IDENTIFYING IMPORTANT ECOSYSTEM GOODS & SERVICES IN PUGET SOUND

Draft summary of interviews and research
for the Puget Sound Partnership

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I. OVERVIEW

The World Resources Institute (WRI), Meridian Institute, and NOAA Fisheries are assisting the Puget Sound Partnership in identifying the most important regional ecosystem goods and services through a series of interviews with key stakeholder groups. "Ecosystem services" are the variety of benefits that ecosystems (e.g., forests, wetlands, eelgrass beds) provide to people, communities, and businesses. These benefits include food, freshwater, timber, flood control, erosion control, and recreation, among others *(see Appendix A for a list and definitions of more than 25 ecosystem services).* The "most important" ecosystem goods and services are the 5-10 benefits derived from Puget Sound that the region's stakeholders most value or that most contribute to stakeholder well-being.

Purpose

Identifying the most important ecosystem goods and services in Puget Sound could contribute to the Puget Sound Partnership's 2020 Action Agenda and its activities in several ways. In particular, it could help to: (1) refine general goal statements and elaborate on objectives for which progress will be reported, and (2) focus priority strategies and actions that point towards – and most efficiently sustain and restore – the services people care most about.

1. Help refine goals and indicators

- *Help define what a "healthy Sound" is.* The Partnership has been asked to define "What is a healthy Puget Sound?" Gathering input from stakeholders about what benefits they want the regional ecosystem to provide can help answer this question. Those ecosystem goods and services that are most highly valued or utilized by stakeholders are those that, if in good condition, citizens and policymakers would recognize as defining a "healthy Puget Sound."
- *Help communicate the goals of the Partnership.* The Partnership will be communicating its goals and action agenda to lawmakers and the general public. Communicating goals and the benefits of protection and restoration in terms of specific ecosystem goods and services that people relate to and value can help strengthen the communications effort. For instance, describing the goals and benefits in terms of recreational opportunities and improvements for commercial fishing is more likely to resonate with the public than just using scientific measures such as biological oxygen demand or concentrations of toxics in sediment.
- *Help prioritize indicators for measuring and monitoring the status of the Sound.* The Partnership will be proposing a set of indicators for continuously measuring and monitoring the status and trends in the Sound's health. Many candidate indicators exist including population levels of species such as salmon and orca, water quality, sediment transport, acres of important habitat types, levels of toxic contamination, and many more. A technical analysis of existing indicators is underway, and will provide a scientific basis for selecting among metrics for tracking ecosystem health. However, the Partnership cannot measure or report on all of them; having too many indicators would be expensive to monitor and difficult to succinctly communicate. Knowing which ecosystem goods and services are considered "most important" by stakeholders will help the Partnership select those indicators that are most relevant to people's needs and easier to communicate when reporting progress to the public.

2. Help prioritize strategies and actions

- *Help focus strategies and actions.* The Partnership is also working to answer the question, "What actions must be taken that will move us from where we are today to a healthy Puget Sound by 2020?" Public policies, general strategies, regulatory changes, and specific capital projects will comprise many of these actions but there are many candidate strategies from which to choose. Understanding which ecosystem goods and services are most valued by stakeholders will help the Partnership concentrate on selecting and designing the policies and strategies most likely to sustain or restore these benefits.

Process

From mid-May through early July 2008, WRI and the Meridian Institute interviewed 45 people representing many of the major stakeholder "sectors" in the Puget Sound region. Stakeholder sectors included agriculture, business, cities, counties, environmental interests, fishing and aquaculture, forestry, homebuilding, ports and shipping, recreation, tourism, and tribal governments. Partnership staff—in some cases with input from the Partnership's Ecosystem Coordination Board (ECB) members—identified the interviewees. Table 1 outlines the affiliations and stakeholder sector of the interviewees.

Through a structured discussion, interviewees were asked a series of questions in order to identify:

- Which ecosystem goods and services (from the list in Appendix A) most contribute to the well-being or interests of the sector they represent?
- In what way do these services benefit the sector?
- What major ecosystem service trade-offs need to be managed?

WRI and Meridian conducted the interviews by telephone. Each interview session lasted between 25 and 75 minutes with some participants interviewed individually while others in groups of two or three. According to the interview ground rules, the interviewers would not attribute specific statements to specific individuals, only to the specific sector that they represent. Comments attributed to the interviewees in this report (referencing only the sectors they represent), including those in quotation marks, are paraphrases, as these interviews were not conducted on a recorded line.

Table 1. Interviewee affiliations, by sector

Sakuma Brothers	agriculture
Western Washington Agricultural Assoc.	agriculture
Association of Washington Business	business
Building Industry Association of Washington	business
Microsoft	business
Seattle Chamber of Commerce	business
Starbucks	business
Association of Washington Cities	cities
City of Kent, Environmental Engineering	cities
City of Kent, Environmental Conservation	cities
Federal Way City Council	cities
Port Townsend	cities
City of Sultan	cities
Pierce County Council	counties
Pierce County Water Programs	counties
San Juan County Council	counties
People for Puget Sound	environmental interests
The Nature Conservancy	environmental interests
Northwest Indian Fisheries Commission	fishing and aquaculture
Sport Fishing Alliance	fishing and aquaculture
Taylor Shellfish	fishing and aquaculture

Family Forest Foundation	forestry
Port Blakely Tree Farms	forestry
Washington DNR	forestry
Washington Forest Protection Association	forestry
Built Green Washington	homebuilding
Master Builders Association	homebuilding
Quadrant Homes	homebuilding
Port Angeles	ports/shipping
Washington Ports Association	ports/shipping
American Whitewater	recreation
Marine Trades Association	recreation
Washington Recreation and Park Association	recreation
Washington Scuba Alliance	recreation
Washington Wildlife and Recreation Coalition	recreation
National Parks Service	tourism
Port of Seattle, Cruise Lines Div.	tourism
San Juan Safaris	tourism
Trade and Economic Development (CTED)	tourism
Washington State Convention and Trade Center	tourism
Washington State Parks	tourism
Nisqually Tribe	tribal governments

II. INTERVIEW RESULTS

Summary

Table 2 summarizes the results of the interviews. If at least one interviewee representing a particular sector attached "high importance" to an ecosystem service, then the cell was shaded. The maximum score an ecosystem service could receive is 12 (if at least one interviewee in every sector cited that ecosystem service as having "high importance"). Ecosystem services that scored an 11 or 12 were ranked as "Tier I" services. Services that scored 8 through 10 were ranked "Tier II" services.

After tabulating the results, two tiers of ecosystem services emerged from the analysis as "most important" to the stakeholders interviewed. "Most important" can be interpreted as those ecosystem services that contribute to the well being or interests of the broadest range of Puget Sound stakeholder groups that were interviewed.

Table 2. Interview results. If at least one interviewee representing a particular sector attached "high importance" to an ecosystem service, then the cell was shaded. Ecosystem services that scored an 11 or 12 (highlighted in blue) were ranked as "Tier I" services. Services that scored 8 through 10 (highlighted in green) were ranked "Tier II" services.

	SECTORS												
ECOSYSTEM SERVICES	Environmental interests	Tribal governments	Cities	Counties	Recreation	Agriculture	Forestry	Fishing & aquaculture	Tourism	Homebuilding	Business	Ports & shipping	Total sectors citing 'high importance' (n=12)
Crops													5
Livestock													1
Capture fisheries													9
Aquaculture													0
Wild foods													2
Timber and other wood fiber													6
Other fibers													0
Biomass fuel													0
Water													12
Genetic resources													3
Biochems, nat meds, pharmacls													1
Air quality regulation													3
Global climate regulation													1
Regional and local climate regulation													0
Water regulation													11
Erosion regulation													7
Water purification and waste treatment													9
Disease regulation													1
Pest regulation													0
Pollination													0
Natural hazard regulation													3
Recreation and ecotourism													11
Ethical and existence values													11

Tier I services (highlighted in blue in Table 2), which scored 11 or 12, are:

- Water
- Water regulation
- Recreation and ecotourism
- Ethical and existence values

Tier II services (highlighted in green in Table 2), which scored 8, 9, or 10, are:

- Capture fisheries
- Aquaculture
- Water purification and waste treatment

The following describes in more detail each of these services and the benefits they provide to the interviewees. It begins with a discussion of the water-related services (i.e., water, water regulation, water purification and waste treatment). It continues with a discussion of the cultural services (i.e., recreation and ecotourism, ethical and existence values). It concludes with a discussion of "capture fisheries" and "aquaculture".

