

PUGET SOUND MARINE AND NEARSHORE GRANT PROGRAM

SYNTHESIS OF 2011-2014 RESULTS AND KEY RECOMMENDATIONS FOR FUTURE RECOVERY EFFORTS

FINAL ANALYSIS REPORT

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1. INTRODUCTION

The Puget Sound Marine and Nearshore Grant Program (“the Grant Program”) is a partnership between the Washington Department of Fish and Wildlife (WDFW) and the Washington Department of Natural Resources (WDNR). Since 2011, the Grant Program has distributed National Estuary Program funds to support more than 75 projects to implement recovery priorities identified in the [Action Agenda for Puget Sound](#).

Five years into their current 6-year funding cycle, the Grant Program funded the Puget Sound Institute (PSI) to analyze and synthesize the results of their first 4 years of awards. The aim of this grant was to evaluate the results of completed work in order to inform and optimize future work at project, programmatic, and Puget Sound recovery levels.

PSI evaluated and synthesized the reports and deliverables of 50 grants in a series of three Analysis Reports:

- Part 1 covered 14 regulatory effectiveness and stewardship grants (Table 1);
- Part 2 covered 9 grants related to high-priority threats, and the Puget Sound Pressures Assessment (Table 2); and
- Part 3 covered 20 habitat protection and restoration grants, as well as 6 outreach efforts (Table 1).

This report provides an overview of key products, results, and recommendations presented in our 3 previous reports. We have organized key findings into the following categories:

1. Regulatory effectiveness
2. Promoting armor removal and “soft shore” protection techniques
3. Sea level rise planning and adaptation
4. Invasive species
5. Oil spill prevention and response
6. Eelgrass restoration
7. Habitat restoration and protection

These categories correspond broadly to top stressors identified in the Grant Program-funded 2014 Puget Sound Pressures Assessment (McManus et al. 2014), or to strategies for reducing specific stressors. Overall, the Grant Program’s funding strategy aligned well with Pressure Assessment stressor rankings for marine basins (Kinney et al. 2016a). The largest Grant Program investments focused on stressors with the highest potential impact rankings.

Detailed information and analyses related to the individual grants, as well as data from individual grants and additional recommendations, can be found in the Part 1-3 Reports. Not all grants are covered in this summary. The aim of this summary is to capture some of the key over-arching findings and messages that emerged from the synthesis and analysis.

Table 1. Grants Reviewed in Part 1 Analysis Report (Kinney et al. 2015)

Grant Award	Project Partners	Product Citations
Marine Shoreline Monitoring and Compliance Pilot Project in WRIA 9	King County Water and Land Resources	King County (2014)
Compliance Assessment	Ecology and WDFW	Talebi and Tyson (2014)
Targeted Outreach to Reduce Impacts from Shore Hardening in the PSMA	Northwest Straits Foundation, Coastal Geologic Services, EE Outcomes Consulting, Island and Snohomish Counties and MRCs	Johannessen (2013 a-b)
Marine Shoreline Design Guidelines	WDFW, Ecology, Coastal Geologic Services, and Qwg Applied Geology	Johannessen et al. (2014)
Nearshore Permitting Effectiveness through T.A.C.T.	Kitsap County, WDFW, and San Juan County	Barnhart et al. (2015) Dionne et al. (2015) Key (2013)
Puget Sound Shoreline Master Program Improvement	Futurewise	Futurewise (2014 a-d)
Protecting the Strait of Juan de Fuca Nearshore	Coastal Watershed Institute, Clallam County, WDNR, Ecology, and Earth Economics	Flores et al. (2013) Kaminsky et al. (2014) Shaffer et al. (2014) Parks (2015)
Puget Sound Feeder Bluffs Mapping	Ecology and Coastal Geologic Services	MacLennan et al. (2013)
Support Public Awareness, Outreach and Engagement on SMP Updates	Puget Sound Partnership, WSU Mason County Extension, Heidi Keller Consulting, and Friends of the San Juans	Keller (2012) WSU Mason County Extension (2013)
Sea Level Rise and Cumulative Effects Management Tools	Friends of the San Juans, Coastal Geologic Services, and Salish Sea Biological	MacLennan et al. (2013) Whitman and Hawkins (2013) Loring (2013) Whitman et al. (2014) Friends of the San Juans (2014)
20% More Eelgrass by 2020	WDNR and PNNL	Thom et al. (2014)
Ensuring Regulatory Effectiveness in Puget Sound's Most Special Places	Washington Environmental Council	Washington Environmental Council (2013)
Protecting Nearshore and Marine Habitat in Mason County	Mason County Community Development	Adkins (2013)
Social Marketing Strategy to Reduce Shoreline Armoring	Colehour + Cohen, Social Marketing Services, Futurewise, Coastal Geologic Services, and Applied Research Northwest	Colehour + Cohen et al. (2014 a-e)

Table 2. Grants Reviewed in Part 2 Analysis Report (Kinney et al. 2016a)

Grant Award	Project Partners	Product Citations
Ballast Water Management Assessment	WDFW and UW School of Aquatic and Fishery Sciences	Cordell et al. (2015)
Assessment of Biofouling Threats to Puget Sound	Portland State University and Smithsonian Environmental Research Center	Davidson et al. (2014)
Toxic Contamination Monitoring in Mussels (Mussel Watch Pilot Expansion)	WDFW	Lanksbury et al. (2012) Lanksbury et al. (2014)
Impacts of Outfalls on Eelgrass	WDNR	Gaeckle (2012) Gaeckle (2014) Gaeckle et al. (2015)
Assessing Threats from Large Oil Spills (Vessel Traffic Risk Assessment)	Puget Sound Partnership, George Washington University, and Virginia Commonwealth University	Van Dorp and Merrick (2014)
Community Engagement for Oil Spill Response and Readiness	Northwest Straits Foundation (NWSF)	NWSF (2015)
Swinomish Oil Spill Preparedness Project	Swinomish Indian Tribal Community	Swinomish Tribal Community (2014a-b)
Preparing COASST Post-Spill	UW Coastal Observation and Seabird Survey Team (COASST)	COAAST (2014)
Geographic Expansion of Seabird Survey and Early On-Scene Training	Seattle Audubon Society	Ross and Joyce (2014)
Puget Sound Integrated Risk Assessment	Puget Sound Partnership (PSP)	McManus et al. (2014) Labiosa et al. (2014)

Table 3. Grants Reviewed in Part 3 Analysis Report (Kinney et al. 2016b)

