



Identification of Ecosystem Components and Their Indicators and Targets

Technical Memorandum

November 2009

Authors of This Memorandum

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November 6, 2009

Dear Reviewer:

This is one of a series of technical memoranda released by the Partnership in conjunction with the 2009 State of the Sound Reporting.¹ These technical memoranda present the current products of work by staff from the Partnership and additional entities to implement Action Agenda activities addressing the development of the Partnership's performance management system (Action Agenda Chapter 3, Section E.1).

The audience for these memoranda includes the leadership of the Partnership; implementers of Action Agenda actions; elected officials, decision-makers and funders tracking progress in implementing the Action Agenda; and members of the scientific community whose work addresses the Puget Sound ecosystem or elements of it.

Outcomes we hope to achieve with these memoranda include:

- Broad ownership of the formative steps toward accountability for and adaptive management of the Action Agenda
- Maintained or increased levels of advocacy for the performance management system as a tool for helping ensure our investments are strategic and effective
- Awareness of technical, policy, and programmatic assumptions that are driving the Action Agenda, and the needs and opportunities to address inaccurate assumptions
- Early recognition of what will be used as performance measures, status indicators, benchmarks and targets to measure progress toward 2020 goals
- An initial sense of the implications of this work for key 2010 activities including budget development for the 2011-2013 biennium and consideration of the need to revise strategies in the 2008 Action Agenda

These technical memoranda represent an important advance toward having the performance management system assembled and informing strategic decisions by mid-2010. The Partnership is using the technical memorandum format to solicit feedback on the initial steps toward assembling the performance management system for the Action Agenda. The three memoranda focus on the application of the framework provided by the Open Standards for the Practice of Conservation. The parts of the framework addressed in these memoranda include: identification and rating of threats

¹ This 2009 report meets the statutory reporting requirements for the "State of the Sound Report."

to the 2020 goals; identification of ecosystem components and their indicators; and development of results chains linking strategies and actions to threats and ecosystem components.

Each memorandum includes a set of specific guidance questions that will serve as a guide for focusing the review. While reviewer feedback on the entirety of the content is welcome, feedback that addresses the guidance questions directly will be the most useful and relevant in informing future decisions driving the form and function of the performance management system. The feedback the Partnership receives will be used to both refine the material presented and help us set a prioritized work plan that will focus our work on building the performance management system.

To facilitate timely incorporation of review feedback into the next steps of the work, **comments are due to the Partnership by December 4, 2009**. Comments can be submitted to the Partnership at actionagenda@psp.wa.gov. Comments can also be sent through the regular mail to the Partnership at the following address:

Martha Neuman
Puget Sound Partnership
PO Box 40900
Olympia, WA 98504

Thank you for your interest in advancing the development of the performance management system for the Action Agenda. We look forward to working with you in the coming months to build the foundation for a robust and functional system that will advance our shared goal of a clean and healthy Puget Sound ecosystem by 2020.

Sincerely,



David D. Dicks
Executive Director

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Guidance Questions for Reviewing this Memorandum

1. How would you recommend the Partnership refine its framework for describing and evaluating ecosystem status?
 - a. Do the statutory goals and broad-indicator categories used for 2009 reporting on ecosystem status adequately represent the ecosystem we are trying to recover?
 - b. Is it important that the Partnership use the framework of the statutory goals to organize its evaluation of ecosystem status?
 - c. Does the May-June 2009 Open Standards-based framework of components and attributes provide a complete, credible, and defensible representation of the ecosystem we are trying to recover?
 - d. What changes would you recommend to Partnership-adopted focal components and key attributes to better represent the ecosystem?
2. Do status indicators selected for 2009 reporting adequately portray the condition of the ecosystem?
3. Independent of the framework adopted, are there indicators, as additions or substitutes, that should be included in Partnership efforts to evaluate ecosystem status? What do these indicators represent?
4. Does the existing data support the assessment of current status?¹
5. Are there new or additional data (relevant to adopted indicators) that should be included in the assessment of ecosystem status?
6. How important is it that the Partnership develop and use a systematic approach to rating the current status of the ecosystem?
7. Do the anticipated next steps presented in this memo provide a reasonable approach for the Partnership to establish components, indicators and targets?
8. Do the anticipated next steps presented here provide an appropriate science-basis for the ecosystem status elements of Partnership's performance management system?

¹ Please refer to: Ecosystem Status & Trends Technical Memorandum (2009).

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Acknowledgements

The following individuals were instrumental in the Partnership's 2009 efforts to describe focal components and identify ecosystem indicators:

Project leads: Scott Redman (Partnership staff) and Kari Stiles (Jones & Jones Architects, Landscape Architects and Planners)

Ecosystem indicators advisor: Sandie O'Neill, NOAA Fisheries Northwest Fisheries Science Center

Open Standards advisors: Nick Salafsky and Caroline Stem, Foundations of Success; Kirsten Evans, TNC

Indicators advisors for ecological components: Curtis Tanner, WDFW; Phil Bloch, WSDOT; Tim Quinn, WDFW; Kara Nelson, TNC; Melisa Holman, TNC; Ken Currens, Northwest Indian Fisheries Commission; Mary Ruckelshaus, NOAA Fisheries Northwest Fisheries Science Center

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Science Panel members: Joel Baker, Tim Quinn, Trina Wellman, Usha Varanasi, John Stark, Jan Newton, Frank Shipley, Guy Gelfenbaum, and Bob Johnston

Participants in Partnership's May and June 2009 Open Standards Workshop and June 2009 Science Panel work session on indicators

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1. Introduction

The top level of results to be tracked and evaluated by the Puget Sound Partnership's performance management system relate to the status of the ecosystem and the relationship of current conditions and trajectories to desired conditions for a restored Puget Sound ecosystem. This focus of performance management is emphasized in the first two questions of the Partnership's 2008 Action Agenda:

- What is a healthy Puget Sound?
- What is the status of Puget Sound?