Water (Tier I)

Definition: Inland and marine bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses, as well as for water-borne navigation and commerce services.

Types of benefits cited by interviewees *(why this ecosystem service is valued by stakeholders)*:

- Sufficient quantities of water for households and industry, as well as sufficient in-stream flows for ecological functions
- Water for hydropower
- Marine navigation and commerce

Perspectives of some of the sectors:

Homebuilding sector: Need sufficient water supplies in areas where they are building to be able to proceed with development.

Cities sector perspective: Need water supplies for industrial needs and for housing development. Need to ensure development envisioned can take place, given available water resources and water rights.

Business sector perspective: Low electricity rates provide a competitive advantage (90% of power generated for Seattle and Tacoma comes from hydroelectric facilities).

Ports and shipping sector perspective: Puget Sound provides a variety of marine navigation and commerce services: 1) deep water industrial terminals, 2) barge terminals for short sea shipping or marine highways, 3) recreational and commercial fishing, 4) recreational boating, and 5) ferry and passenger services.

Discussion:

Sufficient quantities of water for households, industry, agriculture. Many of the interviewees were concerned about current and future prospects for securing sufficient quantities of freshwater to meet their goals. A representative of the homebuilding sector, for example, noted that some jurisdictions have had development moratoria because of water issues. Surface water rights, furthermore, are increasingly impacting the ability of some jurisdictions to meet density and growth management goals. A representative of the cities sector observed that development envisioned is not in balance with the water rights available. In one city, a paper mill is in process of coming out of bankruptcy. If the mill gets going again, there will not be enough water supply for expanded city development.

In-stream flows that can support ecological functions (including in-stream temperatures required to support many native fish species). Many of the stakeholders interviewed, including representatives of tribal governments, the fishing and aquaculture sector, the environmental sector, the recreation sector, and the cities sector, have noted the problem of keeping sufficient quantities of water flowing in rivers and streams to support aquatic life and natural processes.[1] The issue of "permit-exempt" wells (which are exempted by statute from having to obtain a water right permit) and their impact on stream flows was cited several times as an issue of growing concern.

Hydroelectric power. A representative of the county sector noted the issue of rising rates for electricity. A representative of the business sector, citing the potential problem that climate change poses for hydropower generation, noted that "this year there has been more snow than any time recently, which is good for hydropower and water supply, but we can't bank on it continuing. If most of the precipitation falls as rain instead of snow it is problematic. The snowpack here serves as a natural storage facility. It is a Herculean task to even think of building new storage reservoirs because of the environmental hurdles. People in the energy and industrial fields understand the situation. Our low electricity rates are a competitive advantage for us – if they go up, it creates a dilemma for us."

Water-borne navigation and commerce. Puget Sound provides a variety of waterborne navigation and commerce services: 1) deep water industrial terminals, 2) barge terminals for short sea shipping or marine highways, 3) recreational and commercial fishing, 4) recreational boating, and 5) ferry and passenger services. A representative of the ports and shipping sector is concerned about their continued access to the shoreline as measures are enacted to protect shorelines. Washington, with its 75 port districts, is the most trade-dependent state in the United States.[2] One source notes that "taken together, the Ports of Seattle and Tacoma are the third largest container complex in the United States. More than $40 billion worth of goods travel through the ports of Puget Sound each year leading to tens of thousands of direct and indirect jobs."[3]

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[1] Even if the state establishes an in-stream flow rule for a watershed, the state water code does not allow the in-stream flow water right to supersede more senior water rights established prior to the rule. See *Puget Sound Partnership Freshwater Resources Topic Forum* paper, draft dated April 14, 2008, pp. 26-27. "[The Washington State] water code, and western water law generally, is based on the 'prior appropriation doctrine.' This doctrine, also known as 'first in time, first in right,' means that the most senior right in the basin is entitled to its entire quantity of water before the second most senior right receives any water."

[2] http://www.washingtonports.org/

[3] http://www.pugetsoundnearshore.org/technical_papers/coastal_habitats.pdf

Water regulation (Tier I)

Definition: Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape**.**

Types of benefits cited during interviews *(why this ecosystem service is valued by the stakeholders)**:***

- Storm water management
- Timing and availability of water supplies
- Flood and drought mitigation
- Natural storage as snowpack

Perspectives of some of the sectors:

Counties sector perspective:

- Rely on natural landscapes to collect and filter storm water so as to ensure a high quality, sustainable supply of freshwater and preclude surface contaminants from mixing with storm water runoff
- Rely on high functioning natural floodplains and wetlands, which can provide natural flood prevention
- Rely on the natural water storage function of snowpack, which sustains agriculture, fisheries, and other users during late spring and summer months

*Environmental sector perspective**:*** Rely on adequate levels of ground water recharge to ensure that stream flows are sufficient to support freshwater habitats and wildlife.

Tribal governments perspective: Water regulation is instrumental for flood mitigation and protection of ecological assets.

Discussion:

Storm water management. Storm water runoff was perhaps the most oft-cited cause of deteriorating water quality in the Sound by those interviewed. The storm water pollution problem is largely a function of converting land to paved and built surfaces, which increases storm water runoff into surface waters instead of its infiltration through soils into groundwater. The large volume of storm water runoff carries various types of pollutants with it into streams, rivers, lakes, and ultimately marine waters.

Timing and availability of water supplies (for water users and hydroelectric power production). A number of factors appear to be diminishing the availability of water supplies during low flow (summer) periods[4]. Recent work conducted for the Partnership notes that "in-stream flow rules have been set by [Department of] Ecology in 12 [of 19] watersheds in the Puget Sound region. In

[4] *Puget Sound Partnership Water Quantity Topic Forum Discussion Paper*, July 11, 2008, p. 8.

most of these 12 watersheds, stream flows were met less than 50% of the time during low-flow periods, and in some watersheds, less than 80% of the time."[5]

Flood and drought mitigation. A representative of the counties sector emphasized the importance of preserving high functioning natural floodplains and wetlands. These floodplains and wetlands can provide natural flood attenuation, habitat and other benefits. He also noted that the area has lately been experiencing increasing record floods.

Natural storage as snowpack. The importance of snowpack as a natural store of water is not only important for hydropower generation, but also for all other users of water and for flood and drought mitigation. A representative of the counties sector is concerned over loss of snowpack, noting that when precipitation comes down as rain instead of snow, there are water shortage impacts on agriculture, fisheries, and other users, as drought conditions generally follow periods of low snowfall.

Water purification and waste treatment (Tier II)

Definition: Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water; assimilation and detoxification of compounds through soil and subsoil processes**.**

Types of benefits cited during interviews *(why this ecosystem service is valued by the stakeholders)**:***

- Natural filtration (role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water)
- Capacity to assimilate pollution

Perspectives of some of the sectors:

Forestry sector perspective: Intact forests play an instrumental role in filtering freshwater. Active forest management in Seattle and Tacoma watersheds helps provide good water quality to these cities and protects the watersheds from development.

Counties sector perspective: Ecosystems can assimilate, filter and decompose pollution, but they have a finite capacity to do so. This capacity is being overwhelmed.

