				2,801
1981	1,367	98	1,465	399				1,066
1982	2,270	131	4,252	601				3,651
1983	2,726	143	2,869	755				2,114
1984	3,066	214	3,280	510				2,770
1985	5,151	116	5,267	1,201				4,066
1986	2,896	65	2,961	836				2,125
1987	2,272	74	2,346	594				1,752
1988	2,844	96	2,940	1,327				1,613
1989	1,633	87	1,720	195				1,525
1990	927	12	939	121				818
1981-1990(Avg)\4			2,804	654				2,150
1991	682	100	782	92				690
1992	1,596	27	1,623\5	331	30	10	20	1,232

1 Personal communication from R. Klinge, Douglas County PUD.
2 Personal communication from W. Wallein, Winthrop National Hatchery Manager
\3 Personal Communication from B. Jateff , Methow Valley Hatchery Manager.
\4 Not a moving average.
\5 An additional 107 adults and 4 jacks were counted by video during "non counting" hours.

On the Twisp River, a weir was constructed at River Mile 6.1 for broodstock collection. Most fish were able to swim over or jump the weir during high water periods in May and June even though 1992 was a low flow year. However, 16 fish were trapped in May and 30 in June. As flows subsided during July and August the weir proved to be a block to some fish that had not passed during high water and had not located the entrance to the trap. However, some fish did enter the trap with 3 captured in July and 21 during August.

A total of 20 females and 51 males was eventually trapped and 30 chinook, 12 females and 18 males, were retained as broodstock (Table 2). The remainder were released above the weir. During June, 4 females and 6 males, were killed by stranding on the weir.

Prespawning mortality at the hatchery was 3 each for males and females or 17% and 25% respectively for fish collected for broodstock. Approximately 37,000 eggs were taken during the period August 13 to September 3.

Fulton Dam at River Mile 1.1 on the Chewuch River was modified and the existing denil (steep-pass) ladder was reconstructed for broodstock trapping. Spring flows eroded a portion of the boulder dam modification thus enabling most chinook to pass over the dam and avoid the ladder trapping system. During this period, 11 fish were trapped in May and 8 in June. Flows subsided rapidly and by mid-July the dam became impassable. During July, fish did not enter the ladder, however, 14 were trapped in August.

Eighteen females and 15 males were trapped with 20 chinook, 13 females and 7 males, retained as broodstock (Table 2). Prespawning mortality was 1 (8%) female and 2 (29%) males. Approximately 53,000 eggs were taken between August 20 and September 14.

Broodstock trapping and Winthrop Hatchery returns show that most chinook migrate upstream during May and June. Only 4 fish were trapped during July on the Twisp River and none on the Chewuch River. Beginning in mid-August, some chinook began entering the trapping facilities in both areas. These fish were approaching maturity and were probably moving aggressively upstream to spawn.

8.0 METHOW RIVER BASIN FLOWS

Flows measured at the Pateros gauge (USGS) show lower than normal flows during the period of spring chinook upstream migration during May and June (Appendix Table I) . Flows in the upper Methow, Twisp and Chewuch rivers were also low during the same period (Appendix Tables II-V). Flows declined during the spawning period and some areas of the upper Methow and Twisp rivers were dry by mid-September, after spawning had been completed.

9.0 RESULTS AND DISCUSSION

The spawning ground surveys commenced on July 25 and continued through September 23, with a final survey conducted from October 26-28. A total of 127 river miles was surveyed, with prime spawning reaches being surveyed at least once a week. Spawning usually occurred first in the upper reaches of the system, and later in the lower areas, usually coincidental with declining water temperatures.

Because of the broodstock trapping on the Twisp and Chewuch rivers, the surveys encompassed these entire basins beginning on July 26 to determine if the adult fish were delayed or blocked. Surveys of the lower reaches of the Methow River were initiated on August 10.

9.1. Timing, location and magnitude of spawning.

9.1.1. Methow River

The first redds were counted in Sections 6 and 8 on August 10 (Table 3). The heaviest concentration of spawning (109 redds or 32.4% of the total) occurred in Section 7, the 5.3 mile stretch downstream from the Weeman Bridge. Within the index areas (Sections 5 and 6), 90 redds (26.8%) were counted.

Spawning peaked from August 24 to September 3 with 233 redds (69.3% of the 336 total) counted during this period (Table 3). Spawning occurred in all sections from the Lost River confluence to the Carlton Bridge. Redds were not found in the West Fork.

Table 3. Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Methow River, 1992.

RIVER SECTION	Road miles	SURVEY DATES AND NUMBER OF REDDS										TOTALS	
		JULY		AUGUST				SEPTEMBER					
		26	30	3	10&11	17-18-20	24-25-27	31-1-3	7-8-10	14-15-16	21-22-23	Number	Percent
1.W.Fork Ballard C.G. to Lost R. Confl.	2.2		0		0		0		0			0	0
2.Lost River Confl. to Gate Creek	2.5	0		0	0	0	15	9	0		0	24	7.1
3.Gate Creek to Early Winters Cr.	1.3			0	0	7	12	0	0		0	19	5.7
4.Early Winters Cr. to Mazama Bridge	1.9			0	0	0	2	0	0		0	2	0.6
5.Mazama Bridge to Road Barrier	2.2			0	0	0	3	8	1	0	0	12	3.6
6.Road Barrier to Weeman Bridge	3.0			0	2	4	24	33	11	4	0	78	23.2
7.Weeman Bridge to Hiway 20 along riv.	5.3			0	0	7	35	43	24	0		109	32.4
8.Hiway 20 along riv. to Wolf Creek	1.1			0	2	1	6	5	3	0		17	5.1
9.Wolf Creek to Diversion Dam	1.5				0	8	10	4	3	0		25	7.4
10.Diversion Dam to Winthrop Bridge	1.3				0	5	10	5	2	0		22	6.5
11.Winthrop Bridge to Diversion Dam	5.0					2	1	5	1	2	3	14	4.2
12.Diversion Dam to Twisp Bridge	4.1					0	0	3	1	1	2	7	2.1
13.Twisp Bridge to Carlton Bridge	10.5									2	5	7	2.1
Totals	41.9	0	0	0	4	34	118	115	46	9	10	336	100
Temperature range (F)		48-52	48-53	50-59	49-63	51-66	45-59	50-62	45-57	46-54	47-59		

The Methow River redd count was 336 or 45.3% of the total basin count of 741 (Table 4). This is the largest count since the expanded surveys were initiated in 1987 and significantly greater than the average of 32.4% of the total basin redds occurring in the river from 1987 to 1991 (Table 4). Redd counts in Section 10, the confluence of the Chewuch and Methow rivers, increased significantly since 1987. This change in spawning distribution suggests that some fish destined for the Chewuch did not pass the trapping site at Fulton Dam either because of the physical barrier presented by the dam modifications or low flows later in the migration season and alternatively spawned in the Methow. Spawning habitat is not available in the Chewuch River downstream from Fulton Dam at River Mile 1.1 and at the Methow confluence.

Similarly, passage problems encountered by the chinook at the Twisp River weir may have contributed to the increased Methow River redd count. With an increase in spawning numbers observed in the 6.1 miles of marginal habitat below the weir, displacement from the weir may also have resulted with more chinook seeking suitable habitat out of the Twisp River into the mainstem Methow. The redd count in the Methow River increased primarily in Section 7 to 10, from the Weeman Bridge downstream to the Winthrop Bridge.

The first exposed, dewatered, redds resulting from low flows were observed on September 14 in Section 5. By September 21, the upper Methow River from approximately one mile downstream from the Lost River confluence to the Early Winters Creek confluence was completely dry. Surveys on this date in Sections 2-6 showed 24 exposed redds or 18% of the 135 redds in these sections. A final spot check survey was conducted in Sections 2-6 on October 26-28 and an additional 8 redds were found dewatered for a total of 32 redds or 24% of the total redds in these sections. Redds were not found to be dewatered downstream from the Weeman Bridge during the October survey.

On September 4, four sockeye were observed spawning in Section 7, downstream from the Weeman Bridge. On September 22, 16 sockeye were spawning in Section 13, downstream from the Twisp Bridge. Some summer chinook were also observed in the Methow River downstream from Winthrop after mid-September. These fish were not actively spawning.

Table 4. Number and percent of redds found in the Methow River and tributaries, based on expanded surveys, 1987-1992.

Year	Methow River		Chewuch River		Lost River		Twisp River		Early Winter Cr.		Gold Cr.		Lake Cr.		Wolf Cr.		Totals	
	Redds	Per-cent	Redds	Per-cent	Redds	Per-cent	Redds	Per-cent	Redds	Per-cent	Redds	Per-cent	Redds	Per-cent	Redds	Per-cent	Redds	Per-cent
1987	254	37.4	188	27.6	56	8.2	161	23.7	14	2.1	3	0.4	4	0.6	0	--	680	100
1988	262	35.1	202	27.1	53	7.1	199	26.7	17	2.3	4	0.5	9	1.2	0	--	746	100
1989	110	21.2	160	30.8	57	11.0	179	34.4	11	2.0	3	0.6	0	--	0	--	520	100
1990	194	38.6	158	31.5	33	6.6	113	22.5	1	0.2	3	0.6	0	--	0	--	502	100
1991	74	29.6	91	36.4	16	6.4	69	27.6	0	--	0	--	0	--	0	--	250	100
1987-91 Average	-	32.4	--	30.7	--	7.9	--	27.0	--	--	--	--	--	--	--	--	--	--
1992	336	45.3	185	25.0	73	9.9	141	19.0	3	0.4	0	--	3	0.4	0	--	741	100

9.1.2. Chewuch River

The first redd was observed on August 4 in the Dibble Springs area of Section 2 (Table 5). The count peaked in this section on August 11 and spawning was completed by August 25.

Spawning peaked downstream from Section 2 on September 1, with 81 (43.8%) redds counted and was completed by September 17 (Table 5). Spawning did not occur in Sections 1, 3, 4, and 5 because of lack of suitable habitat. The single redd located in Section 13 was in the upper end of the Chewuch Irrigation Canal. The redds were distributed throughout the remainder of the river with 74 redds (40.0%) in Sections 9 and 11. The index area, Sections 7-10, contained 77 (41.6%) of the redds. Only 9 redds (4.9%) occurred in the lower river between the Chewuch River road bridge and the mouth, Sections 14 and 15, as compared with 23 redds (28.8%) in 1991. Spawning habitat is not available from Fulton Dam downstream to the mouth but habitat is available from the dam upstream to the bridge. Decrease in spawning in this area may be attributable to increased water temperature or blockage of later arriving fish that would then possibly utilize the lower river for spawning because of low flows at Fulton Dam. Even though the ladder at the dam was in operation with good attraction flows during the low flow period of July and August, the chinook do not have a proclivity for denil (steep-pass) ladders.

The Chewuch River redd count of 185 was 25% of the total basin count of 741. Percentage of total basin redds from 1987-1991 has ranged from 27.1% to 36.4% with an average of 30.7% (Table 4). As mentioned above, it is possible that some fish destined for the Chewuch spawned in the Methow River because of passage problems.

Spot check surveys in late October did not reveal dewatered redds in the Chewuch River.

Table 5. Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Chewuch River, 1992.

RIVER SECTION	ROAD MILES	SURVEY DATES AND NUMBER OF REDDS										TOTALS	
		JULY		AUGUST				SEPTEMBER					
		25	28	4 & 6	11 & 13	18 & 20	25 & 27	1	8 & 10	15 & 17	22 & 23	Number	Percent
1.Falls to Thirty Mile Bridge	3.4 (est.)				0							0	0
2.Thirty Mile Bridge to Roadside Camp	2.5	0 \1	0 \1	1	5 \1	3 \1	3 \1	0				12	6.5
3.Roadside Camp to Andrews Creek	3.4			0								0	0
4.Andrews Creek to Lake Cr. C.G.	2.4			0								0	0
5.Lake Cr. C.G. to Buck Cr.	2.0		0	0	0	0	0					0	0
6.Buck Creek to Camp 4	1.2	0	0	0	0	5	9	9	3	0		26	14.0
7.Camp 4 to Roadside Camp	1.2		0	0	0	0	0	6	1	0		7	3.8
8.Roadside Camp to Chewuch C.G.	1.6		0	0	0	0	0	4	10	1	0	15	8.1
9.Chewuch C.G. to Mile 6	1.9		0	0	1	0	3	17	14	3	0	38	20.5
10.Mile 6 to Falls Cr. C.G.	1.4		0	0	0	0	0	9	7	1	0	17	9.2
11.Falls Creek C.G. to Eight Mile Ranch	2.9		0	0	0	0	1	29	5	1	0	36	19.5
12.Eight Mile Ranch to Memorial Br. Piers	1.5		0	0	0	0	2	7	12	3	0	24	13.0
13.Memorial Br. Piers to Chewuch River Road Bridge	0.9								1 \3		0	1	0.5
14.River Road Bridge to 1/2 Way Point	3.3			0			1		5	3	0	9	4.9
15.1/2 Way Point to Mouth	3.4		0 \2	0			0	0	0	0	0	0	0.0
Totals	33.0	0	0	1	6	8	19	81	58	12	0	185	100
Temperature range (F)		51-62	53-66	54-65	51-64	54-67	44-59	45-53	45-56	42-51	50-55		

\1 Dibble Springs Area only.
\2 Fulton Dam to Methow confluence.
\3 Redd in Chewuch Irrigation Canal.

9.1.3. Lost River

The initial survey was made on July 25 with the first redds counted on August 17 (Table 6). Spawning peaked on August 24 with a count of 34 redds. Nine additional redds were located on August 31 and no new redds were found on September 7, the final survey .

Since 1987, the Lost River redd counts have ranged from 6.4% to 11.0% of the total basin count (Table 4). This years redd count of 73 was 9.9% of the basin total, an increase over the five year average of 7.9%. It was also the third highest count of record, exceeded only by the 1962 and 1970 counts of 104 and 101, respectively.

9.1.4. Twisp River

Surveys were initiated on July 26 and continued through September 16. Because of the weir operation and its potential for shifting spawning distribution, the entire river was surveyed on a weekly basis through September 9 (Table 7).

The first redds were observed in Sections 4,5 and 8 on August 12 (Table 7). Spawning peaked between August 20-26 with 91 (64.5% of the total) redds counted. The index area, Sections 5-7, contained 73 (51.8%) of the total redds in the river. Lack of suitable habitat precluded spawning in Sections 1, 2, 10, 11 and 15.

Forty redds (28.4%) of the 141 total were located from the weir at RM 6.1 downstream to the Twisp River road bridge (Sections 12-14). The spawning gravel in this area is marginal and only 10 total redds were found in these sections during the four previous years 1988-1991. Five of the 40 redds were constructed immediately below the weir. Measurements were made of two redds below the Poorman Bridge and were 3 feet wide by 30 feet long and 3 feet wide by 23 feet long. Both redds were constructed amidst large boulders and rubble.

Table 6. Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Lost River, 1992.

RIVER SECTION	MILES (EST)	SURVEY DATES AND NUMBER OF REDDS									TOTALS	
		JULY		AUGUST					SEPTEMBER			
		25 & 26	30	3	10	17	24	31	7	21	Number	Percent
1. Sunset Cr. to Eureka Cr.	2.0					0					0	0
2. Eureka Cr. to Bridge	4.0	0	0		0	30	32	9	0		71	97.3
3. Bridge to Methow River	0.5	0	0	0	0	0	2	0	0	0	2	2.7
Totals	6.5	0	0	0	0	30	34	9	0	0	73	100
Temperature (F) range		51-56	52-56	50-51	51-58	49-57	46-53	49-54	44-45	44		

Table 7. Date and number of spring chinook surveys, timing of spawning, location, number and percentage of redds by river section, total redds, and water temperature range of the Twisp River, 1992.

RIVER SECTION	ROAD MILES	SURVEY DATES AND NUMBER OF REDDS								TOTALS	
		JULY	AUGUST				SEPTEMBER				
		26-27 & 29	5 & 6	12	20	26	2 & 3	9	16	Number	Percent
1.Road End C.G. up for 2 miles	2.0 (est.)							0		0	0
2.Road End C.G. to South Cr. Bridge	3.1	0						0		0	0
3.South Creek Br. to Poplar Flats C.G.	2.0	0	0	0	2	4	0			6	4.3
4.Poplar Flats C.G. to Mystery Br.	2.0	0	0	4	1	1	0			6	4.3
5.Mystery Br. To War Creek	4.4	0	0	8	17	6	0			31	21.9
6.War Cr. Br. to Cabin on Left Bank Rd.	2.2	0	0	0	4	9	3	0		16	11.3
7.Cabin to Buttermilk Br.	2.5	0	0	0	13	9	4	0		26	18.4
8.Buttermilk Br. to Br. with Gate	0.7		0	1	2	5	1	0		9	6.4
9.Br. with Gate to Little Br. Cr.	2.0		0	0	0	1	5	1	0	7	5.0
10.Little Br. Cr. to Newby Br.	1.3		0	0	0	0	0	0		0	0
11.Newby Br. to Fish Weirs	1.2		0	0	0	0	0	0		0	0
12.Fish Weirs to Wooden Br.	1.0	0	0	0	2	10	4	1	0	17	12.1
13.Wooden Br. to Poor Man Br.	1.3	0	0	0	1	0	4	3	0	8	5.7
14.Poor Man Br. to Twisp River Rd.Br.	2.4	0	0	0	2	2	1/ 10	1	0	15	10.6
15.Twisp River Rd. Br. to Mouth	1.2	0	0	0	0	0	0	0	0	0	0
Totals	29.3	0	0	13	44	47	31	6	0	141	100
Temperature range (F)		48-65	49-67	48-66	47-71	45-66	45-68	44-60	44-54		

1/ Six redds located in Methow Valley Irrigation Canal.

Six redds were found in the Methow Valley Irrigation Canal between the headgate and the fish screen. Gravel in the canal is ideal for spawning and the canal is watered throughout the year. The canal supervisor reported that redds had not been constructed in this area since 1988.

Since 1987, redd counts in the Twisp River have ranged from 22.5% to 34.4% of the basin total for an average of 27.0% (Table 4). In previous years, almost all these redds were found upstream from the weir site. This year, only 19% of the redds in the Methow Basin were found in the Twisp River and only 101 redds (13.6%) were located upstream from the weir (Table 7).

The total of 141 redds in the Twisp River or 19.0% of the 741 redds found in the basin and the concentration of redds downstream from the weir suggests the weir was a major blockage to some migrating adults. Low flows may have also contributed to the delays and blocks at this point.

By September 9, the six redds in Section 3 were dewatered. The final spot check survey in late October did not reveal additional dewatered redds.

9.1.5. Other tributaries

Three redds were found in Early Winters Creek on August 24 (Table 8) and 3 were counted in Lake Creek on August 20 (Table 9). Redds were not located in Gold or Wolf Creeks (Tables 10-11).

Table 8. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Early Winters Creek, 1992.

CREEK SECTION	ROAD MILES	SURVEY DATES AND NUMBER OF REDDS						TOTALS	
		JULY	AUGUST				SEPTEMBER		
		30	3	10	24	31	14	Number	Percent
1.Klipchuck C.G. to Early Winter Br.	0.9				1	0		1	--
2.Early Winter Br. (C.G. Rd.) to Highway 20 Br.	1.3		0		1	0	0	1	--
3.Highway Br. to Diversion Dam (EWCG)	1.5		0		1	0	0	1	--
4.Diversion Dam to Highway 20 Br.	0.2	0		0	0	0	0	0	--
5.Highway Bridge to Mouth	0.5	0		0	0	0	0	0	--
Totals	4.4	0	0	0	3	0	0	3	100
Temperature range (F)		62-63	55-58	53-58	49-54	51-56	44-46		

Table 9. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Lake Creek, 1992.

CREEK SECTION	SURVEY DATES AND NUMBER OF REDDS				
	ROAD MILES	AUGUST 20	SEPTEMBER 17	TOTALS	
				Number	Percent
1.Lake to Halfway Point	1.5	N.S.	N.S	---	---
2.Halfway Point to Parking Lot	1.5	N.S.	N.S.	---	---
3.Parking Lot to Mouth	2.2	3	0	3	100
Totals	5.2	3	0	3	100
Temperature Range (F)		54-56	43-45		

N.S. no survey

Table 10. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Gold Creek, 1992.

CREEK SECTION	SURVEY DATES AND NUMBER OF REDDS				
	ROAD MILES	AUGUST 13	SEPT. 21	TOTALS	
				Number	Percent
1.Foggy Dew C.G. to North Fork Bridge	2.4	0	0	0	--
2.North Fork Bridge to South Fork Road Br.	1.8	0	0	0	--
3.So. Fork Rd. Bridge to Gold Cr. Rd. Br.	1.1	0	0	0	--
4.Gold Cr. Rd. Bridge to Mouth	0.1	0	0	0	--
Totals	5.4	0	0	0	--
Temperature range (F)		55-61	52-53		

Table 11. Date and number of spring chinook surveys, timing of spawning, location and number of redds by creek section and water temperature range of Wolf Creek, 1992.

CREEK SECTION	SURVEY DATES AND NUMBER OF REDDS				
	ROAD MILES	AUGUST 17	SEPT. 7	TOTALS	
				Number	Percent
1.Diversion Dam to First Bridge	0.2	0	0	0	--
2.Bridge to Mouth	1.0	0	0	0	--
Totals	1.2	0	0	0	--
Temperature range (F)		54-56	46-46		

9.1.6. Water temperatures

Water temperatures were taken at the beginning and end of all surveys and are summarized in Tables 3 and 5-11. Lower stream flows resulted in higher water temperatures than 1991. The Twisp River temperatures were very high beginning in August and continued through September 9. Many fish spawned in water temperatures exceeding 60° F., at least during part of the daylight hours. The peak of spawning in the Twisp River occurred between August 20-26. Temperatures in the Methow and Chewuch rivers exceeded 60° F through August 20, though peak spawning in both systems occurred after this date.

9.2. Live Fish Counts

Live fish counts are depicted in Table 12. A total of 748 fish or 60.7% of the 1,232 spring chinook estimated to be spawning in the Methow were counted. However, some fish were enumerated more than once. This live count was much greater than the 20% observed in 1991 and is attributed to better visibility resulting from decreased stream flows.

9.3. Carcasses Recovered

During the surveys, 177 carcasses, 67 males and 110 females, were recovered. Of the 110 females examined, 101 (91.8%) were completely spawned, 2 (1.8%) were partially spawned with 500 plus eggs remaining, and 7 (6.4%) were unspawned. Two of the unspawned fish had been killed by poachers. From 1987 through 1991, the percentages of completely spawned females were 89%, 90%, 88%, 95% and 90%, respectively (Kohn, 1987, 1988, 1989; Edson, 1990; and Meekin, 1991).

Table 12. Number of live spring chinook counted and carcasses examined by week, 1992.

Week	Methow River			Chewuch River			Lost River			Twisp River			Early Winters Cr.			Lake Creek			Totals		
	Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses		Live	Carcasses	
		M	F		M	F		M	F		M	F		M	F		M	F		M	F
July 19-25				0	0	0	0	0	0										0	0	0
July 26-Aug. 1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0				4	0	0
Aug. 2-8	1	0	0	4	0	1	0	0	0	1	1[1]	0	0	0	0				6	1	1
Aug. 9-15	2	0	0	2	2[2]	3[5]	2	0	0	16	0	1	0	0	0				22	2	4
Aug. 16-22	32	1[1]	5[3]	10	0	1[6]	16	0	0	53	1	1				2	0	0	113	2	7
Aug. 23-29	135	2	3	24	0	1	15	1	1	56	7[2]	2	7	0	1				237	10	8
Aug. 30-Sept 5	144	11	22[4]	89	1	2	4	0	2	14	5	4	0	0	2				251	17	32
Sept. 6-12	33	15	22	60	7	9	0	0	3	5	7	5							98	27	39
Sept. 13-19	4	3	7	12	1	4				0	0	0	0	0	0	0	0	0	16	4	11
Sept. 20-26	0	1	2	1	1	6	0	0	0										1	2	8
Totals	351	33	61	202	12	27	37	1	6	149	21	13	7	0	3	2	0	0	748	67	110

[1] Green male.
[2] 1 male was green.
[3] 5 unspawned females.
[4] 1 female partially spawned.
[5] 1 female unspawned (killed by poachers).
1 female partially spawned.
[6] Unspawned female (killed by poachers).
Note: Live fish and carcasses were not observed in Gold and Wolf Creeks.

