# Considerations for Puget Sound Restoration Programs That Restore Beach Ecosystems

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**Abstract.** Ecological goods and services provided by Puget Sound beaches are threatened by loss of sediment supply caused by the armoring of eroding bluffs and banks—a compelling crisis that pits private property protection against public trust resources. Armoring impacts are broadly distributed and increasing, research on the precise impacts of sediment starvation in Puget Sound is limited, and beach systems are large in scale and overlap complex shoreline ownership patterns. These factors challenge the effectiveness of traditional restoration funding programs that focus on funding small sequential projects on individual parcels. Restoration programs implement beach projects despite ongoing degradation, substantial knowledge gaps, and weak stakeholder appreciation for ecosystem dynamics. On-the-ground restoration actions are implemented through networks of stakeholders. To compensate for these factors an effective beach restoration program integrates planning, stewardship, learning, and communication activities with project implementation. Restoration program performance typically considers acres of treatment and rapidity of implementation, sometimes discouraging activity beyond that necessary to deliver those measures. An effective beach restoration program thus is challenged to quickly deliver performance measures, while also meeting planning, learning, stewardship, and communications objectives necessary to actually achieve long-term restoration outcomes. This challenge may be most efficiently met by integrating planning, learning, stewardship, and communications into the more traditional restoration activities of project development and funding, with the intent of developing an effective restoration system that spans organizational boundaries. Boundary-crossing networks allow restoration systems to pool limited resources, and integration allows programs to capture opportunities that arise out of project work. This article proposes a skeletal framework for organizing restoration program activities along these lines.

## Introduction

Restoration projects are not typically implemented by government funding agencies, but rather by external project sponsors. On-the-ground projects result from an elaborate series of transactions among stakeholders involving solicitations, applications, competitions, negotiations, contracts, permits, and communications. No one actor is singularly responsible for the complete action. Thus, on-the-ground restoration is the result of the function of a collective restoration 'system,' rather than the function of an individual restoration program. Yet, because of their fiduciary obligations, public funding programs are uniquely responsible for the outcome of public investments in restoration, and have a unique and powerful role in shaping collective restoration systems. Throughout this analysis, 'restoration program' refers to a public funding entity that funds restoration projects, whereas 'restoration system' is the entire program of interagency activity created by the distribution of public funds.

This paper attempts to provide a wide-ranging but logical analysis of the role of public restoration programs in the context of Puget Sound beach ecosystem restoration. This requires consideration of the character of Puget Sound beaches and the traditional structure of restoration programs, only then concluding with a potential policy framework and approach.

## The Risk of Armoring Puget Sound Beaches

The Puget Sound can be divided into approximately 812 'beach systems' or 'littoral drift cells' (Simenstad and others, 2010). Each cell is a largely self-contained physical system in which sediment, supplied by erosion, is moved by waves along a reach of shoreline, resulting in a slow-motion sediment 'conveyor belt' that we call a beach. If sediment supply is high, or transport slows, sediment accumulates as barrier beaches, spits, and other physical shoreline structures (Finlayson, 2006; Shipman, 2008). These structures create diverse wave energy environments, and in turn a diversity of physical environments in which shoreline biota live. The wave energy environment and resulting sediment characteristics drive the structure of shoreline biological communities (Dethier, 1990). Thus, shoreline structural complexity resulting from transport and deposition of sediment creates a range of protected and exposed environments and varied substrates that strongly determines the composition and configuration of nearshore biological communities.

