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

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

Habitat strategy

Key Issues to Improve Certainty

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

- Further develop explicit conceptual life stage specific linkages relating habitat conditions to responses in population viability characteristics, better document the data used and the conceptual model as it becomes available.

- Further develop a detailed and specific habitat recovery strategy tiered down from more explicit hypotheses on conceptual linkages relating habitat conditions to salmon viability via life stage specific potential responses.
- 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 greater level of certainty for this plan.

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

A conceptual model was used for the South Puget Sound to evaluate the potential responses of Chinook populations to changes in nearshore and freshwater habitat conditions. The certainty in the analytical model used to link changes in habitat conditions and processes to fish population response in the South Sound plan is low/moderate.

- Documentation of qualitative model is from draft nearshore guidance documents (Kurt Fresh). Also general information on nearshore processes and some specific information on habitat conditions were provided to support the approach taken.

  Near-term steps to improve certainty:
  - Clearly state the qualitative model linking (1) freshwater processes and habitat conditions and (2) nearshore processes and habitat conditions with VSP for south Puget Sound stocks.
  - Document assumptions made in developing such a qualitative model.

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

There is little support in watershed-specific data for the nearshore and freshwater habitat factors estimated to be limiting recovery of the Chinook populations using south Puget Sound.

- Support for the recovery hypothesis using watershed specific data was low, but could be readily improved with available data.
- The stated hypothesis in the draft South Sound recovery plan is that nearshore and freshwater habitat conditions and processes are limiting recovery of populations using south Puget Sound, and if a number of these habitat factors are corrected, the Chinook using South Puget Sound waters will recover.
- Hypothesis does not include VSP—good discussion of nearshore habitat and process function (especially water quality), but no link between habitat and VSP.

- There is very little information in the South Sound area on the interactions among habitat-forming processes and land use attributes and how they affect freshwater and nearshore habitat conditions.

  Near-term steps to improve certainty:
  - Summarize what is known in the South Puget Sound about the mechanistic links between habitat-forming processes, land use, and in-stream habitat conditions.
  - Document assumptions made about the VSP status of Chinook using south Puget Sound waters, the data used and the conceptual model.
  - Use available data from other areas on juvenile utilization and on relating specific life stage linkages to increase the analytical support.

  Longer-term steps to improve certainty:
  - Continue to coordinate and collect data on juvenile use of and survival in different habitat types.
  - Monitor natural-origin and hatchery-origin Chinook use at different life stages throughout the south Puget Sound.
  - Monitor and study linkages between habitat-forming processes, land use, and freshwater and nearshore habitat conditions so that mechanistic links among those can be better understood, protected and restored.

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

Overall comment: The habitat recovery strategy in the draft South Puget Sound recovery plan is not completely consistent with the hypotheses for what population status and habitat, harvest and hatchery problems are limiting recovery.

- The strategy is to improve condition of degraded nearshore habitat areas and protect natural shorelines.
- The habitat hypotheses are specific and ecological process-based approaches, which is a very important base to start from to help increase the certainty that management actions will have sustainable results.
- However, the hypotheses for the relationships between stressors and VSP characteristics need further development.
- Hypotheses specific to VSP characteristics or ESU persistence are needed to better conceptually relate recovery actions to more explicitly defined habitat recovery strategies for protection and restoration that, in turn related to expected responses in VSP.
- More detail is needed in the habitat strategy for which areas, how many, in what sequence (i.e., priority) will be protected or restored.
- It is not clear how the habitat strategy stated in the South Puget Sound plan relates to the hatchery and harvest management strategies for recovery of the populations and the objectives for harvest in southern Puget Sound.

Near-term steps to improve certainty:

- Clearly state the hypotheses for what freshwater and nearshore habitat factors are most important in limiting the status of populations using south Puget Sound.
- Provide more detail in the habitat strategy for which areas, how many, in what sequence (i.e., priority) will be protected or restored.
- Provide a description for how the habitat recovery strategy is consistent with the strategies for hatchery and harvest management for the south Puget Sound Chinook stocks.

Longer-term steps to improve certainty:

- Develop more explicit detailed qualitative linkages between each of the specific protection and restoration action plans for nearshore or shoreline areas and the hypothesized VSP responses.

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

The existing habitat recovery strategy does not state how it will preserve options for implementation of the overall recovery strategy.

- Preserving options requires an adaptive management plan to respond to changes and uncertainty as they occur.

