PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Dworshak Impacts/M&E And Biological/Integrated Rule Curves

BPA project number: 8740700
Contract renewal date (mm/yyyy): 1/2000 ☐ **Multiple actions?**

Business name of agency, institution or organization requesting funding
Nez Perce Tribe

Business acronym (if appropriate) NPT

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
10.3C.6, 10.3C.8, 5.5A.1, 5.5A.2, 2.2F.1

FWS/NMFS Biological Opinion Number(s) which this project addresses
The U.S. Army Corps of Engeineers is currently preparing a Biological Assessment for Dworshak Dam and Reservoir operations relative to the threatened bull trout (FR Doc. 98-15319 Filed 6-5-98) that occur within the project area.

Other planning document references
NPPC. 1992. Strategy for salmon. The Northwest Power Planning Council calls to seek mitigation for lower water levels in Dworshak Reservoir and to evaluate impacts of flow operations on resident fish in Dworshak Reservoir.

Fickeisen, D.H. and D.R. Geist. 1994. Resident fish planning: Dworshak Reservoir, Lake Roosevelt, and Lake Pend Oreille. Project 93-026. BPA. Portland, Oregon. The authors identify a need for additional Dworshak Reservoir baseline information on populations of interest and on the physical-chemical environment under various operating conditions.

CBFWA RFM. 1997. Multi-year implementation plan for resident fish protection, enhancement and mitigation in the Columbia River Basin. Resident Fish. Appendix C of the FY 1998 Annual Implementation Work Plan. Portland, Oregon. This planning document identifies a strategy for Dworshak Reservoir to manage water levels to maximize terrestrial invertebrate influx, plankton production, and benthic production.

Short description
Obtain and assess thermal, physical, chemical, primary production, zooplankton and benthic data for formulating biological/integrated rule curves for Dworshak Dam and Reservoir and for enhancing baseline data for monitoring and evaluation.

Target species
bull trout, westslope cutthroat trout, kokanee, smallmouth bass

Section 2. Sorting and evaluation

Subbasin
Clearwater

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
☐ Anadromous fish ☒ Resident fish ☐ Wildlife	☒ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☐ Watershed councils/model watersheds ☐ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☐ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
8709900	Dworshak Dam Impacts Assessment and Fisheries Investigations	Identifies operational criteria for Dworshak Dam to minimize kokanee entrainment for incorporation in rule curves. Monitors the Dworshak kokanee population to evaluate effects of operations.

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1993	Joint NPT/IDFG report leading to cessation of smallmouth bass minimum size limits for Dworshak Reservoir.	
1993	Identification of causative operational factors pertaining to the decline of the redside shiner population in Dworshak Reservoir.	
1993	Identification of broad biologically based criteria for Dworshak Reservoir operations.	
1993	Change in fisheries management approach to minimize stocking of exotic rainbow trout to avoid potential genetic introgression of native westslope cutthroat trout.	
1994	Identification of potential temperature/oxygen barriers to migrating kokanee, and possibly bull trout, resulting from summer drawdown operations for anadromous fish flow augmentation.	
1996	A draft report from contractor characterizing and evaluating limnological conditions in Dworshak Reservoir under various operating conditions from 1993-1995.	

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Collect and assemble biological/environmental data for developing biological and integrated rule curves for Dworshak Reservoir. Measurable operational objectives, such as preferred seasonal pool elevations, will be identified with rule curve development.	a	Characterize reservoir thermodynamics.
		b	Characterize primary production and loss under various operating conditions.
		c	Characterize zooplankton densities and loss under various operating conditions.
		d	Characterize benthic invertebrate densities relative to reservoir operations.
2	Develop rule curve model.	a	Obtain the MFWP Hungry Horse Reservoir model (HRMOD) source code and input files, develop Dworshak specific relationships using parallel data sets, and work with a contracted modeler and consult with MFWP expertise to develop a Dworshak specific model.
		b	Work with a contracted modeler and consult with MFWP expertise to refine and calibrate Dworshak rule curve modeling, including incorporation of kokanee entrainment data and results of an IFIM study for the Clearwater River downstream from Dworshak Dam.
		c	Collect data and provide to contracted modeler for refinement and calibration of the Dworshak model.
3	Implement rule curve.	a	Present proposed Dworshak integrated rule curve to NPPC for approval and adoption.
4	Monitor rule curve implementation.	a	Monitor Dworshak Dam and Reservoir operations for adherence

			to rule curve criteria as adopted by NPPC.
5	Monitor and evaluate the response of the reservoir ecosystem to rule curve implementation.	a	Monitor primary production, secondary production, smallmouth bass reproduction, smallmouth bass PSD, redside shiner abundance, and kokanee and bull trout abundance (IDFG).
6	Promote informed fishery resource decisions pertaining to Dworshak Reservoir operations by providing technical input to pertinent regional water management fora.	a	Participate in pre-season planning and in-season meetings of the Fish Passage Advisory Committee and other fora that have direct bearing on Dworshak Dam and Reservoir operations.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	3/1993	12/2000			45.00%
2	6/1998	12/2000			46.00%
3	1/2001	3/2001		X	
4	3/2001	12/2073			
5	3/2001	12/2073			
6	1/1993	12/2010			9.00%
				Total	100.00%

Schedule constraints
Effort required to calibrate rule curve model, unforeseen influences on reservoir dynamics, effort required to integrate kokanee entrainment relationships and Lower Clearwater IFIM relationships, time required to gain NPPC approval of the rule curve.

