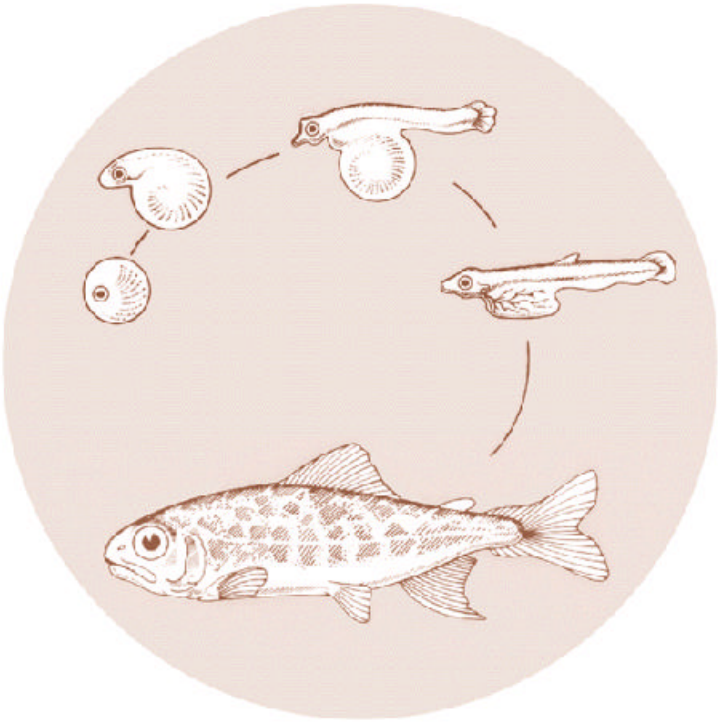
AUGMENTED FISH HEALTH MONITORING FOR WASHINGTON DEPARTMENT OF WILDLIFE

Five Year Project Report

Annual Report 1990



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AUGMENTED FISH HEALTH MONITORING FOR THE WASHINGTON DEPARTMENT OF WILDLIFE

Annual Report 1990
Five Year Project Report

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Abstract

The Augmented Fish Health Monitoring Project was funded by the Bonneville Power Administration (BPA) with the mandate to collect fish health data on the anadromous fish stocks of the Columbia River Basin in a standardized manner. The Washington Department of Wildlife began the project in 1986. Cumulative data and a final summary for this project are presented in this document.

Fish stocks were examined monthly for length, weight, and health status at all Washington Department of Wildlife Columbia River Basin hatcheries. Assays for specific fish pathogens were conducted on all stocks of broodfish and smolts in the study area. Pathogens of interest were replicating viral agents, erythrocytic inclusion body syndrome virus (EIBSV), and Renibacterium salmoninarum. Sea-run cutthroat (SCT) were also sampled midway through the rearing cycle for R. salmoninarum. Juvenile fish were examined for the presence of any pathogen. Assays for Myxobolus cerebralis were conducted on fish stocks in several locations along the Columbia River. An organosomatic index analysis was made on each stock of smolts at the Cowlitz and Wells hatcheries.

Results of the organosomatic index analysis were consistent between the years at each facility. However, the fish reared at Cowlitz displayed tissue changes associated with ceratomyxosis while those reared at Wells had a more desirable color and quality.

Cell culture assays for viral agents in broodfish were positive for infectious hematopoeitic necrosis virus (IHNV) in all stocks at the Cowlitz Hatchery four out of five years in the study. Other stations were less consistent over the years. Only the sea-run cutthroat stock spawned at Beaver Creek was negative for any virus. Infectious pancreatic necrosis virus (IPNV) was isolated from summer-run steelhead (SS) broodfish at Wells in 1989 and 1991 and at Yakima in 1991. Inclusions that are characteristic of EIBSV were found in red blood cells of brood fish from the Wells Hatchery in 1990 and 1991. Data collected on EIBSV during the first two years of the project cannot be compared with the later three years due to changes in laboratory protocol. Isolations of IHNV in smolts were made from Cowlitz and Skamania hatcheries and the Gobar Rearing Pond. Epizootics of IHN occurred at Lyons Ferry, Beaver Creek, Cowlitz and Skamania hatcheries during the project, EIBSV inclusions were identified in very low levels from smolts from Beaver Creek, Chelan, Cowlitz, Eastbank, and Ringold.

Assays for R. salmoninarum on broodfish and smolts revealed very low levels of infection and the disease was not a problem. Enteric redmouth disease was not observed in the project area. Cytophaga psychrophila was a chronic problem in young fish at Vancouver, Beaver Creek and Cowlitz hatcheries. Ceratomyxa Shasta was the only reportable parasite observed in the fish within the study area and caused yearly outbreaks of ceratomyxosis at the Cowlitz Hatchery. Fish at the Beaver Creek Hatchery were treated for furunculosis three of the five years of the project. An ozone water treatment plant has been installed to minimize the disease.

Flow and density indexes and feed conversion did not vary significantly at the hatcheries during this project. Egg mortality averaged 12.94% throughout the project with a range from 4.39% to 29.10%. The mean fry mortality during the project was 15.08% with a range of 2.01 to 37.43%. The overall mortality for early rearing was 20.43%. Prespawning broodstock mortality was recorded for SS and SCT and averaged 5.18% with a range from 0 to 38.8%. Fungal invasion was the primary cause of death in adult fish.

Epizootics of furunculosis, ceratomyxosis, bacterial coldwater disease, and IHN occurred during the project. Fewer cases were reported in more recent years.

The BPA augmented fish health project helped WDW identify problem areas in fish health while they were occurring. This knowledge allowed us to develop strategies for improved fish quality. Overall the project has been invaluable in assisting us in the improvement of the health of our fish.

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Introduction

The augmented fish health monitoring project was funded by the Bonneville Power Administration (BPA) with the mandate to collect fish health data on anadromous fish stocks of the Columbia River Basin in a standardized manner. The segment of the project reported here was carried out by the Washington Department of Wildlife (WDW). The project began in 1986 and culminated in 1991. This report summarizes fish health findings of anadromous cutthroat and steelhead trout stocks reared at WDW facilities during that time.

Before the inception of the BPA augmented fish health project, diagnosis of fish health problems and research on solutions were performed, primarily, on an as needed basis. This project allowed fish health specialists to make monthly visits to the WDW Columbia River Basin hatcheries. Data collected provided us with insight on early signs of disease and effective forms of treatment. A more thorough understanding of the magnitude of fish health problems and the severity of chronic and acute diseases was gained.

Information gathered has provided impetus to alter facility design and management practices for improved fish health through prevention of pathogen exposure and minimization of stress. Treatment efficacy was more closely monitored due to the monthly analysis of fish stocks. Disease prevention and control are better understood as a result of this project. The goal was to improve fish health and, ultimately, increase adult returns. Long term gains from this project will continue to be made as we implement the changes indicated through this study.

Description of Study Area

This project was designed to collect and summarize fish health related data from WDW facilities in the Columbia River drainage. Washington Department of Wildlife rears winter-run steelhead, summer-run steelhead, and sea-run cutthroat trout in these facilities. However, not all three species/stocks are raised at all stations. Location of the facilities and rearing programs are indicated on Figure 1 and Table 1.

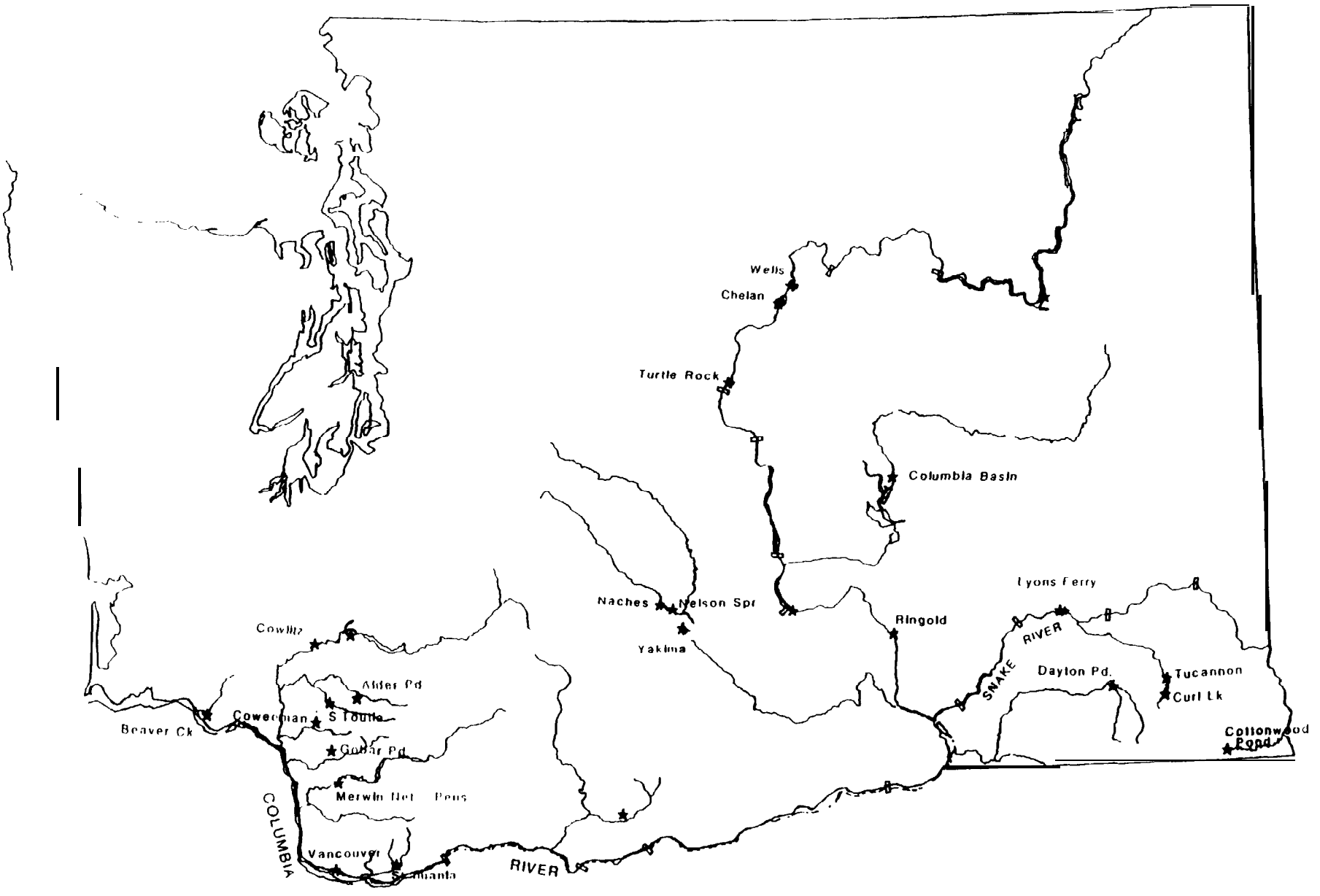

Figure 1. Location of Washington Department of Wildlife Columbia River anadromous fish rearing programs

Table 1. WDW Columbia River basin anadromous fish rearing programs

Installation	Location Number	Drainage	Annual Program
Beaver Cr. Hatchery	1	Elochoman	SW* Smolts SW Pre-Smolts for 2 and 7 SS* Smolts SS Pre-Smolts for 5 SCT* Smolts SCT Pre-Smolts for 3 SCT and SW broodstocks
Upper Coweeman	2	Coweeman	SW Smolts
Lower Coweeman	3	Coweeman	SCT Smolts
Alder Creek Pond	4	Toutle	SS Smolts
South Toutle Trap	5	Toutle	SW Smolts
Cowlitz Hatchery	6	Cowlitz	SW Smolts SS Smolts SCT Smolts SS/SW/SCT/LSW broodstocks
Gobar Pond	7	Kalama	SW Smolts
Merwin Net Pens	8	Lewis	SS Smolts
Vancouver Hatchery	9	L. Columbia	SS Smolts
Skamania Hatchery	10	Washougal	SW Smolts SS Smolts SS Pre-Smolts for 4, 7 and 8 SCT Smolts SS/SW/SCT broodstocks
Yakima Hatchery	11	Yakima	SS Smolts SS Fingerling for 12 SS Broodstock
Nelson Springs Raceway	12	Naches	SS Smolts
Naches Hatchery	13	Naches	SS Fingerling for 12
Ringold Pond	14	Mid-Columbia	SS Smolts
Columbia Basin Hatchery	15	Crab Creek	SS Fingerling for 14
Turtle Rock Pond	16	Mid-Columbia	SS Smolts
Chelan PUD Hatchery	17	Mid-Columbia	SS Smolts SS Fingerling for 16
Eastbank Hatchery	18	Mid-Columbia	SS Smolts SS Broodstock from 14
Wells Hatchery	19	Mid-Columbia	SS Smolts SS Broodstock
Lyons Ferry Hatchery	20	L. Snake	SS Smolts SS Pre-Smolts for 20 and 21 SS Broodstock
Curl Lake	21	Tucannon	SS Smolts
Cottonwood Pond	22	Grande Ronde	SS Smolts
Dayton Pond	23	Touchet	SS Smolts

*SW - winter-run steelhead, SS - summer-run steelhead, SCT - sea-run cutthroat, LSW - late winter-run steelhead

Materials and Methods

Task 3.1. Organosomatic Analysis at Index Hatcheries

Organosomatic analysis were performed using the organosomatic index as developed by Ron Goede (Goede 1988). The Cowlitz and Wells hatcheries were selected as index hatcheries within the Columbia River drainage (Table 2).

