CHAPTER 3 ECOSYSTEM PROFILE

3.1 Introduction and Overview

This Chapter describes how landscape processes affect Island County's shorelines in the context of their watersheds. It begins with this brief overview of the county's watershed conditions, followed by a more detailed summary of how ecosystem-wide processes affect shoreline functions at the countywide scale, beginning with climate, geology, and landforms, followed by living systems. The ecosystem profile provides context for the reach-scale discussion provided in subsequent chapters of this report.

There are approximately 196 miles of marine shoreline in Island County. Whidbey Island, the largest island in Puget Sound, is approximately 35 miles long and 169 square miles and has 143 miles of marine shoreline. Camano Island is approximately 18 miles long, 40 square miles and has approximately 52 miles of shoreline. The county also has approximately 11 miles of freshwater lake shoreline, including five lakes on Whidbey Island and one on Camano Island.

Climate and geology have combined to make Island County a beautiful place to live and an important collection of habitats for the many species that reside in or migrate through the Puget Sound region. Situated at the north end of Puget Sound, Island County has a relatively cool and moist climate that is conducive to development of dense coniferous forests on land, and a rich and diverse sea life. Since shortly after the last major glaciation in Puget Sound about 13,000 years ago, forests with enormous fir, cedar, and hemlock trees covered most of the island until about 150 years ago, when they began being logged off. (White, 1980).

Island County stands at the gateway to two major water bodies. On its west flank, Island County includes a portion of Admiralty Inlet, the mouth of Puget Sound through which the vast majority of tides currents entering and leaving Puget Sound must pass. The islands also flank Skagit Bay and Port Susan, where the Skagit River, the second largest river basin in the state, and the Stillaguamish River respectively empty into Puget Sound. These rivers are very important to the salmon that run between the Cascade Mountains and the Pacific Ocean, and a great deal of attention is currently focused on restoring their delta areas to facilitate salmon recovery.

3.1.1 Ecosystem Processes

Ecosystem processes are interactions among physical, chemical, and biological attributes of an ecosystem that lead to an outcome of change in character of the ecosystem and its components (i.e., changes in ecosystem state). The nearshore processes that influence the marine and estuarine shorelines of Puget Sound are classified into three general scales of influence on nearshore ecosystems: regional influences, broad physiographic processes, and local geochemical and ecological processes. The large-scale, long-term regional influences form the backdrop for the broad physiographic processes, within which occur even more local, fine-scale geochemical and ecological processes. Regional influences include factors such as climate, wave exposure, geology, inherited physiography, sea level history, and tidal regime. The broad physiographic processes are landscape-forming processes. Examples of broad physiographic processes include sediment input to beaches and distributary channel formation. The local

geochemical and ecological processes that occur within a given landscape structure are shaped by the combined effect of the regional influences and broad physiographic processes. They vary on the order of meters, within the local structure of nearshore ecosystems, and thus are spatially and temporally complex.

Examples of local geochemical and ecological processes include geochemical reactions that lead to nutrient cycling, primary production of plants, and food web interactions. (PSNERP Strategic Needs Assessment Report January – Draft 2010)

The broad physiographic processes identified by Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) as being most important to the creation, maintenance, and function of Puget Sound's shoreline ecosystems are listed in Table 3-1 (from Simenstad et al. [in review]).

Table 3-1. Nearshore Ecosystem Processes

Nearshore Ecosystem Process	Process Description
Sediment Input	• Delivery of sediment from bluff, stream, and marine sources into the nearshore; depending on landscape setting, inputs can vary in scale from acute, low-frequency episodes (hill slope mass wasting from bluffs) to chronic, high-frequency events (some streams and rivers). Sediment input interacts with sediment transport to control the structure of beaches.
Sediment Transport	• Bedload and suspended transport of sediments and other matter by water and wind along (longshore) and across (cross-shore) the shoreline. The continuity of sediment transport strongly influences the longshore structure of beaches.
Erosion and Accretion of Sediments	• Deposition (dune formation, delta building) of non-suspended (e.g., bedload) sediments and mineral particulate material by water, wind, and other forces. • Settling (accretion) of suspended sediments and organic matter on marsh and other intertidal wetland surfaces. These processes are responsible for creation and maintenance of barrier beaches (e.g., spits) and tidal wetlands.
Tidal Flow	• Localized tidal effects on water elevation and currents, differing significantly from regional tidal regime mostly in tidal freshwater and estuarine ecosystems.
Distributary Channel	• Change of distributary channel form and location caused by combined freshwater and tidal flow. Distributary channel migration affects the distribution of alluvial material across a river delta.
Tidal Channel Formation and Maintenance	• Migration • Geomorphic processes, primarily tidally driven, that form and maintain tidal channel geometry. • Natural levee formation.
Freshwater Input	• Freshwater inflow from surface (stream flow) or groundwater (seepage) in terms of seasonal and event hydrography. Freshwater input affects the pattern of salinity and sediment and soil moisture content across the nearshore.
Detritus Import and Export	• Import and deposition of particulate (dead) organic matter. • Soil formation. • Recruitment, disturbance, and export of large wood.
Exchange of Aquatic Organisms	• Organism transport and movement driven predominantly by water (tidal, fluvial) movement.
Physical Disturbance	• Change of shoreline shape or character caused by exposure to local wind and wave energy input. • Localized and chronic disturbance of biotic assemblages caused by large wood movement, scour, and overwash.
Solar Incidence	• Exposure, absorption, and reflectance of solar radiation (e.g., radiant light and heat) and resulting effects. Solar incidence controls photosynthesis rates and temperature patterns in the nearshore.