Completion date
2073

Section 5. Budget

FY99 project budget (BPA obligated): $199,999

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel	2/3 FTE biologist, 1 FTE	%41	82,174

	technician, P/T supervisory biologist, admin. assistant.		
Fringe benefits		%12	23,222
Supplies, materials, non-expendable property		%1	2,150
Operations & maintenance		%8	16,950
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		%0	
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel		%1	1,825
Indirect costs		%15	29,054
Subcontractor	Modeling consultant	%17	33,510
Subcontractor	benthic invertebrate analysis	%3	6,850
Subcontractor	Aqua ID zooplankton analysis	%2	3,750
Other		%0	
TOTAL BPA FY2000 BUDGET REQUEST			$199,485

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
		%0	
		%0	
		%0	
		%0	
Total project cost (including BPA portion)			$199,485

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$206,000	$212,180	$218,545	$225,101

Section 6. References

Watershed?	Reference
☐	Arnsberg, B., W. Connor, and E. Connor. 1992. Mainstem Clearwater River Study: assessment for salmonid spawning, incubation, and rearing. Nez Perce Tribe and EBASCO Environmental Final Report to BPA, Contract No. DE-BI79-87BP37474, Portland, Oregon.

☐	Bennett, D.H. 1997. Evaluation of current envirinmental conditions and operations at Dworshak Reservoir, Clearwater River, ID, and an analysis of fisheries management alternatives. Final Report to the Army Corps of Engineers, Walla Walla, Washington.
☐	Botrell, H.H., A. Duncan, Z.M. Gliwez, E. Grygierek, A. Herzig, A. Hillbricht-Ilkowska, H. Kurasawa, P. Larsson, and T. Weglenska. 1976. A review of some problems in zooplankton studies. Norwegian Journal of Zoology, 24:419-456.
☐	CBFWA RFM. 1997. Multi-year implementation plan for resident fish protection, enhancement and mitigation in the Columbia River Basin. Resident Fish Appendix C of the FY 1998 Annual Impllementation Work Plan, Portland, Oregon.
☐	Fickeisen, D.H. and D.R. Geist. 1993. Resident fish planning:Dworshak Reservoir, Lake Roosevelt, and Lake Pend Oreille. Project No. 93-026, Bonneville Power Administration, Portland, Oregon.
☐	Juul, S.T.J. 1996. A limnological reevaluation of Dworshak Reservoir, Idaho. A Progress Report Prepared for the Nez Perce Tribe and the U.S. Army Corps of Engineers,WSU Project Numbers 11W-3815-2857 and 11W-3998-2628, Pullman, Washington.
☐	Maiolie, M.A., D.P. Statler, and S. Elam. 1993. Dworshak Dam impact assessment and fishery investigation and trout, bass, and forage species. Final Report. Bonneville Power Administration, Portland, Oregon.
☐	Marotz, B., D. Gustafson, C. Allen, and B. Lonon. 1996. Model development to establish integrated operation rule curves for Hungry Horse and Libby Reservoirs. Montana Fish, Wildlife & Parks report to Bonneville Power Adminisration, Portland, Oregon.
☐	Northwest Power Planning Council. 1992. Strategy for salmon. Document 92-21, Portland, Oregon.
☐	

PART II - NARRATIVE

Section 7. Abstract

This project is directly relevant to Section 10.3C.6 of the September 13, 1995, amended Columbia Basin Fish and Wildlife Program, which authorizes BPA to:

"In consultation with the Nez Perce Tribe and appropriate state agencies, fund research, monitoring and evaluation activities to determine the potential impacts of multipurpose flow operations on resident fish in Dworshak Reservoir. This information will be used to develop analytical methods, such as biological and/or integrated rule curves for reservoir operations similar to those developed by the Montana Fish, Wildlife & Parks (MFWP) for Hungry Horse and Libby reservoirs."

The underlying goal of this project is to maintain the productive health of Dworshak Reservoir for resident fish, including threatened native bull trout, while serving other multi-purpose needs, such as flood control, power production and flow needs for anadromous fish.

We are applying the Hungry Horse Reservoir Model (HRMOD) approach developed by the MFWP to develop a site specific model for Dworshak Reservoir. The basic approach, as described in Marotz et al. (1996) is to apply extensive data sets to develop empirical relationships which capture as much of the observed biological variation as possible. Equations describing relationships between dam operation and physical and biological factors are only as complex as the field data justify. The use of theoretical relationships are held to a minimum. The expected outcome is to identify an operational strategy for Dworshak Dam to mimic the downstream natural hydrograph (beneficial to endangered Snake River salmon spawning, rearing and migration) and to maintain a productive reservoir environment for resident fish.

The target date for rule curve formulation and submittal to the Northwest Power Planning Council is 2001. After the proposed operational rule curve is officially adopted by the Northwest Power Planning Council, and the rule curve is applied, results will be monitored and evaluated by: pre- and post-rule curve primary and secondary (zoopplankton and benthos) production indicators; kokanee entrainment estimates; kokanee population estimates; kokanee spawner count indices; smallmouth bass reproduction; smallmouth bass PSD; smallmouth bass relative weights, and ; bull trout abundance.