Table 2. List of index hatcheries, species and stocks in which organosomatic analysis was performed

Hatchery	Species	Stock
Cowlitz	Summer-run Steelhead	Cowlitz
Cowlitz	Winter-run Steelhead	Cowlitz
Cowlitz	Sea-run Cutthroat	Cowlitz
Cowlitz	Late Winter-run Steelhead	Cowlitz
Wells	Summer-run Steelhead	Wells

Individual fish were examined for organ color, fat content, and clinical signs. Sixty fish were sampled annually and scored from each stock on each station. Data was entered in Lotus 123 worksheet. Mean length (mm), weight (gms), and hematocrit (%), were determined along with a standard deviation for each parameter. The following items were examined, scored, and summarized as a percent of the population.

Organ	Classification:
Eyes	Normal, exopthalmia, hemorrhage, blindness, cataracts, or absence
Gills	Normal, fraying, clubbing, marginated, pale
Pseudobranchs	Normal, lithic, swollen, inflammed, pale
Thymus	Normal, degree of hemorrhage
Fat	Percent of pyloric caeca covered
Sex	Male, female, precocious male, undeveloped
Spleen	Black, red, granular, enlarged, nodular
Hind gut	Normal, degree of hemorrhage
Kidney	Normal, pale, swollen, granular, mottled, urolithiasis
Liver	Red, bright red, pale, mottled, fatty, nodular
Gall bladder	Green, yellow, empty, dark green

Task 3.2. Test for Specific Pathogens

Standard techniques as defined by the Fish Health Section of the American Fisheries Society were employed for the analysis of all samples collected for the project. Viral assays were run under an interagency subcontract by the Washington Department of Fisheries. Cell culture assays utilized were consistent with the Procedures for the Detection and Identification of Certain Fish Pathogens (Amos 1985), hereafter referred to as the Blue Book. One milliliter (ml) of ovarian fluid was mixed with one ml of antibiotic solution (containing penicillin, streptomycin, gentimycin, and fungizone), and incubated overnight at 4 C or two hours at 15 C. Kidney/spleen samples were homogenized with Hank's balanced salt solution (HBSS) at a 1:10 dilution. Three ml of homogenate was placed in tubes and centrifuged at 2000 x g for 10-12 minutes. One ml of the supernatant was mixed with 3 ml of antiobiotic solution and incubated as above. Monolayers of chinook salmon embroyo -214 (CHSE) and epithelial papillosum cyprini (EPC) cells were prepared in 24 well

plates approximately 24 hours in advance of use. Samples were centrifuged again and 0.1 ml of supernatant added to each well. Ovarian fluid was plated on EPC cells and kidney/spleen homogenate on CHSE cells. Replicates were made of each sample and a negative control of HBSS/antibiotic solution was added to each plate. Samples were adsorbed onto the cell culture for one hour at 15 C. A methylcellulose overlay was added to EPC cells and -5 overlay to monolayers of CHSE at 0.5 ml/well. Samples were incubated at 15 C for 14 days. Observations were made the day of plating and weekly thereafter. Samples displaying cytopathic effect (CPE) were subsampled with the serum neutralization test for infectious hematopoietic necrosis virus (IHNV) and infectious pancreatic necrosis virus (IPNV). Serial dilutions of the suspect sample were made and mixed with the antisera at 1:l ratio. Samples were incubated at 15C for one hour. Following centrifugation at 2000 x g for 10-12 minutes, samples were plated on EPC monolayers as described above. Negative and positive controls were prepared on the same plate. During the 1989-90 spawning season, techniques were altered for the remainder of the project. One drop of 7% PEG was added to each well of EPC cells prior to the addition of 0.2 ml of the sample. After one hour of adsorption, the samples were covered with 0.5 ml of methylcellulose overlay.

Assays for erythrocytic inclusion body syndrome virus (EIBSV) were carried out at the WDW laboratory. Samples were obtained by severing the caudal peduncle and collecting blood in a heparin coated hematocrit tube. A drop of blood was then placed on a glass slide and spread in a thin film by lightly dragging the end of a second slide across it. Slides were air dried, fixed in absolute methanol for five minutes, and prepared with pinocynol chloride stain (Yasutake 1986). Slides were examined at 1000X by light microscopy for two minutes each or until two cytoplasmic inclusion bodies were found. Positive inclusions were basophilic and ranged in size from 0.8 to 2.0 microns (Holt and Piacentini 1989). In 1988, a workshop was conducted to aid in the identification of EIBSV and to promote uniformity between agencies participating in the project. The parameters used to identify inclusions thought to be unique to the EIBSV were different than those previously utilized by WDW and so prevalence cannot be compared between results obtained before 1988 with those subsequently obtained. Assay results were reported as the prevalence at the time of assay.

Samples for Myxobolus cerebralis were collected from hatcheries and streams. Fish heads were split longitudinally, anterior to posterior, and one half of the head prepared for the plankton centrifuge method according to the protocol listed in the Blue Book. The other half was fixed in Bouin's solution for 1 l/2 days followed by preservation in 70% isopropyl alcohol. This tissue was used for histological examination when suspect spores were found by the plankton centrifuge method. The histological examination was used as a confirmatory identification of M. cerebralis. Thick sections were cut and stained with Giemsa for reading. Histological samples were prepared by Jan Yancey and analyzed by John Morrison of the USFWS, Olympia Fish Health Center.

The direct fluorescent antibody technique (DFAT) was used to assay all samples for the presence of Renibacterium salmoninarum, the causative agent of bacterial kidney disease (BKD). Goat anti-R. salmoninarum immunoglobulin conjugated with fluorescein isothiocyanate was obtained from Anadromous, Inc. (Corvallis, OR) or Kirkegaard and Perry Laboratories (Gaithersburg, MD). By the manufacturer's recommendation, the Anadromous, Inc. conjugate was diluted 1:100 with 0.01 M physiological buffered saline (PBS). The Kirkegaard and Perry Laboratories conjugate was diluted 1:30 with 0.01 M PBS. Both were filtered through a 0.2 micron acrodisc filter.

Ovarian fluid or kidney imprints were collected from broodfish for R. salmoninarum assays; kidney imprints were collected from pre-smolts The ovarian fluid was collected in micro-centrifuge tubes and centrifuged for 5 minutes at 10,000 x g to remove cellular debris. The supernatant was decanted and the cell pellet swabbed onto a spot slide with a sterile cotton swab. Slides were air-dried, fixed in absolute methanol, and air dried again. Kidney samples were collected by inserting a sterile cotton swab through the kidney and smearing a thin layer onto a spot slide. Slides were then air dried and heat fixed. Fixed slides were flooded with anti-sera, incubated in a dark humid chamber for one hour, rinsed with PBS, flooded with Evan's blue counterstain (diluted at 1:lOO) for 3 to 5 minutes, washed twice, and air dried. Coverslips were mounted with buffered glycerol mounting medium. The slides were examined under epifluorescent ultraviolet light at 600X for two minutes. Suspect bacteria were examined at 1000X. Bacteria were considered positive if they were 0.3 x 1.0-1.5 microns and displayed a bright apple green fluorescent ring.

Task 4.3. Monitoring Flow and Loading Densities

Flow index (FI) and density index (DI) data were collected for all WDW Columbia River anadromous fish hatcheries. Both indices were calculated using the method described in Fish Hatchery Management (Piper et al, 1982). The calculations are written below.

$$FI = \text{Biomass}^{1}/(\text{flow}^{2} \times \text{length}^{3})$$

$$DI = \text{Biomass}/(\text{volume}^{4} \times \text{length}^{3})$$

1 - Biomass = pounds of fish in a pond
2 - Flow = water flow to pond in gallons/minute
3 - Length = average length of fish in inches
4 - Volume = cubic feet of the pond.

Data was entered into a Lotus 123 worksheet for each pond of fish within each lot of fish. The mean indices were calculated for each lot. Results were reported as the range and the mean.

Task 6.1.2. Total Number and Percent Loss of Each Lifestage of Fish Species

Lot production data from the WDW Columbia River hatcheries were entered into a Lotus 123 worksheet. The total number and percentage mortality in each lot was calculated from egg to hatch and again from hatch to ponding. Total mortality for early rearing was also calculated.

Adult prespawning mortality data was collected from the hatcheries and entered into a Lotus 123 worksheet. Results were expressed as the percentage of fish that died from the total captured.

Task 6.1.3. Number and Causative Agents of Epizootics, Type, and Amount of Medication Used

Disease outbreaks causing significant mortality (cumulative..O.lO%) occurred at Columbia Basin hatcheries between July 1, 1986 and June 30, 1991. Data on population size, percentage mortality, pathogen, and treatment were recorded in a Lotus 123 spreadsheet.

Task 6.1.4 Feed Conversion

Feed conversion for all lots of fish at WDW Columbia River hatcheries was calculated as (pounds of fish produced/pounds of feed used). This data was entered into a Lotus 123 worksheet.

Results

Objective 1.0 Complete Start-up Phase

Task 1.1 Acquire Competent Staff

Project staffing during the five years of the study was as follows:

Project Leader: Jim Gearheard, September 1, 1986 to April 30, 1989.
John Kerwin, May 1, 1989 to August 30, 1991.

Fish Pathologists: Steve Roberts, September 1, 1986 to August 30, 1991.
Don Chase, January 21, 1987 to August 10, 1987.
John Kerwin, October 20, 1987 to April 30, 1989.
Leni Oman, July 18, 1989 to August 30, 1991.

Fish Biologists: Bruce Bolding, March 1, 1987 to August 30, 1991.
Shelley Evans, June 14, 1991 to August 8, 1991

Objective 2.0 Serve on technical steering committee

Task 2.1 Technical Steering Committee

A number of technical steering committee meetings were held during the project period. Discussions at the meetings were about the project progress, technical problems, and interpretation and modification of project tasks. A list of the technical steering committee meetings, along with WDW personnel who attended the meeting, is listed below.

Location	Date	WDW Representative(s)
Boise, ID	March 4, 1987	Gearheard, Roberts
Bozeman, MT	June 22, 1987	Roberts
Olympia, WA	October 8, 1987	Gearheard, Roberts, Bolding
Clackamas, OR	March 29-30, 1988	Gearheard, Kerwin, Roberts
Olympia, WA	June 2, 1988	Gearheard, Kerwin, Roberts
Couer D'Alene, ID	September 20, 1988	Gearheard, Roberts
Portland, OR	January 19, 1989	Gearheard
Union, WA	April 20, 1989	Gearheard, Roberts, Kerwin, Bolding
Twin Falls, ID	October 17-18, 1989	Kerwin, Roberts, Oman
Wenatchee, WA	April 25-26, 1990	Kerwin, Roberts

Task 2.2 Technology transfer

Information was disseminated within WDW in the manner listed below.

1. A meeting was held on April 9-10, 1987 at the Mossyrock Hatchery to brief hatchery managers involved in the project on data requirements and collection methods.

2. Bruce Bolding presented an overview of the project to the Fisheries Management Division meeting in Port Townsend, WA on June 10, 1988.

3. Significant findings, such as viral isolations, were reported in The Leaky Boot, the quarterly WDW hatchery newsletter, which is distributed inside and outside the agency.

Information transfer to other agencies and the general public listed below.

1. Steve Roberts presented an overview of the project at the Western Fish Disease conference in Bozeman, MT on June 25, 1987.

2. Steve Roberts presented a paper entitled 'IPNV in Washington Salmonids' at the Western Fish Disease Conference in Vancouver, BC in June 1988.

3. Copies of the annual reports for this project were sent to the Washington State Library for public access.

Task 2.3 Facility impediments

The following list was compiled to provide BPA with a list of fish health impediments at each hatchery as well as to itemize the expected benefit and costs. The impediments have been listed as those that pertain to all hatcheries (Table 3) and those that are site specific (Table 4). Costs are expressed in 1988 dollars.

Table 3. System-wide fish health impediments

Project	cost	Benefit	Justification
Fish health training	$2,00O/facility	High	Increase facility personnel awareness to improve fish health; increase diagnostic capabilities.
Microcomputers and training	$5,000/facility currently not computerized.	Medium	Optimize feed conversion under CHOP program and provide facility database.
Flow measurement instrumentation	$lO,OOO/facility	Medium	Provide ability to determine rearing densities to produce higher smolt quality.

Table 4. Site specific fish health impediments

Facility	Project	costs	Benefits	Justification
Alder Creek Pond	None			
Beaver Creek	Water development project	$ 500,000	High	Facility has seasonal low flows. Increased flows will improve fish health.
	Oxygen injection system	$ 500,000	High	Facility suffers from seasonal high water temperatures and low DO's resulting in chronic stress. Increased DO's will increase fish health.
Chelan	Acclimation ponds for Wenatchee & Entiat rivers	$ 500,000	High	Ponds will reduce stress and disease during smolting.
Columbia Basin	Increase water flows	$ 100,000	High	Increased flows will improve rearing environment resulting in improved fish quality.
	Cover springs	$l,lOO,OOO	High	Covered springs will reduce pathogen transfer.
Coweeman Pds	Construct large rearing ponds (2)	$ 250,000	Medium	Pond construction will optimize rearing efficiency and improve fish quality.
Cowlitz	Adult holding pond rehabilitation	$ 500,000	High	Allow segregation by species and sex and reduce spread of disease.
	Adult holding pond covers	$ 100,000	Medium	Increase egg quality and reduce disease transfer.
Gobar Pond	None			
East Fork Lewis River	Construct imprinting pond	$	Medium	Imprinting pond will reduce *stress* during smolting, decrease straying and improve survival.

Table 4 (Cont.)