Sediment in Island County comes from two primary sources: river deltas of the Skagit and Stillaguamish, and the eroding bluffs along the marine shoreline. The river deltas have formed large complexes of wetlands and mudflats in the eastern waters of the county. Most beaches in the county are backed by bluffs that erode and feed the beaches below. Bluffs are susceptible to landslides, particularly during periods of heavy precipitation, but also due to toe erosion. The beaches are important habitat for birds, shellfish, and small fish that larger fish species forage on. In a few areas, coastal lagoons have formed on the shorelines, typically behind a barrier beach. These lagoons and other shoreline features like pocket estuaries and embayments provide important habitat for salmonids and other marine life, protected from waves, currents, and larger predators, and rich in forage species. Salmon, in turn, provide sustenance for a wide range of predators, including the endangered Southern Resident orca population often seen from the shores of Island County.

3.1.2 Human Activities

Human activities such as land clearing, creation of impervious surfaces, diking of floodplains, shoreline armoring, and others can negatively affect ecosystem-wide processes. By changing the movement of water, sediment, wood, nutrients, pathogens, and toxic compounds through the watershed, human activities can degrade natural habitats and their functions.

About 10,000 to 12,000 years ago, humans began to inhabit islands in northern Puget Sound. Humans modified the environment in a few coastal areas of Island County using fire to maintain prairies that were used as both gardens and hunting grounds. However, it was not until European-American settlers arrived in the 19th century that significant changes to the forest and widespread human settlement began to occur. European-American settlers had the technology to harvest and the markets to sell the huge timbers, and as a result, all but a small fraction of the forest was logged off. Replanting was not economical, and many areas were cleared to use as farmland. By 1950, approximately 51,455 acres were actively farmed in Island County. Farming introduced the practice of diking and draining coastal lagoons in order to create pasture land (White, 1980). Rolling farmlands and forested tracts are important components of the Island's rural ambiance. Farming which occurs on 40 acres or greater tracts, includes some livestock (dairy and beef), vegetable, berries and commercial seed production. Smaller farms of less than 20 acres in size support a variety of specialty crops.

Although the county once had a sizable shipbuilding and timber milling industry on its shorelines, depletion of forests and the shift away from wooden craft caused these businesses to close. In the early 20th century, the county became known for its scenery and rural tranquility, especially as the automobile and the construction of new roads made it possible to tour the dramatic vistas from the growing urban areas of Seattle, Everett, and Bellingham. Since that time, recreational and residential uses have grown steadily and are now the dominant uses of the shorelines. Because the dramatic scenery is part of the quality of life people are drawn to, residential use has meant further clearing of the forest along the shorelines for roads, views, and homes sites, (White, 1980).

In some cases, bluffs were cut with hydraulic cannons to create beachfront property for cabins and homes. To protect development from coastal erosion, which is common on many of the county's shorelines, bulkheads have been constructed in some areas. Residential use has driven

water consumption, and the limited fresh water supplies on the island have been strained in several areas (Island County/WRIA 6, 2005). Recreational demand drove the creation of lakes from coastal lagoons, residential docks around lakes, marine residential communities with dredged channels for boats, and numerous public parks along shorelines.

These changes to Island County shorelines, together with other changes throughout the region, have altered the ecosystem in several ways that have been detrimental to fish, marine mammal, bird, shellfish, and native plant populations in Island County, and also affect the health safety and welfare of the people of Island County.

3.2 Climate, Geology, and Landforms

3.2.1 Climate

Precipitation is important to Island County because most of the county's drinking water from aquifers that are recharged only by rainfall. Due to the rain-shadow effect of the Olympic Peninsula Mountains, areas of Island County vary in precipitation from 17 inches to 40 inches annually. Shorelines are particularly susceptible to saltwater intrusion into groundwater wells, a topic discussed in the Groundwater section.

Wind is a factor in both direct erosional effects on western Whidbey Island and in wave effects throughout the county's shorelines. The topography adjacent to Puget Sound constrains the wind within fjord-like channels, which are primarily oriented north-south, except near the Strait of Juan de Fuca. From October through March the air flow is predominantly from the south-southwest. Through the spring, air flow gradually reverses direction until it is predominantly from the north. Highest monthly wind speeds are in the range of 6 to 9 m/sec (13-19 mph) and are from the south between September and May. Highest monthly wind speeds from the north are in the range of 5 to 7 m/sec (11-15 mph). (Williams et al. 2001, Coomes et al. 1984).

Climate change projections suggest that in the Puget Sound region overall precipitation will remain about the same or rise slightly (Snover et al. 2005). Some models show large seasonal changes, especially toward wetter autumns and winters and drier summers. Two regional climate model simulations generally indicate increases in extreme rainfall magnitudes throughout the state over the next half-century, but their projections vary substantially by both model and region (Littel, et al., 2009). Higher precipitation could improve groundwater conditions in the county, but higher intensity storms could also increase runoff rates, resulting in a lower percentage stored in groundwater. Drier summer conditions could exacerbate the high groundwater demand periods already experienced in some areas. See groundwater discussion below.