Grant Award	Project Partners	PRISM Project
Puget Sound Derelict Net Removal and Pilot Response	Northwest Straits Foundation	n/a
Pt. Heyer property acquisition	King County	Project #11-1282
Barnum Point property acquisition	The Nature Conservancy	Project #11-1651
Dabob Bay property acquisition	Northwest Watershed Institute and the Nature Conservancy	Project #11-1657
Southeast Lummi property acquisition	Lummi Island Heritage Trust	Project #14-1870
Waterman property acquisition	Whidbey Camano Land Trust	Project #14-1917
Lyre River property acquisition	North Olympic Land Trust	Project #14-1998
Maury Island property acquisition	King County	Project #14-2226
Skokomish restoration	Mason Conservation District and Skokomish Tribe	Project #11-1361
Port Susan restoration	The Nature Conservancy	Project #11-1650
Milltown Island restoration	Skagit River System Cooperative	Project #11-1669
Woodard Bay restoration	WDNR	Project #10-1116
Beard's Cove restoration	Great Peninsula Conservancy	Project #14-1326
Brown Island restoration	Friends of the San Juans	Project #13-1177
Seahurst Park restoration	City of Burien	Project #09-1415
Meadowbrook (3 Crabs) restoration	North Olympic Salmon Coalition	Project #11-1343
Howarth Park restoration	Snohomish County	Project #13-1106
Bowman Bay restoration	Northwest Straits Foundation	Project #13-1235
Fort Townsend restoration	Northwest Straits Foundation	Project #13-1234
Titlow Beach Park restoration	South Puget Sound Salmon Enhancement Group	Project #15-1447
Brown Island outreach	Friends of the San Juans	n/a
Seahurst Park outreach	Environmental Science Center	n/a
Meadowbrook (3 Crabs) outreach	North Olympic Salmon Coalition	Project #15-1329
Bowman Bay outreach	Northwest Straits Foundation	Project #15-1367
Fort Townsend outreach	Northwest Straits Foundation	n/a
Howarth Park outreach	Snohomish County Parks	Project #15-1422

2. REGULATORY EFFECTIVENESS

2.1 COMPLIANCE AND ENFORCEMENT

2.1.1 KEY RESULTS

- There is evidence that shoreline construction is often occurring in the absence of or out of compliance with permits (King County 2014; Friends of the San Juans 2014; Dionne et al. 2015; Barnhart et al. 2015; Futurewise 2014a). Inadequate compliance programs undermine the effectiveness of local SMPs. Compliance monitoring conducted in two Puget Sound counties and one city found that, on average, about half of shoreline modifications did not have required permits. Where permits were obtained, requirements were sometimes violated in nontrivial ways. On-site evaluations of permitted shoreline armoring projects in two counties found that some structures were built longer or closer to the water than was specified in permit documentation.
- Most local jurisdictions do not have dedicated enforcement staff and are not tracking Shoreline Master Program (SMP) compliance (Talebi and Tyson 2014; Futurewise 2014a; Johannessen 2013a). Agency resources are focused on development or review of regulations and guidelines, while compliance monitoring and enforcement are not prioritized.
- The wide range of compliance rates reported reflects the variation in outcomes measured (Figure 1) and data collection methods employed (Table 4 and Table 5). The highest quality data on *unpermitted* construction derived from surveys using field-based methods (boat surveys and site visits). Efforts that relied on remote methods (aerial photo interpretation) for baseline data appeared to identify fewer armoring projects.

Figure 1. Types of Compliance Outcomes Measured

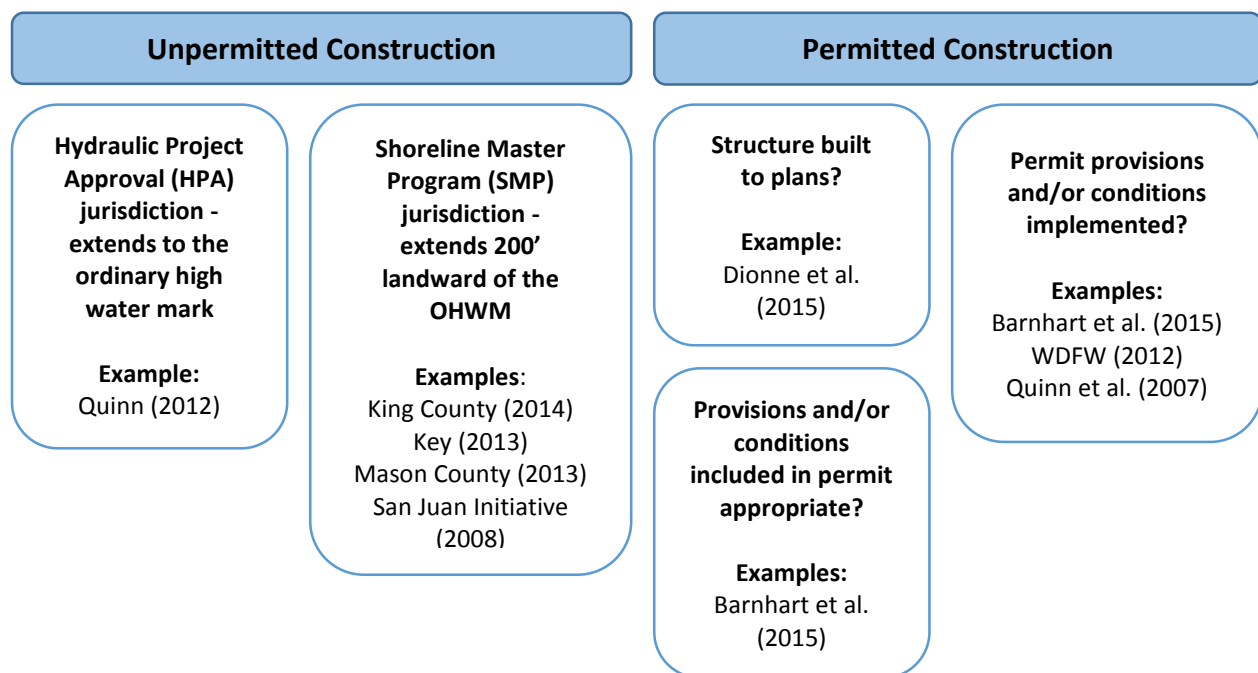


Table 4. Summary of Existing Puget Sound Shoreline Compliance Data – *Unpermitted Construction*

