PUGET SOUND MARINE AND NEARSHORE GRANT PROGRAM

ANALYSIS OF 2016-2019 SHORELINE ARMORING INVESTMENTS

A REVIEW OF GRANT PROGRAM RESULTS, PART 4

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EXECUTIVE SUMMARY

Since 2011, the Puget Sound Marine and Nearshore Grant Program distributed National Estuary Program funds to support more than 75 projects that implement recovery priorities identified in the Action Agenda for Puget Sound.

This report summarizes recent results of investments related to shoreline armoring: 2 scientific investigations into the impacts of hard armor and biological/physical responses to its removal, and 10 grants used to establish then expand incentive programs for residential homeowners.

IMPACTS OF SHORELINE ARMORING

The Grant Program funded a multidisciplinary team of researchers from several organizations who produced new data and analyzed existing datasets in an effort to evaluate effects of armor. The intent of this grant was to decrease uncertainty about the impacts of hardened shores in Puget Sound by establishing quantitative linkages between armoring and changes to geomorphic and ecological conditions at multiple scales.

Project partners collected and evaluated biological and physical data at 37 pairs of armored and unarmored beach sites. This work contributed to a pivotal scientific paper, Dethier et al. (2016), that demonstrated armor impacts on several ecological and geomorphic parameters.

Project partners mapped then analyzed geomorphic features of 7 drift cells in the Whidbey Basin with varying amounts of bulkheading to characterize long-term landscape changes. Hood et al. (2016) developed a simplistic box model of sediment movement from one beach segment to the next. Further refinements to this model could result in simulations to estimate how changes to drift cells (e.g., new armor or armor removal) would impact beach morphology.

Project partners examined potential future impacts of existing armor under changing sea level and wave conditions to identify vulnerabilities in 27 northern Puget Sound drift cells. McBride et al. (2016) provides a useful analysis of sea level rise vulnerability and opportunities to increase resilience.

This body of work provides rigorous scientific evidence in support of regulatory, protection, and restoration actions. Results can be used to identify restoration projects likely to result in more beneficial changes to ecosystem function and have implications for protection/restoration project prioritization.

WATERFRONT HOMEOWNER INCENTIVE PROGRAMS

Between 2014 and 2016, the Grant Program awarded 10 grants for local incentive programs intended to motivate waterfront homeowners to remove bulkheads and/or choose alternatives to hard armor on their property. Grantees engaged an impressive number of participants in a variety of “Shore Friendly” program activities:

- The grantees hosted 24 homeowner workshops with a total of 672 attendees.
- The grantees held 23 trainings attended by 499 professionals that provide information to homeowners as they are making shoreline management decisions.
- The grantees conducted 562 site visits to teach shoreline homeowners about their property and management options.
- The grantees provided design services for 23 armor removal or soft shore projects and permitting assistance for 17 projects.
- The grantees disbursed mini-grants worth $111,586 to 49 homeowners in support of project implementation. Projects included armor removal, vegetation management, and drainage improvements.
- Grantees collaborated with regulators to identify ways to streamline permitting for armor removal and soft shore projects.
- Grantee efforts resulted in 15 armor removal projects along 3,185 linear feet of shoreline.
- Four additional projects to remove 940 linear feet of armor are moving towards implementation with completed designs and permit packages.

ECONOMIC ANALYSIS OF DIFFERENT SHORELINE TREATMENTS

Island County (2016b) reported that participants in their contractor/consultant workshops were interested in further information about the relative cost of constructing soft shore protection versus hard armoring. In response, Cote and Domanski (2019) conducted several analyses to determine the relative costs and benefits—both economic and ecological—of five different shoreline treatments.

Cote and Domanski (2019) compiled and analyzed costs associated with 28 shoreline stabilization projects (installation of new and replacement armor, removal of existing hard armor, and installation of soft shore protection). Project costs ranged from $30,000 to $100,000 per property. Replacing hard armor with new hard armor was the most expensive type project. Removing existing armor and allowing a natural beach to develop was the least expensive. However, many property-specific variables affect construction cost.

The cost of moving homes ranges from $35,000 to $60,000. Costs associated with excavation, foundation construction, utilities, and permits add an additional $50,000 to $75,000.

Cote and Domanski (2019) found that the net effect of armor on land value varies, depending on the height of the bank or armoring. Hard armoring is correlated with higher land values for mid-bluff and high-bluff parcels. The greatest benefit was observed for mid-bluff parcels. Low bluff homes are likely to gain the greatest private benefit from incentives to conduct armor removal.

SHORELINE RESTORATION MONITORING

The Grant Program funded the establishment of common monitoring protocols to assess the effectiveness of armor removal projects and implementation of a first phase of monitoring for 14 Puget Sound restoration sites.

Dionne (2015) developed a detailed monitoring protocol for application to current and future restoration activities. Structural beach features are a focus of the protocol so that impacts to processes supporting nearshore habitat can be observed. Use of a standardized monitoring framework allows for more direct comparisons of parameters and ensures repeatability beyond the scope of the current project.

Faulkner (2019) reported results from monitoring at the 14 sites between 2015 and 2018. The common responses to armor removal across sites – beach elevation and width, number of logs and width of log line, wrack accumulation, and riparian shade – all reverted towards the configuration of natural reference shorelines. Faulkner (2019) is one component of the largest study to date focused on the effectiveness and impacts of shoreline restoration, and specifically armor removal, in the Puget Sound region.

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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). Between 2011 and 2018, the Grant Program distributed National Estuary Program funds to support more than 75 projects that implement recovery priorities identified in the Action Agenda for Puget Sound.

In 2015, 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 four analysis reports:

- Part 1 covered 14 regulatory effectiveness and stewardship grants (Kinney et al. 2015)
- Part 2 covered 9 grants related to high-priority threats and the Puget Sound Pressures Assessment (Kinney et al. 2016a)
- Part 3 covered 20 capital investments in habitat protection and restoration (Kinney et al. 2016b)
- A final report synthesizing all 2011-2014 investments (Kinney et al. 2016c)

In 2018, the Grant Program funded PSI to analyze and synthesize results of projects completed since 2016. Results of the 30 most recent awards are summarized in 3 addendums to the original analysis reports and this new Part 4 analysis report. **This report summarizes recent shoreline armoring results: 10 grants used to establish then expand incentive programs for residential homeowners (Table 1) and 2 scientific investigations into the impacts of hard armor and biological/physical responses to its removal (Table 2)**.