The basis for answering these questions is scientific information about how the Puget Sound ecosystem functions, including current, recent, and historic conditions of key features of the ecosystem. An integrated science-policy synthesis of this information may be used to define aspects of the ecosystem, which the Partnership will emphasize in measuring progress. In its 2009 biennial science work plan the Partnership commits to integrated ecosystem assessment as an organizing framework to analyze ecosystem information to address these questions and the other analytic questions used to structure the Action Agenda.

This technical memorandum describes the work the Partnership is doing to explicitly and clearly define the status and desired future conditions of the Puget Sound ecosystem, including the products of work completed to date. The Partnership's approach builds from the process suggested in the Open Standards for the Practice of Conservation (Conservation Measures Partnership, 2007). Additional perspective and guidance for the application of the Open Standards process has been provided by the Nature Conservancy (TNC 2007, Parrish et al. 2003, Braun 2007).

The sections that follow describe the 2009 status of the Partnership's work on the following elements:

- Identification of focal components of the Puget Sound ecosystem
- Identification of ecosystem indicators
- Evaluation of ecosystem status
- Identification of targets and benchmarks for ecosystem status
- Anticipated next steps

Reporting and commenting on current ecosystem status and trajectories of change are important elements of the overall Partnership's performance reporting . The 2009 State of the Sound reporting uses an approach to describing ecosystem status based on the Partnership's six statutory goals for ecosystem recovery. This approach may be revised in coming years, and as early as 2010, based on scientific advice presented in the 2010 Puget Sound Science Update. The scientific synthesis

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developed in the 2010 Puget Sound Science Update is also intended to contribute substantial scientific basis for the Partnership's adoption of targets and benchmarks for ecosystem status.

2. Identification of Focal Components of the Puget Sound Ecosystem

A first step in answering the Partnership's questions about the status and desired future for Puget Sound is to define a suite of ecosystem features that represent and encompass the ecosystem. The Partnership defines these features as "focal components"² and their "key attributes." Focal components and their key attributes are the focus for setting performance targets and benchmarks for ecosystem status (Figure 1). These features are also the focus for identifying threats to the ecosystem³ and the ultimate results we expect from recovery strategies and actions.⁴ The Partnership has not firmly established a framework of focal components. This section describes the Partnership's work to develop this framework along two complementary fronts: one organized around the Partnership's statutory goals for ecosystem recovery and the other that applies the Open Standards approach. The final section of this memo on anticipated next steps describes some options for future efforts to complete this work.

2.1 Scope of Partnership Interests in the Puget Sound Ecosystem

In its initial May-June 2009 efforts to apply the Open Standards to the Action Agenda, the Partnership described the scope of its interests in and concerns about the Puget Sound ecosystem as follows:

The Puget Sound ecosystem spans from the crests of the Cascade and Olympic mountains to the marine environments of Puget Sound, Hood Canal, the Strait of Juan de Fuca and the Strait of Georgia. This large ecosystem covers more than 16,000 square miles and includes diverse marine, nearshore, freshwater, and terrestrial systems and human communities.

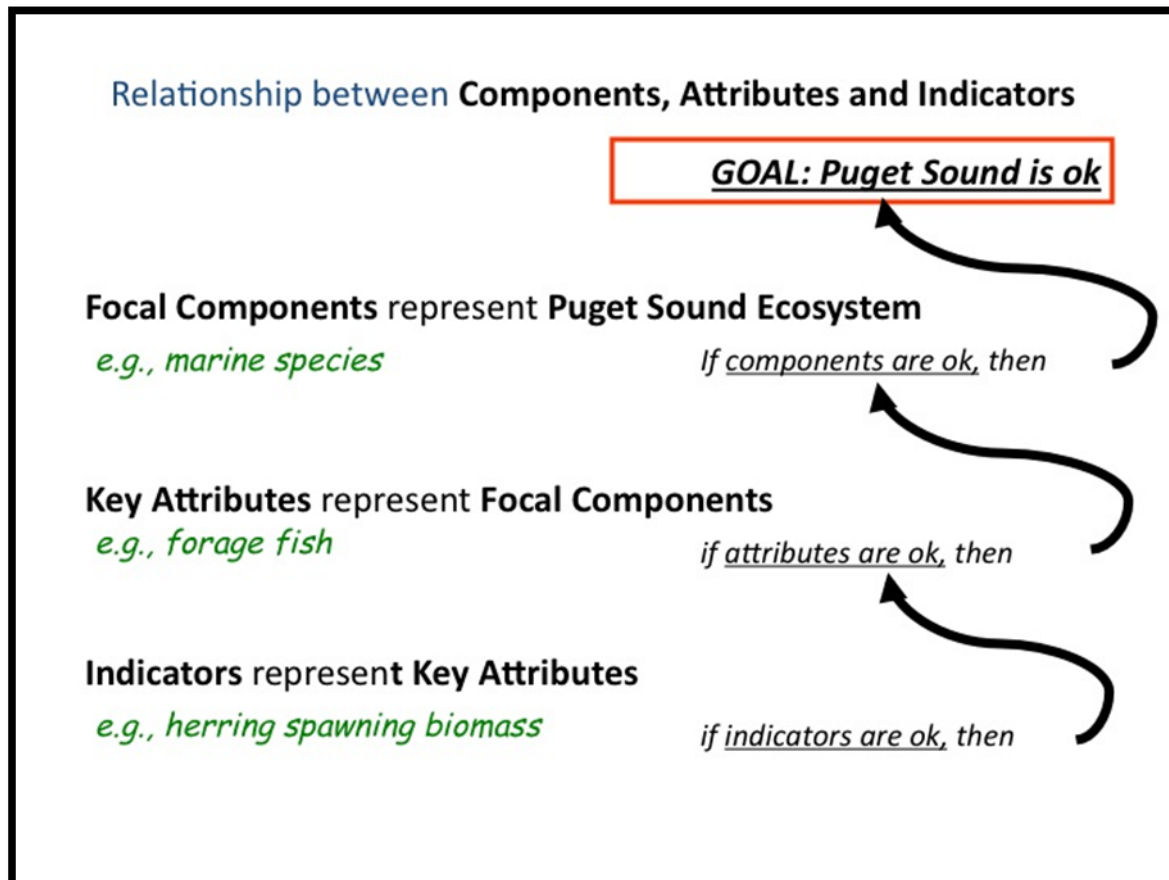
² The Partnership uses the term "focal ecosystem component" to refer to what the Conservation Measures Partnership and The Nature Conservancy call a "focal conservation target." As discussed elsewhere in this memorandum, the Partnership reserves the term "target" (following a definition in state statute) to refer desired ecosystem conditions in 2020.

