Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Analytical Support-Path And ESA Biological Assessments

Bonneville project number, if an ongoing project 9800100

Business name of agency, institution or organization requesting funding
Hinrichsen Environmental Services

Business acronym (if appropriate) HES

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Subcontractors.

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NPPC Program Measure Number(s) which this project addresses.
3.2C.1, 3.2C.2,4.2A,4.3A,5.0A,7.1A.1,7.1E.1

NMFS Biological Opinion Number(s) which this project addresses.

Other planning document references.
Snake River Salmon Recovery Plan: 2.1d2, 2.1.d3,2.11.a; Consideration of Ocean Conditions in the Columbia River Basin Fish and Wildlife Program Northwest Power Planning Council May 29, 1997: 2d.

Subbasin.
N/A

Short description.
Formulate alternative hypotheses, provide biological rationale, and develop and test model structures to identify key uncertainties in salmon and steelhead life-cycle survival processes..

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production	X	Population dynamics
+	Oceans/estuaries	X	Research	+	Ecosystems
+	Climate	+	Monitoring/eval.		Flow/survival
	Other		Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat en-hancement/restoration
			Acquisitions		

Other keywords.
modeling, life history, ocean survival, alternative hypotheses, climate regimes, model diagnostics

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
9600600	PATH - FACILITATION, TECH ASSISTANCE & PEER REVIEW	Provide alternative hypothesis for PATH decision analysis, peer review of analytic methods
9600800	PATH (PLAN FOR ANALYZING AND TESTING HYPOTHESES) - PARTICIPATION	Work with state agencies and tribes to develop retrospective and prospective analyses under PATH. Assist with peer review.
9700200	PATH -- UW TECHNICAL SUPPORT	Develop alternative hypotheses for use in PATH. Provide biological rationale for alternative hyptheses.r
9601700	TECHNICAL SUPPORT FOR PATH - CHAPMAN CONSULTING, INC.(NOW BIOANAL	Recommend data of opportunity and areas of data scrutiny necessary for development of alternative models.

9303701	TECHNICAL ASSISTANCE WITH THE LIFE CYCLE MODEL	Develop and implement analytical methods for analyzing life-cycle data

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Define alternative hypotheses and quantify implications for survival of salmon and steelhead over their life-cycle with regard to responses to management actions.	a	Test for relationships between salmon and steelhead productivity and ocean conditions.
		b	Provide biological rationale for suitable hypotheses, and methods for incorporating viable alternatives into a decision analysis.
		c	Quantify anthropogenic effects versus climate effects.
		d	
		e	
	Improve existing models and/or develop new models to better evaluate the likelihood of persistence and recovery of salmon and steelhead stocks under alternative management scenarios;	a	Provide model diagnostics showing the sensitivity of model results to various subsets of data..
		b	Test retrospective and prospective models against data unused in the calibration process.
		c	Develop retrospective models for fall chinook, steelhead, and sockeye
		d	Develop prospective models for fall chinook, steelhead, and sockeye
		a	

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	11/1998	03/1999	50%
2	04/1999	09/1999	50%
			TOTAL 100.00%

Schedule constraints.

Completion date.
2003

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel	Hinrichsen at $75/hour for 1,306 hours	$97,950
Fringe benefits		
Supplies, materials, non-expendable property		
Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags:	
Travel	Workshop and meeting attendance for PATH	2,000
Indirect costs		
Subcontracts	Evans-Hamilton $95/hr for 210 hours	$19,950
Other		
TOTAL		$119,900

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$105,000	$110,000	$120,000	$125,000
O&M as % of total	0.00%	0.00%	0.00%	0.00%

Section 6. Abstract

The recent precipitous declines of several salmon and steelhead populations in the Columbia basin have prompted the need to understand what role management actions can play in recovering stocks. Decision-makers seek information about the expected effectiveness of management actions in the face of enormous uncertainties. Our modeling effort is underway to contribute to the understanding of those uncertainties, with the goals of identifying management techniques that are robust to various alternative hypotheses for explaining salmon declines. As part of a large modeling effort underway through PATH, we will develop model structures that allow a large array of hypotheses to be included. We will include alternative hypotheses on the role of climate variability in salmon and steelhead production, using historical productivities to estimate climate/ocean variability on the future success of index salmon and steelhead populations.

