ESRP Learning Proposal:
Identifying Target Beaches for Restoration & Protection

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Project Start Date: July, 1 2015

Most Puget Sound shores consist of drift cell beach systems, where sediment from eroding feeder bluffs sustains down-drift shoreforms and habitats. Sound-wide beach management strategies have been applied at the drift cell scale, but they relied upon obsolete or inadequate data. This effort will result in the identification of more refined beach restoration and protection targets and new and refined spatial data for beach managers and others working to effectively restore and protect Puget Sound beach systems.
Technical Information

Problem Statement
Most Puget Sound shores consist of drift cell beach systems, where sediment from eroding feeder bluffs sustains down-drift shoreforms and habitats. Sound-wide beach management strategies have been applied at the drift cell scale, but they relied upon obsolete or inadequate data. This effort will compile and refine new data into a beach strategy geodatabase. Collaborative meetings with regional nearshore experts will create new prioritization metrics to identify targets for restoration and protection of beach ecosystems. The resulting updated beach strategies will offer improved accuracy and resolution to more effectively restore and protect Puget Sound beach systems.

Hypothesis Statement
This project will inform an analysis gap affecting our ability to advance beach restoration and protection projects in the Puget Sound planning area. The motivation for this work and our working hypothesis is that there is a need among restoration practitioners and leaders for improved information to guide their work identifying and developing effective projects. This project addresses that need by:

♦ Building upon the PSNERP Strategies work by Cereghino et al. (2012) by incorporating the latest information on shore conditions to characterize the inter-related nature of shoreforms,
♦ Seeking input by technical experts and local restoration leaders in the development of the analysis and recommendations, and
♦ Providing accessible and clear communication of the strategy development inputs and outputs.

This project will advance our knowledge base for identifying restoration and protection priority drift cells, and will identify the highest priority beaches and bluffs to focus efforts upon within drift cells. A key element of the analysis will be the addition of information on the direction and distance of sediment drift within each drift cell. This technique, called linear referencing, will allow for analysis of the interdependence of shoreforms within drift cells. For example, with directionality information in the geodatabase, we can identify an accretionary shoreform such as a barrier beach and calculate the number and length of intact and/or degraded up-drift sediment source areas. This highly relevant information will be used to identify bluffs sustaining important down-drift habitats that should be high priority restoration and protection targets.

Tools and recommendations developed through this work will enable practitioners to “manage by drift cell”, a concept that has long been promoted but not implemented in the Puget Sound region. This effort will also address priority pocket beaches. These valuable habitats have been overlooked in previous strategy work.

Within each drift cell, Puget Sound feeder bluff mapping (MacLennan et al. 2013) will be used to update current understanding of sediment supply process degradation. Linear referencing will be applied to shoreform mapping to discover the relative importance of different sediment supply areas for sustaining down-drift shores and the disproportionate benefit of restoring sediment processes based on sediment supply and transport patterns.
Methods
The methods for this work entail three main components:

1) Development of a geodatabase with newly available and improved data sets to inform beach prioritization analysis,
2) Engagement with an advisory group of technical experts and restoration leaders through a series of collaborative work sessions, and
3) Analysis and reporting of drift cell and shoreform priorities for restoration or protection.

These components are accomplished in 6 tasks, which are described in the tasks section of this proposal.

The first component to develop a geodatabase includes a limited amount of original data collection, a significant amount of data refinement using geoprocessing tools in ArcGIS, and quality assurance/quality control (QA/QC) review of all data sets. The new geodatabase will use some of the data layers used in the preceding PSNERP analyses as well as new data sets available since 2013. Table 1 identifies several newly available data sets that can be refined for use in this project. The table identifies “refinements applied by CGS”, which are previously conducted refinements CGS is able to bring to the project, and “proposed refinements”, which will be completed as part of this project.

The new data collection portion of the work will be limited to collaborative efforts with the Puget Sound Ecosystem Monitoring Program (Nearshore PSEMP) to refine and update the existing Puget Sound shore armor mapping (see task description). Data collection methods will likely be a boat-based field mapping effort in which armor is mapped along up to 200 miles of shores. Mapping segments are delineated using a differentially correcting GPS from a boat paralleling the shore at high tide.

QA/QC of data collection and GIS data refinements will include randomly selecting locations to confirm accurate mapping. QA/QC is conducted remotely in GIS with supporting aerial photography. Manual measures will confirm automated measures for linear referencing. The results of metrics can be confirmed by spot checking the query results against source data. Topology will be run to all shoreline files to assure there are not errors in the file geometry and that all lines stack accurately.

The second component entails convening an advisory group to provide technical input while also ensuring the outputs are supported and usable by the restoration and conservation community. The advisory group will include participation by some or all members of the Nearshore PSEMP and Lead Entity Coordinators actively involved in nearshore issues related to salmon recovery. The Lead Entity Coordinators that may participate are a group of 8 to 12 individuals working in watersheds distributed throughout the Puget Sound Planning Area. Representatives from the Nearshore PSEMP and Lead Entity Coordinators group have been contacted regarding this role and have expressed interest. Additional advisory group participants may also be invited. These anticipated advisory group participants serve critical leadership roles in restoration and protection through their work at a regional level, as well as with individual project sponsors developing opportunities.
Table 1. Data Products and Proposed Data Refinements.

