Scope for Risk Analysis
February 2008

A Risk Analysis for the Puget Sound Ecosystem

The Puget Sound Partnership has been given the task of protecting and restoring the Puget Sound ecosystem by 2020. The initial Partnership adopted an ecosystem-based management approach, and recommended that an ecosystem assessment be used to organize the scientific and policy analyses needed to support their ambitious objectives. In order to chart a path towards a 'healthy' Puget Sound by 2020, the new Partnership will need to (1) adopt clearly defined and measurable outcomes for each of their 6 ecosystem goals, and (2) implement strategies and actions necessary to achieve the desired outcomes. An ecosystem assessment is a synthesis and analysis of information of relevant physical, chemical, ecological and human processes in relation to specified ecosystem objectives. Ecosystem assessments result in a forecast of ecosystem status under different management strategies; and thus are instrumental in informing decisions about how to achieve ecosystem goals. Such ecosystem assessments have been used successfully in Australia and Europe; and the United Nations, NOAA, and a growing number of regional governments are beginning to incorporate them into their ecosystem-scale management approaches.

The first two steps of an ecosystem assessment are to (1) define objectives and how progress towards ecosystem health will be measured, and (2) conduct a risk analysis that summarizes information about the current status of ecosystem components (i.e., water quality and quantity, species and food webs, habitats and their processes, human health, and human socio-economic and cultural well-being) and the relative magnitude of threats or drivers that are affecting the ecosystem components. For the first step, the initial Partnership outlined broad ecosystem goals, and a separate science-policy process currently is underway to identify provisional indicators of ecosystem health (see scope of work for indicators project.) Results from the second step of the ecosystem assessment, the risk analysis, allow attributes of each ecosystem goal (e.g., particular species for the species/food web goal; dissolved oxygen, temperature and nitrogen for the water quality goal) to be classified relative to their current status and their susceptibility to natural drivers or human threats. Policy decisions about which attributes of ecosystem health are highest priority for action (e.g., possibly those which are most vulnerable) and what actions are most likely to improve an attribute's status (e.g., those actions addressing the biggest threats) will be informed by the risk analysis. Over the longer term as a full ecosystem model is developed, the effects of alternative actions on the status of ecosystem attributes relative to their desired condition can be quantitatively assessed.

Approach

There are two parallel stages of a risk analysis: (1) estimating the current status of each of the ecosystem components, and (2) conducting a vulnerability assessment to ascertain the degree of threats facing each component and the resiliency of the components. These two stages are described in more detail below. The first iteration of the risk analysis in the first part of 2008 will be largely qualitative; as more data are amassed in the latter half of 2008 and into the future, increasingly quantitative analyses will be included in the

risk analysis so that better estimates of the potential ecosystem response to threat mitigation are available for decisions on priority actions.

The first phase of the risk analysis (through late spring 2008) largely will entail a summary of existing status and threats assessments that are available across the Puget Sound basin. Some additional spatial analyses will be conducted as time allows. Information on status of and threats to the human socio-economic and cultural well-being goal has not been summarized in existing assessments; thus a risk analysis for this goal will not be available in phase I of this project. Results from a more comprehensive quantitative risk analysis for the Puget Sound ecosystem will be available in early 2009.

Ecosystem goals. Attributes or indicators of: water quantity, water quality, species/food webs, habitats/processes, human health and well-being.

Status assessment

The status assessment will summarize the current condition of ecosystem components such as water quantity, water quality, species/food webs, habitats/processes, human health and well-being. In most cases, an ecosystem component will be further described by a set of attributes, or more specific traits that can be measured and reported. Status of a component or attribute can be estimated by such indicators as its abundance, trend, productivity, spatial distribution or extent, diversity, some indicator of its quality, or an estimate of the likelihood of its persistence or condition into the future. Status for each ecosystem component will be reported, depending on the availability of information. Gaps in our understanding of status will be noted for those attributes lacking information.

Ultimately, results from a status assessment will be a ranking of the condition of attributes (and collectively, ecosystem components) relative to narrative outcomes, or where possible, quantitative targets, or historical or other useful reference conditions. The status assessment also will highlight where gaps in knowledge occur, since for many attributes, we do not know their historical or current status.