We also bring a wide array of techniques to challenge and test the assumptions of the models used in the decision support -- a part of the modeling effort that has been lacking until recently. With our techniques, we seek further quantification of the uncertainties in the decision analysis. We ask two questions: (1) Are there exceptional data of low quality that are driving the performance of management alternatives? and (2) How well do the models predict data unused in their calibration? (This is crucial because prospective models are used to measure probabilities of persistence and recovery in the future.) After identifying these key uncertainties, we apply the results to answer basic design adaptive management questions: How long should the experiment last (sample size?). How large a response is needed to deem the experiment a success (statistical power)? Most basically, how do we alter management schedules to derive the most useful information on key uncertainties?

Section 7. Project description

a. Technical and/or scientific background.

Overall problem

The overall problem we address is the quantification of the effectiveness of management decisions concerning anadromous salmonid ecosystems under uncertainty. We develop and implement life-cycle models that explore management questions of interest and the alternative hypotheses relevant to these questions. We also collect and analyze data available to test these hypotheses. These are the goals of PATH-- a process in which we participate. For our part, we will quantify and model the uncertainty of climate and anthropogenic effects on salmon and steelhead productivity and determine how uncertainty influences the effectiveness of management actions. We will also develop model structures necessary to incorporate a wide range of hypotheses, and provide peer review of model structures and their underlying data, as well as guidance on implementation.

Planning documents and decision support

Decision support. There is a need for decision support in the development of specific recovery plans for listed salmon and steelhead stocks; the Endangered Species Act mandated Section 7 consultation process; and, the development of rebuilding programs under the NWPPC Fish and Wildlife Program (see sec. 2.2-4 <u>Strategy for Salmon</u> Vol. II). The region benefits in these areas from a coordinated technical analysis supporting salmon rebuilding and recovery efforts. In recognition of the need, the NWPPC (Ibid., Sec. 7.3) has called for "....a process to provide for continuing review, coordination and development of analytical tools to assist decision making, facilitate program evaluation and identify critical uncertainties." Our participation in the PATH process is intended to help ensure that the region has the benefit of the use of best available scientific methods, and information in the analyses supporting recovery/rebuilding efforts, including the quantification of key uncertainties that might otherwise be overlooked.

Alternative climate hypotheses. The need for including ocean and climate effects in management decisions has been made law and is now included in several planning documents. On September 12, 1996, Congress enacted the first and only amendment to the Northwest Power Act of 1980. Section (4)(h)(10)(D)(vi) of the Act, they instructed the NWPPC to "consider the impact of ocean conditions on fish and wildlife populations" in making its recommendations to Bonneville regarding projects to be funded. In response to this, NWPPC concluded “ocean conditions have their most direct impact on anadromous fish populations, such as salmon and steelhead,” and directed the region to “integrate current scientific knowledge regarding biological impacts of ocean conditions with the regional fish and wildlife planning and management.”(See action 2.D, “Consideration of Ocean Conditions in the Columbia River Basin Fish and Wildlife Program," NWPPC, May 29, 1997). The proposed recovery plan for Snake River Salmon also called for investigation of the influence of ocean conditions on salmon production (see task number 4.8d, “Proposed Recovery Plan for Snake River Salmon,” NMFS, March 1995).

Scientific review of literature

Decision support – alternative hypotheses, model development and evaluation

The need for consideration of alternative scientific hypotheses (represented as different models) and model evaluation is crucial in PATH and other decision support endeavors. Punt and Hilborn (1997) summarize the steps involved in a decision analysis: (1) Identify hypotheses about population dynamics, (2) determine relative weight of evidence in their support, (3) identify alternative management actions, (4) evaluate the expected value of the performance measures, and (5) present the results to the decision maker. In order to make scientific progress, we need alternative models representing different hypotheses on the states of nature. A too-narrow range of alternative hypotheses considered will produce overconfidence in the rankings of the effectiveness of management options (see PATH memo, Randall Peterman, May 31, 1997). During FYs 1997-1998 Hinrichsen worked with PATH to develop alternative model structures in the preliminary decision analysis document, particularly the development of the alpha model which incorporated passage model output with a Ricker spawner-recruit model. The model was subsequently used in analysis of management decisions (see Preliminary Decision Analysis Report on Spring/Summer Chinook, PATH, 1998).

