# PUGET SOUND TECHNICAL RECOVERY TEAM TECHNICAL COMMENTS:
# COMBINED TEMPLATE AND PROBABILISTIC NETWORK ANALYSIS

## Hood Canal Chinook Recovery Plan

This technical feedback has three components:

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

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

## I. SUMMARY OF CERTAINTY ANALYSIS

The content of this section summarizes the results of our probabilistic network analysis (for a description of the approach, see *Section III* of this document.) We suggest 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 the 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 - Skokomish*

No recovery plan for Chinook in the Skokomish River Basin was provided for technical review.

#### *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:

- Present short- and long-term recovery goals for the Chinook population(s) in the Skokomish River.

- Present hypotheses for which of the 4 VSP parameters are most limiting the recovery of the Chinook population(s) in the Skokomish.
- Present hypotheses for which habitat-forming processes or conditions, if protected or restored, have the greatest potential to recover the population(s).
- Provide a description of a habitat recovery strategy that will address the hypothesized problems with population status and habitat factors.
- Provide a description for how the habitat recovery strategy is consistent with the strategies for hatchery and harvest management for Hood Canal salmon.
- Develop an adaptive management plan that integrates the habitat, hatchery and harvest management strategies.

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

***Did the analysis use one or multiple independent models to understand potential fish status and responses?***

- No model was presented for the Skokomish chinook population(s) to describe the potential responses of the population(s) to changes in habitat conditions.

***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? (Analytical Support)?***

- No hypotheses for VSP attributes or habitat factors limiting recovery of the Skokomish Chinook population(s) were provided.

***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? (Watershed Data Quality)***

- No hypotheses for VSP attributes or habitat factors limiting recovery of the Skokomish Chinook population(s) were provided.

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

- No habitat recovery strategy was presented for the Skokomish Chinook population(s).

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

- No habitat recovery strategy was presented for the Skokomish Chinook population(s). There was no description of an adaptive management plan for the Skokomish Chinook population(s).

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

- We cannot determine whether a clear and logical relationship exists between the "all-H" recovery strategy and the proposed habitat recovery actions, since no strategy was presented.

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

- Since no habitat recovery strategy for the Skokomish Chinook population(s) was presented, we cannot evaluate whether actions are consistent with the strategy.

## *Habitat Strategy – Mid-Hood Canal*

***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:

- Present hypotheses for which of the 4 VSP parameters are most limiting the recovery of the Chinook population in mid-Hood Canal.
- Present hypotheses for which habitat-forming processes or conditions, if protected or restored, have the greatest potential to recover the population.
- Provide a description of a habitat recovery strategy that will address the hypothesized problems with population status and habitat factors.
- Provide a description for how the habitat recovery strategy is consistent with the strategies for hatchery and harvest management for Hood Canal salmon.
- Develop an adaptive management plan that integrates the habitat, hatchery and harvest management strategies.

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

***Did the analysis use one or multiple independent models to understand potential fish status and responses?***

- No model was presented for the Mid-Hood Canal chinook population to describe the potential responses of the population to changes in habitat conditions.

***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? (Analytical Support)?***

- No hypotheses for VSP attributes or habitat factors limiting recovery of the Mid-Hood Canal Chinook population were provided.

***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? (Watershed Data Quality)***

- No hypotheses for VSP attributes or habitat factors limiting recovery of the Mid-Hood Canal Chinook population were provided.

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

- No habitat recovery strategy was presented for the Mid-Hood Canal Chinook population.

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

- No habitat recovery strategy was presented for the Mid-Hood Canal Chinook population(s). There was no description of an adaptive management plan for the Mid-Hood Canal Chinook population(s).

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

- We cannot determine whether a clear and logical relationship exists between the "all-H" recovery strategy and the proposed habitat recovery actions, since no strategy was presented.

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

- Since no habitat recovery strategy for the Mid-Hood Canal Chinook population(s) was presented, we cannot evaluate whether actions are consistent with the strategy.

## *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:

- Refine the recovery hypothesis
- Integrate the recovery strategy across all management sectors (habitat, harvest, and hatcheries) to achieve VSP characteristics of the population.
- Develop and implement a monitoring and evaluation program for the effects of hatchery actions.