Gradual warming of the planet is melting ice caps, causing gradual sea level rise. Models vary but the average projection for Puget Sound is an approximately 1.5-foot rise in sea level by 2100 (Canning, 2005). Local warming is not projected to be as great as the global model, ranging up to 2.2 degrees increase by 2040 (Littel et al., 2009).

3.2.2 Geology

The underlying geology of Island County was formed by numerous faults that cross the county (Dragovich et al. 2005). The majority of Island County geology consists of glacial and non-glacial fluvial deposits from multiple continental glacial ice sheet advances and interglacial periods (Easterbrook et al. 1967, Easterbrook 1992). Beaches backed by coastal bluffs made of glacial deposits comprise the majority of the shorelines, followed by barrier beaches fed by eroding coastal bluffs, and bedrock is exposed only on a small percentage of the county shore near Deception Pass. Further discussion of shoreline landforms (shoreforms) is included below.

Coastal bluffs are the primary source of sediment for most Puget Sound beaches (Keuler 1988, Downing 1983). Mass wasting (landslides) and erosion of these bluffs deliver sediment to the beach in large quantities. A secondary sediment source is rivers and streams, but these are thought to contribute only on the order of 10 percent of beach sediment (Downing 1983, Keuler 1988). This is not considered to be a major issue for most of Island County, but is a factor in the northeast portions in Skagit Bay and Port Susan. Feeder bluffs actively supply sediment to the nearshore across approximately 38 percent of the shore length (Johannessen and Chase 2005). Active toe erosion and recent landslides affect adjacent down-drift shoreline character and composition of critical habitats, such as spits and beaches.

Landslides along coastal bluffs are the result of numerous interacting variables, including climate, sea level rise, and several site-specific factors (Bray and Hooke 1997). Site-specific factors include: the characteristics of the bluff material, local topography, hydrodynamics and the protection offered by the beach, landslide history, and management practices (Emery and Kuhn 1982). In Puget Sound, bluff erosion is typically driven by a combination of factors; for example, seasonal drivers such as storms interact with locally variable bluff geology, toe (basal) protection and other factors, including management practices (Shipman 2006).

Coastal landslides typically occur during periods of high precipitation on bluffs with a combination of characteristics making the bluff more vulnerable to slope failure (Tubbs 1974). Landslides are more likely to occur in areas where there is a history of landslides or where the lower bluff strata is comprised of an unconsolidated, permeable layer (sand), overlaying a (more) consolidated impermeable layer (such as dense silt or clay) (Gerstel et al. 1997). As water seeps through the permeable layer and collects above the impermeable layer a zone of weakness or "slip-plane" is created.

Undercutting of the toe of the bluff is the long-term "driver" of bluff recession (Keuler 1988). Windstorms that create significant wave attack of the bluff toe also trigger bluff failures. Bluffs that are exposed to greater fetch are subject to higher wave energy during storms, resulting in greater toe erosion and bluff undercutting, thus more frequent landslides (Shipman 2004). Bulkheads can reduce wave attack to bluff toes but can accelerate erosion of the beach by reflecting wave energy.

Coastal erosion rates vary throughout Island County and are not only important processes in habitat formation, but also affect stability of structures. In 1988 Keuler calculated rates for several locations based on 20 years of recorded data. Erosion was measured in two ways:

- linear retreat in centimeters per year (cm/yr), and
- volume of material in cubic meters per lineal meter of shoreline per year ($m^3/m/yr$).

Table 3-2 shows the erosion rates for all sites evaluated combined into a single ratio of cm/m^3 per meter of shoreline per year.

Table 3-2. Erosion rates from selected sites in Island County (Keuler 1988).

Reach	Erosion Rates - Average erosion using 20 years of data (cm/volume m^3 per meter of shoreline per year)					
Sub-area	Site 1	Site 2	Site 3	Site 4	Site 5	Site Average
W. Whidbey	14/3	22/7	4/2	11/1.6	--	13/3.4
E. Whidbey	13/0.4	5/0.2	6.5/1.4	11/1.6	15/1.7	10/1.1
Camano	3/2	--	--	--	--	3/2

*Erosion rate denoted as x/y where x = linear retreat in cm/yr and y = erosion volume in m^3/m shoreline each year.

The most extensive coverage of erosion rates was from the east side of Whidbey Island, followed by the west side of Whidbey Island. Camano Island only had one recorded erosion rate site, which was located at Sunset Beach on Saratoga Passage. Overall, west Whidbey Island had the highest erosion rates, averaging 13 cm/yr with an estimated volume loss of 3.4 $m^3/m/yr$, but as can be seen in table 3-1, rates varied significantly at the various sites. East Whidbey averaged less bluff retreat and less volume loss. The one erosion rate site on Camano Island measured 3 cm/yr linear retreat with an estimated volume loss of 2 $m^3/m/yr$ of shoreline. Point Partridge located along West Whidbey Island (Site 2) in the Strait of Juan de Fuca, exhibited both the highest linear retreat rate (22 cm/yr) the highest erosion volume rate (7 m^3/m) of volume loss per year. The importance of understanding this range of values is to recognize that erosion rates need to be evaluated on a site specific basis when permitting new development or otherwise modifying shorelines. Retreat rates are important because they can inform decisions about where to safely locate a home or other development. The volume of eroded material is important because this is what feeds the beach, and by stopping the supply of such material with artificial stabilization, downdrift beaches can experience increased erosion.

