Priority Science to Support Puget Sound Recovery

A SCIENCE WORK PLAN FOR 2020-2024 (SWP FOR 2020-2024)







PUGETSOUND PARTNERSHIP

PUGET SOUND PARTNERSHIP SCIENCE PANEL
Approved by the Leadership Council as an Official Document of the Puget Sound Partnership

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CONTENTS

SUMMARY

Priority Science to Support Recovery of the Puget Sound Ecosystem: A Science Work Plan for 2020-2024 (SWP for 2020-2024) describes the information, learning, and interaction needed to support the coordinated efforts to recover, protect, and improve the resilience of the Puget Sound ecosystem. The Puget Sound Partnership's Science Panel (Panel) is guided by the principles that ecosystem recovery actions should proceed in the face of uncertainty and that generating and sharing information to address and reduce uncertainties will improve the likelihood that recovery efforts will accomplish the region's six recovery goals as measured through the Puget Sound Vital Signs. These recovery goals are a healthy human population, vibrant quality of life, thriving species and food web, protected and restored habitat, abundant water quantity, and healthy water quality. Through identifying 15 Priority Science Work Actions, The Panel highlights science that adds value by filling critical gaps, supports science innovation, supports continuity, links socio-ecological resilience, or changes the policy landscape.

These Science Work Actions and the broader recommendations to improve ongoing science identify important initiatives that will sustain the robust ongoing research, modeling, and monitoring programs that deliver essential, management-relevant information to decision situations and to improve public and partner understanding and awareness. These Science Work Actions and broader recommendations are rooted in the needs identified by partners and decision makers. The Panel encourages the Puget Sound Partnership ("Partnership") to continue to strengthen its role as a backbone organization through advancing science and supporting the robust existing network of recovery including tracking Vital Signs and their indicators, utilizing the Puget Sound Ecosystem Monitoring Program (PSEMP), employing the Action Agenda and Implementation Strategies, and collective work towards adaptive management. The Panel appreciates that over 760 organizations work on Puget Sound recovery in one way or another and the public has a high interest in Puget Sound recovery. The Panel encourages the broader recovery community to look to the complete list of Science Work Actions and broader recommendations for areas of inquiry where multiple sources are identifying similar knowledge gaps and needs.

Objectives for Science Work Actions

The Panel identified five objectives to guide the selection of priority Science Work Actions for 2020-2024. These objectives reflect the unique role and perspectives of the Science Panel to provide recommendations on the knowledge most needed to advance the socio-ecological goals of ecosystem recovery in the Puget Sound. Science Work Actions within the SWP prioritize scientific research that can:

- Add value by filling critical gaps,
- Support science innovation,
- Support continuity,
- Link socio-ecological resilience, or
- Change the policy landscape.

The Panel evaluated and discussed 106 Science Work Actions, which were informed by over 500 articulated needs from the recovery community, to identify 15 Priority Science Work Actions. They are grouped thematically, but not listed in order of importance. The Panel will directly support—financially, in legislature, and otherwise—the implementation of the Priority Science Work Actions.

Priority Science Work Actions

Human-biophysical Interactions

1. Evaluate how current and future social, economic, and political factors, such as population growth and urban development, will affect habitat quality and quantity, both negatively and positively as gauged by salmon viability.

2. Identify and adopt appropriate frameworks connecting human wellbeing to ecosystem health to evaluate climate change impacts to holistic health, considering and appropriately addressing issues of scale, psychological shifting baselines and perceptions of environmental governance, sense of place, and psychological wellbeing.

3. Assess the degree, and how, access to marine and coastal resources (e.g. fisheries, open space, native foods) is changing among different communities in the Salish Sea.

Effectiveness of Recovery Interventions

4. Assess what factors contribute to effective co-governance and/or co-management between jurisdictions (including Indigenous and non-Indigenous governments).

5. Determine what incentives, human well-being factors, market drivers, tax systems, and characteristics influence residents', developers', and purchasers' choices that contribute to or prevent habitat conversion.

6. Assess the effectiveness of incentive approaches in Puget Sound recovery efforts.

Ecological Conditions and Effects

7. Characterize human health and environmental risks from chemicals of emerging concern.

8. Assess toxic contaminant sources, (both historic and ongoing) and prioritize their clean-up or replacement based on environmental and human health impacts.

9. Determine benefits to viability of Southern Resident Killer Whales from improved prey availability, and reduced disturbance and toxic chemical exposure; assess benefits individually and cumulatively through monitoring and modeling. Consider benefits in context with potential risks associated with reduced Southern Resident Killer Whale and salmonid genetic diversity.

10. Identify and address gaps in current efforts to assess water use in Puget Sound with a focus on groundwater quality and quantity discharged to Puget Sound.

11. Build upon recommendations of the Salish Sea Marine Survival Project to further define bottom-up and top-down food web effects on juvenile salmonid mortality in Puget Sound.

Science-Based Decision Support

12. Refine risk assessment tools and scenario development and analyses to improve our understanding of highly uncertain, complex and inter-related challenges and solutions to provide information that can be used to identify actions to achieve a more resilient Puget Sound ecosystem.

13. Develop a framework of recommended approaches for including risk analyses, including extreme events and uncertainty, into planning and decision making.

14. Better define tipping points for cumulative impact of multiple individual human activities on habitat quantity and quality, water quality and species recovery.

15. Explore and advance the use of methods to integrate human dimensions with biophysical targets and goals by decision makers.

Recommendations to improve ongoing science

In addition to specific Science Work Actions, the Panel also identified broader recommendations that support the development, efficacy, and implementation, of science. These concepts were raised by the broader community. Many of these underlying conditions for improving ongoing science are related to strengthening the knowledge network (A) and its components related to Indigenous knowledge (B), capacity for assessment and reporting(C), and the coordination and use of interdisciplinary research (D). Others speak to how this knowledge is used, both across science-policy interfaces (E) and through communication with diverse audiences (F). Finally, the Panel highlights work to analyze alternative, uncertain futures to assess trade-offs and improve planning (G).

A. Collaboratively broaden and improve the knowledge network that supports Puget Sound ecosystem recovery

The Panel intends to partner with others to develop a more inclusive, coordinated knowledge network that supports Puget Sound recovery. The concept of a coordinated network of individuals and organizations who work individually and together to generate and exchange knowledge is rooted in approaches used in the Sound and in other regions. Existing networks convened and engaged by the Partnership and the Puget Sound Ecosystem Monitoring Program (PSEMP) implement aspects of this concept, building from the capacities of various entities in the region.

The Panel seeks to partner with regional leaders and organizations dedicated to science and other ways of knowing, recognizing the central importance of Indigenous knowledge and environmental justice to:

- better articulate the vision of Puget Sound recovery and related scientific questions to pursue,
- improve the impact of science findings and Indigenous and local knowledge on Puget Sound recovery efforts,
- improve the legitimacy and transparency of decision making, and
- hold one another accountable for achieving recovery objectives.

The Panel recommends that the Partnership, the federal science and monitoring work group, PSEMP, and the region's western science programs intentionally partner with a diversity of organizations and individuals who generate and exchange knowledge to describe and increase participation in a network of knowledge generating and sharing capacities. This more inclusive, coordinated knowledge network will provide perspectives, information, tools, models, and other products in the planning, decision-making, and implementation processes of the Puget Sound ecosystem recovery system.

B. Improve incorporation of Indigenous knowledge into science and monitoring efforts

Indigenous peoples have lived and thrived in the Sound since time immemorial. They carry forward millennia of traditional ecological knowledge and experience, constituting a long-term and fine-grained observing network over timescales rarely possible in western scientific research. Over the last two centuries, the ecology of the Sound that supported traditional lifeways has been significantly altered and degraded, leaving many of the resources that supported Indigenous lifeways struggling for survival. The magnitude of today's problems is daunting and at a greater scale than has been faced before. We must therefore mobilize a diverse array of knowledge in seeking solutions.

Given the many ways in which Indigenous science and traditional ecological knowledge can broaden and deepen knowledge of the problems we face and possible solutions, our specific recommendations are:

1. to find creative and meaningful ways to partner with Indigenous science programs in our collective effort to restore a resilient and sustainable Sound, and

2. to invest in research strategies that recognize traditional ecological knowledge and build on that knowledge to generate a collective understanding of ecosystems relationships and systems thinking.

C. Develop capacity and coordinate efforts to assess and report on ecosystem conditions and the effectiveness of interventions

The Science Panel continues to advocate for greater capacity to generate and share information that will improve decisions about recovery efforts and improve understandings and awareness of ecosystem conditions and progress toward goals. In its Strategic Science Plan (PSP 2010), the Panel recognized that a science-informed recovery effort would have the ability to (1) analyze and synthesize existing information; (2) develop and apply innovative tools to understand structure and function and to predict and document change; (3) foster exploration and discovery; (4) effectively communicate and integrate science; and (5) continually review the quality, depth, and breadth of our understanding in open, transparent, and constructive ways. The Panel of a decade ago noted that the capacity for this existed across institutional sectors (e.g., federal, tribal, state, local, private, academic organizations) and that these would need to grow and be coordinated to be effective; building and sustaining these capacities remains a priority need for the Puget Sound recovery system.

D. Coordinate production and use of interdisciplinary research that explores and emphasizes the integrated nature of socio-ecological systems

The problems we need to solve for Puget Sound are at the nexus of ecosystems and society and are interdisciplinary in nature. If we are to reach our goal of creating a resilient Puget Sound, it will be because we make better decisions that consider the multiple ecological and social interactions and tradeoffs inherent in our world. The majority of environmental problems we must confront are human issues. Application of social science theories and methodologies can help us find better ways to approach environmental problems that are rooted in human behaviors.

Economic development and sustainability are often cast as opposites. We have an opportunity, in the era of Covid-19, to rethink how sustainability and economic prosperity can both be realized. The natural world provides innumerable benefits to human communities including economic and human well-being benefits.

Addressing and mapping the interconnections between humans in the ecosystem is a critical strategy for coming to terms with the complexity of environmental issues. There are a variety of robust frameworks that may be employed (e.g., Integrated Socio-Ecological Systems, Coupled Natural Human Systems). The Panel recommends that we collaborate as a knowledge network to prioritize research that considers the interactions of fundamental social and ecological questions. This will require collaboration across the array of biophysical, social science, and other field to study the core problems and solutions relevant to Puget Sound restoration and protection.

E. Build and sustain robust programs and relationships across science-policy interfaces to inform recovery

The Panel recognizes the distinct challenges and benefits of productive and trusted interactions among knowledge holders, implementers and managers, and decision makers. Through the backbone functions of the Panel and the Partnership's science team and numerous boundary-spanning organizations, communication among scientists and policy makers is occurring. It can be further enriched. The Partnership's adaptive management framework (2013) identifies a number of recurring opportunities for information and scientific process to advise and support adaptation of recovery efforts by hundreds of management entities and decision makers. Boundary spanning organizations and boundary spanning efforts by knowledge holders provide necessary capacity to share learning and knowledge among various entities focused on Indigenous and local knowledge, science, management, and policy, especially the boards and advisory groups of the Puget Sound Partnership management conference. Identifying opportunities when 'policy windows' are open, linking knowledge to action, and engaging decision makers in the production and sharing of policy-relevant information must be critical elements of the Puget Sound program.

F. Communicate science findings clearly and to the appropriate audiences

The Science Panel and Partnership have a key role to disseminate science that is relevant to all facets of the recovery effort, from the ecology of Puget Sound to the political ecology of our region and what society wants in a resilient Puget Sound. A well-informed public is essential to sustaining the Puget Sound recovery effort. Disseminating information that supports recovery and ecosystem resilience is important for cultivating political will among state and local policy makers. Those policy makers enact initiatives that form the framework for protection and restoration programs. The Partnership and Panel will need to foster partnerships that support access to the full range of tools that build and sustain the case for Puget Sound recovery.

G. Develop and analyze alternative future scenarios to explore and express desired futures and evaluate trade-offs among possible approaches

As a step to improve ongoing science, the Science Panel recommends the continuous use of scenario analysis to express and explore anticipated and desired futures and to evaluate trade-offs among possible policy and management approaches. Current-day and future drivers of change present an ongoing challenge for a resilient Puget Sound. The dynamics of population growth, economic cycles, climate change, and other drivers of uncertainty all make simple predictions about the future problematic. Without an understanding of the deeper connections, feedbacks, and system structures driving future conditions, actions to achieve ecosystem recovery are likely to come up short. In such a context, a common scenario framework allows scientists, policy makers, partners, and other stakeholders to jointly consider the many ways the future may unfold and how strategies can be made more responsive and effective.

Conclusion

This document offers an opportunity to engage partners in a discussion to expand and augment the networks of collaborating individuals and entities working to advance these priorities. The Panel and Partnership staff will use this document to engage knowledge holders, program managers, and others who generate and share information about ecosystem recovery in conversations about how to work together effectively to support Puget Sound ecosystem recovery. The Panel's expectation is that improved networking and collaboration will spur innovative thinking and tap additional resources. The Panel will also work within this network to actively encourage the implementation of Priority Science Work Actions.

1. Introduction

Priority Science to Support Recovery of the Puget Sound Ecosystem: A Science Work Plan for 2020-2024 (SWP for 2020-2024) presents the Puget Sound Partnership Science Panel's selection and prioritization of discrete Science Work Actions that address 5 objectives, where additional information could have an outside impact. The SWP for 2020-2024 also articulates broader recommendations for improving ongoing science and dissemination and use of the results to inform Puget Sound recovery and improve understanding and awareness of ecosystem conditions and relationships. These Science Actions and broader recommendations describe **the knowledge development and exchange processes needed to recover, protect, and improve the resilience of the Puget Sound ecosystem** including the robust ongoing research, modeling, and monitoring programs that deliver essential, management-relevant information to decision situations and to improve public and partner understanding and awareness.

The Puget Sound Partnership seeks to strengthen its role as a backbone organization and drive science toward providing information on the health and recovery of Puget Sound to decision makers and the public. Over 760 organizations work on Puget Sound recovery in one way or another and the public has a high interest in Puget Sound recovery. In its backbone role, the Partnership strives to identify and address strategic science needs to benefit the recovery community. Appendix D provides background on the Partnership and the important entities that engage as the recovery community.

The strategic focus articulated in this document will be used by the Partnership to direct the allocation of the limited resources available for science. The Partnership will direct resources to the issues and studies where they are most needed to advance ecosystem recovery and have the greatest likelihood of informing decision-making and public and partner awareness. In addition, the Partnership's Science Panel and staff will use this document in discussions with western science programs, tribes, entities engaged in Indigenous knowledge and environmental justice, and other partners who generate and exchange information to encourage attention and investments to the issues and topics identified in this report.

This document, developed in 2020, reflects the policy and programmatic priorities expressed in the *2018-2022 Action Agenda* and addresses science needs identified in that recovery plan, in other policy and management documents, and in recommendations by scientists engaged in recovery efforts. This *SWP for 2020-2024* differs from prior versions in a few important ways:

- It is not being developed concurrently with an Action Agenda. This means that the *SWP for 2020-2024* is based, in part, on the *2018-2022 Action Agenda* and provides recommendations that can be incorporated into the *2022-2026 Action Agenda*.

- It is the first SWP developed for implementation over a four-year period. This means that the Panel took a longer-term view of needs, potential actions, and recommendations.

- It is the first SWP created after the Partnership began receiving a state appropriation for Puget Sound scientific research, which provides resources for funding at least a portion of the priority science work that is not implemented by other means.

The Panel envisions a number of audiences for, or users of, the *SWP for 2020-2024*. The text box below describes how this document can be used by the Panel and others over this four-year period to focus investments in information gathering, investigations, and relationship building. Recovery partners and entities who generate and share information that supports recovery include state and federal agencies, Puget Sound tribes, local governments, non-governmental organizations, businesses, and academic institutions. Appendix D provides additional information about the partnering roles of the array of organizations that chart and pursue recovery efforts.

Entities	Role in developing and implementing the Science Work Plan
Science Panel, an advisory board of the Puget Sound Partnership, with members appointed by the Partnership's Leadership Council	Guide the vision of the SWP and knowledge network; responsible, per state statute, for developing the SWP that articulates priority actions and broader recommendations for a four-year period; use the SWP to prioritize topics and select investigations to receive funding for Puget Sound scientific research; encourage or commission synthesis of findings to guide ecosystem recovery decisions
Puget Sound Partnership staff	Review resources, compile recommendations, support Panel's development and prioritization of Science Work Actions and broader recommendations; partner across organizations to strengthen the knowledge network and its ability to implement the actions and recommendations in this document; guide work to incorporate key aspects of this SWP in the *2022-2026 Action Agenda*
Other Partnership boards and advisory groups	Advise the Panel's development of the SWP and incorporation of key aspects of this SWP into the *2022-2026 Action Agenda*; actively encourage efforts by the Panel, the Puget Sound Partnership, and others to implement this plan
Entities developing and sharing knowledge to support Puget Sound ecosystem recovery	Provide source recommendations material; review and contribute to Science Work Actions; implement Science Work Actions and broader recommendations in this document; report on Science Work Actions; actively participate in developing and coordinating the knowledge network that supports Puget Sound ecosystem recovery; synthesize science findings and other information to provide a guide for ecosystem recovery decisions
Recovery partners	Provide source recommendations material that describes the information needed to support ecosystem recovery; review and contribute to selection and prioritization of Science Work Actions; support implementation of Science Work Actions and broader recommendations; report on Science Work Actions; learn about and apply scientific findings and other information to support decision making

Our current state

The Puget Sound ecosystem spans the lands and waters from the crests of the Cascade and Olympic mountains and the marine waters of Washington State extending east from the mouth of the Strait of Juan de Fuca and south from the Canadian waters of the Strait of Georgia. More than 5 million people – with homes in large metropolitan areas, more than 100 other cities, and in unincorporated areas of 12 counties – live in this large and ecologically, socially, institutionally, and economically complex ecosystem. Processes, structures, and functions within each of these spheres are affected by ongoing pressures and by periodic shocks to the system.

We sit at a pivotal moment as governments, NGOs, tribes, and businesses work to protect public health and revitalize the economy amid a global pandemic while also confronting social injustices rooted in systemic racism. The global spread of SARS-CoV-2 in 2020 has tested socio-economic structures and processes in the Puget Sound region and around the world. It has also offered glimpses into ecological impacts from reduced motor vehicle use, ship and boat traffic, and other disruptions. The widespread protests against systemic racism and their call for anti-racist reforms indicate how social and institutional change can develop rapidly through linked local and global systems.

It is, of course, unclear how the ensuing months will unfold. The region has an opportunity to shape how it rebounds and rebuilds.

The Science Panel commends scientists, recovery partners, and our colleagues on the Partnership's other boards and advisory bodies who use our learning about complex, coupled human-natural systems to improve how we engage in ecosystem recovery efforts. The shocks of 2020 call on us to expand our vision of resilience and efforts to address public health risks and disparities, economic vulnerabilities, and social inequities. The Panel will work with a diversity of partners to explore how to employ anti-racist thinking and action in the implementation of this document and in the development of a more inclusive, coordinated network of knowledge generation and exchange to support Puget Sound ecosystem recovery.

The Science Panel provides backbone support to an inclusive, coordinated knowledge network

The Science Panel and Partnership envision that the strategic focus articulated in this document will catalyze efforts to build relationships with more diverse partners and develop a more inclusive, coordinated network of individuals and entities who effectively and efficiently generate and share information that can support Puget Sound ecosystem recovery. This builds on the *2018-2022 Action Agenda*, in which the Science Panel and Partnership staff committed to building a "well-organized, substantively funded science enterprise that supports Puget Sound ecosystem recovery planning and recovery efforts." An improved, more inclusive, coordinated knowledge network seeks to expand from existing entities and relationships to diversify efforts to develop, share, and convey scientific findings, including a central focus on Indigenous knowledge and environmental justice that address needs and questions articulated by managers and policymakers. The concept of this inclusive, coordinated knowledge network is discussed among the broader recommendations presented in Section 4.

The Science Panel and the Partnership's science program staff currently provide backbone support for the regional network of knowledge generators and exchangers in much the same way that the Partnership serves in a backbone role to support Puget Sound ecosystem recovery. The Vital Signs, Implementation Strategies, Action Agenda, and PSEMP among other initiatives are essential elements of the existing network. Working toward a more inclusive network may require a creative approach to providing backbone support, including the potential for distributed leadership and more diverse representation on the Science Panel, particularly representing Indigenous knowledge and environmental justice.

Backbone roles for the Science Panel include:

- identifying the critical information needs from across the system,
- coordinating the measurement and monitoring infrastructure that supports Puget Sound ecosystem recovery through PSEMP
- expressing regionally developed prioritized sets of science actions (e.g., in this document and other reports that describe and develop the inclusive, coordinated knowledge network), and
- supporting partners in implementing investigations and in communicating findings with policy makers and other decision makers.

