Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Path-Facilitation, Technical Assistance, And Peer Review

Bonneville project number, if an ongoing project 9600600

Business name of agency, institution or organization requesting funding
ESSA Technologies Ltd.

Business acronym (if appropriate) ESSA

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NPPC Program Measure Number(s) which this project addresses.
3.2.A, 3.2.F , 4.2a, 4.3, 7.1E

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

Other planning document references.
NMFS Recovery Plan task 0.3.b and 2.11.b

Subbasin.

Short description.
Facilitation, technical assistance, peer review of PATH.Test hypotheses underlying salmon management decisions, develop decision analysis to evaluate management strategies, and assist in designing research, monitoring and adaptive management experiments.

Section 2. Key words

Programmatic

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

Other keywords.
modeling, decision analysis, conservation biology, adaptive management

Section 3. Relationships to other Bonneville projects

Project #		Nature of relationship
9600800		PATH scientific support
9203200	Life cycle modelling for system and subbasin planning in Snake River	PATH scientific support
9303701	Technical assistance with the life cycle model	PATH scientific support
9601700	Technical support for PATH - Chapman Consulting	PATH scientific support
8910800	Monitoring and evaluation modeling support	PATH scientific support

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Determine the overall level of support for key alternative hypotheses, and propose other hypotheses and/or model improvements that are more consistent with existing data.	a	Update and finalize retrospective analyses for spring/summer chinook, fall chinook, and steelhead. Publish selected spring/summer retrospective analyses.
		b	Summarize conclusions of retropective analyses for fall chinook and steelhead in peer-

			reviewed conclusions documents
2	Advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance	a	Complete prospective analyses for steelhead, largely by comparison with spring/summer chinook.
		b	Update preliminary prospective/decision analyses for spring/summer and fall chinook
		c	Integrate findings of prospective/decision analyses of spring/summer chinook, fall chinook, and steelhead into overall evaluation of alternative management options.
3	Assess the ability to distinguish among competing hypotheses from future information, and advise agencies on research, monitoring, and adaptive management experiments that would maximize learning	a	Explore feasible range of experimental management options.
		b	Use overall decision analysis framework (integrated across species) to evaluate research, monitoring, and adaptive management experiments.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	11/1998	10/1999	20.00%
2	11/1998	10/1999	60.00%
3	11/1998	10/1999	20.00%
			TOTAL 100.00%

Schedule constraints.
Litigation among agencies disrupts good working relationships & impair productivity. There were no major court cases in FY96 or 97, but the amount of future litigation is uncertain.
Unexpected problems with run reconstructions (fall chinook & steelhead.

Completion date.
2002

Section 5. Budget

FY99 budget by line item

Item	**Note**	**FY99**
Personnel	Direct ESSA Fees	$205000
Fringe benefits		
Supplies, materials, non-expendable property	Report production, workshop expenses, communications	$20,000
Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags:	
Travel		$25,000
Indirect costs		
Subcontracts	including subcontract administration	$200,000
Other		
TOTAL		$450,000

Outyear costs

Outyear costs	**FY2000**	**FY01**	**FY02**	**FY03**
Total budget	$400,000	$350,000	$300,000	
O&M as % of total	0.00%	0.00%	0.00%	

Section 6. Abstract

Section 7. Project description

a. Technical and/or scientific background.

Salmon populations in the Columbia River Basin have been in decline since the early days of western settlement, with dramatic declines occurring in the last three decades. The annual production of the Snake River spring/summer chinook during the late 1800's was probably in excess of 1.5 million fish or 39% to 40% of all Columbia River spring/summer chinook (NMFS Biological Opinion, 1995). Today the population of

Snake River spring/summer chinook is approximately 0.5% of its historic abundance, with approximately 1,800 spring/summer chinook returning to the Snake River. The story is similar for the Snake River fall chinook. From 1938, when Bonneville dam was completed, to 1950, the returns of Snake River fall chinook fell from approximately 72,000 to 29,000. Today, after completion of the Snake River dams approximately 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).

Past efforts to halt the decline have been ineffective because : 1) they didn't adequately reduce hydrosystem mortality; 2) not all entities shared common objectives, and; 3) hydrosystem decisions were dominated by lawsuits, with analyses presented in very adversarial forums. A common adaptive management framework (analytical monitoring, evaluation and management assessment approach) for guiding research and monitoring activities and providing management advice for salmon population conservation and restoration, could have helped clarify these issues. Therefore, there is an urgent need for coherent, defensible biological guidance to decision makers.

The 1995 NMFS Biological Opinion on operation of the federal Columbia River Power System (pg. 124, Rec. 17) stated that "The BPA shall participate with NMFS in activities to coordinate the regional passage and life cycle models and to test the hypotheses underlying those models." NMFS noted that the emphasis should shift to analyses that test the different assumptions underlying the models, rather than refining our understanding of how the models are different. NMFS concurred with the recommendation of the Scientific Review Panel (SRP) to conduct an analysis of alternative hypotheses, and worked with BPA to ensure that this work was funded out of the dollars dedicated to actions arising out of the Biological Opinion. This was the genesis of the Plan for Analyzing and Testing Hypotheses (PATH). Critical to the success of PATH are three components: 1) facilitation and funding of the interagency scientific working groups, 2) specialized expertise in Bayesian statistics, multivariate analysis, and Columbia Basin salmon stock assessment and population dynamics; and 3) external, independent peer review.

Though not specifically called for by the 1994 NPPC Fish and Wildlife Program, PATH fulfills many of the key functions outlined in the following measures: **3.2.A, 3.2.F , 4.2a, 4.3, 7.1E.**

PATH has made tremendous progress in bringing together scientists from agencies with conflicting opinions and positions. (i.e. BPA, NMFS, CORPS, State and Tribal agencies, NPPC). The lack of lawsuits, the development of joint publications (such as the PATH Conclusions Document of Jan/97), and the gradual increase in trust, is in large measure due to the integrity and expertise provided by ESSA in facilitation, coordination and integration. It is also due to the objective opinions provided by the independent scientists working as subcontractors to ESSA, either as PATH team members (Peterman, Deriso, Botsford) or as members of the SRP (Walters, Saila, Collie, Dennis, Kitchell). The SRP has provided three generally positive and extremely valuable reviews of PATH products. While disputes still exist, they are debated in a scientific and civil manner, and alternative hypotheses are evaluated quantitatively for their impact on decisions. This forces a higher view of scientific disputes, and frames the level of evidence required to change decisions.