Storms that coincide with elevated water levels, such as a storm surge or extraordinary high-high tide, often initiate landslides throughout the Puget Sound region (Johannessen and Chase 2003). The wave attack caused by a storm that occurs in conjunction with heightened water level can produce dramatic toe erosion, which then undermines and destabilizes a larger portion of the bluff that may not fail (slide) until subsequent wet-weather months.

Seepage can sometimes be observed in the bluffs of Island County. The highest volumes of groundwater observed seeping from the bluff face typically occurs following prolonged heavy precipitation. Periods of high rainfall intensity and duration (especially during saturated soil

conditions) are the most common trigger of coastal landslides (Tubbs 1974, Thorsten 1987), such as those observed at New Years 1996-97 (Gerstel et al. 1997, Shipman 2001).

Surface water volumes often increase and become more concentrated as a result of development of housing and roads. This is due to decreased infiltration and interception of water. Concentrated surface water can locally erode bluff crests while also saturating soils, which exacerbates "natural" slope stability problems along coastal bluffs and can trigger landslides (Shipman 2004). Runoff flowing down a driveway and rapidly across a lawn (which can absorb little water when wet) as sheet flow to the bluff face is an example of this process. A broken drainage pipe (often called a "tightline" and typically a low-strength, flexible, corrugated pipe) on a bluff face is another form of development triggering slides; failed tightlines have often contributed to initiating coastal landslides in Island County.

Removal or lack of bluff vegetation can result in low root strength (of scattered ornamental plants and grass) and increased likelihood of future landslides (Schmidt et al. 2001, Zimmer and Swanson 1977, Bishop and Stevens 1964). Bluffs with significant modifications to both the natural drainage regime and vegetation are particularly susceptible to landslides. Reestablishment and maintenance of native vegetation cover or installation of a fibrous-rooted vegetation cover along with some type of drainage control can reduce the likelihood of the bank failures (Gray and Sotir 1996, Menashe 2001, Roering et al. 2003).

3.2.3 Landforms

Coastal landforms (also referred to as shoreforms) in Island County have been characterized in previous efforts by Shipman (2008) in the Technical Report: A Geomorphic Classification of Puget Sound Nearshore Landforms. Figure 3-1shows the percentage of shore length of each shoreform type as they occur in Island County, and broken down in the West Whidbey, East Whidbey, and Camano Island geographic areas. These shoreforms are shown on Map 10 in Appendix A.

For the county as whole, bluff back beaches comprise nearly 58 percent of the shoreline, and barrier beaches comprise another 25 percent. Because they are so prevalent and so essential to the formation and maintenance of other shoreforms, the management of bluff back beaches affects almost all shoreforms. Coastal lagoons, embayments, and pocket estuaries cover a smaller percentage of the shoreline but are in some ways more important because they are relatively scarce and they support a wider diversity of life forms and stages of life. These habitats have also been heavily altered for agriculture, dammed to create freshwater lakes, or filled or dredged to support recreational and residential development. The importance of coastal lagoons, marshes, and other wetlands is discussed further in the description of fish and wildlife habitats below.

As with the county as a whole, on the West Whidbey Island shore the most dominant shoreform (by length) is bluff back beaches. Barrier beaches are more common on West Whidbey Island than other parts of the county, comprising 34 percent of the shoreline length. Artificial landforms comprise 12 percent of the West Whidbey shore, the highest percentage in this category of the three geographic areas. Approximately half of those modifications are located in two developments that include small lot development clustered around dredged channels, and total

nearly 4 miles of shoreline length. Although this proportion appears to be high, PSNERP rated the shoreline processes on the two largest reaches of West Whidbey Island as "least" or "less" degraded, compared to other Puget Sound shorelines. Approximately 10 percent of the shores of West Whidbey are lagoons, marshes or other wetland habitats, a relatively high percentage. This includes barrier lagoons (4%), barrier estuaries (3%), and closed lagoons and marshes (3%). Pocket beaches (1%), open coastal inlets (0.8%), and rocky platform shores (0.6%) make up the rest of the shores of west Whidbey.

