Snohomish Plan: Skykomish and Snoqualmie Chinook Salmon Populations – November 2004 Technical Feedback

Puget Sound Technical Recovery Team / Shared Strategy

This 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).

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 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.
- Include habitat protection or restoration strategies that take into account the potential effects of water quantity management on flows, temperature, and fine sediment.
- Provide a description for how the habitat recovery strategy is consistent with the strategies for hatchery and harvest management for the Skykomish and Snoqualmie populations.
- Develop an adaptive management plan.

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.

1. *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?*

Two quantitative models were used for each of the Skykomish and Snoqualmie populations to evaluate the potential responses of Chinook populations to changes in habitat conditions. The certainty in the analytical models used to link changes in habitat conditions to fish population response in the Snohomish plan is high.

- This is one of the better plans for describing and quantifying a model for how habitat conditions affect VSP. EDT and SHIRAZ models used to estimate quantitatively the effects of changes in habitat conditions on all 4 VSP attributes of the 2 populations.
- Neither model incorporated 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 Snohomish does have a good qualitative model and quantitative analyses of the potential degrees of impairment of habitat-forming processes in the Basin, and how those might have affected in-stream habitat conditions relevant to Chinook—these are not discussed in the plan.
- Documentation for process analyses and SHIRAZ is good. Assumptions for current path and test case alternatives modeled in SHIRAZ and EDT are well documented. How the effects of modeled projects were translated into habitat conditions in EDT is documented in spreadsheets in the computer, but these methods are not yet summarized in the plan.
- No sensitivity analyses for EDT 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. Sensitivity analyses for how improvements in different life stages affect overall population dynamics have been conducted for SHIRAZ.
- A calibration of the EDT and SHIRAZ models in the Snohomish watershed was conducted for current habitat conditions and current Chinook abundance and productivity data. No calibrations of the EDT 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.

2. *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 moderate support in watershed-specific data for the habitat factors estimated to be limiting recovery of the Skykomish and Snoqualmie populations.

- The stated hypothesis in the draft Snohomish recovery plan is that specific habitat factors are limiting recovery and if they are corrected, the Chinook in the 2 populations will recover.
- The current condition of the habitat and the functioning of habitat-forming processes in the Basin are relatively well understood.
- Life-stage specific Chinook productivity data are not available for either population.
- 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 Snohomish Basin about the mechanistic links between habitat-forming processes, land use, and in-stream habitat conditions.

Longer-term steps to improve certainty:

- Collect data on juvenile use of and survival in different habitat types.
- 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.

3. *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 Snohomish recovery plan is mostly consistent with the hypotheses for what population status and habitat, harvest and hatchery problems are limiting recovery.

- The habitat hypothesis stated in the plan is that key habitat problems in the Snohomish River are limiting recovery.
- The proposed habitat recovery strategy addresses habitat problems such as potential sources of fine sediment and impaired riparian functioning. In contrast, the habitat recovery strategy does not clearly address how changes in water management will affect flows.
- Furthermore, it is not clear how the habitat strategy stated in the Snohomish plan relates to the hatchery and harvest management strategies for what is hypothesized to be needed for recovery of the 2 populations. There is a good start at describing how these 3 H's interact.

Near-term steps to improve certainty:

- Include habitat protection or restoration strategies that take into account the potential effects of water management actions on flows.
- Provide a description for how the habitat recovery strategy is consistent with the strategies for hatchery and harvest management for the Skykomish and Snoqualmie populations.

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

The habitat recovery strategy in the draft Snohomish recovery plan does not have a well-developed adaptive management plan that preserves options for implementation of the overall recovery strategy.

- The habitat recovery strategy protects existing VSP structure and opportunities for future improvements in the "all-H" condition for both populations.
- 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:

- Design and implement a comprehensive monitoring and evaluation program.
- Use information from monitoring over time to adjust the recovery strategy as needed.

5. *Are the habitat recovery actions consistent with the recovery strategy?*

There is moderate empirical support for the habitat recovery actions identified in the draft Snohomish 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.

Longer-term steps to improve certainty:

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

6. *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 draft Snohomish 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

The most important way to improve the certainty for effective hatchery strategy in this plan is to develop and implement an adaptive management plan.

The recovery plan for Snohomish watershed Chinook salmon populations follows a consistent scientific logic. Based on our analysis, the hatchery strategy for the population does one of the better jobs of reducing uncertainty. The major element missing is an adaptive management plan. Implementing the adaptive management plan with monitoring and evaluation of ecological interactions would address some of the uncertainties in the plan. Based on our analysis, by developing and implementing an adaptive management plan, the likelihood of a "high" level of certainty for biological effectiveness would more than double.

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

- 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 model for the Snohomish River populations. Because Snohomish salmon recovery planners are using a population dynamic model, SHIRAZ, to examine a variety of recovery scenarios, they could potentially adapt the model to include a quantitative analysis of hatchery effects, which would allow for sensitivity analyses. This would allow planners to evaluate how their decisions might be affected by uncertainty in different management sector factors that drive recovery. We are aware such analyses exist, and including them in the plan will increase its certainty. In addition, good demographic and genetic data (e.g. straying and interactions with harvest) are available for these populations, which would allow the model to be partially calibrated with

local data. Studies are underway to examine potential ecological interactions in the estuary, but assessment of ecological affects is based on weak inference.
- Key actions for this question are to collect more information on ecological interactions of hatchery and wild fish on VSP characteristics. In addition, exploring results from existing models and further developing models will allow managers to understand how the overall results and certainty of their decisions depend on changes in different actions (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 was moderate.
- This question asks if the watershed has data that has been used to independently support the results of the qualitative analysis. The working hypothesis in this watershed is that the hatchery programs, which are intended to provide harvest, will not interfere with recovery. Demographic and some genetic data supported the watershed recovery hypothesis, but information was lacking for the effects of ecological interactions on VSP characteristics.
- Key actions for this question are to collect more information on ecological interactions of hatchery and wild fish and their effects on VSP characteristics

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

- Yes, but some weaknesses.
- The strategy is to use local stocks and release of hatchery fish at isolated locations to minimize ecological interactions, and to adjust production levels according to escapement and NOR goals in the fishery management plan. This is consistent with the recovery hypothesis for most VSP characteristics. However, the effects of the strategy on spatial structure (e.g. above Wallace River Hatchery) and the effects of the steelhead (e.g. in Tokul Creek) and coho salmon hatchery programs need to be addressed.
- Key actions for this question are to develop and implement a plan to monitor ecological interactions between hatchery and wild fish and their effects on VSP characteristics.

