

ANNUAL REVIEW OF BPA-FUNDED ANADROMOUS FISH PROJECTS

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INTRODUCTION

In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act. The Act assigned BPA responsibilities for protecting and enhancing fish and wildlife affected by Columbia River Basin hydroelectric dams. The Act also required the Northwest Power Planning Council to gather recommendations from the region's fish and wildlife agencies and Indian tribes in order to develop a comprehensive Fish and Wildlife Program. The Council developed the Program in November 1982.

Of the Program's 220 measures, nearly half are assigned to BPA. The Division of Fish and Wildlife carries out BPA's responsibilities to "protect, mitigate, and enhance** fish and wildlife resources affected by development and operation of hydroelectric power on the Columbia River and its tributaries.

The Fish and Wildlife Division of BPA annually hosts a meeting of contractors to present the results of work on projects specifically related to anadromous salmonids. The 1986 presentations were held at the Holiday Inn Airport on March 18-20. This document contains abstracts of the presentations from that meeting. The abstracts are indexed by Project Number and by Fish and Wildlife Program Measure.

CONTENTS

INTRODUCTION	iii
PANEL DISCUSSION: FISH AND WILDLIFE PROJECTS IN WESTERN MONTANA	1
Montana's Resident Fish Studies	3
Evaluation of the Effects of Wildlife and Wildlife Habitat Associated with Development of Hydroelectric Projects in Montana	5
Effects of Water Levels on Productivity of Canada Geese in the Northern Flathead Valley.	5
Ural-Tweed Bighorn Sheep - Wildlife Mitigation Project	6
FISH HEALTH AND PHYSIOLOGY	7
Effects of Vitamin Nutrition on the Immune Response of Hatchery-Reared Salmonids	9
Epidemiology and Control of Infectious Diseases of Salmonids in the Columbia River Basin	10
Stock Identification of Columbia River Chinook Salmon and Steelhead Trout	12
Evaluation of a Subunit Vaccine to Infectious Hematopoietic Necrosis (IHN) Virus	13
Etiology of Early Lifestage Diseases: Whitespot, Coagulated Yolk and Pinhead (Dropout)	14
Development of a Vaccine for Bacterial Kidney Disease in Salmon	15
Development of a Rapid, Serodiagnostic Test for the Detection, Surveillance, and Diagnosis of Five Important Pathogens of Fishes in the Columbia River Basin	16
HABITAT ENHANCEMENT AND PASAGE IMPROVEMENT- OREGON 1	17
A Comprehensive Plan for Rehabilitation of Anadromous Fish Stocks in the Umatilla River Basin, Oregon	19
Evaluation of Lower Umatilla River Channel Modifications Below Three Mile Dam	21
Three Mile Falls Diversion Dam Fish Passage Improvements, Umatilla River, Oregon	22

CONTENTS (cont.)

Minthorn Springs Creek Summer Steelhead Juvenile Release
and Adult Collection Facility. 23

Operation And Maintenance of the Bonifer Springs Juvenile Acclimation and
Adult Holding Facility 24

Habitat Quality and Anadromous Fish Production Potentials
on the Warm Springs Indian Reservation 25

Grande Ronde River Habitat Enhancement Project:
Joseph Creek Drainage Habitat Improvement 26

PASSAGE IMPROVEMENT AND NATURAL PROPAGATION - WASHINGTON 27

Yakima River Basin Fish Passage Improvements 29

Fisheries Evaluation of the Sunnyside Canal Fish Screening Facility 30

Temporary Fish Passage on Upper Toppenish Creek. 31

Development of New Concepts in Fish Ladder Design 32

Yakima River Spring Chinook Enhancement Study 33

HABITAT ENHANCEMENT AND PASSAGE IMPROVEMENTS - OREGON II. 35

Clackamas/Hood River Habitat Enhancement. 37

John Day River Habitat Enhancement 39

North Fork John Day Sub-Basin Habitat Improvement. 41

Hood River Fish Passage. 42

FUTURE HYDROELECTRIC ASSESSMENTS 43

Methodologies for Assessing Cumulative Effects of
Hydroelectric Development on Fish and Wildlife in the
Columbia River Basin 45

Pacific Northwest Rivers Study - Protected Areas
Methodology and Hydroelectric Power Supply Forecasting 46

An Evaluation of the Contribution of Chinook Salmon
Reared At Columbia River Hatcheries To The Pacific Salmon Fisheries 47

Development of Rations for the Enhanced Survival of Salmon 49

CONTENTS (cont.)

Pen Rearing and Imprinting of Fall Chinook Salmon 50

Willamette Spring Chinook Study Plan 51

Cabinet Gorge Hatchery Design and Construction 52

HABITAT ENHANCEMENT AND PASSAGE IMPROVEMENT - IDAHO 53

Habitat Enhancement of Lolo and Crooked Fork Creeks
(Clearwater River, Idaho) 55

South Fork Clearwater River Habitat Enhancement 56

Camas Creek (Meyers Cove) Habitat Enhancement 57

Panther Creek, Idaho Habitat Rehabilitation 58

Habitat Enhancement - Middle Fork and Upper Salmon River,
I d a h o 5 9

Salmon River Habitat Enhancement, Bear Valley Creek 61

Enloe Dam Passage Project. 62

DOWNSTREAM MIGRATION: FLOWS AND MONITORING. 63

Smolt Passage Behavior and FLOW-Net Relationships
in the Forebay of John Day Dam 65

Summer Flow Studies: Subyearling Chinook Salmon. 67

Smolt Condition and Timing of Arrival at Lower Granite
Reservoir 68

Water Budget Management 69

A Study to Determine the Technical and Biological
Feasibility of a New Fish Tagging System 70

Hydroacoustic Monitoring at Lower Monumental and
The Dalles Dams 71

Use of a Fish Transportation Barge for Increasing Returns
of Steelhead Imprinted for Homing 73

Juvenile Radio-tag Studies 75

CONTENTS (cont.)

DOWNSTREAM MIGRATION: RESERVOIR IMPACTS 77

Total Dissolved Gas Measurement, Data Transmission, and System Modeling -
Part 3: System Spill Allocation Model (GASSPILL) 79

Feeding Activity, Rate of Consumption, Daily Ration,
and Prey Selection of Major Predators in the John Day Pool 80

PANEL DISCUSSION: HABITAT EVALUATION AND MONITORING 81

Fish/Wash Creek Habitat Improvement Evaluation:
Clackamas River, Oregon 83

PANEL DISCUSSION: FISH AND WILDLIFE PROJECTS IN WESTERN MONTANA

MONTANA'S RESIDENT FISH STUDIES

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BPA Project Numbers: 81-SO5 85-6, 83-465, 83-467 85-23, 83-463
Program Measure Numbers: 804(a)(2), 804(a)(9), 804(b)(I)(D), 804(b)(3),
804(b)(4), 804(b)(5), 804(e)(2)

Relationship to Program Measure: The overall goal of Montana's Resident Fish Program under Section 800 of the Columbia River Basin Fish and Wildlife Plan is to (1) identify impacts of hydropower development and operation on important fisheries in the upper Columbia River system in Montana and (2) recommend mitigation for the impacted fisheries. Specific projects address:

- Impacts of Hungry Horse and Kerr Dam operations on the kokanee fishery on the Flathead Lake/River system. Program Measure: 804(a)(2).
- . Fishery losses to the Flathead system due to the construction of Hungry Horse Dam. Program Measure: 804(b)(4).
- . Quantification of Libby and Hungry Horse Reservoir water levels needed to maintain or enhance the reservoir fisheries. Program Measure: 804(b)(3).
- . Instream flow and rearing potential of tributaries to Libby Reservoir and the Kootenai River. Program Measure: 804(a)(9).
- . Effects of Painted Rocks water releases on resident fish in the Bitterroot River. Program Measure: 804(e)(2).

In addition, the MDFWP is in various stages of negotiations with various private hydropower operators (Montana Power Company, The Washington Water Power Company, and Pacific Power & Light Company) regarding Program Measures 804(a)(4-6), 804(e)(1), and 804(e)(I 1).

Technical Results: We are continuing our evaluation of the effects of recommended study flows in the Flathead River below Hungry Horse Dam on kokanee reproduction in the Flathead system. The flows, initiated in 1981, have increased kokanee spawning success in river spawning areas. The 1985 **kokanee** escapement of over 150,000 spawners in the Flathead system was the largest recorded since studies began in 1979. Kerr Dam operations have reduced spawning success along the shoreline of Flathead Lake. We will begin directing a portion of our study efforts to evaluating the survival and food habits of young kokanee in Flathead Lake and their interaction with other fish species, zooplankton, and Mysis relicta (opossum shrimp).

The Libby/Hungry Horse Reservoir studies have focused on the effects of reservoir operations on the water quality, physical habitat, phytoplankton, zooplankton, aquatic macroinvertebrates, and fish populations in the reservoirs. The studies are in their third year of data collection and analysis. We conducted a creel census on both reservoirs and measured angler use and gamefish harvest. Based on sonar and purse-seining techniques, we estimated that there were 2.5 million kokanee salmon in Libby Reservoir during the summer of 1984. We will begin to incorporate the data collected during these studies into a quantitative model which will predict impacts of reservoir operations on the fishery.

We are estimating the fisheries losses to the Flathead Lake/River system due to the construction of Hungry Horse Dam. Dam construction removed the South Fork of the Flathead from the interconnected spawning and rearing system. We will estimate (1) total fishery losses, (2) fisheries losses in the 57 km of flooded river, and (3) fisheries losses in the portions of 50 inundated tributaries to the South Fork. A habitat-based approach based on stream order and gradient will be used to estimate the losses. Fisheries and habitat information from 150 stream reaches in other portions of the drainage (North and Middle Forks) is available for comparison.

We are determining instream flow requirements, and spawning and rearing potential in tributaries which are important for salmonid recruitment to Libby Reservoir and the Kootenai River. Low and medium flow profiles were collected on 13 tributaries, and fall spawning surveys were conducted. We will be filing for legal instream flow rights to protect these tributaries for spawning and rearing.

Instream flow requirements and trout population levels have been determined for the 135 km of the Bitterroot River from Painted Rocks Reservoir to Stevensville. Water releases from the reservoir increased streamflows and enhanced rainbow trout populations in the river. Irrigators in the Bitterroot Valley have intercepted a portion of the river and reduced the benefits of the supplemental releases.

Technical Review: Projects are reviewed by staff biologists and the Chief of Fisheries Research of **the Montana** Department of Fish, Wildlife and Parks. Independent consultants who are recognized experts in their fields have assisted in study design. We have subcontracted with experts for studies relating to groundwater systems, quantitative and conceptual aquatic modeling, computer and statistical design, and fish age growth analysis. Portions of our research have been reviewed and are in press in the *North American Journal of Fisheries Management* and the *Proceedings of the Third International Symposium on Regulated Streams*.

Evaluation of Effectiveness: The fisheries resources affected by hydropower projects in the upper Columbia are very important to the state of Montana. These resources provide nearly 200,000 angler days and a harvest of one-half million to one million gamefish. Effectiveness of Montana's Resident Fish Projects will be best measured by their success in producing reasonable mitigation recommendations for the affected fisheries, and integrating major study results into the state's adaptive fisheries management program. Montana's recommendations will need to be coordinated with the overall plan for water management in the Columbia system. Specific evaluations of effectiveness will be measured by the degree of attainment of study objectives and program measures relating to each project.

Degree of Program Measure Fulfillment: This is the fifth year of our BPA-funded fisheries program. The program is building on a foundation of data from previous studies funded by the Environmental Protection Agency, the Bureau of Reclamation, the U.S. Army Corps of Engineers, and many years of work by the regional MDFWP staff.

Most of the MDFWP studies under Section 800 are scheduled to be completed by early 1988. At that time, we will present fisheries mitigation recommendations to the Northwest Power Planning Council. **Recommendations will** be coordinated with the Confederated Salish and **Kootenai Tribes and other concerned agencies in** the Upper Columbia Basin. Some evaluation of the mitigation recommendations and monitoring of the fishery should continue beyond that point for the most effective fulfillment of the program measures.

**EVALUATION OF THE EFFECTS ON WILDLIFE AND WILDLIFE HABITAT
ASSOCIATED WITH DEVELOPMENT OF HYDROELECTRIC PROJECTS IN MONTANA**

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BPA Project Number: 83-464
Program Measure Number: 1004(b)(3)

Consistent with Program Measure 1004(b)(3), MDFWP prepared loss estimates and mitigation plans for Hungry Horse, Libby, Thompson Falls, Noxon Rapids, and Cabinet Gorge hydroelectric facilities. Council approval is pending for the Hungry Horse and Libby mitigation plans. Implementation of the mitigation plan for Noxon Rapids and Cabinet Gorge is being discussed between MDFWP and Washington Water Power.

**EFFECTS OF WATER LEVELS ON PRODUCTIVITY OF CANADA GEESE
IN THE NORTHERN FLATHEAD VALLEY**

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Program Measure Number: 1004(b)(2)

Relationship to Program Measure: Consistent with Program Measure 1004(b)(2), this project is designed to address the effects of water-level fluctuations and drawdown of Flathead Lake, the loss of habitat due to erosion, and the losses in production and habitat requirements of waterfowl.

Technical Results: Two years have been completed of a three-year study to determine the biology and habitat use of Canada geese on the Flathead River and north shore of Flathead Lake during the nesting and brood-rearing periods. Lake and river water-level regimes are being determined to compare with breeding chronology. An analysis of aerial photography indicated the loss of 1,859 acres of habitat along the north shore of Flathead Lake due to inundation and continuing erosion.

Technical Review: This project is coordinated with a similar study on the south end of Flathead Lake, conducted by the Confederated Salish and Kootenai Tribes. Dr. I. J. Ball, Montana Cooperative Wildlife Research Unit, is a consultant to the project.

Evaluation of Effectiveness: The ultimate goal of this project is to develop mitigation measures for the effects of water-level fluctuations which will be consistent with the management goals for Canada geese and with mitigation for other fish and wildlife resources of the Flathead Valley. Recommendations will be based on 1984-86 data.

Degree of Program Measure Fulfillment: Upon completion of this project, appropriate mitigation measures will be proposed.

URAL-TWEED BIGHORN SHEEP - WILDLIFE MITIGATION PROJECT

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Program Measure Number: 1004(b)(3)

Relationship to Program Measure: Consistent with Program Measure 1004(b)(3), this is a cooperative project with the Kootenai National Forest to maintain and enhance bighorn sheep habitat at Libby Dam.

Technical Results: Between September 1, 1984 and December 31, 1985 habitat treatments and pretreatment vegetation sampling were initiated on 7 sites totalling 650 acres. The treatments include selective slash and burn, prescribed fire, and fertilization. Future projects have been delineated for other areas frequented by bighorn sheep.

Eight adult bighorn sheep (four ewes and four rams) were fitted with radio transmitters. Systematic surveys monitor the movements and seasonal habitat preferences of the radio-collared sheep. Age and sex information will aid in the development of a population simulation model. Monthly pellet group collections were initiated in May 1985 to sample for food habits, nutritional level, and lungworm larvae.

Technical Review: The habitat manipulation areas and study methods were selected based on results of previous studies, knowledge of the personnel associated with the project, and extensive literature review and consultation with several professors.

Evaluation of Effectiveness: The project is designed to mitigate the impacts of the Libby Dam project on the Ural-Tweed bighorn sheep population. It is anticipated that the mitigation efforts combined with other ongoing habitat treatments will allow the bighorn population to respond to a population level estimated at 200-250 animals. The project is designed to primarily benefit bighorn sheep; however, other species such as mule deer, blue grouse, osprey, and nongame wildlife are also considered in the development of the habitat treatment.

Degree of Program Measure Fulfillment: The accomplishment of this project combined with the implementation of a long-term habitat management plan should provide complete mitigation of the impacts of the Libby Dam on the Ural-Tweed bighorn sheep population.

FISH HEALTH AND PHYSIOLOGY

EFFECTS OF VITAMIN NUTRITION ON THE IMMUNE RESPONSE OF HATCHERY-REARED SALMONIDS

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Program Measure Number: 704(h)(4)

Relationship to Program Measure: The goal of this project is to find ways to improve the vitamin nutrition supplied by fish feeds. Salmon smolts fed those improved diets will be healthier, more resistant to diseases, and better able to survive to adulthood after release from hatcheries. The results will be applicable to Program Measures 704(k), 704(j), and 704(h) as well as 704(h).

Technical Results: Evaluation and optimization of assays for assessing immunocompetence in fish have been completed. These assays include in vitro induction of antibody response, stimulation of lymphocytes by mitogens, mixed lymphocyte reactions, phagocytosis, plasma immunoglobulin levels, differential analyses of leukocytes, and in vitro production of antibody to Renibacterium salmoninarum. These tests have been used in preliminary range-finding trials with spring chinook salmon fingerlings fed diets containing differing concentrations of pyridoxine and folic acid. Results indicated enhanced in vitro production of antibodies to trinitrophenylated lipopolysaccharide and increased lymphocyte stimulation by Vibrio anguillarum antigen when fish were fed diets in which the vitamin concentrations were higher than the National Research Council (NRC). This is of particular interest because increased dietary pyridoxine and folic acid had no effect on growth. Confirmatory experiments are underway.

