Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P1	1	Building a Puget Sound Wide, Community Watershed Database and Analysis System to Facilitate Science-Based Resource Management and Restoration	This grant will develop a comprehensive set of analysis tools and databases across the basin to help address flood and floodplain management, erosion mitigation, riparian protection strategies, aquatic habitat restoration and areas of particular sensitivity to climate change. A region-wide system of stakeholder supported watershed databases are already being developed for large areas of federal lands in Western Washington. This project will extend this system to remaining lands at lower elevations and include new tools for evaluating and assessing floodplain and estuarine areas.
P2	1	Effect of Forestry on Headwater Streams in Erodible Lithology	This grant will fund a study to determine if the state's forestry rules are effectively preventing degradation of water quality and habitat in the headwaters of Puget Sound watersheds. The information will be paired with ongoing companion studies. The resulting package of studies and assessments will create a foundation of science to support a formal regulatory review of Washington's forest practices rules in these vulnerable headwater areas.
P3	1	Integrated Modeling and Decision-Support System for Water Management in the Puget Sound Basin	Management of stormwater, flooding, and temperature stress on salmon are priorities across the watersheds and estuaries of Puget Sound. These management challenges depend on accurate estimates of the freshwater flows and water temperatures delivered from snowpack and precipitation at higher elevations. This project will create an integrated decision support system for the Snohomish River Basin that will improve information on freshwater flow and temperature across different climate and land development scenarios. Accurate modeling of water flows and temperature regimes in the watersheds and estuaries will provide improved tools for stormwater management, with the addition of other water quality parameters, including concentrations and movement of toxic contaminants. Outcomes: Provides greater knowledge of water quality water flow and species and will inform growth supply planning.
P4	1	Strategies for Preserving and Restoring Small Puget Sound Drainages	The King County Water and Land Resources Division and the Washington Department of Ecology have finalized a two year interagency agreement for $135,469 titled, “Strategies for Preserving and Restoring Small Puget Sound Drainages” funded by federal pass through funds as part of the Puget Sound Action Agenda Ecosystem and Protection Project. The purpose of this project is to develop strategies and cost estimates for preserving all Puget Sound drainages with “excellent” benthic index of biotic integrity (B-IBI) scores, and for restoring 30 drainages from “fair” to “good” B-IBI scores. This project is intended to accomplish certain near-term actions (NTAs) identified in the Puget Sound Partnership’s 2012/2013 Action Agenda for Puget Sound including C2.1 NTA 2: managing urban runoff at the basin and watershed scale and C2.3 NTA 2: map, prioritize and restore degraded streams. The Action Agenda had identified King County as leading on these NTAs, contingent on funding being made available. This project addresses recovery of B-IBI which is a key indicator of overall watershed condition, available fish habitat, and water quality yet little is known about how to recover degraded benthic macroinvertebrate communities. If strategies developed through this project can be implemented and B-IBI scores are improved, it will signal measurable improvements in overall stream condition in the Puget Sound region.
P5	1	Integrated watershed management plan using Puget Sound Watershed Characterization Project	Complete an integrated watershed management plan using the Puget Sound Watershed Characterization that will guide the development of an in-lieu-fee mitigation program in the Hood Canal region.
P6	1	Watershed based land-use planning	Kitsap County will prepare land-use recommendations for the county’s 2016 comprehensive plan update, based on an analysis through the Puget Sound Watershed Characterization project. The state departments of Ecology and Fish & Wildlife and Puget Sound Partnership used an EPA grant to develop this regional-scale tool which helps highlight the most important areas to protect and restore, and those most suitable for development throughout the Puget Sound region.
P7	1	Predictive modeling, protecting coastal salmon streams	The tribe and its partners will identify priority coastal streams in Island County watersheds to protect and restore to ensure this information is incorporated in updates to regulations, ordinances, and plans. Previous study information will be used to develop a predictive model to identify coastal streams that have key characteristics making them suitable salmon rearing habitat. The model will be used in conjunction with watershed characterization data to prioritize protection and restoration efforts. The information will be incorporated into Island County’s shoreline master program and critical areas ordinance updates as well as other planning processes. Partner organizations: Skagit River System Cooperative, Wild Fish Conservancy, Northwest Indian Fisheries Commission, Island County, and Whidbey Watershed Stewards

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P8	1	Channel Migration Zone Assessments	Provides critical information and tool for shoreline management planning, flood hazard reduction, and aquatic and terrestrial habitat protection and restoration. CMZ technical guidance/methods manual; improved planning level CMZ delineation method; ID of conditions affecting channel migration; ID of streams with potential to migrate.
P9	1	Island Co. waterhsed analysis & update of FWHCA	Outcomes: Improved baseline for habitat conditions in Island County; improved protection of existing habitats; improved implementation of FWHCA critical area regulations; improved public understanding of habitat protection needs. Outputs: Updated FWHCA language in County CAO; report on best available science for FWHCAs and baseline condition of habitats in County; web interface (e.g., story map) for public use and to show lessons learned on watershed- based land use planning
P10	2	How to incorporate cultural ecosystem services into resource management decisions: testing a visualization tool	Testing the influence of a visualization tool for cultural ecosystem services in the Puget Sound on decisions about shoreline master plan
P11	2	NOAA/NWFSC—Defining Target Levels for Puget Sound's Ecosystem Components: A Socio-Ecological approach	This project will develop an approach for identifying ecosystem protection and restoration targets that consider social perspectives. This project will identify a set of critical ecosystem attributes and use a food web model to examine potential changes as a result of simulations on nearshore habitat and water quality. It will also conduct social norm analyses in which stakeholders are asked to rate the desirability of a range of potential ecosystem conditions. The goal is to blend ecological and social science to inform scientifically rigorous and socially responsive management targets.
P12	3	Long-term monitoring of Lake Washington plankton	We are continuing the long-term monitoring started by WT Edmondson in the 1950s on the plankton of Lake Washington. This work was initiated to understand the causes and consequences of eutrophication in Lake Washington. More recently the focus has been on understanding the implications of climate change for plankton dynamics, and to provide estimates of the prey base upon which juvenile salmon rely upon in the ecosystem. This latter information is critical for the adaptive management approach of the Lake Washington sockeye salmon hatchery on the Cedar River.
P13	3	Wetlands Change Analysis - Tracking No Net Loss of Wetlands	Wetlands are a critical resource in maintaining water quality in Puget Sound and providing wildlife habitat. This grant will help determine losses or gains in wetland areas across the Puget Sound basin. It will apply existing methods to data and satellite imagery dating back to 1985 to create a status and trends analysis. A complementary project will assess the feasibility of developing a method to classify wetlands using low-level aerial photography. Outcomes: Filling data gaps related to filled or altered wetlands.
P14	3	Elwha River Restoration Project: the Dynamics and Downstream Impacts of Fine Sediments Released After Dam Removal	The Elwha River Restoration Project is the largest single restoration action planned for the Puget Sound region in the foreseeable future. The removal of two large dams is expected to begin in 2011 and take approximately 2.5 years. Sediment accumulated behind the dams is expected to erode and enter the river, creating impacts on freshwater, estuarine and nearshore ecosystems. This study will provide data to manage the restoration project with respect to sediment erosion and passage into the marine zone and to provide a better understanding of the impacts of large-scale dam removal on downstream ecosystems. Outcomes: High quality information-based outputs helps adequate monitoring of an extreme volume of sediment moving through a highly braided estuary.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P15	3	Qwuloot/Snohomish estuary restoration monitoring	The Qwuloolt restoration project is a 150 hectare area of the Snohomish River estuary, scheduled to have tidal inundation returned via levee breach in late 2014. The project size, presence of remnant populations of several wild salmon species, potential for additional restoration in the Snohomish River estuary, and extent of pre-breach monitoring data make Qwuloolt an estuary restoration project of national significance. Ensuring rigorous scientific evaluation of this project will be a significant contribution to restoration science and practice. Comprehensive pre-breach monitoring of the project has been ongoing through collaboration between NOAA Fisheries and the Tulalip Tribes, and is currently in its fourth year of baseline data collection. The Qwuloolt monitoring plan which covers a comprehensive suite of abiotic and biotic monitoring components at the Qwuloolt project area and adjacent reference sites with options for two levels of effort: core (the recommended minimum that ensures the collection of field data and limited analysis) and supplemental (additional effort that increases the informational value of the monitoring through measurement of additional attributes, processing of archived samples, and more in depth analysis). Efforts so far include: continuous hydrologic monitoring; elevation, vegetation, macroinvertebrate, and bird surveys; and over three full years of intensive, year-round fish sampling to characterize whole fish assemblage use of the study area. Special emphasis is placed on juvenile salmon to rigorously document density, individual size, origin, feeding ecology, and life history. The Qwuloolt monitoring is coordinated with a larger, estuary-wide sampling effort designed to rigorously characterize juvenile Chinook use of the entire estuary, providing a landscape context for individual projects, and establishing a baseline to evaluate cumulative effects of restoration actions.
P16	3	Effects of urbanization on lakes in the greater Seattle area	We are studying the effects of urbanization on nutrient cycles, food webs, and terrestrial-aquatic coupling in the greater Seattle area. Lakes become eutrophied at the suburban fringe as they become developed, though seem to recover with eventual urbanization. Aquatic-terrestrial coupling is distinctly shut down as urbanization proceeds, having important implications for aquatic food webs.
P17	3	Marine and Terrestrial Bird Indicators for Puget Sound	Along with water quality, habitat and quality of life indicators, PSP recommended a portfolio of species and food web indicators that included terrestrial and marine birds. This indicator was ambiguous and in need of refinement. Consequently, we were tasked by the Puget Sound Partnership with developing terrestrial and marine bird indicators. To accomplish this, we used existing compilations of indicators and screening criteria to rank and refine these lists of potential indicators and to finally provide recommendations for specific indicators and their reporting strategy. We define the geographic scope for our work as the U.S. portion of the Salish Sea (Puget Sound, including the Strait of Juan de Fuca) and associated watersheds (this includes the upland habitats in these watersheds). We emphasize that the bird indicators that we recommend are intended to be coarse-grained, i.e., aimed at the general public and policy makers and easily understood and is not intended to provide the detailed information necessary to diagnose specific problems, monitor responses of the ecosystem to management actions or assess the causes for the patterns in the data. They are intended to indicate something about marine and terrestrial bird populations in the region primarily and secondly to provide an integrative view of the health of Puget Sound, in contrast to being indicators of something specific like habitat, contaminants or prey. After completing this review process, we recommend two marine bird indicators: 1) *Spring/summer density trends for seabirds breeding in Puget Sound and Strait of Juan de Fuca and that are highly dependent on the marine environment of this region, including pigeon guillemot, rhinoceros auklet, and marbled murrelet. 2) Abundance trends for over-wintering seabird species in Puget Sound and Strait of Juan de Fuca that are highly dependent on Puget Sound's marine environment, specifically, scoter species.* And two terrestrial bird indicators: *1) Breeding abundance trends of resident species associated with interior conifer forests. 2) Breeding abundance trends of resident synanthropic species.* In addition we recommend methods for reporting annual results and trends. We intentionally do not propose associated recovery targets for these indicators because they are high level indicators intended to communicate to the general public about overall ecosystem conditions (e.g., are marine bird populations healthy) and are not indicators intended to track the effectiveness of specific conservation actions.
P18	3	Port Madison bottom trawling	Bottom trawling at standard depths of 10, 25, 50 and 70 m in the afternoon, dusk, night, dawn, and morning at set locations in Port Madison, Puget Sound, including enumeration and measurement of all fishes, and counts of macro-invertebrates. Data collected annually since 1990.
P19	3	Lake Washington fish sampling	Mid-water trawling for fish, with zooplankton sampling and water column temperature in central Lake Washington. Samples taken each April, and in many years in October as well, since 1990.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P20	4	Measuring Watershed and Climate Impacts of the "Environmental Stewardship Footprint": A Framework for the Green-Duwamish Watershed	As government funding for resource management and restoration projects declines, citizen-based environmental stewardship activities may provide an effective supplementary tool to address environmental goals related to water and climate change in the Puget Sound region. However, little is known about the actual or potential consequences of citizen-based environmental stewardship on ecosystem function, nor are there accepted methodologies for assessing these influences. We propose to investigate the relationship between citizen-based environmental stewardship activities and ecosystem-scale water and climate goals in the Puget Sound region, using the Green-Duwamish watershed as a case study. Using existing literature and data (e.g., stewardship organization data base, survey of organizations, threat assessments, monitoring data), we will identify and characterize: 1) the major ecosystem threats in the Green-Duwamish watershed; 2) the nature and extent of citizen based environmental stewardship efforts with respect to their goals, relationship to regional environmental policies, sources of participant motivation, and biophysical as well as social outputs; and 3) the match (or mismatch) between ecological threats and stewardship activities and outputs (a form of gap analysis). We will develop of a pilot analytical framework linking specific stewardship outputs with larger-scale human and biophysical ecosystem outcomes.
P21	4	Collaborative Environmental Management for Solving Complex Marine Problems: An evaluation of Puget Sound Salmon Recovery	This article looks to examine the performance of the collaborative effort involved in the Puget Sound salmon recovery project. Collaborative environmental governance works especially well for salmon recovery efforts because of the complexity of the issue combined with the inability of a single government agency to solve the problem. Indicators for success used in this study include membership selection, stakeholder performance, stakeholder accountability, and enforcement of outputs. Dolsak and Mandler's findings establish the importance of funding, number and availability of staff, external help, and the use of regulatory and incentive-based approaches.
P22	5	Farms, fish and floods initiative	The grant will be used to bring together interest groups in the Skagit Delta area to restore the estuary and protect agricultural lands. TNC and its partners will identify and prioritize potential restoration projects, and will also complete the Lower Skagit Delta Agricultural Land Base Analysis to evaluate long-term farmland protection needs to maintain a viable agricultural industry. The project focuses on addressing three core issues in the Skagit Delta: salmon recovery, farmland preservation, and flood risk reduction. Partner organizations: Western Washington Agricultural Association, Skagitonians to Preserve Farmland, National Oceanic and Atmospheric Administration, and Washington Department of Fish & Wildlife
P23	5	[No information]	
P24	6	Channel Migration Assessments: Providing Puget Sound Communities with Information & Technical Assistance for Shorelines Master Programs, Floodplain Management & Riverine Protection & Restoration Strategies	This grant will update channel migration zone mapping in an effort to protect Puget Sound flood zones and shorelines. Channel migration zones and river floodplains are ecologically productive areas heavily impacted by development. A further understanding of their extent is critical to assessing risks to both human development and habitat. This grant will update the channel migration zone mapping methodology; map areas for local trend analysis; and develop restoration and protection strategies. Outcomes: Identification and mapping of coastal management zones important for floodplain protection.