<table>
<thead>
<tr>
<th>GIS Layer (year developed)</th>
<th>Refinements applied by CGS</th>
<th>Proposed Refinements</th>
</tr>
</thead>
</table>
| Shore armor (2013)        | • Augmented CGS armor mapping with Change Analysis armor layer for all areas outside drift cells.  
                            • Integrated updated armor mapping from Island and San Juan Counties | • Limited new data collection  
                            • Incorporate updated mapping from WRIA 9 and Sandy Pt. (Whatcom Co.)  
                            • Assess data quality of Clallam County  
                            • Attribute with source data and method  
                            • Summarize by drift cell  
                            • Populate metadata  
                            • QA/QC. Run topology. |
| Net shore-drift cells (2013) | • Transferred mapping from WDOE mean high water shoreline to the WDNR ShoreZone shoreline.  
                            • Revised historical drift to represent current drift. Applied hundreds of revisions to original mapping based on field observations. | • Re-integrate divergence zones (from Simenstad et al. 2011) not in updated current net shore-drift layer (MacLennan et al. 2013).  
                            • Add linear referencing information to inform directionality.  
                            • QA/QC. Run topology. |
| Puget Sound Feeder Bluff Mapping (2013) | • Identified bluffs that were historically feeder bluffs.  
                            • Identified drift cells with high sediment supply loss. | • Apply linear referencing to inform direction of sediment transport and potential spatial extent of restored sediment processes. |
| Integrated shoretypes (2013) | • Integrated Puget Sound Feeder Bluff mapping within drift cells with Change Analysis shoreforms in NAD areas.  
                            • Includes refined pocket beach mapping (MacLennan and Williams 2011). | • QA/QC. Run topology.  
                            • Could add embayment shoreform types. |
| Fetch and erosion potential (2013) | • Erosion potential is a combination of shoreform and fetch. This layer was originally created for the Social Marketing to Reduce Shore Armor project. | • QA/QC. Run topology.  
                            • This layer requires QA/QC to assure data accuracy. |

Advisory group involvement will occur in a series of working meetings that will occur throughout the duration of the project. The meeting topics are expected to progress from an overview of desired project outcomes and geodatabase contents, to the iterative collaborative identification of lines of analysis (or queries) to run to characterize existing beach sediment conditions, and ultimately to the identification of priority drift cells and shoreforms within drift cells for restoration or protection.

The third component is iteratively conducting and reporting on the spatial analysis. Analysis outputs will be discussed with the advisory group and analyses adjusted as needed to properly inform the identification of priorities. Metrics development to identify beach restoration and protection targets will begin following data compilation and refinement. Some of the current elements of PSNERP’s existing beach strategies will be maintained and others will be updated using the new data. Metrics will be applied to identify priorities at multiple scales, ranging from drift cells to parcels.
The report and geodatabase products will be developed to be understandable and accessible to people interested in beach restoration and protection. Results of the metrics will be packaged with the new data sets to produce a beach strategy geodatabase that can function as a cohesive, scalable road map for beach systems that would be publically available to local and regional nearshore professionals. The final data products will be packaged for other regional GIS users and potentially loaded onto one of the region’s web-based mapping sites.

**Budget Narrative**

Funding for the Identifying Target Beaches for Restoration and Protection project will come in many forms, though the bulk of support for the proposed project will come from ESRP. CGS will provide several interim data products that were developed for other projects that will provide a valuable head-start to the project. Unsecured match will be potentially provided by the Nearshore PSEMP armoring sub-committee, the broader Nearshore PSEMP group, and the Nearshore 8, each of which will potentially donate time to this effort. Travel expenses are included in the budget to reimburse Nearshore 8 members for mileage to Advisory Group meetings.

The total project budget is $168,587. Without a secured match, this total also represents our total ESRP request.

Task 3 accounts for the largest portion of the budget and consists of 3 different major elements. These include: (3a) the development of a Sound-wide shore armor layer, (3b) data compilation and geoprocessing of several other layers relevant to nearshore management, and (3c) beach targets metrics development and draft application. Task 3a will be a collaborative effort with the PSEMP Shore Armor sub-group. CGS will provide an updated shore armor layer, participate in 3 PSEMP armor sub-group meetings, and perform data collection and GIS processing to support the efforts to update and refine the Sound-wide shore armor data layer. CGS updated armor mapping will be limited to 200 miles of new data collection (or 7 field days), geoprocessing, and QA/QC of the new mapping. If additional mapping is requested by the PSEMP Shore Armor sub-group, then a revised scope of addendum may be developed at a later date. The Nearshore PSEMP Shore Armor sub-group has offered to also provide match in the form of in-kind meeting attendance and effort collaborating on the development of the updated Puget Sound shore armor layer.

Task 3b work includes additional geoprocessing and applying refinements to other data products that were developed by CGS in-kind for use in his project. The interim data sets cumulatively represent hundreds of hours of CGS time and over $30,000 in match. Minor refinements still need to be applied to these data before they can be included as stand-alone products in the project geodatabase. The data sets that are in need of final revisions include: current net shore-drift mapping, applying linear referencing to identify the direction of drift and location a given shoreform within the net shore-drift cell, minor refinements and QA/QC to integrated shoreform mapping (combines mapping from MacLennan et al. with the Puget Sound Change Analysis (Simenstad et al. 2011), measured fetch, and calculated erosion potential. Erosion potential is a function of integrated shoretype and exposure.

Task 3c is devoted to the proposal, development, and application of metrics to identify target beaches for restoration and protection. These metrics will be developed in collaboration with the Nearshore 8 the Nearshore PSEMP sub-group. The participation of both entities will potentially also be an in-kind contribution that can function as match for the project.
Map
The spatial extent of the project’s study area is the entire Puget Sound region, from Neah Bay and the Canadian Border south into Hood Canal and South Puget Sound. This is the same Puget Sound planning area as was used by PSNERP.

Outputs and Outcomes
This approach was developed with the awareness that restoration efforts are occurring at different scales at different locations around Puget Sound by a broad community of professionals. Much work is being done by local practitioners looking for meaningful project opportunities within the geographic limits of their work area (e.g., within county limits). The updated beach strategy outputs will provide new tools to guide the identification of what drift cell to work in and where within the drift cell (by shoreform or parcel) will restoration provide the greatest benefits. For those practitioners working at more of a regional scale, the additional information provided by this project will provide a more complete and accurate understanding of the relative condition of drift cells and the landscape-scale linkages required to achieve true process-based restoration.

The outputs and data products developed for this project will be compiled in a beach strategy geodatabase, designed for nearshore professionals. The geodatabase will include spatially coincident data layers with a brief user’s guide that includes an inventory of data sources, condition, strengths, weaknesses and suggested utility. The layers included in the geodatabase will include shore armor, current net shore-drift cells, feeder bluff mapping, shoreline residential parcels (without ownership data), exposure, erosion potential, an integrated shoretype layer, and the results of the applied metrics. Additional Sound-wide data products may be compiled in the data set, based on the recommendations of the advisory group (i.e., the Nearshore PSEMP and the Lead Entity Coordinators). Table 2 outlines deliverables from the project.