Discussion:

Natural filtration. Forests, wetlands, floodplains, and natural buffers filter polluted runoff (from farms, roads, lawns, houses and other infrastructure). Active forest management in the Seattle and Tacoma watersheds helps provide good water quality to these cities and protects the watersheds from development. One recent study identifies Seattle as one of several U.S. cities that have avoided construction of filtration plants through watershed protection. The study estimated Seattle's avoided costs at $150-200 million (gross).[6]

[5] Ibid., p. 14.
[6] Postel, Sandra L. and Barton H. Thompson, Jr. *Watershed protection: Capturing the benefits of nature's water supply services.* Natural Resources Forum 29(2005), p. 100.

Ability to assimilate pollution. Several interviewees pointed to the problem of overloading the ability or marine waters to absorb waste. A representative of the counties sector noted how development on or near the shoreline has been increasing. Smaller homes are being converted to huge homes on the same lot size, but the accompanying septic systems are often not upgraded. There are approximately 500,000 septic systems in the Puget Sound basin[7]. Many of these systems fail or are not properly maintained. In addition, septic systems are generally not designed for nitrogen removal, and discharges contain high levels of nutrients.[8] Portions of Puget Sound tend to show higher sensitivity for hypoxia and other problems related to nutrients.[9] Wastewater is also a source of nutrients.[10] Another representative of the county sector noted that wastewater treatment plants are treating to a high level but there is a lot more effluent being discharged into the Sound than in the past, probably boosting the nutrient load. It would make more sense – where possible – to reuse wastewater treated to Class A standards than to discharge it to the Sound, as this would not only reduce nutrient loading in the Sound, but could also, in certain circumstances, support the freshwater ecosystem through reduced dewatering.[11]

Recreation and ecotourism (Tier I)

Definition: Recreational pleasure people derive from natural or cultivated ecosystems.

Types of benefits cited during interviews *(why this ecosystem service is valued by the stakeholders)**:***

- Numerous recreational opportunities for residents
- Premier destinations of uncommon quality
- Dynamic tourist destination with both urban *and* natural attractions
- Large source of revenue and jobs for the local economy
- Recreational amenities which help recruit and retain employees

Perspectives of some of the sectors:

Cities sector perspective: Most residents recognize that tourism is a large component of the economy.

Tourism sector perspective: The Seattle area is particularly dynamic in regard to its ability to provide recreation and tourism opportunities, as the city is not only a premier tourism destination in and of itself, but also serves as a gateway to natural amenities.

*Business sector perspective**:*** The recreational amenities provided by the Sound provide area residents with a good quality of life and help local businesses recruit and retain employees.

Discussion:

Recreation and tourism are thriving components of the local economy. A representative of the tourism sector noted that "having an attractive, unique destination is essential. The Seattle brand is

[7] *Puget Sound Partnership Water Quality Topic Forum Discussion Paper*, August 1, 2008, p. 15.
[8] Ibid., p. 16.
[9] Ibid., p. 18.
[10] Ibid., p. 56.
[11] Ibid., p. 58.

'metro natural' – which is a combination of the city experience mixed with the natural environment. From a downtown building you can see the Sound and the Olympic Mountains and you can walk to the water. We sell the boating, fishing and the experience. Seattle is a gateway to natural amenities." A recent study prepared for the Puget Sound Nearshore Partnership notes that "visitor and recreation activity in Puget Sound generates $5.2 billion in revenue and 62,000 jobs… the 4 million people living in the Puget Sound watershed own nearly 500,000 boats, sailboats, and other watercraft that are moored in more than 280 marinas…".[12]

Ethical and existence values (Tier I)

Definition: Spiritual, religious, aesthetic, existence, or other values people attach to ecosystems, landscapes, or species.

Types of benefits cited during interviews *(why this ecosystem service is valued by the stakeholders)**:***

- Aesthetic value of area attracts "best and brightest" members of the labor force
- Aesthetic value of area provides residents with quality places to live
- Traditional tribal ways of life
- A healthy, thriving waterfront
- Agricultural lifestyles

Perspectives of some of the sectors:

Forestry sector perspective: The attractiveness of the area is what brings creative, innovate people – and results in a vibrant, dynamic, high tech industry.

Homebuilding sector perspective: The aesthetics of the area is what attracts people to move to the region.

Tribal governments perspective: Locally grown food, gathering of wild foods, fisheries, and shellfish – those services that support tribal cultures – are of utmost importance

Ports and shipping sector perspective: A thriving waterfront is important.

Agricultural sector perspective: Rural lifestyles and open space are valuable.

Discussion:

This highly attractive area:

- *Attracts creative and innovative people, resulting in vibrant, dynamic industries.* One interviewee representing the forestry sector cited author Richard Florida: "His thesis is that the most creative of our culture, the entrepreneurs, are attracted to an area because of its livability. It isn't the companies that create the draw. The attractiveness of the area is what brings creative, innovate people – and results in a vibrant, dynamic, high tech industry. People come [to the Puget Sound area] because it is drop-dead gorgeous, with no black fly or mosquito issues. That's a reason to look after the land and waters here."

[12] http://www.pugetsoundnearshore.org/technical_papers/coastal_habitats.pdf

- *Provides residents with quality places to live.* A representative of the homebuilding sector notes that "we want to build homes in areas where there is a high quality of life/ambiance. That's a large part of what this area sells – what attracts people to want to live here."

Capture fisheries (Tier II)

Definition: Wild fish captured through trawling and other non-farming methods**.**

Types of benefits cited during interviews *(why this ecosystem service is valued by the stakeholders)**:***

- Sustainable livelihoods for tribal nations
- Recreational value for boaters

Perspectives of some of the sectors:

Fishing and aquaculture sector perspective: Tribal communities harvest salmon for the sustainability of their livelihoods.

Recreation sector perspective: Capture fisheries are valued by boaters seeking to selectively harvest fish stocks

Aquaculture (Tier II)

Definition: Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for purposes of harvesting**.**

Types of benefits cited during interviews *(why this ecosystem service is valued by the stakeholders)**:***

- Shellfish cultivation and harvesting important segment of local economy
- Particularly important component of tribal economies and livelihoods

Perspectives of some of the sectors:

Counties sector perspective: The shellfish industry is a multi-million dollar industry ("Washington State [is] the second largest oyster-producing region in the country, now worth about $50 million per year…geoduck harvest has generated $60 million of public funds through auctions of harvest quotas…"[13])

Tribal governments perspective: "Shellfish are very important for providing for our people and for the economy"

[13] http://www.pugetsoundnearshore.org/technical_papers/coastal_habitats.pdf

III. IMPLICATIONS OF INTERVIEW FINDINGS

Identifying what 12 stakeholder groups broadly consider to be the "most important" ecosystem goods and services provided by the Puget Sound can provide insights to a number of aspects of the Action Agenda:

1. Defining a "healthy Puget Sound"
2. Communicating the goals of the Partnership
3. Prioritizing indicators for measuring and monitoring the status of the Sound
4. Prioritizing strategies and actions.

1. Defining a "healthy Puget Sound"

The first step in developing the Action Agenda is to define a healthy Puget Sound. Knowing what major stakeholders consider "most important" in the Sound can strengthen the Partnership's ability to define a "healthy Puget Sound".

Table 3 lists the seven "most important" ecosystem services identified through the interview process, together with a summary of the benefits each of these services provides. These services (and terms that point to these services) are good candidates for including in any description of a healthy Sound.

Table 3. Defining what a "healthy Sound" is. This table lists the seven "most important" ecosystem services identified through the interview process, together with a summary of the benefits each of these services provides.