Based on our analysis, by developing and implementing the key issues identified above, the likelihood of a "high" level of certainty for biological effectiveness would increase 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 effects of hatchery actions on populations. The model addressed all VSP criteria. Documentation is available for the basic model structure but not for how local watershed data (as opposed to general information from the scientific literature and

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

***How well supported are 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 hypothesis generated by the qualitative analyses. The recovery hypothesis for the mid-Hood Canal population was not well defined. Based on the recovery plan, it was unclear to the TRT what factors are hypothesized to be limiting viability of this population and how that might be relevant for identifying a recovery hatchery strategy. Few data are available from the mid-Hood Canal population to support the recovery hypothesis. Most of the information appeared to be inferential or based on local knowledge.
- The key action for this question would be to refine the recovery hypothesis ad 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 hypotheses for population status and key habitat factors limiting recovery? (Consistent with Hypothesis)***

- No
- The proposed strategy is to use hatchery supplementation to restore natural spawning and recovery in conjunction with producing fish for harvest. The plan did not provide enough details to show how the interactions of different hatchery programs, harvest, and available habitat were an integrated strategy for recovering a viable population.
- The key action for this question is to provide more detail on how the recovery strategy integrates across all management sectors (habitat, harvest, and hatcheries) to achieve VSP characteristics of the population.

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

- No
- Many of the changes in hatchery management undertaken by the co-managers in recent years will help preserve and increase options for recovery. 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 and implement an adaptive management program.

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

- Yes

- Many of the changes in hatchery management undertaken by the co-managers in recent years are consistent with the recovery strategy. These include managing for population structure between Skokomish River and Mid-Hood Canal regions, use of local brood stock for a supplementation program, reductions in production, elimination of net pens, and delayed release of other hatchery species that could prey on listed populations.

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

- Empirical 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 other stocks into population, 3) actions to reduce domestication and loss of productivity in hatchery fish spawning in the wild, and 4) the size of the programs given the capacity of the habitat and ability to support natural spawners.

## *Harvest Strategy - Skokomish*

NOTE: This evaluation is based on the Skokomish Management Unit profile, pages 172-177 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*, as well as material presented in the plan submitted by the Skokomish watershed group.

The harvest management portion of the recovery plan is based on the hypothesis that decreased exploitation rates are contributing to increased escapement levels and that a current escapement goal of 3,650 fish supports current habitat conditions; this includes both hatchery and in-stream spawners.

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

- Develop exploitation rate guidelines based on productivity and abundance estimates of the Skokomish Chinook population.
- Broaden the hypothesis to include the effects of harvest on diversity and spatial distribution.
- Broaden the strategy to also address diversity and spatial structure.
- Incorporate existing local data pertaining to spatial distribution and diversity to support the expanded hypothesis and the expanded strategy and actions based on it.

***Was the analysis based on one or many models?***

- One – qualitative relating exploitation rates estimated from FRAM using the George Adams indicator stock with escapement estimates.

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

- Low

- The model includes qualitative descriptions of the link between harvest management and abundance and productivity. The effects of harvest on diversity and spatial distribution are not addressed.
- Quantitative estimates of a rebuilding exploitation rate for the Skokomish Chinook population have not been developed. There is also no information presented on the breakout of escapement into natural-origin and hatchery-origin components.
- 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 are the recovery hypotheses with watershed specific data? (Watershed Data Quality)***

- Moderate
- The plan states that a spawner abundance of "50% of the current MSY estimate…represents a level necessary to ensure in-system diversity and spatial distribution (Magnuson-Stevens Act, National Standard for Overfishing Review Threshold)." Certainty could be increased by discussing the derivation of this guideline and the rationale for its application to the Skokomish Chinook population.
- Data are available for total escapements, but are not calculated for hatchery versus natural components; therefore, no estimations are made as to effect of harvest on the natural component.

***Is the recovery strategy consistent with the recovery hypotheses? (Consistent with Hypothesis)***

- No
- The strategy places a limit on the exploitation rate in Southern US fisheries, not on the total (all fisheries) exploitation rate.
- The strategy does not address the effect of harvest on the diversity and spatial structure VSP parameters.

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

- No
- The harvest strategy does not include any consideration of whether the natural component of the escapement is being protected or how diversity and spatial distribution will be protected or enhanced.
- An adaptive management plan for harvest management is not provided.

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

- Yes, probably.
- Estimates of exploitation rates in Southern US fisheries are not presented.
- The most recent post-season FRAM analysis presented, 1998, indicates that total exploitation rates were less than 20%.