Technical Review: The project was reviewed by a BPA evaluation team consisting of several fish disease specialists and experts in fish culture. Also, a manuscript describing the methods for in vitro measurement of antibody production was reviewed and accepted for publication in *Veterinary Immunology and Immunopathology*.

Evaluation of Effectiveness: The project is designed to provide results which are directly applicable to formulating practical production diets. Effectiveness will depend upon the extent to which fish nutritionists and feed manufacturers heed and apply recommendations for producing improved feeds. The project co-leader from the U.S. Fish and Wildlife Service is responsible for setting manufacturing specifications for one practical salmon feed (Abernathy Diet); therefore, technology transfer will be immediate and direct in that case.

Degree of Program Measure Fulfillment: The project addresses one aspect of disease control, i.e., improved nutrition. The investigations are concentrating on a select group of vitamins and one species of fish. The nutritional needs of other species will need to be investigated. Also, several other vitamins remain to be examined, and the effects of other classes of nutrients and nutrient interactions need study.'

EPIDEMIOLOGY AND CONTROL OF INFECTIOUS DISEASES OF SALMONIDS IN THE COLUMBIA RIVER BASIN

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Program Measure Number: 704(h)(2)(d)

Relationship to Program Measure: The goal of this project under Program measure 704(h)(Z)(d) is to investigate the epidemiology of three major salmonid pathogens, Ceratomyxa shasta, Renibacterium salmoninarum, and infectious hematopoietic necrosis virus. in the Columbia River basin and establish procedures for their detection and control.

Technical Results: The infectious stage of C. shasta in the Snake River at Little Goose Dam was reconfirmed during 1985. No susceptible rainbow trout exposed in the Yakima and Umatilla Rivers died of ceratomyxosis. Two years of tests indicate prolonged exposures to the infective stage of C. shasta will cause a higher infection rate even among resistant Columbia River basin salmonids. However, when duplicate groups of these fish are held in either fresh or salt water the disease was greatly reduced in salt water, suggesting recovery from ceratomyxosis. This means that Columbia River smolts remaining in fresh water after liberation will suffer a higher mortality than recognized by previous stock susceptibility studies.

Data from groups of Columbia River chinook salmon held after capture in either fresh or salt water suggests R. salmoninarum is an effective pathogen in salt water. After four years of sampling smolts from the open ocean, numbers of this bacterium sufficient to cause death have been detected in chinook (7 percent) and coho salmon (2 percent) and steelhead trout (1 percent). Antigenic differences among strains of R. salmoninarum and common antigens present on both R. salmoninarum and other Gram positive bacteria have been demonstrated for the first time using monoclonal antibodies.

Field tests with molecular filtration indicated approximately 10^{10} IHN virions were released each day into the Deschutes River at the peak of the steelhead trout spawning at Round Butte Hatchery. Two possible reasons for inconsistencies in data from IHN transmission studies at Round Butte Hatchery are: (1) UV treatment does not completely sterilize the water, and (2) vertical transmission occurs, but under as yet unknown conditions. Comparisons of filtered and unfiltered ovarian fluid samples suggest that cellular components in ovarian fluid are responsible for the delayed appearance of IHN after storage at 4°C. for 8 to 16 days.

Technical Review: Procedures to determine distribution and stock susceptibility to C. shasta have been described in *J. Fisheries Res. Bd. of Canada* 34:933-936 and *Trans. Amer. Fisheries Soc.* 112:541-543. Methods to produce monoclonal antibodies against R. salmoninarum have been described in *Selected Methods in Cellular Immunology* (ed. Mishell and Shiigi, 1980; W. H. Freeman and Co., San Francisco). Modifications of procedures in *Appl. Environ. Microbiol.* 49:426-428 were used to recover IHN from hatchery water.

Evaluation of Effectiveness: Livebox studies have shown an extension in the range of C. shasta within the Columbia River basin and that no salmonid stocks are completely resistant, especially after prolonged exposure. Determining the life cycle of this parasite, especially any intermediate hosts, is necessary for the development of control methods.

Renibacterium salmoninarum typically causes a chronic mortality in salmonids prior to liberation; however, a mortality of greater extent may occur after the smolts enter salt water. The described vertical transmission of this disease requires reliable and sensitive methods for detecting the bacterium in carrier fish. Monoclonal antibodies produced against unique components of R. salmoninarum will make these determinations possible.

The presence of IHNV in broodstocks has been detected with increasing frequency. Determining the role of vertical transmission in the spread of this virus will significantly alter control procedures. Observations describing the delayed appearance of IHNV in ovarian fluid suggests that sampling procedures may also need revision.

Degree of Program Measure Fulfillment Livebox studies in additional Columbia River tributaries will more exactly define the range of the C. shasta infective stage. Completion of laboratory trials to produce a monoclonal antibody reagent specific for R. salmoninarum will eliminate cross-reactivity with other bacteria. Once the importance of vertical transmission of IHNV has been determined, hatchery practices can be modified to prevent or minimize this disease.

STOCK IDENTIFICATION OF COLUMBIA RIVER CHINOOK SALMON AND STEELHEAD TROUT

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Program Measure Number: 704(h)(2)(c)

Relationship to Program Measure: The goal of this project, under Program measure 704(h)(2)(c), is to provide the information necessary to maintain genetic integrity and optimize production potential of Columbia Basin stocks of chinook salmon and steelhead trout. Specifically, this project will characterize hatchery and wild stocks of chinook salmon and steelhead trout by using electrophoretic and anatomical characters. We will combine our data with life history data provided by the Stock Assessment Study to determine the similarities of the various stocks so as to provide guidelines for making management decisions on stock transfers.

Technical Results: Electrophoretic analyses of 56 stocks of steelhead trout and **57** stocks of chinook salmon have been completed. Morphological analyses of these stocks are nearly completed and will be analyzed in the near future.

The cluster analyses of chinook salmon stocks and the steelhead stocks suggest that stocks of common areas are similar. The analyses also suggest that there are electrophoretic differences between the races of chinook salmon; however, there were no differences between summer and winter steelhead stocks from the same area. Anatomical and life history data will be incorporated into our final analysis, and this may provide a basis for separating the winter and summer races. We will also characterize the stream systems and correlate Columbia River sub-basin classification to our characterization of stocks. We believe that possible reasons for stock differences will emerge from this technique.

Technical Review: Methods and designs for these studies were reviewed and approved by the Oregon Department of Fish and Wildlife and the National Marine Fisheries Service.

Evaluation of Effectiveness: The analysis of similarities among stocks should provide a basis for: (1) identifying stocks requiring unique management decisions, (2) protecting the genetic integrity of the existing stocks, and (3) selecting donor stocks for depleted runs.

Degree of Program Measure Fulfillment: This project will complete the assessment of electrophoretic and anatomical characteristics and provide a relative measure of heterozygosity among stocks.

EVALUATION OF A SUBUNIT VACCINE TO INFECTIOUS HEMATOPOIETIC NECROSIS (IHN) VIRUS

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BPA Project Number: 84-43
Program Measure Number: 704(h)(4)

Relationship to Program Measure: The goal of this project under Program Measure 704(h)(J) is to develop and test an effective, safe, and economical vaccine for infectious hematopoietic necrosis virus (IHNV), a major pathogen in Columbia River steelhead and salmon fish stocks.

Technical Results: A prototype subunit vaccine to IHNV is being developed by recombinant DNA techniques. The techniques involve the isolation and characterization of the glycoprotein gene, which encodes the viral proteins responsible for inducing a protective immune response in fish. The viral glycoprotein gene has been sequenced. The gene has been cloned into bacterial expression systems, pATH1 and pATH3. A protein that binds with antisera to IHN virus is made in these systems. immunization trials are being conducted.

Technical Review: Expression of viral genes is accomplished in Escherichia coli as described in *Proc. Natl. Acad. Sci.*, U S A 82:4944-4948. The dideoxy chain termination method for DNA sequence analysis and the recloning of the isolated gene in single-stranded M13 phage vectors have been conducted as described in *Gel Electrophoresis of Nucleic Acids, A Practical Approach* (ed. Rickwood and Hames, 1982, IRL Press Limited, Oxford). immunization trails have been conducted as described in *J. Fish Disease* 5:197-205.

Evaluation of Effectiveness: The incidence of IHNV infections in hatcheries along the Columbia River has risen at an alarming rate. More than 25 million eggs and fish have been destroyed in the past four years in an attempt to control the disease. Three IHNV outbreaks in Washington alone have caused the loss or destruction of 6.5 million eggs and fish. The potential value of this resource has been estimated at over f230 million. The development of a viral vaccine by molecular cloning is attractive because the result is an inexpensive, subunit-type vaccine that has none of the drawbacks of live viral vaccines. The problems of recombination and reversion to virulence are eliminated. Moreover, once efficient expression of the virus protein has been attained in bacteria, vaccine production should be very inexpensive. The ultimate evaluation of effectiveness will come from field trials and the adoption of the vaccine by hatchery managers for treatment of the fish.

Degree of Program Measure Fulfillment: Once the vaccine has been demonstrated to be fully effective in laboratory trials and all parameters governing the immunization process (e.g., dose, age of host, duration of immunity) have been characterized, then field trials should be initiated.

ETIOLOGY OF EARLY LIFESTAGE DISEASES: WHITESPOT, COAGULATED YOLK AND PINHEAD (DROPOUT)

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Program Measure Number: 704(h)(4)

Relationship to Program Measure: Within the guidelines of Measure 704(h)(4), this project is to determine if the several species of bacteria or their toxic products recently detected within the yolk of salmon eggs collected at spawning are associated with subsequent mortalities during incubation and rearing. The significance of bacteria within eggs are that: (1) disease could be spread from basin to basin via egg transport and (2) many of the fish which survive could be immunologically impaired and less able to survive in the wild. The ultimate goal of this project is to develop protocols for use at or near spawning to eradicate the bacteria within the eggs.

Technical Results: During the 1984 and 1985 brood years, groups of eggs from 30 fall chinook salmon, *Oncorhynchus tshawytscha*, have been incubated and reared through the first 12 weeks on feed, and the mortalities determined for each group of eggs. The mean of the mortalities in 1984 was 16.98% (range 2.85%-96.18%). In 1985 (data to swim-up) the mean of the mortalities was 36.82% (range 5.03%-100%).

Microbiologic testing of maternal blood, ovarian fluid, and yolk from surface sterilized eggs reveals a wide range of bacterial numbers and species. Yolk from surface sterilized eggs collected at spawning when tested without prior enrichment showed that the eggs from some females were devoid of bacteria, while others had counts in excess of 100,000 bacteria per cc of yolk and contained seven different genera. Tests for *Cytophaga* sp. and *Flexibacter* sp. were negative. Following three weeks of incubation, yolk from "good" eggs and moribund "bad" eggs was tested. In the moribund eggs, 26 of the 30 egg lots had bacterial growth (range 1,000 to over 100,000 per cc of yolk) with *Aeromonas hydrophila* being the most common species. The "good" eggs from 20 of the 30 egg lots were free of bacteria, while the 10 egg lots containing bacteria had counts of 1,000 to 30,000 per cc of yolk and contained four genera of bacteria. Tests on yolk from eyed eggs and sac fry are in progress. Due to the growth characteristics of *Listeria* sp., the presence of this organism is not reflected in the colony counts; however, 15 of the 30 egg lots have been found to contain this organism. One egg lot contains only *Listeria* and exhibited a mortality rate of 85.84% through swim-up. Confirmation of identification of several bacterial isolates is being conducted in other laboratories.

A positive correlation of endotoxin levels in ovarian fluid with subsequent mortalities within egg lots has been found.

Degree of Program Measure Fulfillment: When associations of certain bacterial species with mortalities during the incubation and rearing process are established, it will then be possible to either treat the brood salmon with antibiotics prior to spawning, or water harden eggs in bactericidal substances to eradicate certain bacteria within the eggs, thereby reducing in-hatchery mortalities.

DEVELOPMENT OF A VACCINE FOR BACTERIAL KIDNEY DISEASE IN SALMON

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Program Measure Number: 704(h)(4)

Relationship to Program Measure: Program Measure 704(h)(4) calls for the improved propagation in existing facilities via disease control. The goal of this project is to produce a vaccine for bacterial kidney disease (BKD) of salmonids. Such a vaccine would reduce or eliminate losses of hatchery-reared fish due to bacterial kidney disease. This vaccine would increase the efficiency of fish propagation under Program Measures 704(i) and -(j) and produce immune fish that would make safer candidates for the supplementation of naturally spawning stock [Program Measure **704(k)**].

Technical Results: Renibacterium salmoninarum soluble antigens have been employed in developing an ELISA test, for the purpose of determining antibody titers in salmon. A lymphocyte proliferation assay has also been developed, which will allow for the determination of cell-mediated immune response to Renibacterium antigens. These methods are being used to assess the degree and form of immunity elicited by the various prototype vaccines.

A Western blot assay has been developed which allows for the simultaneous detection of the three soluble Renibacterium antigens. This assay has been used to detect free Renibacterium antigens in the sera of infected fish. The coupling of molecular weight and **serological analysis that this assay provides can aid in the resolution of false positives** seen in other **assay systems**.

Whole Renibacterium salmoninarum cells and soluble antigen have been admixed with the immunopotentiating agents Vibrio anguillarum extract, E, coli lipopolysaccharide (LPS), muramy! dipeptide, and Mycobacterium in Freund's incomplete adjuvant. Determination of antibody levels, cellular immune responses, and resistance to live Renibacterium challenge are being assessed.

Conjugates of whole Renibacterium cells have been made to Vibrio extract, **E. coli** LPS, muramy! dipeptide, and keyhole limpet hemocyanin and the antigenic analysis of these prototypes assessed.

Technical Review: The project was reviewed by a BPA evaluation team consisting of several fish disease specialists and experts in fish culture. These studies will also be subject to peer review by the submission of manuscripts to various professional journals for publication.

Evaluation of Effectiveness: Not currently applicable.

Degree of Program Measure Fulfillment: The control of diseases at our hatcheries is a major problem. The product of this project should aid in the partial fulfillment of this measure by increasing survival in the hatchery and by increasing the returns for spawning. After the bacterial kidney disease problem has been resolved, however, it will be essential to turn our attention to other, as yet unresolved, fish disease problems.

**DEVELOPMENT OF A RAPID, SERODIAGNOSTIC TEST FOR THE DETECTION,
SURVEILLANCE, AND DIAGNOSIS OF FIVE IMPORTANT PATHOGENS OF FISHES
IN THE COLUMBIA RIVER BASIN**

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BPA Project Number: 83-304
Program Measure Number: 704(h)(2)(D)

Relationship to Program Measure: This project specifically addresses Measure 704(H)(Z)(D), which identifies a need for improvement in the detection, diagnosis and control of fish diseases and parasites. Detection techniques are being developed for five fish pathogens: two viruses, Infectious Hematopoietic Necrosis Virus (IHNV) and Infectious Pancreatic Necrosis Virus (IPNV), and three bacteria, Aeromonas salmonicida, Renibacterium salmoninarum, and Yersinia ruckeri.

Technical Results: Plate and immunoblot ELISA systems have been developed for the detection and identification of IHNV and IPNV. Presently, amplification of infectivity in cell culture is required for detection of virus when the sample infectivity is less than 10^5 PFU/ml. ELISAs have been developed to detect specific antigens of near 10 mg/ml. Due to antigenic diversity between the sorbitol-fermenting isolates of Y. ruckeri, that ELISA is restricted to detection of sorbitol-nonfermenting serotypes.

Technical Review: The methods to produce monoclonal antibodies against IHNV have been published (Fish *Pathology* 20 (2/3): 339-341), as well as the immunoblot assays for salmonid fish viruses (*J. Wildlife Diseases*, in press) and the analysis of bacterial lipopolysaccharides by transfer to nitrocellulose (*J. Immunol. Meth.*, in press).

Evaluation of Effectiveness: The choice of a diagnostic method for each pathogen has been made under the guideline that it will improve on both the speed and sensitivity of current techniques. Application of tests that fulfill these requirements will have an immediate impact on the field of fish health. Not only will diagnostic testing be accomplished in a fraction of the time now required, screening of returning adults and prerelease smolts will be possible *on* a scale adequate for use at production facilities. This will provide an additional tool to fish health managers for use in working toward "cleaner" hatcheries in the Columbia River Basin.

Degree of Program Measure Fulfillment: As a group, all of the assays have shown that it is feasible to detect the five fish pathogens using contemporary detection methods. All are to the point of field testing, which will determine their suitability for routine use.