As a result of the constructive approach taken by PATH, and the high-quality, rigorously-tested analyses that have been produced, PATH is beginning to identify biological performance measures such as improvements in survival over the salmon life-cycle and smolt to adult return rates (SARs) which are need to achieve population recovery goals. This PATH work and the conceptual foundation provided by the ISG in their Return to the River report, will together strengthen the scientific basis for the difficult and urgent decisions that must be made for salmon conservation and recovery.

b. Proposal objectives.

Objectives:

The goal of this contract is to have ESSA Technologies continue the facilitation and coordination of the PATH process with respect to salmon and steelhead recovery and rebuilding. In addition, this contract is to continue to fund the valuable contributions of the independent scientists working as subcontractors to ESSA, either as PATH team members (Peterman, Deriso, Botsford) or as members of the SRP (Walters, Saila, Collie, Dennis, Kitchell).

PATH's primary objectives were originally defined as:

1. Determine the overall level of support for key alternative hypotheses based on existing information (Retrospective analyses). Propose other hypotheses and/or model improvements that are more consistent with the data.

   Sub-objectives for Objective 1:
   - 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;
   - compile and analyze information to assess the level of support for alternative hypotheses (component, composite, and aggregate hypotheses);
   - publish retrospective findings in peer-reviewed reports and journal articles;
   - propose other hypotheses and/or model improvements supported by the weight of evidence of these analyses;

2. Advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance.

   Sub-objectives for Objective 2:

   - define the management decisions that serve to focus analytical activities;
   - 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;
   - provide guidance to the development of regional programs that would stabilize, ensure persistence of, and eventually restore depressed salmon stocks to self-sustaining levels;

3. Assess the ability to distinguish among competing hypotheses from future information. Advise various institutions on research, monitoring and adaptive management experiments which would maximize the rate of learning and clarify decisions.[1]

   Sub-objectives for Objective 3:

   - 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
   - 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).

Products:

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. The purpose of the exercise is not to simply compare the existing belief systems embodied in the various models, though modeling plays a large role. Instead, the framework that is laid out is not limited to existing models. Ultimately, this should also lead to improvements in analytical tools.

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[1] Barnthouse, L.W. and D. Marmorek; April 5, 1995. A new direction for Columbia River Basin Salmonid Model Evaluation and Use.

Objective 1:

Through FY98, retrospective analyses should be largely completed for spring/summer chinook, fall chinook and steelhead. Specific tasks for FY99 retrospective analysis are:

a. Update and finalize retrospective analysis for spring/summer chinook, fall chinook and steelhead.
b. Develop a final conclusion document on fall chinook, that summarizes the findings of the retrospective analyses. This report should specifically address the evidence for and against competing hypotheses.
c. Complete a synoptic retrospective analysis for Snake River sockeye.
d. Develop a final conclusion document on steelhead, that summarizes the findings of the retrospective analyses. This report should specifically address the evidence for and against competing hypotheses.

Objective 2:

Through FY 98, preliminary prospective analysis should be completed for spring/summer chinook and fall chinook. In FY 99, there are 3 major tasks concerned with Snake River fall chinook and steelhead prospective analyses, and an integrated prospective analysis for spring/summer chinook, fall chinook, and steelhead:

a. Complete preliminary prospective/decision analyses for steelhead and submit for peer-review. Estimate the improvement in life cycle survival required to reach various salmon objectives (survival, recovery, rebuilding) and the uncertainty associated with these estimates. These survival improvements can be expressed as Biological Objectives consistent with the 1994 NWPPC Fish and Wildlife Program.
b. Incorporate additional management actions proposed by IT into the steelhead, spring/summer chinook, and fall chinook prospective analyses. Document the biological rationale for alternative hypotheses. Estimate the probabilities associated with alternative hypotheses, based on available empirical information and expert elicitation.
c. Integrate the findings of prospective analyses on spring/summer chinook, fall chinook and steelhead into an overall decision analysis of alternative management options for the region. This analysis would identify conflicts and complements in the proposed action plans for individual species, and identify means by which research, evaluation, and monitoring actions can be streamlined to address multiple species.
d. Publish a peer-reviewed integrated decision analysis report.

Objective 3:

a. apply the analytical approaches described above to assess the ability of adaptive management experiments to distinguish among competing hypotheses from future information. Develop a quantitative adaptive management framework for development of a regional salmonid recovery program.
b. Advise various institutions (IDFG, ODFW, NMFS, NPPC, USFWS, WDFW, and Columbia River treaty tribes) on research, monitoring and adaptive management experiments to maximize the rate of learning and clarify decisions.
c. Integrate research monitoring and evaluation findings with the RRG in development of a regional research, monitoring, and evaluation plan.

c. Rationale and significance to Regional Programs.

Snake River spring/summer and fall chinook, steelhead, and sockeye populations have declined dramatically since completion of the Federal Columbia River Power System (FCRPS). Spring/summer and fall chinook are listed as threatened under the Endangered Species Act (ESA) in 1992, and sockeye are listed as endangered. ESA listings are pending for steelhead in the Snake and upper Columbia rivers. Under the ESA, the National Marine Fisheries Service (NMFS) is charged with developing and implementing management plans to ensure survival and recovery of the listed salmon populations.

Three different modeling systems have evolved to address recovery planning and rebuilding assessment for Columbia River salmon stocks. State and tribal fishery managers, federal fishery managers, federal hydropower operators and NWPPC reached consensus and implemented in 1992 a coordinated, peer reviewed effort to address the analytical needs of the region with respect to Columbia River salmon recovery and rebuilding. Reviews of the models and some of the analytical approaches were prepared by a scientific peer review panel (SRP) of academic experts funded by BPA during FY 1994 and 1995. One report from that effort recommended that model review and comparison should be focused on hypothesis formulation and testing to resolve crucial differences in assumptions and data interpretation.