Four (6%) of the 67 male carcasses examined were classified as green. The male to female ratio for the carcass sample was 1.0 to 1.6. Data from 1987-1991 show male to female ratios of 1 to 1.33; 1 to 2; 1 to 1.9; 1 to 1.6 and 1 to 1.6, respectively.

Scale samples were collected from carcasses and will be analyzed at a later date. Based on previous years length frequency data for 3, 4 and 5-year old fish, this years data indicated that 14 carcasses (7.9%) were 3-year fish (55 cm or less); 145 (81.9%) were 4-year fish (56 to 71 cm); and 18 (10.2%) were 5-year fish (72 cm or greater).

In mid-September, an adipose clipped chinook carcass was recovered from the Methow River downstream from the Winthrop Bridge. The coded wire tag showed this 1988 brood year fish had been released on March 6, 1990 from S.F. Klaskanine Pond, Youngs River, Oregon

9.4. Fish Per Redd

Surveys of the entire spring chinook spawning area in the Methow Basin and the estimated number of fish available for spawning permits the calculation of a fish per redd factor of 1.66 (Table 13). This factor is considered low and is similar to 1990 (1.63%) which was also low and was attributed to a delayed spring chinook migration at Wells Dam when late arriving spring chinook were counted as summer chinook. Reasons for this years low factor are unknown but may be a combination of unknown prespawning mortality, fewer males on the spawning grounds as indicated by the Winthrop Hatchery returns or better visibility because of low flows.

Table 13. Number of spring chinook per redd in the Methow River Basin, 1987-1992.

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

9.5. Spawning Distribution

The 1992 spawning index area distribution in the tributaries is shown in Table 14. Compared with the previous five years of data, there was a shift in the 1992 spawning populations of areas downstream from the index area (Table 15). As previously mentioned, this occurred primarily in the Twisp River but was also noted in the Methow River.

Table 4 depicts the spawning distribution within the Methow Basin since the expanded surveys were initiated in 1987. There was a change in the tributary distribution of spawning with the mainstem Methow increasing to the highest percentage of the total run and the Chewuch and Twisp rivers decreasing to the lowest percentage of the total run. The percentage in the Lost River increased only slightly while the remaining smaller tributaries did not contain significant numbers of spawners.

The data suggests that there was a shift in the spawning distribution during 1992, both tributary-wise and within the tributaries, primarily the Twisp downstream from the weir and to some extent the Methow below the index area, and in the Chewuch lower river, just upstream from Fulton Dam. This change in distribution is attributed to two factors: broodstock trapping on the Twisp and Chewuch rivers resulting in delays and blocks to the adult migration; and lower flows during the later part of the migration.

Table 14 Spring Chinook redd count summary, numbers and percentages for the Methow River Basin, 1992, (Redd counts are divided into three sections: above, below, and within the index areas).

River	Index Area	Above Redds (%)	Index Redds (%)	Below Redds (%)	Total Redds (%)
Methow River	Mazama Br. to Weeman Br.	45 (13.4)	90 (268)	201 (59.8)	336 (100)
Chewuch River	Camp 4, CG to Falls Cr.CG	38 (20.6)	77 (41.6)	70 (37.8)	185 (100)
Lost River	Eureka Cr. to Mouth	0 (0)	73 (100)	0 (0)	73 (100)
Twisp River	Mystery Br. to Buttermilk Br.	12 (8.5)	73 (51.8)	56 (39.7)	141 (100)
Early Winters	Fish Screens to Mouth	1 (33.3)	2 (66.7)	--- ---	3 (100)
Basin Total		96 (13.0)	315 (42.7)	327 (44.3)	\1 738 (100)

\1 An additional 3 redds were in Lake Creek for a basin total of 741.

Table 15. Distribution of redds in relation to the index areas in the Methow Basin 1987-1992.

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

\1 An additional 7 redds were in Lake and Gold Creeks for a basin total of 680.

\2 An additional 13 redds were in Lake and Gold Creeks for a basin total of 746.

\3 An additional 3 redds were in Gold Creek for a basin total of 520.

\4 An additional 3 redds were in Gold Creek for a basin total of 502.

\5 An additional 3 redds were in Lake Creek for a basin total of 741.

10.0 SUMMARY

1. The Methow Basin spring chinook escapement as measured at Wells Dam was 1,623 fish of which 1,232 were available for spawning after hatchery returns and broodstock trapping.

2. Spring chinook surveys were conducted from July 25 through September 23 and encompassed approximately 127 miles.

3. The initial redd was observed in the Chewuch River on August 4 and the final one in the lower Methow River on September 23.

4. A total of 741 redds were located with 336 (45.3%) in the Methow River and 185 (25.0%), 73 (9.9%) and 141 (19.0%) found in the Chewuch, Lost and Twisp rivers, respectively. Three redds each were located in Early Winters and Lake creeks. Redds were not found in Gold or Wolf creeks. Twenty sockeye salmon were observed spawning in the Methow after mid-September.

5. A total of 748 live fish was counted and 177 carcasses were examined. The male to female ratio was 1.0 to 1.6 and 91.5% of the females were spawned out. The fish per redd factor was 1.66.

6. There were changes in the spawning distribution, both in the overall basin and within the Twisp, Methow and Chewuch rivers. This change in distribution was attributed to broodstock trapping in the Chewuch and Twisp rivers and to low stream flows.

7. Most of the spawning in the Twisp River occurred when water temperatures exceeded 60° F. during a portion of the daylight hours.

8. Stream flows decreased rapidly after spawning and by late October an estimated 32 redds were dewatered in the upper Methow River and 6 were exposed in the upper Twisp.

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APPENDIX TABLES

Appendix Table I. Mean monthly flows (cfs) of the Methow River at Pateros, WA., 1987-1992.

Month	Year					
	1987	1988	1989	1990	1991	1992
JAN	275	344	350	399	549	313
FEB	308	272	333	342	547	356
MAR	495	321	399	496	682	1012
APR	1673	1821	1704	2498	1667	1784
MAY	5862	4285	4215	3132	5688	3682
JUN	2750	3962	4526	5452	6866	2576
JUL	906	1290	1107	2049	4185	1308
AUG	374	413	439	677	1079	508
SEP	255	262	291	411	447	306
OCT	294	373	340	433	366	
NOV	294	424	482	1327	373	
DEC	297	340	529	789	346	

Appendix Table II. Mean monthly flows (cfs) of the Methow River above Goat Creek near Mazama, WA., 1990-1992.

Month	Year		
	1990	1991	1992
JAN		-	0
FEB		-	2
MAR		-	405
APR		-	823
MAY		2439	1780
JUN		2876	1250
JUL		1945	438
AUG		391	118
SEP		74	15
OCT	-	11	
NOV	-	12	
DEC	-	2	

Appendix Table III. Mean monthly flows (cfs) of the Methow River at Winthrop, WA., 1989-1992.

Month	Year			
	1989	1990	1991	1992
JAN		247	330	213
FEB		215	374	251
MAR		354	473	873
APR		1858	1274	1570
MAY		2358	4265	3165
JUN		4099	5264	2066
JUL		1407	2944	1028
AUG		467	737	390
SEP		265	297	204
OCT	---	263	236	
NOV	---	915	244	
DEC	337	506	223	

Appendix Table IV. Mean monthly flows (cfs) of the Chewuch River, as estimated from the Methow River Goat Creek and Winthrop flows, 1991-1992.

Month	Year	
	1991	1992
JAN		213
FEB		249
MAR		468
APR		747
MAY	1835	1385
JUN	2388	816
JUL	999	590
AUG	346	272
SEP	223	189
OCT	225	
NOV	233	
DEC	221	

Appendix Table V. Mean monthly flows (cfs) of the Twisp River at Twisp, WA., 1989-1992.

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

NOTES FROM THE
WELLS COORDINATING COMMITTEE
FOR 1992

APPENDIX - H

WELLS PROJECT COORDINATING COMMITTEE
MEETING JANUARY 29, 1992

SUMMARY[1]

Agreements Reached

1. The committee asked for a proposal from the Intertribal Fish Commission relating to monitoring of adult passage at Zosel Dam. The committee will review and approve it prior to implementation by Douglas County P.U.D..

2. The committee will consider further whether a study plan for hydroacoustic monitoring of adult passage at Zosel Dam should be prepared in the event that spill is such that it provides passage other than through the spillway.

3. The committee recommended that Douglas County P.U.D. proceed in the spring and summer of 1992 with the third year of evaluation of the bypass, as called for in the Settlement Agreement.

4. The committee agreed to postpone the project mortality study which the Settlement Agreement calls for. It will not be done in 1992.

5. Comments on a proposal for sockeye enhancement submitted by Washington Department of Fisheries will be due by the end of February, 1992.

6. A subcommittee was appointed to plan the sockeye workshop the committee has agreed to conduct. Members are Rick Klinge, Douglas County P.U.D.; Bill Hevlin, NMFS; Bob Heinith, CRITFC; and a person from Washington Department of Fisheries to be named. The workshop was scheduled for March 5 and 6, 1992 at Sea-Tac.

7. Because there will be no trapping facility for spring chinook on the Methow River in 1992, Douglas County P.U.D. proposed taking adults at Wells Dam in order to obtain eggs to produce fish to be reared at the Methow Hatchery. The committee did not approve, because of concerns about unknown genetic effects. If the hatchery is to be used, fish will have to be obtained elsewhere.

8. Because of concern about scheduling for the trap, Douglas County P.U.D. will prepare a critical path diagram showing check points for construction. A conference call will be arranged after the diagram is circulated to the committee.

9. Douglas County P.U.D. will increase the counting period for adults passing Wells Dam from 16 hours daily to 24 hours daily.

10. For evaluation of the supplementation projects, the committee asked for copies of the draft plan being developed for evaluation of the projects under the Rock Island Settlement. The agencies will provide copies.

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[1] Prepared by R. Whitney

11. The next meeting was scheduled for March 2, 1992 at Sea-Tac.

12. A site visit was scheduled for May 5, 6, and 7, 1992.
The meeting was held at 9:00 A.M. January 29, 1992 at the Radisson Hotel near Sea-Tac. The agenda, along with the meeting notice was mailed to the full mailing list on January 14, 1992. Those in attendance are listed on the attached roster.

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I. Status of 1991 Studies

A. Hydroacoustic sampling of adult passage at Zosel Dam, 1991. Rick Klinge summarized the study. They were late getting the equipment installed. The study was not successful.

B. Feasibility of estimating sockeye escapement at Zosel Dam with underwater video technology. Douglas County P.U.D. is leaning toward having the Intertribal Fish Commission monitor adult passage with underwater television. He suggested that monitoring the spill gates was probably not essential because 90% of the fish use the ladder. There was a discussion of this point. It was suggested that the volume of spill might affect the number of adults that use the spillway to pass the dam. Some thought both hydroacoustic monitoring of the spillway and video monitoring of the ladder might be important. Perhaps a hydroacoustic study plan could be in hand and implemented in the event that significant spill occurs, but not otherwise. The committee asked to review the proposal by the Intertribal Fish Commission. The committee agreed they should review and approve any study proposal.

II. Status of 1992 Studies

A. Radio telemetry studies at Wells with Okanogan sockeye. Rick Klinge reported that Lowell Stuehrenberg is gathering equipment in preparation for the study in spring 1992. The reporting schedule called for in the proposal was reduced from a daily to a weekly transmittal of data. This will reduce the staff time required. There was a discussion of the particulars of the study. Fish will be trapped at Rocky Reach Dam. The trap will be upgraded. Stuehrenberg said that they will download data in the lower river on a daily basis. Expeerience there will tell them whether the equipment is reliable enough to leave it unattended for a week, and they will proceed accordingly at Wells.

B. Bypass evaluation for 1992. Klinge reported that he had consulted Skalski as asked to do by the committee. The committee had copies of Skalski's response. Klinge asked the committee whether they felt another bypass evaluation was necessary in 1992, considering that the previous two years of study showed the criteria were met. The 1991 study produced an estimate with a very narrow confidence interval. After full discussion, the committee decided that the study should indeed be repeated in 1992. They felt that although the results are quite favorable, there is always a possibility that another species mix or set of flow conditions could lead to a different result. There was a discussion of whether both the spring and summer studies needed to be repeated. The committee decided both should be conducted in 1992 as called for in the Settlement Agreement.

C. Project mortality study. Klinge had raised the question at the last meeting whether the project mortality study should be conducted in

1992 as called for in the Settlement Agreement. He suggested that it be postponed. Rod Woodin indicated that Washington Department of Fisheries would have no problem with a delay because they would not be in a position to follow through soon with implementation of any increased production that might be indicated from the study. The committee agreed that there is no need to conduct the project mortality study in 1992.

III. Okanogan Sockeye

A. Washington Department of Fisheries proposal for enhancement. Rod Woodin distributed copies of a proposal outline from Washington Department of Fisheries for a sockeye enhancement study. It would involve using 300 adult sockeye to be taken at the trap at Wells Dam. This evaluation would fall under the provision of the Settlement Agreement that calls for production of 8,000 pounds of sockeye juveniles. There was a thorough discussion of the potential ramifications, including the fact that this is a transboundary stock, of interest to the Canadians, the desire on the part of some members to work out a total sockeye package and not approach it piecemeal, possible intermingling of stocks such as those from the Methow River, and so on. Perhaps the workshop can help resolve the issues. It was agreed that comment should be provided by the end of February, 1992.

B. Status of mini-workshop on sockeye. Klinge reported that he had contacted individuals in fishery agencies in the British Columbia Provincial and Canadian Federal Government. They are interested in being involved in the workshop. He distributed a tentative outline following discussions at the last meeting. Some of the members indicated they had not yet received it. Klinge will send it out again. There was a discussion of the format the workshop should take. It was agreed to separate the background information from the committee analysis. One suggestion was to have a day of presentations followed by half a day of committee analysis. A subcommittee was appointed to plan further for the workshop. Members of the committee are Rick Klinge for Douglas County P.U.D.; Bill Hevlin for NMFS; Bob Heinith, for the Intertribal Fish Commission; and a member to be named from the Washington Department of Fisheries. Dates for the meeting were agreed upon as March 5 and 6, 1992.

IV. Update on Methow Hatchery and Traps

A. Proposal to take spring chinook broodstock at Wells Dam. Klinge outlined a proposal to take spring chinook brood stock for the Methow hatchery at Wells Dam. The proposal as first envisioned included genetic screening of fish with the hope of identifying the Methow stock to be used. However, the geneticists are telling us that with present technology it is not possible to separate fish from various streams in the mid-Columbia. Coordinator is of the opinion that any differences that might be found are not of management significance. The committee has some reservations.

There was a discussion of options for obtaining fish to rear at the Methow hatchery in 1992. The hatchery will be ready this spring. The suggestion was made that perhaps fish could be thinned at the Fish and Wildlife Service hatchery at Winthrop and the fish moved to the Methow Hatchery.

B. Methow River trap location. Ed Donahue discussed the problems with the trap site on the Methow River. He feels that the area above the Foghorn Ditch is the best location. It would require installation of a floating weir. Modifications in the floating weir design that are required to make it function at such a location are being tested. He produced some sketches of a design. Bill Hevlin said that he had discussed this with Steve Rainey of NMFS. It might be necessary to make the dam higher in order to force the fish to use the ladder rather than simply jump over the dam. Erho pointed out that the Foghorn site is being investigated as a feasibility study. The Fish and Wildlife Service is proceeding with improvement of the ladder and trap within the budget provided them. There have been some hurdles with respect to permits for construction, which the Fish and Wildlife Service has to obtain from NMFS. Donahue reported that if there is to be a trap in 1993 a decision will be needed soon. There will be a plan for both sites. Rod Woodin asked what are the deadlines for a decision. There was a discussion of the factors that would affect a decision. The committee asked Douglas County P.U.D. to prepare a critical path diagram showing decision points for construction and distribute it to the committee. The committee would then like to have a telephone conference call to discuss the matter.

C. Status of Twisp trap. Donahue reported that phases 1 and 2 are complete. Phase 3 is provision of attraction water. It will be completed May 1, 1992. The weir panels were ordered this week. They will be installed March 7, 1992. They are an improved design with metal planer boards and other features.

The trap on the Chewack River will be completed May 1, 1992. It is a modification of an existing trap at the Fulton Ditch. They will modify tthe barrier to encourage fish toward the ladder more effectively.

D. Current status of the hatchery. Donahue said there were problems with the pipe supplier. But the facility should be completed by the end of May, 1992 if the weather permits.

V. Other Topics

A. 24 hour counts of adult passage at Wells Dam. Klinge announced that Douglas County P.U.D. will increase the schedule for counting of adults at Wells Dam from 16 hours per day to 24 hours per day. The counts are made from video cameras. They will simply tape input for the additional 8 hours and have their personnel read the tapes during lulls in the daytime period. Reading should go rapidly because there probably will be few fish that use the ladders during the night hours.

B. Rod Woodin presented a first draft proposal for protocol on brood stock collection in 1992. He asked for comments by the end of the month. Klinge noted that some decision points would require return of fish to the river if a given percentage is not achieved in the ladder counts. This is based on genetic concerns. Woodin noted that the emphasis in the proposal is on minimum population size of 40 fish as recommended by their geneticist. There was a discussion of the potential complications in applying the protocol. Dick Nason expressed a concern as to effects on the Rock island Program.

C. Evaluation of supplementation efforts in the Settlement Agreement. There was a discussion of how the committee might proceed with development of studies to evaluate the supplementation projects. It was agreed that a starting point would be to review the draft evaluation plan being developed under the Rock Island Settlement. Agency representatives will provide copies to the Wells Project Coordinating Committee.

D. The committee approved the summary of the meeting of December 12, 1992.

E. The committee agreed to meet again March 2, 1992 at Sea-Tac.

F. There will be a site visit May 6, 7, and 8, 1992. The members are especially interested in visiting the new sites that are being developed as part of the Wells Settlement.

WELLS PROJECT COORDINATING COMMITTEE
ATTENDANCE ROSTER
MEETING JANUARY 29, 1992

Name	Representing
Craig Tuss	U.S. Fish and Wildlife Service
Bob Heinith	Columbia River Intertribal Fish Commission
Ron Boyce	Oregon Department of Fish and Wildlife
Bill Hevlin	National Marine Fisheries Service
Jerry Marco	Colville Confederated Tribes
Tony Eldred	Washington Department of Wildlife
Rod Woodin	Washington Department of Fisheries
Tom Scribner	Yakima Indian Nation
Cary Feldman	Power Purchasers
Rick Klinge	Douglas County P.U.D.
Jim Ruff	Northwest Power Planning Council
Lowell Stuehrenberg	National Marine Fisheries Service
Ted Bjornn	Idaho Cooperative Fish and Wildlife Research Unit
Dick Whitney	The committee

Others present during discussion of items of common interest with mid-Columbia Coordinating Committee

Steve Hays	Chelan County P.U.D.
Labh Sachdev	Seattle City Light
Stuart Hammond	Grant County P.U.D.
Don Zeigler	Grant County P.U.D.
Bruce Ransom	HTI
Dick Nason	Chelan County P.U.D.

WELLS PROJECT COORDINATING COMMITTEE
MEETING March 2, 1992
SUMMARY[1]

Agreements Reached

1. The committee agreed to provide a time for comments until March 16, 1992 on the proposal for video monitoring of sockeye adult passage at Zosel Dam. If there are none, the committee will assume it is approved as written.

2. Douglas County P.U.D. has asked Biosonics to prepare a proposal for hydroacoustic monitoring of adult sockeye at Zosel Dam should it prove to be necessary due to spill during the time of passage.

3. The bypass operating plan was approved with the understanding it will be modified to include dates for the beginning of monitoring of juveniles (April 2) and operation of the bypass (April 17, 1992).

4. Designated representatives for scheduling bypass operation are as follows: Rick Klinge, Douglas County P.U.D., Jerry Marco, Confederated Colville Tribes, and Rod Woodin, Washington Department of Fisheries.

5. The committee provided a time for comments until Friday March 6, 1992 on the study plan for evaluation of the bypass. If none are received the study plan will be accepted as submitted.

6. Because several members had scheduling conflicts, the meeting that had been scheduled Friday March 6, 1992, to follow the workshop the previous day, was cancelled. The committee will meet immediately following the workshop on Thursday March 5, 1992.

7. Douglas County asked for a change in the protocol for taking brood stock at the traps to eliminate the provision for returning to the river any adults that might have been taken, if the total take does not reach 40 fish. Washington Department of Fisheries will review the comments on the protocol and respond by the end of next week.

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The meeting was held March 2, 1992 immediately following the meeting of the mid-Columbia Coordinating Committee. The agenda followed was mailed to the full mailing list along with the meeting notice on February 24, 1992. Those in attendance are listed on the attached roster.

I. Status of 1992 Studies

A. Radio telemetry studies at Wells (progress report). Klinge called upon Lowell Stuehrenberg for a report. They are on schedule obtaining equipment. George Swan has looked at the trap at Rocky Reach and says that it will require only a little work to make it usable.

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[1] Prepared by R. Whitney

B. Zosel Dam video monitoring (study proposal from CRITFC). Klinge noted that the committee had asked for a copy of the proposal, and it was provided. The committee agreed there should be two weeks for comments on the proposal until March 16, 1992. If there are no comments, the committee agreed that the proposal should be accepted as written. If there are comments Klinge will circulate a revised copy.

There was a discussion of hydroacoustic monitoring at Zosel Dam, which the committee had discussed at the previous meeting. Klinge said that Douglas P.U.D. had asked Biosonics to prepare a proposal for a study that would be used in the event that spill occurs at Zosel during the time of passage. He will distribute the peoposal as soon as it is available.

II. 1992 Bypass operation at Wells Dam.

A. Approval of Bypass Operational Plan submitted December 12, 1991. There was a question about the date when the baffles would be in place and ready to operate. Klinge reported that the baffles will be in place April 2, 1992 and ready to operate April 17, 1992. They plan to begin monitoring April 2, 1992, as called for in the settlement. The committee asked Klinge to modify the plan to include those dates as well as the ending date for operation of the bypass, which will probably be the end of August. He will distribute a revised plan.

B. Selection of bypass team members. The following members were appointed to the bypass team: Rick Klinge, Douglas County P.U.D., Jerry Marco, Confederated Colville Tribes, and Rod Woodin, Washington DEpartment of Fisheries. Hevlin asked that fyke netting be kept to a minimum. Klinge responded that last year the bypass team delayed fyke netting until the middle of May. Only the center array of nets was used in order to keep the catch to a minimum. The primary purpose is to identify species late in the season when there is a need to be sure that sockeye from lake Osoyoos have passed.

C. Annual Passage Monitoring Plan. Klinge provided an Annual Passage Montioring Plan for the 1992 Bypass Season. Woodin noted that the Settlement Agreement calls for a five year average, so the way he reads it, the first annual plan would not be required until five years after the Settlement went into effect. The important thing for 1992 is the passage monitoring index numbers available from hydroacoustic monitoring. These will be available on a daily basis.

D. FPE evaluation plan (Biosonics). Klinge distributed copies of the study plan for evaluation of the bypass. It is identical to the plan used last year. It includes a 45 day period during the spring outmigration and a 15 day period during the summer. The array of transducers is the same. The committee approved the study plan with the understanding there would be an additional time period until Friday March 6, 1992 for comments. If none are received, the plan will be considered to be approved as submitted. If comments are received, Kling will distribute a revised plan.

