Nooksack Chinook Salmon – 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

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?

For each of the populations, a single model (EDT) was used to evaluate the response of the Chinook population to changes in habitat conditions. The certainty in this analytical model is no more than moderate given the lack of clear quantitative links among land use, dominant processes, and habitat conditions that produce the fish response.

The EDT model was used to estimate the effects of habitat conditions on all 4 VSP parameters for both the North Fork and South Fork populations. The EDT model, however, did not incorporate quantitative estimates linking habitat-forming processes (e.g., sediment dynamics, riparian dynamics, hydrologic and floodplain dynamics) and land use characteristics to habitat conditions and population characteristics (VSP parameters). Still, there is a good discussion of forestry and land use that could be carried forward via a qualitative or semi-quantitative model to link with habitat-forming processes. Additionally, the watershed is poised to address peak and low flows with a combination of actions including headwater forest management and floodplain connectivity. Documentation for the model inputs is contained in appendices but project inputs for the model remain as digital spreadsheets—the assumptions are not provided or summarized in the body of the plan. No sensitivity analysis of the EDT model is apparent so it is unclear how the modeled effects of habitat projects on environmental conditions would change under differing assumptions. Similarly, no analysis has been undertaken to explore the sensitivity of the model's population results (VSP) to differing assumptions about habitat conditions in the future. No empirical test was performed on the model although one could have been done for abundance and productivity using observed R/S data. Similarly, there is no discussion in the plan about calibration of the model rules and relationships to current habitat conditions in the Nooksack watershed or for chinook abundance and productivity. Likewise, no calibration occurred to fit the model's assumptions to empirical effects of habitat actions or for the VSP parameters of diversity and spatial structure.

Near-term steps to improve certainty:

- Highlight the use of multiple, independent lines of evidence that were used to support the analytical model and the interactions among land use, habitat forming processes, habitat conditions and population response;
- Document assumptions for how the effects of project actions (protection and restoration) affected in-stream habitat conditions.
- Complete analysis that supports actions in the plan that address flows and floodplain management.

Long-term steps to improve certainty:

- Conduct sensitivity analyses for the EDT model to explain the relative importance of assumptions and model inputs for the estimated (modeled) effects of recovery actions on habitat conditions and population parameters.

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

The hypotheses of the plan appear to be that habitat conditions, especially channel structure, riparian condition, and estuary capacity, are limitations to viability (recovery) and that these conditions are mediated through altered habitat-forming processes such as hydrologic and sediment transport dynamics. Data in support of these hypotheses is moderate; although much of this data appears to underlie the EDT model, it is not clearly provided in the plan as support for the hypotheses. There is also quite limited data concerning juvenile use of the estuary on which to base conclusions about capacity. Life-stage specific productivity data is lacking.

Near-term steps to increase certainty:

- Bring forward a summary of the empirical habitat and population data that supports the hypotheses found in the plan. Especially discuss the mechanistic links between land use and the altered processes that drive habitat condition;
- Summarize the existing data for the VSP status of the population.

Long-term steps to increase certainty:

- Collect data on juvenile use and survival in various habitat types in order to evaluate life stage specific productivity; this is particularly important for the estuary. This data should be geared toward evaluating life stage productivity and the capacity of the estuary;
- Use a spatially-explicit model to evaluate the mechanistic links between land use and the habitat forming processes in the Nooksack watershed.

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

In our estimation, the strategy is not entirely consistent with the hypotheses for recovery. The use of engineered log jams is a centerpiece of the long-term riverine strategy but a strategy for increasing capacity in the estuary is lacking. Although there is an assumption that estuary capacity is well above current population requirements—and will be for some time—a complete restoration strategy must include attention to the capacity issues described as limiting recovery. Moreover, there is not a clear linking of harvest and hatchery strategies with the habitat strategy to produce a clearly integrated strategy for recovery. This is particularly important for the South Fork where large scale habitat work could create conditions inhospitable to a small, recovering population for quite some time. How will the harvest and hatchery strategies accommodate the prolonged effects as the habitat readjusts to the re-structuring of the channel and floodplains brought about by the extensive use of ELJs?

Near-term steps to increase certainty:

- Describe, at least in conceptual form, a strategy for addressing the estuarine capacity issues;
- Discuss the habitat strategy implications for harvest and hatchery strategies. Are the strategies consistent in so far as they complement each other?