HABITAT ENHANCEMENT AND PASSAGE IMPROVEMENT -
OREGON I

A COMPREHENSIVE PLAN FOR REHABILITATION OF ANADROMOUS FISII STOCKS IN THE UMATILLA RIVER BASIN, OREGON

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Program Measure Number: 704(d)(1) and 704(i)(1)

Relationship to Program Measure: The Umatilla River once supported large runs of fall and spring chinook and coho salmon before overfishing, extensive water use, habitat degradation, and Columbia River hydroelectric projects eliminated runs. The Umatilla presently supports a small run of about 2,000 native summer steelhead. Development of the Umatilla Rehabilitation Plan was initiated in July 1984. The plan has three primary goals:

- (1) Establish fishery rehabilitation objectives for naturally and hatchery-produced salmonids.
- (2) Estimate natural and hatchery production fishery benefits from proposed fishery rehabilitation and flow-enhancement projects.
- (3) Develop a plan to set priorities, implement, and evaluate projects to achieve rehabilitation objectives.

Development of the plan was a cooperative effort by the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, the Fish and Wildlife Service, the National Marine Fisheries Service, the Bureau of Reclamation, and the Forest Service.

Technical Results: The final draft of the plan was completed in 1985. Natural and hatchery rehabilitation objectives for the basin are 7,500-8,500 summer steelhead, 21,000-21,500 fall chinook, and 10,500- 11,500 spring chinook, depending on flow.

Fishery rehabilitation projects evaluated include upstream and downstream passage improvements at diversion dams and canals and in the lower channel below Three Mile Falls Dam, adult and smolt trapping/trucking projects, and habitat improvements in important headwater streams. Projects were evaluated under present and three enhanced flows (the Bureau of Reclamation's Columbia River Pumping and Columbia River Pumping/Meacham Dam Plans and the McKay Storage Plan). Projects not evaluated include the hatchery for production of 200,000 summer steelhead smolts (to be constructed) and Boniferr and Minthorn Springs adult collection/juvenile release facilities (constructed in 1983 and 1985, respectively).

Technical Review: Cooperating agencies and the Pacific Northwest Utilities Conference Committee extensively reviewed a June 1985 draft of the plan. We incorporated many of the suggested changes in the final draft. The final draft will be distributed early in 1986.

Evaluation of Effectiveness: Simple life history models were used to determine benefits of the rehabilitation and flow projects to natural and hatchery production. Under each of the flows, accomplishment of all projects would provide substantial fishery benefits in the basin. For example, the number of naturally and hatchery produced summer steelhead and spring and fall chinook ranges from 22,500 adults under existing to 1,500 adults under enhanced flows of the Bureau's flow projects.

We have given the Bureau's flow projects top priority in plan implementation because fishery and tribal needs in the basin would be met, water use conflicts would be resolved, and the need for fish trucking would be reduced. Hatchery production projects received high priority. Other high priority projects include upstream and downstream passage improvements at the five major diversion dams on the main stem and adult smolt trapping/trucking projects. These are followed by downstream passage improvements at small diversions and habitat improvements.

Degree of Program Measure Fulfillment: Completion of the plan is a major milestone of this project. Acceptance and implementation of the plan will fulfill the program measures.

EVALUATION OF LOWER UMATILLA RIVER CHANNEL MODIFICATIONS BELOW THREE MILE DAM

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BPA Project Number: 83-834
Program Measure Number: 704(d)(1)

Relationship to Program Measure: This project, in response to Program Measure 704(d)(1) of the Fish and Wildlife Plan, was conducted to evaluate the adequacy of channel modifications made in the lower Umatilla River to improve adult anadromous salmonid passage to Three Mile Dam, determine if fish passage **or** delay problems existed at Three Mile Dam, and recommend site-specific corrective measures if needed. Channel modifications were made under the supervision of the U.S. Army Corps of Engineers (BPA Project No. 83-434).

Technical Results: Steelhead passage was examined in November and December 1984 and, although some delays were observed at sites within the modified channel, those delays may have been volitional, since observations were made early in the spawning run. Upriver bright **fall** chinook salmon passage was examined in September through November 1985, but insufficient numbers of adult salmon (six adults) returned to evaluate the adequacy of channel modifications, and the study was terminated.

Technical Review: Project sampling design and data analysis techniques were technically reviewed by biologists from various agencies including ODFW, USFWS, NMFS, CTUIR, USBR, and BPA. Critical comments were solicited through technical work group meetings.

Evaluation of Effectiveness: Adequacy of channel modifications in improving passage of steelhead was effectively evaluated in 1984. However, insufficient returns of upriver bright fall chinook precluded **an** effective **evaluation of** the adequacy of channel modifications in improving salmon **passage at lower flows, earlier in the fall.** Incidental observations of jacks and one radio-tagged adult salmon indicate that passage was facilitated at flows greater than 245 cfs.

Degree of Program Measure Fulfillment: Adequacy of channel modifications to improve adult salmon passage at low flows, early in the run (September and October) remains unknown, pending establishment of a sufficiently large return of upriver bright fall chinook to the Umatilla River. **Efforts must still be made** in future years to evaluate passage of salmon at various flows in the lower river channel.

THREE MILE FALLS DIVERSION DAM FISH PASSAGE IMPROVEMENTS
UMATILLA RIVER, OREGON

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Program Measure Number: 704(e)(1)

Relationship to Program Measure: The goal of this project is to improve fish passage at Three Mile Falls Diversion Dam on the Umatilla River. The existing fish facilities at the dam are quite antiquated and inadequate. The ladders are poorly designed with no or ineffective attraction flows, resulting in difficulties and delays in upstream passage. The headworks of the West Extension Irrigation District (WEID) Canal which is located at the dam is equipped with fish louvers to prevent juveniles from entering the canal. These louvers are not effective, and a substantial percentage of downstream migrating juveniles are probably lost into the canal.

The project will consist of constructing a new fish ladder near the right abutment of the dam, modifying the existing left bank fish ladder, and constructing a fish screen in the WEID Canal. Fish trapping and tagging facilities will be provided at the ladders. The fish screen will include a juvenile holding facility for use when flows below Three Mile Falls Dam are inadequate to provide passage.

Technical Results: During 1985, detailed plans and schedules for the fish facilities were finalized. Design data has been collected including geologic drilling of the foundations. The Bureau is set to begin final design of the facilities.

Construction is scheduled to begin on the right bank ladder in the spring of 1987. Work on the canal screen and left bank ladder will begin in the late summer of 1987. Some minor channel improvements along the downstream toe of Three Mile Falls Dam is scheduled for the summer of 1986. An operation and maintenance agreement for these facilities is being developed between the Bureau and BPA.

Technical Review: Fishery criteria have been provided by the State of Oregon Department of Fish and Wildlife, National Marine Fisheries Service, Fish and Wildlife Service, and the Confederated Tribes of the Umatilla Indian Reservation. Engineering plans are reviewed by the Department of Fish and Wildlife and the National Marine Fisheries Service.

Evaluation of Effectiveness: This project will remove a major obstacle to both adult and juvenile fish passage on the Umatilla River, and in conjunction with basin-wide fish enhancement programs will help establish viable runs of chinook salmon and steelhead trout in the basin.

Degree of Program Measure Fulfillment: Completion of the entire project is scheduled for July 1988. Interim completion dates for the right bank ladder and WEID Canal screen are September 1987 and March 1988, respectively.

**MINTHORN SPRINGS CREEK SUMMER STEELHEAD JUVENILE RELEASE
AND ADULT COLLECTION FACILITY**

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BPA Project Number: 83-435
Program Measure Number: 704(i)(1)

Relationship to Program Measure: The Minthorn Springs Juvenile Release and Adult Collection Facility, part of Program Measure 704(i)(1), is a key element in the Umatilla Basin salmon and steelhead restoration program. The facility consists of a concrete fishway and two juvenile raceways near the mouth of Minthorn Springs Creek on the Umatilla Indian Reservation.

Starting in the spring of 1986, the facility will be used for acclimation of juvenile salmon and steelhead and for holding of adults before spawning. Adult steelhead that return to Minthorn Springs Creek or eggs from those fish will be outplanted in underseeded natural production areas throughout the Umatilla drainage.

The Minthorn facility will also be used for restoration of chinook salmon runs to the Umatilla Basin. Upriver bright fall chinook juveniles from Bonneville Hatchery will be released annually for development of hatchery and naturally producing runs. Spring chinook will be released as soon as they are available.

The Umatilla Hatchery, also part of Program Measure 704(i)(1), is now in the preliminary design phase and will be the "mother" steelhead hatchery for both the Minthorn and Bonifer facilities.

Technical Results: The Minthorn facility was constructed in the summer and fall of **1985**. Final inspection of the facility, including a test run on all pumps and equipment, was conducted late in **1985**. The facility will be capable of acclimating approximately 150,000 smolts (more for pre-smolts) and holding of about 250 adult salmon or steelhead.

Technical Review: The Tribe and Oregon Department of Fish and Wildlife both reviewed and commented on the final designs prior to construction. A project design and construction engineer conducted numerous inspections during construction to ensure that specifications were met.

Evaluation of Effectiveness: All or a portion of the juveniles released will be tagged for later evaluation of adult returns.

Degree of Program Measure Fulfillment: Projects under Program Measure 704(i)(I) include the Bonifer and Minthorn Acclimation Facilities on the Umatilla Reservation and the Umatilla Hatchery to be located near Irrigon, Oregon. Remaining projects include the construction of the Umatilla Hatchery for annual production of 200,000 steelhead smolts and the operation and maintenance of all three facilities.

OPERATION AND MAINTENANCE OF THE BONIFER SPRINGS JUVENILE ACCLIMATION AND ADULT HOLDING FACILITY

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Program Measure Number: 704(i)(1)

Relationship to Program Measure: The Bonifer Springs Juvenile Release and Adult Holding Facility, part of Program Measure 704(i)(1), is located on the Umatilla Indian Reservation. The Bonifer facility, completed in 1983, consists of a fishway at the outlet of a one-acre spring-fed pond. Juvenile salmon and steelhead are acclimated in the pond, and adults are held in the fishway before spawning. Adult returns or eggs from those fish will be outplanted in underseeded areas throughout the Umatilla drainage. Some returning fish (adipose fin clipped) may be used for broodstock, but wild fish will be the major broodstock component to maintain genetic integrity.

The Umatilla Hatchery, also part of Program Measure 704(i)(1), is now in the preliminary design phase and will be the “mother” steelhead hatchery for both the Bonifer and Minthorn facilities.

Technical Results: In early 1985, 104 adult steelhead were captured in the lower Umatilla River and were held at Bonifer prior to spawning. Approximately 150,000 eggs were taken from 32 females. Most eggs were transported to Oak Springs Hatchery for incubation, rearing, and later release **back to** Bonifer in the spring of 1986. Some eggs were supplied to a local sports club for hatch-box incubation. This resulted in a 14,000-fry outplant in Birch Creek. In the spring of 1985, 140,000 yearling upriver bright fall chinook and 60,000 yearling summer steelhead smolts were acclimated and released from Bonifer Pond. Another 50,000 sub-yearling fall chinook were reared for three months and released in late October.

Evaluation of Effectiveness: Returns from annual steelhead releases (50,000-60,000) at Bonifer Pond are expected to double the previous **adult** run size of 1,000 fish within three years. Observed facility advantages have been low mortalities of juveniles before release and adults before spawning. **All** or a portion of the juveniles released have been tagged for later evaluation of adult returns.

Degree of Program Measure Fulfillment: Projects remaining for completion of Program Measure 704(i)(1) include construction and maintenance of the Umatilla Hatchery for annual production of 200,000 steelhead smolts and operation and maintenance of the Bonifer and Minthorn acclimation facilities.

HABITAT QUALITY AND ANADROMOUS FISH PRODUCTION POTENTIALS ON THE WARM SPRINGS INDIAN RESERVATION

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Program Measure Number: 704(d)(1)

Relationship to Program Measure: The Warm Springs Indian Reservation's anadromous fish habitat and production project is determining anadromous fish production potentials of reservation streams and improving habitat to increase spring chinook salmon and steelhead trout populations.

The rivers and streams of the Warm Springs Indian Reservation provide over 100 miles of spawning and rearing habitat for naturally produced spring chinook salmon and summer steelhead trout. Salmonid production levels are being measured and evaluated to determine what factors are limiting production. Insufficient juvenile rearing and overwintering habitat are thought to be major factors limiting potential fish production.

Technical Results: In 1985, the fourth **year of** the project, established monitoring sites were field sampled to determine fish biomass levels and water quality and quantity parameters on the Warm Springs River system and Shitike Creek. The 1984 brood spring chinook salmon were fin marked at the Warm Springs National Fish Hatchery. A Humphrey scoop trap was operated near the mouth of the Warm Springs River to estimate spring and fall anadromous fish out-migration from the Warm Springs River system. Habitat classification surveys were conducted in a channelized reach of Beaver Creek. The Beaver Creek survey data was analyzed and a habitat improvement plan to increase the amount of juvenile rearing area was developed. **The** Beaver Creek plan will be implemented in the summer and fall of 1986. Redd count surveys were conducted to determine chinook and steelhead stream seeding levels and evaluate previous BPA and tribally funded improvement projects.

Technical Review: Biologists of the U.S. Fish and Wildlife Service, U.S. Forest Service, Oregon Department of Fish **and** Wildlife, and other individuals who are specialists in design of in-stream structures and barrier removal have been consulted and have assisted with reservation projects.

Evaluation of Effectiveness: Improvement projects on the Warm Springs Indian Reservation are being evaluated through a multiyear project funded by BPA and the Confederated Tribes of Warm Springs. Twenty-eight miles of stream have been opened up to spring chinook salmon and steelhead trout production. Juvenile production is projected to increase by 300% as a result of habitat improvement in the Beaver Creek enhancement project.

Degree of Program Measure Fulfillment This was the fourth year of the scheduled 1 1-year Warm Springs Indian Reservation anadromous fish production and habitat improvement program. Since the rivers of the Warm Springs Indian Reservation represent only a small amount of the Columbia River Basin, a significant portion of Program Measure 704(d)(1) will need to be accomplished upon completion of this project.

**GRANDE RONDE RIVER HABITAT ENHANCEMENT PROJECT:
JOSEPH CREEK DRAINAGE HABITAT IMPROVEMENT**

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and

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BPA Project Number: 84-9 and 84-25
Program Measure Number: 704(d)(1)

Relationship to Program Measure: The Joseph Creek Habitat Enhancement Project [Program Measure 704(d)(1)] is improving spawning and rearing habitats for wild summer steelhead and rainbow trout in Joseph Creek tributaries.

The Joseph Creek system constitutes a major drainage within the Grande Ronde River Basin of Northeast Oregon. Though Joseph Creek and its tributaries have historically been excellent producers of summer steelhead, recent redd counts indicate returns to this drainage to be we!! below those observed in the late 1970s and early 1970s. Reasons for declines of anadromous fiuh include: (1) problems with passage at mainstem Columbia and Snake River dams, (2) user demands for the fishery resource, and (3) degradation of spawning and rearing habitats. Considerable effort and money have already been put into resolving mainstem dam passage problems and controlling ocean and river harvest of these stocks, and there are now indications that these efforts are resulting in increased numbers of spawning steelhead returning to their native spawning grounds in Snake River tributaries. Observations in the Joseph Creek drainage, however, indicate that optimum rearing and spawning habitats for summer steelhead are limited in large portions of the drainage by: (I) lack of deep pools for holding and rearing fry, (2) high summertime water temperatures resulting from lack of shade-producing streamside vegetation, and (3) a lack of adequate spawning gravels.

Technical Results: During 1985, 8.8 miles of corridor fence were installed to protect 56.7 acres of riparian habitat along 5.3 miles of creek within the Joseph Creek Drainage; an additional 6.9 miles of pasture fence were installed to protect 4.0 miles of creek. These fenced riparian areas were also planted with 8,996 plants of 9 different species during 1985.

Thirty new instream structures . were installed, and 38 existing structures modified along 4.0 miles of creek to increase juvenile steelhead rearing habitat.

Habitat inventories were completed along 20.5 miles of creek within the drainage.

Technical Review: Results of 1985 projects were viewed and critiqued by personnel from the Bonneville Power Administration, U.S. Forest Service, Nez Perce Tribe, and Oregon Department of Fish and Wildlife.

Evaluation of Effectiveness: Effectiveness of 1985 habitat enhancement projects within the Joseph Creek Drainage will be evaluated as part of a statewide evaluation study which is currently being developed by the Oregon Department of Fish and Wildlife.

Degree of Program Measure Fulfillment: This was the third year of the multiyear Joseph Creek Drainage Habitat Enhancement Project. Since Joseph Creek represents only a small portion of the Columbia River Basin, a significant portion of Program Measure 704(d)(1) will remain to be completed at the conclusion of this project.

**PASSAGE IMPROVEMENT AND NATURAL PROPAGATION -
WASHINGTON**

YAKIMA RIVER BASIN FISH PASSAGE IMPROVEMENTS

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Relationship to Program Measure: The goal of the 20 fish passage improvement projects under Program Measure 904(D) is to provide fish passage for adult salmon and steelhead over irrigation diversion **dams**, and to pass juvenile salmon and steelhead from irrigation canals back to the Yakima River.

