Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Technical Assitance With Life Cycle Modeling

Bonneville project number, if an ongoing project 9303701

Business name of agency, institution or organization requesting funding
Paulsen Environmental Research Ltd.

Business acronym (if appropriate) PER Ltd.

Proposal contact person or principal investigator:

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Subcontractors.

Organization	**Mailing Address**	**City, ST Zip**	**Contact Name**
Beak Consultants Inc.	317 S.W. Alder Suite 900	Portland, OR 97204	Tim Fisher

NPPC Program Measure Number(s) which this project addresses.
3.2F2, 4.3, 5.0A, 7.1E

NMFS Biological Opinion Number(s) which this project addresses.
NMFS BO RPA 13; RPA A17; Program Support

Other planning document references.

Subbasin.

Short description.
Assist regional management agencies in evaluating how changes in hydro and hatchery operation, climate, and habitat may affect survival and recovery of ESA-listed salmonids

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 enhancement/restoration
			Acquisitions		

Other keywords.
life cycle models, ESA stocks, Statistical analysis, BIOP

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
9601700	Technical Support for PATH - Chapman Consulting	Data exchange, review of reports, coordination
9600600	PATH- Facilitation, Technical Assistance, Peer Review	Review of reports, report compilation, coordination
9600800	PATH- Participation by State and Tribal Agencies	Data exchange, review of reports
9720320	Life Cycle Modeling for System and Subbasin Planning in Snake River	Data exchange, coordination
9700200	PATH- UW Technical Support	Data exchange, coordination
9800100	Analytical Support-- PATH and ESA Biological Assessments	Statistical methods development, review of reports

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Improve understanding of	a	Revise and update exisiting and

	relationships betweeen land management patterns and ESA spring/summer chinook and steelhead parr-to-smolt survival		ongoing (FY98) use of Snake River PIT tag data and land management data and methods
		b	Apply methods developed under [1a] to Snake River natural steelhead
2	Improve understanding of effects of hatchery releases on spring/summer chinook spawner-recruit survival	a	Revise and update ongoing (FY98) use of data on spawner-recruit survival and subbasin releases
3	Improve understanding of the effects of ocean conditions on Columbia Basin chinook	a	Revise and update existing ongoing (FY98) use of coded wire tag, spawner-recruit data, and their relationship to major ocean condition indicators
4	Improve understanding of potential information gains from adaptive management strategies	a	Investigate potential of adaptive management strategies to generate information to resolve critical uncertainties in ESA stock survival and recovery
5	Participate in PATH process and disseminate research results	a	Improve research products under this contract and related ones via participation in PATH discussions, meetings, and reviews; disseminate research results via refereed journals, as appropriate

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1998	10/1999	25.00%
2	10/1998	10/1999	15.00%
3	10/1998	10/1999	20.00%
4	10/1998	10/1999	20.00%
5	10/1998	10/2000	20.00%
			TOTAL 100.00%

Schedule constraints.
Work for FY99 depends in part on timely, successful completion of work in FY98 under this and other PATH projects. In addition, ESA-related litigation could make substantial demands on PATH analysts time in FY98 and FY99

Completion date.
fy03

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$135,000
Fringe benefits		
Supplies, materials, non-expendable property	Statistical software purchase and leasing	$3,000
Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags:	
Travel	1 trip per month at $500-$600 per trip	$7,000
Indirect costs		
Subcontracts	Beak Consultants	$30,000
Other		
TOTAL		$175,000

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$180,000	$185,000	$190,000	$195,000
O&M as % of total	100.00%	100.00%	100.00%	10000.00%

Section 6. Abstract

This project is part of the PATH (Plan for Testing and Analyzing Hypotheses) program. It has three overall goals. The first is to improve our understanding of the effects several important factors on wild fish survival: habitat quality, hatchery releases, and ocean conditions. The second is to develop methods to gain the most information possible from adaptive management actions and associated monitoring activities. The third is to ensure that the results are communicated effectively to both specialist and management audiences.