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

- No
- Overall, some of the best data for Puget Sound Chinook salmon comes from the Snohomish watershed. The co-managers are working on an improved monitoring program. Preserving options also requires an adaptive management plan, which does not currently exist except through fishery management processes, to respond to changes and uncertainty as they occur.
- Key action for this question is to develop an adaptive management plan.

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

- Yes

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

- 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—Skykomish population

NOTE: This evaluation is based on the Snohomish Management Unit profile, pages 136-151 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*, as well as material presented in the plan submitted by the WRIA 7 group.

The harvest management portion of the recovery plan is based on the hypothesis that the intrinsic natural productivity of the Skykomish population, under current habitat conditions and recently observed poor marine survival conditions, is sufficiently high to allow for the population to recover if the adult equivalent exploitation rate is less than or equal to the rebuilding exploitation rate (RER) that will guide annual management of this population. The RER for the Skykomish population is .24, which has been adjusted downwards to .21 to reflect the observed discrepancy between exploitation rates estimated directly from coded-wire tag analysis (which the RER calculations used) and exploitation rates estimated by FRAM. The comanagers fitted the observed spawner and recruit data (available in the TRT's Abundance and productivity tables) to three spawner-recruit models and simulated population performance for 25 years with 1000 replications at each exploitation rate tested. The RER was the highest exploitation rate that showed both a smaller than 5% probability of going below the lower escapement threshold of 942 natural spawners in all years and a greater than 80% probability of the population escapement being above the current MSY level at the end of 25 years.

Key Issues to Improve Certainty

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

- Restate or clearly reference in the final recovery plan those aspects of the comanagers' harvest management plan that are essential parts of the recovery plan
- Expand the hypothesis and the recovery strategy to include the effects of harvest on diversity and spatial distribution.
- Include existing local data pertaining to spatial distribution and diversity to support the expanded hypothesis, the expanded strategy, and actions based on the integrated strategy.

Specific ratings:

Was the analysis based on one or many models? One (VRAP).
The harvest management analysis used one model (VRAP) that looks at three different functions for the spawner-recruit relationship.

The analysis could be improved by incorporating another simulation model that could incorporate spatial structure and diversity. The FRAM model incorporates spatial structure, at least of the fisheries, which could then be related to the segments of the population being fished.

Analytical support for model: Moderate.
The model includes qualitative and quantitative descriptions of the link between harvest management and abundance and productivity. In addition, there is a qualitative discussion of the effects of harvest management on diversity. The effects of harvest on spatial distribution are not addressed. The documentation for the quantitative analysis is presented in detail in the Comanagers' Harvest Management Plan appendix. There was some sensitivity analysis performed for model selection but not for parameter estimates. Empirical data from the Skykomish support the model conclusions for abundance and productivity, however the North Fork Stillaguamish is used as an exploitation rate indicator stock because there is no local indicator stock.

- The analysis will be improved in the future using the local indicator stock from the Wallace River hatchery.
- Including some discussion of the potential effects of harvest management on spatial structure would increase certainty.
- Integrated H-modeling could incorporate both diversity and spatial structure in a quantitative assessment of the effects of harvest management. We are aware that the beginning of such an analysis exists in recent results from SHIRAZ modeling, and additional analyses are underway using EDT.

Quality of data used to support recovery hypothesis: Moderate
The recovery hypothesis is supported by local escapement data for the whole population. Recent exploitation rates are well documented for this population, but the exploitation rate assessment uses the North Fork Stillaguamish as an indicator stock. There are good local data on the contribution of hatchery strays to the natural escapement so that escapement trends for natural origin fish can be assessed. There are also local data available to support hypotheses regarding the effects of harvest on diversity and spatial distribution.

- This certainty rating could be increased if the hypothesis were expanded to include diversity and spatial distribution using existing data pertaining to these factors.

Recovery strategy preserves future options: Yes
The harvest strategy appears to protect the existing VSP structure. This is demonstrated for abundance and productivity from recent spawner-recruit data and assumed for diversity and spatial structure because of declining exploitation rates. The harvest management plan has adaptive management built in to it and there is a local Wallace River indicator stock, which can be used to assess exploitation rates and productivity annually once sufficient CWT recoveries are available.

- The plan could be strengthened with a definite schedule for implementing the adaptive management plan, including the conditions under which the RER would be modified.
- If information from the Wallace River indicator stock are used for assessment of this population's exploitation rates (once sufficient CWT recoveries are available), the plan's certainty would increase.

Recovery strategy is consistent with recovery hypothesis: No
The harvest management strategy is consistent with the hypothesis regarding abundance and productivity. However, the hypothesis does not consider diversity and spatial distribution and therefore these are not included in the strategy. Furthermore, the recovery strategy outlined in the Snohomish draft plan is not yet integrated across habitat, hatchery and harvest management approaches.

- If hypothesis and strategy are expanded to include the effects of harvest on diversity and spatial distribution, the plan's certainty will increase.
- A truly all-H integrated strategy does not yet exist in the Snohomish plan. We are aware that the beginning of such an analysis exists in recent results from SHIRAZ modeling, and additional analyses are underway using EDT. If such results are included in the plan to help design an integrated, all-H strategy, the plan certainty will increase.

How certain is the empirical support for the effectiveness of the recovery actions?:
High/Moderate
The recovery plan calls for reduction of the annual exploitation rate to the RER or below. Unfortunately, there is no indicator stock for the Snohomish populations. Results from using aggregate indicator stocks from other populations, FRAM model analysis, and CTC model analysis all indicate that the exploitation rates have been reduced. Escapement has not shown an increase as exploitation rates have been reduced. Skykomish is augmented by good data on the contribution of hatchery fish to this natural escapement. The plan addresses the FRAM model that will be used for annual implementation of the RER and the RER has been adjusted based on a comparison of the FRAM and CWT assessments of the exploitation rate. Management uncertainty is included in estimates of exploitation rates.