III. Okanogan Sockeye

A. Washington Department of Fisheries proposal for sockeye enhancement. Comments were received from National Marine Fisheries Service and Douglas County P.U.D.. The committee would like to wait until after the workshop to make a decision on this proposal. A question was raised about the CRITFC proposal for limnological study of lake Osoyoos. It was noted that the committee had decided to delay a decision on that until an integrated approach could be developed. Woodin asked the members to study the Settlement Agreement wherein there is a provision calling for the kind of enhancement proposed by WDF.

B. Status of mini-workshop on sockeye for March 5 and 6, 1992. Klinge has developed an agenda as requested by the committee. He reported that he had made an effort to get participation by the Canadians. He was only successful in getting Bruce Shepherd to agree to participate. Those in the Canadian federal service are inhibited by travel restrictions at this time. Klinge plans to visit them for discussion on Lake Osoyoos when he attends the meeting of the North Pacific Chapter of the American Fisheries Society at Bellingham later this year. Ted Bjornn was asked to participate but had a problem getting permission from NMFS. Bill Hevlin was asked to see what might be done to work this problem out so that Bjornn could attend. Klinge listed the people he was able to line up for participation. Klinge will moderate the discussions.

There was a discussion of the workshop agenda. The schedule calls for a meeting of the committee on Friday March 6, 1992, as had been suggested at the previous meeting of the committee. However, several of the members had developed conflicts in their schedule on Friday. It was agreed to cancel that meeting and in its place to arrange a meeting of the committee at the end of the day on Thursday, following the workshop. There was a discussion of what subjects would be considered at that meeting. Some thought it would be too soon to make decisions on the program to be followed at Lake Osoyoos. It was decided to wait and see what develops. Woodin again emphasized the need to review the Settlement Agreement in this context to track where the whole sockeye situation is headed. Hevlin expressed concern about the condition of the stock. The committee has no problem with discussing the potential problems with enhancement.

IV. Update on Methow Hatchery and traps

A. Methow River trap location. Klinge reviewed the two options that are being explored. One is to trap fish in conjunction with the ladder on the dam at the Foghorn Irrigation Ditch. The committee had asked for a critical path diagram to see what time period might be involved in installation. Sverdrup Corp. has prepared a hydraulic model to analyze the situation. Steve Rainey of NMFS will look at it. The other option is a floating weir at another location, rather than the Foghorn. By the end of the month the critical path diagram will be available. Hevlin pointed out that design changes recommended in the ladder will lead to a situation where the ladder modifications probably will not be started until August, 1993, unless work proceeds in the winter. Whether or not that is feasible would depend on the weather. Klinge noted that at one time they had thought about placing a Denil trap in the ladder. Now, it is not clear how it could be made to work. Ed Donahue is exploring some possibilities.

B. Status of Twisp River trap. The panels are scheduled for installation March 10, 1992. They are on the way, being shipped at this time. The collection box is being completed. Fencing and the road will be in place in the next six weeks.

At the Chewack, improvements are being made to the existing fishway at Fulton Dam. Larger rocks are being placed in front of the dam among other things. Work should be completed this month.

C. Status of the hatchery. Klinge reported that finish work is going forward at the hatchery. They are working on the electrical, and installing paneling and piping. May 15, 1992 is the scheduled date for completion. They are on schedule and will be ready then to receive brood stock.

D. Methow Hatchery trap protocol for 1992. Washington Department of Fisheries had submitted a proposed protocol for dealing with adults taken for brood stock. It contains a proposal to return to the river all fish collected if the numbers collected do not reach 40 fish. Douglas P.U.D. objected to that provision and asked for further justification or elimination of that provision. Woodin noted that he had talked to their Shakley, the WDF geneticist and understands that the provision results from a risk assessment. They are willing to talk. WDF will respond by the end of next week to Douglas P.U.D.'s comments. He will arrange a conference call with the committee following that.

V. Other topics

A. Evaluation Plan. Klinge has received a copy of the draft proposal for evaluation of the Eastbank facility. He will study it and respond.

B. Detailed Fisheries Operating Plan. Klinge was asked to update an introductory statement in the DFOP with regard to Wells Dam. Klinge will respond next week.

C. Summary of meeting of January 29, 1992. With a change suggested by Rod Woodin, the meeting summary was approved. His change clarifies the fact that brood stock can be obtained from one of the other two traps in the system even if the one on the Methow proper is not available in time.

WELLS PROJECT COORDINATING COMMITTEE
MEETING March 2, 1992
ATTENDANCE ROSTER

Name	Representing
Cary Feldman	Power Purchasers
Rick Klinge	Douglas County P.U.D.
Tony Eldred	Washington Department of Wildlife
Lowell Stuehrenberg	National Marine Fisheries Service
George Swan	National Marine Fisheries Service
Bill Hevlin	National Marine Fisheries Service
Bob Heinith	Columbia River Intertribal Fish Commission
Craig Tuss	U.S. Fish and Wildlife Service
Ron Boyce	Oregon Department of Fish and Wildlife
Jerry Marco	Colville Confederated Tribes
Rod Woodin	Washington Department of Fisheries
Dick Whitney	The Committee

WELLS 92-3

WELLS PROJECT COORDINATING COMMITTEE
SOCKEYE WORKSHOP MARCH 5, 1992
SUMMARY[1]

The workshop was requested by the Wells Project Coordinating Committee to help develop the best action plan for enhancement of sockeye in the Okanogan River basin. It was held at the Radisson Hotel near Sea-Tac beginning at 9:00 A.M. Thursday, March 5, 1992. Those in attendance are listed on the attached roster. The agenda followed had been reviewed and approved by the committee at the March 2, 1992 meeting.

I. Introduction and special concerns with Okanogan sockeye

A. The desires of the Wells Committee. Rick Klinge, Douglas County P.U.D.. Klinge welcomed the participants and expressed regrets that the Canadian Department of Fisheries and Oceans representatives were unable to attend. He expressed appreciation that Bruce Shepherd, from the British Columbia Ministry of the Environment was present. Klinge gave an overview of the context within which the workshop was organized. He hoped for a round table discussion of options that might be explored to meet the requirements of the Wells Settlement Agreement.

B. Overview of the Wells Settlement Agreement. Rod Woodin, Washington Department of Fisheries. Woodin was one of those who helped draft the Settlement Agreement. He explained how sockeye enhancement fits into the Settlement Agreement. The history goes back to the original proceeding before the Federal Energy Regulatory Commission dating from 1979. In that proceeding, the parties agreed to study ways to improve the survival of juvenile salmonids in the mid-Columbia reach. In the process, they arrived at the bypass system now installed at Wells Dam, which diverts juveniles away from the turbine intakes and into spill. They realized there would still be losses of fish not diverted. A mitigation package was developed. Sockeye were part of this. They estimated that one-third of the migrant sockeye would not be diverted. There was no shelf item that could be used for mitigation of sockeye losses. The first step was a feasibility study. The agreement identifies 8,000 pounds of sockeye at 25 to the pound to be produced as an evaluation of the feasibility. On the basis of the results of this study, the committee will then decide whether to expand production or to shift to chinook.
Another option was to explore using underutilized habitat in the Okanogan River and Lake Osoyoos, if any exists. The agreement calls for a study to determine what the situation might be with respect to this factor. The Pratt and Chapman study was conducted for this purpose. Woodin emphasized that the sockeye provision in the agreement is a compensation program. Insofar as enhancement can accomplish that all is well. However, the basic objective is compensation. There is a formula in the Settlement Agreement for calculating the appropriate compensation level. Total project mortality at Wells Dam, including reservoir mortality was estimated to be 14%.

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[1] Prepared by R. Whitney

A discussion followed. The agreement calls for study through three brood years. Washington Department of Fisheries has submitted a proposal for a study. There was a question whether the agreement calls for a study of limiting factors on sockeye production. Woodin's response was that it does not. The agreement does call for exploration of underutilized habitat. Tom Scribner commented that the Pratt and Chapman report raised some questions. There might be some better options than straight production.

C. The International Issue. Mike Erho pointed out that international complications associated with sockeye in Lake Osoyoos were a concern during settlement negotiations, and these concerns were left to be resolved later. That is why we are here. We are not locked into a specific production poundage. It depends on what opportunities are present or not present. Bruce Shepherd commented that the sockeye issue may be a difficult one. His agency is managing Lake Osoyoos for warm water species and kokanee. A shift to sockeye would require negotiations that would include the Canadian Department of Fisheries and Oceans. The situation is complex. Oddvin Vedo noted that the Okanogan Band has made a proposal to the Canadian Department of Fisheries and Oceans for restoration of sockeye in Lake Okanogan. Shepherd noted that they are just getting started with discussions. Removal of a barrier to migration is one thing that is being considered. Tom Meekin said that he used to meet regularly with Canadian biologists to talk about sockeye. Shepherd noted that from the provincial point of view there is no advantage to sockeye. There are good sport fisheries for largemouth and smallmouth bass in Lake Osoyoos, and for trout and kokanee upstream. McIntyre Dam blocks migrations of sockeye. Woodin said that Washington Department of Fisheries is designing a fish ladder that will pass salmonids but not warm water species.

D. Enhancement in an Era of Endangered Species. Mike Erho commented that the discussions leading to the settlement agreement did not consider the Endangered Species Act. Now that is a big issue. There have been some concerns expressed with regard to the Okanogan sockeye. Shepherd said there is a high diversity of fish species in Lake Osoyoos. The Umatilla Dace is found only in the Similkameen River. Jim Mullan mentioned the pygmy whitefish.

E. The Concealed Options for Enhancement. Klinge said that without the presence of the Canadian DFO it was difficult to discuss options for enhancement in the Okanogan system. Woodin suggested that Palmer Lake might be used for pen rearing of Okanogan sockeye and the fish released into the Okanogan.

II. Historical Perspective of the Run.

A. Sockeye Management in the mid-Columbia 1930 to Today. Karen Pratt. Pratt gave a general review. The stock originated from several sources. The Grand Coulee fish maintenance project brought fish from many local sources, and from Lake Quinault. In spite of this or because of it, it appears that the stock is distinct, perhaps not original but unique. She described the spawning and rearing habitat. Fish are harvested in a mixed stock fishery. By the 1930's the habitat had been severely reduced. The dam at Penticton was built in 1915. The drought from 1928 to 1930 had an adverse effect. Flows were reduced to 6 to 48 cfs, from a usual level of 175 cfs. The population was very low when supplementation began. Only 4% of the habitat was available. In the 1950's McIntyre Dam reduced the habitat even further.

Spawning habitat was lost due to straightening of the stream from a length of 28 miles to 17 miles. The stock is surviving. There are no good counts of fish reaching the spawning areas before the 1930's when Rock Island Dam was built. Those counts include the Wenatchee and Okanogan sockeye. Escapement counts are made below McIntyre Dam. They are point estimates, not collected in the same way over the years. Recent smolt counts are lower than formerly. Eutrophication of lake Osoyoos began in the 1970's. Sewage is emptied into the lake. Northcote, et al, (1975), conducted a limnological study.

Discussion. Shepherd said that in the last 10 years phosphorus additions have been reduced, but not nitrogen. There have been many changes in the sluiceway at Zosel Dam with time. Meekin observed that even though there is spawning in the 17 mile straightened stretch, the gravel is not good. In actuality there is only a small fraction of the former spawning area that is now available.

B. Adult Run Size. Meekin noted that in the period 1930 to 1935 there were no fish up there at all. Mullan said that one of the most persistent Indian fisheries was in the Okanogan River. Shepherd provided the information that formerly there were about 2000 sockeye that spawned below McIntyre. When the dams went in the counts went up to 20,000. Then with the cycle they dipped to 1500. Meekin was of the opinion that the fishery was responsible for the dip. Mullan provided some information on the run sizes as counted at Rock Island Dam. With Rocky Reach counts an estimate can be made of the number turning off into the Wenatchee. About 38% of the run returns to the Wenatchee River and 62% to the Okanogan. Lake Osoyoos is not a typical sockeye lake, but it is one of the most productive. There are three distinct basins, with three different stratification patterns. The 10 year average count at Rocky Reach is 34,000 sockeye. He is of the opinion that there is a benefit from the sewage emptying into the lake. If there has been a reduction in sockeye production, he thinks it is probably due to the phosphorus reduction in sewage.

Discussion. Steve Hays asked about swings in sockeye abundance. He wondered whether drought conditions affect stratification in the lake and thus the amount of area available for sockeye juveniles. Mullan responded that when inflow is low an early tight stratification results, with little or no mixing. With high inflow there is more mixing. Jerry Marco asked whether there is a problem with smolts finding their way out of the lake. Mullan thought there might be a problem at times of low flow. Shepherd reported that the City of Osoyoos did their own water quality study several years ago, on the basis of which they decided to take steps to reduce nutrients going into the lake. It is a popular recreational area. In consideration of recreational uses, the Water Board regulates the flow. They agree on a summer lake level. During kokanee spawning they attempt to maintain the level within 6 inches to prevent drying up of the eggs which are deposited in the shallow shore zones.

Klinge distributed graphs showing the counts of sockeye at Wells Dam. He noted that the relationship of the runs into Lakes Wenatchee and Osoyoos is not constant. The Wenatchee varies from 10% to 80% of the run. Mullan pointed out that Lake Osoyoos is twice the size of Lake Wenatchee. On the average it produces two-thirds of the run. Klinge went on to observe that the counts at Rocky Reach starting in 1962 were as low as 9000, prior to construction of Wells Dam. Peak counts are in mid-July. They pass through the Rocky Reach reservoir in one day. Hydroacoustic studies in 1991 showed that the run passed the warm area in the Okanogan River with no delay. He discussed trends in sockeye abundance. Mullan observed that abundance varies considerably from time to time. The overall trend is perhaps slightly downward if one goes back far enough. He thought that reversal of eutrophication is the likely explanation. Meekin suggested that changes in water flows would explain a downward trend also. Reduced flows exposed eggs. Pratt said that spwaning area is limited. The rearing area is underutilized as indicated by the high growth rates of juveniles.

C. Characteristics of This Population. Jeff Fryer. Fryer showed scale patterns of sockeye from the two systems. Returning adults from Lake Wenatchee appear first at Bonneville Dam. They tend to take more of the Lake Wenatchee fish in the fishery in the lower river than of the Osoyoos fish. The Wenatchee population appears to be more stable in numbers. He finds a number of eary maturing sockeye, both male and female. A very small portion of the fish are three ocean fish. When he separates the counts by brood year he finds wide fluctuations in the abundance from lake Osoyoos year to year. He speculated that this might be due to flow conditions in the Okanogan system. Smolt abundance at McNary Dam matches his figures for brood year analysis. Highest fresh water growth occurs in years of lowest abundance, but the smolts are nearly the same size every year, at least in terms of scale dimensions. In Lake Wenatchee when there is high growth, more adults return. He thinks that in Lake Osoyoos when the water gets warm, sockeye might die. They observed damage to adults sampled at Wells Dam. There was descaling, bruised noses and other damage. The incidence was higher than at Bonneville or Tumwater Dam. They have no explanation for these injuries at this time. They plan to investigate in 1992.

D. Harvest of Okanogan Sockeye. Bob Heinith. Heinith reported that a creel survey in the zone 6 fishery showed only a handful of sockeye were taken. The Colville Tribe has a snag fishery. The Okanogan Band in British Columbia takes some fish. Bruce Shepherd reported that there is a substantial sport fishery for kokanee/sockeye in Lake Osoyoos. The Okanogan Band has fished for sockeye for years, largely ignored by the Province and DFO. Only in the last few weeks have they begun cooperative discussions. The members of the Okanogan band fish at the drop structures by snagging, dipping, gaffing and spearing. Jerry Marco provided further information on the Colville fishery. There is a snag fishery for chinook and sockeye in July and August at the Chief Joseph tailrace. They take 500 to 1500 fish per year. In the 1950's they took 5,000 fish there and 10,000 in the river below, using nets. Rod Woodin reviewed the mechanisms used for decisions on the non-treaty fishery. They have a preseason forecast, based on the smolt index two years previously, which generally is reliable only at a gross level. If it is very low, they will conduct no fishery in a given year. If the number is sufficient to justify it, they will conduct a test fishery. The test fishery provides the best information on the actual size of the run. Catch per effort is closely related to the run size. If there is no test fishery it is still possible to relate the pattern of counts at Bonneville to the expected run size. It is not likely that they will have a fishery in the traditional area of the lower river, due to concerns about the Snake River endangered sockeye. If there are sufficient numbers in the future, they might open a fishery in the mid-Columbia. [Mike Dell reports that WDF issues sockeye permits to members of the Wanapum Tribe. They probably take 500 sockeye.]

E. **Resident Fish Issues.** Bruce Shepherd. The B.C. Ministry of Environment has produced a management plan. It sets four goals: 1. conserve wild fish, 2. preserve habitat, 3. serve the public interest, and 4. develop strong corporate management. The first two have shifted the emphasis away from hatchery produced fish. Biodiversity is now a concern. There is a Wildlife Watch program, which among other things involves viewing platforms for the public to observe fish. There is no management plan for Lake Osoyoos at this time. In 1985 there was a general plan developed, which focused on warm water game fishes. They have done very little field work in the lake. In the early 1970's they conducted a creel survey, but nothing since. Their work has centered on Okanogan Lake which is 10 times as large as Lake Osoyoos. It has more recreational potential. They want a scientifically based management plan. They expect to develop it in the next few years. There are seven lakes in the area. There is good fishing for rainbow trout and kokanee, as well as bass and crappie in recent years. There have been problems in Lake Osoyoos with algal blooms. The center basin might have a problem. *Mysis relicta* is present in Lake Okanogan. It was introduced in the mid- 1960's. They have not moved downstream into Osoyoos. Kokanee declined in Lakes Okanogan and Skaha following the *Mysis* introduction. The effects are confounded with nutrient reduction. There is a spring/fall trout fishery concentrated mostly in the north basin. Trout are present in two groups, those around two pounds and a seven pound group. They catch fish from five to seven pounds in the fall. The Okanogan River provides mostly a fly fishery. Largemouth Bass are taken from march to December in the shallow zones. They have looked at enhancement. Access into shallow backwaters and oxbows has been provided for bass. Artificial reefs were placed in the north basin. There is a developing burbot fishery near the bridge. In addition to these, whitefish, perch, carp, suckers and other fishes are taken in the sport fishery. In 1972 there were 58,000 angler days spent in Okanogan Lake. The catch was 0.06 rainbow per hour. In 1988 there were 309,000 angler days and the catch was 0.05 -0.07 rainbow per hour and 0.3 to 0.4 kokanee per hour, which is down from the earlier period. In Lake Osoyoos the catch is less, probably around 1000 rainbows per year.

Irrigation intakes might not be properly screened to keep out juvenile kokanee. Management objectives are to protect the rainbow, kokanee and bass fisheries, and enhance these if possible. They need more information. In B.C. there is severe competition for water. There may be a problem maintaining kokanee. Any enhancement of sockeye has potential for effects on kokanee. The kokanee fishery is one of the fastest growing recreational fisheries in B.C.. They will be reluctant to have anything happen that might put the kokanee at risk.

Discussion. A question was asked whether there is stocking of fish in the lakes. Shepherd responded that there is supplemental stocking of kokanee. Kokanee from Lake Okanogan have been planted into Lake Skaha. They may have gone right out. They have done some enhancement of habitat. The largest kokanee caught was $9^3/_4$ pounds. Eurasian milfoil was established in the 1970's. It is now in all of the valley lakes. Yellow perch are increasing along with the milfoil. In Lake Okanogan perch grow up to a pound. In Lake Osoyoos perch are smaller and there are lots of them. Lake Kalamalka, which empties into Lake Okanogan has *Mysis* and Lake Trout.

They have a spring index of water quality in all of the lakes. Water withdrawals are a serious problem in the basin.They are revising their water regulations because until now, fish had no right to water. The water available has basically been given away in water rights. The Water Management Board is responsible for allocations. Lack of legislation is a problem. Politically, enforcement is also a problem. Thinking is changing though.

III. Biological Concerns.

A. Adult Migration from Wells Dam to Spawning Grounds.

1. Thermal Concerns in the Okanogan River. Tom Meekin. Meekin recounted his experience when he worked in the area for Washington Department of Fisheries. Temperatures at Wells Dam are 60 to 64 degrees when sockeye pass in July. In August, temperatures in the Methow River are about 70 degrees, while they are about 80 degrees in the Okanogan. Temperatures begin to decline after Labor Day. In spite of the high temperatures, fish do pass upstream. He provided some fish counts in support. At Zosel Dam in 1934 there were no fish counted. By 1937 there was a run which peaked in August. During the 1930's the run ranged from 260 fish to 2,000 fish at Zosel Dam. In 1944 there were 897 sockeye and they came in August when the temperature was 79 degrees. The picture was similar from 1945-1947. In the period 1952-1954, the counts were 52,000; 67,500; and 3,780, respectively. He provided counts showing that there were lots of fish missing in the counts by the time they reached Zosel Dam. They never saw a lot of fish at Zosel Dam. At night temperatures would decline to 68 degrees. Possibly the fish passed then. Fish observed at Zosel Dam were lethargic but alive. He estimated a two week delay in 1969, and perhaps longer in 1973. A lot of fish go up, but a lot do not. He did see dead fish at times. There is a possibility that some fish went up in August, but the majority may have gone up in September when the temperature went below 65 degrees. He concluded that there is delay due to temperature, but he was not able to muddle through all of the data and demonstrate it. In his opinion the Okanogan stock will survive no matter what is done.

Discussion. Mullan pointed out that there are differences in counts on the spawning grounds in the Wenatchee versus Rock Island/Rocky Reach that are comparable to what Meekin saw in the Okanogan, but in his opinion that is not necessarily due to mortality. There was a discussion of the expansion factors used to estimate total number of spawners from periodic counts on the grounds. Meekin used a factor of five. Shepherd uses 2.3 for kokanee.

2. Adult Holding in the Columbia and Osoyoos. Tom Meekin. Meekin thinks there is uncounted mortality of fish that hold in the Columbia and never reach Zosel Dam. Klinge reported on the work of Biosonics in 1991. They mounted transducers to be able to count the adults as they passed Zosel Dam. However, the schedule called for in the study was apparently late, because few fish were detected during that time, August 19, 1991 to October 20, 1991. Meanwhile, numerous fish were seen by Meekin on the spawning grounds. They concluded that the fish had passed earlier. Douglas P.U.D. plan to monitor the adult run in 1992 using the CRITFC video technique. The Wells Committee has approved a study for 1992 involving radiotelemetry of sockeye adults from Rocky Reach to above Wells Dam. They want to find out where sockeye go in the reservoir and elsewhere above Wells Dam.

3. Prespawn Mortality. Klinge recapped what Meekin had already discussed on this subject. There was a discussion of measures that might be taken to provide cooler water input to the Okanogan River. Jerry Marco mentioned that the Colville Tribe had looked at ways of cooling the Similkameen using Palmer Lake. The proposal would be to draw water from below the thermocline at Palmer Lake to cool the river. Once the river would reach a base level, they would draw water from either Lake Osoyoos or Palmer. The amount would be 50 to 100 cfs, which would be about 10 - 15% of the river flow at the base level.This idea is still under consideration. The Similkameen is cooler than the Okanogan River. Shepherd referred to a syphon in Horsefly Lake that was used to get cooler water. Unfortunately, they had a gas supersaturation problem.

Discussion. During the discussion a question was raised about the possibility of transporting adult sockeye from the trap in the Wells Dam fish ladder to Lake Osoyoos to bypass the warm water at the mouth of the Okanogan River. Lowell Stuehrenberg noted that the fish could be tracked with the radio tags.