The NMFS' 1995-1998 Biological Opinion on operation of the FCRPS (NMFS 1995) created a process called PATH--Plan for Analyzing and Testing Hypotheses. The PATH process was designed to clarify the nature of the differences among the models and point the way towards helping to resolve them (Marmorek and Parnell 1995). Though initiated by written directives (i.e. the Scientific Review Panel, NMFS and NWPPC), the direction of PATH responds to periodic meetings with senior management and policy personnel in NMFS, BPA, NWPPC, WDF, ODFW, IDFG, US Fish and Wildlife Service (USFWS) and CRITFC.

The region has a continuing need to consider analytical results in decision making in a number of areas, including: 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 Strategy for Salmon Vol. II). The region has and will continue to benefit significantly in these areas from a coordinated and consistent approach to technical analyses 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."   The PATH process is intended to ensure that the region has the benefit of the use of best available scientific methods and information in the analyses supporting salmon recovery/rebuilding efforts.

The first phase of PATH is retrospective (Objective 1), and involves explicitly stating hypotheses about the distribution of mortality over the life cycle, evaluating strengths and weaknesses of supporting evidence, and testing those alternative hypotheses which have significant management implications. Hypotheses are organized within PATH by anthropogenic (habitat, harvest, hatcheries and hydropower) and environmental (climatic/oceanographic) factors. The analyses have clearly confirmed patterns of spatial and temporal change in spring-summer chinook stocks, which not only elucidate the most likely causes of recent declines, but also lay the groundwork for grouping stocks for future adaptive management experiments. By bridging across different types of data sets and studies (e.g. migration corridor survival, transportation benefit, spawner-smolt survival, spawner-recruit survival, climate and ocean indicators, land use and hatchery indicators), PATH has generated a higher level understanding of how to integrate across life history stages and spheres of management action (hydro, hatchery, habitat, harvest).

The hypothesis and decision frameworks we developed and applied in PATH have provided a means of harnessing a wide array of information, analytical tools and unpublished scientific knowledge to inform key management decisions (Objective 2). In particular, the decision analysis framework developed by PATH is an essential tool for rigorously evaluating alternative management strategies, and for quantitatively assessing the effects of remaining uncertainties on the outcomes of these strategies.

PATH accomplishments in increasing our understanding of the distribution of mortality across life history stages and in developing a structured decision analysis framework for evaluating alternative strategies provide a concrete foundation for designing adaptive management programs and coordinating research initiatives (Objective 3). PATH scientists have recommended several specific research, monitoring and evaluation approaches to resolving critical uncertainties (e.g. assessing the magnitude of delayed mortality of both transported and in-river migrants). In addition, by rigorously assessing the value of additional information from research studies, monitoring, and adaptive management experiments, PATH will provide a scientific basis for assisting in prioritizing expenditures for conserving and restoring these populations given limited financial resources.

The PATH scientific review panel has recommended that in light of the major uncertainties that are difficult to resolve with current information, we focus attention on experimental management options which vary management actions over time and space in a deliberate attempt to test key hypotheses pertaining to response of fish populations. The design of this adaptive management framework is already in progress: it is being driven by the management questions of interest, the alternative hypotheses relevant to these questions and the data available to test these hypotheses. In FY 1998 PATH is conducting a workshop on experimental management options.

PATH work would continue through the year 2002 because after the 1999 decision, there will remain considerable uncertainty with respect to the response of the Columbia River and Snake River fisheries populations to the 1999 decisions. Assessment of these responses will require thoughtful design of region-wide research, monitoring and evaluation programs *with a quantitative focus;* and an interagency analytical team that is able to provide informed evaluation of new information, integrating new data with the historical information. The retrospective analyses and formal decision analyses completed by PATH will provide a foundation for such work. In addition , the PATH group's broad approach will provide much insight on the post-1999 interpretation of new information (e.g. survival studies, spawner-recruit estimates, oceanographic information, transportation studies detailed project-specific evaluations). Furthermore, there will be a need to integrate the assessment of the other H's (habitat, hatchery, harvest) with the post-1999 evaluations. Continued development of an operational means to implement adaptive management is a high priority for the region, as stressed in the 1994 Fish and Wildlife Program. The tools developed by PATH are an excellent foundation for the region to quantitatively explore the implications of different adaptive management strategies, not only in hydrosystem operations, but also in the realm of harvest, habitat and hatchery activities

d. Project history

PATH was created by the NMFS' 1995-1998 Biological Opinion on operation of the FCRPS (NMFS 1995). The PATH process was designed to clarify the nature of the differences among the models and point the way towards helping to resolve them (Marmorek and Parnell 1995).

In the 2 years of its existence, PATH has already made considerable progress towards achieving its objectives. Specific achievements include:

- clarification of management decisions with senior personnel in the major institutions;
- development of hypothesis frameworks relevant to management decisions;
- considerable data reconnaissance, acquisition and refinement;
- detailed retrospective analyses for hypotheses related to hydrosystem, habitat, hatchery and harvest management decisions;
- five workshops, each involving about 30 research scientists, to plan retrospective and prospective analyses, review the results of preliminary analyses and assess their implications for management decisions;
- a series of technical meetings to advance progress on specific retrospective analyses;
- novel development and/or application of analytical tools to assist in decision making
- three-level hypothesis framework