Source	Outcome(s) Measured	Method(s) to Determine Baseline	Time Period	Area	Data	Compliance Rate
King County (2014) *	changes in shoreline condition cross- checked against permit records (includes 200' landward of OHWM)	boat-based surveys and aerial photographs	2004-2013	92 miles of shoreline in King County (6 jurisdictions)	<ul style="list-style-type: none"> • 145 distinct changes in shoreline condition, including 7 new armoring and 66 armoring repairs • 46 changes permitted 	32%
Mason County (2013) *	unpermitted improvements	aerial photographs	2001-2011	10.5 miles of shoreline in Mason County	<ul style="list-style-type: none"> • 42 new overwater structures • 2 new shoreline armoring 	87%
Quinn (2012)	changes in beach structures cross- checked against HPA permit records	aerial photographs	2006-2012	55 miles of shoreline along Bainbridge Island	<ul style="list-style-type: none"> • 82 shoreline changes • 64 HPAs issued 	80%
Quinn (2012) and Key (2013) *	changes in in beach structures cross- checked against HPA and SMP permit records	aerial photographs	2006-2012	34 miles of shoreline in San Juan County	<ul style="list-style-type: none"> • 32 shoreline changes • 10 projects with both HPAs and SMP permits • 6 projects had only HPA or only SMP permits • 16 projects with no permits • 63% of the parcels with no permits on record involved armoring 	50%
Friends of the San Juans (2010)	baseline inventory of shoreline structures	boat-based surveys	April-July 2009	408 miles of shoreline in San Juan County	<ul style="list-style-type: none"> • 710 armored beaches • 472 docks 	not applicable
San Juan Initiative (2008)	shoreline modifications from MacLennan and Johannessen (2008) cross-checked against SMP permit records	boat-based surveys and aerial photographs	1977-2006	34 miles of shoreline in San Juan County	<ul style="list-style-type: none"> • >200 parcels • 9 SMP permits • 12 HPAs 	<10%

* funded by the Grant Program

Table 5. Summary of Existing Puget Sound Shoreline Compliance Data – *Permitted Construction*

Source	Outcome(s) Measured	Data Collection Method	Time Period	Area Evaluated	Number and Type of Data Points	Compliance Rate
Barnhart et al. (2015) *	number of shoreline armoring projects that complied with SMP permit conditions	review of permit records	2007-2012	unincorporated Kitsap County	<ul style="list-style-type: none"> • 60 bulkhead permits evaluated • 32 had at least 1 condition • 9 documented instances where conditions not met 	72%
Dionne et al. (2015) *	as-built dimensions and position of shoreline stabilization structures compared to corresponding measurements specified in issued HPAs	field measurements and review of permit records	permits issued 2006-2014	unincorporated Kitsap County and 34 miles of shoreline in San Juan County	<ul style="list-style-type: none"> • 45 shoreline stabilization structures measured • Compliance was difficult or impossible to measure for several projects because of information missing from the permit record: 6% had no clear statement of structure length and 55% lacked a fixed reference point. 26% longer than permitted • 26% taller than permitted • 21% further waterward than permitted 	
WDFW (2012)	number of projects that complied with mitigation provisions included in HPAs	site visits	2010-2011	12 counties	<ul style="list-style-type: none"> • 95 marine bank protection HPAs • 66 marine overwater structure HPAs 	91%
Quinn et al. (2007)	number of projects that complied with mitigation provisions included in HPAs	site visits	2005-2006	6 counties	<ul style="list-style-type: none"> • 14 marine bank protection HPAs 	73%
Whitman (2007)	temporal and spatial assessment of shoreline permit activity	geo-database development and queries	1972-2005	408 miles of shoreline in San Juan County	<ul style="list-style-type: none"> • 2,607 permits total • 372 violation permits 	40-100% depending on provision
San Juan Initiative (2008)	number of projects that complied with permit conditions	not provided	2006	34 miles of shoreline in San Juan County	<ul style="list-style-type: none"> • 9 SMP permits • 12 HPAs 	86%
						<50%

* funded by the Grant Program

2.1.2 RECOMMENDATIONS

- Prioritize compliance monitoring and enforcement activities. Reliable and consistent data on SMP and Hydraulic Code regulatory compliance need to be collected and acted upon. Rigorous baseline inventories of shoreline structures at the parcel scale are useful for identifying violations and tracking overall compliance rates.
- Coordinate enforcement efforts among departments or agencies to increase identification of unpermitted and non-compliant structures, as well as the efficiency of subsequent enforcement actions (Futurewise 2014a-b; Barnhart et al. 2015). Prioritize inspections before, during, and after construction of new and repair/replacement marine shoreline stabilization projects (Dionne et al. 2015; Barnhart et al. 2015).
- Encourage compliance by implementing penalties or other adverse consequences sufficient to deter non-compliance (Futurewise 2014a).
- Improve local program capacity by increasing access to technical experts in state agencies; training on legal/procedural requirements for enforcement actions; and providing resources to effectively manage permit data (Futurewise 2014a; Barnhart et al. 2015).

2.2 IMPLEMENTATION

2.2.1 KEY RESULTS

- Improving SMP permitting processes can strengthen protection of nearshore and marine resources without requiring changes to laws or regulations.
- Local shoreline management staff surveyed had concerns about their programs' capacity to process permits quickly and with adequate conditions and provisions, as well as with their access to technical expertise (Talebi and Tyson 2014).
- SMP implementers benefit from collaboration with WDFW Area Habitat Biologists during project review, but coordination is limited by staffing levels and workload demands (Barnhart et al. 2015).
- SMP program fee structures can result in restrictions on staff time that limit activities which could minimize impacts, such as pre-application assistance, research on protected species and habitats in the project area, and pre-construction inspections (Barnhart et al. 2015; Futurewise 2014a; Johannessen 2013b). This is especially true for exempted development. Between 2007 and 2012, an average of 80% of the shoreline armoring permits issued by Kitsap and San Juan Counties were processed as exemptions (Barnhart et al. 2015).
- Barnhart et al. (2015) found that staff conducting field inspections often had no training on locating the ordinary high water mark (OHWM). This is problematic where regulatory programs focus on minimizing negative impacts of marine shoreline development by limiting activities below OHWM.

2.2.2 RECOMMENDATIONS

- Provide financial resources and/or technical support to local jurisdictions for creating or updating electronic SMP data management systems to better support project review and enforcement.
- Develop standardized SMP review and inspection forms, procedures, tools, and definitions to improve the permit process and subsequent monitoring/tracking (Barnhart et al. 2015). Addition of

tracking metrics to permit records can assist with both compliance monitoring and implementation of “no net loss” requirements.

- Implement procedural improvements for permit review to ensure that SMP exemptions for shoreline protection projects are conditioned in a manner protective of priority habitats. Barnhart et al. (2015) identified several considerations for improving consistency in applying permit conditions.
- Develop an interagency mitigation manual to set standard mitigation requirements for shoreline erosion protection. A region-wide mitigation manual could encourage consistency across the multiple jurisdictions and agencies responsible for regulating shoreline development; result in more efficient and predictable permit review; and result in more avoidance, minimization, and compensatory measures incorporated into regulatory approvals (Futurewise 2014c). A mitigation manual could also provide jurisdictions with easy-to-apply conditions for projects processed as exemptions.