Does the habitat recovery strategy preserve options for recovery of all four VSP parameters across all Hs?

The recovery strategy in the Nooksack does not have a well-developed adaptive management plan that preserves options for implementation of the recovery strategy.
The lack of such a plan suggests the potential for a strategy from which there may be no effective retreat if conditions predicted by the strategy do not materialize. If this is so, then options are not preserved in the recovery plan.

Near-term steps to increase certainty:

- Include an adaptive management decision framework in the plan that highlights the following elements: strategic goals and objectives, metrics to measure progress toward objectives, nature of the data required to evaluate metrics, criteria for using the metrics to make decisions, alternative pathways for decisions in the attainment of recovery.

Long-term steps to increase certainty:

- Develop the appropriate metrics and evaluation criteria to support the decision framework;
- Design and implement a monitoring and evaluation program to feed the decision framework and adjust the recovery strategy as necessary to achieve the goals.

Are the habitat recovery actions consistent with the recovery strategy?

Except for the as yet-undeveloped strategy and subsequent actions for the estuary, the actions appear to be mostly consistent with the recovery strategy. However, there is some concern that the spatial implementation and sequencing of the actions are not entirely clear nor wholly supportive of the strategy. Such an aggressive habitat strategy cannot be made entirely opportunistic and the sequencing of habitat actions must be carefully considered so that pathological effects on the habitat and population do not result. If such effects are predicted, then the habitat actions may require modification and the hatchery and harvest strategies may require reevaluation.

Near-term steps to increase certainty:

- Describe the sequencing and spatial distribution of the first set of habitat actions proposed by the plan. Discuss the predicted outcomes of these actions on habitat conditions and VSP parameters;

Long-term steps to increase certainty:

- Develop a set of actions derived from the estuarine strategy and evaluate them using a some predictive model such as EDT.

How well have the habitat actions been shown to work?

There is good empirical evidence for the effect of the individual actions proposed by the habitat portion of the plan; however, the magnitude of the cumulative effects of so many ELJs has been little studied. There is an (assumed) expectation that effects from the actions will be mainly positive; that may prove to be true but one should expect some significant changes in habitat structure and rates and magnitudes of various in-channel and riparian processes as the river responds to the renewed LWD loadings. Some discussion of potential negative effects on VSP parameters should be provided in the plan.

North Fork Hatchery Strategy

Key Issues to Improve Certainty

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

- Develop a single hatchery strategy so that the hatchery strategy is consistent with recovery.
- Develop an adaptive management plan.

Based on our analysis, developing and implementing the key items above would increase the likelihood of a "high" level of certainty nearly eight-fold.

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 model for Nooksack River populations. The recovery plan indicates that the co-managers have good genetic and demographic data, which we assumed were used to assess the effects of hatchery actions on abundance, diversity, and to some extent spatial structure. Information to assess the effects of ecological interactions (e.g. competition, predation, and disease) and domestication on productivity and spatial structure appeared to be less available.
- Key actions for this question are 1) better documentation of assumptions of how the analysis was used and 2) using models that will allow managers to assess how the certainty of the results and their decisions is affected by changes in different factors of the model (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 have data that has been used to independently support the results of the qualitative analysis. In the Nooksack River watershed, the co-managers had good genetic information supporting affects of straying on diversity and spatial structure. Most of the information appeared to be inferential or based on local knowledge.
- 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, but could be Yes.

- We received two separate hatchery plans reflecting agreement on some issues and some differences, which left us uncertain of how to evaluate the proposed actions. Our perception is that many of the actions being proposed for the watershed and already taken in the watershed (e.g. reduction in the coho salmon releases, ending fall Chinook production at Kendall Creek, introductions into the Middle Fork) suggest a strategy that should be consistent with recovery.
- Key action for this question is to resolve the differences between the two plans and develop a focused consensus strategy.

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

- Not yet.
- The plan strongly emphasizes preserving genetic diversity, which does preserve future options. Preserving options also requires an adaptive management plan 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
- As noted above, many of the current and proposed actions are consistent with a possible strategy for maintaining the genetic diversity of this population.