Dam and reservoir operations that control kokanee entrainment and promote food production at various trophic levels in the pelagic and littoral zones should assist in achieving quantitative biological objectives for Dworshak Reservoir as described by Fickeisen and Geist (1993): 30-50 age-2 kokanee per hectare; smallmouth bass PSD of 30; smallmouth relative weights of 100 for all size ranges.

Section 8. Project description

a. Technical and/or scientific background

The 717 foot high Dworshak Dam is located within the Nez Perce Indian Reservation on the North Fork of the Clearwater River 1.9 miles upstream from its confluence with the Clearwater Mainstem, Clearwater, County, Idaho. Dworshak Reservoir is 53.6 miles long, and has 175 miles of shoreline and 17,090 surface acres at full pool (elevation 1600 ft msl). Dworshak Dam is a multi-purpose project built and operated by the U.S. Army Corps of Engineers, and is operated for flood control, power generation, recreation, water quality and fish and wildlife uses.

Annual fall/winter drawdowns of up to 155 feet for flood control and power generation can reduce surface area by as much as 52%. In addition, the National Marine Fisheries Service?s 1995 Biological Opinion on Operation of the Federal Columbia River Power

System and Juvenile Transportation, pursuant to Section 7 of the Endangered Species Act, calls for an annual drawdown of 80 feet (elevation 1520 ft msl) through August 31 for flow augmentation. Therefore, current operational demands on Dworshak Reservoir include fall/winter drawdown for flood control and power generation and spring/summer drawdown for flow augmentation. During the last few years, Dworshak Reservoir has also been called upon to provide volumes of cold water during summer to reduce water temperatures in the Lower Snake River reservoirs.

These various demands for Dworshak Reservoir to provide flood control storage space and to provide water for flow augmentation and power generation result in pool drawdowns and fluctuations that may have profound adverse effects on reservoir biological productivity and fisheries. Marotz et al. (1996) reported that reservoir fluctuations affect primary production by changing the volume of water of optimal temperatures, nutrient cycling and light transmittance. Marotz et al. (1996) also indicated that zooplankton production was reduced with increased withdrawals, and that zooplankton loss was significant when the reservoir was isothermal and when surface elevation approached the outlet depth. Marotz et al. (1996) showed that benthic insects are most severely impacted by deep drawdown. Biomass of benthic insect larvae was least in the frequently dewatered zone and varied inversely with the frequency of dewatering. Marotz et al. (1996) also reported that less than full pool condition during July through September reduces the amount of terrestrial insect deposition that is available as food for fish.

The proposed project will ultimately provide for in-kind mitigation, by ameliorating disruptive actions to the Dworshak ecosystem and the array of species functioning within that ecosystem. The proposed work is a logical extension of the BPA funded MFWP modeling efforts for Hungry Horse (HRMOD) and Libby (LRMOD) Reservoirs (Marotz et al. 1996). The intent is to apply the methodology and approach developed for these reservoirs to a similar problem at Dworshak Reservoir, modifying the model relationships as needed to account for conditions specific to Dworshak and the downstream Clearwater River.

The modeling methodology involves simulation of the physical operation of Dworshak Dam including the water budget and downstream flood concerns, and prediction of resulting thermal structure of the reservoir and the discharge temperature. Biological responses include: primary production and entrainment, zooplankton production and entrainment, terrestrial inverterate deposition on the reservoir surface, and benthic dipteran production. Additional biological responses that will be included in the Dworshak model include kokanee entrainment and downstream habitat in the Lower Clearwater River. (Note: HRMOD and LRMOD will also include a downstream habitat linkage as IFIM-based studies are completed. An IFIM-based study was completed for the Lower Clearwater River was completed in 1992.)

b. Rationale and significance to Regional Programs

The rationale for biological/integrated rule curve formulation and adoption for Dworshak Dam and Reservoir is based on the recognition that there may be competing uses of multi-purpose reservoir resources. The intent of the integrated rule curve approach is to achieve a balanced approach to water resource management. The need for considering the productivity of the Dworshak ecosystem is heightened with the increased concern of native inhabitants, including threatened bull trout and westslope cutthroat trout.

The 1994 Fish and Wildlife Program, as amended in 1995, recognized the potential impact to the Dworshak ecosystem as a result of multi-purpose operations. Section 5.5A.1 of this Program provides for the participation of appropriate Indian Tribes to:

"...identify specific research, monitoring and evaluation activities needed to determine the potential impacts of salmon and steelhead flow operations on resident fish and wildlife, particularly native species in and around Hungry Horse, Libby, Grand Coulee, Brownlee and Dworshak reservoirs. Use this information to develop analytical methods or biological rule curves for reservoir operations, similar to those being developed by the Montana Department of Fish, Wildlife and Parks for Hungry Horse and Libby reservoirs."

Section 5.5A.2 provides for the Bonneville Power Administration (BPA) to:

"Fund research, monitoring, and evaluation activities needed to determine the potential impacts of salmon and steelhead flow operations on resident fish and wildlife, particularly native species, in and around Hungry Horse, Libby, Brownlee, Dworshak and other reservoirs."