The shoreline incentive work builds upon several previously completed projects funded by the Grant Program (Johannessen 2012, Keller 2012, Johannessen 2013a-b, Colehour + Cohen et al. 2014a-e). **The Part 1 report provides a summary of the formative research and early pilot efforts upon which the projects covered in this report are based.**

In 2018, a formal recovery plan intended to reduce hard armoring in Puget Sound—the Shoreline Armoring Implementation Strategy (Habitat Strategic Initiative 2018)—was released. That plan includes an incentive strategy based upon early incentive projects funded by the Grant Program. **The lessons learned from the more recent projects and studies synthesized here are intended to inform adaptive management of the Implementation Strategy, as well as administration of new and ongoing "Shore Friendly" programs housed at WDFW's Estuary and Salmon Management Program beginning in 2019.**

Table 1: Grants for shoreline homeowner incentive programs

Award	Grantee	Products
Shore Friendly in the San Juans (2014)	San Juan County	San Juan County (2016)
Enhancing Shore Friendly Incentives (2016)	San Juan Island Conservation District	San Juan Islands Conservation District (2019)
Landowner Incentives to Reduce Puget Sound Shoreline Armoring in Island County (2014)	Island County	Island County (2016a) Island County (2016b)
Shoreline Armoring Reduction Incentives (2016)	Island County	Island County (2019) Cote and Domanski (2019)
Social Marketing Campaign to Reduce Shoreline Armor through Incentives (2014)	Kitsap County	Shore Friendly Kitsap Planning Team (2017a) Shore Friendly Kitsap Planning Team (2017b)
Continuing Shore Friendly Kitsap (2016)	Kitsap County	Shore Friendly Kitsap Planning Team (2019) WSU Kitsap Extension (2018a) WSU Kitsap Extension (2018b)
Shore Friendly Mason (2014)	Mason Conservation District	Mason Conservation District (2016a) Mason Conservation District (2016b)
Continuing Shore Friendly Mason (2016)	Mason Conservation District	Mason Conservation District (2019a) Mason Conservation District (2019b)
Landowner Incentives to Reduce Shoreline Armoring (2014)	Northwest Straits Foundation	Northwest Straits Foundation (2016)
Shoreline Armoring Reduction Project (2016)	Northwest Straits Foundation	Northwest Straits Foundation (2019a) Northwest Straits Foundation (2019b)

Table 2: Adaptive management grants to advance shoreline science

Award	Grantee	Products
Quantifying Impacts from Shoreline Armoring	Skagit River System Cooperative	Dethier et al. (2016) McBride et al. (2016a) Hood et al. (2016) McBride et al. (2016b)
Shoreline Restoration Monitoring	WDFW	Faulkner (2019) Dionne (2015)

2. IMPACTS OF SHORELINE ARMORING

The intent of this grant was to decrease uncertainty about the impacts of hardened shores in Puget Sound by establishing quantitative linkages between armoring and changes to geomorphic and ecological conditions at multiple scales. A multidisciplinary team of researchers from several organizations produced new data and analyzed existing datasets in an effort to evaluate effects of armor.

The body of work summarized here provides rigorous scientific evidence in support of regulatory, protection, and restoration actions. Results can be used to identify restoration projects likely to result in more beneficial changes to ecosystem function and have implications for protection/restoration project prioritization.

2.1 LOCAL-SCALE EFFECTS

Project partners collected and evaluated **data from 37 pairs of armored and unarmored sites** to evaluate how armoring affected the beach immediately seaward of the armoring.[1] This work resulted in a pivotal scientific paper—Dethier et al. (2016)—that demonstrated armor impacts several ecological and geomorphic parameters.

Relationships between shoreline status, ecological function, and physical geomorphology were analyzed after collecting biological and physical data from the paired sites:

- Wrack[2] composition and invertebrates – Percent cover of seagrass, algae, and terrestrial vegetation in wrack; number of logs and width of log line; invertebrates from insect traps, wrack, and the top of sediment.
- Beach profile and grain size – Beach face elevations and slope; bulk sediment samples for grain size distribution

Local impacts were evaluated through paired t-tests that compared differences between mean values of each of 27 measured response variables at each pair of beaches. Larger-scale effects were evaluated by testing the effects of **relative encroachment**[3] and proportion of the drift

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[1] The beach pairs were located throughout the Whidbey Basin, San Juan Islands, and Georgia Strait. Sites were sampled in 2012 and 2013. **The data collection effort funded by this grant expanded previous sampling** of 29 paired sites in central and south Puget Sound that occurred 2010-2012. **Dethier et al. (2016) reported on analysis of data from both datasets (65 pairs total).**

[2] **Wrack** is organic material that is cast up onto the beach by surf, tides, and wind. Wrack accumulations are referred to as the "wrack line" which usually corresponds to high tide. Wrack provides food and habitat for many species, including invertebrates, fish, and birds.

[3] **Relative encroachment** is the elevation of armoring relative to **mean higher high water (MHHW)**. Positive values indicate that armoring was located below MHHW elevation, while negative values indicate the toe was above MHHW. This value accounts for varying tidal elevations throughout the study area and enables meaningful assessment of impacts of armor located on lower/higher on beach profiles.

cell[4] that was armored on response variables using a mixed effects model. Results are summarized in Table 3.

Table 3. Summary of significant relationships between armor variables and response parameters as described in Dethier et al. (2016)

Variable	Armor Status	Relative Encroachment	Proportion of Drift Cell Armored
Beach width	unarmored > armored	—	—
Beach slope	not significant	decrease	increase
Shade on upper shore	unarmored > armored	—	—
Number of logs	unarmored > armored	—	—
Width of log line	unarmored > armored	—	—
Wrack terrestrial % cover	unarmored > armored	decrease	not significant
Wrack algae % cover	unarmored > armored	decrease	not significant
Wrack total % cover	unarmored > armored	decrease	not significant
Wrack total mass	unarmored > armored	decrease	decrease
Wrack algae mass	unarmored > armored	decrease	decrease
Wrack terrestrial mass	unarmored > armored	decrease	not significant
Wrack total invertebrates	not significant	decrease	decrease
Wrack total amphipods	not significant	decrease	not significant
Wrack total insects	not significant	decrease	not significant
Wrack total Collembola	unarmored > armored	decrease	decrease
Wrack Megalorchestia	unarmored > armored	—	—
Very coarse gravel	not significant	not significant	increase
Medium sand	not significant	not significant	decrease
Fine sand	not significant	not significant	decrease

NOTE: Significant relationships between the response variables and the 7 other grain sizes sampled were not observed.

Despite high natural variability and the large number of factors affecting the parameters measured by the grantees, they were successful in detecting an armor signal in several of the data sets:

- The paired tests demonstrated that **armor is associated with reductions in beach width, number of accumulated logs, beach wrack, and beach-associated invertebrates**. The number of stranded drift logs were higher and the log line wider on unarmored beaches.

[4] A **drift cell** is a discrete coastal compartment containing its own sources and sinks of sediment and a defined direction of net transport along the shoreline (Shipman 2008). Puget Sound has been divided into 744 distinct drift cells (Cereghino et al. 2012).

