Plan for Analyzing and Testing Hypotheses (PATH)

Second Scientific Review Panel Report

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1.0 Introduction

For the past several years, the Bonneville Power Administration, the Northwest Power Planning Council, the National Marine Fisheries Service, and various state and tribal resource agencies have been attempting to work together to compare and enhance the models used by all of the agencies to evaluate management options intended to enhance recovery of depleted Columbia River Basin salmon stocks. A number of reports comparing the behaviors of mainstem passage and life-cycle models over a wide range of management scenarios and natural climate conditions have been prepared. These products, together with comments from several external review panels, have helped to clarify the nature of differences among the models and have pointed the way towards helping to resolve them.

This report presents comments by an expert Scientific Review Panel on the Draft Final Report on Retrospective Analyses produced by the Plan for Testing and Analyzing Hypotheses (PATH) group. The PATH group consists of quantitative fisheries scientists, statisticians, and theoretical biologists who work with federal, state, and tribal resource management agencies, universities, and consulting firms. The PATH Final Retrospective Analyses report documents progress on a number of technical tasks related to using historical data to evaluate alternate hypotheses concerning the causes of the recent decline in production of wild salmon stocks in the upper Columbia River basin and the likely effectiveness of the management actions that have been proposed to restore these depleted stocks.

The Draft Final Report is a revision/expansion of an earlier draft report prepared in March 1996. The new draft incorporates comments made by the review panel on the earlier draft. Most chapters have been extensively revised and expanded. Six chapters of the Draft Final Report are considered by the authors to be in essentially final form, although some of the analyses may be revised to incorporate new data. Most of the remaining chapters are complete enough so that preliminary conclusions could be drawn. This review, therefore, provides the first comments by the reviewers on the validity of the methods and conclusions reached. Following the Third PATH Workshop in October, 1996, the PATH Synthesis Group prepared a “Conclusions” document summarizing the current state of knowledge based on retrospective analyses completed in FY1996, with emphasis on naturally-spawning spring-summer chinook salmon. The review panel’s comments on the draft Conclusions document are also included in this report.

Members of the review panel include:

Dr. Jeremy Collie, Graduate School of Oceanography, University of Rhode Island

Dr. Brian Dennis, Department of Fish and Wildlife, University of Idaho

Dr. Saul Saila, Graduate School of Oceanography, University of Rhode Island (emeritus)

Dr. Carl Walters, Fisheries Centre, University of British Columbia

1.1 Background

The PATH project grew out of the earlier model comparison and review activities conducted by the agencies and tribes. Results of these comparisons and reviews demonstrated that each modeling system has different strengths and weaknesses. Where differences in results exist among the modeling systems, the primary cause has been differences in basic hypotheses and assumptions regarding the impact of recent and potential management actions. A 1994 scientific review panel report concluded that there were three major differences between the modeling systems: 1) the distribution of survival over the life span; 2) the effect of flow on survival, and 3) the benefit of transportation. The panel felt that as long as these differences exist the models were going to give different answers in a fairly predictable fashion. The panel concluded that, rather than continuing with model comparison activities, the modeling groups should attempt to resolve the fundamental issues through hypothesis formulation and testing.

The 1994 review panel report was the stimulus for the development of the PATH project. During the Spring and Summer of 1995 a planning committee identified the following as specific objectives of PATH:

> define the management decisions that serve to focus analytical activities;
>
> bound the anadromous salmon ecosystem components that need to be considered;
>
> lay out alternative hypotheses for the functioning of these ecosystem components, in terms of the distribution of survival over the populations' life cycle and the life stages and population responses to management actions under different natural conditions;
>
> compile and analyze information to assess the level of support for alternative hypotheses;
>
> propose other hypotheses and/or model improvements supported by the weight of evidence from these analyses;
>
> identify knowledge and data gaps that could be filled through management experiments, research and monitoring, improving our ability to discriminate among competing hypotheses, and maximizing the rate of learning and clarity of decisions;
>
> provide guidance to the development of regional programs that would stabilize, ensure persistence, and eventually restore depressed salmon stocks to self-sustaining scenarios; and

e PATH three-level hypothesis framework

vel 1: exploratory analyses to determine if there are differences in trends of abundance and productivity icators among different Pacific northwest species and stocks. Hypotheses at this level seek to identify erences in trends among species/stocks, but do not propose mechanisms to explain those differences.

vel 2: explanation of trends in stock indicators in terms of spatial contrasts and temporal changes in a) survival ng particular life history stages; or b) pressure/stressor indicators associated with survival in one or more life ory stages. Hypotheses at this level provide potential inferences concerning life stages on which management ons should be focused.

vel 3: explanation of life-stage-specific mechanisms associated with observed population trends. Level 3 otheses link directly to key management decisions.