Evaluation of the models in a Bayesian analysis is accomplished in many ways (Gelman et al., Bayesian Data Analysis, 1995). These are implemented for a common reason: to not be misled by models that do not fit reality and are sensitive to the arbitrary specification of model structures and probability distributions. We further evaluate models by identifying exceptional data that have large influence on important parameter estimates, and ultimately the ranking of management options (Belsley et al. 1980; Cook and Weisberg, 1982). During FYs 1997-1998, Hinrichsen conducted sensitivity analysis on the spring/summer chinook spawner-recruit model to detect exceptional data. Spawner-recruit data in the John Day Middle Fork were found to be highly influential on key parameter estimates and of poor quality (see Preliminary Decision Analysis report on Spring/Summer Chinook, PATH document, 1998; Hinrichsen 1998). Distressingly little attention has been paid to model diagnostics. Because models are used prospectively, it is crucial to assess the ability of the models to predict outside the range of the data fit. These diagnostics are needed to improve our models and identify key uncertainties in the decision support analyses.

Climate and salmon ecosystems

Widespread ecological changes related to interdecadal climate variations in the Pacific have been observed in this century. Dramatic shifts in many marine and terrestrial ecological variables in western North America coincided with changes in the physical environment in the late 1970s. This array of rapid and widespread changes is known as the 1977 climate regime shift. The 1977 regime shift is not unique in the climate record or in the record of North Pacific salmon production. Signatures of other regime shifts are evident in the Pacific basin ecological systems starting in the 1700s (1925 and 1947 in this century). (See Mantua et al. 1997, Minobe 1997). Among salmon species shown to have interdecadal variability were Alaskan sockeye, Alaskan pink salmon, Columbia River spring chinook, and Washington-Oregon-California (WOC) coho. While the climate regime from 1977-present favored Alaskan salmon production, it was associated with decreased production of West Coast salmon stocks south of Alaska (Hare et al. 1997, Pearcy 1992).

The marine ecological response to regime shifts may start with the plankton at the base of the food chain and work its way up to top-level predators such as salmon (Francis et al. 1997). After the 1977 regime shift, there was a zooplankton biomass increase and a re-distribution around the Subarctic gyre, creating favorable feeding conditions for migrant salmon smolts (Brodeur and Ware 1992, Sugimotoa and Tadokoro 1997). Conversely, off the West Coast , there was a dramatic decrease in zooplankton production due to stratification of the California Current waters and loss of advective products from the westwind drift (Roemmich and McGowan, 1995). This relatively barren ocean environment was unfavorable for West Coast smolts (Hare et al. 1997).

The apparent biological effects of these regime shifts have been dramatic. Catches of Alaskan pink and sockeye salmon decreased by about 57% in 1947, and increased by about 230% during the 1977 climate regime shift. The 1947 shift, which was bad for Alaskan stocks, was good for Columbia River upriver spring chinook, which showed a 49.1% increase. The 1977 regime shift, though good for Alaskan stocks, was bad for Columbia River upriver spring chinook, which showed a 55.5% decrease (PATH 1998). Hinrichsen conducted a preliminary intervention analysis of spring chinook run size, comparing run size during three different climate regimes in this century. He estimated climate effects that outweighed anthropogenic effects by a ratio of 3/2 to 5/2 (PATH 1998).

Higher frequency oscillations in the NE Pacific are also apparent in biological production and physical variables, but their connection with salmon production is not well studied. The bidecadal oscillation of 20-25 years and the El-nino-Southern oscillation of 5-7 years described by Ware (1985) will also be investigated using catch, run size, and spawner-recruit data of salmon and steelhead.

During FYs 1997-1998 Hinrichsen worked with PATH to (a) provide the biological rationale for a climate regime shift hypothesis, (b) quantify its effect on spring/summer chinook populations, and (c) to develop model structures to describe its effect in a decision analysis (PATH 1998).

b. Proposal objectives.

Specific Measurable Objectives:

Our objectives are a critical part of the overall framework of PATH or any decision analysis concerning the Columbia Basin anadromous salmonid ecosystem.