- decision trees for hydrosystem, habitat and hatchery management decisions
- a Bayesian maximum likelihood estimation (MLE) framework to evaluate ability of different models to predict stock-recruitment patterns
- several different statistical analyses (cluster analyses, multiple regression, analysis of variance and covariance) to assess patterns implied by spatial and temporal contrasts in stock-recruitment
- a method for evaluating survival trends in the freshwater spawning/rearing life stage
- prospective analyses for determining the required improvements in the chinook salmon life cycle survival needed for achieving recovery goals
- development of a Bayesian population model to be used to simulate the implications of habitat, harvest, hatchery, and hydro management actions for survival and recovery of listed Snake River spring/summer chinook stocks
- a plan for formal decision analysis to assess through a variety of performance measures the effects of different combinations of actions in each of the four H's (hydrosystem, hatcheries, habitat, harvest]
- a 30-page Conclusions Document synthesizing the major findings from the 620-page Final Report on Retrospective Analyses for FY96, including outstanding information needs necessary to resolve major uncertainties
- Preliminary decision analysis report on spring/summer chinook which tests the decision analysis formulated over the last two years, provides decision makers with our preliminary insights into the range of population responses to alternative management decisions, and characterizes the magnitude of uncertainties and demonstrates their relative importance in affecting outcomes of alternative management decisions.
- a set of presentations on progress by PATH participants to the Implementation Team (IT) Committee on PATH and other IT representatives; members of the NPPC and the public; meetings with the Research Review Group of the IT; and meeting with the Independent Scientific Group (now the Independent Scientific Advisory Board)
- numerous reports, including: (see Section g for full citation)

<u>FY95</u>
Marmorek, D.P. and I. Parnell (eds.). 1995.

<u>FY96</u>
Marmorek, D.R, I, Parnell, L. Barnthouse and D.R. Bouillon. 1995.
Barnthouse, L. (ed.), J. Collie, B. Dennis, S. Saila, and C. Walters. 1996.
ESSA Technologies Ltd. (compl.) 1996.
Marmorek, D.R., D.R. Bouillon, and I. Parnell. 1996.
Marmorek, D.R. (ed.)., and 21 other authors. 1996.

<u>FY97</u>
Marmorek, D. and C. Peters (eds.). 1996.
Peters C. and D. Marmorek. 1996.
Barnthouse, L. (ed.), J. Collie, B. Dennis, S. Saila, and C. Walters. 1997.
ESSA Technologies Ltd (compl.) 1997a
ESSA Technologies Ltd (compl.) 1997b

ESSA Technologies Ltd (compl.) 1997c
ESSA Technologies Ltd (compl.) 1997d
Peters C. and D. Marmorek. 1997a.

FY98
Peters C. and D. Marmorek. 1997b.
Marmorek, D. and C. Peters (eds.). 1998.

e. Methods.

PATH consists of an iterative series of workshops, analytical activities and reporting steps to test key hypotheses underlying management decisions, coordinated by an interagency PATH Planning Group. (The PATH Planning Group includes the PATH facilitator, David Marmorek (ESSA Technologies); H. Schaller, ODFW (representing the State fishery agencies); J. Geiselman, BPA (representing the power system operating agencies); C. McConnaha, NPPC; E. Weber, CRITFC; and C. Toole, NMFS.) The workshops and reports force participants to complete tasks, and provide for fruitful exchange, feedback and internal peer review. Both a core set of 25 PATH participants, and an extended set of 15 - 20 occasional participants, provide input to analytical activities. Interaction with the Implementation Team for the Draft Recovery Plan and NPPC helps to prioritize major goals.

Iteration within the PATH process occurs as the logical framework of hypotheses is revised over time in response to improvements in both information and analytical methods. This framework is intended to:

1. 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;
2. provide guidance to the development of regional programs that would stabilize, ensure persistence, and eventually restore depressed salmon stocks to self-sustaining levels; and
3. provide a structure for an adaptive learning approach to development and implementation of a regional salmonid recovery program.

The overall PATH process has five features to ensure high quality outputs: 1) fisheries scientists from the participating agencies; 2) active participation of three internationally recognized independent fisheries scientists in PATH workshops and technical meetings (Drs. Peterman, Deriso and Botsford); 3) the formation of interagency work groups to address specific topics, which ensures strong internal review of all work products; 4) overall coordination , mediation and integration by the PATH facilitator; and 5) external review by the Scientific Review Panel (Drs. Walters, Collie, Saila and Dennis).

PATH uses a weight-of-evidence approach to hypothesis testing, looking for consistency across all available evidence, and the sensitivity of conclusions to the weights assigned to different data sources and analytical results. The retrospective analyses provide the foundation for prospective analyses.

Approach for Retrospective Analyses:

1. Identify the key uncertainties that affect management questions.
2. Compile historical data relevant to key uncertainties and assess its quality.
3. Based on data availability, decide on a set of retrospective analyses test alternative hypotheses about key uncertainties. Specific techniques used here include classical statistical techniques for hypothesis testing, maximum likelihood estimation, and synthesis of information around key questions.
4. Summarize peer-reviewed retrospective analyses in a conclusions document. Conclusions documents represent the consensus view of PATH scientists on the major conclusions from retrospective analyses, the relative degree of certainty in those conclusions, the relative strength of underlying evidence, and information that would be needed to increase the degree of certainty in conclusions.
5. Propose other hypotheses and/or model improvements that are more consistent with the data. Develop improved models that incorporate what has been learned from the retrospective analyses.

Retrospective analyses will be finalized, and conclusions document produced, for fall chinook and steelhead in FY99. Data collection and retrospective analyses of Snake River sockeye will begin in FY99.

Approach for Prospective/Decision Analyses:

1. Estimate the improvement in life cycle survival required to reach various salmon objectives (survival, recovery, rebuilding) and the uncertainty associated with these estimates, using a Bayesian modeling approach that incorporates all uncertainties.

2. Develop a formal decision analysis framework, which provides a common tool for incorporating alternative management action packages, alternative states of nature (with their respective posterior probabilities based on retrospective analyses), and a variety of performance measures. The decision analysis framework will permit the calculation of the expected value of various performance measures (e.g. probably of survival, probability of recovery, expected rates of learning), given a number of different hypotheses about key processes, and their associated probabilities. In some cases (e.g. hydro) these probabilities may be computed from retrospective analyses, whereas in other cases (habitat, hatcheries) they may need to be more subjectively assigned (although bounded by inferences of empirical stock performance). The development of a suite of performance measures will involve interaction with the Research Review Group and the Independent Scientific Advisory Board (ISAB). Development of a set of action packages for the decision analysis will involve interaction with the Implementation Team as well as other entities. A modular set of interacting software tools is expected to evolve within this task to permit all PATH

investigators to flexibly explore the implications of alternative model formulations. This modular framework would include the output from different passage models; tests of this output against both stock-recruitment, SARs, passage survival, and transportation studies (using an MLE framework to estimate Bayesian posterior probabilities); and a decision analysis tool to generate expected values of different performance measures given the model output and associated probabilities.