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

The PATH project is structured by a framework consisting of three nested “levels” of hypotheses (Box 1). At the first PATH workshop, held in October, 1995, this framework was refined and developed into a specific set of hypotheses and tasks. Some of the tasks involve quantitative modeling; others involve qualitative synthesis and evaluation of data. All of the tasks involve analyses of historical information to address the validity of hypotheses that have significant implications for management decisions. Working groups were organized to address each of the tasks.

In March of 1996, a draft “Retrospective Analyses” report presenting preliminary results for each task was prepared. Following review of the draft by the panel, this draft was discussed at the second PATH workshop in April, 1996. Plans for revision and extension of the preliminary analyses were made at that time. The revised and expanded report was sent to the review panel in September, 1996 and the results of the review were presented at the October 1996

1.2 Structure of This Report

This report presents results of the second review. Sections 2 and 3 contain, respectively, a summary of the general comments of the reviewers on the Retrospective Analyses report as a whole, and a summary of the reviewers’ comments on each of the individual chapters. Chapter 4 contains the panel’s comments on the Conclusions document.

Copies of the individual reviews can be obtained from:

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2.0 Summary of General Comments

As they did with the preliminary draft report, the review panel members generally endorsed the PATH concept, commended the authors on their progress, and pushed them to do even better.

Several suggestions were made by Dr. Collie concerning the structure of the report. He suggested that more linkages and cross references were needed across chapters. Because several of the chapters are derived from the same stock-recruitment data, he recommended (1) providing a detailed description of data sources and documentation of the run reconstruction methodology, and (2) providing tables and plots of the stock-recruitment data early in the report. He recommended providing more linkages and cross references across chapters. He noted that hypothesis generation is the first step in adapative management; the next step is to identify the different management policies and construct models to predict the outcomes of those policies. He thought that policy evaluation should be given a high priority for future work.

Dr. Dennis noted that the results to date are already sufficient to rule out some modeling and risk analysis approaches. He again stressed the need for publishing results in the scientific literature; he stated that progress toward that goal has been “excellent.” He also thought that more attention needs to be paid to communication with the public at large. Types of communication he recommended include an executive summary, a press release, articles in trade magazines, and presentations in public forums.

Dr. Saila provided several cautions concerning the current makeup of the PATH team and the general approach being used. He noted that the team is does not include experts in genetics, physiology, or statistics, all of whom (especially a statistician) could significantly enhance the project. Although the project relies fundamentally on analysis of data and models to achieve rigorous results, Dr. Saila noted that often a professional consensus achieved with minimal reliance on statistical modeling exercise can be just as successful.

Both Dr. Walters and Dr. Collie noted that during the next phase of the project the PATH group should begin formulating and evaluating adaptive management policies for the Columbia River basin. Dr. Walters saw a danger that the project might produce a set of uncoordinated recommendations aimed at fine-tuning individual components of the salmon management system. He challenged the group to develop “... a nested experimental design that tests a variety of management options at scales ranging from local habitats to mainstem dams, with bold manipulations rather than fragmentary monitoring studies.”

s chapter demonstrates two approaches to testing the PATH Level 1 hypotheses concerning whether there has n a similar trend in the state indicators for anadromous salmonid species/stocks that spawn in a variety of graphic locations in the Pacific Northwest. The methods used to perform the analyses were modified in ponse to comments on the Preliminary Report, and six new stocks were added to the data set.

relation analysis and cluster analysis were used to identify geographic patterns in historic spawner-recruit a for upriver and downriver salmon stocks. The results, although still preliminary, suggest that (1) trends in ndance and survival measures differ significantly among stocks, and (2) stocks within basins or subbasins tend xhibit similar patterns in abundance and survival.

3.0 Chapter-Specific Comments

Chapter 2: The Snake River in the Context of Broad Scale Patterns of Climate Change in Stock Indicators **[C. Paulsen]**

Dr. Collie concluded that, apart from the addition of new data, relatively few changes had been made in the chapter. He suggested a more in-depth analysis of regional patterns in survival and abundance, including identification of additional factors that differentiate stock groupings. He noted that, although an appendix on data soures has been written, there is no information presented on the run reconstruction methods **[note: a report documenting those methods, by Beamesderfer et al., has since been completed and distributed to PATH participants and reviewers]**. He had a number of suggestions on analytical methods:

> Time-series data could be detrended to eliminate intraseries correlations (he suggested several approaches.
>
> Pairwise comparisons could make more complete use of the available data.
>
> The correlation tables and clustering figures are difficult to interpret and patterns are not evident. A better plotting method is needed.
>
> Analysis of Similarity Randomization Tests (ANOSIM) that are being used in benthic ecology could be used determine whether the observed patterns arose by chance.