(1) ALTERNATIVE HYPOTHESES: Define alternative hypotheses and quantify their implications for survival of salmon and steelhead over their life cycle. Apply these analytical approaches to assess the ability of adaptive management experiments to distinguish among competing hypotheses from future information. Goals for FY99 include:

Publish biological rationale for climate regime-shift for spring/summer analyses in a peer-reviewed journal.

Publish the evidence for and against influences of a climate regime shift on salmon and steelhead populations.

Hypothesis. We will test the hypothesis that there are significant relationships between climate indicators and salmon and steelhead production at the time scales known to be important in ocean processes. Needed to test these hypotheses are production data, which may include spawner-recruit data or catch data extending from the present to before 1947, and preferably, the 1925 climate regime shift.

Benefits to FWP: Our work provides quantification of key uncertainties surrounding climate variability and salmon and steelhead production. It also provides a vehicle for including climate in management decisions as mandated by law and as recommended by NWPPC.

(2) MODELS: Our objectives are to

(a) Improve existing model and/or develop new models to better evaluate the likelihood of persistence and recovery of salmon and steelhead stocks under alternative management scenarios.
(b) Publish peer-reviewed reports and journal articles demonstrating the overall level of support for key alternative hypotheses. (c)
(c) Emphasize implications for management decisions on endangered or threatened salmon populations of the Columbia River Basin.
(d) Provide guidance to management agencies (particularly NPPC and Implementation Team) based on these outputs in written format and through oral presentations.
(e) Propose alternative hypotheses and/or model improvements that are more consistent with the data.
(f) Develop improved models that incorporate what has been learned from the retrospective analyses and model checking procedures.

Goals for FY99 include:

Complete outstanding retrospective and prospective analyses for salmon and steelhead.

Complete memos and decision support documents which include thorough evaluations of models used by PATH.

Hypotheses and quantification. We will test for dependency of model results on exceptional data and test for model departures from critical assumptions. We will quantify how well models can predict data unused in their calibration. A key assumption is that this test will provide insight into how well models can predict the future under different management actions.

Benefits to FWP: Quantification of key uncertainties regarding model structures and exceptional data used in their calibration. Testing of models employed in decision support analyses.

c. Rationale and significance to Regional Programs.

Salmon populations in the Columbia River Basin have been in decline since the beginning of western settlement. The annual production of the Snake River spring/summer chinook during the late 1800s might have been greater than 5 million fish or about 40% of all Columbia River spring/summer chinook (NMFS Biological Opinion, 1995). The present population of Snake River spring/summer chinook is approximately

0.5% of its historic abundance. From 1938 to 1950, the returns of Snake River fall chinook were approximately between 72,000 to 29,000. Now only 350 Snake River fall chinook return. Such declines have led to both races of Snake River chinook being listed under the Endangered Species Act, though both have continued to decline since listing (NMFS, Proposed Recovery Plan for Snake River Salmon, 1995). The Snake sockeye's largest spawning areas was the headwaters of the Payette River, where 75,000 were taken one year by a single fishing operation in Big Payette Lake. During the early 1800s, returns to the headwaters of the Grande Ronde River in Oregon were estimated between 24,000 and 30,000 fish. During the 1950s and 1960s, adult returns to Redfish Lake numbered more than 4,000 fish (NMFS, Proposed recovery Plan for Snake River Salmon, 1995). Present counts (1990-1996) at Lower Granite Dam show an average of only 7 sockeye returning per year. Summer steelhead enter the Columbia from March through October, and peak in late June through early September. Those entering in late August through October (Group B) are destined primarily for tributaries of the Snake River. The Group B wild/natural run totals in 1993, 1994, and 1995 (11,200, 9,900, and 6,300, respectively) were below the Zone 6 escapement goal of 13,000 fish during 1984-95 (WDFW and ODFW, "Status Report. Columbia River Fish Runs and Fisheries, 1938-1995," 1996). The low levels of wild steelhead in the Snake River basin prompted the NMFS to declare them threatened on August 11, 1997.