P25	6	Assessment of Marine and Floodplain Riparian Vegetation in the Hood Canal and Strait of Juan de Fuca	This grant funds an air photo assessment of riparian conditions along marine shorelines and selected major river corridors/floodplains of the Strait of Juan de Fuca and Hood Canal sub-basins. Riparian maps and datasets are planning tools that will inform tribes and partners in updating Shoreline Master Programs and Critical Area Ordinances; they will help refine salmon and nearshore habitat protection and landowner stewardship priorities; and these datasets would represent a baseline from which trends in riparian conditions could be measured. Outcomes: Shoreline protection; riparian protection; floodplain protection
P26	6	Floodplains by design – habitat recovery through collective action	The Nature Conservancy will identify floodplain areas in Puget Sound that have the highest potential to advance multiple benefits such as habitat and flood protection. The Conservancy and its partners will use this analysis as a basis to integrate flood risk reduction and ecosystem restoration information. This framework will help ensure that floodplain management decisions support Puget Sound recovery and community goals such as public safety and recreation. Partner organizations: Puget Sound Partnership, National Oceanic and Atmospheric Administration, Federal Emergency Management Agency, and U.S. Geological Survey

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P27	7	Analysis of Vegetation Effects on Levees	Project goal is to determine whether levee vegetation makes levees and revetments more or less susceptible to flood damage. Since the 1990s, King County, WA floodplain managers have observed that incorporating native vegetation in flood facility repairs decreases susceptibility to damage while supporting the objectives of the Clean Water Act and Endangered Species Act. Conversely, the U.S. Army Corps of Engineers has hypothesized that woody vegetation increases the risk of flood damage to levees. Thus woody vegetation must be removed from levees for local governments to be eligible for Corps cost-sharing programs to repair damaged levees and revetments. According to the 2008 Biological Opinion on the National Flood Insurance Program, there are 115 levees throughout Puget Sound enrolled and eligible for federal cost-sharing under Public Law 84-99. In King County, 46 miles of levees out of the County's 120-mile inventory of flood facilities are enrolled in the cost-sharing program. All are subject to the vegetation removal requirements. While an abundance of information has been gathered about the effects of native riparian vegetation on habitat characteristics natural riparian areas, little information is available on the role of vegetation in the structural integrity of levees and revetments, particularly those in the Puget Sound basin. Providing data to resolve this question is important because of the enormous public expense of repairing and maintaining flood infrastructure on rivers, and the need to conduct these public works in a most cost-effective manner.
P28	8	Lake Sammamish Kokanee Modeling	The overall objective of this work is to estimate the change in the amount of suitable habitat for kokanee (Oncorhynchus nerka) in Lake Sammamish, Washington, expected in this century due to climate change. Kokanee abundance in Lake Sammamish has declined dramatically since at least the 1970's, resulting in a petition for ESA protection in 2007. Currently, USFWS participates in a conservation supplementation effort to attempt to rebuild the population. However, the efficacy of such restoration efforts remains unknown, given expectations for the effects of climate change on habitat suitability. Kokanee require suitable dissolved oxygen concentration and temperature conditions to survive. Berge (2009) postulated that climate change (warming) could exacerbate the spatial and temporal extent of unsuitable dissolved oxygen concentration and temperature conditions for kokanee in Lake Sammamish. Unfortunately, like many restoration efforts, consideration of the effects of climate change has not been conducted (Battin et al. 2007). Results of this work will include estimates of future reductions in suitable habitat conditions for kokanee in Lake Sammamish. These results should provide a sound, quantitative basis for making future conservation and management decisions. The resulting model and methods can also be applied to other lakes and species in the region.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P29	9	Salish Sea Marine Survival Project	Changes in the Salish Sea are thought to be significantly affecting the abundance of our region's salmon and steelhead. Smolt-to-adult survival rates (primarily a reflection of survival in the marine environment) for many stocks of Salish Sea Chinook salmon, coho salmon, and steelhead has declined, in some cases to less than one tenth of the levels experienced in the 1980s. And extraordinary variations in sockeye, chum and pink salmon populations are perplexing scientists who work to predict their return as adults for harvest management. While there is a reasonable understanding of issues affecting salmon and steelhead productivity in the freshwater, we are hampered by an inadequate and fragmented understanding of issues affecting productivity in the marine environment. This is of great concern since we know the marine life stages are of equal importance to salmon and steelhead survival. Furthermore, the early marine phase, as juveniles in the Salish Sea, is generally considered one of the most critical periods for salmon and steelhead, where they are known to experience some of their most rapid growth and highest mortality rates. The Salish Sea Marine Survival Project (Project) is a transboundary effort to determine the primary factors affecting juvenile salmon and steelhead survival in the Salish Sea. The Project, coordinated by nonprofits Long Live the Kings (U.S.) and the Pacific Salmon Foundation (Canada), brings together multidisciplinary expertise from over 20 Federal and State agencies, Tribes, academia and nonprofit organizations on both sides of the U.S.-Canada border. Through the development of a comprehensive, ecosystem-based research framework; coordinated data collection and standardization; and improved information sharing, the Project will help managers better understand the critical relationship between salmon and the Salish Sea. This Project was initiated in 2012 and will last seven years. Relevance to Puget Sound Science Work Plan and Action Agenda: The Salish Sea Marine Survival Project works to determine the most significant factors affecting juvenile salmon survival in the Salish Sea, directly addressing priority actions identified in the 2011-2013 Puget Sound Partnership Science Plan (p. ii, Table ES-1, 9th bullet) and in the Puget Sound Partnership 2012/2013 Action Agenda (p. 93, A6. Protect and Recover Salmon, Tribal Habitat Priorities table, item 6g).
P30	9	Puget Sound salmonid tracking	Ultrasonic tracking of salmonids in Puget Sound, including coho, Chinook, steelhead, and cutthroat trout, in collaboration with other investigators
P31	10	Combating invasive species	The council will use the grant to continue work already started to identify the extent and impact of invasive species in Puget Sound watersheds. The council will build a database and species maps, and develop a survey tool to update the information annually. This work will bring together information from a variety of existing sources into one database, allowing the council to assess the current status of invasive species and identify information gaps.
P32	10	Costs of living for juvenile Chinook salmon in an increasingly warming and invaded world	Rapid environmental change in freshwater ecosystems has created a need to understand the interactive effects of multiple stressors, with temperature and invasive predators identified as key threats to imperiled fish species. We tested the separate and interactive effects of water temperature and predation by non-native smallmouth bass (Micropterus dolomieu) on the lethal (mortality) and sublethal (behavior, physiology, and growth) effects for juvenile Chinook salmon (Oncorhynchus tshawytscha) in seminatural stream channel experiments. Over 48 h trials, there was no difference in direct predation with warmer temperatures, but significant interactive effects on sublethal responses of juvenile salmon. Warmer temperatures resulted in significantly stronger and more variable antipredator responses (surface shoaling and swimming activity), while physiological indicators (plasma glucose, plasma cortisol) suggested suppression of physiological mechanisms in response to the combined stressors. These patterns corresponded with additive negative growth in predation, temperature, and combined treatments. Our results suggest that chronic increases in temperature may not increase direct predation over short periods, but can result in significant sublethal costs with negative implications for long-term development, disease resistance, and subsequent size-selective mortality of Pacific salmon.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P33	10	Prey naivety in the behavioural responses of juvenile Chinook (Oncorhynchus tshawytscha) salmon to an invasive predator	Non-native predators might inflict proportionally higher mortality on prey that have no previous experience of them, compared to species that have coexisted with the predator for some time. We tested whether juvenile Chinook salmon (Oncorhynchus tshawytscha) were less able to recognise a non-native than a native predator, by investigating behavioural responses to the chemical cues of the invasive smallmouth bass (Micropterus dolomieu) and the native northern pikeminnow (Ptychocheilus oregonensis) in both laboratory and field experiments. Laboratory results demonstrated strong innate antipredator responses of individual juvenile Chinook salmon to northern pikeminnow; fish spent 70% of time motionless and exhibited 100% greater panic response than in controls. By contrast, antipredator responses to the chemical cues of smallmouth bass did not differ from controls. These results were supported by similar differences in recognition of these predator odours by groups of juvenile Chinook salmon in fully natural conditions, though responses reflected a greater range of antipredator behaviours by individuals. In field trials, responses to northern pikeminnow odour resulted in increased flight or absence, reductions in swimming and foraging, and increased time spent near the substratum, compared to smallmouth bass odour. Given that survival of juvenile fish is facilitated by predator recognition, our results support the hypothesis that naivety may be an important factor determining the effect of non-native predators on prey populations. Efforts to manage the effect of native and non-native predators may benefit by considering complex behavioural interactions, such as these at the individual and group levels.
P34	10	The aquarium trade as an invasion pathway in the Pacific Northwest	The aquarium trade moves thousands of species around the globe, and unwanted organisms may be released into freshwaters, with adverse ecological and economic effects. We report on the first investigation of the ornamental pet trade as an invasion pathway in the Pacific Northwest region of the United States, where a moderate climate and a large human population present ample opportunities for the introduction and establishment of aquarium trade species. Results from a regional survey of pet stores found that the number of fish (n=400) and plant (n=124) species currently in the aquarium trade is vast. Pet stores import thousands of fish every month, the majority of which (58%) are considered to pose an ecological threat to native ecosystems. Our propagule pressure model suggests that approximately 2,500 fish (maximum ~21,000 individuals) are likely released annually to the Puget Sound region by aquarists, and that water temperatures in many parts of Washington are suitable for establishment of populations. In conclusion, the aquarium trade may be a significant source of past and future invasions in the Pacific Northwest, and we recommend enhanced public education programs, greater regulation of the aquarium industry, and improved legislation of nonnative species in the ornamental trade.
P35	10	The state of native and invasive crayfish in the Pacific Northwest	We summarize the state of knowledge on crayfish in the Pacific Northwest region of the United States and Canada, emphasizing distributions and conservation status of native species, as well as known introductions and distributions of alien crayfishes, and reviewing fishing regulations relevant to crayfish across five states and provinces. We found the present distribution and ecology of native crayfishes in this region to be poorly known, inhibiting accurate conservation assessments and management. The number of alien crayfishes established in the region, ranging in distribution from localized to widespread and including several major invasive species, now exceeds the diversity of native crayfishes. The treatment of crayfish by fishing regulations and laws varies among states and provinces, potentially impairing successful management and conservation of these species in shared ecosystems such as the Snake and Columbia rivers. We conclude with recommendations for crayfish management and regulation, and a call for more research on the ecology of crayfish in the Pacific Northwest.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P36	10	Crayfish occupancy and abundance in lakes of the Pacific Northwest, USA	Crayfish are ecologically important in freshwater ecosystems, but few investigators have evaluated landscape patterns of their prevalence and abundance in temperate lakes. We report results of a crayfish survey for 100 lakes in the Puget Sound lowlands of Washington State (USA) serving as a census of the distributions of the signal crayfish Pacifastacus leniusculus and previously unknown populations of nonnative crayfish, including the red swamp crawfish Procambarus clarkii. We modeled crayfish presence and abundance with classification and regression trees based on multivariate ordinations of lake-, riparianzone-, and watershed-scale predictors. The presence of P. leniusculus was best predicted by a lake-scale gradient of greater depth (present) to greater productivity (absent), but forested riparian zones with firm or rocky substrates also supported crayfish presence. Prevalence and abundance of P. leniusculus were low relative to what has been reported for native crayfish in other lake districts or for P. leniusculus in its Asian and European invasive ranges. We hypothesize that the erratic distribution of P. leniusculus in Puget Sound lakes may be attributable to challenges of postglacial colonization in this region and potentially to human introductions of this crayfish. Our study expands the geographic and taxonomic scope of inquiry into relationships between crayfish populations and lakes at landscape scales and provides a baseline for monitoring and understanding crayfish in an increasingly urban and invaded region of North America.
P37	10	Forecasting the vulnerability of Washington lakes to aquatic plant invasions	Prevention is an integral component of many management strategies for aquatic invasive species, yet this represents a formidable task when the landscapes to be managed include multiple invasive species, thousands of lakes, and limited resources to implement management strategies. Species distributional modeling can facilitate prevention efforts by identifying lakes that are most vulnerable to future invasion based on the likelihood of introduction and environmental suitability for establishment. We used a classification tree approach to predict the vulnerability of 319 lakes (Washington State) to three widespread invasive plants: Eurasian milfoil, Brazilian elodea, and curly leaf pondweed. Overall, the distribution models predicted that 54 study lakes (17% of the study lakes) were at risk of being invaded by at least one aquatic invasive plant, and many of these predicted vulnerable lakes currently support high native plant diversity and endemism. Highly vulnerable lakes are concentrated in western Washington in areas with the highest human population densities, and in eastern Washington along the Columbia Basin Irrigation Project and the Okanogan River Basin that boast hundreds of lakes subject to recreational use. Overall, invasion potential for the three species was highly predictable as a function of lake attributes describing human accessibility (e.g., public boat launch, urban land use) and physical-chemical conditions (e.g., lake area, elevation, productivity, total phosphorous). By identifying highly vulnerable lake ecosystems, our study offers a strategy for prioritizing on-the-ground management action and informing the most efficient allocation of resources to minimize future plant invasions in vast freshwater networks.
P38	10	Assessing lethal dissolved oxygen tolerance for invasive tunicate Ciona savignyi in Puget Sound	Ciona savignyi is a solitary tunicate (Phylum Chordata, Class Ascidiacea) native to Japan that has invaded coastal habitats in the north-east Pacific and New Zealand. In the Puget Sound of Washington, USA, we examined the ability of C. savignyi to survive in artificially created hypoxic environments to determine if reduced dissolved oxygen (DO) treatments could be a viable control method. In laboratory bioassays, treatment groups that were immersed in DO concentrations ranging from completely hypoxic (1 mg/L) to low DO (5 mg/L) had zero survivorship of individually isolated tunicates after 14 to 22 days of exposure, respectively. Additionally, hypoxic conditions (approximately 1.5 mg/L) were created in the field using polyethylene tarp wraps applied around dock surfaces fouled with C. savignyi in a Puget Sound marina. To estimate mortality rates underneath the tarp wraps, dock units with clusters of C. savignyi remained wrapped for 10, 14 and 18 days and displayed decreasing survivorship with increased wrap time (76%, 51% and 33%, respectively). Our laboratory and field experiments indicate that wrapping docks fouled by C. savignyi with polyethylene tarps may be an effective management option to locally-control and reduce the spread of this tunicate species from marina habitats, which serve as hubs for non-native species transport via hull fouling. These results inform the development of a rapid response plan for C. savignyi in the state of Washington and may be a viable control method for other high priority non-native tunicates pending further work on species-specific tolerances to low DO.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P39	10	Does aquatic weed management promote habitat restoration for Olympic mudminnow?	A principal goal of aquatic weed control is to improve habitat conditions for fish and wildlife, but limited resources can preclude evaluation of habitat condition and occupancy by native fishes following removal. Given this, considerable opportunities exist to examine ecological benefits of aquatic weed control for native fishes in Washington. This project assesses fish response in the Chehalis River basin to invasion and removal of two aquatic nuisance species: Brazilian elodea (Egeria densa) and parrotfeather (Myriophyllum aquaticum). Both are Class B Noxious Weeds distributed in numerous counties in Washington State, and the subject of ongoing control efforts in the Chehalis River. To quantify fish response, we are focusing on the habitat preferences and abundance of Olympic mudminnow (Novumbra hubbsi) as a model organism; as a sensitive species of concern in the State of Washington, mudminnow are in need of science which supports effective restoration programs. We will also quantify the effect of weed removal on generalized habitat suitability metrics for other fish species. Our study has three objectives: 1. Establish aquatic vegetation preferences for Olympic mudminnow, 2. Assess differences in population abundance and habitat quality for Olympic mudminnow between areas with and without aquatic weed infestations and, 3. Assess the potential for invasive weed removal to improve habitat quality and availability for fish populations. These objectives are being accomplished through a hierarchical field survey of infested and uninfested sites and an impact study designed around existing and planned (future) control efforts by project collaborators in the basin.