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

- Support for the proposed actions is moderate.
- Experience in other watersheds suggests that the actions may work, although there are some conflicting results and uncertainty. Areas that are especially uncertain are 1) the actions to reduce competition or predation, if it occurs, 2) the actions to reduce straying of the North Fork hatchery fish, 3) and the size of the North Fork program given the capacity of the habitat and ability to support natural spawners.

South Fork Hatchery Strategy

Key Issues to Improve Certainty

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

- Develop a single hatchery strategy.
- Develop the details of the hatchery program for South Fork Chinook salmon.
- Develop an adaptive management plan.

Based on our analysis, developing and implementing the key items above would increase the likelihood of a “high” level of certainty nearly 20-fold.

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.
- See the discussion for the North Fork for an explanation.
- Key actions for this question are 1) better documentation of assumptions and 2) using models that will allow managers to understand how the overall results depend on changes in different actions (e.g. through a sensitivity analysis) greatly increase the certainty of analytical support.

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 have been used to independently support the results of the qualitative analysis. The co-managers had good genetic information supporting hypotheses about the effects of straying of North Fork early-returning Chinook salmon and fall Chinook on diversity and spatial structure. This was linked to the changes in habitat in the stream. Other information appeared to be largely inferential or based on local knowledge of the watershed.
- 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, but could be Yes.
- We received two separate hatchery plans reflecting agreement on some issues and some differences, which left us uncertain of how to evaluate the proposed actions. However, many of the actions being proposed for the watershed such as the recovery hatchery program for early-returning South Fork Chinook salmon suggest the beginning of a strategy that should be consistent with recovery. In general, the plan had too little detail on the proposed hatchery recovery program to evaluate whether it would be consistent with the recovery hypothesis.
- There are two key actions for this question. First, we strongly encourage you to resolve the differences between the two plans. Furthermore, we also encourage you to develop the details of the proposed supplementation for the South Fork. The TRT felt a well-designed and operated program that maintains the genetic integrity of the population could contribute to recovery in two ways. First, it could be a short-term solution to the level of straying into the South Fork that is an immediate threat to the population. Second, the hatchery could provide a demographic buffer to the population if the aggressive use of engineered logjams to rehabilitate habitat is not as successful as the planners hope and the intervention leads to short-term loss of spawning habitat until the system equilibrates.

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

- Not yet.

- The plan strongly emphasizes preserving genetic diversity, which is critical for preserving future options. Preserving options also requires an adaptive management plan 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
- As noted above, many of the current and proposed actions appear to be consistent with a possible strategy for maintaining the genetic diversity of this population.

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

- Support for the proposed actions is low, but they could be improved to a moderate level.
- The proposed hatchery actions were too vague to evaluate. There is some empirical evidence from other watersheds that well-designed and implemented recovery hatchery programs can be successful in maintaining populations, but we had too few details to evaluate that (See discussion above). Other areas that are especially uncertain are 1) actions to ensure homing of South Fork Chinook salmon under the proposed supplementation program, 2) actions to reduce competition or predation, if it occurs, and 3) the actions to reduce straying of North Fork early-returning hatchery fish and fall Chinook salmon.

North Fork Harvest Strategy

This evaluation is based on the Nooksack Management Unit profile, pages 85-94 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*, as well as material presented in the plan submitted by the WRIA 1 group.

The harvest management portion of the recovery plan is based on the hypothesis that the intrinsic natural productivity of the NF Nooksack 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). However, it is also acknowledged that due mainly to interceptions of this population north of the border, the spawning escapement is not likely to exceed the lower threshold of 1000. Therefore, the harvest management plan is to maintain the exploitation rate south of the US/Canada border to a level supporting a very minimal set of directed fisheries and incidental impacts in fisheries directed at other stocks and species. The comanagers have postponed calculating an RER for this population since the lower escapement threshold will drive management in the near term.

Key Issues to Improve Certainty

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

- The comanagers move as quickly as possible to assemble the necessary information so that an RER can be computed.

- Until the effects of northern fisheries on this population are adequately addressed, there is a high probability that northern interceptions will impede the ability of this population to recover. Include an approach for addressing those interceptions in the plan.
- The hypothesis needs to be expanded to include the effects of harvest on diversity and spatial distribution and the strategy needs to be expanded to address these factors.
- Existing local data pertaining to spatial distribution and diversity should be brought into the plan to support the expanded hypothesis and the expanded strategy and actions based on it.