Facility	Project	costs	Benefits	Justification
Lyons Ferry	Bird predation control	$ 100,000		Minimize transfer of pathogens and stress on fish.
Merwin Net Pens	None			Will be discontinued with construction of the Lewis River hatchery.
Nelson Spgs.	None			Will be discontinued with the development of the Yakima project.
Naches	None			Will be discontinued with the development of the Yakima project.
Ringold	Asphalt pond	$ 300,000	Low	Reduce the reservoir of pathogens.
	Cover springs	$ 50,000	Medium	Covered springs will reduce disease transfer.
Skamania	Adult barrier	$ 300,000	High	Adult barrier will reduce level of adults migrating upstream of hatchery intake and pathogen load in water supply; adult returns will be maximized.
	Water treatment	$ 500,000	High	High copper levels in water stress fish. Removal will improve health.
	Construction of new raceways	$1,250,000	Medium	Rearing raceways need replacement to maximize rearing flows and eliminate pathogen transfer.
	Downstream SW barrier removal	$ 150,000	Medium	Impassable velocity barrier removal would allow SW broodstock returns in all years.
	Facility repiping to allow volitional release from raceways	$ 400,000	High	Eliminate handling stress and optimize release strategies while improving smolt quality.

Table 4 (Cont.)

Facility	Project	costs	Benefits	Justification
S.Toutle Trap	Raceway development (if operation continues)	$ 250,000	Medium	Currently no permanent raceways. Fry survival will be increased.
Turtle Rock	None			
Vancouver	Construction of new raceways	$ 750,000	Medium	Replacement of round ponds will maximize flows and improve fish health.
	Development of new water source	$ 500,000	High	Facility requires water replacement source to maximize potential.
	Spring redevelopment	$ 150,000	Medium	Springs require redevelopment to maximize flow potential.
Yakima	None			Yakima steelhead production will be discontinued with development of the Yakima master plan.
Wells	Water treatment for rearing ponds	$1,000,000	Medium	Reduce pathogen load in Columbia River water supply.
	Asphalt ponds	$ 300,000	Low	Improve pond draining characteristics, reduce stress during pond drainage, reduce pathogen habitat.
Dayton Pond	None			
Curl Lake	None			
Cottonwood Pd	None			

An ozone plant was constructed by Tacoma City Light at the Cowlitz Trout Hatchery in 1990-91. It is currently in its first year of use and will be evaluated for the impact on ceratomyxosis. Initial results are promising.

The Eastbank Hatchery has been constructed and the SS production from Turtle Rock Hatchery has been moved to the new site. Summer steelhead fingerlings are moved from Chelan Hatchery to Turtle Rock to be reared to smolts.

Task 3.1 Organosomatic analysis at index hatcheries

The overall condition of the smolts at Wells Hatchery was better in all categories than the smolts at the Cowlitz Hatchery. This determination was based on the percentage of fish that were closer to normal on the organosomatic index. The fish at Wells were longer, heavier, with a better condition factor and a higher average hematocrit level than those at Cowlitz (Table 5). In addition, the Wells fish had a greater pyloric fat level. The fish at Cowlitz had varying degrees of abnormality, such as enlarged and inflamed hind guts and mottled kidneys or pale gills. The less desirable condition of the fish at the Cowlitz Hatchery was attributed to the presence of the protozoan parasite Ceratomyxa Shasta in the intestinal tract of the fish. The pathological signs listed above are classic for C. Shasta infections (Bartholomew 1989). The parasite was found in all production lots at Cowlitz and has been implicated as the causative agent in the loss of up to 80% of some production lots there. Tables 5 and 6 list the comparative data for all stocks examined with the organosomatic index.

A comparison of the 1991 data with that of the previous four years shows almost no change in the Wells summer steelhead. The size and condition of the fish are almost identical. The four stocks of fish examined at the Cowlitz, however, display different values from previous years in all measured categories. This is attributed to ceratomyxosis in the fish during all five years of the project.

Table 5. Organosomatic index results. Mean values for species and stock for measured parameters: length, weight, condition factor (K factor), and hematocrit. 1986 to 1991

Location	Species	Year	Length	Weight	K factor	Hematocrit
Cowlitz	ss	1987				
		1988	186	59.9	0.8	36.4
		1989	171	50.9	1.0	39.0
		1990	162	42.5	1.0	37.0
		1991	184	59.7	1.0	41.7
		SD	9.8	7.2	0.1	2.1
Cowlitz	SW	1987	212	93.8	1.0	42.1
		1988	169	41.9	0.9	36.9
		1989	174	59.5	1.1	40.0
		1990	154	36.4	1.0	44.8
		1991	162	50.7	1.0	42.2
		SD	20.1	20.3	0.1	2.6
Cowlitz	SCT	1987	210	94.5	1.0	44.4
		1988	182	55.2	0.8	37.2
		1989	183	66.8	1.1	42.0
		1990	173	56.1	1.0	39.1
		1991	205	84.1	1.0	45.8
		SD	14.3	15.6	0.1	3.2
Cowlitz	LSW	1987	189	78.4	1.2	44.8
		1988				
		1989	180	60.4	1.0	49.0
		1990	163	45.6	1.0	45.2
		1991	158	41.1	1.0	48.3
		SD	12.5	14.5	0.1	1.8
Wells	ss	1987	205	75.6	0.9	50.4
		1988	192	66.2	0.9	53.8
		1989	189	66.2	1.0	54.0
		1990	198	72.7	0.9	57.0
		1991	198	70.7	0.9	48.9
		SD	5.5	3.1	0.0	2.9

Table 6. Summary of percentage of organosomatic index characteristics by organ for species/stock/hatchery for Cowlitz and Wells Hatcheries, 1986 to 1990

Location	Species	Year	Score	Fat	Spleen	HindGut	Kidney	Liver	Gills
Cowlitz	ss	1987	0						
			1						
			2						
			3						
			4						
Cowlitz	ss	1988	0	70.0%	90.0%	45.0%	100.0%	98.3%	
			1	28.3%	3.3%	41.7%	0.0%	1.7%	
			2	1.7%	6.7%	13.3%	0.0%	0.0%	
			3	0.0%	0.0%	0.0%	0.0%	0.0%	
			4	0.0%	0.0%	0.0%	0.0%	0.0%	
Cowlitz	ss	1989	0	40.0%	45.0%	57.0%	100.0%	97.0%	97.0%
			1	55.0%	45.0%	43.0%	0.0%	4.0%	4.0%
			2	5.0%	5.0%	0.0%	0.0%	0.0%	0.0%
			3	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	ss	1990	0	48.0%	17.0%	47.0%	98.0%	27.0%	88.0%
			1	30.0%	48.0%	33.0%	0.0%	70.0%	12.0%
			2	20.0%	30.0%	0.0%	2.0%	2.0%	0.0%
			3	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%
			4	0.0%	8.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	SS	1991	0	20.0%	32.0%	50.0%	82.0%	25.0%	95.0%
			1	28.0%	65.0%	50.0%	0.0%	75.0%	5.0%
			2	35.0%	3.0%	0.0%	18.0%	0.0%	0.0%
			3	15.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	SW	1987	0	20.0%	45.0%	61.0%	0.0%	100.0%	
			1	51.7%	50.0%	35.0%	20.0%	0.0%	
			2	20.0%	0.0%	3.3%	0.0%	0.0%	
			3	8.3%	0.0%	0.0%	0.0%	0.0%	
			4	0.0%	5.0%	0.0%	80.0%	0.0%	
Cowlitz	SW	1988	0	93.2%	80.0%	7.5%	100.0%	96.7%	
			1	6.8%	3.3%	58.3%	0.0%	3.3%	
			2	0.0%	26.7%	34.2%	0.0%	0.0%	
			3	0.0%	0.0%	0.0%	0.0%	0.0%	
			4	0.0%	0.0%	0.0%	0.0%	0.0%	
Cowlitz	SW	1989	0	70.0%	75.0%	55.0%	97.0%	97.0%	100.0%
			1	30.0%	20.0%	43.0%	3.0%	3.0%	0.0%
			2	0.0%	2.0%	2.0%	0.0%	0.0%	0.0%
			3	0.0%	3.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	SW	1990	0	53.0%	53.0%	35.0%	58.0%	35.0%	84.0%
			1	40.0%	28.0%	47.0%	35.0%	50.0%	16.0%
			2	6.0%	18.0%	18.0%	2.0%	7.0%	0.0%
			3	0.0%	0.0%	0.0%	5.0%	2.0%	0.0%

Table 6. (Cont.)

Location	Species	Year	Score	Fat	Spleen	HindGut	Kidney	Liver	Gills
			4	0.0%	0.0%	0.0%	0.0%	3.0%	0.0%
Cowlitz	SW	1991	0	45.0%	58.0%	7.0%	17.0%	60.0%	95.0%
			1	52.0%	38.0%	93.0%	5.0%	40.0%	5.0%
			2	3.0%	3.0%	0.0%	78.0%	0.0%	0.0%
			3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	SCT	1987	0	11.7%	70.0%	91.7%	3.3%	90.0%	
			1	10.0	10.0%	8.3%	18.3%	6.7%	
			2	6.7%	0.0%	0.0%	0.0%	0.0%	
			3	15.0%	20.0%	0.0%	0.0%	1.7%	
			4	56.7%	0.0%	0.0%	78.3%	1.7%	
Cowlitz	SCT	1988	0	45.0%	43.3%	73.3%	96.6%	86.7%	
			1	50.0	50.0%	23.3%	3.4%	13.3%	
			2	5.0%	5.0%	3.4%	0.0%	0.0%	
			3	0.0%	1.6%	0.0%	0.0%	0.0%	
			4	0.0%	0.0%	0.0%	0.0%	0.0%	
Cowlitz	SCT	1989	0	7.0%	43.0%	100.0%	95.0%	97.0%	100.0%
			1	28.0%	65.0%	50.0%	0.0%	75.0%	5.0%
			2	35.0%	3.0%	0.0%	18.0%	0.0%	0.0%
			3	15.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	ss	1990	0	53.0%	53.0%	35.0%	58.0%	35.0%	84.0%
			1	40.0%	28.0%	47.0%	35.0%	50.0%	16.0%
			2	6.0%	18.0%	18.0%	2.0%	7.0%	0.0%
			3	0.0%	0.0%	0.0%	5.0%	2.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	3.0%	0.0%
Cowlitz	SW	1991	0	45.0%	58.0%	7.0%	17.0%	60.0%	95.0%
			1	52.0%	38.0%	93.0%	5.0%	40.0%	5.0%
			2	3.0%	3.0%	0.0%	78.0%	0.0%	0.0%
			3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	SCT	1987	0	11.7%	70.0%	91.7%	3.3%	90.0%	
			1	10.0	10.0%	8.3%	18.3%	6.7%	
			2	6.7%	0.0%	0.0%	0.0%	0.0%	
			3	15.0%	20.0%	0.0%	0.0%	1.7%	
			4	56.7%	0.0%	0.0%	78.3%	1.7%	
Cowlitz	SCT	1988	0	45.0%	43.3%	73.3%	96.6%	86.7%	
			1	50.0	50.0%	23.3%	3.4%	13.3%	
			2	5.0%	5.0%	3.4%	0.0%	0.0%	
			3	0.0%	1.6%	0.0%	0.0%	0.0%	
			4	0.0%	0.0%	0.0%	0.0%	0.0%	
Cowlitz	SCT	1989	0	7.0%	43.0%	100.0%	95.0%	97.0%	100.0%
			1	78.0%	50.0%	0.0%	5.0%	3.0%	0.0%
			2	15.0%	7.0%	0.0%	0.0%	0.0%	0.0%
			3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowl itz	SCT	1990	0	2.0%	55.0%	77.0%	98.0%	15.0%	82.0%
			1	15.0%	45.0%	22.0%	2.0%	83.0%	18.0%
			2	28.0%	0.0%	2.0%	0.0%	2.0%	0.0%
			3	47.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 6. (Cont.)

Location	Species	Year	Score	Fat	Spleen	HindGut	Kidney	Liver	Gills
			4	8.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	SCT	1991	0	0.0%	10.0%	85.0%	83.0%	85.0%	82.0%
			1	2.0%	90.0%	15.0%	0.0%	15.0%	18.0%
			2	53.0%	0.0%	0.0%	17.0%	0.0%	0.0%
			3	27.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	LSW	1987	0	6.7%	75.0%	80.0%	0.0%	95.0%	
			1	3.3%	25.0%	16.7%	100.0%	50.0%	
			2	15.0%	0.0%	3.3%	0.0%	0.0%	
			3	25.0%	0.0%	0.0%	0.0%	0.0%	
			4	50.0%	5.0%	0.0%	80.0%	0.0%	
Cowlitz	LSW	1988	0						
			1						
			2						
			3						
			4						
Cowlitz	LSW	1989	0	0.0%	7.0%	2.0%	100.0%	96.7%	100.0%
			1	80.0%	90.0%	98.3%	0.0%	0.0%	0.0%
			2	20.0%	3.0%	0.0%	0.0%	0.0%	0.0%
			3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	LSW	1990	0	2.0%	30.0%	95.0%	100.0%	28.0%	100.0%
			1	12.0%	70.0%	0.0%	0.0%	72.0%	0.0%
			2	45.0%	0.0%	5.0%	0.0%	0.0%	0.0%
			3	40.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cowlitz	LSW	1991	0	0.0%	46.0%	98.0%	98.0%	73.0%	98.0%
			1	3.0%	53.0%	2.0%	0.0%	27.0%	0.0%
			2	43.0%	1.0%	0.0%	2.0%	0.0%	0.0%
			3	53.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wells	ss	1987	0						
			1						
			2						
			3						
			4						
Wells	ss	1988	0	0.0%	100.0%	100.0%	100.0%	98.3%	
			1	33.3%	0.0%	0.0%	0.0%	0.0%	
			2	66.7%	0.0%	0.0%	0.0%	0.0%	
			3	0.0%	0.0%	0.0%	0.0%	0.0%	
			4	0.0%	0.0%	0.0%	0.0%	0.0%	
Wells	ss	1989	0	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
			1	3.3%	0.0%	0.0%	0.0%	0.0%	0.0%
			2	67.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wells	ss	1990	0	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
			1	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			2	37.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			3	58.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 6. (Cont.)