P40	11	Hydrogeomorphic classification of Washington State rivers to support emerging environmental flow management strategies	As demand for fresh water increases in tandem with human population growth and a changing climate, the need to understand the ecological tradeoffs of flow regulation gains greater importance. Environmental classification is a first step towards quantifying these tradeoffs by creating the framework necessary for analysing the effects of flow variability on riverine biota. Our study presents a spatially explicit hydrogeomorphic classification of streams and rivers in Washington State, USA and investigates how projected climate change is likely to affect flow regimes in the future. We calculated 99 hydrologic metrics from 15 years of continuous daily discharge data for 64 gauges with negligible upstream impact, which were entered into a Bayesian mixture model to classify flow regimes into seven major classes described by their dominant flow source as follows: groundwater (GW), rainfall (RF), rain-with-snow (RS), snow-and-rain (SandR), snow-with-rain (SR), snowmelt (SM) and ultra-snowmelt (US). The largest class sizes were represented by the transitional RS and SandR classes (14 and 12 gauges, respectively), which are ubiquitous in temperate, mountainous landscapes found in Washington. We used a recursive partitioning algorithm and random forests to predict flow class based on a suite of environmental and climate variables. Overall classification success was 75%, and the model was used to predict normative flow classes at the reach scale for the entire state. Application of future climate change scenarios to the model inputs indicated shifts of varying magnitude from snow-dominated to rain-dominated flow classes. Lastly, a geomorphic classification was developed using a digital elevation model (DEM) and climatic data to assign stream segments as either dominantly able or unable to migrate, which was cross-tabulated with the flow types to produce a 14-tier hydrogeomorphic classification. The hydrogeomorphic classification provides a framework upon which empirical flow alteration–ecological response relationships can subsequently be developed using ecological information collected throughout the region.
P41	11	Are large-scale flow experiments informing the science and management of freshwater ecosystems?	Greater scientific knowledge, changing societal values, and legislative mandates have emphasized the importance of implementing large-scale flow experiments (FEs) downstream of dams. We provide the first global assessment of FEs to evaluate their success in advancing science and informing management decisions. Systematic review of 113 FEs across 20 countries revealed that clear articulation of experimental objectives, while not universally practiced, was crucial for achieving management outcomes and changing dam-operating policies. Furthermore, changes to dam operations were three times less likely when FEs were conducted primarily for scientific purposes. Despite the recognized importance of riverine flow regimes, four-fifths of FEs involved only discrete flow events. Over three-quarters of FEs documented both abiotic and biotic outcomes, but only one-third examined multiple responses, thus limiting how FE results can inform dam management. Future FEs will present new opportunities to advance scientifically credible water policies, and here we highlight a number of examples from the Pacific Northwest region of the United States.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P42	12	Peak Flows and Chinook Survival in the Stillaguamish Watershed: Modeling the Relative Importance of Natural and Antrhopogenic Factors; Prioritizing Restoration and Protection Actions Utilizing a Parcel-Based GIS Framework	This project investigates the mechanisms of flow driven Chinook mortality, separate climate induced peak flow drivers from those related to anthropogenic factors, and develops a parcel based prioritization framework for restoration and protection actions in the North and South Fork of the Stillaguamish River. Outcomes: Hydrological protection and restoration
P43	12	White River Bioenergetics	The overall objective of the study is to evaluate how current and potential future hydraulic conditions between the A Street Bridge and the 8th Street Bridge on the Lower White River affect the potential for fish habitat and growth. Specific objectives of the study are to: 1. Estimate the abundance and distribution of potential juvenile spring Chinook habitat in the study reach for current and simulated post-setback levee conditions under low- and high-flow conditions; and 2. Estimate the abundance and distribution of energetically favorable locations under current and future conditions for low- and high-flow conditions using a nested 2-dimensional hydrologic, invertebrate-drift, and bioenergetics model. Project website http://wa.water.usgs.gov/projects/whiteriverbio/summary.htm
P44	12	Kitsap Co: Improve stream data to protect freshwater ecosystems	County will expand its water typing assessment by conducting a field survey of stream reaches and developing, testing and refining a computer model to better predict distribution of streams and fish habitats throughout the county. This includes developing an interactive, internet-based site available to the public. Partner organizations: Wild Fish Conservancy and University of Washington
P45	13	Mapping Puget Sound Feeder Bluffs	The primary outputs of this project are sound-wide data on the location of feeder bluffs and guidance on the significance and use of this information. Secondary outputs include coordination and engagement with other organizations, supporting interest and projects by advisory group members, and increased capacity at Ecology to provide coordination and guidance on these issues.
P46	13	Protecting the Strait of Juan de Fuca Nearshore	The work funded through this grant will provide new data and improved tools to support and enhance effective shoreline regulation in Clallam County. It will link coastal physical processes, the economic values of these functions, and the land use practices required to protect these functions. New data such as high-precision bluff erosion rates will help to delineate hazardous areas. The project will also quantify the economic values of ecosystem services in the Elwha and Dungeness Nearshore and share the results with landowners, developers, and other stakeholders. Community outreach and workshops will enhance public understanding of the connection between land use, property management, and nearshore ecosystem functions and values along Clallam County's shoreline. Partners: Clallam County, Washington Department of Natural Resources, Washington Department of Ecology, Earth Economics
P47	13	Protecting Ecosystem Functions with Sea Level Rise and Cumulative Effects Management Tools	The goal of this project is to achieve long-term protection of nearshore ecosystems by creating new technical tools and adaptive management strategies to address cumulative impacts and sea level rise within existing regulatory frameworks, provide policy reform recommendations, and encourage improvements to conservation policies at the local and regional level. Partners: Coastal Geologic Services, Salish Sea Biological and a technical team of local, state, tribal and university experts
P48	13	Model sediment-water interactions in Puget Sound	Ecology proposes to build a sediment diagenesis component to the Puget Sound Dissolved Oxygen Model developed by PNNL. Dissolved oxygen modeling efforts are indicating that sediment-water interactions strongly influence primary productivity, particularly in shallow embayments. These regions are where human impacts on dissolved oxygen could be greatest. The current efforts prescribe sediment oxygen demand and nutrient releases and adjust these fluxes based on alternative external loading. Where nutrient loads decrease, the sediment-water interactions also weaken. The relationship is externally specified, but a sediment diagenesis component would couple those fluxes to changes in external loading. A sediment diagenesis model would allow us to understand the timing of sediment interactions. This could improve model performance through better seasonal variability, and it would allow us to understand how differences in winter discharges carryover to summer dissolved oxygen impacts.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P49	13	Population identity of Pacific herring spawning in May 2012 at the Seattle waterfront	Pacific herring show relatively little variation in spawning times compared to Atlantic herring, spawning from January in the south (California) to June in Alaska (Gustafson et al. 2006). However, even within specific regions, spawning times can be vary over several months (Gustafson et al. 2006). In Puget Sound as well as in British Columbia, most populations spawn January – March, with the exception of a few populations spawning as late as May and June (Stick & Lindquist 2009). Cherry Point is one of these late spawning populations, with special conservation interest because it once was the largest population in Puget Sound but now is one of the smallest. Previous genetic studies in both Puget Sound (Small et al. 2005; Mitchell 2006) and British Columbia (Beacham et al. 2008) demonstrated that differences in spawning time was a major isolation mechanisms, resulting in significant genetic differences among populations with different spawning times. Beacham et al (2008) also showed that those genetic differences were sufficient to allow population identification in samples of unknown origin.In May 2012, spawning was observed for the first time in Elliott Bay, the Seattle waterfront. This spawning event took place at a similar time as at Cherry Point, suggesting that these herring were Cherry Point spawners, even though earlier spawning populations are in close vicinity. Although spawners could not be sampled, fertilized eggs were collected. We have shown previously that herring eggs can be used for population studies (Mitchell et al, unpubl data), although care has to be taken not to include related eggs which could bias allele frequency estimates.
P50	13	Local adaptation in Puget Sound Pacific cod (Gadus macrocephalus): phenotypic and genomic differentiation and the conservation of a depleted population in a warming environment	We propose to investigate the level of local adaption in Salish Sea Pacific cod by carrying out a genome scan using next generation sequencing technologies in combination with captive common garden experiments. The proposal responds to one of the four primary goals of WSG "understanding the marine environment and conserving marine resources while providing for sustainable use and ensuring healthy populations in the future" (Living Marine Ecosystems). This goal is particularly important in species supporting large fisheries in part of their range while being depressed in others, such as Pacific cod. Understanding the reasons for such differences in population status would "support the recovery of depleted species" and help understanding "natural variability in marine biodiversity". As Puget Sound cod appear to be affected by warm temperatures, a thorough understanding of genetic factors involved in local adaptation also aligns with the WSG strategy to "monitor, forecast …. ocean stressors such as climate change" (Ocean and Coastal Environmental Health).
P51	13	Coastal Habitats in Puget Sound – Effects of Urbanization Task	The U.S. Geological Survey (USGS) Multi-Disciplinary Coastal Habitats in Puget Sound Project (CHIPS) addresses the need for scientific understanding about the physical and biogeochemical processes and socio-economic values that shape and sustain healthy nearshore habitats and ecosystems. The "Effects of Urbanization" Task investigates how non-natural disturbances associated with urban development and human activities in coastal watersheds and along shorelines alter physical, chemical, and biological conditions and processes in the nearshore.
P52	13	McGlinn Causeway Sediment Transport Modeling	A causeway and a jetty have restricted juvenile salmonid access to prominent rearing habitat available in Padilla Bay and reduced freshwater input to the channel. This has greatly increased channel salinity and created a physiological barrier for juvenile Chinook salmon, which are very sensitive to high salinity. Restoring river-channel connectivity is necessary to allow juvenile salmon access to rearing habitat in Padilla Bay. The overall objective of the McGlinn Island Causeway Feasibility study was to evaluate the potential of restoring historical connectivity between the North Fork Skagit River and the Swinomish Channel connecting Skagit and Padilla Bays. The objective of the associated PNNL modeling task was to conduct hydrodynamic simulation of the proposed restoration alternatives to assess whether expected benefits such as creation of brackish environment and desired level of connectivity for downstream fish migration could be achieved. The hydrodynamic model of Skagit Bay, Swinomish Channel, and Padilla Bay was refined to include small-scale geometric features associated with the existing river training structures at the site, including the jetties and the dikes. The model reproduced the existing hydrodynamic condition and is being used to evaluate two alternative restoration concepts. Concept 1 involves lowering a river training jetty from McGlinn Isand across the river channel. Concept 2 consists of creating a causeway and a dredged channel connecting the North Fork of the Skagit River to Swinomish Channel through Dunlop Bay.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P53	13	Nonlinear Responses to Global Change in Linked Aquatic and Terrestrial Ecosystems and Effects of Multiple Factors on Terrestrial Ecosystems	This project was motivated primarily by a deep concern about the possibility of a projected sea-level rise and future hydrologic changes affecting coastal fisheries through altered circulation and transport, reduction of available brackish tidal marsh habitat, and increased turbidity. Higher salinity and turbidity in the river distributaries could affect drinking water and agricultural water supplies and drainage. However, there is a lack of quantitative site-specific information and considerable uncertainty about the extent and magnitude of resulting estuarine response due to the oceanographic complexity associated with the Skagit sub-basin within the Puget Sound inland fjord setting. The overall objective of this project was to develop a practical tool that can predict ecological consequences and likely impacts on the landscape from sea-level rise and future river flow and sediment load alteration. We made progress toward achieving this objective by developing and linking a spatially explicit hydrodynamic and sediment transport model of Padilla Bay and Skagit Bay to inform the development of a mechanistic wetland elevation dynamics and vegetation unit model (Western Washington University [WWU]), and development of models of tidal channel geomorphology and juvenile salmon abundance and distribution (Skagit River System Cooperative).
P54	13	Land Use Planning Tools for Coastal Habitat - Cumulative Effects of Nearshore Restoration on Habitat and Fish Migration in Northern Puget Sound, Washington	The loss of habitat is regarded as one of the major causes for declining fish stocks. Restoration actions ideally suited from the perspective of restoration of ecological functions may result in economic losses because of unexpected outcomes, such as flooding during high flow seasons or land mass loss due to erosion. Restoration actions planned without the benefit of tools, such as estuarine circulation models and hydraulic and hydrologic analysis packages, run the risk of not achieving the desired outcome because the estuarine response may be different from that envisioned. The objective of this research was to develop a numerical modeling tool and techniques for restoration managers and land-use planners to use when planning and designing restoration actions. We accomplished this goal by refining the methods for incorporating high-resolution light detection and ranging (LiDAR) data into the simulation of estuarine circulation and transport in the intertidal mudflats with wetting and drying marsh features.
P55	13	Fir Island Farm Restoration	The Fir Island Farm estuary restoration project along Skagit Bay will involve setting back an existing dike and restoring approximately 127 acres of tidal wetland to restore tidal interaction and improve salmonid rearing habitat. The complex and dynamic Skagit River Delta and Skagit Bay estuarine system calls for the need of a multi-faceted and multi-dimensional analysis using a variety of tools through an integrated modeling approach. In particular, a high resolution coastal ocean model was utilized to simulate the hydrodynamic conditions driven by tides, river inflow and wind. Analysis on the effects of wind-induced wave and surge under extreme storm events, as well as future sea level rise on the maximum water level near the project site was also conducted. Shannon & Wilson Inc. (S&W) contracted Battelle Memorial Institute, Pacific Northwest Division to provide hydrodynamic modeling analysis and consulting support in connection with Fir Island Estuary Restoration project. The modeling effort consists of four tasks: 1) Hydrodynamic modeling of existing conditions in Skagit Bay and the restoration site; 2) Hydrodynamic modeling of the full dike removal restoration alternative; 3) Hydrodynamic modeling of the dike removal with spur dike restoration alternative; 4) Model analysis on the effect of extreme storm events and sea level rise on water levels near the project site.