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

- One (VRAP).
- The harvest management analysis used one model (VRAP) that looks at three different functions for the spawner-recruit relationship. VRAP is the simulation model that determined the rebuilding harvest rate (RER) and used as inpurt a spawner-recruit relationship that was determined from two models, the Dynamic Model and EDT.
- The analysis could be improved by incorporating another simulation model that could incorporate spatial structure and diversity.

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

- Low.
- The model includes qualitative and quantitative descriptions of the link between harvest management and abundance and productivity. The effects of harvest on diversity and spatial distribution are not addressed. There is no documentation or sensitivity analysis because the analysis has not yet been carried forward to compute an RER. There are some empirical data available to support a model, but these have not yet been used to develop relationships. There is an in-system coded-wire tag group that could be used as an exploitation rate indicator for this population.
- Future analyses should attempt to project the exploitation rate exerted by fisheries north of the border since these have such a large effect on the Nooksack populations.
- There should be some discussion of the potential effects of harvest management on diversity and spatial structure.
- Integrated H-modeling, for example by including harvest and hatchery effects with an EDT assessment, could incorporate both diversity and spatial structure in a quantitative assessment of the effects of harvest management.

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

- Moderate.
- The recovery hypothesis is supported by local escapement data for the whole population. Escapements have increased as exploitation rates have declined. 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, although these aren't assessed in the plan.
- This rating could be increased if the hypothesis were expanded to include spatial distribution using existing data pertaining to these factors.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with 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.
- The hypothesis needs to be expanded to include the effects of harvest on diversity and spatial distribution and the strategy needs to be expanded to address these factors.

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

- No
- The harvest strategy appears to protect the existing VSP structure. However, as the plan acknowledges, the existing condition is critical. 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 does not have adaptive management built in because the comanagers have little control over interceptions north of the border.
- Until the effects of northern fisheries on this population are adequately addressed, there is a high probability that northern interceptions will impede the ability of this population to recover. Therefore, the plan should include an approach for addressing those interceptions.

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

- Yes.
- If appropriate actions to implement the strategy could be found, the strategy is consistent with the habitat and hatchery actions in the plan.

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

- Moderate.
- It is clear from the information presented that spawning escapements can increase somewhat if exploitation rates are reduced. However, it isn't clear that the proposed action (controlling exploitation rates only south of the border) will provide sufficient, or any, overall reduction in exploitation rates.

South Fork Harvest Strategy

This evaluation is based on the Nooksack Management Unit profile, pages 85-94 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*, as well as material presented in the plan submitted by the WRIA 1 group.

The harvest management portion of the recovery plan is based on the hypothesis that the intrinsic natural productivity of the SF Nooksack 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). However, it is also acknowledged that due mainly to interceptions of this population north of the border, the spawning escapement is not likely to exceed the lower threshold of 1000. Therefore, the harvest management plan is to maintain the exploitation rate south of the US/Canada border to a level supporting a very minimal set of directed fisheries and incidental impacts in fisheries directed at other stocks and species. The comanagers have postponed calculating an RER for this population since the lower escapement threshold will drive management in the near term.

Key Issues to Improve Certainty

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

- The comanagers should move as quickly as possible to assemble the necessary information so that an RER can be computed.
- Until the effects of northern fisheries on this population are adequately addressed, there is a high probability that northern interceptions will impede the ability of this population to recover. Therefore, the plan should include an approach for addressing those interceptions.
- The hypothesis needs to be expanded to include the effects of harvest on diversity and spatial distribution and the strategy needs to be expanded to address these factors.
- Existing local data pertaining to spatial distribution and diversity should be brought into the plan to support the expanded hypothesis and the expanded strategy and actions based on it.

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

- One (VRAP).
- The harvest management analysis used one model (VRAP) that looks at three different functions for the spawner-recruit relationship. VRAP is the simulation model that determined the rebuilding harvest rate (RER) and used as inpurt a spawner-recruit relationship that was determined from two models, the Dynamic Model and EDT.
- The analysis could be improved by incorporating another simulation model that could incorporate spatial structure and diversity. Doesn't the FRAM model incorporate spatial structure (at least of the fisheries, which could them be related to the segments of the population being fished)?