Research under the first goal is needed to address concerns raised in the FWP, the Gorton Amendment, and in *Return to the River*. The ISG report in particular raises concerns about the effectiveness of habitat enhancement actions, the potential impacts of hatchery

production on wild stocks, and the way that ocean survival is viewed as a “black box” in FWP planning.
The statistical methods employed are modifications of work done in FY97 and ongoing research in FY98. These past results have been favorably reviewed by PATH’s outside review team (Jeremy Collie, Brian Dennis, Saul Saila, and Carl Walters). Work for FY99 will take reviewers’ into account in planned analyses. We expect further reviews of the FY99 and future results as well. Results from these and other PATH research will be used in developing adaptive management models.
The results from FY99 will be tested with new data in subsequent years. If the models are reasonable, they should be able to predict future effects (of habitat, hatchery releases, and ocean conditions) accurately. We expect that related research will extend to FY03.

Section 7. Project description

a. Technical and/or scientific background.

Most of the objectives for FY99 follow from work done under this and other PATH projects for FY97 and FY98 (see literature reviews in Paulsen et al 1997: Chapter 4 and in Wilson 1996). In particular, PATH (as well as the ISG, *Return to the River*) have identified several areas of scientific uncertainty that are important to achieving ESA and FWP objectives. These include the effects of habitat enhancement on wild fish survival, the effects of hatchery releases on wild fish survival, and the effects of ocean conditions on fish survival. Obviously, these are all extremely broad topics; only selected subsets can be addressed in the course of a single project. For these three topics, the general objective is to use existing data or data from ongoing (PIT tag and CWT) monitoring programs to investigate the effects of the above three factors on short term (single season to single generation) fish survival.

A fourth objective of the project is to begin work on the design of adaptive management strategies to resolve these and other uncertainties. Because this will be the first year of work on the topic, we do not anticipate advancing beyond the design and modeling stage. The fifth objective relates to review and dissemination of research products (reports, journal articles, etc.).

The principal investigator (Charles Paulsen) has been involved with research on Columbia salmonid issues for over ten years. He has been involved in PATH since its inception, and with its predecessors (ANCOOR, BRWG) for about five years. He was principal investigator for FY96-FY98 research on the first three topics, all of which have received favorable reviews from the PATH Scientific Review Panel (Jeremy Collie, Brian Dennis, Saul Saila, and Carl Walters).

b. Proposal objectives.

1. The first objective is to improve our understanding of the relationship between land management patterns and the parr-to-smolt survival of stream-rearing salmonids that rear in subbasins above Lower Granite Dam. The null hypothesis—based on FY97 and FY98 work under this project—is that vegetation, land forms, and land management do not affect the parr-to-smolt survival of yearling (spring/summer) chinook and steelhead. Testing this hypothesis using PIT tag data requires a number of assumptions (beyond those needed for short-term, active migrant PIT tag survival studies). First, one must be able to measure any and "control" for important factors that may be correlated with land management patterns (e.g., distance for rearing areas to Lower Granite, the first dam where PIT tagged fish are detected). Second, the form of the statistical model(s) estimated must be assumed to be correct; this is testable to some degree using different forms of the model (e.g., Poisson or logistic) and a variety of model diagnostics. Finally, the effects of land management—if present—must persist over time, so that model results can be compared to data acquired in the future. One product will be a report (reviewed by PATH participants and the PATH Scientific Review Panel [SRP]) for submission to an appropriate journal. In addition, we expect that the results may help guide recovery planning and management actions, assuming that land management does have an affect on survival. Finally, since FY99 work will build on work from FY98 and will have new (migration year 1998) recovery data available, we will systematically test the predictive accuracy of the model(s) developed.
2. The second objective is to improve our understanding of the effects of hatchery releases on spring-summer chinook life cycle survival – from spawners to recruits to the mouth of the Columbia. The null hypothesis behind this objective is that neither subbasin releases of hatchery fish (spawning adults, fry, parr, etc.) nor releases of smolts into the migration corridor affect the survival of wild spring/summer chinook. Because data sets of subbasin release information are limited in length (10-20 years), we can only perform statistical tests for relatively short-term effects. These may include disease transmission, competition for food and other resources, and demographic effects (e.g., hatchery parr will add to the abundance of that generation's recruits). We cannot investigate mechanisms that may act over several generations (e.g., outbreeding depression) with this data. One product will be a report (reviewed by PATH and the SRP) for submission to an appropriate journal. In addition, we expect that the results may help guide recovery planning and management actions, assuming hatchery releases do affect wild fish survival. Finally, since FY99 work will build on work from FY98 and have new (brood years 91-93) data available, we will systematically test the predictive accuracy of the model(s) developed.
3. The third objective is to improve understanding of the effects of ocean conditions on Columbia Basin chinook. The specific null hypothesis – based on earlier work under this project -- is that there is no relationship between ocean conditions and