Dr. Collie recommmended against pursuing discriminant analysis at this time, and recommended insted the use of randomizaiton methods for hypothesis testing.

Dr. Dennis noted that the analysis of ln(R/S) vs. S residuals as having theoretical support. He agreed that bias in estimates of "α" and "β" are not of great concern, given the purpose of this analysis. He suggested using a stochstic Ricker model to track trends in density-dependent populations and recommended exploration of additional ways to explicitly incorporate distance between rivers in the analysis.

Dr. Saila commended the authors for their additional efforts. He found the term "oblique principal compnents" to be confusing and suggested clarification of terminology and inclusion of a brief

This chapter examines time trends in stock indicators for upriver and downriver/coastal stocks, before and after hydropower development. Temporal patterns in abundance and survival of lower-Columbia stocks indicate recent declines that may be related to poorer oceanic or environmental conditions. However, spatial and temporal comparisons indicate that upriver (Snake River and upper Columbia) stocks fared much worse. Empirical evidence best supports the hypothesis that productivity and survival of the spring and summer chinook stocks that were most affected by hydropower development declined more and became more variable over time than did those of the downriver stocks. Productivity and survival declines in the upriver stocks over the past 50 years were quite abrupt and corresponded with the construction and completion of the hydropower system.

explanation of principal components anlysis (PCA). He suggested that more appropriated methods than PCA are availble, and that an expert multivariate statistician should be consulted.. He noted that clusters identified in the cluster analysis appear to correspond to geographic areas.

Dr. Walters disagreed with the assertion that time series bias in estimates of “α” and “β” can be ignored. He suggested the presentation of results in terms of Nei or distance diagrams, arguing that this method would more clearly demonstrate the apparent high correlations between stocks that are geographically closer.

Chapter 3. *Contrasts in Stock Recruitment Patterns of Snake and Columbia River Spring/Summer Chinook Populations* **[H. A. Schaller, C. E. Petrosky, and O. P. Langness]**

Dr. Collie found the chapter to be “much improved” from the draft version. He noted that the chapter extends the correlation studies of Chapter 2 by making specific comparisons between the Snake River, upper Columbia, and lower Columbia stocks. Hypotheses are clearly stated and tests are described and conducted. He supported the authors’ interpretation of the results. He expressed “concern” that fitting the Ricker model separately to short series of data increases the likelihood of spurious parameter estimates, and noted that estimates of the Ricker a obtained for the Snake River stocks prior to 1970 appear unusually high.

Dr. Dennis agreed that emphasis on variability in addition to decline is important. He had suggested some alternative analyses that would specifically test for changes in variability in production and survival during the pre- and post-construction periods. He found the use of residuals as “indices of survival rates” confusing. He suggested that the Ricker α confounds survival and productivity, and that a time-dependent model for α might be useful.

Dr. Saila was concerned about the low values of r^2 for fits to the Ricker stock-recruitment function. In his opinion, it is dangerous to apply formal parametric tests to cases in which less than 50% of the variance is explained by the model. He noted that r^2 values declined after 1970 (i.e., variability in the number of recruits per spawner increased), and stated that this could be an important observation.

Walters called the study “spectacular” and recommended open-literature publication. He raised several issues that are also relevant to chapters 4 nd 5; these are comments he also raised in his review of the earlier draft. The principal issue is that the index stocks may not be representative of the range of stocks present in the Snake River basin, because they may be unusually productive compared to stocks that were apparently healthy before completion of the dams but have since s chapter describes an analysis of the influence of "environmental stressor" variables on stock indicators for cks in the Middle Fork Salmon River and John Day River basins. The environmental variables employed are se thought to influence salmon survival in different life stages. The idea is to use multiple regression and other ltivariate techniques to identify which variables, and therefore which life-stages, have contributed the greatest ability to the variation in stock and recruitment indicators for the different stocks.

teen Columbia River spring chinook stocks have been included in the analyses performed to date. Although ults should be interpreted cautiously, some patterns were evident. Spawning escapement was negatively related with stock peformance indicators for most stocks. Correlations between stock indices and measures of Migration-corridor flows and (2) numbers of dams traversed during migration were consistent with othesized influences of the hydropower system.

collapsed. Dr. Walters suggested that this issue could be dealt with in the paper through a discussion of whether or not there were stocks that precipitiously declined or became extinct coincident with hydropower development.

