Puget Sound

Northern Skagit County Bays and Shoreline Habitat Conservation and Restoration Blueprint 2005 Update

A Plan to Restore and Protect the Habitats and Heritage of the Northern Bays of Skagit County

Prepared for the Skagit County Marine Resources Committee

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Skagit County Marine Resources Committee

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Executive Summary

While there is now a significant body of information collected for nearshore habitat in Puget Sound, it has not been organized or analyzed in such a way to make it useful to identify specific conservation and restoration targets. To address this critical need, the Skagit County Marine Resources Committee (MRC) and People For Puget Sound developed the Bays Blueprint. This tool gathers together the available information in an organized fashion, incorporates the information into a GIS-based spatial nearshore habitat analysis, and prioritizes specific on-the-ground actions and projects based on biological information, social, political, and economic constraints. The strength of the Skagit Bays Blueprint project lies in the partnerships developed in the feasibility study phase that can lead to on-the-ground projects. The overall methodology includes four phases:

- Compile and organize existing datasets on nearshore habitat conditions and marine resources in the project area and provide available documentation for each dataset.

- Inventory the nearshore habitat using oblique shoreline photos (WA Department of Ecology, 2000).

- Analyze and evaluate habitat conditions based on their ability to support forage fish, juvenile salmonid use of the nearshore habitat, aquatic vegetation, shorebird use of the nearshore, and sediment supply to the nearshore, and apply criteria for prioritizing nearshore habitat restoration and conservation areas.

- Apply feasibility criteria based on social, political, and economic constraints that identify a short list of possible conservation and restoration projects. These projects are summarized in site-reports that provide rationale for choosing these projects, benefits of these projects, and anticipated "hurdles" to site conservation/restoration actions. People For Puget Sound and the Skagit MRC will present these findings to property owners and land managers to identify and scope at least two projects for conservation or restoration actions in 2004 and 2005.

The important first step in the Bays Blueprint project was gathering key geographic information systems (GIS) datasets and compiling a datasbase of all datasets characterizing nearshore habitats. We added to that existing knowledge base by using well-trained volunteers to survey shorelines using the Washington

Department of Ecology's Shoreline Oblique Photographs from 2000. Each oblique photograph captures a section of shoreline approximately 800 to 1000 feet long during extreme low daytime tides.

We synthesized all the collected data from both the compiled GIS datasets *and* the Nearshore Photo Inventory, using a series of conceptual models that were selected from the Rapid Shoreline Inventory (RSI) Analysis and redeveloped to encompass new information gathered by this project. These models describe the relationship between habitat features and indicators of habitat quality. The five models characterized nearshore habitat for:

- Forage fish spawning (species group)
- Juvenile salmonid use of nearshore (species group)
- Aquatic vegetation (species group/ecosystem process)
- Sediment Supply to the nearshore (ecosystem process)
- Birds that depend on Marine Shorelines and Features (species group)

The resulting data, restoration and conservation scores, and the spatial location of each photo point can be found in the data tables in Appendix G, and are displayed visually in the Map Book. A percentile-ranking scheme was created to display and present the model results visually in maps 44 through 55. This aided in systematically ranking and prioritizing the analysis results**.**

The overall maps and model maps provided the MRC sub-committee with tools to visually identify areas with the highest biological importance along their shorelines. In 2004, the MRC sub-committee with the help of People For Puget Sound was able to select 21 sites from the 343 original points to be assessed for potential actions to be taken**.**

The aerial oblique photographs and other on-the-ground data, such as the Battelle report recommendations and the data results from the models, guided People For Puget Sound in proposing actions to be taken at each site and developing potential projects. The MRC sub-committee met with People For Puget Sound to evaluate the multiple actions proposed at the 21 sites and to begin project development. Local knowledge and diverse expertise shared though exchanges between the MRC sub-committee and People For Puget Sound made the process of assigning feasibility scores exceedingly more complete and accurate.

The MRC sub-committee's deliberation of the 21 prioritized sites with multiple proposed actions resulted in 24 potential projects. People For Puget Sound produced Site Reports for each of these potential projects, which can be found in **Appendix F**. The criteria questions of the feasibility worksheets were designed to detect a discernable difference in the scoring of the potential projects, giving the MRC an additional way of prioritizing projects to be implemented.

The ultimate goal of the prioritizing process is to begin implementing potential projects that currently have the highest feasibility. Several of the potential projects fell into this arena. The MRC subcommittee, again, using their local knowledge and expertise, selected three sites for further project development. People For Puget Sound elaborated with project recommendations that included scope of work, cost estimates, and potential funding possibilities.

Applying the Bays Blueprint methodology in Skagit County has occurred in two stages. Compiling existing datasets and creating the GIS occurred in 2003, followed by inventory and analysis of the Skagit County mainland shoreline in 2004. This first stage captured the shoreline area from the Whatcom/Skagit border through Samish Bay, Padilla Bay, Fidalgo Bay across the top of Fidalgo Island. The update of the project occurred in 2005 and captured Guemes, Huckleberry, Saddlebag, Hat and Dot Islands. Data inventoried from these Islands was included in the larger Skagit County GIS and the entire area was re-analyzed for conservation and restoration priorities. In addition, staff ran the analysis on Guemes Island alone to provide the Guemes Island Planning Committee (GIPAC) with much needed information of the Island's habitats. This additional Blueprint of Guemes is available in the Guemes Rapid Shorline Inventory (RSI) 2005. Guemes Island residents assisted People For Puget Sound and the Skagit MRC in conducting the RSI in priority areas to capture on-the-ground habitat information.

In fall of 2005 Guemes, Saddlebag, Huckleberry, Hat, and Dot Islands were surveyed adding another 120 points to the original 343 points, for a total of 463 points surveyed. No additional sites were selected and studied for feasibility. The inclusion of the islands into the survey area changed the conservation and restoration priorites in two ways. The additional points added to the total number of points in each rank category and shifted the ranking of certain points to a lower or higher priority. This shifting of rank was most apparent in the conservation scores, due to the high conservation potential of Guemes Island's shorelines, and lowered the ranking of some of the mainland sites. Secondly, the improvements to the model have also changed the resulting scores.

Recommendations and Next Steps

- As the science and understanding of nearshore habitats increase, new data will become available to include into the Bays Blueprint analysis. Datasets such as new forage fish spawning data, bird surveys, and juvenile salmonid use of the nearshore, more detailed drift cell analyses, new oblique aerial photographs, and new county data arising from Shoreline Master Plans (SMP) updates should be included.

- A technical team comprised of scientists, GIS modelers and analysts, would develop a more powerful and efficient modeling tool that produces biologically significant results from which to build the feasibility component.

- This is an important tool for analyzing restoration and conservation priorities, and should be considered in the updates of Shoreline Master Plans and Critical Area Ordinances. Education about the best available science for planning purposes should be conveyed to the public.

- Expand the Northern Skagit County Bays and Shoreline Habitat Conservation and Restoration Blueprint to the rest of Puget Sound basin and the Northwest Straits.

Introduction

Puget Sound is a unique environment consisting of a diverse array of marine resources. These waters also serve as a center of economic activity resulting in an increase of human settlement and development throughout the region. The heavy concentration of shoreline development has caused the modification and destruction of nearshore habitats and the depletion of important marine resources. About one-third of Puget Sound's shorelines have been developed and over 80 percent of estuaries have disappeared. Since 1980, populations of invertebrates, bottom fish, salmonids, marine birds, and marine mammals have declined precipitously (Washington Sea Grant, 1998).

In response to the depletion of marine resource in Puget Sound, and subsequently the Northwest Straits, U.S. Senator Patty Murray (D) and U.S. Congressman Jack Metcalf (R) convened a citizen’s panel in 1997 to identify possible strategies and solutions to the decline of marine resources in the region. The resulting Northwest Straits Marine Conservation Initiative established the Northwest Straits Commission (NWSC) to provide oversight and coordination of restoring and protecting the marine resources of the Northwest Straits ecosystem.

The NWSC is a voluntary panel of citizens who are charged with recommending steps to improve the region’s sustainability. County-based Marine Resource Committees (MRCs) were formed in each of the seven northwest counties of the state including Clallam, Jefferson, San Juan, Whatcom, Skagit, Snohomish, and Island counties to support the mandates of the Initiative. The MRCs coordinate all their activities through the NWSC.

The Northwest Straits Marine Conservation Initiative outlines “Benchmarks for Performance”, which guide the work of the MRCs and provide measures of success for the program. The Northern Skagit County Bays and Shoreline Habitat Conservation and Restoration Blueprint (Bays Blueprint) was developed to inventory and evaluate nearshore habitats in order to address the benchmark specifying the need to restore and protect nearshore habitats that support marine resources in the Northwest Straits. The results intend to accomplish the following:

- Assist the MRC in compiling existing datasets characterizing nearshore habitats, and
- Identify high priority areas for specific on-the-ground habitat restoration or increased levels of conservation actions and projects.

Goal and Objectives

While there is now a significant body of information collected for nearshore habitat in Puget Sound, it has not been organized or analyzed in such a way to make it useful to identify specific conservation and restoration targets. To address this critical need, the Skagit County MRC and People For Puget Sound developed the Bays Blueprint. This tool gathers together the available information in an organized fashion, incorporates the information into a GIS-based spatial nearshore habitat analysis, and prioritizes specific on-the-ground actions and projects based on biological information, social, political, and economic constraints. The strength of the Skagit Bays Blueprint project lies in the partnerships developed in the feasibility study phase that can lead to on-the-ground projects. The overall methodology includes four phases:

1. Compile and organize existing datasets on nearshore habitat conditions and marine resources in the project area and provide available documentation for each dataset.

2. Inventory the nearshore habitat using oblique shoreline photos (WA Department of Ecology, 2000).

3. Analyze and evaluate habitat conditions based on their ability to support forage fish, juvenile salmonid use of the nearshore habitat, aquatic vegetation, shorebird use of the nearshore, and sediment supply to the nearshore, and apply criteria for prioritizing nearshore habitat restoration and conservation areas.

4. Apply feasibility criteria based on social, political, and economic constraints that identify a short list of possible conservation and restoration projects. These projects are summarized in site-reports that provide rationale for choosing these projects, benefits of these projects, and anticipated “hurdles” to site conservation/restoration actions. People For Puget Sound and the Skagit MRC will present these findings to property owners and land managers to identify and scope at least two projects for conservation or restoration actions in 2004 and 2005.

Description of Project Area

The project area for the Bays Blueprint includes approximately 80 miles of shoreline from the northern Skagit county line, through Samish Bay, around Samish Island, through Padilla Bay, into Fidalgo Bay, along the southern side of Guemes Channel, and Guemes, Saddlebag, Huckleberry, Hat, and Dot Islands.

(**Map 1 in Map Book**). This includes tidal waters of these bays as well as adjacent habitats. These shorelines contain a wide variety of beach habitat types, from the rocky headlands of Square Bay to the sandy shores of Camp Kirby to the mudflats of Fidalgo Bay.

For this project, nearshore habitats are defined from a depth of 10 meters (33 feet) below Mean Lower Low Water (MLLW) to Mean Higher High Water (MHHW), including adjacent backshore areas. The lower extent of the nearshore zone (–10 meters MLLW) is based on the upper limit at which healthy benthic vegetation can be found in Puget Sound. The nearshore zone also includes backshore and upland areas in which the strongest intertidal-upland interaction occurs. This is where bluffs provide the sediments that nourish beaches, the upland transition vegetation stabilizes beaches, and the fringing vegetation shades the intertidal zone and contributes insects, leaf litter, and woody debris directly into the aquatic environment (Williams and Thom 2001).