More wrack accumulated on unarmored beaches. Unarmored beaches had more shade from overhanging vegetation. Invertebrate taxa that inhabit the wrack or under logs were more abundant on unarmored beaches

- **As increasing proportions of shorelines in a drift cell were armored, significant geomorphic changes were observed.** Beaches in the more extensively-armored drift cells had significantly higher proportions of coarse sediments and significantly lower proportions of sand. Mean slope of the upper beach was steeper in more-armored drift cells, and beach width was consistently reduced.
- The elevation of armoring on the shore affects several characteristics. **Armor placed lower on the beach face has progressively greater impacts.** Logs are virtually excluded from a beach when relative encroachment is 1.44 feet or more (armoring lower on the beach profile). A similar pattern was seen in total wrack mass. Dethier et al. (2016) suggest that a **threshold of 1-2 vertical feet below MHHW could be used to identify restoration projects likely to result in more beneficial changes to ecosystem function.**

The grantees generally found it more challenging to document geomorphic responses to armoring. With the exception of beach width, the paired t-tests did not detect significant differences in response variables; correlations were observed only at the drift cell scale. Regional differences also confounded the results. For example, data from the northern study sites hinted at a pattern of erosion in front of armoring, but this was not evident on the central and southern sites. McBride et al. (2016a) suggest that there may be geological, tidal, wind, wave, and/or temporal (e.g., age of armor) factors at play, and recommend methodological adjustments for future investigations.

2.2 LANDSCAPE-SCALE EFFECTS

Project partners mapped then analyzed geomorphic features of 7 drift cells (96.4 km of coastline) along Camano Island and eastern Whidbey Island with varying amounts of bulkheading to characterize the **indirect effects of armor on down-drift beaches**.

The intent was to provide statistical support for two hypotheses relating to the effect of shoreline armor on drift cell processes:

- Shoreline armor prevents feeder bluff erosion and results in sediment starvation down-drift of the armored shoreline. This leads to sediment loss in down-drift beaches due to wave erosion uncompensated by sediment supply. Consequently, the beach narrows.
- Large woody debris (LWD) on shorelines originates primarily from feeder bluff erosion, so shoreline armor that prevents bluff erosion would starve down-drift beaches of LWD.

A simple statistical was used to test relationships between predictive (sediment supply, percent armoring, significant wave height) and response (beach width, area large woody debris or LWD, beach width change) variables. Results of the statistical model and notes about calculated inputs are presented in Table 4.

Table 4. Summary of relationships between predictive geomorphic variables and response variables as described in Hood et al. (2016)

Response Variable	Sediment Supply Index	Percent Armoring	Significant Wave Height
Beach width	not significant	decrease	increase
LWD area	increase	not significant	not significant
Beach width change	not significant	increase	not significant
Simulated beach width	increase	—	—

NOTES:

- **Sediment Supply Index** was calculated through GIS analysis of a LiDAR-based digital elevation model; erosion resistance data from WDNR; proportions of shoreline armored as determined from aerial photographs; and a shoreform weighing factor.
- **Beach width change** was calculated relative to the width of the segment immediately up-drift.
- **Simulated beach width** was determined using a simplistic box model of sediment movement from one beach segment to the next. The model was a rule-based simulation to explore how feeder bluffs, transport zones, and armored shorelines might interact sequentially to affect beach width.

The statistical analysis revealed some patterns, but the predictive value was low.

- Wave height and **proportion of shoreline armored** are **significant predictors of beach width**. Beaches with larger waves are wider compared to those with smaller waves and more armoring results in narrower beaches.
- **Higher amounts of sediment delivered to beaches is associated with higher amount of wood on the beach**.
- **Percent armor is a significantly related to beach width in adjacent down-drift beaches**. Beaches immediately down-drift of highly armored beaches are narrower than beaches immediately down-drift of less armored beaches.
- The **beach width simulation** qualitatively reproduced some of the graphical patterns derived from empirical data for individual drift cells. The box model approach demonstrated that **sequencing characteristics of shoreline segments has a strong effect on down-drift cells, including local increases in beach width and larger scale decreases along a drift cell**.

Hood et al. (2016) attributed the predictive failure in their statistical analyses to the stochastic and inherently unpredictable nature of drift cell systems; the potentially non-linear interactions among the processes involved; and/or the omission of other potentially relevant factors/effects in the statistical models. They suggested **the box-model approach could be a productive line of inquiry in future efforts** and made recommendations for improvements. If such models are perfected, they expect that changes in real drift cells (e.g., new armor or armor removal) could be simulated to estimate expected changes in beach morphology.

2.3 SEA LEVEL RISE VULNERABILITY ASSESSMENT

Project partners examined potential future impacts of existing armor under changing sea level and wave conditions to identify vulnerabilities in 27 northern Puget Sound drift cells. McBride et al. (2016b) provide a useful analysis of sea level rise vulnerability and identify opportunities to increase resilience.

The grantees mapped drift cells by shore type and the degree to which cells are armored. Each drift cell was scored on a 1-4 scale for four factors:

1. the extent of shore type likely to be impacted by climate change (i.e., are landward migration zones present, is a high percentage of sediment impounded behind armor leading to a sediment deficit, are pocket estuaries impounded, does armoring encroach deeply into the intertidal, etc.);
2. the reversibility of armor impacts (i.e., can resilience be restored through beach nourishment or armor removal);
3. the probability of impacts based on landscape conditions and best professional judgement (i.e., how likely is the expected scenario); and
4. the number of lines of evidence supporting the findings.

Scores were summed, with **higher scores indicating the drift cell is more vulnerable**. The maximum score possible was 48. Detailed notes in the report provided information justifying the scores. Drift cell vulnerability scores ranged from a low of 9 to a high of 38, with an average of 25 (Table 5).

Table 5. Range of drift cell sea level rise vulnerability scores

Vulnerability Score	Number of drift cells
10 and under	2
11 to 20	6
21 to 30	10
31 to 40	9
41 and over	0

Notes about the drift cells were informative in that they identified where coastal squeeze (inability of nearshore habitats to migrate landward as sea level rises due to natural or human impediments) is a concern; where sediment starvation is likely; where houses and/or infrastructure are at risk of flooding; and where armoring encroaches deeply into the intertidal.

2.4 RECOMMENDATIONS

1. Dethier, Toft, and Shipman (2016) translated the findings of Dethier et al. (2016) into two key messages for shoreline planners and practitioners. Cite and repeat these messages frequently and widely to maximize the impact of armoring-related projects, programs, and plans in the region.
    - Where armoring is clearly necessary, place or move it as high on the beach as possible.
    - Prioritize protection or restoration (armor removal) of feeder bluffs that are critical for sediment supply to the beach.
2. Consider supporting additional development of the nearshore sediment box model and sea level rise vulnerability analysis to support identification of high-value protection and restoration targets.
    - The vulnerability analysis could be used to focus outreach efforts associated with the homeowner incentive programs described in Section 3 of this report.
    - Vulnerability scores could be mapped to communicate assessment results.
    - The sediment model could help quantify benefits of armor removal projects by providing estimates of sediment inputs to down-drift beaches. As described in (Kinney et al. 2016b), the area restored by beach restoration projects is currently measured in linear feet of armor removed. Outcomes relating to sediment supply and transport are not quantified. The result is an understatement of the geographic area affected by beach projects and incomplete accounting of benefits associated with individual projects. This has implications for proposal ranking/selection and program performance evaluations.

Worth noting is that the work funded here, and the results from the funded projects, build upon the process-based restoration framework developed by the Puget Sound Nearshore Ecosystem Restoration Project. This framework emphasizes the importance of geological processes for establishing ecosystem structure, upon which ecosystem function, including biological communities and populations, depends. A next step in identifying restoration priorities is understanding how restored physical processes, such as sediment supply from feeder bluffs and transport within drift cells, translates into use of habitat by recovery priority species and communities, namely salmonids and forage fish.