³ Please refer to: *Identification, Definition and Rating of Threats to the Recovery of Puget Sound Technical Memorandum (2009)*.

⁴ Please refer to: *Using Results Chains to Develop Objectives and Performance Measures for the 2008 Action Agenda, Technical Memorandum(2009)*.

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Figure 1: components, attributes, and indicators represent and allow evaluation of the status of the ecosystem



2.2 Statutory Goals as the Partnership's Primary Categories for Describing Puget Sound Ecosystem in 2008 and 2009

The Partnership's original selection of ecosystem features to represent and encompass its interests in the Puget Sound ecosystem derive from the six statutory goals for Puget Sound ecosystem recovery (from RCW 90.71.300):

a healthy human population supported by a healthy Puget Sound that is not threatened by changes in the ecosystem;

a quality of human life that is sustained by a functioning Puget Sound ecosystem;

healthy and sustaining populations of native species in Puget Sound, including a robust food web;

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a healthy Puget Sound where freshwater, estuary, nearshore, marine, and upland habitats are protected, restored, and sustained;

an ecosystem that is supported by groundwater levels as well as river and stream flow levels sufficient to sustain people, fish, and wildlife, and the natural functions of the environment and;

fresh and marine waters and sediments of a sufficient quality so that the waters in the region are safe for drinking, swimming, shellfish harvest and consumption, and other human uses and enjoyment, and are not harmful to the native marine mammals, fish, birds, and shellfish of the region.

Building from the framework used by the original Puget Sound Partnership (2006) and in statute, the Partnership's 2008 scientific evaluation of ecosystem indicators was organized around these six goals (O'Neill et al. 2009, Schniedler & Plummer 2008, Science Panel 2008).

The Partnership's Action Agenda addresses *What is healthy?* and *What is the current status?* using these six goals as the fundamental organizing framework for assessing the health of the Puget Sound ecosystem. The Partnership's 2009 reporting on ecosystem status uses the six statutory goals as the primary dimensions for describing ecosystem conditions and trajectories.

2.3 Attributes Defining the Key Aspects of the Partnership's Statutory Goals

In the 2008 Action Agenda, the Partnership articulated a small number of outcome statements that define key attributes of each statutory goal for ecosystem recovery. The outcome statements presented in the Action Agenda were derived from those developed by the original Puget Sound Partnership (2006) as refined by the scientific indicators evaluation conducted in 2008 (see tables 1 through 11 in O'Neill et al. 2009).

The Partnership structured its 2009 reporting on ecosystem status around two to three broad indicator categories for each statutory goal. These broad categories, presented in Table 1, were selected to represent key features associated with each statutory goal. These broad categories were based on the Science Panel's consideration of the 2008 scientific evaluations of ecosystem indicators for Puget Sound, indicators reported in the 2009 status report, the Open Standards-based approach described below, and scientists' advice (derived from National Research Council (2002), U.S. EPA 2002, and Heinz Center 2008) about types of indicators and attributes to capture in suites of indicators.

The broad indicators listed in Table 1 are used to organize the Partnership's reporting on ecosystem

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status in the 2009 Report.⁵

Goal	Broad Indicator
Human Health	Safety of seafood
	Safety of water
Human Well-being	Working resource lands & industries
	Nature-based recreation
Species & Food Webs	Species of greatest conservation concern
	Flagship species (ecologically important & valued)
	Food webs
Habitats	Extent of ecological systems
	Condition of ecological systems
Water Quantity	Stream flow
	Hydrologic regime
Water Quality	Toxic contaminants in different media
	Water quality index

Table 1: Broad indicator categories adopted by the Puget Sound Partnership for 2009 ecosystem status and trend reporting

2.4 The Open Standards Approach to Defining Ecosystem Features and Attributes

As part of the initial efforts to use the Open Standards, the Partnership has developed a complementary approach to defining focal components and key attributes for the Puget Sound ecosystem. Table 2 presents a suite of focal components and attributes that represent and encompass the Partnership's interests in the Puget Sound ecosystem. These focal components and key attributes were used to define and evaluate threat-target pairs in the Partnership's May and June 2009 work applying the Open Standards to the Action Agenda.⁶

⁵ For a full description of the broad indicators please refer to: *Ecosystem Status & Trends Technical Memorandum (2009)*.