Although this project area does not contain large metropolitan areas, several cities and large communities abut the nearshore habitats. These areas include Bay View, Anacortes, and along the shoreline of Samish Island. A balanced approach to ecosystem protection and industry may allow Skagit County Bays to remain healthy and biologically productive.

Project Organization and Approach

The project approach follows the four specific objectives described above. An overview of the approach is depicted in **Figure 1**. Essential to the success of this project was MRC members and local-level stakeholder participation throughout the process. The group's input and feedback ensured that no important sources were overlooked and provided expertise on the criteria developed to determine high priority restoration and/or conservation areas, as well as on-the-ground feasibility criteria and project selection.

An important component of this project was not only to compile and organize regional and local datasets, but to *add* new information at the local level into a database to be used in a GIS-based spatial nearshore habitat analysis. The nearshore habitat analysis was designed to be adaptive to the MRC and to incorporate new and updated datasets as they become available. The analysis illustrates five different approaches for using the compiled datasets to determine priority restoration and conservation areas. The various approaches used in the habitat analysis reflect the amount of data that is currently available to describe habitat conditions and its relation to the target species and geomorphic processes. Once science-driven priority restoration and conservation areas were identified, specific actions and projects were assessed against social, economic, cultural, and political principles to define the ease of these projects. We can then prioritize our efforts accordingly.

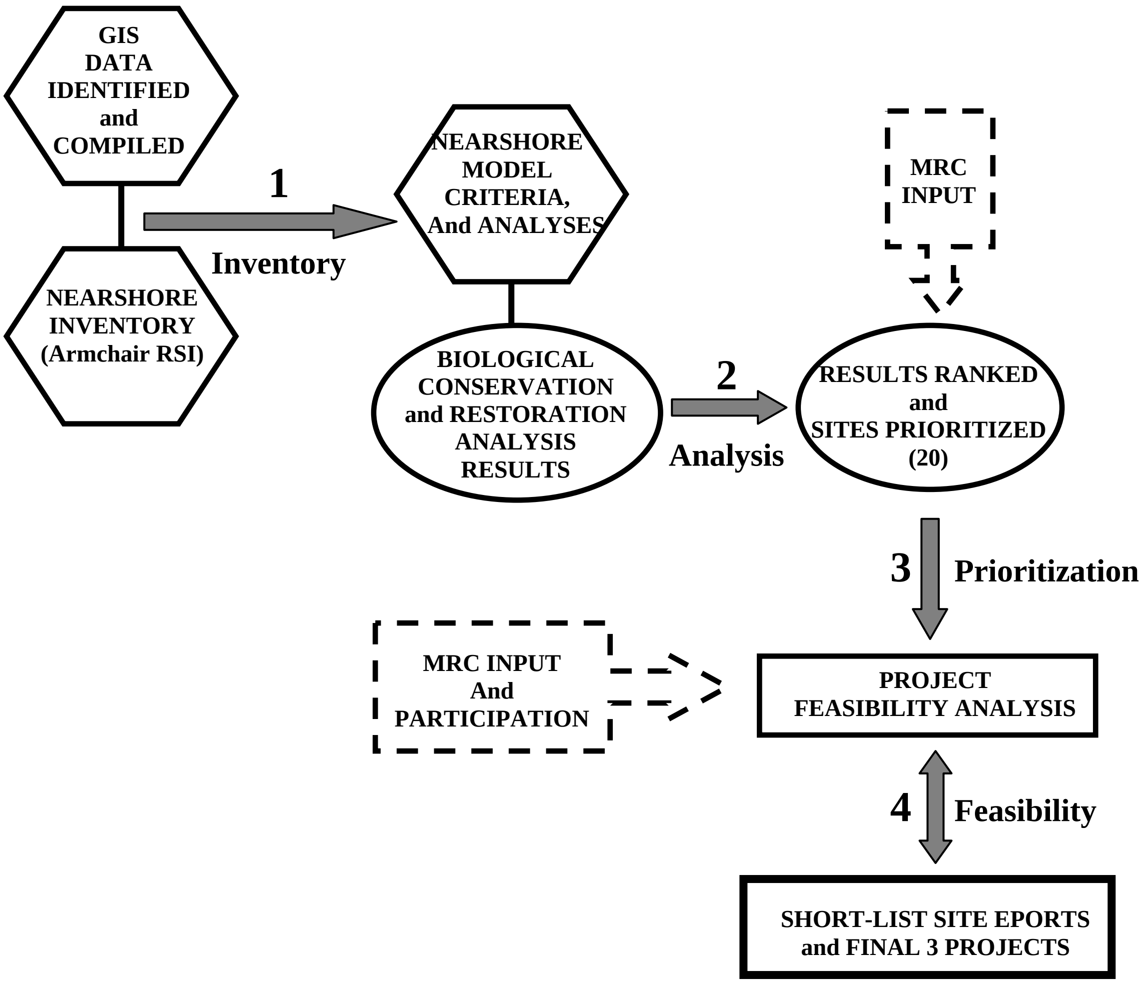


Figure 1. Overview of Bays Blueprint Approach

Section I. Inventory

Data Sources Identified and Compiled

Identifying key geographic information systems (GIS) datasets and compiling a database of all datasets characterizing nearshore habitats was the important first step in the Bays Blueprint project. These include data compiled from the Northwest Straits Inventory report (2002) as well as additional datasets made available since then. Sources for available data include state and federal agency surveys and reports, local and county research, tribal research, and university research. State and federal agency publications were culled from Washington Department of Fish and Wildlife (WDFW), Washington Department of Natural Resources (WDNR), Washington Department of Ecology (DOE), Washington Department of Health (WDOH), National Oceanic and Atmospheric Administration (NOAA), National Marines Fisheries Services (NMFS, now NOAA Fisheries), United States Fish and Wildlife Service (USFWS), United States Geological Survey (USGS), and the United States Army Corps of Engineers (USACE) for documents and datasets pertaining to nearshore habitat conditions in the northern Skagit Bays. A summary of the various datasets is provided in **Appendix B** and copies of these datasets can be found on the accompanying CD ROM.

Key regional datasets identified include Washington State's ShoreZone Inventory, WDFW's Priority Habitats and Species Database, Streamnet, the Puget Sound Ambient Monitoring Program's marine mammal and bird distribution (PSAMP), the Puget Sound Environmental Atlas Update, DOE Slope Stability and Drift Cell data, and DOE Oblique Shoreline Photographs (2000). Key county datasets identified include Skagit County Assessor Parcels and Samish Island and March Point Rapid Shoreline Inventory.

New data sets include Department of Ecology 2000 oblique photographs, Digital Airborne Imagery 2001 from Skagit County and © Space Imaging LLC, Drift Cell and Slope Stability digital data from the Department of Ecology Shorelands and Coastal Zone Management Program, and historic shoreline and bathymetry of Fidalgo Bay and Guemes Channel from the WDFW. Identification of local datasets relied on "word of mouth" recommendations from county representatives, environmental consultants, and university professors. A summary of the various datasets is provided in Appendix B. A description of key dataset is given below:

- WDNR's ShoreZone Inventory: this inventory characterizes the geomorphic and biological resources of the intertidal and nearshore habitats of the entire Puget Sound coast, including the Northwest Straits region. Aerial imagery was taken at low tide providing a "snap-shot" in time of habitat conditions. This dataset was used to map substrate, subtidal and intertidal vegetation, and shoreline modifications.

- Priority Habitats and Species Database: this database includes information collected by WDFW based on field surveys, reports from reputable sources, and best professional judgment of their biologists. Datasets contained in this database Nearshore Habitat Inventory include the Marine Resource Division's data on shellfish distributions (crabs, clams, and oysters) and forage fish spawning areas; mapped areas that support diverse, unique, and/or abundant communities of fish and wildlife (i.e., eelgrass); wildlife heritage points including non-game species of concern and state and federal listed species; marbled murrelet distributions; and seabird distributions.

- StreamNet: this database is a cooperative venture among the Pacific Northwest's fish and wildlife agencies and tribes containing statewide anadromous fish distribution information compiled by fish experts from many different agencies and organizations.

- Puget Sound Ambient Monitoring Program: this dataset contains seasonal (summer and winter) sightings of marine bird and mammal species observed during aerial surveys between 1992 and 2000.

- 1992 Puget Sound Environmental Atlas Update: this data source is a compilation of marine resource datasets for the Puget Sound region. Information contained in the atlas includes shellfish distributions (clams and oysters); pinniped haulout sites, marine mammal distributions (whales and porpoises); seabird nesting areas; groundfish distributions; tribal, commercial and recreational fishing areas; and wastewater discharge sites.

- Net Shore-Drift: this dataset depicts the net longshore drift of sediment between two points representing a closed or nearly closed system in areas throughout the Northwest Straits. The Washington Department of Ecology and Western Washington University cooperated in a series of net shore-drift studies of the Washington marine shoreline, including Schwartz's report for the Pacific Ocean and Strait of Juan de Fuca Region and Northern Bays and Straits Region, and Jim Johannessen's report for San Juan, and parts of Jefferson, Island, and Snohomish Counties.

- Slope Stability: These digital maps were originally published as hard copy maps in the Coastal Zone Atlas of Washington between 1978 and 1980. These maps indicate the relative stability of coastal slopes as interpreted by geologists based on aerial photographs, geological mapping, topography, and field observations. This mapping represents conditions observed in the early and mid-1970s.

- 2000 DOE Oblique Shoreline Photographs: this dataset contains oblique aerial photos and a map display for a section of Skagit County's coastline. Beginning in the spring of 2000, the Washington State Department of Ecology began shooting oblique digital photographs of the state's marine shoreline. Each photo is approximately 1000 feet of shoreline, with resolution of 300 pixels per inch. The photos were shot from an airplane flying along the coast at approximately 90-100 ft elevation.

Habitat Characterization Maps

Key habitat features and shoreline configurations were mapped and can be found in the accompanying **Map Book**. These maps are presented to give a general overview of the resource and habitat conditions found throughout the county and are representative examples of the data sources described in Appendix B. Data layers were grouped together in appropriate subsets and displayed separately for clarity. Mapped data layers displayed in each map are listed below:

- Map 2. Shoreline Classification
- Map 3. Drift Cells and Adjacent Slope Stability
- Map 4. Skagit County Tax Assessor Parcels
- Map 5. WDFW Puget Sound Ambient Monitoring Program (Marine Birds)
- Map 6. WDFW Puget Sound Ambient Monitoring Program (Marine Mammals)
- Map 7. WDFW Marine Resources and Species and Streamnet (Forage Fish and Salmonid Bearing Streams)
- Map 8. Northwest Straits Nearshore Habitat Inventory (Juvenile Salmon Habitat Restoration Potential)
- Map 9. March Point Rapid Shoreline Inventory (Potential Forage Fish Habitat Restoration)

- Map 10. Samish Island Rapid Shoreline Inventory Overall Restoration Analysis
- Map 11. USGS Digital Raster Graphics and Digital Orthophoto Quads, and DOE Oblique Photos
- Map 12. Historic NOAA Nautical Chart
- Map 13. Fidalgo Bay Historic and Current Shoreline with Historic Bathymetry
- Map 14. Guemes Island Rapid Shoreline Inventory 2005 Recommendations

Together, the maps characterize the physical, biological, and anthropogenic features that are used to define the habitat conditions in the Northwest Straits region. Maps 9, 10 , 14, and **Appendix A: NPSNHA** were taken from previous reports. For more information contact People For Puget Sound.