P56	14	Vulnerability and Resilience of Coastal Estuaries	This project will focus on restoring river deltas and estuaries across the Sound. Currently, habitats and species are declining due to altered ecological processes and habitat loss. Restoration has been limited due to existing land uses and costs of restoring these important coastal habitats. This project will build both technical capacity and community support for large scale restoration projects in seven different estuaries across Puget Sound: the Nooksack, Skagit, Stillaguamish, Snohomish, Nisqually, Skokomish and Elwha. A mix of habitat restoration strategies including the protection of existing land use will be conducted across these seven estuaries. Both estuary protection and restoration approaches will be discussed and evaluated with the support of local communities and land owners. Outcomes: Map vulnerability portfolio for each of the seven deltas at a scale directly usable by local planners.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P57	14	Puget Sound Nearshore Ecosystem Restoration Project Selection and Design	Many characteristics of Puget Sound depend upon the nearshore zone, which is defined as encompassing the shallow waters of estuarine deltas to the outer marine shorelines - from the tops of the coastal bluffs to water depths where light supports plant growth, and up coastal rivers and streams to the limits of tidal influence. The Puget Sound Nearshore Ecosystem Restoration Project and general investigation study focuses on this nearshore zone. It will provide preliminary design and cost estimates for 30 - 45 restoration projects concentrated in this nearshore zone. The goals of the program are to identify significant ecosystem problems, evaluate system-scale solutions, and restore critical nearshore processes and habitats, including bluffs, beaches, shorelines, mudflats, salt marshes, gravel spits and estuaries.
P58	14	Monitoring and Adaptive Management of the Nisqually Delta Tidal Marsh Restoration: Restoring Ecosystem Function for Salmon	Project description: The Nisqually Delta represents the largest tidal marsh restoration in Puget Sound. It remains uncertain how the Delta and its biota will respond to restoration of tidal inundation. The purpose of this proposal is to fund research by the Nisqually Tribe and three U.S. Geological Survey partners focused on assessing the effectiveness of the Delta projects at restoring estuarine processes, habitats, and the capacity of the Delta for supporting Chinook salmon and other fish.
P59	14	20% More Eelgrass by 2020: Restoration Site Identification, and Investigating Restoration Barriers	This project will locate sites within Puget Sound and the Strait of Juan de Fuca suitable for successful eelgrass restoration, with specific focus on identifying sites that would be conserved from future anthropogenic disturbances and resilient to climate change. This project will develop a habitat suitability ratings specific to Puget Sound; apply and link a nearshore hydrodynamic model and a water properties model to predict conditions required by eelgrass; interact with local, regional, and tribal shoreline planners and regulators and research scientists to determine where regulations are not effectively reducing stress to eelgrass; and provide recommendations on restoring and protecting resilient eelgrass meadows. Partners: Pacific Northwest National Laboratory
P60	14	Port Susan Bay Dike Setback—River Delta	Funds will be used to complete the implementation phase and initiate evaluation phase of this project for dike setback and restoration of 150 acres of estuarine habitat.
P61	14	Milltown Island/ South Fork Skagit River Restoration —River Delta	This river delta restoration project includes demolition of ½ mile of relic dikes on Milltown Island and evaluation of conditions at Deepwater and Wiley Slough project sites. These activities will inform adaptive management recommendations targeted toward future actions in the South Fork delta.
P62	14	Quantifying the Impacts of Shoreline Armoring	Using a multidisciplinary approach, the Skagit River System Cooperative will study the impacts of shoreline armoring on nearshore processes and species. Project partners include the Swinomish Indian Tribal Community and University of Washington researchers. The information gathered will serve to fill a critical knowledge gap identified by Puget Sound resource managers and researchers. Partners: University of Washington, Swinomish Tribal Community, Tulalip Tribe, NOAA
P63	14	Social Marketing Strategy to Reduce Puget Sound Shoreline Armoring	This project is part of a multi-pronged effort to ultimately reduce the amount of armoring along Puget Sound marine shorelines, evaluate the barriers and motivators for private shoreline landowners in choosing to remove or forgo bulkheads, rip rap, and other modifications. Shoreline armoring locks beaches into a fixed state that prevents them from adjusting to changes in sea level. This project will provide clear, innovative, and realistic approaches for entities in the Puget Sound region to implement social marketing and behavior change campaigns. In the future, the Grant Program will provide this social marketing and behavior change strategy, as well as information about incentive options, to local governments and other entities interested in implementing armoring reduction programs.
P64	14	Marine Shoreline Design Guidance	WDFW will lead the development of engineering guidance on soft shoreline armoring techniques. A lack of good guidance on softer shoreline armoring is a significant barrier to the use of alternatives to hard armoring in Puget Sound. This project will evaluate the performance of six major shoreline protection techniques with respect to site and process unit conditions, and compile a set of best practices and determine which techniques are appropriate in certain environments.
P65	14	Monitoring and Adaptive Management of the Nisqually Delta Tidal Marsh Restoration: Restoring Ecosystem Function for Salmon	The Nisqually Delta represents the largest tidal marsh restoration in Puget Sound. It remains uncertain how the Delta and its biota will respond to restoration of tidal inundation. The purpose of this proposal is to fund research by the Nisqually Tribe and three U.S. Geological Survey partners focused on assessing the effectiveness of the Delta projects at restoring estuarine processes, habitats, and the capacity of the Delta for supporting Chinook salmon and other fish. Outcomes: Estuary habitat restoration monitoring

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P66	14	Evaluating the Ecological Health of Puget Sound's Pelagic Foodweb	The pelagic zone is a large and important component of Puget Sound's ecosystem, but basic information is lacking on differences among oceanographic basins, linkages between abiotic features, water quality, and pelagic biota, and the effects of anthropogenic activities. This dearth of information complicates our ability to identify useful metrics to measure the pelagic zone's key characteristics determining ecological health. To address these issues, we conducted a multi-trophic level assessment in six oceanographic basins within Puget Sound using a sampling scheme designed to detect both basin-wide differences and relationships between pelagic ecosystem attributes and land use in catchments surrounding sites. We measured over 20 potential indicators of nearshore pelagic ecosystem health at 79 sites in six oceanographic basins of Puget Sound. These metrics included measurements of abiotic conditions and nutrient availability, and abundance and diversity of phytoplankton, bacteria, zooplankton, jellyfish, and pelagic fish species. In many taxa from lower to middle trophic levels, and for a comprehensive suite of abiotic attributes, we observed strong seasonal and spatial structure. South Sound and Hood Canal had the most reduced dissolved oxygen and pH, highest relative abundance of jellyfish, and lowest abundance of forage fish and fish species richness. In contrast, Rosario (north of Fidalgo Island) and Whidbey Basins were characterized by relatively few abiotic or nutrient problems, few deviations in the abundance of different groups of microbes and phytoplankton, relatively high densities of non-gelatinous (i.e., not jellyfish) zooplankton, and high fish species richness and relatively high forage fish abundance. Admiralty Inlet and the Central Basin scored in between this range, although they too exhibited high jellyfish abundance and reduced forage fish abundance and fish species richness relative to Rosario and Whidbey Basins. Furthermore, many of the potential indicators we measured were sensitive to land use, with a general pattern that abiotic and lower trophic patterns were most sensitive, and patterns in fish abundance and diversity were the least sensitive. We found positive relationships between land use and jellyfish abundance, as well as shifts of jellyfish diets to lower trophic levels in sites with greater land use. These findings provide empirical support for the bifurcated foodweb hypothesis, which predicts that stressors from development simplifies foodweb structure, leading to cascading effects on middle trophic levels like planktivorous salmon and forage fish, and favoring jellyfish and other consumers of microplankton. Despite these patterns, land use rarely explained more than 5% of the variation in observed data, indicating a dominant marine influence and the potential for resilience of Puget Sound's pelagic waters to anthropogenic influence. The strong spatial structure observed in our results indicates that different pelagic food webs exist across the system. Consequently, target conditions, current health status, or both, cannot be uniform across greater Puget Sound. These are critical considerations for management of the Puget Sound ecosystem, and we expect that further analysis of our results in the context of other studies will improve our understanding of the underlying causes of the patterns we observed across Puget Sound.
P67	14	Qwuloot/Snohomish estuary restoration monitoring	
P68	14	Keyport Restoration and Adaptive Management Plan	Project purpose is to develop a mitigation/restoration and adaptive management plan in support of compensatory mitigation to be conducted on a coastal lagoon located at Naval Underwater Warfare Center (NUWC), Division, Keyport, WA. The adaptive management plan will identify restoration goals, define performance metrics required to evaluate the ecological benefits of the restoration, provide an existing conditions/baseline monitoring quality assurance project plan, document baseline sampling and analysis, provide recommended options for restoration alternatives, and undergo technical review and evaluation by resource agencies, tribes with treaty rights, environmental groups and other stakeholders, as well as the scientific community.
P69	14	Impacts of armoring on Puget Sound beaches: diverse effects on diverse scales.	Aims to determine systematic physical and biological effects of beach armoring
P70	15	Impacts of Outfalls on Eelgrass	DNR will study locations where outfalls discharge in close proximity to eelgrass beds to identify areas of greatest potential impacts, summarize impacts to eelgrass from outfalls through literature review, and gather data through tissue samples of eelgrass contamination in Puget Sound. This information will contribute to the understanding of the impacts of outfalls on eelgrass and will support informed management. It is linked to the "Toxic Contaminant Monitoring in Mussels" grant

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P71	15	Milwaukee Dock Eelgrass Restoration	Eelgrass restoration at the Milwaukee Dock in Eagle Harbor on Bainbridge Island is being done in conjunction with the Elliott Bay Trustee Council (and therefore numerous state and federal agencies along with the Suquamish and Muckleshoot Tribes) to improve regional natural resources off Bainbridge Island. Large depressions outside Eagle Harbor are being filled with appropriate sediment to a depth conducive for supporting eelgrass populations. Eelgrass on the perimeter of these depressions was collected by scientific divers and cultivated at the PNNL Marine Sciences Laboratory in Sequim, Washington during construction activities. The eelgrass is being planted back into the newly created habitat to restore the full extent of the eelgrass meadow. The planting is being conducted experimentally such that the results will help guide future restoration projects in region. This project is also unique in that it employs habitat engineering and collaborations between numerous entities to increase the ecosystem services provided in the area.
P72	15	Eelgrass Protocol	PNNL produced a guidance document for activities in the Pacific Northwest that might impact local eelgrass populations. This protocol explains the importance of eelgrass locally, explores potential stressors to eelgrass from construction and other activities, summarizes the legal protections for eelgrass in the area, discusses methods for assessing populations and potential impacts, and addresses on potential mitigation strategies. The document was produced with input from state, federal, and tribal entities and resides with the US Army Corps of Engineers. It is hoped this document will be provided to applicants for permits relating to activities in coastal marine habitats.
P73	16	Can qualitative food-web modeling provide management guidance in data-poor systems?	Understanding the trade-offs among management actions related to marine species is critical for prioritization. The best approach for assessing trade-offs among interacting species is within a food web model. However, some food web models are notoriously data- and time-intensive to build. We offer a simplified approach to food web modeling, qualitative food web models, that are simpler to assemble and may offer a more straight-forward approach to assessing trade-offs between management actions.
	17		[no projects]
P74	18	Demographic structure of Puget Sound herring	Small-scale genetic and demographic diversity can stabilize populations on a larger scale. However, subpopulations of pelagic fish species can be difficult to distinguish. Here, we examine demographic diversity in 21 stocks of Pacific herring (*Clupea pallasii*) in Puget Sound, WA using a multivariate auto-regressive state-space (MARSS) model. Herring populations associated with individual spawning beaches are asynchronous share a common negative growth rate across the Puget Sound basin. We use survey data from both acoustic trawls and beach egg surveys to estimate growth trends. We find that both survey techniques observe the same underlying processes, and egg surveys on beaches are a more accurate estimator of total spawning biomass. We estimate the effects of local environmental conditions on spawning beaches and regional conditions on a basin-wide scale. Winter upwelling and Pacific Decadal Oscillation (PDO) do not explain variation in stock biomass, but may instead affect recruitment. The absence of correlation between spawning beach conditions and total spawning biomass suggests that environmental factors affecting juvenile herring may not be manifested in year-to-year fluctuations in adult spawning biomass.
P75	18	Habitat Limitation of Pacific Herring in Puget Sound	Pacific herring (*Clupea pallasii*) and eelgrass (*Zostera marina* L.) are two ecosystem indicators identified by the Puget Sound Partnership, for which targets have been developed. Some Pacific herring populations in Puget Sound have demonstrated downward trends in abundance in recent years. Very little is known about the limitations on Puget Sound herring productivity, and recovery requires identifying vulnerabilities of herring to natural and human pressures in the ecosystem. Pacific herring spawn in nearshore habitats, attaching their eggs to submerged vegetation, including eelgrass , as well as other substrates. Because some eelgrass meadows have contracted in their areal coverage in some areas in Puget Sound, it has been hypothesized that recovery of herring populations is linked to increasing eelgrass areal coverage in Puget Sound. This project aims to determine whether Puget Sound herring populations are limited by available eelgrass habitat. To do this, we will conduct field surveys of multiple herring spawning sites in Puget Sound, measuring the rates at which herring eggs are lost or senesce before maturation, on various spawning substrates through time. We will also retain a portion of all samples collected to each spawning site to incubate in the laboratory and estimate intrinsic egg mortality rates. These two metrics will be combined to determine which habitats are the highest quality for herring spawn. We will then use vegetation survey data from WDFW to quantify the amount of available high-quality (and other) habitat at each spawning site to determine whether this high-quality habitat is less available than other habitat, and therefore whether herring population trends may be related to availability of high-quality spawning habitat.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P76	18	Historical habitat effects on Puget Sound herring	Nearshore beach and vegetated habitats are utilized as spawning habitat for many forage fishes. One of the least understood aspects of Puget Sound forage fish biology is how changes to nearshore habitats may affect the productivity and sustainability of these forage fish populations. We are using habitat and herring spawning information collected during WDFW spawning surveys (1972-2012) to ask if available vegetated habitat has systematically changed over the past 40 years and if any of these change in available habitat have affected the location and intensity of herring spawning events. Going forward, we hope to incorporate additional habitat information about shoreline development and the presence of marine contaminants and ask if these factors are linked to temporal changes in herring spawning. We will develop our methods for one or two populations initially with an eye toward expanding our work to all Puget Sound herring populations over the next few years.
