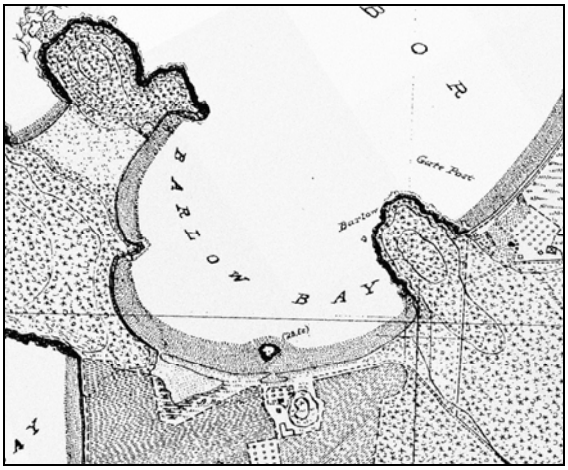
MacKaye Harbor Community Shoreline Restoration Project—Restoration Plan: Final Report



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INTRODUCTION

This study was conducted to conceptualize and assess the feasibility of potential nearshore restoration projects in MacKaye Harbor and Barlow Bay on southern Lopez Island, Washington. MacKaye Harbor and Barlow Bay ranked very high for bulkhead removal and rehabilitation in the study Soft Shore Protection/Structure Removal Blueprint for San Juan County Forage Fish Beaches (abbreviated to SJSSP; Johannessen and MacLennan/Coastal Geologic Services 2006). This area ranked 3rd out of all of San Juan County shore reaches with mapped forage fish spawning habitat in combination with shore modifications.

Coastal Geologic Services, Inc. (CGS) was contracted by the Friends of the San Juans (FRIENDS) to evaluate the feasibility for restoration of the two beach segments mentioned above and to develop conceptual restoration approaches. The aim of this assessment was to identify the best projects for beach enhancement and restoration based on the presence of valuable nearshore habitats, site characteristics that determine project sustainability, relative cost, and land-owner willingness data (conducted by FRIENDS).

MacKaye Harbor and Barlow Bay were identified as priority restoration sites based on the following characteristics: documented spawning of surf smelt and pacific sand land (forage fish) in the area, multiple spawning sites documented in close proximity, spawning documented in multiple seasons, spawning documented in the region by historic WDFW surveys (1989-1999) and the San Juan County Forage Fish Spawning Habitat Assessment Project (2000-2003), and the presence of eelgrass prairies.

Based on the findings in the SJSSP, emphasis for this project was placed on investigating armored sections of these beaches; including multiple shore protection sections with rock revetments, the locations of roads, tide gates, and associated culvert drainage systems. Derelict shore modifications and debris were also included to assess the restoration potential and feasibility for removal throughout the study area. Analysis of the restoration potential was conducted by compiling several biological and morphological data sets in ArcGIS and historic analysis, including air photo analysis and field assessment.

This study provided the scientific framework and recommended actions toward nearshore ecosystem restoration in MacKaye Harbor and Barlow Bay. On a larger scale, this project represents a unique collaboration by which to implement nearshore restoration by including project partners from the private sector, non-profit sector, local and tribal governments, along with community members. The integration of geomorphic, biologic and social elements in the MacKaye Harbor Community Shoreline Restoration Project increases the likelihood of successful implementation of projects in the region.

BACKGROUND

The San Juan Islands are located in a portion of Puget Sound referred to as the San Juan Archipelago in northwestern Washington State. Lopez Island is one of the largest and most populated islands of the San Juans. The southern portion of the island is comprised of a variety of Mesozoic and Cenozoic igneous and metamorphic rock (Brandon et al. 1988). This bedrock is

locally exposed in relatively high relief portions of the uplands and in headlands adjacent to beaches in the study area. Low elevation areas landward of the beaches contain extensive wetland complexes.

The beaches at Barlow Bay (defined as the north-facing beach close to Agate Beach) and MacKaye Harbor (defined as the mostly west-facing beach) are pocket beaches constrained by metamorphic rock headlands at both ends of the beach (Figures 1 and 2). Salmon Point marks the west end of Barlow Bay, and a rock headland marks the north end of the study area in MacKaye Harbor. The northern half of the backshore area and uplands are mapped as beach deposits, and the southern half as marine diamicton (also called glaciomarine drift; Dethier 1996). This corrected the erroneous earlier geologic mapping of the area as Vashon till (WA Dept. of Ecology 1978). The southern portion of the bank at the site is classified as “unstable” in the Coastal Zone Atlas of Washington (WA Dept. of Ecology 1978), while the northern portion of the bank and backshore area was classified as “stable”.

Morphology of Barlow Bay and MacKaye Harbor

Shorelines of Lopez Island are generally composed of sandy bluffs, broad beaches, bedrock headlands with pocket beaches, and long bedrock sea cliffs. In the study area, Barlow Bay and MacKaye Harbor are dominated by bedrock headlands and large pocket beaches (Figures 1 and 2). Beach sediment on both of these beaches was sand and pebble with shell hash.

A pocket beach represents a unique shoretype that is common within the San Juan Islands (Johannessen and MacLennan 2007). Pocket beaches are beaches that are contained between two bedrock headlands, essentially creating a closed system and are not typically within net shore-drift cells (Kremer, 1976). Theoretically, minimal exchange of sediment occurs between the pocket beach and their adjacent shores and thus the substrate in a pocket beach becomes continually reworked by wave action (Kremer, 1976). Pocket beaches are characteristically swash aligned (oriented parallel with predominant incoming waves), limited in length, crescentic in plan shape, and display well sorted materials.