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Publications by the Puget Sound Nearshore Ecosystem Restoration Project present a generalized profile of the risks of shoreline armoring on Puget Sound beach ecosystems[2]. Construction of bulkheads is increasing (Gabriel and Terich, 2005) and reduces sediment supply from bluffs and banks. This supply of sediment from coastal bluffs is necessary to sustain Puget Sound beach ecosystems (Downing, 1983). Although armoring may reduce sediment supply, wave-driven transport of sediment is likely to continue unabated, increasing beach slope, reducing beach elevation, and coarsening beach texture over time, resulting in the loss of valued ecosystem goods and services, including forage fish spawning, backshore and down-drift wildlife habitats, and mitigation of wave erosion (Johannessen and MacLennan, 2007). Ultimately, the absence of sediment supply may result in the eventual loss of depositional features like spits and barrier beaches, reducing the diversity of habitat services. Global sea level rise and increased storm energy associated with climate change are anticipated to further increase sediment transport and erosion (Pilkey and Wright, 1988; Pethick ,2001; Johannessen and MacLennan, 2007). Increasing erosion risk creates short-term incentives to increase armoring, which would further reduce sediment supply. A recent Pacific Northwest sea-level rise scenario estimates the loss of 48 percent of existing estuarine beach area by 2050 in the absence of beach system evolution (Glick and others, 2007). Sediment provided by increased bluff erosion provides the only feasible mechanism for recovering this scale of lost beach area.

Although the logic of this scenario is compelling, the precise impact of a particular bulkhead has seldom been studied, making it difficult to associate specific injuries with specific actions, or to identify regulatory thresholds. The dependency of a particular drift cell on bluff-derived sediment as opposed to alluvial sediment may vary. Rates of sediment transport, and therefore the responsiveness of the system to changes in sediment supply, are likely to vary with orientation of the shoreline and wave energy regime. Some beaches are naturally sediment poor, whereas others are sediment rich, and the texture of sediment source can vary. The ecologies of many beach-dependent species are poorly understood. These uncertainties create opportunities for weak and uncoordinated public and governmental support for beach conservation. Although management of sediment supply seems to be an important element of ecosystem restoration, restoration programs to date have had difficulty evaluating the specific nature of project benefits, or identifying the relative importance in an ecosystem context of restoration of sediment supply and transport as compared to other ecosystem restoration activities.

[2]A series of technical publications cited herein can be accessed at www.pugetsoundnearshore.org.

Regardless, few argue that sediment supply is not critical to beach ecosystem function, or that systematic armoring of eroding bluffs will not result in the systematic reduction of sediment supply. Concern over coastal erosion, sediment supply, armoring effects, and sea level rise is not unique to Puget Sound (Pilkey and Wright, 1988; Pethick, 2001; Cooper and McKenna, 2008; Cai and others, 2009; Defeo and others, 2009; McKenna and others, 2009). Although most shoreline parcels and tidelands in Washington are owned by private landowners, national laws like the Endangered Species Act describe a public interest in the condition of shoreline habitats, which are in turn dependent on some undefined level of sediment supply. This public interest in sediment supply is exemplified by the concept of 'sand rights' wherein sediment supply is considered a public resource under the 'doctrine of public trust' (Dean, 1991; Stone and others, 2005), and has provoked debate within regulatory agencies (Canning and Shipman, 1995; Titus, 1998).

## Private/Public Tradeoffs in Shoreline Development

Bulkheads are designed and installed where there is a perceived or real risk of property loss from toe erosion of shoreline banks, bluffs, and beaches. Washington State Hydraulic Code specifically requires the Washington Department of Fish and Wildlife to issue permits for shoreline armoring "in order to protect the property of marine waterfront shoreline" (Chapter 77.55.141 RCW). An analysis of permit data indicates a rate of new bulkhead construction of approximately 100 sites per year, not including reinforcement of existing bulkheads, and new construction outstrips removal by approximately 30 to 1 (Carman, Washington Department of Fish and Wildlife, oral commun., 2009). Given the incidence of unpermitted armor installation, these rates likely underestimate the annual increase in shoreline armoring. Recent history provides dramatic examples of rapidly increasing armoring along developing shorelines (Gabriel and Terich, 2005). Approximately 27 percent (1,070 km) of Puget Sound's shoreline has been armored to date (Simenstad and others, 2010). In the more developed Central Basin, 62.8 percent has been armored (Simenstad and others, 2010).