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

- Moderate

- The effects of the harvest plan on diversity and spatial structure have not been evaluated. Uncertainties in the effects of habitat and hatchery management have not been incorporated into the analysis used to derive the harvest management guideline.

### *Harvest Strategy – Mid-Hood Canal*

NOTE: This evaluation is based on the Mid-Hood Canal Management Unit profile, pages 178-180 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*, as well as material presented in the plan submitted by the Mid-Hood Canal watershed group.

The harvest management portion of the recovery plan is based on the hypothesis that the stocks comprising this population are all at low levels and cannot withstand much harvest.

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

- Develop exploitation rate guidelines based on productivity and abundance estimates of the Mid-Hood Canal Chinook population.
- Broaden the hypothesis to include the effects of harvest on diversity and spatial distribution.
- Broaden the strategy to also address diversity and spatial structure.
- Incorporate existing local data pertaining to spatial distribution and diversity 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 status and responses?***

- One or none? There is no indicator stock to estimate exploitation rates, although George Adams is used as a surrogate.

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

- Low
- The model includes qualitative descriptions of the link between harvest management and abundance and productivity. The effects of harvest on diversity and spatial distribution are not addressed.
- Quantitative estimates of a rebuilding exploitation rate for the Mid-Hood Canal Chinook population have not been developed. There is also no information presented on the breakout of escapement into natural-origin and hatchery-origin components.
- 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 are the recovery hypotheses with watershed specific data? (Watershed Data Quality)***

- Moderate

- There is no indicator stock for the Mid-Hood Canal population and it is not known if George Adams is an adequate indicator stock. The plan states that the terminal harvest rates for Mid-Hood Canal and Skokomish would be different due to location of fisheries within Hood Canal. There is no estimate of hatchery versus wild component of the natural spawners.
- The plan should indicate how it will be possible to assess the natural- and hatchery-origin components of natural escapement and how this will be applied to revised assessment for the harvest management model.

***Is the recovery strategy consistent with the recovery hypotheses? (Consistent with Hypothesis)***

- No
- The strategy places a limit on the exploitation rate in Southern US fisheries, not on the total (all fisheries) exploitation rate.
- The strategy does not address the effect of harvest on the diversity and spatial structure VSP parameters.

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

- No
- The harvest strategy does not include any consideration of how diversity and spatial distribution will be protected or enhanced.
- An adaptive management plan for harvest management is not provided.

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

- Yes, probably.
- Estimates of exploitation rates in Southern US fisheries are not presented.
- The most recent post-season FRAM analysis presented, 1998, indicates that total exploitation rates were less than 20% for the Skokomish population.

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

- Moderate
- The effects of the harvest plan on diversity and spatial structure have not been evaluated. Uncertainties in the effects of habitat and hatchery management have not been incorporated into the analysis used to derive the harvest management guideline.

## II. REVIEW OF TECHNICAL CONTENT

**Reviewer's Name**: **Technical Reviewers**

**Watershed Plan**: **Hood Canal**

**Populations or ESUs considered**: **Skokomish and Mid-Hood Canal Chinook**

**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.

| | |
|---|---|
| ***Format:*** | Document prepared by WDFW, PNPTC, Skokomish Tribe, and Port Gamble S'Klallam entitled "Co-managers Input to the Hood Canal Salmon Recovery Chapter". |
| ***Scope:*** | Skokomish and Mid-Hood Canal Chinook salmon populations. |
| ***Participants:*** | WDFW, PNPTC, Skokomish Tribe, and Port Gamble S'Klallam |
| ***Goal:*** | Quantitative goals have been established for the watershed-specific components of the Mid-Hood Canal population: 1) Hamma Hamma River 250 spawners at 3.0 adults per spawner and 1,000 spawners at 1.0 adult per spawner; 2) Duckabush River 325 spawners at 3.0 adults per spawner and 1,200 spawners; and 3) Dosewallips River 750 spawners at 3.0 adults per spawner and 3,000 spawners at 1.0 adult per spawner. Goals have not been established for the Skokomish population. |
| ***Summary of Approach:*** | The plan summarizes information from other existing documents, including the hatchery and harvest resource management plans, the Summer Chum Salmon Conservation Initiative (SCSCI), the Hood Canal Coordinating Council Salmon Habitat Recovery Strategy, and Limiting Factor Analysis. |

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

   The plan reports results from EDT modeling where "PFC-plus" conditions were used as inputs (i.e., PFC in freshwater and "pristine" estuarine conditions) to define a planning target for the Mid-Hood Canal population. The extent of actions necessary to achieve those targets has not been determined. Planning targets for the Skokomish River have not been established. The plan states that "litigation between Tacoma City Light and the Skokomish Tribe is in progress and currently serves as a obstacle to recovery planning (including the setting of recovery goals) for the watershed."