4. Disease Issues. Lee Harrell. Harrell reported that the first record of IHN was at the Leavenworth Hatchery by Bob Rucker. Harrell would be surprised if IHN were not in the sockeye brood stock throughout the basin. Shepherd said that IHN has been reported in the Okanogan system. Harrell went on to say that experience in Prince William Sound and elsewhere, including Lake Wenatchee, now indicates that sockeye can do well under culture now thanks to new diagnostic and culture techniques. Sockeye seem to be the most susceptible of the salmonids to diseases. They are rather resistant to *Ceratomyxa*. They do have BKD. Culturists have found a way to manage around IHN. Vertical transmission is not the problem it was once thought to be. For example, IHN positive adults were the source of some of the juveniles reared in the Lake Wenatchee net pens, yet none of those offspring showed the disease. In Alaska they disinfect on a per parent basis. Eggs are compartmentalized, so that if necessary bad egg batches can be destroyed.

Discussion. Meekin remarked that the management strategy with endangered sockeye at Redfish Lake might be different. They will not destroy any fish that test IHN positive. There will be no culling. There is no evidence that it has an effect. He referred to the Lake Wenatchee situation where there is a high incidence of IHN, but there has been no outbreak of the disease in the net pens. Shepherd noted the desirability of exercising care in the selection of a water supply for incubation. With their kokanee, they made sure there were no fish in the water source. Kathy Hopper is of the opinion that BKD is a greater concern than IHN with cultured sockeye. Harrell mentioned furunculosis. Hopper agreed furunculosis is likely to be a problem. But the only diseases she would cull out would be VHS and IPN. Meekin reported that a study by Battelle had shown columnaris in every fish examined. Peven reported that in 1990 there were numerous Okanogan sockeye smolts examined at Rock Island that showed fungus infections. At the time, they thought the fungus might have been a secondary infection. Harrell thought this was unusual, perhaps the result of flukes. Shepherd noted that they have a hatchery for kokanee in the Cascadian area which they think has exacerbated a disease incidence among fish in the area. It is a concern. He does not think they have seen BKD. Klinge emphasized that the fish are fighting a thermal barrier with the 80 degree water at the mouth of the

Okanogan. Meekin thinks the fish are a tough breed and will survive regardless of what we do.

B. Spawning Grounds

1. Extent and Quality. Chris Carlson. Carlson had been involved in spawning ground surveys as part of the transportation study being conducted by Grant County P.U.D. under the mid-Columbia Coordinating Committee. They were looking for marked fish, and not focusing on trying to estimate the extent or success of spawning. Nevertheless he has some observations that are pertinent. Sockeye tended to spawn in the same areas from year to year. They seemed to spread over the spawning grounds even when there were small numbers of spawners. To him this suggested there was low survival at high rates of egg deposition due to superimpositon of redds. The sex ratio was slightly skewed toward females. About 2% unspawned females were observed. Many carcasses were found around the drop structures in the river. They tended to be buried in silt on the downstream side. Weather conditions sometimes made it difficult to see the carcasses.

2. Sockeye/Kokanee Spawning. Bruce Shepherd reported that he had observed kokanee spawning in Lake Osoyoos. They were peculiarly colored, with speckles like trout. It appeared to him that there was a spatial separation of sockeye and kokanee spawning. There is shore spawning by kokanee.

Discussion. There was a discussion of water temperatures at the time of spawning. Pratt referred to a USGS station below Osoyoos. Klinge said that temperatures at Zosel Dam were 10 degrees higher than in the lower river until August, at which time the temperatures below came up to match. He suspects that the Similkameen River was tempering the lower river for a time.

3. Lake Spawning. Meekin did see shore spawning one year in the north basin, which was one out of four years he checked. He counted seven redds and five or six fish. Bruce Shepherd reported there are 250,000 kokanee that are shore spawners over a short time period in Okanogan Lake. They rarely see carcasses.

Discussion. Woodin asked whether there was any indication of late spawning in 1990. Carlson said they saw none, in spite of high effort that year. Fryer noted that was the year when there was a big difference between the Rocky Reach and Wells Dam counts. Ron Boyce suggested the spawning surveys should be continued with a different objective. Klinge said that Douglas P.U.D. will use video taping at Zosel Dam this year. They will also be ready to carry out a hydroacoustic survey of spill, if necessary.

Meekin said that he has measurements of fines in the spawning gravel. Conditions worsened after the 1950's. Stream beds became hard packed.

4. Incubation and Fry Migration Concerns. Klinge suggested there might be heavy losses of fry to irrigation canals. Bruce Shepherd said there is a need for better screening, but no way to break the funds loose to do the work at this time. It would help to have more information. It is possible that with the warm water, fish come out before the irrigation season begins.

5. **Irrigation and Agricultural Issues.** Shepherd repeated that revised Acts in B.C. are intended to provide flows for fish. These should be in place in the next year or two. Scribner commented that in the U.S., the Yakima Tribe was successful in showing that water rights that are bought out and designated for fish cannot be withdrawn downstream.

C. **Nursery Environment.**

1. **Lake Chemistry and Trophic Levels.** Doug Hatch. Lake Osoyoos contains three separate basins. The north two are entirely in Canada. The southern basin is half in the U.S. and half in Canada. Maximum depth of that basin is 75 feet. The center basin is 200 feet deep. The three basins are separated by shallow zones with water about 25 feet deep. Mean depth of the southern basin is 35 feet. Limnological studies were conducted by Northcote et al in the 1970's. The central basin is high in mercury content. In 1971 there was no thermal stratification of the central and southern basins. The morphology of the lake presents a difficult situation for enhancement. There is a need to take kokanee into account in a decision to enhance sockeye. They will be direct competitors.

Discussion. Bruce Shepherd noted that Vassa Lake, between Skaha and Osoyoos Lakes, is a virtual milfoil bed.

2. **Competition and Predation.** Bruce Shepherd described the interactions between rainbow and sockeye. One school of thought says introduced trout may maintain themselves on sockeye for a time and then shift to kokanee. In Shuswap and Okanogan Lakes, trout do not follow that food particle size theory. Chinook and coho hatcheries release fish and they might buffer trout predation on kokanee.

Discussion. Scribner referred to Babine Lake and the Skeena River, where predation was thought to be a problem. Shepherd responded that in that situation there appears to be a bottleneck downstream, perhaps in the marine environment, not due to predation.

3. **Smolt Enumeration from Lake Osoyoos.** Pratt reviewed the available information on smolt enumeration. Klinge provided information on hydroacoustic surveys that had been conducted one year. In March one year, they found 300,000 sockeye smolts in the north basin and 100,000 in the south basin.

Discussion. The survey could not distinguish between sockeye and kokanee. Cary Feldman reported that Puget Power and Light will fund a study on Baker Lake to sample otoliths to determine whether parents of the fish came from fresh water or salt water. The procedure seems promising.

III The options for Enhancement.

A. **Low Tech Egg Boxes.** Mark LaRiviere. In Lake Ozette, sockeye spawn on the lake shore. The Makah Tribe has a program to increase the fry recruitment using lake shore spawners as brood stock. They use streamside incubators for the egss. A total of $^{1}/_{4}$ million eggs are placed in four boxes. They held the fish to 1 gram and then took them to the limnetic zone and released them away from cutthroat trout, the primary predator on sockeye. Surface temperatures were 17-18 degrees, underneath they were 6-7 degrees. The fry emerged in April. They used a vertical gill net to sample for juveniles. Incubators were placed suspended in the lake. The design was based on one used in Alaska by Ken Robertson. Light diffuser panels were used to hold the eggs. They were cut into 15 cm squares and screens placed over both sides. These were then suspended vertically in rows of four just beneath the surface of the lake. The compartment isolated the eggs to reduce the spread of *Saprolegnia*, so it was not necessary to pick the eggs. There is a very large population of kokanee in the lake. Competition is a factor in the program. He tried a new procedure with eggs in boxes on shore, supplied with pumped water.

Discussion. The success of the program has not been assessed as yet. The adults are just scheduled for return. He noted that the Quinault program with sockeye rearing in net pens was abandoned due to a disease problem. The goal of the program is to restore the sockeye run, which at one time was 20,000. It is now 200 to 1000 sockeye. The tribe is working with the National Park Service. Success will be measured in terms of returning adults, including numbers coming up the river and any future catch. There are pressures on the stock from many directions, but it persists.

B. **Net Pens and Location.** Kathy Hopper. Hopper described the Lake Wenatchee net pen culture of sockeye. Washington Department of Fisheries is excited about sockeye culture. Adults are trapped and held in net pens until ripe. The eggs are then taken and the juveniles are reared in the net pens. WDF has submitted a proposal to the Wells Coordinating Committee. The proposal has two options. The first option calls for trapping adults at Wells Dam, holding them in a net pen in cold water - perhaps behind Chief Joseph Dam, incubate the eggs in pathogen free water, then transfer the fry to Lake Osoyoos as soon as the ice is off. This avoids potential problems with adult straying and so on. The second option would take the adults at Wells Dam and transfer them to the Methow Hatchery where there is a good facility for sockeye incubation, rear the fry on well water, then acclimate and release them in Lake Osoyoos. She noted that Bill Hevlin had expressed some concerns. She has talked to Fish and Wildlife Service personnel. Because IHNV would be the primary pathogen of concern, the Fish and Wildlife Service indicated there should not be a problem of interaction between the Winthrop Hatchery and the Methow Hatchery because IHNV is present in the Methow River Adults.

Discussion. Bruce Shepherd reported that kokanee released from hatcheries into tributaries have returned to the point of release. There might be problem obtaining a shoreline permit required to release fish from trucks. If this became a problem it might be possible to barge fish out to the center of the lake. There was a question about what size these sockeye juveniles might reach. Hopper was not certain because she did not have available information on temperatures of the water in which they would be reared. They would be planted as zeros from Wells Hatchery or yearlings from the Methow Hatchery. Neither scenario would be a permanent arrangement. Adults are surprisingly easy to hold in net pens. In Lake Wenatchee they held them at 68 degrees. They had some *Columnaris*, which was the only problem. Mortalities stopped when they stopped lifting the net to check the fish. Steve Hays reviewed the Lake Wenatchee program. It exists as part of the compensation package in the Rock Island Settlement Agreement. The situation is less complicated. There is no temperature block in the Wenatchee. Fry plants are not used. The lake seems to be poor producer of smolts. Seeding is probably adequate. The limiting factors may be overwinter survival and early fry survival. It did not appear to be feasible to hold fish through the winter due to ice conditions. They are released in the fall. The fish seem to be contributing to the run. Adults have been held free of disease, and healthy smolts have been released and were observed at McNary Dam. The next question is what will they contribute to the number of returning adults?

Discussion. Erho asked whether there was agreement that the measure of success would be the number of returning adults? Hays responded that opinions might differ on that score, but that is his own thinking. In 1990 they reared 270,000 sockeye juveniles in the net pens as a pilot study, using 300 adults as brood stock. In 1991 they released 300,000. According to samples taken by WDF at McNary Dam these 300,000 made up 17% of the Lake Wenatchee juveniles sampled there. The net pens are locate near the mouth of the White River which has a high titer of IHN, but the juveniles showed no effects. Hopper said that the WDF proposal calls for release of 8,000 pounds of juveniles, which amounts to 200,000 at 25 per pound. They would be released in the lower basin.

C. Transport Adults to the Spawning Area. Klinge asked Bruce Shepherd what he thought of the idea of transporting sockeye adults from Wells Dam into Lake Osoyoos. Shepherd responded that "We see no potential benefits and some possible adverse effects of sockeye enhancement, for example on the kokanee fishery." There would be some hard negotiating to work something out. Fryer mentioned that CRITFC had transport 300 of the adult sockeye they sampled at Wells Dam to the reservoir.

Cary Feldman said that Puget Sound Power and Light has 40 years of experience at Baker Lake. Sockeye are trapped at the base of the dam and all are transported to the lake in a trip that requires $1^{1}/_{2}$ to 2 hours. These sockeye are thought to be a beach spawning population. Puget Power and Washington Department of Fisheries built a pool on the shore and covered the bottom with gravel to make a spawning channel. There are two divisions which hold 3,000 fish each. The fry emerge to go out into the lake. This program has been in effect since 1959 or 1960. Survival is 70 to 80%. In 1985 they started net pen rearing. They took some fry from the beach spawning facility and reared them in pens. The program has been successful. However, this year, for the first time, they observed no marked fish in the adult return, although there was a good return of unmarked fish. They don't know what the problem is. BKD was diagnosed in the juveniles and could be a factor in survival.

Discussion. Tom Scribner reviewed the workshop from his perspective. He noted that Jim Mullan had said growth of sockeye in Lake Osoyoos was good. From then on, everything he heard about the prospects of sockeye enhancement in Lake Osoyoos was negative. There are problems with predators, thermal concerns, possible effects on other fisheries, political ramifications, and so on. Perhaps transporting the adults would have some benefit, but the Canadian concerns need to be addressed. Additional investigation of the habitat might clear up some questions. Right now, there seems to be little promise along those lines. Oddvin Vedo commented that the Okanogan Band has expressed an interest in sockeye restoration. They do not see the boundary question in the same way others might. The band is in discussion with DFO and the Ministry of the Environment of B.C. on the subject of comanagement. This issue should be clarified in the next few weeks.

Klinge wondered whether it would be constructive for the group to meet again in the near future and bring in the Canadian federal government representatives. Klinge was asked to consult with them on behalf of the committee as soon as possible.

The workshop adjourned at 4:30 P.M..
Klinge expressed appreciation to all who participated.

WELLS PROJECT COORDINATING COMMITTEE
MEETING March 5, 1992
SUMMARY[1]

Following the workshop there was a meeting of the Wells Project Coordinating Committee. The meeting had been tentatively set for the following day, but a number of members had developed conflicts, as recorded in the summary of the meeting of March 2, 1992. The committee therefore decided to meet immediately following the workshop, for the purpose of discussing what had been learned to see whether a consensus might have developed on enhancement measures that might be undertaken for sockeye. In attendance were Rick Klinge, Douglas County P.U.D.; Kathy Hopper, Washington Department of Fisheries; Ron Boyce, Oregon Department of Fish and Wildlife; Bob Heinith, Columbia River Intertribal Fish Commission; Bill Hevlin, National Marine Fisheries Service; Tom Scribner, Yakima Tribe; Jerry Marco, Colville Confederated Tribes; Cary Feldman, Power Purchasers; and Richard Whitney for the committee.

Each member was asked to attempt some kind of a summary statement. Bill Hevlin said that from what he had heard, the possibilities for enhancement that might affect Canadian interests were better when the measure involved dealt with non-living elements, such as irrigation screening and the like.

Ron Boyce pointed out that a decision needs to be made whether to go with artificial versus natural enhancement. Taking spawners from the run might contribute to the problem rather than solve it. ODF&W has adopted a wild fish policy, and would probably prefer natural enhancement. He needs to talk to his people. Tools to fully evaluate effects of a hatchery program are not available. Until there is a better understanding, it is probably better to emphasize natural production.

Tom Scribner wondered in what way the WDF proposal differs from the Lake Wenatchee program. It seems similar to him. It is small in scale. The Settlement Agreement calls for it.

Kathy Hopper pointed out that it takes so long to get information back from a hatchery evaluation that is is best to get started soon. There is a place for hatchery fish. The recovery team working on the Snake River probably will recognize the hatcheries at Lyons Ferry and Tucannon as part of the recovery effort. If we hadn't done some studies, such as the one proposed, we would not be in a position to suggest how they might be used. She reviewed the Settlement Agreement again.

Bob Heinith thinks the committee is headed in the right direction with enhancement. We need to improve smolt production or survival. It would be wise to err on the side of being conservative. However, the Wenatchee experience suggests it can be done. We do need further information as we proceed. We need to continue spawning ground counts, and better assessment

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[1] Prepared by R. Whitney

of limiting factors. He likes the option of using Palmer Lake either to rear sockeye or to cool the Okanogan River.

Hevlin agreed that there was a need for continued information gathering. An inventory of screens and diversions would be helpful. On the other hand, a lot of thought went into the Settlement Agreement. NMFS agreed to it. There would be a problem too if we reverted to summer chinook production as specified in the agreement. We would have to look at the possible ramifications if we back out of the agreement.

Hopper agreed there is a need for evaluation as we proceed. She thought it innapropriate to be rethinking the agreement at this stage. The agreement is in hand after long negotiations, and we should go ahead with it.

Cary Feldman noted that there may be other ways of arriving at the 8,000 pounds specified in the agreement.

Bob Heinith commented that he could see a potential problem in trying to proceed without Canadian agreement.

Jerry Marco said he views the Settlement Agreement as a commitment. Actually, in his view the agreement cut sockeye short, partly because people were not certain they could accomplish enhancement of sockeye. That is where the idea for the study came from. We did not want to forget sockeye. But we do need an evaluation.

Rick Klinge said he was encouraged by what WDF had proposed. He has a real concern about the interest of the Canadians. We need to talk further about that. If the fish return to the spot where they were released, then those adults that are transported might be lost. If the committee approves, Douglas County P.U.D. is ready to proceed right now with the WDF proposal. Our people see the proposal as satisfying the terms of the Settlement Agreement. How far they might be willing to go in other directions is unknown.

Hevlin indicated that perhaps the first thing to agree upon would be a monitoring and evaluation section in the WDF proposal. There is a need to be specific about the procedures that would be used for evaluation.

The committee asked the coordinator for his opinion. Whitney said he felt the parties were committed in the Settlement Agreement to evaluation of a sockeye enhancement program through production of 8,000 pounds of juveniles. The WDF proposal outlines a way of achieving that. He favors the proposal. The proposal needs to include a monitoring and evaluation phase. Canadian concerns must be taken into account, preferably through an agreement with them. Klinge should meet with the federal people in Canadian DFO as soon as possible - probably in conjunction with the meeting of the North Pacific Chapter of the American Fisheries Society. We see that there are different views among the Canadian interests. According to what we heard here, comanagement might become a reality very soon. When that occurs, there will be a better basis for negotiation with the Canadians. We will have to offer them something they all want. Perhaps those might be sockeye, kokanee, fish ladders [that don't pass warm water fish] and screens.

The meeting adjourned at 5:30 P.M..

WELLS PROJECT COORDINATING COMMITTEE
SOCKEYE ENHANCEMENT WORKSHOP
MARCH 5, 1992

ATTENDANCE ROSTER

Name	Representing
Karen Pratt	K.L. Pratt Consulting
Rick Klinge	Douglas County P.U.D.
Tom Meekin	Consultant
Bruce Shepherd	B.C. Ministry of Environment
Chris Carlson	Grant County P.U.D.
Lowell Stuehrenberg	National Marine Fisheries Service
Doug Hatch	Columbia River Intertribal Fish Commission
Bob Heinith	Columbia River Intertribal Fish Commission
Oddvin Vedo	Okanogan Indian Band
Mark LaRiviere	Tacoma Public Utilities
Bill Hevlin	National Marine Fisheries Service
Steve Hays	Chelan County P.U.D.
Tom Scribner	Yakima Tribe
Sandy Noble	U.S. Fish and Wildlife Service
Jon Hansen	Colville Confederated Tribes
Jerry Marco	Colville Confederated Tribes
Cary Feldman	Power Purchasers
Mike Erho	Douglas County P.U.D. (Consultant)
Chuck Peven	Chelan County P.U.D.
Dick Whitney	The Committee
Jim Mullan	U.S. Fish and Wildlife Service
Tom Flagg	National Marine Fisheries Service
Lee Harrell	National Marine Fisheries Service
George Swan	National marine Fisheries Service
Rod Woodin	Washington Department of Fisheries
Jim Ames	Washington Department of Fisheries
Ron Boyce	Oregon Department of Fish and Wildlife
Jeff Fryer	Columbia River Intertribal Fish Commission
Kathy Hopper	Washington Department of Fisheries

WELLS 92-4

WELLS PROJECT COORDINATING COMMITTEE
MEETING APRIL 17, 1992
SUMMARY[1]

Agreements Reached

1. The committee agreed that all of the suggestions in Hevlin's memo of April 2, 1992 which has to do with potential sockeye enhancement, are things the committee can get involved in to various degrees.

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The meeting was held by telephone conference call in conjunction with a meeting of the mid-Columbia Coordinating Committee on April 17, 1992. The purpose of the meeting was to review the memo sent by Bill Hevlin of National Marine Fisheries Service dated April 2, 1992, which included a list of suggested objectives for 1992, and for 1993 and beyond, having to do with enhancement of sockeye. Participating were Ron Boyce, Oregon Department of Fish and Wildlife; Rod Woodin, Washington Department of Fisheries; Jerry Marco, Colville Confederated Tribes; Bob Heinith, Columbia River Intertribal Fish Commission; Rick Klinge, Douglas County P.U.D.; Bill Hevlin, National Marine Fisheries Service; and Richard Whitney, Chairman.

Klinge noted that all of the things on Hevlin's list are things that we can get involved with to a degree. The committee discussed them individually.

Monitoring:

1. Initiate an annual spawning ground count, index or assessment. Klinge said that the P.U.D. is geared up to get spawning ground counts. Several entities have expressed an interest in doing the work.

2. Monitor the temperature and flow regime in the Okanogan Basin seasonally at the following three sites:(1) just below the confluence of the Okanogan and Similkameen Rivers, (2) Mallot USGS Station on the Okanogan River, and (3) RM 6.0 on the Lower Okanogan River (Phase 1 of study). Klinge said that he has 3 temperature recorders placed on the Okanogan. At present there are none below Zosel Dam. He could move them if people want that.

With respect to flow, there are USGS Stations, but several are not equipped. The USGS in Tacoma has the data from their stations.

Habitat Inventory:

1. Evaluate fry protection at irrigation diversions between Vaseaux Dam and Lake Osoyoos, including screen inventory and entrainment study. Klinge will talk to Bruce Shepherd.

2. Outline the annual water management plan for the Okanogan

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[1] Prepared by R. Whitney

River between Vaseaux Dam and Lake Osoyoos. Detail the flow regime during spawning, incubation, and emergence. Determine timing of irrigation withdrawals. Klinge reminded the committee that Bruce Shepherd had described the group that regulates flow through the Okanogan River. Perhaps the committee could get the information from them.

Management:

Coordinate with Canadian DFO, BC Fisheries, and the Okanogan Tribe to determine each of their respective management objectives and enhancement plans for the Okanogan sockeye stock and resident fisheries, and acquire harvest rate data. Klinge suggested that in June the committee might sit down with the Canadians to talk about the trans boundary stock issue. Heinith reported that he has been talking to representatives of the Okanogan Band. They are moving ahead with plans for sockeye enhancement. The DFO Aboriginal Fisheries Section has been pushing for it. There is scheduled a June 15 meeting in Princeton, which will include all the parties. There is a proposal for a hydropower development on the Similkameen at Princeton. It will include fish passage facilities.

Production:

Evaluate the well site on the Lower Okanogan River as a potential future location for an artificial production facility for Okanogan sockeye. Klinge said that the P.U.D. can provide information on the production well. It can pump 4-500 gpm. Jerry Marco reported that the temperature is 48 degrees now that the facility is fully operational. It does warm somewhat later in the year.

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Klinge said that the P.U.D. would check the list by July and revisit the subject.

OTHER:

1. Adult Monitoring at Zosel Dam. Bob Heinith expressed concern that the video monitoring at Zosel might not be accomplished as planned. There has been a contracting problem between the P.U.D. and Intertribal Fish Commission. Klinge reported that the lawyers are going over the contract. The Commissioners have approved the expenditure. It is just a matter of getting an agreement on paper. We are working on it.

2. Sockeye Production Proposal. Rod Woodin said that WDF has not thrown in the towel on their proposal for sockeye enhancement. They are looking at some other options and will report soon with a revised proposal.

3. Adult Sockeye Passage Study. Klinge reported that NMFS has reviewed the contract and said they would send it back to the P.U.D.. They have not yet done so.

4. Protocol for Taking Adult Brood Stock in the Methow. Woodin reported that the draft protocol has been revised by Bob

Bugert. He will send it out by FAX on Monday, April 24, 1992.