3. PROMOTING ARMOR REMOVAL AND “SOFT SHORE” PROTECTION TECHNIQUES

3.1 MARINE SHORELINE DESIGN GUIDELINES

3.1.1 KEY RESULTS

- The Marine Shoreline Design Guidelines (Johannessen et al. 2014), also known as MSDG, provides:
 1. A comprehensive framework for site assessment and alternatives analysis that can be applied to evaluate the need for shore protection and inform selection of appropriate erosion management techniques with deliberate consideration of physical processes and ecological impacts.
 2. Detailed descriptions and standardized design guidance for 5 engineered shore protection options: beach nourishment, large wood, reslope-revegetation, bulkhead removal, and hard armor. Information on application, effects, design considerations, costs, and monitoring/maintenance requirements is included.
- The MSDG is a key tool that can be used to determine where alternatives to traditional armoring are a feasible option for erosion control, to encourage techniques for minimizing impacts of existing structures undergoing repair, and to identify candidate sites for bulkhead setbacks or removal.
- The MSDG approach to determining the level of protection necessary at a site is based upon a cumulative risk model that integrates information on the causes and potential magnitude of erosion with risks to infrastructure. The type and proximity of structures are critical to qualifying risk at a site, with the magnitude of the risk directly corresponding to setback distance. The risk model helps distinguish actual need from perceived need. Considered along with other site characteristics, the risk score defines which design techniques are optimal for erosion control.
- Dionne et al. (2015) applied the risk model and decision tree to compare design recommendations generated by the MSDG with as-built conditions for 85 erosion control structures constructed 2006-2014. They found that 68% of the projects were more risk averse than the MSDG recommendation (e.g., hard armor instead of beach nourishment or LWD placement).
- Educational programs and focused outreach based upon the MSDG approach may help change widespread perceptions regarding the effectiveness and necessity of bulkheads for shore protection.

3.1.2 RECOMMENDATIONS

- Build regional capacity for specialized technical support on geological and engineering issues associated with shoreline projects. Develop a training program covering technical application of MSDG site assessment and design selection tools for engineers, consultants, and contractors.
- Develop additional training resources for SMP implementers covering the MSDG and alternative shoreline stabilization techniques. Investigate ways to expand participation in existing training opportunities for SMP implementers, for example by using webinars to reduce costs associated with travel/lodging.

3.2 SHORE FRIENDLY SOCIAL MARKETING STRATEGY

3.2.1 KEY RESULTS

- Residential parcels should be the focus of efforts to reverse current shoreline armoring trends:
 1. Residential parcels comprise almost 1,400 miles—roughly 57%—of the shoreline of Puget Sound and the southern Strait of Juan de Fuca (Colehour + Cohen et al. 2014c).
 2. 71% of the 1,200 HPAs issued for new and replacement marine shoreline stabilization structures between 2005 and 2012 were single family residential (Dionne et al. 2015).
 3. 48% of Puget Sound’s residential parcels are currently armored (Colehour + Cohen et al. 2014c).
- A significant number of hard armor structures that have been in place for decades are losing their structural integrity (Johannessen et al. 2014). Many of these bulkheads were installed prior to implementation of the SMA, when structures were commonly built in intertidal areas.
 1. Between 2007 and 2012 in Kitsap and San Juan Counties, 74% of issued permits were for repair or replacement of existing structures (Barnhart et al. 2015).
 2. In King County, 95% of observed changes in shoreline armoring between 2004 and 2013 were repairs (King County 2014).
- Structures approaching the end of their life span—many in areas where coastal erosion is not a pending threat to buildings, roads, or other infrastructure—present a major restoration opportunity. Bulkhead removal, setbacks, and/or incorporation of soft shore techniques can reverse some of the damage inflicted by erosion control structures in Puget Sound (Johannessen et al. 2014).
- Colehour + Cohen et al. (2014c) developed a Puget Sound parcel database to categorize properties by armor status, erosion potential, and presence/absence of homes. The project partners used this information to identify target behaviors, barriers, and motivations for each of these parcel groups, then developed social marketing incentive tools and messaging strategies to encourage preferred armoring behaviors (see Table 6).
- Landowners do not understand how armor impacts the health of Puget Sound and many see armor as a desirable, or even crucial, element in protecting shoreline properties (Colehour + Cohen et al. 2014d-e; Keller 2012).
- Working with landowners on a voluntary basis can address both the existing impacts of armoring and the future demand for it. Financial incentives, technical design assistance, and streamlining of permit processes can encourage landowners to consider alterations to existing structures and/or installation of alternative shore protection techniques.
- Direct and focused landowner engagement is key to changing landowner perceptions and behavior related to armoring (Colehour + Cohen et al. 2014d-e; Keller 2012; Futurewise 2014d; Shaffer et al. 2014; Johannessen 2013b). Participation of trusted community members resulted in positive responses from property owners. Technical assistance is best offered in a non-regulatory context.
- There is high demand for site visits where landowners can receive site-specific management recommendations from local experts in a non-regulatory context (Johannessen 2013b; Shaffer et al. 2014). Bluff landowners are particularly interested in information about upland management practices.

- The “Shore Friendly” social marketing framework was developed to motivate residential shoreline landowners to voluntarily choose alternatives to hard armor. It provides a coordinated set of audience-tested messages and incentive tools with great potential to change landowner perceptions and behavior regarding the effectiveness and necessity of bulkheads for shore protection.
- The cost of armor removal is a barrier that must be overcome in order for a social marketing effort around armor removal to succeed. Currently, there are not adequate financial incentives in place to overcome the cost barrier (Colehour + Cohen et al. 2014b).

3.2.2 RECOMMENDATIONS

- Expand current and develop additional incentive programs to encourage armor removal and/or soft shore techniques. Financial incentives, streamlined permitting, and technical assistance programs should be prioritized.
- Enhance the Puget Sound Conservation District’s regional capacity for nearshore technical assistance to landowners through training in Shore Friendly and MSDG resources.