In 2020 the Science Panel represented expertise on a broad array of natural and social science topics:

- integrated ecosystem assessment, ecosystem monitoring, decision analysis and decision support, and influence of social data in recovery planning;
- weather and climate in the Pacific Northwest, linkages between climate and marine ecosystems
- forest health and productivity;
- stream ecosystems, freshwater ecology of salmon, and wetland assessment and indicators;
- water quality and air quality assessments in complex ecosystems, microplastics and their toxicity to marine organisms, assessment of metals in freshwater systems;
- stormwater management practices, permits, and planning;

- stream restoration and stormwater management in urban ecosystems, impacts of forest practices on streams, salmon, and ecosystem values;
- coastal habitat ecology, impacts of human activities on ecosystems, fish health and genetics and ecological analyses related to salmon recovery;
- seafood safety, net pen aquaculture, and salmon hatchery management;
- human wellbeing relationships to ecosystem recovery, reconstructing past practices, human-environmental interactions, sense of place, and culture and cultural ecosystem services; and
- governance of common pool resources, ocean management, and natural resource controversies

The Panel members' perspectives (as indicated by their current and recent affiliations) represent federal agencies in the U.S. and Canada, state agencies, tribal governments, public universities, private corporations, and consulting firms. Additional information about the Panel members in 2020 is presented in Appendix D.

Approach and outline to the 2020-2024 Science Work Plan

This document builds from a foundation of the Science Panel's objectives for system-oriented science. It also incorporates recommendations from others about the information needed to identify, coordinate, and implement effective recovery and protection strategies for the Puget Sound ecosystem. The intent of this approach, which follows the SWP approach specified in RCW 90.71.290(5), is to motivate investigators from a wide-range of institutions to take up the management and policy-relevant recommendations from this report that intersect with their areas of expertise.

In developing this document, the Panel focused on two complementary questions:

- What are the priority Science Work Actions for 2020-2024?
- What broader recommendations should be pursued to improve ongoing science and its dissemination?

The Panel's objectives for science work are discussed in section 2; these objectives inform both questions. These objectives reflect the unique role and perspectives of the Science Panel to provide recommendations on the knowledge most needed to advance the socio-ecological goals of ecosystem recovery in the Puget Sound.

The Panel identified and evaluated potential Science Work Actions as described in the first part of section 3. The full list of Science Work Actions reflects the larger pool from which the Panel identified priority Science Work Actions. The Panel also used the objectives in section 2 as criteria for evaluating the relative priority of Science Work Actions.

A latter part of section 3 presents the Panel's selection of priority Science Work Actions. The Panel commits to actively encouraging scientists, leaders of western science programs, and other partners to implement these high priority items. In early 2021 and again in early 2023, the Panel will use the priority Science Work Actions to define a specific scope and focus for its solicitation of Puget Sound scientific research projects that the Partnership will fund in 2021-2023 and 2023-2025, respectively.

Section 4 presents the Panel's broader recommendations for improving ongoing science. These recommendations center on the collaborative development of a more inclusive, coordinated network of knowledge generators and exchangers, ideas raised in the Panel's comments in the 2019 State of the Sound, and recommendations from others. The Panel will work with the region's western science programs and other partners and with the Partnership's Executive Director, policy boards, and advisory groups to implement these recommendations. This may include the incorporation of one or more of these recommendations as key science program activities in the Action Agenda implementation plan for 2022-2026.

2. Objectives for selecting and prioritizing Science Work Actions

The Science Panel identified five objectives to guide the selection of priority Science Work Actions for 2020-2024. These objectives reflect the unique role and perspectives of the Science Panel to provide recommendations on the knowledge most needed to advance the socio-ecological goals of ecosystem recovery in the Puget Sound. Many organizations – state and federal agencies, tribes, non-governmental organizations, and universities – generate the research, monitoring, and analyses for their own programs that support this broad enterprise.

The objectives identified by the Panel, which it used to evaluate and reduce the many possible science actions to key actions for 2020-2024, built on the thinking of earlier Science Panels. This Science Panel, like early ones, recognized that the science needed should be actionable; identify emerging issues; advance best management practices; and continue to build the network of scientists, science-policy relationships, and funders. To focus on select issues within this broad universe of possibilities, the Science Panel identified key objectives from previous science work plans that were used to prioritize science actions. It also solicited ideas for objectives from the Leadership Council and Science Panel members. The Panel distilled these and refined them iteratively through a series of discussions and evaluations in mid-2020 to reduce ambiguity and redundancy. The Panel's final objectives are described below. Additional details, including examples for each objective, are presented in Appendix A.

Adds value by filling gaps

This objective refers to work that the Panel views as an important gap that should be filled, but that is not part of the objectives of an ongoing program of an agency or research entity and is unlikely to become so without outside initiation and support. The Panel holds a whole ecosystem perspective, has the role of an umbrella organization, and has the flexibility to adapt because its science programs are not encumbered by legislative or legal mandates.

The Panel recognizes and supports that existing entities fill critical knowledge gaps within their mandates. For example, the Stormwater Action Monitoring Program studies the effectiveness of stormwater management and Implementation Strategies regularly prepare state of the knowledge reports. This objective seeks to identify knowledge gaps that are outside of others' scopes of work. For example, the development of Atlantis modeling for Puget Sound was the result of cross-agency collaboration and advocacy.

Support Science Innovation

This objective is intended to capture science that explores new ideas or approaches that could be transformative for future researchers and conservation practitioners if successful but might also fail. This extends beyond tried-and-true approaches. Taking risks is important. Without support for this kind of innovation, agencies or research entities may only invest in tried-and-true approaches, potentially delaying much-needed advancements.

Science inquiry that falls under Science Innovation includes testing new technology or approaches. For example, the Partnership funded work to test new acoustic startle devices to deter pinniped predation on salmon. Work that repeats other studies (for example, in a new location), while important for increasing confidence, is not the role of the Science Panel to highlight.

Support Continuity

This objective is intended to allow the Partnership to support programs or initiatives that would be eliminated because of funding shortfalls or a change in an agency's priorities, but that provide valuable science necessary for ecosystem restoration and protection. Continuity maintains data quality and improves management decisions. This is especially important for cross-cutting programs. The Partnership may not be the long-term advocate or funder but may be able to fill intermediate gaps by supporting continuity.

The Panel recognizes and supports the critical value of ongoing programs, initiatives, and work to monitor and assess the status and trends of the ecosystem, especially towards Vital Signs and indicators. For example, monitoring the catch of a fishery is essential to management. The Panel also recognizes and supports ongoing (and innovative) work pursuing Implementation Strategies. The Panel seeks to highlight specific studies where continuity is important but is unlikely to be maintained without additional attention. For example, the Panel once supported stop-gap funding to maintain data collection from an ORCA monitoring buoy.

Link Socio-Ecological Resilience

This objective is intended to promote science to refine our understanding of resilience, coupled human-natural systems, feedback loops, and human dimensions. Linking socio-ecological resilience includes ensuring the impacts of decisions in systems interventions are borne equitability and do not inordinately affect one group, particularly those already disadvantaged, disenfranchised, or underrepresented.

This objective seeks to highlight work that connects multiple disciplines, for example, extending Atlantis modeling to understand the benefits provided to people. Connecting human health and well-being to ecosystem conditions is another area of inquiry meeting this objective. Developing a practical understanding of social networks and communities of practice would also fall under this objective. Work that is squarely within a single disciple will likely not meet the objective to link social and ecological resilience.

Change the Policy Landscape

This objective is intended to meet articulated science needs by decision makers to inspire or inform significant policy changes, or to break policy deadlocks. Because these opportunities are often unpredictable but depend on robust science-policy relationships this objective focuses on improving access to information and increasing trust by increasing communication with decision makers, finding opportunities to build trust, and developing capacity to respond quickly to policy opportunities as they emerge.

Research that supports changing the policy landscape might include the development of modeling or decision tools, or policy-oriented synthesis.

3. Science Work Actions

The Science Panel developed 106 Science Work Actions to encapsulate over 500 recommendations compiled from the recovery community (appendix B, tables B.1-B.3). The Panel used the objectives (section 2) to guide the selection of priority Science Work Actions.

Recommendations from the Recovery Community

As the initial step, Partnership staff compiled recommendations from the recovery community. This included reading source material for identified science gaps, research needs, or uncertainties. Different source documents called out needs in different way and the initial compilation of recommendations sought to be inclusive and capture all potential needs. With the intent of highlighting decision-relevant science, the focus was on materials that articulated the science and questions from managers and policymakers:

- Regional Priority Approaches from the 2018 Action Agenda
- Tribal Habitat Strategy and associated notes about priorities for Partnership implementation
- Implementation Strategies and their identification and characterization of uncertainties including all uncertainties in the Implementation Strategies Grand Uncertainties Matrix
- Synthesis of Local Integrating Organization (LIO) plans and the plans themselves
- Southern Resident Orca Task Force recommendations
- Lead Entities recommendations
- Marine Resources Advisory Council updated report on ocean acidification

Staff also gathered recommendations from source materials developed by groups of scientists organized to support Puget Sound or Salish Sea recovery:

- Science and monitoring activities identified by the regional implementation team of the Federal Puget Sound Task Force
- Social Sciences for the Salish Sea
- Puget Sound Ecosystem Monitoring Program
- Salmon Science Advisory Group

Recommendations were filtered to ensure that they reflected areas for scientific inquiry. For example, while valid, recommendations to increase funding for ecosystem restoration or protection or to change policies are outside of the scope of the Science Work Plan. In other cases, recommendations related to increasing the efficacy of science, for example through communication or relationship development. These could not be addressed through a specific science actions but were considered in the creation of broader recommendations (section 4).

Recommendations from the recovery community that could be addressed through science investigations were grouped thematically (e.g. chemicals of emerging concern and their impact on species and habitats) in clusters of 3-15.

Science Work Actions

The Panel and Partnership staff used these preliminary groupings to draft potential Science Work Actions. Topical experts from the Science Panel looked at recommendations within their field of expertise and suggested potential Science Work Actions that reflected the content and intent of multiple recommendations. Science Work Actions represent discrete and actionable areas of investigation that a scientific study could reasonably be initiated to answer or address though they do not estimate cost or specify owners (as Near-Term Actions in the 2018 Action Agenda does).

This resulted in the Panel's identification of 106 potential Science Work Actions as presented in Appendix B, Tables B.1-B.3. These tables express the 106 Science Work Actions (bolded) and the original recommendations from the recovery community that inform them (in italics). The tables are organized based on the intersection of science and policy:

1. Best Management Practices (BMP): Areas where scientific knowledge supports articulated policy issues, but where innovation is needed to address important or urgent issues. (Table B.1);
2. Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making. s (Table B.2);
3. Uncertainty and Doubt (US): Areas where both scientific knowledge and articulation of policy issues are poorly developed and where the body of scientific knowledge can be improved through research, monitoring, or modeling and reduce uncertainties that can serve as barriers to action. (Table B.3)

Prioritization of Science Work Actions

The Science Panel used the five objectives (section 2) as criteria to guide the selection and prioritization of Science Work Actions for inclusion in this report. Selected Science Work Actions should advance one or more of the stated objectives in order to be elevated as a priority in the next four years. To accomplish this, Panel members used both quantitative assessment and qualitative discussion.

Each Science Panel member scored each Science Work Action against each objective on a scale of 1 to 9. Resulting scores were averaged across Science Panel members. This process identified Science Work Actions for which there some agreement that the Science Work Action met one or more objective. This process also identified Science Work Actions that, while potentially important to specific programs or initiatives, did not meet the regional and cross-sectoral objectives of the Panel. Codes in Tables B.1-B.3 indicate the overall quartile rating of each Science Work Action for each objective. Sixty-two Science Work Actions ranked in the top 15 for at least one objective or scored within 20% of the top score. Individuals from the Panel then used these Science Work Actions to identify the top 10-20 Science Work Actions. Partnership staff compiled these lists to determine areas of consensus and disagreement.

The Panel used the results of the simple scoring exercise and individual prioritization as a starting place for a discussion around prioritization. For Science Work Actions with relatively high consensus (i.e. high scoring or identified as priorities for multiple Science Panel Members), Panel members confirmed their importance or offered revisions to the language to clarify intent. In cases where there was not consensus, Panel members were able to explain why they felt a Science Work Action was especially important. This helped to ensure that the selected Priority Science Work Actions were not simply from the most well understood or popular fields.

Priority Science Work Actions

Human-biophysical Interactions

1. Evaluate how current and future social, economic, and political factors, such as population growth and urban development, will affect habitat quality and quantity, both negatively and positively as gauged by salmon viability. (UD 10)

2. Identify and adopt appropriate frameworks connecting human wellbeing to ecosystem health to evaluate climate change impacts to holistic health, considering and appropriately addressing issues of scale, psychological shifting baselines and perceptions of environmental governance, sense of place, and psychological wellbeing. (UD 3/18)

3. Assess the degree, and how, access to marine and coastal resources (e.g. fisheries, open space, native foods) is changing among different communities in the Salish Sea. (UD 19)

Effectiveness of Recovery Interventions

4. Assess what factors contribute to effective co-governance and/or co-management between jurisdictions (including Indigenous and non-Indigenous governments). (UD 1)

5. Determine what incentives, human well-being factors, market drivers, tax systems, and characteristics influence residents', developers', and purchasers' choices that contribute to or prevent habitat conversion. (EBS 11)

6. Assess the effectiveness of incentive approaches in Puget Sound recovery efforts. (EBS 41)

Ecological Conditions and Effects

7. Characterize human health and environmental risks from chemicals of emerging concern. (EBS 52)

8. Assess toxic contaminant sources, (both historic and ongoing) and prioritize their clean-up or replacement based on environmental and human health impacts. (EBS 10)

9. Determine benefits to viability of Southern Resident Killer Whales from improved prey availability, and reduced disturbance and toxic chemical exposure; assess benefits individually and cumulatively through monitoring and modeling. Consider benefits in context with potential risks associated with reduced Southern Resident Killer Whale and salmonid genetic diversity. (EBS 56)

10. Identify and address gaps in current efforts to assess water use in Puget Sound with a focus on groundwater quality and quantity discharged to Puget Sound. (EBS 15/16/58)

11. Build upon recommendations of the Salish Sea Marine Survival Project to further define bottom-up and top-down food web effects on juvenile salmonid mortality in Puget Sound. (EBS 14)

Science-Based Decision Support
12. Refine risk assessment tools and scenario development and analyses to improve our understanding of highly uncertain, complex and inter-related challenges and solutions to provide information that can be used to identify actions to achieve a more resilient Puget Sound ecosystem. (EBS 31) 13. Develop a framework of recommended approaches for including risk analyses, including extreme events and uncertainty, into planning and decision making. (EBS 28) 14. Better define tipping points for cumulative impact of multiple individual human activities on habitat quantity and quality, water quality and species recovery. (EBS 32/33) 15. Explore and advance the use of methods to integrate human dimensions with biophysical targets and goals by decision makers. (EBS 30)

Using Priority Science Work Actions

Over the next four years, the Panel will directly encourage, support, and fund the implementation of the Priority Science Work Actions, and the objectives that informed them. Specifically, Priority Science Work Actions will be used to guide the development of a request for proposals for 2021-2023. The Panel will also identify opportunities to facilitate collaboration in the broader recovery community to fulfill these priorities. The Panel hopes that the broader recovery community will look to the complete list of Science Work Actions for areas of inquiry where multiple sources are identifying similar knowledge gaps and needs.

4. The Panel's recommendations to improve ongoing science

In addition to specific Science Work Actions, the Panel also identified broader recommendations that support the development, efficacy, and implementation, of science. These recommendations originate from the same source materials that provided recommendations for discrete science needs (section 3), the Panel's comments in the *2019 State of the Sound*, and the Panel's objectives for improving science (see Appendix C for additional information on sources).

A. Collaboratively broaden and improve the knowledge network that supports Puget Sound ecosystem recovery

The Science Panel and Partnership envision that the strategic focus articulated in the *SWP for 2020-2024* will be bolstered by the development of a more inclusive, coordinated knowledge network to support Puget Sound recovery. The concept of a coordinated network of individuals and organizations who work individually and together to generate and exchange knowledge is rooted in approaches used in the Sound and in other regions. Existing networks convened and engaged by the Partnership and PSEMP implement aspects of this concept, building from regional entities in the region.

The Panel seeks to partner with regional leaders and organizations dedicated to science and other ways of knowing, recognizing the central importance of Indigenous knowledge and environmental justice, to:

- better articulate the vision of Puget Sound recovery and related scientific questions to pursue,
- improve the impact of science and Indigenous and local knowledge on Puget Sound recovery efforts,
- improve the legitimacy and transparency of decision making, and
- hold one another accountable for achieving recovery objectives.

The Panel recommends that the Partnership, the federal science and monitoring work group, PSEMP, and the region's western science programs, intentionally partner with a diversity of organizations and individuals who generate and exchange knowledge to describe and increase participation in a network of knowledge generating and sharing capacities. This more inclusive, coordinated network will provide perspectives, information, tools, models, and other products that support the planning, decision-making, and implementation processes of the Puget Sound ecosystem recovery system.

The Panel recommends the following activities to achieve its objectives of broader engagement and improved coordination and integration of science and other ways of knowing:

- Talk with a diversity of partners to hear their perspectives about what is important in how the knowledge network grows from the current situation and how it functions into the future;

- Talk with colleagues in other systems and conduct literature reviews to identify governance and management approaches that have fostered broader engagement and improved network outcomes, especially those that have emphasized incorporation of Indigenous knowledge and addressed environmental justice;

- Discuss and identify practical means by which science programs and other knowledge providers can access and manage financial and intellectual resources to sustain management-relevant investigations and boundary spanning activities;

- Consider perspectives from diverse partners about what makes information "legitimate" and the limitations of traditional western approaches to applied science; and

- Enhance networking among different types programs and diverse groups of individuals across Puget Sound and the entire Salish Sea

B. Improve incorporation of Indigenous knowledge into science and monitoring efforts

Indigenous peoples have lived and thrived in Puget Sound since time immemorial. They carry forward millennia of traditional ecological knowledge and experience, constituting a long-term and fine-grained observing network over timescales rarely possible in scientific research. Over the last two centuries, the ecology of the Sound that supported traditional lifeways has been significantly altered and degraded, leaving many of the resources that supported Indigenous lifeways struggling for survival. The magnitude of today's problems is daunting and at a greater scale than any that has been faced before. We must therefore mobilize a diverse array of knowledge in seeking solutions.

Traditional ecological knowledge offers information on long-term ecological baselines, ecosystem relationships, and time-vetted strategies for sustainably harvesting and managing the Sound's resources that can help address the knowledge gaps outlined in this *SWP for 2020-2024*. As a scientific community, we must partner more effectively with Tribal programs by fostering and expanding collaborations with Indigenous communities and their research goals. For example, Swinomish-led research into ocean acidification's effects on shellfish growth and how these impacts can be mitigated helps ensure healthy and productive shellfish beds will exist in the future (Greiner et al 2018). Tribal fish hatchery initiatives and primary research into salmon viability add to long-standing, time-vetted Indigenous management practices for maintaining sustainable fish stocks (https://nwifc.org/a-new-look-at-hatcheries/). The archaeological record of Indigenous peoples of the Sound constitutes a storehouse of traditional ecological knowledge as it has been accumulated and applied over millennia, providing insights into resource management practices and harvesting strategies that have worked for the Sound.

In all these respects, Tribal peoples and Indigenous Nations are inherent partners in our call for a more inclusive, coordinated knowledge network. Given the many ways in which Indigenous Science and traditional ecological knowledge can broaden and deepen knowledge of the problems we face and possible solutions, our specific recommendations are to (1) find creative and meaningful ways to partner with Indigenous science programs in our collective effort to restore a resilient and sustainable Puget Sound, and (2) invest in research strategies that recognize traditional ecological knowledge and build on that knowledge to generate a collective understanding of ecosystems relationships and systems thinking.

C. Develop capacity and coordinate efforts to assess and report on ecosystem conditions and the effectiveness of interventions

The Science Panel continues to advocate for greater capacity to assess ecosystem conditions, progress toward goals, and the effectiveness of strategies and actions. In its Strategic Science Plan (PSP 2010), the Science Panel recognized that a sound science program must have the ability to (1) analyze and synthesize existing information; (2) develop and apply innovative tools to understand structure and function and to predict and document change; (3) foster exploration and discovery; (4) effectively communicate and integrate science; and (5) continually review the quality, depth, and breadth of our understanding in open, transparent, and constructive ways. The Panel of a decade ago noted that these capacities are present across institutional sectors (e.g., federal, tribal, state, local, private, academic organizations) and that these would need to grow and be coordinated to be effective; building and sustaining these capacities remains a priority need for the Puget Sound recovery system.

The Science Panel recommends continuing and increasing the collaboration and coordination of science capacities across the many groups that are contributing or could contribute to this effort. The evolution of PSEMP is an excellent example of the challenges and success of growing capacity by catalyzing coordination. PSEMP grew out of the Puget Sound Ambient Monitoring Program (PSAMP), which began in 1988 to capture the expertise and efforts of individual agencies doing research in the Salish Sea. With the creation of the Partnership in 2010, PSEMP was formed as a broader, multi-stakeholder effort that would capitalize on the vast, loosely organized network of federal, tribal, state, local, academic, non-governmental, and citizen scientists doing work in the Salish Sea. Enlisting and growing the capacity of a network of individuals and diverse groups that are not formally organized by a common hierarchy comes with significant challenges (Sørensen and Torfing 2016). Since 2010, PSEMP has made significant progress in building capacity. PSEMP has recognized and built on the unique characteristics of networks and the kinds of governance that are most appropriate; organized assessments around common indicators and metrics, such as the Vital Signs; developed synthesis documents; and catalyzed involvement through dedicated funding for coordinators of self-organized, topic-based work groups, which are supported by a multi-stakeholder steering committee. Although the strength of this approach lies in the combined capacities and capabilities of the different participating scientists and organizations, based on the lessons learned by PSEMP in identifying and overcoming these challenges, the Science Panel concludes that the dedicated funding that catalyzes these kinds of interactions is essential and should continue and grow.