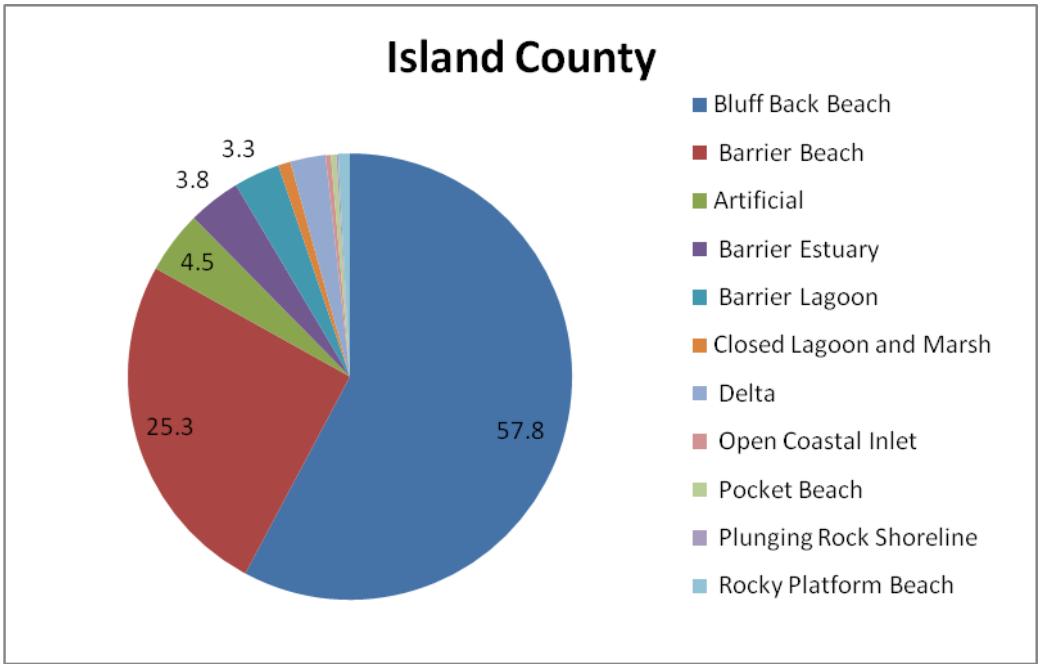
The East Whidbey shore has the highest percentage of bluff back beaches among the three geographic areas with 70 percent. The East Whidbey shore also has a relatively large proportion of barrier beaches with 19 percent. Artificial landforms were mapped along 1.4 percent of the shore along this geographic area, despite the fact that this includes all of the incorporated areas of the county. Other landforms that occur along the East Whidbey area include barrier estuary (4%), rocky platform beach (2.4%), barrier lagoon (2%), plunging rock shoreline (0.5%), open coastal inlet (0.4%), and pocket beach (0.2%).

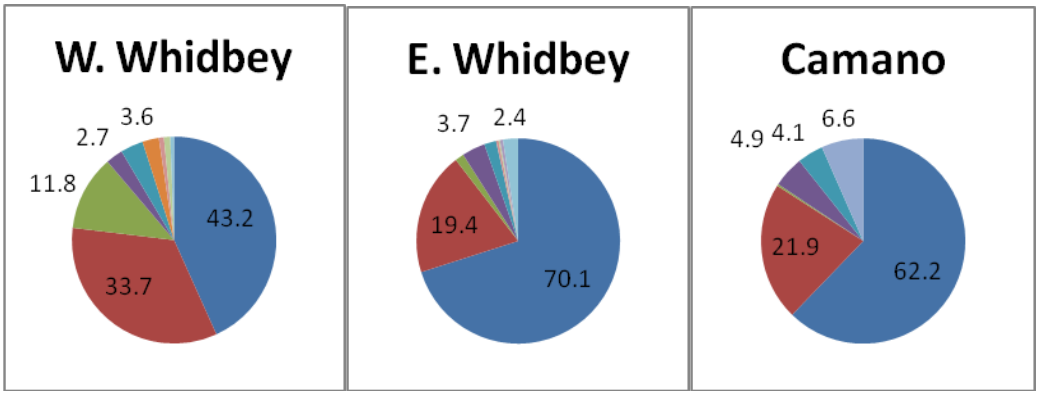
On Camano Island bluff backed beaches with make up 62 percent of the total shoreline length. And barrier beaches make up 22 percent. The delta landform is important on Camano Island, encompassing 7 percent Island's shoreline, primarily along the east shore of the island due to the influence of the Stillaguamish River and the Skagit River northeast of the island. Barrier estuaries and barrier lagoons also occur more on Camano Island than in the West Whidbey and East Whidbey sub-areas, with 5 percent and 4 percent, respectively. Far fewer artificial shoreforms (0.3%) were mapped on Camano Island than on Whidbey Island.

3.2.4 Vegetation

It is recognized that most vegetation is beneficial to the shoreline; however, native vegetation is generally more beneficial because local species have evolved together; thus, native vegetations is more likely to be self-sustaining and to sustain healthy ecological functions. Important functions of shoreline vegetation include, providing shade necessary to maintain water temperatures required by salmonid, forage fish, and other aquatic biota; regulating microclimate in riparian and nearshore areas; providing organic inputs necessary for aquatic life, including providing food in the form of various insects and other benthic macro invertebrates; stabilizing banks, minimizing erosion and sedimentation, and reducing the occurrence/severity of landslides; reducing fine sediment input into the aquatic environment by minimizing erosion, aiding infiltration, and retaining runoff; improving water quality through filtration and vegetative uptake of nutrients and pollutants; providing a source of large woody debris to moderate flows, create hydraulic roughness, form pools, and increase aquatic diversity for salmonid and other species; and, providing habitat for wildlife, including connectivity for travel and migration corridors.

Figure 3-1. Percentage of coastal shoreline landforms/shoreforms (Shipman 2008).





Marine Shoreline	Lineal Miles
W. Whidbey	67
E. Whidbey	77
Camano Is.	52
Island County	**196**

3.3 Surface and Ground Water

Surface water features are shown on Map 4 in Appendix A. There are numerous small streams to reach the shoreline throughout Island County. The fact that the streams are so small owes to the limited land area in each drainage basin, as well as to soil permeability and rainfall rates. For similar reasons, there are a total of almost 300 lakes in Island County, yet only six with at least 20 acres of open water and therefore within shoreline jurisdiction. Most are natural lakes but in a few locations like Dugualla Bay and Cranberry Lake on Whidbey Island, freshwater sources have been impounded to create freshwater lakes where there had been tideflats or coastal lagoons. Surface waters also include wetland areas (shown on Map 4 Appendix A); these are discussed in the fish and wildlife section below.