The Nearshore Photo Inventory (Armchair RSI)

Well-trained volunteers surveyed shorelines using the Washington Department of Ecology's Shoreline Oblique Photographs from 2000. Each oblique photograph captures a section of shoreline approximately 800 to 1000 feet long during extreme low daytime tides. Each photograph is tied to a specific, geo-referenced beach section represented by a dot on a map and captured in a GIS dataset. The survey data was carefully entered and compiled in a Microsoft Access database and then transferred to a GIS, which displays the data on maps. The GIS was then used to assign values to the data to produce priority areas for voluntary conservation and restoration actions.

Methodology

The Nearshore Photo Inventory (a.k.a., Armchair RSI) was designed to collect accurate, comprehensive data on contiguous sections of Puget Sound shoreline, and to present the results in an organized fashion. In developing this program, great consideration was given to ensure that the data being collected:

- Complemented rather than duplicated existing data sets. The scale at which the Nearshore Photo Inventory program was implemented allowed for a more refined collection of data than is currently available in existing data sets. This inventorying method provided a finer scale look at the health of nearshore habitats. In turn, this detailed information may indicate to resource managers the need for even more meticulous, targeted data collection to be undertaken on-site by biologists, volunteers, or specialized professionals.

- Was accurately collected by trained volunteers or interns. People For Puget Sound recognized that volunteers can be a valuable asset in gathering information that would be cost-prohibitive for agency personnel to collect. However, it was also recognized that collecting certain types of data (such as biological data to the species level), may be best accomplished by professional staff. The data sets presented by this approach were those for which volunteers have proven to be successful in absorbing the requisite training and in implementing the collection of accurate data.

- Provided data geared toward answering specific resource questions: Each data type within the Nearshore Photo Inventory was selected for its direct applicability to shoreline resource management. While there is a tremendous amount of information that would be 'good to know', the Nearshore Photo Inventory was designed to provide resource managers and biologists data that can be directly used to make resource management decisions. For example, the data can provide the baseline information to identify specific shoreline areas that are high priority areas for conservation or for habitat restoration.

The inventory process was divided into three activity areas:

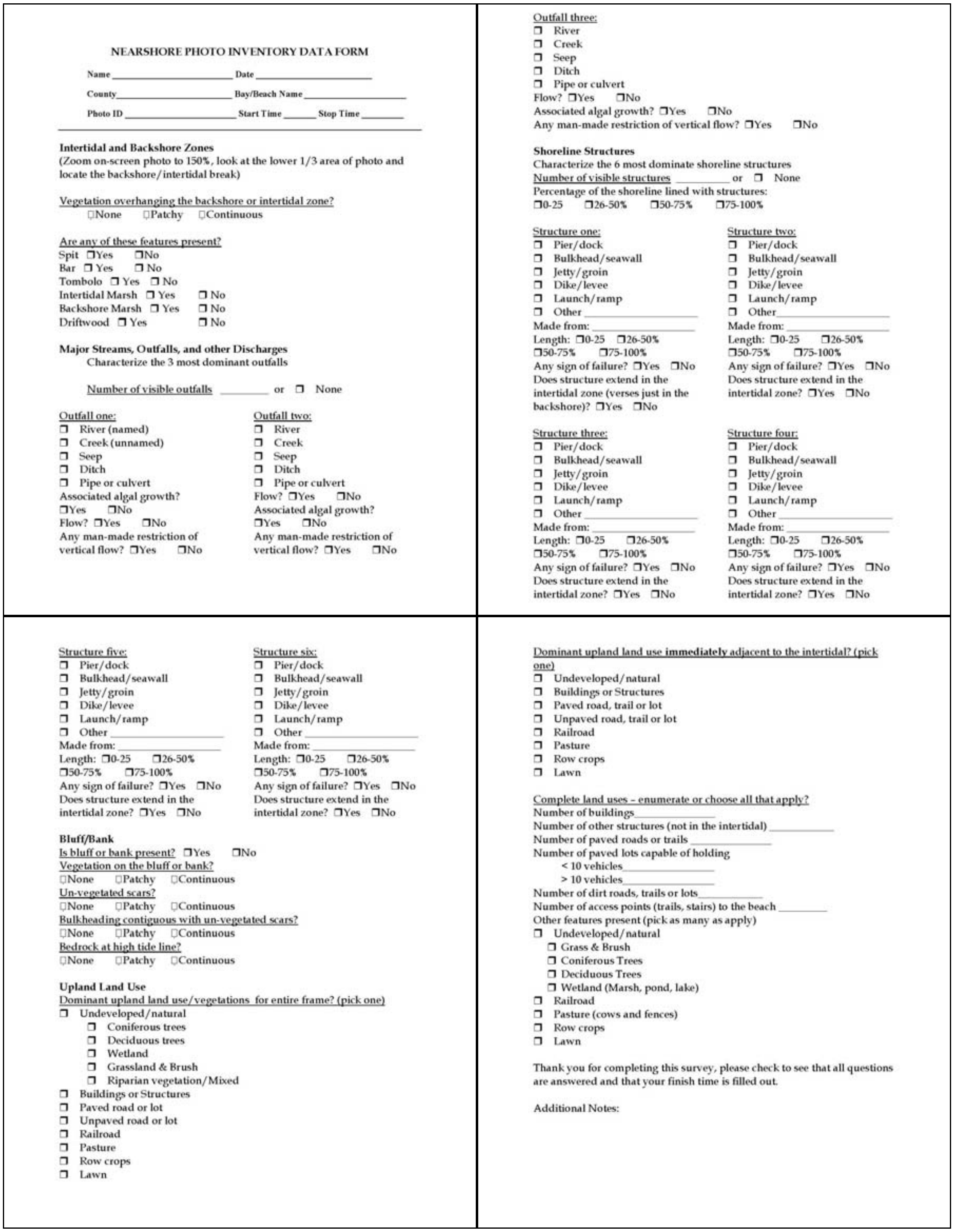
1. Training/setup: All volunteers new to the Nearshore Photo Inventory program completed a training session, comprised of a one on one session with the staff.

2. Implementation: People For Puget Sound staff GIS Analyst assisted and managed volunteers on inventory days. On that day, the GIS Analyst assigned data collectors sections of the shoreline. At the end of the day, the GIS Analyst assured that each assigned section was inventoried and that each form was complete.

3. Data processing/analysis/presentation: Once all shoreline sections have been inventoried, volunteers were trained to enter the data, and their work was reviewed systematically by staff. The data were checked and corrected in table form, and transferred to a Geographic Information System (GIS).

Detailed descriptions of this inventory protocol can be found in **Appendix C**.

Volunteers used a detailed data form, which places data into clear, discrete categories, to collect this information off the oblique photographs (**Figure 2**). The data form limits errors and makes the data as consistent as possible. The inventory data are displayed on 28 maps, providing a visual inventory of resources around this project area. (**Map Book, Maps 15 – 43**).



NEARSHORE PHOTO INVENTORY DATA FORM

Name ____________ Date ____________

County ____________ Bay/Beach Name ____________

Photo ID ____________ Start Time ______ Stop Time ______

Intertidal and Backshore Zones
(Zoom on-screen photo to 150%, look at the lower 1/3 area of photo and locate the backshore/intertidal break)

Vegetation overhanging the backshore or intertidal zone?
☐None ☐Patchy ☐Continuous

Are any of these features present?
Spit ☐Yes ☐No
Bar ☐Yes ☐No
Tombolo ☐Yes ☐No
Intertidal Marsh ☐Yes ☐No
Backshore Marsh ☐Yes ☐No
Driftwood ☐Yes ☐No

Major Streams, Outfalls, and other Discharges
Characterize the 3 most dominant outfalls

Number of visible outfalls ______ or ☐ None

Outfall one:
☐ River (named)
☐ Creek (unnamed)
☐ Seep
☐ Ditch
☐ Pipe or culvert
Associated algal growth?
☐Yes ☐No
Flow? ☐Yes ☐No
Any man-made restriction of vertical flow? ☐Yes ☐No

Outfall two:
☐ River
☐ Creek
☐ Seep
☐ Ditch
☐ Pipe or culvert
Flow? ☐Yes ☐No
Associated algal growth?
☐Yes ☐No
Any man-made restriction of vertical flow? ☐Yes ☐No

Outfall three:
☐ River
☐ Creek
☐ Seep
☐ Ditch
☐ Pipe or culvert
Flow? ☐Yes ☐No
Associated algal growth? ☐Yes ☐No
Any man-made restriction of vertical flow? ☐Yes ☐No

Shoreline Structures
Characterize the 6 most dominate shoreline structures
Number of visible structures ______ or ☐ None
Percentage of the shoreline lined with structures:
☐0-25 ☐26-50% ☐50-75% ☐75-100%

Structure one:
☐ Pier/dock
☐ Bulkhead/seawall
☐ Jetty/groin
☐ Dike/levee
☐ Launch/ramp
☐ Other ____________
Made from: ____________
Length: ☐0-25 ☐26-50% ☐50-75% ☐75-100%
Any sign of failure? ☐Yes ☐No
Does structure extend in the intertidal zone (verses just in the backshore)? ☐Yes ☐No

Structure two:
☐ Pier/dock
☐ Bulkhead/seawall
☐ Jetty/groin
☐ Dike/levee
☐ Launch/ramp
☐ Other ____________
Made from: ____________
Length: ☐0-25 ☐26-50% ☐50-75% ☐75-100%
Any sign of failure? ☐Yes ☐No
Does structure extend in the intertidal zone? ☐Yes ☐No

Structure three:
☐ Pier/dock
☐ Bulkhead/seawall
☐ Jetty/groin
☐ Dike/levee
☐ Launch/ramp
☐ Other ____________
Made from: ____________
Length: ☐0-25 ☐26-50% ☐50-75% ☐75-100%
Any sign of failure? ☐Yes ☐No
Does structure extend in the intertidal zone? ☐Yes ☐No

Structure four:
☐ Pier/dock
☐ Bulkhead/seawall
☐ Jetty/groin
☐ Dike/levee
☐ Launch/ramp
☐ Other ____________
Made from: ____________
Length: ☐0-25 ☐26-50% ☐50-75% ☐75-100%
Any sign of failure? ☐Yes ☐No
Does structure extend in the intertidal zone? ☐Yes ☐No

Structure five:
☐ Pier/dock
☐ Bulkhead/seawall
☐ Jetty/groin
☐ Dike/levee
☐ Launch/ramp
☐ Other ____________
Made from: ____________
Length: ☐0-25 ☐26-50% ☐50-75% ☐75-100%
Any sign of failure? ☐Yes ☐No
Does structure extend in the intertidal zone? ☐Yes ☐No

Structure six:
☐ Pier/dock
☐ Bulkhead/seawall
☐ Jetty/groin
☐ Dike/levee
☐ Launch/ramp
☐ Other ____________
Made from: ____________
Length: ☐0-25 ☐26-50% ☐50-75% ☐75-100%
Any sign of failure? ☐Yes ☐No
Does structure extend in the intertidal zone? ☐Yes ☐No

Bluff/Bank
Is bluff or bank present? ☐Yes ☐No
Vegetation on the bluff or bank?
☐None ☐Patchy ☐Continuous
Un-vegetated scars?
☐None ☐Patchy ☐Continuous
Bulkheading contiguous with un-vegetated scars?
☐None ☐Patchy ☐Continuous
Bedrock at high tide line?
☐None ☐Patchy ☐Continuous

Upland Land Use
Dominant upland land use/vegetations for entire frame? (pick one)
☐ Undeveloped/natural
  ☐ Coniferous trees
  ☐ Deciduous trees
  ☐ Wetland
  ☐ Grassland & Brush
  ☐ Riparian vegetation/Mixed
☐ Buildings or Structures
☐ Paved road or lot
☐ Unpaved road or lot
☐ Railroad
☐ Pasture
☐ Row crops
☐ Lawn

Dominant upland land use immediately adjacent to the intertidal? (pick one)
☐ Undeveloped/natural
☐ Buildings or Structures
☐ Paved road, trail or lot
☐ Unpaved road, trail or lot
☐ Railroad
☐ Pasture
☐ Row crops
☐ Lawn

Complete land uses – enumerate or choose all that apply?
Number of buildings ____________
Number of other structures (not in the intertidal) ____________
Number of paved roads or trails ____________
Number of paved lots capable of holding
  < 10 vehicles ____________
  > 10 vehicles ____________
Number of dirt roads, trails or lots ____________
Number of access points (trails, stairs) to the beach ____________
Other features present (pick as many as apply)
☐ Undeveloped/natural
  ☐ Grass & Brush
  ☐ Coniferous Trees
  ☐ Deciduous Trees
  ☐ Wetland (Marsh, pond, lake)
☐ Railroad
☐ Pasture (cows and fences)
☐ Row crops
☐ Lawn

Thank you for completing this survey, please check to see that all questions are answered and that your finish time is filled out.