Tier I and II Services	Benefits
Water	•Water for homes, industry, agriculture •Water for ecological functions •Water for hydropower generation •Water-borne navigation and commerce
Water regulation	•Storm water management •Timing and availability of water supplies •Flood and drought mitigation •Natural storage (snowpack and glaciers)
Water purification and waste treatment	•Natural filtration •Capacity to assimilate pollution
Recreation and ecotourism	•Provide residents with numerous recreational opportunities •Premier destinations of uncommon quality •Dynamic destination that provides both urban *and* natural attractions •Large source of revenue and jobs for local economy •Recruit and retain employees
Ethical and existence values	•Attract creative and innovative people •Provide residents with quality places to live •Support traditional Tribal ways of life •Provide a healthy, thriving waterfront •Support agricultural lifestyles
Capture fisheries	•Sustainable livelihoods for Tribes •Large source of revenue and jobs for the local economy •Recreational value
Aquaculture	•Sustainable livelihoods for Tribes •Large source of revenue and jobs for the local economy

2. Communicating the goals of the Partnership

The Partnership will be communicating its goals and action agenda to lawmakers, stakeholders, and the general public. Communicating goals and the benefits of restoration in terms of specific ecosystem goods and services that people relate to and value can help strengthen the communications effort. For instance, describing the goals and benefits in terms of recreational opportunities and improvements for commercial fishing is more likely to resonate with the public than just using scientific measures such as biological oxygen demand or concentrations of toxics in sediment.

Some general suggestions for strengthening communication of the Partnership's goals in light of the identified "most important" ecosystem services include:

- Reference the "benefits" associated with the seven Tier I and II services
- Highlight the links to human well-being
- Link the ecosystem services being protected or restored to the stakeholder groups ("sectors") that will benefit from such actions

The Partnership's *Initial Strategic Priorities for Puget Sound (June 19, 2008)*[14] articulates a number of goals of the Puget Sound Partnership. Table 4 includes a couple of examples of how these goals are currently expressed and the ecosystem services to which they relate. With the results of the stakeholder interviews in mind, the third column offers some suggested ways to strengthen how these goals could be articulated *(the new language does not attempt to replace all of the information in the original quotes)*. These are just suggestions and there may very well be other ways to strengthen the articulation of each goal. Likewise, Table 4 does not assess every goal in the "Initial Strategic Priorities". But a similar analysis could be applied to the goals not listed in Table 4 in order to strengthen how the Partnership communicates its objectives to the public and policymakers.

Table 4. Examples of ways to strengthen Partnership communications. This table includes a couple of examples of how Partnership goals are currently expressed, the ecosystem services to which they relate, and suggested ways to strengthen how these goals could be articulated.

Current expression of goal	**Tier I or II ecosystem service addressed**	**Example of way to strengthen communication**
"Protection of existing functional upland and marine ecosystem processes is critical for maintaining wildlife habitat, flows of fresh water, groundwater infiltration, controlling the volume and composition of storm water runoff, and many other ecosystem functions."	– Water – Water regulation	"Protecting natural landscapes can boost the quantity and quality of freshwater available to urban users, ease the growing problem of competition for scarce freshwater resources, and reduce the high costs associated with floods and droughts."
"Nutrients from human and animal	– Water purification and waste	"Pollution from a number of

[14] http://www.psp.wa.gov/downloads/AA2008/aa_priorities.pdf

wastes and fertilizers are depleting oxygen levels in waters of Puget Sound where circulation is limited. At a system wide level we must reduce this ongoing pollution if we are to recover the Sound."	treatment – Ethical and existence values – Capture fisheries and aquaculture	sources—including septic tanks, discharges from wastewater treatment plants, and runoff from agricultural lands and lawns—is beginning to create 'dead zones' imperiling marine life in places like Hood Canal. This, in turn, will likely further undermine commercial fisheries (especially shellfish) in Puget Sound."

3. Priority indicators for measuring and monitoring the status of the Sound

The Partnership will be proposing a set of indicators for continuously measuring and monitoring the status and trends in the Sound's health. However, the Partnership cannot measure or report on all of them; having too many indicators would be expensive to monitor and difficult to succinctly communicate. Knowing which ecosystem goods and services are considered "most important" by stakeholders will help the Partnership select those indicators that are most relevant to people's needs and easier to communicate when reporting progress to the public.

As a first step towards selecting a set of indicators that are relevant to people's needs, the Partnership might consider classifying each candidate indicator according to the Tier I and II service benefit(s) it addresses. A second step would involve classifying the indicator according to the DPSIR framework element it addresses.

The DPSIR framework, which NOAA and the Partnership have been employing in their recent analyses, links (1) ***drivers*** of ecosystem change to (2) ***pressures*** placed on ecosystems, to (3) ecosystem ***states***, to (4) ***impacts*** on populations, to (5) societal ***responses***. It is important to ensure that the indicators chosen by the Partnership for each Tier I and II service include indicators from each of these categories, so as to allow the Partnership to track the condition of these important services, the threats that affect them, and policy responses that seek to mitigate the effects of the threats on these key ecosystem services.

Once the candidate indicators have been classified, a gap analysis can be conducted in order to identify (1) which ecosystem service benefits are not adequately covered by the candidate indicators, (2) which elements of the DPSIR framework are not adequately covered by the candidate indicators.

Table 5 provides an example of what such a gap analysis might look like. The first two columns in the table show the Tier I and II services, and their associated benefits. For each ecosystem service benefit (or set of benefits), the third column lists some examples of indicators currently being considered by the Partnership.[15] Columns four, five, and six represent the DPSIR categories:

[15] We reviewed indicators included in the August 22, 2008 ECB meeting handout entitled "Indicators and Benchmarks – Agenda Item #6". We also reviewed indicators included in a document entitled "HWB Indicators", by Morgan Schneidler and Mark Plummer of the NOAA Northwest Fisheries Science Center.

drivers/pressures, state, and impact/response (note: the Partnership has combined the DPSIR categories in this manner; in order to provide consistency, the authors have combined them in the same manner). Each indicator can be classified by DPSIR category. The final column assesses whether or not the indicators under consideration address the ecosystem service benefits. The color green denotes "adequate" coverage, yellow denotes "possible gap" in coverage, and red denotes "apparent gap" in coverage. *Table 5 is intended for illustrative purposes only – a full gap analysis would need to be undertaken by a group of subject matter experts.*

Table 5 only classifies the indicators associated with "water for homes, industry, agriculture" by DPSIR category, in order to illustrate how this part of the gap analysis might be done.[16] All of the indicators associated with this ecosystem service benefit address the "state" category, and the Partnership may therefore want to consider identifying additional indicators for this ecosystem service benefit that address "drivers/pressures" and "impact/response".

[16] The indicators included for "water for homes, industry, agriculture" all come from "Indicators and Benchmarks – Agenda Item #6" (see footnote #14).

Table 5. Indicators under Partnership consideration vis a vis the Tier I and II services and elements of the DPSIR framework – example gap analysis. The first two columns in the table show the Tier I and II services, and their associated benefits. For each ecosystem service benefit (or set of benefits), the third column lists some examples of indicators currently being considered by the Partnership. Columns four, five, and six represent the DPSIR categories: drivers/pressures, state, and impact/response. Each indicator can be classified by DPSIR category. The final column assesses whether or not the indicators under consideration address the ecosystem service benefits. The color green denotes "adequate" coverage, yellow denotes "possible gap" in coverage, and red denotes "apparent gap" in coverage.