Precipitation falling within the many Whidbey and Camano Island basins is conveyed directly to lakes and streams by surface runoff or travels in the subsurface as groundwater flow. Water from precipitation generally soaks into the ground, but during heavy rainfall the ground quickly becomes saturated, inhibiting further infiltration. Water that is unable to infiltrate travels down slope across the ground surface as stormwater runoff. Surface runoff may erode soil, which is conveyed to wetlands, lakes, and streams and eventually to the shoreline of Puget Sound. Impermeable surfaces such as pavement, rooftops, or compacted ground increase stormwater runoff. Conversely, vegetation promotes infiltration by intercepting rainfall, effectively spreading precipitation events over longer periods of time and reducing peak flows and associated sediment transport. Vegetation also reduces erosion by holding soil in place and reducing splash erosion.

Many of Island County's small lakes, associated wetlands, and depressional wetlands are located in areas of poorly drained soils. The County's lakes and depressional wetlands regulate the flow of water within a watershed by storing water during precipitation events, slowing the conveyance of water from the upland to the shoreline, and increasing infiltration. Development has altered the area of wetlands and small lakes at variable levels across the County, however these freshwater areas still provide significant flow attenuation, infiltration, and base flow maintenance functions.

Along with these hydrologic functions, the numerous lake and wetland areas naturally provide physical and chemical filtration and treatment functions supporting maintenance of surface water quality. Lakes and wetlands are also generally a sink for sediments suspended in inflow surface waters. For surface water areas situated in basins that are altered by rural, residential, forestry, or agricultural land uses, water quality degredation is common. Water quality in lakes (i.e. trophic state) is commonly determined by a combination of three indicators: clarity, nutrient levels (total phosphorus), and algae levels (chlorophyll concentrations). Trophic state results are used to classify lake water quality into three categories: oligotrophic (refers to lakes of low productivity), mesotrophic (moderately productive), and eutrophic (highly productive). Although lake productivity is essential to life in a lake, high productivity can be undesirable due to the potential for increased algae growth. Rapid changes in a lake's trophic state may also indicate effects from human-induced activities. Water quality and trophic state information (where available) for shoreline jurisidcitonal lakes within Island County is discussed in Chapter 7.

Groundwater is Island County's main water source for human consumption. Seventy-two percent of Island County residents rely on groundwater. Furthermore, the quality and quantity of groundwater reaching the shoreline can impact shoreline habitat, human health, and aquacultural uses. As such, groundwater quantity and quality are of critical importance to Island County, and were the focus of a document prepared by Island County in 2005 entitled: *Island County Water Resource Management Plan* (Island County, 2005). The following summary is excerpted from that plan unless otherwise noted.

Island County's groundwater geology is highly complex. Its aquifers are made up of multiple layers of unconsolidated sand and gravel capable of supplying water to wells. Mixed between these aquifers are layers of silt and clay that pass water more slowly (aquitards). From place to place in Island County, aquifers and aquitards vary in thickness, width, and depth below surface. There may also be several aquifer layers present, each with different characteristics (recharge, pressure, capacity, etc.).

Islands in marine waters pose unique challenges for groundwater management. All of Island County's groundwater aquifers are recharged only by rainfall infiltrating through land surfaces. Due to the rain-shadow effect of the Olympic Peninsula Mountains, areas of Island County vary in precipitation from 17 inches to 40 inches annually. Some of the county's aquifers (such as those at or below sea level near the shorelines) are connected to the saltwater of Puget Sound. Portions of these aquifers may contain saltwater. Seawater intrusion, the movement of marine saltwater into freshwater aquifers, is a serious issue in some areas of the county.

A U.S. Geological Survey (USGS) study estimated that 20-34 percent of rainwater falling on Island County is available to recharge its groundwater aquifers (approximately 22 billion gallons). Remaining precipitation runs off the surface of the land, evaporates, or percolates to the root zone and is used by plants. Island County estimated that current (as of 2005) water use was approximately 13 percent of the rainfall that reaches the aquifer. While this suggests that there is ample water to accommodate growth, not all of the remaining 87 percent of the water reaching the aquifer is available for human use. Seawater may replace freshwater if it is over-extracted, and so some quantity of fresh groundwater must remain in aquifers in order to maintain pressures sufficient to maintain equilibrium. So far, Island County has generally had an adequate supply of groundwater to support its population and economic growth. There are isolated areas where supply has been limited or dewatered, and/or subject to seawater intrusion. Sea level rise can also impact the freshwater component of groundwater, because a rise in sea level is accompanied by a landward movement of saltwater in the ground.

Groundwater quantity is dependent upon maintenance of adequate groundwater recharge rates. Human activities can greatly decrease groundwater recharge rates by removing vegetation (which slows runoff rates), adding impervious surfaces and directing runoff to pipes or streams rather than allowing natural percolation.

Managing surface contaminants is vital for maintaining groundwater quality. Surface contaminants can enter groundwater aquifers through the groundwater recharge process. Contaminant sources include roads, septic systems, agriculture, and residential lawns. In high recharge rate areas, surface water may move through soil and subsurface layers too rapidly for adequate removal of contaminants. Where groundwater aquifers are shallow, rainwater may not

move through enough soil and sub-surface material to filter out contaminants. Source protection is the most practical approach to prevent contamination, particularly in areas where surface water may percolate too rapidly for adequate filtering of contamination.

