Puget Sound Technical Recovery Team Technical Comments: Combined Template and Probabilistic Network Analysis

Nisqually Chinook Salmon

This technical feedback has three components:

- Brief summary of results of our review concerning certainty, and discussion and recommendations of factors we believe are critical to address in order to improve certainty of your plan;
- Consolidation of technical reviewers' composite and detailed comments on your June 30th draft; and
- A description of the methods by which we performed the certainty analysis (i.e., the probabilistic network analysis).

The "near-term steps" suggested in Section 1 of the feedback should occur by April 30th, because they will help you finalize your draft chapter. The "long-term steps" should generally occur as you implement your adaptive management program.

I. Summary of Certainty Analysis

The content of this section summarizes the results of our probabilistic network analysis (for description of the approach, see *Section III* of this document.) We view using this certainty analysis in an iterative fashion, to help you in guiding plan revisions. This analysis also will help us strategically track the elements of your plans and how information at each step affects the overall certainty that the proposed actions in your plan will contribute to population and ESU recovery. This section is divided into separate discussions of the certainty in habitat, hatchery and harvest management elements of your plan. You will notice that several questions within each "H" encourage us to check how well the habitat, hatchery and harvest strategies are integrated in the plan. We fully expect that the certainty in your plan's outcomes can be increased by providing more information and documentation—we have highlighted areas we think would be particularly fruitful to focus on in near-term revisions in each section below.

Habitat Strategy

Key Issues to Improve Certainty

The most important ways for this plan to improve the certainty of an effective habitat strategy in the near-term plan are to:

- Highlight where multiple, independent lines of evidence are used to support analytical model linking habitat-forming processes, land-use and habitat condition to Chinook population responses;

- Document assumptions made and inputs to EDT for how habitat-related protection and restoration projects affect in-stream habitat conditions;
- Provide a description for how the habitat recovery strategy is consistent with the strategies for hatchery and harvest management for the Nisqually and south Puget Sound Chinook populations; and
- Develop an adaptive management plan that integrates the habitat, hatchery and harvest management strategies.

Based on our analysis, developing and implementing the key items above would greatly increase the likelihood of a "high" level of certainty for this plan.

Did the analysis use one or multiple independent models to understand potential fish responses to actions? What is the nature of the analytical support for the model linking salmon population status to changes in habitat-forming processes and in-stream habitat conditions?

One model was used for the Nisqually population to evaluate the potential responses of Chinook populations to changes in habitat conditions. The certainty in the analytical model used to link changes in habitat conditions to fish population response in the Nisqually plan is moderate.

The EDT model was used to estimate quantitatively the effects of changes in habitat conditions on all 4 VSP attributes of the Nisqually population. The EDT model did not incorporate quantitative estimates of the effects of changes in habitat-forming processes (e.g., sediment dynamics, riparian function, floodplain dynamics) or land use/land cover conditions on in-stream habitat conditions or on Chinook. The August 2001 Nisqually plan included a good description of the methods for the EDT model. The assumptions for how the EDT model was parameterized for the Nisqually population were not well documented. How the effects of modeled projects were translated into habitat conditions in EDT is not yet summarized in the plan. No sensitivity analyses for EDT appear to have been conducted, so it is not clear how modeled results of the effects of habitat restoration and protection projects on habitat conditions might change under different assumptions. Similarly, no analyses have been conducted exploring the sensitivity of the EDT model results to assumptions about how habitat conditions affect Chinook population status. No calibration of the EDT model in the Nisqually watershed was conducted for current habitat conditions or current Chinook abundance, productivity, or diversity data. No calibrations of the model occurred for the effects of habitat restoration projects or for how Chinook diversity might respond to modeled actions.

Near-term steps to improve certainty:

- Highlight where multiple, independent lines of evidence were used to support analytical model linking habitat-forming processes, land-use and habitat condition to Chinook population responses.
- Document assumptions made and inputs to EDT for how habitat-related protection and restoration projects affected in-stream habitat conditions.

Longer-term steps to improve certainty:

- Conduct sensitivity analyses for EDT so that the relative importance of assumptions and model inputs for estimated effects of recovery actions can be understood.

How well supported are the hypotheses for (1) what VSP attributes are most limiting recovery and (2) the habitat-forming processes or conditions that are limiting population response? What is the nature of the watershed-specific data to support either of those 2 hypotheses?

There is little support in watershed-specific data for the habitat factors estimated to be limiting recovery of the Nisqually population.

The stated hypothesis in the draft Nisqually recovery plan is that juvenile survival and capacity are key life stages limiting population recovery, and if a number of habitat factors (e.g., estuarine capacity, floodplain channelization) are corrected, the Chinook in the Nisqually will recover. The current condition of habitat in the Basin is relatively well conveyed, but information on the function of habitat-forming processes is not provided. Life-stage specific Chinook productivity data are not available, nor are natural-origin spawning, spatial structure or diversity information. In addition, there is very little information in the Basin on the interactions among habitat-forming processes and land use attributes and how they affect the in-stream habitat conditions used in their modeling.