3. Use the decision analysis approach and other methods to assess the rate of learning associated with alternative sets of management actions, research and monitoring activities, and adaptive management experiments. Learning can be represented in the decision analysis by changes in the probabilities of alternative hypotheses. This analysis of the benefits of different management and research directions would be linked to ongoing research, monitoring and evaluation programs, guide management decisions to minimize risks to extremely depressed populations, to assess how existing activities could be modified to better answer key uncertainties, and also to suggest new activities which could be added to those already planned. A component of this objective is to define performance measures to optimize the likelihood of reaching survival improvement objectives.

Prospective/decision analyses for spring/summer chinook, fall chinook, and steelhead will be updated and finalized in FY99. Prospective modeling, decision analysis, and experimental management design work integrating all three species will be undertaken in FY99. Experimental management work for spring-summer chinook will be initiated in FY98, and continued in FY99. Summary outputs and quarterly presentations are an integral part of the PATH process and are an important means of communication between PATH and interested groups in the region. Some PATH products are also available on the BPA-maintained www site.

f. **Facilities and equipment**.

PATH facilitation uses existing facilities and equipment. The budget does not include purchase of any new equipment.

g. **References**.

Barnthouse, L. (ed.), J. Collie, B. Dennis, S. Saila, and C. Walters. 1996. Plan for Analyzing and Testing Hypotheses (PATH): First Scientific Review Panel Report. Prepared by ChemRisk Division, McLaren/Hart Environmental Engineering Co., Oak Ridge, TN for Bonneville Power Administration, Portland, OR, 20 pp.

Barnthouse, L. (ed.), J. Collie, B. Dennis, S. Saila, and C. Walters. 1997. Plan for Analyzing and Testing Hypotheses (PATH): Second Scientific Review Panel Report. Prepared by ChemRisk Division, McLaren/Hart Environmental Engineering Co., Oak

Ridge, TN for Bonneville Power Administration, Portland, OR, 20 pp.

Beamesderfer, R.C.P., H.A. Schaller, M.P. Zimmerman, C.E. Petrosky, O.P. Langness, and L. LaVoy. in preparation. Spawner-recruit data for spring and summer chinook populations in Idaho, Oregon and Washington. July 1996 Draft Documentation for PATH - Plan for Analyzing and Testing Hypotheses, Retrospective Analysis.

Langness, O. P. and H. A Schaller. 1996. Contrasting Stock-Recruitment, Harvest, and Upstream Passage Survival Patterns of the Columbia River Stream-Type Chinook Populations. Draft Chapter 13 in: Plan for Analyzing and Testing Hypotheses (PATH).

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ESSA Technologies Ltd. (compiled) 1997. Plan for Analyzing and Testing Hypotheses (PATH): Package #1 for the Scientific Review Panel. Compiled by ESSA Technologies Ltd., Vancouver, B.C. June 3, 1997.

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Marmorek, D.R, I, Parnell, L. Barnthouse and D.R. Bouillon. 1995. PATH - Plan for Analyzing and Testing Hypotheses. Results of a Workshop to Design Retrospective

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Marmorek, D.R., D.R. Bouillon, and I. Parnell. 1996. Plan for Analyzing and Testing Hypotheses (PATH): Results of the Kah-Nee-Ta Workshop on Retrospective and Prospective Analyses, (April 17-19, 1996). Prepared by ESSA Technologies Ltd., Vancouver, BC for Bonneville Power Administration, Portland, OR, 52 pp. and appendices.

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1. An Overview of PATH and Retrospective Analyses
2. Level 1 Hypotheses
3. Contrasts in Stock-Recruitment Patters of Snake and Columbia River Spring and Summer Chinook Populations
4. Level 2 Hypotheses
5. Retrospective Analysis of Passage Mortality of Spring Chinook on the Columbia River
6. Hydro Decision Pathway and Review of Existing Information
9. Evaluation of Productivity and Survival Rate Trends in the Freshwater Spawning and Rearing Life Stage for Spring and Summer Chinook
10. Trends in Upstream Spawning and Rearing Habitat
11. PATH Hatchery Impacts
12. Review of the Influence of Climate on Salmon
13. Contrasting Stock-Recruitment and Harvest Patterns of the Columbia River Stream-type Chinook Populations

Chapters 2, 3, 5, and 9 are to be submitted to Canadian Journal of Fisheries and Aquatic Sciences.

Marmorek, D. and C. Peters (editors) and 24 co-authors. 1996. PATH - Plan for Analyzing and Testing Hypotheses. Conclusions of FY 96 Retrospective Analyses. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. December 10, 1996

Marmorek, D.R. and C. Peters, editors. 1997. Preliminary decision analysis report on spring/summer chinook. In preparation for submission to the Scientific Review Panel.

PATH Hydro Workgroup, Data Subcommittee. May 1997. Draft Review of survival and travel time estimates for yearling chinook salmon through various reaches in the Snake and Columbia system.

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Peters C. and D. Marmorek. 1996. Detailed notes from PATH Workshop 3, Wenatchee, Washington (October 7-11, 1996). Prepared by ESSA Technologies Ltd., Vancouver, BC for Bonneville Power Administration, Portland, OR, 24 pp.

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Petrosky, C.E., H.A. Schaller and R.C.P. Beamesderfer. 1995. Spawner-recruit relationships for spring and summer chinook populations in several Columbia and Snake River subbasins. Draft prepared for PATH Workshop 1

Petrosky, C.E. and H.A. Schaller. 1996. Evaluation of survival trends in the freshwater spawning and rearing life stage for Snake River spring/summer chinook. Chapter 9.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996.

Petrosky, C. 1997. Steelhead data reconnaissance and run reconstruction. Progress Report for PATH Workshop 5. October 20-23, 1997. 5 p. plus tables and figures.

Schaller, H.A., C.E. Petrosky and O.P. Langness. 1996. Contrasts in stock recruitment patterns of Snake and Columbia River spring/summer chinook populations. Chapter 3.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective

Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996.