Beach processes and sediment transport in San Juan County are driven by waves, which are typically formed by wind acting over a fetch or open water distance. San Juan County exhibits an extreme range of wave regimes due to the complex configuration of islands. Both study area beaches are relatively protected from open water, but MacKaye Harbor has nearly twice the fetch of Barlow Bay at 2.0 and 0.8 miles respectively.

Net shore-drift cells are not present in the study area, due to the preponderance of bedrock sea cliffs and presence of pocket beaches (Johannessen 1992). The sea cliffs occupy areas of no appreciable drift (NAD), which is used in areas where there was no appreciable net volume of sediment transport, due to a lack of wave energy or a lack of sediment volume, such as along bedrock shores.

All beaches serve as a buffer against direct wave attack for the adjacent uplands. The function of a "healthy" beach fronting uplands include absorbing storm wave energy and serving as transition

zones. All shoretypes, including bluffs, beaches, headlands, and pocket beaches are completely connected to the nearshore and together are *integral parts of a coastal system*.

Nearshore Habitats

Nearshore areas are areas of marine and estuarine shore. In the Puget Sound region the nearshore is defined as the area between the crest of marine banks and backshore areas, beaches and shallow marine waters down to the depth of light penetration, including estuaries and the upstream limit of saltwater intrusion. The nearshore provides critical habitats for salmon, other marine fish, many species of birds, and countless other species of this diverse and rich ecosystem. The greater Puget Sound is home to more than 200 species of fish, including native salmon species, and 10 species of marine mammals, including orca whales (Gelfenbaum et al. 2006). Resources that depend on the nearshore provide goods and services of high economic value to the people of Washington State and the United States. Due to the high level of productivity and species diversity, protection and restoration of nearshore areas of the region has become a high priority in recent years (PSAT 2003, Gelfenbaum et al. 2006). Successful restoration of coastal ecosystems depends on identifying, understanding, and restoring the nearshore ecosystem processes where possible.

Eelgrass beds are essential to the function of the nearshore ecosystem. Eelgrass provides structure to the nearshore food web for many marine organisms including, most notably, various species of shellfish, forage fish, and juvenile salmon (Johannessen and MacLennan, 2007). Lower order organisms, such as shellfish and forage fish, rely on eelgrass beds for spawning, habitat, and protection. Some species of forage fish lay eggs exclusively on blades of eelgrass (Mumford 2007). Higher order species, such as juvenile salmon, find abundant food sources within eelgrass beds as they transition into the marine environment. Eelgrass serves as valuable habitat, spawning grounds, protection, and food source to nearshore ecosystem, and has become increasingly protected from human impacts.

Eelgrass inhabits the intertidal to subtidal range in relatively calm or quiet bodies of water. The numerous protected embayments and pocket beaches in the San Juan Islands provide great habitat for eelgrass, which has an outer limit based on sunlight penetration and a landward limit based on desiccation (Mumford 2007). Due to their need for sunlight, human impacts such as piers, docks, and buoys pose a large threat to eelgrass beds and the species that rely on this habitat. Large but discontinuous eelgrass beds exist in the study area (Figures 3 and 4).

Forage fish are small, schooling fish that are key prey items for larger predatory fish, such as salmon, and other wildlife in a marine food web. In Puget Sound, forage fish species occupy every marine and estuarine nearshore habitat. Nearshore habitats are of special concern, because many species use them for spawning. Surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus)* are commonly found within the nearshore zone of Pacific Northwest beaches (Penttila 2007). Surf smelt and sand lance spawning habitat areas are found in the upper intertidal portion of fine gravel and sand beaches, with a high percentage of 1-7 mm sediment (Penttila 1978), which is fine gravel (smaller than pea gravel) to coarse sand. Sandlance require 0.5-3.0 mm sediment for spawning.

Although existing information about forage fish spawning is incomplete, seasonal tendencies of spawning has been documented. Surf smelt spawning in Northern Puget Sound commonly occurs during the summer months. Spawning can occur throughout the year, possibly spawning every month (Penttila 2005) at MacKaye Harbor. Incubation periods for surf smelt eggs vary from a few weeks to a month depending on temperature and season. Sand lance spawning typically takes places in the fall and winter months from November to February with incubation periods of up to a month (Penttila 2005).

Documented forage fish spawning occurs throughout the MacKaye Harbor Road beach and the central Barlow Bay beach, and as noted above occurs throughout the year. The remainder of the study area beaches have suitable sized sediment to make them potential forage fish spawning substrate (Figures 3 and 4).

Puget Sound salmon (genus *Oncorhynchus*) spawn in freshwater and feed, grow, and mature in marine waters. During their transition from freshwater to saltwater, juvenile salmon occupy nearshore ecosystems in Puget Sound to varying degrees. The period of nearshore residence is critical to the viability, persistence, and abundance of Puget Sound salmon (Fresh 2006). Naturally produced juvenile Chinook salmon and juvenile chum salmon use the nearshore extensively and south Lopez Island has been documented as a 'hotspot' for outmigrating juvenile salmon (Wyllie-Echeverria and Barsh 2005). Habitat function depends upon both local attributes and the context of that habitat within the bigger picture of its surrounding larger ecological systems (referred to as landscape attributes); landscape attributes include the arrangement of habitats, habitat shape, location and connectivity (Fresh 2006).

Nearshore assessments in the Puget Sound region have found that large estuaries and small "pocket" estuaries provide very high value nearshore habitat for salmon as well as other species (Beamer et al. 2003, Redman and Fresh 2005). Protection and restoration of pocket estuaries has been a priority Sound-wide (Fresh 2006, Gelfenbaum et al. 2006).

Impacts of Shore Modifications on Nearshore Habitat

Shore modifications, such as bulkheads, almost without exception impact the ecological functioning of nearshore coastal systems. The proliferation of these structures has been viewed as one of the greatest threats to the ecological functioning of coastal systems (PSAT 2003, Thom et al. 1994). Modifications often result in the loss of the very feature that attracted coastal property owners in the first place, the beach (Griggs 2005).