chinook survival, either from smolt to adult, or from spawner to recuit (to the mouth of the Columbia). Assumptions which parallel those in Objective 1 apply to testing the hypothesis. Coded wire tag (CWT) and stock-recruit data will be used for 20+ chinook stocks from the Columbia. One product will be a report (reviewed by PATH and the SRP) for submission to an appropriate journal. In addition, we expect that the results may help guide recovery planning and management actions, assuming ocean conditions do affect chinook survival. Finally, since FY99 work will build on work from FY98 and have new (brood years 91-93) data available, it should be possible to systematically test the predictive accuracy of the model(s) developed.

4. The fourth objective is to improve understanding of potential information gains from adaptive management strategies. Because work under this objective is new for FY99, this objective is not as sharply defined as the other four. Work to date under other PATH projects has revealed substantial uncertainty regarding the past effects of many management actions, including smolt transportation, climate, and mainstem hatchery releases. The objective is to demonstrate possible reductions in these and related uncertainties via simulation modeling of management strategies that would be quite different from present policies. The results (by assumption) would be monitored intensively to extract as much information as possible about their effects on ESA stock mortality. Products will include reports (to be reviewed by PATH and the SRP), for submission to an appropriate refereed journal. In addition, we expect the reports to be useful in designing future monitoring programs and experimental management actions.
5. The fifth objective is to participate in PATH and help review and disseminate research results. The purpose is to help improve the research results of this and other PATH projects via reviews of research products and results, and to assist in disseminating results within the region via production of "corporate" PATH reports and presentations to management and policy groups.

c. Rationale and significance to Regional Programs.

Overall objectives and rationale for the PATH process are as follows (from ESSA FY98 work statement):

> PATH is an iterative process of defining and testing a logical framework of hypotheses relating to the Columbia River anadromous salmonid ecosystem, while moving towards stock recovery and rebuilding. Iteration within the PATH process should occur as this logical framework is revised over time in response to improvements in both information and analytical methods. The revised objectives of the PATH effort are:
>
> 1. define the management decisions that serve to focus analytical activities;
>
> 2. bound the anadromous salmonid ecosystem components under consideration;

3. explicitly define alternative hypotheses and implications for the functioning of ecosystem components, in terms of the distribution of survival over the populations' life-cycle, and the life stage and population responses to management actions under different natural conditions;

4. compile and analyze information to assess the level of support for alternative hypotheses (component, composite, and aggregate hypotheses);

5. propose other hypotheses and/or model improvements supported by the weight of evidence of these analyses;

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

7. improve existing model and/or develop new models to better evaluate the likelihood of persistence and recovery of salmon and steelhead stocks (i.e. assess conservation risk) under alternative management scenarios;

8. provide guidance to managers on the strategic implications of hypotheses tests for key management decisions, and for the design of research, monitoring and adaptive management experiments that maximize the rate of learning and clarity of decisions; and

9. provide a structure for an adaptive learning approach to development and implementation of a regional salmonid recovery program (i.e. iterative evaluation of results of research, monitoring, and adaptive management experiments; assess implications of alternative hypotheses on subsequent actions).

   The logical framework developed in PATH will assist in management decisions concerning the Columbia Basin anadromous salmonid ecosystem. The design of this framework is driven by the management questions of interest, the alternative hypotheses relevant to these questions, and the data available to test these hypotheses… [T]he framework that is laid out is not limited to existing models. Ultimately, this should also lead to improved analytical tools.