D. Coordinate production and use of interdisciplinary research that explores and emphasizes the integrated nature of socio-ecological systems

The problems we need to solve for Puget Sound are at the nexus of ecosystems and society and are interdisciplinary in nature. If we are to reach our goal of creating a resilient Puget Sound, it will be because we make better decisions that consider the multiple ecological and social interactions and tradeoffs inherent in our world. The majority of environmental problems we must confront are human issues. Application of social science theories and methodologies can help us find better ways to approach environmental problems that are rooted in human behaviors.

Biophysical sciences can help us understand the physical nature of the problems we face, but social sciences are fundamental to understanding how we create a sustainable quality of life for the millions of current and future human and non-human residents of Puget Sound. It is essential to integrate social sciences research and human dimensions into practice in order to account for individual and social values and systems, perspectives, and objectives, thereby creating more holistic recovery strategies, effective decisions, and a more resilient Puget Sound.

Economic development and sustainability are often cast as opposites. We have an opportunity, in the era of covid-19, to rethink how sustainability and economic prosperity can both be realized. As we invest in a broadly framed recovery, the social sciences can provide a means to promote investments that produce an equitable distribution of costs, benefits, and tradeoffs. Ecosystem services reflect the multiple benefits--including economic and human wellbeing benefits—that the natural world provides to human communities. Sustainably managing, protecting, and recovering these services is integral to the Partnership's work, and reflects the necessity of the social sciences to effectively and equitably maintain balance of development and sustainability.

Addressing and mapping the interconnections between humans in the ecosystem is a critical strategy for coming to terms with the complexity of environmental issues. There are a variety of robust frameworks that may be employed (e.g., Integrated Socio-Ecological Systems, Coupled Natural Humans Systems, etc.). It is the recommendation of the Science Panel that we and the broader knowledge network prioritize research that considers the interactions of fundamental social and ecological questions. This will require both biophysical and social scientists to collaborate with researchers from other disciplines and with individuals and organizations who develop, hold, and share other types of knowledge to study the core problems and solutions relevant to Puget Sound restoration and protection.

E. Build and sustain robust programs and relationships across science-policy interfaces to inform recovery

The Panel and recovery partners understand that the Puget Sound ecosystem is both complex and complicated, especially as defined using broad 'snowcaps to whitecaps' language and explicitly including multi-faceted 'human dimensions' of ecosystem recovery. This general understanding leads to at least a superficial endorsement of the notion that management and policy decisions should be 'science-based', or at least 'science-informed'. Scientists understand that decision makers must balance a range of considerations that extend far beyond science. Effective and efficient stewardship of complex and complicated systems such as Puget Sound require robust and enduring capacity to develop and share knowledge and dialog between scientists, other knowledge holders, managers, and decision makers and permanent conduits for exchange between scientific and policy organizations.

Interactions among scientists, other knowledge holders, managers, and decision makers are by necessity two-way streets that recognize that various parties come from different perspectives and use different languages and tools to achieve overlapping but not identical goals. Decision makers and scientists prioritize actions differently and what is the 'best' or 'most important' or 'most interesting' to a scientist may not align with what actions are 'politically feasible (or bold)' or 'most acceptable' or 'least likely to run into opposition'. Tension often results from the level of certainty (or tolerance for risk) each group is willing to accept for science to be 'actionable' versus 'publishable'.

The Science Panel recognizes the distinct challenges and benefits of productive and trusted interactions among scientists, other knowledge holders, and decision makers. Through the backbone functions of the Panel and the Partnership's science team and numerous boundary-spanning entities, communication among scientists, managers, and policy makers is occurring. It can be enriched. The Partnership's adaptive management framework (2013) identifies several recurring opportunities for information and scientific process to advise and support adaptation of recovery efforts by hundreds of management entities and decision makers. Boundary spanning organizations and boundary spanning efforts by scientists and other knowledge holders provide necessary capacity to share learning and knowledge among various entities focused on science, Indigenous and local knowledge, management, and policy, especially the boards and advisory groups that comprise the management conference. Identifying opportunities when 'policy windows' are open, linking knowledge to action, and engaging decision makers in the production and sharing of policy-relevant information must be critical elements of the Puget Sound program.

F. Communicate science findings clearly and to the appropriate audiences

The Science Panel and Partnership have a key role to disseminate science that is relevant to all facets of the recovery effort, from the ecology of Puget Sound to the political ecology of our region and what society wants in a resilient Puget Sound. A well-informed public is essential to sustaining the Puget Sound recovery effort. Disseminating science that supports recovery and ecosystem resilience is important for cultivating political will among the state and local policy makers who enact and support initiatives that form the framework for protection and restoration programs.

Broad and strategically targeted communication through our recovery network is essential to building trust and providing a foundation of information from which partners can discuss shared and separate objectives and motivations. The Science Panel and Partnership staff both have roles to explore the most effective means to communicate relevant research findings and other information in a manner that is accessible and useful to various audiences and sectors in the Puget Sound region.

A recent editorial in the research journal Science (26 June 2020, Vol 368, Issue 6498, p. 1405) points to the need to look closely at why current efforts to communicate scientific findings are not having a larger positive effect on public acceptance of science. The approach of encouraging scientists, journalists, and others to do a better job at telling the stories of science has not been enough. The examples around COVID-19 are illustrative: from disputes about the science supporting use of masks and social distancing to concerns that herd immunity would not be achieved because of the anti-vaccine sentiment by some. This illustrates that even a combination of well-reasoned and well-placed op-eds, articles in popular venues, and public speaking engagements by science leaders has not been sufficient to achieve public acceptance of science, let alone science-informed behavior change. The Partnership and Science Panel will need to foster partnerships that support access to the full range of tools that build and sustain the case for Puget Sound recovery.

G. Develop and analyze alternative future scenarios to explore and express desired futures and evaluate trade-offs among possible approaches

As a step to improve ongoing science, the Science Panel recommends the continuous use of scenario analysis to express and explore anticipated and desired futures and to evaluate trade-offs among possible policy and management approaches. Current-day and future drivers of change present an ongoing challenge for a resilient Puget Sound. The dynamics of population growth, economic cycles, climate change and other drivers of uncertainty all make easy predictions about the future problematic. Without an understanding of the deeper connections, feedbacks, and system structures driving future conditions, actions to achieve ecosystem recovery are likely to come up short. In such a context, a common scenario framework allows scientists, policy makers and other stakeholders to jointly consider the many ways the future may unfold and how strategies can be made more responsive and effective.

It is important to invigorate the dialogue between scientists and decision makers to improve clarity around critical anticipatory decisions and the scientific information needed to inform them. The Science Panel, the Partnership, and scientists in other institutions can utilize scenario work to ensure that appropriate research, multi-disciplinary collaboration, and social science methods are tied effectively to the development of long-term plans. It bears emphasizing that scenario planning is useful even in cases with imperfect understanding of the structures and processes involved. The knowledge network can provide the fundamental applications of quantitative modelling, appropriate study design, and techniques to evaluate costs, benefits, and risks to scenario discussions and restoration policy. Importantly, knowledge holders can help bridge an understanding of the events that can be forecasted and those that must be approached through structured learning. To these ends, scenario planning should not be a one-time exercise but more of an ongoing requirement at the science-policy interface when desired future conditions are being addressed.

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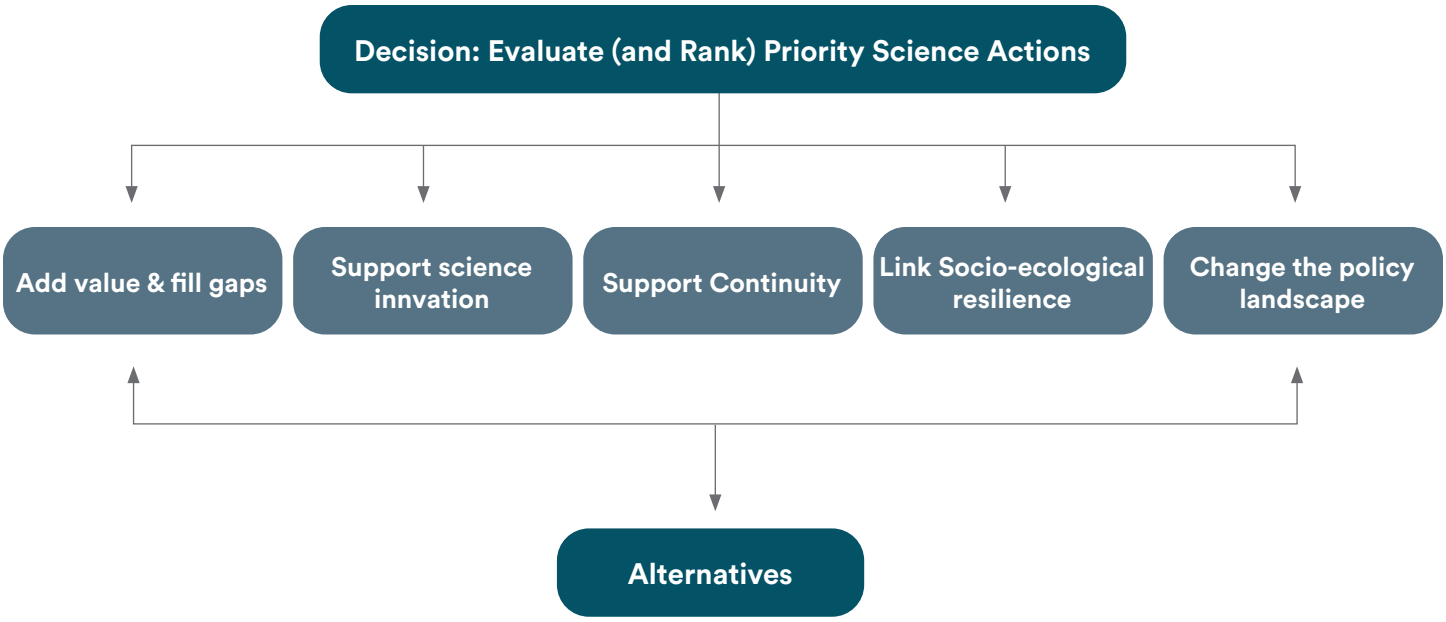
Appendices

Appendix A: Objectives and additional information:



Objective	Keywords	Description	Inclusion Criteria with examples	Exclusion Criteria with examples	Relation to other objectives (esp.opportunities for confusion)
Adds value by filling gaps	gap, decision-critical,	This objective refers to work that the Science Panel views as an important gap that should be filled, but that is not part of the objectives of an on-going program of an agency or research institution and is unlikely to become so without outside initiation and support. PSP holds a whole ecosystem perspective, has the role of an umbrella organization, and has the flexibility to adapt because its science programs are not encumbered legislative or legal mandates.	Work that would be unlikely to be advanced otherwise. - E.g. Atlantis modeling developed as an approach for cross-agency collaboration as PSP advocated for it; - E.g. initial investments in zooplankton monitoring might not have gotten off the ground without PSP joining PSEMP, UW, and tribal advocates	Work that is already funded or within another program's mandate. - E.g. Studies of the effectiveness of stormwater management are well within the Stormwater Action Monitoring Program (SAM) that has a determined approach for evaluating stormwater and securing funding for priority studies. -E.g. Preparing 'state of knowledge' reports for recovery planning is supported by EPA's Science-Implementation Strategy award	Is distinct from Support Continuity in that this objective supports new fields of work. Is distinct from Science Innovation in that this objective is more attentive to the value of scientific contributions to management or policy questions

Objective	Keywords	Description	Inclusion Criteria with examples	Exclusion Criteria with examples	Relation to other objectives (esp.opportunities for confusion)
Support Science Innovation	innovation, technology, risk, return on investment, advance-ment, methods	This objective is intended to capture science that explores new ideas or approaches that could be transformative for future researchers, if successful, but might also fail. This extends beyond tried and true approaches. Taking risks is important. Without support for this kind of innovation, agencies or research institutions may invest in tried-and-true approaches, potentially slowing down much needed advancements	Work that is testing new approaches. - E.g. testing new technology like acoustic startle devices to deter pinniped predation on salmon; - E.g. using dogs to sniff out whale feces to understand whale diets; - E.g. eDNA development as a tool to characterize species presence or absence; - E.g. applying a new discipline to a standing problem	Work that confirms or repeats other studies - E.g. repeating a study in a new location, on a new species, or in a new year -E.g. Studies to improve a methodology's accuracy or precision without articulation of a recovery-related need for better data quality	Is distinct from Add Value in its emphasis on new approaches. Is distinct from Change the Policy Landscape in its emphasis on science advancement
Support Continuity	Bridge, continue, complete, follow-through, next phase, funding, monitoring	This objective is intended to allow PSP to support programs or initiatives that would be eliminated because of funding shortfalls or a change in an agency's priorities but that provide valuable science necessary for ecosystem restoration and protection. Continuity maintains data quality and improves management decisions. This is especially important for cross-cutting programs. PSP may not be the long-term advocate or funder but fills an intermediate gap by supporting continuity.	Important past or ongoing work that would otherwise go unfulfilled. - E.g. stop-gap funding to maintain data collection from an Orca monitoring buoy; - ensuring a long-term, continuous approach to zooplankton monitoring; - completion of the Salish Sea Marine Survival project; - maintaining an acceptable network of smolt traps or stream gauges	Work that is well covered by other programs or well aligned with programs' mandates - E.g. monitoring the catch of a fishery -assessing year-to-year variability in wastewater discharges	Is distinct from Add Value by Filling Gaps in its emphasis on continuing past programs rather than supporting new initiatives Is a complement to Support Science Innovation in its concern for implementation of tried and true approaches

Objective	Keywords	Description	Inclusion Criteria with examples	Exclusion Criteria with examples	Relation to other objectives (esp.opportunities for confusion)
Link Socio-Ecological Resilience	resilience, coupled human-natural, feedback, human dimensions, ecosystem services, benefits from nature, co-benefits, traditional knowledge, local knowledge	This objective is intended to promote science to refine our understanding of resilience, coupled human-natural systems, feedback loops, and human dimensions. Linking socio-ecological resilience includes ensuring the impacts of decisions in systems interventions are borne equitability and not inordinately by one group, particularly those already disadvantaged, disenfranchised, or underrepresented.	Work that links multiple disciplines or is centered in social science. - E.g. scenario analysis, - E.g. human dimensions modeling, such as when Atlantis extends results to provisioning ecosystem services, - E.g. the impacts of floodplain water dynamics on adjacent human populations	Work that fits squarely within one discipline or does not account for system feedbacks. - E.g. floodplain hydrology with no consideration of the built environment or human risks -E.g. examinations of past conditions as indicative of the future; treatment of systems as static	Is distinct from Change the Policy Landscape in its emphasis on system dynamics and linkages Is distinct from Support Science Innovation in its emphasis on systems thinking
Change the Policy Landscape	decision-making, decision-support tools, synthesis, communication	This objective is intended to meet articulated science needs by decision makers or that will inspire or inform significant policy changes or break policy deadlocks. In addition, these actions will likely involve focused efforts to increase communication with decision makers, build trust, and develop capacity to respond quickly to opportunities as they emerge. Since it's unpredictable what will change the policy landscape, this objective focuses on improving access to information and increasing trust.	Work that supports decision-making through communication, tools, or trust. - E.g. model building, - E.g. decision tools, - E.g. policy-oriented syntheses	Work that is unconnected to policy-level decision-making. - E.g. floodplain hydrology - E.g. studying the effectiveness of BMPs	Is distinct from Link Socio-Ecological Resilience in its emphasis on management tools and interventions Is a complement to Support Science Innovation in its concern for improved policy and management

Appendix B: Science Work Actions from recommendations

Table B.1 Best Management Practices (BMP): Areas where scientific knowledge supports articulated policy issues, but where innovation is needed to address important or urgent issues;

Table B.2. Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making;

Table B.3. Uncertainty and Doubt (US): Areas where both scientific knowledge and articulation of policy issues are poorly developed and where the body of scientific knowledge can be improved through research, monitoring, or modeling and reduce uncertainties, which can serve as barriers to action.

Science Work Actions are bolded. The recommendations informing each Science Work Action are directly below in italics. These recommendations are direct quotes from source documents and have not been edited. See section 3 for a description of how Science Work Actions were determined and organized. The codes next to the Science Work Action indicates the sources (and number from each source) that informed that action. The lettering next to the recommendation indicate its source. LIO = Local integrating organization plan, OTF = Orca Task Force, FTF = Federal Task Force, GovB = Governor's Budget, RPA = Action Agenda Regional Priority Approach, TH = Tribal Habitat Strategy, S4 = Social Sciences for the Salish Sea, PSEMP = Puget Sound Ecosystem Monitoring Program, IS-Ch = Chinook Implementation Strategy, IS-GUM = Implementation Strategy Grand Uncertainty Matrix, IS-TIF = Toxics in Fish Implementation Strategy, IS-Sh = Shellfish Implementation Strategy, IS-MWQ = Marine Water Quality Implementation Strategy, OA = Ocean Acidification report, LE = Lead Entity, SSAG = Salmon Science Advisory Group.

Each science work action was scored against each objective (right 5 columns, see section 3 for additional details). The quartile of the resulting rank is coded in the right-hand columns. High=ranked top 25% for that objective, med-high=ranked 25-50% for that objective, med-low = ranked 50-75% for that objective, low=ranked lowest 25% for that objective.

Science Panel Priorities are denoted with an * next to the ID

Table B.1: Science Work Action relating to Best Management Practices

ID	Best Management Practices (BMP): Areas where scientific knowledge supports articulated policy issues, but where innovation is needed to address important or urgent issues	Sources	Quartile Rank of Scored SWA:				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
BMP 1	**Advance science, integrate traditional knowledge, and improve best management practices to increase effective climate adaptation in riparian areas and floodplains**	**TH (3)**	med-high	med-high	med-high	high	low
BMP 1.01	*(Adaptive Management) Advance the science and best practices of effective climate change adaptation in riparian areas.*	*TH*					
BMP 1.02	*(Data Collection and Analysis) Advance the science and BMPs of effective climate change adaptation in floodplains.*	*TH*					
BMP 1.03	*Research best practices for using floodplain function to reduce the impacts of climate change, integrating traditional knowledge*	*TH*					
BMP 2	**Investigate performance and adoption of best management practices on working and rural land**	**RPA (1)**	med-low	low	med-low	med-high	med-high
BMP 2.01	*Facilitate the increased use or performance of best management practices on working/rural lands*	*RPA*					
BMP 3	**Investigate fish hatchery operations and production to inform adaptation of hatchery management**	**OTF (1), IS-MWQ (5)**	low	low	med-low	low	low
BMP 3.01	*On hatchery: Adaptive management and five-year comprehensive reviews. To continue ongoing hatchery production with funding at the increased levels, WDFW must conduct annual adaptive management and five-year comprehensive reviews and adjust production and practices accordingly to limit impacts on natural salmon stocks if the reviews provide evidence of significant risk to the recovery of natural salmon stocks.*	*OTF*					

ID	Best Management Practices (BMP): Areas where scientific knowledge supports articulated policy issues, but where innovation is needed to address important or urgent issues	Sources	Quartile Rank of Scored SWA:				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
BMP 3.02	*On Hatcheries: Production numbers: Who determines how much or why? Are we obligated to produce X amount for native catch, for example?*	*IS-MWQ*					
BMP 3.03	*Is there nitrogen control in hatchery permits?*	*IS-MWQ*					
BMP 3.04	*Under hatcheries' general permit, what are the effluent conditions?*	*IS-MWQ*					
BMP 3.05	*What is AKART for hatcheries?*	*IS-MWQ*					
BMP 3.06	*What is the application of polyculture at/in hatcheries?*	*IS-MWQ*					
BMP 4	**Investigate and evaluate floodplain regulation across Puget Sound jurisdictions to inform adaptation of management approaches**	**IS-GUM (1)**	low	low	low	med-high	high
BMP 4.01	*What are the opportunities to harmonize or strengthen existing regulations within and across jurisdictions to encourage an integrated approach to floodplain management?*	*IS-GUM*					
BMP 5	**Develop monitoring approaches and tools to improve assessments of ecosystem conditions**	**IS-GUM (1), LE (1), PSEMP (1)**	med-low	high	high	med-high	low
BMP 5.01	*How should flood risk be assessed? Which projected flood patterns should be used in assessing flooding risks in order to change or integrate policies that affect development and infrastructure in floodplains?*	*IS-GUM*					
BMP 5.02	*Fine sediment input into the Upper Green-Guidance on how to establish a baseline and monitor this cost effectively*	*LE*					
BMP 5.03	*Use existing monitoring and assessment results to create synthetic indicators of (predicted) future states of the ecosystem, with emphasis on ecosystem goods and services.*	*PSEMP*					
BMP 6	**Implement best practices to monitor indicators of human wellbeing and ecosystem recovery**	**PSEMP (1)**	high	high	med-low	high	med-high
BMP 6.01	*Identify and implement best practices to monitor and track progress on human wellbeing and social-ecological goals, and targets, using indicators and other approaches.*	*PSEMP*					