Additionally, Section 10.3C.6 of the September 13, 1995, amended Program authorizes BPA to:

"In consultation with the Nez Perce Tribe and appropriate state agencies, fund research, monitoring and evaluation activities to determine the potential impacts of multipurpose flow operations on resident fish in Dworshak Reservoir. This information will be used to develop analytical methods, such as biological and/or integrated rule curves for reservoir operations similar to those developed by the Montana Department of Fish, Wildlife and Parks for Hungry Horse and Libby reservoirs."

The proposed project will ultimately provide for in-kind mitigation, by ameliorating disruptive actions to the Dworshak ecosystem and the array of species functioning within that ecosystem. The proposed work is a logical extension of the BPA funded MFWP modeling efforts for Hungry Horse (HRMOD) and Libby (LRMOD) Reservoirs. The intent is to apply the methodology and approach developed for these projects to a similar problem at Dworshak Reservoir, modifying the effort as needed to account for conditions specific to Dworshak Reservoir and the downstream Clearwater River.

The modeling methodology involves simulation of the physical operation of Dworshak Dam, including the water budget and downstream flood concerns, and prediction of

resulting thermal structure of the reservoir and the discharge temperature. Biological responses include: primary production and entrainment, zooplankton production and entrainment, terrestrial inverterate deposition on the reservoir surface, and benthic dipteran production. Additional biological responses that will be included in the Dworshak model include kokanee entrainment and downstream habitat in the Lower Clearwater River. (Note: HRMOD and LRMOD will also include a downstream habitat linkage as IFIM-based studies are completed. An IFIM-based study was completed for the Lower Clearwater River in 1992.)

c. Relationships to other projects

Project 8346500, Libby and Hungry Horse Technical Analysis, provides the template for the rule curve modeling approach being applied to Dworshak Dam and Reservoir under Project 8740700. Marotz et al. (1996) described the integrated rule curve approach developed by MFWP for Hungry Horse and Libby Reservoirs as a tool to aid decision-making regarding striking a balance between power production, flood control and aquatic resources. Rule curve modeling provides a framework to compare incremental trade-offs to resident fish and anadromous fish associated with various operational stategies. The goal is to benefit all fish from a system-wide perspective by establishing regional equity in system operations. Marotz et al. (1996) indicated that the rule curve modeling strategy as applied to Hungry Horse and Libby Reservoirs is portable to other reservoir systems where sufficient data are available. Parallel applications of this modeling strategy can enjoy accellerated data acquisition and model development, and reduced costs, based on past experience. MFWP to date has invested about 14 years in developing and refining reservoir and river models for HRMOD. Project 8740700 has been actively collected data for rule curve modeling since 1993 (6 years) and has begun developing model relationships. Project 8346500 is also developing an optimization program to link IFIM-based river models of the Flathead and Kootenai basins to existing reservoir models for Hungry Horse and Libby Reservoirs. Project 8740700 will coordinate with Project 8346500 in making an optimization link with the Dworshak Reservoir and Lower Clearwater IFIM models. (See relationship with Project 8801500, below)

Project 8801500 completed an IFIM study of the Lower Clearwater River downstream from Dworshak Dam (Arnsberg et al. 1992). Results of this modeling effort will be used to link Dworshak Reservoir modeling for reservoir ecosystem conditions with downriver fishery habitat needs.

Project 8709900, sponsored by the Idaho Department of Fish and Game, involves investigation of kokanee entrainment losses relative to Dworshak operations. Kokanee entrainment is influenced by operations. Operational relationships regarding kokanee entrainment will be incorporated in rule curve development. Continued estimates of kokanee entrainment, abundance, and spawning indeces will be incorporated in the monitoring and evaluation of Dworshak rule curve implementation. Monitoring of kokanee populations is important for fisheries management and for bull trout prey.

Project 9501600, sponsored by the NPT, addresses the conservation of native westslope cutthroat trout genetics in the North Fork Clearwater Basin, and its relationship to Dworshak Reservoir fish stocking strategies. This project is an outgrowth of Project 8740700 (Maiolie et al. 1993). Westslope cutthroat trout rear in Dworshak Reservoir, therefore, the productivity of the Dworshak ecosystem (and rule curve development and implementation) is also relevant to the conservation of this species.

The US Army Corps of Engineers Dworshak Resident Fish Mitigation Review has funded the University of Idaho to review the efficacy of current resident fish mitigation (rainbow trout stocking), funded by the USACE pursuant to the original USFWS Coordination Act Report. Dr. David Bennett of the U of I has coordinated directly with project personnel to formulate a revised Dworshak mitigation strategy (Bennett 1997).

d. Project history (for ongoing projects)

BPA funded work on Dworshak Reservoir (Project 8740700) by the Nez Perce Tribe began in 1987, as authorized under the NPPC?s FWP. From 1987 through 1991 the NPT investigated the status of smallmouth bass, rainbow trout and their fisheries. Incidental data on westslope cutthroat trout and bull trout were also collected. During this same period, the Idaho Department of Fish and Game investigated the status of kokanee and reservoir limnology.

From 1993 through 1995 project personnel provided extensive input to the System Operation Review of the Federal Columbia River Power System (FCRPS) conducted by the BPA, U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. This role was primarily as advisor, evaluator and contributor regarding impacts relative to Dworshak Reservoir fisheries. During this period, we assisted in the development of basic impact assessment models for evaluating over 100 operational alternatives.