5. Bypass Operation. Klinge reported that the bypass began operation yesterday even though the index numbers were lower than they have been in the past when operation began. The evaluation procedure began this morning at 8:00 A.M.. The bypass group thought that the Winthrop fish should arrive there tonight. The flows this spring have several times fallen below 140 cfs. This means that it is lower than plant capacity and units have been shut off at times.

WELLS 92-5

WELLS PROJECT COORDINATING COMMITTEE
MEETING MAY 14, 1992

SUMMARY[1]

Agreements Reached

1. The committee approved the revised proposal from Washington Department of Fisheries for production of 8000 pounds of sockeye as called for in the Settlement Agreement.

The meeting was held by telephone conference call at 1:30 P.M. Thursday, May 14, 1992. Those participating were Rick Klinge, Douglas County P.U.D.; Tom Scribner, Yakima Indian Tribe; Cary Feldman, Power Purchasers; Rod Woodin, Washington Department of Fisheries; Bob Heinith, Columbia River Intertribal Fish Commission; Jerry Marco, Colville Confederated Tribes; Ron Boyce, Oregon Department of Fish and Wildlife; Bill Hevlin, National Marine Fisheries Service; and Richard Whitney, Chairman.

The primary purpose of the meeting was to review and approve the revised proposal from Washington Department of Fisheries for a program to meet the conditions of the Settlement Agreement relating to the production of sockeye under Phase I of the Hatchery Based Compensation Program. The proposal had been distributed to the committee in a memo dated April 29, 1992. Rod Woodin noted that there was need for an early decision if there was to be action in 1992. Rick Klinge noted that there had been concern expressed over the previous proposal due to the potential for interactions with Canadian fisheries management objectives in Lake Osoyoos. He had talked to Bruce Shepard in British Columbia about the proposal. Bruce had concluded that there was little possibility that these fish would be able to move into the Canadian portion of the lake. Furthermore, the numbers were small and he felt that any effect would likely be in the kokanee population on the U.S. side of the lake. Klinge felt that it would have been helpful to have Canadian representation on this conference call. However, some of the committee members had expressed their concern over that suggestion and he had not pressed the matter.

The proposal calls for raising the sockeye to a size of 25/ pound by April of 1993. Jerry Marco questioned whether that was a realistic goal. Woodin said that the proposal calls for hatching and rearing in Wells Hatchery water, which is near 50 degrees. At that temperature, the fish should reach that size in the 3 months after they hatch. Rick Klinge has talked to Kathy Hopper of Washington Department of Fisheries. She is confident that they can achieve that size, taking into account the temperature of the

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[1] Prepared by R. Whitney

water at the Wells Hatchery. Jerry expressed an interest in having a contingency plan available in case the fish do not reach that size. Woodin noted that this is a feasibility study. If the fish don't make that size then the plan could be adjusted the next year. There was a question about marking of the fish. Woodin responded that the fish would be marked with a small piece of colored latex or a filament of nylon injected into the adipose tissue behind the eye (visual implant tag). WDF has applied these tags on both coho and chinook in recent evaluations of the technique. WDF personnel are collecting sockeye samples at McNary Dam to confirm that sockeye at about 25 per pound have sufficient adipose eye tissue to accomodate the tag.

Ron Boyce asked for a clarification of the recovery rates expected at McNary from the number of sockeye in the experiment. He also suggested that there be given more information on the methods to be used for recovery of adults. Thirdly, he feels that there is a need to define in the proposal the criteria for success of the program. Woodin said he would work with Bob Bugert of WDF to enlarge on those subjects in the proposal.

Hevlin inquired whether there was a possibility of conflict with the adult passage study. Both would be using adult sockeye taken from the Wells trap. Woodin thought there would be no conflict either with the adult passage study or the study of sockeye being conducted by the Intertribal Fish Commission. Rick Klinge agreed there would not be a conflict. They have a protocol for operations that will guide the taking of adults.

Hevlin suggested there would be an opportunity for study of effects of the trap operation on passage rates of adults in the ladder.

Woodin noted that the proposal is for a 3 year period, depending on the success of the effort. If the fish do not reach size and migrate then we will consider other options.

After full discussion, the committee approved the proposal with the understanding that WDF would provide the additional information requested, as discussed above.

Klinge noted that there is a critical time period. The proposal calls for Douglas County P.U.D. to obtain the necessary permits from Okanogan County. Douglas P.U.D. might need letters of support from the agencies represented on the committee as they apply for the shorelines permit required.

2. Progress Report on the Methow Hatchery Construction Project. Klinge reported that the hatchery was scheduled for completion in April, but that it is not yet ready. There was an initial delay as the contractor battled a high water table and had difficulty pouring footings. Then his pipe supplier was several weeks late. The pipe work is still not completed. The hatchery can not hold adults. It will probably be another three weeks before it would

be safe to put the adults there. Meanwhile adults will be appearing soon. Rick and WDF propose to hold the adults in the summer chinook acclimation ponds at Twisp. The juveniles are out of the pond so it is available. Kathy says there is no problem with disease. The comment was made that the Twisp facility might soon be too warm. Klinge was asked to watch the water temperature. If it reaches the upper 50's or lower 60's there could be a problem. There was also a question about how the adults would be removed from the pond. The answer was probably by seine, but Rick will discuss this with Kathy of WDF and report back to the committee. He reported that the Twisp trap is functioning well.

3. Counting of Adult Sockeye at Zosel Dam. Klinge reported that Douglas P.U.D. has been negotiating a contract with the Intertribal Fish Commission for this work. He thinks they have resolved matters and will soon be able to sign it.

4. Other.
Adult Passage Study. Bob Heinith said that he thought that once the committee approved a proposal the P.U.D. should fund it. He had heard that Lowell Stuehrenberg was not comfortable with the contract negotiated with Douglas P.U.D.. He might have had his budget trimmed too closely for comfort. Klinge responded that Douglas P.U.D. had received two proposals for the adult sockeye passage study, one from Ted Bjornn, and one from Lowell Stuehrenberg. Bjornn's proposal did not include all of the things Klinge felt were desirable. On the other hand, Lowell's proposal was for about twice the amount the P.U.D. had budgeted for the work. Klinge had asked Lowell to try to cut the costs - without compromising the integrity of the study. He noted that the Settlement Agreement calls for a study at Wells Dam. The P.U.D. had gone beyond that to try to get some answers to questions about sockeye behavior above the dam in the reservoir and tributaries. He had thought Lowell was satisfied. He will talk to Lowell to be sure they are thinking alike on the subject.

Fyke Net Samples at Wells Dam. Rod Woodin asked that the fyke netting at Wells Dam be delayed for another week due to the fact that chinook have delayed leaving the Similkameen facility. Klinge agreed. The bypass subcommittee will deal with this.

Next Meeting. The committee agreed to convene again by telephone conference call at 8:00 A.M. May 21, 1992. The agenda will be to discuss implementation of the sockeye enhancement suggestions listed in the Hevlin memo of April 2, 1992.

Adult Passage Study in 1993. Ron Boyce noted that there is a meeting scheduled with the Corps of Engineers on Wednesday, May 20, 1992 to discuss proceeding jointly with the mid-Columbia P.U.D.'s to trap and mark at John Day Dam for the adult passage study in 1993.

WELLS 92-6

WELLS PROJECT COORDINATING COMMITTEE
MEETING MAY 21, 1992
SUMMARY[1]

Agreements Reached

1. Douglas County P.U.D. will begin the process to obtain a permit from Okanogan County to place net pens in Lake Osoyoos in 1992 for the sockeye production project.

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The meeting was held by telephone conference call at 8:00 A.M. May 21, 1992. Participating were Rick Klinge, Douglas County P.U.D; Rod Woodin, Washington Department of Fisheries; Cary Feldman, Power Purchasers; Bob Heinith, Columbia River Intertribal Fish Commission; Jerry Marco, Colville Confederated Tribes; Bill Hevlin, National Marine Fisheries Service; and Richard Whitney, Chairman. The purpose of the meeting was to discuss steps being taken to implement the suggestions in the Hevlin memo of April 2, 1992, having to do with determining the potential for enhancement of sockeye, progress with the construction of the Methow Hatchery, and other subjects.

1. **Potential for Establishing Sockeye Populations:** Per the Hevlin memo of April 2, 1992, the following items were discussed: 1). **Spawning Ground Surveys.** Klinge reported that he has two proposals in hand that are being developed into contracts. He wants to award contracts in June. 2). **Temperature Records.** Klinge has 3 thermographs in place, one at Zosel Dam, one at Mallot, and one in the Columbia River above the confluence with the Okanogan River. Washington Department of Fisheries has one on the Similkameen. There was a suggestion that one be placed in the Okanogan River below the Similkameen. Bob Heinith mentioned that the Canadian Department of Fisheries and Oceans has issued a report in which they say that there is a potential problem below reservoirs and a lack of information. Klinge asked him to send a copy of the report. After he studies it he will talk to the committee further on the subject. 3). **Fry Protection at Irrigation Diversions.** Klinge has information from the Ministry of the Environment that shows water withdrawals for irrigation from the Okanogan River. He does not yet have information on the schedule for withdrawals or on screening of the irrigation intakes. Heinith said that although the law requires screening of intakes, they have not been installed in all locations. For example, McIntyre Dam needs a screen. Jerry Marco said that the dam at Oliver is not screened. 4).**Water Management Plans for the Okanogan River.** Klinge sat in on a meeting among the Canadian interests. He observed that little flow was provided from October through April, which covers the incubation period for sockeye and kokanee. The flow dropped from 440 cfs to 220 cfs in that period. Redds placed at the higher flow probably went dry during incubation. Bruce Shepherd told him they will "ramp" the flow next winter rather than have a sudden reduction. The objective of the high flow in the fall is to draw down the reservoir for flood control. Jerry Marco suggested that one

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[1] Prepared by R. Whitney

of the reasons for high flow in the fall is to provide for chinook spawning.

There was a discussion of whether there is a need to provide a written statement on these items. The chair suggested that the meeting summaries of the April 17, 1992 meeting and the present one would provide a written record. The committee should review those before deciding what might be needed.

2. **Sockeye Production.** Rod Woodin reported that WDF is working on the study outline of their sockeye production project to provide more information in several areas, as requested by the committee at the May 14, 1992 meeting. They are clarifying the section on criteria to be used in evaluating the success of the project. WDF has a video illustrating the marking method proposed for the juvenile sockeye. He will show it at the next in-person meeting if the committee would like to see it. In addition, an estimate of expected numbers of recoveries is being developed by WDF staff at McNary Dam. Potential sites for location of the net pens are being investigated. Woodin suggested the pool just above Zosel Dam. Cary Feldman expressed a concern that the adults when they return might have trouble orienting upstream at Wells Dam. Woodin thought that Bruce Shepherd had mentioned that kokanee were observed to pass their point of release and continue to the spawning grounds. Klinge said that Douglas P.U.D. will begin work to apply for shoreline permits from Okanogan County to locate the net pens for juveniles. A permit may also be required from the Corps of Engineers. Kathy Hopper of WDF has contacted Sea Farms, Inc. for permission to use their net pens above Chief Joseph Dam for holding adult sockeye. This appears to be a promising possibility.

Klinge questioned whether the sockeye could reach 25 per pound as stated in the WDF proposal. As an accelerated smolt program a lot depends on this factor. He also expressed concern about where the adults might return. Kathy Hopper is working on a paper analysis that will demonstrate what the potential is for sockeye growth rates under the given conditions.

There was a discussion of the duration of the study. Klinge emphasized that the project is for the first year of a three year feasibility study called for in the Settlement Agreement. However, if it shows some promise, Douglas P.U.D. will not wash their hands of it and walk away. Woodin said that there will still be time to back out after kathy Hopper finishes her analysis. He will ask her to make a presentation at the June 18, 1992 meeting of the committee.

3. **Progress on Methow Hatchery.** Klinge reported that the contractor has pressure tested all of the pipes. There is still electrical work to be done, particularly on the alarm system. The first week of June there will be a 120 hour test, during which the entire system will be tested, including the alarms. The first adult has been collected at the Chewack. It has been put in the holding pond near Twisp. They have water spraying across the pond. Fish held there will be moved to the hatchery the second week of June. The protocol for collection of fish calls for taking the first fish and releasing the next two at continuing intervals.

4. **Radiotelemetry Study of Sockeye.** The committee at the May 14, 1992 meeting had expressed a concern that the contractor might be feeling that

money might be too tight to accomplish the objectives of the study. Klinge talked to Lowell Stuehrenberg about that. Lowell's concern had to do with the way proposals were compared. He felt that his proposal was more comprehensive than others and therefore more expensive. When asked about the study, he expressed optimism. He feels that we will have a fine study and things should work out well. He is not concerned about bumping up against a financial lid on the study.

The meeting adjourned at 9:00 A.M..

WELLS 92-7

WELLS PROJECT COORDINATING COMMITTEE
MEETING JUNE 18, 1992
SUMMARY[1]

The meeting was held at the West Coast Sea-Tac Hotel, in conjunction with the meeting of the mid-Columbia Coordinating Committee on June 18, 1992. Those in attendance are listed on the attached roster. The agenda followed was mailed to the full mailing list along with the meeting announcement on May 29, 1992.

1. Bypass Evaluation. Rick Klinge reported that the evaluation began April 17, 1992. There were no complications in the study this year. Biosonics personnel are still bit-padding the data preparatory to analysis.

The bypass is still operating, but only at night. There was an unusual late spike of abundance in juveniles in the fyke nets and hydrocaoustics. They are on the verge of closing down for the season. There was a discussion on criteria for operation of the bypass. The Settlement Agreement leaves it up to the bypass team. There is no specification about a percentage of the run that is to be protected. Klinge thinks that the low flows slowed the migration. There has been rain recently and BPA has increased the flow, which brought more fish. Flow presently is 160 KCFS. There will be a summer evaluation for 15 days at a time to be decided by the bypass team.

2. Progress Report on Compensation Package. Methow Hatchery and Associated Facilities. Klinge reported that there was still some work to do at the satellite facilities. He reminded the committee that Douglas P.U.D. had asked the contractor to concentrate on the main hatchery to try to get it ready on time. The hatchery is now within days of the startup week in which there will be a long test of operations. The first test of the computer system "fried" the system. This has required two weeks to redo the work. He called upon Kathy Hopper for a report on brood stock collection. She reported that the protocol is being followed. At the Chewack trap there were 8 fish passed as of this morning and 5 were collected. At the Twisp there were 16 passed and 11 collected. There were 6 dead fish on the Twisp rack. Evidently the angle of the rack is now too flat. Fish jumping over the trap can be stranded. There was a discussion of how to correct the problem. Fish were held at the Twisp acclimation pond until last Friday and then transferred to the hatchery. All were alive and well. The sex ratio is 50:50. The last fish was passed on the Twisp on June 10. Last summer WDF proposed gaffing on the Twisp, but decided not to do so because of concern about the minimum population size. WDF is now proposing that they obtain fish by gaffing and set a target of 150,000 fish to rear from the Twisp. The Methow goal is 400,000 fish. They would have fish to go through the winter and not leave the ponds empty. Bill Hevlin asked about adjustments

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[1] Prepared by R. Whitney, Chairman

that could be made in the Chewack trap. Kathy said it is adjusted by regulating the amount of water going into the box. This does not affect the Denil. Klinge noted that the Denil is now high enough that flow is not a factor in its operation.

As to the Methow proper, Klinge reported that Douglas P.U.D. is now leaning toward a trap at the Foghorn Ditch. The U.S. Fish and Wildlife Service has the lead responsibility there. Things have moved slowly. Craig Tuss was called in to help work the problem. They hope to resolve the matter soon. They want to have something in place in time to collect fish.

Rod Woodin referred to the memo from Bob Bugert discussing a proposed family size evaluation. The idea would be to take sublots from females and fertilize the eggs with separate and individual males. These would be randomized, but they would keep track of them so that they can see what is the relative contribution to smolts produced. The committee discussed the proposal and approved it. There was a question whether there would be recovery of marked adults.

A subcommittee was scheduled to meet at Douglas County P.U.D. next Tuesday to discuss the hatchery evaluation.

3. WDF Sockeye Production Project. Rod Woodin referred to Kath Hopper's information on growth which had been requested. He called upon Tony Eldred who distributed a memo from Washington Department of Wildlife expressing concern about releasing sockeye with IHN into the river at a time when steelhead are present. Kathy Hopper agreed to keep the sockeye separated. There was a discussion of the alternatives. It was noted that there will never be a totally risk free scenario. Hopper noted that the Methow facility is nice, but the problem is that the fish would not reach a suitable size in time because the water is colder than at Wells hatchery. Rick Klinge mentioned Cassimer Bar as a possibility. The P.U.D. has two wells there. Perhaps the P.U.D. could develop that site if the committee likes th idea. He commented that the Wells Hatchery is a plumber's nightmare, and we would have to be certain that the sockeye were isolated. The fact that adult fish do accumulate below the hatchery is a point of concern. Scribner asked for 1). more information on the potential for holding adults in the net pens at Rufus Woods reservoir, 2). more information on the incubation process at Eastbank Hatchery for the Lake Wenatchee Program, 3). more information on Cassimer Bar. As for Cassimer Bar, he has a portable incubation trailer that fits on a flat bed truck that could be used there.

After full discussion, the proposal was modified to start with adults to be held in net pens at Rufus Woods reservoir, eggs to be incubated at Wells hatchery. The committee felt that it was also essential to have the juveniles held in net pens for a time prior to release into Lake Osoyoos. Klinge said that the P.U.D. is working with Okanogan County to obtain permits for putting nets pens in the lake. They are thinking in terms of 1-2 months acclimation and release in the spring.

4. Potential for Sockeye Enhancement (Hevlin Memo).

A. Spawning Ground Surveys. Klinge reported that the P.U.D. has in hand two proposals for spawning ground surveys in the Okanogan. He distributed copies to the committee. The proposals were labelled "A" and "B", with the names of those submitting them omitted. The committee recommended proposal "B". They did not like the part of proposal "A" that included seining and marking of adults prior to spawning.

B. Flows and Temperatures. Klinge reported that this is being accomplished. He referred to correspondence with Bob Heinith. The committee discussed Heinith's suggestion that the thermograph at Zosel Dam be moved to a site below the dam. The committee decided there were advantages to the present site, where it is protected from vandalism. With Tom Scribner abstaining, the committee recommended that the thermograph be left where it is.

C. Screen Inventory. Klinge reported that the P.U.D. will do most of the tasks listed under that heading in Hevlin's memo. However, they will not be able to obtain photographs of all of them as was suggested. 1). They will look at British Columbia Laws, 2). They will investigate agreements between the U.S. and Canada, and 3) They will determine what the irrigation period is and what problems might be experienced with fish, 4). They will also determine what is the watter management plan.

D. Enhancement Plans for Sockeye. These are being discussed at a meeting at Penticton at this time. The Canadian interests are attempting to reach agreement among themselves.

Klinge referred to Cassimer Bar again in this context, noting that there was a 200 foot test well that found a good aquifer at 60 feet with 54 degree water.

5. Weekly Report. The committee asked Klinge to provide a weekly report of significant activities during the summer.

6. Next Meeting. The committee agreed to meet again early in September in conjunction with the mid-Columbia Coordinating Committee meeting.

ATTENDANCE ROSTER

WELLS PROJECT COORDINATING COMMITTEE
MEETING JUNE 18, 1992

Name	Representing
Tony Eldred	Washington Department of Wildlife
Rick Klinge	Douglas County P.U.D.
Bill Hevlin	National Marine Fisheries Service
Ron Boyce	Oregon Department of Fish and Wildlife
Rod Woodin	Washington Department of Fisheries
Kathy Hopper	Washington Department of Fisheries
Tom Scribner	Yakima Indian Nation
Dennis Rohr	mid-Columbia P.U.D.'s
Richard Whitney	Chairman

WELLS 92-8

WELLS PROJECT COORDINATING COMMITTEE
MEETING JULY 6, 1992
SUMMARY[1]

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Agreements Reached

1. The committee agreed to a compromise on the sockeye production proposal that consists of a project in 1992 using 2,000 pounds of production, holding adults and incubating eggs at the Methow Hatchery, and transferring fry to isolated portable raceways at the Wells Hatchery. This evaluation is to determine whether fish can achieve a size of 25 per pound by April. That study would be followed by three full years of evaluation, using the 8,000 pounds of production called for in the Settlement Agreement, but locating the facilities for accomplishing it to Cassimer Bar, which would be appropriately developed for isolating sockeye.

The meeting was held by telephone conference call at 3:00 P.M. July 6, 1992. Participating were Rick Klinge, Douglas County P.U.D.; Ron Boyce, Oregon Department of Fish and Wildlife; Bill Hevlin, National Marine Fisheries Service; Kathy Hopper, Washington Department of Fisheries; Rod Woodin, Washington Department of Fisheries, Tony Eldred, Washington Department of Wildlife; Gerry Marco, Colville Confederated Tribes; Cary Feldman, Power Purchasers; and Richard Whitney, Chairman. The purpose of the meeting was to review the rearing proposal for sockeye. Washington Department of Wildlife, and the Colville Tribes had raised some concerns about the proposal as it stood and the potential for spread of IHN. Washington Department of Fisheries had responded with a July 1, 1992 proposal that addressed those concerns. Douglas County P.U.D. on July 6, 1992 also presented an alternative proposal that was FAXED to the members of the committee.

Rod Woodin began with an explanation of the Washington Department of Fisheries proposal. It is a modification of the original plan, put together to address concerns of the Department of Wildlife and the Colvilles. The modification consists of holding adults at the Methow Hatchery rather than in net pens in Rufus Woods Reservoir above Chief Joseph Dam. Tony Eldred said that the proposal successfully addresses the concerns of the Department of Wildlife. Gerry Marco said that from the Colville's point of view the problem associated with holding adults goes away. He asked whether space requirements at the Methow Hatchery would permit carrying out the three year evaluation called for in the Settlement Agreement. Woodin responded that between now and next year the P.U.D. proposal for Cassimer Bar development could be explored, or they could look further at Rufus Woods net pens. Klinge commented that if they go with Cassimer Bar there would be no need for the Rufus Woods pens.

Klinge then described the P.U.D. proposal. He pointed out that the P.U.D has always pushed the Cassimer Bar idea. It has several advantages, he feels. For one, it would be solely a sockeye facility, avoiding the concerns about disease transmission to other salmon or steelhead. It is not

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[1] Prepared by R. Whitney, Chairman

near other hatcheries. It would be there for the duration, avoiding the problem with temporary availability of some of the other facilities that are included in the Department of Fisheries proposal. There was a question about the volume of flow from the wells at Cassimer Bar. Kathy Hopper said that the output would be right around what would be required up to the point where the juveniles would be put into net pens for acclimation. For adult holding, it might be on the low side. Larger ponds would be required for the adults. She noted that if the P.U.D. wants to go with that idea some construction would probably be required, such as for concrete ponds. Klinge said that the P.U.D. wants to avoid permanent structures. If necessary, they would like to be able to restore the property to as near original condition as possible. They have asked Sverdrup to design a facility that would serve the purposes and meet that requirement. Kathy suggested that perhaps covers over the pond would help keep it cool. Klinge said that they had discussed covers, including the possibility of a quonset hut type building over the ponds.

Woodin suggested that the committee go with the WDF proposal in 1992 and follow with the P.U.D. proposal in 1993. Ron Boyce commented that there would be a gain with hands on experience. It would also determine whether the zero age smolt is attainable. If not, it might be necessary to go with chilled incubation as at Eastbank for the Lake Wenatchee sockeye program in order to keep the fish from reaching too large a size at release.

There was a discussion of the time of release into Lake Osoyoos. Kathy thought April would be the time to move the fish to the Lake. Rod noted that the temperatures in the lake would be similar to ground water at that time. Concerns were expressed about changing the procedures in the study between years. It was thought that if the fish reach the same size in all years that problem would be minimized. Kathy noted that all fish would go to the lake for acclimation and release. The only difference in treatment would be in the incubation temperature and the location of adult holding. Woodin noted that it probably will be necessary to make some changes after the first year based on experience obtained.