Location	Species	Year	Score	Fat	Spleen	HindGut	Kidney	Liver	Gills
Wells	ss	1991	0	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%
			1	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			2	37.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			3	58.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			4	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Scores: Fat: 0 - none, 1 - <50% caecum covered, 2 - 50% caecum covered, 3 - 50% caecum covered, 4 - caecum completely covered
Spleen: red (R), 1 - black (B), 2 - granular (G), 3 -- nodular (N), 4- enlarged (E)
Hind Gut: 0 no inflamation, 1 - mild inflammation, 2 - severe inflammation
Kidney: 1 - normal (N), 1 - swollen (S), 2 - mottled (M), 3 - granular (G) 4 - urolithiasis (U)
Liver: 0 - normal (A), 1 - Pale (B), 2 - fatty (C), 3 - nodules (D), 4 - focal discoloration (E), 5 - slight general discoloratin(F)
Gills: 0 - normal (N), 1 - pale (P), 2 - frayed (F), 3 - clubbed (C), 4 - marginate (M)

Task 3.2 Test for Specific Pathogens

Viral pathogens

Viral assays run in 1990-91 revealed that six stocks of steelhead broodfish and one stock of cutthroat broodfish at three hatcheries had detectable levels of IHNV (Table 7) though no mortality was attributed to viremia. Infectious pancreatic necrosis virus was detected in summer steelhead broodfish at the Wells Hatchery during 1991. IPNV was also detected in one summer-run steelhead broodfish at the Yakima Hatchery in 1991. This was the first isolation of IPNV from a WDW hatchery other than Wells since 1983. Table 7 lists all isolations of replicating viral agents from broodfish sampled from 1983 to 1991 for this project.

Table 7. Isolations of IHNV/IPNV from WDW Columbia River basin broodstocks from 1987 to 1991.

Hatchery	Species	Stock	1987	1988	1989	1990	1991
Beaver Creek	SCT	Elochoman	-				
	SW	Elochoman	-	IHNV	-		IHNV
Chelan	ss	Ringold					NF
Cowlitz	SCT	Cowlitz		IHNV	IHNV	IHNV	IHNV
	ss	Cowlitz		IHNV	IHNV	IHNV	IHNV
	SW	Cowlitz		IHNV	IHNV	IHNV	IHNV
	LSW	Cowlitz		IHNV	IHNV	IHNV	IHNV
Lyons Ferry	ss	Lyons Ferry	IHNV	-	IHNV	IHNV	-
Skamania	SCT	Washougal	-			IHNV	-
	ss	Washougal	IHNV	-		IHNV	IHNV
	SW	Washougal	-	IHNV	IHNV	IHNV	-
Wells	ss	Wells			IHNV\IP	-	IPNV
Yakima	ss	Yakima					IPNV

- = No virus detected
NF = No fish on facility

Assays for erythrocytic inclusion body syndrome virus (EIBSV) were carried out by WDW staff. A three percent incidence of the virus was detected in summer steelhead broodfish at Wells Hatchery in 1990. In 1989 Wells SS broodstock was also positive at a 50% prevalence. Assays of all other broodstocks were negative for the viral inclusions (Table 8). These low levels of the virus are consistent with the previous two years. Data from 1986 and 1987 can not be compared to later years due to changes in assay technique.

Table 8. Prevalence of EIBSV in WDW Columbia River basin broodstock from 1986 to 1990.

Hatchery	Species	Stock	1987	1988	1989	1990	1991
Beaver Creek	SCT	Elochoman	3%	5%	0%	0%	0%
	SW	Elochoman	30%	15%	0%	0%	0%
Chelan	ss	Ringold	78%	28%	0%	0%	NF
Cowlitz	SCT	Cowlitz	98%	NS	0%	0%	0%
	ss	Cowlitz	18%	8%	0%	0%	0%
	SW	Cowlitz	42%	36%	0%	0%	0%
	LSW	Cowlitz	NS	0	0%	0%	0%
Lyons Ferry	ss	Lyons Ferry	58%	5%	0%	0%	0%
Skamania	SCT	Washougal	NS	NS	0%	0%	0%
	ss	Washougal	47%	NS	0%	0%	0%
	SW	Washougal	37%	NS	0%	0%	0%
Wells	ss	Wells	90%	8%	0%	5%	3%
Yakima	ss	Yakima	23%	22%	0%	0%	0%

NF = No fish on facility
NS = Not sampled

Cell culture assays on 1991 smolt samples were negative for replicating viral agents (Table 9). Beaver Creek had a 5% prevalence of EIBSV in SCT smolts; Chelan and Eastbank had 2% in SS smolts, Ringold SS, had 3%, and Cowlitz SW had a prevalence of 2%. These levels are consistent with the low levels found the previous four years (Table 10).

In October 1990, IHNV was isolated from winter-run steelhead fingerlings at the Cowlitz Hatchery. This infection was concurrent with an epizootic of ceratomyxosis and mortality was attributed primarily to the parasitic infection. IHNV was isolated from SS and SW steelhead fry and searun SCT fry at Beaver Creek hatchery in May. Mortality reached epizootic levels in the two steelhead stocks but not in the cutthroat (Table 20).

Table 9. Isolations of IHNV/IPNV from smolts at WDW Columbia River basin hatcheries from 1987 to 1991.

Location	Species	Stock	1987	1988	1989	1990	1991
Alder Creek Pond	SS	Washougal			NF	NF	NF
Beaver Creek	SCT	Elochoman					
Beaver Creek	SS	Washougal					
Beaver Creek	SW	Elochoman					
Chelan	SS	Wells					NF
Cottonwood Pond	SS	Wallowa					
Coweeman Pond, Lower	SCT/SW	Elochoman					
Coweeman Pond, Upper	SCT/SW	Elochoman					
Cowlitz	SCT	Cowlitz					
Cowlitz	SS	Cowlitz		IHNV			
Cowlitz	SW	Cowlitz					
Cowlitz	LSW	Cowlitz		NS		IHNV	
Curl Lake	SS	Lyons Ferry					
Dayton Pond	SS	Lyons Ferry					
Eastbank	SS	Wells	NF	NF	NF		
Gobar Pond	SS/SW	Washougal	IHNV				
Lyons Ferry	SS	Wells		NF	NF	NF	NF
Lyons Ferry	SS	Lyons Ferry					
Lyons Ferry	SS	Wallowa					
Merwin Net Pen	SS	Washougal					
Nelson Springs	SS	Yakima					
Nile Pond	SS	Yakima	NF	NF	NF		NF
Ringold	SS	Ringold					
Skamania	SCT	Washogual					
Skamania	SS	Washougal	IHNV			IHNV	
Skamania	SW	Washougal					
South Toutle Trap	SW	Elochoman	NF	NF			
Turtle Rock	SS	Ringold					
Vancouver	SS	Washougal					
Wells	SS	Wells			-		
Yakima	SS	Yakima					

- = No virus detected
NF = No fish on facility
NS = Not sampled

Table 10. Prevalence of EIBSV in smolts from WDW Columbia River basin hatcheries from 1987 to 1991.

Location	Species	Stock	1987	1988	1989	1990	1991
Alder Creek Pond	ss	Washougal	NS	0%	NF	NF	NF
Beaver Creek	SCT	Elochoman	25%	0%	3%	5%	5%
Beaver Creek	ss	Washougal	25%	0%	0%	0%	0%
Beaver Creek	SW	Elochoman	56%	0%	0%	0%	0%
Chelan	ss	Wells	45%	0%	0%	2%	2%
Cottonwood Pond	ss	Wallowa	35%	0%	0%	0%	0%
Coweeman Pond, Lower	SCT/SW	Elochoman	27%	0%	0%	0%	0%
Coweeman Pond, Upper	SCT/SW	Elochoman	42%	0%	0%	0%	0%
Cowlitz	SCT	Cowlitz	32%	0%	0%	0%	0%
Cowlitz	ss	Cowlitz	50%	0%	0%	0%	0%
Cowlitz	SW	Cowlitz	97%	0%	0%	0%	2%
Cowlitz	LSW	Cowlitz	NS	0%	0%	0%	0%
Curl Lake	ss	Lyons Ferry	17%	0%	0%	0%	0%
Dayton Pond	ss	Lyons Ferry	32%	3%	0%	0%	0%
Eastbank	ss	Wells	NF	NF	NF	2%	2%
Gobar Pond	ss\sw	Washoual	36%	0%	0%	0%	0%
Lyons Ferry	ss	Wells	0%	0%	0%	0%	NF
Lyons Ferry	ss	Lyons Ferry	50%	0%	0%	0%	0%
Lyons Ferry	ss	Wallowa	0%	0%	0%	0%	NF
Merwin Net Pen	ss	Washougal	7%	0%	0%	0%	0%
Nelson Springs	ss	Yakima	27%	0%	0%	0%	0%
Nile Pond	ss	Yakima	NF	NF	NF	0%	NF
Ringold	ss	Ringold	22%	5%	0%	3%	3%
Skamania	SCT	Washougal	23%	0%	0%	0%	0%
Skamania	ss	WAshougal	22%	0%	0%	0%	0%
Skamania	SW	Washougal	28%	0%	0%	0%	0%
South Toutle Trap	SW	Elochoman	40%	0%	0%	0%	0%
Turtle Rock	ss	Ringold	55%	0%	0%	0%	0%
Vancouver	ss	Washougal	23%	0%	0%	0%	0%
Wells	ss	Wells	42%	0%	0%	0%	0%
Yakima	ss	Yakima	17%	0%	0%	0%	0%

NF = No fish on facility
NS = Not sampled

Bacterial pathogens

Clinical signs of enteric redmouth disease were not observed during the monthly visits of this project. Furunculosis as epizootics occurred at the Beaver Creek Hatchery in 1986, 1987, 1988, and 1989. Aeromonas salmonicida was also isolated from SS juveniles at Columbia Basin Hatchery in 1987. Cytophaga psychrophila, the causative agent of bacterial coldwater disease, was isolated from fish at Cowlitz Hatchery, Beaver Creek Hatchery, Vancouver Hatchery, and Lyons Ferry Hatchery. Low grade, chronic mortality was associated with the pathogen and it was concurrent with coagulated yolk at Vancouver and IHN at Beaver Creek in 1991.

Results from the 1990-91 broodstock assays for R. salmoninarum revealed a very low rate of infection. Sea-run cutthroat broodfish had a prevalence of 3% at Cowlitz and 2% at Skamania. This finding is consistent with the previous four years (Table 11).

Table 11. Prevalence of renibacterium salmonlnarum In WDW Columbia River basin broodstock from 1987 to 1991.

Hatchery	Species	Stock	1987	1988	1989	1990	1991
Beaver Creek	SCT	Elochoman	5%	6%	2%	0%	0%
	SW	Elochoman	5%	3%	0%	2%	0%
Chelan	SS	Ringold	0%	0%	2%	0%	NF
Cowlitz	SCT	Cowlitz	3%	3%	2%	0%	3%
	SS	Cowlitz	0%	0%	0%	2%	0%
	SW	Cowlitz	0%	0%	0%	0%	0%
	LSW	Cowlitz	0%	0%	3%	0%	0%
Lyons Ferry	SS	Lyons Ferry	3%	3%	8%	0%	0%
Skamania	SCT	Washougal	0%	0%	0%	0%	2%
	SS	Washouga;	0%	0%	0%	0%	0%
	SW	Washougal	5%	6%	2%	0%	0%
Wells	SS	Wells	2%	3%	0%	0%	0%
Yakima	SS	Yakima	7%	7%	0%	0%	NS

NF = No fish on facility
NS = Not sampled

The 1990 smolts showed an equally low number of bacteria. Only the SS smolts from Vancouver were positive at a prevalence of 2% (Table 12). In 1991 11 of 26 stocks were infected. Five percent or less of each sample was positive. Clinical signs were not observed in the fish sampled. Prevalence of infections have been 5% or less with the exception of the Coweeman Ponds in 1987 when infection at the Coweeman Ponds reached 20% and 30% (Table 12).

Renibacterium salmoninarum was not detected in the 1990 broodyear sea-run cutthroat midterm samples collected in the fall of 1990. Table 13 shows the cumulative data for the five years of the study. Low levels of the bacterium were found in all stocks in 1987 and in the Skamania SCT in 1988. All samples collected in 1989 and 1990 were negative.

Table 12. Prevalence of penibacterium salmoninarum in WDW Columbia River basin smolts from 1987 to 1991.