Chapter 4. Level 2 Hypotheses **[C. Paulsen]**

Dr. Collie found this chapter to be much improved over the previous draft. In particular, the data, assumptions, and methods were more fully explained and numerical data rather than dummy variables were used in the analyses.

He made several specific suggestions:

> Because much of the data rely on peak redd counts (an imprecise method for counting salmon), substantial unexplained variation in stock indicators should be expected.
>
> Recruitment estimates will tend to be spuriously correlated if spawners are assumed to have the same age composition as neighboring stocks when they reall do not, or if stocks with similar run timing are assumed to have the same harvest and interdam mortality when they in fact do not.
>
> It is a good idea to state hypotheses about the expected results; these predictions aid in interpreting the volumimnous regression results.
>
> The stressors included in a multiple regression analysis do not have to be independent, however, lack of independence makes the results of the analysis more difficult to interpret.
>
> Sea-surface temperature might be a useful additional stressor or environmental variable.

Dr. Collie again expressed discomfort with the multiple age-class models and recommended concentrating on the multiple stocks, pooled-recruitment models.

Dr. Dennis found the discussion of independence to be confusing and in need of refinement. He noted that stochastic dependence among contemporaneous populations in differenct locations should be expected, due to similarities in environmental conditions. He suggested that the analysis could benefit by using some of the model selection indices discussed in Chapter 5.

Dr. Saila noted that the chapter still does not include either (1) a discussion of the assumptions underlying the regression models or (2) a summary of diagnostics for the analyses. He was particularly concerned about the distribution of residuals. He stated that methods other than mutliple regression are available for analysis of relationships among variables. He provided, as an example, an Abductive Information Model (AIM) network analysis of data provided in Appendix Table 2 of Chapter 6.

Dr. Walters suggested providing a graphical summary of the success with which the various environmental factors explain recruitment anomalies. His opinion was that correlation problems are still not adequately addressed. Autocorrelated time series have many fewer real degrees of freedom for cross-correlation comparisons than would be expected from the number of observations.

s chapter presents results of retrospective modeling conducted to assess the overall effects of mainstem sage down the Columbia River. In contrast to the linear regression methods used in Chapters 2-4, Chapter 5 ploys a Maximum Likelihood Estimator (MLE) that examines the difference in incremental mortality between iver (Snake River system) and downriver (Lower and Mid Columbia) stocks, using spawner and recruit data n seven Snake River and six downriver spring chinook stocks. The results indicate that, for the 1970-1990 od years, passage from Lower Granite Dam to John Day Dam resulted in a significant reduction in recruitment he Snake River stocks.

Chapter 5. Retrospective Analysis of Passage Mortality of Spring Chinook of the Columbia River **[R. Deriso, D. Marmorek, I. Parnell]**

Dr. Collie found the results to be "compelling," but was still concerned about potential biases in the estimated parameter values. He found the correlation between α and μ to be "worrisome," and thought that it might suggest that the α values are artificially inflated. He approved of the way in which FLUSH and CRiSP mortality estimates were incorporated in the stock-recruitment models, but thought that equally credible results were obtained using travel time as a surrogate for passage mortality. He endorsed the use of MLE-derived spawner-recruit models for prospective analysis of management strategies, but suggested that Monte Carlo simulation would be as effective as Bayesian decision analysis as an analytical approach.

Dr. Dennis approved the way in which model selection indices were used to evaluate the models developed in this chapter, although he questioned the theoretical validity of the proposed Bayesian approach for prospective analysis.

Dr. Saila sugested that the process through which recruitment estimates were derived from the raw data should be explicitly modeled, so that the covariance structure between recruitment measurement error and spawner measurement error could be estimated.

Dr. Walters recommended providing a posterior distribution for μ. He found the results plotted in Figure 5.6 to be extremely important because they suggest that water transit time is a poorer predictor of survival than is asserted elsewhere in the report. He thought that Figure 5.8 was "worrisome" and supported his assertion, provided in comments on Chapter 3, that the Snake River basin index stocks are unusually productive compared to other stocks that were formerly present. If this were true, then restoration schemes derived from analysis of the index stocks might be inadequate to support restoration of less-productive stocks.

s chapter presents (1) a decision flow chart for evaluating management options for the federal Columbia River ver system, (2) a list of specific questions that must be answered before making each management decision, (3) mmary of the currently available information relating to each question, (4) a determination of which of the stions can be resolved with currently available information, and (5) a compilation of information needed to olve the remaining questions. The chapter has been significantly expanded to include information formerly sented in Chapters 7 and 8 of the preliminary draft; these chapters have now been merged into Chapter 6.