Toole, C., A. Giorgi, E. Weber, , W. McConnaha, and anonymous. 1996. Hydro Decision Pathway and Review of Existing Information. Chapter 6.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996.

Weber, E., P. Wilson, H. Schaller, R. Beamesderfer and C. Petrosky. 1997. Internal PATH Review of Williams, Matthews and Myers. 1997. The Columbia River hydrosystem: does it limit recovery of Snake River spring/summer chinook salmon? PATH document, submitted June 1997. 19 p. plus tables and figures.

Wilson, P. and anonymous authors. 1996. PATH: Hatchery Impacts. Chapter 11.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996.

Wilson, P., E. Weber, C. Petrosky and H. Schaller. 1997. Draft proposed general framework for prospective modeling with detailed examples for one hypothesis about delayed mortality. PATH document, submitted August 1, 1997.

Wilson, P. and H. Schaller. August 1997. Passage and prospective model linkage. PATH progress report.

Section 8. Relationships to other projects

PATH currently involves cooperation among scientists from NMFS, BPA, NPPC, ODFW, IDFG, WDFW, CRITFC, USFS, CBFWA, 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 has participated in PATH since its inception (Phil Mundy, Jim Lichatowich, Chip McConnaha, and recently Chuck Coutant). Close cooperation with the ISAB is very important to PATH. PATH provides a formal process to efficiently utilize and focus the regional technical expertise. The PATH work will also be coordinated with US vs Oregon Columbia river Management Plan activities and the Mid- Columbia Habitat Conservation processes. The PATH project provides better integration of decision making among management agencies through a clear framework for decision analysis and adaptive management experiments. The PATH project directly links and coordinates the work of 7 Bonneville fish and wildlife program projects (identified in section 3 of the proposal).

Section 9. Key personnel

David R. Marmorek

Birthdate: **December 6, 1952**
Citizenship: **Canadian**

Post-Secondary Education

- **M.Sc. Zoology,** University of British Columbia, 1983. Thesis topic: Effects of lake acidification on zooplankton community structure and phytoplankton-zooplankton interactions: an experimental approach. 397 pp.
- **B.E.S. (Honors), Man-Environment Studies and Mathematics,** First class honors, University of Waterloo, 1975.

Professional Experience

1993 - now	**Director,** ESSA Technologies Ltd.
1991 - now	**Adjunct Professor,** School of Resource and Environment Management, Simon Fraser University.
1983 - 1993	**Director,** ESSA Environmental and Social Systems Analysts Ltd.
1981 - 1983	**Systems Ecologist,** ESSA Environmental and Social Systems Analysts Ltd.
1975 - 1978	**Applied Ecologist/Urban Planner,** Proctor and Redfern Ltd.

Relevant Experience and Publications

- used maximum likelihood estimation models and decision analysis to assess the impacts of power plant water withdrawals on Hudson River fish species (for the New York Dept. of Environmental Conservation)
- coordinated an interagency group of fisheries modellers, policy advisors and peer reviewers in a series of analyses of Columbia River salmon stocks
- guided research, monitoring and modelling activities to restore salmonid populations in Kennedy Lake, BC, working with native bands, fisheries agencies, logging companies, and local community groups
- served as modeller, facilitator and data analyst for a series of projects which resulted in the development of a regional model of aquatic effects of acidic deposition with a focus on fisheries and six other classes of aquatic biota.
- major contributor to the 1990 NAPAP Integrated Assessment. Responsibilities included critical analysis and synthesis of studies of impacts of acid deposition on aquatic systems, simulation modelling, and coordination of a team of 15 scientists and modellers;

Korman, J., D.R. Marmorek, G. Lacroix, P.G. Amiro, J.A. Ritter, W.D. Watt, R.E. Cutting, D.C.E. Robinson. 1994. Development and evaluation of a biological model to assess regional scale effects of acidification on Atlantic salmon. Can. J. Fish. Aquat. Sci. 51:662-680.

Marmorek, D.R. and J. Korman. 1993. The use of zooplankton in a biomonitoring program to detect lake acidification and recovery. Water, Air, and Soil Pollution 69: 223-241.

Marmorek, D.R., M.L. Jones, C.K. Minns, and F.C. Elder. 1990. Assessing the potential extent of damage to inland lakes in eastern Canada due to acidic deposition. I. Development and evaluation of a simple "site" model. Can. J. Fish. Aquat. Sci. 47: 55-66.

Thornton, K., D. Marmorek, P. Ryan, K. Heltcher, and D. Robinson. 1990. Methods for projecting future changes in surface water acid-base chemistry. State-of Science/Technology Report 14. Prepared for National Acid Precipitation Assessment Program. 271 pp.

Marmorek, D.R., D.P. Bernard, C.H.R. Wedeles, G.D. Sutherland, J.A. Malanchuk, and W.E. Fallon. 1989. A protocol for determining lake acidification pathways. Wat. Air and Soil Poll. 44: 235-257.

Marmorek, D.R. 1984. Changes in the Temporal Behavior and Size Structure of Plankton Systems in Acid Lakes. In: Early Biotic Responses to Advancing Lake Acidification. G.R. Hendrey (ed.), Butterworth Publishers, pp. 23-41.

Calvin N. Peters

Birthdate: **April 26, 1967**
Citizenship: **Canadian**

Post Secondary Education

- **Masters of Resource Management**, Simon Fraser University, Burnaby, B.C. 1996
  Interdisciplinary training in integrated environmental management, specialization in policy analysis and quantitative approaches to decision-making in fisheries management
- **B.Sc. Ecology**, Simon Fraser University, Burnaby, B.C. 1992.
  (Specialization in evolutionary and behavioural ecology)
- **Diploma of Technology (Honors), B.C. Institute of Technology (1988)**
  Professional training in financial management, capital budgeting and financing, and computer systems analysis, design, and programming.