Bluff erosion is a different name for the phenomenon of beach sediment input. Those bluffs that are eroding rapidly are providing greater quantities of sediment, and preventing bluff erosion is the same as preventing sediment input. Assuming that bulkhead construction on bluff-backed beaches is a response to risk of property damage from erosion and waves, bulkhead construction should be greatest where erosion rates are high and shoreline population density is increasing, the confluence of maximum erosion threat to newly developed properties. Thus, the location of shoreline armoring is likely to be disproportionately focused where it will most strongly reduce sediment supply/erosion, in effect maximizing the ecosystem impacts of future armoring. These factors result in a potential tradeoff between the short-term interests of private shoreline land owners and the long-term natural resource interests of the general public.

## Restoration Programming and the Challenge of Beach Conservation

In Washington State, restoration programs typically use public bond revenue that is distributed through ‘capital budgets’ to fund projects that attempt to reverse ecosystem degradation. Historically, these sources of funds have been used to defray costs of building public health, transportation, education, and energy infrastructure. The 1998 listing of Puget Sound Chinook salmon under the Endangered Species Act and subsequent state and federal agency response has resulted in the development of a ‘salmon recovery economy,’ which today distributes tens of millions of dollars a year to Puget Sound organizations to restore habitat functions predicted to limit salmon populations. The current political leadership in Washington State has identified the Puget Sound as a threatened ecosystem of national importance that requires active management to prevent ecological decline (Puget Sound Partnership, 2008). Both federal and state budgets for Puget Sound ‘ecosystem restoration’ have increased substantially since 2006, and these investment levels have been largely sustained despite recent budget shortfalls.

Government restoration programs typically are responsible for project selection and contracting of funds, but not for implementation. A complex network of advocates, landowners, planners, technical experts, designers, contractors, contract managers, policy analysts, regulators, communication specialists, and stakeholders interact throughout development and implementation of a restoration authority to deliver on-the-ground projects. This ‘restoration system’ is more extensive, interdependent, and complex than is reflected in individual restoration authorities, and the structure and dynamics of the ‘restoration system’ strongly affects the outcomes of an individual restoration authority.

Some challenges faced by restoration programs working in beach ecosystems are common to all ecosystem restoration, but others are unique to beach ecosystems. Public benefit from ecosystem services is difficult to quantify, tracking the condition of an ecosystem is expensive, shoreline ecosystem degradation is frequently accepted as necessary for human well-being, and public dialog over shoreline land use is frequently stymied by conflicts over tradeoffs and ideological views of the relative importance of private property versus public trust rights. Public understanding of beach system dynamics and armoring impacts is limited.

On the other hand, restoration programs enjoy socio-political advantages not shared by regulatory programs. Although regulatory programs may reduce the profitability of some private enterprise, restoration programs generate economic activity that benefits local communities, and results in tangible outputs that can be seen by political leadership and their constituents. Restoration programs also may generate human capital through development of professional workgroups, opportunities for ecological learning, opportunities to increase the visibility of conservation issues, and an audience of influential policy makers interested in conservation and the outcome of public cash investments.

In this setting, more than a dozen individual state and federal restoration funding programs are selecting and implementing a small but increasing population of beach conservation actions. These include removal or modification of armoring, beach nourishment, removal or modification of overwater structures or fill, substrate modification, revegetation, and acquisition of development rights.

## Contemporary Beach Restoration Practices

Projects focused on beach system restoration are less common in Puget Sound than those focused on deltaic tidal marsh, river floodplain, or tributary channel habitats. Few restoration programs explicitly solicit beach restoration actions, and few restoration workgroups are aggressively developing beach restoration projects. Proposal reviewers frequently lack resources with which to accurately evaluate the benefits of individual projects. Recent studies associated with Shoreline Management Plan updates are supporting assessment and strategy development for shoreline restoration (Diefenderfer and others, 2009). In 2007, the Estuary and Salmon Restoration Program received the heretofore unique legislative mandate to restore nearshore processes “including protection and restoration of beach sediments and removal of existing bulkheads” (ESHB 1216 Section 3155). In 2009, the Washington State Recreation and Conservation Office, which manages natural resource grant programs, added technical staff in 2010 to explicitly improve evaluation of nearshore projects, including those affecting beach systems. The nature of beach systems creates a particular set of logistical challenges to restoration:

8. Beach sediment supply is maintained by allowing erosion of property that is highly valued for residential development. The high value of shoreline properties makes conservation more difficult and expensive than in freshwater or upland settings.