Near-term steps to improve certainty:

- Summarize what is known in the Nisqually Basin about the mechanistic links between habitat-forming processes, land use, and in-stream habitat conditions.
- Document assumptions made about the VSP status of the Nisqually population.

Longer-term steps to improve certainty:

- Collect data on juvenile use of and survival in different habitat types.
- Monitor natural-origin and hatchery-origin Chinook use at different life stages throughout the Basin.
- Monitor and study linkages between habitat-forming processes, land use, and in-stream habitat conditions so that mechanistic links among those can be better understood, protected and restored.

Is the recovery strategy consistent with the recovery hypotheses for population status and key habitat factors limiting recovery?

The habitat recovery strategy in the draft Nisqually recovery plan is not completely consistent with the hypotheses for what population status and habitat, harvest and hatchery problems are limiting recovery.

It is not clear how the habitat strategy stated in the Nisqually plan relates to the hatchery and harvest management strategies for recovery of the Nisqually population and the objectives for harvest in southern Puget Sound.

Near-term steps to improve certainty:

- Provide a description for how the habitat recovery strategy is consistent with the strategies for hatchery and harvest management for the Nisqually population and south Puget Sound Chinook stocks.

Does the habitat recovery strategy preserve options for recovery in all 4 VSP attributes through all of the H's?

The existing adaptive management plan for the Nisqually does not yet state how it will preserve options for implementation of the overall recovery strategy.

The habitat recovery strategy in the draft Nisqually recovery plan contains one of the best adaptive management plans we saw for Puget Sound. Nevertheless, the plan is not yet fully developed, and the plan authors acknowledge there are missing pieces yet to be completed (e.g., p. 56 of the plan, plan transmittal letter July 121, 2004). The habitat recovery strategy protects existing VSP structure and opportunities for future improvements in the "all-H" condition for the Nisqually population. In contrast, there is not a well-developed adaptive management and monitoring program that preserves options for implementation of the all-H strategy.

Near-term steps to improve certainty:

- Include an adaptive management decision framework in the plan that highlights where information from monitoring and evaluation of habitat projects and fish population responses will affect decisions about the overall recovery strategy.

Longer-term steps to improve certainty:

- Use information from monitoring over time to adjust the integrated, all-H recovery strategy as needed.

Are the habitat recovery actions consistent with the recovery strategy?

There is moderate empirical support for the habitat recovery actions identified in the Nisqually recovery plan.

There is some empirical evidence of the effectiveness of the proposed habitat restoration actions in similar settings, but there are few tested applications of projects such as engineered log jams in the broader context of other restoration and protection actions. Although model predictions about the effects of individual actions are available, some conflicting empirical results occur. Very little is understood about how the cumulative effects of the actions interact to affect habitat-forming processes or in-stream habitat conditions. Furthermore, the analysis of the effects of habitat recovery actions does not incorporate uncertainty in assessments. In particular, evidence for the effects of habitat protection measures (e.g., critical areas ordinances, shoreline management plans) is not discussed.

Near-term steps to improve certainty:

- Summarize existing modeled or empirical support for the effectiveness of habitat protection and restoration actions identified in the plan;
- Address instream flows

Longer-term steps to improve certainty:

- Continue to implement a comprehensive monitoring and evaluation program that can track the integrated, cumulative effects of habitat recovery actions over time.

How well have the habitat recovery actions been shown to work?

A clear and logical relationship exists between the "all-H" recovery strategy and the proposed habitat recovery actions in the Nisqually recovery plan.

The major habitat protection and restoration actions identified clearly reflect the major elements of the recovery strategy. The habitat recovery actions logically derive from the spatial and temporal elements of the recovery strategy, and the actions have clear and logical outcomes that are predicted to be consistent with achieving the recovery strategy.

Hatchery Strategy

Key Issues to Improve Certainty

This review is based on the 2001 Nisqually Chinook Recovery Plan. We are aware that the Plan is undergoing extensive revision and that many of the concerns we raise in this review are being addressed.

The most important ways to improve the certainty of an effective hatchery strategy in this plan are to

- Revise the strategy to be consistent with the recovery hypothesis
- Develop and implement a monitoring and evaluation program for the effects of hatchery actions
- Revise actions to be consistent with the new recovery strategy

Based on our analysis, by developing and implementing the key issues identified above, the likelihood of a "high" level of certainty for biological effectiveness would triple.

How well supported is the understanding of the links between hatchery actions and population viability (VSP) characteristics used in the planning (Analytical Support)?

- The analytical support was moderate.
- The co-managers used a qualitative model (e.g. the Benefit-Risk Assessment Procedure cited in co-managers' resource management plan) to understand the potential affects of hatchery actions on populations. The model addressed all VSP criteria. Documentation is available for the basic model structure but not for how local watershed data (as opposed to general information from the scientific literature and expert guesses) were used to calibrate the assessment for the Puyallup River populations. The co-managers also used EDT as a quantitative model to examine the interaction of habitat, harvest, and hatchery production on abundance and productivity. The plan included documentation for the EDT model. Most of the analyses were based on weak inference.

- Key actions for this question are to use better local information to assess the effects of hatchery actions and to develop models that will allow managers to understand how different factors affect the certainty of the results from hatchery management decisions (e.g. through a sensitivity analysis).