To rebuild these runs, there is a need for scientifically sound guidance to decision-makers. Formulation of alternative hypotheses regarding factors affecting salmon production and their associated uncertainties is needed to reflect the range of responses of performance measures (e.g., salmon and steelhead productivity) due to management decisions. Among these alternative hypotheses and uncertainties must be the effects of climate. Consideration of climate in the range of hypotheses has been emphasized in the 1996 amendment to the 1980 Power Act, September 12, 1996. NWPPC concluded "ocean conditions have their most direct impact on anadromous fish populations, such as salmon and steelhead," and directed the region to "integrate current scientific knowledge regarding biological impacts of ocean conditions with the regional fish and wildlife planning and management."(See action 2.D, "Consideration of Ocean Conditions in the Columbia River Basin Fish and Wildlife Program, NWPPC, May 29, 1997). The proposed recovery plan for Snake River Salmon also called for investigation of the influence of ocean conditions on salmon production (see task number 4.8d, "Proposed Recovery Plan for Snake River Salmon," NMFS, March 1995).

The results of these decision analyses will be as good as the models and data upon which they are based. Our thorough testing and validation of models and review of data will help quantify uncertainties in management recommendations.

Testable hypotheses

The approach of PATH places hypotheses into three groups. (1) Level 1 Hypotheses are exploratory. We assess patterns in stock indicators over space and time to identify differences in trends among species and stocks, without investigating mechanisms to explain those differences. (2) Level 2 Hypotheses explain trends in stock indicators in terms of changes in either the survival of particular life history stages, or the stresses affecting life stage survivals, thereby providing inferences on where to focus management actions. (3) Level 3 hypotheses explain mechanisms associated with observed trends in survival of key life stages identified at Level 2, and link directly to management decisions.

This is the approach we will use for testing for the effects of climate in salmon and steelhead populations.

Relationship to other projects
The development of alternative hypotheses and model evaluation we propose are essential to the goals of PATH and its related projects (see projects 9600600, 9600800, 9700200, 9601700, and 930701).

d. Project history

Project History
The project (number 9800100) began FY98 on October 19, 1997.

Results Achieved in FY 1998:

Developed alternative model structures for use in retrospective and prospective modeling.
Developed alternative hypotheses for inclusion in decision support analysis.
Co-authored PATH preliminary decision analysis report.
Provided biological rationale of climate regime shift hypothesis.

Reports for FY 1998
PATH. 1998. Preliminary Decision Analysis Report on Spring/Summer Chinook.

Hinrichsen, R. A. 1998. Influence of Exceptional Spawner-Recruit data of the John Day Middle Fork on the Delta Model Parameters. PATH memo. See http://www.cqs.washington.edu/~hinrich/PATH/INFLUENCE/abst_inf.html

Budget
The FY 1998 budget totaled $100,000.

Adaptive Management Implications
The hypotheses and decision frameworks we have developed have been synthesized with a wide array of information for making management decisions. The models and hypotheses developed should aid in the design of adaptive management experiments. Given the past data and model fits, we are poised to answer fundamental questions of experimental design. How large must changes in performance measures be to achieve statistical and biological significance (power)? How many years should the experiment be

run (sample size)? We will continue to explore the predicted outcomes of adaptive management experiments and their uncertainties from the prospective analyses.

e. **Methods**.

The two overall research objectives of the proposed research are critical to PATH.

(1) Define alternative hypotheses and quantify implications for survival of salmon and steelhead over their life cycle with regard to responses to management actions. We will focus mainly on the development of alternative climate hypotheses for our part of the analysis.
(2) Improve existing model and/or develop new models to better evaluate the likelihood of persistence and recovery of salmon and steelhead stocks under alternative management scenarios. We will treat modelling as an iterative process that involves model testing and validation.

The tasks are integral to those of PATH (identified below).

A. Compile and analyze information to assess the level of support for alternative hypotheses relevant to key management decisions, identifying knowledge and data gaps that could be filled through management experiments, research and monitoring.

B. Provide guidance to the development of regional programs that would stabilize, ensure persistence, and eventually restore depressed salmon stocks to self-sustaining levels.

C. Provide a structure for an adaptive learning approach to development and implementation of a regional salmonid recovery program.

Task 1.a. Test for relationships between salmon and steelhead productivity and ocean conditions.