In addition to mapping products, a report describing each of the metrics, their supporting rationale, supporting data sets, and their intended application will be delivered.

The intent is that the project will produce guidance on priority drift cells to focus efforts in, while also providing a valuable tool for those interested in working in a specific area to identify where their efforts should be focused. That is, if a County employee is limited to working in a geographic area that does not have any priority drift cells at a regional scale, the project outputs will provide useful information to find beneficial project opportunities in drift cells located in their geographic area of focus.
Table 2. Deliverables to be prepared.

<table>
<thead>
<tr>
<th>Task</th>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project plan</td>
<td>This task represents the final scope of work for the project</td>
</tr>
<tr>
<td>2</td>
<td>Wiki content development</td>
<td>Description of all Beach Strategy project elements on the Salish Sea Wiki website</td>
</tr>
<tr>
<td>3a</td>
<td>Shore Armor updates</td>
<td>Deliver interim CGS shore armor data compilation. Research and collaborate on status of existing shore armor mapping. Attend at least 3 Nearshore PSEMP Shore Armor sub-group meetings. Updated shore armor mapping from up to 200 miles of (secondary) priority shores as identified by the PSEMP Shore Armor sub-group.</td>
</tr>
<tr>
<td>3b</td>
<td>Beach Strategy geodatabase</td>
<td>After data refinement, updated data sets will be compiled into a single geodatabase for distribution to Puget Sound beach professionals. Various refinements and geoprocessing techniques will be applied to the data layers. A geodatabase user’s guide will outline how local and regional users should use the data.</td>
</tr>
<tr>
<td>3c</td>
<td>Beach Strategy metrics development and draft application</td>
<td>List of all beach strategy advisory group participants. Power point presentations for the 5 meetings with of the advisory group. Draft list of beach strategy metrics, associated queries and scientific justification for each query.</td>
</tr>
<tr>
<td>4</td>
<td>Interim results analysis</td>
<td>A memo that summarizes the final results of the beach strategy metrics, including spatial distribution.</td>
</tr>
<tr>
<td>5</td>
<td>Final project report</td>
<td>The metrics methods, application, results, and supporting recommendations will be delivered in both draft and final versions.</td>
</tr>
<tr>
<td>6</td>
<td>PowerPoint of final presentation</td>
<td>Final presentation to both Nearshore PSEMP and Nearshore 8 showing results of final metrics and strategy outputs.</td>
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Task Descriptions

The start and end dates for this work will be dependent on the progress of the PSEMP Shore Armoring sub-group and ultimately the completed shore armor data layer. The completed shore armor GIS layer is a critical element of the beach systems database and a necessary pre-requisite to the metrics application. Once the updated armor layer is finalized, then Tasks 3b and 3c can progress. It is expected that these tasks will take approximately 6 months to complete. Tasks 4 – 6 will require approximately 6 months to complete.

Task 1. Project Plan

In this task, final adjustments to the project approach and scope will be documented in a project plan.

Task 2 Wiki Content Development

Per ESRP guidelines, the project will post a description of project elements on the Salish Sea Wiki website.

Task 3. Geodatabase Development and Advisory Group Working Meetings

Sub-task 3a. Data Refinement

Sub-task 3b. Development of Beach System Geodatabase

Sub-task 3c. Convene Working Meetings of Advisory Group
The bulk of the work occurs in Task 3, which entails 3 sub-tasks to accomplish the first two project components described in the methods section. In sub-task 3a, spatial data sets will be refined to improve their utility in the analysis. These steps and deliverables are described in the methods section (see table 1). A limited amount of new data collection will be undertaken to address concerns of the Nearshore PSEMP Armor sub-group. Both CGS and the PSEMP Nearshore Shore Armor sub-group have been working to describe and better understand the current status of shore armor mapping in the Puget Sound region. In this task CGS will attend 3 PSEMP Shore Armor sub-group meetings in order to exchange knowledge, collaborate on data refinements, and strategically update the shore armor data set. CGS will update shore armor mapping in one or more priority areas up to 200 miles in length. The timeline will be dependent on the progress of the PSEMP Shore Armor sub-group at the time that ESRP funding is awarded.

In sub-task 3b, the improved data sets will be organized in a geodatabase to conduct the analysis. The geodatabase will provide an ideal analytical framework to conduct the spatial analysis needed to develop recommendations for priority restoration and protection areas.

In sub-task 3c, a series of meetings with the advisory group will be convened to develop the lines of analysis necessary to conduct and inform the prioritization. The advisory group will include technical experts and leaders in nearshore restoration, including the Nearshore PSEMP and Lead Entity Coordinators leading nearshore issues in local salmon recovery efforts. This is a vital step because the long-term utility of the work hinges on both the technical quality of the analysis as well as the acceptance of the end product and tools. The advisory group participation fosters “user group” awareness, acceptance, and understanding of the project strategies and outcomes. Advisory group members will collaborate in the development of metrics to identify optimal targets for beach restoration and protection. Pocket beach metrics will also be developed, since these beaches were previously not included in the last iteration of strategy work. The results of draft metrics will be presented to the advisory group for review. A second iteration of metrics could be run after the original results are presented, if refinement is deemed necessary. The anticipated output of the new GIS analyses will be spatially explicit recommendations of priority drift cells for restoration and protection, as well as target beaches for restoration or protection within drift cells and pocket beaches (separately).

**Task 4 Interim Results Analysis**
Task 4 includes a summary of the draft metrics, summary of results, spatial analysis of results, and the draft of the geodatabase.

**Task 5 Final Project Report**
Task 5 is focused entirely on reporting, and will include a descriptive report documenting the methods applied and results of each element of the project in draft and final version.