The installation of structures, such as bulkheads and road revetments, typically result in the direct burial of the backshore area and portions of the beachface, resulting in reduced beach width (Griggs 2005) and loss of habitat area (Thom et al. 1994). Alteration of the beachface and intertidal areas can impede natural coastal processes, even in the pocket beaches of the study area (MacDonald et al. 1994). Previously-documented, site-specific impact of bulkheads is increased wave reflection onto the upper beach during high water periods, which can lead to upper beach erosion (Pilkey 1988, Griggs 2005). Additionally, off-site impacts of a bulkhead include the formation of "end effects" or scour adjacent to the ends of a bulkhead (Tait and Griggs 1990). This could negatively affect adjacent properties and could pose a possible liability issue.

Shore modifications can directly and indirectly affect forage fish spawning habitat (surf smelt and sand lance) spawning habitat, through the installation of bulkheads and other shore modifications by directly burying spawning areas (Penttila 2007), causing coarsening of upper beach sediment, or through sediment impoundment (Johannessen and McLennan 2007, Rice 2006). Habitats in the intertidal and subtidal ranges are also impacted by modifications, such as docks and pile structures.

Bulkheading also leads to reduction in epibenthic prey items, potentially increased predation of salmonids, loss of organic debris (logs, algae) and shade, and other ecological impacts (Thom et al. 1994, Rice 2006). The reduction in beach sediment supply can also lead to an increase in coastal flooding and wave-induced erosion of existing low elevation armoring structures and homes (Nordstrom 1992).

Habitat components of particular value to the local nearshore system that are substantially impacted by shore armoring include large woody debris (LWD). LWD is a valuable habitat and geomorphic attribute of all beaches, and is usually transported away from the shore following installation of shore modifications, with corresponding changes in habitat. Riparian vegetation is also typically reduced due to the installation of bulkheads (Brennan 2007). These impacts usually lead to a direct loss of nearshore habitats due to reduction in habitat patch area.

Pocket estuaries and lagoons can be impacted through reduction in sediment input or sediment transport due to bulkheading. Other alterations and site-specific impacts induced by modifications can include partial or major loss of spits that form estuaries and embayments (Johannessen and McLennan 2007).

The presence of coastal roads and associated adjacent rock shore protection presents an ongoing threat to the quality and quantity of intertidal habitat, and will further degrade the beaches for as long as they are present (MacDonald et al. 1994). These structures often bury important nearshore habitats in the intertidal and backshore (Thom et al. 1994), such as forage fish spawning habitat. Wave energy reflects off of a shore modification rather than being dissipated by a storm berm, causing the loss of additional beach sediment from modified beaches (MacDonald et al. 1994, Miles et al. 2001). Increased wave reflection and hydraulic turbulence can also remove sand and fine gravel from areas waterward of revetments, sometimes causing the loss of sediment suitable for forage fish spawning (Thom et al. 1994, Rice 2006). Roads and associated armor can also cause sediment impoundment. This leads to beach sediment to coarsening over time, and the ensuing loss of valuable forage fish beach spawning habitat. This impact to beaches will only increase with local sea level rise. Therefore, with consideration of all these factors, shore modifications can have substantial negative impacts on nearshore habitats and are often considered for removal when assessing restoration options.

General Implications of Sea Level Rise and Climate Change

A general discussion of the anticipated impacts of sea level rise is included here. A detailed site-specific investigation was not completed for this report, but information is presented here from a recent report prepared for Snohomish County (MacLennan and Johannessen 2008). The predicted

increased rate of sea-level rise, as a result of global warming, will generally lead to higher coastal water levels, thereby altering geomorphologic configurations, displacing ecosystems and increasing the vulnerability of infrastructure (IPCC 2001, Pethick 2001).

Recent research has also reported that non-bedrock shores, such as the pocket beaches of the study area are likely to be subjected to erosion in the future due to sea-level rise. Retreat rates may also be amplified in many areas due to increased precipitation, storminess (wave energy), storm frequency, and higher ground water levels (Stone et al. 2003, Hosking and McInnes 2002). Puget Sound area winters are predicted to include increased storminess (Snover et al., 2005), which may exacerbate erosion of the lower elevation shores of the study area. Changes in sea level will also result in a spatial geomorphic response, landward and upwards, in a concept known as the Bruun law (1962). This basic idea (though its accurate application to individual beaches has been debated) appears to apply to all coastal landforms (Pethick 2001). The landward migration of the shoreline is a response to the changes in energy inputs brought about by sea-level rise. Knowing that this translation is to occur offers resource managers a tool, allowing decisions to be made to accommodate and, where possibly, facilitate such migration (Pethick 2001).

Accommodating space to enable shoreline translation can enable salt marshes, sand dunes, and beaches to transgress (move landwards while maintaining their overall form). This concept is commonly referred to as “managed retreat” or “managed realignment” (Cooper 2003). Accommodating sea level rise prevents the diminishment and loss of natural features such as intertidal, upper beach and dune habitats, from being lost between a static backshore (such as a bulkhead or rock revetment) and rising sea level. The concept is commonly referred to “the coastal squeeze”.

As a result of processes related to global climate change, the shores of our region will undoubtedly incur considerable habitat loss along its many modified shores, unless managers choose to take a pro-active approach and start initiating programs focused on accommodating sea level rise and utilizing strategies such as managed realignment (e.g. removing shore armoring, relocating coastal roads, etc). There will also be further pressure to construct emergency erosion control structures as a result of increase erosion rates, storminess and storm frequency. Permitting the building of additional bulkheads is not likely to provide a long-term solution to the erosion control, and will only amplify habitat loss caused by the coastal squeeze.