Professional Experience

1996- (Sept-)	**Systems Ecologist**, ESSA Technologies Ltd., Vancouver, BC. Responsibilities include: proposal preparation, workshop facilitation, data analysis, ecological modelling, statistical and decision analysis, and report writing.
Jan. 01/96- Aug. 31/96	**Research Assistant**, Simon Fraser University, Burnaby, BC. (Contract position with Dr. Randall Peterman)
1994-1995	**Recreational Fisheries Policy Analyst**, Fisheries Branch, B.C. Ministry of Environment, Lands, and Parks

Mr. Peters carries out much of the detailed analytical work in PATH, in consultation with other PATH members. Calvin Peters is highly skilled at integrating the biological, economic, and social components of environmental problems into comprehensive solutions. Mr. Peters has an interdisciplinary background in computer systems, financial management, ecology, and natural resource management. He specializes in quantitative and analytical tools for the development and evaluation of environmental policy and practices. Mr. Peters has applied his skills with the B.C. Ministry of Environment, where he developed a decision-making framework for lake stocking policy in the management of B.C. freshwater fisheries, and with the B.C. Ministry of Forests, where he assisted in the development and delivery of a workshop on quantitative approaches to decision-making for Ministry staff. He has considerable expertise in analytical and technical writing, and has prepared technical documents for a Royal Society of Canada expert panel on Global Change and Canadian Marine Fisheries while doing post-graduate research at Simon Fraser University. Since joining ESSA in the fall of 1996, Mr. Peters has been leading the application of decision analysis to endangered Columbia River salmon stocks. He has also helped develop designs and working modules for fish simulation tools. He has received numerous academic awards.

Publications and Reports

Peterman, R.M., C. Peters. S Frederick and C. Robb. (in prep.) Benefits of taking uncertainties into account when making decisions in fisheries management: Example applications of Bayesian decision analysis. In: T. Pitcher (ed.). Reinventing Fisheries Management: Proceedings of a Symposium held February, 1996.

Peterman, R.M. and C. Peters. (in prep.) Using decision analysis in adaptive management of forests. In: V. Sit (ed.). Adaptive Management of Forest Resources. B.C. Ministry of Forests Technical Report.

Peters, C.N., D.R. Marmorek, and T.M. Webb. 1997. Design of FFIP Management Model: Summary of FFIP Meetings held December 5,6, 1996 and February 5, 1997 at University of British Columbia. Prepared by ESSA Technologies Ltd., Vancouver, BC for Integrated Resource Management Section, Research Branch, BC Ministry of Forests, Victoria, BC, 28 pp. and appendices.

Summary Professional Vitae
Richard B. Deriso

c/o Scripps Institution of Oceanography
La Jolla, CA 92093
Research Associate, ESSA Technologies Ltd.

Formal Education

- Ph.D. in Biomathematics (Quantitative Ecology) 1978, University of Washington
- M.S. in Mathematics 1975, University of Florida
- B.S. in Industrial Engineering 1972, Auburn University

Academic Honors

Tau Beta Pi, Pi Alpha Mu (scholastic honor societies)
1981 W.F. Thompson Award from American Institute of Fishery Research Biologists for publication (Deriso, 1980 CJAFS).

Major Research Interests

- Fisheries Population Dynamics
- Quantitative Ecology
- applied mathematics, statistics

Recent Professional Experience

- Chief Scientist of the Tuna-Billfish Program, Inter-American Tropical Tuna Commission, 1988-present.
- Associate Adjunct Professor, Scripps, Institution of Oceanography, UCSD, 1990-present.
- Affiliate Associate Professor of Fisheries, University of Washington, 1987-present; 1982-1986, Assistant Professor.
- Scientific and Statistical Committee member, Western Pacific Management Council, 1993-present.
- Population Dynamicist, International Pacific Halibut Commission, Seattle, WA, 1980-1988.
- Visiting Research Assistant Professor, Marine Sciences, University of North Carolina at Chapel Hill, 1979-1980.
- Consultant to several agencies and institutions, including US Minerals Management Service, Exxon, ESSA Ltd., Australian Department of Primary Industry, Great Lakes Fishery Commission, Ontario Ministry of Natural Resources, University of Alaska at Juneau, Applied Biomathematics Inc., Living Marine Resource Inc., National Marine Fisheries Service, North Carolina Sea Grant Program, and US Environmental Protection Agency.

Other Professional Activities

- Over 30 seminars given at various universities, agencies, and conferences.
- Taught several graduate courses, including:
  - FISH 557 course (Theoretical Models of Exploited Animal Populations, University of Washington),
  - QSCI 598 (Decision analysis for exploited populations, University of Washington),
  - SIO 276 (Quantitative theory of populations and communities, Scripps Institution of Oceanography, with G. Sugihara).
- Served on several committees and working groups, including groups with ICES, FAO, NAS, and NRC. Currently co-chairman, NRC Committee on Fish Stock Assessment Methods.

Publications and Reports

Over 40 publications and reports, including:

- Deriso, R.B. 1978. Non-linear age-structured models for seasonally breeding populations. Ph.D. dissertation, University of Washington, 159 pp.
- Deriso, R.B. ;1980. Harvesting strategies and parameter estimation for an age-structured model. Can. J. Fish. Aquat. Sci. 42: 268-282.
- Deriso, R.B., T.J. Quinn II, and P.R. Neal. 1985. Catch-age analysis with auxiliary information. Can. J. Fish. Aquat. Sci. 42: 815-824.
- Deriso, R.B., R.G. Punsly, and W.H. Bayliff. 1991. A Markov movement model of yellowfin tuna in the Eastern Pacific Ocean and some analyses for international management. Fish. Res. 11: 375:395.

Randall M. Peterman

B.Sc. (Biological Sciences, University of California at Davis).
Ph.D. (Zoology, University of British Columbia)
Professor, School of Resource and Environmental Management

Dr. Randall Peterman is a population ecologist who specialized in quantitative methods to improve fisheries management. His research interests include the application of simulation modeling, statistical power analysis, Bayesian statistics, and decision analysis to problems in resource management. Some of his research applies these methods to the design of monitoring programs. He is also developing quantitative techniques for ecological risk assessment and for detecting the effect of climate change on fish productivity.