Chapter 6. Hydro Decision Pathway and Review of Existing Information **[PATH Hydro Work Group]**

Dr. Collie found this chapter to be "much improved" from the previous draft. He found the interim survival goals developed in section 6.3 to be "plausible" and "an immense help." He noted that some of the results relating to survival of transported smolts appear inconsistent. Evidence presented in this chapter suggests that survival of smolts during transport is high, yet data on smolt-to-adult returns suggests that the long-term survival of transported fish has been on average lower than the level required to meet the interim survival goal. Dr. Collie noted that increases in the fraction of fish transported between 1972 and 1989 should have resulted in a near-doubling of smolt-to-adult returns, but the analyses presented in Chapter 5 show that a decline has occurred instead. Regarding the management questions in section 6.4, Dr. Collie agreed with the tentative answer to question 1.5, i.e., that in-river survival under current conditions is insufficient to meet the interim survival goals. He noted that the per-dam survival estimates presented in Chapter 6 are consistent with the mean passage survival estimate developed in Chapter 5. He commented favorably on the quantitative evaluation of the benefits of natural river drawdown (question 2.1), but thought that the survival rates in the different reaches needed to be more clearly defined. If a decision is made to decommission one or more dams, Dr. Collie's recommendation would be to design appropriate pre-and post-decommissioning studies so that the removal could provide adaptive management information.

Dr. Dennis suggested that insect phenology models, which describe the numbers and developmental times of cohorts of insects passing through various developmental stages, might be applicable to fish passage data.

Dr. Saila recommended that experimental studies be performed to evaluate delayed mortality of transported fish. Specifically, he recommended comparisons of physiological condition (degree of smoltification, osmoregulatory ability, and stamina) in several stocks. He also suggested a comparative analysis of seawater adaptation in chinook and steelhead. Dr. Saila's rationale for these recommendations is that the construction of dams has significantly altered the timing of arrival of smolts to the estuary and also the energy required for downstream movement; these changes may have disrupted the normal smoltification process. Dr. Saila also provided an alternative analysis of the descaling mortality data in Appendix 1, Table 2. His analysis, performed using a network modeling tool (AIM ™), provided an improved fit to the data.

Dr. Walters characterized the chapter as providing an "objective and pessimistic overview of the possibility of improving passage survival through transportation and manipulation of hydrosystem operations." He argued that process-level studies of direct and delayed mortality associated with the hydrosystem should not be pursued and recommended instead that effort and funding be devoted to tagging and other studies designed to evaluate the overall effects of alternative s chapter examines evidence for, and tests whether, a net decrease in survival in freshwater spawning and ring life stage has occurred since completion of the hydropower system. Such a change could partially explain decline of Snake River spring/summer chinook. Numbers of wild spring/summer chinook spawners and lts were indexed at the uppermost dam from available data sets for brood years 1962-73, 1962-82, and 1990-3. A strong density-dependent relationship in smolt survival was found. Smolt survival has been much higher ecent years than in earlier years when spawner abundance was higher. The results do not rule out small reases in spawner-to-smolt survival during recent years, but they provide no empirical support for the othesis that spawner-to-smolt survival is the primary life stage responsible for the decline of Snake River ng/summer chinook.

management practices on salmon survival and productivity. He further suggested that long-term population viability modeling is needed to support the suggested targets for smolt-to-adult return (SAR) provided in the chapter. He noted that the reservoir survival patterns presented in Appendix 3 to Chapter 6 are consistent with the overall estimates of μ developed in Chapter 5 and suggested that a discussion and cross-reference should be developed.

Chapter 9. Evaluation of Survival Trends in the Freshwater Spawning and Rearing Life Stage for Snake River Spring/Summer Chinook **[C. E. Petrosky and H. A. Schaller]**

Dr. Collie noted that he had "relatively few" comments on this chapter and that the authors had acted on suggestions made in his review of the earlier draft. He found the results to be "fairly clear cut." He concurred with the conclusion that the number of wild smolts produced per spawner has increased since 1980. He made several suggestions concerning presentation of the regression analysis results, and repeated his earlier suggestion that an analysis of smolt-to-adult survival could be performed using a similar approach.

Dr Dennis noted that Chapters 9 and 10 are potentially contradictory and recommended that authors of each of these chapters discuss the other chapter's findings. He found the analyses in chapter 9 to be "sound" and to indicate that reductions in downstream-passage mortality would be the most effective means of promoting recovery of the stocks.