How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)

- Support for the recovery hypothesis using watershed specific data for was low.
- This question asks if the watershed has data that has been used to independently support the results of the hypothesis generated by the qualitative analyses. The plan and references cited contained few examples of watershed specific data that supported the recovery hypothesis. This may reflect the logistical difficulties in obtaining accurate demographic information, genetic information, and information in ecological interactions in this river system. This may improve as marking of fish and sampling continues.
- Key action for this question would be to use available data from other watersheds to increase the analytical support and to document the assumptions that would be part of that.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)

- No.
- The plan does a good job of identifying objectives, such as maintaining genetic diversity and minimizing ecological interactions, which address general concerns from hatchery programs that might limit recovery. The current strategy outlined in the recovery plan focuses on maintaining a large, integrated production program to support harvest with a supplementation program of up to 500,000 fish in the tributaries of the river. The TRT concluded that the size of these programs, the expected harvest rates, estimated current productivity from the EDT analysis, and the expected proportion and spatial distribution of hatchery and wild fish in the river do not appear to be demographically or genetically consistent with goal of developing a locally adapted population and other objectives stated in the plan.
- Given the short-tem and long-term goals of the plan, the key action for this question are to revise the recovery strategy to focus on a staged strategy to control the mixture hatchery and wild fish on the spawning grounds and in the brood stock and to ensure treaty harvest.

Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

- Yes
- The TRT concluded the plan preserves options for two reasons. First, the Nisqually Chinook Plan outlines one of the best adaptive management plans we examined. Technically, it is lacking an adequate monitoring program for the effects of the hatchery strategy and actions on VSP characteristics of the population (see recommendation below). However, the TRT was impressed by the structure of plan outlining management goals and tasks to achieve the goals and make management decisions. The TRT believed that the current process of revising the plan to implement a better strategy given new information was evidence that the adaptive management plan could work. Second, the native Nisqually Chinook salmon is assumed to be extinct and much of the genetic diversity of the extant Nisqually Chinook salmon is maintained in the current hatchery program.

- Key action for this question is to develop and implement a monitoring program.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)

- Yes.
- The proposed actions are consistent with the proposed strategy. We note, however, that the actions described in the co-managers' hatchery resource management plan (RMP) and the hatchery and genetic management plan (HGMP) are not consistent with strategy proposed in the recovery plan
- The key action for this question is to revise recovery actions so that they are consistent with a revise recovery strategy.

How well have the recovery actions been shown to work? (Empirical Support)

- Empirical support for the proposed actions is moderate.
- Some evidence exists that these recovery actions may work, although the evidence is not overwhelming. Especially uncertain is the effectiveness of actions to 1) minimize domestication in production hatchery programs such that it minimizes effects on productivity of natural origin fish and 2) to limit potentially negative ecological interactions of hatchery fish (all species) and natural fish.

Harvest Strategy

This evaluation is based on the Nisqually Management Unit profile, pages 168-171 of the Co-managers' Puget Sound Chinook Harvest Management Plan, as well as material presented in the plan submitted by the Nisqually watershed group.

The harvest management portion of the recovery plan is based on the hypothesis that achieving the natural escapement goal of 1,100 combined natural and hatchery origin fish will provide sufficient natural spawning to create a sustainable, locally-adapted Chinook run in the Nisqually River. The escapement goal was determined from an EDT analysis using current conditions of freshwater habitat and recently-observed low marine survival conditions. Using the Beverton-Holt curve for population performance from EDT, 1,100 was identified as the escapement that would produce the maximum yield on a sustainable basis.

Key Issues to Improve Certainty

Key improvements to the harvest management portion of the recovery plan include:

- Integrate harvest and hatchery strategies to provide harvest and allow local adaptation by developing tools to provide harvest and also control the numbers and proportions of natural origin and hatchery origin fish on the spawning grounds and to the hatchery.
- Develop strategy for allowing escapement to increase as habitat capacity and productivity improve.
- Expand harvest analysis to include the effects of harvest on diversity and spatial distribution.

- Gather and analyze population data to support EDT or other modeling efforts' predictions of the effects of harvest actions on VSP characteristics.

Did the analysis use one or multiple independent models to understand potential fish responses to actions?

The analysis used one model, EDT, to determine escapement goal under current conditions.

How well supported is the understanding of the links between harvest actions and population viability (VSP) characteristics used in the planning (Analytical Support)?

- Moderate.
- The model includes qualitative and quantitative descriptions of the link between harvest management and abundance and productivity, but the effects of harvest on diversity and spatial distribution were not well described. Although the general framework of the model was well documented, the sensitivity of the results to variation in the parameter values is unknown. This is especially important because although the model was calibrated using local habitat data, it did not use demographic data.
- Provide assumptions and support for effects of harvest management on diversity and spatial structure. Conduct a sensitivity analysis on the results.