- Integrated analysis of the H's is needed to determine cause of escapements not improving significantly.
- Existing data could also be used to document whether reduced exploitation rates can improve spatial distribution and diversity.

Are the harvest management recovery actions consistent with the plan's all-H recovery strategy?: Yes
The harvest management strategy is based on an analysis that incorporates the abundance and productivity that results from existing habitat conditions. The strategy includes a discussion of how guidelines will be modified if improved or degraded habitat changes abundance or productivity.

Harvest strategy—Snoqualmie population

NOTE: This evaluation is based on the Snohomish Management Unit profile, pages 136-151 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*, as well as material presented in the plan submitted by the WRIA 7 group.

The harvest management portion of the recovery plan is based on the hypothesis that the intrinsic natural productivity of the Snoqualmie population, under current habitat conditions and recently observed poor marine survival conditions, is sufficiently high to allow for the population to recover if the adult equivalent exploitation rate is less than or equal to the rebuilding exploitation rate (RER) that will guide annual management of this population. Because it was not possible to fit the observed Snoqualmie data to a model, the same RER was used for the Snoqualmie as for the Skykomish population.

Key Issues to Improve Certainty

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

- Restate or clearly reference in the final recovery plan those aspects of the comanagers' harvest management plan that are essential parts of the recovery plan.
- Expand the hypothesis and strategy to include the effects of harvest on diversity and spatial distribution.
- Include existing local data pertaining to spatial distribution and diversity to support the expanded hypothesis, the expanded strategy, and actions based on the strategy.

Specific ratings:

Was the analysis based on one or many models? One (VRAP).
The harvest management analysis used one model (VRAP) that looks at three different functions for the spawner-recruit relationship.

- The analysis could be improved by incorporating another simulation model that could incorporate spatial structure and diversity. The FRAM model incorporates spatial structure, at least of the fisheries, which could then be related to the segments of the population being fished.

Analytical support for model: Moderate.
The model includes qualitative and quantitative descriptions of the link between harvest management and abundance and productivity. In addition, there is a qualitative discussion of the effects of harvest management on diversity. The effects of harvest on spatial distribution are not addressed. The documentation for the quantitative analysis is presented in detail in the Comanagers' Harvest Management Plan appendix. There was some sensitivity analysis performed for model selection but not for parameter estimates. Because of difficulty is estimating escapement in the Snoqualmie in some years, local escapement data could not be fitted to a spawner-recruit model and therefore the analysis for the Skykomish population had to be carried over to the Snoqualmie.

- The analysis could be improved in the future using the local indicator stock from the Wallace River hatchery.
- Some discussion of the potential effects of harvest management on spatial structure would increase certainty.

- Integrated H-modeling could incorporate both diversity and spatial structure in a quantitative assessment of the effects of harvest management. We are aware that the beginning of such an analysis exists in recent results from SHIRAZ modeling, and additional analyses are underway using EDT.

Quality of data used to support recovery hypothesis: Moderate
The recovery hypothesis is supported by local escapement data for the whole population. Escapements have increased as exploitation rates have declined (the decline is assumed from the analysis of the Skykomish data). There are good local data on the contribution of hatchery strays to the natural escapement so that escapement trends for natural origin fish can be assessed. There are also local data available to support hypotheses regarding the effects of harvest on diversity and spatial distribution.

- This rating could be increased if the hypothesis were expanded to include spatial distribution using existing data pertaining to these factors.

Recovery strategy preserves future options: No
The harvest strategy appears to protect the existing VSP structure. This is demonstrated for abundance and productivity from recent spawner-recruit data and assumed for diversity and spatial structure because of declining exploitation rates. The harvest management plan has adaptive management built in to it and there is a local Wallace River indicator stock, which should be used to assess exploitation rates and productivity annually once sufficient CWT recoveries are available. However, the plan lacks a separate assessment of the status of the Snoqualmie population by itself and there is no adaptive management plan provided for harvest management. Therefore, the adaptive management will not be responsive to changes in the status of this population.

- If the plan includes a definite schedule for implementing the adaptive management plan, including the conditions under which the RER would be modified, its certainty would increase.
- Information from the Wallace River indicator stock could be used for assessment of this population's exploitation rates once sufficient CWT recoveries are available.

Recovery strategy is consistent with recovery hypothesis: No
The harvest management strategy is consistent with the hypothesis regarding abundance and productivity. However, the hypothesis does not consider diversity and spatial distribution and therefore these are not included in the strategy. Furthermore, the recovery strategy outlined in the Snohomish draft plan is not yet integrated across habitat, hatchery and harvest management approaches.

- This rating could be increased if the hypothesis were expanded to include the effects of harvest on diversity and spatial distribution.
- A truly all-H integrated strategy does not yet exist in the Snohomish plan. We are aware that the beginning of such an analysis exists in recent results from SHIRAZ modeling, and additional analyses are underway using EDT. If such results are included in the plan to help design an integrated, all-H strategy, the plan certainty will increase.

How certain is the empirical support for the effectiveness of the recovery actions?: High/Moderate

The recovery plan calls for reduction of the annual exploitation rate to the RER or below. Unfortunately, there is no indicator stock for the Snohomish populations. Results from using aggregate indicator stocks from other populations, FRAM model analysis, and CTC model analysis all indicate that the exploitation rates have been reduced. Escapement has increased slightly on the Snoqualmie spawning grounds, although it cannot be said whether this is a result of reduced harvest rates. Snoqualmie is augmented by good data on the contribution of hatchery fish to this natural escapement. The plan addresses the FRAM model that will be used for annual implementation of the RER and the RER has been adjusted based on a comparison of the FRAM and CWT assessments of the exploitation rate. Management uncertainty is included in modeled establishment of exploitation rates.