⁶ Please refer to: *Identification, Definition and Rating of Threats to the Recovery of Puget Sound: Technical Memorandum*

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Table 2: Ecosystem focal components and attributes for Puget Sound ecosystem: June 2009. Relationships between these components and attributes and the Partnership's statutory goals for ecosystem recovery are illustrated in Appendix A.

Cluster ⁷	Focal component	Key attribute
Estuarine and marine habitats	River deltas and coastal embayments	Estuarine wetlands
		Delta or river mouth condition
		Coastal embayments and lagoons
		Resilience to sea level rise
	Marine shorelines	Forage fish spawning habitat/substrate
		Condition of shorelines and condition of beaches
		Resilience to sea level rise
	Marine waters	Benthic condition
		Biotic condition of marine waters
Marine water condition		
Freshwater resources ⁸	Freshwater habitats	Freshwater condition
		Freshwater extent
		Freshwater species
Marine fish and shellfish	Marine fish	Forage fishes
		Condition of key fish populations
		Marine fish habitat condition
	Marine shellfish and invertebrates	Population size of key populations
		Condition of key populations
		Community condition
Marine mammals and birds	Marine mammals	Size of key populations
		Condition of key populations
		Marine mammal food web
	Marine birds	Size of key populations
		Condition of key populations
Salmon	Salmon	Extent of all species
		Condition of listed species
		Spatial structure of listed species
Terrestrial	Terrestrial habitat	Spatial extent of ecological systems

(2009).

⁷ Workshop 2 recommended adding a food webs cluster with components for marine, freshwater and terrestrial food webs. Attributes for the food web components are presented in Appendix A.

⁸ Workshop 2 recommended a different organization of the freshwater resources cluster with separate components for lakes, streams, and wetlands. Attributes for these alternative freshwater components are presented in Appendix A.

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Cluster ⁷	Focal component	Key attribute
resources		Condition of ecological systems or plant associations
		Functional condition for key terrestrial species
		Functional condition for key terrestrial species
		Resilience to climate change
	Terrestrial species (birds)	Size of key populations
		Condition of key populations
		Resilience
Human dimensions	Built environment	Space for living and working
		Energy resources
		Movement of goods and people
		Water supply for end users
		Flood protection
	Human health	Illness/death associated with natural resources
		Water and biological resources
		Environment: air, water, sediment
	Working marine industries	Commercial and tribal fisheries businesses
		Commercial and tribal fisheries resources
		Working waterfront
		Aquaculture
		Stewardship activities
	Working resource lands and industries	Farm businesses
		Farm lands
		Forest businesses
		Forest lands
		Stewardship activities
	Nature oriented recreation	Access to water
		Commercial tourism
		Recreational harvest
		Wildlife viewing
		Stewardship activities
	Aesthetics, scenic resources, and existence values	Scenic and intrinsic landscape values
		Biologically rich and functioning natural systems
	Tribal values and resources	addressing abundance and intrinsic value of cultural resources and practices, including tribal sites, cultural traditions, and areas of significance

Table 2: Ecosystem focal components and attributes for Puget Sound ecosystem: June 2009. Relationships between these components and attributes and the Partnership's statutory goals for ecosystem recovery are illustrated in Appendix A.

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Appendix A shows how the Partnership's statutory ecosystem recovery goals were addressed by the proposed components and how the Science Panel's recommended indicator categories aligned with the proposed attributes. These components were not adopted for use in reporting ecosystem status in the 2009 Report. In its June and July 2009 discussions of frameworks for selecting ecosystem status indicators for 2009 reporting, the Science Panel noted the Open Standards framework of components and attributes had promise, but the Partnership's application of the framework required further vetting and analysis before being fully implemented. Next steps and approaches for further work by the Partnership to develop and vet the components concept, in 2010 and beyond, is summarized within the final section of this memorandum..

3. Identification of Ecosystem Indicators

Both the Partnership's authorizing statute and the Open Standards (per Figure 1) support the use of ecosystem indicators to provide information about the status of the ecosystem as a foundation for setting priorities and making improvements to strategies and actions. As noted in Figure 1, indicators represent key features of the ecosystem.

3.1 Ecosystem Indicators for 2009 Reporting on Ecosystem Status

As discussed above, the Partnership's 2009 reporting is organized by the six statutory goals and broad-indicator categories recommended by the Science Panel. Science Panel members worked with Partnership staff and experts in summer 2009 to select specific indicators to report on broad-indicator categories. Indicators were selected with reference to the 2008 indicators evaluation work and the indicators identification accomplished during the Partnership's May-June 2009 efforts to conduct the viability analysis steps of the Open Standards.⁹

O'Neill (in prep.) provides an evaluation of the suite of indicators that the Partnership developed for 2009 reporting on ecosystem status. This paper uses the frameworks developed by the Heinz Center (2008) and EPA's Science Advisory Board (U.S. EPA 2002) to evaluate how well the Partnership's 2009 indicators measure ecological condition. A draft version of O'Neill (in prep.) offers the following analysis and critique of the Partnership's 2009 indicators for reporting on ecosystem status:

- The Partnership's 2009 reporting indicators are largely represented by measures of biotic condition (38.9%), and goods and services pertinent to human health and human well being goals of the Partnership (33.3%). The remaining indicators measure the extent of habitats, also referred to as landscape condition (11.1%) and chemical, physical or hydrological characteristics that support species and food webs.
- Terrestrial, freshwater and marine and nearshore systems are not equally represented in the Partnership's 2009 reporting indicators. Two-thirds of the indicators report on the marine and nearshore systems, whereas freshwater and terrestrial each are assessed by only one-sixth of the indicators.
- Expansion of the list of indicators to include all currently available and proposed indicators in the 2009 Status and Trends Technical Memorandum would place more emphasis on species

⁹ The Ecosystem Status & Trends Technical Memorandum (2009) details the specific indicators developed by the Partnership for 2009 reporting on ecosystem status. It provides recommendations for the continuing development of indicators within the framework of statutory goals and broad indicator categories used in 2009 reporting.