Table B.2: Science Work Action relating to Evidence-Based Solutions

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 1	**Assess drift cells, estuaries, and floodplains at a parcel scale to link assessment to scale of landowner management**	**LIO (3)**	med-high	low	low	med-high	high
EBS 1.01	*Parcel-by-parcel (drift cell) analyses (Data Gap - Assessment)*	*LIO*					
EBS 1.02	*Parcel-by-parcel (estuary) analyses (Data Gap - Assessment)*	*LIO*					
EBS 1.03	*Parcel-by-parcel (floodplain) analyses (Data Gap - Assessment)*	*LIO*					
EBS 2	**Assess how a lack of woody debris and floodplain connectivity (levees, revetments) and affect adequate instream rearing habitat**	**LE (1)**	low	low	med-high	low	low
EBS 2.01	*Rearing and refuge – What are the effects of a lack of woody debris and floodplain connectivity (levees, revetments) and other features of adequate instream rearing habitat?*	*LE*					
EBS 3	**Assess the effects of artificial light and predation in Lake Washington, Lake Sammamish, and the Ship Canal**	**LE (1)**	low	med-high	low	low	low

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 3.01	*Lake survival – What are the effects of artificial light and predation in Lake Washington, Lake Sammamish, and the Ship Canal (predation in Ship Canal may be a key limiting factor)?*	*LE*					
EBS 4	**Assess, map, and communicate shoreline characteristics, including permitted and unpermitted hardening**	**IS-GUM (3)**	low	low	med-high	med-low	med-low
EBS 4.01	*Bank hardening: Inventory, catalog, and share bank hardening data and distribute consistent information on connected versus disconnected floodplain areas.*	*IS-GUM*					
EBS 4.02	*How much unpermitted armor is there and what are its attributes (length, elevation, shore type is it present on, etc.)?*	*IS-GUM*					
EBS 4.03	*Remote sensing technologies support protection -- Current (2017) shoreline armoring inventory developed along freshwater and saltwater habitats across the entire region, including but not limited to docks, bulk-heads, boat rails, man-made structures, etc. that are not permitted*	*IS-Ch*					
EBS 4.04	*Develop a sound-wide dataset related to the biological condition (not just habitat quantity) of both beaches and tidal wetlands that could serve as baselines for assessing the ecological response of these ecosystems to both restoration actions and increases in stressors.*	*PSEMP*					
EBS 5	**Characterize and map the features and processes of sub-estuaries, shorelines, and watersheds**	**IS-GUM (1)**	low	low	high	med-low	low
EBS 5.01	*How do sub-estuaries (creek mouths, embayments, inlets) map onto shoreline segments and watersheds?*	*IS-GUM*					
EBS 5.02	*What are the characteristics and features of linked sub-estuaries/shorelines/watershed units?*	*IS-GUM*					
EBS 6	**Monitor eelgrass, kelp, and forage fish responses to restoration and land use changes**	**FTF (1), LIO (1), IS-GUM (1), IS-Ch (1)**	med-high	low	high	med-low	med-low
EBS 6.01	*Conduct hypothesis-based process studies for forage fish and eelgrass*	*FTF*					
EBS 6.02	*GRP forage fish spawning data*	*LIO*					
EBS 6.03	*How does eelgrass respond to tidal wetland restoration projects and other stressors? Do tidal wetland resto-ration projects benefit eelgrass recovery?*	*IS-GUM*					
EBS 6.04	*Conduct eelgrass monitoring and stressor-response research to better understand causes of local declines (so that Impact of point and nonpoint sources of pollutants on salmon resources better understood)*	*IS-Ch*					
EBS 7	**Determine regional rates of marine shoreline erosion to support site assessments of need for and design of protection**	**IS-GUM (1)**	med-low	low	med-high	low	low
EBS 7.01	*What are regional erosion rates (for support of site assessments)?*	*IS-GUM*					
EBS 8	**Expand monitoring of changes in estuarine, riverine, and floodplain habitats**	**IS-GUM (2), LE (1), LIO (4), RPA (2), TH (1)**	med-high	med-low	high	med-low	low
EBS 8.01	*What are the habitat functions and resilience for each delta system?*	*IS-GUM*					
EBS 8.02	*What are the riverbed dynamics in rivers? Resurvey rivers to get a better grasp on the dynamics.*	*IS-GUM*					
EBS 8.03	*specific data needs are: (1) identification and quantification of impairments to natural processes; (2) inven-tory and characterization of habitat conditions; (3) identification and characterization of biotic interactions; and (4) characterization of salmonid populations*	*LE*					
EBS 8.04	*Baseline data and information*	*LIO*					
EBS 8.05	*Functional estuary assessments (Data Gap - Assessment)*	*LIO*					
EBS 8.06	*Lack of baseline and historical data (identified by 9 LIOs)*	*LIO*					
EBS 8.07	*Pocket estuary habitat trend analyses (Data Gap - Assessment)*	*LIO*					
EBS 8.08	*Create a balance sheet for habitat gain and loss in the watershed*	*RPA*					
EBS 8.09	*Gain a better understanding of current habitat conditions*	*RPA*					
EBS 8.1	*(Data Collection and Analysis) Compile and maintain data on floodplain extent, condition, and where and how much existing regulations have allowed habitat loss.*	*TH*					

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 9	**Determine the primary stressors affecting stream condition at a sub-basin scale**	**IS-GUM (1)**	med-low	med-low	med-high	med-high	med-low
EBS 9.01	*What are the primary stressors affecting stream condition at a sub-basin scale?*	*IS-GUM*					
EBS 10*	**Assess toxic contaminants sources (both historic and ongoing) and prioritize their clean-up or replacement based on environmental and human health impacts**	**IS-TIF (1)**	high	high	high	med-high	high
EBS 10.01	*Are there inventories for creosote pilings (DNR) or legacy PCB-containing electrical equipment?*	*IS-TIF*					
EBS 11*	**Determine what incentives, human well-being factors, market drivers, tax systems, and characteristics influence residents', developers', and purchasers' choices that contribute to or prevent habitat conversion.**	**IS-GUM (2)**	med-high	high	med-low	high	high
EBS 11.01	*Which parts of the property tax system influence developers' and purchasers' choices between rural and urban development? How do impact fees (including septic system monitoring, maintenance requirements, drinking water, and stormwater) differ between rural and urban developments?*	*IS-GUM*					
EBS 11.02	*What are the underlying costs of rural living?*	*IS-GUM*					
EBS 12	**Investigate factors affecting shellfish production and harvestability and the ecological and human wellbeing effects of shellfish aquaculture**	**FTF (1), IS-sh (1), RPA (1)**	med-low	med-high	med-high	high	high
EBS 12.01	*Federal Shellfish Research Program*	*FTF*					
EBS 12.02	*Microbial Source Tracking (MST): What is the status of MST? What are realistic expectations of how MST can now, and in future, contribute to shellfish beds recovery?*	*IS-Sh*					
EBS 12.03	*Ensure environmentally sustainable shellfish aquaculture that is based on sound science*	*RPA*					
EBS 12.04	*What is the current reliance on shellfish aquaculture and hatcheries (in contrast to wild harvests) among Indigenous and non-Indigenous economies, and what are the implications for aquaculture and hatchery management?*	*S4*					
EBS 13	**Evaluate the effects of marine, estuarine, and freshwater habitat conditions on viability of salmonids**	**IS-Ch (1), LE (4)**	low	med-high	high	med-low	med-high
EBS 13.01	*Develop clearinghouse for all applicable climate change information and recommendations (so Climate impacts on VSP understood)*	*IS-Ch*					
EBS 13.02	*Ballard Locks and Ship Canal operations – What are feasible solutions to improve conditions related to high temperature, low dissolved oxygen, and concomitant decreased resistance of salmonids to disease/parasites?*	*LE*					
EBS 13.03	*High water temperature – What are the effects of high-water temperature in the Ship Canal and Sammamish River?*	*LE*					
EBS 13.04	*Piers and docks – What are the effects of overwater structures on salmon migration and survival?*	*LE*					
EBS 13.05	*What is the impact of pressures other than Marine Shoreline Infrastructure and Roads & Driveways?*	*LE*					
EBS 13.06	*Establish science-based standards region-wide when protecting and restoring effective riparian zones on all salmon and steelhead streams. Include other key biological attributes, such as floodplains, off channel habitats, and riverine wetlands*	*RPA*					
EBS 14*	**Build upon recommendations of the Salish Sea Marine Survival Project to further define bottom-up and top-down food web effects on juvenile salmon mortality in Puget Sound.**	**FTF (1), IS-ch (5), LE (4), OTF (1), RPA (4)**	med-high	med-high	high	med-low	med-low
EBS 14.01	*Develop hindcast and forecast tools to assess juvenile marine survival of ESA-listed Pacific salmon coupled with process studies on growth and survival.*	*FTF*					
EBS 14.02	*Complete research to fully understand relationships between Chinook, key prey (e.g. herring and larval crab), and drivers of prey availability (so Food web dynamics better understood)*	*IS-Ch*					
EBS 14.03	*Conduct a white paper review of all recent science and studies of pinniped predation on juvenile, sub-adult, and adult salmon, and include a section on potential management options (so Effects of pinniped and other predation on salmon better understood)*	*IS-Ch*					
EBS 14.04	*Develop and implement forecasting techniques (so Climate impacts on VSP understood)*	*IS-Ch*					
EBS 14.05	*Execute Salish Sea Marine Survival Project and include management recommendations in recovery plans (so Marine survival for Chinook better understood)*	*IS-Ch*					

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 14.06	*Identify contributing factors and test management actions to address predation (as a way that Salmon expert group works with researchers to make practical management recommendations)*	*IS-Ch*					
EBS 14.07	*Genetic introgression or other issues related to hatchery operations – What are the effects of hatcheries on the genetic fitness of natural origin salmon?*	*LE*					
EBS 14.08	*Proposed research actions include investigating: • Life histories and habitats used by yearling Chinook • Hatchery fish predation in river • Nutrient and carcass cycling • Sediment and scour • Impacts of global warming on delta habitats • Impacts of beavers on delta habitats • Juvenile Chinook use of nearshore habitats • Hatchery/wild interactions in the delta and nearshore • Impacts of boat harbors on Chinook salmon • Impacts of diking on eelgrass • Forage fish ecology • Pinniped predation • Predatory birds • Life history strategies and marine survival • Juvenile Chinook salmon origin and use of habitats within Puget Sound, Straits of Juan de Fuca, and Georgia Straits basins*	*LE*					
EBS 14.09	*Sources of sediments impacting egg to fry survival; the role of beavers in the tidal delta; the ecology of forage fish, as it relates to salmon during nearshore rearing; the role of predation by seals and birds in limiting Chinook productivity; and further refinement of our understanding of Chinook rearing and survival in nearshore habitats, including the impacts of specific land uses.*	*LE*					
EBS 14.1	*Conduct a pilot project for the removal or alteration of artificial haul out sites where sites are associated with significant outmigration and predation of Chinook smolts. Fund a study to determine if pilot removal accomplishes the goal of significantly reducing Chinook smolt predation.*	*OTF*					
EBS 14.11	*Develop a better understanding of the causes of poor marine survival of steelhead (and Chinook salmon and other species) in Puget Sound through support of the Salish Sea Marine Survival Project's research program*	*RPA*					
EBS 14.12	*Develop a white paper review of all recent science and studies on pinniped predation on juvenile, sub-adult, and adult salmon. Develop potential management options, and/or identify and implement necessary changes to rules and regulations to address pinniped predation*	*RPA*					
EBS 14.13	*Emphasize funding support for efforts that build our understanding of ecological interactions that likely influence how Puget Sound Chinook salmon populations perform*	*RPA*					
EBS 14.14	*Identify contributing factors that exacerbate predation and mortality and implement solutions*	*RPA*					
EBS 15/16/58*	**Identify and address gaps in current efforts to assess water use in Puget Sound with a focus on groundwater quality and quantity discharged to Puget Sound**	**LIO (3), FTF (1), IS-GUM**	med-high	med-high	med-high	high	high
EBS 15.01	*Investigation of the connection between and development withdrawals is required for Summer Stream Flow planning. summer flow*	*LIO*					
EBS 15.02	*Recharge project hydrological constraints (Data Gap – Assessment)*	*LIO*					
EBS 15.03	*Water resource data gaps (Data Gap – Assessment)*	*LIO*					
EBS 16.01	*Consistent flood projections- Identify the future flood projections to use in integrated floodplain management, develop water decision support tool for the Puget Sound region, and recommend solutions and communication methods to best address flood risk management needs.*	*IS-GUM*					
EBS 58.01	*Generate and compile data and information on groundwater resources and water use to assist development of WRIA and regional-scale water-resource management strategies that are protective of summer low flows while ensuring adequate water supply for domestic, agricultural, and other out-of-stream uses*	*FTF*	high	med-high	med-low	high	high
EBS 17	**Determine how factors like roads, transit and other infrastructure influence development patterns**	**IS-GUM (1)**	low	low	low	med-high	high
EBS 17.01	*How do factors like roads, transit and other infrastructure influence development patterns?*	*IS-GUM*					
EBS 18	**Assess changing land cover over time, evaluate impacts to ecological flows, and determine and where ecologically important lands are under high pressure of conversion (from development or other risks).**	**IS-GUM (1), TH (3)**	med-high	med-high	med-low	high	high
EBS 18.01	*What are the cumulative effects of rural development on ecologically important lands - showcase results using data visualization tools.*	*IS-GUM*					
EBS 18.02	*(Address regulatory inadequacies that fail to protect nearshore ecology and function) Identify, map and develop plans that identify places most at risk for development, and prioritize their protection.*	*TH*					

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 18.03	*(Address regulatory inadequacies that fail to protect nearshore ecology and function) Identify, map and develop plans that identify places most at risk for development,) Utilizing habitat status and trends monitoring throughout Puget Sound, monitor and evaluate habitat and fish trends at the scale of watersheds, to assess how processes are functioning – and (if applicable) how land cover is changing. Use that monitoring information to inform management.*	*TH*					
EBS 18.04	*Map and evaluate impacts to ecological flows*	*TH*					
EBS 19	**Determine which land uses can exist congruently without adverse impacts on adjacent land across a watershed and what and where strategies are most effective at reducing negative impacts.**	**IS-GUM (3), LIO (1)**	med-low	low	med-low	med-high	med-low
EBS 19.01	*Is there a successful means of merging low impact development and long-term stewardship in ecologically important lands?*	*IS-GUM*					
EBS 19.02	*What are land uses that can exist congruently without having impacts on other adjacent land uses, particularly considering which upland land uses potentially affect the functionality of ecologically important lands across the watershed?*	*IS-GUM*					
EBS 19.03	*Where are opportunities in agricultural operations to capitalize on strengths and improve or eliminate weaknesses and threats to the agricultural viability in each county?*	*IS-GUM*					
EBS 19.04	*There is a lack of knowledge about where to target certain types of strategies due to inconsistent geographic assessment and prioritization.*	*LIO*					
EBS 20	**Identify ecology important land and determine the existing and potential areas for protection, restoration, farmland preservation.**	**IS-GUM (9), IS-ch (3), LIO (1), OTF (1), RPA (2), SSAG (1), TH (1)**	med-low	low	med-low	med-high	high
EBS 20.01	*How many residential sites have potential for protection, removal, or soft shore replacement due to existing infrastructure and site attributes*	*IS-GUM*					
EBS 20.02	*Map agricultural lands: Where is the existing agriculture land base in each county? Identify the land base and inform planning and zoning regulations where appropriate.*	*IS-GUM*					
EBS 20.03	*What is the definition of ecologically important lands for the purposes of the Vital Sign target and the Implementation Strategy? Where are the ecologically important lands throughout Puget Sound and at various scales? Where would restoration efforts have the highest impact? Where are lands that should be protected from development pressure? What types of regulatory protections should be used to protect open spaces in Urban Growth Areas? Establish common definitions, standards, metrics, and geographic information to develop a regional approach to support the protection and identify recovery actions for ecologically important lands throughout the Puget Sound Basin.*	*IS-GUM*					
EBS 20.04	*Where are the primary areas for protection, restoration, farmland preservation, and other compatible and non-compatible uses.*	*IS-GUM*					
EBS 20.05	*Where is (and what lands consist of) the existing agricultural land base to inform planning and zoning regulations?*	*IS-GUM*					
EBS 20.06	*Where is the existing land base of parcels available for infill and redevelopment within each Urban Growth Area in Puget Sound? What is the reason for underdevelopment of compact sites in the Urban Growth Areas? What tools and incentives can be used to promote growth in underdeveloped compact sites in the Urban Growth Areas (including brownfield parcels)? .*	*IS-GUM*					
EBS 20.07	*Which land uses are compatible across a watershed? What land uses can exist congruently without having impacts on the other adjacent land uses, particularly considering which upland land uses (including forestry and compact/rural development) potentially affect the functionality of floodplains.*	*IS-GUM*					
EBS 20.08	*Collect and analyze data necessary to create the definition or overlay (so Actions directed to areas of high impact)*	*IS-Ch*					
EBS 20.09	*Develop or use an existing climate change adaptation framework (e.g., Tim Beechie's framework in "Restoring Habitat for a Changing Climate") to strengthen salmon habitat restoration plans in the face of changing climate conditions (so Climate change considerations incorporated into plans and projects)*	*IS-Ch*					
EBS 20.1	*Use the framework described in "Chinook Salmon Projects and Climate Change" to 1) take both short-term and long-term salmon habitat protection and restoration project effectiveness into account in light of climate change projections, 2) identify salmon habitat protection and restoration projects that address emerging climate-related risks and encourage changes to Chinook salmon recovery plans (where appropriate), and 3) develop salmon habitat protection and restoration projects with explicit consideration of how climate may affect projects over time. (so Climate change considerations incorporated into plans and projects)*	*IS-Ch*					

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 20.11	*Where does protection or restoration of feeder bluffs have the maximum potential ecological value and/or social/land-use opportunity.*	*IS-GUM*					
EBS 20.12	*Which projects have the greatest regional impact? Which state highway facilities have the biggest impact on floodplain connectivity and function?*	*IS-GUM*					
EBS 20.13	*"Zone of No Save" analyses incomplete*	*LIO*					
EBS 20.14	*In 2019, the governor and Legislature should provide funding through WDFW and regional salmon recovery organizations to coordinate with tribes, local governments, National Oceanic and Atmospheric Administration and other key partners to assess and prioritize appropriate locations based on potential benefits, costs, management, operations and other key information necessary to reestablish salmon runs as soon as possible above the dams and in the watersheds agreed to by the parties.*	*OTF*					
EBS 20.15	*Collaborative, multiple-benefit groups develop a plan that prioritizes locations to restore or protect*	*RPA*					
EBS 20.16	*Develop a regional application of critical areas and ecologically important habitat, including coordination of data (GIS exercise) to compile this overlay*	*RPA*					
EBS 20.17	*Support the development of spatial data on locations with the highest potential for supporting increased salmon populations in Puget Sound, and a companion synthesis on the importance of refugia*	*SSAG*					
EBS 20.18	*Identify primary riparian sites for acquisition at the local scale.*	*TH*					
EBS 21	**Develop the approach and include ecosystem service valuation in our understanding of natural lands and in our assessment of conservation easements and acquisitions**	**IS-ch (1), IS-GUM (2), LIO (1), RPA (1)**	med-high	med-high	low	high	med-low
EBS 21.01	*Develop an approach to using ecosystem service values in conservation easements and property acquisitions*	*IS-Ch*					
EBS 21.02	*Analyze the economic impact of soft shore protection designs on overall property value*	*IS-GUM*					
EBS 21.03	*What is the value of ecosystem services provided by each delta?*	*IS-GUM*					
EBS 21.04	*Water storage and groundwater recharge options; Water retention services valuation; Evaluation of available water resources*	*LIO*					
EBS 21.05	*Develop an acquisition strategy that values conservation easements and property acquisitions on ecosystem services provided to the region*	*RPA*					
EBS 22	**Include social, economic, physical, and ecological trade-offs of landscape management alternatives**	**IS-GUM (1)**	low	med-low	low	high	med-low
EBS 22.01	*What are the social, economic, physical, and ecological tradeoffs of delta landscape management alternatives?*	*IS-GUM*					
EBS 23	**Evaluate the effects of nearshore protection and restoration practices on ecosystem function and process**	**IS-GUM (1), TH (3)**	med-low	med-low	med-low	med-low	med-low
EBS 23.01	*What are the ecosystem benefits of soft shore and armor removal methods?*	*IS-GUM*					
EBS 23.02	*(Improved oversight for permit data collection by federal, state and local government) Work with federal, state and local jurisdictions to develop a unified system to track permits and permit-related data in order to evaluate effectiveness in protecting nearshore ecological function.*	*TH*					
EBS 23.03	*Condition new nearshore restoration projects (referenced above) to ensure that they provide a net benefit to forage fish habitat and would create a greater ecosystem lift on a project by project basis.*	*TH*					
EBS 23.04	*Ensure that nearshore restoration projects (i.e. bulkhead removal or conversion) are being implemented in a way that creates the greatest lift in ecosystem processes.*	*TH*					
EBS 24/29	**Develop a standardized habitat monitoring and assessment methodology and decision framework of the effectiveness of recovery actions and management interventions to inform future recovery work.**	**PSEMP (3), RPA (2), IS-GUM (3), FTF (1), LIO (1)**	high	med-low	high	med-high	high
EBS 24.01	*Encourage and fund PSEMP Work Groups to conduct assessments and develop products (e.g. syntheses, synopses, manuscripts) to link scientific findings directly to management decisions (e.g., effectiveness of recovery actions, syntheses that inform priority activities).*	*PSEMP*					
EBS 24.02	*Develop a framework to determine how salmon are responding to current habitat protection, restoration, and management actions*	*RPA*					