We will test for variation in productivities, ideally described by log(Recruits/Spawners) for spawner-recruit data, coincident with changes in ocean production regimes at various time scales: El Nino/Southern Oscillation (7 years), Bidecadal Oscillation (~20 years), and the Pacific Interdecadal Oscillation (~60 years). We will use the methods of spectral analysis, time series analysis, and where appropriate intervention analysis. Where spawner-recruit data are not available, we will test catch data for variation at these various time scales and changes coincident with known changes in ocean/climate indices. Preliminary analysis of the upriver spring chinook run sizes shows variation at the 60-year oscillation appear to be important, coincident with the major climate regime shifts (1947 and 1977). To test for this relationship in other species, we will analyze salmon and steelhead data prior to 1947 (the beginning of the last cold/wet climate regime). We will test for significant changes in production corresponding to outmigration years 1977 (switch to warm/dry regime) and, if possible 1925 (shift to cold/wet regime). The length of the historical record will dictate the sample size.

Task 1.b. Provide biological rationale for suitable hypotheses and provide methods for incorporating viable alternatives into a decision analysis.

The biological rationale regarding climate hypotheses will include first the statistical relationships (if any) found between known climate/ocean indicators and salmon or steelhead production. We will then include documentation on the life history stage most likely influenced by climate/ocean variability, and likely mechanisms that account for the statistical relationships. The results and rationale will be reviewed by an independent panel provided by PATH.

Task 1.c. Quantify anthropogenic effects versus climate effects.
At long time scales it may be possible to resolve differences in anthropogenic versus climate/ocean regime shift effects. This involves comparing the productivity of salmon and steelhead stocks during similar climate regimes in the presence and absence of particular anthropogenic effects. The early warm/dry regime (1925-1947) gives us a base level of production we would expect during the present warm/dry regime (1977-present) in the absence of increased negative anthropogenic effects post-1947. By comparing the productivities during these two warm/dry regimes, we can estimate a post-1947 anthropogenic effect.

Objective (2) above concerns mainly the iterative process of model selection, which is defined below (Box et al. 1994):

	(i)	Postulate general class of models
b	(ii)	Identify model to be tentatively entertained
c	(iii)	Estimate parameter in tentatively entertained model
d	(iv)	Diagnostic checking (is the model adequate?) If not, go to (ii)
	(v)	Use model prospectively in decision analysis

It can be difficult to decide whether the model is adequate, but there are many diagnostic tests available. In the tasks below, we identify diagnostics that have recently proven useful and revealing in PATH and entertain others which should be employed.

Task 2.a. Provide model diagnostics showing the sensitivity of model results to various subsets of data.
This task is part of the iterative process of model building which must be implemented with each proposed model and is a part that has, until recently, been largely neglected in PATH (Hinrichsen 1998). Techniques for detecting exceptional observations (Cook's distance, for example), are well known and will be employed in the retrospective analyses (Cook and Weisberg 1982, Belsley et al. 1980). The quality of observations of high

influence will be scrutinized carefully, and possibly down-weighted or removed if necessary.

Task 2.b. Test retrospective and prospective models against data unused in the calibration process.
This task is part of the iterative process of model building, and falls within the realm of model validation. We have identified three types of data-of-opportunity: (1) stock-recruitment data from non-index stocks, (2) and run size data prior to the time window of data fit.

The techniques utilizing these types of data in validation are fairly well known. In the case of (1), we will incorporate the new observations and determine whether the estimates of parameters and conclusion of the decision analyses change. The techniques of model fitting are exactly those used in the fitting of the retrospective models (Deriso et al., "Retrospective Analysis of Passage Mortality of Spring Chinook of the Columbia River," Chapter 5 of "Plan for Analyzing and Testing Hypotheses," July 19, 1996).

In the case of (2), we will use the retrospective models to hindcast population trajectories prior to the window of spawner-recruit data used in their fit. Given the estimates of the model parameters in the retrospective model fit and their various assumptions, how well does the model hindcast observed population sizes? For example, in the retrospective spring chinook model, identified as the delta model, there is an inherent assumption that in the absence of dams, average fluctuations in productivity would be the same for upriver (Snake) and down river spring chinook populations. If true, then in the time period when the influence of mainstem dams was the same for upriver and down river stocks (1938-1952), the index stocks should be a good estimator of the spring chinook run at large. We propose to use the model retrospectively by using the same assumptions employed in its prospective use, except with the conditions of the pre-1952 hydrosystem and harvest levels used as model inputs. We will test whether the observed trajectories fall within the range or probabilities calculated by the model. Without running tests of this kind we cannot be confident that the model will perform well in predicting future population sizes.