Additional Notes:

Figure 2. Four pages of the data form used by volunteers to collect data off the Oblique Photographs.

Habitat characterizations captured off the oblique photographs focused on the physical, biological, and anthropogenic features of the nearshore that define or affect the condition or function of nearshore habitats. For example, physical features and some biological attributes, such as vegetation, of the nearshore environment define the habitat setting that determines which species occupy an area. Similarly, individual species distributions indicate areas currently meeting the habitat requirements of that species. Furthermore, nearshore modifications including bulkheads, docks, and piers directly affect nearshore processes and the ecology of nearshore species (MacDonald et al. 1994; Thom et al. 1994).

Data Uses

The data are intrinsically valuable as indicators of beach types and as baselines of physical and biological information. The data can show simple correlations between upland and intertidal land use and ecosystem health indicators on the adjoining beach. People For Puget Sound staff, working with nearshore habitat experts, created a system to analyze Nearshore Photo Inventory data and existing GIS datasets in a way that enhances its value. Different "scores" are assigned to different pieces of datum in order to prioritize areas that are appropriate for habitat conservation and restoration actions (see Nearshore Inventory Data Analysis below).

Nearshore Characteristics and Analysis Results

Intertidal/Backshore Zone (Maps 15 through 20)

The intertidal zone, the shoreline between the low and high tide lines, is home to a wide range of flora and fauna — many of which spend their entire lives there, or are dependent on the intertidal for some critical stage of their lives. The Nearshore Photo Inventory captures information from the low tide line to the high tide line where several species of forage fish spawn (**Figure 3**). Two of Puget Sound's three primary forage fish, surf smelt and sand lance, need specific sizes of substrate at or near the top of the intertidal zone in which to lay their eggs: namely, from sand to very small gravel below 4 mm in diameter (Bargmann, 1998). Pacific herring, the third of these three forage fish, attach their eggs to eelgrass and kelp (Bargmann, 1998).

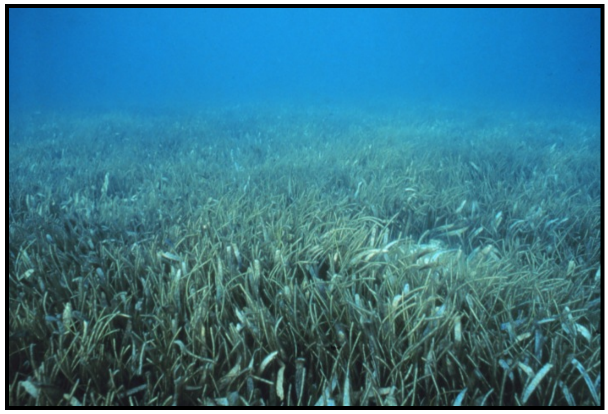


Figure 3: Beds of eelgrass that occur in the lower intertidal and subtidal zones are critical nursery habitat for a variety of species (image courtesy of NOAA).

The backshore is a "splash zone," often a flat area at the top of the beach that collects driftwood and where most of the plants can tolerate occasional salt spray (**Figure 4).** The driftwood and plants in the backshore provide habitat for small invertebrates, which in turn provide food for migrating juvenile salmon (King County Department of Natural Resources, 2001). This zone is often reduced or eliminated when bulkheads are built. High energy beaches with high bluffs may naturally have no backshore present at all.

Very often the two zones were not distinguishable from the photographs. We grouped these two zones on the data forms to capture as much information as possible. Where a backshore feature was distinctly identified in the nearshore zone, we distinguished between intertidal and backshore (e.g., a backshore marsh versus an intertidal marsh).

The Washington DNR ShoreZone dataset was used to capture information on intertidal habitats defined by substrate attributes in the study area. The dominant habitat was sand and gravel beach (25%), followed by mud flat (23%), and sandy flat (11%). Along the water line at low tide, many of the photo sections had substrate that would support eelgrass (sand or sandy mud) (Koch, 2001). Continuous patches of eelgrass were found in 43% of photo sections, while 30% of the photo sections contained patchily distributed eelgrass.

Vegetation that hangs over the intertidal zone is important for shade to protect forage fish spawn (helps to prevent desiccation of the eggs), and as a source of insects that drop into the water thus providing food for juvenile salmon. A majority of sections, 65%, contained at least some vegetation overhanging the intertidal zone. Only 12% of those sections had continuous coverage. Driftwood was present on 82% of the backshores.

Figure 4: Backshore habitat can include driftwood, salt-tolerant vegetation, salt marshes, and sand dunes.

Bluff/Bank Characteristics (Maps 36 through 37)

Bluffs and banks just shoreward of the beach (**Figure 5**) provide a variety of unique habitat niches. Two birds found in marine environments, the kingfisher and the pigeon guillemot, are known to nest in holes in sandy bluffs (Alsop, 2001). Most importantly, sand and gravel that dislodges and slides from bluffs and banks re-supplies fine substrates to the intertidal zone, maintaining the structure and profile typical of beaches from Anderson Island north to Samish Island. Bluffs and banks that provide a steady source of sediment to the shoreline are commonly called "feeder bluffs".

Figure 5: Large and small feeder bluffs are critical sources of sediment for Puget Sound shorelines.

Bluffs or banks, either natural or armored, were present on 70% of the sections. Ninety-six percent of these sections with bluffs, had at least some vegetation coverage.

Un-vegetated scars, usually an indication of a recent slide and potential supply of sand to the beach, were continuous for 2% of these sections, while 61% had patchy scars. Eighteen percent of all sections containing bluffs or banks had bulkheads at the base of the bluff or bank.

Adjacent Land Use (Maps 38 through 43)

The ways that land owners build on and maintain the land adjacent to the shoreline can directly impact the quality of nearshore habitat (**Figure 6**). Vegetated riparian buffers act as natural filters, absorbing water from flood events and filtering out toxins and excess nutrients. Clearing trees and shrubs to create views removes shade and food sources on which many species rely (King County Department of Natural Resources, 2001), and lawn and garden fertilizers and pesticides can be washed into the water. Un-managed access points can cause erosion and trampling of shoreline vegetation. Roads and parking lots along the water can increase the runoff of oil, gas, and antifreeze. Agricultural and industrial runoff is not always filtered or treated.

Figure 6: Land use adjacent to the shoreline has an impact on many characteristics of the nearshore environment, including riparian vegetation, aquatic vegetation, erosion, pollutants, and wildlife habitat use.

The dominant upland land cover captured by the photographs was undeveloped (53%), followed by row crops (20%) and lawn (12%). Fifty-seven percent of the *immediately adjacent upland* to the intertidal was predominately undeveloped as of the time of this survey. This relatively moderate number likely related to the fact that much of the residential shoreline development in this area is set well back from the beach, with healthy riparian buffers adjacent the high tide line. The next highest category of immediately adjacent land to the intertidal use was unpaved road, path, or lot at 10%, followed by paved road, path, or lot at 9%, and lawn at 7%. However, several instances of commercial and industrial development were recorded, especially near Anacortes and March's Point.

Streams, Outfalls and Other Freshwater Outflows (Maps 21 through 29)

In many cases, fresh water flowing onto the beach can be an important part of the nearshore ecosystem. Streams and creeks can create deltas or marshes, and can allow fish to move upstream to spawn. But water can also bring pollutants and garbage onto the beach (**Figure 7**). The Nearshore Photo Inventory counted the numbers and types of discharges (which include rivers, creeks, ditches, pipes, and seeps), looked for potential signs of pollution (excessive algal growth), and recorded whether or not the discharge is flowing.

Figure 7: Freshwater discharges entering the nearshore environment can carry excess nutrients or toxic pollutants onto the beach.

Thirty-six percent of sections surveyed contained one or more discharges. A total of 262 discharges were recorded, with 60% being seeps, 20% pipes, 12% creeks, 5% rivers, and 3% ditches. Sections that contained outfalls had an average of 2 per section. Samish Island has a relatively large amount of freshwater seeping onto the beach, and a very low percentage of associated algae. However, the survey area in general showed a moderately high occurrence of algae (continuous or patchy on 45% of sections).

Shoreline Structures (30 through 35)

The Photo Inventory looked for structures built on the shoreline such as bulkheads, docks, ramps, jetties, and levees. Shoreline structures can serve many purposes, from helping protect upland areas from erosion to providing a place to dock or launch boats (**Figure 8**). Some may be un-necessary or in disrepair, with owners that may be un-aware of their potential impacts on nearshore habitat. Bulkheads and jetties can block the flow of sand onto and along the beach, and can force juvenile salmon into deep water, exposing them to predators (Williams and Thom, 2001). Many structures can amplify the energy of waves, which in turn can scour sand from the top of the beach or increase erosion on adjacent or neighboring properties (Shipman, 1995). Failing structures, especially rip-rap bulkheads, can litter the beach with large materials that cover habitat for clams and other sand-dwelling invertebrates (People For Puget Sound, 2001).

Figure 8: Structures are often intended to prevent erosion or to provide people with access to the shoreline. Both types of structures can negatively impact nearshore habitat, especially as the structures begin to fail.

Nine hundred and nine structures were described during this inventory. Seventy-one percent of the photo section contained structures. Of those sections, the average number of structures was 3. There were no clear majority of one type of structure with 33% bulkheads or seawalls, 19% piers or docks, 9% dikes or levees, 6% launches or ramps, 2% jetties or groins, and 31% for other structure types, such as pilings.

Seventy eight percent of the structures were in good or excellent condition, meaning that they were serving their intended purpose. Twenty two percent were in poor condition, meaning that they were in some stage of obvious failure.