How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)

- Low
- The harvest objective (a fixed escapement) is based on EDT, not empirical data. The plan provided no additional information to support the EDT conclusions.
- If appropriate data are available, the hypothesis for the role of harvest in recovery could be strengthened by presenting independent analyses (e.g. spawner-recruit curves, density dependence relationship, spatial distribution information) that would support EDT analyses. This information should improve as marking and sampling of fish continues.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)

- No
- The harvest management strategy is not consistent with the hypothesis that escapement goal management will lead to a locally-adapted stock. As EDT was the method for modeling harvest effects, this lack of consistency may reflect the inability of EDT to readily address local adaptation and the relative proportion of hatchery and natural origin fish that reproduce in the wild or in the hatchery (see additional technical comments in the Plan review template).
- Developing consistent actions needs to include a consideration of the natural- vs. hatchery-origin status of the natural spawning population and how to integrate harvest and hatchery strategies to provide harvest and allow local adaptation controlling the numbers and proportions of natural origin and hatchery origin fish on the spawning grounds and to the hatchery.

Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

- No
- The harvest strategy does not include consideration of how diversity and spatial distribution will be protected or enhanced. The plan has an excellent framework for an adaptive management plan, however, which will help preserve future options, if the monitoring and evaluation are implemented.
- Develop and implement monitoring and evaluation that includes identification of natural-origin and hatchery-origin components. Develop framework for how escapement goals may change as habitat improves.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)

- Yes
- The proposed actions are consistent with the proposed strategy and some of the short-term objectives. As noted above, the certainty of achieving local adaptation is low.

How well have the recovery actions been shown to work? (Empirical Support)

- Moderate
- There is good empirical evidence that harvest management can control population abundance, spatial structure, and diversity.

II. Consolidated Comments on Technical Review Template

REVIEW TEMPLATE FOR TECHNICAL REVIEW OF DRAFT WATERSHED PLANS

Reviewer's Name: **Puget Sound TRT & Technical Reviewers**

Watershed Plan: **Nisqually**

Populations or ESUs considered: **Nisqually**

Summary
What is the watershed's technical basis to the answer to the questions from the Shared Strategy: (1) What are the major physical and biological changes necessary to meet the population planning targets? And (2) What are the expected changes in H's and fish population responses over the next 5-10 years?

Review of Plan—Overview

The material provided to the Shared Strategy outlines goals, objectives, actions, and costs to recover Nisqually River Chinook salmon. The materials were submitted to the Shared Strategy by the Nisqually Chinook Recovery Team (Team). The recovery team provided two documents for review: 1) the 2001 Nisqually Chinook Recovery Plan (Plan) and 2) Habitat Project Costs in the Nisqually Chinook Recovery Plan. This review focuses on the Plan, which is one of the first steps in an integrated, multi-species planning effort to recover and sustain salmon and the economic, cultural, and aesthetic benefits derived from them in the Nisqually River.

The Plan does an excellent job of organizing goals and objectives into long-term and short-term planning horizons. All the goals are framed as hypotheses, given the assumptions about how landscape level processes, habitat conditions, and harvest and hatchery actions affect the biological characteristics of fish populations. The long-term goals of the plan focus on a 50-100 year time frame. The goals are narrative descriptions and do not include quantitative benchmarks. The technical focus of the plan, however, is on two shorter term planning horizons. Short-term goals focus on a 50 year planning horizon and are also narrative descriptions. The narrative descriptions are a suite of habitat attributes for "properly function conditions" (PFC). The substance of the plan is a technical description of how the Team translated the narrative descriptions of short-term goals into quantitative benchmarks. An action plan outlines objectives to be accomplished within 15 years.

1. What biological and physical changes does the plan state are required for the population(s) in the watershed to achieve their targets?

The Plan does a mixed job of describing the biological and physical changes required to achieve their short-term targets. The plan outlines two basic kinds of changes: 1) Physical and habitat changes that correspond to PFC and 2) biological changes in a locally adapted population to correspond to levels of abundance, productivity, spatial structure, and diversity (VSP characteristics) that might be attained under PFC. The Plan does a good job of describing these population characteristics. Target ranges of abundance and productivity are described in terms of Beverton-Holt spawner-recruit curves that are bounded by different assumptions about the recovery of estuarine habitat. This is an effective way of capturing the uncertainty associated with estuarine recovery. In addition, the plan includes tables with specific abundance, productivity, and diversity targets for different natural production areas of the Nisqually River: Nisqually River mainstem, Mashel River, Ohop Creek, miscellaneous tributaries, and McAllister Creek. This incorporates spatial structure into the goals.

It would be useful for the Plan to include more specificity on three aspects of goals. First, it is difficult for anyone not familiar with both the technical basis of the how the Plan goals were derived and how the TRT planning ranges were derived to see consistency between the numbers identified in the Plan and the numbers identified by the TRT. A short section describing how these are consistent would strengthen the plan. Second, PFC conditions are never defined or described. Including citations to the original concept of PFC (Spence et al. 1996), the NMFS derivation, and the parameters used in the analysis would improve clarity and documentation of the plan. Third, the Plan should include a definition of what is mean by "locally adapted", because this could be an important additional benchmark for judging success, given the history of genetic changes to the historical population and the importance of hatchery production in this system. Scientifically, the term is ambiguous, because local adaptation is a process and locally adapted can mean a state almost anywhere in that process—from possessing unique morphological and behavioral traits as a result of isolation and natural selection in a unique environment to being self-sustaining.