Technical Results: The Yakima Passage Program began in 1983 and is approximately 50 percent complete. Completed facilities include Sunnyside screens and ladders, Wapato screens and West Branch ladder, Toppenish/Satus screens and ladders, and Horn Rapids screens and ladders.

Technical Review: The Yakima Passage Program is reviewed monthly by the Yakima Technical Workgroup, consisting of BPA, USBR, NPPC, YIN, NMFS, USFWS, BIA, WDF, WDG, WDOE, PP&L, and the Yakima Basin Irrigation Districts.

Evaluation of Effectiveness: The passage improvements are, and will be, evaluated upon completion of construction. When completed, the facilities are expected to increase the runs of anadromous fish from 2,000 to more than 20,000.

Degree of Program Measure Fulfillment: Upon completion in 1988, the passage program will have fulfilled Program Measure 904(D).

FISHERIES EVALUATION OF THE SUNNYSIDE CANAL FISH SCREENING FACILITY

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Program Measure Number: 904(d)

Relationship to Program Measure: The goal of this project under Program Measure 904(d) is to evaluate the effectiveness of fish screening facilities constructed in the irrigation canals of the Yakima River Basin. The construction of the fish screening facilities is part of the Northwest Power Planning Council's plan to enhance natural propagation of salmonids in the Columbia River Basin.

Technical Results: Fish are safely diverted from the Sunnyside Canal back to the Yakima River at the Sunnyside Fish Screening Facility. About 4,000 chinook salmon, Oncorhynchus tshawytscha, and 2,000 steelhead, Salmo gairdneri, smolts were released in front of or within the Sunnyside Screen Facility. We caught 3,625 chinook salmon, and less than 2 percent were descaled or dead. We caught 507 of the steelhead, and none were descaled or dead.

Technical Review: The Sunnyside Screen Facility is in the Sunnyside Canal, about 360 m downstream of the Sunnyside Dam on the Yakima River (river kilometer 167). The screening facility diverts fish that have entered the canal back into the Yakima River. Descaling and mortality data were gathered by releasing branded fish into the canal upstream of the facility, and capturing them before they returned to the river. Captured fish were anesthetized and examined for descaling that occurred during passage through the screening facility.

Evaluation of Effectiveness: Anadromous salmonids are probably the most significant fisheries resource of the Yakima River Basin. Dams on the main stem Columbia River and overutilization of the water resources in the Yakima River Basin have reduced annual salmonid runs of 500,000 to 600,000 fish to about 2,000 fish. Overutilization of water resources in the Yakima River Basin results in inadequate flows for up- and downstream migration of fish. The construction of fish passage and protection facilities at existing irrigation structures will enhance anadromous fish production in the Yakima River Basin. The evaluation of the fish screening facilities is limited to the program designed to correct passage problems at existing irrigation facilities.

Degree of Program Measure Fulfillment: The evaluation of the Sunnyside Fish Screening Facility is complete. Other screening facilities will have to be evaluated as they are constructed.

TEMPORARY FISH PASSAGE ON UPPER TOPPENISH CREEK

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Program Measure Number: 904(d)(4)(K)

Relationship to Program Measure: Toppenish Creek is a tributary to the Yakima River. As with many of the streams in the Yakima Basin, an irrigation diversion structure was constructed in the early 1900s. While this diversion dam is not high, a 7-foot differential exists between the crest and apron. The barrier is submerged at flows greater than about 1200 cfs. When peak flows are less than about 1000 cfs, the 45" angle on the downstream face of the dam creates a sheet flow and a hydraulic jump (roller) which prevent fish from moving past the dam.

Technical Results: Model design and construction commenced in May 1985, with testing beginning in September. Two designs were tested: the first one, a V-shaped tailwater control structure with a pool and weir fishway along the left bank, and the second, a pool and weir fishway extended over the crest of the dam. The initial design of the tailwater control, V-shaped structure, would have caused extensive erosion downstream of the right bank dam abutment. This problem was eliminated by moving the V-structure downstream. The weir and pool fishway extending up over the face of the dam created two major problems. At lower discharges, the water flowing over the dam was very shallow, and would not send enough flow through the fishway for passage. The extended fishway partially reduced the spillway capacity, which caused more flow down the right side of the channel, and resulted in accelerated scour along the right bank. During final tests different combinations of structural component elevations and placements were tested to determine the best arrangement. Installation of the prototype fishway constructed of rock-filled gabion wire baskets began on November 7, 1985 and was completed on December 12, 1985. The weather created a few operational problems, but the project was completed before additional snow fell and before any floods occurred.

Technical Review: The final design of the prototype structure was discussed on site with personnel from the Yakima Tribe Fisheries Section, Corps of Engineers, Wapato Irrigation District, Bureau of Reclamation, and the NPPC. All these people expressed a desire to view the installation during high flows.

Evaluation of Effectiveness: The effectiveness of this project will be measured when the winter-spring high flows and steelhead upstream migration begin. Evaluation of the hydraulic performance of the structure will be made over the entire range of flows occurring this spring. Our monitoring program is set up with an on-site resident Tribal member so that we can quantify the number of fish using the structure. Discharge will be monitored.

Degree of Program Measure Fulfillment: This research project was designed to test the applicability of this passage technique which amounts to modification of the hydraulic characteristics of the structure, rather than building the proposed concrete slotted fishway on the opposite bank. This project used some of the results from Project 82-14 in developing the passage design and dam modifications. After observing the structure in operation over a wide range of flows, we will make any modifications necessary to improve structural performance. This structure should provide passage for at least 20 years at a cost of about \$20,000 to \$30,000.

DEVELOPMENT OF NEW CONCEPTS IN FISH LADDER DESIGN

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Program Measure Number: 604

Relationship to Program Measure: This project was initiated in 1982 prior to the development of the NPPC Fish and Wildlife Program. It does fit in Measure 600 on Upstream Migration, but has broad application. One project objective was to increase the economic, fish-passage, and water-use efficiencies of fishways which support a number of the measures.

Technical Results: A new fish ladder design, using a weir-baffle-pool system, was developed, tested and applied. In addition the following tasks were accomplished: an assessment of the historical development of fishway designs; studies of the fluid mechanics of waterfall and weir jets, their air entrainment, and the formation of standing waves by air bubbles which assist fish leaping; the development of baffles to dissipate flow energy and thereby reduce the size of fish-ladder chambers (the baffles were found to be significant also in guiding fish and improving their leaping success; preliminary tests of a new chute fishway with roughness elements only on the floor, which holds promise; an analytical model to compare the energy expenditure of fish passing through fishway ports, up an inclined chute, and over weirs; a mathematical model of the requirements for successful fishway attraction flows was developed and verified; the relationships among stimulus, response and stress in fish passage structures was addressed; new materials were examined for cost savings through modular construction; a classification system was produced for analyzing barriers to upstream migration (waterfalls, chutes and culverts); a systems analysis approach was used to interrelate river, fishway, and fish subsystems in a bioengineering perspective; a projectile analysis of fish leaping in water and air was completed, which explains why steelhead can leap 14 feet; and prototype tests of the new fish ladder design were conducted at a fish hatchery using chum and coho subjects. Since completion of the project, two prototype fish ladders have been constructed at an initial savings of about 5200,000.

Technical Review This was accomplished throughout the project by: (1) an international design survey and subsequent communications with respondees, (2) interviews with engineers and biologists, and (3) visitations to our Hydraulics Laboratory and field sites by colleagues. Our most inspirational moments came when we were told, "You are wasting your time, because fish won't leap except as a last resort!"

Evaluation of Effectiveness: The full effect of this project has not been felt due to the short time for feedback. But, as mentioned above, \$200,000 of savings have been realized already.

Degree of Program Measure Fulfillment: About 80 percent of the project objectives have been achieved. Due to a construction error unassociated with the research project, our laboratory trout were lost. Also, flow conditions in the Washougal River were such that we could not use the hatchery ladder facilities to test the new designs with chinook and a larger coho stock. There are still several series of tests to be run in the laboratory and in the field on the new weir-baffle-pool fish ladder and the new chute fishway, utilizing various sizes and species of salmon, steelhead, and other trout, to complete the spectrum of design data.

YAKIMA RIVER SPRING CHINOOK ENHANCEMENT STUDY

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BPA Project Number: 82-16
Program Measure Number: Non-Measure

Relationship to Program Measure: The Yakima Indian Nation was contacted by BPA in 1982 to evaluate hatchery supplementation techniques that can be used to increase runs of naturally produced spring chinook in the Yakima River. This project was initiated before adoption of the Fish and Wildlife Program, but is concerned with determining the best methods of introducing hatchery fish to rebuild naturally spawning stocks. The approach taken is twofold: (1) To determine the distribution, abundance, and survival of native Yakima River spring chinook. By determining the life history of these stocks the negative effects of introductions of hatchery fish can be minimized. (2) To determine the relative effectiveness of different methods of hatchery supplementation.

Technical Results: A total of six spring chinook redds were successfully capped in 1985. The mean survival to emergence was 62.5 percent and ranged from 29.3 percent to 84.8 percent. The survival from egg to smolt was calculated using the 1981, 1982, and 1983 redd counts and the 1983, 1984, 1985 smolt outmigration at Prosser. The estimated survival was 6.4 percent, 4.7 percent, and 4.4 percent for 1981, 1982, and 1983 brood years. Monthly beach seining indicated a general downstream movement of fry soon after emergence in both the Yakima and Naches Rivers. Few fish reared in the lower river during the summer due to excessive temperatures.

The 1985 smolt outmigration was monitored at Wapatox on the Naches River and Prosser on the lower Yakima. The spring outmigration at Wapatox was estimated to be 41,511 smolts. A fall outmigration of 59,459 pre-smolts was estimated to pass Wapatox in October and November. A total outmigration of 82,567 spring chinook smolts was estimated to pass Prosser in 1985.

There were 3,783 adult spring chinook and 423 jacks for a total return of 4,206 counted at Prosser Dam in 1985. The survival from smolt to adult was calculated as 2.5 percent from the 1983 smolt outmigration and the 1984 jack return and 1985 adult return.

Hatchery groups being tested are (1) smolts trucked from Leavenworth NFH and released directly to the river, (2) smolts released from acclimation ponds, (3) fingerlings released in June, September, and November, (4) wild brood stocks, and (5) wild/hatchery hybrid brood stocks.

Technical Review: Proposed projects are reviewed by fisheries biologists on YIN staff. and independent consultants have been employed to assist in the design of the statistical procedures for estimating smolt outmigration.

Evaluation of Effectiveness: All hatchery supplementation groups are evaluated for fresh water survival and as returning adults in this multiyear project. All spring chinook released are coded wire tagged and 10 percent are cold branded. Freshwater survival of each release group is determined by use of the Prosser downstream migrant trap, and returning adults are counted at Prosser and Roza Dams. In addition, extensive spawning ground surveys take place. and tags are recovered from carcasses, as well as from various fisheries. Survival rates of various release groups will be compared to determine the best method of enhancement.

**HABITAT ENHANCEMENT AND PASSAGE IMPROVEMENT -
OREGON II**

CLACKAMAS/HOOD RIVER HABITAT ENHANCEMENT

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BPA Project Number: 84-11
Program Measure Number: 704(d)(1)

Relationship to Program Measure: This project is habitat rehabilitation and passage restoration conducted under Program Measure 704(d)(1).

Fish and Wildlife Program work is being done on the Clackamas, Hood River, and Fifteenmile Creek systems. It is complemented by projects funded from a variety of Forest Service funding sources. Emphasis species are spring chinook, coho, and winter steelhead. Project work is primarily focused on increasing the quantity and quality of available rearing habitat, and improving access at passage barriers. The primary goal of all project work is to maximize the capability of accessible habitat for the natural production of salmon and steelhead trout. Development of a comprehensive monitoring and evaluation program for Forest-wide fish habitat improvement work has received particular emphasis in the past year. Coupled with an annual post-project critique process, improved learning and project efficiency are increasingly apparent in the Forest program.

Technical Results: Eight projects were conducted in 1985. Three projects were designed to increase rearing habitat capability. A total of 2,655 m² of improved rearing habitat was created. This involved: creation of two side channels (1,600 lineal feet), installation of 60 structures for cover and pool development, excavation of two prototype alcoves, and development of one off-channel rearing pond.

Three projects were associated with improved fish passage. Two projects were planned and implemented, resulting in 4.9 miles of additional habitat. One project, Collawash Falls, involved completion of a feasibility study and environmental assessment. This project will improve access to more than seven miles of exceptional habitat for anadromous fish.

Two projects involved pre-project analysis and planning. Major efforts centered on characterization of habitat, water quality, and fish populations in the Fifteenmile Creek basin of the Mt. Hood National Forest. This will provide an information base for the development of a basin-wide enhancement schedule in cooperation with the Oregon Department of Fish and Wildlife.

Technical Review: All are subject to annual pre-project design reviews, periodic field reviews, and annual post-project field review and critiques. In addition to these reviews, all projects are closely coordinated with Oregon Department of Fish and Wildlife personnel and Confederated Tribes of the Warm Springs fisheries personnel on projects involving ceded lands.

Evaluation of Effectiveness: A comprehensive monitoring/evaluation program was implemented in 1985. The program ensures pre- and post-program analysis of all fish habitat improvement projects. One of three data gathering intensities is selected and implemented on each project. The base and medium intensities concentrate on site-specific effects, while the highest intensity, represented by the Fish Creek Evaluation, focuses on evaluating multiyear results of draining wide enhancement work. The Fish Creek evaluation is a cooperatively funded effort between BPA and USDA Forest Service conducted by PNW Experiment Station. Integration of the evaluation findings into project planning and implementation has substantially improved the focus of ongoing enhancement work.

Degree of Program Measure Fulfillment: The work completed under this contract is the third year of fish habitat improvements scheduled for Clackamas, Hood River, and Fifteenmile Creek basins. The Mt. Hood National Forest is implementing these habitat projects utilizing both BPA and appropriated funds, as available.

JOHN DAY RIVER HABITAT ENHANCEMENT

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BPA Project Officer: Larry Everson
BPA Project Number. 84-21
Program Measure Number: 704(d)(1) (July 1, 1985-March 31, 1986)

Relationship to Program Measure: The John Day River Habitat Improvement Project [704(d)(1)] is improving **spawning and rearing habitat for spring chinook** salmon and summer steelhead trout in the John Day River located on private lands. The program is funded by BPA.

The John Day River system supports the largest remaining totally wild runs of spring chinook and summer steelhead in Northeast Oregon. An absence of rearing pools, large structure, and riparian vegetation are partially responsible for a scarcity of quality spawning, rearing, and overwintering habitat. As a result, habitat capability, smolt production, and adults returning are below the potential carrying capacity for anadromous fish in this basin. Habitat work was implemented in 1985 on the mainstem John Day River in three locations and on two tributaries of the North Fork system, Fox Creek and Deer Creek.

Technical Results: Work completed in 1985 on the mainstem consisted of excavating two side channels totally 753 feet to increase rearing and overwintering habitat. We constructed 146 rock jetties to increase pool area for rearing. We placed 751 boulders to provide additional rearing and holding areas. Two rock weirs were constructed to provide juvenile rearing and adult holding pools. A total of 1,725 feet of rock riprap was placed in 9 locations for bank stabilization and riparian recovery and for some instream structure. Several pieces of woody debris were positioned within the jetties and riprap as an experimental component in this year's project, to monitor them throughout the winter. Several logs were cabled in along the banks for cover and to monitor them for icing effects. One on-channel water gap and one off-channel water source were developed for livestock watering. One livestock/equipment gate crossing was placed in the riparian fence. A total of 1.7 miles of five-strand barbed wire riparian exclusion fence was constructed. Approximately one mile of stream bank was seeded with a grass-seed mixture containing several species of indigenous grasses.

Work completed on Fox Creek consisted of constructing 3.0 miles of five-strand barbed wire riparian exclusion fence and 2.4 miles of four-strand electric riparian exclusion fence. Three water gaps were constructed and one spring development was partially completed.

Work completed on Deer Creek consisted of constructing 13 miles of four-strand electric riparian/pasture fence. Within this fence a total riparian enclosure electric fence was constructed for 500 feet per side and 20 feet perpendicular from the channel for plant community growth and development to assess the riparian community regeneration within the enclosure versus the riparian/pasture area outside of the total enclosure area.

Technical Review: The project was reviewed by biologists of Oregon Department of Fish and Wildlife. The Grant County Soil and Water Conservation District is a subcontractor of the ODFW to assist in the design and implementation of instream structures, riparian plantings, riparian monitoring, and landowner contacts.

Evaluation of Effectiveness Working with private landowners to **gain** access to these valuable resources has been an excellent cooperative agreement for the landowner, state, and federal agencies involved to mutually benefit agricultural, fisheries, and watershed management objectives. **According to** USFS, North Fork **of the** John Day River Sub-Basin Anadromous Fish Habitat Improvement Environmental **Assessment No. 2630** (September 1984, Umatilla National Forest), instream structures placed in the mainstem will produce 7,171 chinook smolts, 107.56 adults, and 2,796 steelhead smolts, 111.60 adults.