METHODS

The following methods were applied using the best available science on coastal geomorphology, and nearshore habitats. Data compilation and integration efforts were carried out in collaboration between Coastal Geologic Services, Friends of the San Juans, and other project partners, including San Juan County Public Works and Tulalip Tribes.

Field Assessment

A detailed field assessment was performed for both beach segments in Barlow Bay and MacKaye Harbor during April of 2008. Both beaches were investigated for potential restoration projects. During these site visits emphasis was placed on investigating hard armor removal, including rock

armor for the road and tide gates, and debris and structure removal, including creosoted piles, concrete, and derelict structures. Several types of data were collected during the site visit and later categorized for creating explanatory maps, obtaining quantitative data, and ranking restoration projects.

Data on structures and existing conditions were recorded using a handheld Thales *MobileMapper* Global Positioning System (GPS) unit in the WGS 84 (World Geodetic System or Latitude/Longitude) coordinate system. The GPS unit was WAAS (wide area augmentation system) enabled, and generally had an accuracy of +/- 9 ft. Waypoints were marked at the location of potential restoration projects identified in the field. The waypoints were correlated with additional attribute data and notes that were recorded in a field notebook.

GIS Work

The GPS data was downloaded using *MobileMapper Office* (Thales Corporation), and waypoints was created. The text file was then opened in Excel for import into ArcMap 9.2. The Excel file was imported into ArcMap 9.2. The event file was exported from ESRI shapefile format. The shapefile was then re-projected into NAD 83 State Plane North (4601).

Data collected in the field fell into the following categories: simple debris removal, structure removal, restack rock (rock revetment or rockery), moving a portion of Barlow Bay Road, tide gates and culverts, and wetland areas controlled by tide gates. Physical measurements were taken in the field using tape measures recorded in tenths of feet to determine potential gain of restack rock and calculations for tide gate removal and wetland restoration. All data collected was photo documented during the site visit.

Shapefiles were created for each of the different categories of data collected in the field, as mentioned above. Relevant site notes and calculations performed in the field or in GIS were added to the attribute table. Existing data, such as eelgrass polygons and potential and documented forage fish spawning habitat shapefiles were used to assess habitat improvements offered by a potential restoration project.

Historic Conditions Mapping

The objective of the historic analysis portion of this study was to characterize the historic (pre-development) geomorphic character of beaches and nearshore habitats of MacKaye Harbor and Barlow Bay, and to document change over time.

Historic nearshore geomorphic conditions provide a valuable management tool for better understanding biological assemblages and ecosystem structures of shorelines and nearshore environments. This was most important in the portions of the study area that were modified from their original condition. Comparing current and historic conditions of these beaches displayed the loss of coastal wetlands and associated potential impacts to a myriad of species dependant upon this ecosystem. Delineating historic conditions also helps managers to prevent further degradation of nearshore habitats while providing relevant data for prioritizing restoration projects aimed at enhancing wetland and nearshore habitat character and function, including habitat used by forage fish and juvenile salmon.

Aerial photographs from the Washington Department of Transportation (DOT) were also used to assess changes to the nearshore and intertidal habitats in MacKaye Harbor and Barlow Bay. A vertical aerial photograph from 1969 was georeferenced to the base aerial photograph (2004 ColorIR) used in GIS. Another vertical aerial photo from 1977 was obtained from the Washington Dept. of Ecology. Through comparative views from 1969 to 2004 changes in beach width, wetland character, and potential impacts to the nearshore due to modifications were examined.

All areas characterized as modified in the field mapping were examined to determine their historic character. Other segments were assumed to be the same in the pre-development period. A potential weakness of this assumption results from the fact that time lags often exist between erosion, transport and deposition of unconsolidated sediment (Brunsden 2001). Since current conditions mapping documents the present geomorphic character of the study area's shores, and beaches are inherently dynamic features, it is possible for a portion of the shore to have changed geomorphic character during the period between pre-development and current conditions.

Restoration Project Ranking and Feasibility

The ranking of potential restoration projects was conducted using a relative scoring system. This simple scoring system was designed to reflect the objectives of the study in identifying and ranking optimal sites for improving habitat by removing shore modifications and restoring functions and habitats to enhance forage fish spawning habitat and tidal connectivity between the nearshore marine environment and coastal wetlands.

Each project was listed, scored, and ranked based on three criteria:

1. Relative habitat improvement, with double points
2. Approximate cost
3. Geomorphic feasibility

Each of the 24 individual restoration projects identified was assigned values for each of the three criteria listed above. Scores were assigned for relative habitat improvement using the best available science mentioned in the *Background* section of this report along with current best available science reports in the "Valued Ecosystem Components White Paper" series published by the US Army Corps of Engineers along with the Puget Sound Nearshore Partnership (PSNP) (http://www.pugetsoundnearshore.org/technical_reports.htm), which covers nearshore species such as juvenile salmon and forage fish, along with nearshore habitats such as beaches and bluffs, marine riparian areas, and eelgrass. The habitat improvement scores were assigned by integrating the different potential habitat improvements (along with any potential loss in certain habitat areas with the underlying assumption that restoration of valuable and uncommon habitats (such as protected coastal lagoon/estuarine systems) represented a relatively large improvement. Also, intertidal and subtidal habitat improvements were considered greater improvements than backshore.

In the ranking system, the relative habitat improvement point value was doubled since habitat improvement was the primary goal of this assessment. Assigned values represented a relative ranking of Very High (VH), High (H), Medium (M), and Low (L) (Table 1). For example the best

possible ranking for a project, under these criteria, would be a VH for relative habitat improvement (score then doubled), an L in associated cost, followed by a VH in geomorphic feasibility, yielding a score of 16. Note that the feasibility of a project could be undermined by high cost; therefore a project with a low (L) cost received high scores. Ties were broken if one of the tied ranks had a higher habitat improvement score, which placed that project ahead.