Tier I and II services	Benefits	Indicators under consideration by Partnership (examples)	Indicates what?			Comment
			D/P	S	I/R	
Water	Water (quantity and quality) for homes, industry, agriculture	Annual mean flow Annual maximum daily flow Annual 7-day low flow Snowpack Glacier mass balance Drinking water quality – toxics, nutrients Quality of groundwater for drinking Water quality index Toxics in water Stream water quality parameters Fecal bacteria – streams Fecal bacteria at lake non-swimming beaches		X X X X X X X X X X X X		• Additional and more robust water scarcity indicators may be needed (e.g., supply-demand imbalance in a watershed) • No apparent indicator for groundwater extraction and recharge
	Water (quantity and quality) for ecological functions	Violations of Ecology in-stream flows Annual mean flow Annual 7-day low flow Water temperature – lakes Water quality index				
	Water for hydropower generation					• No apparent indicators for hydropower
	Water-borne navigation and commerce	Marine cargo handling - annual payroll Port and harbor operations - annual payroll Marinas - annual payroll Other water transportation services - annual payroll				
Water regulation	Storm water management Timing and availability of water supplies Flood and drought mitigation Natural storage (snowpack and glaciers)	Land cover trends Change in wetland acreage Floodplain connectivity Frequency of flood events				• No apparent indicator for changes in floodplain acreage • No apparent indicator for frequency of drought conditions • No apparent indicator for % developed land requiring retrofitting for stormwater management

Tier I and II services	Benefits	Indicators under Partnership consideration (examples)	Indicates what?			Comment
			D/P	S	I/R	
Water purification and waste treatment	Natural filtration	Land cover trends				
	Capacity to assimilate pollution	Nutrients in marine water Sensitivity to eutrophication				• Not clear whether these indicators show nutrient loadings in relation to the recipient water's capacity to assimilate these loadings
Recreation and tourism	Provide residents with numerous recreational opportunities Premier destinations of uncommon quality Dynamic destination that provides both urban *and* natural attractions Large source of revenue and jobs for the local economy Recruit and retain employees	Percent of swimming beaches that meet safe standards Shore access Upland land ownership and public access Land ownership along shorelines Puget Sound harvest - recreational (various species) Swimming/wading at a beach (5 measures) Canoeing, kayaking, row boating, etc. (5 measures) Scuba or skin diving (5 measures)				• No apparent indicator that adequately captures potential deterioration of recreational opportunities to the point that the Sound is no longer a 'premier' recreational destination that can attract or retain tourists, high-skilled workers and local residents (might possibly be done through surveys)

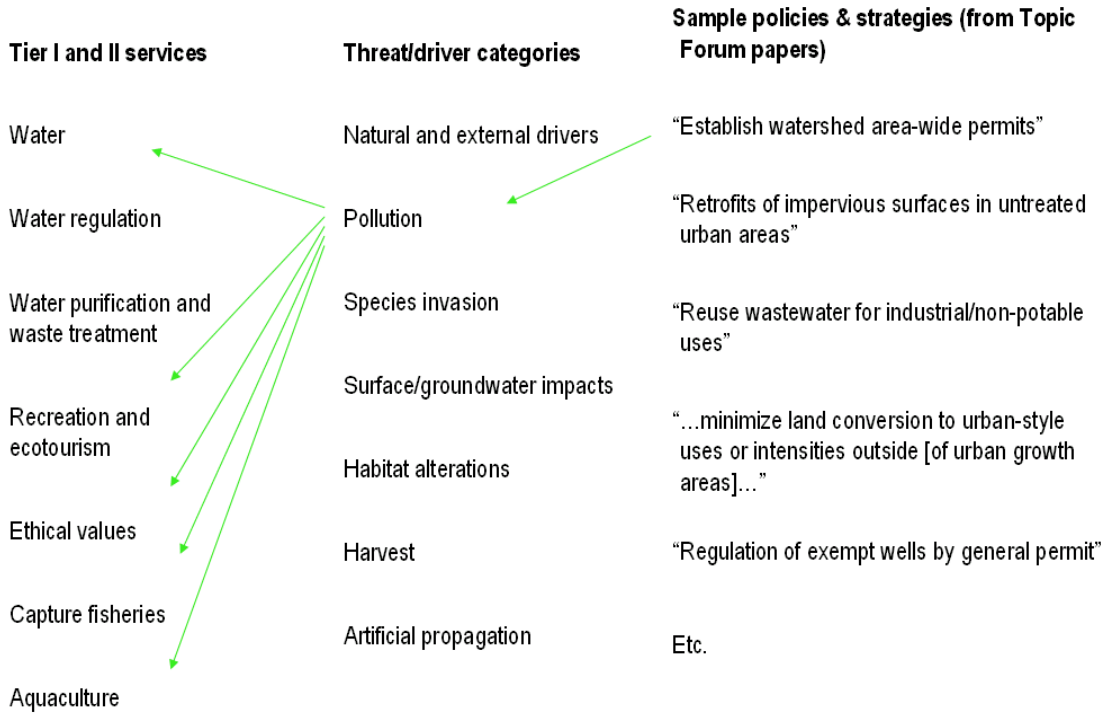
Tier I and II services	Benefits	Indicators under Partnership consideration (examples)	Indicates what?			Comment
			D/P	S	I/R	
Ethical and existence values	Attract creative and innovative people Provide residents with quality places to live	Shore access Upland land ownership and public access Land ownership along shorelines Bird, orca, wildlife populations				• No apparent indicator that adequately captures potential deterioration of aesthetic or other values to the point that the Sound is no longer a highly attractive place for people to live (might possibly be done through surveys)
	Support traditional Tribal ways of life	Puget Sound harvest - tribal (various species) Salmon populations				• No apparent indicators for the ability of ecosystems to provide certain key services necessary to support traditional Tribal ways of life, such as wild food harvesting (might possibly be done through surveys)
	Provide a healthy, thriving waterfront					• No apparent indicator that adequately captures the cultural value of a thriving waterfront
	Support agricultural lifestyles	Agriculture: farms, land in farms, value of land in buildings, and land use Market value of agricultural products sold				
Capture fisheries	Sustainable livelihoods for Tribal nations	Puget Sound harvest - tribal (various species) Salmon populations				• Will indicators of fish and shellfish abundance and distribution be included?
	Large source of revenue and jobs for the local economy	Puget Sound harvest - commercial (various species) Marine fish consumption advisories				• Will indicators of fish and shellfish abundance and distribution be included?
Aquaculture	Sustainable livelihoods for Tribal nations	Puget Sound harvest - tribal (various species)				• Not clear whether this indicator captures shellfish harvesting
	Large source of revenue and jobs for the local economy	Shellfish fishing - annual payroll Toxics in clams, mussels Shellfish closures				

4. Priority strategies and actions

The Partnership is working to answer the question "What actions must be taken that will move us from where we are today to a healthy Puget Sound by 2020?" Public policies, general strategies, regulatory changes, and specific projects will underlie many of these actions but there are many candidate strategies from which to choose. Understanding which ecosystem goods and services are most valued by stakeholders will help the Partnership concentrate on selecting and designing the policies and strategies most likely to sustain or restore these benefits.

Having identified the seven Tier I and II services allows one to better evaluate the relative merits of numerous candidate policies and strategies. Figure 1 depicts a framework for analyzing possible linkages among policies and strategies, threats, and the Tier I and II services. The first column lists the seven Tier I and II services, the second column lists the seven categories of threats/drivers identified by NOAA in its ongoing analysis (the table in Appendix C lists these categories of threats and drivers affecting the functioning of the Puget Sound ecosystem and examples of each), and the third column lists a subset of the candidate policies and strategies from the Partnership's topic forum papers (for illustrative purposes).[17]

Figure 1. Linking policies and strategies, threats, and Tier I and II services. The first column lists the seven Tier I and II services, the second column lists the seven categories of threats/drivers identified by NOAA in its ongoing analysis, and the third column lists a subset of the candidate policies and strategies from the Partnership's topic forum papers (for illustrative purposes only). It is important to know whether a proposed policy or strategy addresses one or more threats, and whether the threats impact one or more key services.



[17] http://www.psp.wa.gov/aa_topic_forums.php

By linking the policies and strategies to the threats, and in turn linking the threats to the Tier I and II services, one is now in a position to identify:

- Policies and strategies that address multiple threats
- Policies and strategies that address a threat that impacts multiple services
- Threats that are not addressed by any policies
- Services that are not addressed by any policies (via the threats).

Appendix D maps several dozen example policies and strategies recommended to the Partnership in the topic forum papers[18] to the seven NOAA threat categories and, in turn, to the seven Tier I and II ecosystem services.