Degree of Program Measure Fulfillment: This was the second year of the multiyear John Day River Habitat Improvement Program. Work not completed on the mainstem consists of building 3.0 miles of five-strand barbed wire riparian fence. We have 12.6 miles of five-strand barbed wire riparian fence to build and three spring developments to construct on Fox Creek.

NORTH FORK JOHN DAY SUB-BASIN HABITAT IMPROVEMENT

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BPA Project Number: 84-8
Program Measure Number: 704(d)(1)

Relationship to Program Measure: This project, which responds to Program Measure **704(d)(1)** Table 2, will improve off-site anadromous fish habitat on streams in the North Fork John Day Sub-Basin.

Technical Results: Personnel from the Umatilla National Forest completed all construction work planned for 1985. Work on the North Fork John Day River consisted of opening 6 side channels, constructing 2 alcove or blind channels, constructing 16 side channel and 22 main stem rock weirs, placing 6 rock deflectors at side channel entrances for flow control, constructing 17 rock deflectors to direct flow in side channels, planting 8 shrubs and 182 cuttings, and placing 283 large boulders and 35 logs in side channels and in the main river to provide instream cover.

Work on Desolation Creek last year created an estimated 18,664 square feet of rearing pool habitat by constructing 52 rock weirs, 1 adult holding pool, and 5 alcove or blind channels in 0.8 miles of Desolation Creek. In addition, 0.3 miles of side channel were constructed, 97 boulders and 11 logs were placed in the stream, and 18 cottonwood cuttings were planted to provide shade and improve juvenile anadromous fish rearing habitat.

A detailed stream survey of anadromous fish habitat covering 70.5 miles of stream in the lower North Fork John Day Sub-Basin was completed, and an anadromous fish habitat improvement project planned for Wilson Creek.

An environmental assessment that discusses anadromous fish habitat improvement within the Umatilla Sub-Basin was completed during the spring of 1985. This report was prepared with interdisciplinary input from soils, watershed, and wildlife specialists as well as participation by Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and Oregon Department of Fish and Wildlife (ODFW).

Evaluation of Effectiveness: Effectiveness will be determined by how well the project reduces the factors that limit fish production. It is anticipated that the project will provide an increase in survival of spring and summer steelhead from egg to smolt within the project area. Monitoring of project results is being coordinated with the Oregon Department of Fish and Wildlife.

Degree of Program Measure Fulfillment: The North Fork John Day Side Channel portion of the project is approximately 70 percent complete. Activities planned for the 1986 field season should complete another 20 percent of the project. The Granite and Clear Creeks portions of the project are essentially complete.

HOOD RIVER FISH PASSAGE

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BPA Project Number: 83-341
Program Measure Number. 704(d)(1)

Relationship to Program Measure: The Hood River Fish Passage Project [Program Measure 704(d)(1)] is restoring summer steelhead and spring chinook access to more than 23 miles of spawning and rearing habitat in the upper reaches of the West Fork Hood River. The project of providing fish passage over Moving Falls is administered by ODFW and funded by BPA.

West Fork Hood River and its major tributary, Lake Branch Creek, are the most important producers of anadromous fish in the Hood River Basin. Within the last 10 to 15 years hydraulic cutting created a migrating water falls that had reached a height of approximately 15 feet and all but stopped all fish migration in the West Fork Hood River above river mile 3.0.

Technical Results: In 1985, the third year of this project, contractors completed construction of 12 weirs across the West Fork that effectively laddered the former Moving Falls. Construction activities included the use of more than 110,000 pounds of steel reinforcing rod and 700 cubic yards of concrete.

Technical Review: The project plans were developed by Oregon Department of Fish and Wildlife engineers. Department engineering personnel supervised all construction activities.

Evaluation of Effectiveness: Adult steelhead were observed moving upstream over the completed structure within hours of the initial water-up. overall project effectiveness will be best determined during future spawning ground surveys in the upper watershed. Correction of this migration barrier should allow full utilization of the system by an estimated potential of 2,000 adult summer steelhead and several hundred spring chinook.

Degree of Program Measure Fulfillment: This was the third year of the Hood River Fish Passage Project. Even though this project is now complete, a significant portion of Program measure 704(d)(1) remains to be completed in the Columbia River Basin.

FUTURE HYDROELECTRIC ASSESSMENTS

**METHODOLOGIES FOR ASSESSING CUMULATIVE EFFECTS
OF HYDROELECTRIC DEVELOPMENT
ON FISH AND WILDLIFE IN THE COLUMBIA RIVER BASIN**

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BPA Project Number: 84-41
Program Measure Number: 1204(b)(2)

Relationship to Program Measure: The goal of this project under Measure 1204(b)(2) is to develop criteria and methods for assessing cumulative effects of hydroelectric development on fish and wildlife. These methodologies will assist federal processes for review and authorization of hydroelectric projects.

Technical Results: Key fish and wildlife and habitats which could potentially be affected in a cumulative manner by hydroelectric development were identified. Cumulative effects of hydroelectric development on fish **and** wildlife were described and ranked according to importance and significance. Cumulative interactions between hydroelectric development and other development actions in the Basin were identified. Over 200 inquiries to other agencies identified only a few cumulative assessment techniques or methodologies. These 8 assessment techniques and I I potential cumulative effects assessment methodologies were described and evaluated for application to the Columbia River Basin. Both Adaptive Environmental Assessment Methods (AEAM) and matrix tables were judged the better methods. A new methodology which combined the best parts of these two methods was developed and recommended for application.

Technical Review This project was coordinated with the Hydropower Assessment Steering Committee of the Northwest Power Planning Council. The results have been presented to the Committee, and they have reviewed the draft task reports. Other agencies and individuals with experience in cumulative effects assessment have also reviewed the documents.

Evaluation of Effectiveness: As a result of this work, agencies and tribes are much closer to having a satisfactory cumulative assessment methodology. This project has led to a much **better understanding of cumulative effects.** Early stages of this work influenced the improvement of techniques used by the Federal Energy Regulatory Commission in the application of the Clustered Impact Assessment Procedure for evaluating small hydroelectric projects in the Basin.

Degree of Program Measure Fulfillment: This work resulted in the recommendation of a cumulative effects assessment methodology. Before the methodology can be generally applied, it must be shown to be effective. Work remaining includes a “bench test” of the methodology, development of guidelines for application of the methodology, and a test application of the methodology to some parts of the Basin.

**PACIFIC NORTHWEST RIVERS STUDY -
PROTECTED AREAS METHODOLOGY
AND HYDROELECTRIC POWER SUPPLY FORECASTING**

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BPA Project Number: 84-40
Program Measure Number: 1204(c)(1)
Conservation and Electric Power Plan Action -Items 14.2 and 14.3

Relationship to Program Measure: The **goal** of the Pacific Northwest Rivers Study (as the major component of the Northwest Power Planning Council's Hydro Assessment Study) is to provide a basis for orderly hydropower development consistent with protection of critical fish and wildlife habitat and conservation of other valuable river resources. Results of the Rivers Study will provide a basis for:

- (1) Protected Areas: When combined with the results of the anadromous fish assessment and an examination of the region's hydropower potential, this information will enable the Council to designate Protected Areas [Fish and Wildlife Program Section 1204(c)].
- (2) Energy Supply Forecasting: Rivers Study results will increase the accuracy of regional hydropower **supply** forecasts through the identification of potential institutional and environmental constraints.
- (3) Hydropower Site Ranking The results of the Rivers Study will be used to refine an interim site ranking completed by the region's resource agencies in 1985 (Power Plan Action Item 14.2).

Technical Results: BPA awarded nine contracts to initiate the Rivers Study at the beginning of Fiscal Year 1985. During FY 1985, the study progressed from identifying the resource categories to be assessed through an inventory of existing information and the development of evaluation criteria and standards (assessment guidelines). The bulk of the year was spent by resource experts evaluating individual resource categories (resident fish, wildlife, natural features, cultural features, recreation, and institutional constraints). The process was a **cooperative effort between state, federal, Indian tribal, and user group resource** experts. Draft resource valuations were completed at the end of November 1985. The remainder of the project includes packaging, review, data base development, and applications.

Technical Review: Verification and review of study results have been accomplished throughout the project due to the nature of the cooperative resource assessment process. Additional participant review will occur during the spring of 1986.

Evaluation of Effectiveness: The Rivers Study itself does not **deal** with anadromous fish. However, results from the Council-sponsored anadromous fish assessment will be combined with Rivers Study results on the value of streams for resident fish, wildlife and other environmental values to set aside certain areas from all future hydro development (Protected Areas).

Degree of Program Measure Fulfillment: Once the data from the Rivers Study, the anadromous fish assessment, and the hydro site data base have been packaged, the Council will have the information necessary to designate Protected Areas [Measure 1204(c)(2)].

**AN EVALUATION OF THE CONTRIBUTION OF CHINOOK SALMON
REARED AT COLUMBIA RIVER HATCHERIES
TO THE PACIFIC SALMON FISHERIES**

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BPA Project Number: 79-2
Program Measure Number: Non-Measure

Relationship to Program Measure: This project does not directly address a Fish and Wildlife program measures but does provide information relevant to Program Measures 504 and 704. The results from this project will provide a basis for improved propagation of fall chinook at existing facilities [704(h)], provide data to determine the effectiveness of hatcheries constructed as mitigation for hydroelectric developments, and provide guidelines for assessing the contribution of hatcheries and low-capital propagation facilities constructed under the Program [704(i), -(j)]. In addition, data from this project are important to state harvest management agencies and regulatory bodies, such as the Pacific Fishery Management Council, which establish escapement objectives [504(a)], regulate harvest [504(b)], and examine mixed-stock fisheries [504(c)].

This project is a cooperative effort among the Washington Department of Fisheries (WDF), Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and Bonneville Power Administration (BPA). The fishery agencies jointly developed the project objectives and study design.

Technical Results: Fall chinook from brood years 1978 through 1981 were tagged at 18 to 20 facilities on the Columbia River System. Nearly 14 million tagged and 335 million untagged fall chinook were released from 1979 to 1982. Catches of these fish began occurring in 1980 and will continue through 1986. Final catch data are available through 1983 for most of the major fisheries on the Pacific Coast. Four years of final catch data are available for analysis of the 1978 brood, and three years of data are available for the 1979 brood.

It is evident that the contribution of the 1979-brood fish to the Pacific Coast fisheries is larger than that for the 1978 brood. Contributions per 1,000 fish released for all hatcheries combined are 2.7 for the 1978 brood and 3.6 for the 1979 brood. Fishery contributions among hatcheries within the same brood year vary substantially. Spring Creek Hatchery has the greatest contribution to the fisheries at 8.3 and 12.8 fish per 1,000 fish released for the 1978 and 1979 broods, respectively. The Spring Creek contribution is followed by Stayton Pond, Abernathy, Bonneville, and Big Creek at 6.5, 4.2, 2.9, and 2.6 fish per 1,000 releases for the 1978 brood. Contributions for the 1979 brood are 8.4, 6.7, and 4.7 for Big Creek, Stayton Pond, and Abernathy, respectively. Other facilities had contribution of 2 fish or less per 1,000 releases. These contributions are minimums, since final data for all possible catch years and fisheries are not yet available.

Technical Review: The study design and results are technically reviewed by staff from WDF, ODFW, USFWS, and NMFS.

Evaluation of Effectiveness: Data from this study are already stimulating research projects to improve the propagation of fall chinook at WDF facilities.

Degree of Program Measure Fulfillment: When completed, this non-measure project will have determined the distribution, contribution, **and** value of the fall chinook production from each rearing facility on the Columbia River to the Pacific Coast salmon fisheries. It will also have determined the contribution of hatchery fall chinook from the Columbia River to individual Pacific salmon fisheries by age class of fish.

DEVELOPMENT OF RATIONS FOR THE ENHANCED SURVIVAL OF SALMON

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BPA Project Number: 83-363
Program Measure Number: 704(h)(2)

Relationship to Program Measure: The goal of this project under Program Measure 704(h)(2) is to establish the influence of feed regimes composed of high quality vacuum-dried fish protein on the hatchery production efficiency and the survival of coho and chinook salmon to the Columbia River system.

Technical Results: The rearing phase of the second brood-year replicate of hatchery-scale survival investigations was completed with coho salmon at the Oregon Department of Fish and Wildlife Sandy Hatchery and with fall chinook salmon at their Bonneville Hatchery. Duplicate ponds of 1983-brood coho (Sandy stock) of 58,000+ fiih each were reared from June 1, 1984 to release on April 30, 1985 on a control ration (Oregon pellet) and test rations containing major protein complements derived from vacuum-dried salmon carcasses and Pacific hake both supplemented- with vacuum-concentrated hydrolyzed and bone-free fish. Between 25-28,000 coded wire-tagged (10/14-19/84) fiih were released from each pond. Single ponds of 1984-brood fall chinook (tule stock) of about 600,000 fish were reared on a control ration (Oregon pellet) and a test ration containing a major protein complement derived from vacuum-dried salmon meal and supplemented with vacuum-concentrated hydrolyzed and bone-free fish from December 28, 1984 to January 31, 1985. Control and test fiih ponds were split into duplicates, and fish were reared to May 13, 1985. Between 82-83,000 coded wire tagged (4/14-18/85) fiih were released from each pond. The rearing **phase** of the third replicate brood-year of coho salmon was initiated at the Oregon Department of Fish and Wildlife hatchery. Feeding was initiated on June 1, 1985, and around 28,000 fiih per pond were coded wire tagged (10/1 1-22/85). A May 1, 1986 release date is anticipated.

Technical Review: The design of the hatchery-scale survival tests has been technically reviewed by Oregon Department of Fish and Wildlife staff.

Evaluation of Effectiveness: The effectiveness of this project will be determined by the degree to which rations containing high-quality fish protein complements will enhance survival of Columbia River stocks of salmon in a cost-effective manner. Results will provide guidelines for formulating feeding procedures applicable to other hatchery ration systems.

Degree of Program Measure Fulfillment: Improvement of hatchery husbandry for efficiency and survival of released fiih is a broad program measure, of which nutrition is a key facet. Development of sources of high quality protein and their introduction into commercial ration systems would demonstrate that survival can be enhanced by high quality test rations.

PEN REARING AND IMPRINTING OF FALL CHINOOK SALMON

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BPA Project Number: 83-313
Program Measure Number: 404(c)(2), 704(j)(1), and 704(i)(2)

Relationship to Program Measure: Construction of John Day Dam destroyed spawning and nursery habitat for upriver bright fall chinook salmon. Pen rearing studies are evaluating the use of temporary, low-cost facilities for off-station rearing of hatchery-produced, age-0 fall chinook salmon to enhance upriver bright chinook runs to the mid-Columbia River Basin [704(j)(1)]. The temporary rearing of fish at points of release may improve survival of juveniles and subsequent homing of adults to upriver release sites [404(c)(2), 704(i)(2)].

Technical Results Rearing strategies developed during 1984 trials were used in 1985 to rear and release fiih at two off-station sites in John Day Reservoir. Coded-wire-tagged groups of fiih were reared for three to seven weeks in April, May, and June in net pens and a large barrier net. Mortality of fed fiih reared in pens was low, and physiological development surpassed that observed in hatchery fish. Growth of groups reared for five weeks was better than for hatchery fish, but growth of groups reared for three weeks was similar to, or slightly less than, the hatchery. Unfed fish reared in a large barrier net grew poorly and suffered high mortality over a seven-week period.

Technical Review: A summary review of the pen rearing project was presented to a peer panel for their evaluation in August 1985. Additional comments and input have been solicited from private, as well as state and federal agency biologists throughout the study.

Evaioation of Effectiveness: Survival and homing of upriver bright fall chinook salmon may be improved by rearing the fiih at intended release sites, rather than transporting them from the hatchery for immediate release. Increased adult returns of upriver bright fall chinook salmon would partially mitigate losses of natural runs which were destroyed by John Day Reservoir.

Degree of Program Measure Fulfillment: Rearing strategies developed during the present studies should be evaluated on a management basis if benefit/cost of rearing fish using these methodologies appears favorable. Additional rearing scenarios, as well as other species, remain to be tested.

WILLAMETTE SPRING CHINOOK STUDY PLAN

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BPA Project Number: 85-68
Program Measure Number: 704(k)(2)

Relationship to Program Measure: Measure 704(k)(2) directs development of a plan of study to determine the best method of supplementing natural stocks of spring chinook with hatchery stocks in the Willamette River. We have completed Phase 1 of this requirement through publication of “Outplanting Anadromous Salmonids - A Literature Review,” a report which surveyed the available literature related to “supplementation.” answered specific questions asked by the Artificial Propagation Panel related to Willamette spring chinook, and proposes as Phase 2 a field study which will evaluate efficiency of outplanting hatchery stocks of Willamette spring chinook.

Technical Results: Few hatchery supplementation operations have been adequately evaluated. Published references indicate that introducing stocks of hatchery fish will supplant rather than supplement wild fish, thus degrading gene pools. **We** conclude that outplanting should not be practiced in streams where maintenance of wild stocks is a concern.