Status information for each ecosystem component will be summarized on a '0 (poor) to 1 (good)' scale of ecosystem health where possible, using existing status assessments. In cases where information on abundance, productivity, spatial distribution, or diversity for an attribute are available, but the values are not related to overall 'good' to 'poor' status, the risk analysis will summarize available data as "H-M-L" condition. Status will be summarized for ecosystem components for each Action Area. All units and methods for summarizing current status information will be clearly documented and peer-reviewed.

Products/steps in status assessment and timeline:

1. Agree on common list (of manageable length) of attributes for each ecosystem component using existing assessments (e.g., TNC, PSAMP, PS Update, etc.) as a starting point.
2. Summarize existing assessments for attributes of each ecosystem component at sub-region scales (and roll-up to ecosystem scale) (by late February 2008).

Where possible, include status information from historical or reference periods. Final summary report for current and reference status by April 2008.

3. Identify gaps in status information for each attribute/component (by April 2008). Review existing status information and methods for summarizing in workshop in February 2008, include feedback in final report by late March 2008. Include monitoring needs (i.e., gaps) for ecosystem component status assessment in March 2008 report.
4. Where possible, amass existing information and conduct analyses to estimate current status for attributes with data that have not yet been summarized or analyzed (year 2 and beyond). Prioritization of which attributes are highest priority for this task should be discussed with policy leaders through Partnership.
5. Use food web/ecosystem models to identify those attributes within a goal that best capture its status. This work will hone the list of provisional attributes within each goal and also can be used to identify indicators of ecosystem status, as described in that scoping paper (year 2 and beyond).

Vulnerability assessment

The vulnerability assessment will help identify which threats or drivers have the biggest potential impact on ecosystem components. The impact of threats will depend on their relative magnitudes, and the differences in response of ecosystem components to threats due to the inherent susceptibility and resilience of ecosystem attributes. Policy leaders can use the results of this assessment to help make decisions about which threats to focus on first, depending on their likely impacts on ecosystem attributes. By explicitly providing a summary assessment of which threats/drivers are likely to have the greatest impact on ecosystem attributes, the results also will provide guidance on the scales over which strategies might be most relevant—e.g., strategies to address climate impacts are more likely to be needed at the global scale; yet strategies to address habitat loss may be needed at the local or sub-regional scale.

Primary questions:

- What are the relative magnitudes of threats to (or drivers of) ecosystem elements within sub-regions and throughout the Puget Sound? (i.e., which threats or drivers are of greatest potential impact?)

NOTE: these bullets below are not included in this first Phase and will be addressed through the quantitative risk analysis as part of the overall integrated ecosystem assessment (IEA) being led by NOAA Fisheries:

- Which ecosystem elements are most vulnerable or susceptible to human activities in each sub-region? (i.e., what is the likely impact of a threat on an ecosystem element?) Vulnerability of each ecosystem element is defined based on:
    - spatial scale, frequency, magnitude and functional impact (single species to whole ecosystem) of threat
    - Susceptibility (combined probability of experiencing a threat and the response of the ecosystem element to the threat—e.g., taking into account resistance to the threat.)
    - Resilience or recovery time following disturbance

- What are the relative magnitudes of threats to (or drivers of) ecosystem components or attributes within sub-regions and throughout the Puget Sound? (i.e., which threats or drivers have the greatest potential to perturb ecosystem components?)
- Which ecosystem components or attributes are most vulnerable to human activities in each sub-region? (i.e., what is the likely impact of a threat on an ecosystem component or attribute?) *Vulnerability* of each ecosystem component is defined based on:
    - Spatial scale, frequency, magnitude and functional impact (e.g., single species to whole ecosystem) of the threat
    - Susceptibility (combined probability of experiencing a threat and the response of the ecosystem component/attribute to the threat—e.g., taking into account resistance to the threat.)
    - Resilience or recovery time of the attribute following disturbance

Products/steps in vulnerability assessment and timeline

1. Agree on common list of threats to be used using existing assessments as a starting point (e.g., TNC, PSAMP, etc.). Use attributes for each ecosystem component identified in the status assessment part of the risk analysis for estimating vulnerability and impact.
2. Categorize threats and drivers, based on magnitude of threat. Summarize what is known about vulnerability for each attribute using existing threat assessments (e.g., TNC, PSAMP, Salmon Recovery Plan, species plans, PSNERP, etc.) (by January 2007).
3. Rank threats for each sub-region for individual attributes and possibly combine/summarize across threats and attributes. Review initial ranking results from current assessments in a workshop in February 2008. Final report for sub-region and ecosystem scales by March 2008.
4. Summarize conceptual models of linkages between threats/drivers and ecosystem attributes. These models will be used to help interpret the potential impacts of reducing threats or drivers on ecosystem response.
5. In phase 2, it would be possible to project future vulnerability of ecosystem attributes under alternative scenarios of a model. This step would involve developing a causal model of vulnerability (i.e., hypothesize which attributes are vulnerable to what threats, drivers), describing factors and pathways, and potentially formalizing it into a qualitative/quantitative model. The impact assessment step also could include existing or new analyses of future trends in human sources of change, for ex.