Location	Species	Stock	1987	1988	1989	1990	1991
Alder Creek Pond	ss	Washougal	3%	0%	NF	NF	NF
Beaver Creek	SCT	Elochoman	0%	0%	0%	0%	200%
Beaver Creek	SS	Washougal	0%	0%	0%	0%	0%
Beaver Creek	SW	Elochoman	0%	0%	0%	0%	0%
Chelan	SS	Wells	0%	0%	0%	0%	0%
Cottonwood Pond	SS	Wallowa	3%	0%	0%	0%	2%
Coweeman Pond, Lower	SCT/SW	Elochoman	20%	3%	0%	0%	0%
Coweeman Pond, Upper	SCT/SW	Elochoman	33%	0%	2%	0%	NF
Cowlitz	SCT	Cowlitz	0%	0%	0%	0%	0%
Cowlitz	SS	Cowlitz	0%	5%	0%	0%	0%
Cowlitz	SW	Cowlitz	0%	2%	0%	0%	0%
Cowlitz	LSW	Cowlitz	0%	0%	0%	0%	0%
Curl Lake	SS	Lyons Ferry	0%	0%	0%	0%	2%
Dayton Pond	SS	Lyons Ferry	0%	0%	0%	0%	0%
Eastbank	SS	Wells	NF	NF	NF	2%	3%
Gobar Pond	SS\SW	Washoual	0%	0%	0%	0%	0%
Lyons Ferry	SS	Wells	0%	0%	0%	0%	NF
Lyons Ferry	SS	Lyons Ferry	0%	0%	0%	0%	2%
Lyons Ferry	SS	Wallowa	0%	0%	0%	0%	NF
Merwin Net Pen	SS	Washougal	0%	2%	0%	0%	0%
Nelson Springs	SS	Yakima	0%	0%	0%	0%	2%
Nile Pond	SS	Yakima	NF	NF	NF	0%	NF
Ringold	SS	Ringold	0%	0%	0%	0%	5%
Skamania	SCT	Washougal	0%	0%	0%	0%	0%
Skamania	SS	WAshougal	0%	0%	0%	0%	0%
Skamania	SW	Washougal	0%	0%	0%	0%	3%
South Toutle Trap	SW	Elochoman	0%	0%	0%	0%	0%
Turtle Rock	SS	Ringold	0%	0%	0%	0%	2%
Vancouver	SS	Washougal	0%	0%	0%	2%	0%
Wells	SS	Wells	0%	8%	2%	0%	3%
Yakima	SS	Yakima	0%	0%	0%	0%	2%

NF = No fish on facility
NS = Not sampled

Table 13. Prevalence of Renibacterium salmoninarum in WDW Columbia River basin juvenile sea-run cutthroat trout from 1987 to 1990.

Hatchery	Stock	1987	1988	1989	1990
Beaver Creek	Elochoman	3%	0%	0%	0%
Cowlitz	Cowlitz	2%	0%	0%	0%
Skamania	Washougal	5%	5%	0%	0%

Parasitic pathogens

No samples were processed for Myxobolus cerebralis this year. Table 14 lists all the hatcheries and natural waters sampled during this project. All 18 sites assayed for M. cerebralis were negative. Ceratomyxa shasta continues to cause significant losses in production lots at the Cowlitz Hatchery, our only site which is plagued by the parasite. An ozone water treatment plant has been installed by Tacoma City Light in an attempt to control the ceratomyxosis. The system was tested during the summer of 1991 and initial results are promising. The causative agent of proliferative kidney disease (PKX) was not detected during routine necropsy and clinical signs of the disease were not observed at any of the Columbia River basin facilities.

Table 14. Locations, species, stock, lifestage, and results of fish sampled for Myxobolus cerebralis, 1986 to 1990.

Location	Sampling date	Species	stock	Lifestage	Sample size	Result
Beaver Creek Hatchery	02/02/88	SW	Elochoman	Juvenile	20	Negative
Beaver Creek Hatchery	01/01/87	SW	Elochoman	Juvenile	60	Negative
Cottonwood Pond	04/25/88	SS	Wallowa	Smolt	60	Negative
Coweeman Pond	10/14/88	SW	Elochoman	Juvenile	25	Negative
Cowlitz Hatchery	03/22/88	SW	Cowlitz	Smolt	60	Negative
Curl Pond	01/01/87	SS	Lyons Ferry	Smolt	60	Negative
Curl Pond	04/26/88	SS	Lyons Ferry	Smolt	60	Negative
Gobar Pond	09/22/88	SS/SW	Washougal/ Elochoman	Juvenile	60	Negative
Merwin Net Pen	03/01/88	SS	Washougal	Smolt	60	Negative
Nelson Springs Pond	01/12/87	SS	Yakima	Juvenile	40	Negative
Skamania Hatchery	01/01/87	SS	Washougal	Juvenile	60	Negative
Skamania Hatchery	03/18/89	SS/SW	Washougal	Smolt	20	Negative
south Toutle Trap	09/07/88	SW	Elochoman	Juvenile	60	Negative
Turtle Rock Pond	01/01/87	SS	Ringold	Juvenile	60	Negative
Turtle Rock Pond	12/17/87	SS	Ringold	Juvenile	60	Negative
Wells Hatchery	01/01/87	SS	Wells	Juvenile	60	Negative
Wells Hatchery	02/17/88	SS	Wells	Juvenile	60	Negative
White Salmon River	10/12/88	RB	Wild	Juvenile	21	Negative
				Total	906	

Objective 4.0 Monitoring Hatchery Water Supplies

Task 4.1 Sample Hatchery Water Supplies

A sampling plan was completed in the 1986 annual report (Table 15). BPA did not select a laboratory for water analysis so sampling was not initiated.

Task 4.2 Monitoring Flow and Loading Densities

The flow and density index data for the project are summarized in Table 16 and are presented as the mean, minimum, and maximum loadings for each facility. The loadings did not vary significantly during the study.

Table 15. Proposed locations and dates for water sampling at WDW Columbia River basin hatcheries.

Hatchery Location	Water Supply	Sample Date
Alder Cr. Pond	Alder Cr	April
Beaver Cr.	Beaver Cr.	April, October
	Well source	January
	Elochoman River	July
Chelan	Well source	April, October
	Spring source	April, October
Columbia basin	Spring	August
Cottonwood Pond	Cottonwood Cr.	April
Coweeman CT Pd	Creek	April
Coweeman SW Pd	Creek	April
Cowlitz	Well source	April, October
	Cowlitz	July
Curl Lake	Tucannon River	April
Dayton Pond	Touchet River	April
Gobar pond	Gobar Cr.	April
Lyons Ferry	(sampled per WDF contract)	
Merwin Net Pen	Merwin Res.	April
Naches	Seep system	May, November
Naches River		June
Nelson Springs	Spring	April
Ringold Springs	(sampled per WDF contract)	
Skamania	Skamania River	April, October
Vogel Cr.		January
S. Toutle Trap	Creek	April
Turtle Rock	(sampled per WDF contract)	
Vancouver	Spring	April, October
Keffel Lake		January
Wells	(sampled per WDF contract)	
Yakima	Spring	April, November
Spring Cr.		April

Table 16. The range and mean of temperature, flow index, and density index for WDW Columbia River basin hatcheries from 1983 to 1990.

Location	Species	Stock	Year	Pond Type	TEMP min	TEMP max	DI min	DI max	DI avg	FI min	FI max	FI avg
Beaver Creek	SS	Washougal	1988	R	40	65	0.09	0.24	0.15	0.06	1.45	0.95
		Washougat	1989	R	44	58	0.06	0.26	0.18	0.34	3.92	1.28
		Washougal	1990	R	45	66	0.05	0.28	0.20	0.25	1.38	1.05
			AVG		43	63	0.07	0.26	0.18	0.22	2.25	1.09
			SD		2.16	3.56	0.02	0.02	0.02	0.12	1.18	0.14
Beaver Creek	SW	Elochoman	1987	R	42	52	data inc:omplete		for year			
		Elochoman	1988	R	40	65	0.09	1.17	0.25	0.41	1.86	0.97
		ELochoman	1989	R	44	58	0.07	0.39	0.23	0.44	1.84	1.00
		Elochoman	1990	R	44	66	0.01	0.91	0.26	0.20	2.15	1.22
			AVG		44	62	0.06	0.82	0.25	0.35	1.95	1.06
			SD		0.00	4.00	0.03	0.32	0.01	0.11	0.14	0.11
Beaver Creek	SW	Elochoman	1987	RP	42	52						
		ELochoman	1988	RP								
		ELochoman	1989	RP	44	52				0.88	2.03	1.49
		Elochoman	1990	RP	45	51	0.16	0.37	0.29	0.82	1.87	1.47
			AVG		45	52	0.16	0.37	0.29	0.85	1.95	1.48
			SD		0.50	0.50	0.00		0.00	0.03	0.08	0.01
Beaver Creek	SCT	Elochoman	1988	R	40	65	0.10	0.24	0.17	0.42	1.66	0.97
		Elochoman	1989	R	44	58	0.01	0.31	0.18	0.31	2.07	1.19
		ELochoman	1990	R	45	66	0.16	0.59	0.23	2.15	0.20	1.22
			AVG		43	63	0.09	0.38	0.19	0.96	1.31	1.13
			SD		2.16	3.56	0.06	0.15	0.03	0.84	0.80	0.11
Chelan	ss	Wells	1987	R	54	56	0.16	0.09	0.29	1.12	0.53	2.94
		Ringold	1987	R	54	56	0.15	0.05	0.27	0.88	0.33	1.54
		Wells	1988	R	55		0.12	0.03	0.24	0.92	0.22	1.95
		Wells	1989	R	55		0.16	0.09	0.28	1.30	0.72	2.21
		Wells	1990	R	54	56	0.13	0.09	0.16	1.01	0.76	1.24
			AVG		54	56	0.14	0.07	0.25	1.05	0.51	1.98
			SD		0.49	0.00	0.02	0.03	0.05	0.15	0.21	0.59
Columbia Basin	SS	Skamania	1987	R	58	60	0.19	0.06	0.30	0.70	0.22	1.06
		Ringold	1987	R	58		0.22	0.17	0.29	0.79	0.62	1.04
		Skamania	1988	R	59		0.11	0.02	0.19	0.39	0.06	0.68
		Ringold	1988	R	59		0.17	0.13	0.27	0.61	0.45	0.96
		Lyons Ferry	1988	R	58	60	0.14	0.14	0.15	0.51	0.49	0.53
		Ringold	1989	R	59		0.12	0.11	0.13	0.44	0.40	0.47
			AVG		59	60	0.16	0.11	0.22	0.57	0.37	0.79
			SD		0.50	0.00	0.04	0.05	0.07	0.14	0.18	0.24
Cowlitz	ss	Cowlitz	1988	R	48	53	0.01	0.17	0.08	0.05	1.75	0.74
		Cowlitz	1989	R	44	54	0.01	0.03	0.01	0.03	0.10	0.05
		Cowlitz	1990	R								
			AVG		46	54	0.01	0.10	0.05	0.04	0.93	0.40
			SD		2.00	0.50	0.00	0.07	0.04	0.01	0.82	0.34
Cowlitz	ss	Cowlitz	1989	RP	44	47			0.01			0.04
		Cowlitz	1990	RP								
			AVG		44	47	0.00	0.00	0.01	0.00	0.00	0.04
			SD									
Cowlitz	SW	Cowlitz	1988	R	48	54	0.01	0.26	0.11	0.35	0.56	1.37
		Cowlitz	1989	R	45	56	0.00	0.16	0.03	0.05	0.07	0.05
		Cowlitz	1990	R								
			AVG		47	55	0.01	0.21	0.07	0.20	0.32	0.71
			SD		1.50	1.00	0.01	0.05	0.04	0.15	0.25	0.66

R - raceway, RP - rearing pond, C - circular

Table 16. flow and density index data continued

Location	Species	Stock	Year	Pond Type	min	max	min	max	avg	min	max	avg
Cowlitz	SW	Cowlitz	1988	RP	48	55				1.29	3.03	1.80
		Coulitz	1989	RP								
		Cowlitz	1990	RP								
			AVG		48	55				1.29	3.03	1.80
			SD		0.00	0.00						
Coulitz	SCT	Cowlitz	1988	R	48	51	0.07	0.15	0.08	0.02	1.95	0.99
		Cowlitz	1989	R	44	56	0.01	0.02	0.10	0.02	0.04	0.04
		Coulitz	1990	R								
			AVG		46	54	0.04	0.09	0.09	0.02	1.00	0.52
			SD		2.00	2.50	0.03	0.07	0.01	0.00	0.95	0.48
Cowlitz	LSW	Cowlitz	1988	R	48	51	0.10	0.22	0.14	0.57	2.16	1.31
		Cowlitz	1989	R	46	51	0.00	0.02	0.01	0.00	0.04	0.03
		Coulitz	1990	R								
			AVG		47	51	0.05	0.12	0.08	0.29	1.10	0.67
			SD		1.00	0.00	0.05	0.10	0.06	0.29	1.06	0.64
Eastbank	ss	Wells	1989	RP	48	56	0.04	0.01	0.06	1.14	0.54	1.56
		Wells	1989	RP	48	54	0.03	0.02	0.05	1.00	0.73	1.25
		Wells	1990	R	48	51	0.16	0.07	0.26	1.21	0.82	1.58
			AVG		48	54	0.08	0.03	0.12	1.12	0.70	1.46
			SD		0.00	2.05	0.06	0.03	0.10	0.09	0.12	0.15
Lyons Ferry	SS	Wallowa	1987	RP	52	53	0.01	0.00	0.02	0.65	0.28	1.32
		Wal lowa	1987	R	50	54	0.06	0.03	0.08	0.39	0.15	0.58
		Lyons Ferry	1987	R	48	54	0.10	0.04	0.16	0.66	0.37	1.38
		Lyons Ferry	1987	RP		52	0.01	0.00	0.02	0.90	0.34	1.49
		Wallowa	1988	R		53	0.10	0.06	0.16	0.81	0.56	1.61
		Wallowa	1988	RP	51	53	0.01	0.01	0.02	0.87	0.32	1.22
		Lyons Ferry	1988	RP	51	53	0.01	0.00	0.02	1.02	0.18	1.66
		Lyons Ferry	1988	R	52	53	0.11	0.04	0.21	0.90	0.44	1.41
			AVG		51	53	0.05	0.02	0.09	0.78	0.33	1.33
			SD		1.37	0.60	0.04	0.02	0.07	0.19	0.12	0.32
Naches	ss	Yakima	1987	R	52	59	0.36	0.10	0.59	1.39	0.85	1.90
		Yakima	1988	R	46	58	0.32	0.13	0.53	1.09	0.51	2.10
			AVG		49	58.5	0.34	0.115	0.56	1.24	0.68	2
			SD		3.00	0.50	0.02	0.02	0.03	0.15	0.17	0.10
Nelson Springs	SS	Yakima	1987	R	49	51	0.31	0.24	0.37	1.41	1.37	1.51
		Yakima	1988	R	50		0.28	0.25	0.32	1.08	0.94	1.22
		Yakima	1989	R	50		0.35	0.29	0.41	1.33	1.11	1.55
			AVG		50	51	0.31	0.26	0.37	1.27	1.14	1.43
			SD		0.47	0.00	0.03	0.02	0.04	0.14	0.18	0.15
Ringold	ss	Ringold	1987	RP	50	60	0.02	0.01	0.03	2.51	1.32	4.52
		Ringold	1988	RP	52	59	0.02	0.01	0.02	2.12	1.12	3.25
		Skamania	1989	RP	54	59	0.01	0.01	0.02	1.92	1.11	2.74
		skamania	1990	RP	52	59	0.02	0.01	0.02	1.55	0.78	2.26
			AVG		52	59	0.02	0.01	0.02	2.03	1.08	3.19
			SD		'1.41	0.43	0.00	0.00	0.00	0.35	0.19	0.84
Skamania	ss	washougal	1988	R	40	57	0.07	0.38	0.21	0.33	1.48	1.01
		Washougal	1989	R	41	59	0.14	0.26	0.21	0.68	1.46	1.19
		Uashougal	1990									
			AVG		41	58	0.11	0.32	0.21	0.51	1.47	1.10
			SD		0.50	1.00	0.04	0.06		0.18	0.01	0.09