Table 6. Shore Friendly Social Marketing Campaign Framework (Colehour + Cohen et al., 2014b)

Audience	Desired Behavior(s)	Barriers	Motivations	Potential Incentive Tools
Category 1 52% of parcels	leave shore unarmored	concern with erosion and storms, waves, or tides might change shoreline	<ul style="list-style-type: none"> • being confident their property would be protected or enhanced • enjoying the natural look • providing healthy habitat for fish and wildlife 	<ul style="list-style-type: none"> • free erosion assessment • Shore Friendly ambassador (single point of contact for questions, referrals, assistance) • certified contractor program • workshops • new homeowner packets and visits • stewardship recognition and awards • communication response after erosion events
Category 2 46% of parcels	remove all or a portion of armor replace armor with soft shore protection, if needed	concern with erosion	<ul style="list-style-type: none"> • being confident their property would be protected or enhanced 	<ul style="list-style-type: none"> • free erosion assessment • free technical assistance • Shore Friendly ambassador • certified contractor program • workshops • new homeowner packets and visits • stewardship recognition and awards
		expense of removing armor	<ul style="list-style-type: none"> • tax break • loan or grant 	<ul style="list-style-type: none"> • property tax breaks • grants • loans • group rates for neighborhoods • free technical assistance • free or discounted permits
		complicated nature of regulatory and permitting process to remove armor	<ul style="list-style-type: none"> • streamlined permitting process 	<ul style="list-style-type: none"> • special Shore Friendly permits • free technical assistance • certified contractor program • expedited permitting • free or discounted permits • Shore Friendly ambassador • ShoreFriendly.org

Armor removal and soft shore alternatives are generally less feasible for the remaining 1% of parcels due to high erosion potential.

4. SEA LEVEL RISE

4.1 KEY RESULTS

- Modeling and GIS tools can identify vulnerable infrastructure and habitats and support adaptation planning.
- MacLennan et al. (2013) identified almost 20 miles of public and private roads and 1,200 shoreline structures—primarily residential—that are vulnerable to future inundation and erosion hazards in San Juan County.
- Beach-spawning forage fish may be particularly vulnerable to sea level rise. Based on vertical egg distribution data from San Juan County, a rise in sea level of 1 foot would inundate 33% of surf smelt eggs, and a 2-foot rise would inundate 79% of eggs (Whitman et al. 2014).
- Intact sediment supply is a critical element of beach resilience to sea level rise (Johannessen et al. 2014).
- Projecting changes in shoreline position supports prioritization of infrastructure protection and relocation measures, as well as identification of long-term restoration and conservation targets. Relocation and/or redesign of public shoreline road infrastructure is a significant opportunity for habitat restoration and enhancement, as well as change adaptation.

4.2 RECOMMENDATIONS

- Fund additional sea level rise vulnerability evaluations to support local government efforts to incorporate climate change forecasts into local plans, regulations, and policies.
- Consider climate resiliency—of both communities (e.g., decrease public infrastructure like roads along the shoreline) and vulnerable habitats (e.g. forage fish spawning beaches)—as a decision criterion for restoration projects.

5. INVASIVE SPECIES

5.1 KEY RESULTS

- At least 74 marine and estuarine non-indigenous species (NIS) occur in Puget Sound (Davidson et al. 2014). The lack of data on impacts of marine and estuarine NIS established in the region hampers analyses of risks associated with these species.
- Records of marine and estuarine NIS introduction and spread in Puget Sound have increased over time (Davidson et al. 2014). Vessel biofouling and ballast water are currently the most significant vectors.
- Ballast water exchange regulations have reduced, but not eliminated, the discharge of NIS zooplankton into Puget Sound (Cordell et al. 2015). Total estimated coastal zooplankton discharged into Puget Sound declined dramatically after 2008; this increase in ballast water management compliance coincides with WDFW's focus on ship inspections, sampling, and review of ballasting records during this time period.
- Cordell et al. (2015) developed prioritization criteria to identify high-risk vessels for inspections and other management actions. Tankers from California are particularly high-risk, and exempt from federal regulations requiring ballast treatment system installation. Ballast water from the Columbia River is also categorized high-risk, but exchange is not required before entering Puget Sound under current regulations.
- The vessel biofouling vector is not currently managed in Washington, but development of a biofouling program is underway. High-risk commercial vessels can be identified through the age of their anti-fouling coating (i.e., hull maintenance schedule) and length of recent lay-ups. Biofouling risk is compounded by a lack of effective in-water cleaning systems that prevent release of both invasive species and pollutants (Davidson et al. 2014).
- Implementation of ballast water management criteria and development of a biofouling program is hindered by a lack of staff resources. Funding for WDFW's Aquatic Invasive Species and Ballast Water programs has declined in recent years, resulting in deferral of several high-priority activities.

5.2 RECOMMENDATIONS

- Support WDFW Aquatic Invasive Species and Ballast Water programs so that they can implement the risk criteria developed as part of previously-funded work; resolve policy issues involving changes to the state's Common Water Zone; and work with Ecology to examine tradeoffs between invasive species and toxins management measures.
- Conduct zooplankton monitoring and research to establish a baseline for detecting future invasions. The Asian copepod *Oithona davisae* is of particular concern. The PSEMP Forage Fish and Food Webs Workgroup could provide a venue to foster collaboration between NIS investigators and other researchers (e.g., Long Live the Kings' zooplankton monitoring program).

6. OIL SPILL PREVENTION AND RESPONSE

6.1 KEY RESULTS

- A Vessel Traffic Risk Assessment (VTRA) by Van Dorp and Merrick (2014) found that operation of three proposed maritime terminal developments—the Gateway bulk carrier terminal, the Trans-Mountain/Kinder Morgan pipeline expansion, and Delta Port terminal expansions—would increase the probability of an oil spill in US/Canadian trans-boundary waters. However, most of the POTENTIAL increased risk could be mitigated using a well-designed portfolio of management measures such as speed limits, one-way traffic regimes, and a rescue tug. Some of these interventions should be considered for implementation even if none of the terminal developments are constructed.
- Restoration sites and other high-value habitats may not be included in the six Geographic Response Plans that are used to guide coordinated spill response in Puget Sound. These plans can be strengthened with input from Tribes, local jurisdictions, and community organizations. Having access and other logistical issues worked out before a spill should significantly improve the performance of defensive measures intended to protect habitat (Swinomish Indian Tribal Community 2014a).
- Community volunteers can be engaged in some elements of spill response, but regular investment in recurring training sessions is required (NWSF 2015; COASST 2014; Ross and Joyce 2014). Keeping organizations and individuals engaged in maintaining volunteer response capabilities may prove to be challenging given the mismatch between the frequency of required trainings and the frequency of spill events.

6.2 RECOMMENDATIONS

- Use VTRA results to inform maritime vessel traffic management schemes, as well as future investments in community preparedness programs and regional response planning.
- Support community preparedness programs, but consider encouraging alternative training strategies for volunteer activities. Certifying organization staff to deliver HAZWOPER training to their volunteers and/or moving to a “just-in-time” model could help reduce costs and volunteer attrition.
- Update Geographic Response Plans (GRPs) with: specific locations where oil is likely to accumulate; access points and staging areas for responders; and high quality habitats where defensive measures can be prescribed. Tribes, local jurisdictions, and community organizations could contribute valuable knowledge to significantly increase the level of detail provided in current GRPs

7. EELGRASS

7.1 KEY RESULTS

- Protection and enhancement measures are needed to achieve recovery targets for eelgrass. Numerical biomass and habitat suitability models developed by Thom et al. (2014) found significant acreage with physical conditions suitable for eelgrass but with no eelgrass present, indicating stressors need to be managed. Survey input from technical experts and shoreline managers suggests locals can play a key role in managing stressors because of the site-specific nature of direct impacts like mooring buoys, overwater structures, and recreational shellfish harvest. Rigorous pre-planting site evaluations did not guarantee restoration success, so protection is vital.
- It is difficult to demonstrate a cause and effect relationship between outfall effluent and eelgrass decline in Puget Sound. However, concentrations of copper, lead, and zinc in eelgrass tissue collected from Puget Sound by (Gaeckle 2014) were within ranges where adverse effects have been observed elsewhere.