How well supported is the understanding of the links between harvest 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. The effects of harvest on diversity and spatial distribution are not addressed. There is no documentation or sensitivity analysis because the analysis has not yet been carried forward to compute an RER. There are

empirical data available from the South Fork demonstrating density dependence and therefore the appropriateness of the Beverton-Holt model.

- Future analyses should attempt to project the exploitation rate exerted by fisheries north of the border since these have such a large effect on the Nooksack populations.
- There should be some discussion of the potential effects of harvest management on diversity and spatial structure.
- Integrated H-modeling, for example by including harvest and hatchery effects with an EDT assessment, could incorporate both diversity and spatial structure in a quantitative assessment of the effects of harvest management.

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

- Moderate.
- The recovery hypothesis is supported by local escapement data for the whole population. Escapements have increased as exploitation rates have declined. 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, although these aren't assessed in the plan.
- This rating could be increased if the hypothesis were expanded to include spatial distribution using existing data pertaining to these factors.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with 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.
- The hypothesis needs to be expanded to include the effects of harvest on diversity and spatial distribution and the strategy needs to be expanded to address these factors.

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- The harvest strategy appears to protect the existing VSP structure. However, as the plan acknowledges, the existing condition is critical. 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 does not have adaptive management built in because the comanagers have little control over interceptions north of the border.
- Until the effects of northern fisheries on this population are adequately addressed, there is a high probability that northern interceptions will impede the ability of this population to recover. Therefore, the plan should include an approach for addressing those interceptions.

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

- Yes.
- If appropriate actions to implement the strategy could be found, the strategy is consistent with the habitat and hatchery actions in the plan.

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

- Moderate.
- It is clear from the information presented that spawning escapements can increase somewhat if exploitation rates are reduced. However, it isn't clear that the proposed action (controlling exploitation rates only south of the border) will provide sufficient, or any, overall reduction in exploitation rates.

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: **Nooksack River, WRIA 1**

Populations or ESUs considered: **N.F. Nooksack Chiook Salmon**
S.F. Nooksack Chinook Salmon

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

A coalition of cities (Bellingham, Blaine, Ferndale, Lynden, Nooksack, and Sumas), Whatcom County, Lummi Nation and Nooksack Tribes, and Washington Department of Fish and Wildlife in Water Resource Inventory Area (WRIA) 1 provided materials for review. The materials were not provided as an integrated recovery plan. Rather, they were provided as a "recovery planning status report." The materials included

- WRIA 1 Responses to the Shared Strategy Questions (Responses)
- Preliminary Draft Recovery Plan (Draft Plan)
- WRIA 1 Salmonid Habitat Restoration Strategy
- An alternate draft of the Hatchery Plan Module
- An alternate draft of the Harvest Plan Module
- Stakeholder Group Comments on the Draft Plan

The lack of a consensus plan and specific differences in the approach and assumptions of some of the material provided make it difficult to answer many of the questions below. For example, some of the materials focus on a multiple species approach, whereas others focus only on early-returning Chinook salmon. Likewise, some of the materials were developed for other processes and although the actions are clearly relevant, they have not been well integrated. The TRT has tried to absorb all of this, however because to the lack of integration, failure to comment on aspects of the material submitted should not be construed as a TRT endorsement.

The June 30 submittal does a good job of organizing goals and objectives into three planning horizons: long-term recovery goals, interim goals (2030, 2055), and short-term goals (2015) for early-returning Chinook salmon. The long-term recovery goals are based on narrative standards that are a suite of habitat attributes for "properly function conditions" (PFC). These standards were quantified and modeled using the ecosystem diagnosis and treatment (EDT) model, which uses a suite of rules to examine the relationship between land uses, which affect environmental attributes, and the survival of fish. Short-term goals are to implement eight key action items during the next 10-year period. Interim goals were based on the expected result in 25 years based on EDT analysis of the key action items. The main focus of the plan is on the short-term actions and 25-year interim results.

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

The submittal does an extensive job of identify habitat changes that would be necessary to achieve interim population goals. Seven of the eight key action items are focused on habitat. These are detailed in a variety of tables in the Draft Plan, Responses, and Restoration Strategy. In developing an overall recovery plan, we recommend that WRIA 1 take a consistent approach to organizing and presenting these actions. This does not appear to be present yet in these materials. For example, the Draft Plan and Responses indicate that list of actions identified have not been prioritized or agreed to, whereas the Restoration Strategy indicates that actions have been prioritized.