2. What biological goals does the plan aim to achieve (in 5-10 years and over longer term)?

The Plan outlines short-term objectives (1-15 years) in an action plan that includes habitat, artificial production, and harvest. The benchmarks are fish-based, habitat-based, and people-based. The Action Plan prioritizes habitat restoration and protection, defines a hatchery management strategy, and identifies a harvest management strategy that is hypothesized to result in 500 natural-origin recruits.

The expectation is that the identified habitat actions will result in the target VSP characteristics. Habitat actions include: acquisition, restoration of former estuarine habitat, placement of LWD, and land-use restrictions against incompatible uses. The Plan does an excellent job of clearly identifying these.

The short-term action plan for artificial production is more confusing. The action plan defines a strategy, which is to operate hatcheries to maintain a genetically integrated stock resulting in specific numerical objectives for 1) increasing natural spawning in the river and 2) providing for harvest. Additional actions address ways to minimize important risks of hatcheries, such as loss of genetic diversity, domestication, and predation. The action plan does not provide narrative or quantitative benchmarks for determining whether these actions are successful. This lack of narrative or quantitative benchmarks for these actions and the overall "locally adapted" goal contributes to the confusion about whether the hatchery actions are consistent with the goal (see discussion below). The action plan does an excellent job, however, of identifying monitoring needs related to these actions.

The action plan identifies short-term quantitative objectives of pre-terminal fisheries, in-river fisheries, and maintaining treaty fisheries. The action plan does a good job of identifying monitoring needs. An important source of confusion that the Plan needs to address, however, is the relationship between these numbers and short-term recovery goals. For those interested in the plan and who are not well-versed in harvest management, the difference between the maximum-sustainable-yield benchmark of 1,100 and the productivity and capacity goals in Table 5.1 will not be obvious and it will be difficult to judge whether meeting the MSY benchmark is consistent with achieving the targets. Similarly, the consistency between the near-term escapement goal of 500 natural origin recruits, when Table 5.1 suggests a capacity of over 7,000, raises questions about consistency. Explaining the consistency of these numbers will add clarity to the plan.

3. What is the biological RATIONALE for identified actions in all of the H's (i.e., is the "hypothesis-strategy-action" logic presented in the watershed guidance document used?)

<u>Status & Hypotheses</u>

The Plan provides a brief but useful description of historical changes in the status of population and the habitat. The critical threats to the population are described at several levels of resolution. The relative importance of restoration and protection measures for geographic areas are described on page 34; reach attributes are described on page 39, and individual reach and life stages are described in Appendix 6.

Much of the biological rationale for the actions identified in this plan came from analyses using the ecosystem diagnosis and treatment (EDT) model. Based on a suite of rules, the model examines the relationship between land uses, which affect environmental attributes, and the survival of fish. Consequently, the hypothesis of how landscape processes and human intervention affect habitat conditions and fish in Nisqually River is based on the rules in EDT and the characterization of attributes provided by of the analysts. The Plan contains an excellent general description of the model, its structure, and the population dynamic assumptions, but it does not document the assumptions about the links between habitat and fish response. Although it may not be necessary to have extensive detailed assumptions documented in the plan, these should be available to the watershed planners, because the whole plan is based on these assumptions. The attributes used to model the current status of the population and to identify actions focuses on the freshwater and estuarine environment and did not consider nearshore environments, although the Plan does state (page 44) that degradation of the nearshore environment has occurred with significant effects on the performance of the Nisqually population.

An important assumption of the Plan is that the indigenous Chinook salmon populations are extinct. This is justified in Appendix 3. Including existing evidence from genetic analyses would help support this conclusion. The assessment of the current status of the population relies on model predictions from EDT model. Including empirical information on fish abundance, productivity, and distribution would strengthen these assessments and the Plan. The modeled assessments are useful, however, because they provide estimates for all four VSP characteristics (Table 4.4) and these can be compared to the projected results of the 15-year action plan, based on the EDT modeling, which are provided in Table 5.2. An important assumption of using EDT to project future status is that in areas where habitat protection, acquisition, and enhancement are not occurring, the status of the habitat remains at current conditions. In other words, the working hypotheses are that the habitat will be protected and there will be no continued degradation. This assumption is important to be able to assess how much effect the proposed actions could have in order to prioritize them, but it is important that the Plan recognize that the projected status is not a prediction.

<u>Consistency of Strategy with Hypotheses</u>

The general strategic approaches—acquire and restore habitat, promote local adaptation through hatchery management, and use harvest management to allow the population to rebuild—are consistent with the hypotheses of the status and functioning of the population and its environment. The discussion of the general strategy (page 46, protect good habitat, enhance good habitat, restore habitat associated with lost population segments) and the detailed discussion that followed was helpful. However, the links between the diagnosis (page 39) and the actions (appendix 4) could be more explicit. At least one attribute (competition with hatchery fish) that was identified as high priority did not appeared to be addressed in the action plan.