Section II. Analysis

Nearshore Inventory Data Analysis

Habitat inventories contain significant inherent values and descriptions of habitat and can inform habitat conservation decisions when used in geospatial models that define and describe habitat quality. To synthesize all the collected data from both the compiled GIS datasets *and* the Nearshore Photo Inventory, a series of conceptual models were selected from the Rapid Shoreline Inventory (RSI) Analysis and redeveloped to encompass new information gathered by this project. These models also describe the relationship between habitat features and indicators of habitat quality. Like the RSI models, Nearshore Photo Inventory models apply positive values to habitat characteristics perceived to be beneficial to habitat quality. Negative values are assigned to habitat features that impact habitat forming processes (e.g., erosion), are indicators of physical disturbances, or directly impact a species group. The models attempt to define how various measurable characteristics of nearshore habitat affect habitat quality with respect to target biological communities or geophysical processes. The models were chosen because they represent key elements of a functioning nearshore ecosystem typical of Puget Sound.

This methodology is based on the best available science for the relationship between marine nearshore habitats and key ecosystem processes and nearshore-dependent species in Puget Sound. However, scientific study in this area is not abundant. Moreover, the scoring system presented below represents value judgments made by staff scientists based on the scientific literature and other unpublished scoring schemes. These values can be adjusted to reflect other priorities and emerging research. The five models characterized nearshore habitat for:

- Forage fish spawning (species group)
- Juvenile salmonid use of nearshore (species group)
- Aquatic vegetation (species group/ecosystem process)
- Sediment Supply to the nearshore (ecosystem process)
- Birds that depend on Marine Shorelines and Features (species group)

Large amounts of geospatially-referenced species and habitat data are compared and contrasted by these models and the models are designed to assess each geo-referenced photo inventory point for both conservation opportunities and restoration opportunities. The habitat criteria chosen to evaluate the relationship between the species group or ecosystem processes and the current state of the shoreline are derived from the Nearshore Photo Inventory habitat characteristics and the data from the compiled GIS datasets. The justification for choosing the habitat criteria for use in the models are given in **Appendix D.** For each species group and ecosystem process model, a conceptual model, the model equation for how the specific criteria are used to determine the habitat conservation and restoration score, and how each specific habitat characteristic and impact is scored can also be found in Appendix D.

Invited reviewers were given the opportunity to edit and critique the models and the scoring scheme. Table 1 lists the invited professionals under the heading of the specific model they were asked to review:

Table 1. Invited Reviewers who were given the opportunity to critique the models.

Forage Fish
Dan Pentilla (WDFW)

Juvenile Salmon Nearshore Habitat Use
Kurt Fresh (NOAA)
Eric Beamer (Skagit Systems Cooperative)
Colin Levings (Fisheries Oceans Canada)
Charles Simenstad (Wetland Ecosystem Team)

Sediment Supply to Beaches
Hugh Shipman (WDOE)

Aquatic Vegetation
Tom Mumford (WDNR)
Helen Berry (WDNR)

Intertidal Shorebirds
Joe Buchanan (WDFW)

Project Feasibility
Fred Geotz (USACE)
Bernie Hargrave (USACE)
Jeff Dillion (USACE)

*Skagit MRC Bays Blueprint Subcommittee members also made comments on all models

Habitat Conservation Analysis

To find habitat conservation opportunities, the models were used to rate individual 800-ft shoreline sections on a scale of -100 to 100 with higher scores reflecting higher quality habitat. Positive scores were assigned to positive attributes such as riparian vegetation. Negative scores were assigned to habitat impacts such as bulkheads or signs of pollution. The conservation score is then simply the sum of the positive and negative values added for any 800 ft. photo section.

This analysis is helpful for identifying areas of highly functional habitat as well as areas not impacted by invasive organisms or anthropogenic development. While scores vary between the -100 and 100, it is important to recognize that this is a semi-quantitative model that provides a relative indication of site conservation value (sites scoring higher will generally be more favorable) for areas included in this study. The precise scores achieved may have little meaning taken outside the context of this specific analysis.

Habitat Restoration Analysis

The restoration analysis was based on the same scientific literature and data-driven ranking system used in the conservation model. For restoration opportunities, the goal is to identify those sites with a high level of current ecosystem function *and* a significant degree of impairment. This was achieved by multiplying the habitat attribute score and the habitat impact score, and then taking the absolute value of the product of the two numbers. The restoration scores range from zero (sites that have either no current habitat attribute or no obvious habitat impacts) to 10,000 (sites that have both the maximum score in the habitat attributes and impacts present). A site with a high restoration score might have multiple positive habitat attributes such as pea gravel, a spit, eelgrass, and riparian vegetations, but also habitat impacts such as intertidal structures, a boat ramp, and several outfalls.

For the restoration analyses, the scores increase along with increasing attributes and increasing intensity of impact (more impact equals a larger negative number). This results because the impact and attribute values are multiplied instead of added. The implications of this model are that sites with very low habitat attribute or very low habitat impact are not prime targets for restoration. Instead, sites that still have substantial remaining or inherent positive habitat value but also have significant impairment, represent the best opportunity to make significant gains for the ecosystem through restoration.

As with any model analysis, the interpretation of scores requires care and consideration. Since this approach is semi-quantitative, the direction of scores (higher being more favorable than lower) is more important than the specific score or precise difference between scores.

The conservation and restoration scoring scheme does not take into account the quality of immediately adjacent 800 ft. shoreline section, or groups of adjacent sections. In this sense, the study and analysis does not explicitly account for habitat continuity along the shoreline. For example, multiple continuous sections of good to moderate quality habitat might be more important for conservation than one cell of excellent quality habitat in the middle of a larger area of very low quality habitat. While scores for individual sections do not reflect this larger spatial context, viewing groupings of scores on the display maps can help identify important habitat "clusters".

Model 1. Potential Forage Fish Spawning Habitat

Forage fish, including populations of Pacific Herring (*Clupea harengus*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*), are an essential component of the Puget Sound food web. These three species comprise an essential trophic link within the nearshore environment, and are a major component of the diet of many predatory species like salmonids (Bargmann 1998). While little is know about the adult life stages of forage fish, spawning preferences and requirements are generally understood. This analysis is an extension of surveys that identify forage fish spawn; the model focuses on both current and potential spawning habitat. While forage fish may use the same sites for spawning over long periods of time (Pentilla 1995), a site may be abandoned for no apparent reason only to become used again at some point in the future (Robards et al. 1999).

Shoreline surveys that identify spawning beaches have been conducted by the Washington State Department of Fish and Wildlife since 1972. Based on information obtained during these surveys, surf smelt and sand lance are thought to spawn selectively in shorelines that have deposits of either sand or pea-gravel sized sediment in the upper intertidal zone (Bargmann 1998). In addition to substrate preferences and requirements, forage fish eggs tend to have lower mortality when there is riparian vegetation adjacent to shoreline that can provide shade and moderate temperatures (Robbards et al. 1999). Pacific herring vary slightly from smelt and sand lance in that herring spawns primarily in lower intertidal and shallow subtidal zones, attaching eggs to vegetation such as eelgrass or kelp.

The forage fish analysis focuses on identifying those beaches with conditions that would seem to favor forage fish spawning and spawn survival. Positive attributes for shorelines include appropriate sediment found in the upper intertidal, overhanging vegetation, as well as aquatic vegetation that might be used for spawning. Negative components are primarily those that interrupt or disturb potential spawning areas or the processes that form potential spawning areas. These include artificial outfalls which may supply excessive nutrients or toxic chemicals to the shoreline, bulkheads which alter nearshore hydrography, or piers that shade subtidal vegetation. A conceptual model that describes high potential for forage fish spawning habitat along the nearshore is found in **Figure 9**.

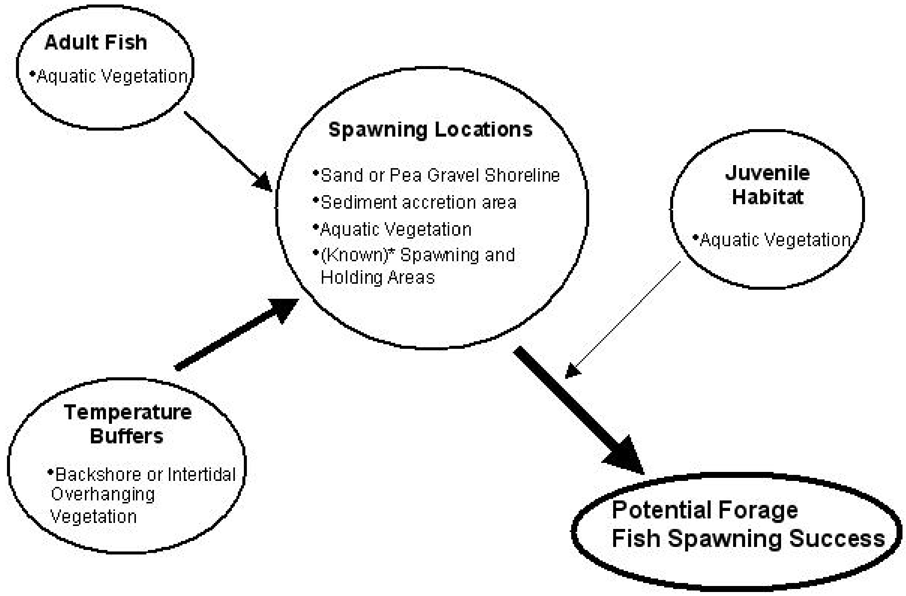


Figure 9. A conceptual model describing the relationship between shoreline characteristics and forage fish spawning success.

The scoring system for each of the forage fish model criteria can be found in Appendix D. The narrative descriptions to determine the habitat conservation and restoration equations are also found at the bottom of this model's description in Appendix D.

Model 2. Potential Nearshore Habitat Use by Juvenile Salmonid

The salmon habitat analysis relies on the assumption that nearshore habitats provide key functions for development and survival of juvenile salmon, such as chum and ocean-type chinook. Nearshore marine habitat may serve as migration corridors, feeding areas, physiological transition zones, refuge from predators, or refuge from high energy wave dynamics (Mason 1970; MacDonald et al. 1987; Thrope 1994; Levings 1994; Spence et al.1996). Most juvenile salmon use the shallow waters of estuaries and nearshore areas as migration corridors to move from their natal streams through Puget Sound to the ocean (Williams and Thom 2001). Estuarine environments provide a gradual transition area for juvenile salmon to adjust physiologically to salt water (Simenstad et al. 1982). With declines in aquatic vegetation that formerly served as feeding grounds and refugia for juvenile salmonid, it is likely that juvenile salmon have shifted their distributions and now use shallow water as an alternate refuge habitat (Ruiz et al. 1993).

This model focuses on evaluating individual sites for their capacity to serve as feeding area, refugia, or migration corridors for juvenile salmon. Emergent vegetation (*Carex lyngbyei*, *Scirpus spp*., etc.) and riparian shrubs and trees have been identified as vital components that provide detritus and habitat for chinook food organisms (Levings et al. 1991, Cordell et al. 2001), and were scored appropriately. Habitat impacts are those features that are known to displace habitat or impede habitat forming processes. These include structures that reduce shallow water nearshore habitat or adjacent land uses that may impact vegetation and upland food sources. A conceptual model that describes potential juvenile salmonid use of nearshore habitat is found in **Figure 10**.