3. WATERFRONT HOMEOWNER INCENTIVE PROGRAMS

Between 2014 and 2016, the Grant Program awarded 10 grants for local incentive programs intended to motivate waterfront homeowners to remove bulkheads and/or choose alternatives to hard armor on their property. Two of the grants continued a shoreline armoring reduction project begun by the Northwest Straits Foundation (NWSF) in 2012. The eight others supported development and implementation of Shore Friendly programs in four counties (Kitsap, Mason,

San Juan, and Island).[5] The Shore Friendly programs were led by county departments or conservation districts; implementation partners included private consultants, WSU Extension, Washington Sea Grant, Futurewise, and Friends of the San Juans.

Each program was tailored to local needs and had a slightly different emphasis. Training workshops for landowners and influencers[6] occurred to varying extents. Some campaigns focused on encouraging landowners to remove existing armor, while others prioritized keeping unarmored properties from being hardened.

Grantees experimented with the large menu of potential incentive tools identified in the Shore Friendly strategy (Colehour + Cohen et al. 2014a-e). **Offerings were adapted over time based on participant feedback and/or program evaluations.** In some cases, approaches were discontinued (e.g., volunteer ambassador programs were too staff-intensive or had trouble recruiting participants; there was a lack of interest in recognition programs). Other tools received more resources as programs matured (e.g., permitting and financial assistance). The next section describes the core incentive approaches and specific accomplishments between 2014 and early 2019.

3.1 PROGRAM OUTPUTS

As documented below, grantees engaged an impressive number of participants in different program activities. A variety of high-quality educational materials were developed and distributed to individual landowners and their influencers. Outreach mechanisms included promotion during community events, boat tours, "intervention" at the permit counter, and direct mail targeting specific parcels. Grantees evaluated program performance with written evaluations and/or participant interviews.

Table 6 summarizes program outputs between 2014 and 2018.

[5] NWSF's "Targeted Outreach to Reduce Impacts from Shore Hardening in the Port Susan Marine Stewardship Area" project was underway while Colehour + Cohen et al. were developing the Shore Friendly social marketing strategy. NWSF's work provides some independent validation of Shore Friendly's findings and strategies. Over time the incentive approaches converged and during the 2016 grant NWSF began to use Shore Friendly branding to increase regional alignment.

[6] **Influencers** are people who provide information to property owners when they are making shoreline modification decisions. They include realtors, contractors, county permitting/outreach staff, neighbors, conservation district staff, and NGO staff.

Table 6. Homeowner incentive program outputs (2014-2018)

Tools and uptake	Total	Island	Kitsap	Mason	NWSF	San Juan
Homeowner workshops	24	see note	–	6	17	1
Number of participants	672	–	–	92	550	30
Realtor trainings	18	4	1	–	3	10
Number of participants	376	114	52	–	60	150
Other influencer trainings	5	2	1	2	–	–
Number of participants	110	30	42	51	–	–
Preliminary site visits	278	17	75	137	7	42
Technical site visits	284	54	32	69	115	14
Design services	23	2	–	8	9	4
Permitting services	17	–	3	6	7	1
Permit fees waived/rebated	7	1	6	–	–	–
Mini-grants provided	49	–	16	33	–	–
Amount disbursed	$111,586	–	$80,500	$31,086	–	–
Removal projects completed	15	see note	10	2	3	–
Linear feet	3,185	–	918	277	1,190	–
Prospective removal projects	4	–	–	2	1	1
Linear feet	940	–	–	530	200	210

NOTE: This table understates the accomplishments of Island County's Shore Friendly Program. Island County collaborated extensively with NWSF, particularly during the 2016-2018 grant period. They co-hosted 1 Realtor training and 4 homeowner workshops; care was taken not to double-count events and participants here. Over time, Island County also shifted technical assistance and project development activities to NWSF so the County could focus on providing a local connection for homeowners and a link to permit staff. The 3 completed armor removal projects attributed to NWSF all occurred in Island County and were the result of collaboration between these programs.

HOMEOWNER WORKSHOPS

The grantees hosted 24 homeowner workshops with a total of 672 attendees. These classes covered coastal and beach processes; how to manage beach and bluff erosion; alternatives to hard armoring; benefits of bulkhead removal or reduction; and managing vegetation and drainage for slope stability. Two specialty workshops focusing on vegetation management were held in response to participant requests for more information on this topic.

Evaluation results demonstrated changes in knowledge about shoreline processes and impacts of armor (Mason Conservation District 2016b, NWSF 2016, NWSF 2019b). A majority of participants indicated that they are more aware of the value of natural shorelines, alternatives for managing erosion, and the importance of native vegetation.

However, Mason Conservation District (2016b and 2019b) concluded that one-on-one guidance was generally more effective than broad community education. Their workshops had

reasonably high attendance but generated few follow-up participants. Likewise, Kitsap Shore Friendly Planning Team (2017a) noted that their least staff-intensive engagement method (mailed postcards) generated the most inquiries about the program.

INFLUENCER TRAINING

The grantees held 23 trainings attended by 499 professionals that provide information to property owners as they are making shoreline management decisions. Four influencer audiences were reached:

- 3 contractor/consultant trainings with a total of 72 participants
- 18 realtor trainings attended by 376 real estate professionals
- San Juan County developed a curriculum certified by Department of Licensing for 7.5 clock hours for realtors. This curriculum was used by grantees in other jurisdictions.
- In addition, San Juan County gave informal presentations about the Shore Friendly program during a weekly staff meeting at each of the 7 local real estate offices.
- 1 training on marine shoreline tree and vegetation management attended by 38 arborists
- The Pacific Northwest Chapter of the International Association of Arborists offered clock hours for participants.
- 1 training about providing shoreline technical assistance attended by 13 staff members of 5 Puget Sound Conservation Districts

Evaluation results indicated that most attendees found these sessions valuable and had or were likely to share the information they learned with clients (San Juan County 2016, NWSF 2019b). Participants also expressed interest in development of specific educational resources that they could distribute to their clients. Island County (2016b) used this feedback to develop outreach materials as well as an economic analysis of the costs and benefits of different shoreline treatments. The economic analysis is summarized in Section 4 of this report.

SITE VISITS

The grantees conducted 562 site visits to teach shoreline homeowners about their property and management options. Site visits allow participants to receive property-specific guidance and an opportunity to discuss concerns. They help to build relationships and increase homeowner confidence in management strategies that avoid hard armor.

The number cited above does not reflect the total number of parcels visited. This discrepancy has two causes and calls attention to an **opportunity to improve reporting**.[7]

[7] Recommendations to improve and/or standardize program data management and reporting are compiled in Section 3.3.

- Some programs conducted preliminary site visits with program staff or volunteers *before* sending a licensed professional (coastal geologist/engineer) to conduct a technical site visit that results in a written assessment report. During these grants, **278 preliminary site visits and 284 technical site visits occurred**.
- Site visit recipients were often encouraged to invite their neighbors, so multiple parcels may have been included in a visit and/or report.