P77	18	Let the predators speak for themselves - an analysis of predator diets	The abundance of forage fish species is notoriously difficult to quantify directly via surveys. Fortunately, these small fish species play a vital role as prey for many other fish, bird, and mammal species that we can readily observe. Therefore these predator species provide the possibility that we can use the predators as indirect samplers of forage fish in Puget Sound. From the predator's perspective we can ask: what are the most important forage species in Puget Sound? We will compile an inventory of current available information about what is known about predator exploitation of forage fishes in Puget Sound. We will include analysis of how predator use varies across years, by season, and among Puget Sound regions. We will also perform a scoring of predator vulnerability based on behavior, life history, and degree of dependence on forage species. We will also explicitly enumerate gaps in available predator information and highlight areas that could benefit from additional study.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P78	18	Shifting baselines in Puget Sound: population abundance of Pacific herring and its use by Native Americans over the millennia	Although healthy marine ecosystems have become a top priority for management and conservation bodies, the definition of ecosystem health is difficult and usually based on data from populations that have already been affected by anthropogenic change such as exploitation, climate change and habitat destruction. The incremental erosion of natural ecosystems is also directly linked to the erosion of social systems, especially in indigenous peoples. Pacific herring is an excellent example for such 'shifting baselines', as intense fishing in both Canada and the US predate recent biomass estimates. Furthermore, the predominance of herring bones in archaeological remains and the importance of herring in local oral history are often not matched by the limited significance of tribal herring fisheries today. Here, we propose to reconstruct pre-industrial levels of population diversity of Pacific herring in Puget Sound, and to gather traditional local knowledge on its past abundance and cultural importance to local tribes. Our project responds to the WSG goal that "Ocean and coastal resources are managed using ecosystem-based approaches", including calls to "build knowledge of coastal ecosystems", "effectively rebuild depleted populations" and "incorporate social and cultural considerations into ecosystems based management". Connecting the population history of Puget Sound herring with patterns of traditional tribal herring use would also help to integrate "Washington's unique tribal … maritime heritage into activities to support coastal communities". Our results will also inform the recovery targets for Pacific herring in the Puget Sound Action Agenda, which are set based on biomass estimates over the past 25 years, a very short period in a dynamic species such as herring. Rationale: Herring in Puget Sound are an important ecosystem foundation and have been a cultural keystone species for local tribes. However, even within the relatively short timeline of recent biomass records, the largest stock, Cherry Point spring spawners, has seriously declined and overall population diversity has decreased. Fisheries have been closed except for a small bait fishery in the central sound. On the other hand, herring feature prominently in archaeological records as well as in traditional knowledge of local tribes, suggesting the loss of an important socioeconomic and cultural resource. Establishing baselines of the pre-industrial era is thus not only crucial for setting biological recovery targets, but also for cultural revitalization and efficient co-management of resources by native peoples. This project brings together social and natural scientists to provide a synergistic assessment of preindustrial herring diversity and use. It benefits from established methods in the synthesis of traditional knowledge and zooarchaeology as well as recent technological advances in large scale genome surveys of genetic variation and ancient DNA analysis. Importantly, these new genetic markers can assign individual herring bones to the population of origin, which traditional markers (microsatellites) cannot. WSG support is appropriate because the aims of the project fall centrally within WSG's mission. Furthermore, WSG support is cost efficient because the graduate student has partial support for salary and tuition from an NSF IGERT program. The benefits of the project lie in the potentially transformative re-evaluation of management goals in Puget Sound. Wide dissemination of results will further integrate tribal and state management of finfish resources in Puget Sound and foster the discussion about achievable and desirable management goals between tribal and other stakeholder groups.
P79	18	[No information]	
P80	19	Causes of decline in abundance of marine birds.	The results show that risk diving birds that eat schooling forage fish or mussels are at extreme risk of decline. The study shifted onus to recovery of prey (forage fish) to save marine birds in decline.
	20		[no projects]
P81	21	Water Management Assessment	The goal of this project is to assess current ballast water management practices, which require vessels to perform an open sea ballast water exchange to minimize discharge and transport of coastal invasive species. Analysis of existing and new ballast water samples will indicate the rate of compliance, assist in targeting enforcement efforts, and lead to improved ballast water management strategies.
P82	21	Assessment of Biofouling Threats to Puget Sound	This project will evaluate and report on biofouling-associated aquatic invasive species invasions in Puget Sound. It will provide information on history and current status, and insights into priorities for a state biofouling management strategy that will interrupt and decrease the risk of this potent invasion pathway.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P83	22	Juvenile Chinook Salmon Contaminant Monitoring (including WDFW sample collection)	WDFW will sample juvenile Chinook salmon for measuring exposure to known chemicals of concern entering Puget Sound via stormwater, wastewater treatment facilities, atmospheric deposition to marine waters, and groundwater. WDFW will sample fish sound-wide from four Puget Sound embayments in 2013. Within each embayment, sampling sites will include the river mouth and two adjacent marine shorelines. This sampling augments previous sampling initiated as early as 1998, and will be used to establish a solid time series of contaminant conditions in juvenile Chinook salmon that can be used to fulfill the Toxics in Fish goal of tracking time trends of fish health. Outputs: The primary output of the proposed project will be a current measurement of the extent and magnitude of toxic contaminant exposure in wild juvenile Chinook salmon from four major Puget Sound river mouths and embayments encompassing a wide gradient of contaminant inputs. Outcomes associated with providing an assessment of the extent and magnitude of toxic contaminant exposure in wild juvenile Chinook salmon include: 1) an assessment of progress towards 2020 recovery goals for toxic in fish, 2) a measure of the effectiveness of current strategies and near term actions outlined in the 2012 Action Agenda to reduce the toxics threat to juvenile Chinook salmon, and 3) guidance on toxics reduction strategies.
P84	22	EPA Loadings Reduction	Fish consumption advisories for Puget Sound and Lake Washington indicate that polychlorinated biphenyls (PCBs) are present at hazardous levels. This project will develop a dataset and models to enable management prioritization of major PCB pathways (combined sewer overflow, stormwater, road runoff, river input, and air deposition) to the Lake Washington watershed. Mass loadings of PCB and PBDE will be estimated from existing and new data collected by this project. Fate and bioaccumulation models will be developed to enable evaluation of total PCB load reduction scenarios. Model results for scenarios will inform managers of the most important PCB pathways needing control to reach safe levels in fish, how long the system may take to respond to potential loading reductions, and how much total loadings reductions will improve PCB concentrations in fish. Other outcomes include estimated total loadings of PCBs and PBDEs to Puget Sound, relative contributions of these compounds from major pathways to Lake Washington, and remaining data gaps.
P85	22	Persistent organic pollutants in the Puget Sound: forage fish and their seabird predators	Organochlorine contaminants in Pacific salmon, Pacific herring, harbor seals, and killer whales inhabiting Puget Sound are at consistently higher levels than from other west coast locations. We compared persistent organic pollutants (PCBs, DDTs, PBDEs, and other organochlorine pesticides) in forage fish prey (Pacific sandlance, Pacific herring, northern anchovy, surf smelt, and Chinook and chum salmon) obtained from rhinoceros auklets breeding in Puget Sound (Protection Island), at the tip of the Olympic Peninsula (Tatoosh Island), and on the outer Washington coast (Destruction Island). Forage fish prey collected from Puget Sound and inland water auklets had wet weight concentrations of PCBs and PBDEs, but not DDTs, that were 2-5 times more contaminated than prey fish collected on the outer coast, especially for the fish species most commonly brought to auklet chicks. Prey samples from Puget Sound had contaminant signatures generally more similar to each other than to those from the outer Washington coast. Some Chinook salmon samples from the outer coast had elevated levels of PCBs, DDTs, and PBDEs, perhaps reflecting regional (Columbia River) influences. We used a modified food basket approach to calculate mean contaminant burdens for rhinoceros auklet chicks over their entire nestling period; because sandlance and herring dominated the observed diet on Protection Island, PCB and PBDE burdens for auklet chicks in Puget Sound were magnified relative to those of outer coast colonies. Contaminant levels in marine birds breeding in Puget Sound may rival those of other upper trophic level consumers; we advocate assessing breeding auklets, their prey, and other resident marine birds to assess heretofore unappreciated risk to marine birds as well as potential biomagnification impacts in the Puget Sound marine ecosystem.
P86	22	Puget Sound Crab and Shrimp Assessment	Current toxics monitoring programs do not adequately address Dungeness crabs and spot prawns. These species are important because of their abundance, their role in the food web, and because people eat them. Ecology signed an Inter-Agency Agreement (IAA) with the Washington Department of Fish and Wildlife (WDFW) to analyze these species for chemical contamination. The Department of Health (DOH) will analyze the results for seafood safety. Outcome: Data to assess contaminant levels in crab and spot prawn. Baseline information to assess effectiveness of actions to reduce toxics in seafood Reduced risk to consumers from consumption of crab and spot prawn. Output: Final QAPP- Final Report- Data on crab and spot prawn in Puget Sound as support for a human health risk assessment from consumption of these species

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P87	22	Demonstration Study of the National Monitoring Network for U.S. Coastal Waters and Their Tributaries -- Puget Sound, WA	The USGS will develop a coastal monitoring Network for Puget Sound that meets the goals of the National Water Quality Monitoring Network for U.S. Coastal Waters and their Tributaries, while also being well aligned with existing Federal and cooperative monitoring efforts in the region. A second technical objective is to begin to fill critical monitoring gaps concerning sediment and toxic chemical loads to Puget Sound from large rivers.
P88	22	Development of a Fish Consumption Rate	Under our state's Clean Water Act authorities, Washington is revising its fish consumption rates to better protect people who eat its fish, and also to protect our environment and restore Puget Sound. The state's fish consumption rates are important because they drive regulatory standards about how clean the state requires our waters and sediments to be. The current fish consumption rates, developed in the 1980s and 1990s, are not accurate. New rates are necessary to protect high consumers of fish. The fish consumption rate is part of the equation that is used to calculate chemical criteria for toxics, and is an important driver in establishing water quality permit conditions and limits, and regulating the discharge of toxics into the aquatic environment. EPA has changed its default fish consumption rate. Ecology and the Northwest Indian Fisheries Commission (NWIFC) entered into an interagency agreement (IAA, pdf) to determine a state fish consumption rate acceptable to NWIFC member tribes. Output: Determine a state fish consumption rate acceptable to NWIFC member tribes for Washington clean-up and water quality criteria development. Outcome: Ecology can adopt a more appropriate fish consumption rate.
P89	22	Modeling contaminants through Puget Sound food web	There is concern about the level of toxic contaminants (such as PCBs, PBDEs, and PAHs) found in aquatic organisms throughout the Puget Sound food web, including groundfish, salmon, herring, and orcas. The Puget Sound Institute is partnering with scientists at NOAA's NWFSC and WDFW to model the flow of contaminants through the Puget Sound food web, to shed light on the potential pathways by which contaminants reach animals at higher trophic levels. These pathways will aid in the management of toxic contaminants entering Puget Sound.
P90	23	Pesticide Use Survey	When pesticides reach waterbodies they cause problems, and the Puget Sound Toxics Assessment found that urban pesticide use was the leading source of copper. The Washington State Department of Agriculture (WSDA) will conduct a survey of typical urban pesticide use. Assessment WSDA will mail surveys to 6,000-8,000 homeowners and complete in-person surveys of professional commercial and public applicators. Results will drive future education and outreach efforts. Outputs: (1) Establish stakeholder advisory committee. (2) Draft and final QAPP. (3) Survey designed and executed. (4) Draft and final Report. Outcomes: WSDA and USDA NASS will provide an overview of pesticide use in urban areas. (1) Increased knowledge of pesticide use in urban areas, (2) developed and approved survey protocol for gathering pesticide use information in urban areas, and (3) identification of education and outreach opportunities leading to a potential decrease in urban pesticide use and pesticide loading to Puget Sound.
P91	23	Roofing Project	The Puget Sound Toxics Loading Assessment identified roofing materials as one of the largest potential sources of cadmium, copper, and zinc in the Puget Sound Basin. This study will evaluate leaching of metals and phthalates from various roofing materials in common use in the Puget Sound region. Outputs: (1) Final QAPP. (2) Alternatives assessment for roofing materials. Outcomes: Final Report (1) Better alternatives implemented for roofing materials. (3) Educational outreach to inform consumers on lower impact roofing materials. (2) Data on metals and phthalates found in various roofing materials. (3) Metals and phthalate inputs to Puget Sound reduced. (4) Biological impairments to Puget Sound from metals and phthalates reduced. (5) Data on metals and phthalates in runoff from various roofing materials.
P92	23	Development of a Chemical Hazard-Based Technical Alternative Assessment Guidance (TAAG) Document	With the assistance of two consultants, Ecology is leading a collaborative process with stakeholders to define elements of and finalize a method for conducting safer alternative assessments, using existing models as a starting point for discussion. Based on the results of the Puget Sound Toxics Assessment, Ecology will identify chemicals or products that are good candidates for scientifically defensible assessment and work with partners to conduct alternatives assessments. Outputs: Final Alternative Assessment Guidance document vetted through stakeholder process and posted to website. Conduct safer alternatives assessment on at least one chemical or product. Outcomes: Businesses and governments will use the Alternative Assessment Guidance to conduct alternative assessments on chemicals they are using. The annual pounds of hazardous materials are reduced. By 2015, increase the use of safer chemicals cumulatively by 40%.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P93	23	Establishing a Green Chemistry Center	To form a Green Chemistry Center as a point-of-contact and catalyst for collaborative green chemistry research and development, education, and technical assistance.
P94	24	Modeling PCB/PBDE Loadings Reduction Scenarios for the Lake Washington Watershed	Project description: Fish consumption advisories for Puget Sound and Lake Washington indicate that persistent bioaccumulative toxics (PBTs) are present at hazardous levels. This project will prioritize major PBT chemical pathways including sewer overflows, stormwater, road runoff, river input and air deposition to the Lake Washington watershed and Puget Sound via the Chittenden Locks. Sources of PCBs and polybrominated diphenyl ethers (PBDEs), both industrial contaminants, will be sorted from existing and new data collected by this project. This will help to manage PBT pathways and to help identify priority sources of these chemicals and to reach safe levels in fish. Outcomes: This project will produce a PBT loading budget for Lake Washington with relative contributions from sewer overflows, inlets, stormwater, road runoff and bulk air deposition clarified. The modeling framework is adaptable for other toxics loadings to the lake.
P95	24	Toxic Contaminant Monitoring in Mussels	The primary goal of this project is to evaluate the geographic extent and magnitude of contamination in nearshore biota, using mussels as an indicator, and developing an expanded network of monitoring sites. This worked is linked to the "Impacts of Outfalls on Eelgrass" project as well as to the development of status and trends monitoring in support of the National Pollution Discharge Elimination System in Puget Sound.