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and habitat conditions and the processes that support them, but less emphasis on goods and services pertinent to human health and human well-being. Expanding to this full suite of available and proposed indicators would also place more emphasis on freshwater and terrestrial systems relative to marine/nearshore systems.

- This expanded list of indicators assesses biotic and landscape condition throughout marine, nearshore, freshwater and terrestrial systems but provides limited spatial coverage for assessment of chemical and physical characteristics and processes that create and maintain habitat (i.e. ecological, hydrological and geological processes and natural disturbance regimes).
- Inclusion of all 43 available and proposed indicators in future SOS reports would constitute a 155 % increase over the existing number in the 2009 SOS and require significant time and money to develop.

O'Neill (in prep) provides a more complete summary of how well the available and possible future indicators assess conditions in the Puget Sound ecosystem.

3.2 Status Indicators for Open Standards-based Components and Attributes

In a complementary effort not explicitly represented in 2009 reporting on ecosystem status, the Partnership developed a preliminary suite of ecosystem status indicators for the focal components and key attributes as part of its initial efforts to use the Open Standards. The indicators listed in Appendix B were identified through discussions with experts and stakeholders. Following the proposal of these indicators in mid-2009, this suite of indicators has not been reviewed and refined but may be revisited as part of future work.

An evaluation of ecosystem indicators will be provided in the upcoming 2010 Puget Sound Science Update. The Partnership anticipates that the Science Update will contribute to the basis for the adoption of a refined suite of ecosystem indicators in the future.

4. Evaluation of Ecosystem Status

Answering the Action Agenda's second question – *What is the status of Puget Sound?* – requires an evaluation of current and/or recent ecosystem conditions portrayed by the suite of selected ecosystem indicators. By characterizing ecosystem status, and comparing current and recent conditions to the natural range of variation, thresholds and/or science-policy derived statements of desired conditions, the Partnership can articulate the specific ecosystem situations that need to be addressed by ecosystem recovery.

The Partnership's 2009 evaluation of ecosystem status is summarized within the 2009 Ecosystem Status & Trends Technical Memorandum. Under the leadership of the Science Panel, Partnership staff worked with subject matter experts and data providers to develop and evaluate information on specific indicators. Science Panel members reviewed this information and developed interpretations of recent status and brief synopses of what might affect (or cause) current/recent conditions and how other aspects of the ecosystem might be affected. The Partnership's 2009 evaluation of ecosystem status was informed by a review of scientific information but did not follow a systematic approach, as suggested by the Open Standards framework.¹⁰

A comprehensive synthesis of scientific information on ecosystem status for Puget Sound will be provided in the Puget Sound Science Update. The Partnership anticipates that this synthesis will contribute to the basis for more systematic approaches to characterizing ecosystem conditions.

¹⁰ Step 1B of the Open Standards includes a detailed approach to assessing the current status of focal components that involves: determining indicators for each attribute of focal components (discussed above); describing the range of variation for each indicator; identifying thresholds related to the range of variation; and defining a rating system based on these thresholds and range of variation that can be used to characterize observed conditions. This type of systematic rating can also be used to define desired future conditions (e.g., targets and benchmarks).

5. Identification of Targets and Benchmarks for Ecosystem Status

The Partnership's approach to answering the Action Agenda's first question – *What is a healthy Puget Sound?* – involves the specifying targets and benchmarks for ecosystem indicators. A target is the desired future numeric value for an ecosystem status indicator in 2020. A benchmark is a measurable interim (i.e., pre-2020) milestone set to demonstrate progress toward a target for an ecosystem status indicator. By establishing targets and benchmarks to describe desired ecosystem conditions, the Partnership will provide a powerful tool for evaluating progress toward ecosystem recovery and overcome much of the ambiguity inherent in assessments of ecosystem conditions performed in the absence of targets and benchmarks..

Although the Partnership did not develop targets and benchmarks for ecosystem indicators in 2009, some of the Partnership's results chains work produced examples of component-related targets and benchmarks (e.g., shellfish growing acres, streamflow).¹¹

A synthesis of scientific information on ecosystem indicators, thresholds and alternative futures for the Puget Sound ecosystem will be provided in the Puget Sound Science Update. The final section of this memo discusses how this synthesis might be used by the Partnership to develop targets and benchmarks.

¹¹ Please refer to: Using Results Chains to Develop Objectives and Performance Measures for the 2008 Action Agenda Technical Memorandum (2009).

6. Next Steps and Recommendations

Options for future work on these key performance management topics currently under consideration include continuing with the Open Standards-based approach in conjunction with the Puget Sound Science Update and other science-based processes to:

1. Recommend a list of components and attributes that encompass and represent Partnership interests (using the framework of statutory ecosystem recovery goals and/or adopting, revising, or replacing May-June 2009 components and attributes).
2. Update ecosystem status reports.
3. Provide a scientific basis for policy-science discussions of targets and benchmarks for ecosystem indicators.

The science input from the initial Puget Sound Science Update will be used in Spring 2010 to inform the Partnership's adoption of a performance management system, including a framework for top/ultimate level of performance per the Open Standards approach.