In another suite of model tests, we will withold data in the calibration of the models, then simply run the models prospectively exactly as done with the full data set present and determine how well it predicts the data withheld. In the case of the spring chinook prospective model, we will calibrate to the 1952-(1952 + X) data, then see how well the prospective model predicts the observed (1952+X+1) – 1990 data. This analysis is more straightforward than the hindcasting of (2), but both tell of the robustness of the models used in prediction.

Task 2.c. Develop retrospective models for fall chinook, steelhead, and sockeye.
Assist in the task of developing these models under PATH and introducing alternative hypotheses and the means for testing them.

Task 2.d. Develop prospective models for fall chinook, steelhead, and sockeye.
Assist in developing these models under PATH and introducing alternative hypotheses. Develop the means of testing these models.

f. Facilities and equipment.

The facility for conducting the research will be the offices of Hinrichsen Environmental Services, Seattle, Washington. Hinrichsen has acquired the necessary Internet access, statistical software, and word processing software to complete the work and communicate with other researchers on related projects. No special equipment purchases will be necessary to complete the work.

g. References.

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Section 8. Relationships to other projects

James Anderson's and colleagues' participation in PATH 8910800 CRiSP Modeling

Al Giorgi's hydrosystem work participation in PATH 9601700 Technical Support for Path - Chapman Consulting, Inc. (now Bioanalysts, Inc.)

Paulsen's simulation modeling participation in PATH 9303701 Technical Assistance With the Life Cycle Model

U.S. Forest Service for quantitative habitat assessments (Danny Lee) participation in PATH 9203200 Life-cycle Model Development and Application, and Analysis of Fish-habitat Relationships

ESSA for PATH, Facilitation, Tech Assistance & Peer Review- work with planning group to develop specific PATH workplans and reports to be submitted to PATH peer review process. 9600600

COOPERATION

Through PATH, Hinrichsen currently cooperates with scientists from NMFS, BPA, NPPC, ODFW, IDFG, WDFW, CRITFC, USFS, CBFWA, and CORPS, as well as from a number of academic and research institutions (U. Washington, Simon Fraser University, UC Davis, UBC, U. Rhode Island, U. Idaho, Inter-American Tropical Tuna Commission) and private firms (ESSA Technologies, Paulsen Environmental Research, Don Chapman Consultants). In addition, the Independent Scientific Group (ISG) has participated in PATH since its inception (Phil Mundy, Jim Lichatowich, Chip McConnaha, and Chuck Coutant). Close cooperation with the ISG is very important to our work.

Opportunities for relationships exist for several non-BPA funded projects for ocean/climate effects:

The U.S. Global Ocean Ecosystems Dynamics (U.S. GLOBEC) is a research program organized by oceanographers and fisheries scientists of the National Science Foundation (NSF), and the Coastal Ocean Program (COP) and the National Marine Fisheries Service (NMFS) divisions of the National Oceanic and Atmospheric Administration (NOAA). The program has a goal of understanding how physical processes influence marine ecosystems, to predict the response of the ecosystem to climate change.

The Pacific Northwest Coastal Ecosystem Regional Study (PNCERS) is a joint interdisciplinary effort of the Oregon Coastal Management Program, the Oregon and Washington Sea Grant Programs, and the National Marine Fisheries Service Northwest Fisheries Science Center. The goal of the PNCERS program is to improve the understanding of natural variability and anthropogenic factors on coastal ecosystems that support Pacific salmon, and to translate that understanding into improved management of resources and activities that affect coastal ecosystems.

El Nino/Southern Oscillation (ENSO) Watch Advisories are prepared and issued monthly since 1982 by the National Weather Service (NWS) of NOAA. This service includes analyses of coastal ocean mean sea surface temperatures (SST), deviations of SST from normal, information on ocean currents, thermocline structure, and other conditions as available.