- Integrated analysis of the H's is needed to determine cause of escapements not improving significantly.
- Existing data could also be used to document whether reduced exploitation rates can improve spatial distribution and diversity.

Are the harvest management recovery actions consistent with the plan's all-H recovery strategy?: Yes

The harvest management strategy is based on an analysis that incorporates the abundance and productivity that results from existing habitat conditions. The strategy includes a discussion of how guidelines will be modified if improved or degraded habitat changes abundance or productivity.

II. CONSOLIDATED COMMENTS ON TECHNICAL REVIEW TEMPLATE

REVIEW TEMPLATE FOR TECHNICAL REVIEW OF DRAFT WATERSHED PLANS

Reviewer's Name: **Technical reviewers**

Watershed Plan: **Snohomish**

Populations or ESUs considered: **Skykomish and Snoqualmie**

Summary

Overview of Shared Strategy questions and how well the watershed plans address the technical aspects of those questions. In particular, 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

Overall summary of approach, scope of plan (geography, species, populations, ESUs, included), stated goals, participants in plan development, etc.

See p. 3-3 for a list of the Forum members.
This is a multi-species plan, including analyses aimed at improving the status of Chinook, coho, bull trout, and other anadromous species in the Basin. The plan states that the co-managers' recovery planning targets are the goals for the plan, in addition to measures for improving the status of bull trout and coho. To accomplish these, the plan proposes to focus on achieving a set of quantitative recovery milestones for the next 10 years

The plan is organized around sub-basin scale planning, so that the units for which habitat attributes and actions needed are specified are 62 sub-basins within the overall Snohomish Basin. These sub-basins were grouped into 12 sub-basin strategy groupings, based on 3 criteria: sub-basin location, condition of watershed processes and salmonid use (p. 5-3ff).

Harvest management is based on the co-managers' Chinook plan, hatchery management and recent reforms designed to reduce negative effects of hatchery fish on wild fish.

Not yet true H-integration.

The Forum has a clear timeline for revising and completing their plan by June, 2005. At that point, the plan will have gone through a formal process of Forum approval.

Brief narrative of how well the plan addresses the following; including strengths and weaknesses:

1. **What biological and physical changes does the plan state are required for the population(s) in the watershed to achieve their targets? __1, 2, or 3__ pts.**

   For watersheds without targets, what biological and physical changes are needed for the habitat to be considered functioning for anadromous fish?

   I don't see an explicit discussion of this question—the focus of the plan is to describe quantitative habitat condition milestones that need to be achieved in the next 10 years for each sub-basin strategy group. The plan also lists what kinds of actions are consistent with achieving the 10-year habitat milestones.

The Snohomish Plan focuses on the following for physical changes:

1. Improve the habitat quanity and quality in the nearshore, estuary, and mainstem
2. Focus on floodplain connection and complexity
3. Minimize habitat loss and make habitat gains in tributaries
4. Quantitative habitat goals include:
   Tidal marsh, edge habitat, riparian, off-channel, and wood debris.
5. They have specific 10 year habitat gains. Quite a big discrepancy between goals needed by 2015 and 10 years from now for some categories. The physical changes needed are stated, assumptions are relatively clear and there is an attempt to link to the biological change.

The plan does an excellent job of compiling and synthesizing the historical, current, and potential future conditions of the watershed and the associated viability status of the Chinook populations. Multiple analyses are used to characterize the state of habitat-forming processes, habitat conditions, and species relationships and responses to habitat conditions. Over the longer term, the results of the SHIRAZ modeling suggest that the test case scenario approaches the planning targets for the Skykomish and Snoqualmie populations (p. 7-7).

The plan could more explicitly bring forward both a summary discussion of the historical baseline and the projected effects of water quality and quantity regimes on the populations as part of the basis for the required changes discussion.

H-integration is not yet completed in the plan. It states that both harvest and hatchery practices will change with habitat change, but it does not identify any methods, mechanisms, etc. on how that will actually occur. I believe this is where adaptive management needs to be made explicit. Also, it is not clear from an adaptive management perspective, if one component, such as harvest or hatchery practices, triggers an action with another component, such as habitat (or visa versa).

2. What biological goals does the plan aim to achieve (in 5-10 years and over longer term) ____ pts.
What are fish-based and habitat, hatchery or harvest management-based goals?

The long-term vision for recovery in the Basin is to achieve the planning targets set forth by co-managers. These targets are 8,700 (3.4 R:S)-39,000 (1 R:S) for the Skykomish and 5,500 (3.6)-25,000 (1) for the Snoqualmie (Table 4.1 p. 4-3). The SHIRAZ modeling suggest their efforts over the long term will result in the Skykomish population achieving the targets and the Snoqualmie population will be somewhat below the target. There is an excellent discussion of the biological interpretation of the goals as population performance curves in section 4 of the plan. On p. 4-5, the plan also includes a table from the HPVA analysis that reports the number of juvenile migrants associated with high and low productivity population conditions.

The goal section mentions the other 2 VSP parameters—spatial structure and diversity—but does not mention what the plan's goals are for these 2 population attributes. All 4 VSP attributes are mentioned in evaluating the restoration scenarios (current path and test case) in terms of the effects of habitat improvement on spatial structure and diversity. In other words, spatial structure and diversity are considered in choosing a restoration scenario, in spite of the plan not explicitly stating goals up front for those 2 VSP parameters.

Over the next 10 years, the plan proposes to focus recovery efforts on (1) improving habitat quantity and quality in nearshore, estuary and mainstems, and (2) minimizing habitat losses and making gains in the rest of the Basin. In addition, the Forum agreed to pursue 10-year quantitative habitat improvement milestones for tidal marsh, edge habitat, riparian habitat, off-channel habitat, large woody debris, forest cover and impervious area. EDT modeling suggests results from implementing their 10-year actions (projected out over longer term) in Table 7.2, p. 7-7.

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?) _________ pts.

(a) What is the population's current status for all 4 VSP (this should come out under the hypotheses)?

This is not clearly mentioned in one place in the plan. This information is available in the EASC document, but it is not referred to in the plan, and therefore the link between population status and hypotheses, strategies is not clear.