Key near-term steps to reduce uncertainty:

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

Key long-term steps to reduce uncertainty:

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

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

There is moderate empirical support for the habitat recovery actions identified in the south Puget Sound recovery plan.

- General experience suggests that nearshore protection and restoration actions may work, although there are some conflicting results and uncertainty. Areas that are especially uncertain are 1) the effectiveness of shoreline regulatory protection programs, 2) validation that habitat actions to rehabilitate or enhance nearshore habitats increase the capacity of the nearshore to support chinook and chum salmon life stages.
- The goal of protecting existing habitat is good. However, fee simple purchases and conservation easements along with public education are listed as the centerpiece for habitat protection strategies. How do we know whether this strategy will work and what is the certainty that remaining habitat will not be lost? How long would it take to protect the remaining habitat under this strategy?

Near-term steps to improve certainty:

- Summarize the existing modeled or empirical support for the effectiveness of habitat protection and restoration actions identified in the plan.

Longer-term steps to improve certainty:

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

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

The actions described in the plan are very general, so it is difficult to evaluate whether a clear and logical relationship exists between the "all-H" recovery strategy and the proposed habitat recovery actions.

Near-term steps to improve certainty:

- More specific definitions of protection and restoration actions are needed.
- Focusing the recovery actions through a more defined habitat recovery strategy will help to reduce uncertainties.

Longer-term steps to improve certainty:

- Develop better empirical and analytical support for the above relationships between protection and restoration actions and hypotheses specific to VSP characteristics or ESU persistence.

Hatchery and Harvest Strategies

See technical comments on certainty in hatchery and harvest strategies for Nisqually plan.

Also refer to technical comments on certain in hatchery and harvest strategies for the Puyallup/White and Clover Creek/Chambers draft submittal.

II. CONSOLIDATED COMMENTS ON TECHNICAL REVIEW TEMPLATE

Reviewer's Name: **All technical reviewers**

Watershed Plan: **South Sound**

Populations or ESUs considered: **All populations using south Puget Sound waters**

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.

This plan covers the marine waters in southern Puget Sound, south of the Tacoma narrows bridge. It includes the mouth of the Nisqually River, which is the only independent population of Chinook identified by the TRT in this region. Several of the streams in this area currently or historically contained Chinook spawning, and juveniles and adults migrate through the estuarine and nearshore/marine waters. Five WRIAs drain into this part of South Puget Sound (SPS).

This is a Chinook and bull trout plan that uses an ecosystem functioning approach to identify stresses to nearshore and marine habitats in SPS. The group has divided the SPS region into 9 primary landscape regions (map 1) around which they organize their stressor analysis. The plan focuses on describing habitat and habitat forming processes in terms of properly functioning condition, describing the models that will be used to relate human actions to the condition of watershed and nearshore habitat, and then manage human activities and behavior to affect a desired condition.

The plan is comprehensive in listing the types of threats to nearshore habitat, but not very specific about which types of restoration actions are highest priority. It suggests that protection is most important, and restoration is second priority. It does not attempt to determine which kinds of habitat degradation most limit recovery.

The plan does not address specific populations (except that it mentions its greatest benefit will be for Nisqually Chinook). A description of occurrence of the species in the tributary drainages is included in the plan. Brief reference is made elsewhere to known use of the nearhore areas by non-natal chinook.

It is not clear whether there is a policy group that oversees decisions about salmon recovery in this recovery planning area.

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

1. **What biological and physical changes does the plan state are required for the population(s) in the watershed to achieve their targets? __1, 2, or 3__ pts.**
   For watersheds without targets, what biological and physical changes are needed for the habitat to be considered functioning for anadromous fish?

   Achieve properly functioning nearshore ecosystems. The plan focuses on reducing human caused stressors to habitat conditions and habitat [forming] processes. The plan lists many specific actions that may be required to achieve functioning nearshore habitats. They are prioritized in terms of protection versus restoration, but there is no explanation of which processes or habitats are likely the ones that most affect Chinook VSP parameters.

   The basic way of breaking the planning area down into the 9 landscape units and then smaller reaches within LU is appealing and places planners in a good position to develop strategies and actions (by LU).

   Because there are no goals provided, the plan does not make clear what they do not really know (information gaps) and what they need to do in order to achieve or support recovery. No spatially explicit actions are proposed. However, the planning team has made a tremendous amount of progress in a short time towards that end and those involved need to be commended for their efforts. The plan has a thorough technical and policy framework to succeed given sufficient additional state and federal support to better develop the linkages to the viability characteristics of populations.