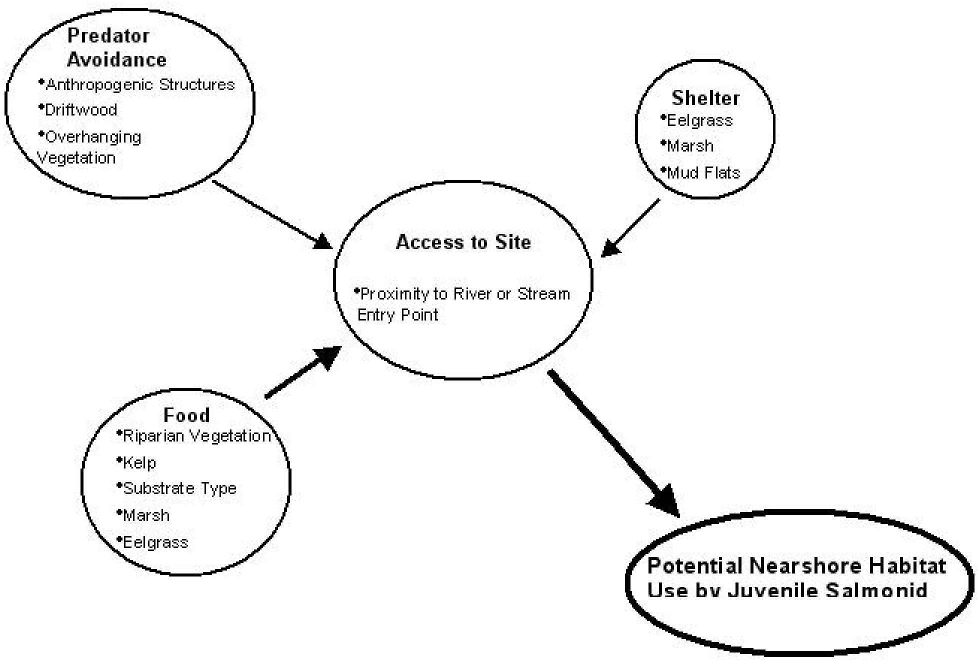


Figure 10. A conceptual model describing the relationship between shoreline characteristics and juvenile salmonid use of nearshore habitat.

The scoring system for each criterion in the juvenile salmonid model can be found in **Appendix D**. The narrative descriptions to determine the habitat conservation and restoration equations are also found at the bottom of this model's description in Appendix D.

Another criterion for juvenile salmon habitat conservation might be the area's proximity to large, chinook-bearing rivers. Recent research in the Skagit River suggests that juvenile chinook can be prematurely forced out of estuaries and into marine shorelines (Beamer et al., 2003), although this has yet to be documented for other sub-estuaries of Puget Sound. Juvenile salmon also use the beach as a migration corridor; the continuity of good habitat was addressed in this report by including proximity of each shoreline section to the mouth of rivers and creeks.

Model 3. Presence of Aquatic Vegetation

Primary production forms the base of any food web, and in the Puget Sound the primary producers are seaweeds, sea grasses, benthic microalage, kelps, marsh macrophytes, and phytoplankton. In Puget Sound, areas of increased algae and seagrass density or biomass, contain more species and a greater abundance of epibenthic invertebrates than do areas of lower vegetative cover or structure (Cheney et al. 1994). With the exception of estuary marsh vegetation, which was formerly widespread in and around the major bays and deltas of the Sound (Bortleson 1980), primary production is limited to a relatively narrow band of habitat as a result of the steep fjord-like character of Puget Sound's nearshore habitat. Any attempt to determine the suitability of certain areas as habitat for submersed aquatic vegetation (SAV) must take into consideration light and parameters that modify light (epiphytes, total suspended solids, chlorophyll concentration, nutrients) (Koch 2001). Anthropogenic nitrogen loads to shallow coastal waters have been linked to shifts from seagrass to algae-dominated communities in many regions of the world (McClelland and Valiela 1998). Propagules of most types of aquatic vegetation are generally a result of either inappropriate habitat for colonization and survival or displacement by another type of aquatic vegetation (Moore et al. 1996).

The focus of this analysis is on direct observations of aquatic vegetation with individual types of aquatic vegetation valued primarily for their ecological "services". Implicit in the scoring of this model is the underlying assumption that each type of aquatic vegetation typically occupies a particular zone in the nearshore environment, from the subtidal to the upper intertidal. Figure 11 shows a conceptual model that describes potential juvenile salmonid use of nearshore habitat.

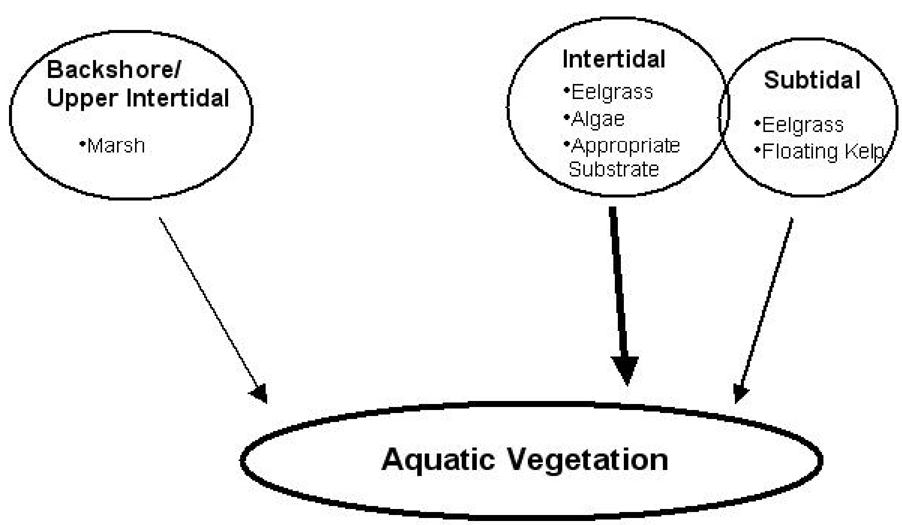


Figure 11. A conceptual model describing the relationship between shoreline characteristics and aquatic vegetation found within the nearshore habitat.

The scoring system for each criterion in the aquatic vegetation model can be found in Appendix D. The narrative descriptions to determine the habitat conservation and restoration equations are also found at the bottom of this model's description in Appendix D.

Model 4. Beach Sediment Supply

Puget Sound's shorelines are composed of hundreds of littoral cells that redistribute sediment along the shoreline. In the relatively protected waters of the Sound, the primary sources of sediment to the shoreline are alongshore and onshore transports, bluff erosion, and beach nourishment. Sediment is lost from the beach as a result of erosion and longshore transport or deposition onto spits (Downing 1983). Shoreline development and armoring actively impact beaches by altering sediment supply and transport processes and by directly modifying and occupying critical habitats (Shipman and Canning 1998, Shipman 1995).

The focus of this analysis is on identifying signs that sediment budget is being filled by looking for evidence of active erosion, in particular bluff faces, and areas of deposition that are found at the end of drift cells such as tombolos and spits. Below is a simplified model of factors affecting sediment supply to beaches using existing geospatially-referenced species and habitat data within Puget Sound. A conceptual model that describes potential sediment supply to the nearshore is found in **Figure 12**.

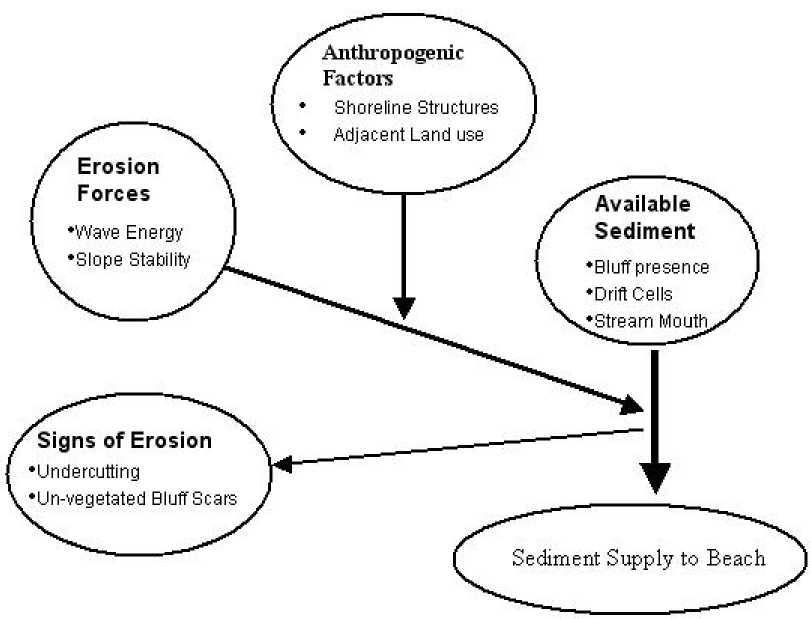


Figure 12. A conceptual model describing the relationship between shoreline characteristics and sediment supply to the nearshore.

The scoring system for each criterion in the beach sediment supply model can be found in Appendix D. The narrative descriptions to determine the habitat conservation and restoration equations are also found at the bottom of this model's description in Appendix D.

Model 5. Marine Bird

Many terrestrial animals spend part or all of their lives within the nearshore environment and have a great impact on the composition and functions of the nearshore ecosystem. An essential component of the nearshore ecosystem is marine birds; specifically the intertidal birds. Marine birds are often the dominant predators along rocky and sandy beaches (Hori and Noda 2001). In addition to being a dominant consumer of animals, most birds are omnivores and play a critical role in structuring both fauna and flora species assemblage in the nearshore ecosystem.

This analysis focuses on habitat components that contribute to the feeding and nesting behaviors exhibited during the breeding season of many intertidal feeding shorebirds. This analysis looks at a variety of shoreline features that are beneficial for a variety of birds that depend on marine shorelines. It awards points for fine sediment where intertidal shorebirds forage and niche habitats where rivers and creeks meet salt water. Negative components are primarily anthropogenic structures that encroach on to nesting and foraging habitats adjacent to and along the shoreline. A conceptual model that describes potential sediment supply to the nearshore is found in **Figure 13**.

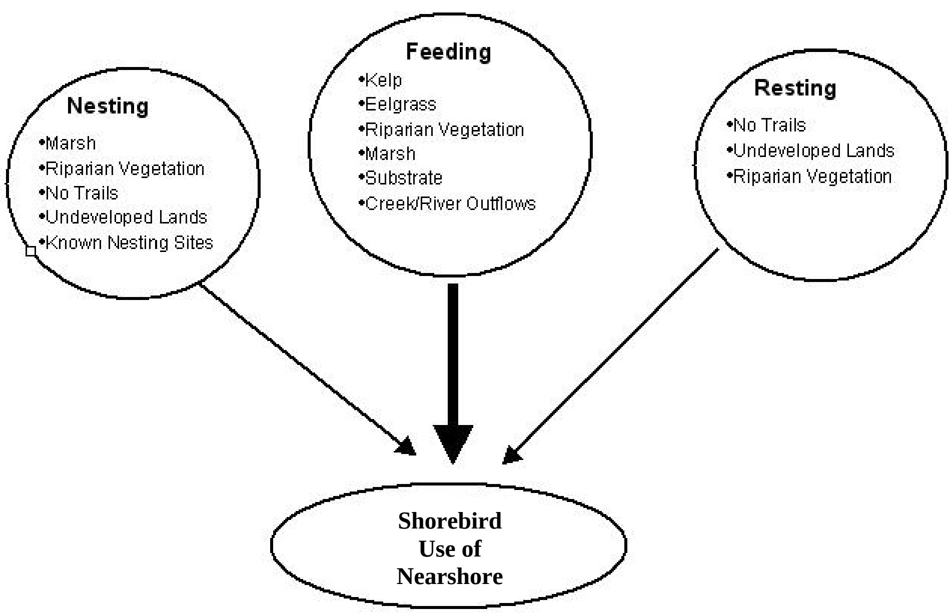


Figure 13. A conceptual model describing the relationship between shoreline characteristics and shorebird use of the nearshore habitat.