**Task 6 Final Presentation of Project Outcomes**
Task 6 includes a final presentation in which all major elements of the project will be described to an invited audience of restoration practitioners.
Policy Impact
The practical value of a beach strategy is generally a function of the quality of the data sets used to identify strategic priorities. Therefore, developing refined data products with improved spatial precision and accuracy, which are ready for distribution and use by nearshore practitioners, will result in more effective beach strategies. Metrics can be developed that highlight specific parcels for restoration and conservation outreach and education, management approaches, restoration, and protection.

The previous iteration of beach strategies did not incorporate key information (e.g., directional nature of drift cell or sequence of shoreforms) to adequately characterize and guide efforts to restore and protect beach systems sediment processes. Further need for improving upon earlier efforts stems from the availability of several new data sets that will provide greater accuracy and spatially explicit results to the beach strategies work. In this way, these multi-scaling, next-generation, collaborative restoration metrics will help to protect Puget Sound beaches for future generations.
Jay Krienitz  
Estuary and Salmon Restoration Program Manager  
Washington Department of Fish and Wildlife  
600 Capitol Way North  
Olympia, WA 98501

Dear ESRP Review Team:

This letter of support encourages the ESRP team to fund the learning project proposed by Andrea MacLennan and Paul Schlenger that will develop refined beach restoration strategies.

Island County has 200 miles of shoreline, therefore nearshore restoration is the major focus of our recovery efforts. As the Lead Entity Coordinator for the WRIA 6/Island Lead Entity, I am responsible for guiding my Lead Entity through the development of salmon recovery strategies that will achieve the goals identified in our 2005 Multi-Species Salmon Recovery Plan. All 22 populations of Chinook utilize our beaches, estuaries, spits, embayments and streams for refuge and feeding as they out-migrate from the three major natal rivers (Skagit, Snohomish and Stillaguamish) that lie directly across from Whidbey and Camano Islands, as well as from central and south Puget Sound on their way through Admiralty Inlet.

Having well documented support of strategies to address nearshore restoration will greatly assist the defensibility of our workplan. The proposed partners for this project are the exact right people to be developing these strategies as it is their earlier work that we currently use to the best of our ability. With the proposed further refinements to their existing work, we will be able to better and more site-specifically explain to stakeholders the rationale behind our restoration efforts. The incorporation of a Beach Strategy Working Group (phase 2) is particularly exciting to us as it will provide the opportunity to build the bridge between the science and on-the-ground implementation. This is crucial to getting research and methodology off the shelves and into workplans resulting in actual restoration of important nearshore habitat.

I look forward to following this project over the next year and then taking it and putting it into action on our 200 miles of shoreline.

Sincerely,

Dawn Pucci  
WRIA 6 (Island) Lead Entity Coordinator
Qualifications

*Andrea MacLennan’s* understanding of both coastal geomorphology and coastal ecology enables her to provide valuable syntheses of nearshore processes. She specializes in nearshore geomorphic and habitat assessments, restoration/conservation prioritization and planning, net shore-drift analysis, applied coastal management, and historic shore change analyses. She has been applying her skills to better understanding nearshore ecosystem processes in the Puget Sound region since 1999 and working at CGS for over 10 years. At CGS Andrea manages projects, performs field surveys, develops analytical methods and models, performs GIS mapping and air photo analysis, data/statistical analysis and writes reports. She has been involved in several large-scale efforts to assess nearshore processes in Puget Sound including: Historical Change and Impairment of Puget Sound Shorelines (“The Change Analysis”), the Strategic Needs Assessment of Puget Sound, and several other efforts for the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP pugetsoundnearshore.org). She has characterized conditions, identified and prioritized on-the-ground nearshore restoration and conservation opportunities for salmon recovery (in WRIAs 1, 2 and 15) and coastal management throughout most Puget Sound counties (Whatcom, Island, Clallam, Jefferson, Pierce, and Mason counties among other jurisdictions). Andrea recently managed the compilation and completion of Puget Sound Feeder Bluff Mapping for the Washington State Department of Ecology and developed and applied a sea level rise vulnerability model for San Juan County.

Education

**MS, Geography (Earth Surface Processes)** — Western Washington University, Bellingham, WA, 2005  
*Masters Thesis*: Relations of marsh vegetation, large woody debris, and historic LWD abundance.  
**BS, Environmental Science** — Evergreen State College, Olympia, WA, 1999

Experience

**Sea Level Rise Vulnerability of San Juan County for Friends of the San Juans San Juan County, WA.**  
Project manager and technical lead on the development of a SLR vulnerability assessment model for San Juan County. The objective of this study was to attain greater understanding of the areas within San Juan County that are vulnerable to implications of sea level rise. Inundation modeling was paired with bluff recession estimates (based on background erosion rates) across two SLR scenarios (moderate, high) and planning horizons (2050, 2100). A countywide mapping tool was developed that highlights areas potentially at risk (to inundation or erosion) for which management strategies could be developed.
to reduce, avert and mitigate the specific vulnerability. In addition, these results can be used to identify additional long-term restoration and conservation targets throughout the County.

**Feeder Bluff Mapping of Puget Sound for Washington State Department of Ecology, WA.** Project manager for Sound-wide Feeder Bluff Mapping. The objective of this project was to produce comprehensive mapping of Puget Sound feeder bluffs and related coastal landforms suitable for guiding improved shoreline management. The CGS team compiled and evaluated 26 data sets for potential inclusion into the Sound-wide data set. Ten existing data sets covering 700 miles of shore met the assessment criteria for inclusion. A combination of remote and field-mapping were applied to complete the Sound-wide geodatabase using the same mapping methods applied in the existing data sets. All data were analyzed at the drift-cell and county scales to enhance understanding of geomorphic processes and countywide resource management. A set of 1:100,000 scale maps were created in addition to the project geodatabase, which also contains updated net shore-drift cell mapping.