R - raceway, RP - rearing pond, C - circular

Table 16. flow and density index data continued

Location	Species	Stock	Year	Pond Type	TEMP min	TEMP max	DI min	DI max	DI avg	FI min	FI max	FI avg
Skamania	su	Elochoman	1988	R	40	57	0.07	0.35	0.23	0.37	1.89	1.21
		ELochoman	1989	R	41	59	0.11	0.31	0.24	0.50	1.72	1.26
		Elochoman	1990									
			AVG		41	58	0.09	0.33	0.24	0.44	1.81	1.24
			SD		0.50	1.00	0.02	0.02	0.00	0.07	0.09	0.02
Skamania	SCT	Elochoman	1988	R	40	57	0.02	0.35	0.21	0.11	1.87	1.11
		Elochoman	1989	R	41	59	0.25	0.08	0.17	0.39	1.16	0.77
		Elochoman	1990									
			AVG		40.5	58	0.135	0.215	0.19	0.25	1.515	0.94
			SD		0.50	1.00	0.12	0.13	0.02	0.14	0.35	0.17
Turtle Rock	ss	Ringold	1987	RP	37	47	0.13	0.12	0.14	1.05	0.99	1.11
		Ringold	1988	RP	36	53	0.1	0.09	0.11	0.79	0.67	0.83
		Wells	1989	RP	37	53	0.12	0.08	0.16	1.02	0.7	1.23
			AVG		36.5	50	0.115	0.105	0.125	0.92	0.83	0.97
			SD		0.50	3.00	0.02	0.02	0.02	0.13	0.16	0.14
Vancouver	ss	Washougal	1988	RP	49	53			0.01			1.76
		Uashougal	1989	RP	45	52	0.01	0.01	0.01	1.2	3.64	2.81
			AVG		47	52.5	0.005	0.005	0.01	0.6	1.82	2.285
			SD		2.00	0.50	0.01	0.01	0.00	0.60	1.82	0.52
Wells	ss	Uells	1987	RP	37	62	0.01	0	0.02	1.89	0.48	3.21
		Uells	1987	R	52	53	0.21	0.08	0.41	1.08	0.41	1.98
		Wells	1988	R	53		0.12	0.09	0.15	0.59	0.46	0.72
		Wells	1988	RP	38	58	0.01	0.01	0.02	1.64	0.94	2.21
		Wells	1989	RP	35	60	0.01	0.01	0.02	1.61	1.02	2.27
		Wells	1989	R	53		0.19	0.13	0.27	0.94	0.63	1.32
			AVG		44.7	58.3	0.1	0.1	0.1	1.3	0.7	2.0
			SD		8.06	3.34	0.09	0.05	0.15	0.45	0.24	0.78
Yakima	ss	Yakima	1987	C	52	58	0.11	0.03	0.19	2.55	0.67	4.49
		Yakima	1988	C	50	58	0.12	0.06	0.18	2.23	0.95	3.08
		Yakima	1989	C	57	58	0.1	0.07	0.14	1.85	0.85	2.82
		Yakima	1990	C	55	56	0.09	0.09	0.25	3.55	1.67	4.84
			AVG		53.5	57.5	0.1	0.1	0.2	2.5	1.0	3.8
			SD		2.69	0.87	0.01	0.02	0.04	0.63	0.38	0.87

R - raceway, RP - rearing pond, C - circular

Objective 5.0 Record, Analyze and Report Fish Health Monitoring and Related Data

Monthly monitoring data and specific pathogen testing information was entered into a dBase III+ database program. The flow and density data has been entered into Lotus 123 worksheets.

Objective 6.0 Estimate the Project's Benefits

Task 6.1.1 Severity of Pathogens and Mortality Caused

Viral Pathogens:

At the beginning of the BPA project, data on the status of fish health at WDW Columbia River hatcheries was reviewed. Data on pathogen isolation and identification from 1983 to 1986 is presented in this section.

IHNV was isolated from adult fish at the Cowlitz Hatchery in 1981 and 1982 but is not included in the table.

The incidence of IHNV isolated from each hatchery varied substantially from 1983 to 1985. Results of IHNV isolations are listed in Table 17.

IPNV was isolated from adult summer steelhead from Tucannon and Wells hatcheries. After 1983, the IPNV isolations were only found in adult steelhead at Wells hatchery. The incidence at Wells was less than one percent of the adult fish sampled. The historical isolations of IPNV from WDW Columbia River broodstocks are shown in Table 17.

Juvenile fish were not sampled for replicating viral agents prior to 1986. Samples were not collected from adult or juvenile fish for EIBSV before 1986.

Table 17. Isolation of IHNV/IPNV from WDW Columbia River basin broodstocks from 1983 to 1986.

			Year			
Hatchery Location	Species	Stock	1983	1984	1985	1986
Beaver Creek	SCT	Elochoman	--	--	--	--
	SW	Elochoman	--	--	IHNV	--
Chelan	SS	Ringold	NF	NF	NF	--
Cowlitz	CT	Cowl itz	--	--	--	--
	SS	Cowlitz	--	--	--	--
	SW	Cowlitz	--	--	--	--
Lyons Ferry	SS	Lyons Ferry	--	NF	NF	--
Skamania	SS	Washougal	IHNV	--	--	--
	SW	Washougal	IHNV	--	--	--
Wells	SS	Wells	IPNV	IPNV	--	--
Yakima	SS	Yakima	--	--	--	--

-- = No virus detected
NF = No fish on facility

Bacterial Pathogens:

No systematic sampling for any bacterial pathogen was done at any WDW facility in either adults or juveniles for 1983 to 1986. Identification of bacterial pathogens has been limited to diagnostic cases and epizootics are listed in Table 20.

Parasites:

Sampling for M. cerebralis was sporadic at WDW facilities in past years. One sample was collected from summer steelhead (Wallowa stock) from Lyons Ferry Hatchery (April, 1985). Sixty fish were sampled to certify them for shipment to Oregon and all were negative for the pathogen.

Routine sampling for C. Shasta and PKX was not done at any WDW hatcheries prior to 1986. However, ceratomyxosis was diagnosed every year in juvenile steelhead and cutthroat stocks from the Cowlitz Hatchery.

Task 6.1.2 Total number and percent loss of each lifestage of fish species

Lot Production Mortalities

The average egg mortality for the 1989 broodyear was 16.17% with a range of 2.92% at Lyons Ferry (Wallowa stock) to 42.60% at Lyons Ferry (Lyons Ferry stock). The average fry mortality for the 1989 broodyear was 15.68% with a range of 0.07% at the Columbia Basin Hatchery to 73.55% at Cowlitz Hatchery. The resulting egg and fry mortality yielded an overall average mortality from egg to fry of 28.62%. A summary of the egg and fry mortality for the 1983 to 1989 broodyears is contained in Table 18.

Adult Prespawning Mortalities

Adult prespawning mortality data is reported in Table 19.

Task 6.1.3 Number and causative agents of epizootics, type and amount of medication used

Disease outbreaks causing significant mortality occurred at Columbia basin hatcheries between July 1, 1986 and June 30, 1989 (Table 20). When possible, epizootics were treated with medication.

Task 6.1.4 Feed Conversion

Feed conversion for hatchery stocks in the Columbia River basin during the project are listed in Table 21.

Task 6.1.5 Total survival of smolts to adults from index hatcheries

Fish were not tagged for smolt to adult survival during this project,

Table 18. Summary of egg and fry mortality at lumbia River basin hatcheries: 1983 to 1990.

Location	Species	Stock	Broodyear	Egg mortality	Fry mortality	Total mortality
Beaver Creek	SS	Skamania	1983	0.22%	8.68%	8.87%
			1984	7.23%	12.61%	18.93%
			1985	0.10%	10.55%	10.64%
			1986	14.53%	12.03%	24.81%
			1987			
			1988	5.01%	11.10%	15.55%
			1989	27.23%	18.89%	40.98%
			AVG	7.76%	10.55%	17.11%
			SD	0.09	0.05	0.12
Beaver Creek	SW	Elochoman	1983	5.24%	52.34%	54.83%
			1984	26.46%	16.90%	38.89%
			1985	12.26%	17.88%	27.95%
			1986	14.70%	0.19%	14.87%
			1987			
			1988	26.88%	1.04%	27.65%
			1989	13.14%	44.00%	51.36%
			AVG	14.10%	18.91%	30.79%
			SD	0.09	0.20	0.18
Beaver Creek	SCT	Elochoman	1983	49.80%	102.59%	101.30%
			1984	32.86%	14.27%	42.45%
			1985	12.86%	23.95%	33.73%
			1986	27.97%	10.91%	35.83%
			1987			
			1988	38.77%	29.56%	56.87%
			1989	41.43%	4.92%	44.31%
			AVG	29.10%	26.60%	44.93%
			SD	0.16	0.32	0.28
Chelan	ss	Wells	**1983**	10.10%	8.10%	17.40%
			1984	2.40%	7.90%	10.20%
			1985	3.50%	9.60%	12.80%
			1986	4.10%	8.40%	12.10%
			1987	4.90%	6.50%	11.00%
			1988	5.40%	10.60%	15.50%
			1989	8.30%	7.50%	15.10%
			AVG	5.53%	8.37%	13.44%
			SD	0.03	0.01	0.02
Chelan/ Turtle Rock	ss	Wells	**1983**	18.60%	26.70%	40.40%
			1984		38.70%	38.70%
			1985	6.70%	21.70%	26.90%
			1986	8.20%	3.70%	11.60%
			1987	6.30%	4.60%	9.60%
			1988	29.80%	14.30%	39.80%
			1989	4.90%	11.00%	15.30%
			AVG	12.42%	17.24%	26.04%
			SD	0.09	0.12	0.13
Columbia Basin/ Ringold	ss	Ringold	1986	0.00%	7.10%	7.10%
			1987	0.00%	10.20%	10.20%
			1988	0.00%	11.70%	11.70%
			1989	0.00%	0.70%	0.70%
			1990	0.00%	1.90%	1.90%
			AVG	0.00%	6.32%	6.32%
			SD	**0.00**	0.04	0.04