Evaluation results indicate that site visits were greatly appreciated by recipients. Site visits increased homeowner understanding of their property and benefits/impacts of armor (Island County 2016b, San Juan County 2016, Shore Friendly Kitsap Planning Team 2017b, NWSF 2019b, Mason Conservation District 2019b). Many participants changed the way they view erosion concerns and plan to implement at least one of the recommendations they received from the site visit. Vegetation management was mentioned most frequently across all of the programs.

Mason Conservation District (2019b) included some observations about the important role site visits play in their program:

- **Homeowners are easily overwhelmed by information and responded best to site-specific guidance presented as a series of prioritized actions relevant to their property**.
- Site visits provide neutral professional guidance on property management options without financial pressure or an emphasis on expensive, sometimes unnecessary interventions.
- The number of site visit requests consistently exceeded staff capacity to respond.
- Gardening is a popular activity for many homeowners and an excellent entry point into discussion about land management impacts. Homeowners appreciate that staff with landscape design experience consider aesthetics.

PROFESSIONAL ASSISTANCE

Designing, permitting, and managing a shoreline construction project is a complex, long and expensive process involving professionals from several disciplines. **Grantees offered different types of project support for homeowners interested in proceeding with armor removal and/or soft shore protection.** Project support took the form of surveys, engineering designs, construction documents, permitting assistance, and construction oversight.

- 23 homeowners received design services.
- 17 homeowners received permitting assistance. The range of support varied substantially:
- Advice on permit sequencing
- Preparation of a local permit package
- Preparation of a full federal package including assessments needed for Endangered Species Act and National Historic Preservation Act compliance

- Architectural renderings were developed for 2 projects. These allowed homeowners and community members (one project is located on a WDNR-managed public access site) to visualize how a site would look after restoration.

Grantee reports were not always clear about overlap in services provided for individual projects, so the total number of homeowners supported is unknown. This is an **opportunity to improve reporting**.

Evaluation results indicate that professional assistance was a major motivator for participants who moved forward with a removal project (Mason Conservation District. 2019b, WSU Kitsap Extension 2018a). Some respondents added that the permitting assistance was more valuable than the monetary assistance. **"Hand-holding" throughout the entire bulkhead removal process was associated with completed projects** (Shore Friendly Kitsap Project Team 2019, Mason Conservation District 2019a).

Permitting challenges are a real barrier for bulkhead removal projects so **inclusion of team members experienced in navigating complex permit process is crucial for project success**. Restoration permitting requirements remain somewhat restrictive, unclear, and varied (Shore Friendly Kitsap Team 2017a, San Juan County 2016). Being aware of **archeological issues** early in project planning is important (San Juan County 2016, NWSF 2019a).

FINANCIAL ASSISTANCE

Cost was consistently identified as a barrier to project implementation and financial assistance was a key motivator to move forward with a bulkhead removal project (Mason Conservation District 2019b, Shore Friendly Kitsap Project Team 2019). Grantees offered a few different types of financial incentives: project mini-grants, free or reduced cost permitting, and help securing other sources of project funding.

- **49 homeowners received mini-grants worth $111,586** to support project implementation. Projects involved armor removal, native plantings, and drainage improvements. In a few cases, mini-grants were used for costs incurred earlier in the project development process (e.g., geotechnical investigations).
- 7 landowners received free or reduced-cost County permits.
- **Grantees also helped homeowners identify other funding sources and, in some cases, prepare grant applications**. Additional sources of financial assistance for project implementation came from the Salmon Recovery Funding Board, WDNR Creosote Removal Program, Washington Conservation Commission, and separate National Estuary Program awards.

Financial incentives were associated with completed projects. Kitsap County and Mason Conservation District both provided mini-grants, and had relatively large numbers of projects implemented. San Juan County (2016) described homeowner frustration that there was not actually money available to implement armor removal and soft shore work proposed during site

visits. NWSF (2016) identified several property owners who were willing to consider removing failing bulkheads and installing soft shore alternatives, but unable or unwilling to pay.

COORDINATION WITH REGULATORS

Some grantees collaborated with regulators and other county departments:

- Shore Friendly Island hosted 4 workshops with Planning and Community Development Department permit staff to **identify ways to streamline permitting for soft shore projects**. They also worked with the Public Health and Public Works Departments to promote collaboration, consistent messaging, and identify potential restoration and soft-shore projects.
- Shore Friendly Kitsap worked with Department of Community Development permit staff and WDFW Habitat Biologists to streamline the permit review process for bulkhead removals. This collaboration resulted in: (1) a **new "bulkhead removal" project category in the County permitting database**, and (2) a **grading permit exemption for bulkhead removal projects**. When the exemption is used, the state Hydraulic Project Approval becomes the governing permit and WDFW agrees to inspect the project for water quality/stormwater impacts.
- Shore Friendly San Juan began to develop a Shore Friendly permit process, but this effort was later dropped due to management shifts and a lack of capacity by the Department of Community Development.
- Shore Friendly Mason worked with permitting staff to develop an "intervention-style" strategy to intercept residents when they inquire about replacement permits.
- Grantees also **shared outreach materials with local permit offices**. Recent interviews with local planners and permit reviewers at 12 Puget Sound jurisdictions indicate that Shore Friendly handouts and the "Your Marine Waterfront" brochure (also funded by the Grant Program) were very popular (Fishman 2019).

Feedback about these efforts has been positive. Some notes of interest from project and evaluation reports follow.

- Evaluation results from WSU Kitsap Extension (2018b) indicated that permit staff had concerns about some soft shore techniques and were uncomfortable applying code in new ways for restoration. They also noted that some homeowners want to trade restoration for other benefits (e.g., approval for a boathouse).
- The Shore Friendly Kitsap Project Team (2019) noted that **WDFW Habitat Biologists provided critical resources and support**. Habitat Biologist engagement was helpful in determining if sites meet criteria for shoreline restoration (and subsequently exemption from shoreline substantial development permit requirements).

- Island County (2019) reports that their Department of Public Works is considering soft shore protection to stabilize the shoulder of a shoreline road. Public Works staff also referred 3 homeowners to the Shore Friendly program for site visits.

PROJECT IMPLEMENTATION

Grantee efforts resulted in **15 armor removal projects along 3,185 linear feet** of shoreline.

- NWSF and Shore Friendly Island County collaborated on 3 armor removal projects (1,990 linear feet) that were completed or underway by the end of the grant period. The Maylor Point project was **not on private residential land**; the U.S. Navy is the landowner along this 1500-foot-long stretch of shoreline.
- Shore Friendly Kitsap completed 10 bulkhead removal projects (918 linear feet)
- Shore Friendly Mason completed 2 bulkhead removal projects (277 linear feet) and 1 soft shore project

Several additional projects involved what Colehour + Cohen et al. (2014e) categorize as **"supporting behaviors" that reduce the actual or perceived need for armor**. As Mason Conservation District (2019a) explains, sometimes homeowners inadvertently create shoreline conditions that exacerbate erosion. Empowering them to understand and manage vegetation and drainage appropriately is a powerful mechanism to decrease the likelihood of armor installation.