Technical Review The Phase 1 literature survey was based on a review of more than 200 publications by fishery scientists. The Phase 2 project proposal was reviewed by ODFW biologists and statistical sensitivity analyses were provided by ODFW’s biometrician.

Evaluation of Effectiveness: The Phase 1 literature review indicated that outplanting hatchery fish will not protect or enhance production of wild fish. However, when applied to habitats that are currently barren of anadromous fish or to hatchery-impacted streams, outplanting may have substantial mitigative potential. The Phase 2 field study will evaluate outplanting of unfed fry, presmolts, and gravid adults into Willamette Basin tributaries and quantify results in terms of increase in adult return.

Degree of Program Measure Fulfillment: The Phase 1 literature review and study plan development is complete. Phase 2, if pursued, will determine if outplanting fish from hatcheries is an effective mitigation tool, and not a “supplementation” effort as 704(k)(2) envisioned as a method of enhancing production of wild fish.

CABINET GORGE HATCHERY DESIGN AND CONSTRUCTION

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Program Measure Number: 804(e)(5)

Relationship to Program Measure: This project entails the design and construction of the Cabinet Gorge Kokanee Hatchery. The purpose of the hatchery is to restore a reasonable level of Kokanee salmon in Lake Pend Oreille, taking into account the extent to which both hydroelectric development and other factors have contributed to the decline of the fish populations. The specific production goal of the facility is to release 20 million advanced-stage Kokanee fry annually into Lake Pend Oreille.

Technical Results: This project was authorized under a three-party agreement by Bonneville Power Administration, The Washington **Water** Power Company, and the Idaho Department of Fish and Game. Under the terms **of** this agreement, BPA and WWP each contributed \$1.1 million of capital construction funds, and IDFG will fund any capital construction costs over the \$2.2 million plus pay annual operation and maintenance costs.

The design of the hatchery was completed in September 1984, and bids for the facility (less residences) were opened in December 1984. The facility was deemed substantially complete on December 6, 1985, and the first shipment of water-hardened Kokanee eggs delivered the same day.

Technical Review: The conceptual design of the facility was accomplished by fisheries engineers and hatchery personnel of the IDFG with technical review by biologists of BPA and WWP. A consulting firm was selected to prepare contract documents and periodic cost estimates. The design and associated costs of the facility were reviewed at the 30 percent, 60 percent, and 90 percent stages by representatives of BPA, WWP, and IDFG.

Engineers from various fisheries agencies throughout the Northwest were consulted regarding the design of the fish ladder.

Evaluation of Effectiveness: Lake Pend Oreille Kokanee, being adfluvial in lieu of anadromous, will migrate from Lake Pend Oreille up the Clark Fork River to the hatchery's ladder in four to five years after release. With the 20 million advanced-stage fry release from the hatchery, it is anticipated that the historic level of 800,000 to 1,200,000 adult Kokanee harvest may again be realized. It is not expected that the hatchery will achieve its full production capacity for several years.

Degree of Program Measure Fulfillment: After final cleanup in March 1986, the program measure will be fulfilled.

**HABITAT ENHANCEMENT AND PASSAGE IMPROVEMENT -
IDAHO**

**HABITAT ENHANCEMENT OF LOLO AND CROOKED FORK CREEKS
(CLEARWATER RIVER, IDAHO)**

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Program Measure Number: 704(e)

Relationship to Program Measure: The goal of this project under Program Measure 704(e) was to provide passage for spring chinook salmon and summer steelhead to upstream spawning and rearing habitats by removing natural migration barriers-

Technical Results: During FY 1985, both barrier removal projects were completed. The projects were initiated in 1984 with the partial removal of four barriers in Eldorado Creek and seven barriers in Crooked Fork Creek. Forest Service crews working with portable rock drills and explosives altered natural waterfalls and rock outcrops so that adequate jumping and resting pools were created. Evaluation of the project indicated that additional work would be required in 1985 to enlarge and deepen the take-off pools. Because of the difficulty of working with basalt, the work in Eldorado Creek was contracted in 1985.

Evaluation of Effectiveness: Upon the completion of the 1985 work, the projects were evaluated for effectiveness. All the barriers were removed or altered in a manner that eliminated excessive jumps and created deep take-off pools and resting areas. Provision of passage in these Clearwater River tributaries will help mitigate the loss of habitat and production due to hydroelectric development in the basin. A total of 125 acres of rearing habitat and 4.0 acres of spawning habitat have been provided by this project. Upon the advent of adequate seeding, this habitat will produce a total of 51,000 chinook salmon and 39,500 steelhead trout smolts. This should help speed the recovery of upriver stocks in the Clearwater Basin.

Degree of Program Measure Fulfillment: Only one project - Colt Creek Barrier - remains to be completed under Program Measure 704(e).

SOUTH FORK CLEARWATER RIVER HABITAT ENHANCEMENT

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Program Measure Number: 704(d)(1)

Relationship to Program Measure: The goal of this project, under Program Measure 704(d)(1) - Habitat Improvement, is to increase smolt production of anadromous fish in the South Fork Clearwater River system. This goal is being accomplished by improving spawning and rearing habitat in tributaries to the South Fork.

Technical Results: During FY 1985 approximately one mile of Red River and two miles of Crooked River received initial treatments utilizing weirs, deflectors, boulder placement, cover structures, bank stabilization, side channel construction, and building a flood plain (Crooked River only). In the Crooked River, one mile of stream treated last year received additional placement of in-stream cover.

Technical Review Fish populations in the project areas are being monitored by Idaho Department of Fish and Game (under another BPA contract). Results will be available as a separate report from IDFG. Physical parameters are being monitored by the U.S. Forest Service Intermountain Research Station (under a subcontract with IDFG). Additional data on these streams are being collected by USFWS - FAO (Dworshak Fisheries Assistance Office), University of Idaho (**Cooperative** Fisheries Unit). An attempt will be made to bring all these entities together for an information exchange.

Evaluation of Effectiveness: Past grazing and mineral activities in the South Fork Clearwater River have greatly reduced its capability to produce fish. Major impacts resulting from placer mining are: stream channel alterations, sediment, removal of streamside vegetation, elimination of flood plain, and removal of gravel from the stream channel. Overgrazing has resulted in sediment, bank damage, and removal of vegetation. Project activities are designed to reverse these impacts. Increased production is anticipated through improved survival and increased availability of spawning and rearing habitat. Final evaluation of effectiveness will be based on monitoring programs in the project areas.

Degree of Program Measure Fulfillment: Once these projects are completed (1990). Red River and Crooked River should be approaching full production potential of anadromous smolts. There are other tributaries to the South Fork Clearwater River which have similar problems and should be treated. Tributaries such as Newsome Creek are currently being treated utilizing U.S. Forest Service funds. Others, like portions of American River and its tributaries, have been submitted to BPA as a joint proposal' by the BLM and USFS> Implementation of this project would put the South Fork system well on the way to full recovery.

CAMAS CREEK (MEYERS COVE) HABITAT ENHANCEMENT

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BPA Project Number. 84-23
Program Measure Number: 704(a)(1) Table 2

Relationship to Program Measure: The objectives associated with the Camas Creek (Meyers Cove area) habitat enhancement project [Program Measure 704(d)(1)] relate to improving wild propagation essential to the survival and vigor of genetically significant wild stocks of chinook salmon and steelhead trout in the Middle Fork of the Salmon River. The project consists of two separate, but interrelated, phases. The first is a feasibility and design evaluation of potential enhancement options applicable to the Meyers Cove area. This phase will be followed by an implementation phase, wherein enhancement options identified would be completed according to schedule. The project is a cooperative effort involving the U.S. Forest Service, Idaho Department of Fish and Game, and Bonneville Power Administration.

Camas Creek is a major tributary to the Middle Fork and provides habitat suitable to produce substantial numbers of both chinook salmon and steelhead trout. The Meyers Cove area contains a section of Camas Creek which has been impacted from past land-use activities. As a result, habitat capability and smolt production is below potential for both anadromous species.

Technical Results: Project activities in 1985 included final collection of stream channel stability information, final analysis of habitat information collected from past sampling dates, a review and evaluation of enhancement options most suitable to existing conditions, and a cost analysis associated with the enhancement options. Information and results derived from the project activities will be formulated into a habitat management action program which will guide future habitat management activities.

Technical Review Upon completion, the program document will be reviewed by appropriate personnel from both the U.S. Forest Service and the Idaho Department of Fish and Game. The Forest Service review will center on activity compliance with Forest Plan direction, manual direction, and multiple use resource management. The State review will address compliance with species management goals.

Evaluation of Effectiveness: Phase I of this enhancement project will provide the documentation necessary to develop future budget needs for implementation of enhancement options. It is anticipated that improvement in riparian and instream conditions would result in a substantial increase in smolt production capability from Meyers Cove area of Camas Creek.

Degree of Program Measure Fulfillment: This is the final year of Phase I of the Camas Creek Project (84-23). Upon completion of the enhancement program report, Phase I will be completed in full and the terms of agreement No. DE-AI79-84BP16063 will be satisfied. Completion of both phases of the Camas Creek project will result in a small portion of the Columbia River Basin Fish and Wildlife program being completed.

PANTHER CREEK, IDAHO HABITAT REHABILITATION

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Program Measure Number: 704(d)(I)

Relationship to Program Measure: This project is involved with Section 704(d)(1) of the Fish and Wildlife Program, which targets several streams within the Salmon River drainage for habitat enhancement projects. Panther Creek, cited as one of the target streams, has problems associated with mining, dredging and sedimentation. The Panther Creek Project is focused on eliminating contaminants entering Panther Creek (primarily copper and iron emanating from an adjacent mine operation), thereby enhancing its water quality and habitat characteristics. The ultimate goal of the project is to allow the reestablishment of viable runs of chinook salmon and steelhead trout into the Panther Creek drainage, a system which contains about 100 miles of usable habitat.

Technical Results: This project has included geological, hydrological, and biological field studies. In 1985, the sources and extent of contaminants emanating from the Blackbird Mine area were defined, and conceptual engineering alternatives formulated for abating the toxic effluent problem. Separate alternative abatement programs were identified for the Bucktail and Blackbird Creek drainages, with the alternatives organized into two main headings, those with treatment and those without. Construction cost estimates for the alternatives ranged from \$3.3 million (with a \$600K per year operation and maintenance cost) for the treatment **alternative** (Alternative 1B) to \$8.1 million (with a \$200K per year maintenance cost) for the most expensive non-treatment alternative. Present worth estimates for these alternatives range from \$10.3 to \$9.5 million respectively.

Quantitative habitat analyses were also computed on the seven streams within the Panther Creek drainage including: Panther Creek, Moyer Creek, Muskgrove Creek, Deep Creek, Clear Creek, Napias Creek, and Beaver Creek. Smolt production estimates were made based on available salmon and steelhead trout spawning and juvenile rearing habitat. Smolt production estimates ranged from 215,000 to 848,000 chinook, and from 36,000 to 173,000 steelhead. Adult returns were estimated **at** from 1,078 to 4,235 chinook and from 366 to 1,737 steelhead. These values result in a median estimated annual monetary value of from \$476,505 to \$1,260,974 for the two species combined; present worth values range from \$6,047,013 to \$13.032665.

Technical Review: A draft report of the results of the study was prepared and submitted to appropriate state and federal agencies and private companies for technical review and comment. In addition, this project has included several coordination meetings during which the status of the project was reviewed and questions and recommendations entertained.

Evaluation of Effectiveness: This project has involved the identification and conceptual design of remedial measures aimed at eliminating toxic conditions in Panther Creek. The effectiveness of such measures can only be evaluated after they are implemented and appropriate monitoring programs have been initiated.

Degree of Program Measure Fulfillment: Once this project is completed, there will remain several steps before the Panther Creek drainage can be brought back to production. These include the identification of funding sources necessary for implementing/constructing the remedial measures, implementing the measures, monitoring of the measures for effectiveness, and the phased reintroduction of salmon and steelhead into the drainage.

HABITAT ENHANCEMENT - MIDDLE FORK AND UPPER SALMON RIVER, IDAHO

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Program Measure Number: 704(d)(1), Table 3, L, N, S, T

Relationship to Program Measure: Results from Phase I (aerial photography of the project area completed in 1984) of the Middle Fork and Upper Salmon Rivers enhancement project [Program Measure 704(d)(1)] were used extensively in 1985 to complete an inventory of riparian and aquatic habitat conditions (Phase II) of the project area. Inventory data will be analyzed to identify habitat problems and justify habitat enhancement recommendations (Phase III). The ultimate objective of the project is to provide increased summer steelhead (A strain) and spring and summer chinook salmon smolt production as off-site mitigation for losses occurring downstream in the Columbia River Basin hydroelectric system. The project is jointly funded by the Forest Service (FS) and BPA. The Idaho Department of Fish and Game and Shoshone-Bannock Tribes (S-BT) have provided extensive technical assistance.

Technical Results: As part of the intensive inventory, approximately 4,000 transects were completed (to characterize aquatic habitat) and 500 miles of riparian plant communities identified, with associated streambanks classified as stable, depositional, or cut/slough. Inventory data will be used to evaluate several hypotheses, including: (1) Streambank stability varies by riparian community type; (2) grazing use affects streambank stability within community types; (3) streambanks' stability affects the quality of spawning and rearing habitats; and (4) land use affects the quality of spawning and rearing habitats. On the basis of this analysis and field observations, factors limiting spawning and rearing habitat extent and success will be identified, and proposed treatments prioritized. Cost estimates for enhancement opportunities will also be developed.

Technical Review: Inventory methods and data analysis objectives were developed cooperatively by a "technical advisory committee" composed of FS, IDFG, S-BT, and BPA biologists. FS hydrologists, soil scientists, and range conservationists provided additional technical review. Independent consultants with recognized expertise in their fields were employed to conduct the inventory and data analysis.

Evaluation of Effectiveness: The streams within the project area contain vast habitats for the potential spawning and rearing of summer steelhead (A strain) and spring and summer chinook salmon. Some of this habitat is presently not usable because of irrigation water withdrawals and natural passage blocks. Other components of this habitat are thought to have reduced production potential because of impacts associated with livestock grazing, timber harvest, road building, and mining activities. Until data analysis is complete and recommendations are made for enhancement activities that address habitat features limiting anadromous fish production, it is impossible to forecast how many more smolts and adult fish this project will produce. Escapement and production data being collected within the project area by IDFG under BPA contract will document pre- and post-project implementation conditions and provide a thorough evaluation of the effectiveness of recommended enhancement measures.

Degree of Program Measure Fulfillment: The habitat inventory analysis and enhancement opportunity identification phase of the Middle Fork and Upper Salmon Rivers habitat enhancement project will be completed early in 1986. Implementation of enhancement work will take place over the next several years. The project is only one of many projects that constitute Program Measure 704(d)(1). Completion of the project, although significantly contributing to fulfillment of the program measure, will leave other portions of the measure to be addressed.

SALMON RIVER HABITAT ENHANCEMENT BEAR VALLEYCREEK

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Program Measure Number. 704(d)(1), Table 2 (1984 edition)

Relationship to Program Measure: The objective of this project, which addresses Program Measure 704(d)(1) Table 2, is to enhance 4.5 km of anadromous salmonid habitat within an inactive placer mine near the headwaters of Bear Valley Creek, Valley County, Idaho. Fine granitic sediments from the privately-owned mine have been redeposited downstream on spawning gravels and in rearing areas of spring chinook salmon (*Oncorhynchus tshawytscha* and steelhead trout (*Salmo gairdneri*) since the late 1950s. A feasibility study determined the preferred alternative for reducing erosion and enhancing salmonid habitat within the mine. Controlling erosion at the mine will ultimately reduce sedimentation in downstream spawning and rearing areas on federal land.

Technical Results - Monitoring: Physical (one time per year) and biological (two times per year) variables were measured in seven sites within each of seven strata along the length (55 km) of Bear Valley Creek during 1984 and 1985 (pretreatment). Water, cover, and substrate variables did not differ significantly ($P > 0.05$) within a stratum between 1984 (normal water year) and 1985 (low water year) but did differ significantly among strata in 1984 or 1985. Young-of-year chinook salmon densities differed significantly among strata and were significantly lower in 1985 (0.036 fish/m²; 15 redds in 1984) than in 1984 (0.110 fish/m²; 55 redds in 1983). Young-of-year chinook salmon were significantly shorter, heavier, and in better condition in most strata in July 1985 than in July 1984. Age I+ chinook salmon, age I+ bull trout, young-of-year and juvenile mountain whitefish, and age II+ and older rainbow/steelhead trout densities differed significantly within strata between July 1984 and July 1985.

Technical Results - Implementation: Final design of the enhancement measures were completed, and stream alteration permits were acquired for most of the project during summer 1985. From September 9 to November 9, 1985 stabilization treatments were applied to 550 meters of the bank having the highest erosion potential. Approximately 16,500 m³ of soil were excavated to construct a new floodplain. Stabilization treatments within the new floodplain include 3:1 bank sloping, riprap armoring, seeding with high-altitude grasses, and installation of geotextile and biodegradable erosion control fabrics. Planting of pine tree seedlings and rooted willow shoots is also planned as part of revegetation efforts in 1986.