Current status is expressed in terms of recent spawner numbers (Table 4.1, p. 4-7) and EDT modeling (Figs 4.1 and 4.2).

(b) What is the population's predicted status for all 4 VSP over the short- and long-term?

This is stated in the EASC document under the alternatives modeled using SHIRAZ, but it is not mentioned in the plan. EDT results for the short term are reported.

(c) What are critical threats affecting the populations? Have all been identified and considered in the stated hypotheses? Are there potential threats that are missing from the plan? Be explicit about each threat or potential factor limiting recovery.

Habitat

There is an excellent presentation of what general habitat hypotheses should address at the sub-basin and Basin scale (p. 5-1 ff). The stated hypotheses in this early section are very general and not directly linked in this section to a strategy. This link is made more clearly (I think) in the EASC document, and it would be worth bringing the logic into this document to make the linkages more clear. More specific hypotheses (though not stated as such) are mentioned for each habitat factor considered in the alternatives on pp. 5-8ff and very extensively in Chapter 10 for each sub-basin strategy group.

Primary habitat threats needing improvement are described in this plan as: loss of intact riparian forest, blocked stream length by human-caused barriers, off-channel habitat disconnected, loss of edge habitat in natural banks, loss of large woody debris in streams, reduction in forest cover, increase in impervious area, increase in road density, and reduction in total intact habitat. Sub-basin specific descriptions of the relative importance of these habitat threats are provided in Ch. 10. The more detailed threats in Ch. 10 include: pollution/water quality, railroad, shoreline modification, dredging, urban and rural development, pier modification, loss and degradation of forest cover, conversion of forest lands to development, isolation of river from its floodplain, culverts, etc.

The plan also describes very specific projects (e.g. I-5 expansion, RR maintenance, development) as known habitat threats in each sub-basin strategy group in Ch. 10.

It is important to note the way this plan presents threats, in that the focus of habitat impacts in is on how habitat conditions (described generally as quality and quantity) in particular areas have changed and how their improvements might affect VSP. There is not a clear description in this plan between the habitat conditions, processes, or land-uses and the actions/projects that might be implemented to change those habitat features. These linkages are laid out in the EASC in a general sense—i.e., linkages between land-use changes, processes and habitat conditions and their effects on overall population VSP (in the SHIRAZ write up section). An explicit link of projects to expected effect on VSP would be helpful and should be explored.

To answer the question of what are critical 'threats', a discussion of both current habitat conditions and processes is needed, and then in turn, what land use or other actions affect the state of the instream conditions or processes (e.g., is sediment a critical problem? Temperature?)

The plan should summarize an important missing link in its logic (which is contained in the EASC document): what are the current and desired states of salmon population status, what habitat factors are most critical in limiting recovery to VSP goals, and what actions will effectively improve habitat factors so that VSP targets can be achieved?

The importance of watershed processes in contributing to salmon recovery is mentioned throughout the section on habitat hypotheses. GIS-based statistical analyses are used to characterize the likely state of watershed process functioning in sub-basins. The sub-basins are categorized as "intact, mod degraded, or degraded", based on criteria from the literature and empirical relationships between land use and instream habitat condition in the Snohomish.

The plan could be strengthened by an explicit general discussion on the affects of hydroelectric and water diversion facilities, as well as wastewater discharges and non point source loadings. In the latter case, a discussion on the historic baseline for nutrients specific to the role of salmon as a nutrient transport vector is an important missing element of the habitat forming processes technical basis for the plan. Little is currently known about what changes may be needed in the present nutrient loadings relative to historic conditions to support viability and it is important to note this uncertainty in the analytical basis for the plan.

<u>Harvest</u>
There is a well-stated hypothesis for past and present harvest effects on the Snohomish populations (p. 6-1). The details underlying these statements are provided in the co-managers' harvest plan.

<u>Hatchery</u>
The potential effects of hatchery practices (generally and specifically for the Snohomish) are well described in the plan (Ch. 6). It is not stated how well the hatchery management practices fared in the HSRG review and whether any changes in hatchery management suggested by the HSRG are anticipated in the future.

(d) Is the strategy for H management changes consistent with the identified hypotheses for current population status, desired future population status, and primary threats? What elements of the strategy are missing? Be explicit about each threat or potential factor limiting recovery.

The strategies (generally called approaches to recovery throughout the plan) are discussed for each sub-basin strategy group in Ch. 10. The plan mostly does this in the identification of the subbasin strategy groups. There are additional strategies for addressing problems within each subbasin strategy group, but since the particular VSP problem isn't highlighted at that scale, it's difficult to match up the identified habitat problems and VSP status problems with the strategies. The logic isn't absent, it just isn't clearly stated.

For habitat, the restoration projects in each subbasin strategy group are keyed to identified threats within each group. The habitat conservation strategy appears to be missing one element and it insufficiently addresses another. Though increasing water use is noted as a primary management issue for the future, there are no explicit strategies addressing flow regimes needed for habitat functions to support the populations. The element for flow regimes would need to address both hydroelectric facilities and water diversions. While water quality management is discussed, the effects of the water quality factors on the populations are not quantitatively analyzed nor dealt with specifically enough to ensure that regulatory mechanisms will be effectively applied over time to protect and restore habitat functions supporting the populations and to directly protect the inherent productivity of the populations.

Harvest management strategy is based on whole life cycle assessment of population performance under current conditions and therefore addresses the potential threat from harvest management only. It is not possible to evaluate the strategy for harvest and hatchery management, given the detail presented in the plan. A concise statement of how harvest levels or hatchery management practices are adjusted based on desired salmon population goals(or a reference to that effect) would strengthen the plan. Hatchery management is based on measures to reduce risks from identified potential hazards. Several hazards (such as predation and competition) have unknown risks which need to be determined through monitoring.

Explicit linkage between the H's seems to be missing from the strategy. Again, what types of methods can be utilized to make this management link between habitat, hatcheries, and harvest more explicit?

(e) How are actions in the H's linked to fish population status? Both existing and future/planned H actions should be addressed. Are these links based on empirical or modeled estimates or both? Be explicit about each threat or potential factor limiting recovery.