Do the example proposed policies and strategies address all the threat categories?
Several of the threat categories—pollution, surface/groundwater impacts, habitat alterations—are addressed by many of the proposed policies and strategies. Other threat categories, shaded in red in Table 6 (indicating an apparent gap in coverage), are not addressed very extensively by the proposed policies and strategies. The Partnership may want to consider strengthening the proposed responses to the problems of species invasion, harvest, and artificial propagation. Natural and external drivers, shaded in yellow in Table 6 (indicating a possible gap in coverage), is a fairly broad threat category which includes the threat of climate change. Only three of the proposed policies and strategies appear to directly address the threat of climate change, and the Partnership may therefore want to consider strengthening the proposed responses to climate change-related threats.

Table 6. Number of example proposed policies/strategies addressing each of seven threat categories.
Several of the threat categories are addressed by many of the proposed policies and strategies. Other threat categories, shaded in red in this table (indicating an apparent gap in coverage), are not addressed very extensively by the proposed policies and strategies. "Natural and external drivers", shaded in yellow in this table (indicating a possible gap in coverage), includes the threat of climate change. Only three of the proposed policies and strategies appear to directly address the threat of climate change

Threat/driver categories	**Number of policies/strategies addressing each threat/driver (n = 48)**
Natural and external drivers	16
Pollution	21
Species invasion	01
Surface/groundwater impacts	32
Habitat alterations	10
Harvest	01
Artificial propagation	00

Do the example proposed policies and strategies address all the Tier I and II services?
The table in Appendix D indicates that the example proposed policies and strategies generally address all the Tier I and II services. When one examines whether they address all the specific benefits

[18] Not every policy/strategy in the topic forum papers is included in the table in Appendix D. Some proposals, such as those calling for the creation of modeling tools or for improved scientific understanding of problems, have been omitted.

associated with these services, however, potential gaps in coverage begin to emerge. Table 7 identifies benefits for which there is a possible gap in coverage (those in yellow) and benefits for which there is an apparent gap in coverage (those in red).

The policies and strategies, for example, do not appear to address "water-borne navigation and commerce." And while water for hydropower is implicitly addressed via efforts to maintain sufficient stream flows for various uses, it is not generally singled out as a benefit that needs to be protected, even though the cities of Seattle and Tacoma depend on hydro for 90% of their power needs. There appear to be few policies and strategies directly aimed at addressing flood/drought mitigation and natural water storage (snowpack and glaciers).

Recreation/ecotourism and ethical/existence values will no doubt benefit from efforts to reduce pollution, maintain adequate stream flows, and preserve/restore natural habitat. Little reference is directly made to these ecosystem services in the policy and strategy discussions, however, raising the concern that these services may not *optimally* benefit from the Partnership's efforts. Natural habitats such as wetlands, for example, might be preserved in order to maintain key ecological functions such as water filtration and water regulation. However, protecting a wetland to provide these services does not necessarily mean that the wetland will provide sufficient recreational opportunities.

Table 7. Do the policies and strategies address all the Tier I and II services? This table identifies benefits for which there is a possible gap in coverage (those in yellow) and benefits for which there is an apparent gap in coverage (those in red).

Tier I and II Services	Benefits
Water	•Water for homes, industry, agriculture •Water for ecological functions •Water for hydropower generation •Water-borne navigation and commerce
Water regulation	•Storm water management •Timing and availability of water supplies •Flood and drought mitigation •Natural storage (snowpack and glaciers)
Water purification and waste treatment	•Natural filtration •Capacity to assimilate pollution
Recreation and ecotourism	•Provide residents with numerous recreational opportunities •Premier destinations of uncommon quality •Dynamic destination that provides both urban *and* natural attractions •Large source of revenue and jobs for local economy •Recruit and retain employees
Ethical and existence values	•Attract creative and innovative people •Provide residents with quality places to live •Support traditional Tribal ways of life •Provide a healthy, thriving waterfront •Support agricultural lifestyles
Capture fisheries	•Sustainable livelihoods for Tribes •Large source of revenue and jobs for the local economy •Recreational value
Aquaculture	•Sustainable livelihoods for Tribes •Large source of revenue and jobs for the local economy

Conclusion

The Ecosystem Services Approach can be a useful framework for addressing environmental policy and management issues because it expands the focus beyond how human and economic activities *affect* ecosystems to include how such activities *depend* on ecosystems.[19] By highlighting people's dependence on ecosystems and the services they provide, a powerful rationale can be developed for promoting sustainable stewardship of our natural resources.

Through the interview process that was conducted for this project, seven ecosystem services were identified as being "most important" across the 12 sectors interviewed (the "most important" services identified through this process in the Puget Sound differ from those that would be identified in other locations around the country and around the world; they might also differ from those that would be identified for each sub-region of Puget Sound). We have used the results to suggest how the Partnership might go about (1) defining a "healthy Puget Sound", in essence a vision for the Partnership's future work; (2) communicating the goals of the Partnership; (3) selecting priority indicators for measuring and monitoring the Sound's status; and (4) selecting priority strategies and actions. In creating a commonly-agreed upon set of ecosystem service priorities, it is hoped that this project may also have begun to lay the groundwork for an eventual consensus among diverse stakeholder groups regarding how to go about achieving the Partnership's overarching goal of protecting and restoring Puget Sound.

[19] Ranganathan, J., *et. al*., *Ecosystem Services: A Guide for Decision Makers*, (World Resources Institute, 2008).

APPENDIX A. DEFINITIONS OF ECOSYSTEM SERVICES[20]

Service	Sub-category	Definition	Examples from Puget Sound
Provisioning services			
Food	Crops	Cultivated plants or agricultural produce that are harvested by people for human or animal consumption as food	· Red raspberries · Flower bulbs · Vegetable seeds
	Livestock	Animals raised for domestic or commercial consumption or use	· Dairy · Poultry
	Capture fisheries	Wild fish captured through trawling and other nonfarming methods	· Salmon · Dungeness crab · Clams
	Aquaculture	Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for purposes of harvesting	· Salmon · Geoduck · Oysters
	Wild foods	Edible plant and animal species gathered or captured in the wild	· Mushrooms · Berries
Fiber	Timber and other wood fiber	Products made from trees harvested from natural forest ecosystems, plantations, or nonforested lands	· Logs · Pulp
	Other fibers (e.g., cotton, hemp, silk)	Nonwood and nonfuel fibers extracted from the natural environment for a variety of uses	· Textiles (clothing, linen, accessories) · Cordage (twine, rope)
Biomass fuel		Biological material derived from living or recently living organisms—both plant and animal—that serves as a source of energy	· Fuelwood
Water		Inland and marine bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses	· Drinking water · Hydro-electric power · Transportation and access to waterfront
Genetic resources		Genes and genetic information used for animal breeding, plant improvement, and biotechnology	· Individual salmon stocks · Diversity of crop lines
Biochemicals, natural medicines, and pharmaceuticals		Medicines, biocides, food additives, and other biological materials derived from ecosystems for commercial or domestic use	· Salmon for extraction of DHA[21] · Seaweed harvest for carageenans[22]
Regulating services			
Air quality regulation		Influence ecosystems have on air quality by emitting chemicals to the atmosphere (i.e., serving as a "source") or extracting chemicals from the atmosphere (i.e., serving as a "sink")	· Lakes as sinks for industrial sulfur · Forest fires emit particulates
Climate regulation	Global	Influence ecosystems have on global climate by emitting greenhouse gases or aerosols to the atmosphere or by absorbing greenhouse gases or aerosols from the atmosphere	· Forests and eelgrass systems capture and store carbon dioxide
	Regional and local	Influence ecosystems have on local or regional temperature, precipitation, and other climatic factors	· Forests impact regional rainfall levels

[20] The original version of this table was adapted by the World Resources Institute from reports of the Millennium Ecosystem Assessment (2005) and published by WRI in *The Corporate Ecosystem Services Review: Guidelines for Identifying Business Risks and Opportunities Arising from Ecosystem Change* (2008). The table has been modified for purposes of this project with input from the NOAA Fisheries Northwest Fisheries Science Center.