Technical Review: Project documentation and reports have been and will be subjected to technical review by Idaho Fish and Game, BPA, U.S. Forest Service, and other agencies.

Evaluation of Effectiveness: We are evaluating treatment effects by monitoring aquatic habitat and fish communities over time. Baseline or pretreatment measurements were made in 1984 and 1985 (prior to construction start-up).

Degree of Program Measure Fulfillment: The feasibility study was completed. BPA and a Project Interagency Task Force accepted the treatment selected for implementation. Implementation and future monitoring (fulfillment of program measure) will be completed with continued funding from BPA.

ENLOE DAM PASSAGE PROJECT

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Program Measure Number: 704(e)(i), Table 5(A)

Relationship to Program Measure: The goal of this project is to achieve fish passage at Enloe Dam and establish summer steelhead and summer chinook runs throughout the 320 miles of spawning and rearing habitat of the Similkameen River basin. This action would be considered off-site mitigation for juvenile fish losses occurring on the mainstem of the Columbia River.

Technical Results: An extensive fiscal year 1983 habitat assessment in the Similkameen River estimated 961,000 m² of spawnable area for steelhead trout, which could accommodate 98,000 spawners. Nearly 367,000 m² of chinook spawnable area was also estimated capable of accommodating 55,000 spawners. Rearing area for steelhead trout was estimated for the whole system at 1.8 million m². Juvenile chinook salmon smolt rearing area was estimated at 700,000 m². Smolt production from the system was estimated at about 610,000 steelhead trout and between 1.6 and 4.8 million chinook salmon.

In fiscal years 1984 and 1985, emphasis was placed on evaluation of the Wells Hatchery summer steelhead stock's suitability for introduction, and conceptual design of several passage alternatives. Existing data on run timing and adult return rates to the Methow and Similkameen Rivers was used to determine preliminary run strength projections, stocking strategies, and harvest management scenarios. Six passage alternatives including dam removal, three trap-and-haul, and two fishway options were conceptually designed, costed, and evaluated. **The NEPA process was initiated** to assess the potential environmental impact that would arise from any of the six alternative modes of fish passage at Enloe Dam.

Technical Review: Throughout this project BPA has conducted an extensive consultation program with agencies, tribes, and other organizations and groups in both the U.S. and Canada that have an interest in fish passage at Enloe Dam. Part of the response from the consultation program has been the identification of a broad array of issues relating to the feasibility of fish passage and the establishment of an anadromous fish run in the upper Similkameen basin.

Evaluation of Effectiveness: The project would develop a major summer steelhead sport fishery in Washington and B.C. waters. Initially, based on a probable scenario of 10% juvenile loss per dam, a mean smolt to adult survival of 1.52%, a 10% exploitation of adults in the Columbia River below Wells Dam, an annual stocking of 250,000 Wells Hatchery smolts and limited exploitation of returning adults, a spawning escapement of 15,550 could be achieved by years 19-24. Further research is required regarding the feasibility of developing the summer chinook run which presently spawns in the lower Similkameen River.

Degree of Program Measure Fulfillment: Should adult passage be achieved and a commitment made to annually stock 250,000 Wells Hatchery steelhead smolts in the Similkameen River, development of the "wild component" of the run could be evaluated. The success of natural spawning and rearing will determine the future requirements for hatchery supplementation.

DOWNSTREAM MIGRATION: RESERVOIR IMPACTS

SMOLT PASSAGE BEHAVIOR AND FLOW-NET RELATIONSHIPS IN THE FOREBAY OF JOHN DAY DAM

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Program Measure Number: 304(d)(1)

Relationship to Program Measure: This research project was initiated before the Fish & Wildlife Plan was adopted; however, the project has been aligned to address Program Measure 304(d)(1). The project involves monitoring current patterns, defining fish distribution with purse-seine sampling, and assessing the value of new application of radio-tag methodology assigned to examine passage behavior of juvenile salmonids.

Technical Results: During 1982 through 1985, research was conducted to define the migration patterns of downstream migrant juvenile salmonids in the forebay of John Day Dam and to assess them in relation to current velocities, water turbidity, and temperature. To accomplish this, we monitored current velocities at fixed positions in the forebay during the outmigrations and collected physical limnological data describing turbidity and temperature patterns in the forebay. Fish distribution patterns and migration routes were identified using both purse-seine sampling and radio-telemetry techniques.

Purse-seine sampling revealed that juvenile steelhead, sockeye, and both subyearling and yearling chinook salmon altered their distribution across the forebay as they approached the dam. Upon intercepting the foreign novel water mass discharged from the John Day River, they either avoided the plume or were entrained in it and swept toward the Washington shore. However, there is no evidence to suggest that juvenile salmonids approaching John Day alter their migration routes in response to current patterns in the forebay.

Radio telemetry studies of yearling chinook salmon corroborate the purse seine results; 7 percent of radio-tracked fish followed the demarcation of the plume toward the Washington shore. Less than 2 percent of the radio-tagged chinook salmon were detected in water that could be visually identified as the turbid plume.

A new research application of radio-tag methodology was successfully executed. From 57 percent to 100 percent (average = 79 percent) of the individuals in various groups of spring chinook salmon smolts fitted with radio tags released 6 km upstream from John Day Dam successfully migrated to **and were** detected at the dam. Furthermore, it was possible to positively identify the specific passage route (spillway, powerhouse, fish ladder, or navigation lock) used by each uniquely coded individual.

Juvenile outmigrants are predisposed to spill passage by virtue of their lateral distribution across the **forebay**. Fish are concentrated on the Washington side of the river where the spillway is situated. Radio-telemetry studies demonstrated that yearling chinook salmon which arrive at the dam at night when spill was provided were detected at the spillway at a rate significantly in excess of the percentage of the river flow being discharged over the spillway. Typically, fish arriving during daylight hours delayed passage until nightfall. Fish arriving at night pass the dam with little delay.

We observed that extreme variations in dam operations cause only slight perturbations in forebay current patterns. Current perturbations were apparent within an hour and stabilized with 2 h. The program system developed for this study which cartographically displays forebay patterns at prevailing river conditions and dam operations can be utilized in investigations at other dam sites.

Technical Review: Drafts of project results were submitted to BPA for distribution to appropriate technical reviewers.

Evaluation of Effectiveness: This research has demonstrated that forebay current patterns, as influenced by dam operations, do not affect the migration routes of juvenile salmonids through John Day Reservoir. However, migratory routes are affected by the intrusion of novel water from the John Day River. Evaluation of the effectiveness of spill in passing juvenile salmonids is confounded by the tributary effects.

Juvenile radio tag methodology developed at this site was successful in quantifying the numbers of fish passing the facility via either the spillway or powerhouse. The technique may be employed at other dam sites to address questions regarding the effectiveness of spill as a passage conduit.

Degree of Program Measure Fulfillment: Applicability of conducting similar work at other facilities will remain to be evaluated in this program measure.

SUMMER FLOW STUDIES: SUBYEARLING CHINOOK SALMON

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BPA Project Number: 82-8
Program Measure Number. 304(d)(1)

Relationship to Program Measure: The National Marine Fisheries Service, in cooperation with BPA, is conducting a six-year study of the effects of instream river flow on the **passage** of time, survival, and migrational behavior of juvenile fall and summer (O-age) chinook salmon in John Day Reservoir. This project was initiated in 1981 and is scheduled for completion in 1987. The remaining work will involve the collection and analysis of adult tag returns. Results of the project are applicable to Program Measure 304(d)(1).

Technical Results: Fifty-one groups (209,129 fish) of marked O-age chinook salmon were wire-tagged, branded, **and** released into the tailrace at McNary Dam from 1981 through 1983. An additional 88 groups (49,080 fish) were branded and released into the reservoir at fixed transects.

Sampling at John Day Dam, using the airlift pump system in the B and C slots of Turbine Intake Unit 3, captured 200,562 subyearling chinook salmon including 1,745 mark recoveries. Additional marks (1,145) were recovered from purse-seine samples taken at various sites throughout the reservoir.

Weekly mean fork lengths of **O-age** chinook salmon captured at McNary and John Day Dams and in the reservoir by purse seine ranged from 103 mm in mid-June to 166 mm in mid-December. Analysis of stomach samples taken in 1982 and 1983 from purse seine catches indicates active feeding is taking place in the reservoir.

The average reservoir residence time (calculated from the median date of the mark recoveries from each group at John Day Dam) was 22.5 days.

Based on data obtained during the summer and fall, 1981 to 1983, the rate of downstream movement of subyearling chinook salmon was not significantly affected by instream water **flows**. Values for Spearman's correlation coefficient (r_s) were: 0.030 in 1981, 0.111 in 1982, and 0.012 in 1983. In each instance the coefficient was not statistically different from zero.

Adult return data continue to be acquired for coded wire tags recovered at dams, hatcheries, spawning grounds, and both commercial and sport fisheries. **A** complete analysis of this data will be conducted when the final returnees are realized in 1987.

Technical Review Drafts of project results were submitted to BPA for distribution to appropriate technical reviewers.

Evaluation of Effectiveness: This program has established that there is no correlation between fish movement and the amount of flow provided in the reservoir during the summer and fall months.

Degree of Program Measure Fulfillment: We are in the process of evaluating the adult returns and will continue to do so through 1987.

SMOLT CONDITION AND TIMING OF ARRIVAL AT LOWER GRANITE RESERVOIR

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BPA Project Number: 83-323B
Program Measure Number: 304(d)

Relationship to Program Measure: "Smolt monitoring is the key element necessary to achieve all or part of each Water Budget measure (Section 304(d)] . . .," This statement, taken from the Water Budget Measures Program "Operations-Research-Monitoring Report of 1983." indicates the necessity of smolt monitoring for implementation of the Water Budget. The goal of the Idaho Department of Fish and Game's smolt monitoring project is to monitor the condition and time of arrival of smolts at Lower Granite Reservoir.

Technical Results: Three migrant smolt traps, one near Whitebird, Idaho on the lower Salmon River, two at the head of Lower Granite Reservoir, and one each on the reservoir's Snake and Clearwater Rivers' arms, provide the Water Budget Center with daily smolt passage indices. Trap operation begins in mid-March, thus providing the first information on smolt movement in the Snake River system. Smolts branded at hatcheries are monitored for travel time and migration rates from release sites, past the migrant traps and on to Lower Granite Dam. The effects of various abiotic factors, including river discharge, on migration rates are assessed, both in the rivers and reservoir above Lower Granite Dam.

Daily monitoring of smolt condition relative to scale loss is recorded and compared to smolt condition at hatcheries prior to release and to smolts at Lower Granite Dam.

Smolt passage is estimated and compared to that at Lower Granite Dam.

Technical Review: The methods used to operate the traps, estimate trapping efficiency, estimate smolt passage, and determine rates of descaling are described in "Smolt Condition and Timing of Arrival at Lower Granite Reservoir," 1983 annual report to BPA. Objectives and methods were discussed and updated as a result of meetings with BPA, NMFS, and IDFG biologists in July of 1983 and 1984 at Pasco, Washington.

Evaluation of Effectiveness: It is important to provide adequate flows during that portion of the spring when some smolts are actually migrating downstream. The Snake River water budget is not sufficient to provide strong flows during the entire spring season. Smolt monitoring provides the information necessary to allow the Water Budget Center to effectively implement the water budget. Additionally, the improved understanding of smolt migration relative to river discharge as observed at migrant traps may result in further refinements in water budget management.

Degree of Program Measure Fulfillment: The permanence of the Columbia River system hydroelectric projects indicated that the water budget and its careful management will be needed in the foreseeable future. Thus smolt monitoring will be needed also. The techniques of smolt monitoring with migrant traps need improvement. however, especially on the Clearwater and Salmon Rivers, where dramatic increases in discharge and associated debris curtail smolt monitoring prior to peak runoff each year.

WATER BUDGET MANAGEMENT

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BPA Project Officer: Steve Smith
BPA Project Number: 83-491/536
Program Measure Number: 304(a)(b)(c)(d); 1500(33.3)

Relationship to Program Measure: This is a position created to provide the Columbia Basin Tribes with expert assistance “to ensure that requirements for fish are made a part of the river system planning and operations.” The incumbent acts on behalf of the tribes in managing the water budget and implementing other applicable measures related to fish passage and survival. Another function is to organize and conduct periodic coordination meetings of the 12 Columbia Basin Tribes. The desired result is to maximize survival of migrating juvenile salmon and steelhead.

Technical Results: The tribal water budget manager is directly involved in the development and implementation of the annual water budget implementation plan, the fishery agency and tribal detailed fishery operating plan covering all aspects of adult and juvenile fish passage, and the research and monitoring plan for the smolt monitoring program to guide system operations and provide for evaluation of the effectiveness of actions taken.

Technical Results: Weekly reports are published during the water budget/smolt migration season, detailing major events and problems. Annual reports and plans include: Water Budget Managers Annual Report; Smolt Monitoring Program, Part I - Survival, and Part II - Travel Time; Annual Research and Monitoring Plan; Annual Fish Passage Plan; Annual Coordinated Plan of Operation for the water budget; and Annual Detailed Fishery Operating Plan, giving detailed guidelines for operating fish passage facilities at each of the dams.

Evaluation of Effectiveness: Effectiveness evaluations are an integral part of the process, which will require several years experience to properly assess. The ultimate measure will be the success in increasing juvenile salmon and steelhead survival and, in turn, the numbers of returning adults.

Degree of Program Measure Fulfillment: These are continuing program measures with no defined end point.

A STUDY TO DETERMINE THE TECHNICAL AND BIOLOGICAL FEASIBILITY OF A NEW FISH TAGGING SYSTEM

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BPA Project Number: 83-319
Program Measure Number: 304(d)(1)

Relationship to Program Measure: The objective of the project is to evaluate the technical and biological feasibility of using a new miniature identification system with salmonids. The system is referred to as a Passive Integrated Transponder (PIT) tag. The new tag would enable investigators to gather information more effectively on the relationships among flows, spills, and travel time to smolt survival.

Technical Results: Results of both laboratory and field related studies using juvenile and adult steelhead and chinook salmon have been encouraging. No differences in survival or growth, no adverse tissue response to the tag, and no impairment of locomotive ability have been observed between control and **PIT tagged fish**. Tag retention in juvenile fish appears related to size and perhaps species, with nearly 100 percent retention for all fish exceeding 8 g. Many of the laboratory studies have been confirmed in field tests. Tag monitoring equipment in the field has shown reading efficiencies exceeding 90 percent in all tests with 100 percent accuracy.

Technical Review: Proposed laboratory studies are reviewed by biologists of Bonneville Power Administration (**BPA**) and National Marine Fisheries Service. Field related studies are reviewed by biologists of BPA, the Water Budget Center, and the Fish Passage Committee.

Evaluation of Effectiveness: **Data obtained to date strongly suggests** that the PIT tag fish identification system has the potential of being an effective research tool that circumvents many of the inherent problems associated with traditional fish identification systems. Traditionally large numbers of fish have been needed to obtain statistically significant results. Preliminary PIT tag data suggest a 90-95 percent reduction in the number of fish needed for many types of studies. Furthermore, once a fish is PIT tagged, no further handling of the fish **is required**. PIT tagged fish can be automatically integrated for identification at dams equipped with monitoring systems. Repetitive readings on the same fish are possible during its outmigration. For each fish read, the date, time, location, and fish identification number are automatically displayed on a computer and printed, thus immediately becoming available for analysis. Tag longevity is anticipated to exceed that of all salmonids.

Degree of Program Measure Fulfillment: This was the third year of a multi-year program to evaluate the technical and biological feasibility of adapting the PIT tag to salmonids. Based upon results obtained in the laboratory and field to date, and the results we hope to obtain during the 1986 field season, the identification system would be ready for implementation in 1987.

HYDROACOUSTIC MONITORING AT LOWER MONUMENTAL AND THE DALLES DAMS

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Program Measure Number: 304(d)(1)

Relationship to Program Measure: Program Measure 304(d)(1) requires gathering of additional evidence to determine the relationship between river flow, spill, travel time, and smolt survival. In this study hydroacoustic techniques were employed to monitor juvenile salmonids migrating past Lower Monumental and The Dalles Dams. The study was funded by the BPA.

Bypass methods to increase the survival rate of migrants passing downstream through the two dams are being evaluated. For these evaluations it is essential to know the migrants' distribution and timing as they approach and pass the dam, including estimates of the relative proportions utilizing spillway, sluiceway, and turbine passage routes.

Technical Results: The proportions of downstream migrants passing through the spillways were estimated. At Lower Monumental Dam spilling occurred nightly at 50 percent of river flow during May, 1985. Relative to fish passage throughout the 24-hour day, an average of 57 percent of migrants were estimated to have passed through spill.

At The Dalles Dam, spilling occurred daily at averages of 22 percent of river flow during May 1985. and 18 percent of river flow during 10 days in July 1985. Relative to fish passage throughout the 24-hour day, averages of 9 percent and 23 percent of migrants were estimated to have passed through spill during the May and July study periods, respectively.