One goal of the recovery strategy is to "develop locally adapted fall chinook" (page 43). As noted above the plan provides an extensive discussion of why the authors believe local adaptation has been lost, but in the TRT's judgment it does not provide a suite and sequence of actions that will result in achieving the goal of a locally adapted stock. In general, local adaptation in a population with gene flow between hatchery and wild components is driven primarily by the relative proportion of wild and hatchery-origin fish reproducing and rearing in the hatchery and wild environments (Lynch and O'Hely. 2001. Conservation Genetics 2:363-378; Ford. 2002. Conservation Biology 16:815-825) and to a lesser extent by strength of selection in these environments. The action plan does identify natural rearing strategies for hatcheries as an action, presumably because it could reduce the strength of selection in the hatchery environment, but it does not address the proportion of hatchery and wild fish on the spawning grounds or in the brood stock. This oversight—which is a major one—probably arises from the assumptions about domestication and local adaptation in the EDT model and it illustrates why it is important for the watershed planners to understand the assumptions of the model.

Preserving Future Options

Overall, the Plan could preserve future options. There are two key issues here. First is how well existing habitat structure and function is protected. The unique geography of the Nisqually River and the focus of the action plan on habitat protection and acquisition may allow better protection than in other watersheds in the Puget Sound. Because the historical Nisqually population no longer exists, most of the genetic diversity of the population now exists in the hatchery component of the population and the action plan and Appendix 3 describe how this genetic diversity can be maintained.

The second key issue is preservation of future options through adaptive management. The Nisqually Plan outlines an adaptive management structure and the beginning of a monitoring and evaluation program targeted at the Plan objectives. Whether it succeeds will dependent on how well it is designed and implemented.

4. What is the empirical or modeled SUPPORT for the answers to question #3? How well do the assessment data for the population status and the H's support the hypotheses proposed?

Addition of empirical data would strengthen the Plan. The Plan does not contain much empirical support for the modeling results. Areas where this would be useful would be: 1) data on current status, 2) stock-recruit analyses could help validate the EDT predictions for current population performance, and 3) genetic data that could support the conclusion that no difference exists between hatchery and natural fish.

5. How are the individual and interacting effects of the H's on the 4 VSP parameters considered for each population? How likely is it that the proposed suites of H actions will achieve the short- and longer-term stated goals? How certain are we in their translation into effects on salmon population VSP?

The use of EDT provides an analytical framework to integrate across habitat, harvest, and hatchery management sectors. As noted earlier, we have doubts about the results of the integration based on the model, because the proposed hatchery actions do not appear consistent with getting to a locally adapted population. The possible suites of actions that might move the population towards local adaptation will require a staged sequence of harvest and hatchery changes that will allow control of the proportion of hatchery and wild fish on the spawning grounds and in the hatchery brood stock, while allowing for harvest. We recommend a revised, integrated analysis. It would be worthwhile in this analysis, to incorporate the ecological effects integrated management, including ecological effects such as competition, predation, and nutrient contribution from carcasses.

The Plan does not provide good information to judge the likelihood of achieving the short and long-term goals. As noted earlier, the projections in Table 5.2 should not be considered predictions, unless all the assumptions of the model are met. There are at least three sources of uncertainty about the model that were not described in the Plan. First is the uncertainty about the parameters that went into the model (parameter estimates and sensitivity analysis). Second is the uncertainty about future conditions, ranging from no degradation of existing conditions to changing climatic conditions. Third is the effectiveness of implementation.

6. How does the plan acknowledge uncertainties and how are they factored into decisions, future actions?

The fundamental approach for addressing uncertainty in this Plan is adaptive management. With implementation of an appropriate monitoring and evaluation program, this will be a major strength of the plan and a model for other watersheds.

7. Make any suggestions for approaches or methods for addressing concerns mentioned above or reducing gaps in the plan.

These are incorporated into answers of the individual questions and the summary of the probabilistic network analysis.

III. Analyzing Certainty of Biologically Effective Recovery Plans

All watersheds in the Puget Sound are unique. Not surprisingly, different watershed planning groups identify different long-term and short-term goals and propose different suits of actions to achieve those goals. The certainty that the actions in every watershed will be biologically effective in moving the populations towards recovery is a key factor in the recovery of the whole evolutionarily significant unit (ESU). Consequently, the Puget Sound Technical Recovery Team (TRT) has focused its analysis of watershed recovery plans on identifying ways to increase the certainty of the plans. The TRT hopes that these analyses will encourage watershed groups to improve the certainty of plans before the TRT does it analysis of the final plans next year.

To provide these analyses, the TRT used a probabilistic network (PN). A probabilistic network is a graphical model that shows how different states of the world of interest—in this case the scientific factors that provide certainty of biologically effective actions—are related (Figure 1). The basic approach is to assess certainty by applying conditional probabilities, which can be expressed as "Given event *b*, the likelihood of event *a* is *x*." In Figure 1, for example, the states of the variables in boxes that point to another variable (e.g. "Use of Independent Models" and "Analytical Support") are the events that condition the likelihood of the states for the latter variable (e.g. "High", "Moderate", and "Low" in the Certainty of the General Fish Response Model). Users provide evidence for the initial conditioning events (or diagnostic nodes); software for PNs use a set of sophisticated algorithms for recalculating the joint probability distributions for all the potentials based on tables of conditional probabilities provided by the analyst (Jensen 2001). Using a PN gave the TRT a rigorous, transparent, repeatable method of analyzing certainty across watershed plans and habitat, harvest, and hatchery management sectors.