**Water Resource Inventory Area 1 Nearshore Assessment and Estuarine and Restoration Prioritization, City of Bellingham, Whatcom County, WA**

CGS recently completed a comprehensive assessment and restoration/conservation prioritization of the marine and estuarine shores of Water Resource Inventory Area (WRIA 1). Andrea managed this phased project, which first entailed an assessment of conditions, data gaps and a review of recent, innovative restoration prioritization tools used in the Salish Sea. The second phase entailed developing and applying a new prioritization tool that incorporated best available science with user-flexibility. Strategies (enhance/restore/protect) were identified at multiple scales based on the occurrence of valued ecosystem components and process degradation within coastal landforms and net shore-drift cells. Results linked site specific opportunities with benefits to nearshore processes and specific ecosystem components. A separate analysis was applied for the Nooksack River estuary, the results of which weighted the benefits, constraints and sequencing complexities of the many different opportunities in the delta. Both tools and analytical outputs integrated regional and local data sets, concepts and regional priorities, and fundamental geomorphic and landscape ecology principals aimed at successfully achieving process-based nearshore restoration in the Salish Sea.

**Puget Sound Strategic Needs Assessment Team for the PSNERP (USACE/WDFW), Puget Sound, WA.**

Provided coastal geomorphic expertise in a collaborative effort to define restoration and develop conservation strategies based on the results of the PSNERP Change Analysis. Aided in the development of GIS rules to identify areas with degraded processes (the Process Evaluation Framework) upon which additional restoration strategies were developed. Composed report “narratives” describing the occurrence and associated impacts of shoreline armoring and stressors on embayment shoreforms. Analyzed the occurrence of shoreform change Sound-wide, the results of which highlighted the regional impact of road and rail causeways on embayment shoreforms.

**Marine Shorelines Design Guidelines, Washington Dept. of Fish and Wildlife, Puget Sound, WA.**

Collaborated on assessment design, collected and analyzed field data, and drafted written content for new guidance document in Washington State’s Aquatic Habitat Guidelines series, titled Marine Shoreline Design Guidelines. Written content focused on site and coastal processes assessments, alternatives analysis, LWD installation, beach nourishment, bulkhead removal design techniques.
Paul Schlenger is a principal fisheries biologist with 18 years of experience in marine nearshore ecology, habitat assessment, and habitat mitigation/restoration. Paul’s work focuses on characterizing fish and other biological resource distributions in relation to habitat conditions and manmade modifications. Paul has been integrally involved in marine nearshore planning and restoration projects throughout Puget Sound, focusing on multiples scales of analysis to inform decision-makers and identify priority restoration and protection opportunities. Paul frequently employs GIS to investigate some of the spatial and temporal patterns and relationships between water quality and fish ecology. Paul has applied his fisheries expertise to salmon recovery planning efforts in several western Washington watersheds and serves on the Salmon Recovery Funding Board Technical Review Panel.

Representative Projects

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP), U.S. Army Corps of Engineers (Corps), Puget Sound, WA. *Assistant Project Manager and Estuarine Ecologist.* Managed a diverse range of on-call technical services to the Corps while serving as the primary point of contact and technical lead on a series of task orders. Led the consultant team’s effort to implement a Soundwide analysis of changes in shoreline and watershed conditions between current and historic (late 1800s) habitat conditions. Lead author of PSNERP’s Strategic Needs Assessment Report, which developed and implemented an analysis of ecological process degradation along the shorelines and deltas of the Puget Sound planning area. During this assessment, managed the meetings of a 10-person team of representatives from federal, state, local, tribal, and nonprofit organizations. Applied marine biology expertise and management skills to effectively advance the team’s efforts to develop technically sound analytical approaches to identifying restoration priorities. Led consultant team’s work on the development of a restoration benefit metric that was applied to evaluate the relationship between project costs and benefits.

Nearshore Sediment Assessment and Restoration Design between Mukilteo and Everett, Snohomish County, Everett, WA. *Lead Marine Ecologist.* Contributed marine nearshore expertise to a large-scale restoration planning and design project along the Puget Sound shoreline between Mukilteo and Everett. The feasibility assessment to identify the highest priority site(s) included an analysis to identify a suite of restoration opportunities in the project area and convening of a series of stakeholder meetings. Restoration designs at four priority sites have been prepared to 60% and work is underway to finalize the designs. Design for one site entails fill removal and beach restoration for a shoreline park, and designs for the remaining sites involve the placement of ungraded beach nourishment material that will be naturally redistributed through wave action. The restoration...
designs focus on improving habitat for rearing juvenile salmon and spawning forage fish. The stakeholder process has led to significant partnerships that have been crucial for this project and are noteworthy for future restoration in other shoreline areas. In particular, a partnership has been forged with the Corps to beneficially reuse dredge material to enhance beach conditions. BNSF is also a key collaborator and supporter of the project, because much of the work will occur within its right-of-way.

Watershed Strategic Assessment, King County Department of Natural Resources and Parks, King County, WA. Assistant Project Manager. Served as the primary point of contact for this on-call contract to support salmon recovery planning efforts for King County. This work focused on the Cedar-Lake Washington-Sammamish and Green-Duwamish watersheds—Water Resource Inventory Areas (WRIAs) 8 and 9, respectively. Working in the Green-Duwamish watershed, coordinated an intensive field data collection of in-stream and riparian habitat parameters in the Lower Green River. Actively participated in a project focusing on developing the functional linkages between salmon and habitat. Conducted a series of workshops to bring together representatives from local, state, federal, private industry, and environmental groups to identify a suite of nearshore habitat actions to include in the draft recovery plan. When a suite of land-use, site-specific, and public education actions were identified for WRIA 8, helped develop a series of GIS-based graphics that illustrate the importance of an integrated approach to implementing the actions.

Greater Mason County and Oakland Bay/Hammersley Inlet Nearshore Habitat Assessment, Squaxin Island Tribe, Mason County, WA. Project Manager and Lead Ecologist. Led two nearshore habitat assessments in Mason County to identify priority sites for restoration and conservation in order to improve or maintain key ecological functions for juvenile salmonids. Intensive data collection activities focused on the riparian, intertidal, and subtidal resources, including macroinvertebrates and shellfish, in order to fill data gaps and provide a complete understanding of nearshore conditions. Developed a GIS model to evaluate the ecological function of habitats for juvenile salmonids. Input to the GIS model was contributed by PSNERP Nearshore Science Team members during both studies. Using the model results as well as fundamental principles of landscape ecology, priority areas for restoration and conservation were identified.