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 24.03	*What are the habitat responses and restoration outcomes of specific design approaches to levee removal?*	*IS-GUM*					
EBS 24.04	*Identify and communicate lessons learned from existing watershed-scale habitat protection, restoration, and management efforts about actions that have been successful —or not successful— to meet salmon recovery goals. This could involve comprehensive assessments of social, economic, and ecological effects of restoration efforts at the watershed or river basin scale.*	*PSEMP*					
EBS 24.05	*Continue post-dam removal sediment studies in the Elwha River system, including studies of ecosystem responses to changes in the sediment-regime.*	*FTF*					
EBS 24.06	*How effective are restoration projects (for ecological, social, and economic objectives) at the site and landscape scale?*	*IS-GUM*					
EBS 24.07	*Address remaining or new high priority monitoring gaps identified by PSEMP Work Groups in 2016 or other sources as essential to understanding ecosystem status, trends, and response to recovery actions. (Appendix presents specific topical recommendations)*	*PSEMP*					
EBS 24.08	*How has land cover changed over time at the regional and local levels? Where are ecologically important lands under high pressure of conversion?*	*IS-GUM*					
EBS 24.09	*Lack of data regarding infrastructure inventory/ assessment/prioritization (shoreline armoring, green infrastructure effectiveness studies, fish passage barriers) (identified by 6 LIOs)*	*LIO*					
EBS 29.01	*Develop a standardized habitat assessment methodology and decision framework that supports regulatory alignment and harmonization of plans, processes, voluntary measures, and actions among agencies and across all levels of government*	*RPA*					
EBS 25	**Determine how can watershed evaluations be downscaled to site-specific actions**	**IS-GUM (1)**	med-high	med-low	med-low	med-low	low
EBS 25.01	*How can watershed evaluations be downscaled to site-specific actions?*	*IS-GUM*					
EBS 26	**Evaluate how the scale of watershed-based planning might affect protection and restoration outcomes**	**IS-GUM (1)**	med-low	med-low	low	med-low	low
EBS 26.01	*At which scale is it most appropriate to conduct watershed-based planning for protection and restoration?*	*IS-GUM*					
EBS 27	**Develop spatially explicitly (specifically Local Integrating Organization) strategies that are informed by localized Vital Sign status information and potential contribution to Puget Sound wide goals.**	**LIO (1)**	med-high	med-low	med-high	med-low	med-high
EBS 27.01	*Ideally, PSP would facilitate the dissemination of Vital Sign target status information broken out by LIO area to inform how each LIO develops strategies and evaluation the potential contribution to Puget Sound wide goals.*	*LIO*					
EBS 28*	**Develop a framework of recommended approaches for including risk analyses, including extreme events and uncertainty, into planning and decision making.**	**IS-GUM (2)**	high	high	low	high	high
EBS 28.01	*How should risk analysis account for climate change? How might planners address more extreme weather events in risk projections?*	*IS-GUM*					
EBS 28.02	*How should risk be incorporated? How can risk-based decisions be incorporated into land use planning analyses and decisions?*	*IS-GUM*					
EBS 29	**Develop a standardized habitat assessment methodology and decision framework to monitor, estimate and evaluate effectiveness of various management interventions**	**RPA (1)**	med-high	med-low	med-low	med-high	med-high
EBS 29.01	*Develop a standardized habitat assessment methodology and decision framework that supports regulatory alignment and harmonization of plans, processes, voluntary measures, and actions among agencies and across all levels of government*	*RPA*					
EBS 30*	**Explore and advance the use of methods to integrate human dimensions with biophysical targets and goals by decision makers.**	**PSEMP (1)**	high	high	low	high	high
EBS 30.01	*Identify and implement methods to holistically and explicitly integrate human dimensions and social science considerations with biophysical targets and goals to ensure well-informed decision-making by funders and policy makers.*	*PSEMP*					

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 31*	**Refine risk assessment tools and scenario development and analyses to improve our understanding of highly uncertain, complex and inter-related challenges and solutions to provide information that can be used to identify actions to achieve a more resilient Puget Sound ecosystem.**	**FTF (3), IS-MWQ (1), OA (1), PSEMP (1), LIO (1)**	high	high	med-high	high	med-high
EBS 31.01	*Develop an ecosystem-scale model for Puget Sound in collaboration with the Marine Survival Project. Atlantis is the platform for ecosystem scale model.*	*FTF*					
EBS 31.02	*Implement the Coastal Storm Modeling System (CoSMoS) at the scale of Puget Sound to model the combined impacts of sea level rise, increased winter river flooding, and storm surge on large storm-related coastal flood events*	*FTF*					
EBS 31.03	*VELMA project to model effectiveness of riparian buffers and other watershed management practices*	*FTF*					
EBS 31.04	*How well do the Salish Sea Model and Live Ocean compare? How could a comparison be used to evaluate estimated model uncertainties?*	*IS-MWQ*					
EBS 31.05	*Continue development of mathematical models to be applied to ocean acidification assessment, including testing and results verification, and refine source emission estimates*	*OA*					
EBS 31.06	*Products supported under this theme that support system modeling efforts, and that will be interpreted in the context of the regional adaptive management framework. Comments urged filling data gaps before focusing on modeling, doing more scenario modeling based on what we already know, and using modeling as a tool in service of the indicators, recovery, and policy needs.*	*PSEMP*					
EBS 31.07	*Lack of data and modeling for different setback scenarios (South Sound)*	*LIO*					
EBS 32/33*	**Better define tipping points for cumulative impact of multiple individual human activities on habitat quantity and quality, water quality and species recovery.**	**FTF (1), IS-GUM (2), IS-Ch (2), LE (1), PSEMP (1), IS-Sh (1), TH (2)**	high	high	med-high	med-high	high
EBS 32.01	*NRCS has requested participation in the Conservation Effects Assessment Project (CEAP) for Puget Sound. CEAP assessments are carried out at the field, watershed and landscape scale and include analysis of the cumulative effects and benefits of conservation practices on the natural resources and environment.*	*FTF*					
EBS 32.02	*What are the policy and programmatic changes of federal, state, and local flood risk management, flood mitigation, and ecosystem protection and restoration programs to foster integrated floodplain management? What changes would have the highest impact for floodplains protection and restoration?*	*IS-GUM*					
EBS 32.03	*What type of protection and restoration actions have the largest and most lasting impact on floodplain function and which types of actions are cost effective?*	*IS-GUM*					
EBS 32.04	*Evaluate effectiveness of watershed-scale actions, and report findings (so Effectiveness of actions evaluated and shared)*	*IS-Ch*					
EBS 32.05	*Design and implement a study of a particular regulatory regime or mechanism (so that Enhanced understanding of regulatory regimes and mechanisms that impact fisheries resources)*	*IS-Ch*					
EBS 32.06	*Four types of information needed for adaptive management (1) Baseline and trends information for relevant indicators (2) Progress in achieving implementation benchmarks (3) Assessment of action effectiveness (4) Validation of key assumptions and assessment in population performance*	*LE*					
EBS 32.07	*Assess the patterns in Vital Sign indicators in terms of the impact of natural and anthropogenic factors, and linkages to other progress measures. Assess whether recovery efforts are helping to achieve Vital Sign goals.*	*PSEMP*					
EBS 32.08	*A systematic comparison of practices: some Watershed Investment Districts are conducting their own monitoring and self-compliance. How do results of self-compliance and monitoring compare with results of agency monitoring? There are many approaches around PS that can and should be compared more systematically.*	*IS-Sh*					
EBS 33.01	*(Improved oversight for permit data collection by federal, state and local government) Apply cumulative impacts analysis when permitting the repair and/or replacement of shoreline modification and overwater structures.*	*TH*					
EBS 33.02	*(Improved oversight for permit data collection by federal, state and local government) Engage in federal/tribal analysis, research and policy development regarding cumulative impacts of permitted actions.*	*TH*					
EBS 34	**Monitor to evaluate the effectiveness of local pollution control approaches, such as pollution identification and control (PIC) programs, regulatory programs, watershed improvement districts, and loan and grant programs**	**IS-Sh (1), OTF (1)**	med-high	med-low	high	med-high	med-high

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 34.01	*re: Stewardship, PIC programs, and Shellfish Protection Districts -- how can compliance, cooperation, and access be improved?*	*IS-Sh*					
EBS 34.02	*Collect high-quality nutrient data in watersheds to fill key knowledge gaps of baseline conditions.*	*OTF*					
EBS 35	**Assess the near- and long-term costs and benefits of alternative restoration or protection actions for ecologically important lands to inform future best management practices**	**IS-GUM (4), IS-MWQ (1)**	high	high	med-low	med-high	med-high
EBS 35.01	*What are the cost benefit relationships of restoration and protection actions?*	*IS-GUM*					
EBS 35.02	*What is the estimated cost of Puget Sound recovery of ecologically important lands?*	*IS-GUM*					
EBS 35.03	*What are the short-term (installation) and long-term (maintenance) costs of hard armoring and soft protection designs?*	*IS-GUM*					
EBS 35.04	*What is the (quantifiable) value of benefits of BMP installation?*	*IS-GUM*					
EBS 35.05	*What is the cost and potential return for methane (bio-gas) generation to fuel homes/facilities versus other treatment upgrades? How does the full life cycle cost for both look? For example, chemical inputs, greenhouse gas emissions, facility and infrastructure costs over time, etc. WOULD IT BE FEASIBLE TO REVOLUTIONIZE OUR WASTE SYSTEM NOW, as part of this upgrade effort?*	*IS-MWQ*					
EBS 36	**Holistically assess the costs and risks of flooding, floodplain development, and floodplain buy-outs**	**IS-GUM (3), LIO (1)**	med-high	med-low	med-low	med-high	med-low
EBS 36.01	*How does agricultural damage scale with flood depth?*	*IS-GUM*					
EBS 36.02	*What are the costs and risks of flooding? Develop a cost subsidy analysis to identify and communicate the comprehensive costs of developing in the floodplain (include incentives for agriculture, development, and buy-outs for emergency responses).*	*IS-GUM*					
EBS 36.03	*Where are the repeatedly flooding areas? Where are the priority crucial buy-out flood-prone areas? Incorporate risk tolerance information, cost subsidy information, best available science on ecosystem functions, public safety, and gauge the feasibility of the political climate.*	*IS-GUM*					
EBS 36.04	*NRDA baseline valuation damage assessments*	*LIO*					
EBS 37/57	**Conduct research, science and monitoring to inform decision making, adaptive management and implementation of actions to recover Southern Residents.**	**IS-Ch (1), OTF (4), PSEMP (1)**	med-low	med-high	med-high	med-high	high
EBS 37.01	*Continue to support study of Salish Sea food web dynamics - including zooplankton monitoring, modeling, and investigating Chinook predator/prey relationships (so Relationship between southern resident killer whale recovery and salmon recovery as prey better understood)*	*IS-Ch*					
EBS 37.02	*Conduct research, science and monitoring to inform decision making, adaptive management and implementation of actions to recover Southern Residents.*	*OTF*					
EBS 37.03	*Provide funding to PSP, WDFW, the Governor's Salmon Recovery Office and Ecology to evaluate the effectiveness of task force recommendations through monitoring and adaptive management while leveraging existing efforts*	*OTF*					
EBS 37.04	*Request that National Oceanic and Atmospheric Administration Northwest Fisheries Science Center model the task force's Year One recommendations related to the three major threats to determine the degree of benefit to Southern Resident orcas that the recommended actions may produce under a reasonable range of future growth and development scenarios.*	*OTF*					
EBS 37.05	*The governor and Legislature should also provide funding to WDFW and co-managers to coordinate with NOAA and Long Live the Kings and begin testing pilot actions in hatcheries in 2019. These pilots should aim to: (1) increase marine survival of Chinook, (2) adjust return timing and locations to align with orcas' needs, (3) assess the feasibility and develop a plan to potentially increase size and age of returns and (4) reduce potential competition with wild fish. This work should build from and test findings of the Salish Sea Marine Survival Project, NOAA's salmon ocean program and other relevant efforts that are working to determine what is driving the survival of Chinook as they migrate downstream and through the marine environment.*	*OTF*					
EBS 57.01	*Priority monitoring needed to support regional efforts to identify and mitigate increased threats to Southern Resident Orcas (e.g., contaminants, zooplankton, forage fish, Chinook, ocean acidification, and climate change).*	*PSEMP*					
EBS 38	**Continue monitoring the effectiveness of stormwater management actions and communicate the findings**	**IS-TIF (1), FTF (1)**	low	low	high	med-low	high
EBS 38.01	*Test/verify stormwater BMPs (e.g., bioretention) for capturing contaminants of concern for this group.*	*IS-TIF*					

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			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 38.02	*The Regional Stormwater Monitoring Program (RSMP) [now Stormwater Action Monitoring] is a collaborative monitoring program with western Washington municipal stormwater permittees, federal and state agencies to measure the effectiveness of stormwater management actions and communicate widely applicable information on the finding.*	*FTF*					
EBS 39	**Assess the strengths and weaknesses of different motivational, enforcement and delivery models and entities (regulatory governmental, non-profit, nonregulatory governmental etc.; regulation vs. social marketing vs. enforcement) and socio-psychological predictors for specific desired behavioral outcomes**	**IS-GUM (2)**	low	med-high	low	high	med-high
EBS 39.01	*Are regulations not adequate, or are implementation and enforcement the issue?*	*IS-GUM*					
EBS 39.02	*What are the strengths and weaknesses of different delivery models and entities (regulatory governmental, non-profit, nonregulatory governmental etc.)*	*IS-GUM*					
EBS 40	**Assess the impact of recovery approaches on different Puget Sound human populations**	**S4 (1)**	med-low	med-low	low	high	med-low
EBS 40.01	*How do resource management and conservation affect people in different and differential ways (i.e., economic, psychological, physical, and cultural effects)?*	*S4*					
EBS 41*	**Assess the effectiveness of incentive approaches in Puget Sound Recovery efforts**	**IS-Ch (2), IS-GUM (6), IS-Sh (1), RPA (1)**	med-low	med-low	med-low	high	high
EBS 41.01	*Design and conduct a project to adaptively manage incentive-based programs (so Incentive based programs utilized by landowners)*	*IS-Ch*					
EBS 41.02	*Identify which incentives are most effective in specific watersheds, certain land types, etc.*	*IS-Ch*					
EBS 41.03	*Do incentive programs result in meaningful and environmentally beneficial projects?*	*IS-GUM*					
EBS 41.04	*How many property owners need to receive outreach materials in order to have sufficient gains in participation incentive programs*	*IS-GUM*					
EBS 41.05	*What are the incentives that motivate practitioners such as contractors, consultants, real estate agents to be trained in, use, and deliver messages about healthy shoreline practices?*	*IS-GUM*					
EBS 41.06	*What are the most effective incentives to improve the outcome of armor replacement decisions such that there is more removal, alternative techniques, or landward movement?*	*IS-GUM*					
EBS 41.07	*What incentives (or alignment of incentives) are effective in protecting and restoring ecologically important lands? How are local land use incentives effective at preserving ecologically important lands?*	*IS-GUM*					
EBS 41.08	*What incentives, human well-being factors, and market drivers influence residents' choices between urban and rural living? What conditions improve the quality and accessibility of compact living? What are the desires of Puget Sound home buyers? How can the behaviors inform developers in building affordable and environmentally benign, yet desirable living spaces in both compact and rural neighborhoods?*	*IS-GUM*					
EBS 41.09	*Do incentives work? Which incentives work best?*	*IS-Sh*					
EBS 41.1	*Monitor and report on landowner use and implementation of inventive-based programs to address salmon habitat protection and restoration needs. Regional coordinating entities can use monitoring data to track local progress and pursue adaptative management and corrections as needed; where necessary, tailor program implementation to local conditions to achieve salmon recovery goals at the watershed scale*	*RPA*					
EBS 42	**Evaluate the effectiveness of various management interventions in protecting and restoring habitat functions and processes**	**IS-Ch (1), IS-GUM (3), LIO (2), TH (2)**	med-high	med-low	med-low	med-high	high
EBS 42.01	*Collect and analyze data on effectiveness of specific land use policies, and communicate it to relevant decision makers (to Increase understanding of effectiveness of land use policies)*	*IS-Ch*					
EBS 42.02	*What are the local policies, regulations, and incentive programs that are effective at preventing floodplain degradation, disconnection, and/or the expansion of levees?*	*IS-GUM*					
EBS 42.03	*What regulations are effective in protecting and restoring ecologically important lands? Where and how are local land use regulations or incentives effective at preserving ecologically important lands? What are the root barriers in place to keep local jurisdictions from effectively protecting those lands?*	*IS-GUM*					
EBS 42.04	*Ecological assessment data is needed to inform the development and prioritization of strategies. This includes assessments of habitat types quality and assessments of policy effectiveness.*	*LIO*					
EBS 42.05	*SMP No Net Loss (NNL) Effectiveness (Data Gap – Assessment)*	*LIO*					

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			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 42.06	*(Demonstrate the ineffectiveness of voluntary-based programs in protecting and restoring riparian areas across the landscape) Compare current riparian conditions against the jurisdiction and land-use laws, regulations, etc., that guide management in those riparian areas.*	*TH*					
EBS 42.07	*(Demonstrate the ineffectiveness of voluntary-based programs in protecting and restoring riparian areas across the landscape) Describe desired riparian conditions and the BMPs that support robust salmon and shellfish productivity.*	*TH*					
EBS 42.08	*What is the effectiveness of alternatives from other regions (e.g. Chesapeake Bay Foundation low cost loans/ grants) and other sectors (e.g. CRAFT 3 low interest septic loans and green infrastructure loans) to provide grants or low-cost loans to property owners*	*IS-GUM*					
EBS 43	**Evaluate and compare the effectiveness of shoreline management approaches: permitting, conditional use designations, in-lieu-fee programs**	**IS-GUM (3)**	med-high	med-low	med-low	med-high	high
EBS 43.01	*Evaluate the permit outcomes of jurisdictions that use exemptions vs CUPs to determine if CUP approach achieves more protective outcomes*	*IS-GUM*					
EBS 43.02	*How can Washington design, permit and maintain conservation banks and in lieu-fee programs for nearshore development and restoration?*	*IS-GUM*					
EBS 43.03	*What are restoration permitting challenges and what is the ability of different approaches (streamlined review procedure, assistance incentives, special permit, etc.) to address challenges*	*IS-GUM*					
EBS 44/45/46	**Monitor salmon habitat to assess status and effectiveness of restoration actions and to inform the adaptation of recovery plans**	**LE (1), IS-Ch (1), FTF (1), IS-Ch (2), RPA (3), IS-GUM**	low	med-low	med-high	low	high
EBS 44.01	*Evaluate land use policies and their effectiveness in protecting habitat critical to salmon and salmon recovery*						
EBS 44.02	*Identify, review, and address regulatory regimes and mechanisms that adversely affect fisheries resources, including regulatory exemptions that adversely, or potentially adversely, impact fish habitat*	*x*					
EBS 45.01	*Natural sediment recruitment in the Middle Green, the upper section of the Lower Green, and the Duwamish–Guidance on how to monitor this effectively*	*LE*					
EBS 45.02	*Protected / restored habitats monitored and tracked (different than tracking contractual aspects of projects). (so Monitoring informs prioritization and research needs)*	*IS-Ch*					
EBS 45.03	*Develop and implement a basin-scale habitat status and trends assessment for watersheds and associated marine nearshore*	*FTF*					
EBS 45.04	*Baseline inventory of common datasets for analyzing habitat conditions established; use THS platform*	*IS-Ch*					
EBS 45.05	*Implement a project to use the Chinook Common Indicators, and other monitoring data as needed, to analyze and report on habitat gain and loss in one or more watersheds. (so Improved understanding of salmon habitat gained and lost)*	*IS-Ch*					
EBS 46.01	*Invest in making more accurate estimates so we can better manage and recover Chinook salmon. Invest funding and capacity to improve accuracy and precision for Chinook salmon populations where status and trends estimates of key life stages (such as, escapement, juvenile migrants, etc.) are lacking, or highly uncertain. Evaluate existing watershed-scale efforts for lessons learned on actions that have been successful – or not successful. Share information and conclusions with all watershed-scale efforts for adaptive management of their program implementation*	*RPA*					
EBS 46.02	*How would embayment restoration impact salmon populations? Which embayments are of highest priority for salmon rearing and other benefits?*	*IS-GUM*					
EBS 47	**Improve monitoring tools and estimates for life-stage specific abundance, survival, and diversity of salmon and steelhead**	**IS-Ch (2), LE (2), PSEMP (1), RPA (1)**	med-low	med-high	high	low	med-high
EBS 47.01	*Trends monitored at watershed scale and evaluated for processes and land cover change (e.g., Common Indicators) -- Quantify uncertainty in adult escapement estimates through employing new survey designs or technology*	*IS-Ch*					
EBS 47.02	*Use the Adult Fish Data Exchange (AMX) to manage, share, and make better estimates of adult fish data between co-managers (so that Existing information and data synthesized and made available)*	*IS-Ch*					