Since 1993, the study has been collecting data on primary and secondary production, and the physical/chemical environment towards development of a biological/integrated rule curve model for Dworshak Reservoir, patterned after the MFWP HRMOD. Model source codes and input files were obtained from MFWP in 1998. Data analyses for Dworshak Reservoir modeling are currently focusing on specific relationships pertinent to the HRMOD rule curve modeling approach. Submittal of a proposed Dworshak Reservoir integrated rule curve to the NPPC is a project milestone scheduled for 2001.

<u>Adaptive Management Implications</u>

Knowledge gained from this project will aid in the adaptive management efforts to consider reservoir fish resource needs in conjunction with downstream needs for anadromous fish, flood control and power production. Biological information generated from this project data was used to evaluate over 90 operation strategies for the FCRPS as part of the SOR. These analyses indicated that operational criteria resulting in relatively stable pool levels are most conducive to maintaining productivity of the Dworshak

Reservoir ecosystem. This information has been and is being applied within the Regional Forum established as part of the NMFS 1995 Biological Opinion on operation of the FCRPS. Within the broader program management framework, biological information from this project has increased the awareness and sensitivity of the Regional Forum process to resident fishery resources and has fostered a multi-species ecosystem approach.

Project Reports and Technical Papers

Juul, S.T.J. 1996. A limnological reevaluation of Dworshak Reservoir, Idaho. A Progress Report Prepared for the Nez Perce Tribe and the U.S. Army Corps of Engineers,WSU Project Numbers 11W-3815-2857 and 11W-3998-2628, Pullman, WA.

Juul, S.T.J, and M.A. Hagerman. 1993. Primary productivity evaluation of Dworshak Reservoir: first interim report. Prepared for the Nez Perce Tribe, WSU Project Number 11W-3815-2857, Pullman, WA.

Maiolie, M.A., D.P. Statler, and S. Elam. 1993. Dworshak Dam impact assessment and fishery investigation and trout, bass, and forage species. Final Report. Bonneville Power Administration, Portland, OR.

Statler, D.P. 1988, 1989, 1990. Dworshak Investigations: trout, bass and forage species. Nez Perce Tribe Department of Fisheries Resources Management, Annual Report to Bonneville Power Administration, Contract DE-AI79-87BP35165, Project 87-407, Portland, OR.

USACE, USBR and BPA. 1994. Columbia River System Operation Review DraftEnvironmental Impact Statement, Appendix K - Resident Fish, DOE/BP-2409, Portland, OR.

USACE, USBR and BPA. 1995. Columbia River System Operation Review Final Environmental Impact Statement, Appendix K - Resident Fish, DOE/EIS-0170, Portland, OR.

Summary of Major Results Achieved

As a result of recommendations in a 1993 project report prepared jointly by the Nez Perce Tribe and the Idaho Department of Fish and Game, the stocking of rainbow trout in Dworshak Reservoir for resident fish mitigation has been limited pending investigation of rainbow trout-cutthroat trout hybridization (Project 9501600). Based on project studies, the 12-inch minimum size limit for smallmouth bass was withdrawn, thereby expanding harvest opportunities in Dworshak Reservoir for this popular self-sustaining non-native species.

As a result of our input in regional water management fora, including CBFWA Fish Passage Advisoy Committee and the Technical Management Team of the NMFS Regional ESA Forum, flow augmentation strategies from Dworshak have had less abrupt fluctuations in flows and temperatures and have resulted in higher Dworshak pool elevations later in the summer. Our input has also resulted in spring flows that are structured closer to the natural spring hydrograph. This has been achieved, in part, by

promoting reservoir refill as early as possible in late winter and early spring, then matching reservoir outflow with inflow as close as possible during the peak hydrograph within flood discharge limits.

Years Underway and Past Costs

Year	1987	1988	1989	1990	1991	1992	1993
Costs	111,517	109,783	145,829	106,593			

Year	1994	1995	1996	1997	1998	1999
Costs	159,969	163,596	172,554	143,392	174,677	199,999

e. Proposal objectives

1) Collect and assemble biological/environmental data for developing biological and integrated rule curves for Dworshak Reservoir. Measurable operational objectives, such as preferred seasonal pool elevations, will be identified with rule curve development.

Hypothesis: Dworshak annual pool fluctuations (dewaterng cycles) impact benthic production.

Hypothesis: Zooplankton entrainment is influenced by Dworshak Dam operational parameters (quantity of discharge, depth of discharge, seasonal discharge patterns).

Hypothesis: Dworshak discharge patterns and pool fluctuations impact primary production.

2) Develop rule curve model.

Model assumtions for the HRMOD that would need to be investigated for applicability to the Dworshak modeling effort are:

A) Component models are more easily verified than are whole system, ecosystem models.
B) Empirically measured relationships are more reliable than are mechanistic relationships derived using unmeasurable coefficients.
C) Nutrient loading to the reservoirs will not be measurably changed by human activities. If changes are detected, the model must be recalibrated.
D) Water temperature of the dam discharge equals the temperature in the reservoir forebay at the depth of water withdrawal.
E) The thermal structure in the reservoir forebay, calculated by the thermal model, is extrapolated throughout the reservoir.
F) All discharged water must pass through the turbines (no spill) unless default specifications are superceded by the model user. Spill is allowed when historical discharge data are input to simulate a specific annual operation.