In Spring 2010 the Partnership will define components and associated attributes of the ecosystem to characterize status and assess the viability of the ecosystem as the ultimate means of assessing recovery. Per guidance from the Leadership Council and Cross-Partnership Work Group on performance management, the 2009 characterization of ecosystem status by broad categories under goals may be revised based on the science synthesis produced in the 2010 Puget Sound Science Update.

In Spring 2010 the Partnership will define 2020 targets and benchmarks for indicators of ecosystem status using science input from the 2010 Puget Sound Science Update.

In addition, the Partnership will work to develop data flows for adopted status indicators via coordinated monitoring program and information management systems.

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Appendix A: Partnership Statutory Goals and 2009 Proposed Focal Components and Attributes

Broad indicator categories developed for 2009 ecosystem status reporting (bold bulleted entries) are shown aligned with the Open Standards-based focal components they address. Key attributes for focal components are shown aligned with the Partnership’s statutory goals that they address.

Focal Component	Biota			Water	
	Species	Food Web	Habitat	Quantity	Quality
River Deltas & Coastal Embayments			<ul style="list-style-type: none"> • Extent of ecological systems (at risk) • Connectivity and fragmentation • Estuarine wetlands • Delta or river mouth condition • Coastal embayments and lagoons • Resilience to sea level rise 	<ul style="list-style-type: none"> • Delta or river mouth condition 	<ul style="list-style-type: none"> • Contaminants in different media • Water quality index
Marine Shorelines		<ul style="list-style-type: none"> • Forage fish spawning habitat 	<ul style="list-style-type: none"> • Extent of ecological systems (at risk) • Connectivity and fragmentation • Forage fish spawning habitat • Condition of shorelines • Condition of beaches • Resilience to sea level rise 		<ul style="list-style-type: none"> • Contaminants in different media • Water quality index • Forage fish spawning habitat • Condition of shorelines
Marine Waters			<ul style="list-style-type: none"> • Extent of ecological systems (at risk) • Connectivity and fragmentation • Benthic condition • Biotic condition of marine waters 		<ul style="list-style-type: none"> • Contaminants in different media • Water quality index • Benthic conditions • Marine water condition

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Focal Component	Biota			Water	
	Species	Food Web	Habitat	Quantity	Quality
Freshwater Systems – Streams	<ul style="list-style-type: none"> • Biotic condition 	<ul style="list-style-type: none"> • Biotic condition 	<ul style="list-style-type: none"> • Extent of ecological systems (at risk) • Connectivity and fragmentation • Hydrologic dynamics and structural characteristics • Riparian condition 	<ul style="list-style-type: none"> • # of streams with established instream flow standards; % meeting standards • Storm event runoff • Hydrologic regime 	<ul style="list-style-type: none"> • Contaminants in different media • Water quality index • Chemical and physical characteristics • Biotic condition
Freshwater Systems – Wetlands	<ul style="list-style-type: none"> • Freshwater biotic condition 		<ul style="list-style-type: none"> • Extent of ecological systems (at risk) • Connectivity and fragmentation • Wetland condition • Wetland extent 		<ul style="list-style-type: none"> • Contaminants in different media • Water quality index • Water quality
Freshwater Systems – Lakes	<ul style="list-style-type: none"> • Lake biotic condition 		<ul style="list-style-type: none"> • Extent of ecological systems (at risk) • Connectivity and fragmentation • Lake condition • Lake extent • Lake context • Water quality 		<ul style="list-style-type: none"> • Contaminants in different media • Water quality index • Chemical and physical properties
Marine Fish	<ul style="list-style-type: none"> • Herring • # species at risk • Extent of forage fish populations • Condition of key fish populations • Marine fish habitat condition 		<ul style="list-style-type: none"> • Marine fish habitat condition 		<ul style="list-style-type: none"> • Marine fish habitat condition
Marine Invertebrates	<ul style="list-style-type: none"> • # species at risk • Extent of key populations • Condition of key populations 		<ul style="list-style-type: none"> • Condition of key populations 		<ul style="list-style-type: none"> • Condition of key populations

Identification of Ecosystem Components and Their Indicators and Targets

Focal Component	Biota			Water	
	Species	Food Web	Habitat	Quantity	Quality
Marine Mammals	<ul style="list-style-type: none"> • # species at risk & status of select species such as orca • Extent of key populations • Condition of key populations 	<ul style="list-style-type: none"> • Marine mammal food web 	<ul style="list-style-type: none"> • Condition of key populations 		<ul style="list-style-type: none"> • Condition of key populations
Marine Birds	<ul style="list-style-type: none"> • # species at risk • Extent of key populations • Condition of key populations 				
Salmon	<ul style="list-style-type: none"> • # species at risk & status of select stocks • of key populations • Condition of listed species • Spatial structure of listed species 				
Terrestrial systems			<ul style="list-style-type: none"> • Extent of ecological systems (at risk) • Connectivity and fragmentation • Spatial extent of ecological systems • Condition of ecological systems • Functional connectivity • Resilience to climate change 		
Terrestrial Species	<ul style="list-style-type: none"> • # species at risk & status of select species • Extent of key species • Condition of key species • Resilience 		<ul style="list-style-type: none"> • Resilience 		

Identification of Ecosystem Components and Their Indicators and Targets

Focal Component	Biota			Water	
	Species	Food Web	Habitat	Quantity	Quality
Food webs – marine		<ul style="list-style-type: none"> • Jellyfish abundance -- total and relative to finfish • Material flow • Energy flows • Community attributes • Growth rates 			
Food Webs – Freshwater		<ul style="list-style-type: none"> • Material flow • Energy flows • Community attributes • Growth rates 			
Food Webs – Terrestrial		<ul style="list-style-type: none"> • Material flow • Energy flows • Community attributes • Growth rates 			