P96	24	Survival of juvenile chinook salmon outmigrating through contaminated estuaries in Puget Sound	This study examined the rate of survival for hatchery-reared, ocean-type juvenile chinook salmon (Oncorhynchus tshawytscha) to the adult life stage in relation to contamination status for estuaries where they temporarily reside. The hypothesis tested here is that juvenile chinook from Puget Sound (WA, USA) area hatcheries exhibit differential survival as categorized by the state of contamination in their respective natal estuaries. Data were examined from 20 hatcheries that released fish to 14 local estuaries in the greater Puget Sound area over 37 years (1972 – 2008). A parallel analysis was also conducted for coho salmon (O. kisutch) outmigrating from many of the same hatcheries. For all years combined, juvenile chinook transiting contaminated estuaries exhibited an overall rate of survival that was 45% lower than for chinook moving through uncontaminated estuaries, which was confirmed when tested year by year. The results for coho originating from the same hatcheries and sharing a similar marine distribution indicated no substantial differences among estuaries. These observations have important implications for wild juvenile chinook that spend more time in the estuary compared to hatchery-reared fish.
P97	24	Box Model and Storm Data	"Box Model" Analysis of PAHs in Puget Sound: Ecology will update the computerized prediction tool called the "Box Model" with new information and will analyze polycyclic aromatic hydrocarbons (PAHs) and reanalyze polychlorinated biphenyls (PCBs). The model will be used to help develop an overall source reduction strategy to protect aquatic life in Puget Sound and meet Puget Sound Partnership targets for toxics.
P98	24	Nutrient Synopsis	Ecology will combine already summarized information into a web site targeting the general public and local governments. The purpose is to highlight elements of various publications that have quantified nitrogen from various sources and pathways to Puget Sound. Outputs: Draft and final compilation of nitrogen in the Puget Sound ecosystem as web page. Draft and final report summarizing recent field observations to better understand how water is exchanged between Puget Sound and the Strait of Juan de Fuca through Admiralty Inlet. Outcomes: Qualitative and quantitative information on nitrogen in the Puget Sound ecosystem. Improved communication to both technical and general audiences.
P99	24	PBDE Product Ban Enforcement	Numerous persistent, bioaccumulative toxics (PBTs) and other toxics have been recently banned for certain uses in Washington: While it is illegal to sell the specified products containing these toxics, there was no active enforcement to check if the bans are working. This project includes purchasing items likely to contain PBDEs, sampling the products, and communicating with retailers and manufacturers if PBDEs are found. Outputs: Sample products offered for sale to Washington consumers for specific banned chemicals, and work to ensure that any manufacturer found to violate the law is brought into compliance. Expand the amount of knowledge available on the prevalence of other halogenated flame retardants (especially PBT flame retardants) used as substitutes in applications where PBDEs have been banned. Outcomes: Reduce the use of banned PBDEs in Washington State.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P100	24	Assessing Stormwater Data	Cities and counties currently collect water quality data on discharges of polluted runoff (stormwater). – These discharges that are the largest pathway for toxic chemicals entering Puget Sound. Ecology will compile and analyze the monitoring data from the eight "Phase 1" stormwater jurisdictions to provide an integrated analysis of stormwater. This information will be useful in managing stormwater inputs to Puget Sound.
P101	24	Two year grant to study the effects of chemicals of emerging concern (CEC) on chinook and staghorn sculpin	This project uses an integrated effects-based biomarker assessment in two complementary ecological indicator species, Pacific staghorn sculpin and juvenile Chinook salmon, in the contaminated Puget Sound estuaries. We will use multi-analyte HPLC/MS/MS analysis to characterize Chinook and sculpin exposures to a wide range of chemicals of emerging concern (CEC), including personal care products, pharmaceuticals, and industrial compounds that we believe are highly relevant for Puget Sound. Following, we will use an integrated approach of effects-based biomarkers, whole genome microarrays, and physiological indices to assess CEC effects on salmon health and identify gene pathways and diagnostic indices for CEC toxicity. Staghorn sculpin, a benthic species with high site fidelity, will be used to assess the effects of CEC on endocrine function and to compare diagnostic effects-based markers in a second species. Based upon the results of our field studies, we will conduct a controlled feeding experiment of juvenile Chinook salmon to a mixture of CEC. The feeding experiment will provide toxicity thresholds for CEC and also a comprehensive toxicological assessment that will validate CEC biomarkers for use in subsequent Puget Sound investigations. In summary, this project uses the most modern scientific methods within an integrated laboratory and field approach to link exposures of CEC with adverse outcomes in complementary, ecologically sensitive Puget Sound indicator species. Our approach can be used throughout the Puget Sound region to identify sites and sources of concern, and better inform decision making associated with the ecological risk of chemicals of emerging concern.
P102	24	Coho prespawn mortality (PSM) in Puget Sound urban watersheds	Urban streams in Puget Sound have been the focus of habitat restoration projects in the 1990s. Post-project effectiveness monitoring surveys revealed anomalous behaviors among adult coho salmon returning to spawn in restored reaches. These included erratic surface swimming, gaping, fin splaying, and loss of orientation and equilibrium. Affected fish died within hours, and female carcasses generally showed high rates (.90%) of egg retention. Beginning in the fall of 2002, systematic spawner surveys were conducted to 1) assess the severity of the adult die-offs, 2) compare spawner mortality in urban vs. non-urban streams, and 3) identify water quality and spawner condition factors that might be associated with the recurrent fish kills.
P103	24	Predictive mapping of coho PSM in Central Puget Sound watersheds	A series of spatial analyses was conducted to identify correlations between land use and land cover (roadways, impervious surfaces, forests, etc.) and the magnitude of coho mortality in six streams with different drainage basin characteristics. Coho salmon mortality in urbanized waterways was correlated with the relative proportion of local roads, impervious surfaces, and commercial property within a basin. These and other correlated variables were used to identify unmonitored basins in the greater Seattle metropolitan area where recurrent coho spawner die-offs may be likely. This predictive map indicates a substantial geographic area of vulnerability for the Puget Sound coho population segment, a species of concern under the U.S. Endangered Species Act. Our spatial risk representation has numerous applications for urban growth management, coho conservation, and basin restoration (e.g., avoiding the unintentional creation of ecological traps).
P104	24	Future declines in coho population abundance caused by PSM	To evaluate the potential consequences of current and future urbanization on wild coho salmon, we constructed life-history models to estimate the impacts of prespawn mortality on coho populations and metapopulations. Results show that degraded stormwater quality has the potential to drive local coho populations to extinction on a timeline of a few years to a few decades based on the observed, real-world range of spawner mortalities in Puget Sound urban streams.
P105	24	Next generation transcriptional profiling of PSM-affected coho spawners	[no description]
P106	24	Effectiveness of LID at reducing coho PSM	[no description]

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P107	24	Puget Sound Estuary Program, PBDEs and Chinook Salmon Health	Chinook salmon are an important resource and also a critical species in the Puget Sound food web. They are accumulating particular chemicals, polybrominated diphenyl ethers (PBDEs), which are industrial contaminants that accumulate in the salmon tissue. There is limited information on adverse biological effects associated with PBDEs in salmon and other fish. This grant will fund a study to expose salmon to PBDE levels found in Puget Sound Chinook in order to understand these contaminants' effects on salmon health. This will aid in the development of protective standards for aquatic life and for reducing these chemicals in our local environments.
P108	24	Transport and Fate of Nutrient and Pathogen Loadings into Nearshore Puget Sound	Shellfish are commercially, recreationally and culturally important resources in our region, and are highly valued among a diversity of stakeholders. A PSP priority is to reduce the risks of shellfish growing area closures and adverse effects on human health. Information that can predict pathogen concentrations along transport pathways where they pose a risk to shellfish and human health will help in achieving this goal. This project will develop and apply an approach capable of assessing how climate and land use strategies affect variation in the levels of terrestrial and marine-derived water quality indicators (i.e., nutrients, fecal coliforms, and naturally occurring pathogens), and how changes in water quality in turn affect the magnitude of ecosystem service values provided by shellfish growing areas including commercial and recreational harvest opportunities.
P109	25	Biomonitoring for Emerging Contaminants	There are a wide range of chemicals in use in the Puget Sound basin which information is lacking on occurrence, exposure and biological impacts. Many of these chemical have characteristics that make them potentially persistent, bioaccumulative and/or endocrine disrupting. Through a competitive grant process, Ecology selected a University of Washington proposal for funding. Outputs: Information on occurrence, exposure and biological impacts from endocrine disrupting compounds. Data to support development and improvement of Puget Sound toxics indicators for protection of biological resources. Final reports summarizing results of individual studies. Outcomes: Prioritize source control strategies to reduce impacts from endocrine disrupting compounds on Puget Sound ecosystem. Support development of toxics related indicators and benchmarks to assess the health of Puget Sound. Reduce impacts from endocrine disrupting compounds on the Puget Sound ecosystem.
P110	25	Measurement of PPCPs and PFASs in Elliott Bay Sediments	Pharmaceuticals and Personal Care Products (PPCPs) and Perfluoroalkyl Substances (PFASs) are Contaminants of Emerging Concern (CECs) that have been reported in detectable concentrations in surface waters, wastewater treatment plant influent and effluent, groundwater, and biota collected from Puget Sound and Washington State rivers and lakes. They were also measured in 2010 in sediments collected in Bellingham Bay for Ecology's Urban Waters Initiative (UWI), and at 10 long-term monitoring stations throughout Puget Sound as part of the Puget Sound Ecosystem Monitoring Program (PSEMP). While sediment baseline values were established for these locations, they are lacking from other urban bays in the Sound. For this project, sediment samples will be collected from 30 stations in Elliott Bay in June, 2013 as part of the UWI. Funding from the Environmental Protection Agency's National Estuary Program (NEP) will be used to measure concentrations of PPCPs and PFASs in these urban samples, establishing a second set of baseline values for these CECs for Puget Sound urban bays. Analyses will be conducted for the same suite of 119 PPCPs and 13 PFASs examined in Bellingham Bay to determine the detectable suite of these chemicals present in Elliott Bay and how they differ from Bellingham Bay.
P111	25	Prioritization of Management/Monitoring of Contaminants of Emerging Concern	There are thousands of compounds (i.e., Chemcials of Emerging Concern; CECs) in use in the Puget Sound basin, many of which are poorly characterized in terms of occurrence, exposure and/or biological impacts. In order to develop a rational management response it is necessary to gain further information. However, there lack resources to develop and execute a monitoring program to characterize all compoundsl; a prioritization strategy is needed. Under this project, resources from the Puget Sound Institute, and in coordination with the Puget Sound Environmental Monitoring Program, a prioritization effort will be undertaken. The initial stages of the project will include a review of the salient literature and a compilation and synthesis of regional CEC monitoring information. This will serve to support the decision-making process reuired to develop a full prioritization.
P112	25	Use of Emerging Contaminants as an investigative tool for pollutioninvestigation and correction	The purpose of this project is to use a suite of chemical compounds, referred to as Emerging Contaminants, to develop an innovative tool for identifying sources of bacterial contamination entering Puget Sound area waters.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P113	25	SoundCitizen	SoundCitizen works with undergraduates from the University of Washington Tacoma and a region-wide network of volunteers, schools and community organizations to collect data on emerging contaminants in watersheds and marine waters.
P114	25	Characterizing Contaminnts of Emerging Concern in an impacted low land stream	Boise Creek in southern King County is impacted by microbial contamination, likely from anthropogenic sources including agricultural acitivites and/or human wastewater. King County environmental services in conducting an extensive sampling program to inform management options. The Puget Sound Institute hasperformed a set of water quality sampling events to evalaute the utility of CECs as indicators of specific sources of bacterial contamination in the watershed. This information will serve to characterizing the extent of CEC contamination in an impacted creek. This information was previously lacking.
P115	26	Enhancement and Standardization of Benthic Macroinvertebrate Monitoring and Analysis Tools for the Puget Sound Region	Macroinvertebrates such as snails, worms and insects are an important indicator of stream health across all of the watersheds draining into Puget Sound. While many regional agencies use macroinvertebrate data, inconsistencies and lack of analysis tools prevent a comprehensive knowledge across the river basins of Puget Sound. This project will develop standardized monitoring tools to help use macro-invertebrate data as an important ecosystem indicator across the jurisdictional boundaries of Puget Sound. Outcomes: Alignment and clarification of protocols will have broad benefits to enhance the utility of macroinvertebrate data.
P116	27	Estimating costs of EPA Stormwater Retrofit	The project is developing estimates of the number, type, and cost of stormwater best management practices low impact development techniques needed to meet future in-stream flow conditions and water quality goals in the Duwamish River Watershed or Water Resource Inventory Area 9 (WRIA 9), along with an extrapolated cost for stormwater facilities needed throughout the Puget Sound region. These estimates are needed because stormwater pollution has been identified as one of the biggest threats to Puget Sound health.
P117	27	Putting science to work to address surface water runoff	This grant will support extensive testing of bioretention methods and permeable pavement at the Washington State University Research & Extension Center in Puyallup. These results will be used to develop scientifically-defensible performance and design guidelines for low impact development techniques that will be disseminated and applied on-the-ground with partners in four different watersheds across Puget Sound. Partner organizations: Port of Tacoma, City of Bellingham, City of Puyallup, and Kitsap County
P118	27	Innovative Penn Cove surface water runoff control project	Construct an innovative constructed wetland facility that will collect, clean and cool surface water runoff before the water is discharge into Penn Cove. Some of the cleaned water will also be used for irrigation during the summer months. The project will assess the effectiveness of this facility to reduce the harmful effects of human activities on water quality and habitat in Penn Cove, which has a robust commercial shellfish industry. Partner organizations: University of Washington, Island County Marine Resources Committee, Island County Local Integrating Organization, and SvR Design
P119	27	Develop Low Impact Development Module for Western Washington Hydrology Model	This project will result in improvements to the Western Washington Hydrology Model that include new LID features, updated precipitation data, and other improvements. This model is used by engineers and planners throughout western Washington in planning for stormwater from new development, in planning for stormwater retrofits, and many other uses.
P120	27	Expanded/validated predictions for PSM hotspot	[no description]
P121	27	Neurobehavioral toxicity of copper to juvenile salmon	[no description]
P122	27	Impacts of pharmaceuticals and other CECs on marine fish	[no description]
P123	27	Highway runoff toxicity characterization	[no description]
P124	27	Biological effectiveness of bioretention mesocosms	[no description]

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P125	27	Evaluating the Effectiveness of Water Treatment Residuals as a Bioretention Media Ammendment for Phosphorus Control	Stormwater runoff can be a significant source of phosphorus which can negatively impact water quality in reivers, streams, and lakes. There is currently no cost-effective media amendment for stormwater treatment. In this project we investigate the effectiveness of Water Treatment Residuals (WTR) for phosporus removal from stormwater. WTR is widely available and considered a waste product; identifying a beneficial use would be advantageous. Phosphorus removal by WTR under laboratory and field conditions will be investigated,.