Table 18. summary of egg and fry mortality continued

Location	Species	Stock	Broodyear	Egg mortality	Fry mortality	Total mortality
Cowlitz	ss	Cowlitz	1983	3.1%	16.2%	18.7%
			1984	7.5%	11.2%	17.9%
			1985	6.8%	45.7%	49.4%
			1986	7.9%	76.2%	78.1%
			1987	7.6%	39.8%	44.4%
			1988	11.5%	3.65%	14.69%
			1989	9.3%	34.34%	40.46%
			1990	7.6%	39.83%	44.39%
			AVG	7.66%	33.37%	38.50%
			SD	0.07	0.22	0.20
Cowlitz	SW	Cowlitz	1983	5.6%	27.3%	31.4%
			1984	3.8%	30.3%	33.0%
			1985	7.0%	21.9%	27.3%
			1986	5.6%	28.6%	32.6%
			1987	23.3%	37.5%	52.1%
			1988	7.60%	0.66%	7.27%
			1989	23.35%	37.50%	52.09%
			1990	8.07%	10.00%	18.07%
			AVG	10.63%	36.29%	31.73%
			SD	0.10	0.26	0.14
Cowlitz	SCT	Cowlitz	1983	1.4%	22.7%	23.8%
			1984	12.4%	27.1%	36.2%
			1985	16.3%	37.7%	47.9%
			1986	25.4%	60.6%	70.6%
			1987	15.5%	73.6%	77.7%
			1988	10.74%	4.20%	14.49%
			1989	15.50%	73.55%	77.65%
			1990	23.98%	10.00%	33.98%
			AVG	15.17%	37.43%	47.79%
			SD	0.15	0.27	0.23
Cowlitz	LSW	Cowlitz	1983	21.0%	10.5%	29.3%
			1984	12.6%	9.9%	21.3%
			1985	17.0%	5.1%	21.2%
			1986			
			1987			
			1988	11.4%	3.5%	14.6%
			1989	31.0%	1.2%	31.9%
			1990	16.4%	10.00%	16.4%
			AVG	13.68%	5.04%	16.83%
			SD	0.11	0.04	0.11
Eastbank	ss	Wells	1989	0.00%	0.20%	0.20%
			1990	17.40%	10.50%	26.10%
			AVG	8.70%	5.35%	13.15%
			SD	0.09	0.05	0.13
Lyons Ferry	ss	Wallowa	1983	6.50%	7.10%	13.10%
			1984	4.20%	3.30%	7.30%
			1985	7.80%	7.10%	14.30%
			1986	3.60%	2.10%	5.60%
			1987	1.10%	4.10%	5.10%
			1988	4.70%	16.30%	20.30%
			1989	2.90%	5.60%	8.30%
			1990	4.30%	1.70%	6.00%
			AVG	4.39%	5.91%	10.00%
			SD	0.02	0.04	0.05

Table 18. summary of egg and fry mortality continued

Location	Species	Stock	Broodyear	Egg mortality	Fry mortality	Total mortality
Lyons Ferry	ss	Wells	1983	3.70%	6.80%	10.20%
			1984	8.90%	9.20%	17.30%
			1985	4.10%	3.80%	7.80%
			1986	9.80%	3.90%	13.30%
			AVG	6.63%	5.93%	12.15%
			SD	0.03	0.02	0.04
Lyons Ferry	ss	Lyons Ferry	1986	27.50%	9.10%	34.10%
			1987	16.40%	4.90%	20.40%
			1988	12.20%	13.50%	24.10%
			1989	42.60%	5.10%	45.50%
			AVG	24.68%	8.15%	31.03%
			SD	0.12	0.04	0.10
Naches	ss	Nelson Springs	1983	9.30%	22.70%	29.90%
			1984	4.10%	6.30%	10.10%
			1985	8.00%	52.30%	56.10%
			1986		2.80%	2.80%
			1987	7.50%	27.20%	32.70%
			1988	2.40%	20.70%	22.60%
			1989	8.50%	37.10%	42.40%
			1990		6.00%	6.00%
			AVG	6.63%	21.89%	25.33%
			SD	0.03	0.16	0.17
Skamania	ss	Skamania	1983	30.9%	1.0%	31.6%
			1984	22.6%	21.1%	38.9%
			1985	3.4%	1.1%	4.5%
			1986	8.0%	2.7%	10.5%
			1987	17.1%	8.1%	23.8%
			1988			
			1989	19.5%	0.8%	20.2%
			1990	17.1%	8.1%	23.8%
			AVG	14.84%	5.36%	19.18%
			SD	0.10	0.07	0.12
Skamania	SW	Elochoman	1983	72.4%	4.0%	73.5%
			1984	16.2%	46.1%	54.8%
			1985	3.3%	3.1%	6.3%
			1986	4.4%	1.8%	6.1%
			1987	10.0%	2.3%	12.0%
			1988			
			1989	19.2%	4.4%	22.7%
			1990	10.0%	2.3%	12.0%
			AVG	16.94%	8.00%	23.44%
			SD	0.22	0.14	0.25
Skamania	SCT	Elochoman	1983	4.0%	84.9%	85.6%
			1984	10.1%	83.9%	85.5%
			1985	2.1%	12.6%	14.4%
			1986	1.8%	9.5%	11.1%
			1987	7.9%		13.9%
			1988			
			1989	8.0%	2.2%	10.01%
			1990	7.9%	6.6%	13.92%
			AVG	5.22%	24.97%	29.31%
			SD	0.03	0.35	0.33

Table 18. summary of egg and fry mortality continued

Location	Species	Stock	Broodyear	Egg mortality	Fry mortality	Total mortality
Vancouver	ss	Skamania	1983	8.3%	0.2%	8.4%
			1984	0.2%	6.5%	6.7%
			1985	10.0%	15.0%	23.4%
			1986	5.8%	9.9%	15.1%
			1987	11.9%	18.3%	28.1%
			1988			
			1989	5.5%	19.4%	23.9%
			1990	0.9%	11.8%	12.6%
			AVG	6.09%	11.58%	16.89%
			SD	0.04	0.06	0.08
Wells	ss	Wells	1983	25.90%	1.20%	26.80%
			1984	9.40%	1.20%	10.50%
			1985	15.60%	2.70%	17.90%
			1986	10.70%	0.50%	11.20%
			1987	8.80%	2.00%	10.60%
			1988	24.80%	5.90%	29.20%
			1989	17.80%	1.60%	19.10%
			1990	8.60%	1.00%	9.50%
			AVG	15.20%	2.01%	16.85%
			SD	0.07	0.02	0.07
Yakima/ Columbia Basin/ Ringold	ss	Ringold	1983	23.20%	6.80%	28.40%
			1984	24.60%	22.10%	41.30%
			1985	16.00%	10.10%	24.50%
			AVG	21.27%	13.00%	31.40%
			SD	0.04	0.07	0.07
Yakima	ss	Yakima	1986	12.60%	20.00%	30.10%
			1987	25.50%	7.50%	31.10%
			1988	31.10%	7.10%	36.00%
			1989	25.40%	3.70%	28.10%
			1990	31.60%	18.10%	44.00%
			AVG	25.24%	11.28%	33.86%
			SD	0.07	0.07	0.06

Table 19. Prespawning broodstock mortality at WDW Columbia River basin hatcheries: 1986 to 1990.

Location	Species	Stock	Year	Number trapped	Number dead	Mortality (%)
Beaver Creek	SCT	Elochoman	1986	741	8	1.1%
Beaver Creek	SCT	Elochoman	1987	929	23	2.5%
Beaver Creek	SCT	Elochoman	1988	553	13	2.4%
Beaver Creek	SCT	Elochoman	1989	493		
Beaver Creek	SCT	Elochoman	1990			
Beaver Creek	SW	Elochoman	1986	1214	26	2.1%
Beaver Creek	SW	Elochoman	1987	553	13	2.4%
Beaver Creek	SW	Elochoman	1988	929	23	2.5%
Beaver Creek	SW	Elochoman	1989	1085		
Chelan	SS	Ringold	1986	588	36	6.1%
Chelan	ss	Ringold	1987	394	153	38.8%
Chelan	ss	Ringold	1988	140	2	1.4%
Cowlitz	SCT	Cowlitz	1986	1313	62	4.7%
Cowlitz	SCT	Cowlitz	1987	508		
Cowlitz	SCT	Cowlitz	1988			9.8%
Cowlitz	SCT	Cowlitz	1989			
Cowlitz	SCT	Cowlitz	1990			
Cowlitz	ss	Cowlitz	1986	713	87	12.2%
Cowlitz	ss	Cowlitz	1987	938		
Cowlitz	ss	Cowlitz	1988			15.7%
Cowlitz	ss	Cowlitz	1989			
Cowlitz	ss	Cowlitz	1990			
Cowlitz	SW	Cowlitz	1986	1280	31	2.4%
Cowlitz	SW	Cowlitz	1987			
Cowlitz	SW	Cowlitz	1988	5070		
Cowlitz	SW	Cowlitz	1989			4.6%
Cowlitz	SW	Cowlitz	1990			
Cowlitz	LSW	Cowlitz	1988			1.0%
Cowlitz	LSW	Cowlitz	1989			
Cowlitz	LSW	Cowlitz	1990			
Lyons Ferry	ss	Lyons Ferry	1986	876	35	4.0%
Lyons Ferry	ss	Lyons Ferry	1987	1129	56	5.0%
Lyons Ferry	ss	Lyons Ferry	1988	1239	28	2.3%
Lyons Ferry	ss	Lyons Ferry	1989	2322	82	3.5%
Lyons Ferry	ss	Lyons Ferry	1990	2526	21	0.8%
Skamania	ss	Washougal	1987	115	0	0.0%
Skamania	ss	Washougal	1988			
Skamania	ss	Washougal	1989	3475		

Table 19. continued

Location	Species	Stock	Year	Number trapped	Number dead	Mortality (%)
Skamania	SCT	Washougal	1986	713	87	12.2%
Skamania	SCT	Washougal	1987	2057	104	5.1%
Skamania	SCT	Washougal	1988	3110	47	1.5%
Skamania	SCT	Washougal	1989	19497	56	3.0%
Skamania	SCT	Washougal	1990			
Skamania	SW	Washougal	1986	493	0	0.0%
Skamania	SW	Washougal	1987	300	0	0.0%
Skamania	SW	Washougal	1988			
Skamania	SW	Washougal	1989			
Wells	ss	Wells	1986	650	4	0.6%
Wells	ss	Wells	1987	603	2	0.3%
Wells	ss	Wells	1988	653	18	2.8%
Wells	ss	Wells	1989	725	21	2.9%
Wells	ss	Wells	1990	749	15	2.0%
Yakima	ss	Yakima	1986	132	12	9.1%
Yakima	ss	Yakima	1987	80	4	5.0%
Yakima	ss	Yakima	1988	157	9	5.7%
Yakima	ss	Yakima	1989	106	11	10.4%

Table 20. Summary of epizootics at WDW Columbia River basin hatcheries from January 1, 1983 to June 30 1991.

Hatchery	Date	Species	Disease	Mortality No.	Mortality %	Medication Type
Beaver Creek	May-83	SW	IHN	110,000	NR	None
Beaver Creek	Jul-83	CT	Furunculosis	NR	NR	NR
Beaver Creek	Jul-83	ss	Furunculosis	NR	NR	NR
Beaver Creek	Jul-83	SCT	Furunculosis	NR	NR	NR
Beaver Creek	Jul-83	SCT	IHN	90,500	NR	None
Beaver Creek	Ott-83	SW	IHN	296,000	100.0%	None
Beaver Creek	Apr-85	SW	Furunculosis	NR	NR	NR
Beaver Creek	May-85	SW	BCWD	NR	NR	NR
Beaver Creek	Aug-85	SCT	Furunculosis	NR	NR	NR
Beaver Creek	Sep-85	SCT	Furunculosis	NR	NR	NR
Beaver Creek	Mar-86	SW	BCWD	NR	NR	NR
Beaver Creek	Mar-86	SW	Furunculosis	NR	NR	NR
Beaver Creek	Jul-86	SW	Furunculosis	NR	NR	NR
Beaver Creek	Jun-87	SW	Furunculosis	NR	NR	NR
Beaver Creek	Jul-87	SCT	Furunculosis	6,100	10.0%	Romet
Beaver Creek	Jul-87	SW	Furunculosis	8,800	2.0%	Romet
Beaver Creek	Jul-87	ss	Furunculosis	17,200	6.0%	Romet
Beaver Creek	Jul-88	ss	Furunculosis	81,100	19.0%	Romet
Beaver Creek	Jul-88	SW	Furunculosis	25,300	6.0%	Romet
Columbia Basin	Jun-87	ss	Furunculosis	16,200	5.2%	Romet
Cowlitz	90-91"	SW	Ceratomyxosis	738,640	36.6%	None
Cowlitz	90-91*	ss	Ceratomyxosis	196,345	37.0%	None
Cowlitz	89-90*	SW	Ceratomyxosis	788,000	41.0%	None
Cowlitz	89-90*	ss	Ceratomyxosis	153,000	26.0%	None
Cowlitz	Jan-83	ss	Ceratomyxosis	NR	NR	NR
Cowlitz	Jan-83	SCT	Ceratomyxosis	NR	NR	NR
Cowlitz	Feb-83	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	May-83	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Jun-83	SCT	BCWD	NR	NR	NR
Cowlitz	Ott-83	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Dee-83	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Jan-84	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Feb-84	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Mar-84	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Nov-84	ss	Ceratomyxosis	NR	NR	NR
Cowlitz	Nov-84	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Jul-85	SW	BCWD	NR	NR	NR
Cowlitz	Jul-85	SW	BCWD	NR	NR	NR
Cowlitz	Sep-85	ss	Ceratomyxosis	NR	NR	NR
Cowlitz	Sep-85	SW	Ceratomyxosis	NR	NR	NR
Cowlitz	Sep-85	SCT	Ceratomyxosis	NR	NR	NR
Cowlitz	Nov-85	ss	Ceratomyxosis	NR	NR	NR
Cowlitz	Nov-85	SCT	Ceratomyxosis	NR	NR	NR
Cowlitz	Jun-87	SW	IHN	92,600	29.3%	None
Cowlitz	Ott-88	ss	IHN	41,000	3.0%	None

NR - not recorded
* - chronic mortality during rearing cycle

Table 20. summary of epizootics continued

Hatchery	Date	Species	Disease	Mortality No.	Mortality %	Medication Type
Gobar Pond	Apr-87	ss	IHN	NR	NR	NR
Lyons Ferry	May-86	ss	BCWD	NR	NR	NR
Lyons Ferry	Apr-89	ss	IHN	543,000	58.0%	None
Lyons Ferry	Jul-89	ss	IHN	291,000	100.0%	None
Lyons Ferry	Apr-91	ss	BCWD			None
Nelson Springs	Feb-87	ss	BCWB	700	0.8%	TM-50
Skamania	Apr-83	ss	IHN	NR	NR	None
Skamania	Apr-83	SCT	IHN	49,000	NR	None
Skamania	Jan-84	ss	BCWD	NR	NR	NR
Skamania	Jun-85	SCT	BCWD	NR	NR	NR
Skamania	Aug-85	ss	BCWD	NR	NR	NR
Skamania	Jun-86	ss	BCWD	NR	NR	NR
Skamania	Mar-87	ss	IHN	24,900	6.9%	None
Skamania	Jul-89	SW	IHN	56,000	100.0%	None
Skamania	Apr-90	SW	IHN	167,000	63.0%	None
Skamania	Apr-90	ss	IHN	156,000	48.0%	None
Turtle Rock	Apr-86	ss	IHN	9,000	4.7%	None
Vancouver	Jun-85	ss	Furunculosis	NR	NR	

NR - not recorded

Table 21. Summary of feed conversion for steelhead and sea-run cutthroat trout at WDW Columbia River basin hatcheries from 1983 to 1990.