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

The short-term goals are to implement eight key actions. The interim 25-year goals are the expected biological results of actions, if the key habitat actions were implemented. The goals are expressed in terms of abundance, productivity, diversity, as modeled by EDT. Goals for spatial structure appear to be limited to the distribution of the two early-returning populations in the North and South forks. Although a gene conservation program in the S.F. was proposed as a key action, it does not appear to have been included in the EDT analysis. No goals were identified for late-returning Chinook salmon.

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 Draft Plan provides an excellent and well documented discussion of the status of the population, the habitat, including limiting habitat factors, and the historical reasons for their decline. Completing the sections that remain incomplete will be a valuable addition to the Plan and important resource.

Part of the biological rationale for the habitat actions identified in this plan came from analyses using the ecosystem diagnosis and treatment (EDT) model. (As noted above, it appears that the rationale for some of the actions provided appear to have been developed in other processes). 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 Nooksack River is based on the rules in EDT and the characterization of attributes provided by of the analysts. The Plan and associated material do not provide much description of the model, its structure, and rules. Although it may not be necessary to have extensive detailed assumptions of the model documented in the plan, these should be available to the watershed planners, because the plan is based on these assumptions.

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 will remain at current conditions. In other words, the working hypotheses is the habitat will be protected and there will be no continued degradation. This assumption is important to be able to compare different proposed actions to prioritize them or to set goals, but it is important that the Plan recognize that the projected status is not a prediction. The Draft Plan does a good job of documenting the links between actions and EDT attributes.

The Draft Plan does a good job of stating the biological hypothesis for the proposed hatchery strategies. This is that given the status of the populations and habitat, properly operated artificial production programs that use principles of conservation biology, ecology, and fish culture can maintain abundance and the genetic diversity of threatened populations for conservation and harvest. It describes guiding principles drawn from a variety of different sources, including the scientific literature, co-manager plans, and guidelines advocated by the Hatchery Scientific Review Group (HSRG). The Alternative Draft also contains some of the same guiding principles.

The Draft Plan does a good job of stating the fishery management hypothesis for the proposed fishery programs. This is that under appropriate fishery management, harvest will not cause further decline or inhibit recovery of the stocks. It describes guiding principles and fishery management process and agreements under which fishery management occurs. The Alternative Draft also contains some guiding concepts, but primarily describes historical and current patterns in harvest and population abundance.

Consistency of Strategy with Hypothesis

The general strategic approach for habitat is consistent with the understanding of how landscape processes and human activities affect fish habitat and the potential response of fish to habitat changes. It is not clear to the TRT that the artificial production strategy is consistent with the hypothesis for two reasons. First, we received two apparently competing hatchery plans, which left us uncertain of how to evaluate what the proposed actions and strategies were. Our perception is that many of the actions being proposed for the watershed and already taken in the watershed (e.g. reduction in the coho salmon releases, ending fall Chinook production at Kendall Creek, introductions into the Middle Fork, a proposed gene bank program in the South Fork) suggest a strategy that should be consistent with recovery. Based on our understanding of the status of the populations, we believe artificial propagation is an important tool for preserving options for recovery. Although we did notice a difference in approach between these two plans, we strongly recommend that the differences between these two plans be resolved as soon as possible in favor of an integrated strategy that supports recovery. The same recommendation applies to the two harvest plans that were provided.

Preserving Options

Overall, the plan could preserve future options, but it does not do so now. There are three key issues here. First is how well existing habitat structure and function are protected. The interim goals based on EDT model projections assume that habitat will be protected. Although the Plan cites a variety of regulatory mechanisms that could protect habitat, it is not clear to us that these will be effective.

Second, in our opinion the proposed gene banking program proposed for the South Fork is an important strategy for preserving options for recovery of that population. There are two reasons for this. Operated the right way, the program could maintain abundance and conserve the remaining genetic resources of the population until the immediate threat of straying and interbreeding from North Fork Chinook salmon and fall Chinook salmon can be controlled. In addition, the program could provide an important refuge for these fish while the stream responds to the aggressive use of engineer log-jams (ELJ). A potential risk of the ELJ habitat rehabilitation approach is that it could temporarily disturb spawn gravels and further threaten the stock.