For this project, the different objectives contribute to these overall goals in different ways, as shown below.

Objective 1. The ISP (*Return to the River*) is concerned that habitat enhancement activities may not be especially effective at increasing fish survival. Under this objective, we will explore whether or not fish from habitat with different land management types (agriculture, grazing, wilderness, etc.) in fact have different survival rates from tagging as parr to their arrival at Lower Granite the following spring. This should help reduce uncertainties about land management patterns (and by implication habitat enhancement) and their effects on juvenile salmonid survival.

Objective 2. In *Return to the River* and elsewhere within the FWP, it is obvious that the effects of subbasin and mainstem hatchery releases on wild fish survival may not be known with sufficient certainty to make confident management recommendations. Using spawner-recruit data, subbasin release information, and mainstem releases, work under this objective will help elucidate the historical relationships between releases and survival and test these derived relationships with new S-R and release data as they become available. The intent is to reduce the uncertainty surrounding the effects of hatchery releases on wild stocks, and so assist in making more informed hatchery management decisions.

Objective 3. Although ocean conditions are largely beyond human control, they can influence the apparent success or failure of management actions. In years when good ocean conditions prevail, high adult returns may lead one to believe that an action has enhanced survival; bad ocean conditions may suggest to opposite. *Return to the River*, the Gorton amendment, and recent NPPC publications all suggest that these problems should be addressed in the FWP. Work under this objective should help resolve how ocean survival and distribution may have changed over time, and how it may differ among stocks.

Objective 4. Although current and past FWP documents call for an adaptive management approach, on-the-ground applications of the approach have been rare, at best. Work under this objective is intended to help show how adaptive management scenarios should be planned to obtain the most information about critical uncertainties. In the design phase, we will also consider how management activities might be changed as information is gained over the course of the management "experiments".

Objective 5. Work under this objective is designed to ensure that regional managers are made aware of relevant results of this project, following review by PATH members, the ISP, and other interested regional parties.

d. Project history

Project number and title are unchanged

Selected project reports:

Paulsen, C. and T. Fisher, 1997. "Ocean Distribution of Coded Wire Tagged Spring/Summer Chinook," report to PATH, July, 1997.

Botsford, L. and C. Paulsen, 1997. "Chapter 2: Covariability in Abundance among Index Stocks of Columbia River Spring/Summer Chinook Salmon," PATH report, July 1997

Paulsen, C., T. Fisher, and R. Hinrichsen, 1997. "Chapter 4: Effects of Climate and Land Use on Index Stock Recruitment," PATH report, June, 1997.

Paulsen, C., T. Fisher, and R. Hinrichsen, 1997. "Over-wintering Survival of Snake River Spring and Summer Chinook PIT-tagged fish," report to PATH, May, 1997.

Note that many of these are updated versions of previous (1996) reports.

Major Accomplishments:

The above reports and related memorandums have been favorably reviewed by the SRP and many PATH participants. Suggestions based on the reviews form much of the basis for planned work for FY98 and FY99.

Past Costs:

FY	Cost
94	43,500
95	76,500
96	215,105
97	174,820
98 (Projected)	175,000

**e.	Methods**.

Note on objectives 1-3: In all case, this project will use data—spawning stock abundance, hatchery release data, PIT tags and coded wire tags (CWT) releases and recoveries--from other sources and regional programs. As such, sample sizes, treatments, and other variables are beyond the control of the this project.

For Objectives 1 and 3, we will use data from PITAGIS on parr PIT-tagged in subbasins above Lower Granite Dam. Parr in these subbasins have been tagged in most years since 1989, with the number of fish tagged varying widely among subbasins, species (chinook or steelhead) and years. Since the focus for these objectives is on the effects of land management patterns on survival, we will concentrate our analysis on fish tagged in the summer or fall, which over-winter for 5-9 months before they are detected at Snake River traps or dams.