Facilities	Specie6	Stock	Broodyear 1986	1987	1988	1989	1990	AVG
Beaver Creek	SCT	Elochoman		1.14	1.22	1.19		1.18
	ss	Washougal	1.73	0.65	1.23	1.37		1.25
	SW	Elochoman	1.23	1.19	1.20	1.29		1.23
Chelan	ss	Wells	1.01	1.25	1.14	1.16		1.14
Chelan - Turtle Rock	SS	Mixed	1.25	1.12	1.12	NF	1.47	0.99
Col. Basin\Yakima - Ringold	ss	Mixed	1.57	1.36	1.47	1.35	1.31	1.41
Cowlitz	SCT	Cowlitz	2.09	3.58	1.52	1.41	1.41	2.00
	ss	Cowlitz	3.44	2.98	1.45	1.95	1.95	2.35
	SW	Cowlitz	1.29	2.14	1.52	2.10	2.10	1.83
	LSW	Cowlitz			NF	1.52	1.41	1.38
Eastbank	ss	Wells	NF	NF	1.11	NF	1.21	0.53
Lyons Ferry	ss	Lyons Ferry	1.03	1.25		0.96	1.07	0.89
	ss	Wallowa	1.44	1.28	1.47		1.19	1.27
	ss	Wells	1.49	NF	NF	NF	NF	0.30
Naches - Neleon Springs	ss	Mixed	0.77	1.53	1.07	1.14	1.46	1.19
Skamania	SCT	Washougal	1.08	1.12	1.25	1.35	1.35	1.23
	SS							
	SW	Washougal Elochoman	1.39 1.25	1.33 1.34	1.25 1.25	1.35 1.35	1.35 1.35	1.34 1.31
Vancouver	ss	Washougal	1.13	1.19	0.90	1.47	1.24	1.19
Wells	ss	Wells	1.32	1.36	1.45	1.37	1.40	1.38
Yakima	ss	Yakima	1.16	1.00	1.18	1.07	1.53	1.19

NF = No fish on station

Discussion

The BPA Augmented Fish Health Monitoring Project enabled WDW fish health specialists and hatchery managers to gain a greater understanding of fish diseases at the Columbia River facilities. During the five-year project we were able to expand the fish health program by adding a biologist and an additional fish pathologist. This increased our time available for field work and provided laboratory back up. Bonneville Power Administration funding also allowed us to purchase state of the art equipment for field and laboratory use. The microscopes provided greatly enhanced our field diagnosis capabilities. The computers and software allowed us to begin a database to provide easy access to fish health information.

The knowledge that we gained through this project assisted us in justifying changes in management at hatcheries such as increasing cleaning frequency and improving disinfection practices. The information obtained by hatchery managers from monitoring by pathologists and their own sampling allowed them to make monthly assessment of fish cultural needs.

Discussion of fish diagnostic techniques at the Technical Steering Committee meetings and training workshops helped us to refine our diagnostic capabilities and to develop a consistency in sampling among the agencies. The project also provided a means for improving communications between the fish health labs in Washington, Oregon, and Idaho. It is now easier to obtain historical information about a hatchery from the computerized databases. Overall, communication and awareness about fish health issues has improved at hatcheries and laboratories.

Results of the specific parameters monitored also provided insight into fish health problems. The organosomatic index results were less desirable than normal and highly variable at the Cowlitz Hatchery where fish suffered yearly infections of C. Shasta. Of the fish reared at Cowlitz, the LSW had the best growth, condition factor, and hematocrit level. The results for LSW were also more consistent between years than those of the SW, SS, and SCT. The LSW are spawned in May and held on well water throughout most of their hatchery impoundment, whereas the other three stocks are held on river water much longer. The SS and SW indices varied greatly from year to year with 1987, 1988, and 1989 having the smallest fish. These findings do not correlate with low water temperature for those years but are attributed to chronic ceratomyxosis. The data collected from smolts reared at the Wells Hatchery were very consistent between the years. Chronic diseases are not a problem at Wells because the fish are reared on well water.

Hematocrit values, condition factor, and weight were much lower in all stocks at Cowlitz in comparison to the stock examined at Wells. This difference is attributed to ceratomyxosis in the smolts at Cowlitz and healthy smolts at Wells.

Viral assays of the WDW Columbia River broodstocks were consistently positive for IHNV at the Cowlitz Hatchery. All other hatcheries had variable results for replicating viral agents. The Cowlitz Hatchery broodfish are held on Cowlitz River water and re-use water from the juvenile fish. The hatchery intake is also downstream of the WDF Cowlitz Salmon hatchery. Spring chinook salmon, fall chinook salmon, and coho are spawning at the WDF hatchery, and in the Cowlitz River, during the time SS, SCT, and SW are being trapped and held at the Cowlitz Trout Hatchery. These salmon stocks are also historically

positive for IHNV. The upstream fish may provide a reservoir for the pathogen. This coupled with the poor water quality in the adult holding ponds could promote infection of the broodfish with IHNV. The potential also exists for steelhead and searun cutthroat to be trapped with a latent IHNV infection.

Infectious pancreatic necrosis virus was isolated from SS broodfish at Tucannon SS in 1983, Yakima SS in 1991, and Wells Hatchery SS from 1988 to 1990. The number of pools found to be positive were very low and no pathological changes were found in adults. Eggs from the fish in the positive pool were destroyed. Infections pancreatic necrosis virus has never been isolated from juvenile fish at the facilities.

Smolts from Cowlitz, Skamania, and Gobar Pond were positive for IHNV in some years. All these facilities are supplied with surface water for rearing. Adult anadromous fish migrate above the intakes at Cowlitz and Skamania and may provide the reservoir for infection. The SS/SW smolts at Gobar originated from the Skamania Hatchery. It is possible that the smolts were infected with IHNV prior to transfer. Epizootics of IHNV occurred in juveniles at Skamania, Cowlitz, and Beaver Creek. All stations are fed by surface water and adult anadromous fish are allowed above the intake at Cowlitz and Skamania. Adult passage may have occurred prior to the outbreak at Beaver Creek during repair of a passage barrier screen. IPNV was not isolated from smolts or juveniles.

Methods of identification of EIBSV were significantly different in 1986-87 from the last three years of the project and so cannot be compared. The only broodfish with EIBSV were found at Wells Hatchery SS in 1990-91. During the 1988-91 period 6 of the 31 stocks of smolts tested were positive for the inclusions: Beaver Creek (SCT - 3 years), Chelan(SS - 2 years), Cowlitz (SW - 1 year), Eastbank (SS - 2 years), Ringold (SS - 3 years), and Dayton Pond (SS - 1 year). Pathological changes were not associated with the identification of the viral inclusions. Steelhead and anadromous cutthroat trout appear to be resistant to the pathogen and disease.

Renibacterium salmoninarum was identified by DFAT in low numbers in several broodstocks. The highest prevalence was 8% of the 60 fish sampled at Lyons Ferry in 1989. Overall, 1986 and 1987 both had 7 positive stocks; 1989 had 6 positive stocks; and 1990 and 1991 both had 2 positive stocks. Assays of smolts showed 11 positive stocks in 1991. The 1991 samples were read by different technicians than the previous four years and may have contributed to the higher prevalence of positive samples. The highest prevalence was found at Wells Hatchery (8%). Sea-run cutthroat were assayed midway through the rearing cycle. In 1987 all stocks were positive for R. salmoninarum but in 1988 only one stock was positive (Skamania) and the following two years were negative for the pathogen. In general, the infection rate was very low and bacterial kidney disease was not observed. Data from the project indicates that R. salmoninarum is not a serious pathogen for steelhead or sea-run cutthroat trout.

Ceratomyxa Shasta and Ichthyopthirius multifilis were the only parasites at **WDW Columbia River basin hatcheries to cause significant losses.** Ichthyopthiriasis can be controlled through frequent chemotherapy when water temperature exceeds 60 F. Treatment with formalin is expensive and while it ameliorates the impact it does not eliminate the parasite. Mortality is frequently not attributed to ichthyopthiriasis but to secondary infections that plague the stressed fish. Ceratomyxosis caused severe losses at the Cowlitz Hatchery during this project. No method of control is known for this

pathogen except avoidance. Organosomatic analysis will be performed over the next few years and compared with the BPA project data for an evaluation of the effect of the recently installed ozone water treatment plant.

Flow index and density index data revealed that water flow is the limiting factor at our WDW Columbia River hatcheries. Density index data indicated that space is rarely a problem. Fish disease outbreaks did not correlate with high flow index (>1.5) but we would suggest that more data is needed to show whether low mortality health problems are related (i.e., fin erosion, bum eye, tail rot, etc.).

Egg and fry mortality varied greatly from hatchery to hatchery. The percentage of this mortality at a hatchery was also highly variable between years. The average egg mortality reached 29% at the Beaver Creek Hatchery in the SCT but averaged 12.94% for all hatcheries. Lack of ripe males at the time of spawning or overripe or green eggs may have decreased fertilization. Fungal infections on the eggs still cause high losses on occasion. Eggs from IHNV positive parents are culled at all stations except the Cowlitz Trout Hatchery. All eggs were water-hardened in an iodophore solution (100 ppm; 1 part eggs/2 parts solution) for one hour to minimize transfer of pathogens. As no trend (increasing or decreasing) in mortality is seen with the hatcheries over the years it is assumed that the mortality is a combination of the factors listed above.

The mean fry mortality was highest in the Cowlitz SCT with 37.43%. The mean for all hatcheries was 15.08% mortality. Bacterial coldwater disease, environmental gill disease, and coagulated yolk are the most common pathogens of fry in the hatchery. Visceral mycosis is seen occasionally. Management practices are aimed at minimizing these common conditions but even with close monitoring the problems can blossom overnight in this size fish. Overall mortality from spawn to ponding averaged 20.43%.

Prespawning broodstock mortality was typically low and ranged from 0.8 to 38.8% of the fish trapped. Winter-run steelhead mortality was frequently not recorded as fish were in spawning condition upon arrival. This was also true of SCT. Summer-run steelhead are held four to eight months prior to spawning and incurred the highest mortality. The 38.8% mortality was found in Chelan SS and was attributed to a Saprolegnia infection and, to a lesser degree, Ichyopthirius multifilis and Henneguya salmonicola. Losses are usually due to Saprolegnia infections and are exacerbated by the practice of reusing water from juvenile fish for the adults.

There were few epizootics at the hatcheries throughout the project. The causative agents of the epizootics that occurred were C. Shasta, Myxobacteria, (BCWD), Aeromonas salmonicida, and IHNV. Coldwater disease and furunculosis were treated with Terramycin or Romet. Fish with ceratomyxosis were removed from the pond when moribund or dead. Fish with IHN as juveniles were destroyed. Smolts with IHN from Skamania were planted in the hatchery drainage and the excess destroyed. The monthly monitoring made possible by this BPA project has helped to keep fish healthier through prophylactic treatments and preventive measures.

The feed conversion for all stocks but Cowlitz ranged from 0.65 to 3.58. Conversions at Cowlitz reached as high as 3.58 due to the emaciation caused by ceratomyxosis.

Even though the BPA project has been completed, WDW plans to maintain monthly fish health monitoring at the hatcheries. Sampling for bacterial and parasitic pathogens will be conducted if indicated by necropsy and historical occurrence. Assays for R. salmoninarum will be performed for certification purposes only as project data indicates the prevalence of the pathogen is low and the occurrence of BKD even lower. Assays of broodfish and smolts for EIBSV inclusions will be carried out on an as needed basis only as the occurrence in steelhead and sea-run cutthroat was found to be very low during this project. All stocks of broodfish and many stocks of smolts will be sampled for replicating viral agents. Smolt sampling will be based on the history of the station, water source, and stocking plans. The organosomatic index analysis of smolts will be continued at the Cowlitz Hatchery as part of the evaluation of the ozone water treatment plant that has just been installed.

The knowledge gained from this project has been invaluable to WDW. The status of fish health will continue to improve from the information, training, and equipment provided by BPA for the Augmented Fish Health Monitoring Project.

Overall the BPA Augmented Fish Health Monitoring project gave us the opportunity to monitor the fish with the frequency necessary to see how and why fish diseases occur. It is obvious that fish reared on surface water suffer more disease and require more monitoring to keep them healthy. Facility design was also shown to have an impact on the health of the fish with raceways and some rearing ponds providing a much better rearing environment than circular ponds. Even at facilities with older ponds and a poor water source, the project helped us plan management practices and prophylactic treatments to maximize fish health. The understanding of fish health problems at WDW has been enhanced through the augmented fish health project made possible by BPA.

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