7.2 RECOMMENDATIONS

- Identify and mitigate site-specific activities that disturb eelgrass. Educate harbor masters, waterfront homeowners with mooring buoys, and park managers about boating impacts to eelgrass and how to minimize them.
- Evaluate and abate water quality stressors in areas where the Thom et al. (2014) model indicates they are suitable for eelgrass but eelgrass is absent or sparse.
- Conduct field investigations to identify relationships between stressors and eelgrass response.

8. HABITAT RESTORATION AND PROTECTION

8.1 KEY RESULTS

The Grant Program funded 20 restoration and acquisition projects through 2014. Locations of the 12 restoration sites, 7 property acquisitions, and derelict net removal sites that received Grant Program funding during Rounds 1-4 are shown in Figure 2. Individual projects are listed in Table 3 and described in the Part 3 Analysis Report (Kinney et al. 2016b).

Measurable results of these capital investments include:

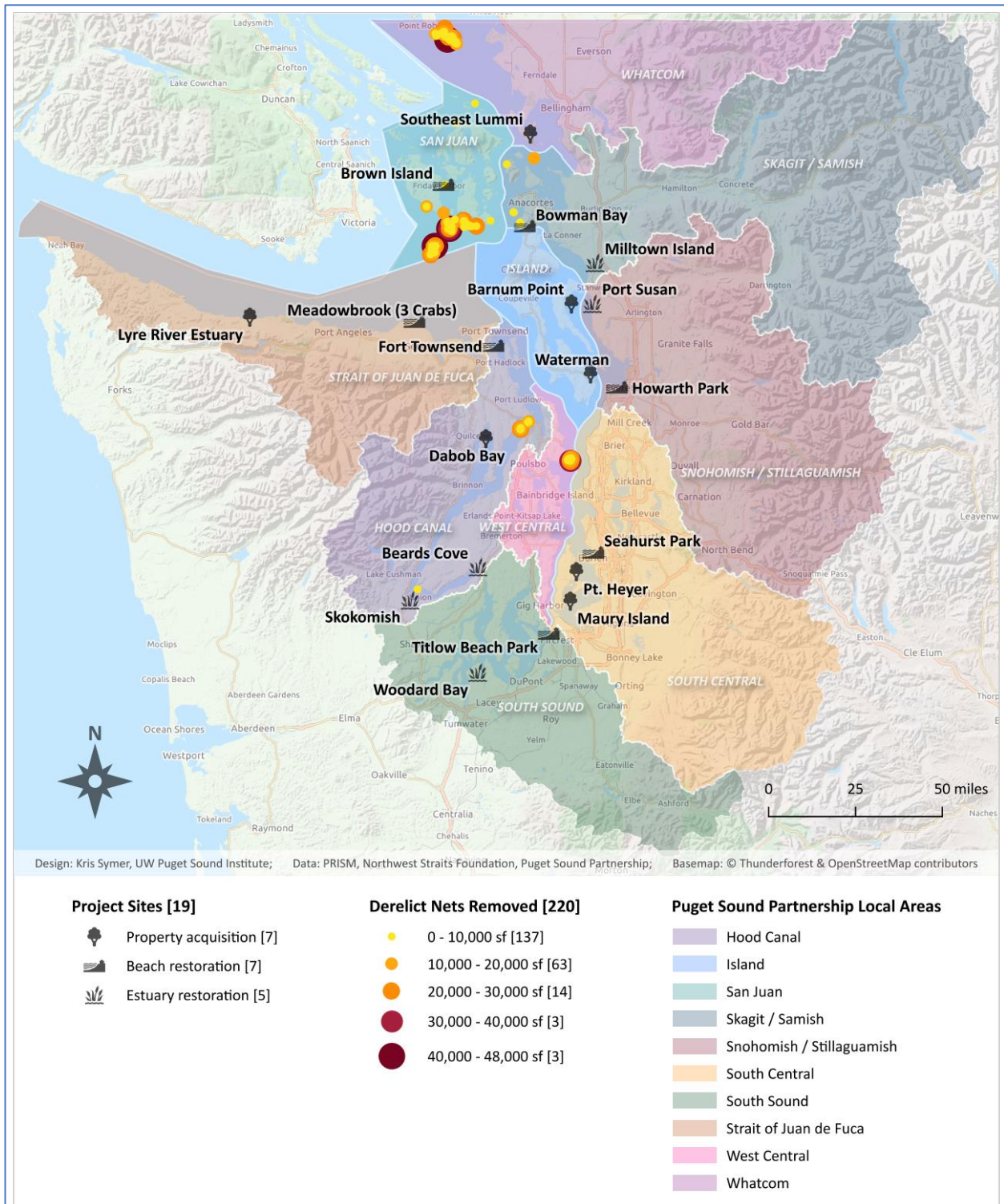
- 423 acres of restored and/or enhanced tidal hydrology at 3 major river deltas;
- 0.92 mile (4,801 linear feet) of shoreline armor removed;
- 373 acres of shoreline habitat and 2.85 miles (13,582 feet) of shoreline permanently protected;¹
- 57 acres of restored and/or enhanced tidal hydrology in 2 small estuaries;
- 600 toxic creosote pilings removed; and
- 48 acres of subtidal rocky reef habitat uncovered by removal of 220 derelict fishing nets.

Acquisition of intact bluff-backed beaches and armor removal projects received the bulk of capital funds. Beaches were a program priority because they tended to be underfunded, relative to other critical habitats like estuaries, by other state and federal funding sources.

Our Part 3 Analysis Report provides an evaluation of project costs relative to the area restored. We observed a very large range of calculated cost-per-acre values, with beach projects being significantly more expensive compared to estuary projects. It cost nearly \$8 million to remove a little under 1 mile of armoring. Further analysis revealed that this variation is a consequence of non-equivalent reporting of area restored for these two types of projects. The result is an understatement of the benefits of beach projects relative to estuary projects, which has implications for both program performance evaluations and proposal ranking/selection. This effect may extend to other project types with relatively high calculated costs per acre (e.g., toxics removal).