At The Dalles Dam, the proportion of downstream migrants passing through the powerhouse ice and trash sluiceway was estimated. The sluiceway was operated with the three sluiceways over Turbine Unit 1 open. The proportion of river flow into the sluiceway ranged from 1 percent to 5 percent. During May 1985, with the turbines, sluiceway, and spillway operating, an average of 23 percent of migrants used the sluiceway. During 10 days in July 1985, again with turbines, sluiceway, and spillway operating, an average of 14 percent of migrants used the sluiceway. For the remainder of July and a portion of August, when only turbines and sluiceway were operating, an average of 49 percent of migrants used the sluiceway.

Other parameters of smolt passage measured during this study included diel variability in rates of migration, daily estimates of run timing, and the horizontal and vertical distributions of migrants passing through the **dams**.

Evaluation of Effectiveness: This year's estimates of the proportions of downstream migrants utilizing spillway and sluiceway passage routes were obtained during periods of "standard operational conditions,**" thus providing a basis for determining the need to conduct future experiments to improve bypass effectiveness by altering spillway and/or sluiceway operations.

This year's efforts demonstrated the potential for using hydroacoustic techniques to monitor run timing and to make "real time" decisions regarding the opening of bypass portals.

Degree of Program Measure Fulfillment: Future experiments are recommended to determine the relationship between differing levels of spill and the proportions of fish passing through spillways at these two dams. Additionally, the effects of differing combinations of spillgate openings and differing hours of spill should be evaluated. Furthermore, a “real time” management system for making daily decisions regarding the need to open bypass portals should be implemented.

**USE OF A FISH TRANSPORTATION BARGE FOR INCREASING RETURNS
OF STEELHEAD IMPRINTED FOR HOMING**

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BPA Project Number: 82-2
Program Measure Number. 404(b)(18)

Relationship to Program Measure: The objective of this project under Program Measure 404(b)(18) is to determine if groups of steelhead smolts reared and imprinted at Dwonhak National Fish Hatchery (NFH) and then transported by truck to a transfer site near Lewiston, Idaho, released into barges, and transported via barge to a release site below Bonneville Dam will produce a greater return **of adults to the hatchery and** fishery than fish released directly at the hatchery. Our goal is to increase the number of steelhead available to various Columbia and Clear-water River fisheries while maintaining or increasing the number of adults for spawning at the hatchery.

Technical Results: In 1982-83 over 250,000 smolts per year were marked with coded wire tags and brands and released at the hatchery or transported by barge over a major portion of the spring outmigration period.

Experimental Design for Dwonhak NFH Steelhead in 1982 and 1983¹

<u>Release Sites</u>	<u>Release Date</u>		<u>Paired Control and Test Treatments</u>
	<u>1982</u>	<u>1983</u>	
First	April 19	April 20	<u>Control</u> - Fish were released from hatchery into Clearwater River; one lot in 1983 was also released into North Fork Clearwater River. <u>Test</u> - Fish held on raw N. Fork Clearwater River water (min. 6 d). One lot was pumped from reuse water to raw water (held min. 6 d); fish were trucked to Lewiston, Idaho, transferred to a barge in the Clearwater River, and transported to a release site below Bonneville Dam.
Second	April 30	May 3	
Third	May 19	May 24-25	
Fourth	May 31²		

¹ Each year's release consisted of eight lots of approximately 31,500 fish each.

² No control lot was released at this late date because of the probability that the smolts would revert to parr before completing an outmigration of 500 miles.

Approximately 7,500 adults have been recovered in Columbia River commercial (Zone 6) and sports fisheries, Columbia and Snake River trapping facilities at dams, Snake and Clearwater fisheries, and at Dwonhak NFH. Further adult recovery data will be available in the 1986-87 migration seasons.

Technical Review: The proposed research was reviewed by senior biologists for the NMFS and approved by the CRFWC and the CRFPC. Statistical treatment of the data has been recommended by staff biometricians according to methods described by Bishop, et al. (*Discrete Multivariate Analysis*, 1975, MIT Press, Cambridge MA).

Evaluation of Effectiveness From the preliminary data it appears that the project objective can be fully realized. Tentative conclusions are: (1) Survival of adults from the control lots (1982 and 1983) was greatest for releases made on April 19 to May 2; (2) survival of adults from fish barged (1982 tests) to below Bonneville Dam was highest from the April 30 and May 19 releases; (3) the best homing to Dworshak NFH (1982 tests) appears to be correlated with the best overall survival (April 30 release); (4) survival of adults from fish barged in 1983 was greatest from releases made on April 20 and May 3; (5) although survival of test fish was high, there was some homing impairment, though observed straying was nil (1982 releases).

Degree of Program Measure Fulfillment: Based on earlier studies (Project 78-1) and current findings, transportation direct from Dworshak NFH provides management with a viable downstream passage alternative - especially in low-flow years when expected mortality to in-river migrants is extreme. Further study is required to determine how best to achieve maximum homing and survival when direct transportation is used at other hatchery facilities.

JUVENILE RADIO-TAG STUDIES

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BPA Project Number: 85-35
Program Measure Number: 304(d)(1)

Relationship to Program Measure: The National Marine Fisheries Service (NMFS), in cooperation with BPA, is conducting a research program to evaluate juvenile radio tags as a tool for addressing juvenile salmonid passage problems at dams on the Columbia and Snake Rivers. This project was initiated in FY 1985, and the evaluation is scheduled for completion in 1986. Results of the project are applicable to Program Measure 304(d)(1).

Technical Results: In 1985 assumptions were tested regarding the reliability of the radio tags and the effects of the tag on the host fish, yearling chinook salmon. Tag failure was determined to be negligible after the first 12 hours in the fish (this is the period that the smolts are allowed to adjust to the tag before release), and tag life exceeded the three days required for the research design. In laboratory tests, tag regurgitations occurred within 10 hours following insertion of the tags. Only chinook salmon smolts larger than 155 mm fork length can accommodate the radio tag. However, length frequency comparisons at Lower Granite Dam in 1985 indicated that the guidance rate of fish of this size into the gatewells was not significantly different from the guidance rate of the general population. Tag-related mortality was minimal. Only 3 of 259 fish tested in the laboratory died within the expected tag detection period. Two areas were observed where test and control animals differed. During protracted swim tunnel tests, the tagged smolts displayed reduced stamina levels compared to the control fish; however, the decreased performance was not statistically significant. Radio-tagged fish also displayed some difficulty adjusting their buoyancy to compensate for the weight of the tag. The significance of these factors is uncertain at this time.

Another objective in 1985 was to assess the effectiveness of a juvenile radio tag system for evaluating spill effectiveness, collection efficiency, fish guidance efficiency, and survival through various passage routes. The primary components of the system include: a group of radio-tagged fish, each bearing a unique code, and assorted antennas and accompanying monitors which are deployed at specific sites on and downstream from the dam.

Between 75 percent and 80 percent of the group-released fish were detected after release. There was excellent separation between the powerhouse and spillway, and between the gatewells and the forebay. Some smolts were detected at the downstream sites that were not observed going through the dam. We believe that the fish either moved through the dam at a rate too fast for our scanning monitors or that the fish were too deep for detection.

Technical Review: Drafts of project results are submitted to BPA for distribution to appropriate reviewers.

Evaluation of Effectiveness: The effectiveness of this tool will be determined ultimately by representatives of the assorted fisheries agencies and tribes, as well as by BPA personnel. We will be submitting our comprehensive report to the appropriate research review committees and BPA upon completion of the FY 1986 research.

Degree of Program Measure Fulfillment: An additional year of research will be conducted at Lower Granite in FY 1986. Results from both years will be analyzed, and the effectiveness of this tool for estimating spill effectiveness, collection efficiency, fish guidance efficiency, and survival will be evaluated.

DOWNSTREAM MIGRATION: FLOWS AND MONITORING

**TOTAL DISSOLVED GAS MEASUREMENT, DATA TRANSMISSION,
AND SYSTEM MODELING
PART 3: SYSTEM SPILL ALLOCATION MODEL (GASSPILL)**

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Program Measure Number: 304(d), 404(b), 404(c)

Relationship to Program Measure: Nitrogen supersaturation created by spill affects the survival of migrating juvenile fish. Therefore, the goal of this project under Program Measures 304(d), 404(b), and 404(c) is to develop and test a set of computer routines to allocate spills to the various dams in the Columbia/Snake River system to prevent localized high saturation levels of dissolved gas.

Technical Results: A basic spill allocation algorithm has been developed, and the necessary computer codes written. The technique uses an existing Corps of Engineers' Nitrogen Model to: (1) predict areas of high nitrogen concentration; (2) determine the spill required to keep nitrogen concentration within acceptable limits; and (3) allocate the required spill reduction amount to user-specified and/or model-selected projects to achieve an optimum system-wide nitrogen concentration. The Model can operate on a real-time basis using input data extracted directly from operational data bases such as CROHMS. Corresponding system power output is also calculated.

Technical Review: The Model was installed on the Corps' computer system and tested for computational accuracy by the Corps staff. Last year's low flows and the resulting negligible spills did not provide the needed data to conduct the model testing. Arrangements are being made for further testing during the 1986 fish migration season. Also, other optimization procedures involving alternate spill priorities will be investigated.

Evaluation of Effectiveness: The Model should prove helpful to the water budget managers and the Corps' Reservoir Control Center in scheduling spills that are safe to fish and that do not adversely impact other project functions. Effectiveness of the Model, however, remains to be tested on real-time data.

Degree of Program Measure Fulfillment: Management of spill to minimize high nitrogen concentration for improved migrant fish survival is an important part of Program Measures 304(d), 404(b), and 404(c). Continued research and development in this and other related fields will be required to fully satisfy the program measure objectives.

FEEDING ACTIVITY, RATE OF CONSUMPTION, DAILY RATION, AND PREY SELECTION OF MAJOR PREDATORS IN THE JOHN DAY POOL

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BPA Project Number: 82-3
Program Measure Number: 404(c)(1)

Relationship to Program Measure: Program Measure 404(c)(1) directs BPA to continue its existing study and fund any further studies necessary to investigate juvenile salmon and steelhead losses to predators while the fish are migrating through Columbia and Snake River reservoirs. This project to estimate the average consumption of salmonids by predators (BPA Project 82-3) is being conducted in conjunction with another study to estimate the abundance of major predators (BPA Project 82-12) in John Day Pool, a mainstem Columbia River reservoir.

Technical Results: Field sampling to estimate consumption of juvenile salmonids was initiated in April 1982 and will continue through 1986. Predator and prey fishes are collected annually from April through August at tailrace, mid-reservoir, and forebay locations. Results from dietary analyses indicate that reservoir location, time of year, and predator size account for variability in salmonid consumption. Northern squawfish exhibit a piscivorous size threshold of 250 mm; fish this size and longer consumed from 0.08 to 0.80 salmonids per predator at McNary tailrace and John Day forebay. Consumption rates for walleye and channel catfish were similar and ranged from 0.02 to 0.56 salmonids per predator. Smallmouth bass collected at all locations consumed salmonids, but had the least number of salmonids in the stomach contents (0.01-0.14 salmonids/predator). Laboratory results of digestion experiments on northern squawfish indicate that evacuation rate (percent digestion over time) of salmonids is significantly increased by increasing water temperature and decreasing size of salmonids consumed. Various predator control and prey protection measures have been identified through an intensive literature review.

Technical Review: Project reports are submitted to various fish and wildlife agencies for technical review and comment. Portions of the study have been submitted to technical journals for publication.

Evaluation of Effectiveness: Results of this project will be used to estimate loss of juvenile salmonids to predation. Once the magnitude of the loss has been determined, strategies for reducing the loss will be developed based upon the feasibility and potential effectiveness of selected predation control measures. The ultimate evaluation of the effectiveness of predation control measures will come from results of field tests comparing various control measures.

Degree of Program Measure Fulfillment: Effects of predation have been evaluated only in John Day Reservoir during high and moderate flow years. Therefore, similar studies may be required at other locations and during low flow conditions. Studies to develop management practices and evaluate their effectiveness may also be required to meet the intent of the program measure.

PANEL DISCUSSION: HABITAT EVALUATION AND MONITORING

**FISH/WASH CREEK HABITAT IMPROVEMENT EVALUATION:
CLACKAMAS RIVER, OREGON**

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BPA Project Number: 84-11
Program Measure Number: 704(d)(1)

Relationship to Program Measure: This five-year project, which began in 1983, is designed to evaluate habitat improvements constructed in the Fish Creek Basin by personnel of the Estacada Ranger District, Mt. Hood National Forest. The project addresses Program Measure 704(d)(1) and is jointly funded by BPA and the U.S. Forest Service.

The physical, biological, and economic viability of projects designed to improve chinook and coho salmon, and steelhead trout spawning **and** rearing habitat, have been evaluated. Specific improvements being evaluated include boulder berms, off-channel ponds, alcoves, side channels, woody debris, and hardwood plantings to improve riparian vegetation.

Factors in the basin that limit production of salmonids in Fish Creek are also being evaluated.

Technical Results: In 1985, the evaluation was focused primarily on monitoring the smolt migration and establishing the behavior and winter habitat preferences of juvenile anadromous salmonids in the basin. Coho smolt data indicate that the off-channel pond has been an unparalleled success, boosting the coho migration from the basin by 15.6% in one year. Greater outputs are expected when the pond is fully seeded. The steelhead smolt migration indicated that Fish Creek is an outstanding producer of steelhead, producing 21% of the upper Clackamas smolt output from just 10% of the basin area. No portion of the steelhead out-migration could be linked directly to habitat improvement.

Evaluation of winter habitat in the basin has proved to be difficult but rewarding. Our observations indicate that as water temperatures decline in the fall, juvenile salmonids move into pools and appear to concentrate in the upper reaches of the basin. There also appears to be some movement of steelhead and chinook from the Clackamas River into Fish Creek. Availability of winter habitat appears to be adequate for age 1+ presmolt steelhead which use bouldery mainstem habitats.

Habitats for coho, however, which use complex stream margins in winter, appear to be inadequate.

Evaluation of all habitat improvements is continuing, but to date the off-channel ponds show the most promise for increased fish production in the Fish Creek basin.

Technical Review: Results of this work are reviewed in annual project presentations. Written reports will be subjected to technical review by agencies or groups selected by BPA.

Evaluation of Effectiveness: Short-term benefits- or losses are difficult to determine, but after three years' evaluation, the off-channel ponds appear to be highly effective projects. The success of each improvement must be measured in terms of increased smolt outputs.

Degree of Program Measure Fulfillment: Evaluation of habitat improvements in the Fish Creek Basin will be completed in 1988. Two ways to limit the risk of failure associated with habitat improvement projects are (1) to analyze in detail the limiting factors in a basin, and (2) to evaluate physical and biological changes in a basin (e.g., smolts produced) that result from improvements.

BPA PROJECT NUMBER INDEX

79-2	47
81S-5 85-6.	3
81S-8	25
82-2	73
82-3	80
82-8	65, 67
82-14	32
82-16	33
82-18	24
83-304	16
83-312	10
83-313	50
83-319	70
83-323B.	68
83-341	42
83-359	61
83-363	49
83-435	23
83-436	22
83-451	12
83-463	3
83-464	5
83-465	3
83-467 85-23	3
83-477	62
83-491/536	69
83-498	5
83-834	21
84-5	56
84-6	55
84-8	41
84-9	26
84-10	19
84-11	37,83

BPA PROJECT NUMBER INDEX (cont.)

84-13	79
84-19	52
84-21	39
84-23	57
84-24	59
84-25	26
84-29	58
84-39	6
84-40	46
84-41	4 5
84-43	13
84-45A
84-45B
84-46	15
85-35	75
85-62. - - - - -	30
85-68	51
85-83	71
85-85	31
88-44	14

PROGRAM MEASURE INDEX

304(a)(b)(c)(d); 1500(33.3)	69
304(d).68,79
304(d)(1)	65, 67, 70, 71, 75
404(b).	79
404(b)(18).	73
404(c).	79
404(c)(1).	80
404(c)(2).	50
604	32
704(a)(i) Table 2	57
704(d)(1)	19, 21, 25, 26, 37, 39, 41, 42, 56, 58, 83
704(d)(1), Table 2.	61
704(d)(1), Table 3, L, N, S, T	59
704(e).	55
704(e)(1).	22
704(e)(i), Table 5(A)	62
704(h)(2)	49
704(h)(2)(c)	12
704(h)(2)(d)	10, 16
704(h)(4)	9, 13, 14, 15
704(i)(1)	19, 23, 24
704(i)(2).	50
704(j)(1).	50
704(k)(2)	51
804(a)(2).	3
804(a)(9).	3
804(b)(1)(D)	3
804(b)(3)	3
804(b)(4)	3
804(b)(5)	3
804(e)(2).	3
804(e)(5).	52
904(d).	29, 30
904(d)(4)(K)	31

PROGRAM MEASURE INDEX (cont.)

1004(b)(2)	5
1004(b)(3)	5.6
1204(b)(2)	45
1204(c)(1)	46
Non-Measure	33.47