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

   Quantitative goals have been established for the watershed-specific components of the Mid-Hood Canal population: 1) Hamma Hamma River 250 spawners at 3.0 adults per spawner and 1,000 spawners at 1.0

adult per spawner; 2) Duckabush River 325 spawners at 3.0 adults per spawner and 1,200 spawners; and 3) Dosewallips River 750 spawners at 3.0 adults per spawner and 3,000 spawners at 1.0 adult per spawner. Goals have neither been established for the Skokomish population, nor for the spatial structure or diversity of either of the populations.

**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?)**

The hypothesis-strategy-action approach is not used in this plan.

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

The plan discusses population status by providing the SaSI stock status and annual escapement from 1993 through 2003:

| Population | Average Natural Spawners 1993-2003 | SaSI Status |
|---|---|---|
| Skokomish | 1,162 | Depressed |
| Mid-Hood Canal [1] | 303 | Critical |

[1] Excludes 1996 and 1997 when limited or no estimates were available

Genetic analysis suggests that "returns to the Hamma Hamma River are not genetically distinct from the Skokomish River returns, or recent George Adams or Hoodsport hatchery broodstock…The reasons for this similarity are unclear, but straying of chinook that originate from streams further south in Hood Canal, and hatchery stocking, could be contributing causes." Productivity and spatial structure of the populations are not discussed.

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

Predicted populations status is not addressed because the benefits of actions have not been analyzed.

(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.

General habitat threats identified in the SCSCI are described as: 1) riparian degradation; 2) instream habitat degradation; 3) floodplain diking; 4) degradation and loss of estuaries. The plan also noted three other high priority regional concerns: 1) physical blockages, destruction of habitat, and functional degradation of estuaries and alongshore processes associated with US Highway 101; 2) sediment delivery from erosion and mass wasting on US Forest Service roads; and 3) low dissolved oxygen, particularly in southern Hood Canal. Documentation of these threats is limited, and no assessment of their relative importance is provided.

The plan summarizes predictions of fishing mortality as computed by the Fishery Regulation Assessment Model (FRAM). Exploitation rates for the Skokomish River population are predicted to have declined from approximately 70-80% in the period from 1983 through 1992 to less than 20% in 1998. Predicted exploitation rates for 2004 are summarized in the table below:

| Population | Southern US | Canada and Alaska | Total |
|---|---|---|---|
| Mid-Hood Canal | 12.1% | 18.7% | 30.8% |
| Skokomish | 33.3% | 18.7% | 52.0% |

The plan states that the co-managers have "expressed strong reservations" about NMFS' no jeopardy decision for the 1999 annexes of the Pacific Salmon Treaty.

Potential threats that the hatchery programs may pose are not explicitly identified, but the hatchery resource management plans, HGMPs, and recommendations of the Hatchery Science Review Group are referenced.

(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.

This question is addressed in Section I.

(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.

This question is addressed in Section I.

(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)?

The plan generally does not describe assumptions for habitat conditions and actions outside of the WRIA.

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

This question is addressed in Section I.

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?**

This question is addressed in Section I.

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?**

It would be helpful 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 plan provides answers to a series of integration questions, but additional documentation would be helpful as well as a formal assessment of integration.

The certainty of the technical analysis is discussed in Section I.

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

The plan generally does not discuss uncertainty or how it was addressed in the development of recommended actions. Limited discussion of monitoring and adaptive management is provided with references to the co-managers harvest and hatchery resource management plans.

(a) Uncertainties in data and information?
(b) Uncertainties in environmental conditions in the future?
(c) Uncertainties in effectiveness of actions?

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 certainty analysis presented in Section I addresses this question in part, but additional technical and policy analyses will be required before the risk to the population can be fully assessed.

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

   This question is addressed in Section I.