¹ Some of these output numbers suggest more precision than likely exists. In several cases the shoreline length metrics were recorded in miles protected or restored, which is not an optimal scale for smaller sites.

Figure 2. Acquisition and Restoration Project Locations



8.2 RECOMMENDATIONS

- Improve reporting metrics for beach projects by focusing on feet—not miles or acres—of armor removed. Even more useful would be including data on feeder bluff length and type.
- While reviewing and ranking armor removal proposals, strive to maximize project outcomes by focusing on sediment supply and transport (as the key habitat-forming process for Puget Sound beaches) rather than outputs like length of armor removed. The scale of a project relative to the size of its drift cell and the proportion of the drift cell with functional sediment dynamics are important evaluation criteria in this context. Keep in mind that the 2016 ranked list of armor removal Near Term Actions (NTAs)² was a result of proposals and a scoring process that lacked this level of specificity.
- Given the extent of new armoring that is continuing to be built, regulatory and incentive-based approaches are crucial for progress towards the [Shoreline Armoring indicator target](#). Opportunities for armor removal on public lands have largely been exhausted, so a focus on private properties is necessary.
- Use findings and products of ongoing technical investigations as decision support tools to identify areas where beach restoration and Shore Friendly incentive investments would have the most impact.
- Support monitoring of project performance relative to intended physical and biological outcomes. In the near-term, emphasize investment in monitoring beach geomorphology after armor removal projects because this information is most crucial for optimizing selection of future projects.

² NTAs are new programs, projects, investigations, or other actions intended to advance priority recovery sub-strategies. They are the core of the Implementation Plan component of the [2016 Action Agenda Update](#). Information on the fall 2015 solicitation, subsequent review process, and ranked lists of NTAs can be found on the Puget Sound Partnership's [2016 Near Term Action Proposals website](#).

9. CONCLUSIONS AND FUTURE FUNDING RECOMMENDATIONS

In Appendix B, we connect 2016 NTA proposals to specific recommendations made in this report and identify gaps that could be filled via future proposal solicitations. This summary demonstrates the value of a synthesis step to maximize the utility of prior investments in recovery and integrate past learning into future decisions. This work will support the development of the Shoreline Armoring Implementation Strategy, by providing technical and programmatic information related to the best available science around shoreline armoring, as well as setting the policy and human context.

A small number of innovative projects stand out, among all those we reviewed, as particularly suitable for translation to other jurisdictions. The following efforts formulated and tested solutions for priority stressors:

- Nearshore Permitting Effectiveness through T.A.C.T. (Barnhart et al. 2015 and Dionne et al. 2015)
- Marine Shoreline Monitoring and Compliance Pilot Project in WRIA 9 (King County 2014)
- Targeted Outreach to Reduce Impacts from Shore Hardening in the PSMA (Johannessen 2013 a-b)
- Shore Friendly Social Marketing Strategy (Colehour + Cohen et al. 2014 a-e)
- Sea Level Rise Vulnerability Assessment for San Juan County (MacLennan et al. 2013)
- Development of a Sediment Budget in Clallam County using Boat-based LiDAR (Kaminsky et al 2014)
- Swinomish Oil Spill Preparedness Project (Swinomish Tribal Community 2014 a-b)

This project required synthesis of dozens of reports and final deliverables from recipients of NEP funding. Based on this review, we make the following recommendations for deliverables and requirements for future NEP funding recipients:

- Grantees should be required to produce a 1-page summary of their findings for communication to a broad audience.
- Grantees should provide a list of project deliverables to accompany their submission.
- Grantees should provide project metadata (where the project occurred, how much it cost, how much area was impacted, etc.) to the Puget Sound Project Atlas and, for the northern Puget Sound counties, any raw data and spatial location to SoundIQ, maintained by the Northwest Straits Commission.

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APPENDIX B: SUMMARY OF 2016 NTA PROPOSALS RELATED TO PSI RECOMMENDATIONS

Recommendation	2016 NTA Proposal	Owner	Rank
ASSESS COMPLIANCE AND IMPROVE ENFORCEMENT OF EXISTING REGULATIONS			
Develop standardized compliance monitoring protocols, including baseline inventories of shoreline structures.	GAP <i>WRIA 9 Pilot is a model that could be expanded to other jurisdictions</i>		
Identify unpermitted and non-compliant shoreline structures.	0116 WRIA 9 marine shoreline monitoring and compliance	King County Natural Resources and Parks	6
	0377 Hydraulic Code compliance assurance program	WDFW	115
Direct resources to enforcement programs: inspections before, during, and after construction; staff salaries; training on legal and procedural requirements for enforcement actions; and access to technical experts in state agencies.	GAP		
STRENGTHEN IMPLEMENTATION OF EXISTING REGULATIONS			
Create or update electronic SMP and HPA data management systems to better support project review and enforcement.	0280 Regional local regulatory compliance tracking systems pilot	Jefferson County Public Health	103
	0049 Online application and database management tools for HPAs	WDFW	204
Develop standardized SMP review and inspection forms, procedures, tools, and definitions to improve permit review and subsequent monitoring/tracking.	GAP <i>T.A.C.T. is a model that could be expanded to other jurisdictions</i>		
Develop tools and training to support local implementation of “demonstration of need” and “no net loss” SMP provisions. Encourage use of the MSDG alternatives evaluation framework to support mitigation sequencing for shoreline protection projects.	0350 Improving implementation of shoreline modification regulations	WDFW	66
	0272 Guidance manual for no net loss of ecological functions in critical areas	WDFW	77
	0354 Habitat evaluation procedures	Seattle DCI	139
	0314 No net loss evaluation framework	The Watershed Company	178

Recommendation	2016 NTA Proposal		Owner	Rank
Compile data on how local jurisdictions review and conditions projects exempt from substantial development permit procedural requirements. Examine if/how permit fee structures limit staff hours dedicated to review of exempt projects.	GAP	<i>Will be included in the Base Program Analysis for Shoreline Armoring</i>	<i>UW Puget Sound Institute</i>	
Collect and map data on priority habitats and species for use by shoreline planners during permit review and conditioning.	0165	Eelgrass and forage fish mapping in Snohomish County	Snohomish MRC	139
	0392	Critical forage fish habitat identification and protection	WDFW	169
	0079	Forage fish survey and baseline habitat map for Commencement Bay	Citizens for a Healthy Bay	189
	0060	West Sound eelgrass monitoring program	Suquamish Tribe	194
PROMOTE ARMOR REMOVAL AND “SOFT SHORE” PROTECTION TECHNIQUES				
Develop a training program covering technical applications of MSDG site assessment and design selection tools for engineers, consultants, and contractors.	0380	MSDG engineering technical assistance, training, and outreach	WDFW	115
Enhance regional capacity for Puget Sound Conservation Districts to provide nearshore technical assistance to landowners.	0172	Expand Conservation District Shore Friendly programs across Puget Sound	Mason Conservation District	37
	0268	Expand Conservation District shoreline technical assistance in Puget Sound	Puget Sound Conservation District Caucus	48
Support technical assistance and other incentive programs that promote desired armoring behaviors on private property.	0001	Shoreline armoring reduction project	NWSF	4
	0139	Permanent marine shoreline protection in San Juan County	Friends of the San Juans	31
	0327	Marine shoreline technical assistance and project identification	King Conservation District	37
	0145	Shoreline stewardship technical assistance program	San Juan Islands Conservation District	54