9. Restoration or protection of sediment supply must be implemented at a scale relevant to the beach system being managed. Littoral cell length ranges over 4 orders of magnitude with a median length of approximately 3 km, where parcel density ranges from 6 to 21 parcels per km (PSNERP, 2009).

10. The thresholds of sediment supply necessary to conserve beach goods and services within a particular system are typically unknown.

A review of beach restoration awards and proposals to the Estuary and Salmon Restoration Program to date suggests three general classes of restoration actions related to the management of sediment supply and transport:

A. ***Protection of sediment supply***—projects that seek to prevent loss of sediment supply through property rights acquisition that allows for continued bluff erosion by preventing or removing shoreline development.

B. ***Restoration of sediment supply***—projects that seek to restore sediment inputs or transport within a beach system through removal of bulkheads or barriers to longshore sediment drift.

C. ***Beach nourishment***—projects that place mined and imported material on existing beaches to create lower gradient, higher elevation, or finer textured beaches.

No existing state regulatory authority can stop armoring of coastal shorelines for the purpose of protecting private property. Therefore, the protection of sediment supply is limited to acquisition of shoreline parcels, among the most expensive property in the Puget Sound region. Funding for protection of sediment supply through property rights acquisition, however, reduces the funds available for restoration of the 27 percent of shoreline already armored.

In order for beach conservation to be effective, it must over time restore or protect sufficient sediment supply to maintain ecosystem services, and allow the shoreline to respond to sea level change. Because of the need for willing land owners, voluntary project work within a typical littoral cell is incremental. To be successful over time, however, the scale of work must match the degree of sediment supply degradation. Future shoreline development may outpace restoration of sediment supply. In addition, stressors like water pollution may cause a decline in ecological services despite intact ecosystem structures.

## Restoration Programming—Systems for Restoring Systems

The preceding analysis briefly defines the ecological risks of bluff armoring, the social context of beach restoration, and the tools and challenges typical of traditional restoration programs. The combination of limited restoration resources and widespread and ongoing degradation suggests that diffuse and opportunistic bulkhead removal by isolated restoration programs is unlikely to resolve the cumulative impacts of 1,070 km of armored shorelines, especially when the rate of armoring exceeds the rate of armoring removal.

In the opinion of this author, however, restoration programs provide a suite of tools and resources that are ultimately necessary for the restoration of beach ecosystems. Restoration programs manage substantial capital flows, define the terms and conditions for project implementation, implement and inform strategic planning, and develop regional restoration information networks (as discussed by Tichy and others, 1979; Plastrik and Taylor, 2006). Restoration programs are challenged to leverage limited resources and the “capital project tactic” into a strategic conservation response that achieves a long range goal of increased beach ecosystem functions. Under the scenario of extensive ongoing degradation of sediment supply, the program outputs likely to achieve long term program success are not the length of bulkhead removed, but rather the use of strategic prioritization to deliver pilot efforts that showcase exemplary beach management, and frame public debate on the management of sediment supply.

As described earlier, ‘restoration systems’ are local or regional social and economic networks driven by the funding from public restoration programs. Through project selection and funding, restoration programs are uniquely and collectively responsible for developing these ‘restoration systems’. In addition to reaching physical objectives of ecosystem change, a highly functioning ‘restoration system’ could (1) study the ecological dynamics of beach systems (Bell and others, 1997), (2) create a forum for discussion of beach issues with property owners, (3) develop accurate parametric estimates of future restoration costs, and (4) create public events that increase awareness of the risks associated with sediment starvation. These effects can be obtained from a restoration program at a relatively small incremental cost, as they take advantage of existing activities. These ‘secondary’ benefits may be very important in developing the social and regulatory environment that would make program goals of broad-scale ecosystem restoration possible.