Kitsap County Marine Shoreline Sediment Supply Mapping and Prioritization, Kitsap County Department of Community Development, Kitsap County, WA. Senior Fisheries Biologist. Part of a multi-disciplinary consulting team working for Kitsap County to map sediment supplies along the marine shoreline and identify priority opportunities for restoration and conservation. Contributed to the team’s development of a scoring framework to characterize the relative magnitude of sediment inputs from mapped sediment sources. The framework was an effective way to interpret the “potential” sediment inputs along a shoreline, and the “existing” sediment inputs based on the extent to which shoreline armoring has disconnected sediment supplies. Made presentation in a landowner workshop and conducted a site visit focused on identifying shoreline landowners interested in alternatives to hardened shoreline armoring.

San Juan County Strategic Salmon Recovery Planning, San Juan County Lead Entity, San Juan Islands, WA. Fisheries Biologist. A primary contributor to team effort to assess marine nearshore habitat conditions and fish use in San Juan County in order to prioritize salmon recovery actions. The work included developing and applying assessment tools at multiple spatial scales to characterize juvenile Chinook salmon and forage fish habitat utilization. The project utilized comprehensive resource mapping and fish use data collection that had been conducted in recent years and the results prioritize areas in which to focus restoration and protection efforts. Project incorporated coastal landform resilience to sea level rise associated with climate change.
Qualifications

Jim Johannessen, Owner and President, founded CGS in 1992 to provide consulting services for coastal and estuarine processes, coastal bluff geologic processes, and coastal management throughout the Pacific Northwest coastline, with specific focus on the Puget Sound-Salish Sea. He has nearly 30 years of experience performing site assessments, developing erosion control measures, design development, monitoring, and technical studies for coastal projects. His expertise spans from beach and estuarine processes to gravel beach nourishment, environmental assessments, and project planning for nearly any type of coastal project.

Jim Johannessen is considered a regional expert in soft shore protection and coastal restoration services and has been recognized for his design work in these fields. He typically serves as project manager and often collaborates with engineers, biologists, landscape architects and others. Several of Jim’s projects have received national awards for their success. Mr. Johannessen looks for innovative solutions to coastal management challenges. He also provides technical services for developing and updating shoreline management plans, coastal guidance documents, and develops and presents educational programs on these issues.

Expertise
- Littoral drift assessment/ drift cell analysis
- Erosion control and habitat restoration
- Beach nourishment design
- Alternative shoreline erosion control using large woody debris and vegetation
- Bulkhead removal design
- Coastal reach management
- Nearshore assessments
- Shoreline change/historic GIS mapping
- Beach and estuarine processes
- Support for biological and ecological management/ ecosystem recovery
- Assessment of coastal dynamics for planning and management of coastal property
- Shoreline management and planning
- Workshops and educational programs on coastal geology, bluff and beach processes

Education

MS, Geology — Western Washington University, Bellingham, WA, 1993
BS, Geology and Oceanography — University of Rhode Island, Kingston, RI, 1984

Licenses & Certifications

Licensed Engineering Geologist, Washington State, 2002
Licensed Geologist, Washington State, 2001

Selected Experience

Marine Shorelines Design Guidelines for Washington Dept. of Fish and Wildlife, Puget Sound, WA. CGS completed a new guidance document for Washington State’s Aquatic Habitat Guidelines series, titled Marine Shoreline Design Guidelines. This document focuses on alternative techniques for minimizing erosion (beach nourishment, use of large logs, bank reslope and revegetation); bulkhead removal for habitat enhancement and process restoration; and traditional approaches (rock revetments and vertical bulkheads). Phase 1 involved quantitative performance assessment through field measurements at 25 sites Sound-wide. Phase 2 includes a final document to be produced in early 2014.
This document was designed for use by project designers, agencies, contractors, and homeowners. Available online at: http://wdfw.wa.gov/publications/01583/

Feeder Bluff Mapping of Puget Sound for Washington State Dept. of Ecology, Puget Sound, WA. CGS conducted Puget Sound-wide feeder bluff mapping for the WA Dept. of Ecology funded by the US EPA. The mapping project defined key sediment sources (feeder bluffs) and accretion shore segments of all drift cells in the Sound. Current conditions were mapped through comprehensive field reconnaissance by small boat applying geomorphic mapping rules developed to classify the shores into one of five shoretypes. The project created maps in ArcGIS and provided analysis of nearshore trends and restoration and conservation needs. A protocol for drift cell analysis relative to bluff sediment supply was developed for prioritizing conservation and restoration of nearshore natural sediment sources.

Bulkhead Removal and Beach Creation at Boulevard Park, Bellingham for Bellingham Parks, Eastern Bellingham Bay, WA. Design lead for partial bulkhead removal, beach creation through gravel nourishment to enhance recreation opportunities and beach habitats, and reconstruction of failing shore protection structures. This project was designed for one of Bellingham’s most popular and most degraded waterfront parks. Construction of Phase 1 was completed in fall of 2013.

Port Angeles Waterfront & Transportation Improvement Plan, Wave Model Development, and Beach Design of City of Port Angeles Planning Dept., Port Angeles, WA. Beach design lead as part of consultant team designing the Waterfront & Transportation Improvements Plan for the City of Port Angeles to convert 2,000 linear feet of heavily altered waterfront into a community friendly destination with considerable ecological improvements. CGS developed a wave model used for new beach design and coastal structure design wave criteria. The design allowed for the creation of two functional gravel pocket beaches in the current location of a 20 ft tall riprap revetment defending extensive fill. The gravel beaches were constructed in the summer of 2014 as part of a phased construction project.

Restoration Design for Causeway Removal and Nearshore Processes Restoration, PSNERP/WDFW, Kilisut Harbor, WA. Project manager and design lead on feasibility assessment and design for the Flagler Road causeway at the head of Kilisut Harbor between Marrowstone and Indian Islands for the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) and Washington Department of Fish & Wildlife (WDFW). The proposed design consists of removing the causeway and undersized culverts and replacing it with an elevated bridge that spans the embayment mouth/historic channel for estuary restoration. Associated armor and fill will also be removed. Conceptual designs were provided along with materials quantities. This causeway replacement at Kilisut Harbor is one of the 40 sound-wide action areas for PSNERP and one of seven conceptual designs by CGS for this project.