G) Local flood control constraints are mandatory in all simulations. Default specifications may be superseded by the model user when historic discharge data are used to simulate a specific annual operation.

H) Total zooplankton production is proportional to measured primary production,minus a loss function established for plankton communities in oligotrophic, temperate waters.

I) Total zooplankton production can be subdivided into estimated of production within each zooplankton taxon, based on relative biomasses of taxa captured in monthly sampling.

J) The vertical distribution of larval chironomids is proportional to densities enumerated in triplicate dredge samples in each depth zone.

K) The seasonality and relative abundance of terrestrial insects are assumed to be proportional to captures in replicate surface tows in nearshore (<100 m) and offshore zones.

3) Implement rule curve.

An integrated rule curve proposal for Dworshak Reservoir is scheduled to be presented to the NPPC in 2001. A critical assumption is that that NPPC will approve the rule curve proposed.

4) Monitor rule curve implementation.

After the proposed operational rule curve is officially adopted by the Northwest Power Planning Council, Dworshak Dam operations will be monitored for adherence to rule curve criteria.

5) Monitor and evaluate the response of the reservoir ecosystem to rule curve implementation.

After the proposed operational rule curve is officially adopted by the Northwest Power Planning Council, and the rule curve is applied, results will be monitored and evaluated by: pre- and post-rule curve primary and secondary (zoopplankton and benthos) production indicators; kokanee entrainment estimates; kokanee population estimates; kokanee spawner count indeces; smallmouth bass reproduction; smallmouth bass PSD; smallmouth bass relative weights, and ; bull trout abundance.

Dam and reservoir operations that control kokanee entrainment and promote food production at various trophic levels in the pelagic and littoral zones should assist in achieving quantitative biological objectives for Dworshak Reservoir as described by Fickeisen and Geist (1993): 30-50 age-2 kokanee per hectare; smallmouth bass PSD of 30; smallmouth relative weights of 100 for all size ranges.

6) Promote informed fishery resource decisions pertaining to Dworshak Reservoir operations by providing technical input to pertinent regional water management fora.

f. Methods

Scope

The project is to develop a compartmentalized biological/hydrological/thermal model for Dworshak Reservoir upon which to base formulation of an integrated operational rule curve. The project also links completed IFIM-based modeling data for the downstream Clearwater River with the reservoir modeling to optimize balanced operations for reservoir and downstream river resources. Geographically, this scope encompasses 53.6 miles of Dworshak Reservoir proper and 38 miles of the Lower Clearwater River.

Approach

The project applies the reservoir modeling approach developed by the Montana of Fish and Wildlife and Parks (MFWP) for Hungry Horse (HRMOD) and Libby (LRMOD) Reservoirs. The basic approach, as described in Marotz et al. (1996) is to apply extensive data sets to develop empirical relationships which capture as much of the observed biological variation as possible. Equations describing relationships between dam operation and physical and biological factors are only as complex as the field data justify. The use of theoretical relationships are held to a minimum.

Reservoir model formulation will consist of three main components: physical environment, thermal dynamics and biological dynamics. The compartmental structure facilitates evaluation and refinement of the model. Calculations of the biological responses in higher trophic levels are based on the results of the lower trophic level submodels. The approach for model development is linear programming with sequential modules. Each submodel is calibrated to field measurements and verified with empirical data. A variety of assumptions were applied to the HRMOD and LRMOD development and will be investigated for applicability to the Dworshak Reservoir model:

1) Component models are more easily verified than are whole system, ecosystem models.
2) Empirically measured relationships are more reliable than are mechanistic relationships derived using unmeasurable coefficients.
3) Nutrient loading to the reservoirs will not be measurably changed by human activities. If changes are detected, the model must be recalibrated.
4) Water temperature of the dam discharge equals the temperature in the reservoir forebay at the depth of water withdrawal.
5) The thermal structure in the reservoir forebay, calculated by the thermal model, is extrapolated throughout the reservoir.
6) All discharged water must pass through the turbines (no spill) unless default specifications are superseded by the model user. Spill is allowed when historical discharge data are input to simulate a specific annual operation.

7) Local flood control constraints are mandatory in all simulations. Default specifications may be superseded by the model user when historic discharge data are used to simulate a specific annual operation.
8) Total zooplankton production is proportional to measured primary production, minus a loss function established for plankton communities in oligotrophic, temperate waters.
9) Total zooplankton production can be subdivided into estimated of production within each zooplankton taxon, based on relative biomasses of taxa captured in monthly sampling.
10) The vertical distribution of larval chironomids is proportional to densities enumerated in triplicate dredge samples in each depth zone.
11) The seasonality and relative abundance of terrestrial insects are assumed to be proportional to captures in replicate surface tows in nearshore (<100 m) and offshore zones.

Detailed methodology

A detailed description of the methodology applied to formulate HRMOD and LRMOD, upon which this project is patterned, is contained in Marotz et al. (1996). This reference contains a 104 page description of detailed methodology pertinent to the Dworshak modeling effort. In summary, the modeling methodology involves simulation of the physical operation of Dworshak Dam including the water budget and downstream flood concerns, and prediction of resulting thermal structure of the reservoir and the discharge temperature. Biological responses include: primary production and entrainment, zooplankton production and entrainment, terrestrial inverterate deposition on the reservoir surface, and benthic dipteran production. Additional biological responses that will be included in the Dworshak model include kokanee entrainment and downstream habitat in the Lower Clearwater River. (Note: HRMOD and LRMOD will also include a downstream habitat linkage as IFIM-based studies are completed. An IFIM-based study was completed for the Lower Clearwater River in 1992.)