Nitrates are a contaminant of concern in some areas of Island County. Nitrate sources include septic systems and agriculture. Nitrates are not typically present in groundwater. Septic systems are currently designed to use the root zone of the upper soil layers to filter out nitrates. With inadequate design, operation or failure, however, nitrates may not be removed from septic systems and are free to migrate downward to aquifer supplies. The presence of nitrates indicates that other contaminants may soon be present: ammonia, total dissolved solids, nitrites, chloride, iron, lead, manganese, mercury, and fecal coliform bacteria. Island County has rated areas of the county for nitrate levels and mapped areas for their overall susceptibility to contamination, and found about 15 percent of aquifers to have high susceptibility. These are primarily in southern and northeastern Camano Island and several locations in central Whidbey Island.

County health standards have been adjusted to address potential saltwater intrusion and contaminant issues in establishing new wells or water appropriation rights.

Puget Sound weather patterns include occasional short-term (one- or two-year) periods of lower than average rainfall. In Island County, this affects surface waters almost immediately, but can also affect groundwater. The majority of aquifers in Island County are 200 to 300 feet deep. Due to low permeability soils and geology in most areas of Island County, travel-time between when a raindrop hits land surface and when it reaches the aquifer is on the order of several decades. Long travel time reduces the immediate effects of short-term droughts. However, during droughts, Island County aquifers are susceptible to over-pumping of wells, largely because people increase watering for landscaping. Aquifers and wells that are marginally capable of supplying water during normal use can experience low water and/or seawater intrusion during droughts. In fact, most wells in the county that do suffer from dewatering and/or seawater intrusion tend to get worse in the summer and better in the winter. Island County also has some high permeability areas that have travel-times of less than a year, which makes them more susceptible to short-term drought and at high risk for contamination. These areas are found throughout the county, but there are concentrations of high risk areas on southern Camano Island, southern Whidbey Island, and near Deception Pass on northern Whidbey Island.

3.4 Fish and Wildlife Habitats

This section describes some of the key Island County habitats and the ecological functions they provide. The habitats described in this section are summarized in Table 3-3 below.

Table 3-3. Habitats in Island County Shorelines

Coastal Zone/Habitat type (Reference Map in Appendix A)	Examples of Species that Depend on or Favor this Habitat	Example of Habitat in Island County	Thumbnail photo
Beaches, Pocket and Barrier (Map 10) Beaches are areas with unconsolidated sediments that are moved, sorted, and reworked by waves and currents. The beach area includes the upper intertidal zone, and low-tide terraces.	Shorebirds (e.g. Black Turnstone) and Mammals (e.g. River Otter) forage on the intertidal and low-tide terraces. Shellfish (e.g. Geoduck Clam) live in the low-tide terraces. Forage Fish (e.g. Sandlance) live throughout this area at higher tides, and lay eggs here.	Useless Bay Elger Bay Arrowhead Beach	 Elger Bay barrier beach, 2006 Shoreline Oblique Photo (Ecology Coastal Atlas)
Tidal flats (Sand and Mud) (ESTUR on Map 5) Tidal flats are gently sloping, intertidal and shallow subtidal areas with unconsolidated sand or mud substrates. Island County tidal flats are highly productive habitats, supporting high primary productivity and a diverse assemblage of benthic invertebrates and fish. Algal production on the surface of tide flats is an important source of food for prey items of salmonids and other fish.	Shellfish and invertebrates (e.g. little-neck clams, Dungeness crabs), shorebirds / Wading Birds (e.g. Dunlin Great-Blue Heron) forage on tidal flats, as do mammals such as raccoon, birds such as bald eagle, and glaucous-winged gull.	Livingston Bay Juniper Beach Cultus Bay	 Juniper Beach tidal flats (note 'beached' boats on flats), 2006 Shoreline Oblique Photo (Ecology Coastal Atlas)
Kelp and Eelgrass (Map 7) Eelgrass is a marine seagrass that forms extensive meadows or beds on gravel, fine sands or mud substrates in the lower intertidal and subtidal zones. Kelp is a large form of algae that can form dense, highly productive undersea forests that support many species of fish and marine mammals.	Fish species, including salmonids (e.g. Chinook) and forage fish (e.g. Herring) feed on invertebrates that live on eelgrass and kelp. Sea Birds (e.g. Red-throated Loon, Western Grebe; Marbled Murrelet) forage on the fish and crabs attracted to these habitats.	Saratoga Passage Penn Cove Holmes Harbor Admiralty Bay Smith and Minor Islands	 Kelp off of Island County shoreline (photo courtesy of ICMRC and Jim Ramaglia)