Links between habitat and population seemed to be based on modeled estimates. Hypotheses for how habitat factors affected (or are affecting) VSP parameters in the 2 populations are described in the sub-basin strategy group discussions in Chapter 10. Spatial structure and diversity are rarely explicitly mentioned, although the plan considers them by implication. The hypotheses are typically not stated as such—it would be helpful to explicitly lay them out so that the importance of testing them through the adaptive management program is highlighted.

The watershed process GIS analyses were used to assign sub-basins to a subwatershed strategy grouping, which was then used to identify the types of actions needed to address impaired watershed functioning. These links are described in the EASC document, but not in the plan.

The general approach linking habitat factors to population status is to categorize habitat indicators into 7 types (Table 5.2 p. 5-6) and to explore 5 alternative levels of improvement in those habitat indicators and the resulting effects on VSP (with SHIRAZ). The indicators are altered at the scale of the sub-basin strat groups. The levels of the habitat conditions chosen are based on which strategy grouping is being modeled. Not sure how the actual levels are determined, or what the rationale for those is. EDT translates habitat factors (instream conditions) into stage-specific survival or capacity with its' 'rules', which are documented in a report by Mobrand et al.

A big missing piece of the analysis links is between habitat-related projects and how those affect land-use or instream habitat conditions. This information is embedded in the SHIRAZ and EDT modeling, but it is not clearly documented in the plan materials. These assumptions are very important to be transparent about, so they should be summarized in the plan.

There is not an explicit mention of hypotheses for how harvest affected (or is affecting) each VSP parameter in the 2 populations. Information in the co-manager plan suggests that Monte Carlo simulations are used to predict VSP using the VRAP model—a brief description should be included in the plan.

Hatchery effects on VSP are stated in very general terms—not specific to VSP parameters or magnitude of predicted effects. E.g., it is stated that hatchery releases were reduced, but it is not estimated what the magnitude of the effect of that action might be on any VSP parameter (p. 6-4).

(f) What are the plan's stated assumptions about *fish use*, existing habitat conditions or actions outside of the WRIA jurisdictional boundaries covered in the plan (freshwater and estuarine/nearshore)?

It is stated on p. 4-2 that several other populations of Chinook use Snohomish nearshore habitats, and a citation is given. There are no statements about estuarine/nearshore assumptions. Both EDT and SHIRAZ had to make assumptions about survival and capacity of estuarine/nearshore habitats that Snohomish fish use (which implies an assumption about the habitat conditions in those areas). The write-up for SHIRAZ in the EASC document states what the assumed marine-stage survival rates are in the modeling conducted. EDT assumptions for this stage survival and capacity are available, and should be cited.

Assumptions about nearshore and marine conditions outside of WRIA 7 are not given in detail in the habitat or hatchery plans. Because the harvest plan incorporates full life cycle assessment of population performance under current conditions, it implicitly assumes that these conditions, in sum, will remain as they are now.

(g) Are future options preserved in the proposed strategy-action links? How so? Be explicit about each threat or potential factor limiting recovery.

The plan provides for development of an adaptive management plan to adjust the strategies and actions as needed over the long-term. Linkages between monitoring and the adaptive management decision framework should be more clearly spelled out. The plan specifically provides for a review of the progress towards the habitat milestones and adjustments to the strategies by topic, geographic area or land use as warranted.

Preserving future options in the harvest plan is important because, during the period of recovery, harvest is held below the maximum sustainable level under current conditions (except harvest in Canada could result in exceedance of that level). It would also be helpful to resolve uncertainties in the effects of hatchery management (e.g., effects of predation, competition).

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? _________ pts.

(a) What is the population's current status for all 4 VSP (this should come out under the hypotheses)?

This information is provided in the EASC document and the EDT Appendix (not mentioned in the plan for this question) The population status is based on spawner surveys, information from smolt traps and modeling by the co-managers for the harvest management plan. Since there are no explicitly stated hypotheses for what VSP status is, it's not

possible to tell how well the hypothesis is supported by data or models.
[more helpful clarifying notes for this question from Kit Rawson—contact him.]

(b) What is the population's predicted status for all 4 VSP over the short- and long-term?

The EDT model results suggest % improvements in A, P, and D for each population if the 10-year habitat milestones were implemented. The long-term status for VSP as modeled by SHIRAZ—documentation in EASC Appendix. (See clarifying notes from Kit Rawson.)

(c) What are critical threats affecting the populations? Have all been identified and considered in the stated hypotheses? Are there potential threats that are missing from the plan? Be explicit about each threat or potential factor limiting recovery.

The hypothesized effects of the main habitat factors considered for each scenario are bolstered by a narrative argument, results from the EDT modeling, and references where available—e.g., edge habitat p. 5-10. It is very difficult with the information provided to evaluate the rationale for these threats in the local Snohomish habitats—the references are fairly general or documentation for the habitat inputs to EDT is not available (I think Kit is working with M. Purser to better understand these). In the EASC document, the habitat conditions within specific stream reaches are characterized (as intact, mod degraded, degraded) and the basis for those conditions is contained in the HCR report. This smaller-scale characterization is used to help identify actions at the reach scale, but it is not used to summarize overall what are the primary habitat threats affecting the populations. It is not clear how all of the potential habitat threats are prioritized in any order of importance in re: their effects on VSP. It is very difficult to know how to consider the lists of existing and possible projects in different subbasin strategy groups. It appears that these lists were made based on a combination of biological principles, HCR results, EDT results, and opportunities. They are presented as "recovery tools" and possibilities, but not what will be done (yet).

It is not clear what the Forum plans to do about the listed specific habitat threats for each subbasin strategy group (in Ch. 10). Will the I-5 expansion be mitigated, ignored, or will they promote change in design?

There is no reference for the reasoning underlying the harvest hypothesis—either that past rates likely contributed to declines or that present rates should allow for recovery. This information is documented in the co-managers' harvest plan. (See clarifying notes from Kit Rawson.)