The scoring system for each criteria in the marine bird model can be found in Appendix D. The narrative descriptions to determine the habitat conservation and restoration equations are also found at the bottom of this model's description in Appendix D.

Methodology

The data for each model criterion were captured in various GIS datasets and in the Nearshore Photo Inventory database. The information from the GIS datasets were compiled in ArcGIS 9.1® using spatial joins and a script developed to measure the distance between each photo point and features of interest. More information on the GIS and Nearshore Photo Inventory procedures can be found in **Appendix C**. People For Puget Sound compiled all the data into one Microsoft Access database, allowing us the capability to query and organize the data into discrete tables. During the first phase of the Bays Blueprint each model, all data associated with the criteria were captured into separate tables, then analyzed using the open–source software R, developed by The R Development Team©. For the 2005 update the models were coded as SQL queries within the Access database. Each model criteria were scored according to the scoring system described for each model, and compiled into the habitat conservation analysis and the restoration analysis. The output contains the photo point identification number and the habitat conservation and restoration scores for each model and an additional overall conservation and restoration score. The outputs can also be linked to the photo point dataset containing geographic coordinates to be displayed in GIS software. All data and results are displayed using the ESRI ArcGIS 9.1® software.

Analysis Results

The resulting scores for both conservation and restoration calculations of each model are organized and displayed in the data tables found in **Appendix G**. There are 463 photo points that cover the shoreline in the project area. Each photo point is uniquely numbered and chronologically listed. Points identifying each photo section are mapped on the **Key Map** and the subsequent nine maps (**Sheets A – M in Map Book)** can be used as key maps in locating each point along the shoreline. The data tables can be used to view the specific habitat characteristics found at each dot, the scores assigned to these characteristics, the data sources where the characteristics originated, the scoring scheme for each model criteria, and the resulting habitat conservation and restoration scores for each photo point. The information is also spatially linked to a map for referencing via the key maps. Both the maps and the data tables can be used to cross–reference each other.

Section III. Prioritization

Ranking the Analysis Results

The 463 photo points on the maps are associated with the data that make up the conservation and restoration scores described in the analysis section above. Due to this large number of points, it is necessary to organize and display the scores in such a way that helps the user select an appropriate number of points, or sites, to be followed-up with onsite visits, gathering of permits and permissions from property owners, and funding availability.

A percentile-ranking scheme was created to display and present the model results visually, which aided in systematically ranking and prioritizing the analysis results. The scheme provides the process and rationale to identify and select top-scoring sites relative to all other sites. This methodology selects a truncated list of projects, based on biological information, to be followed-up with a feasibility analysis. Conservation and restoration scores were grouped into the following percentile breaks:

- 100% — 96%
- 95% — 91%
- 90% — 86%
- 85% — 81%
- 80% — 71%
- 70% — 51%
- 50% — 0%

The top 20% sites are divided into 5% breaks which yield more separation within the top ranking sites; the 5% breaks highlight high–scoring sites, emphasizing biologically significant areas to select and analyze for project feasibility and implementation.

The resulting data, restoration and conservation scores, and the spatial location of each photo point can be found in the data tables in Appendix G, and are displayed visually in the Map Book. A percentile-ranking scheme was created to display and present the model results visually in **maps 44 through 55**. This aided in systematically ranking and prioritizing the analysis results**.** Each model resulted in both a habitat conservation and restoration map. Because the precise meaning of each individual score is meaningless, it is best to compare sites within a given sampling area. Those sites scoring in the top 10% are likely the most noteworthy sites and should be reviewed for potential conservation or restoration. Overall conservation and restoration values were calculated by averaging the rank orders (between 1 and the maximum number of samples, with 1 being the highest scoring site) of each site for all five models.

This ranking system reveals those conservation and restoration opportunities that would provide the highest value to the living resources — not merely those that are the cheapest or most convenient. While sites identified using this tool are likely to provide ecosystem benefits if they are protected and restored, this ranking scheme only serves as a guide and pre-ranking tool for further detailed site inspections and analysis of site-specific circumstances.

Prioritizing 21 Sites

The overall maps and model maps provide the MRC sub-committee with tools to visually identify areas with the highest biological importance along their shorelines. The conservation maps highlight areas where the habitat features are relatively undisturbed (the largest dots), and should therefore be protected to maintain biological integrity. The restoration maps similarly highlight areas where positive biological aspects currently exist, yet are being disrupted by negative impacts.

The MRC sub-committee was equipped to begin locating sites where actions were needed; determined solely on biological importance. This was accomplished by considering only the overall maps, model maps, and associated biological data. The aerial oblique photos were not used at this time, and an attempt was made to momentarily set aside any known social, cultural, or economic issues, and focus on biological aspects of the sites.

The process began, during the first step of the feasibility phase, by first considering the overall conservation and restoration maps (**Maps 54 and 55 in Map Book)**. The MRC sub-committee determined this to be the best approach, simply because they were interested in all potential projects and not specifically investigating a certain topic, such as forage fish or marine bird habitat. After selecting a single point, or a group of points on the overall map, they then referred to the individual model maps and corresponding data to determine why this area received a high score.

Generally, we found clusters of high-ranking points on both the overall and model maps, as opposed to single high-ranking points. This was not surprising, as the points simply correspond to the aerial oblique photos, and adjacent stretches of shoreline would be expected to have similar or overlapping characteristics. Therefore, a 'site' picked for its overall high-ranking quality, was often composed of several points.

Twenty-one sites were selected from the original 343 points on the maps (prior to the addition of the islands to the GIS). The first six sites were chosen from their high-ranking biological qualities and potential need for conservation. The remaining 15 sites were chosen for their high-ranking quality with regard to restoration needs. A list of these sites was compiled with brief descriptions of the location and immediate area. This list can be found in **Appendix E.**

Section IV. Project Selection and Evaluation

Proposed Actions and Potential Projects

The MRC sub-committee with the help of People For Puget Sound was able to select 21 sites from the 343 original points to be assessed for potential actions to be taken. The model has shown us that these sites are biologically important, and furthermore it has shown us that each of these sites is in need of restoration or protection on some level. Now, we must determine what that need is. The aerial oblique photographs and other on-the-ground data, such as the Battelle report recommendations and the data results from the models, guided People For Puget Sound in proposing actions to be taken at each site and developing potential projects. Where the data results and the aerial oblique photographs show overlapping conditions or characteristics, actions begin to emerge that will potentially enhance the habitat attributes. For example, a site scored high on the forage fish model due to presence of proper substrate and shade vegetation, yet also had a high restoration score. The photo shows several floating docks along that stretch of beach. The overlap of those two data sources tell us that something should be done about those floating docks.

Similar evaluation of each of the 21 sites led to an average of 3 to 4 proposed actions per site. These actions included removing or redesigning shoreline structures that may impede sediment drift, replanting native vegetation to enhance forage fish habitat, intensive beach clean-up and creosote pilling removal, and education actions targeted at stretches of beach where the cumulative effect of multiple homeowners' actions were degrading intertidal habitats.

The MRC sub-committee then took the People For Puget Sound recommendations for actions and developed them into potential projects. This often involved grouping certain actions into a single project, clarifying the language of the action, or adding additional actions into the scope of the project. Due to the large scope of many of these potential projects and constraints of time and available effort, it is necessary to prioritize. The development and use of a feasibility analysis allowed the MRC sub-committee and People For Puget Sound to do just that.

Feasibility Analysis

Increasing development along the shorelines of Puget Sound increases the pressure on already stressed nearshore habitats and natural processes. Therefore, the implementation of projects to protect and restore habitat and natural processes is necessary. As state and county governments, local municipalities, and Native American tribes continue to explore ways to protect or acquire critical habitats and control land use through planning regulation and public education, prioritizing nearshore protection and restoration projects become critical. To that end, we attempt to model the feasibility of projects once biologically significant sites have been identified (**Figure 14)**.

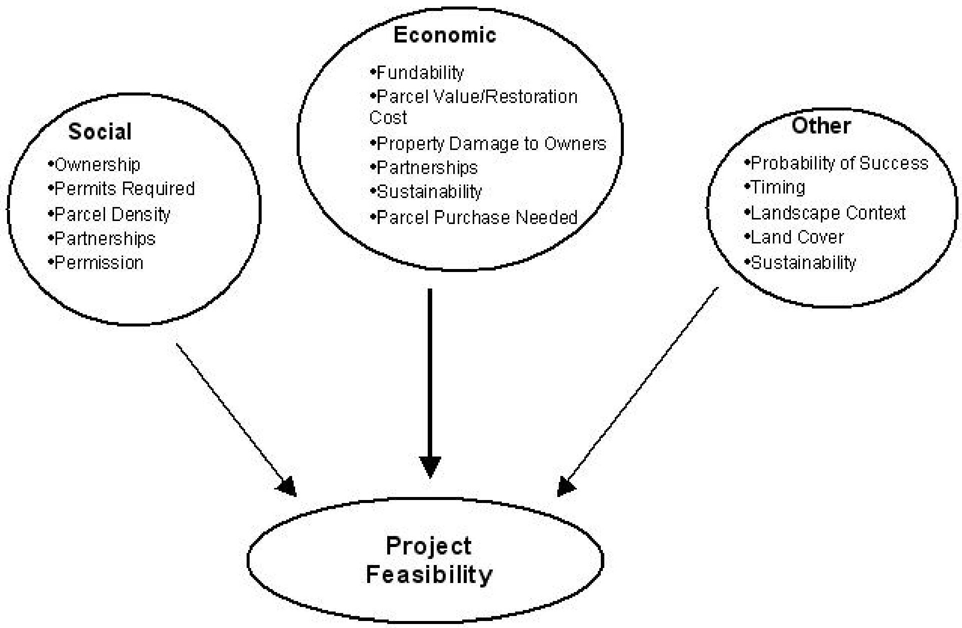


Figure 14. A conceptual model describing the rationale to determine Project Feasibility

Combining the attributes of landscape ecology (Shreffler and Thom 1993) with social, economic, cultural, and political principles, we can define the ease of restoration or conservation projects and prioritize our efforts accordingly. The above criteria were chosen to identify areas where both biologically critical habitats/processes and humans can coexist. In areas where cost is minimal, permission is attainable, and projects easily sustained and monitored, we assign high values. This model does not replace the very important local-level contact and on-the-ground verification steps.

In order to define the elements in the above diagram with local knowledge and site visits, the MRC and People For Puget Sound developed a series of feasibility criteria worksheets. Three worksheets were developed to address the three major types of proposed actions: conservation, restoration, and restoration through education. Examples of each worksheet can be found in **Appendix E.** A brief discussion describing the rationale for each of the feasibility criteria can also be found in **Appendix E**.

The MRC sub-committee met with People For Puget Sound to evaluate the multiple actions proposed at the 21 sites and begin project development. Local knowledge and diverse expertise shared though exchanges between the MRC sub-committee and People For Puget Sound made the process of assigning feasibility scores exceedingly more complete and accurate.

Figure 15. Members of the Skagit MRC Bays Blueprint sub-committee meet to apply the feasibility criteria to determine habitat conservation and restoration opportunities.