Input to the resultant model inludes the annual inflow hydrograph, monthly inflow forecasts beginning January 1, minimum and maximum outflow limits, and a proposed annual schedule of reservoir surface elevations or dam discharges. The model user can specify the water withdrawal depth throughout the simulation. All other parameters and coefficients are fixed based on long-term empirical data. The model will generate short-term predictions specific to Dworshak Reservoir.

Integrated rule curve operational guidelines formulated, based on the modeling effort, will balance reservoir fishery resourses with downstream fishery resources, including fall chinook rearing in the Lower Clearwater River and temperature moderation in the Lower Snake River reservoirs. Operations will also be integrated with flood control and power production.

Following is a detailed description of methods applied to ongoing data collection tasks for obtaining long-term data sets of biological parameters as described in Marotz et al.

(1996). These activities correlate to tasks under Objective 1 (Collect and assemble biological/environmental data for developing biological and integrated rule curves for Dworshak Reservoir).

a) Characterize reservoir thermodynamics. This task is intended to link the pelagic thermal structure of the reservoir with reservoir operation. Thermal structure has an important influence on vertical distribution, growth and densities of phytoplankton, zooplankton, benthos and fishes. This task consists of collecting monthly pelagic temperature and oxygen profiles from 0 to 60 m depth at standardized sample stations RM 3.0, RM 19.0, and RM 35.

b) Characterize primary production and loss under various operating conditions. This tasks is intended to quantify autotrophic phytoplankton production under current operations, and will be completed using ^{14}C liquid scintillation. This work has been subcontracted and coordinated with the State of Washington Water Research Center (WRC), Pullman, WA, semi-monthly from 1993 - 1996. A detailed description of the methods applied in assessing primary production is contained in Juul 1996. These data will be used to model total primary production in available reservoir volume per day through an annual cycle. Vertical data and ^{14}C uptake in the forebay will be used in the interpretation of downstream losses.

c) Collect underwater photometric data at RM 3.0, RM 19.0, RM 35, RM 43.0, E 4.0 and LNF 1.0 to determine site specific euphotic zone depths and for primary production analyses. A recording light meter installed on Dworshak Dam collects data on solar input concurrent with primary production sampling for solar input corresponding with light/dark bottle incubation times. These data also assist in quantifying seasonal influences on primary productivity.

d) Characterize zooplankton densities and loss under various operating conditions. The intent is to characterize the densities of zooplankton, quantify zooplankton losses, and relate this information to reservoir operations. Vertical tows are taken through a 12.2 m column at RM 3.0 from April through October. Zooplankton are the primary food for all age classes of kokanee and are also important to other juvenile fishes. Length frequencies of zooplankton taxa important to fish diets are measured and dry weights obtained (Botrell et al. 1975) to determine relative biomass. Semi-monthly samples are collected immediately below Dworshak Dam to measure zooplankton losses through the dam under various operating conditions.

e) Characterize benthic densities and insect emergence relative to reservoir operations. Quantification of benthic densities at depth zones defined by the frequency of dewatering is accomplished via monthly PONAR dredging at standardized sample stations from April through September. Triplicate random sites are sampled within three strata: (1) permanently wetted; (2) infrequently dewatered and, (3) frequently dewatered.

<u>Factors that may limit success of the project</u>

Primary concerns regarding factors that may affect the success of this project include whether the proposed rule curve is formally adopted by the NPPC and, if adopted, whether operating agencies will adhere to rule curve operating criteria. If one overriding use (e.g., flow augmentation, power production, or flood control) assumes absolute dominance of reservoir operations, failure is likely.

Successful scheduling may be influenced by the amount of effort required to calibrate the rule curve modeling effort to compensate for unforeseen influences on reservoir dynamics. Additional data needs for calibration or other purposes may extend the planning phase.

g. Facilities and equipment

Project personnel are stationed out of the NPT Department of Fisheries Resources field office at 3404 Highway 12, Orofino, ID, 83544. Dworshak Dam and Big Eddy Marina is located about 9 miles from the field office. The Orofino field station consists of office space, storage buildings, and a fenced compound to secure vehicles, boats and trailers.

Two vehicles, one four-wheel drive, are leased from GSA. Water transportation is provided by a 22-foot welded aluminum boat with 150 hp motor. One personal computer and laser printer are assigned to the project. Internet and e-mail capabilities are on-line. The computer is equipped with word processing, spreadsheet, data base, statistical and graphic software. Plankton netting (130-150 micron mesh with pygmy flow meter), benthic (PONAR) dredge, submarine photometer (KAHLSICO), and oxygen-temperature (YSI Model 50B) equipment are assigned to the project.

The project has established business relationships with several contractor and service entities to effect primary production, zooplankton, and benthic invertebrate laboratory analyses. No particular limitations regarding facilities and equipment are foreseen.

h. Budget

Salaries include 2/3 FTE of a project leader level biologist for analyzing data, investigating empirical relationships, and for coordinating with a contracted modeler. In addition, 1 FTE of a senior technician is included to collect field data for model refinement/calibration. Staff support also includes a supervisory biologist and administrative assistant, whose costs are shared among several projects. Fringe benefits are estimated at 28% of salary.