Overall summary results can be displayed in a table for each ecosystem component, highlighting which threats/drivers are of greatest magnitude in each Action Area. These threat rankings then can feed into policy deliberations about priority next steps for threat abatement:

- Overall prioritization approach for which attributes or ecosystem components are most vulnerable to current suite of threats or drivers;

- Subsequent analyses which highlight those strategies or actions that are most likely to address threats on either axis of the vulnerability diagram (e.g., strategies to improve resiliency or strategies to reduce susceptibility).

Overall process for summarizing existing knowledge about ecosystem risk:

1. For each of the ecosystem goals:
    a. Produce draft summaries of status indicators by action area; including indicators for which no information currently exists
    b. Produce draft summaries of threats/drivers to those indicators; including potential threats/drivers for which no information currently exists
2. Produce draft summary integrated regional ecosystem assessment
    a. for status
    b. for threats
3. Summarize existing conceptual models linking change in status to particular threats or drivers.
4. Get peer review of status, threats, ecosystem assessment
5. Revise parts 1, 2 & 3; include human goals (identify timeline)
6. Final report on qualitative risk analysis early April 2008
7. Ongoing results from quantitative risk analysis as part of broader IEA April 2008-December 2009.

Using results from the risk analysis

Results from a risk analysis can be used to help address questions 2 & 4 (below) of those guiding the work of the PSP. The four questions guiding the ecosystem effort in Puget Sound are:

(1) What is a healthy Puget Sound ecosystem?
(2) Where are we now, relative to a healthy condition? In other words, what is the ecosystem's current status, and what are the main threats to its improvement in function?
(3) What actions will it take to achieve a healthy Puget Sound?
(4) Where should we start? In other words, what actions will be most effective in moving the ecosystem on a trajectory towards recovery?

The ecosystem-wide risk analysis will summarize status and threats information that is available at the broadest spatial coverage. There are finer-scale and more detailed assessments of status and threats available in most Action Areas—but because these do not systematically treat status or threats data, they are not summarized in the ecosystem-wide risk analysis. **In addition to the overall risk analysis, information from local assessments will be very useful in priority action deliberations within Action Areas.**

Information to help address question #2
The status information will identify what is known about the current status of attributes (proxy indicators) for each ecosystem goal. Eventually, indicators for each goal will be identified, and their status can be tracked over time. Knowing what status attributes are in 'good' vs. 'poor' condition or health can help choose which components of ecosystem function are in greatest need of restoration (for those in poorest condition) or protection (for those in best condition.) This information on status will be spatially specific where data are available, so a picture of ecosystem condition within each Action Area will be provided. It is a policy choice to determine which ecosystem components are most valued, and how to combine protection and restoration strategies to get the ecosystem on a path to improved health.

The threats/drivers information will highlight those potential threats or natural drivers that deviate most strongly from a reference condition. What to do about such potential threats will be addressed in question #4.

For both status and threats, the risk analysis also will identify where knowledge is lacking. Such information can be used to help set monitoring and evaluation priorities.

Information to help address question #4
The risk analysis can inform setting priority actions by providing information on the potential threats or drivers that deviate most strongly from a reference condition. Existing and newly developed conceptual models linking potential threats/drivers to changes in the status of ecosystem attributes will help to focus the discussion on the threats most likely to impair the function of ecosystem components.

Additional information that will help prioritize early actions will come from:

1. A summary of what is known about the relative effectiveness of particular strategies to address threats for particular ecosystem components being provided through the topic forums.
2. The inventory of current activities/actions being coordinated by the PSP

In the future, the ecosystem model being developed as part of the IEA will be able to translate scenarios of different magnitudes of effort (through different actions) into likely magnitudes of ecosystem response (i.e., estimates of how much the ecosystem will change from a given set of actions with specific levels and locations).