People For Puget Sound also instructed the MRC sub-committee in using the information available, such as the data tables, maps, aerial oblique photos, and other outside information to help answer the feasibility criteria questions on the worksheets. With that knowledge, the MRC sub-committee was able to continue through the entire feasibility process for the remainder of the proposed actions, without the direct assistance of People For Puget Sound. At this point, the Bays Blueprint feasibility process became a tool that can be used by any citizen with an interest in nearshore habitat protection and restoration.

Results of MRC Sub-committee meetings

Several of the 21 selected sites had multiple proposed actions, some of which were logically grouped together by the MRC sub-committee to form a single potential project. In some cases, it was determined to be more reasonable that multiple actions at a single site be grouped into more than one potential project. The MRC sub-committee's deliberation of the 21 prioritized sites with multiple proposed actions resulted in 24 potential projects needing further consideration. People For Puget Sound produced Site Reports for each of these potential projects, which can be found in **Appendix F**.

The criteria questions of the feasibility worksheets were designed to result in a discernable difference in the scoring of the potential projects, giving the MRC an additional way of prioritizing projects to be implemented. The MRC sub-committee quickly discovered that it was not possible to fully assess some of the potential projects using the feasibility worksheets. This was generally due to incomplete knowledge of the site at the time of the assessment, or it was not the proper timing or location for the proposed actions. These projects are included in the list of site reports in **Appendix F**, with a notation of why the project was not taken through the feasibility worksheet.

The majority of the potential projects were ranked using the appropriate feasibility worksheet. A brief synopsis of project recommendations was developed by People For Puget Sound for these sites (see section V on the Site Reports in Appendix F). These synopses included information on locating parcel ownership, contact information for various geo-engineers and civil engineers, County and City permitting information, and details on native planting including native plants dealers, local Conservation District chapters, local native plant nurseries, and local chapters of The Native Plant Society.

The ultimate goal of the prioritizing process is to begin implementing potential projects that currently have the highest feasibility. Several of the potential projects fell into this arena. The MRC subcommittee, again using their local knowledge and expertise, selected three sites for further project development. People For Puget Sound elaborated on the brief project recommendations previously supplied by developing scope of work, cost estimates, and potential funding possibilities. We acquired the help of Jim Johannessen, geological engineer of Coastal Geologic Services, Tom Slocum, District Engineer of the Conservation Districts of San Juan, Skagit, and Whatcom Counties, and Daniel Downs in the Skagit County Planning and Permitting Department, to develop the more comprehensive Site Reports. These three expanded Site Reports provides the MRC with a strong foundation to further project development and implementation. These three projects represent areas that are biologically important, require restoration to some degree, and currently have a high feasibility for being beneficial, achievable, and sustainable.

Conclusions

PPS and MRC are very pleased with the process and outcome of the Northern Skagit County Bays and Shoreline Habitat Conservation and Restoration Blueprint. This project arose from the need for a large–scale, spatial analysis of biological information. Bays Blueprint improved upon that need by determining the most important and feasible sites for on–the–ground conservation and restoration actions. Although it was developed based on rigorous, scientific methodology, the model outcomes are understandable and useable by any citizen with an interest in the health of the nearshore environment.

Building on the Blueprint

Adding new data

As the science and understanding of nearshore habitats increase, new data will become available to include into the Bays Blueprint. Datasets such as new forage fish spawning data, bird surveys, and juvenile salmonid use of the nearshore, more detailed drift cell analyses, new oblique aerial photographs, and new county data arising from Shoreline Master Plans (SMP) updates should be included. Availability of new datasets usually come from word of mouth knowledge from scientists doing the analyses, meetings or conferences where constituents share new information, regional scientific journals, and the websites of city, county, and state agencies, universities and professors. All new datasets should be incorporated into the biological model analysis component of the Bays Blueprint by trained GIS analysts.

Updated parcel ownership, site-specific inventories (RSI) and reports such as the Battelle Report (Antrim et al., 2003), and plans such as updated SMP are some of the resources to be used by the MRC to determine potential projects or actions and aid in project feasibility analysis. One of the most useful pieces of information for the MRC is the updated oblique photographs to view sections of the shoreline. The oblique photographs are taken every five years by the Washington Department of Ecology.

Technical collaboration

The habitat conservation and restoration results drive the project feasibility analysis component of the Bays Blueprint. Just as the evaluation of project feasibility is a group effort, the compiling datasets in to a GIS and modeling important species groups and biological processes also require a collaborative effort. A technical team comprised of scientists, GIS modelers and analysts, and computer developers would develop a more powerful and efficient modeling tool that produces biologically significant results from which to build the feasibility component. Peer review, critical review, and model sensitivity tests are just a few examples of how to build up the validity of this project.

Spreading the word

This important tool should be used as a public education tool, and the Skagit MRC can help by presenting the Bays Blueprint to other MRC groups, local stakeholders, politicians, and tribal entities. People For Puget Sound staff presented preliminary results to the Northwest Straits Commission and the Whatcom, San Juan and Island County MRC's during development of the project. People For Puget Sound also presented this project at the 2004 Restore America's Estuary National Conference to address the scientific community.

The Future of Bays Blueprint

People For Puget Sound is interested in expanding the Northern Skagit County Bays and Shoreline Habitat Conservation and Restoration Blueprint to the rest of Puget Sound basin and the Northwest Straits. This will likely be accomplished on a county by county basis, possibly prioritized by the deadlines of Shoreline Master Program updates. This effort will require collaboration with interested local stakeholders, scientists, and the public.

References

Alsop, Fred J. III. 2001. Birds of North America. DK Publishing, New York, NY.

Antrim et al. 2003. Plan for Habitat Protection,Restoration, and Enhancement: Fidalgo Bay and Guemes Channel. Battelle Memorial Institute, Pacific Northwest Division. Richland, Washington.

Beamer et al. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit System Cooperative Research Department. La Conner, Washington.

Bargmann, G. 1998. Forage fish management plan. Washington Department of Fish and Wildlife. Olympia, WA.

Bortleson, G. C., M. J. Chrzastowski, and A. K. Helgerson. 1980. Historical changes of shoreline and wetland at eleven major deltas in the Puget Sound region, Washington. Prepared in cooperation with the U.S. Department of Justice and the Bureau of Indian Affairs, Renton, Washington. U.S. Geological Survey, Hydrologic Investigations Atlas HA-617, Washington, D.C.

Cheney, D., R. Oestman, G. Volkhardt, and J. Getz. 1994. Creation of rocky intertidal and shallow subtidal habitats to mitigate for the construction of a large marina in Puget Sound, Washington. Bulletin of Marine Science 55 (2-3): 772-782.

Cordell et al. 2001. Biological monitoring at Duwamish River Coastal America restoration and reference sites: a seven-year retrospective. University of Washington School of Aquatic and Fishery Sciences. Seattle, WA.

Downing, J. 1983. The coast of Puget Sound: Its processes and development. Washington Sea Grant Program. University of Washington Press, Seattle, Washington. 126 pp.

Feist, B. 2002. Northwest Fisheries Science Center watershed program open house. March 19, Museum of History and Industry, Seattle.

Hori, M and T. Noda. 2001. Spatio-temporal variation of avian foraging in the rocky intertidal food web. Journal of Animal Ecology 70 (1): 122-137.

King County Department of Natural Resources. 2001. State of the nearshore ecosystem. Seattle, WA.

Koch, E.M. 2001. Beyond light: Physical, geological, and geochemical parameters as possible submersed aquatic vegetation habitat requirements. Estuaries 24 (1): 1-17.

Lawrence, P.L. 1994. Natural hazards of shoreline bluff erosion – A case-study of Horizon View, Lake Huron. Geomorphology 10 (1-4): 65-81.

Levings, C.D., K. Conlin, and B. Raymond. 1991. Intertidal habitats used by juvenile chinook salmon (Oncorhynchus Tshawytsch) reaing in the north arm of the Fraser-River Estuary. Marine Pollution Bulletin 22 (1): 20-26.

Levings, C.D. 1994. Feeding behavior of juvenile salmon and significance of habitat during estuary and early sea phase. Nordic Journal of Freshwater Research 69:7-16.

MacDonald, J.S., I.K. Birtwell, and G.M. Kruzynski. 1987. Food and habitat utilization by juvenile salmonids in the Campbell River Estuary. Canadian Journal of Fisheries and Aquatic Sciences 44: 1233-1246.

Mason, J.C. 1970. Behavioral ecology of chum salmon fry (*Oncorhynchus keta*) in a small estuary. Journal of Fisheries Research Board of Canada 31:83-92.

McClelland, JW, and I. Valiela. 1998. Changes in food web structure under the influence of increased anthropogenic nitrogen inputs to estuaries. Marine Ecology – Progress Series 168: 259-271.

Moore K.A., H.A. Neckles, and R.J. Orth. 1996. *Zostera marina* (eelgrass) growth and survival along a gradient of nutrients and turbidity in the lower Chesapeake Bay. Marine Ecology – Progress Series 142 (1-3): 247-259.

Shipman, H. and D. J. Canning. 1993. Cumulative environmental impacts of shoreline stabilization on Puget Sound. In: Proceedings, Coastal Zone 1993, Eighth Symposium on Coastal and Ocean Management. pp. 2233-2242. American Society of Civil Engineers, New York.

Shipman, H. 1995. The rate and character of shoreline erosion on Puget Sound. In: Proceedings of Puget Sound Research. 1995. pp. 77-83. Puget Sound Water Quality Authority, Olympia, Washington.

Penttila, D.E. 1995. Investigations of the spawning habitat of the Pacific sand lance *Ammodytes hexapterus*, in Puget Sound. In *Puget Sound Research '95 Conference Proceedings* (Robichaud, E., ed.), pp. 855-859. Olympia, WA: Puget Sound Water Quality Authority.

People For Puget Sound. 2001. March Point rapid shoreline inventory. Seattle, WA.

Robards, M.D., J.F. Piatt, and G.A. Rose. 1999. Maturation, fecundity and intertidal spawning of Pacific sand lance in the northern Gulf of Alaska. Journal of Fish Biology 54: 1050-1068.

Ruiz, G.M., A.H. Hines, and M.H. Posey. 1993. Shallow-water as refuge habitat for fish and crustaceans in nonvegetated estuaries – An example from Chesapeake Bay. Marine Ecology – Progress Series 99 (1-2): 1-16.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An underappreciated function. In: V.S. Kennedy ed. Estuarine Comparisons. Pp. 343-365. Academic Press, Toronto.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6507. ManTech Environmental Research Services Corp., Corvallis, OR.

Thorpe, R.M., T.L. Parkwell, D.K. Shreffler, and K.B. MacDonald. 1994. Shoreline armoring effects on coastal ecology and biological resources in Puget Sound. Coastal Management Studies, Volume 7. Shorelands and Coastal Zone Management Program, WDOE, Olympia, WA.

Washington Sea Grant Program. 1998. Murray-Metcalf Northwest Straits Citizens Advisory Commission: Report to the Convenors. Washington Sea Grant, University of Washington.

Williams, G.D. and R.M. Thom. 2001. White Paper: Marine and Estuarine Shoreline Modification Issues. Battelle Marine Sciences laboratory. Prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation.

Map Book

Appendix A

North Puget Sound Nearshore Habitat Assessment (NPSNHA)

Appendix B

Summary of Existing Datasets

Appendix C

Nearshore Photo Inventory and the GIS Inventory Protocol

Appendix D

The Analytic Models

Appendix E

The Feasibility Criteria

and Worksheets

Appendix F

Site Reports

Appendix G

Model Data Tables