Identification of Ecosystem Components and Their Indicators and Targets

Focal Components	Human		Water	
	Human Well Being	Human Health	Quantity	Quality
Built Environments	<ul style="list-style-type: none"> • Flood hazards – building in floodplains • Space for living & working • Energy resources • Movement of goods & resources 		<ul style="list-style-type: none"> • Water supply for end users • Flood protection – rivers & coastal 	
Human Health		<ul style="list-style-type: none"> • Health advisories: shellfish bed closures; fish consump. advisories • Safety of drinking water • Natural resource-assoc. illness/ death • Environment: air, waste, sediment 	<ul style="list-style-type: none"> • Water & biological resources 	<ul style="list-style-type: none"> • Water & biological resources
Working Marine Industries	<ul style="list-style-type: none"> • Commercial & tribal fisheries (businesses) • Commercial & tribal fisheries (resources) • Working waterfront • Aquaculture • Stewardship activities 			
Working Resource Lands and Industries	<ul style="list-style-type: none"> • Farm lands • Farm businesses • Forest lands • Forest business • Stewardship activities 			
Nature Oriented Recreation	<ul style="list-style-type: none"> • Access • Commercial tourism • Recreational harvest • Wildlife viewing • Stewardship activities 			
Scenic Resources & Existence Values	<ul style="list-style-type: none"> • Scenic and intrinsic landscape values • Biologically rich and functioning natural systems 			
Tribal Values & Resources				

Identification of Ecosystem Components and Their Indicators and Targets

Appendix B: Proposed indicators of key attributes of focal components¹²

In mid-2009, the Partnership developed the following preliminary suite of ecosystem status indicators for the focal components and key attributes as part of its efforts to use the Open Standards. As of October 2009, the Partnership has not evaluated current ecosystem status or set targets and benchmarks using these indicators.

River deltas and coastal embayments

- Estuarine wetlands
 - Acreage of wetland classes: total & relative
 - Extent of Spartina invasion
- Delta or river mouth condition
 - Connectivity of floodplain
 - Size of tidal prism relative to historic
 - Channel complexity
- Coastal embayments and lagoons
 - Total area of embayments
 - Number per kilometer of shoreline by subbasin
 - Maximum distance between embayments
- Resilience to sea level rise
 - Habitat availability

¹² Specific indicators were not proposed for two focal components: human health and tribal values and resources.

Identification of Ecosystem Components and Their Indicators and Targets

Marine shorelines

- Extent of forage fish spawning habitat
 - Acreage of suitable beach spawning substrate
 - Acreage of submerged aquatic vegetation available for herring spawning
 - Water quality of suitable spawning habitat
- Condition of shorelines
 - Extent of eelgrass cover
 - Percent of shoreline forested
 - Water quality of nearshore
- Condition of beaches
 - Shoreline alteration impairment scores of drift cells
 - Land use/land cover impairment scores for area within 200 meters of drift cells
- Resilience to sea level rise
 - Habitat availability

Marine waters

- Benthic condition
 - Chemical condition of marine sediments
 - Liver disease in English sole
- Biotic condition of marine waters
 - Plankton community composition
 - Primary productivity
- Marine water conditions
 - Marine water quality index
 - Toxic chemicals in pelagic species

Freshwater systems -- streams

- Hydrologic dynamics & structural characteristic

Identification of Ecosystem Components and Their Indicators and Targets

- Percent of potential floodplain available or connected (relative to historic?)
- Channel morphology and complexity
- Hydrologic regime
 - Percent of streams with flows that create & maintain habitat
 - Percent of streams that meet summer base flows to support species
 - Surface and groundwater flows
 - Water storage
 - Sediment supply/movement
- Riparian condition
 - Percent of stream miles by condition class
- Chemical and Physical Characteristics
 - Material flow – N, C
 - Chemical parameters (dissolved oxygen, nutrients, etc.) and water quality index
- Biotic condition
 - Toxics in biota? (disease in biota?/ physiological condition)
 - Index of Biotic integrity
 - Species at risk

Freshwater systems – wetlands

- Wetland Condition
 - Hydrologic connectivity - % of potential floodplain available or connected
 - percent of wetland shore miles by condition class
 - Material flow – N,P, C cycling
- Wetland Extent
 - Wetland acreage – total
 - Wetland acreage composition - relative
- Freshwater Biotic Condition
 - Freshwater species at risk

Identification of Ecosystem Components and Their Indicators and Targets

- Waterfowl breeding surveys (WDFW)
- Breeding bird survey by species
- Richness of Stillwater amphibian egg masses
- Toxics in biota? physiological condition/disease of organisms
- Water quality
 - Water quality index
 - Chemical parameters

Freshwater systems – lakes

- Lake condition
 - Trophic state index
 - Material flow – N, P, C cycling
- Lake extent
- Lake context
- Lake biotic condition
 - Species at risk
 - Toxics in biota?
- Chemical and physical properties
 - Chemical parameters (nitrogen, phosphorus, dissolved oxygen)

Marine fish

- Forage fishes
 - Herring spawning biomass
 - Pelagic forage fish biomass
- Marine fish diversity
 - Marine fish diversity index
 - Number of marine fish species at risk
- Fish health/physiology
 - Marine fish physiological indicator

Identification of Ecosystem Components and Their Indicators and Targets

- Disease incidence?
- Marine fish habitat condition
 - Volume of sufficient dissolved oxygen per unit time
 - Fish larvae recruitment