Table 1. Numeric ranking scheme used for project prioritization.

Score	Habitat Improvement	Approximate Cost	Geomorphic Feasibility
4	VH	L	VH
3	H	M	H
2	M	H	M
1	L	VH	L

The assignment of scores for cost and geomorphic feasibility was carried out based on application of the science along with extensive practical experience in restoration design and implementation over a 15-year period. This included a considerable amount of work in San Juan County such as numerous restoration assessments and projects and research issues such as mapping net shore-drift county-wide (Johannessen 1992).

One aspect of restoration project feasibility that is not addressed in our ranking system is land owner willingness. Much of Washington's Tidelands are in private ownership, therefore tideland ownership in MacKaye Harbor and Barlow Bay will need to be thoroughly researched and landowner permission obtained to precede with any of the potential restoration projects. It is CGS's understanding that FRIENDS will work on obtaining landowner willingness information. The results will be taken into consideration as a secondary measure of the restoration projects.

Landowner Willingness

In an attempt to assess landowner willingness and gain local support of this restoration project FRIENDS mailed site specific information on nearshore habitats and species in the MacKaye Harbor region of Lopez Island to over 200 local property owners. Educational field days were held for neighbors and the south Lopez community, highlighting the importance of local habitats for surf smelt, Pacific sand lance and outmigrating juvenile salmon through hands-on activities including beach seines and forage fish spawning surveys. Participants provided information on their interest and willingness to support intertidal, beach, and/or wetland restoration projects. Two community meetings were held to present potential restoration projects (identified by CGS), collect input from residents and foster support for on the ground improvements. Multiple meetings and field visits were also held with San Juan County Public Works and the Tulalip Tribes, entities who have extensive management and ownership responsibilities in the project area.

RESULTS

The final restoration project ranking methods (described above) were applied to 24 separate, potential restoration projects. The top-scoring projects correspond to a combination of significantly improved habitat, low associated cost, and sound geomorphic feasibility (the scoring scheme was described in the *Methods* section and Table 1). Results of the different data collection and

quantification efforts and historic analysis will be outlined below, followed by restoration feasibility. Discussion of the top ranked restoration projects, description of project actions, and recommendations will follow. The next tier of ranked sites are briefly characterized also.

The highest ranked potential projects had the highest total score. Some projects scored similarly, although the restoration projects were completely different. Several factors used in the scoring process are discussed in the appropriate section.

Quantitative data obtained in the field or from GIS was used in the score and rank process of some of the listed restoration projects. Quantitative data can be a tool for better estimating habitat recovery or cost of a project. Although data compilation is described above in the field assessment and mapping sections of the *Methods*, due to the variability of each of these datasets, the specific way in which this data was obtained is listed below.

Beach and Nearshore

When eelgrass shapefiles were added to georeferenced aerial photos of Barlow Bay, it was apparent that docks and associated activities in this shallow bay truncated an otherwise continuous band of eelgrass. Loss of eelgrass habitat, noted as 'eelgrass void', was delineated through digitizing the voids in GIS (Table 2, Figures 3 and 4). The extent of which is noted in the table below in square feet.

Table 2. Eelgrass bed voids, west to east.

Location	Description	Area (sq ft)
Salmon Pt comm. dock	Eelgrass void	10,256
R-dock comm dock	Eelgrass void	31,924
Tulalip working dock	Eelgrass void	24,254
Tulalip derelict dock	Eelgrass void	10,073

Coastal Wetlands

Historic coastal lagoons and salt marshes were delineated using GIS mapping that relied on a T-sheet (topographic map) from 1897. The coastal wetlands were digitized and displayed on the current base photo for MacKaye Harbor and Barlow Bay (Table 3, Figures 3 and 4). Much of the modifications made to these study areas after the 1897 T-sheet occurred in Barlow Bay. The measurements below serve as preliminary data for feasibility of tide gate removal and wetland restoration.

Table 3. Historic coastal wetlands, west to east. Note, the west Barlow lagoon is nested within the west Barlow salt marsh.

Location	Description	Area (sq ft)
West Barlow lagoon	T-sheet lagoon – west	78,720
West Barlow salt marsh	T-sheet saltmarsh - west	133,218
Central Barlow lagoon	T-sheet lagoon – central	7,469

Current wetlands were delineated in the field by walking around pools of standing water at a mid tide with a GPS (Figures 3 and 4). This mapping was based on water levels at the time and

identified areas that were considerably smaller than wetlands mapped by soil characteristics. These data was imported into GIS and calculated. In this table the features called West Barlow lagoon and West Barlow salt marsh can be directly associated with the historic lagoon and salt marsh from the 1897 T-sheet (Table 4 and Figure 5). Wetlands in this table are currently controlled by tide gates, and can serve as preliminary data for feasibility of tide gate removal and wetland re-establishment.

Table 4. Current coastal wetlands associated with tide gates, west to east.

Location	Description	Area (sq ft)
West Barlow wetland	Wetland – west	2,435
West Barlow wetland	Wetland – west	8,757
East Barlow wetland	Wetland – east	1,361

Tide gates appear to have been installed in recent decades, apparently as a means to control coastal flooding of the low elevation backshore areas (that included the coastal wetlands). Tide gates allow flow in the waterward direction only. The 3 mapped tide gates in the study area substantially alter the functions and values of the wetland ecosystems by reducing the amount of saltwater inflow and mixing, and allowing for enhanced drainage, thereby altering natural nearshore processes. Through field leveling and calculation of the approximate elevation of the full-basin water level, measured below Mean Higher High Water (MHHW), preliminary investigation into removal of these tide gates was accomplished (Table 5). Water surface elevations mapped in the field in the wetlands were below MHHW, particularly in the larger west Barlow wetland.