Coastal Processes Management Workshops and Programs for Various Clients, Puget Sound, WA. Created and presented programs on coastal geology, beach and bluff processes, and building practices for municipalities, regulatory agencies, educational resources, and community groups. Clients include: Marine Resources Committees, WSU/Island Co. Beach Watchers, WA Sea Grant, Whale Museum, Puget Sound Water Quality Action Team-Now Puget Sound Partnership, Land Use Study Commission, North Cascades Institute, Kitsap Co. PUD, Skagit Co. Conservation District, Jefferson Co. Cooperative Extension, Elderhostel, and others.
Qualifications

*Branden Rishel* has over eleven years of experience with ArcGIS, including ecological analyses for government agencies in Washington and British Columbia. His forest fire map infographics were chosen to present to Congress, and he won a national cartography award for his bathymetric mapping. He has used network analysis to describe alternative transportation use, satellite remote sensing techniques to model insect outbreaks, and air photo interpretation to detect and quantify changes in Pacific Northwest river geomorphology. At CGS Branden primarily conducts GIS mapping, spatial analysis, and database management.

Branden has a long history of managing and analyzing large data sets. He especially enjoys data mining, processing large government datasets, and fuzzy logic.

Branden also provides CGS with experience in graphic design, qualitative analysis, survey design, technical writing, editing, and ecological field research experience. His graphic design work has been used to communicate complex conceptual relationships to the lay-person.

Expertise
- Spatial analysis and visualization
- Data processing and analysis
- Graphic design and scientific illustration
- Cartography and infographics
- Technical writing and editing
- Remote sensing for geomorphology
- Qualitative analysis and survey design
- Field research and field surveys

Education

**BS, Geography** — GIS and Cartography, University of Oregon, Eugene, OR, 2012

Additional Studies: Elective coursework in Pacific Northwest geology, marine geography, climatology, appropriate technology (engineering), architectural drafting, remote sensing, and geographic data analysis.

Experience

**Feeder Bluff Armor Removal Assessment for the Northwest Straits Marine Conservation Foundation, Island and eastern Jefferson Counties, WA.** Potential sites for feeder bluff armor restoration projects were identified through a multiscalar spatial analysis which will later be developed into prioritization metrics though collaboration with experts and stakeholders. The analysis combines several characteristics of bluffs (e.g., erosion potential), parcels (e.g., setback of structures), and shore drift cells (e.g., feeder fish habitats). All of these features were located along drift cells using linear referencing analysis to quantify relative down-drift effects of potential restoration. This can identify, for example, unnecessary armor near the beginning of a starved drift cell. For this project, Branden performed air photo analysis, data processing, raster analysis, digitization, georectification, and linear referencing.

**Puget Sound Shoreline Parcel Geodatabase for Washington Dept. of Fish and Wildlife, Puget Sound, WA.** A geodatabase was developed by CGS of all residential shoreline parcels throughout the Puget Sound region, from Neah Bay and the Canadian border to the southern limits of the Puget Sound and Hood Canal as part of the Social Marketing to Reduce Shoreline Armor project. Each parcel was attributed with supporting information on the physical and ecologic conditions to inform management...
including: geomorphic shoretype, fetch, erosion potential, forage fish spawning, shore armor, restoration benefit and priority. Parcels were then assigned to one of 9 segments based on appropriate target behaviors for improved shoreline management ranging from armor removal to restoring native vegetation. Data summaries and analyses of the distribution and characteristics of parcels and segment populations are described in the project report. Branden’s contributions include GIS analysis linking parcel data with other data sets, performing QA/QC, analyzing and reporting results.

**Marine Shorelines Design Guidelines for Washington Dept. of Fish and Wildlife, Puget Sound, WA.** A new guidance document in Washington State’s Aquatic Habitat Guidelines series, the *Marine Shoreline Design Guidelines* focuses on; alternative techniques for minimizing erosion (beach nourishment, use of large logs, bank reslope and revegetation); bulkhead removal for habitat enhancement and process restoration; and traditional approaches (rock revetments and vertical bulkheads). Branden’s contributions include graphic design of technical illustrations, map production, editing, and prepress.

**Sea Level Rise Vulnerability of San Juan County for Friends of the San Juans San Juan County, WA.** The objective of this study was to attain greater understanding of the areas within San Juan County that are vulnerable to implications of sea level rise. Inundation modeling was paired with bluff recession estimates (based on background erosion rates) across two SLR scenarios (moderate, high) and planning horizons (2050, 2100). A countywide mapping tool was developed that highlights areas potentially at risk (to inundation or erosion) for which management strategies could be developed to reduce, avert and mitigate the specific vulnerability. In addition, these results can be used to identify additional long-term restoration and conservation targets throughout the County. Branden provided graphic design and scientific illustration for this project’s final report.

**Restoration Design for Causeway Removal and Nearshore Processes Restoration, North Olympic Salmon Coalition, Kilsut Harbor, WA.** GIS support for a feasibility assessment and design for the Flagler Road causeway at the head of Kilsut Harbor between Marrowstone and Indian Islands for the North Olympic Salmon Coalition. The proposed design consists of removing the causeway and undersized culverts and replacing it with an elevated bridge that spans the embayment mouth and historic channel for estuary restoration. Brendan provided air photo and map integration in GIS, in support of extensive shore change analysis that was used to develop a rough sediment budget for the local net shore-drift cell.

**Island County LIO Project Development and Data Products, Island County, WA.** CGS worked with the Island County Local Integrating Organization to develop project plans for several high priority Near-term Actions (NTAs). As part of this effort CGS developed some GIS data projects, including bluff crest and building setbacks, to support later assessments aimed at identifying priority parcels for armor removal and/or soft shore alternatives. Branden assisted with air photo interpretation, digitization, and other GIS tasks.