## 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*.

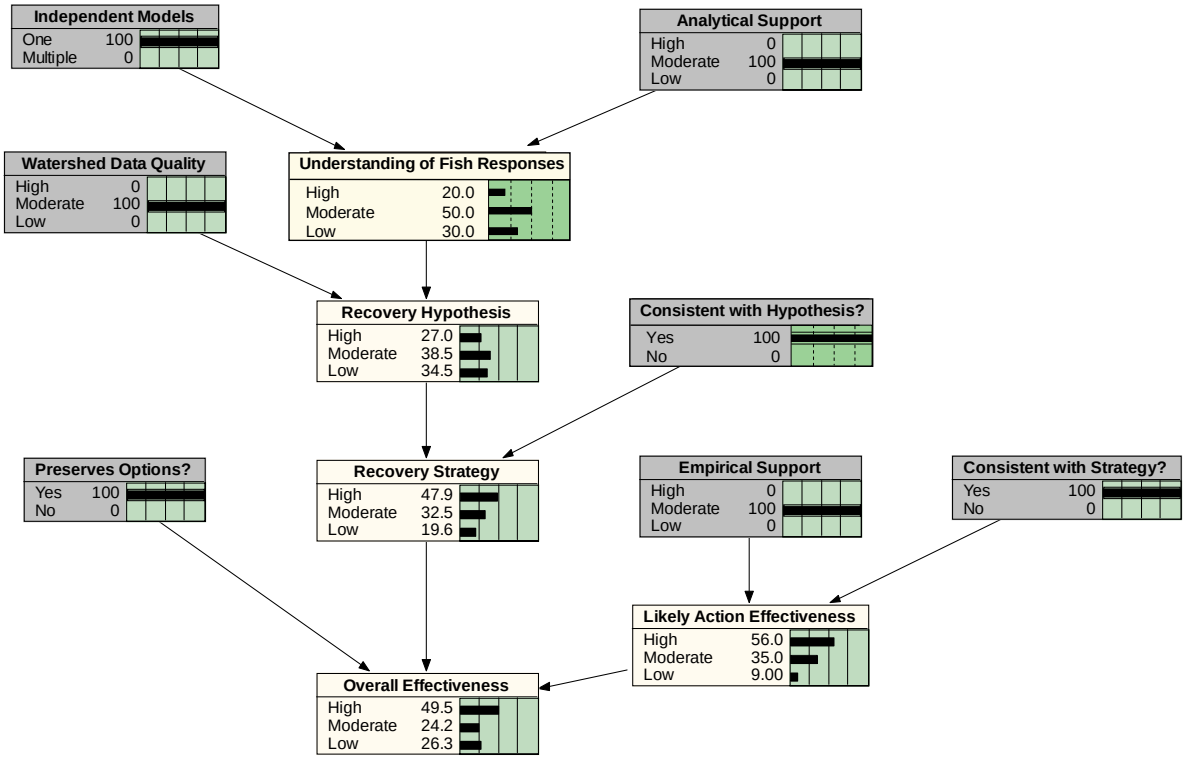


**Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.**

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.

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

| Analysis | Total Score | Attributes (Maximum Possible Score) |
|---|---|---|
| Habitat Models<br>High<br>Moderate<br>Low | <br>0.60 -1.00<br>0.21 - 0.60<br>0 - 0.20 | • Qualitative and/or quantitative description of the relationship landscape processes, landuse, and habitat condition – (0.1 for each analysis)<br>• 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)<br>• Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2)<br>• Sensitivity of model to changes in parameters known – (0.2)<br>• Model tested empirically and calibrated to watershed – (0.2) |
| Harvest Models<br>High<br>Moderate<br>Low | <br>0.60 -1.00<br>0.21 - 0.60<br>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)<br>• Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2)<br>• Sensitivity of model to changes in parameters known – (0.2)<br>• Model tested empirically and calibrated to watershed – (0.2) |
| Hatchery Models<br>High<br>Moderate<br>Low | <br>0.60 -1.00<br>0.21 - 0.60<br>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)<br>• Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2)<br>• Sensitivity of model to changes in parameters known – (0.2)<br>• 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<br>• Main elements of strategy organized around dominant recovery hypotheses<br>• Elements of strategy reflect spatial attributes of recovery hypotheses<br>• 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<br>• Elements of strategy reflect spatial attributes of recovery hypotheses<br>• Elements of strategy reflect temporal attributes and action sequencing of recovery hypotheses<br>• 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<br>• 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 |