For **Objective 1**, habitat quality data is derived from both regional biologists' assessments of quality in spawning and rearing areas (see Paulsen et al. May 1997), and from a categorical regression tree analysis of this information and data gathered in the Eastside Assessment (Lee, 1997).   Essentially, we have (or are producing) information on land use patterns (agriculture, wilderness, managed forest, etc.) and vegetation patterns (grassland, dry forest, etc.). This has been used to "predict" and verify the habitat quality ratings or regional experts.

In an effort to control for environmental and other differences among subbasins, we also will use data on hydrology (stream flows), precipitation, temperature, and snowpack.   In addition, we have data on the size of fish at release, distance from each subbasin or tagging site to Lower Granite, and on each site's elevation.

In FY97, we estimated models using the data just noted, and statistical models of the form (Cormack and Skalski, 1992):

$$E(n_{ij}) \quad = \mu_{ij} = R_i \theta_{ij} f_j \qquad \text{Eq. 1}$$

Where :
i indexes release groups (i.e., release sites or habitat clusters);
j indexes dams (recovery sites);
n_{ij} is the number of fish in release group i found in the fish detected at dam j;
$E(n_{ij})$ is the expected number of tagged fish from release group i in expected to be found in the sample inspected from dam j;
μ_{ij} is the expected number of tag codes from release group i found in the fish detected at dam j;
R_i is the number of fish released in group i;
θ_{ij} is the probability that a fish from release group i is detected at dam j;
f_j is the proportion of smolts at dam j assumed to go through the PIT tag detector.
Equation (1) can be expressed as a log-linear model:

$$\ln(\mu_{ij}) = \ln(R_i f_i) + \ln(\theta_{ij}) \qquad \text{Eq. 2}$$

with variance

$$Var(n_{ij}) = \phi\mu_{ij} \qquad \text{Eq. 3}$$

The $\ln(R_i f_i)$ term in Eq. 2 is used as an offset, and the estimated parameter is constrained to equal one in the estimation procedure (SAS© PROC GENMOD). The ln (θ_{ij}) term in Eq. 2 can be partitioned into effects due to release site, climate covariates, habitat quality cluster, etc.

In work starting in FY98 and continuing in FY99, we will generalize the above work to estimate survival to Lower Granite. Instead of the likelihood of being detected at Lower Granite, we will estimate the probability of detection and survival using SURPH-style maximum likelihood methods (Smith et al 1994). Because of the large sample sizes involved (several hundred thousand fish released) we will estimate these models using SAS.

Once we have estimated the above models (later this winter, prior to the 1998 downstream migration), we will use detections in 1998 and (next spring) in 1999 to test the models' predictions of survival of fish from different habitats.,

An extension to this (for work starting in FY99) is to examine whether or not habitat quality may affect survival in ways that are somewhat less direct. Two approaches are suggested. First, size at release has, in FY97-FY98 work, been found to be have an important (and positive) role in probability of detection. We plan to investigate to what degree fish size at tagging (in the summer or fall preceding migration) may itself be influenced by habitat quality. In addition, substantial release data is available for fish tagged in subbasins in late winter or early spring, just before migration. We plan to investigate whether or not the quality of rearing and overwintering habitat affects their survival, as well. If either or both of these indirect influences appear to be important, we will attempt to incorporate them into a single, coherent statistical model.

Under **Objective 3**, we plan to investigate whether ocean distributions and ocean survival vary measurably over time and across stocks. Some work has been completed on this topic for spring chinook (see Paulsen and Fisher July 1997). In this previous work, using CWT release and recovery data, we estimated models of the following form:

$$E(n_{ij}) = \mu_{ij} = R_i \theta_{ij} f_j \qquad \text{Eq. 4}$$

Where :

i indexes release groups (i.e., tag codes);
j indexes fisheries or recovery areas (state or province in our models);
n_{ij} is the observed number of fish in tag code *i* recovered in fishery *j*;

$E(n_{ij})$ is the number of tag codes from release group *i* expected to be recovered in fishery *j*;

μ_{ij} is the number of tag codes from release group *i* in expected to be found in the sample inspected from fishery *j*;

θ_{ij} is the probability that a fish with tag code *i* is caught in fishery *j*;

R_i is the number of fish released bearing tag code *i*;

f_j is the proportion of fishery *j* inspected for tag codes (expansion factor).