Personal observation and experience in Puget Sound restoration programs suggests six interrelated programmatic functions of a restoration system. Each system function is promoted at some rudimentary level within any given restoration program. An assessment of these six functions at the scale of a restoration system provides a useful framework for analysis of the strengths, weaknesses, opportunities, and threats that are considered as part of a program’s strategic planning process (see Hill and Jones, 2008).

Function 1. **Strategic planning** includes activities that allow for the estimation of project benefits, resulting in comparison and prioritization of projects. Development can range from peer ranking of proposals to definition of a desired future landscape condition.

Function 2. **Capital distribution** includes mechanisms for the obligation and tracking of funds through contracts and agreements. Development can range from isolated solicitation and contracting procedures for each program to collaborative and administratively efficient funding systems that provide support through a restoration project's lifecycle.

Function 3. **Project development** includes those resources applied to bring a specific action from concept to execution, which can range from isolated and inexperienced project managers to strongly networked and interdisciplinary workgroups that use a body of well tested best- management practices.

Function 4. **Communications** maintain alignment of stakeholders around shared goals, and create consensus through the transfer of knowledge. Development can range from the isolated self-promotion of individuals or programs to collaborative national and regional messaging and outreach.

Function 5. **Stewardship** is that collection of mechanisms that prevent the loss of restoration gains and maintain the effectiveness of protection, from short term landowner agreements to conservation land use planning that engages communities and is supported by local governments.

Function 6. **Learning** is the development and application of knowledge to improve decision making. Development ranges from informal professional conversations to collaborative research among groups of projects and reference sites across landscapes.

Many authors have suggested that un-integrated project execution (a system focused on capital distribution and project development) without development of supporting systems (that is, strategic planning, learning, communications, and stewardship) increases the risk that ecosystem restoration will fail either through lack of technical efficacy or lack of public support (Walters and Holling, 1990; Ehrenfeld and Toth, 1997; Goetz and others, 2004; Van Cleve and others, 2004; Gelfenbaum and others, 2006; Reeve and others, 2006; Leschine and Petersen, 2007). However, the thorough integration of strategic planning, learning, communications, and stewardship into the process of project development and funding presents some substantial political and logistical challenges.

Strategic planning for Puget Sound beach restoration requires extensive regional assessment and conceptual modeling (Ehrenfeld and Toth, 1997; Diefenderfer and others, 2009) to direct assets among 812 shoreline segments. Complex private and public ownership of shorelines, the scale of beach impacts, and the scale of ecosystem processes being restored suggest an important role for learning, communications, or stewardship; weakness in these elements threatens program effectiveness. Under the pressures of performance and accountability systems, the short term conversion of capital into performance measures like 'acres restored' can become the focus of program activity to the exclusion of supporting the delivery of 'secondary' benefits like stewardship or learning that are more intangible.

Thus, there is a chronic tension between investing in the development of a more sophisticated restoration system and investing in on-the-ground implementation of projects that appear to show more direct progress toward meeting restoration objectives. This may be a false dichotomy resulting from the difficulty of quantifying social impacts in a system that has relied on measuring return on investment in acres.

## Restoration Program Strategies for Development of Restoration Systems

When compared to the scale and rate of sediment supply degradation, restoration programs are resource limited. The analysis provided heretofore of what may be necessary for effective beach ecosystem restoration has only increased the scope of restoration program responsibility, threatening to draw resources away from on-the-ground restoration actions. By contrast, in the state of Washington, grant program performance is often evaluated by considering the percentage of funds that are 'passed through' instead of being 'consumed' for 'administrative' functions. This form of efficiency evaluation assumes that programmatic investments provide less value than project investments, and again may stem from the difficulty of quantifying the benefits of strategic planning, stewardship, learning, or communications. I foresee three potential advantages to integrating planning, learning, stewardship and communications with on-the-ground project development and funding:

1. 'On-the-ground' actions are what result in potential changes in ecosystem condition. By having 'on-the-ground' workgroups participating in planning, learning, stewardship and communications, we increase the likelihood that these efforts will be relevant to 'on-the-ground' work.