Table 5. Tide gate location and elevation, west to east.

Location	Description	Feet below MHHW
West Barlow tide gate	Remove tide gate/restore wetland	0.65
East Barlow tide gate	Remove tide gate/restore wetland	0.05
MacKaye tide gate	Remove tide gate/restore wetland	na

Coastal Roads

Roads were established in the area during the early 1900s and are a major feature on the landscape at the present. In most cases where roads infringe upon or closely parallel intertidal beaches, the upper beach areas were heavily riprapped, with the rock covering what could otherwise be forage fish spawning habitat (Figures 1 and 2). Storm waves can cause undermining of support for rock and tend to cause loose riprap to topple and move waterward over time, increasing the impact on habitats and necessitating ongoing maintenance. This is particularly true where the structures were not engineered, tightly placed, or keyed into the substrate well. Due to their position in the reach of storm waves, the road and associated rocks likely require periodic maintenance following winter storms. Intermittent road covering or damage tends to occur along coastal roadways, due to their vulnerable and static position along dynamic landforms. Sea level rise and climate change will likely increase road damage where roads are in close vicinity to beaches.

Table 4 of the SJSSP detailed potential upper beach areas that could theoretically be recovered (Table 6). Coastal roads and associated shore protection rated high for relocation in that study.

Potential habitat recovery calculations were conducted using the length of the shore modification, its elevation relative to MHHW, and an assumed beach slope of 1:10. Multiple numbers are listed where multiple modifications could be removed resulting from a single road relocation project.

Table 6. Roads and shore protection and potential habitat recovery, west to east. Note, all sq ft measurements were calculated using an assumed 1:10 ft upper beach slope. This figure adapted from Table 4 of SJSSP report.

Road	Potential Habitat Recovered
Barlow Bay Road	4,314 sf
MacKaye Harbor Road	2,853 sf (above MHHW) and 7,411 sf (above MHHW)

Roads have been relocated in the past in San Juan County. In the late 1990s the southern portion of Deer Harbor Road was relocated due to the short- and long-term threat of coastal erosion and the associated environmental impacts caused by the road and bluff armoring (Johannessen and MacLennan 2007). The road removal project was successful and was positively received by agencies and the community. A popular walking path with park benches now occupies the scenic old road site.

Historic Analysis

An historic T-sheet from 1897 (Figure 5) showed two lagoonal wetlands with surrounding saltmarsh which were filled, drained or otherwise altered over the years. Figure 6 shows the already altered larger lagoon in what appears to be the early 1900s. The lagoon appeared much larger than today, but in a different shape than shown in the T-sheet, which suggests that part of the lagoon was already filled. The area was already mostly cleared and cows were grazing near the lagoon (Figure 6). These areas now have tide gates and culverts that control the water levels in the coastal wetlands. The most distinct changes indicated by the T-sheet are shown below outlined in red (Figure 5).

The beach along the west Barlow Bay wetland actually appears to have been a spit that extended west to a tidal inlet. Salt marsh was mapped on the landward shores of the lagoon (Figure 4). The inlet and wetlands are now mostly filled and the remaining wetland areas are hydrologically controlled by tide gates. The small lagoon feature, which is less typical of protected barrier beach systems in the islands, (outlined by the smaller red box) no longer exists. Due to modifications to the coastal wetlands there is almost no exchange/mixing between fresh water and marine water.

Extensive industrial use of the beaches was underway at the beach south of Salmon Point, as large stacks of lumber and a large dock was captured on a 1919 photo from the Lopez Island Historic Society (Figure 7). A boat launching facility also appears to have been present, which may be the origin of some of the metal debris in the intertidal in this area.

The large wetland located landward of the MacKaye Harbor Road beach was mapped as not connected to the bay at the time of the first mapping (1897), and due to the greater wave energy that this beach is exposed to, it is not realistic to expect a channel that would cross the beach to remain open at this location if it were attempted. The large wetland complex was altered substantially in the mid-1970s, as evidenced by a 1977 air photo by the WA Dept. of Ecology

(Figure 8), which shows what appears to have been dredging of sand to make deep ponds and fill in adjacent areas to raise land to make properties “buildable”. The photo appears to show active grading and perhaps even a crane or dredge in operation at the edge of the altered wetland.

Examination of the historic air photos (since 1969) reveals that the beach and backshore have shown almost no change since 1969 (Figure 8) throughout the study area. Any change that may have occurred in terms of the width of the beach and vegetated backshore areas was so minor that it was not detectable using the high quality air photos in GIS. The position of the backshore roads has also remained the same, such that no loss or gain in beach area was caused by infrastructure, with the exception of the newer dock.

It appears that the beaches in the study area were quite stable and that no trend of accretion or erosion is occurring. However, the predicted acceleration of sea level rise needs to be considered for the fate of the present position of the beach and its associated habitats. Sea level rise will almost certainly cause shore translation, which occurs when rising sea level causes the active beach profile to shift up and landward, thereby causing road damage and/or the need for additional shore protection.

RESTORATION PROJECTS RECCOMMENDATIONS

This section summarizes the top ranking potential restoration projects resulting from this analysis. Using the ranking scheme described in the *Methods* section above, the total scores ranged between 9 and 14 out of a total possible score of 16 points. Many of the projects received the same score. Ties were broken if the relative habitat improvement scores were different, in which case the potential project with the higher score came out at a higher rank. A short narrative of the top ranked sites is included below. Other high ranking projects are also briefly described below.

Potential projects were outlined that aimed to improve habitat conditions for forage fish, juvenile salmon, fish passage, water quality, and/or recreation. In total 24 potential projects were conceptualized and ranked in this way. Potential projects ranged from removal of several isolated creosoted piles to moving roads away from the active beach. The greatest density of potential projects was within Barlow Bay, due the greater degree of alteration there.