Equation (4) can be expressed as a log-linear model:

$$\ln(\mu_{ij}) = \ln(R_i f_j) + \ln(\theta_{ij}) \qquad \text{Eq. 5}$$

with scaled variance

$$Var(n_{ij}) = \phi\mu_{ij} \qquad \text{Eq. 6}$$

where ϕ is an unknown constant of proportionality to be estimated, and the other terms are as defined for (4).

The $\ln(R_i f_j)$ term in Eq. 5 is used as an offset, and the value of the parameter is constrained to equal one in the estimation procedure[1]. The ln (θ_{ij}) term in Eq. 5 can be partitioned into effects due to the hatchery of origin, recovery area, etc. These effects are what of interest in the analysis of ocean distribution and ocean survival.

[1] Note that because of the offset, the dependent variable is, in effect, the proportion of fish recovered in each fishery. In addition, the offset gives a lower weight to recoveries with higher expansion factors.

In work for FY97, the model in eqs. 4-6 was used to investigate whether or not Snake and lower Columbia fish had different ocean distributions. In work for FY98 and FY99, we will use similar models to examine questions of ocean distribution and ocean survival for a variety of chinook stocks, including fall chinook from throughout the Columbia, summer chinook from the mid-Columbia and Snake, and (perhaps) chinook stocks from Oregon and Washington coastal streams. Given recent work by Hare et al (1997) we expect that stocks exhibiting a more northerly distribution may experience lower ocean mortality. In assessing the mortality issue, we will need to assume (or derive) harvest and maturation schedules for the stocks in question. We expect that this will only be possible for fall chinook stocks; spring chinook will likely have too few ocean recoveries. As with work under objective 1, we will test models developed with older data (in FY98) with newer release and recovery data in FY99.

Work under **Objective 2** will use data on subbasin and mainstem hatchery releases, in combination with information on spawning population sizes and recruitment (to the Columbia or to ocean fisheries) to estimate the association between hatchery releases and survival. Data for hatchery releases is primarily from Streamnet; spawner-recruit data is from earlier PATH work (see Paulsen at al. Chapter 4, 1997). This problem is made more difficult because the association may appear to be negative due to management intervention: as natural stocks decline, managers have often increased hatchery releases as a response. Work begun in FY98 has estimated extended Ricker models similar to the following for spring chinook:

$$\ln(R_i) = \ln(S_i) + a - bS_i + c_i\, SUBTOT_i + \varepsilon_i \qquad (7)$$

where:

R_i = subbasin recuits, brood year i

S_i = subbasin spawners, brood year i

$SUBTOT_i$ = total subbasin juvenile releases, brood year i

ε_i = error term, brood year i

Past work with these simple models suggests that the relationship between subbasin releases (for supplementation) and subsequent survival of wild progeny is complex, sometimes showing positive effects and other times negative or negligible effects. Similar models have also been estimated for mainstem releases; again, the results are ambiguous.

For work later this year, extending into FY99, we plan to both broaden the database to include additional stocks, and refine the methodology to account for the fact that releases are often a management intervention. Potential directions include grouping stocks (to account for shared effects, such as ocean or dam mortality), and adding indicators as to whether a stock is declining or increasing prior to hatchery introductions. As with objectives 1 and 3, we will first build models using current data, and then test the models with new data (on hatchery releases, spawning abundance, and recruitment) as it becomes available in future.

Work under **Objective 4** (adaptive management) will not be precisely defined until late in FY98. This work will be done in close cooperation with other PATH members and projects. It will use the results form objectives 1-3 (estimated effects of habitat, hatchery releases, and ocean conditions) to assess the types of management actions that might be altered and monitored, and to assess the likely effects of these management actions. Once these results are available, and have been reviewed, it will then be possible to define work under this objective in more detail.