- Shore Friendly Mason provided financial support for **5 drainage system improvements, 13 shoreline planting projects, and 5 invasive weed control projects**.

WSU Kitsap Extension (2018a) conducted interviews with 7 homeowners who had received a mini-grant and completed an armor removal project.

- All the interviewees had positive responses regarding the funding they received to move their projects forward, but many emphasized that the final cost of their projects was significantly more. The biggest challenge expressed by interviewees was the total financial cost of a shoreline restoration project.
- All the interviewees received a list of local contractors and consultants that provide coastal services. Some received a **wide range of bids from contractors**. The type of equipment needed and site access affects project affordability; need for rental equipment and a barge was associated with higher bids.
- Five of the interviewees agreed that they would participate in the program again. One was reluctant to answer because they were still early in the process. One had mixed feelings; once their property was viewed with a restoration lens, they felt they could only hire a contractor to do restoration or do nothing at all.
- Some interviewees expressed **concern about how their restoration project would perform over time** (e.g., erosion during storms/king tides, continued presence of logs).

PROSPECTIVE PROJECTS

Some grantee reports indicate that several additional armor removal projects are "in the pipeline." Known projects would total about **940 linear feet**, but the level of detail provided varied and not all grantees mentioned prospective projects. **Reporting could be improved** by including some standard information about these projects, how many steps of the process remain, and potential barriers to implementation. If a homeowner decides not to proceed with a project after design and/or permitting services are provided, the reason should also be documented. Below is status information provided in the most recent reports.

- NWSF (2019) described a planned armor removal project along 200 linear feet at Similk Bay in Skagit County. At the end of the grant period, project redesign was underway as a result of cultural resources concerns identified during the permitting process.
- Mason Conservation District (2019a) has completed designs for 2 armor removal projects totaling 530 linear feet. Staff are seeking funding to advance these projects. Two additional projects to be developed further have been identified.
- San Juan Islands Conservation District (2019) has completed a final design and federal/state/local permit application package for an armor removal project along 210 linear feet on Lopez Island.

3.2 CURRENT PROGRAM STATUS

The Shoreline Armoring Implementation Strategy included a strategy for *improving and expanding incentives and education for residential property owners to support removal of hardened shoreline or protection of unmodified shoreline* (Habitat Strategic Initiative 2018). This incentive strategy identified three near-term priorities, and much progress has been made with respect to these priorities over the past year (Table 7).

The most significant development has been adoption of Shore Friendly programs by the Estuary and Salmon Restoration Program (ESRP). When the Implementation Strategy was released, there was concern about the ability of the programs described in this report to continue after 2018. Puget Sound National Estuary Program and Geographic Funds are not intended for long-term support of existing programs, so availability of future grant funding was highly uncertain.

ESRP provides funding and technical assistance for process-based habitat protection and restoration in Puget Sound. It is led by WDFW in partnership with the Washington Recreation and Conservation Office. During their 2019 session, the Washington State Legislature appropriated $1.7 million from the state capital budget to ESRP to support 2 years of local Shore Friendly program implementation**. The institutionalization of Shore Friendly into an ongoing state program increases the likelihood that residential incentives will continue to be offered into the future.**

Table 7. Progress made on Incentive Strategy near-term priorities

2018 Priorities	Recent Progress
Secure sustained funding for incentive and outreach programs. Programs funded almost exclusively through grants between 2012 and 2018. Strategy goal is to identify a more stable funding source that can ensure program longevity.	• Long-term home secured at the Estuary and Salmon Restoration Program (ESRP) • $1.7 million appropriated for 2019-2021 biennium • Development of 6-year agreements for 3 existing Shore Friendly programs; 1 expanded program; and 2 new programs
Continue and expand site visit programs to provide technical assistance. Strategy goal is to expand geographic coverage to include all 12 Puget Sound counties.	• Coverage for all 12 Puget Sound counties is achieved with expansion of Shore Friendly Mason to Thurston and Pierce counties, and new programs at King Conservation District and the Swinomish Tribe • Friends of the San Juans partners with NWSF to increase local impact
Expand financial incentive alternatives available to property owners. Additional financial assistance will be critical to increase the number of completed removal projects. Strategy goal is to expand existing mini-grant programs and identify other options to provide financial support.	• All Shore Friendly programs now include project mini-grants in their incentive toolbox • ESRP dedicates $500,000 (2019-2021 biennium) for a Small Grants Program that could help fund parcel-scale shoreline projects identified through Shore Friendly efforts • Feasibility study for a Shore Friendly loan program is underway

3.3 RECOMMENDATIONS

The following suggestions are for consideration by ESRP and the Habitat Strategic Initiative as they administer current/future agreements related to Shore Friendly programs and plan for auxiliary investments in support of program implementation.

1. **Develop a few standardized reporting metrics and/or tools.** It was surprisingly difficult to pull comparable information out of the many incentive program deliverables reviewed for this report. This made compilation of wrap-up metrics a challenge. At least one grantee, Mason Conservation District (2019a), noted that property tracking and follow-up was an unexpected challenge for staff.

    - NWSF was the only grantee to explicitly mention having built and maintained a property log with fields for stated management concerns, property type, shore type, and feasible/recommended actions. This data is used for tracking and reporting. **ESRP could consider sharing this property log as a template for the other programs.** The inclusion of parcel numbers can support future queries of permit

databases to track changes in armor status (i.e. long-term status of efforts to encourage alternatives to hard armor).

- Mason Conservation District was the only grantee to provide information about project costs and the share paid by different parties. **ESRP should encourage other programs to track and report project costs**. As described in the next section of this report, Cote and Domanski (2019) compiled and analyzed data on the cost of shoreline projects in Puget Sound. ESRP should **consider developing a project cost reporting spreadsheet that assigns costs to the same categories as those used by Cote and Domanski (2019) to facilitate follow-up analyses with equivalent data**.
- Three other tracking needs mentioned previously were (1) all landowners/parcels reached during site visits; (2) overlap in professional assistance offered i.e., design and/or permitting services provided for individual projects; and (3) prospective project details/status/obstacle(s).

2. **Encourage collaborations where there is geographic overlap in program coverage and assess needs for additional regional support where there is not.** The partnership that evolved between the NWSF and Island County increased the efficiency of their efforts and allowed each organization to build on their strengths (Island County 2019). NWSF's strategic focus was Island and Jefferson Counties. Despite a similar number of site visits in the two counties, all of NWSF's completed projects were in Island County. **This collaboration serves as a model for how to structure complimentary programs as Shore Friendly expands throughout the Puget Sound region.** Opportunities to partner with Friends of the San Juans and Swinomish Tribe are in place. Other geographies within the NWSF's 7-county service area lack a local partner. Central and South Sound programs lack a similar regional umbrella organization and could potentially benefit from additional state support.

3. **Continue refining the Shore Friendly parcel segmentation database.** NWSF used a data-driven approach to focus their outreach activities. They worked with Coastal Geologic Services to update and ground-truth the database, which reduced the number of target parcels in priority segments. By identifying parcels where armor removal is most feasible and ecological lift would be high, NWSF was able to allocate resources for maximum impact.