A complete list of potential restoration projects, organized by project type is presented in Table 7, which includes additional data summarizing each project. This table includes information on the location of potential projects, the types of habitat to be improved, and scores assigned for the ranking process. Potential projects are shown in maps presented in Figures 9-12, and Figures 13-16 are Photo pages showing the structures proposed to be removed and the surrounding shore area.

Top Ranking Projects

1. Remove derelict dock – The derelict dock located on the eastern side of Barlow Bay was the highest ranking potential project (Figures 2 and 16), scoring 14 points out of a possible high of 16. The dock spanned from the backshore to the subtidal, and contained no decking past the low-tide level. This structure included approximately 21 creosoted piles (some encased by cement) holding up the remnant pier, and approximately 26 creosoted piles leading out into the subtidal. Several creosoted piles were scattered on the beach nearby. Not only is this derelict structure impeding on a range of nearshore and coastal habitats, but it stands immediately adjacent to (30 ft east) of mapped forage fish spawning habitat. The potential impact of contamination into forage fish spawning areas and the bay cannot be overlooked. Farther out into the subtidal, the remaining piles clearly disrupt an apparent previously-continuous band of eelgrass. Removing this structure would be of high benefit to improve fish passage, improve water quality, and recreation. This project may also be moderately high cost to implement and properly dispose of creosoted piles.

Recommendations: If permission from the Tulalip Tribes can be obtained, remove the structure and surrounding debris associated with the structure. Look into debris removal programs such as those managed by WA DNR. Remove backshore rock and derelict power pole and regrade low dune similar to adjacent shore. Allow the lower beachface to re-equilibrate following debris removal. Consider replanting eelgrass in the eelgrass void spaces where the derelict dock once stood. Consider beach nourishment to supplement coarse sand and fine gravel appropriate for forage fish spawning.

2. Remove west Barlow Bay tide gate and restore tidal lagoon – The tide gate and associated culvert ranked second priority in the ranking scheme, with 12 out of the possible 16 points. The tide gate drains what remains of the historic coastal wetland on the west side of Barlow Bay (Figures 4 and 15). This site is located immediately southwest of the R dock. The tide gate currently drains onto the beachface through a concrete culvert. Historically, the wetland and surrounding marsh encompassed approximately 78,720 sf (1.8 acres) and 133,218 sf (3.1 acres), respectively (Table 3). Prior to the apparent filling of portions of the lagoon, the former lagoon was open and connected to Barlow Bay (Figure 12). The former inlet was approximately 25 ft wide at MHHW, as mapped in 1897 (Figure 5). Restoration of this feature would entail opening up a tidal inlet again and likely some dredging of the filled basin on the landward side of the road, along with salt marsh revegetation. This would replace high quality juvenile salmon refuge and foraging areas that are currently not available in the area. A coastal flooding analysis for removal of the tide gate would need to be carried out to determine risks to any houses and improvements in the vicinity.

Recommendations: Additional work must be done to assess the full range of changes and outcomes from reestablishing this coastal lagoon. The amount of excavation, resulting tidal elevations inside the reestablished lagoon, and the required tidal prism to maintain the recreated inlet would all need to be investigated, along with determining the changes in coastal flooding. Assessing the impact to the surrounding houses, roads, and other infrastructure is crucial to obtaining landowner permission and the feasibility of the project. Additionally, changes to the road infrastructure and/or general design requirements for a bridge or box culvert(s) would need to be determined for this potential project (similar work is currently underway for Point Lawrence Road/

Cascade Creek mouth on Orcas Island for the County). This project would likely be very high cost, however, the benefits of habitat improvement would also be high.

3. Remove 4 flat laying creosoted piles – These creosoted piles lay on the eastern side of the R-Dock, and may be used as a tidal grid (small platform for boats during low tides), for boat maintenance (Figures 11 and 17). This potential project ranked third, with 12 points out of a possible 16. The piles have remnant creosote covering and the surface area in which the creosote comes into contact with the intertidal habitat is greater than typical vertical creosoted piles. Toxic chemicals in creosote present danger to an area mapped as potential forage fish spawning habitat. As well, creosote is documented as impeding larval growth of shellfish and other species. Tide flats immediately to the southwest of this structure are planned to be used for shellfish aquaculture by the Tulalip Tribes. Therefore, this creosoted structure poses a threat to water quality, and on a larger scale to the health and development of shellfish in the area. The cost associated with this restoration project should be very low, although proper disposal at an approved upland facility is required.

Recommendations: Upon obtaining permission from the owners of R-Dock, removal of this simple structure would improve intertidal habitat and water quality in the area. The removal would be straight forward as simple removal, as a small piece of equipment is all that is required. Implementation of this project would be best accomplished together with a number of the medium ranking projects described below to make a much greater economy of scale for bringing equipment out, and for haul and disposal.

Moderately High Ranking Projects

Six potential projects ranked the same with a score of 11 out of 16 possible points. For the ranking, all 6 projects were tied for 4th place out of the group of potential projects (Table 7), as they were all of medium relative habitat improvement. The potential projects in this section can be located on the maps in Figures 10-12. These 6 potential projects are listed in order by type; not in order of priority. Once again, all of these projects would first require landowner permission. These projects are briefly described below.

Restack rock A (project 1) – The rock armor (loose rockery) along the upper beach in the southwest corner of Barlow Bay was apparently constructed to protect Barlow Bay Road. The structure is now partially toppled, and is encroaching on intertidal habitat (Figures 11 and 14). The modified beach in this area is composed of pebble and sand with cobbles. Upper beach sediment is comprised of sand with minor pebble and shell hash. Several species of algae are found along this beach including *Fucus spc.*, *Ulva spc*., and *Enteromorpha spc.*. The recommended restacking method involves moving rock from the upper beach onto the upper portions of the rockery. This would uncover approximately 140 sf of upper intertidal beachface area in an area of potential forage fish spawning habitat. This potential project ranked higher then the other potential restack rock locations since it is located lowest on the beach.