Work under **Objective 5 –** PATH participation, review, and dissemination of results – will consist primarily of meeting and workshop participation, review of PATH-related research done under other projects, and assistance with PATH reports and oral presentations to managers.

f. Facilities and equipment.

The only specialized item to be purchased with project funds will be statistical software (SAS). All other funds are for personnel and travel. No specialized equipment will be required. Office space in Lake Oswego and Portland will be used for most of the work. Meeting facilities will be arranged as needed by ESSA under contract 9600600.

g. References.

Botsford, L. and C. Paulsen, 1997. "Chapter 2: Covariability in Abundance among Index Stocks of Columbia River Spring/Summer Chinook Salmon," PATH report, July 1997

Cormack, R. M. and J. R. Skalski. 1992. "Analysis of coded wire tag returns from commercial catches. Can. J. Fish. Aquat. Sci. 49: 1816-1825.

Lee, D. C. , 1997. Presentation to PATH workshop 4, Warm Springs, Oregon, April.

Hare, S.R., N.J. Mantua, and R.C. Francis. 1997. Inverse production regimes: Alaska and West Coast pacific salmon. *Fisheries*, in review.

Paulsen, C. and T. Fisher, 1997. "Ocean Distribution of Coded Wire Tagged Spring/Summer Chinook," report to PATH, July, 1997.

Paulsen, C., T. Fisher, and R. Hinrichsen, 1997. "Chapter 4: Effects of Climate and Land Use on Index Stock Recruitment," PATH report, June, 1997.

Paulsen, C., T. Fisher, and R. Hinrichsen, 1997. "Over-wintering Survival of Snake River Spring and Summer Chinook PIT-tagged fish," report to PATH, May, 1997.

Smith, S. G. et al. 1994. Statistical Analysis of Fish and Wildlife Tagging Studies: SURPH.1.
Wilson, P. 1996. “Chapter 11: PATH – Hatchery Impacts,” August, 1996.

Section 8. Relationships to other projects

Work under this project will proceed in close cooperation with projects 9601700, 9600600, 9600800, 9770320, 9700200, and 9800100. Beyond mutual review and commentary on project analyses and reports, the we anticipate the following specific relationships:

9601700 Utilize Al Giorgi’s expertise with passage and PIT tag data in review of products from objective 1.
9600600 Preparation of “group” reports, presentations to managers, meeting facilitation, PATH coordination (SRP review is a subset of the contract).
9600800 Utilize stock-recruit data produced by state biologists (Objective 2); rely on their expertise for habitat ratings/rankings (Objective 1). Use FLUSH passage model output for Objectives 2 and 3.
9720320 Utilize Eastside assessment data and habitat quality predictions for Objective 1.
9700200 Use CriSP passage model output for objectives 2 and 3.
9800100 Use Hinrichsen’s statistical expertise in methods development (Objectives 1-4).

Section 9. Key personnel

The principal investigator, Mr. Paulsen of Paulsen Environmental Research, will have lead responsibility for data analysis. Mr. Fisher of Beak Consultants will take the lead on data collection for CWT, PIT tag, and other data required for the project. Mr. Paulsen will devote approximately 75-80% of his time to the project; Mr. Fisher will be employed approximately 25% on the project.

***Resume of*:** Charles Michael Paulsen
Paulsen Environmental Research, Limited
***Education*:** Duke University, Durham, NC.
Master of Environmental Management, 1979.
University of Kentucky, Lexington, KY.
B.A. in Political Science, 1974

National Merit Scholar, 1970 - 1974

***Professional Experience*:**

1994 - Present Independent Consultant, Paulsen Environmental Research, Ltd.

1991 - 1994 Fellow and Environmental Management Program Manager, Resources for the Future (RFF)

1989 - 1990 Research Associate, RFF

1985 - 1988 Chief, Computer Services, RFF

1984 - 1985 Programmer-Analyst, RFF

1983 - 1984 Programmer-Analyst, Fien-Marquardt, Baltimore, MD

1980 - 1983 Research Assistant, RFF

Consultancies

Bonneville Power Administration

Chelan County Public Utility District

The World Bank

International Institute for Applied Systems Analysis

Harvard Institute for International Development

Relevant Publications and Reports

"Ocean Distribution of Coded Wire Tagged Spring/Summer Chinook," (with Tim Fisher), report to PATH, July, 1997.