Recommendation	2016 NTA Proposal	Owner	Rank
	0197 Discovery Bay landowner outreach	Jefferson MRC	54
	0171 Port Susan armor reduction	Snohomish MRC	66
	0236 Shore Friendly incentives in King, Snohomish, and Pierce Counties	Futurewise	93
	0104 Hood Canal shoreline outreach and technical assistance	WSU	121
	0196 West Central nearshore restoration prioritization and armor removal	Kitsap County	126
	1219 Green Shores for Homes implementation	Washington Sea Grant	126
PROTECT AND RESTORE HABITAT-FORMING PROCESSES			
Support efforts that provide data for prioritization of project proposals on a landscape scale.	0398 Strategic mapping of priority drift cells for protection and restoration	Ecology	8
	0123 Beach strategies for nearshore restoration and protection	Coastal Geologic Services	121
	0393 Hood Canal nearshore inventory, assessment, and prioritization	Hood Canal Coordinating Council	178
PROTECT, ENHANCE, AND RESTORE EELGRASS BEDS			
Identify and mitigate site-specific activities that disturb eelgrass. Educate harbor masters, waterfront homeowners with mooring buoys, and park managers about boating impacts to eelgrass and how to minimize them.	GAP		
Evaluate and abate water quality stressors in areas the PNNL model indicates are suitable for eelgrass but eelgrass is absent or sparse.	0357 Implement eelgrass recovery strategy in Quartermaster Harbor focus area	WDNR	93
	0363 Coordinated approach to support effectiveness monitoring	Ecology	200
Conduct field investigations to identify relationships between stressors and eelgrass response.	GAP		

Recommendation	2016 NTA Proposal		Owner	Rank
INVEST IN MONITORING AND ADAPTIVE MANAGEMENT				
Continue HPA effectiveness monitoring field surveys to evaluate the extent to which mitigation provisions result in desired outcomes.	0132	Improve effectiveness of state Hydraulic Code rules	WDFW	174
Encourage use of standardized protocols for monitoring beach response to construction. Compile existing information and monitoring reports (physical and biological) for alternative shore protection and beach restoration projects.	0119	Shoreline Monitoring Toolbox protocol implementation and data management	Washington Sea Grant	115
	0221	A queryable spatial data service for habitat restoration projects	WDFW	198
Monitor project performance relative to intended physical (immediate and intermediate) and biological (end) outcomes to validate hypotheses at the center of the process-based model of restoration.	0328	Monitor the effectiveness of shoreline restoration	UW Puget Sound Institute	44
	0324	Monitoring biological endpoints of eelgrass restoration	UW Puget Sound Institute	58
INVEST IN SEA LEVEL RISE VULNERABILITY ASSESSMENT AND ADAPTATION				
Conduct sea-level rise vulnerability assessments to identify infrastructure and habitats at risk from inundation and/or erosion hazards. Support local government efforts to incorporate climate change forecasts into local plan, regulations, and policies.	0089	Community-scale sea level rise and coastal hazard assessment	UW Climate Impacts Group	2
	0140	Advancing sea level rise adaptation in San Juan County	Friends of the San Juans	48
	0190	Climate change vulnerability assessment and adaptation plan	Kitsap County	93
	0293	Puget Sound integrated coastal inundation modeling and mapping	USGS	103
INVEST IN OIL SPILL PREVENTION AND RESPONSE				
Use VTRA results to inform future investments in community preparedness programs and regional response planning.	0400	Higher volume port area evaluation	Makah Tribal Council	8
	0219	Vessel Traffic Risk Assessment update	Ecology	11

Recommendation	2016 NTA Proposal	Owner	Rank
	0362 Trans-boundary vessel safety summit	Makah Tribal Council	22
Continue to support community preparedness programs, but consider encouraging alternative training strategies for volunteer activities. Certifying organization staff to deliver HAZWOPER training to their volunteers and/or moving to a “just-in-time” model could help reduce costs and volunteer attrition.	0322 Evaluate the status of marine birds at greatest risk from oil spills	Seattle Audubon Society	48
	0138 Oil spill trainings to increase preparedness of local communities	Clallam MRC	66
Update Geographic Response Plans (GRPs) with: specific locations where oil is likely to accumulate; access points and staging areas for responders; and high quality habitats where defensive measures can be prescribed. Tribes, local jurisdictions, and community organizations could contribute valuable knowledge to significantly increase the level of detail provided in current GRPs.	0239 Shoreline segmentation: citizens improving oil spill response data	Northwest Straits Commission	66
INVEST IN INVASIVE SPECIES PREVENTION, DETECTION, AND RESPONSE			
Continue to support WDFW Aquatic Invasive Species and Ballast Water programs so that they can: (1) implement the risk criteria developed as part of previously-funded work; (2) resolve policy issues involving changes to the state’s Common Water Zone; and (3) work with Ecology to examine tradeoffs between invasive species and toxins management measures.	0030 Assessing changes in marine water quality related to antifouling paints	Ecology	58
	0301 Copper-free boat paint implementation	Ecology	7 (Stormwater)
Conduct zooplankton monitoring and research to establish a baseline for detecting future invasions. The Asian copepod <i>Oithona davisae</i> is of particular concern. The PSEMP Forage Fish and Food Webs Workgroup could provide a venue to foster collaboration between NIS investigators and other researchers.	0367 Puget Sound-wide zooplankton monitoring program	Long Live the Kings	66

Recommendation	2016 NTA Proposal		Owner	Rank
UTILIZE PSSA FINDINGS TO GUIDE FUTURE INVESTMENT DECISIONS				
Consider placing additional emphasis on stressors expected to become more impactful under projected climate change scenarios, such as changing ocean conditions and sea level rise.	0405	Ocean acidification hotspots and sources of shellfish resilience	WDNR	66
	0366	Encourage BMPs and behaviors that address nutrient-driven ocean acidification	Washington Sea Grant	93 (Stormwater)
	0408	Add acidification parameters to Ecology monitoring network	Ecology	132
	0063	Samish Bay and Padilla Bay oxygen, acidification, and bacterial submodels	Ecology	189