Remove derelict boat and debris (project 11) – Debris from this derelict boat, some of it likely creosoted, is scattered in a 20 x 30 ft wide section on the intertidal beach, and also includes scattered parts on the adjacent beach (Figures 11 and 16). This derelict boat is in potential forage

fish spawning habitat and is 120 ft northeast of documented forage fish spawning habitat (Figure 4).

Remove 8 creosoted piles (project 15) – A group of 8 short/stub piles located adjacent to the east side of the active Tulalip dock are recommended for removal, unless these are needed for some purpose. These piles are within eelgrass (Figures 11 and 17), and therefore the local water quality impact may be greater than for piles located outside typically high utilization eelgrass beds.

Remove 2 creosoted piles near dock (project 22) – These 2 (vertical) piles are located on the west side of the Salmon Point community dock (Figures 10 and 16). It is unclear whether or not the piles serve a purpose. The presence of creosote is always a negative impact to water quality and nearby habitats.

Remove 2 creosoted piles (project 24) – These 2 (vertical) piles are located centrally in the small bay just east of Salmon Point (Figure 16). The piles do not appear to serve any purpose and due to creosote content, negatively impact water quality.

Remove 2 creosoted piles (project 23) – These 2 (vertical) piles are located on the east side of the small bay adjacent to Salmon Point (Figure 16). The piles do not appear to serve any purpose and due to creosote content, negatively impact water quality.

Unranked Projects

These projects were identified in the field, but did not score high within the ranking system. Several of the more diverse potential projects are outlined here for completeness.

Remove MacKaye Harbor tide gate (project 9) – This tide gate and associated culvert lie along the central MacKaye Harbor beach (northeast portion of the study area) and drains the large and altered wetland system through an approximately 600 ft upland ditch (Figure 8). The tide gate currently drains onto the beachface through a concrete culvert. The wetland complex was larger in historic times, but was likely not connected directly to the nearshore. The scoring of this project was relatively low (8 points) due to the apparent lack of a historic tidal connection and very high relative cost.

Realign road at West Barlow Bay – This road in west Barlow Bay is clearly encroaching on the upper beach in western Barlow Bay, causing “the coastal squeeze”, or a reduction of intertidal habitat due to sea level rise and possible erosion in the presence of a hard armored structure. Construction of the road has also likely altered the coastal wetlands in the uplands.

The western-most portion of Barlow Bay is a sheltered corner of an already low (wave) exposure shore. The beach faces directly north, but being located in the southern corner of MacKaye Bay, the beach is protected by southwest Lopez Island. The maximum fetch at this site measures less than one mile. A minor headland to the west (or tombolo), and a bedrock prominence to the north, further protect this shore from wave attack. The beach is a low gradient, no bank shore with low relief uplands. Several segments of rockery alongshore protects MacKaye Harbor Road and Barlow Bay Road, which extends from the northern end of MacKaye Harbor through Agate Bay and

westward from southern Barlow Bay out to John's Point, respectively. Shoreline modification in the west end was comprised of 2-3.5 ft riprap with smaller rock used further east.

Relocation of MacKaye Harbor Road (along the west portion of Barlow Bay) to a more landward (higher elevation) location would prevent the road from infringing on the beach any further. It would also avoid the need for additional fortification of the road, which will likely experience repeated overtopping and/or inundation based on anticipated sea level rise projections. Relocating the road could provide room for natural shoreline translation (an implication of sea level rise), without the loss of habitat.

Realigning the west portion of Barlow Bay Road, or otherwise altering the road to accommodate and rehabilitate nearshore processes, would take additional work and multiple assessments in engineering, wetlands, and hydrology. However, following through with this project could have major benefits for the nearshore ecosystem and be used as a model for other similar projects throughout the San Juan Islands.

Remove backshore derelict floating dock (project 13) – The remnant of a wooden floating dock was observed in the field in the backshore of central MacKaye Harbor. It was unclear if this dock was washed in or was stored on the upper beach seasonally. The project did not rank high as the old dock was above the intertidal and did not appear to be creosoted. If not in use, removal would be very straight forward.

Remove backshore pile structure (project 16) – This wooden pile structure is located high on the beach in the backshore in central Barlow Bay (Figure 17).

Restack rock B, C, D, and E (projects 2-5) – Rock armory for the road can be restacked in many areas to contribute to a small beach gain. These four projects are located along the west into the central portion of Barlow Bay and did not rank because the beach gain was minimal.

Historic lagoon restoration (project 10) – This historic lagoon was apparent in the central portion of Barlow Bay in the 1897 T-sheet. This project did not rank as a priority project partially because it is difficult to determine whether this was a naturally occurring geomorphic feature or if it was artificially made prior to the 1897 T-sheet.

Remove 6 cement slabs (project 17) – These cement slabs lay on the intertidal beach in central Barlow Bay. Removal of these slabs can potentially be combined with other debris removal projects in the area.

Remove set of 4 concrete bases (projects 18-19) – Two sets of four concrete bases lay on the intertidal beach on the southwest portion of MacKaye Harbor.

Remove metal debris (project 21) – This debris is located on the beach on the south side of the Tulalip dock and could be remnant of the fish processing plant that operated in this area in the past. The metal debris is small, but is in close proximity to documented forage fish spawning habitat.

Remove metal debris (project 20) – This metal debris is located centrally on the small beach just adjacent and to the east of Salmon Point.

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