Methods

The Puget Sound Technical Recovery Team (TRT) used the PN in Figure 1 to assess separately the certainty of biologically effective actions for each plan in four management sectors, 1) freshwater habitat, 2) nearshore habitat, 3) hatchery production, and 4) harvest. Each assessment also considered how well integrated actions were across categories and how the actions affected characteristics of viable salmonid populations (McElhany et al. 2003). The network graphically shows the logic of how different scientific variables affect the biological certainty of effective recovery plans. The model is based on the TRT's *Integrated Recovery Planning for Listed Salmonids: Technical Guidance for Watershed Groups in the Puget Sound* (http://www.sharedsalmonstrategy.org/files). The network shows that the overall biological certainty of an effective recovery plan depends on the certainty of the recovery strategy (Recovery Strategy), the robustness of the strategy (Preserves Options), and the expected effectiveness of actions chosen to implement the strategy. The certainty of the recovery strategy in turn is conditioned by the certainty of how well we understand the biological, physical, and chemical processes that affect the population (i.e. Recovery Hypothesis), which depends on well recognized sources of scientific uncertainty (Lemons 1996), such as model uncertainty (Use of Independent Models), framing uncertainty and stochasticity (Analytical Support), and empirical support for the hypothesis (Watershed Data Quality). After identifying the model structure, the TRT identified and defined different states of the variables (Tables 1-6).

Conditional probabilities may be derived from frequencies from empirical data, simulation results, or subjective probabilities. When data are too few to parameterize simulation models, use of subjective probabilities is important (Bedford and Cooke 2001) and analysts have developed methods for estimating these (e.g. Ayyub 2001). Using experts to estimate subjective probabilities has inherent biases that can be difficult to control (Kahneman et al. 1982, Otway and von Winterfeldt 1992). Using estimates of conditional probabilities within a logical, transparent model such as a PN

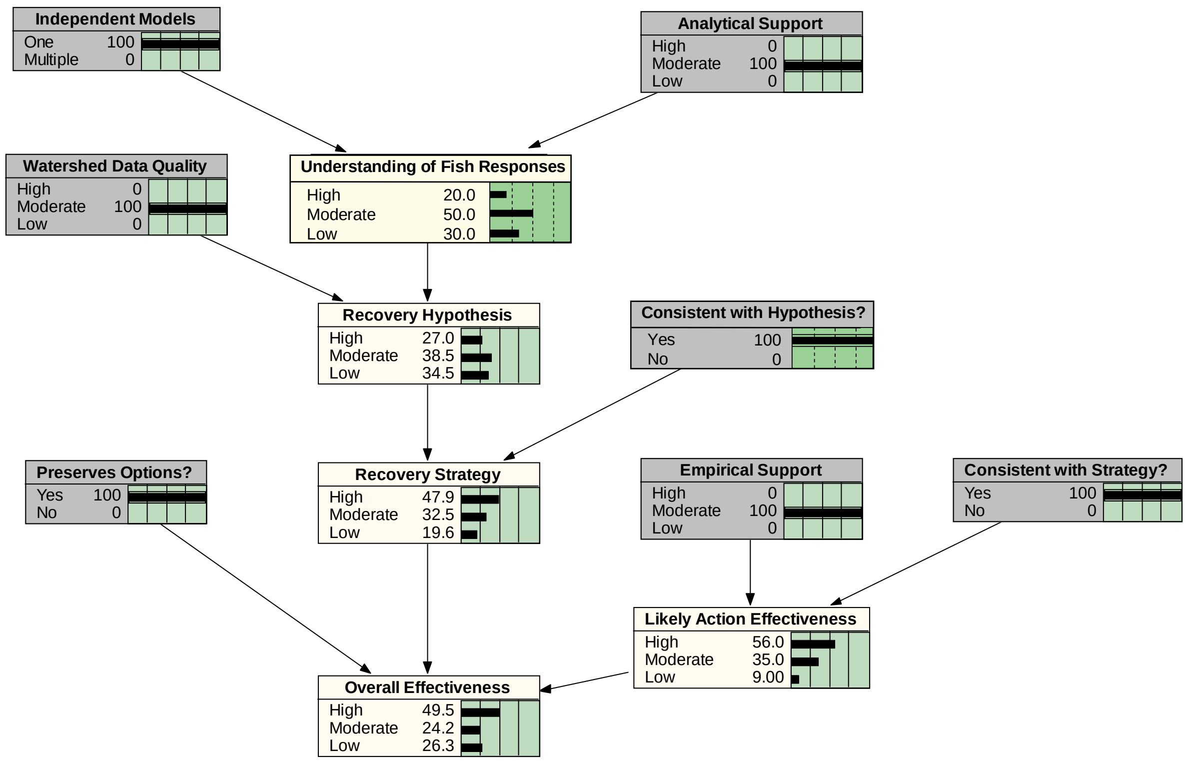

Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.

may reduce these problems compared to asking experts to provide absolute certainty estimates directly without a model. The TRT estimated conditional probabilities using a Delphi process (Helmer 1968, Ayyub 2001) in which TRT members iteratively estimated conditional probabilities individually; the distributions of the results were compiled and shared; and new estimates were generated. Sensitivity of the model was evaluated using the mutual information index (Pearl 1988) which measures the reduction in entropy of variable *A* due to a finding at *B*.