Dr. Peterman and his graduate students also work on methods to deal with uncertainties effectively, for example:

- Peterman, R.M. 1990. Statistical power analysis can improve fisheries research and management. Can. J. Fish. Aquat. Sci. 47:2.
- Robb, C.A. and R.M. Peterman. 1998. Application of Bayesian decision analysis to management of a sockeye salmon fishery. Can. J. Fish. Aquat. Sci. (in press).
- Frederick, S.W. and R.M. Peterman. 1995. Closing fisheries harvest policies: when does uncertainty matter? Can. J. Fish. Aquat. Sci. 52:291.

Dr. Peterman also co-authored “Principles of the conservation of wild living resources”, in 1996 Ecological Applications (6:338) and “Precautionary Approach to Fisheries, Part 1: Guidelines on the precautionary approach to capture fisheries and species introductions”, 1995, Food and Agriculture Organization (FAO) of the United Nations, Fisheries Technical Paper No. 350/1.

Peer recognition for his research in fisheries management includes the 1990 J.C. Stevenson Award for “…creative research on the cutting edge of an aquatic discipline.” Also, in 1992, Peterman and his graduate student, M. McAllister, received a citation for the most significant paper in the North American J. of Fisheries Management for their paper, “Experimental design in the management of fisheries: a review”, (NAJFM 12:1). In 1994, he and two of his graduate students received the W.F. Thompson Award from the American Institute of Fisheries Research Biologists for the best student publication, the paper in the 1992 Can. J. Fish. Aquat. Sci. (49:1294).

Dr. Peterman won an Excellence in Teaching Award from Simon Fraser University in 1990 and a University Research Professorship in 1990-91. He has served on several professional committees in Canada and the U.S. and is currently co-chair of a panel on Canadian Marine Fisheries for the Canadian Global Change Program of the Royal Society of Canada.

Dr. Peterman teaches Applied Population and Community Ecology (REM 611), Current Topics in Fisheries Management (REM 613), and Risk Assessment and Decision Analysis for Management of Natural Resources (REM 625).

CURRICULUM VITAE

Michael L. Jones

Dr. Jones is leading the PATH workgroups responsible for assessing the impacts of habitat change and hatchery activities on endangered chinook and steelhead populations.

Education

B.Sc.(Honours), Zoology, University of British Columbia, 1977
Ph.D. Zoology, University of British Columbia,1986

Professional Experience

- Associate Professor, Great Lakes Fisheries, Michigan State University
- Honourary Conjunct Professor, Watershed Ecosystems Program,Trent University, 1991-present
- Research Scientist-in-Charge, Great Lakes Salmonid Unit, Aquatic Ecosystems Research Section, Ontario Ministry of Natural Resources, 1988-present.
- Director and partner, ESSA Environmental and Social Systems Analysts Ltd., 1983-1988.
- Systems Ecologist and Manager, ESSA Ltd., Toronto Office, 1981-1988
- Lecturer, Institute for Environmental Studies, University of Toronto, 1983-1989

Professional Affiliations

Past Chairman, Board of Technical Experts, Great Lakes Fishery Commission
Director, International Association for Great Lakes Research

Selected Publications

Jones, M.L., and nine coauthors. 1996. Limitations to lake trout (*Salvelinus namaycush*) rehabilitation in the Great Lakes imposed by biotic interactions occurring at early life stages. Journal of Great Lakes Research *in press*

Jones, M.L., R. G. Randall, D. B. Hayes, W. Dunlop, J. Imhof, G. Lacroix, and N. Ward. 1996. Assessing the ecological effects of habitat change: moving beyond productive capacity. Can. J. Fish. Aquat. Sci. 53: (Suppl. 1): *in press.*

Stoneman, C. L., and M.L. Jones. 1996. A simple method to classify stream thermal stability using single observations of daily maximum water and air temperature. N. Amer. J. Fish. Manage. *accepted.*

Stoneman, C. L., M.L. Jones, and L. W. Stanfield. 1996. Habitat suitability assessment models for southern Ontario trout streams. Model development and evaluation. Can. Manus. Rep. Fish. Aquat. Sci. 2345: 45 pp.

Jones, M.L., and J. D. Stockwell. 1995. A rapid assessment procedure for the enumeration of salmonine populations in streams. N. Amer. J. Fish. Manage. 15:551-562.

Jones, M.L., J.F. Koonce, and R. O'Gorman. 1993. Sustainability of hatchery dependent salmonine fisheries in Lake Ontario: the conflict between predator demand and prey supply. Trans. Amer. Fish. Soc. 122(5):1002-1018.

Rand, P.S., D.J. Stewart, P.W. Seelbach, M.L. Jones, and L.R. Wedge. 1993. Modeling steelhead trout population energetics in Lakes Michigan and Ontario. Trans. Amer. Fish. Soc. 122(5):977-1001.

Jones, M.L. and L. Stanfield. 1993. Effects of exotic juvenile salmonines on growth and survival of juvenile Atlantic salmon (*Salmo salar*) in a Lake Ontario tributary. p. 71-79 in R.J. Gibson and R.E. Cutting (ed). Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Can. Spec. Publ. Fish. Aquatic. Sci. 118.

Jones, M.L., C.K. Minns, D.R. Marmorek, and K.J. Heltcher. 1991. Assessing the potential extent of damage to inland lakes in eastern Canada due to acidic deposition. IV. Uncertainty analysis of a regional model. Can. J. Fish. Aquat. Sci. 48:599-606.

Section 10. Information/technology transfer

Once peer reviews are complete, PATH reports are distributed through BPA to decision makers, fisheries managers and the interested public. In addition, BPA maintains a WEB site which allows the public to download reports. In addition, the lead PATH facilitator, David Marmorek, has made five presentation to the NPPC (including members of the public), bimonthly presentations to the Implementation Team, and individual presentations to the ISAB, NMFS, U.S. Army Corps of Engineer Public Round Table, and the Executive Committee. In addition, four PATH analyses are almost ready to be submitted for publication in the Canadian Journal of Fisheries and Aquatic Sciences, who are interested in concentrating these results in a single journal.

In addition, the tools being developed and improved by PATH, particularly the decision analysis tools, will have tremendous benefits to the region over the next few decades. These will be demonstrated to fish managers, with training provided, in FY99.