4. **Develop resources and incentive tools to facilitate conversations with landowners about long-term risks associated with sea level rise and adaptation options.** Island County (2019) noted that increased storm surge and sea level rise was a topic of growing interest during landowner discussions. Washington Sea Grant has produced localized sea level rise projections and guidelines for how to apply this information in decision-making. **Consider funding social marketing formative research on sea level rise messaging and barriers/ motivators for adaptation behaviors like elevating and moving homes inland.**

4. ECONOMIC ANALYSIS OF SHORELINE TREATMENTS

Island County (2016b) reported that participants in their contractor/consultant workshops were interested in further information about the relative cost of constructing soft shore protection versus hard armoring. In response, Cote and Domanski (2019) conducted several analyses to determine the relative costs and benefits—both economic and ecological—of different shoreline treatments. Some of these analyses are summarized below. All tables and figures included here were taken directly from the Cote and Domanski (2019) report.

4.1 SHORELINE TREATMENT COST ANALYSIS

Cote and Domanski (2019) compiled and analyzed data on the cost of 28 shoreline stabilization projects performed in Puget Sound in the past 5 years. The projects included installation of new and replacement armor, removal of existing hard armor, and installation of soft shore protection.

- 20 projects were located in Island County
- 15 projects installed some type of hard armor
- 11 projects removed hard armoring
- 5 projects installed soft shore protection

Project costs were provided by a variety of sources, including private consultants, Conservation Districts, and local agencies. Costs were analyzed to demonstrate factors that affect cost.

Project costs were separated and categorized as follows:

- **Fixed costs** included permitting, design, engineering, biological studies, and cultural resource investigations. These costs do not vary with the size of the property or project.
- **Variable costs** included materials, equipment, and labor. These costs were scaled by linear feet of shoreline treated.
- Projects constructed with grant funding were discretized to separate elements that would not be required if a project was privately funded.

Results are provided in Table 8. These are average values based on a small sample set. The authors caution that site-specific idiosyncrasies can lead to lower or higher prices.

- Project costs ranged from $30,000 to $100,000 per property.
- Projects constructed on multiple parcels at one time were the most cost-efficient, as fixed costs were divided amongst the property owners.

Table 8. Average shoreline treatment costs (from Cote and Domanski 2019)

Cost Components		Price
Fixed Cost		$15,700
Remove Existing Armoring	+	$26,500
Type of Shoreline After Project		
- Natural Beach with logs	+	$5,000
- Concrete Bulkhead	+	$8,900
- Soft Shoreline	+	$22,800
- Vinyl or RipRap Bulkhead	+	$44,200
Cost per Foot	+	$148 per foot

Source: ECONorthwest analysis of data provided by Blue Coast Engineering

COST OF MOVING A HOME

Two additional projects involved moving houses inland by ~40 feet to increase the setback from an eroding bluff. Since the cost of moving a home does not vary with linear feet, they were not included in the list of 28 projects. **The cost of moving these homes ranged from $35,000 to $50,000. The cost of building a new foundation, installing utilities, and replacing the septic system cost an additional $50,000.**

A structural moving company provided additional information on costs associated with moving a home inland or vertically (Table 9). Weight, size, and foundation type are structural factors that affect the cost of moving a home. Houses larger than 5,000 ft^2 will cost more than the ranges provided below because specialized equipment may be required. The cost of excavation, foundation construction, utilities, and permits would add $50,000 to $75,000 to these estimates.

Table 9. Range of costs to elevate or setback a house (from Cote and Domanski 2019)

Size of Structure	House Lift	House Move
Less than 1,500 sf	$30,000 - $40,000	$50,000 - $60,000
1,500 – 3,000 sf	$35,000 - $45,000	$55,000 - $65,000
3,000 – 5,000 sf	$40,000 - $50,000	$60,000 - $70,000

Source: Northwest Structural Moving

An Island County case study described in the next section indicates that increasing the setback between a structure and an eroding bluff may increase property value and partially defray the costs of moving a house.

4.2 SHORELINE TREATMENT IMPACT ON PROPERTY VALUE

Cote and Domanski (2019) evaluated relationships between shoreline treatment and property value both qualitatively and quantitively.

The qualitative analysis describes the expected change in property values (increase, decrease, or no change) when a shoreline protection action is taken. Property value was separated into three discrete components: risk (of erosion) reduction, aesthetic, and shoreline access. Results are shown in Table 10.

- The authors recognized that aesthetic values are subjective. The directions assigned in Table 10 were based on previous economic studies that found generally higher property values for natural beaches or soft shore beaches that appear to be natural (Gopalakrishnan et al. 2011, Gopalakrishnan et al. 2016, Dundas 2017).
- Note that of the six alternatives, soft shore protection is the only option that generates a uniformly positive impact. Change from a natural beach or hard armor to soft shore protection generated a uniformly positive net result.

Table 10. Average private property value impacts from shore stabilization alternatives (from Cote and Domanski 2019)

Existing Condition	Action	Risk Reduction Value	Aesthetic Value	Shoreline Access Value
Natural Beach	Hard Armoring	⇑	⇓	⇓
	Soft Shore Protection	⇑	No Change	No Change
	Relocating House	⇑	⇓⇑*	No Change
Hard Armoring	Armor Removal	⇓	⇑	⇑
	Soft Shore Protection	No Change	⇑	⇑
	Relocating House	No Change	⇓⇑*	No Change

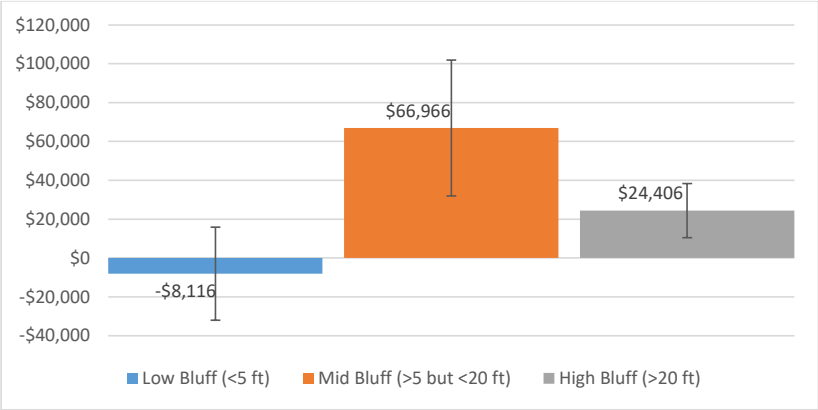
Source: ECONorthwest and Blue Coast Engineering
Note: *Results in an increase or a decrease in aesthetic value based on property specific attributes.

The quantitative evaluation was a hedonic regression of property characteristics on assessed land value to test the relationship between price and shore treatment. Given data limitations, only properties with and without hard armor could be compared.[8] Results indicate that **the net effect of armor on land value varies, depending on the height of the bank or armoring** (Figure 1). Bluff height was categorized as low (<5 feet), medium (5-20 feet), or high (>20 feet).