Dr. Saila provided a power analysis that appeared to show that the analyses presented in this chapter did not meet generally accepted criteria for statistical power and therefore could not be used to support the authors' conclusion that a decline in spawner-to-smolt survival could not have been responsible for the observed decline in productivity of the Snake River stocks. **[note: Through subsequent discussions between Dr. Saila and the authors, it was determined that Dr. Saila's objection applied only to comparisons between estimated mean smolts-per-spawner for the pre-dam and post-dam periods. The authors' conclusion, however, was based on a comparison with the observed decline in recruits-per-spawner between these two periods documented in Chapter 3. The authors argued that the power of their analysis was sufficient to detect a decline in spawner-to-smolt survival as large as the observed change in life-cycle survival estimated in Chapter 3. Dr. Saila agreed that their interpretation was correct.]**

Dr. Walters reiterated his concern that the stocks included in this analysis might not be representative of the range of stocks present in the Snake River basin prior to the 1970s.

purpose of this chapter is to synthesize information relating to the effects of quantity and quality of freshwater itat on the survival of juvenile spring/summer chinook salmon in the Snake River Basin. Five types of rmation are presented: (1) an evaluation of various hypotheses concerning the effects of habitat on salmon ulations, using results of previously-published studies, (2) a comparison of habitat quality (high, medium, or) in subbasins characterized as having strong, depressed, or absent salmon stocks, (3) results of simulation lelling using the Stochastic Life Cycle Model (SLCM), (4) PIT-tag data for stocks originating from streams different habitat quality classifications, and (5) detailed analysis of several case studies. Data from these rces suggest that the quality of freshwater habitat can be an important factor in the abundance and resiliency of hook stocks.

Otherwise he found that the conclusions in this chapter were similar to his own conclusions in examining data from British Columbia, i.e., effects of habitat alteration on salmonid production are smaller than is commonly believed.

Chapter 10. A Decision Tree for Structured Synthesis of Evidence Concerning Changes in Spawning and Rearing Habitat **[C. Pinney, I. Parnell, and D. Lee]**

Dr. Collie characterized this chapter as being "very descriptive and overly wordy." He thought that the authors had accepted "the hypothesis that land use management has had some degree of effect on anadromous salmon" without presenting or critically evaluating evidence for and against the hypothesis. He thought that independent measures of habitat quantity and quality should be developed and integrated into the stock-recruitment models presented in Chapers 3-5. He noted some "confusion" concerning the usefulness of stock-recruitment data and models in testing for habitat effects and survival and clarified the relationship between habitat quality/quantity and the two parameters of the Ricker model (habitat quality influences α, habitat quantity influences β). He also questioned the purpose of the right-hand side of the habitat decision tree (Figure 10-2). If, as indicated by results presented in earlier chapters, hydropower development is the greatest contributor to declines in spring/summer chinook in the Snake River Basin, then habitat improvement cannot "compensate" for hydropwer development unless smolt-to-adult survival is increased to a level that permits stock recovery. Any restoration efforts should be performed with a controlled experimental design in conjunction with PIT tagging, to test whether habitat amelioration can increase egg-to-smolt survival. Overall, Dr. Collie concluded that this chapter overstates the immediate benefits of freshwater habitat improvements in the Snake River basin. He also performed a reanalysis of the PIT-tag detection data (Appendix 4). Whereas the original analysis concluded that travel distance and rearing stream habitat quality affected the rates of detection (and, presumably, survival) of PIT-tagged smolts during downstream passage, Dr. Collie concluded that variations in recovery rates for parr from different rearing streams were best explained by subbasin and year effects.

Dr. Dennis recommended breaking the chapter into smaller, "more digestible" portions. He stated that the chapter has "a major point" to make. If salmon production is constrained by bottlenecks at the spawning and rearing stage due to shortage of high-quality stream habitat, then constraints might exist on the benefits to be obtained from reductions in mortality due to downstream passage. He thought that the authors of Chapters 9 and 10 should carefully consider all of the available information considering the influence of habitat on salmon productivity, and that the development of hypotheses and management strategies could benefit from involvement of a theoretical ecologist with expertise in life history analysis.

Dr. Saila called the chapter “a model of effective writing and objective analysis of available information.” He suggested exploration of an alternative stock-recruitment model that allows for depensation (i.e., a decrease in survival with decreasing spawner abundance) and provided an example.