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			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 47.03	*1) Improve estimates of population specific total escapement to the Nooksack basin, with emphasis on North/Middle and South Fork populations, including natural origin fish, and age data on these fish. 2) Investigate rearing conditions in the river and the estuary and near shore areas to assist in the development of habitat restoration and protection actions. 3) Improve estimates of stock specific natural early chinook smolt outmigration from the North/Middle and South Fork populations and late timed chinook. 4) Develop stock/recruit functions, or other estimates of freshwater survival data to monitor the productivity of the two populations and late timed chinook. 5) Collect information to determine whether the current SUS fishing regime, or the hatchery supplementation program, are exerting deleterious selective effects on the size, sex, or age structure of spawners.*	*LE*					
EBS 47.04	*Collect and synthesize monitoring information identified as priority Puget Sound Chinook and Steelhead recovery needs at regional and watershed scales. This may include monitoring information about ecological interactions that likely influence how Puget Sound Chinook salmon populations perform.*	*PSEMP*					
EBS 47.05	*Align recovery endpoints to Chinook salmon biology and how recovery actions are really implemented*	*RPA*					
EBS 47.06	*Invasive aquatic vegetation – What are the effects of invasive aquatic vegetation on salmon migration and survival?*	*LE*					
EBS 48	**Evaluate the impact of food webs and food web drivers on marine survival of Chinook salmon**	**IS-Ch (1)**	med-high	med-high	high	low	med-low
EBS 48.01	*Complete Puget Sound Atlantis Ecosystem Model and correlative (indicators) analyses to assess relationship between Chinook survival, food web, and drivers of food web (climate, nutrient load, contaminants, predators, etc.) (so Food web dynamics better understood)*	*IS-Ch*					
EBS 49	**Evaluate the effectiveness of various technologies in reducing or remediating toxic contamination**	**IS-TIF (1), OTF (1)**	high	high	med-high	med-low	med-low
EBS 49.01	*What pollutants can be reduced/remediated with emerging technologies and which should be prioritized 2/5/10 years?*	*IS-TIF*					
EBS 49.02	*Prioritize and fund clean-up actions likely to have the greatest benefit to Southern Resident orcas.*	*OTF*					
EBS 50	**Evaluate the potential for management interventions on individual properties to improve BIBI scores**	**IS-GUM (3)**	med-low	med-low	low	med-low	low
EBS 50.01	*What actions improve BIBI score? Will retrofits on individual properties have an impact on B-IBI?*	*IS-GUM*					
EBS 50.02	*Will retrofits on individual properties have an impact on B-IBI?*	*IS-GUM*					
EBS 50.03	*Where will we have the greatest impact?*	*IS-GUM*					
EBS 51	**Assess approaches for monitoring and characterizing chemicals of emerging concern**	**IS-TIF (3), FTF (1)**	high	high	low	low	med-low
EBS 51.01	*What could a regional routine monitoring program that incorporates MS, multi-component analysis tells us? How could such info change how we regulate chemicals?*	*IS-TIF*					
EBS 51.02	*What is the current status of alternative flame retardants in Puget Sound (environment and biota)?*	*IS-TIF*					
EBS 51.03	*When a CEC is identified (e.g., PBDE phthalate) is it possible to research source distribution of that chemical and alternatives?*	*IS-TIF*					
EBS 51.04	*Assess next-generation monitoring tools such as eDNA for use in monitoring juvenile salmon outmigration in large rivers.*	*FTF*					

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			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 52*	**Characterize human health and environmental risks from chemicals of emerging concern**	**IS-TIF (7), LIO (1), OTF (2), IS-Ch (1), RPA (1)**	high	high	med-low	high	high
EBS 52.01	*Human health criteria for CECs - and Ecological as well!*	*IS-TIF*					
EBS 52.02	*What are the cumulative effects of pharmaceuticals, CECs, and legacy contaminants (PCBs, PAHs, PBDEs, etc.) exposures on fish in Puget Sound?*	*IS-TIF*					
EBS 52.03	*What are the ecotoxicological impacts of CECs on biota?*	*IS-TIF*					
EBS 52.04	*There is a lack of understanding of the emerging chemicals of concern in non-point source pollution, and the scale (both number and timescale) is difficult to address.*	*LIO*					
EBS 52.05	*What are the priority compounds in stormwater?*	*IS-TIF*					
EBS 52.06	*Which CECs should be prioritized?*	*IS-TIF*					
EBS 52.07	*Ecology should develop a prioritized list of the chemicals of emerging concern based on greatest benefit to Southern Resident orcas and their prey if action is taken. Ecology, with input and review from regional experts, including Washington Department of Fish and Wildlife and National Oceanic and Atmospheric Administration, should begin this prioritization process in 2018 and complete the list in March 2019.*	*OTF*					
EBS 52.08	*Identify, prioritize and take action on chemicals that impact orcas and their prey.*	*OTF*					
EBS 52.09	*Allowable PCB concentrations for dredged material disposal are known - how does this activity change the risk from PCBs to biota and humans?*	*IS-TIF*					
EBS 52.1	*Do current production PCBs (e.g., PCB-11) have any ecological impacts? What are effects levels?*	*IS-TIF*					
EBS 52.11	*Identify and assess threats from emerging contaminants of concern and communicate findings to decision makers (so Effects of stormwater and wastewater (water quality) on Chinook better understood)*	*IS-Ch*					
EBS 52.12	*Evaluate potential threats from emerging contaminants of concern from wastewater and stormwater as they relate to salmon and their food web*	*RPA*					
EBS 53	**Evaluate effectiveness of management actions on water quality**	**IS-MWQ (4), IS-GUM (2), FTF (2)**	low	low	low	low	med-high
EBS 53.01	*On Geoduck harvest methods: Is there a BMP? What is the impact on Water Quality? (DNR silt plume analysis--aerial, but not sure about water quality, ex. For release of nutrients)*	*IS-MWQ*					
EBS 53.02	*Edge of Field Monitoring contracts. NRCS anticipates obligating four contracts with individual producers to quantify the impacts of conservation work on water quality*	*FTF*					
EBS 53.03	*Do regional stormwater treatment facilities effectively reduce the impacts of stormwater runoff?*	*IS-GUM*					
EBS 53.04	*What is the effectiveness of regulatory programs with regards to BIBI recovery?*	*IS-GUM*					
EBS 53.05	*Conduct comprehensive retrospective study of Thornton Creek (Seattle) restoration outcomes (water quality, stream flow, and biotic responses), synthesizing longer-term monitoring activities from USGS (NAWQA "Urban Indicator" site), WA Dept of Ecology, and other agencies. This project will serve as a model of synthesizing different monitoring program data as a model for effectiveness monitoring.*	*FTF*					
EBS 53.06	*Assess implementation and effectiveness of water quantity and quality regulations, particularly in relation to salmon recovery.*	*PSEMP*					
EBS 53.07	*from discussion guide: how successful have PIC programs been at improving water quality?*	*IS-MWQ*					
EBS 53.08	*from discussion guide: What quantifiable results have CDs achieved?*	*IS-MWQ*					
EBS 53.09	*11. What is the efficacy of nitrogen controls on the watershed (BMPs, plantings, GSI, street sweeping, etc.)?*	*IS-MWQ*					
EBS 54	**Evaluate water quality benefits from various approaches to nutrient reduction**	**IS-MWQ (5), RPA (1**	med-low	med-low	med-high	med-low	med-high
EBS 54.01	*(For each strategy) What percentage reduction could be expected from this strategy?*	*IS-MWQ*					
EBS 54.02	*What (if any) are the nutrient reduction benefits of replacing grass with shrubs, trees, other types of vegetation?*	*IS-MWQ*					
EBS 54.03	*Where (esp. what land uses), with what technology, and at what frequency will sweeping give the greatest benefit? Are these answers the same for nutrients and toxics*	*IS-MWQ*					
EBS 54.04	*(For each strategy) How sensitive is DO reduction to a reduction in this loading?*	*IS-MWQ*					
EBS 54.05	*Support implementation of TMDL studies and other necessary water cleanup plans for Puget Sound to set pollution discharge limits and determine response strategies to address water quality impairments*	*RPA*					

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EBS 54.06	*From discussion guide: What are the highest sources of anthropogenic effects in watersheds?*	*IS-MWQ*					
EBS 55	**Assess Puget Sound region water quality impairments and coordinate findings with local planners**	**LIO (1)**	low	low	med-high	med-low	med-high
EBS 55.01	*A comprehensive assessment of rivers and streams with total maximum daily loads (TMDLs) and impairments for specific parameters needs to be linked to community development planning for water quality protection.*	*LIO*					
EBS 56*	**Determine benefits to viability of Southern Resident Killer Whales from improved prey availability, and reduced disturbance and toxic chemical exposure; assess benefits individually and cumulatively through monitoring and modeling. Consider benefits in context with potential risks associated with reduced Southern Resident Killer Whale and salmonid genetic diversity.**	**OTF (1)**	high	high	high	med-high	high
EBS 56.01	*Request that National Oceanic and Atmospheric Administration Northwest Fisheries Science Center model the task force's Year One recommendations related to the three major threats to determine the degree of benefit to Southern Resident orcas that the recommended actions may produce under a reasonable range of future growth and development scenarios.*	*OTF*					
EBS 59	**Identify geographic areas, specific sites, and types of sources that contribute the highest level of contaminant loading and cause most severe stormwater problems in Puget Sound region**	**IS-TIF (1), FTF (1)**	med-high	low	med-high	med-low	high
EBS 59.01	*Where are the specific sites that contribute contaminants to Puget Sound?*	*IS-TIF*					
EBS 59.02	*Assess stormwater runoff impacts in urban/urbanizing watersheds of Puget Sound by identifying the highest priority toxic stormwater runoff threats to salmonids & their habitats.*	*FTF*					
EBS 60	**Assess the effectiveness of various approaches to stormwater management**	**IS-GUM (5), IS-MWQ (1), PSEMP (1), FTF (1)**	low	low	med-high	med-low	med-high
EBS 60.01	*Can stormwater treatment result in observable biological response? If so, what extent is required?*	*IS-GUM*					
EBS 60.02	*What are the risks/costs of not treating stormwater?*	*IS-GUM*					
EBS 60.03	*What is the effectiveness of various stormwater treatment technologies? Including grass filter strips and buffers.*	*IS-GUM*					
EBS 60.04	*Does sweeping need to be implemented with ordinances and signage to ensure curbs are cleaned? (What is comparison of accumulation rates in downstream catch basin where parking is/isn't prohibited during specified times for sweeping?)*	*IS-MWQ*					
EBS 60.05	*What are the cumulative impacts of restoration work and stormwater management actions?*	*IS-GUM*					
EBS 60.06	*Is there a land-use type (e.g., commercial/industrial) where stormwater treatment will yield the highest level of stream recovery?*	*IS-GUM*					
EBS 60.07	*Support collaboration between science and monitoring community to analyze the effectiveness of policies, programs, and projects identified as high priority by recovery focused stakeholder and leadership boards (Leadership Council, Ecosystem Coordination Board and Salmon Recovery Council) including assessing the effectiveness of land use policies in protecting habitat critical to salmon and salmon recovery. For instance, assess implementation and effectiveness of growth management regulations for salmon recovery. Prioritize locations for stormwater retrofit projects and other water quality improvements across the region.*	*PSEMP*					
EBS 60.08	*Develop & implement green stormwater strategies to ensure the ecological integrity of salmon habitats by identifying mitigation strategies to aid long-term habitat conservation & restoration.*	*FTF*					
EBS 61	**Integrate research, monitoring, and effectiveness assessment to improve program design and outcomes**	**IS-Sh (2)**	high	high	high	med-high	med-low
EBS 61.01	*Research must be integrated with monitoring. Research must dovetail with effectiveness monitoring to identify barriers to progress in more detail, and to yield data that actually advances the program.*	*IS-Sh*					
EBS 61.02	*What can analysis of historical monitoring data reveal about impacts of actions?*	*IS-Sh*					
EBS 62	**Assess nutrient reduction achievable from different areas of Puget Sound and various management interventions**	**IS-MWQ (2), IS-Sh (1)**	med-low	low	med-low	med-low	med-low
EBS 62.01	*Which watersheds have the largest scope for decreasing nutrient loads, and are these the watersheds that are causing the current DO depletions?*	*IS-MWQ*					

ID	Evidence-Based Solutions (EBS): Areas where there is political consensus to act, but where expanded science is needed to support decision making	Sources	Quartile Rank of Scored SWA for each objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
EBS 62.02	*What can models offer? Existing hydrologic models at local and regional scales (e.g. PNNL models) have potential to inform about processes affecting nutrient and bacterial circulation and dilution and causes of recurrent de-classification of growing areas. Could modeling help to understand closures? Would modeling be affordable and informative? For example: Re-examination of the influence of the Samish River and independent drainages on fecal coliform levels in the Samish Bay Growing Area. A further suggestion was that models could address the problem of quantifying coliform contributions from different sources (septic's, ag, wildlife, etc.) in a given bay or basin (complementing research in part 5a and b).*	*IS-Sh*					
EBS 62.03	*(For each strategy) What fraction of N load does this strategy represent?*	*IS-MWQ*					

Table B.3: Potential Science Work Action relating to Uncertainty and Doubt

ID	Uncertainty and Doubt (US): Areas where both scientific knowledge and articulation of policy issues are poorly developed and where the body of scientific knowledge can be improved through research, monitoring, or modeling and reduce uncertainties, which can serve as barriers to action.	Sources	Quartile Rank of Scored SWA for given objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
UD 1*	**Assess what factors contribute to effective co-governance and/or co-management between jurisdictions (including Indigenous and non-Indigenous governments)**	**S4 (3)**	high	med-high	med-low	high	high
UD 1.01	*In which ways have Indigenous groups been, and continue to be, disenfranchised from resources and resource management across their territories (i.e. across landscapes, both on- and off-reservation), and what are the effects on their well-being?*	*S4*					
UD 1.02	*To what degree, and how, are diverse people and their values currently represented in political and decision-making processes, how does representation affect ecosystem recovery outcomes, and how are diverse people affected by these outcomes? *	*S4*					
UD 1.03	*What factors contribute to effective co-governance and/or co-management between jurisdictions (including Indigenous and non-Indigenous governments)?*	*S4*					
UD 2	**Characterize and coordinate the diversity of institutions and jurisdictions in the Salish Sea located in both the US and Canada**	**S4 (1)**	high	high	low	high	high
UD 2.01	*How can the diversity of institutions and jurisdictions in the Salish Sea be characterized and better coordinated?*	*S4*					
UD 3/18*	**Identify and adopt appropriate frameworks connecting human wellbeing to ecosystem health to evaluate climate change impacts to holistic health, considering and appropriately addressing issues of scale, psychological shifting baselines and perceptions of environmental governance, sense of place, and psychological wellbeing.**	**IS-Ch (1), PSEMP (2), S4 (7), IS-GUM (2), IS-TIF (1), LIO (1)**	high	high	low	high	high
UD 3.01	*Define the interface between science and policy (iterative) - as it applies to social science, decision-making, etc. (so Social science produces better information on human behavior)*	*IS-Ch*					
UD 3.02	*Address the question of how climate change impacts the holistic health and well-being of Salish Sea communities.*	*PSEMP*					
UD 3.03	*Goal: Understand and mitigate the effects of changing environmental conditions on human well-being*	*S4*					
UD 3.04	*How does, and will, climate change impact the holistic health and well-being of Salish Sea communities? *	*S4*					
UD 3.05	*How is human well-being related to the environment?*	*S4*					
UD 3.06	*How is the well-being of different social groups affected by changing environmental conditions and ecosystem recovery?*	*S4*					

ID	Uncertainty and Doubt (US): Areas where both scientific knowledge and articulation of policy issues are poorly developed and where the body of scientific knowledge can be improved through research, monitoring, or modeling and reduce uncertainties, which can serve as barriers to action.	Sources	Quartile Rank of Scored SWA for given objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
UD 3.07	*What are the means of inducing behavior change based on public awareness of information such as the value of ecosystem services provided by rural lands or the underlying costs of rural living?*	*IS-GUM*					
UD 3.08	*What is the best strategy for behavior change?*	*IS-GUM*					
UD 3.09	*Social science - what strategies are effective in behavior change? Consumers, institutions*	*IS-TIF*					
UD 3.1	*The region needs to encourage/incentivize agencies and policymakers to engage in ecosystem recovery goals in order to make this work relevant to elected officials and worth their investment of time and support.*	*LIO*					
UD 3.11	*What factors affect human behaviors conducive to ecosystem recovery?*	*S4*					
UD 3.12	*What factors motivate landowners to engage in or resist ecosystem recovery actions? What about land rights-holders, such as Indigenous groups, and other stakeholders, such as the non-landowning public?*	*S4*					
UD 3.13	*What role does sense of place play in motivating or hindering participation in ecosystem recovery and management?*	*S4*					
UD 18.01	*Identify and adopt appropriate frameworks connecting human wellbeing to ecosystem health for the Salish Sea, considering and appropriately addressing issues of scale, psychological shifting baselines and perceptions of environmental governance, sense of place, and psychological wellbeing.*	*PSEMP*					
UD 4	**Evaluate under what conditions humans have become disconnected from nature, and how best can we connect people to green spaces, clean water, and fresh air**	**S4 (1)**	med-high	low	low	high	low
UD 4.01	*Why and how have humans become disconnected from nature, and how best can we connect people to green spaces, clean water, and fresh air?*	*S4*					
UD 5	**Determine the extent of pinniped predation as a limiting factor for Chinook in Puget Sound and along Washington's outer coast, assess factors that contribute to predation, and evaluate management actions.**	**IS-Ch (1), OTF (3)**	high	med-high	med-high	med-low	high
UD 5.01	*Complete assessments of marine mammal impacts (harbor seal, harbor porpoise, potentially sea lion) (so Food web dynamics better understood)*	*IS-Ch*					
UD 5.02	*Complete ongoing regional research and coordinate an independent science panel (Washington Academy of Sciences or National Academy of Sciences) to review and evaluate research needed to determine the extent of pinniped predation on Chinook salmon in Puget Sound and Washington's outer coast. The ongoing and new work should include an assessment of factors that may exacerbate or ameliorate predation such as infrastructure haul-outs, hatchery strategies, the increased presence and impact of transient killer whales and the presence/absence of forage fish or other fish that are staple food for pinnipeds.*	*OTF*					
UD 5.03	*Direct the appropriate agencies to work with tribes and National Oceanic and Atmospheric Administration to determine if pinniped (harbor seal and sea lion) predation is a limiting factor for Chinook in Puget Sound and along Washington's outer coast and evaluate potential management actions.*	*OTF*					
UD 5.04	*Provide funding to WDFW to (1) determine if pinniped predation is a limiting factor for Chinook in Puget Sound and along Washington's outer coast and (2) more effectively manage pinniped predation in the Columbia River*	*OTF*					
UD 6	**Study the food-water-energy nexus: what inter-dependencies exist between food production and consumption (including life cycle analysis), hydropower and river flows, water usage and quality, and protected species viability (salmon)?**	**S4 (1)**	high	high	low	high	low
UD 6.01	*Study the food-water-energy nexus: what inter-dependencies exist between food production and consumption (including life cycle analysis), hydropower and river flows, water usage and quality, and protected species viability (salmon)?*	*S4*					
UD 7	**Determine how important viruses that cause human illness are (e.g. hepatitis and norovirus) and whether they may be more effective markers in wastewater treatment plant rules**	**IS-Sh (1)**	med-low	high	med-high	low	low
UD 7.01	*Viruses: how important are they? WWTP are proposing changing to monitoring male-specific coliphage as a better indicator of Hepatitis and Norovirus. Are viruses more effective markers? Do they survive longer? Should rules change to focus on viruses?*	*IS-Sh*					
UD 8	**Determine the causes and social-ecological consequences of existing and emergent contaminants and how causes and consequences are interrelated**	**S4 (1)**	med-low	high	med-low	high	med-low