- Hard armoring is correlated with lower land value for low bluff properties, though impacts were highly variable (i.e., hard armoring can have either a positive or negative effect on property value).
- Hard armoring is correlated with higher land values for mid-bluff and high-bluff parcels. The greatest benefit was observed for mid-bluff parcels.
- Low bluff homes are likely to gain the greatest value from incentives to conduct armor removal.

[8] Structural characteristics were excluded by only evaluating land value. Neighborhood and environmental characteristics were controlled for using a set of town fixed effects. Acreage of the parcel had a positive and statistically significant effect on assessed land value. Being located in any town also had a positive effect, with Freeland, Clinton, and Greenbank having the largest impact on price.

Figure 1. Property value impacts of hard armor in Island County (from Cote and Domanski 2019)



- An evaluation of changes in property values over time indicates that increasing the setback between a structure and an eroding bluff may increase property value. Table 11 compares setback distance and property value for 4 properties along the same stretch of shoreline. Property 1 was moved inland to reduce potential landslide risk. **The year after the house was moved, the value of the land increased by $50,000. The 2 properties with setback distances <25 feet showed an equivalent decrease in land value during that same interval.**

Table 11. Island County high bluff property value case study (from Cote and Domanski 2019)

	Property 1	Property 2	Property 3	Property 4
Linear Length of Shoreline	90 Feet	63 Feet	71 Feet	199 ft
Setback year 1	22 ft	70 ft	20 ft	25 ft
Setback year 2	56 ft (moved back)	70 ft	20 ft	25 ft
Risk Reduction Protection	Improved erosion risk	No change	No change	No change
Property Value Year 2 (Change in property value)	$200,000 (+$50,000)	$200,000 ($0)	$150,000 (-$50,000)	$200,000 (-$50,000)

Source: Island County Assessor's database and private property owner communication

4.3 RECOMMENDATIONS

1. The Habitat Strategic Initiative and ESRP should encourage their grantees to track project costs using the same categories as Cote and Domanski (2019) to facilitate follow-up analyses with equivalent data.

5. SHORELINE RESTORATION MONITORING

This grant funded the **establishment of common monitoring protocols** to assess the effectiveness of armor removal projects and **implementation of a first phase of monitoring for 14 Puget Sound restoration sites**.

Dionne (2015) developed a detailed monitoring protocol for application to current and future restoration activities. **Structural beach features are a focus of the protocol so that impacts to processes supporting nearshore habitat can be observed.** The protocol closely followed existing protocols found in the *Shoreline Monitoring Toolbox* (Litle and Adams 2014) and developed by long-time forage fish biologist Dan Penttila (Moulton and Penttila 2001). Use of a standardized monitoring framework allows for more direct comparisons of parameters and ensures repeatability beyond the scope of the current project.

Faulkner (2019) reported results from monitoring at the 14 sites **between 2015 and 2018**. Surveys were conducted annually, between May and October. At each site, sampling was conducted along transects within the restoration site and within adjacent natural and armored sites. **At 9 sites, both pre- and post-restoration data was gathered**.

The grantee conducted **188 survey events along 42 transects**. Eight metrics were measured at all transects:

- Beach profile (elevation)
- Beach toe (elevation), from which relative encroachment was calculated
- Log line (width)
- Number of logs
- Wrack line (% cover)
- Riparian cover (waterward extent)
- Forage fish (relative abundance of surf smelt and sand lance eggs)
- Sediment (grain size)

Analyses of treatment effects (armor removal) were conducted and compared with relative change in reference (armored and natural) transects to account for natural changes over the same time period. In addition, results were analyzed at a regional scale, to account for background regional differences. Results are summarized in Table 12. The overall results from this project echo previous findings about the response of beach structure characteristics to armor removal.

The common responses to armor removal across sites – beach elevation and width, number of logs and width of log line, wrack accumulation, and riparian shade – all reverted towards the configuration of natural reference shorelines.

- Results were most consistent across sites at removal transects in the number and width of beach logs, beach width and elevation, and relative encroachment.

- Most restoration sites also showed increased riparian shade and wrack cover, but results varied dependent on local and regional influences.

Table 12. Summary of significant effects of armor removal and direction of response as described in Faulkner (2019)

Response Variable	Direction of Response
Beach toe elevation	Increase
Beach width	Increase
Beach slope	Increase
Number of logs	Increase
Log line width	Increase
Total wrack cover	Increase
Riparian shade	Increase
Relative encroachment	Decrease

- Some regional influences swamped local restoration effects, including beach sediment grain size and beach slope. Larger drift scale processes, seasonal wave energy, or local movement patterns likely had greater influence on sediment composition than local processes.
- Regional differences observed included the relative encroachment of beach toe, which was less at all transect types in the north than in the central and south transects. In addition, there was more beach wrack accumulation in the north, and less seagrass in the wrack on south transects.
- Local geomorphic setting had a greater influence on beach slope than local restoration activities. Local conditions sometimes influenced the response to armor removal. For example, change in riparian shade at one site was affected by the presence of overhanging vegetation prior to removal.
- Across all transect types, there were more logs at sites with less encroachment.
- No analyses of forage fish eggs were conducted owing to lack of confidence in the sample results.

Faulkner (2019) is one component of the largest study to date focused on the effectiveness and impacts of shoreline restoration, and specifically armor removal, in the Puget Sound region. This work suggests that armor removal has structural benefits for beaches, but that some regional processes are more important than local in determining beach structure. In addition, this work highlighted that site-specific conditions can influence restoration impacts, and expected results of armor removal should account for local site conditions, such as the potential for riparian shade. Last, this work provides guidance for future restoration activities, including the importance of conducting baseline surveys, including reference sites, accounting for spatial (especially regional) influences, accounting for the slow response of some variables to armor removal, and the value of a standardized monitoring framework.

5.1 RECOMMENDATIONS

1. The results from this work should inform future restoration activities, based on an understanding of what beach structures and processes respond to restoration. Specifically, sites can be evaluated for their restoration capacity associated with the major structures and functions identified by this work. Practitioners should consider regional and local processes in making restoration decisions.

2. This phase focused on near-term responses of shoreline habitat to restoration efforts, and developing a monitoring framework for capturing such responses. Given the potentially slow response of some variables to armor removal, longer-term monitoring is needed to, for example, capture geomorphic impacts of armor removal and associated changes in beach characteristics such as beach slope or riparian shade. Understanding regional variability in some features, such as beach wrack and sediment grain size, is important in developing monitoring programs.

3. A near-term priority of the Shoreline Armoring Implementation Strategy was to *compile and analyze existing monitoring information on implemented removal and soft shore projects to improve designs and site selection* (Habitat Strategic Initiative 2018). Future efforts should include soft shore projects to determine whether the same or different monitoring frameworks are appropriate, following implementation.

4. This work builds on the Puget Sound Nearshore Ecosystem Restoration Program framework that focused on geological structures of nearshore habitats, and prioritizes ecosystem structure-function links. This work included biological responses to armor removal in the form of beach use by forage fish, which is tightly linked to beach structure (sediment grain and beach width). Additional monitoring programs should be developed to track biological responses beyond the beach, including use of subtidal habitats by fish, and benthic habitat responses.

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