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

The planning targets set forth by co-managers and the planning ranges from the TRT are discussed (p. 25) and it is stated that the SPSSRG "must" identify actions and develop an implementation plan necessary for achieving these targets. It is not clear whether that means these targets are their goals for abundance and productivity.

South Sound appears to adopt Nisqually Chinook targets as part of their approach. However, the plan does not relate the target substantively to the strategies and actions. The plan presents a good general ecological model as a basis for the plan. However, the description of the physical changes needed is only general and unquantifiable, thereby leaving a high degree of uncertainty as to the effects of what is proposed.

The biological goals for both local Chinook spawning and non-natal chinook uses of the watersheds and nearshore are not adequately laid out to form a complete basis for a course of action that can move the plan towards a well informed set of specific quantitative goals and milestones that can likely succeed as a component to the ESU recovery plan. There are a number of potential proxy species that could be used as the basis of an approach to set specific and quantifiable goals and a strategy to relate those to Chinook recovery. No explicit short or long term goals are stated. It is suggested that two levels of goals are needed. The first should be specifically targeted on the Nisqually Chinook population, and the other should be based upon habitat conditions using habitat as a surrogate for non-natal populations.

Protecting habitats and processes are each examples of a reasonable goal. PSNERP has some good material available on processes. The planning team could develop spatially explicit goals. For example, a goal could be to maintain a certain level of habitat functioning at multiple spatial scales. Another example would be to avoid further degradation in certain areas.

The goals section of the draft mentions the two VSP parameters—spatial structure and diversity—but does not mention what the plan's goals are for these two population attributes.

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

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

The plan mentions the potential importance of all 4 VSP parameters (some clarification is needed for some of these p. 24ff). The plan does not discuss what the hypotheses are for current and historical Chinook use in the freshwater streams in South Puget Sound and which Chinook populations use these waters.

A good conceptual model is presented for the overall function of nearshore habitats, as well as for individual processes that shape nearshore habitats. Hypotheses of how these affect VSP are presented, but they are general and unquantified in terms of extent of the problem or likely importance to Chinook status or recovery.

The planners cite the co-managers' SASSI report (pp. 11ff) that states the South Puget Sound Chinook are only present in those streams because of hatchery programs. The TRT's population ID document presents alternative hypotheses for historical population structure in the SPS, which should be considered by the SPS recovery planning group to help identify recovery strategies.

The plan presents hypotheses for how juvenile salmon could use the nearshore/marine habitats in South Puget Sound: (1) for feeding and growth, (2) as refuge from predation and extreme events, (3) during physiological transition, and (4) as migratory corridors. The plan reports that seining and genetic data suggest that juvenile salmon from North Puget Sound streams are found in the South Puget Sound nearshore/ marine waters.

The targets and current status reported on p. 25 are misleading, since the productivity of the population associated with the current numbers is not reported. It is likely that the spawner numbers (targets are reported as equilibrium abundance) are not associated with the same productivities, so apples and oranges are being compared.

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

The plan states that juvenile Chinook use primarily 4 habitat types in the South Puget Sound region: open exposed shores, protected shorelines, pocket estuaries and river and stream estuaries and deltas p. 14. Within those habitat types, further classification of habitat types is available. The plan discusses general functions (e.g., feeding and growth, migratory corridors, etc.) that each of these habitat types provide for salmon. The potential use and functions provided by different habitat types should be stated as hypotheses.

The predictions for population status are general and insufficient to serve as the basis for a plan that can be evaluated for contributions to ESU persistence. There are no specific strategies to resolve very basic and important questions for the ESU. (1) What role do the streams in this watershed play in persistence of the historical ESU? (2) What role does the nearshore play in persistence of the historical ESU, and what effects do the hatchery and harvest management elements have on the functions of the nearshore needed for non-natal chinook viability?

(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.

Potential "human-induced stressors" and their primary locations in the 9 landscape regions in South Puget Sound are summarized in Chapter 4. The hypothesized stressors include: shoreline armoring, overwater structures, ramps, stormwater/wastewater, landfill, riparian loss, wetland/estuarine modification, toxics, predation, boat traffic, invasive species and aquaculture. Linked to the stressors are natural processes that create habitats forming ecosystems inhabited by Chinook and bull trout (p. 28 ff). The key natural processes producing and maintaining nearshore habitats in Puget Sound are: tidal exchange, sedimentation, nutrient input, LWD function in spits, organic matter composition, food webs, freshwater input, prey species input, and sunlight inputs. The hypothesized effects of process functioning on the state of the stressors is presented in a narrative form (e.g., p. 34). Hypotheses associated with each model are a nice start.