The hatchery hypotheses are supported mainly by literature for the general possibilities of effects. There are narrative arguments for how local hatchery programs might affect Chinook through various means (e.g., competition, predation). The HSRG report alone does not provide enough specifics for local **potential** effects and recommended measures to address negative impacts.

(d) Is the strategy for H management changes consistent with the identified hypotheses for current population status, desired future population status, and primary threats? What elements of the strategy are missing? Be explicit about each threat or potential factor limiting recovery.

The rationale for the habitat strategy comes primarily from what is known in local and more general scientific literature. This information is organized in the EDT model, so those results help guide the strategies for each subbasin strategy group. SHIRAZ also is used to bolster strategies (e.g., p. 10-7 SHIRAZ results suggest improvements in juv rearing will help VSP, so improve rearing habitat in estuary/nearshore is a strategy). It is not clear how the specific habitat improvement milestones to be achieved in the next 10 years were calculated. Are they based on % changes in habitat indicators from the Step 7 table?

The basis for the hatchery and harvest management strategies isn't clear from the information provided in the plan. The co-managers' harvest management plan states that the harvest strategy is based on a statistical assessment of current population performance and Monte Carlo simulation modeling using VRAP. Need to consult Appendix A of comanagers' plan.

The plan does not include clear documentation of hypotheses of potential hatchery effects. See HSRG and BRAP documents.

(e) How are actions in the H's linked to fish population status? Are these links based on empirical or modeled estimates or both? Be explicit about each threat or potential factor limiting recovery.

EDT is used to identify those areas (reaches) that if restored or protected, have the greatest potential to improve population status. EDT inputs include estimates of habitat condition in the reaches, so that is the primary basis for existing habitat quality in particular areas. It is not possible with the information provided to evaluate the basis for (and therefore the certainty of) the information on habitat condition that was part of the input to the EDT model. It is understood that the habitat characterization done in the EASC document (i.e., intact, moderately degraded, degraded) was based on a data standard described in another report (the Habitat Conditions Review) and that some of the data were "expert opinion" and other data on habitat condition were local.

The SHIRAZ model is used to link the action classes (i.e., changes in land use/land cover expressed in the Step 7 table of the EASC document) to changes in habitat condition (via statistical models developed using local Snohomish Basin data) to predicted changes in VSP. The primary habitat factors affected by actions and therefore affecting fish population status in the SHIRAZ modeling were: peak flow hydrology, fine sediments, and incubation and pre-spawning temperatures.

The effects of targeted changes in habitat conditions on VSP are evaluated by EDT, but not the effects of actions/projects that aim to change habitat conditions.

There is not enough information provided in the plan to understand how the effects of harvest and hatchery management on VSP are estimated.

(f) What are the plan's stated assumptions about existing habitat conditions or actions outside of the WRIA jurisdictional boundaries covered in the plan (freshwater and estuarine/nearshore)?

A brief statement of the basis for such estimates should be made (e.g., were samples collected from townetting? Over how many years, places, etc.?)

(g) Are future options preserved in the proposed strategy-action links? How so? Be explicit about each threat or potential factor limiting recovery.

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? ________ pts.

Be sure to make note of the assumptions the plan makes about the effects of hatchery and harvest management, existing habitat actions, and survival in the nearshore/ocean, for ex.

The Forum uses several scenarios, or alternative restoration descriptions, to guide their selection of the suite of habitat actions they ultimately choose. This is an excellent way to explore alternative means of achieving their goals, and also to get a rough estimate of how much habitat improvement is needed to achieve the targets. The habitat conditions (i.e., degree of intact riparian forest, % blocked stream length restored by removal of human-caused barriers, %of disconnected off-channel habitat reconnected, % of edge habitat in natural banks, % of degraded reaches needing engineered logjams, % forest cover for each sub-basin strategy group, % impervious area in sub-basin strategy groups, road density, and % total intact habitat considered under current path and test case scenarios are described on pp. 5-7 ff. The bases for the habitat values chosen for the current path and test case scenarios are not well stated in the plan. A definition of "intact" habitat conditions as listed in Table 5.3 (p. 5-13) would be helpful.

The SHIRAZ model was used to evaluate the effects of the 4 habitat restoration scenarios (plus a 5th, the historical conditions assumed for each, to be used as a baseline condition) on VSP. The plan only states the predicted effects on the planning target values (i.e., A & P)—even though the results from SHIRAZ are presented in re: their effects on all 4 VSP. There is an honest (but brief) discussion of how to interpret/use the results from SHIRAZ. Reference to more extensive descriptions that occur in the EASC should be made. Ongoing SHIRAZ modeling is linking hatchery and harvest management effects with habitat changes—preliminary results should be available in early Fall, 2004.

The interactions of the H's are acknowledged and discussed (pp. 6-5 to 6-7). Some of the interactions are addressed in the individual H sections. Some effects of harvest management (for example on size of fish) and the habitats fish are likely to use have not been addressed. A true integrated H analysis has not been completed as part of this plan. Integrated modeling using SHIRAZ is underway. Building on existing EDT and VRAP analyses also could be used in this context. It is unclear how the proposed set of actions for all the H's combine achieve the short and long-term stated goals. For example, it is assumed that hatchery releases to half the level they were a few years ago has minimized potential risks of predation and competition, yet the report also states that such a study is needed. Was this effect modeled, and if so, what does this effect look like in relation to changes in habitat quantity and quality where both hatchery and wild salmonids interact? The translation to effect thus becomes less certain.

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

(a) Uncertainties in data, information, *and interpretation*?

The EASC document (not referenced in this light in the plan) describes a level of certainty for the habitat conditions they identified to the stream reaches. It's not clear how these certainty levels affected subsequent use of the habitat conditions or ultimate decisions about actions.

There is discussion in the presentation of SHIRAZ results in the EASC document for what sources of uncertainty in model results are and how they should be considered in interpreting results for choice of a restoration alternative. How these uncertainties affected decisions by the Forum are not described in the plan. Another case of uncertainty that is not addressed is what happens when habitat conditions modeled in SHIRAZ (or EDT) to produce the targets are not met? E.g., the plan states that the nearshore improvements modeled in SHIRAZ needed to achieve VSP targets probably can't be met. How will that logistical limitation be addressed/offset?