Marine shellfish and invertebrates

- Size of key populations
 - Dungeness crab abundance
 - Native littleneck clams
 - Population size of pinto abalone
- Population condition of key species
 - Olympia oyster settlement (measure of Olympia oyster status and effect of acidification)
- Community condition
 - Marine benthic IBI
 - Intertidal invertebrate community

Marine mammals

- Size of key populations
 - Harbor seal population size
 - Southern resident orca population size
- Condition of key populations
 - Toxic chemicals in harbor seal pup (or southern resident orca) blubber
 - Southern resident orca population growth rate
- Marine mammal food web
 - Orca prey abundance – Chinook salmon population size
 - Sound-wide herring spawning biomass

Identification of Ecosystem Components and Their Indicators and Targets

Marine birds

- Population size
 - Number of active heron rookeries
 - Winter non-breeding abundance of sea birds
 - Shorebird indicator?
 - Density of seabirds during breeding season
- Condition
 - Number of marine bird species at risk
 - Fledglings per year (species specific?)
- Food web
 - Marine shorebird food web interactions
- Habitat?
 - Murrelet nesting habitat

Salmon

- Extent of all species
 - Escapement of hatchery and wild salmon
 - Run size of hatchery and wild salmon
- Condition of listed species
 - Diversity
 - Number of salmon stocks listed
 - Juvenile outmigration (used to estimate productivity)
 - Measure of reproductive potential?
 - Measure of physiological health?
- Spatial structure of listed species
 - Chinook spatial structure
 - Hood Canal summer chum spatial structure
 - Steelhead spatial structure

Identification of Ecosystem Components and Their Indicators and Targets

Terrestrial habitats

- Spatial extent of ecological systems
 - Spatial extent of ecological systems or plant associations
 - Land use/land cover change
- Condition of ecological systems or plant associations
 - Patch size
 - Edge to interior ratio
- Functional condition for key terrestrial species
 - Within forest connectivity
 - Forest - freshwater connectivity
 - Forest - marine connectivity
- Resilience to climate change

Terrestrial species

- Size of key populations
 - Number of terrestrial species at risk
 - Pileated woodpecker abundance
 - Measure of spatial extent?
- Condition of key populations
 - Breeding bird count biodiversity
 - Measure of physiological health?
 - Measure of reproductive potential?
- Resilience
 - Health of forests

Food webs – marine

- Material flow
 - Nutrient cycling?

Identification of Ecosystem Components and Their Indicators and Targets

- Carbon cycling?
- Energy Flows
 - Net ecosystem production (diel changes in O₂ and CO₂ fluxes)
 - Growth efficiency
 - Primary productivity (total chlorophyll per unit area)
- Community attributes
 - Food web structure (e.g., food chain length, mean trophic level)
 - Community composition (biomass spectrum)
 - Community dynamics (predation/ competition rates?)
- Resilience

Food webs – freshwater

- Material flow
 - Nutrient cycling?
 - Carbon cycling?
- Energy Flows
 - Trophic status (e.g., TSI)
- Community attributes
 - Food web structure e.g. food chain length)
 - Community composition
 - Community dynamics
 - Resilience
- Organism growth rates

Food webs – terrestrial

- Material flow
 - Nutrient cycling?
 - Carbon cycling (efficiency of microbial decomposition)?
- Energy Flows

Identification of Ecosystem Components and Their Indicators and Targets

- Net ecosystem production (net organic carbon storage?)
- Growth efficiency (primary production vs. net ecosystem production?)
- Primary productivity (organic carbon storage?)
- Community attributes
 - Food chain length, mean trophic level
 - Community composition (e.g., biomass spectrum)
 - Community dynamics (e.g., succession rates; pollination rates)
 - Resilience
- Growth rates

Built environment

- Space for living and working
 - Extent
 - Affordability
- Energy Resources
 - Price
 - Security/availability
- Movement of Goods and People
 - Efficiency of cargo movement
 - Efficiency of people movement
- Water Supply for End Users
 - Security – water quantity
 - Security – water quality
- Flood Protection
 - Flood protection – rivers
 - Flood protection – coastal

Working marine industries

- Commercial & Tribal Fisheries (businesses)

Identification of Ecosystem Components and Their Indicators and Targets

- Profitability
- Contribution to local economy
- Commercial & Tribal Fisheries (resources)
 - Status of commercially important fish & shellfish stocks
 - Number of commercial shellfish acres open
- Working Waterfront
 - Marine transportation (goods)
 - Marine transportation (people)
- Aquaculture
 - Number of commercial shellfish acres open
 - Profitability (landings)

Working resource lands and industries

- Farm lands
 - Amount of farm lands
 - Conversion rate of agricultural lands by conversion class
- Farm businesses
 - Number of farm businesses
 - Profitability
- Forest lands
 - Lands available for timber harvest
 - Conversion rate of private forest lands
- Forest businesses
 - Private working forests
 - Contribution to local economy

Nature oriented recreation

- Access
 - Access to marine and freshwater for recreational use

Identification of Ecosystem Components and Their Indicators and Targets

- Access to lands for recreational use
- Number of forest passes sold
- Commercial Tourism
 - Nature-base tourism revenue
 - Whale watching (revenue?)
- Recreational Harvest
 - Recreational fishing – user days
 - Recreational fishing – shellfish harvest
- Wildlife viewing
 - Bird watching
- Stewardship activities

Aesthetics, scenic resources, and existence values

- Scenic and intrinsic landscape values
 - Viewshed analysis or other measure of magnitude of scenic resources
- Biologically rich and functioning natural systems
 - Biodiversity measures