Third, adaptive management is essential for preserving future options. The Draft Plan and submitted material do not describe an adaptive management plan. We recommend that this be completed in the plan.

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, which does not contain much empirical support for the habitat modeling results. The Alternate Harvest Plan provides some empirical support for the harvest conclusions. Likewise, the Draft Plan contains some demographic and genetic information on the populations as well as information on response of the North Fork population to hatchery supplementation.

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 a potential analytical framework to integrate across habitat, harvest, and hatchery management sectors for setting goals but it is not as useful as a dynamic model for integrating or prioritizing actions across management sectors (habitat, harvest, and hatcheries). This kind of analysis of was not done. We recommend a revised, integrated analysis.

The Draft Plan does not provide good information to judge the likelihood of achieving the short and long-term goals. As noted earlier, the interim 25-year projections 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 Draft Plan that make it possible that the goals will not be met. 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 plan needs to do a better job of acknowledging and planning for the unexpected. More of the TRT thoughts on uncertainty are in Section I for our full comments to the WRIA 1.

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

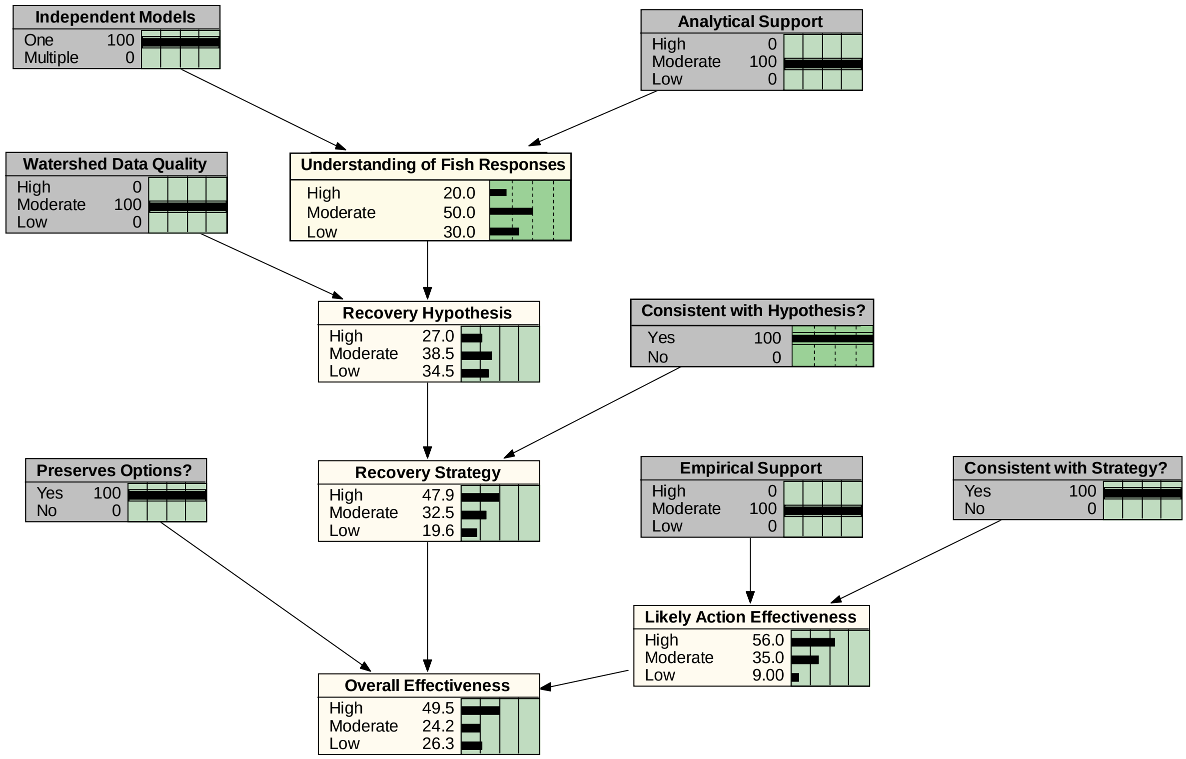

Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.

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.

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