Section 9. Key personnel

Richard A. Hinrichsen, Principal Investigator, 1,306 hours
Duties on project
Hinrichsen will plan and implement the model development and evaluation, and develop alternative hypotheses for decision analysis.
Resume
Education. Doctor of Philosophy (Ph.D.), Quantitative Ecology & Resource Management, University of Washington, Seattle, Washington, December 1994; Master of Science (M.S.), Mathematical Sciences, Clemson University, Clemson, South Carolina, June 1987; Bachelor of Science (B.S.), Mathematics, Central Washington University, Ellensburg, Washington, June 1985.
Current Employer: Self-employed
Current Responsibilities: Resource modeling, development of alternative hypotheses, model development and testing.
Recent Previous Employment: University of Washington, Research Consultant, January 1995-October 1997.
Expertise: Hinrichsen has evaluated and designed models of salmon survival for the past 9 years, beginning with the evaluation of FISHPASS in 1988 and the development of a passage model used for the Biological Opinion and Biological Assessment published annually by the Bonneville Power Administration (BPA) and the National Marine Fisheries Service (NMFS) in the early ‘90s. His expertise in the area of statistics has been particularly useful in the development and testing of models used in decision support. He excels in written communication and is editor-in-chief of the international Shad Journal.
Recent and Relevant publications.

Hinrichsen, R. A. 1998. Influence of Exceptional Spawner-Recruit data of the John Day Middle Fork on the Delta Model Parameters. PATH document. See http://www.cqs.washington.edu/~hinrich/PATH/INFLUENCE/abst_inf.html.

PATH. 1998. Preliminary Decision Analysis Report on Spring/Summer Chinook. Edited by David Marmorek, and Calvin Peters, ESSA technologies.

Hinrichsen, R.A., J.J. Anderson, G.M. Matthews and C.C. Ebbesmeyer. 1998. Assessment of the effects of the ocean and river environment on the survival of Snake River stream-type chinook salmon. Bonneville Power Administration Report. (In Review) Portland, Oregon. USA.

Ingraham, W.J., C.C. Ebbesmeyer, and R.A. Hinrichsen. 1998. Sea surface drift and tree rings signal imminent decadal shift of northeastern Pacific subarctic water movement. *EOS*. (In press)

Anderson, J.J. and R.A. Hinrichsen. 1997. A suite of alternative hypotheses using a passage model in a Bayesian approach. Path Memo. June 1997.

Curtis C. Ebbesmeyer, Sub-contractor, 210 hours
Duties on project. As an oceanographer pioneering in studies of ocean regime shifts and variability he will consult on the biological rationale for ocean effects on salmon production.

Resume.

Education. Ph.D, Physical Oceanography, University of Washington, 1973; M.S., Physical Oceanography, University of Washington, 1968; B.S., Mechanical Engineering, California State University.

Current Employer: Evans-Hamilton, Inc., Seattle, Washington.

Recent previous employment: Not applicable.

Expertise: Dr. Ebbesmeyer is a physical oceanographer with expertise in the analysis of coastal, estuarine, climate, and large-scale oceanographic phenomena. He identified the 1977 climate regime shift and demonstrated its effect on numerous physical and biological variables.

Relevant publications.

Ingraham, W.J., C.C. Ebbesmeyer, and R.A. Hinrichsen. 1998. Sea surface drift and tree rings signal imminent decadal shift of northeastern Pacific subarctic water movement. *EOS*. (In press)

Ebbesmeyer, C.C., D.R. Cayan, D.R. McLain, F.H. Nichols, D.H. Peterson, and K.T. Redmond. 1991. 1976 step in the Pacific climate: forty environmental changes between 1968-1975 and 1977-1984. In: Proceedings of the seventh annual Pacific Climate (PACLIM) Workshop, April 1990. J.L Betancourt and V.L. Tharp, editors. California Department of Water Resources. Interagency Ecological Studies Program Technical Report 26. pp.129-141.

Ebbesmeyer, C.C, and C.A. Coomes. 1989. Strong, low frequency (decadal) environmental fluctuations during the 20th century in the North Pacific Ocean, on the Washington Coast, and in Puget Sound. In: Proceedings of OCEANS ’89 Conference, Vol. 1:242-246. IEEE and Marine Technology Society, Washington, D.C.

Section 10. Information/technology transfer

Information will be posted on the World Wide Web, and will be included in PATH reports on salmon and steelhead, and where appropriate, BPA reports. Models and software developed will be freely distributed over the internet.