The TRT qualitatively assessed the states of seven diagnostic variables (box titles in parentheses) that address these questions:

1. Did the analysis use one or multiple independent models to understand potential fish responses to actions? (Independent Models)
2. How well supported is the model? (Analytical Support)
3. How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)
4. Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

5. Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)
6. Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)
7. How well have the recovery actions been shown to work? (Empirical Support)

The possible answers to these questions are in Tables 1-6. Reviewers usually choose one state, but if this is not possible because of uncertainty, reviewers could assign probabilities to different states (e.g., "Low" = 10%; "Moderate" = 90%). Analyses were performed using Netica (Norsys Software Corporation, Vancouver, BC; http://www.norsys.com).

Interpreting the Results

Even the best recovery plan is inherently uncertain because the future is so difficult to predict. Consequently, the quantitative estimates of certainty generated by the TRT are less important than the relative improvement that watershed planners need to make. For similar reasons, the quantitative estimates of certainty generated by the TRT are not relevant to analyses of certainty performed by regulatory agencies, which depend on a different interpretation and standard of certainty. Based on the TRT analyses, watershed planners may be able to increase the certainty of biological effectives several fold by focusing on several key factors. These are described in individual watershed analyses.

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Table 1. Attributes for different states of analytical support for models.

Analysis	Total Score	Attributes (Maximum Possible Score)
Habitat Models High Moderate Low	 0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of the relationship landscape processes, landuse, and habitat condition – (0.1 for each analysis) • Qualitative and/or quantitative description of the relationship between habitat condition and population viability (VSP) characteristics – (0.1 for each analysis; 025 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)
Harvest Models High Moderate Low	 0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of link between demographic processes, harvest effects, and population viability (VSP) characteristics– (0.2 for each analysis; 0.05 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)
Harvest Models High Moderate Low	 0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of link genetic and ecological processes, hatchery effects, and population viability (VSP) characteristics – (0.2 for each analysis; 0.05 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)

Table 2. Attributes for different states of the quality of watershed data (support for hypotheses)

States	Attributes
High	• Used empirical population, habitat, and management data from the local watershed at multiple spatial scales to support hypotheses; sources clearly documented; assumptions explained
Moderate	• Used empirical population, habitat, and management data for watersheds or populations within the species' range OR used local watershed data but data highly uncertain or assumptions not well explained
Low	• Used theoretical support for hypothesis or expert opinion based on biological principles and local knowledge of the watershed

Table 3. Attributes for different states of consistency of recovery strategy with recovery hypothesis.

States	Attributes
Yes	Clear and logical relationship between the recovery hypothesis based on processes and conditions for habitat, harvest, and hatcheries and the recovery strategy as evidenced by • Main elements of strategy organized around dominant recovery hypotheses • Elements of strategy reflect spatial attributes of recovery hypotheses • Elements of strategy reflect temporal attributes and action sequencing of recovery hypotheses
No	No clear and logical relationship between recovery hypotheses and strategy; one or more of attributes listed above missing

Table 4. Attributes for different states of preservation of options in the recovery strategy

States	Attributes
Yes	• Strategy protects existing population viability (VSP) structure and opportunities for future improvement in habitat, harvest, and hatchery conditions; adaptive management & monitoring program maintains options for implementing strategy
No	• Strategy does not protect existing VSP structure or opportunities for future improvement in habitat, harvest, and hatchery conditions; adaptive management & monitoring program does not maintain options for implementing strategy

Table 5. Attributes for states of consistency of actions with recovery strategy.

States	Attributes
Yes	• Clear and logical relationship between the short-term and long-term actions and recovery strategy recovery hypothesis • Elements of strategy reflect spatial attributes of recovery hypotheses • Elements of strategy reflect temporal attributes and action sequencing of recovery hypotheses • No strong relationship between fish response models and recovery hypothesis
No	• Actions generally consistent with recovery strategy but major actions are missing or staging of major is inconsistent with recovery hypothesis • Little relationship between actions and strategy; major short-term and long-term actions do not follow from the recovery hypothesis and strategy

Table 6. Attributes of empirical support of recovery actions.

States	Attributes
High	• Evidence for effects of suites of actions (in habitat, harvest, or hatcheries) is clear and unambiguous; broad applications have been tested with similar results; uncertainty incorporated in assessments
Moderate	• Some empirical evidence of effectiveness in similar settings; few tested applications; some conflicting results; predictions of effect do not incorporate uncertainty
Low	• Little or no empirical evidence of the action being effective or appropriate