P126	28	PAHs in Sensitive Freshwater Aquatic Habitat near Railroads in Puget Sound	The Puget Sound Toxics Loading Assessment estimated that creosote treated wood accounted for over one-third of the total PAH release in the Puget Sound basin. Marine pilings, railroad ties and utility poles represent the major sources. Statewide, railroad ties were estimated as the largest single source in the PAH Chemical Action Plan. While marine pilings represent a clear and direct pathway for entering Puget Sound, it is unclear whether migration into sensitive aquatic habitats is occurring for railroad ties and utility poles. This project would use the results of a recently-completed GIS mapping project to select sensitive aquatic sites near railroads for environmental testing to determine if elevated levels of PAHs are present. The data could also be used to help establish baseline conditions near railroads prior to future traffic expansion related to coal or petroleum transport. Approximately 10 potentially impacted sites and 2 reference areas would be sampled as part of the project. Water, tissue and soil/sediments would be collected and analyzed for PAHs.
P127	28	Trends in Polycyclic Aromatic Hydrocarbon Concentrations Sampled in the Tacoma Tideflats	Polycyclic Aromatic Hydrocarbons (PAHs) in ambient air were monitored on the EPA's 1-in-6 day schedule from Fall 2011 to Fall 2012 to invetsigate sources and trends of PAHs in the Tacoma Tideflats.
P128	29	Develop Project List for Stormwater Retrofits	This award will fund phase 1 of a program to develop a prioritized stormwater retrofit project list for the four most urban counties in the Puget Sound area. The project will focus on prioritizing retrofit projects related to transportation systems in Snohomish, King, Pierce, and Kitsap counties. Phase 1 will produce a work program for this effort, a background report that explores the major issues related to transportation stormwater impacts, and a scope of work for the entire program.
P129	29	Hood Canal regional stormwater retrofit plan	The council will identify, prioritize, and plan for retrofits of stormwater infrastructure in locations most important to protect and restore to limit surface water runoff and related pollution, and boost rainwater infiltration in the Hood Canal watershed. Member organizations: Jefferson, Kitsap and Mason counties and Port Gamble S'Klallam Skokomish tribes
	30		[no projects]
P130	31	Onsite Septic System Nitrogen Removal	The goal of the study is to evaluate and verify new technologies to reduce nitrogen in domestic wastewater. Ecology entered into interagency agreements (IAAs) with the Department of Health (DOH) and the University of Washington (UW) to provide technical expertise to field test three innovative public domain technologies. If the field testing in the Puget Sound basin shows the technologies are effective and reliable, DOH will take the appropriate steps to develop standards for these nitrogen- removal technologies for use in Washington. Outputs: (1) Establish stakeholder advisory committee. (2) Draft and final QAPP. (3) Selection and installation of treatment technologies to be evaluated. (4) Draft and final Report. Outcomes: (1) DOH will approve (if appropriate) up to two new on-site sewage system technologies. (2) Increased use (either voluntary or regulatory) of nitrogen-removing systems in areas suffering from low dissolved oxygen levels, (3) reductions in nitrogen loading from on-site sewage systems, and (4) improve dissolved oxygen concentrations in sensitive areas of Puget Sound
P131	32	Puget Sound Dissolved Oxygen Modeling Study: Development of an Intermediate Scale Water Quality Model	The Department of Ecology contracted with Pacific Northwest National Laboratory to develop a coupled hydrodynamic and water quality model. Specifically, the project is expected to help determine (1) if current and potential future nitrogen loadings from point and nonpoint sources are significantly impairing water quality at a large scale and (2) what level of nutrient reductions are necessary to reduce or control human impacts to dissolved oxygen levels in the sensitive areas. Model results were consistent with the generally accepted understanding of how Puget Sound circulation and transport processes affect algae, nutrients, and dissolved oxygen kinetics. Further efforts will refine estimates of impacts from human activities on water quality in Puget Sound and the Salish Sea.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P132	32	Effect of hypoxia on pelagic food webs	Low dissolved oxygen (hypoxia) is a widespread threat to coastal marine ecosystems, yet our understanding of how this disturbance shapes marine ecosystems is limited. Here we seek to evaluate how hypoxia affects the flow of energy in pelagic food webs, specifically by looking at its effects on the trophic transfer from mesozooplankton to pelagic fish species that, in turn, support valued species in Hood Canal Washington. We propose to measure hypoxia effects on this critical trophic linkage, using spatial and temporal gradients in the intensity of hypoxia conditions that Hood Canal presents, and also test specific hypotheses about the underlying processes that either produce changes or alternatively maintain constant energy flow despite distributional and community shifts. This work will be widely applicable to a better understanding of hypoxia impacts in coasts and estuaries around the world, while also providing insight into the ful ecological effects of hypoxia on Hood Canal
P133	32	State of the Science for Shellfish Processes, Sediment Interactions, and Watershed Attenuation of Nitrogen in the Puget Sound Ecosystem	USGS will evaluate the state of science for shellfish processes, sediment interactions, and watershed attenuation of nitrogen in the Puget Sound ecosystem. Outputs: Develop reports compiling the current state of the science on shellfish nutrient dynamics, quantifying nutrient fluxes from Puget Sound sediments, and characterizing the nutrient attenuation potential of the Puget Sound Watershed. Outcomes: Increased knowledge of key nutrient processes. More effective and tailored management actions that are more likely to solve nutrient problems.
P134	32	Nutrient Synopsis	Ecology will combine already summarized information into a web site targeting the general public and local governments. The purpose is to highlight elements of various publications that have quantified nitrogen from various sources and pathways to Puget Sound. Outputs: Draft and final compilation of nitrogen in the Puget Sound ecosystem as web page. Draft and final report summarizing recent field observations to better understand how water is exchanged between Puget Sound and the Strait of Juan de Fuca through Admiralty Inlet. Ourcomes: Qualitative and quantitative information on nitrogen in the Puget Sound ecosystem. Improved communication to both technical and general audiences.
P135	32	Nutrient Bioextraction: Shellfish at Work	This project will mitigate anthropogenic nutrient loads and support habitat renewal in Budd Inlet through the establishment of a community-based shellfish gardening and bioextraction program. Outcomes: Mussel aquaculture can 1) augment other strategies for removing excess nutrients from the marine system; 2) utilize the natural system to produce a compost product that is useful to the local community; 3) spur pollution control efforts; and 4) get the community engaged in learning about their local marine system and developing community-based solutions to wastewater issues in urban areas. Further outcomes: contribute to a fishable and swimmable Budd Inlet by mitigating nutrient enrichment while educating the community about local water quality processes and alternative nutrient removal strategies.
P136	32	South Puget Sound Dissolved Oxygen Study: Interim Nutrient Load Summary for 2006-2007	Nutrient loads, particularly nitrogen, are a potential stressor to Puget Sound. The Washington State Department of Ecology initiated the South Puget Sound Dissolved Oxygen Study to determine whether human sources of nitrogen contribute to low levels of dissolved oxygen in South Puget Sound. A statistical method called "multiple linear regression" was applied to develop daily loads of nutrients from field data collected monthly. This report describes the magnitudes and sources of nitrogen loading into South and Central Puget Sound. The study also calculates natural conditions and compares nitrogen loads in Puget Sound to nitrogen loads in other watersheds.
P137	32	Review and Synthesis of Available Information to Estimate Human Impacts to Dissolved Oxygen in Hood Canal	A series of fish kills in Hood Canal triggered public concern and multiple scientific investigations. The Hood Canal Coordinating Council requested that EPA and the Washington State Department Ecology review the available science surrounding dissolved oxygen in Hood Canal. We concluded that human nutrients are not contributing to the episodic fish kills in Central Hood Canal but, due to limitations in the available science, we were unable to determine whether or not human nutrients are violating water quality standards in Lynch Cove.
P138	33	Pollution Identification and Correction: Hood Canal	The HCCC will develop a comprehensive, coordinated regional PIC program plan that will be managed by three counties and two tribes.
P139	33	Pollution Identification and Correction: Kitsap County	Kitsap County will track down and remove 15 newly identified pollution hot spots that threaten 935 acres of shellfish beds in Yukon Harbor.
P140	33	Pollution Identification and Correction: Pierce County	Pierce County will intensively survey onsite sewage systems on the Key Peninsula to identify and correct pollution problems.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P141	33	Pollution Identification and Correction: San Juan County	San Juan County will mobilize its public works and health departments and citizen volunteers to monitor and remove pollution sources in rural stormwater.
P142	33	Pollution Identification and Correction: Skagit County	Skagit County will continue to inspect properties and clean up pollution problems in the Samish watershed and will begin PIC work in the Padilla Bay watershed.
P143	33	Pollution Identification and Correction: Thurston County	Thurston County will track down and fix failing onsite sewage systems in Eld Inlet, and pursue an efficient and sustainable funding model that will help Puget Sound communities pay for long term PIC programs.
P144	33	Characterization of Compost Leachates	Leachate from compost is yellow to dark-brown in color, mainly due to the presence of dissolved and particulate organic matter. The leachate also contains nutrients and, in some cases, pollutants, like pesticides and heavy metals. Application of compost to the environment may therefore introduce pollutants or lead to pollutant mobilization in the environment. For instance, if compost is applied to roadsides, heavy metal and other pollutants running off from the road may be immoblized in the compost, but may later also be mobilized along with leachates coming out from the compost. Our goal is to investigate and characterize leachates coming from compost when compost is applied to the environment. This work will lead to a better understanding of what materials are leached form compost. In certain circumstances the leachates may be undesired, for instance if dissolved organic matter or nutrients are leached into surface or ground waters. A better understanding how much and what chemicals leach from compost will help to better manage applications and use of compost.
P145	34	Harmful Macroalgal Blooms in the Salish Sea Region	The long-term goal of this on-going research is to enhance our understanding of the formation, persistence, and consequences of seaweed blooms in the Salish Sea region. Over the past 8 years, we have used a variety of tools to document the locations of blooms over time; explore the effects of nitrogen, phosphorus, and light of the growth of bloom-forming seaweeds; assess the environmental conditions present at bloom and non-bloom site; identify and monitor toxins produced by bloom-forming seaweeds; and, assess the impacts of chemicals produced by these algae on the atmosphere and other marine organisms.
P146	34	Determine the ecology of the harmful algae Alexandrium catenella in Puget Sound and model bloom scenarios	Perform research to assess critical data and information gaps on Alexandrium bloom dynamics, particularly with respect to germination and dormancy characteristics of dormant resting cysts. These results are improving our understanding of the role of climate in blooms and identifying a new approach for modeling harmful algal blooms
P147	34	SoundToxins Partnership Harmful Algal Blooms Monitoring	SoundToxins responds to an increasing threat of harmful algal blooms (HABs) in Puget Sound. This project will standardize methods and results, create a science advisory group to guide future program direction, and deliver an effective, robust citizen science monitoring program providing critical information to federal and state agencies, tribal harvesters, fish and shellfish farmers, community members and academia for decision-making and resource allocation. Outputs: • On-site training sessions for newly established or expanded SoundToxins monitoring sites. • Protection of public health by minimizing the risks from HABs tainted seafoods harvested from Puget Sound.• SoundToxins database with all data from the project period, as well as historical program data. • 150 samples analyzed for nutrient, chlorophyll a and toxin data (Cellular domoic acid, dinophysistoxins (DSP toxins), and saxitoxin) from comprehensive sites. • Timely alerts to resource managers when HAB species are detected above preset thresholds. • Enhanced volunteer engagement and expertise. Outcomes: • Reduction of potential economic losses to Puget Sound fisheries caused by product recalls and inability to harvest. • Increased efficiency of HABs monitoring by WDOH. • An Ecology-approved QAPP. • Institutionalization of SoundToxins within NWFSC and WSG.
P148	34	Regional Harmful Algal Blooms	Tracking cyanobacterial toxins and phytoplankton in 30 lakes across 3 counties (King, Pierce, and Snohomish) for 3 years to look at rate of HAB incidence and intensity. Entry of all historical HAB-related illness reports into a national database.
	35		[no projects]
P149	36	Addressing Key Threats from Large Oil Spills through Data Analysis and Guidance on Risk Management	This project will assess key threats to Puget Sound from large oil spills, using and expanding on an existing risk model, in order to identify effective management strategies.
P150	36	Local Oil Spill Preparedness and Response Projects	Prepare COASST Post Spill

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P151	37	Geographic Expansion of the Puget Sound Seabird Survey and Early On-Scene Training	The Seattle Audubon Society will expand the Puget Sound Seabird Survey into Strait of Juan de Fuca and northwest Whidbey Island. They will gather data important in assessing ecological damage in the event of an oil spill. This project will also train volunteers to assess conditions at the scene of a reported oil spill in order to provide real-time monitoring and data collection.
P152	37	Bacterial Pollution at Recreational Puget Sound Beaches	Monitor and notify the public about bacterial pollution at recreational Puget Sound beaches.
P153	38	WA Shellfish Initiative Ocean Acidification Blue Ribbon Panel	Washington Sea Grant provided administrative support for the Ocean Acidification Blue Ribbon Panel. Puget Sound is particularly vulnerable to ocean acidification. Washington's coastal waters experience seasonal upwelling where waters that are naturally low in oxygen and rich in carbon dioxide rise to the surface. These upwelled waters are naturally more acidic. Coastal waters also receive excess nitrogen from human activities that can stimulate algae blooms. As these blooms die and sink, bacteria decompose them, depleting oxygen from the surrounding water.
P154	39	Planktonic interactions in a changing ocean: Biological responses of Emiliania huxleyi to elevated pCO2 and their effects on microzooplankton	We have developed a system for regulating the carbon dioxide concentration in semi-continuous cultures of the coccolithophore Emiliania huxleyi. Experiments are underway to determine the effects of elevated pCO2 on E. huxleyi morphology and physiology. We are also investigating the influence of elevated pCO2 on the microzooplankton predators of E. huxleyi, including ciliates and dinoflagellates. Experiments are examining direct effects of elevated CO2 on microzooplankton growth and feeding rates, as well as indirect effects through alterations in prey quality. Our overall goal is to understand the effect of elevated CO2 on lower trophic level interactions, with a focus on microzooplankton predation.
P155	39	Ocean Acidification: Impacts on copepod populations mediated by changes in prey quality	http://www.nsf.gov/awardsearch/showAward?AWD_ID=1220664
P156	40	pH Model Scope	Pacific Northwest National Laboratory (PNNL) will scope a model for addressing pH in Puget Sound. It will 1) define monitoring needs to support pH modeling, 2) assess alternative pH modeling frameworks and identify the preferred alternative, and 3) define how key modeling rates and coefficients will be determined. Output: Plan for simulating pH with the Puget Sound Water Quality model. Better understanding of human nutrient loading effects on low pH in Puget Sound. Therefore, better understanding of how potential nutrient load reductions could improve pH levels. Outcome: Healthier pH levels in Puget Sound waters.