**Assess Proposed Effects on Beach Geomorphology for Port Gamble S’Kllallam Tribe in Jefferson County, WA.** CGS is working to assess the anticipated geomorphological and ecological impacts of proposed US Navy structures, with special consideration of shellfish habitat. To this end, Branden has digitized historical maps and air photos and completed a shore change analysis.
**Expertise**
- Topographic survey mapping and analysis
- Coastal mapping
- Shoreline restoration design
- Tidal lagoon inlet stability analysis
- Beach nourishment
- Shore change analysis
- Sediment sample grain size analysis
- Design drafting, AutoCAD and ArcGIS

**Qualifications**

*Jonathan Waggoner* has more than seven years’ expertise in environmental science and coastal mapping using ArcGIS and AutoCAD. He has extensive experience mapping throughout the Puget Sound and Northern Straits, including coverage in every area county. As the monitoring and survey manager for CGS, Mr. Waggoner has provided this expertise for numerous beach monitoring, bulkhead removal, soft shore protection, and tidal lagoon restoration projects.

**Education**

- **BS, Environmental Science** — Aquatic Ecology, Western Washington University, Bellingham, WA
- **Additional Studies**: Coursework in forest ecology, stream ecology, geomorphology, and GIS.
- **Senior Thesis**: Evaluation by Acid Titration of CaCO3 Content in Stormwater Runoff from Limestone-lined Parking Lots.

**Licenses & Certifications**
- **Certificate in Coastal Engineering**, Old Dominion University

**Experience**

**Culvert Removal for City of Bellingham**, Fairhaven Marsh/Chuckanut Bay, Bellingham, WA. Assessed ecologic and geomorphic implications of removing a culvert that provided tidal flushing for a backshore salt marsh at the north end of the bay. Nearby Chuckanut Creek supports natural spawning stocks of steelhead trout, chum and coho salmon, and opening the Fairhaven Marsh increases the available rearing habitat for juvenile salmonids. Performed a site topographic survey and determined the extent to which the culvert restricts flow and inhibits water flow from the bay. Created a 30% culvert removal design to include removal of the existing parking area and replacement of the road with a foot channel. Removal was expected to allow increased tidal flushing within the salt marsh through the widened channel.

**Bulkhead Removal Feasibility Assessment and Design for the People for Puget Sound, Snyder Point/Squaw Point, Thurston County, Olympia, WA.** The bulkhead at Snyder Point (Squaw Point) is encompassed within the Evergreen State College campus, along the east shore of Eld Inlet, in west Olympia, Washington. Conducted a feasibility assessment for bulkhead removal within a college campus along the east shore of Eld Inlet. Assessed local conditions, and site characteristics and constraints to guide restoration designs (Phase 2 of project). Performed field reconnaissance collaboratively with T. Hammer, including high resolution surveying, analysis of existing data, and GIS (historic) shore change analysis. Met with Evergreen State College facilities staff to discuss two proposed restoration designs.

**Beach Area Restoration Feasibility Assessment for the City of Bellingham, Little Squalicum Park, Bellingham, WA.** Performed a feasibility assessment for beach/nearshore enhancement in the park beach to the southeast side of a filled area known as the Mount Baker Plywood Peninsula. Assessed
three designs for restoration and enhancement actions within the approximately 1,500 ft of shoreline and nearshore study area in northern Bellingham Bay. The study area was altered by the BNSF railway bridge supports, trails, creek channelization and the culvert at the mouth of Little Squalicum Creek, including armor with concrete rubble and riprap and large amounts of fill at the peninsula. Due to the level of alteration, the park and peninsula nearshore habitat areas were in very poor condition. Prepared designs incorporating local coastal processes, the scale of alteration, historic conditions, and opportunities for habitat improvement.

**Beach Restoration Design and Mitigation Action for ICF Jones & Stokes/ British Columbia Transmission Company, Point Roberts, WA.** Performed a site topographic survey and restoration designs at Lighthouse Park for the removal of the rock and soldier pile bulkhead along with placement of 900 cy of beach nourishment sediment. Performed construction oversight during the removal and beach nourishment portions of the project and provided an as-built survey following completion. [Click here to view the completed report.](#)

**Restoration Feasibility Assessment and Design for Snohomish County Surface Water Management, Kayak Point County Park, Snohomish County, WA.** Performed site topographic survey and aided in the development of four preliminary beach restoration/enhancement design options aimed to enhance nearshore habitats and prevent further storm damage to park infrastructure. Aided in the refinement of the designs to final stage. Conducted additional topographic surveys in support of analyzing each beach enhancement alternatives under different (local) sea level rise scenarios. Produced a report for People for the Puget Sound, Barrier Lagoon Feasibility Study for Kayak Point County Park (2011), to explore the possibility of re-creating a self-sustaining barrier lagoon at the park. This lagoon feasibility study was one of four alternatives identified an earlier restoration assessment (2005).

**Estuarine and Salt Marsh Enhancement Design for the City of Bellingham, Post Point Lagoon, Bellingham, WA.** Worked with the City and other consultants to produce designs to enhance the stream mouth located within the lagoon and improve habitat conditions in the adjacent salt marsh in the southern part of Bellingham Bay. The design called for a lower shore slope to increase the area of salt marsh and shallow water habitats to support degraded estuarine marsh and eelgrass habitats. Increased shoreline complexity within the lagoon to enhance migratory pathways used by migrating salmonids.

**Nearshore Restoration Feasibility Report Study for Jefferson County Marine Resources Committee, Jefferson County, WA.** Examined coastal sites for possible restoration actions. Performed feasibility study based on physical characteristics of each site, landowner willingness to participate in the process, and the likely benefits resulting from restoration. Recommended one site for completion of a site survey and prepared 60% restoration design drawings, including recommendations for reconfiguring the shoreline to enhance habitats and ameliorate erosion.

**Bulkhead Removal Feasibility Study for Cascade Land Conservancy, Central Puget Sound, WA.** Performed feasibility study to analyze removal of some or all of the bulkheads fronting this historic nearshore sediment source without threatening a home atop the bluff. Performed an analysis of current and historic bluff conditions to identify the drivers of bluff erosion at the site, determine erosion rates and observe how the bluff changed since bulkheading. Performed surveys, GIS analyses, and geomorphic air photo analyses.