[21] Docosahexaenoic acid, an essential fatty acid, thought to be important to the development of infants, particularly as regards their eyes and brain.

[22] Carageenans are obtained from red seaweeds. They are used in numerous food and non-food applications.

Service	Definition	Examples from Puget Sound
Regulating services (continued)		
Water regulation	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape	· Natural stormwater management by wetlands and floodplains
Erosion regulation	Role vegetative cover plays in soil retention	· Stream buffers prevent soil loss and siltation · Forests on slopes hold soil in place, thereby preventing landslides · Nearshore vegetation stabilizes shorelines
Water purification and waste treatment	Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water; assimilation and detoxification of compounds through soil and subsoil processes	· Wetlands remove harmful pollutants from water · Shellfish clean salt water by filter feeding · Eelgrass cleans salt water by breaking down PAHs[23] and trapping heavy metals
Disease regulation	Influence that ecosystems have on the incidence and abundance of human pathogens	· Harmful algal blooms cause shellfish closures and affect human health
Pest regulation	Influence ecosystems have on the prevalence of crop and livestock pests and diseases	· Predators from nearby forests—such as bats, toads, and snakes—consume crop pests
Pollination	Role ecosystems play in transferring pollen from male to female flower parts	· Bees and other insects pollinate crops
Natural hazard regulation	Capacity for ecosystems to reduce the damage caused by natural disasters such as hurricanes and to maintain natural fire frequency and intensity	· Biological decomposition slows accumulation of fuel for forest fires
Cultural services		
Recreation and ecotourism	Recreational pleasure people derive from natural or cultivated ecosystems	· Hiking, camping, bird watching, whale watching, boating, fishing, clamming, and hunting
Existence values	Benefit derived from knowledge that a particular environmental resource, animal, or organism exists	· Belief that all species are worth protecting, no matter their direct value to humans
Ethical values	Spiritual, religious, aesthetic, intrinsic, or other values people attach to ecosystems, landscapes, or species	· Spiritual fulfillment derived from mountains, lands, rivers, lakes, streams, and the Sound itself
Supporting services		
Nutrient cycling	Role ecosystems play in the flow and recycling of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through processes such as decomposition and/or absorption	· *All of these are fundamental to the operating of the Puget Sound region's ecosystem and the derived services described above*
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation	
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms	

[23] PAHs are a group of chemicals that are formed during the incomplete combustion of substances such as coal, oil, wood and solid waste.

Appendix B. Key tradeoffs identified during the interviews

In addition to asking the interviewees to identify ecosystem goods and services that were of "high importance" to the sector they represent, they were also asked to identify major ecosystem service-related tradeoffs that the Puget Sound region would need to manage in efforts to protect and restore the Sound. This section discusses four of the major tradeoffs that interviewees raised repeatedly, in one form or another, during the interviews.

1. Increasing competition for scarce land and shoreline resources as regional population grows

There are multiple uses for scarce land, some of which include:

- **Forested land**, which provides multiple ecosystem services: timber, water regulation, water purification and waste treatment, carbon sequestration, biomass fuel, wild foods, genetic resources, erosion regulation, recreation, aesthetic values, etc.

- **Agricultural land**, which provides a number of ecosystem services: crops, livestock, water regulation, cultural values, etc.

- **Housing and commercial development**, which provide shelter and economic infrastructure to accommodate an increasing regional population. Developing the land, however, deprives the population of valuable ecosystem services.

A representative of the agriculture sector suggested that the region needs to construct a vision for a desired end state, instead of making day to day decisions which will result in a last man standing situation (farming will not be the last man standing under a business-as-usual scenario). He observed the need to ask ourselves how much of each type of land use we want and where we want to locate it.

A representative of the fishing and aquaculture sector echoed this idea, saying that comprehensive plans are needed in which leaders work with the agriculture and timber sectors to keep forest owners and farmers in place and prevent their lands from being converted.

In recent work undertaken by the Partnership, the land use/habitat topic forum paper notes "large-scale regional planning which could increase consistency and coordination in land use planning has yet to occur in the entirety of Puget Sound. Solid regional planning efforts, such as Puget Sound Regional Council and the Thurston Regional Planning Council, don't exist outside the counties participating in those efforts."[24]

[24] *Puget Sound Partnership Habitat and Land Use Topic Forum Discussion Paper*, July 11, 2008, p. 36. This paper also notes (p. 36) that there is "practical limitation in the [Washington State Growth Management Act] that has left some of its goals unrealized: Although state agencies such as CTED have the ability to review and comment on local ordinances before they are adopted, state agencies lack the authority to approve or deny proposed plans and regulations."

2. Competition for scarce surface water and ground water resources

Following are some indications of current and future water stress:[25]

- Almost every watershed in Puget Sound has local areas where freshwater supplies are not adequate to meet current human demands.
- Many watershed plans and water system plans address uncertainty in meeting future needs either due to water supply shortfalls or seawater intrusion.
- In most of the 12 watersheds in which the Department of Ecology has set in-stream flow rules, stream flows were met less than 50% of the time during low-flow periods, and in some watersheds, less than 80% of the time.
- By 2075, models predict that the average discharge from the Sultan, Tolt, Cedar, Green, and White River basins will decrease by 27-42% during the summer and increase by 41-57% in the winter
- Puget Sound's growing human population poses significant threats to freshwater supply in the region.

3. Protecting the Sound while allowing continued use for water-borne navigation and commerce services

The Sound provides a variety of waterborne navigation and commerce services:

- Deep water industrial terminals
- Barge terminals for short sea shipping or marine highways
- Recreational and commercial fishing
- Recreational boating
- Ferry and passenger services

The ports and shipping sector is concerned about its continued access to the shoreline as measures are enacted to protect shorelines.

4. Public access to forests, shorelines, and marine environment

Access to forest lands

- A representative of the forestry sector noted that general access to forest lands can result in meth labs, which are toxic waste dumps for which the landowner has to bear the cleanup responsibility. He also noted the problem of trespassers burning transformers to try to get copper out, costing land owners a huge amount to clean up. He also noted that broken down cars, refrigerators, and couches are often dumped on forest property.

[25] *Puget Sound Partnership Water Quantity Topic Forum Discussion Paper*, July 11, 2008.

Access to tidelands

- A representative of the fishing and aquaculture sector noted increasing conflicts between shellfish harvesters and shoreline homeowners as shorelines develop adjacent to tidelands

Access to rivers and to the Sound itself

- A representative of the recreation sector noted that ten to twenty years ago there was a lot of private forest land along rivers that one could gain access through. Now, with increasing development, private communities block such access.
- Another representative of the recreation sector noted that scuba divers are increasingly losing access to traditional diving sites for a number of reasons (e.g., DNR removing creosote pilings that divers currently use)

Appendix C. Categories of threats/drivers and examples of each

Categories of threats and drivers affecting the functioning of the Puget Sound ecosystem and examples of each.[26]

Threat/Driver Category	Example attributes
Habitat alterations	Land uses and conversion; Existence of offshore, shoreline, or benthic structures; shoreline armoring/modification; Habitat alterations due to vehicle / vessel operation; Movement and storage of logs and sediments; Littering; Recreation, ecotourism, human presence
Surface/groundwater impacts	Depletion of aquifers / groundwater; Alteration of stream flows; Drainage or disconnection of floodplains
Pollution	Runoff from developed (e.g., roadways, parking lots) or undeveloped (e.g., agricultural, forested) lands into surface waters; Stormwater or wastewater spills/discharges; Discharge from boats; Toxics or oil spills/discharges; Toxics in biota; Groundwater discharges of pollutants to surface waters; Air pollution: Activities contributing to atmospheric deposition
Artificial propagation	Benthic or pelagic aquaculture, net pens, hatchery fish releases, facilities
Harvest	*Logging*: harvest of timber, *Hunting*: over-harvest of sensitive species; disruption of natural behavior, *Fishing*: bottom trawling, longline, set net, pot- and spear-fishing, gillnet, purse seine, angling; *Bycatch*
Species invasion	Conversion of mudflats to non-native marshes; overgrowing of animal populations; change in food web structure
Natural and external drivers	*Natural drivers*: Earthquakes, tsunamis, vulcanism, landslides, storms, floods, wildfires, naturally occurring hypoxia, natural variation and changes in rainfall, snowmelt, air temperature, ENSO, PDO; *Human population growth*: changes in land use patterns, human use patterns; *Climate change*: changes in insect infestations, fire risk, stream flows, etc. due to climate change

[26] Ruckelshaus, Mary et. al. *Assessing the Magnitude and Potential Impacts of Threats/Drivers to Puget Sound Ecosystems: A Demonstration Using DPSIR Conceptual Models* (draft).