2. If learning, communications, and stewardship goals are described in advance, contract negotiations can be used to mobilize a flexible network of non-governmental actors that are often better positioned to achieve results than their governmental counterparts, and without incurring substantial 'administrative' costs.

3. There is a dynamism and energy to on-the-ground activities that can lend energy and imperative to enhance planning, learning, stewardship, and communications.

Restoration systems are created and operated by multiple independent actors and face the challenge of policy coordination common to all governmental efforts. Integration of “off-the-ground” functions increases the imperative of policy coordination. Although most restoration *programs* maintain coordination using a hierarchical chain of command, network and market mechanisms can provide alternative strategies to hierarchical mechanisms for coordination within a *restoration* system (Peters, 2006).

An example of a market mechanism is found in the competitive proposal process, in which a restoration program acts as a consumer, and indicates product preference through a request for proposals. Local organizations involved in project development act as producers, developing on-the-ground products that meet program desires. For this process to work well, the program must adequately describe the desired product and maintain that demand long enough to allow time for project development.

Network mechanisms, wherein individuals freely communicate, align goals, and voluntarily share resources, can provide a range of difficult-to-quantify benefits (Tichy and others, 1979). The structure of organizations can influence a resident individual’s ability to build network ties (Ibarra, 1993; Manev and Stevenson, 2001). In particular support for individuals to work across organizational boundaries can increase innovation by facilitating the transfer of novel information among organizations (Aldrich and Herker, 1977; Tushman, 1977). Restoration programs can support and shape these networks to enhance the sharing of resources or encourage the collaborative delivery of services within restoration systems (Plastrik and Taylor, 2006).

In conclusion, I have included a brief description of some programmatic opportunities being explored by the Estuary and Salmon Restoration Program to support the development and integration of complex restoration system function in Puget Sound.

1. **Strategic peer review:** A local technical network has been identified from the project development, regulatory, and agency communities. Participants are provided an opportunity to review and discuss regional restoration planning guidance, and then conduct a transparent peer review of project proposals. This reduces the cost of proposal review, while increasing network understanding of strategic planning, and increasing the likelihood of future project development aligned with strategic priorities. Competitive mechanisms further insure that projects are well aligned with criteria, and that the distribution of resources is less influenced by political agendas.

2. **Technical grant deliverables:** Grant contracts include specifications for deliverables at key stages of project development. These deliverables document design assumptions, as-built conditions, and monitoring strategies. They become part of a public record, accessible to other project developers, and supporting post-construction project evaluation. This delivery of project documentation provides the secondary function of incentivizing high quality work, because the quality of restoration planning will be memorialized through publically accessible documents.

3. **Project based learning supported by local technical networks**. The Estuary and Salmon Restoration Program is in the process of developing learning strategies including basic monitoring protocols and a prioritized list of project research questions. The protocols are driven by a set of hypotheses that are generated and prioritized through a community process designed to consider how monitoring and research can most directly improve restoration practice. Technical networks, including individuals likely to be involved in future project development, are used to check and guide work completed by local experts.

4. **Enhancement of spending plans and projects to increase learning**. Each annual spending plan is analyzed for the purpose of identifying opportunities to increase useful knowledge through monitoring and analysis of project actions and their outcomes. Although a base level of monitoring is used to verify project outputs (see 3 above), individual projects or smaller groups of projects are selected for the purpose of evaluating and testing uncertainties documented during strategic planning or project development. The contracts of these projects include provisions that support learning. The results of these ‘enhancements’ are used to adjust project selection and contracting, or to revise strategies.

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