Ron Boyce asked again for an estimate of expected numbers of recoveries at McNary Dam. Woodin said he will develop an estimate and provide it to the committee. There was a discussion of what criterion would be used for judging success of the program. Woodin responded that WDF feels success can be measured by the relative contribution of smolts recovered at McNary Dam. Tony pressed the question further and got the response that the intent is to increase the Okanogan run of sockeye. It is a pilot compensation program to supplement the Osoyoos sockeye to compensate for losses at the project.

There was a discussion of the expected size of the juveniles at time of release. Hopper said that it was difficult to come up with a number. The best estimate she could provide is that the 25 fish per pound does not seem out of reach. Some of the members felt this number needed verification.

Klinge said that the P.U.D. had proposed a reduced program to see whether the fish could in fact reach that size. He asked Hopper how many fish would be required as a minimum. Hopper suggested one pond, which amounts to 2,000 pounds of production. Klinge asked if going with 2,000 pounds of production would answer the question as to whether fish can reach 25 per pound the first year. There was a discussion about yearling releases. Woodin noted that he would not expect many recoveries at McNary out of a 2,000 pound release, so the evaluation would probably be only of the questions whether the fish can reach that size. If they don't reach that size then they would probably be too large by fall. There was a discussion of alternatives if it proves to be unfeasible to enhance sockeye. Sockeye are specified as the first choice in the Settlement Agreement. Klinge spoke in favor of continued work on sockeye if this particular approach does not work out. Perhaps we don't need net pens. Perhaps some locations of release could be investigated.

A compromise was suggested to use the P.U.D. proposal at the 2,000 pound reduced level in 1992 to determine whether the 25 fish per pound is achievable, and then if it proves to be achievable, follow in 1993 with three full years of evaluation using Cassimer Bar as the location for the sockeye production project. Bob Heinith, although he was unable to take part in the meeting had conveyed a concern about spreading the take of adults over the duration of the run. The committee felt that with the small numbers of fish involved in the 2,000 pound proposal this year, that would not be a factor. After full discussion, the committee approved the compromise proposal. Hopper said WDF would proceed to collect the necessary brood stock immediately.

WELLS PROJECT COORDINATING COMMITTEE
MEETING SEPTEMBER 17, 1992
SUMMARY[1]

Agreements Reached

1. The committee recommended that Douglas County P.U.D., Washington Department of Fisheries and the Colville Tribe meet to discuss implementation of the sockeye enhancement evaluation project at Cassimer Bar. The site is on the Colville Reservation. The tribe would like to undertake the work. WDF would also like to do it. The committee is hopeful that interests of the three parties can be accomodated in some way so that the project can proceed.

2. A subcommittee is drafting a plan for the hatchery evaluation called for in the Settlement Agreement. They will meet for further discussion before October 1, 1992.

3. The committee agreed to meet again October 28, 1992 at Sea-Tac.

The meeting was held at the Radisson Hotel near Sea-Tac, starting at 9:00 A.M. September 17, 1992. The agenda followed was sent to the full mailing list, along with the meeting notice on August 18, 1992. Those in attendance are listed on the attached roster.

1. Progress Reports

A. Methow Hatchery. Rick Klinge reported that the hatchery is operational and Douglas P.U.D. is proud of it. It is both functional and aesthetically pleasing. Covers for the raceways are not yet in place, but will be soon. A dedication has been planned for October 2 at 10:00 A.M..

Rod Woodin provided a report of trapping of adult spring chinook for brood stock in the Twisp and Chewack traps, information contained in a memo from Bob Jateff to Kathy Hopper. It shows the dates and numbers of fish taken of each sex and the numbers passed. A total of 80,000 eggs have been taken, 40,000 from fish at each facility. Bob Bugert reported that fish were getting past the trap so they increased the percentage of fish to be taken in the protocol. The fish that jumped the weir were counted. They handled about 35% of the fish going through the trap, but only about 15% of the total going upriver. The eggs are kept separate for each family, with one family per stack of Heath incubator trays.

Klinge reported that the notice for bids on modifications of the Foghorn intake went out October 1. Award is scheduled for November 1. There is a possibility that the work will not be done this year if the weather is bad, in which case another chance to collect brood stock in the Methow may be missed.

B. Cassimer Bar. Klinge reported that Douglas P.U.D. is proceeding with site development at Cassimer Bar. They hope to be ready to receive eyed eggs this year. The plan calls for 2,000 pounds of zero age smolts. A second well has been sunk. Portable buildings are available or on order for

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[1] Prepared by R. Whitney

delivery in mid-November.

The P.U.D. owns the property, but it is on the Colville Reservation. Jerry Marco had distributed copies of a proposal from the Colville Tribe to operate the facility at Cassimer Bar. He is confident the tribe could successfully operate the facility. It is near the Colville Hatchery. They could arrange an alarm system from Cassimer to the hatchery. For disease monitoring they could rely on the U.S. Fish and Wildlife Service, who are already monitoring the Colville Hatchery. He sees a potential problem at a policy level with operators other than the tribe being on the reservation. The tribe has its own permitting system. There are some grave sites there. They will look next week and try to deal with that problem. Rod Woodin commented that Washington Department of Fisheries has been in the lead in developing the sockeye proposal and would not be comfortable turning it over to someone else with less experience in working with sockeye. WDF has all of the necessary support structure to carry it out. The committee suggested that Douglas P.U.D. meet with WDF and the Colville Tribe to work out the arrangements. The committee hopes that the matter can be resolved so that the work can proceed on schedule.

C. Wells Bypass Evaluation. Klinge reported that the evaluation had been conducted from April 17 to May 27 in 1992. There were large variations in flow that made the study somewhat different than in the two other years. There were times when the multiplexer called for sampling at a turbine intake when the unit was shut down due to lack of water. This had an effect on sampling frequency. John Skalski is examining the data to see whether anything can be done about that. Biosonics expects to have a draft report available November 1.

D. Trapping and Escapement. Bob Bugert of WDF presented a written report, which he summarized. Summer chinook escapement was very low. Last year was the worst year on record, and this year was even worse. The escapement goal had been 1800 at Wells Dam. They did not achieve that in 1991. They set 1200 as the goal in 1992, and did not achieve that. However, fish are still there and they will resume trapping next week. They reduced the number of adults to trap for the Eastbank facility. Eastbank was given priority over Wells Hatchery. They collected only 18% of the goal in terms of females. However, they have the potential of reaching 70% of their goal in terms of capacity at the Twisp and Similkameen Ponds.

Tony Eldred presented a proposed protocol for trapping of summer steelhead at Wells Dam. Klinge will distribute it to the committee.

E. Radiotelemetry Study of Adult Sockeye Passage. Klinge called upon Lowell Stuehrenberg for a report. He stressed the preliminary nature of his report. They tagged 96 sockeye at Rocky Reach Dam. There were 84 of these tracked over Wells Dam. Of these, they have good information on 61. There were 3 fish that fell back. Of these 2 returned. Median time for passage at Wells Dam was 28 hours. Average time was 53.4 hours. This compares with the Snake River where passage times are generally 1 to 2 days. Median ladder passage time was 3.9 hours, and the maximum was 72.3 hours. He is ready to conclude that passage at Wells Dam is not a problem for sockeye. However, when the fish reached the Okanogan they slowed markedly. Temperature at the mouth of the Okanogan was 80 degrees F. When it cooled to 65, almost overnight, as a result of snow in the watershed, fish were successful in passing upstream in the Okanogan. There were 28 fish recorded at Zosel Dam. Of these, 19 were recorded as they went through the ladder. Median passage time through the ladder was 1.57 hours, with an average of 3.14 hours. There were 10 additional fish that were recorded above Zosel Dam. They probably used the spillway and did not go through the ladder. They noted that the fishway entrances closest to the spillway showed the lowest relative activity. The one on the left bank was used by only 2% of the fish using that ladder, compared to 20% that used the entrance closest to the spillway on the right bank ladder. They monitored at Chief Joseph Dam. A small percentage of the fish went up there. They accounted for 32 fish in the Okanogan River. That leaves 52 of the 84 passing Wells Dam unaccounted for. There might be a problem with the tags being used. Others using Lotek tags reported problems this year. The sockeye tag is different though. The report is due in March, 1993. All the results to date are preliminary.

The committee emphasized the importance of looking for missing fish. Lowell suggested transporting sockeye up the Okanogan might be called for in view of the apparent adverse effect of temperature on their passage to Lake Osoyoos. Hevlin commented that he will consider writing a proposal for study. Bob Heinith provided preliminary counts of adults at Zosel Dam from the video recording. There were 47,000 sockeye counted at Wells Dam. Only 1775 were counted at Zosel. A comparison of Zosel counts with those at Tumwater Dam on the Wenatchee River shows a peak in the daytime at Tumwater and at night for Zosel Dam. This suggests that at Zosel Dam perhaps more fish are using the spillway, and in the daytime, than are using the ladder. This deserves further study. Klinge reported that there had been some concern expressed by Ken Bates and Bob Steele of WDF that the video camera might be interfering with fish passage at Zosel. However, after further analysis, they are now confident that the camera frame was not causing delay. The problem apparently was due to higher velocities through the ladder than it was designed for. This condition was brought about by higher than planned reservoir elevations. The problem was brought under control with stop logs and plywood.

F. Modifications of the Trap at Wells Eastbank Ladder. Klinge reported that all of the changes in the trap agreed to by the committee had been finished. Intertribe sampled 688 sockeye in conjunction with the hatchery crew taking chinook.

G. Hatchery Evaluation. A subcommitte met on June 23, 1992 to discuss the evaluation. They have drafted a program similar to the one adopted for the evaluation of Chelan P.U.D.'s Eastbank facility. Klinge questions how far it will be possible to refine the genetic measurements. The difficulty is to discriminate between normal evolution and hatchery effects. There is a draft document. Klinge will write a repsonse and discuss it with the subcommittee before the end of the month. Woodin commented that he hopes the committee will lay out a "game plan" first, then launch into individual studies. Heinith commented that he thought baseline measurements of smolt abundance are needed. Klinge said the P.U.D. plans to issue an RFP on that subject this fall. Boyce asked that there be full discussion in the committee prior to issuing RFP's and such. Scribner emphasized Woodin's point that there should be in place a coherent plan with defined goals and objectives.

H. Spawning Survey. Klinge reported that the Colville Tribe is initiating the survey. The Canadians have issued a permit. Jerry Marco reported that there are a few sockeye in the river. Thermographs have been deployed. They will be flying the river. Later there will be a carcasse survey. An estimate will be made of the extent and degree of mortality. NMFS has requested that an assessment of prespawning mortality be included in the study.

2. Future Studies

A. Radiotelemetry in 1993. Klinge noted that the Wells Agreement calls for a study of delay and mortality of adults at Wells Dam. Technical representatives on the Rock Island Committee recently have agreed that the study of adult mortality contemplated in the Rock Island Agreement is technically infeasible at this time. He suggested that the Wells Committee agree to a similar statement and that the radiotelemetry study of sockeye is part of the study of delay and mortality called for in the Settlement Agreement. Hevlin commented that he would like to build into the agreement a statement that the study of delay and mortality will be accomplished by integration of the results of the radiotelemetry study, dam counts and spawning ground counts.

Ron Boyce asked about whether Douglas P.U.D. was planning radiotelemetry of sockeye in 1993. Klinge said that they have not been planning for it. It was his understanding that the 1992 sockeye study was a preliminary sort of fesibility study to be followed by the spring and summer chinook study in 1993. Sockeye had been discussed but it appears that it will not be possible to include marking them at John Day as part of the chinook study, due to implications with the Snake River sockeye under the ESA. Ron is interested in following up the 1992 study with modifications of passage where necessary. Klinge wants to wait for the results from the 1992 study to see whether there are passage problems. Bob Heinith expressed some concern about the late start in 1992, thinking we might have missed an early portion of the run. Lowell Stuehrenberg responded that there was a very small portion of the run involved in the two week period under discussion. He did not think it was a factor. Klinge saw no reason why those fish would behave any differently than fish arriving two weeks later. There was a discussion of the provisions of the Wells Settlement Agreement.

With respect to planning for 1993, Hevlin suggested that we might want to add some chinook at Rocky Reach Dam because we can't be sure of the turn off rate for chinook into the Snake River versus the mid-Columbia. Lowell responded that he had planned for 100 fish to turn into the mid-Columbia. He is reasonably confident of that result.

B. Predator Indexing. Klinge summarized progress in moving forward on the study. It is planned as a five-pool effort. There is no provision for a bounty fishery. Ron Boyce indicated that Oregon Department of Fish and Wildlife is in discussions with Washington Department of Wildlife to be sure that data collection is consistent throughout the river.

C. Other.

Juvenile Survival Study. Rod Woodin pointed out that the Settlement Agreement calls for a study of juvenile survival past Wells Dam. He feels that the committee should be planning the study for 1994. This year 1992 was the final year of bypass evaluation. We should allow time in 1993 to make modifications in the operation of the bypass if necessary to improve survival. Klinge said that Douglas P.U.D. is ready to proceed in 1993. John Skalski has prepared a study plan. Klinge's only concern is to get an average flow year. Woodin noted that the survival estimate is keyed to compensation. The compensation program is not up to speed yet anyway and it could not be adjusted at this time. There is therefore no pressing need for the survival study. There was a discussion of the flow forecast and whether it could be used to decide whether to proceed with the study. There was a question whether it would be desirable to design a study around a range of flows. Klinge said Douglas P.U.D. is planning a one-year study. They are not concerned about measuring survival to a fine point. The Settlement Agreement calls for compensation based on an estimate of 14% mortality which is to be adjusted according to the results of the study.

Spawning Ground Surveys in 1993. Heinith asked whether there are plans to conduct surveys in 1993. Klinge said there is a strong likelihood they will want to do more work in 1993. They are interested in fry emergence from the gravel in the Okanogan. It might be important in the context of irrigation removals. They are interested in some limnological work in Lake Osoyoos. The Colville's have done spawning ground surveys in 1992. It was noted that Chelan P.U.D. is printing the results of the surveys of spring and summer chinook that were carried out by the Colville Tribe in 1991. The committee would like to receive copies. The chairman was asked to arrange for copies to be sent.

Contracting. Klinge noted that as a rule Douglas P.U.D. would prefer to keep the contractors anonymous and to review proposals in the committee without reference to who would do the work.

Zosel Dam Adult Counts. Klinge indicated his intention to proceed with video counts of adults at Zosel Dam in 1993.

The Hevlin Memo of April, 1992. Scribner asked to see a schedule for response by Douglas P.U.D. to the items listed in the Hevlin memo. Klinge suggested that a meeting be scheduled in October to talk specifics. He hopes to distribute a response on paper ahead of the meeting. Information is being gathered on habitat in British Columbia. There is a hearing scheduled in Oliver on Monday to discuss closing the irrigation system a couple of weeks earlier than in the past.

Floating Weirs. Rod Woodin announced that a meeting is to be held at Nelson Springs at 1:00 P.M. on September 21, 1992 to discuss adult trapping at the Chiwawa River weir. Results of trapping at the Chewack and Twisp weirs will also be discussed. All are welcome to attend.

Fulton Dam. Bill Hevlin presented a report from Steve Rainey, dated September 9, 1992, in which he expresses the opinion that the trap at Fulton will attract few fish. The Denil needs more attraction water.

D. Next Meeting. The committee agreed to meet again on October 28, 1992 at Sea-Tac.

WELLS PROJECT COORDINATING COMMITTEE
MEETING SEPTEMBER 17, 1992
ATTENDANCE ROSTER

Name	Representing
Ron Boyce	Oregon Department of Fish and Wildlife
Tom Scribner	Yakima Indian Nation
Rod Woodin	Washington Department of Fisheries
Bill Hevlin	National Marine Fisheries Service
Lowell Stuehrenberg	National Marine Fisheries Service
Rick Klinge	Douglas County P.U.D.
Cary Feldman	Power Purchasers
Tony Eldred	Washington Department of Wildlife
Jerry Marco	Colville Confederated Tribes
Bob Heinith	Columbia River Intertribal Fish Commission
Bob Bugert	Washington Department of Fisheries
Richard Whitney	The Committee

WELLS 92-10

WELLS PROJECT COORDINATING COMMITTEE
MEETING October 28, 1992
SUMMARY[1]

Agreements Reached

1. The committee agreed that the adult passage studies program using radiotelemetry, the design of which will be agreed to by the committee, will fullfill the requirement under Section III.G. and IV.A.3.(c)(2) in the Wells Long Term Settlement Agreement for an adult delay/mortality study.

2. The committee agreed that the chairman should distribute a draft of this meeting summary, and particularly the agreement above, early in the week of November 1, 1992, and allow a time for comments or corrections until November 6, 1992. If none are received by that time it will be considered to be approved.

3. The committee agreed to meet again on December 1, 1992 at Sea-Tac

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The meeting was held at 1:00 P.M. on October 28, 1992 at the Holiday Inn at Sea-Tac. The agenda followed was sent to the full mailing list by Rick Klinge on October 16, 1992. Those in attendance are listed on the attached roster.

Progress Reports on Wells Studies

1. 1992 Evaluation of the Wells Bypass System. Rick Klinge called upon Eddie Kudera of Biosonics. He indicated that they are on schedule with preparation of a draft report. it will be ready November 15. He had previously described the problem encountered with analysis due to low flows in the spring that produced many zero observations for particular sections of the bypass at times when they were not actually open and operating. John Skalski has been working with them to revise their analysis. The first thing they had to do was obtain a bypass operating schedule, which they then used to discard readings for those times and places when the bypass was not fully operational due to low flow. Some of those intervals included targets recorded as fish, because fish will enter the spillbay and mill around even when the unit is not operating.

2. 1992 Radiotelemetry Study of Adult Sockeye Passage. Klinge called upon Lowell Stuehrenberg for a report. Stuehrenberg said that there had not been much change since the last meeting when he reported. They have 80 good records of fish, 29 on the spawning grounds. Fifteen tags have been recovered on the spawning grounds. Eight of these were from the Okanogan. He is concerned because 4 of the 8 recovered on the spawning grounds were not running. It is not yet clear whether their failure was due to battery failure or to water leakage around the antenna seal. They were running at Wells Dam so they got information there. He and Ted Bjornn are meeting with

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[1] Prepared by R. Whitney, Chairman

Lotek personnel next week to discuss this problem. They are concerned about possible effects on the study planned for next year.

His arithmetic suggests that as many as 50 fish might have reached the spawning grounds, most of which would not have been detected due to tag failure. There are two weeks left in which tags might be recovered. They will then proceed to analysis and report writing.

His bottom line is that relative to observations made elsewhere in the system, sockeye experience no difficulty in passing the Wells Dam fish ladders. Ron Boyce pointed out that after they see his report the committee will decide whether there is delay or mortality at Wells Dam..

3. Spawning Survey. Klinge called upon Jerry Marco for a report. Jerry feels that they obtained good coverage of the sockeye spawning. They are on schedule with production of a report. The survey being conducted by the Colville Tribe shows that more than 50% of the fish counted at Wells Dam reached the spawning grounds. They observed a lot of activity in shallow water near shore. There could be a problem of dewatering when the water level goes down. There was a discussion of the possibility of working with the Canadians to maintain the flow. It was pointed out that reduced flow could adversely affect kokanee redds as well as sockeye. The Canadian interest in kokanee could lead to efforts to correct the problem, now that Bruce Shepherd is aware of it. Heinith mentioned the Joint Commission that develops minimum flow agreements for streams flowing across the border. Washington Department of Ecology is involved. The committee felt that we need more information before we develop any recommendations. Then we can talk to Bruce Shepherd.

Bob Heinith presented a written report on the adult counts at Zosel Dam. The low counts do not match the expectations based either on Lowell's tag recoveries or Jerry's spawning ground surveys. The fish must be passing in the spillway in larger numbers than through the ladder, where the video camera can see them. Klinge observed that some fish might have passed behind the back board used for the camera. There was a discussion of counts of sockeye at Wells Dam and their relationship to the spawning grounds. There were more than 40,000 sockeye counted at Wells Dam. If Jerry's estimate of the number of fish reaching the spwaning grounds is used, there would be 20,000 fish in about 9 miles of spawning area. Jerry said they are concentrated in about 3 miles of the stream. Spawners are densely packed, with no redds discernable, just one big disturbed area.

Tom Scribner reported that the Yakima Tribe is preparing a report on chinook spawning. A final draft report will be ready next month. They plan to go back to the river in a couple of weeks to see how it looks when the water level is down.

4. Trip to Oliver, B.C. by Hevlin and Klinge (Oct. 7-8). Klinge and Hevlin summarized their observations. Hevlin referred to his memo of October 23. There are 13 drop structures in the channelized section of the river. There are culverts leading into the oxbows that were cut off when the river was dredged. The tour group thought that it would be desirable to install rotary screens at the drop structures in the Okanogan River to prevent smolts from going into the oxbows. On the other hand, perhaps fish do not now go into the oxbows. They need more information. There appears to be no problem of adult passage at the drop structures. Bruce Shepherd indicated they will no longer permit stop logs to be placed at the drop structures.

These might have been a problem for adults. On the last page of his memo he suggested three studies. Klinge said they have information on the first, for the second the P.U.D. is sending out an RFP, and on the third there needs to be more thought before it is clear what should be done.

5. Hatchery Evaluation. Klinge said the P.U.D. has received a draft for a proposed evaluation. The P.U.D. is interested in an evaluation. This draft was based on the Rock Island document. He feels that there is a need to meet with the subcommittee to discuss some of the items. He is not certain that technology is available to accomplish some of the things that are proposed. Woodin noted that the main intent of this draft is to develop an outline of subjects to be covered, and not necessarily how to do the things that are proposed. Ron Boyce thought that since there was a lot of discussion and thought that went into the Rock Island Agreement, it ought to be transferrable to Wells. Klinge said that neither he nor Mike Erho were involved in the Rock Island agreement, so some of the ideas are new to them. Klinge is particularly concerned about the genetic section and how we would go about measuring genetic effects. He noted that steps are being taken at the Methow Hatchery to prevent adverse genetic effects. If it is impossible to distinguish between wild and hatchery fish, why is this an issue? Woodin responded that the intent would be to obtain a baseline measurement with meristic counts and the like, and monitor over the years to see if changes occur. Klinge noted that there are still selective pressures on the genetic composition of the stocks. Evolution of the species can not be stopped. Interpretation of changes will be difficult or impossible. At any rate, the document is in the mill. He expects to hear from Bob Bugert of WDF in response to the P.U.D. review. Boyce asked that if there are any changes the document should come back to the full committee.

6. Cassimer Bar Sockeye Study. Klinge reported that the P.U.D., WDF, and the Colville Tribe have worked out an understanding. Adult sockeye are at the Methow Hatchery. Eggs are being taken. When they hatch, WDF plans to turn them over to the tribe for rearing at Cassimer Bar. Rod Woodin distributed a memo from Kathy Hopper listing requirements they feel need to be met before the transfer is made. Jerry Marco said that the requirements are reasonable, and they will be able to meet them. With respect to item 3 that calls for an alarm system, they have asked the P.U.D. to add an intrusion alarm which will tie in to their other facility. It will have a paging feature. They will have a trailer for personnel to get out of the weather at Cassimer Bar as spelled out in item 4. Item 6 calls for fish health inspection at two week intervals. They will make an effort to do this. They will check with the U.S.Fish and Wildlife Service. There was a concern expressed by WDW about the potential for transfer of fish disease at the Wells Hatchery and in the Okanogan River. Tony Eldred will inquire as to whether his agency is satisfied. Woodin noted that the sex ratio of adults that were taken is weighted toward females, as a result of which they have potential for more eggs than planned. They have taken 80,000 eggs. When the remaining fish mature, they expect to have 100,000. They need to decide what to do with the surplus. Klinge said they will have two - twenty foot diameter circular pools at Cassimer Bar. There is adequate water. The facility could accomodate that number of fish. Woodin noted that WDF will ask for a cross check of the requirements to be sure they are met before the fish are transferred. Klinge said he would see to it.