Appendix D. Linking strategies, threats, and Tier I and II services

Policies and strategies designed to protect and restore important ecosystem services are most effective when they target threats or drivers of ecosystem change. The following table shows how selected policies and strategies recommended to the Partnership in the topic forum papers address various categories of threats and which of the Tier I and II services would thereby benefit.

Policies and strategies included in the topic forum papers[27]	**Threats/drivers addressed by the policies/strategies** (highlighted in green)	**Tier I and II services addressed by the threats/drivers** (highlighted in green)
Water quality		
Begin or accelerate retrofits of impervious surfaces in untreated urban areas where potential for groundwater contamination currently is low.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Aggressively seek pilot opportunities to reuse stormwater generated from rooftops for non-potable uses.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Coordinate with regional transportation efforts.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Complete mapping and conduct economic analyses of interjurisdictional stormwater networks.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Require tertiary or Class A wastewater treatment and reuse or other performance measures at wastewater treatment plants to reduce nutrient loadings in nutrient-sensitive areas of Puget Sound.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries

[27] Not every policy/strategy in the topic forum papers is included in this table. Some proposals, such as those calling for the creation of modeling tools or for improved scientific understanding of problems, have been omitted.

		– Aquaculture
Expand outreach efforts to reduce emerging pollutants in personal care products such as EDCs and pharmaceuticals.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Identify and replace failing septic systems, with particular focus in areas with demonstrated water quality problems such as shellfish closures and hypoxia.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Review wastewater outfalls for potential decommissioning.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Focus protection efforts on intact and high-quality lands and watersheds.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Integrate land use and water resources planning. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Increase the clarity of stormwater regulatory programs.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Establish watershed area-wide permits that focus on the multitude of discharges that occur in logical geographical areas, rather than discharge-specific inputs or jurisdictional boundaries.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture

Implement more comprehensive chemical management in Puget Sound.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Water quantity		
Develop a process and organizational structure to integrate land use planning, utility planning (including stormwater and water supply) and ESA recovery planning. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Consider instream flow needs during planning and permitting for stormwater and reclaimed water infrastructure.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Complete the task within the Puget Sound Salmon Recover Plan for the development and implementation of comprehensive basin flow protection and enhancement programs (PEPS).	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Promote sustainable water use practices through regulations and incentives addressing water use efficiency, use of reclaimed water (including graywater and rainwater), and storage.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Conduct a regionally consistent assessment of water use and future water needs, and availability.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Perform outreach and education to address human expectations about water use.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts	– Water – Water regulation – Water purification and waste treatment

	– Habitat alterations – Harvest – Artificial propagation	– Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Establish instream flows in Puget Sound basins without flow rules.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Update instream flow rules that were adopted prior to 1986.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Identify flow limitations and targets for fish as part of Salmon Recovery Plan implementation.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Consider regulation of exempt wells by general permit, either statewide, by WRIA, or by region (e.g., Puget Sound region).	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Develop water use compliance and enforcement plans in each Puget Sound watershed.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Establish water masters for each basin to ensure compliance with water code.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Require metering and reporting for 80% of water use (by volume) in all watersheds.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism

	– Harvest – Artificial propagation	– Ethical and existence values – Capture fisheries – Aquaculture
Assess the adequacy of flows for estuarine and nearshore marine habitat including channel morphology and flows, salinity levels, and circulation.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Address groundwater management (including monitoring) in the Puget Sound region to protect streamflow.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Identify benchmarks for flow improvements and evaluate them.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Increase the use of innovative stormwater management practices that protect and restore hydrologic processes to support low flows and aquifer recharge.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Develop rules for water reclamation that promote stormwater reuse for appropriate purposes where it is otherwise treated as wastewater and cannot be used to restore hydrologic processes.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Develop a process to recognize federally reserved instream flow water rights that is acceptable to federal, Tribal, state and other water interests.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Amend the current water code to streamline the water rights adjudication process.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values

	– Artificial propagation	– Capture fisheries – Aquaculture
Model climate impacts uniformly in the ESU.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Use the assessments of climate change to estimate regional and local impacts on water supply, water demand, floods, groundwater, and the ability to meet instream flow requirements and fish targets.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Develop strategies that address the impacts [of climate change] identified [above].	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Habitat and land use		
Establish clear, scientific standards that define which habitat processes, structures and functions are critical for the proper functioning of the ecosystem as a whole, and where impacts should be avoided at all costs.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Restoration projects that address impacts to the most important ecosystem processes, structures and functions should receive early attention and funding.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
The region should discuss its vision for a future quality of life. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
The focus should be to minimize land conversion to urban-style uses or intensities outside UGAs and to require best management	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts	– Water – Water regulation – Water purification and waste treatment

practices and low impact development standards within resource and rural lands which have the highest value for preservation of habitat and ecosystems that support the health of Puget Sound.	– Habitat alterations – Harvest – Artificial propagation	– Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Within urban growth boundaries, critical existing ecosystem processes, structures and functions should receive special protection. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Adopt a consistent set of habitat protection outcomes required to be achieved by all jurisdictions (federal, state or local) permitting land use activities within Puget Sound through a mix of regulations and incentive programs. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
At the federal level, the President and Congress should immediately adopt the recommendations of the U.S. Commission on Ocean Policy in its 2004 Final Report. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Examine and promote the best incentive programs at the local level… consider ecosystem cap and trade markets, offsets, and other innovative approaches. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Require low impact development techniques to be used where appropriate in order to reduce the loss of forest cover and impacts from increases in impervious surfaces.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Establish a centralized and transparent approach to	– Natural and external drivers – Pollution	– Water – Water regulation

managing information, maps, studies, plans and data related to the Puget Sound ecosystem and the Action Agenda. ***[Need additional details in order to evaluate]***	– Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Expand the availability of off-site mitigation programs both institutionally and functionally.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Educate the public and business community about how to be stewards of their land. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Human health		
Adopt source control strategies to manage human health risks.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Improve management of older and underfunctioning on-site sewage systems around Puget Sound.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Improve land use regulations and guidance to manage stormwater on-site and limit the amount of impervious area within a development and across a watershed to reduce stormwater volume that needs to be managed.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Improve and update wastewater and stormwater infrastructure.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values

	– Artificial propagation	– Capture fisheries – Aquaculture
Reduce pollutant discharges that threaten shellfish resources.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Expand and accelerate work related to PBTs.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Complete and implement groundwater protection plans.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Species and biodiversity		
Begin to design an ecosystem-based management approach. ***[Need additional details in order to evaluate]***	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Protect important habitats.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture
Undertake a critical assessment of harvest and culture practices.	– Natural and external drivers – Pollution – Species invasion – Surface/groundwater impacts – Habitat alterations – Harvest – Artificial propagation	– Water – Water regulation – Water purification and waste treatment – Recreation and ecotourism – Ethical and existence values – Capture fisheries – Aquaculture