Supplies and materials include office supplies and field sampling gear. Operation and maintenance is for cummunications services, office rent, utilities, vehicle lease, mileage expense, and boat fuel and maintenance. Minimal travel costs are allotted for necessary

project specific coordination (BPA, MFWP, subcontractors, etc.). Indirect costs rates are negotiated with BPA annually. Subcontractor services are needed to assist in developing model codes, and analyzing benthos and zooplankton.

Section 9. Key personnel

Project leader David P. Statler has supervisory responsibility for Project 8740700. As project leader, Mr. Statler is responsible for the sampling of physical, chemical and biological parameters in Dworshak Reservoir and in the downstream North Fork Clearwater River to support the formulation of a biological/integrated rule curve model. He attends regional meetings, symposia and workshops related to Project 8740700. He maintains computer data bases of pertinent physical, chemical and biological data for Dworshak Reservoir. He supervises all staff on the Dworshak Reservoir study effort, and helps supervise and coordinate Orofino Field Office activities with those of the Main Office in Lapwai. Mr. Statler?s resume follows:

David P. Statler

3404 Highway 12
Orofino, ID 83544
208-476-7417

EXPERTISE

I have had 23 years experience as a professional fisheries biologist, during which I have worked for the Federal Power Commission (now the Federal Energy Regulatory Commission), the U.S. Fish and Wildlife Service and the Nez Perce Tribe. During this span, I have gained experience with an array of activities within the discipline, including early development and application of USFWS Habitat Evaluation Procedures, stream alteration impact assessments, coldwater fish culture (chinook salmon, steelhead, and rainbow trout) at Dworshak National Fish Hatchery, harvest management, population dynamics, limnology, NEPA statement preparation and review, preparation of Coordination Act Reports pursuant to the Fish and Wildlife Coordination Act, and technical report preparation. My experience as Project Leader with the Nez Perce Tribe has involved extensive contract, budgetary and programmatic duties. My involvement since 1991 in the Columbia River Fish & Wildlife Authority?s Resident Fish Committee and Resident Fish Managers Caucus has provided a regional perspective of fisheries needs and issues within the Columbia Basin. Extensive technical input to the multi-agency System Operation Review of the Columbia Federal Power System from 1991 through 1995 has also provided a regional perspective on resident and anadromous fisheries needs and issues, especially those related to water management. Direct participation in in-season water management via the CBFWA Fish Passage Advisory Committee has provided further appreciation and understanding of the connectivity and complexity of water management actions within the Columbia Basin.

EMPLOYMENT

Project Leader - Dworshak Study **1987-present**
NEZ PERCE TRIBE DEPARTMENT OF FISHERIES RESOURCES MANAGEMENT OROFINO, ID

In addition to serving as Project Leader, I have been the Director of the Resident Fisheries Division since 1996. I have produced monthly, quarterly, annual and final reports for the Dworshak Study. I have applied knowledge of Dworshak fisheries resources to regional water management forums to promote watershed based ecosystem management.

Harvest Management Biologist **1986-1987**
NEZ PERCE TRIBE DEPARTMENT OF FISHERIES RESOURCES MANAGEMENT LAPWAI, ID

This position involved annual predictions of the number of chinook salmon available for harvest, harvest estimates, and post-season estimates of total fish returns. Duties included development of a model to predict total returns of spring chinook salmon to Rapid River, Idaho.

ION

B.S. in Wildlife Biology (Aquatic Option) **1972**
UNIVERSITY OF MONTANA MISSOULA, MONTANA

Major: My major field of study was aquatic biology with a strong emphasis on ecology.
I was the recipient of a merit scholarship from the UM Excellence Fund and graduated with honors.

CATION AND PUBLICATIONS

Certified Fisheries Scientist (American Fisheries Society) - 1989.
Certified Wildlife Biologist (Wildlife Society) - 1981.

Statler, D.P. 1988, 1989, 1990. Dworshak Investigations: trout, bass and forage species. Nez Perce Tribe Department of Fisheries Resources Management, Annual Report to Bonneville Power Administration, Contract DE-AI79-87BP35165, Project 87-407, Portland, OR.

Maiolie, M.A., D.P. Statler, and S. Elam. 1993. Dworshak Dam impact assessment and fishery investigation and trout, bass, and forage species. Final Report. Bonneville Power Administration, Portland, OR.

Arnsberg, B.D. and D.P. Statler. 1995. Assessing summer and fall chinook salmon restoration in the Upper Clearwater River and Principal Tributaries. Nez Perce Tribe Department of Fisheries Resources Management, Annual Report to Bonneville Power Administration, Contract DE-BI79-BI12873, Project 94-034, Portland, OR.

Section 10. Information/technology transfer

The primary documentation produced will be a final report to the Bonneville Power Administration that will include modeling data, modeling, and rule curve criteria. Information on Dworshak fisheries and operational impacts to these fisheries are applied on an on-going basis in regional water management forums. Examples where this information has previously been shared and applied is the System Operation Review of the Federal Columbia River Hydropower System and the Regional Forum to address fish listed under the Endangered Species Act. Dworshak rule curve development and implementation will function to provide additional quantitative information and criteria on which to base critical water management decisions.

Congratulations!