7. Summary of September 17, 1992 Meeting. The chairman pointed out that

although the committee had discussed at the September 17 meeting the matter of whether the adult passage study would serve the purpose of the delay and mortality study called for in the Wells Agreement, the committee had not actually reached an agreement as to the words that would be used to explain the situation. There is a need to move rapidly in order to prepare for the study in 1993. That is why the chairman drafted the wording in item 3 of the agreements reached in the September 17 meeting summary, and called attention to the item for special review by the committee. He had received suggested wording changes from Bill Hevlin and Rick Klinge. Klinge reported that Douglas P.U.D. now feels that it will be necessary to obtain FERC staff approval for this step. He had a draft of proposed wording that would substitute the adult passage study for the delay and mortality study called for in the Wells Settlement Agreement. There was a lengthy discussion of the matter. The committee worked together to develop wording for the agreement. A consensus was easily reached that there is currently no technology available that could be used for direct measurement of delay and mortality of adults in passage up the river. There was difficulty in arriving at appropriate wording for an agreement. There was a difference of opinion on whether steelhead and sockeye should be included in the statement. Klinge feels that a sockeye study is being completed. He sees no need to study passage for steelhead. They are notorious for their wandering and slow progress up the river. Woodin noted that there is no provision in the Settlement Agreement for compensation for delay or mortality of adult steelhead at Wells Dam. There is a provision for correcting any passage problem. No one was aware of a situation where modification of passage facilities or their operation was made specifically for steelhead. Woodin thought that if chinook can pass, steelhead certainly can pass. His feeling was that if the 1993 study shows no serious problem with passage, there would be no need for further study. Tony Eldred commented that Ken Williams and Larry Brown had indicated an interest in studying the rate of turnoff of steelhead into the Entiat, Methow, and Okanogan Rivers. It was observed that this is quite a different objective than the passage study. In the final analysis, it was concluded that, as provided for in the Settlement Agreement, the committee would need to make decisions on a year-to-year basis as to whether studies beyond 1993 will be needed.

The committee agreed to omit item 3 in the Agreements Reached section of the draft of the September 17, 1992 meeting summary. The committee also agreed that in the interest of expediting the process of FERC review, the chairman should distribute a draft of the meeting summary for this October 28 meeting early in the week of November 1, and provide a time for comments until November 6, 1992. This meeting summary will incorporate a statement on the adult passage study as agreed upon at the meeting. If no comments are received by November 6, it will be concluded that agreement has been reached.

8. Other

A. Trapping Protocol for Steelhead at Wells Dam. Klinge distributed a paper that provides the protocol for steelhead trapping at Wells Dam.

B. Draft RFPs for 1993 studies. Klinge reported that he is preparing some drafts for proposed studies in 1993.

C. Heinith said that the tribes intend to present some project proposals for sockeye studies in the near future. It was observed that the committee had previously asked for development of an overall plan that would set some goals and objectives and identify measures that would likely lead to success in reaching those goals and objectives. Heinith agreed to begin work on a draft of such a plan.

D. Next Meeting. The committee agreed to meet again at 9:00 A.M. December 1, 1992 at Sea-Tac.

ATTENDANCE ROSTER

Name	Representing
Bill Hevlin	National Marine Fisheries Service
Eddie Kudera	Biosonics, Inc.
Colleen Sullivan	Biosonics, Inc.
Rick Klinge	Douglas County P.U.D.
Tony Eldred	Washington Department of Wildlife
Jerry Marco	Colville Confederated Tribes
Tom Scribner	Yakima Indian Nation
Bob Heinith	Columbia River Intertribal Fish Commission
Lowell Stuehrenberg	National Marine Fisheries Service
Rod Woodin	Washington Department of Fisheries
Ron Boyce	Oregon Department of Fish and Wildlife
Cary Feldman	Power Purchasers
Richard Whitney	Coordinator

WELLS PROJECT COORDINATING COMMITTEE
MEETING DECEMBER 1, 1992
SUMMARY[1]

Agreements Reached

1. The committee agreed that the study of feasibility of enhancement of sockeye by release of juveniles reared at Cassimer Bar should be limited to the 70,000 eggs originally planned. Those should be transferred from the Methow Hatchery to Cassimer Bar as soon as possible. Excess eggs should be reared and released as swim up fry into Lake Osoyoos.

2. The committee agreed there is no need to proceed in 1993 with a study of juvenile mortality at Wells Dam.

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The meeting was held at the Radisson Hotel near Sea-Tac on December 1, 1992, in conjunction with the meeting of the mid-Columbia Coordinating Committee. Those in attendance are listed on the attached roster.

1. Bypass Evaluation. Klinge summarized the results of the hydroacoustic evaluation of bypass effectiveness. In spring 1992 there were some data points that were missed in the first two weeks, due to an error in setting the sensitivity of the sensors. With the help of John Skalski they used a statistical estimation technique to recover the lost information. There are three estimates that can be derived for bypass effectiveness during the 1992 spring outmigration. If they use only the time period for which a full set of data is available, the estimate is 86%. This is a very conservative estimate, they feel. The 89% estimate results if the data are not adjusted, while the estimate adjusted for missing data is 92%. The summer study showed bypass efficiency of 93.4%. He distributed a draft report and asked for comments. In particular, he asked the committee to give thought to which of the three procedures would give the best estimate. He called upon Colleen Sullivan to discuss the report. There were questions and answers regarding the missing data. In-turbine counts were the ones affected. She feels the estimates of bypass efficiency are conservative.

2. Progress Report on Radiotelemetry Study. Klinge called upon Stuehrenberg for a report. He noted that the due date for the final draft report is April, 1993, but he expects to have it by mid-February. Woodin asked whether there was any additoinal information on the missing tags - fish that were counted at Wells, but not afterwards. Lowell said that they believe the problem is with some of the tags. There was not a good seal around the antenna. Probably most of the failures occurred after the fish passed Wells Dam.

3. Okanogan Spawning Surveys. Jerry Marco reported that they are doing gravel sample analysis to provide information on the quality of spawning areas. Flows were 17-1900 cfs when they started and went down to 900 cfs. This decline may have led to dewatering of some redds. Klinge said that he

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[1] Prepared by R. Whitney

was there and saw no evidence of drying of redds, although the tribal technician thought there had been some in the side channels. Jerry noted that they had seen some rapid changes in temperature of 4 to 5 degrees in a couple of hours.

4. Hatchery Evaluation Plan. A draft proposal had been submitted to Douglas P.U.D.. They wrote comments and returned it to WDF. Woodin reported that WDF is still reviewing it. It will not be a "warmed over" Eastbank agreement. Ron Boyce requested that the draft be reviewed by the committee.

5. Cassimer Bar Rearing of Sockeye. Klinge reported that they are proceeding well. The plumbing is completed and the electrical work is almost completed. There will be a backup electrical system. The buildings are on site. WDF collected eggs three weeks ago. Adults were trapped at Wells Dam and held at the hatchery until ripe and then spawned. The eggs are at the Methow Hatchery. Water temperatures are low and he expects a one month delay relative to potential hatching time at Cassimer Bar. This may result in failure to get the fish to the target size of 25 per pound. Jerry Marco thought there might be as much as a two month delay if the eggs are hatched and reared at the Methow Hatchery. If they were moved to Cassimer as soon as they are eyed, then they would hatch in March. Otherwise it would be April. Woodin noted that the original plan had been to take 70,000 eggs. They assumed a 1:1 sex ratio in fish taken from the trap, but it turned out they had a high percentage of females. As a result they have 120,000 eggs. They need to decide what to do with the extra eggs. He proposed staying with the objective and limiting the eggs used in the experiment to the 70,000 that were planned. The remainder of the production might be put in Lake Osoyoos as swim up fry. An alternative might be to raise them at Cassimer Bar. That would mean crowding them and compromising the objective of the study. There was a discussion of IHN. Woodin noted that there has been no sign of IHN at Lake Wenatchee. They go through an elaborate protocol to eliminate possibility of transfer of IHN from females to the eggs. Tony Eldred said that WDW would like to have fish health checks every two weeks and let them know within two days if any problem appears.

The committee decided to transfer the 70,000 eggs to Cassimer Bar as soon as possible. The 50,000 remainder will be retained at the Methow Hatchery for later release as fry into Lake Osoyoos.

Site Evaluation for Net Pens. Klinge called upon Jack Rensel, who is conducting a site evaluation. Rensel reported that he is collecting information necessary to obtain permits. They have selected a couple of possible locations in the lower part of Lake Osoyoos. Water velocity is a primary concern. They will model the effects of the net pen on lake chemistry. They will use a sediment model and a water column model. They have done these kinds of analyses on 11 or 12 projects similar to this one. They expect the effects to be negligible. As for biological data, he has found that the Canadians have some data. They will look at oxygen in the basin. There could be a problem with periphyton growth on the nets. But experience indicates it collects on the net strands and tends to leave an opening for water circulation between the meshes. He feels the problem can be overcome one way or another. Klinge said they are working on the permits, but are not sure how long the process will take. Rensel said that it went fast at Rufus Woods.

6. RFP's for 1993 Studies. Klinge said that RFP's are being developed.

Only one of these requires early attention by the committee. That is the proposed study of juvenile mortality at Wells Dam. It had been suggested that we ask Skalski to design a study and determine necessary sample sizes. He indicated that unless others are pushing for it, Douglas P.U.D. is in no hurry to proceed. Woodin said he would like to review the RFP and discuss it at the next meeting. There may be good justification for delaying or even deciding not to conduct the study at all. The sample sizes needed and the reliability of the estimate obtained may not justify the expense. The committee agreed there is no need to conduct a study of juvenile mortality at Wells Dam in 1993.

Heinith said he is developing a draft of an overall enhancement plan, as suggested at the last meeting.

Klinge said he has 4 other RFP's. He asked for guidance from the committee on those.

7. Other.

Next Meeting. The committee agreed to meet again on January 15, 1993, in conjunction with the meeting of the mid-Columbia Coordinating Committee.

Wilderness League. Klinge had distributed copies of correspondence addressed to the Washington Department of Fisheries from the Wilderness League. While the chair noted that it was well for the committee to be aware of the correspondence and the issues raised, the response needed to come from WDF. He could see no role for the committee in this matter, so the discussion was abbreviated.

ATTENDANCE ROSTER
WELLS PROJECT COORDINATING COMMITTEE
Meeting December 1, 1992

Name	Representing
Bill Hevlin	National Marine Fisheries Service
Rick Klinge	Douglas county P.U.D.
Cary Feldman	Power Purchasers
Tony Eldred	Washington Department of Wildlife
Lowell Stuehrenberg	National Marine Fisheries Service
Jerry Marco	Colville Tribes
Bob Heinith	Columbia River Intertribal Fish Commission
Ron Boyce	Oregon Department of Fish and Wildlife
Rod Woodin	Washington Department of Fisheries
Dennis Rohr	mid-Columbia P.U.D.'s
Richard Whitney	The Committee

1992 MEMBERSHIP LIST
OF THE
WELLS COORDINATING COMMITTEE

APPENDIX - I

APPENDIX

1992 MEMBERSHIP LIST

OF

WELLS COORDINATING COMMITTEE

Mr. Ron Boyce
Oregon Department of Fish and Wildlife

Mr. Tony Eldred
Washington Department of Wildlife

Mr. Cary Feldmann
Puget Power Company

Mr. Bob Heinith
Columbia River Inter-Tribal Fisheries Commission

Mr. Bill Hevlin
National Marine Fisheries Service

Mr. Rick Klinge
Public Utility District No. 1 of Douglas County

Mr. Jerry Marco
Colville Confederated Tribes

Mr. Craig Tuss
U. S. Fish and Wildlife Service

Mr. Tom Scribner
Yakima Indian Nation

Dr. Richard R. Whitney
Wells Coordinating Committee Chairman

Mr. Rod Woodin
Washington Department of Fisheries

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. <u>RESOLUTION OF DISPUTES</u>

1. Any dispute between the Parties concerning compliance with this Agreement shall be referred for consideration to the Wells Project Coordinating Committee (the Coordinating Committee) established under Section V. The Coordinating Committee shall convene as soon as practicable following issuance of a written request by any Party. All decisions of the Coordinating Committee must be unanimous. In the event the Coordinating Committee cannot resolve the dispute within fifteen (15) days after its first meeting on a dispute, it will give notice of its failure to resolve the dispute to all Parties. Thereafter, if the dispute qualifies

under subsection I.D.2, any Party may request the FERC to refer the dispute to (1) the presiding judge in the Mid-Columbia proceeding; or (2) in the event the Mid-Columbia proceeding is terminated, to the Chief Administrative Law Judge of the Commission; or (3) to the Division of Project Compliance and Administration within the Office of Hydropower Licensing, or its successor (any one of which is hereinafter referred to as the Decisionmaker), in the order listed herein (unless otherwise agreed by the Parties or directed by FERC), for expedited review in accordance with the procedures set forth in this subsection. Any issue in dispute that is not subject to the expedited review process may be referred to the FERC for resolution pursuant to the FERC's Rules of Practice and Procedure.

2. The expedited review process specified in this subsection shall be utilized, unless otherwise agreed pursuant to subsection I.D.5, to resolve any issue(s) in dispute between the Parties that arises under this Agreement where the amount in controversy is less than $325,000 (1988 dollars). For the purpose of this subsection I.D, the amount in controversy shall be determined by calculating the difference between the calculated annual cost of the Joint Fishery Parties' proposal for resolution of the dispute and the calculated annual cost of the PUD's proposal for resolution of the dispute.

3. Under the expedited review process, each Party that desires to present an initial position statement to the Decisionmaker shall file the statement with the Decisionmaker and all other Parties within twenty (20) days of mailing of notice by a

Party that expedited review is requested. Responsive statements shall be filed and served within forty (40) days of the mailing of the notice. The Decisionmaker shall set a date for submission of any briefing, affidavits or other written evidence and a further date for hearing of oral evidence and argument. Except by agreement of all Parties involved in the dispute, the hearing shall be held not later than seventy (70) days after the date of mailing of the requesting Party's notice or as soon thereafter as the Decisionmaker shall be available. The hearing shall be held in Seattle, Portland or any other location agreed upon by the Parties, or mandated, upon a finding of special circumstances, by the Decisionmaker. The Decisionmaker shall decide all matters presented within fifteen (15) days of the hearing or as soon thereafter as possible.

4. All decisions under the expedited review process shall be effective upon issuance and pending appeal, if any. Nothing in this subsection I.D shall limit or restrict the right of any Party to petition the FERC for <u>de novo</u> review of any decision under the expedited review process. All such appeals shall be in accordance with the FERC's Rules of Practice and Procedure.

5. The Parties may agree to refer any issue subject to expedited review to a third party Decisionmaker other than someone within FERC for processing pursuant to this subsection or as otherwise agreed by the Parties.

E. EFFECTIVE DATES

1. Except as otherwise specified in this subsection I.E, this Agreement shall become effective upon the issuance of a final order by the FERC approving this Agreement.

2. Notwithstanding subsection I.E.1 above, the Parties will immediately upon execution of this Agreement, implement the provisions of the Agreement that do not require formal FERC approval.

3. The Parties agree to immediately seek interim approval by the FERC of Section IV of this Agreement in order to implement construction of hatchery facilities.

II. JUVENILE FISH PASSAGE

A. GENERAL SCOPE OF JUVENILE PASSAGE MEASURES

1. Subject to the schedules, criteria, and conditions in this Agreement, the PUD will fund the installation, operation, maintenance, and evaluation of juvenile fish bypass systems and measures at the Wells Project. Bypass systems and measures are those intended to attract and route juvenile salmonids past operating powerhouse generating units.

2. All facilities under this Agreement shall be designed and constructed using quality materials and then current engineering standards for the purpose of obtaining a high quality product designed to require low maintenance and have a long useful life.

B. BYPASS SYSTEM

The PUD will continue to implement a program of controlled spill using five (5) bypass baffles at the Wells Project to meet the criteria set out in subsections II.C, D, and E.

C. NORMAL BYPASS OPERATIONS CRITERIA

1. No turbine will be operated during the juvenile migration period unless the adjacent bypass system is operating according to the following criteria.

2. The five (5) bypass system bays will be Nos. 2, 4, 6, 8, and 10. Operation of the turbines will be in pairs with the associated bypass system bays, as follows:

Turbines Operated	Bypass Bays Operated
1 and/or 2	2
3 and/or 4	4
5 and/or 6	6
7 and/or 8	8
9 and/or 10	10

(For example, if turbines 1, 5, and 6 are operating, bypass systems 2 and 6 will be operating.)

3. At least one bypass will be operating continuously throughout the juvenile migration period, even if no turbines are operating.

4. The bypass systems and spillgates will be operated in configuration K of the 1987 bypass system report (bottom spill, 1 foot spill gate opening, 2,200 cfs, vertical baffle opening) for all bypass system bays.

5. If top spill is shown to be as effective as bottom spill in bypass bays 2 and 10, then top spill will be allowed in these bays.

6. If the Chief Joseph Dam Uncoordinated Discharge Estimate is 140,000 cubic feet per second (140 Kcfs) or greater for the following day, all five bypass systems will be operated continuously for 24 hours regardless of turbine unit operation.

7. If the Chief Jcseph Dam Uncoordinated Discharge Estimate is less than 140 Kcfs, bypass system operation will be as follows:

Number Turbines Operating	Minimum Number Bypass Systems Operating
10	5
9	5
8	4
7	4
6	3
5	3
4	2
3	2
2	1
1	1
0	1

D. BYPASS OPERATIONS TIMING CRITERIA

1. Bypass systems will be in place at least two (2) weeks prior to preseason forecasted beginning of juvenile migration.

2. Bypass systems will remain in place for at least two (2) weeks after the juvenile migration period ends.

3. Monitoring of fish runs will begin when bypass baffles are in place and will end when the baffles are removed.

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

E. BYPASS PERFORMANCE CRITERIA

1. At a minimum, bypass system operations will be provided as described in subsections II.B, C, and D for the entire juvenile migration period as defined in the annual operations plan under subsection II.F, and subject to the provisions of subsection II.F.3.

2. Bypass operations as described in subsections II.B, C, and D are intended to provide fish passage efficiency (FPE) of at least eighty percent (80%) for the juvenile spring migration, and FPE of at least seventy percent (70%) for the juvenile summer migration. For purposes of this Agreement, FPE is expressed by the following formula:

Where A = Sum of daily migrants successfully passed by the device during the spring or summer migration

and B = Sum of daily migrants passing through the turbine unit intakes during the same migration

$$FPE = \frac{A}{A + B} \times 100$$

3. If bypass operations under subsections II.B, C, and D do not meet the minimum FPE levels specified in subsection II.E.2, the PUD will modify those operations by implementing one or more of the following measures:

(a) Change in configuration or addition of lights or other physical changes.

(b) Change in "normal operation" under subsection II.C to operation of five bypass system bays at forecast flow of 120 Kcfs.

4. Unless and until these modifications are in place to meet the minimum FPE levels specified in subsection II.E.2, or if these modifications are not sufficient to meet the FPE levels specified therein, then the PUD will increase spillbay bypass flow up to two times normal operation (up to a total of 4.4 Kcfs) per bypass at night (1 hour before sunset to sunrise) for the period:

(a) During which 80% of the spring migration pass the Wells Project;

(b) During which 80% of the summer migration pass the Wells Project, or for 40 days, whichever is less.

5. If portions of the runs do not receive protection at the minimum FPE levels specified under subsection II.E.2, then compensation will be provided based on the difference between the minimum FPE levels specified in subsections II.E.2 and 3 and the actual FPE achieved during the evaluation provided under subsections II.H.1 and 2. The appropriate level of compensation will be calculated based on actual loss. The form of this additional compensation (i.e., fish production) will be determined by the Joint Fishery Parties in consultation with the PUD.

F. ANNUAL OPERATIONS PLANS

1. The PUD will develop an annual bypass systems operations plan consistent with the criteria in subsections II.B, C, D, and E in consultation with the Joint Fishery Parties by the December prior to each migration period. The plan will be reviewed and approved by the Coordinating Committee by March 1 of each year. The plan will be developed from inseason projected hatchery release

dates from facilities above Wells and previous passage monitoring data. The plan will contain predicted dates for the beginning and end of the juvenile migration period; criteria for identifying the beginning and end of the spring and summer runs; and procedures for bypass operations within the constraints of subsections II.B, C, D, and E, including dates for installation and removal of spill baffles, dates for run time monitoring, and criteria for initiation and cessation of bypass operations. If unanimous agreement cannot be reached within the Coordinating Committee regarding all items in the plan, disagreements will be resolved by expedited dispute resolution under subsection I.D.

2. A Bypass Team will be established composed of one representative each for the Party fishery agencies, the Party tribes, and the PUD.

3. Notwithstanding the provisions of subsections II.F.1 and 2 above, the Bypass Team may agree to relax the operations and performance criteria of subsections II.C and E for a period between the end of the juvenile spring migration and the beginning of the juvenile summer migration. Such a modification can only be made with the agreement of all of the members of the Bypass Team, and will be limited to one or more of the following measures:

(a) Less than continuous 24-hour operation of bypass systems.

(b) Fewer than one bypass system operated for two adjacent turbines operated.

(c) Less than 1 foot spill gate slot opening.

4. Once the annual bypass plan is adopted, decisions regarding adjustments to the plan will be made by unanimous agreement of the Bypass Team. If unanimous agreement cannot be reached, the decision on such adjustments will be by majority vote of the Bypass Team.

G. ANNUAL PASSAGE MONITORING PLAN

1. The PUD shall develop an Annual Passage Monitoring Plan, in consultation with the Joint Fishery Parties for review and approval by the Coordinating Committee by March 1 of each year. The Plan will include development of inseason indices of relative fish abundance on a daily basis and annual estimates of juvenile migrant production. Estimates of relative abundance will be used to guide bypass operations decisions under subsections II.E.4, II.F.1, II.F.3, and II.F.4. Estimates of juvenile migrant production will be used as the basis for compensation adjustments (Hatchery-Based Compensation - Phase IV) as provided in subsection IV.A.3.

H. FPE EVALUATION PLAN

1. The PUD shall develop an FPE evaluation plan, in consultation with the Joint Fishery Parties, for review and approval by the Coordinating Committee by March 1, 1990. The purpose of the plan shall be to evaluate whether minimum FPE levels set out in subsection II.E are being met. The plan will provide for evaluation beginning in 1990 and continuing for at least three consecutive years after baffles are installed and operating in accordance with this Agreement in all five (5) bypass bays. If physical or

operational changes are made to the bypass systems, additional FPE evaluation under a new or amended plan will be required to provide at least three consecutive years of evaluation after completion of the changes.

2. It is the goal of evaluations under the plan to be able to determine FPE within plus or minus five percent (5%) at the ninety-five percent (95%) confidence level. If the FPE point estimates are equal to or greater than eighty-five percent (85%) for the spring run and seventy five percent (75%) for the summer run, then the accuracy of plus or minus ten percent (10%) at the ninety percent (90%) confidence level is acceptable. If the FPE point estimate for the spring run is between eighty (80) and eighty-five (85) percent, or the FPE point estimate for the summer run is between seventy (70) and seventy-five (75) percent, the PUD will implement one of the following actions:

(a) Take the necessary steps to achieve a FPE accuracy of plus or minus five percent (5%) at the ninety-five percent (95%) confidence level, or

(b) Take steps outlined in subsection II.E.3 to increase the FPE point estimates to eighty-five percent (85%) and seventy-five percent (75%) for the spring and summer runs, respectively.

3. The PUD will fund a biometrician or statistician selected by unanimous agreement of the Coordinating Committee to review the draft plan to ensure that the plan meets the objectives of subsections II.H.1 and 2, and to review results developed under the plan.