ID	Uncertainty and Doubt (US): Areas where both scientific knowledge and articulation of policy issues are poorly developed and where the body of scientific knowledge can be improved through research, monitoring, or modeling and reduce uncertainties, which can serve as barriers to action.	Sources	Quartile Rank of Scored SWA for given objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
UD 8.01	*What are the causes and social-ecological consequences of existing and emergent contaminants? How are causes and consequences interrelated?*	*S4*					
UD 9	**Evaluate how the temporal scope of the ecological baseline limits or expands understandings of potential trajectories for ecosystem recovery and restoration**	**IS-Ch (1), S4 (1)**	med-high	high	med-low	med-high	low
UD 9.01	*Add social science perspective to research, and recommendations for practical application; add social scientist to the SSAG (so Social science produces better information on human behavior)*	*IS-Ch*					
UD 9.02	*How does the temporal scope of the ecological baseline limit or expand understandings of potential trajectories for ecosystem recovery and restoration?*	*S4*					
UD 10*	**Evaluate how current and future social, economic, and political factors, such as population growth and urban development, will affect habitat quality and quantity, both negatively and positively as gauged by salmon viability.**	**RPA (2)**	high	high	med-low	high	med-high
UD 10.01	*Gain a better understanding of future social, economic, and political factors (such as population growth) that will affect habitat*	*RPA*					
UD 10.02	*Gain a better understanding of the social, economic, and political factors currently affecting habitat*	*RPA*					
UD 11	**Assess, reduce, and include uncertainty around climate change in planning and decision making**	**LIO (2), RPA (1)**	med-high	high	low	med-high	med-high
UD 11.01	*Climate change uncertainties (identified by 3 LIOs)*	*LIO*					
UD 11.02	*Uncertainty around climate change (impacts, how to incorporate into planning efforts, funding, etc.).*	*LIO*					
UD 11.03	*Assess risk from climate change to salmon recovery activities and share with watersheds to incorporate into planning processes*	*RPA*					
UD 12	**Project and understand future changes from climate change, urbanization and development, including those to ecologically important habitats and species, to ecological processes, and to rural land uses**	**LIO (2), RPA (2), IS-GUM (6), LE (1), IS-Ch (1), PSEMP (2), S4 (1)**	high	high	low	high	med-high
UD 12.01	*Critical Areas flooding potential (Data Gap – Habitat)*	*LIO*					
UD 12.02	*Gain a better understanding of how habitat may change in the future due to pressures like climate change and population growth*	*RPA*					
UD 12.03	*How are ecologically important lands expected to shift in response to changing climate conditions? (Determine if there are geographic areas where lack of water availability will act as a limiting factor on rural development; assess where sea-level delta areas will no longer be able to support agriculture).*	*IS-GUM*					
UD 12.04	*Which lands are at risk for conversion to non-agricultural uses?*	*IS-GUM*					
UD 12.05	*Add salmon perspective as priority for climate research (so Climate impacts on VSP understood)*	*IS-Ch*					
UD 12.06	*What are the flood and drainage effects of delta landscape management alternatives under future climate conditions?*	*IS-GUM*					
UD 12.07	*What happens to existing infrastructure under various climate change scenarios? Create consistent models, forums, and mechanisms for climate impact projections and research.*	*IS-GUM*					
UD 12.08	*Where does saltwater intrude under climate change scenarios?*	*IS-GUM*					
UD 12.09	*Where is sediment deposited under climate change scenarios?*	*IS-GUM*					
UD 12.1	*Streamflows – What are the effects of low summer flows and "flashy" winter flows?*	*LE*					
UD 12.11	*Climate Change effects on hydrologic regimes*	*LIO*					
UD 12.12	*Complete sea level rise vulnerability assessments and develop new hazard maps to inform decisions related to building restrictions in or near floodplains and trade-offs of moving houses inland versus constructing shoreline armoring.*	*PSEMP*					
UD 12.13	*Work collaboratively with watersheds to identify risks from climate change to salmon recovery activities and incorporate into planning processes, including project prioritization and design.*	*PSEMP*					

ID	Uncertainty and Doubt (US): Areas where both scientific knowledge and articulation of policy issues are poorly developed and where the body of scientific knowledge can be improved through research, monitoring, or modeling and reduce uncertainties, which can serve as barriers to action.	Sources	Quartile Rank of Scored SWA for given objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
UD 12.14	*Improve forecasting of climate change impacts on salmon*	*RPA*					
UD 12.15	*How is urbanization and development impacting the Salish Sea social-ecological system, and how can impacts be mitigated and minimized through planning? **	*S4*					
UD 13	**Develop solutions to vessel disturbance, collision, grounding, and emerging threats**	**GOVB (1), RPA (1), OTF (2)**	med-high	med-low	low	med-low	med-high
UD 13.01	*(Orca-Vessel workgroup support) "...researching and recommending actions necessary to reduce the deleterious effects of vessel noise and disturbance on SRKWs.*	*GOVB*					
UD 13.02	*Assess and implement additional preventative and proactive measures to reduce the risk of vessel collision and grounding*	*RPA*					
UD 13.03	*Conduct a comprehensive environmental review and take action to minimize potential whale-strike risk and underwater noise posed by the growing number and distribution of fast-ferries and water taxis in Southern Resident critical habitat.*	*OTF*					
UD 13.04	*Vessels: Advance and fund solutions to vessel disturbances and noise and respond to emerging threats.*	*OTF*					
UD 14	**Develop social marketing and information approaches for behavior change**	**PSEMP (1)**	low	low	low	high	low
UD 14.01	*Develop information assets that support community based social marketing strategies using data to communicate impacts to Puget Sound and create behavior change that reduces human impacts.*	*PSEMP*					
UD 15	**Address agency barriers to pursuing enforcement**	**IS-GUM (1)**	med-high	low	med-high	med-low	med-high
UD 15.01	*Identify and address agency barriers to pursing enforcement actions*	*IS-GUM*					
UD 16	**Assess what mechanisms exist for engaging and transforming intragroup conflicts related to ecosystem management in the Salish Sea**	**S4 (1)**	high	med-low	low	high	med-high
UD 16.01	*What mechanisms exist for engaging and transforming intragroup conflicts related to ecosystem management in the Salish Sea?*	*S4*					
UD 17	**Determine the best practices for recruiting and maintaining engagement in collaborative processes that support diverse interests**	**S4 (1)**	med-low	low	low	high	low
UD 17.01	*What are the best practices for recruiting and maintaining engagement in collaborative processes that support diverse interests?*	*S4*					
UD 19*	**Assess the degree, and how, access to marine and coastal resources (e.g. fisheries, open space, native foods) is changing among different communities in the Salish Sea**	**S4 (1)**	high	med-high	med-low	high	high
UD 19.01	*To what degree, and how, is access to marine and coastal resources (e.g. fisheries, open space, native foods) changing among different communities in the Salish Sea?*	*S4*					
UD 20	**Explicitly evaluate trade-offs between restoration and agriculture**	**LIO (1)**	med-high	med-low	med-low	high	med-high
UD 20.01	*There are specific conflicts and tradeoffs between estuary restoration and farmland preservation goals. More generally, it is challenging to develop ways of protecting open space that integrate agriculture, ecosystem recovery, and flood management. Policy needs to balance flood management and floodplain restoration, and it is challenging to get a consensus from stakeholders with different values and concerns.*	*LIO*					
UD 21	**Monitor changes in lower trophic levels of the marine food web such as zooplankton and expand monitoring of marine zooplankton**	**IS-Ch (1), PSEMP (1)**	med-low	med-high	high	low	low
UD 21.01	*Execute Puget Sound zooplankton monitoring program. Results help continuously inform management (so Food web dynamics better understood).*	*IS-Ch*					
UD 21.02	*Monitor changes in lower trophic levels of the marine food web.*	*PSEMP*					
UD 22	**Continue and expand monitoring of ecosystem responses to changing climate and ocean conditions.**	**FT (1), PSEMP (4)**	low	med-high	high	low	low
UD 22.01	*Assess and monitor the delivery and routing of sediment to prioritized large river deltas and nearshore environments to aid restoration and floodplain protection efforts and characterize the resilience of these environments to climate change and sea level rise.*	*FTF*					
UD 22.02	*Climate change can impact the timing and amount of stream flows, and amount of groundwater. Stream flow and groundwater monitoring should include consideration of climate change as a stressor.*	*PSEMP*					

ID	Uncertainty and Doubt (US): Areas where both scientific knowledge and articulation of policy issues are poorly developed and where the body of scientific knowledge can be improved through research, monitoring, or modeling and reduce uncertainties, which can serve as barriers to action.	Sources	Quartile Rank of Scored SWA for given objective				
			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
UD 22.03	*Support data collection efforts (e.g. marsh accretion rates across the sound) and associated modeling efforts that facilitate prediction of tidal wetland response of individual deltas to sea level rise. This would enable more explicitly building climate resilience into resource management and planning for estuarine habitats.*	*PSEMP*					
UD 22.04	*Support, expand, or continue monitoring in the context of climate change and resilience, especially as prioritized by the Vital Sign Revision process and informed by sources including the 2011 Climate Change Indicators Report, 2014 Puget Sound Pressures Assessment, 2015 State of Climate Change Knowledge, 2018 O'Neill Report, and the Shifting Snowlines and Shorelines Report.*	*PSEMP*					
UD 22.05	*Use monitoring results to document the impacts of climate variability and change.*	*PSEMP*					
UD 23	**Evaluate nutrient loading from various sources and in specific basins**	**IS-Sh (1), IS-MWQ (2)**	high	med-low	high	low	low
UD 23.01	*What is the scope and scale of third-party manure application? How much of total manure application is done by 'third parties'? What are the sources, and amounts? By how much does third party application contribute to 'the problem', or indeed, 'the solution'?*	*IS-Sh*					
UD 23.02	*from discussion guide: how much does nearshore groundwater nitrogen influence Puget Sound?*	*IS-MWQ*					
UD 23.03	*What are the basin specific nutrient sources? i.e. in Hood Canal treatment plants are negligible; Whidbey*	*IS-MWQ*					
UD 24	**Improve water quality monitoring**	**FTF (1), OA (1), IS-TIF (1)**	low	med-low	high	low	low
UD 24.01	*Compile Puget Sound basin stream temperature data from multiple sources to include newer data (post-2013) and data for currently data-poor areas, model the data, and map stream temperature/cold water refugia at finer scales than the existing NorWEST tool*	*FTF*					
UD 24.02	*Continue development of new chemical and biological monitoring equipment and methods*	*OA*					
UD 24.03	*Investigate point source discharge inputs 24/7 into PS and follow up with NPDES and treatment solutions i.e., wastewater*	*IS-TIF*					
UD 25	**Investigate DO thresholds and sensitivity for Puget Sound species and their life stages**	**IS-MWQ (2)**	high	med-high	med-low	low	low
UD 25.01	*B.a.i. what Puget Sound species (or life stages) are most sensitive to reduced dissolved oxygen?*	*IS-MWQ*					
UD 25.02	*What are the biological DO thresholds for different Puget Sound species and where do they live?*	*IS-MWQ*					
UD 26	**Research and development to reduce toxic chemicals in products**	**IS-TIF (1)**	med-high	med-high	low	low	med-low
UD 26.01	*Tire reformulation study - eliminate Zn*	*IS-TIF*					
UD 27	**Investigate impact of urbanization on marine ecosystems and water quality**	**FTF (1), IS-Ch (1), LIO (1), LE (1)**	low	med-low	med-low	med-high	med-low
UD 27.01	*Conduct investigations on the impact of urbanization on marine ecosystems and on water quality (stormwater) and potential mitigation options*	*FTF*					
UD 27.02	*Research funding secured to execute studies on stormwater and contaminants impacts on Chinook and their key prey (so Effects of stormwater (water quality) and contaminants on Chinook better understood)*	*IS-Ch*					
UD 27.03	*Lack of knowledge of interaction between runoff and water quality*	*LIO*					
UD 27.04	*Advance science documenting stormwater impact on treaty resources*	*TH*					
UD 27.05	*Water quality – What are the effects of stormwater on Chinook salmon, including toxic loading of chemicals and contaminants? Are current stormwater regulations and treatment standards adequate? How can the pace of retrofits be increased?*	*LE*					
UD 28	**Investigate concerns with fecal coliform approach to identifying pathogen problems**	**IS-Sh (3)**	med-low	high	med-high	low	med-low
UD 28.01	*Are non-fecal bacteria an issue of concern in Whatcom Co.? The standard fecal coliform test is sensitive to bacteria that originate not in the intestines of animals or humans, but in plant materials including wood waste applied to berry fields, and pulp or paper mill effluents (e.g. Klebsiella, Enterobacter, and Citrobacter species). These yield false-positive indicators of fecal contamination and are not reduced by current Pollution Identification and Correction methods aimed at reducing fecal material reaching waterways. What is the contribution of false positives to total coliform results?*	*IS-Sh*					

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			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
UD 28.02	*Assessment of fecal coliform survival/proliferation in aquatic sediments. Fecal coliform bacteria may reside in sediments and contribute to loadings if stirred up during storm events. Understanding the extent to which that occurs will have implications for targeting of pollution abatement activities and management of downstream shellfish resources. Determination of the residence time of active bacteria in aquatic sediments would allow resource managers to assess whether ongoing pollution is occurring in a given site or if fecal coliform seen during rain events is "legacy" pollution which theoretically would decline over time.*	*IS-Sh*					
UD 28.03	*What is the wildlife contribution to fecal coliform contamination in the Samish River and Samish Bay? Researchers in Samish Bay have defined a plan that includes sampling around beaver dams, testing whether sediments are storing bacteria and releasing them during storms, and side by side E. coli and fecal coliform sampling in natural areas with no known human or agricultural sources, around silage piles or other possible sources of klebsiella where there is no chance of manure being a source, to see if loading rate of bacteria from natural sources can be estimated during storm*	*IS-Sh*					
UD 29	**Evaluate ecosystem impacts from acidification and climate change**	**OA (1), IS-GUM (1), OTF (2)**	low	med-high	high	med-low	med-low
UD 29.01	*Continue to test and use predictive relationships and models to assess ocean acidification conditions over space and time; release results to end users and expand user base to other affected and interested parties*	*OA*					
UD 29.02	*How is climate change predicted to impact freshwater and sea water mixing, stratification and residence time in deltas?*	*IS-GUM*					
UD 29.03	*Increase Washington's ability to understand, reduce, remediate, and adapt to the consequences of ocean acidification.*	*OTF*					
UD 29.04	*Identify and mitigate increased threats to Southern Residents from contaminants due to climate change and ocean acidification. Prioritize actions that proactively reduce exposure where the increased impacts are expected to be most severe.*	*OTF*					
UD 30	**Improve monitoring of acidification, sea surface temperature, and other climate variables**	**OA (1), GOVB (1), OTF (2), PSEMP (2)**	low	med-high	high	low	low
UD 30.01	*Continue development of biological indicators for the extent of acidification in Washington coastal waters and the Salish Sea*	*OA*					
UD 30.02	*Ocean acidification: Increase monitoring by the departments of Ecology and Natural Resources and the University of Washington for ocean acidification parameters and zooplankton in the nearshore and throughout the state's marine waters. Improve understanding of how ocean acidification impacts marine organisms. Conduct scientific research at the University of Washington on ocean acidification's impacts on salmon and forage fish and better understand the role of harmful algal blooms*	*GOVB*					
UD 30.03	*Continue to invest in Washington's ability to monitor ocean acidification and its effects. This investment will enable effective responses to ocean acidification.*	*OTF*					
UD 30.04	*Over time, responsible agencies and entities will need to monitor how increased intensity and duration of rainfall events, sea level rise and flooding, and warmer temperatures and ocean acidification affect toxics mobility and contaminants in the ecosystem, and proactively and adaptively manage to address expected future conditions.*	*OTF*					
UD 30.05	*Climate change can impact freshwater and marine temperatures. Temperature monitoring should include consideration of climate change as a stressor.*	*PSEMP*					
UD 30.06	*Climate change can impact ocean acidification. There is a need to develop quality, long-term carbon time-series measurements in Puget Sound to help assess the impact of climate change.*	*PSEMP*					
UD 31	**Investigate how on-site sewage systems affect Puget Sound**	**IS-MWQ (1(**	med-low	med-high	med-high	med-high	med-high
UD 31.01	*from discussion guide: how do OSS problems affect Puget Sound?*	*IS-MWQ*					
UD 32	**Investigate the transport of and risks from contaminants transferred to terrestrial and aquatic habitats**	**IS-TIF (2)**	med-low	low	med-high	low	low
UD 32.01	*Does atmospheric transport present a significant risk to biota/humans?*	*IS-TIF*					
UD 32.02	*What is the transfer of compounds from indoor sources to the outdoor environment?*	*IS-TIF*					
UD 33	**Investigate the presence of and risks from PCBs in sewage biosolids**	**IS-TIF (1)**	low	low	med-high	low	low

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			Add value by filling gaps	Support Science Innovation	Support Continuity	Link Socio-Ecological Resilience	Change the Policy Landscape
UD 33.01	*Are PCBs present in biosolids? If so, do they present a risk of recontamination due to leaching?*	*IS-TIF*					
UD 34	**Quantify toxic contaminant and contaminants of emerging concern levels in products and wastes**	**IS-TIF (4), GOVB (1)**	med-high	med-high	med-high	med-low	med-low
UD 34.01	*Do PBDES that are in products that end up in landfills lead to increased risks to humans or fish?*	*IS-TIF*					
UD 34.02	*What chemicals concentrate in biosolids?*	*IS-TIF*					
UD 34.03	*the operating budget includes $2.9 million to enhance testing for toxics in products and $236,000 for reducing pharmaceuticals in wastewater*	*GOVB*					
UD 34.04	*Are exterior industrial building sealants a potential source of PCBs to the local environment? They have not been well studied locally.*	*IS-TIF*					
UD 35	**Improve monitoring of pollutants associated with stormwater and other sources to improve understanding of pollutant impacts to salmon resources**	**RPA (1)**	low	med-low	med-high	low	med-low
UD 35.01	*Improve monitoring of pollutants (such as metals, hydrocarbons, PAHs, and PBDEs) associated with stormwater and other sources. These point and nonpoint sources need to be identified and assessed to improve our understanding of their impacts to salmon resources*	*RPA*					
UD 36	**Investigate biological influences on distribution of and organism exposure to toxic contaminants**	**IS-TIF (3)**	med-low	high	med-high	low	low
UD 36.01	*What is the relative importance of sediment and benthic invertebrate contamination to the pelagic food web?*	*IS-TIF*					
UD 36.02	*How does the lifecycle and behavior of fish impact contaminant exposure/accumulation? What do herring eat in spring and winter? What do we know about the movement and migration of herring?*	*IS-TIF*					
UD 36.03	*How can we differentiate between recycling (within food web), resuspension (from sediments), and runoff loading of toxic contaminants (especially PCBs) in the urban bays?*	*IS-TIF*					
UD 37	**Support and expand marine bio-toxin monitoring**	**RPA (1), PSEMP (1)**	med-high	med-high	high	low	med-low
UD 37.01	*Support and expand marine bio-toxin monitoring*	*RPA*					
UD 37.02	*Support and expand marine bio-toxin monitoring, especially related to harmful algae blooms.*	*PSEMP*					
UD 37.03	*Investigate the ecosystem linkages that increase risks from biotoxins and harmful algae blooms*	*OA (1), RPA (1)*					
UD 38.01	*Complete studies now underway, initiate biological studies on additional local species of commercial and ecological importance, and investigate the relationship between ocean acidification and harmful algal blooms*	*OA*					
UD 38.02	*Research and implement monitoring to understand the specific environmental conditions that produce harmful algal blooms (HABs) and pathogen events*	*RPA*					
UD 39	**Investigate nutrient processes and impacts in the Puget Sound marine ecosystem, especially on marine vegetation**	**IS-MWQ (2), OA (1), OTF (1)**	med-low	high	high	med-low	med-low
UD 39.01	*What are the benefits of nutrients in the marine ecosystem?*	*IS-MWQ*					
UD 39.02	*What would isotope studies show us about sources and their uptake into the food web, particularly to sensitive areas? What is the anthro N portion in Penn Cove mussels, for example?*	*IS-MWQ*					
UD 39.03	*Quantify key natural and human-influenced processes that contribute to acidification based on estimates of sources, sinks, and transfer rates of carbon and nitrogen*	*OA*					
UD 39.04	*Request that the zooplankton monitoring team engage with the Puget Sound Ecosystem Monitoring Program and the Department of Ecology to look at impacts associated with nutrient pollution.*	*OTF*					

Appendix C: Recommendations to improve ongoing science

Recommendation to improve ongoing science for 2020-2024	Source of recommendation	Specific needs articulated in recommendations reviewed in development of science work actions
A. Collaboratively broaden and improve the knowledge that supports Puget Sound ecosystem recovery	• Science Panel's 2019 SOS • Action Agenda • Federal Task Force	• Continue to build sustainable capacity for new information to guide our actions • Describe and develop a well-organized, substantively funded knowledge network that supports Puget Sound ecosystem recovery planning and implementation efforts
B. Improve incorporation of Indigenous knowledge into science and monitoring efforts	• Action Agenda • PSEMP • Social scientists	• How can Indigenous knowledge systems and governance (i.e., traditional knowledge, Indigenous science, and Coast Salish legal orders) be meaningfully applied in ecosystems recovery? • Engage with tribes to explore appropriate ways to incorporate traditional knowledge into science and monitoring efforts in a way that it can support tribal priorities and regional ecosystem recovery.
C. Develop capacity and coordinate efforts to assess and report on ecosystem conditions (and progress toward goals) and the effectiveness of strategies and action	• Science Panel's 2019 SOS • Action Agenda • PSEMP • Federal Task Force • Orca Task Force • Local Integrating Organizations • Chinook Implementation Strategy • Marine Resources Advisory Council	• Continue to build sustainable capacity for new science to guide our actions • Support coordination of the region's existing monitoring network to promote visibility, accessibility, and relevance of monitoring • Support monitoring, analysis, and reporting needed to adaptively manage recovery efforts. Including resources to (1) collect and analyze data on Partnership indicators and other measures and (2) assess effectiveness • Create open and shared database or clearinghouse of georeferenced data • Develop and implement monitoring aspects of management programs (i.e.., local and tribal Pollution Identification and Control programs) • Develop a funding strategy for monitoring and coordination of monitoring networks
D. Coordinate production and use of interdisciplinary research that explores and emphasizes the truly integrated nature of socio-ecological systems and multi-scalar dynamics, processes, and feedbacks between and within human and ecological components of the system	• Science Panel discussions in mid-2020	

Recommendation to improve ongoing science for 2020-2024	Source of recommendation	Specific needs articulated in recommendations reviewed in development of science work actions
E. Build and sustain robust programs and relationships across the science-policy interface to inform recovery	• Science Panel's 2019 SOS • Action Agenda • Tribal Habitat Strategy • PSEMP • Orca Task Force • Social Scientists • Implementation Strategies • Lead Entities • Marine Resources Advisory Council	• Invigorate the dialogue between scientists and decision makers to improve clarity • Communicate about linkages between actions and results by making science more accessible and collaborative • Integrate goals, recovery targets, and ecosystem indicators by focusing on resilience. Investigate how goals, and assessment of trade-offs among them, vary across different communities • Convene managers and scientists to share scientific and evaluate management actions • Convene interdisciplinary efforts to develop and adapt Implementation Strategies • Improve relevance and timeliness of science investigations
F. Communicate science findings clearly and to the appropriate audience	• Science Panel's 2019 SOS • PSEMP	• Communicate about linkages between actions and results • Synthesize and share findings from the monitoring network (e.g., PSEMP symposium, communication products, data systems) • Work with end users to design products and processes to inform, improve and accelerate efforts toward a resilient ecosystem
G. Develop and analyze alternative future scenarios to explore and express desired futures and evaluate trade-offs among possible approaches	• Science Panel's 2019 SOS • PSEMP	• Strategically test the best path forward using scenarios and leveraging best available science • Explicitly evaluate threats and opportunities (trade-offs) to alternative management

Appendix D: The Partnership and the recovery community

Recovery and long-term protection of the Puget Sound ecosystem is a responsibility shared by many, including government agencies, tribes, private-sector institutions, academia, nongovernmental organizations, and the public. The Puget Sound region is home to more than 5 million residents, many of whom belong to tribes and organizations and engage in activities that express diverse interests in Puget Sound and its recovery. The Puget Sound Partnership was created in 2007 to steward the work of a broad set of partners that reflect this diversity toward recovery in a region with a growing, multicultural population. The Partnership's vision is to strengthen this network of partners into a well-coordinated recovery community that is served by a broadly engaged knowledge network.