P157	41	Social Network analysis of Puget Sound ecosystem recovery scientists	Scope, design, and implement data collection and analysis to complete an analysis of the network of interactions among scientists, funders, managers, and policy makers related to research and other scientific investigation of Puget Sound marine and nearshore habitats and species.
P158	41	Social Network analysis of environmental organizations in Puget Sound	Gather information about the extent of organizational networks working on Puget Sound recovery efforts; presents the findings of the survey and use social network analysis to characterize the network.
P159	42	Multi-scale Soundwide pressure assessment: methods (USGS) & assessment (TBD)	Conduct a risk assessment comparing the relative importance of marine habitat threats to inform future strategic investments, including invasive species, oil spills, and physical habitat issues, such as derelict gear.
P160	43	Decision-analytic approach to LIO prioritization of pressures and strategies/actions	Develop and implement a work plan for July 2012 to June 2014 with the Puget Sound Partnership to develop and improve the use of decision support tools to facilitate science-based and transparent decision making by the Puget Sound Partnership's boards and executive director.
P161	44	Monitoring program coordination	Build the infrastructure to implement a cooperative program for monitoring the Puget Sound ecosystem that assesses status and trends of key environmental indictors and targets; evaluates the effectiveness of major management programs and strategies; and provides data that supports evidence-based decision making. Cooperators include federal, state and local government agencies.
P162	44	Evolution of ecosystem indicators	Support PSP Science staff to lead the identification and evaluation of ecosystem indicators for Puget Sound, support PSP staff to discuss and possibly revise the PSP-adopted vital signs (as a subset of PS ecosystem indicators)

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P163	44	Land Use Regulation Environmental Effectiveness and Compliance	The purpose of this study is to develop an approach for effectiveness monitoring and apply that approach to evaluate the effectiveness of current land use regulations to inform the 2012 Growth Management Act (GMA) regulatory review. Our goals are to establish and implement a framework for quantifying environmental responses to development implemented under new (2005) land use regulations and identify where the regulations may be ineffective and need to be changed. Specific objectives are to: (1) Track regulatory implementation and degree of compliance in parcels developed under new regulations; (2) Quantify environmental change in catchments as development proceeds; (3) Determine empirical response relationships; (4) Provide findings to King County Council; and (5) Disseminate framework and results to other appropriate audiences, including other Puget Sound counties. Our working hypothesis is: "If regulations are not effective, then indicators of hydrology, water quality, biology, and stream complexity in treatment sites will respond to land use following the new regulations." Response will be tracked relative to reference sites and to estimates of the amount of potential cumulative impact (PCI) of all known actions in a given catchment. See http://www.kingcounty.gov/environment/data-and-trends/monitoring-data/critical-areas.aspx
P164	44	WRIA 9 Marine Shoreline Monitoring and Compliance	King County will undertake boat based shoreline condition surveys of the 90 mile marine shoreline of Watershed Resource Inventory Area 9 in 2012 and 2013. This information will be compared against existing baseline shoreline condition data. Baseline conditions include data on: shoreline armoring, overwater structures, groins, riparian condition, and boat ramps and rails. Data collected from the surveys will be used as part of status and trends monitoring of the WRIA 9 Salmon plan, as well as providing data for the KingStat's Program's indicator of the environmental health (shorelines) and the Puget Sound Partnership's shoreline armoring dashboard indicator. Any anthropogenic changes in shoreline condition will be followed up with the appropriate permitting agency to ensure compliance with existing regulations.
P165	44	Pathogen Data Management and Reporting System	Improve our ability to track pathogens and notify the public about shellfish closures and biotoxin threats by updating our data management and reporting system.
P166	44	High Resolution Marine Water Quality Monitoring	This project supports six profiling buoys for a comprehensive view of water, oxygen, and nutrient dynamics. The buoys provide high-resolution, near-real time, on-line and calibrated water quality data for Admiralty Reach, South Puget Sound, Hood Canal, the Main Basin, and Dabob Bay. Outputs: Our major output is the high-resolution, near-real time, on- line and calibrated oxygen and water quality data from six profiling buoys throughout Puget Sound, with public access from a variety of sources. Outcomes: Effective regulation and restoration of Puget Sound water quality demands an understanding of oxygen changes due to anthropogenic effects distinct from oceanic input. The use of the high-resolution data in major basins, in concert with other monitoring approaches, facilitates that understanding and optimzes Ecology's ability to make effective water quality regulation and enhances the Puget Sound Partnership's ability to direct effective restoration actions.
P167	44	Ferry-Based Monitoring	To improve data on Puget Sound water quality, Ecology will expand the ferry monitoring network beyond the Victoria Clipper to include public ferries run by the Department of Transportation. Installation of automated instruments on select ferries will allow Ecology to record measurements continuously as ferries make their multiple daily runs. Ferries occupy strategic cross-sections in Puget Sound – often at the very constriction points between basins that would let us most easily measure water exchange and circulation between those basins. These measurements are key to understanding overall water quality and for improving the performance of numerical models in Puget Sound. Outputs: Draft and Final report summarizing the data obtained and its use in improving our understanding of Puget Sound water quality and incorporation into PS models. Improved understanding of the exchange of water between Puget Sound and the Strait of Juan de Fuca through Admiralty Inlet; a key driver of water quality in Puget Sound. Improved numerical models of Puget Sound that can be used for TMDLs and subsequent setting of NPDES permit limits and load allocations for diffuse pollution sources as appropriate. Outcomes: Cleaner water in Puget Sound.
P168	44	Stormwater Center	Stormwater, or polluted runoff, is the leading cause of water pollution in urban areas across the nation. As rain and snow melt runs off rooftops, paved streets, highways, and parking lots, it picks up pollution such as oil, fertilizers, pesticides, soil, trash, and animal waste. Then the runoff carries that pollution into storm drains and downstream waters. Water in storm drains is usually not treated and flows into our lakes, rivers and Puget Sound. For this project, the Washington Stormwater Center will assemble information from a variety of local, regional, and state-wide sources into a web-based information system.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P169	44	Measure program performance and use adaptive management to continuously improve programs	Ecology, local partners, and stakeholders will work to improve water quality at a sub-watershed scale by 1) prioritizing agricultural areas for Best Management Practices (BMPs) implementation, 2) providing baseline data for identifying pollution sources and measuring water quality improvements, and 3) determining both programmatic effectiveness and water quality improvements. Effectiveness of BMPs will be measured from both a water quality standards and a watershed health prospective
P170	45	Mapping recreation in the Hood Canal	Developing an online mapping platform to gather recreation data at the Hood Canal scale
P171	45	Upper Nisqually ecosystem services demonstration	The Tribe and its partners will establish a framework for marketing the environmental and economic benefits that intact lands provide such as habitat protection and reducing surface water runoff. This is intended to provide incentives to landowners to protect and restore forested lands. Potential buyers could be local salmon enhancement groups and utilities. The project focuses on the Mashel River and Ohop Creek in the upper reaches of the Nisqually watershed near Eatonville. Partner organizations: Nisqually River Foundation, Nisqually Land Trust, Northwest Natural Resource Group, Earth Economics, Washington State University, and Washington Department of Natural Resources
P172	45	Watershed services market demonstration projects	The state Department of Natural Resources will initiate demonstration projects in two watersheds to establish markets where forest landowners receive money to protect and maintain their lands. As the buyers in these markets, downstream beneficiaries purchase watershed services such as surface water runoff control and salmon habitat enhancement. The project will establish partnerships, identify priority forest lands, develop measures for valuing specific watershed services, identify potential buyers and sellers, and develop an infrastructure for market transactions. Partner organizations: U.S. Forest Service, Washington Department of Health, Nisqually Tribe, Snohomish County, Nisqually Land Trust, Northwest Natural Resources Group and Willamette Partnership
P173	45	The Values of Place: Recreation and Cultural Ecosystem Services in Puget Sound	Coastal recreation, tourism, and ethical or existence values are among the most important ecosystem service benefits identified by Puget Sound stakeholders (Iceland et al, 2008). Yet the economic, social and cultural values of these benefits have yet to be studied systematically in the context of ongoing efforts to restore and protect the Sound. Our primary project objective is to develop a better understanding of the intersections and trade-offs between Puget Sound residents and recreational users' diverse cultural, social and economic values. For example, to what extent are values regarding recreation, aesthetics and sense of place dependent on specific ecosystem services or attributes? In addition, we seek to understand how these values motivate or impede changes in environmental management, including ecological restoration and development of marine renewable energy. How do values pertaining to recreation drive community engagement in estuary restoration projects? In what ways does renewable energy development pose a threat to community members' sense of place?
P174	45	Evaluating Community Well-being in Relation to Shellfish as a Place- Based Cultural Ecosystem Service of the Puget Sound Region of the Salish Sea	The objectives of the project are to: (1) contribute additional knowledge and refine science-based strategies for protecting and improving both ecosystem services and wellbeing for Puget Sound residents; (2) develop a set of quality of life indicators related to cultural ecosystem services; (3) produce methods that can be used as decision-support tools to: (a) help provide accountability and build partnerships with communities, (b) assess community priorities, and (c) develop quality of life targets; and, (4) help to establish procedural and analytic guidelines to evaluate and incorporate community place-based values. These four objectives align with the four "key ideas" described in the Puget Sound Partnership Action Agenda (2013).Building on more than a decade of socio-eco-cultural indicator development work at the Swinomish Indian Tribal Community with project investigators Drs. Donatuto Satterfield and Gregory (2011) as well as with indigenous and non-indigenous communities in both the US and Canada by project investigators Drs Poe, Gregory and Satterfield (e.g., Gregory et al. 2012; Poe et al. *forthcoming* ; Satterfield et al. 2013), we will employ cultural ecosystem services metrics to better understand the functional, generative and/or provisional relationship of shellfish harvesting, quality of life activities in proximity to shorelines, sense of place, and other aspects of community well-being. This mixed-method project draws from Structured Decision Making (SDM) and qualitative approaches to identify, define and assess well-being associated with the provision of cultural ecosystem services to Puget Sound residents using rigorous, defensible, and locally-vetted indicators.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P175	45	Valuing killer whales, Chinook salmon and the ecosystem services they provide to people in the Puget Sound Region	Killer whales and Pacific salmon have been called "cultural icons" in the transboundary (Georgia Basin/Puget Sound) waters known locally as the Salish Sea (Fraser et al. 2006). These two valued ecosystem components – the southern resident population of killer whales and various stocks of preferred prey, Chinook salmon – form an integral part of a productive marine ecosystem, which supports valuable marine-based fisheries, communities and recreational opportunities. Together, these iconic species are important aspects of establishing a Puget Sound sense of place (Fletcher 1990). Our proposal addresses marine-based recreation and Puget Sound Sense of Place by exploring these species and the human uses that they support as a coupled social-ecological system (Berkes et al. 2003).
P176	46	Human Wellbeing (Quality of Life) Indicators in Hood Canal	Developing a process to select HWB indicators at a watershed scale
P177	46	Developing cultural indicators for salmon habitat restoration	Development of cultural indicators relevant to salmon habitat restoration
P178	47	Sound Behavior Index	Sound Behavior Index: Many of our common day-to-day behaviors and practices seem benign on their own, but, when multiplied by 4.5 million residents, their cumulative effects can harm Puget Sound. Reversing this trend - fostering beneficial behaviors and reducing detrimental ones - is a crucial step in Puget Sound's recovery. The Sound Behavior Index will track selected practices that can affect water quality and aquatic habitat. By measuring long-term shifts in behaviors and practices across the Puget Sound region, the index gives policy makers a tool to set priorities for regional and local programs. Social Capital Index: The Social Capital Index measures how connected people are to each other across the 12-county Puget Sound Region. Social capital generally refers to the levels of trust and community engagement that enable people to accomplish tasks. Social capital is found in a variety of places and forms. It includes community, professional, religious, and recreational organizations and appears in formal and informal social settings. A specific use of social capital is found in the networks that have been created to address Puget Sound issues, including the Puget Sound Partnership's ECO-Net communications network, the STORM coalition of municipalities, and the nonprofit environmental caucus. Social capital forms a context for our collective decisions. It also largely defines how we, as individuals, learn and understand new information.
P179	48	Human Dimensions of Puget Sound Ecosystem Health and Recovery: Social Sciences Scale and Scope	[no description]
P180	[none]	Effects of lake shoreline development on terrestrial-aquatic resource subsidies	The role of resource subsidies across ecosystem boundaries has emerged as an important concept in contemporary ecology. For lake ecosystems, this has led to interest in quantifying the contribution of terrestrial allochthonous carbon to aquatic secondary production. An inverse relationship between habitat area and the role of allochthonous subsidies has been documented on marine islands and assumed for lakes, yet there have been no tests of this pattern among benthic (lake bottom) consumers. Here, we used carbon stable isotopes to trace terrestrial allochthonous and benthic autochthonous carbon use by the crayfish Pacifastacus leniusculus over a gradient of lake area, productivity and urbanization. Consistent with findings from terrestrial islands, habitat size dictated the importance of allochthonous subsidies, as P. leniusculus transitioned from using predominantly terrestrial carbon in small lakes to an increased reliance on autochthonous production in larger lakes. However, shoreline urbanization interacted with this pattern, particularly for small lakes where greater urbanization resulted in reduced use of allochthonous resources.As such,we provide, to our knowledge, the first confirmation of the predicted relationship between habitat size and importance of allochthonous subsidies to lake benthic consumers, but found that urbanization can interfere with this pattern.

Appendix C2: Project Descriptions

Project No.	PSA No.	Project Title	Project Description
P181	[none]	Hybridization in Puget Sound rockfish	Natural hybridization is common in closely related species especially where they invade novel habitat. The patterns of introgressive hybridization are often asymmetrical and are attributed to various influences from selection to gene flow and dispersal. Hybridization has previously been detected in S. auriculatus, S. caurinus, and S. maliger in Puget Sound (the southern Salish Sea) but the details of the history and direction of introgression are incomplete. These Pacific rockfish species are sympatric over most of their geographic range but hybridization has only been detected in Puget Sound. In order to measure interspecific gene flow, we used sequence data from one mitochondrial locus, three nuclear intron loci, and one coding gene to compare interspecific gene flow between collections from the Salish Sea and the Pacific coast. Although ancestral polymorphisms could not be excluded in the analysis of phylogenetic trees, coalescence analysis provided clear evidence for broad-scale, asymmetrical introgression from S. maliger into S. auriculatus and S. caurinus and a much lower incidence of introgression between S. auriculatus and S. caurinus. The absence of F1 hybrids was consistent with historical hybridization events or ongoing, low-level hybridization in the Salish Sea. Although hybrids were found in high frequency, introgressed rockfish in the Salish Sea appear to maintain the morphological characters and coloration of pure parental species morphology. This rockfish hybrid system, with asymmetrical introgression and the maintenance of parental species, may prove useful to study both mechanisms that maintain species boundaries and processes that facilitate speciation