There is no discussion of how freshwater habitat condition could affect nearshore/marine habitats in this region, directly (affecting salmon using those freshwater streams) or indirectly (affecting run-off and nearshore habitat condition and processes.) The plan reports excerpts from Limiting Factors Analyses for each WRIA (pp. 5 ff).

The plan draft lacks discussion about human population growth and water quality as stressors.

The habitat models presented appear well thought out and developed. The habitat hypotheses are specific and ecological process based approaches provide a very important base to start from to help increase the certainty that management actions will have sustainable results.

A discussion on the historic baseline for nutrients specific to the role of salmon as a nutrient transport vector is an important missing element of the habitat forming processes' technical basis for the plan. Little is currently known about what changes may be needed in the present nutrient loadings relative to historic conditions to support viability, and it is important to note this uncertainty in the analytical basis for the plan.

The habitat hypotheses are not linked well to any of the VSP characteristics of the ESU or populations. A more developed rationale for how habitat conditions may affect the VSP characteristics is needed and do-able to a greater degree at present. An adaptive management plan to develop a specific rationale for the relationship between habitat and each of the VSP characteristics should be a primary focus of this plan. I think it is well recognized that the watershed group will need substantial state and federal agencies' technical support to accomplish that.

There is a short section on harvest and hatchery management, and their inclusion is a strength of the plan. A table lists the 10 (text says 11?) hatchery facilities, their locations, and the number of Chinook releases. (Are these planned releases for the future? p. 17). There is no discussion of releases of other species of hatchery fish into SPS areas (e.g., fall chum, coho, etc.) There also is no discussion of the hypothesized impacts of salmonid hatchery juveniles or adults on the naturally-produced juvenile and adult Chinook in South Puget Sound waters.

The discussion of harvest management explains what harvest management conclusions are, but not what the hypothesized impacts of that harvest are on Chinook using South Puget Sound waters (other than the Nisqually Chinook).

To treat information on any "H" threats as hypotheses improves both the plan's treatment of certainty in what is known and its vision for implementation to treat information see TRT Watershed Guidance document.) Phrasing H factors potentially limiting recovery as hypotheses acknowledges that such a judgment is based on best available (but imperfect) information, and also forces plan authors to treat H factors as potential effects on VSP that need to be monitored to that we can learn over time about the nature and magnitude of the actual effects.

Appendix tables and table in Chapter 4 are a nice start.

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

The plan adopts a conceptual model for how nearshore ecosystems function and states that "there must be properly functioning nearshore habitats that serve [Chinook and Bull trout's] rearing, refuge, feeding, physiological transition, and migratory needs." The plan further states that properly functioning nearshore processes are what maintain those habitats. The plan identifies potential human-induced stressors (described as hypotheses) and offers a conceptual model and hypotheses for how each stressor has disrupted natural processes (pp. 31ff). The hypothesized effect of the habitat effects on mechanisms affecting VSP is also described (a good start, but links to VSP are very general—e.g., p. 34).

The next step is to identify locations of the primary stressors/disruption of process functioning in each of the 9 landscape regions identified. (Chapter 5).

The description of habitat management in South Puget Sound is focused entirely on the co-managers' contribution. What about land use/land cover planning, regulations, etc. in freshwater habitats? What other habitat management activities in nearshore/marine waters are likely to affect habitat quantity and quality in the recovery planning area?

Is the survival of the Chinook life stages using these habitats likely to be limiting population performance? Ecosystem or ecological functioning? What VSP parameters are likely to be affected by changes in nearshore/marine habitat quality and quantity? What are the proposed mechanisms for those effects on VSP? (For example, if a certain nearshore/marine habitat type is lost, a life history trajectory cannot be supported; if the connectivity of key juvenile rearing habitats is disrupted, the fish may be unable to successfully disperse among refuge patches.)

Specific well defined strategies action items are identified for the Hs. Significant improvements are needed in quantitatively defining the level of actions to be taken and in an adaptive management approach to relate those to the VSP characteristics of populations and to ESU persistence.

The HSRG report is mentioned, but it is not stated how those recommendations will be considered or implemented. What are the hypotheses for how hatchery reforms could affect the VSP status of Chinook in the SPS waters? What strategies could be developed to address potential impacts from hatchery fish in the region?