A clearer description of how uncertainties (in data, model/analysis interpretation) affected or will affect decisions about projects and where to prioritize effort is needed.

The harvest management plan includes consideration of uncertainty in management error, marine survival and freshwater survival.

(b) Uncertainties in environmental conditions in the future?

The harvest management plan includes uncertainty in marine survival. SHIRAZ sensitivity modeling explored the effects of alternative survival and capacity values for the nearshore and marine environments.

(c) Uncertainties in effectiveness of actions?

There is a good discussion in the adaptive management section about how monitoring will be used to improve decisions based on imperfect info about action effects. The discussion is pretty theoretical, so how uncertainty is actually factored in to decisions will be the real test.

The detailed EDT documentation (not included with plan) records all assumptions used regarding effectiveness of actions in each of the scenarios. These assumptions can be checked against actual effectiveness from monitoring in the future.

7. **Reviewer: What is the estimated overall level of risk for the population(s) included in this plan, relative to low-risk (i.e., viable) population criteria? What is your rationale for this risk estimate? How certain are you in the estimation for each VSP parameter?**

The probabilistic network analysis should help inform the answer to this question.

It is hard to judge risk/certainty at this stage, since the actions provided are aimed at addressing the 10-year habitat milestones, not the overall recovery targets. The populations will still be at relatively high risk after the 10-year actions are implemented, according to the EDT modeling. If the land-use changes in the 7 habitat categories modeled under the alternatives in SHIRAZ are implemented over time, the modeling results suggest that both populations will achieve VSP status in the vicinity of the targets. Whether those population statuses actually occur is uncertain (because of simplifying model assumptions), but a good monitoring and adaptive management program should be able to track progress towards the targets.

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

See summary of technical feedback in July, 2004 and summary of 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 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*.

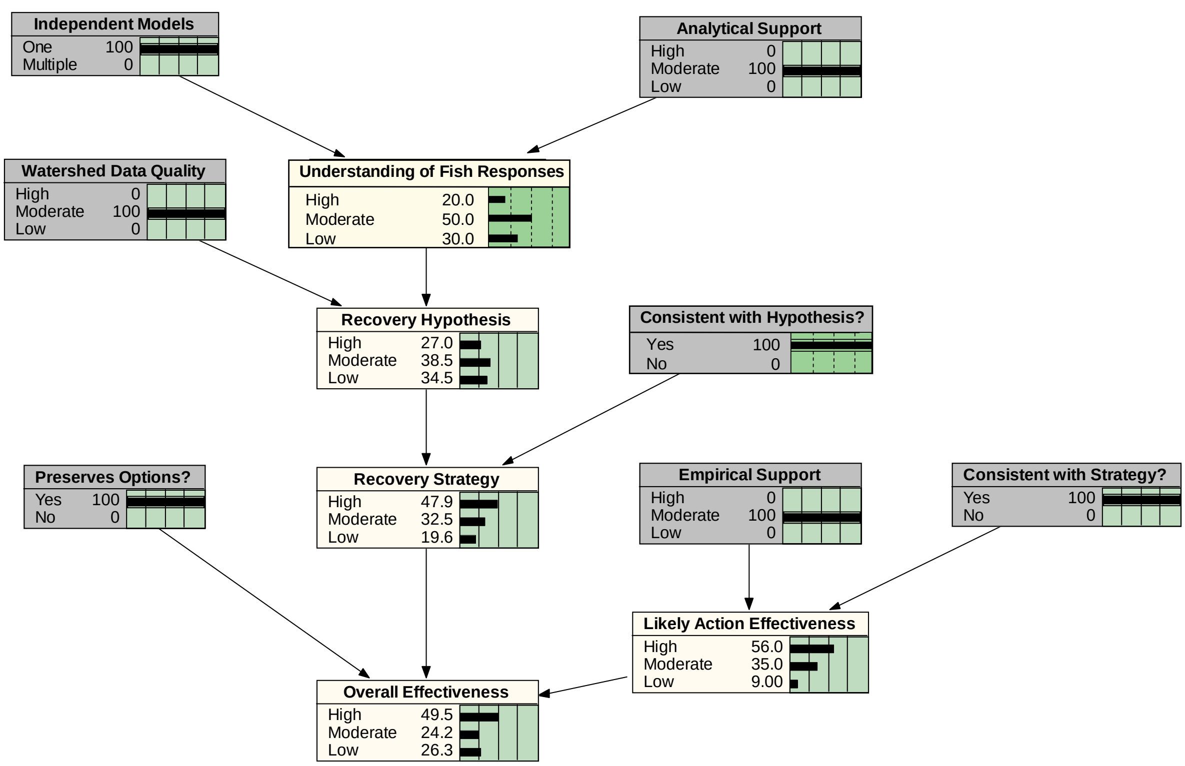

Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.

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.

Literature Cited

Ayyiub, B. M. 2001. Elicitation of expert opinion for uncertainty and risks. CRC Press, Boca Raton, FL.

Bedford, T., and R. Cooke. 2001. Probabilistic risk analysis: foundations and methods. Cambridge University Press, Cambridge, UK.

Pearl, J. 1988. Probabilistic reasoning in intelligent systems: networks of plausible inference. Morgan Kaufmann Publishers, San Francisco, CA.
Jensen, F.V. 2001. Bayesian networks and decision graphs. Springer-Verlag, New York, NY.

Kahneman, D., P. Slovic, and A. Tversky (eds.). 1982. Judgment under uncertainty, heuristics, and biases. Cambridge University Press, Cambridge, UK.

Lemons, J. 1996. Scientific uncertainty and environmental problem solving. Blackwell Science, Cambridge, MA.

Lundquist, C. J., J. M. Diehl, E. Harvey, and L. W. Botsford. 2002. Factors affecting implementation of recovery plans. Ecological Applications 12:713-718.

McElhany, P., M. Ruckelshaus, M. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

Otway, H., and D. von Winterfeldt. 1992. Expert judgment in risk analysis and management: process, context, and pitfalls. Risk Analysis 12:83-93.

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