Dr. Walters recommended a complete reworking of the chapter from an “objective, balanced scientific viewpoint.” He suggested that a thorough evaluation of the available data might provide insights contrary to the conventional wisdom concerning salmonid habitat. As an example, he provided a reinterpretation of the Carnation Creek case study (Appendix 5) in which he pointed out that the observed drop in egg-to-fry survival following logging was more than offset by an increase in fry-to-smolt survival. He was skeptical of the claim that habitat quality indices might be correlated with population performance, arguing that habitat indices typically take too simplistic a view of the habitat requirements of fish and are therefore useless. He thought that Appendix 5 was “blatantly biased” and should be reworked or omitted.

In Dr. Walters’ opinion, section 10.2.3 misrepresents the purpose and results of stock-recruitment analysis as performed in earlier chapters. Those analyses were directed at explaining observed anomalies in the stock-recruitment data, not at developing predictive models or describing the mechanisms relating spawner abundance to recruit production.

Some additional points made by Dr. Walters include:

> The evidence for effects of habitat is uncritically presented. The SLCM model runs, which are cited as evidence in suppport of carrying capacity impacts, are in reality hypothetical simulations without empirical support.
>
> No evidence is provided to support the assertion in the conclusions section that increases in the distribution of high-quality spawning and rearing habitat are required to realize the benefits of improved migration and ocean survival.
>
> The prospective analyses are inadequate; opportunities for well-designed adaptive management experiments related to habitat restoration are not discussed.
>
> There should be a recognition of the spatial complexity and diversity of salmonid habitat as a whole; the simplistic view of population structure exemplified by SLCM is inadequate for management of a complex of populations containing many interconnected stocks.

11. PATH: Hatchery Impacts **[P. Wilson, with support from the Hatchery Evaluation Group]** s chapter presents a brief review of the influence of climate on fish populations. Evidence suggests that the r-class strength of fish populations is related to climatic/ocean fluctuations occuring over large areas and adal time scales. In general, two major climate regimes have been identified; one associated with warm and Pacific Northwest weather and one associated with cool and wet climate in the Northwest. The warm/dry ime, which is presently being experienced, is characterized by weaker year-classes of fish stocks on the west st of the lower United States and strong year classes of tish stocks in northern British Columbia and Alaska.

Dr. Collie stated that the group had mad a good-faith effort to respond to reviewers' comments on the first draft. He thought that the grouping of questions and hypotheses into within-stock impacts and between-stock impacts "makes sense." He noted that the question addressed in section 2 of the chapter is a critical for determining the value of hatchery supplementation programs. He made a number of specific suggestions for improving the draft pilot study presented in section 3, but overall found that it provides "...a rather sobering perspective on the possibilities of supplementing depleted Snake River chinook stocks."

Dr. Dennis did not comment on this chapter.

Dr. Saila was "favorably" impressed by the improvements made in this chapter. He suggested a computer model that might be useful for exploring some of the questions identified in section 1. He recommended consultation with a fish geneticist and a physiologist concerning methods for assessing the relative fitness of hatchery-reared and wild fish.

Dr. Walters thought that the chapter presented an "excellent outline" of the issues and uncertainties involved in hatchery supplementation, and suggested that the information provided could be used to develop experimental designs to assess specific effects of concern. He was surprised by the magnitude of difference between wild and hatchery recruitment-per-spawner in the Warm Springs and Imnaha examples. The results suggested to him that the practice of using wild spawners to seed hatchery stock may have had significant adverse impacts on some wild stocks. He recommended using a nonlinear rather than a linear model for the analyses described in section 3. He thought that the approach employed in Chapter 5 might be appropriate.

12. Review of the Influence of Climate on Salmon **[J. J. Anderson]**

Dr. Collie questioned whether the intent of the chapter was to test specific hypotheses about the effects of climate on chinook salmon or to provide a general review of the influence of climate on fisheries. He thought that the chapter left several questions unanswered. In particular, the correlation between the Pacific Northwest Index (PNI) and spring chinook catch was insufficiently explained. Dr. Collie questioned whether the correlation reported in this chapter was consistent with results presented in chapters 4 and 5.

Dr. Dennis did not comment on this chapter.

Dr. Saila thought that the chapter could be "profitably expanded," and questioned the magnitude and significance of the correlation between catch of Columbia River spring cinook and the PNI.

Dr. Walters did not comment on this chapter.

s chapter, which is still incomplete, is intended to address various hypotheses concerning the influence of in-r harvesting on the survival and recruitment of stream-type (spring and summer) chinook in the Columbia er Basin. At present, the chapter consists of a brief statement of intentions and a harvest management decision .