It is not possible to evaluate the strategy for harvest and hatchery management, given the lack of detail presented in the plan.

(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.

The plan states that functioning populations rely on a functioning ecosystem. By implication, it appears that the hypothesis is that if the nearshore ecosystem is functioning, the salmon populations using it will be healthy.

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

The plan does not explicitly state these assumptions, except to state that salmon coming from South Puget Sound and North Puget Sound streams use the South Puget Sound waters.

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

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

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

The SASSI stock summaries (2003?) are the basis for the descriptions of the current status of Chinook in the Nisqually and South Puget Sound tributaries. The TRT data and the status information in the Nisqually should also be referenced and compared/discussed.

The plan should state as hypotheses the potential uses of the nearshore habitats and what functions they provide for South Puget Sound Chinook (pp. 14ff). The bases for the hypotheses also need to be included (e.g., why is it suggested that protected shoreline habitats provide important feeding and growth opportunities for early fry migrants?). Several previous studies of Chinook suggest that the magnitude of estuarine/nearshore survival of juveniles has a large impact on overall population performance (e.g., Beamer et al., Greene and Beechie, Kareiva et al. Scheuerell et al.) Such studies could be used to bolster the planners' hypotheses about the role South Puget Sound nearshore habitats might play in promoting Chinook population and ESU persistence (through effects on all 4 VSP).

The TRT has identified the role of Chinook using the independent tributaries to Puget Sound as a gap in our understanding of the historical meta-population structure and persistence of the ESU. The empirical data to resolve this question does not currently exist. The draft plan poses this question, but understandably provides little to resolve it and, not so understandably, provides no substantive strategy for addressing a resolution over time.

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

None made

A modest amount of local and general empirical data has recently been developed that demonstrates nearshore utilization by different Chinook life stages. Basic models to relate utilization to VSP characteristics are under development. The strategies and actions in the nearshore will need to be translated into quantifiable milestones that could then be eventually quantitatively related to the VSP characteristics of population(s) of interest.

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

The only treatment of freshwater impacts to salmon in this area is a summary of LFA reports for each WRIA. The critical threats identified in the Nisqually plan should be included and discussed re: their potential impacts on nearshore habitats in the regions covered by this plan.

The hypothesized effects of the main habitat factors considered are bolstered by a narrative argument and a summary of previous studies conducted in the basin. It is very difficult, with the information provided, to evaluate the rationale for these threats in the local South Puget Sound habitats-–the references are fairly general or documentation is not available. It is not clear how all of the potential habitat threats are prioritized in any order of importance regarding their effects on VSP parameters. More explicit thinking is needed about which actions are restoration priorities (i.e., what kind of actions have had the most impact or are likely to have the biggest effect on recovery?).

There is no referenced rationale for the reasoning underlying the harvest hypothesis—either that past rates likely contributed to declines or that present rates should allow for recovery.

The hatchery hypotheses are supported mainly by literature for the general possibilities of effects.

Three major gaps exist:
For Habitat, the role of large woody debris (LWD) as part of the nearshore model for habitat and habitat forming processes is weak. For example, the role of LWD in forming high intertidal debris jams along protected shorelines that trap and hold organic debris mats and sediments forming micro habitat "hotspots" for organisms such as amphipods, isopods and insects that are very important nearshore prey species needs to be incorporated.

For Hatcheries, there are two gaps: the role of the watershed streams noted in (a); and the possible threat that hatchery production could be compromising the function of nearshore in supporting the non-natal populations of the ESU. The first gap is identified in the plan and some actions are generally mentioned, but no substantive strategy for addressing a resolution over time is proposed. The second is identified as a gap and a specific HSRG recommendation to quantify South Sound carrying capacity for salmonids. The action needs to be developed to relate it to population's VSP characteristics.

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

The conceptual model and the ecosystem functions necessary to produce and maintain nearshore habitats important for salmonids are stated in the PSNERP Nearshore Science Team 2003 report (p. 29ff). The existing functioning of nearshore processes was evaluated using existing and new habitat assessments in the South Puget Sound region and expert opinion by local biologists (p. 46). The main report used for waters in Pierce Co. is the KGI Nearshore Salmon Habitat Assessment (2003).

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

(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)?

No rationale is given for the watersheds mentioned as probably contributing salmon that use the South Puget Sound waters.