The backbone roles of the Puget Sound Partnership

The Puget Sound Partnership is a Washington State agency established by state statute (RCW 90.71) to serve as the backbone organization to support the Puget Sound recovery effort. The Puget Sound Partnership coordinates the region's collective effort to recover Puget Sound and, as a National Estuary Program, the "management conference" that develops and oversees implementation of the comprehensive conservation and management plan for this estuary of national significance. The Partnership brings together hundreds of partners to mobilize action and investments around a common agenda. The Partnership is not a regulatory agency. It has only modest capacity for making grants or directly implementing recovery programs and activities. It facilitates collaboration to optimize Puget Sound recovery and knowledge.

A backbone organization is one that supports a cross-sector diversity of groups to work together to achieve common goals. As a backbone organization, the Partnership is committed to continued learning and improvement of the agency's work, the work of partners, and the Puget Sound recovery effort. The Partnership supports Puget Sound recovery with the following actions:

Charting a course for science-informed recovery by leading development of the Action Agenda. The Partnership works to mobilize partners around a regionally developed, science-based, prioritized set of programs and actions. The goal of this shared plan is to provide funders with a credible framework for Puget Sound investment.

Maintaining the shared measurement and monitoring infrastructure that enables learning and constant improvement. The Partnership establishes a framework of progress measures, including Vital Signs and indicators and intermediate and activity progress measures. The Partnership along with the Puget Sound Ecosystem Monitoring Program (PSEMP) maintain the infrastructure for reporting data and ensuring progress and accountability. This information contributes to the evaluation of effectiveness of actions, so that priorities are adjusted as appropriate in response to continued learning.

Supporting partners in implementation. The Partnership supports partners who implement recovery work. The Partnership supports implementation by mobilizing funding for recovery actions, assisting to identify and remove barriers to implementation, and providing credible and relevant information to support policy and decision-making.

The work of the Partnership is directed by management conference boards and advised by coordinating bodies that bring scientific expertise, knowledge of local and regional issues, and decades of relevant experience to Puget Sound recovery. Beyond the agency, boards, and advisory and coordinating bodies of the Partnership, the recovery community involves a number of supporting organizations and work groups and partner entities. The text box below identifies a number of key participants in the recovery community. Sections below briefly describe the roles of the Science Panel, PSEMP, supporting organizations and work groups, and partners.

Puget Sound Partnership	Supporting organizations and work groups	Partners
Boards • Leadership Council • Science Panel • Ecosystem Coordination Board **Advisory & coordinating bodies** • Salmon Recovery Council • Puget Sound Ecosystem Monitoring Program (PSEMP) **Puget Sound Partnership: Executive Director and staff** • Science and evaluation • Adaptive systems and accountability • Integrated planning • Communications • Board support	Tribal management conference Partnership tribal co-management council Salmon recovery watershed groups Strategic Initiative Leads and Advisory Teams Local Integrating Organizations NW Straits Commission and Marine Resources Committees Puget Sound environmental caucus Puget Sound state agency caucus Federal Puget Sound task force and regional teams Transboundary work groups and coordinating bodies	Puget Sound tribes Federal agencies State agencies Local governments and special purpose districts Non-governmental organizations Academic institutions Businesses and business associations

Science Panel

The Science Panel is one of three Puget Sound Partnership boards established in state statute. The Science Panel provides independent scientific advice to the Leadership Council and guidance for preparing the Action Agenda and the State of the Sound. The Science Panel has assisted in developing an ecosystem-level strategic science program, establishing the Vital Sign indicators of ecosystem health, setting policy-based recovery targets, and ensuring the scientific basis for the Action Agenda and Implementation Strategies. The Science Panel is specifically responsible for guiding development and implementation of a regional monitoring program (see section below on PSEMP), identifying critical research needs, and preparing the Strategic Science Plan, Science Work Plan, and Puget Sound Science Update. The Panel's guidance to the Partnership, Leadership Council, and Ecosystem Coordination Board forms the basis of the strategic approach to Puget Sound recovery.

The Science Panel has established a social sciences advisory committee (SSAC) to ensure that perspectives from a diversity of social sciences disciplines are incorporated into the scientific advice provided to the recovery community.

The text box below provides brief descriptions of the Panel membership in 2020.

Membership of the Puget Sound Partnership Science Panel in 2020
Chair, John Stein – former Science and Research Director of NOAA Fisheries' Northwest Fisheries Science Center, Scientist Emeritus with NOAA Fisheries, affiliate faculty member at the University of Washington's School of Aquatic and Fisheries Sciences, and vice chair of PICES, a multinational science organization of Pacific Rim countries. John co-directed a California Current integrated ecosystem assessment, co-led federal marine planning for the West Coast, and led NOAA's Seafood Safety Program in response to the Deepwater Horizon oil spill.
Co-vice chair, Ken Currens – scientist for the Northwest Indian Fisheries Commission, where he serves as a scientific liaison between the Western Washington Treaty Tribes and the federal government, state agencies, and non-governmental organizations on salmon recovery and ecosystem conservation issues. Ken guides a program that provides ecological and genetic analyses for salmon recovery, ecosystem monitoring, and hatchery reform.
Co-vice chair, Nick Bond – Washington State's Climatologist, senior research scientist with the Joint Institute for the Study of Atmosphere and Ocean (JISAO) of the University of Washington, and affiliate associate professor with the university's Department of Atmospheric Sciences. Nick's research is on a broad range of topics with a focus on the weather and climate of the Pacific Northwest, and the linkages between the climate and marine ecosystems of the North Pacific.
Kelly Biedenweg – Assistant Professor of Human Dimensions at Oregon State University. Kelly joined the Panel in June 2020. Kelly is an environmental social scientist whose research currently includes understanding the factors that influence the inclusion of social data in restoration planning, emotional responses to restoration planning, human wellbeing impacts of restoration, and the various cognitive and behavioral dimensions of sense of place. In addition to this role on the Panel, Kelly and colleagues provide social science expertise as part of the Partnership's Implementation Strategies-Science award from U.S. EPA.
Robert Bilby – retired in 2020 as Senior Science Advisor for Weyerhaeuser and affiliate professor in the University of Washington's College of the Environment. For Weyerhaeuser Bob was responsible for coordinating environmental research on company forest lands and developing collaborative programs with federal, academic and ENGO research organizations. Bob has conducted research on stream ecosystems, salmon and the effects of forestry on both since 1975.
Nives Dolšak – Professor in Sustainability Science and Director of the School of Marine and Environmental Affairs at the University of Washington. Nives teaches courses in Climate Governance, International Organizations and Ocean Management, Economic Development and the Environment, Research Design, and Policy Analysis. Nives' research examines institutional challenges in governing common pool resources at multiple levels of aggregation.

Membership of the Puget Sound Partnership Science Panel in 2020
Robert Ewing – former Director of Timberlands Strategic Planning for Weyerhaeuser who currently advises California communities on wildland fires. At Weyerhaeuser Bob was responsible for the development, implementation and tracking of strategic management plans for all of Weyerhaeuser's forestland. Bob's work has included evaluation of forest conditions, modeling forest productivity and health, developing vegetation management and harvest plans, and monitoring the effects of forest practices on ecosystem values.
Colin Grier – Associate Professor in the Department of Anthropology at Washington State University. Colin is a broadly trained anthropological archaeologist, with an analytical focus on zooarchaeology (the analysis of animal remains) in the context of studying human-environmental interactions over the long-term. Colin's research has included reconstructing past salmon-fishing practices in the Salish Sea and past practices that promoted sustainability and resilience among indigenous peoples of the northwest coast of North America, the Korean Peninsula, and Pacific Rim.
Edward Kennedy – Division Manager for the Ecosystem Science Division, Fisheries and Oceans Canada in the Pacific Region. Eddy's research has had a strong focus on aquaculture and coastal management issues, including efforts focused on coastal habitat ecology and the potential impacts of human pressures on marine ecosystem components. Eddy is responsible for managing research and monitoring activities that enhance knowledge on the structure and function of aquatic ecosystems (including the Strait of Georgia) and that support improved understanding of the impacts of stressors on ecosystem components as well as options to mitigate or manage such impacts.
William Labiosa – Research Physical Scientist with U.S. Geological Survey, specializing in watershed and ecosystems management decision analysis and decision support. Bill has extensive ecological experience and knowledge of Puget Sound serving as the project manager and principal investigator for the Puget Sound Ecosystem Portfolio Model project – a model-based evaluation of ecosystem services and metrics of human well-being as influenced by land use change and regional-scale coastal anthropogenic modifications.
Paul Mayer – Ecological Effects Branch Chief for the U.S. Environmental Protection Agency's Western Ecology Division, Office of Research and Development. Paul has extensive research experience in the Chesapeake Bay region, where he led studies of stream restoration and stormwater management in urban ecosystems. Paul's wetland ecosystems work at organismal, microbial, and biogeochemical levels focused on employing ecological indicators of recovery after restoration.
Terre Satterfield – interdisciplinary social scientist; professor of culture, risk and the environment; and director of the University of British Columbia's Institute for Resources, Environment and Sustainability. Terre's research concerns sustainable thinking and action in the context of environmental assessment and decision making. Terre studies natural resource controversies; culture and cultural ecosystem services; and the perceived risk of new technologies. Terre has worked primarily on tensions between indigenous communities and the state and/or regulatory dilemmas regarding new technologies. Although Terre's term on the Panel extends to fall 2021, she has not been an active participant in the past year.
Ruth Sofield – Associate Professor of Environmental Toxicology and Chemistry in the Huxley College of the Environment at Western Washington University. Ruth has worked on projects that include: 1) microplastic monitoring in marine, freshwater and terrestrial environments; assessment of microplastic toxicity to marine organisms. 2) use of passive samplers for metals analysis in freshwater systems. 3) analysis of particulate air pollutants using scanning electron microscopy. 4) snow and high alpine water chemistry and relationship to algal and macroinvertebrate community structure.
Eric Strecker – consulting engineer (P.E. in OR and WA) and fisheries biologist located in Portland, Oregon. Eric focuses on the design, monitoring, and evaluation of sustainable stormwater best management practices (BMPs), the development of major project and watershed master plans and the overall assessment and management planning to protect aquatic resources. He has provided technical direction and assistance to public and private sector clients in Puget Sound and elsewhere in stormwater master planning, permitting, waterbody clean up planning, and related efforts.

Membership of the Puget Sound Partnership Science Panel in 2020
Ken Warheit – Supervisor of Washington Department of Fish and Wildlife's Genetics and Health Laboratories and Affiliate Associate Professor at the University of Washington. Ken joined the Panel in June 2020. Ken oversees the operations of state agency laboratories and field programs and provides oversight of commercial aquaculture, including fish health matters associated with net-pen aquaculture in Puget Sound. Ken is his program's representative on the Washington Cooperative Fish and Wildlife Unit at the University of Washington.
Ex-officio member, Joel Baker – Executive Director of UW Tacoma's Puget Sound Institute. For more than 20 years, Joel has led water and air quality assessments in a variety of complex ecosystems, including the Great Lakes, the Hudson River and Chesapeake Bay. Baker holds the Port of Tacoma Chair in Environmental Science at UW Tacoma and is the Science Director of the Center for Urban Waters. In addition to this ex officio role on the Panel, Joel and his colleagues at the Puget Sound Institute provide scientific expertise as part of the Partnership's Implementation Strategies-Science award from U.S. EPA.

Puget Sound Ecosystem Monitoring Program

The Puget Sound Ecosystem Monitoring Program (PSEMP) is a collaborative network of subject matter experts and practitioners who collect, share, analyze, and synthesize data and information about the status of the Puget Sound ecosystem and the effectiveness of recovery actions. The Puget Sound Partnership supports coordination of PSEMP as part of its monitoring program to provide vetted, scientific information about ecosystem conditions, progress toward recovery, and effectiveness of actions. PSEMP brings together diverse partners—from state, federal, tribal and local government agencies, non-governmental organizations, watershed groups, businesses, academia, Local Integrating Organizations (LIOs), and other private and volunteer groups and organizations—with the goal of coordinating data collection, findings, and assessments that are most relevant to Puget Sound. The Partnership and PSEMP have collaborated to develop a strategic plan that outlines a mission and objectives for PSEMP.

> Mission: Convene a collaborative network of subject matter experts who organize, synthesize, and communicate scientific information from many monitoring organizations and different parts of the ecosystem to directly address foundational management and science questions critical to recovery of the ecosystem. To achieve this mission, PSEMP has adopted the following objectives:
>
> Objective 1. Create and maintain forums to increase *collaboration* across monitoring programs to improve effectiveness and efficiency of monitoring programs and their ability to meet the information needs of planners, managers, and decision makers. Organize and synthesize the data being gathered by existing monitoring programs to increase access to available information and highlight priority knowledge gaps to be filled.
>
> Objective 2. Support *adaptive management* of recovery efforts by evaluating the effectiveness of recovery actions and approaches so that those actions can be prioritized; engaging PSEMP members in planning processes such as Implementation Strategies; and facilitating the exchange of knowledge among PSEMP members and with planners, managers, and decisionmakers.
>
> Objective 3. Improve *communication* within the monitoring and assessment community and to audiences specified in a new communications plan in order to improve access to and use of credible information in decisions about Puget Sound recovery efforts.

PSEMP and the Puget Sound Partnership work with others in the recovery community to understand the effectiveness of implemented actions and how they are contributing to progress toward ecosystem recovery targets. Information on the effectiveness of recovery actions is gathered by scientific investigators, distilled from existing reports, and vetted by local experts to develop findings and share stories. Through this work PSEMP and the Partnership build a base of scientific knowledge on ecosystem recovery that can help ensure the accountability of partner actions, amplify the effectiveness of actions and investments in achieving anticipated outcomes, and promote the consistent evaluation of recovery progress.

A variety of efforts are underway to evaluate the effectiveness and progress of recovery actions to incorporate learning in decision-making at both regional and local scales. These efforts aim to: 1) understand whether project-scale activities were implemented in alignment with the expectations of project plans and designs (implementation monitoring); 2) evaluate whether the immediate goals and objectives of recovery actions are contributing toward ecosystem recovery goals and targets; and 3) assess the impact of regional plans and programs on regional recovery goals and targets, or to test the assumptions, standards, and guidelines used in the development of regional plans or programs.

Supporting organizations and work groups

Multiple other coordinating and advisory bodies and implementing networks are affiliated with and support the Puget Sound Partnership. These supporting organizations and work groups provide scientific, advisory, and implementation support for Puget Sound recovery. Through their work to implement support for Puget Sound recovery, these organizations and work groups have identified the scientific needs of recovery. They also provide specific guidance on the strategies for protecting and restoring watersheds, protecting and restoring nearshore and marine habitat, and preventing, reducing, and controlling nutrient, toxic, and pathogen loadings in Puget Sound. Many of these groups exist for reasons independent of Puget Sound recovery and give generously of their time for our collective effort. Many standing subcommittees and advisory groups support the Puget Sound Partnership. Members are drawn from state and federal agencies and leadership bodies, as well as key partners with subject expertise and interest in Puget Sound recovery.

As part of the greater Salish Sea ecosystem, Puget Sound is influenced and affected by events and activities in Canada. To facilitate coordinated and complementary action for long-term protection and restoration, regional mechanisms promote cooperation on transboundary issues on local and Sound-wide scales.

Partners in Science and Recovery

Puget Sound Tribes

Tribes are leaders and indispensable partners who have made substantial investments in Puget Sound recovery. Tribes are leaders in Puget Sound recovery and indispensable partners who have made substantial investments in recovery efforts. Tribes contribute traditional knowledge of natural resources gained over thousands of years. They also offer significant contributions to the body of science that can shape recovery efforts, provide scientific expertise in restoration, ecology, monitoring, and evaluation. Tribes develop and implement strategic initiatives that connect science with policy and action, which has contributed to hundreds of successful recovery projects.

Federal Agencies

Federal agencies contribute to Puget Sound recovery by promoting information sharing, developing joint work priorities, participating in the Management Conference Boards and advisory committees, and by collaborating across agencies to support the development and implementation of the Action Agenda. Nine federal agencies have signed a Memorandum of Understanding to form a federal task force committed to these working principles, and to affirm that federal agencies with Puget Sound interests are actively participating. Partner agencies include those with environment and natural resource responsibilities—such as the National Oceanic and Atmospheric Administration, Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Geological Survey, Natural Resources Conservation Service, and U.S. Army Corps of Engineers—as well as those with local defense and security responsibilities such as the U.S. Coast Guard, U.S. Army, and U.S. Navy. To guide its engagement with Puget Sound recovery, the federal task force has developed an Action Plan that supports implementation of priority recovery strategies and actions, including science and reporting. In addition, governmental partners coordinate with tribes and the state on other plans relevant to Puget Sound recovery, such as the U.S. Coast Guard's Northwest Area Contingency Plan, the Corps of Engineers' Puget Sound Master Plan, and The Recovery Plan for Southern Resident Killer Whales.

State Agencies

State agencies with natural resource and human health responsibilities promote coordination, communication, and program alignment. Agencies working toward Puget Sound recovery include the departments of Ecology, Natural Resources, Fish and Wildlife, Commerce, Transportation, Health, and Agriculture; the State Conservation Commission; the Recreation and Conservation Office; the Governor's Office; and the Office of Financial Management. Additional leadership roles are taken on by the Departments of Ecology, Fish and Wildlife, Health, and Natural Resources, which serve as Strategic Initiative Leads. The Department of Commerce and Washington State University's Stormwater Center also contribute to the Stormwater Strategic Initiative.

Cities, Counties, and Special-Purpose Districts

Much of the effort and some of the most important decisions to recover Puget Sound occurs at the local level. Cities and counties are at the frontline for addressing impacts—they develop and implement growth management plans and development regulations, manage surface water runoff, treat wastewater, and provide numerous services to residents. Most counties and many cities participate in Local Integrating Organizations and Lead Entities. Working cooperatively with cities and counties is essential for federal and state agencies, tribes, and nongovernmental interests. In addition to participating as individual jurisdictions, counties work together through the Washington State Association of Counties and the County Coastal Caucus, and cities work together through the Association of Washington Cities.

Non-governmental organizations and Academia

Several programs from regional academic institutions contribute to Puget Sound recovery. For example, the Puget Sound Institute was established by the University of Washington, the Environmental Protection Agency, and the Puget Sound Partnership to support the Partnership as the bridge between the scientific community and the groups tasked with protecting and restoring Puget Sound. Likewise, the Washington State University Stormwater Center brings significant expertise to the Stormwater Strategic Initiative.