13. Contrasting Stock-Recruitment and Harvest Patterns of the Columbia River Stream-Type Chinook Population **[O. P. Langness and H. A. Schaller]**

Dr. Collie suggested that the decision tree could be useful in setting harvest policies. He recommended development of a summary decision tree, like the one presented in chapter 6, that fits on one page. In his opinion, the key objectives of the tree are to classify each stock according to its present status and to develop/implement an appropriate harvest rate schedule. He thought that all of the studies listed on page 13-1 would be necessary to establish the relationship between stock productivity and harvest rates.

Dr. Dennis did not comment on this chapter.

Dr. Saila liked the layout and organization of the chapter, especially the explicit statement of objectives and definition of terms. He thought that a separate decision tree for upstream migration would be helpful in future drafts.

Dr. Walters did not comment on this chapter.

sions document synthesizes the results of all of the analyses included in the PATH Retrospective Analyses providing provisional answers to four questions:
all stocks show a similar pattern of recent change in stock indicators?
here a difference in (1) upstream vs. downstream stocks, or (2) pre-1970 vs. post-1975?
at are the contributions of each of the factors evaluated in the report to the observed differences?
what extent can management actions under consideration within each of these factors compensate for past

the above questions are presented by summarizing the overall conclusions to date, briefly discussing the r these conclusions, and identifying the information required to address remaining uncertainties.

4.0 Comments on the draft report, *Conclusions of FY96 Reptrospective Analyses*

Because of their familiarity with the PATH process and the technical analyses, the review panel members were asked to review the draft Conclusions document and comment on its consistency with the material presented in the Retrospective Analyses report. The majority of the comments provided by the reviewers were addressed by the PATH Synthesis Team and incorporated in the final version of the document.

Dr. Collie found evidence of a "broad consensus" in the document, emerging from a variety of studies. He endorsed the report's reliance on stock-recruitment analysis in deriving conclusions. He thought that Quesstion 1 should have a more quantitative answer, i.e., that there should be an explicit quantitative hypothesis test to support the qualitative conclusion. Regarding information needs for Question 2, he argued against expanding the analysis to non-Columbia stocks, unless such an analysis would useful for assessing the status of those stocks. He was "excited" the discussion of questions relating to the relative impacts of various potential stressors, because they seemed to be answerable already with a reasonable degree of confidence. He questioned the feasibility of some of the proposed research and assessment tasks. He found the answers to questions relating to the value of management actions to be "equivocal." He thought that the list of proposed prospective studies should have been prioritized based on results of the retrospective analyses. In his opinion, "lip service" is being paid to the idea of adaptive management experiments without consideration of how such experiments might actually be designed.

Dr. Dennis found the conclusionsto be amply supported by the retrospective analysis. It appeared to him that all of the lines of evidence support the hydrosystem as being the most important cause of past impacts. He expressed concern that the writing style was insufficiently clear to be accessible to a managers who are unfamiliar with the details of the full report. He thought that the document should be more self-contained, and more directed at first-time readers. He provided a number of specific suggestions concerning organization, definition of terms and concepts, and level of detail.

Dr. Saila thought the draft accomplished its goals and provides a model for future summary documents. He suggested amplification of the discussion of habitat effects to emphasize the importance of delayed arrival in the estuary. He requested a more thorough explanation of the "star" system used in the report to rate the level of confidence associated with each conclusion and line of evidence. He thought there should be a further prioritization of research needs. In his opinion, the report should acknowledge that similaries between upper and lower river stocks might be spurious statistical correlations. He felt that the "reasonable confidence" rating given to conclusion 1.1 should really be "low." He thought that the rating for conclusion 3a4 should not even be "low," because no evidence is provided to support that conclusion. He reiterated his view that delayed mortality is a critical problem and that a specific research plan to address it shoul be developed as soon as possible. He recommended studies of physiological changes due to migration delays, and possible changes in food availability.

Dr. Walters agreed in general with the findings, and found that the report did a "fine job" of distilling complex issues.   He thought that it is "depressing" that whied differences in performance among subbasins can be clearly shown, conclusions about efficiacy of the main policy options (transportation, hatcheries, and flow management) are very weak. He suggested that unless new ways to monitor overall survival rates from natal stream to estuary are developed, many stocks will disappear before the critical questions are answered. He was disappointed not to see more quantitative analysis of the smolt-to-adult return goals in relation to possible changing ocean survival rates. He thought that the goals might need to be at the upper end or even above the level cited in order to ensure recovery of the stocks. In his opinion, it is unlikely that improvements in CRiSP and FLUSH will help resolve key uncertainties about downstream survival rates.