III. ADULT FISH PASSAGE

A. GENERAL SCOPE OF ADULT PASSAGE MEASURES

The current operating and maintenance criteria for facilities for the passage of adult anadromous fish over the Wells Project Dam are specified in this Section III. Changes in these criteria must be by unanimous agreement of the Coordinating Committee.

B. WATER DEPTH CRITERIA

The water depth over the weirs of the adult fish ladder will be 1.0 to 1.2 feet.

C. ENTRANCE CRITERIA

1. Head: 1.5 feet

2. Gate Settings:

a) March 1 - November 30

	Side Wing Gate	End Wing Gate
(i) Spill less than 80 Kcfs	4 ft	6 ft
(ii) Spill greater than 80 Kcfs	Closed	8 ft

(iii) Low level fixed orifice entrance to be open whenever side gate is closed.

b) December 1 - February 28

(i) Side and end gates open 2 feet six days per week for 24-hour periods.

(ii) Side and end gates open 4 feet and 6 feet, respectively, one day per week for a 24-hour period.

D. ATTRACTION JET CRITERIA

1. Jets are located in a vertical line immediately upstream of the side wing gates.

2. Lower jet (30-inch diameter) will operate only when the low level fixed orifice entrance is open.

3. Three 24-inch diameter jets (at elevations 700, 708, and 717 msl) will each be discharging when tailwater reaches that level.

E. STAFF GAUGE AND WATER LEVEL INDICATOR CRITERIA

Staff gauge and water level indicators will:

1. Be located upstream and downstream of all entrances, and at convenient locations for viewing along ladder.

2. Be located upstream and downstream of adult fishway exit trashrack.

3. Be readable at all water levels and be kept clean.

4. Be checked against panel board water surface readings to insure proper adjustment of water level sensing equipment.

F. TRASHRACK CRITERIA

1. Visible buildups of debris will be cleaned immediately from picketed leads near counting stations, and from trashracks at adult fishway exits.

2. The staff gauges upstream and downstream of the adult fishway exit trashrack will be monitored for water surface differential, which will reflect buildup on submerged trashrack. The trashrack will be cleaned immediately if the differential reading is greater than 0.3 feet.

G. MONITORING AND EVALUATION OF ADULT PASSAGE

1. In 1990, the PUD, in consultation with the Joint Fishery Parties, will develop a study plan to determine the extent of adult

delay and mortality at the Wells Project. The study plan will be reviewed and approved in advance by the Coordinating Committee. Studies will begin in 1991 and continue for a period of time determined by the Coordinating Committee based on preliminary results.

2. If the study identifies delays and/or mortality, the operating criteria specified in this Section III will be changed to alleviate these problems. If changes in the operating criteria do not alleviate the problems, adult passage facility modifications will be made. Provided, however, that any disagreements over the appropriateness of facility modifications of $325,000 or less (1988 dollars) may be taken through the expedited dispute resolution procedure in subsection I.D. And, provided further, that any disagreements over the appropriateness of facility modifications of more than $325,000 (1988 dollars) may be resolved under the FERC Rules of Practice and Procedure at any time.

IV. HATCHERY-BASED COMPENSATION

The PUD will fund a hatchery-based compensation program (the "Program") as provided in this Section IV. The Program will include the design, construction, operation, maintenance and evaluation of facilities required to implement the elements of a production plan (the "Production Plan") as set forth in this Section. The purpose of the Program is to mitigate for fish passage losses at Wells Dam. The Program is composed of adult collection sites; a central hatchery facility for incubation, early rearing, and adult holding; and acclimation facilities in the tributaries above Wells Dam for final rearing and release.

A. PRODUCTION PLAN

1. The Joint Fishery Parties have developed the Production Plan to define the requirements of hatchery-based compensation under this Agreement. The Production Plan describes juvenile rearing and release requirements, including species mix and target release sizes; and related broodstock requirements under subsection IV.D.

2. The Production Plan will be reviewed annually by the Joint Fishery Parties, and may be modified by the Joint Fishery Parties in consultation with the PUD. Modifications to the Production Plan may include changes to the species mix and rearing and release strategies as required to accommodate the Joint Fishery Parties' management needs. Modifications to the Production Plan will not require an increase in the rearing capability of the Program beyond that required to satisfy Phases One and Two of the Production Plan as shown in subsections IV.A.3(a) and (b) or Phases Three and Four of the Production Plan to be determined as shown in sections IV.A.3(c) and (d). The Production Plan and any modifications thereto will be consistent with guidelines and procedures developed under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program.

3. The Production Plan is comprised of four phases of hatchery-based compensation as described below. It also includes related broodstock requirements under subsection IV.D.

(a) Phase One

Phase One will begin in 1991 and will consist of the following compensation elements:

(1) 49,200 pounds of spring chinook yearlings at about 15/pound;

(2) 8,000 pounds of sockeye juveniles at about 25/pound; and

(3) 30,000 pounds of steelhead smolts at about 6/pound

(4) After 1991, space to rear additional steelhead will be provided by the PUD at Wells Hatchery, if such space is available and not needed to meet other PUD fish production responsibilities. The PUD will not be obligated to fund or supply well water to rear the fish.

(b) Phase Two

Phase Two will begin after evaluation of the Phase One Production Plan and will be restricted to the Program required by either the Phase Two A or Two B Production Plan as shown below. At the time of implementation, the Phase Two A or Phase Two B Production Plan may be modified based on other Phase One evaluations described in subsection IV.C, Studies and Evaluations, subject to the provisions of subsection IV.A.2.

(1) Phase Two A

Increase sockeye production from 8,000 pounds to 15,000 pounds of juveniles at about 25/pound.

(2) Phase Two B

(i) Eliminate sockeye production;

(ii) Add 15,000 pounds of summer chinook yearlings at about 10/pound; and 6,500 pounds of zero-age summer chinook juveniles at about 40/pound.

(c) Phase Three

Phase Three will begin as soon as practicable following Coordinating Committee approval of the results of the Wells Project juvenile mortality/survival study or no later than the third brood year after Coordinating Committee determination of the adjustments required and will consist of the following compensation elements:

(1) Except for steelhead, which shall remain at 30,000 pounds, adjust compensation requirement to reflect the difference between the juvenile mortality rate determined by the mortality/survival study under subsection IV.C.5 and the assumed mortality rate shown in Appendix A; and

(2) Adjust compensation requirement to reflect unavoidable and unmitigated adult losses, as determined by Coordinating Committee approved estimates from studies conducted under subsection III.G, and converted to juvenile production based on adult to smolt ratio estimates as described in Appendix B.

(d) Phase Four

Phase Four will begin at such time as the Coordinating Committee approved five-year rolling average estimate of juvenile run size, estimated as described in subsection IV.C.6 and Appendix A, increases to at least 110% of the 9,034,700 estimated juvenile migrant salmon production used to establish the Phase One and Phase Two compensation levels shown in subsections IV.A.3(a) and

IV.A.3(b). Phase Four will consist of compensation adjustment, if requested by the Joint Fishery Parties, to reflect the percentage increase in juvenile run size, except for steelhead, which shall remain at 30,000 pounds. The Joint Fishery Parties, in consultation with the PUD, will determine the appropriate form of compensation (i.e., fish production) for any adjustments required in Phase Four.

B. COMPENSATION PROGRAM

1. The facilities provided in the Program will be designed, constructed, operated, maintained, and evaluated to produce the hatchery-based compensation set forth in the Production Plan.

2. If the evaluations described in subsection IV.C indicate that the Program is not meeting the production levels called for in the Production Plan, then reasonable modifications to the Program will be made.

3. The PUD will only be obligated to assure the capability of facilities provided under this Agreement to produce high quality juvenile fish at the compensation levels shown in subsection IV.A.3.

4. The Program facilities described in this Agreement are in addition to the existing mitigation program at Wells. The existing mitigation program at Wells consists of annual production of 50,000 pounds of steelhead and 56,500 pounds of summer chinook salmon. Under the 1984 Mid-Columbia Stipulation, which expired in 1989, 400,000 summer chinook at 90/pound have been reared at Wells for release into the Methow River. This production will continue until

Phase One production is initiated. Nothing in this Agreement will affect the annual production of 25,000 pounds of steelhead under the Oroville-Tonasket agreement between the PUD and the U.S. Bureau of Reclamation.

5. Facilities provided in the Program will consist of:

(a) Phase One

Phase One compensation facilities, including satellite facilities, shall be capable of rearing and releasing 57,200 pounds of salmon and 30,000 pounds of steelhead annually.

(b) Phase Two

Phase Two compensation facilities shall be capable of increased production to accommodate the Production Plan as described in subsection IV.A.3(b).

(c) Phase Three

Phase Three compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(c).

(d) Phase Four

Phase Four compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(d). Facilities for the required adjustments will be constructed by the PUD as soon as practicable and be operational no later than the third brood year following the Joint Fishery Parties request under subsection IV.A.3(d).

6. Production and acclimation facilities used in the Program shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The biological criteria and guidelines described in subsection IV.D shall apply to production and acclimation facilities used in the Program.

C. STUDIES AND EVALUATIONS

1. The PUD will develop and fund studies in 1990, approved by unanimous agreement of the Coordinating Committee, to determine:

(a) Potential for spawning and rearing sockeye in unutilized habitat in the Okanogan and Similkameen systems;

(b) Potential for establishing sockeye populations in the new habitat.

2. The PUD will fund the Joint Fishery Parties' effort to determine the success of Phase One sockeye compensation based on review of smolt production. The Joint Fishery Parties may make this determination after the evaluation of the third brood year's production.

3. The PUD will fund the Joint Fishery Parties to develop and conduct studies to evaluate the adequacy of the Program and the effectiveness and success of the Production Plan subject to the provisions of Section V, Coordinating Committee. The studies will meet standards developed for similar efforts under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program. The studies will pass the test of reasonableness with respect to cost and duration.

(a) The studies will involve marking a portion of the juvenile fish produced under subsection IV.B and will involve recoveries of juvenile and adult fish to estimate various parameters such as fish health, fishery contribution, survival, spawning time and spawning locations.

(b) The PUD will fund recovery efforts at Wells Dam and hatchery and tributary spawning areas above Wells Dam. Existing recovery operations, currently funded through different sources, will be utilized to the extent possible. Approved studies may require the PUD's participation in funding a portion of other recovery efforts.

(c) The evaluations provide data necessary to determine the success of the Program to produce the intended compensation levels and the effectiveness of the Production Plan to meet management objectives.

(d) Evaluation of the Production Plan and Program effectiveness will be initiated in Phase One for all species in the Production Plan.

(e) To the extent that the Joint Fishery Parties elect to modify the Production Plan, the PUD will fund studies to evaluate the modifications. The studies will be mutually agreeable and are intended to evaluate only the changes called for in the modification. The studies will be consistent with the provisions of Section V, <u>Coordinating Committee</u>.

(f) The PUD will fund an analysis of annual fish production and adult contribution to harvest and escapement to be conducted by the Joint Fishery Parties. The analysis will be consistent with the provisions of Section V, Coordinating Committee. Draft and final reports will be provided to the Parties.

5. No later than 1990, a Wells Project juvenile mortality/survival study will be developed by the PUD in consultation with the Joint Fishery Parties and approved by unanimous agreement of the Coordinating Committee. The studies will begin in 1991, after the installation of new turbine runners at the Wells Project, for the purpose of determining juvenile losses.

6. The PUD will provide data from its ongoing, annual adult passage monitoring program that will allow the Joint Fishery Parties to compute the five-year rolling average estimate of juvenile run size which will be the basis for Phase Four compensation, as indicated in subsection IV.A.3(d). Calculation of increases in juvenile run size will be based on fish from existing mitigation programs, natural production and future compensation programs. The method of calculation will be as described in Appendices A and B.

D. PRODUCTION/ACCLIMATION FACILITIES

Production and acclimation facilities under this Section shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The following biological criteria and guidelines shall apply to production and acclimation facilities under this subsection IV.D. Criteria are not to be exceeded. Guidelines are not to be exceeded if practicable.

1. Salmon Criteria

   (a) Adult Holding

      (i) Density not to exceed one (1) fish per ten (10) cubic feet of space.

      (ii) Flow must be at least one (1) gallon per minute per 20 pounds of fish.

   (b) Juvenile Rearing

      (i) Density not to exceed 0.75 pounds of fish per cubic foot of rearing space for yearling chinook to a size of 10 fish per pound. Maximum density is achieved at release date. The density through out the rearing period is proportionately lower and directly related to fish size.

      (ii) Pond or raceway loading rate not to exceed 6.0 pounds of fish per gallon of water per minute inflow for yearling chinook at a size of 10 fish per pound. Maximum loading rate is achieved at release date. The loading rate throughout the rearing period is proportionately lower and directly related to fish size.

      (iii) Density for sockeye juveniles in net pens not to exceed 0.33 pounds of fish per cubic foot of rearing space.

(c) Water Supply

(i) Water will be of highest quality practicably available at appropriate sites. Ground water may be required at sites. All water supplies will be pathogen free if practicable. The water source must not preclude transfer of the stocks being reared to their point of origin due to presence of fish disease organisms in the rearing water supply.

(ii) Reuse of water is not acceptable for either egg incubation or juvenile rearing.

(iii) Reuse water is acceptable for adult holding.

(iv) Effluent water from egg incubation may require treatment for fish diseases (e.g., chlorination/dechlorination).

(v) Construction of facilities must accommodate the potential to treat the juvenile rearing and adult holding water for disease pathogens.

(d) General

(i) Facilities must have the capability to maintain stock segregation from adult holding through incubation and rearing.

(ii) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(iii) Protection from mammalian and avian predators must be provided.

2. Salmon Guidelines

(a) Water Temperatures

(i) Egg incubation - no greater than 55°F nor less than 38°F.

(ii) Fry starting - 48-52°F.

(iii) Juvenile rearing - not to exceed 52°F.

(iv) Adult holding - not to exceed 55°F.

(b) Release Size, Time, and Location

(i) Yearling spring chinook - 15 fish/pound in late April.

(ii) Yearling summer chinook - 10 fish/pound in late April.

(iii) Subyearling summer chinook - 40 fish/pound in June.

(iv) Subyearling sockeye - 25 fish/pound in June.

(v) Juvenile fish will be acclimated and released in tributaries above Wells Dam.

(c) Adult Brood Stock

(i) Sufficient adults of the appropriate species and stocks will be trapped and held to meet the egg requirements for each phase of salmon production.

(ii) Fifty percent (50%) of the adults trapped will be females and it is assumed there will be approximately eighty percent (80%) survival of eggs from trapping of females to ponding of fry.

(iii) Adult brood stock will be collected at the following sites:

a) Spring chinook - Chewack River, Methow River above Winthrop, and Twisp River above river mile 2.0.

b) Summer chinook and sockeye - at Wells Dam

(iv) Tributary brood stock collection facilities will require an annually installed rack and a semi-permanent box trap.

(v) Wells Dam brood stock collection may require a separator/sorter in the left bank fishway. The final design of the left bank trap and any modification of the right bank trap will be approved by unanimous agreement of the Coordinating Committee.

(vi) The adults will be transferred in a water-to-water system from traps to tank trucks to holding ponds.

(vii) The PUD shall provide funds for personnel to separate and sort adult fish in the right bank fishway at Wells Dam and at other required adult collection sites. All brood stock collection shall be conducted in a manner to minimize delay of non-target species and individual fish.

3. Steelhead Criteria

The goal for this program is to use the existing facilities including well and river water, raceways, rearing ponds, house, shop, freezer, office, etc., in the manner they are being used now. Most of the following criteria and guidelines fit the existing program.

(a) Adult Holding

(i) Density not to exceed 2.5 pounds of fish per cubic foot of water.

(ii) Flow must be at least one gallon per minute for 3.3 pounds of fish.

(b) Juvenile Rearing

(i) Density: Calculated density limit not to exceed Pipers density formula: W= D x V x L where

W = Permissible weight in pounds.

D = Density index (.25 for raceways and .03 for rearing ponds).

V = Useable volume in container in cubic feet.

L = Fish length in inches.

ii) Water flow: Calculated flow should not allow weight to exceed Pipers flow formula: W= F x L x I where

W = Permissible weight in pounds.

F = The loading factor from Table 1.

L = Fish length in inches.

I = Water flow in gallons per minute.

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

15,000 lbs. of Summer Chinook @ 10/lb.

6,500 lbs. of Summer Chinook at 40/lb.

obligations of Douglas PUD as set forth in this Agreement, and Chelan County PUD under terms of the Rock Island Settlement. In consideration of biological efficiency and logistical effectiveness, the parties have agreed to adjusted compensation obligations under this agreement and the Rock Island Settlement in the following manner:

a. Douglas PUD will assume responsibility for 19,200 pounds of Methow River sub-basin spring chinook production.

b. Chelan PUD will assume responsibility for 40,000 pounds of Methow River summer chinook production.

The resulting changes in production with the Douglas-Chelan compensation exchange agreement are (number of juveniles/year):

	Douglas Production	Chelan Production
Spring Chinook	Increases 288,000	Decreases 288,000
Summer Chinook	Decreases 400,000	Increases 400,000
Sockeye	No Effect	No Effect

c. The resultant Douglas PUD annual compensation program under this agreement (Phase II Production) is:

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.

APPENDIX B

DETERMINATION OF RESPONSIBILITY FOR HATCHERY COMPENSATION

For each year of determination, calculate an average smolt output as follows:

1. Calculate a 5-year running average adult run (by species) for naturally spawned fish (Ays) as follows:

$$\bar{A}ys = \frac{Ay + Ay-1 + Ay-2 + Ay-3 + Ay-4}{5}$$

Where Ay is the total adult count for each species at Wells minus the hatchery escapement for the species in year y; Ay-1 = the same in the previous year (y-1) and so on.

2. Multiply Ays by the average expected adult to smolt production factor Kys for each species, where Kys is calculated as follows:

a. Spring Chinook:

Ksp = 0.94 (Wells Dam to spawner survival) x 0.50 (sex ratio) x 5000 (eggs/female) x 0.10 (av. survival to smolt) = 235

b. Summer Chinook:

Ksu = 0.94 x 0.50 x 5000 x 0.30 = 705

c. Sockeye:

$$Kso = 0.94 \times 0.50 \times 2700 \times 0.12 = 152$$

3. Add the number of hatchery smolts HSys by species, which is a running average of the same 5 years as in Ays.

$$\overline{HSys} = \frac{HSy + HSy\text{-}1 + HSy\text{-}2 + HSy\text{-}3 + HSy\text{-}4}{5}$$

4. Total smolts (by species):

$$\overline{S}ys = Kys \times \overline{A}ys + \overline{HS}ys$$

5. Grand Total = Sum of all species:

$$Sgt = \overline{S}sp + \overline{S}su + \overline{S}so + \overline{.}..$$

6. If other salmon species or races, for which the above smolt production factors (Kys) do not apply, become established in the production areas above Wells Dam, appropriate K factors for these fish will be established by consensus of the Coordinating Committee. Juvenile migrant production will be computed for these species or races. These numbers will be included in the grand total for juvenile migrant production and the 5-year running averages.

WELLS PHASE IV THEORETICAL CALCULATION EXAMPLE

NATURAL PRODUCTION

DATA USED IN EXAMPLE CALCULATION OF NATURAL PRODUCTION

Adult Count	Ay	Ay-1	Ay-2	Ay-3	Ay-4	5 Year Average
Spring Chinook	3,000	2,200	3,100	5,000	2,900	3,240
Summer Chinook	2,400	2,800	3,700	4,000	4,700	3,520
Sockeye	40,000	20,000	35,000	15,000	30,000	28,000

Ay = Wells Count Minus Hatchery Escapement for Year Y

Ksp = Calculated Spring Chinook Smolts

Ksu = Calculated Summer Chinook Smolts

Ksoe = Calculated Sockeye Smolts

Spring Chinook $\bar{A}y$

$$= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

$$= \frac{3000 + 2200 + 3100 + 5000 + 2900}{5}$$

$$= 3240$$

Summer Chinook $\bar{A}y$

$$= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

$$= \frac{2400 + 2800 + 3700 + 4000 + 4700}{5}$$

$$= 3520$$

Sockeye $\bar{A}y$

$$= \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}5}{5}$$

$$= \frac{40{,}000 + 20{,}000 + 35{,}000 + 15{,}000 + 30{,}000}{5}$$

$$= 28{,}000$$

Ksp, su, soc = Adult/redd factor x sex ratio x eggs/female x eggs to smolt survival x dam count minus hatchery return

Calculated Average Total Smolts (Natural)

Spring Chinook Ksp = .94 x .50 x 5000 x .10 x 3240
= 235 x 3240
= 761,400

Summer Chinook Ksu = .94 x .50 x 5000 x .30 x Ay
= 705 x 3520
= 2,481,600

Sockeye Ksoc = .94 x .50 x 2700 x .12 x Ay
= 152 x 28,000
= 4,263,800

Average Total Natural Smolts

= Ksp + Ksu + Ksoc
= 761,400 + 2,481,600 + 4,263,800
= 7,506,800

HATCHERY PRODUCTION

DATA USED IN EXAMPLE DETERMINATION OF HATCHERY PRODUCTION

SMOLT PRODUCTION IN MILLIONS BY YEAR

Hatchery	Y	Y-1	Y-2	Y-3	Y-4	5 Year Average
Winthrop	1.5	1.1	1.0	.95	.95	1.1
Methow	.8	.8	.675	.40	.25	.585
Twisp Acclimation	.40	.40	.40	.25	.2	.33
Sockeye Net Pens	.2	.2	.2	.15	.1	.17

Hatchery Smolt Production

Winthrop Hatchery = 1,500,000 + 1,100,000 + 1,000,000 + 950,000 + 950,000 / 5
= 1,100,000

Methow Hatchery = 800,000 + 800,000 + 675,000 + 400,000 + 250,000 / 5

= 585,000

Twisp Accl. Pond=

$$\frac{400,000 + 400,000 + 400,000 + 250,000 + 200,000}{5}$$

= 330,000

Sockeye Net Pens* =

$$\frac{200,000 + 200,000 + 200,000 + 150,000 + 100,000}{5}$$

= 170,000

*Need Adjustment Factor For Survival To Migration

<u>Average Total Hatchery Smolts</u>

Winthrop = 1,100,000
Methow = 585,000
Twisp = 330,000
Net Pens = 170,000
2,185,000

<u>Average Total Hatchery/Natural Smolts</u>
(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

<u>PHASE IV DETERMINATION</u>

Base Number Smolts Used for Initial Compensation = 9,034,700

Calculated Average Natural + Hatchery Smolts in Years Y-4, Y-3, Y-2, Y-1 and Y = 9,964,000

Calculated Average Natural + Hatchery Smolts Minus Base Number Smolts = 929,300

Difference Between Base Number Smolts and Calculated Natural + Hatchery Smolts X Wells Project Mortality Rate = 929,300 X .14

= Additional Smolts Possible Under Phase IV 130,102

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

Howard Prey
____
Commissioner

Michael
____
Commissioner

T. James Davis
____
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

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FOR PACIFIC POWER & LIGHT COMPANY:

____

FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

____

FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

____

FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

____

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

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Commissioner

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Commissioner

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Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

Bailey
____

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:

Commissioner

Commissioner

Commissioner

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FOR PACIFIC POWER & LIGHT COMPANY:

FOR THE WASHINGTON WATER POWER 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:

6/11/90
____

FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

Ray Ryan 6/11/90
____

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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FOR THE NATIONAL MARINE
FISHERIES SERVICE:

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FOR THE U.S. FISH & WILDLIFE SERVICE:

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FOR THE CONFEDERATED TRIBES AND BANDS
OF THE YAKIMA INDIAN NATION:

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FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

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FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

FOR THE NATIONAL MARINE
FISHERIES SERVICE:

Rolland A. Schmitten

FOR THE U.S. FISH & WILDLIFE SERVICE:

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OF THE COLVILLE RESERVATION:

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

Marvin L. Plenert, Regional Director
FOR THE U.S. FISH & WILDLIFE SERVICE

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Levi George
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