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

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

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

The certainty as to how the proposed actions will affect VSP parameters and ESU persistence is very low. The technical basis for actions is good. The list of action items is thorough, but levels of actions are too general and unquantified. The processes described for implementation of protection in particular are general statements about doing the same processes but better, giving [this reviewer] every assurance that the status quo will continue.

Priorities for types of actions are proposed without any effort to relate these back to the population characteristics. Doing so at a conceptual level in the short term is an important step in testing the basis for the priorities as Chinook recovery actions.

There is no explicit discussion of interactions among the H's, especially on how production hatcheries may alter survival of natural fish in the nearshore, and how harvest affects freshwater ecosystem function (limited escapement and decreased freshwater productivity).

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

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

In general, there does not appear to be much use of the "multiple lines of evidence" approach to designing the recovery strategies in this draft plan. A clearer description of how uncertainties (in data, model/analysis interpretation) affected or will affect decisions about projects and where to prioritize effort is needed.

(b) Uncertainties in environmental conditions in the future?

(c) Uncertainties in effectiveness of actions?

How likely are they to achieve any proposed actions? All actions of high certainty should be bundled in terms of their ability to implement them.

Hatchery and harvest actions are not integrated with habitat. It is not currently possible to estimate the risk to the population; an integrated H strategy is needed.

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

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

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

See comments regarding certainty analysis (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

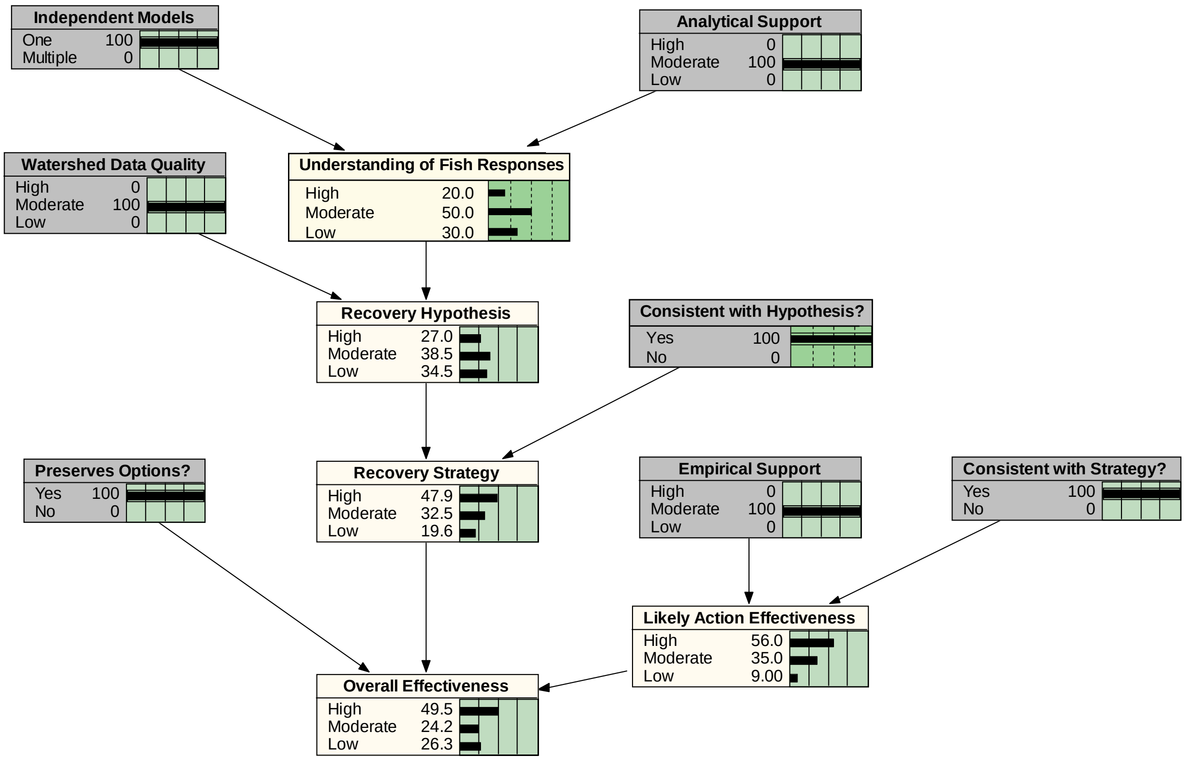

Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.

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

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

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

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

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

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

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

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

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

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

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

Table 6. Attributes of empirical support of recovery actions.

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