"Chapter 2: Covariability in Abundance among Index Stocks of Columbia River Spring/Summer Chinook Salmon," (with Lou Botsford), PATH report, July 1997

"Chapter 4: Effects of Climate and Land Use on Index Stock Recruitment," (with Tim Fisher and Rich Hinrichsen), PATH report, June, 1997.

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"Cost-Effectiveness Analysis for Complex Natural Systems: An Application to the Columbia River Basin," (with Kris Wernstedt), *Journal of Economics and Environmental Management* ,
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"Evaluating Alternatives for Increasing Fish Stocks in the Columbia Basin," (with Kris Wernstedt and Jeffrey B. Hyman), *Resources*, Fall 1992.

"Design of Studies for Development of BPA Fish and Wildlife Mitigation Accounting Policy," (with Allen V. Kneese, Danny C. Lee, and Walter Spofford, Jr.), Bonneville Power Administration, August, 1988.

<u>**TIMOTHY R. FISHER**</u>

Senior Fisheries Biologist

EDUCATION

M.S., 1990, University of Idaho, Fishery Resources

B.S., 1987, Pennsylvania State University, Ecology

MEMBERSHIPS

American Fisheries Society, Pacific Fishery Biologists (President 1994-1995)

EXPERIENCE

<u>BEAK CONSULTANTS INCORPORATED</u>, 1995 to present. Mr. Fisher's areas of expertise include salmonid life cycle and hydropower dam passage modeling, Endangered Species Act consultations, biotic integrity of stream communities, and fisheries data analysis.

Project Manager, BPA Chinook Stock Assessment. Mr. Fisher led a team of biologists in gathering environmental and fisheries data for a coast-wide chinook stock assessment being conducted by a group of state agency and tribal biologists and consultants with funding from the Bonneville Power Administration.

Project Manager, Dioxin Bioaccumulation Study. Mr. Fisher is managing a project to carry out fish sampling for Potlatch Corp. in the Lower Granite Reservoir area on the Snake River in Idaho and Washington.

Task Leader, Mid-Columbia Habitat Conservation Plan Overview Document. Mr. Fisher is responsible for writing a comprehensive overview and analysis of the system-wide issues and concerns which affect the ability of the project owners to limit their take of potential Threatened or Endangered Species of anadromous salmonids.

Fish Passage Modeler, Snake River Coalition. Mr. Fisher performed a CRiSP salmon smolt passage survival modeling exercise for a coalition representing upper Snake River irrigation districts and the State of Idaho.

Fisheries Biologist, Port of Kennewick Expansion. Mr. Fisher participated in the study design and field sampling of the Columbia River for establishing the presence and habitat use of fall chinook salmon smolts in Clover Island marina and adjacent habitats.

Fisheries Biologist, Yuba River Fisheries Evaluation. Mr. Fisher wrote a summary of the literature concerning fall chinook salmon life history as related to freshwater environmental conditions such as water temperature, flow, and habitat for a comprehensive restoration plan for the anadromous fish of the Yuba River in California.

<u>**BONNEVILLE POWER ADMINISTRATION**</u>**,** 1990 to 1995. Division of Fish and Wildlife, Fisheries Biologist. Mr. Fisher dealt exclusively with analysis of Columbia River Basin anadromous salmonid fish populations, especially the endangered Snake River chinook and sockeye salmon populations. His duties included analysis of current population status and the effects of actions, primarily hydrosystem and harvest, under the National Environmental Policy Act (NEPA), the Endangered Species Act, and court-ordered proceedings, using state-of-the-art computer models.

Section 10. Information/technology transfer

Results will be disseminated via written reports to PATH members and other interested parties, and via oral presentations at PATH workshops. In addition, results will be submitted to peer-reviewed journals, following review by PATH participants, the SRP, ISRG, and other interested regional parties.