Coastal Zone/Habitat type (Reference Map in Appendix A)	Examples of Species that Depend on or Favor this Habitat	Example of Habitat in Island County	Thumbnail photo
Salt and Brackish Marsh (Map 10) Salt marshes and brackish marshes are habitats that occur in areas with tidal inundation. Salt marsh vegetation traps and stabilizes sediments. Marshes provide complex, branching networks of tidal channels where juvenile salmonid feed and take refuge from predators, as well as providing habitat connections to riverine and marine environments.	Songbirds (e.g. Common Yellow-throat; Marsh Wren), rails (e.g. Sora), and shorebirds (e.g. Greater Yellow-legs) are bird species that prefer lagoon and marsh habitats. These species forage seasonally in migration (Yellow-Legs, Common Yellow-Throat), or forage and nest year-round in these habitats (Marsh Wren). Mammals like river otter and muskrat live much of their lives in marsh habitats. Bald eagles and ospreys forage in coastal lagoons for fish including salmonids and sand sole.	Arrowhead Beach Lake Hancock Holmes Point	 Northern half of Lake Hancock coastal lagoon on west shore of Whidbey; note fronting barrier beach with open tidal channel; 2006 Shoreline Oblique Photo (Ecology Coastal Atlas)
Freshwater Wetlands (Map 5) Most freshwater wetlands are on slopes or in depressions surrounded by sloping land. Wildlife use of wetland habitats includes breeding, nesting / denning, moving, foraging, and resting.	The species using these habitats include wetlands specialists like waterfowl (e.g. Common Merganser; Green-Winged Teal) and some amphibians, species that spend part of their lives in wetlands, (e.g. Pacific Tree Frog; Yellow Warbler and Willow Flycatcher), and those that travel through wetlands as they move about the landscape, such as black-tailed deer, Northern Flickers, barred owls, and raccoons)	Cornet Bay Deception Pass State Park Lone Lake wetlands	 Freshwater wetlands adjacent to western Whidbey shoreline, near Swan Lake (Ecology Coastal Atlas)

Coastal Zone/Habitat type (Reference Map in Appendix A)	Examples of Species that Depend on or Favor this Habitat	Example of Habitat in Island County	Thumbnail photo
Marine Riparian Zones (Map 1) The riparian habitats of Island County are included within the western hemlock zone, dominated by western hemlock, Douglas fir, western red cedar, shore pine, and grand fir. Other components of this zone that occur in Island County are Oregon white oak and madrona trees, and small areas of Puget Sound prairie.	A diverse assemblage of wildlife species use this habitat, influenced by the amount of disturbance to the native habitats. Many bird species use this habitat year-round (e.g. black-capped chickadee) for foraging, nesting, and movement corridors. Other bird species such as Bank Swallow, Pigeon Guillemot and Belted Kingfisher nest in excavations in bluff faces. Peregrine falcons are raptors that nest in rocky cliff faces.	Deception Pass State Park Fort Ebey State Park	 Marine riparian forest along Deception Pass State Park (Ecology Coastal Atlas)
Forests (Map 12) This is the most extensive habitat in the lowlands on the west side of the Cascades and makes up much of the inland upland habitat across Whidbey Island. Forest habitats form the matrix within which other terrestrial and freshwater aquatic habitats occur as patches, especially streams, riparian areas, and wetlands.	Some species using these habitats include spend most or all of their lives in forests (e.g. Pacific Tree Frog; Yellow Warbler and Willow Flycatcher), while many others travel through forests as they move about the landscape (e.g. black-tailed deer, Northern Flickers, barred owls, and raccoons).	Deception Pass State Park	 Forest within Fort Ebey State Park (Bing Maps)
Streams (Map 5) Numerous relatively short streams drain to the marine shorelines of Island County. Island County streams receive surface water and shallow groundwater input from relatively small contributing basins.	Streams draining to the marine shoreline commonly support both anadromous and resident salmonids, including coho, Chinook, chum, bull trout, and cutthroat trout. Not all streams in Island County are mapped with salmonid use. Streams provide aquatic habitat for numerous other fish (sculpin, dace, stickleback) and invertebrate (crawfish, stoneflies, caddis flies) species. Associated riparian and wetland habitats support an assemblage of bird, terrestrial	Maxwelton Creek, Kristofferson Creek	 Maxwelton Creek and riparian corridor (Bing Maps)

Coastal Zone/Habitat type (Reference Map in Appendix A)	Examples of Species that Depend on or Favor this Habitat	Example of Habitat in Island County	Thumbnail photo
	mammal, and amphibian species.		
Lakes (Map 4) There are a total of almost 300 lakes in Island County, yet only six with at least 20 acres of open water and therefore within shoreline jurisdiction.	The species using these habitats include lake and wetlands specialists like waterfowl (e.g. Common Merganser, Green-Winged Teal) and some amphibians, species that spend part or most of their lives in aquatic areas (e.g. beaver, Pacific Tree Frog, Yellow Warbler and Willow Flycatcher), and those that travel through and/or around lakes as they move about the landscape, such as black-tailed deer, Northern Flickers, barred owls, and raccoons.	Deer Lake, Lone Lake	 Lone Lake shoreline (Bing Maps)
Prairie/Grasslands (Not mapped) Prairie/grasslands are rare throughout lowland Puget Sound and within Island County, with Ebey's Landing National Historical Reserve areas one of the few intact areas. These grasslands often include scattered oak trees. In the absence of wild or managed fire, prairie habitats typically are converted to forest beginning with encroachment of Douglas fir.	Prairies and grasslands provide habitat for an assemblage of terrestrial mammals, including significant habitat for squirrel, rodent, and other small mammal species; grassland birds, such as western bluebirds and raptors; and butterflies. These areas also provide habitat for federally and state threatened plant species.	Ebey's Landing National Historical Reserve	 Prairie habitat (Whidbey Camano Land Trust)

3.4.1 Beaches

Beaches are generally defined as areas with unconsolidated sediments that are moved, sorted, and reworked by waves and currents. The beach area generally includes the upper intertidal zone, beach face, low-tide terraces, and offshore zone to the limit of wave action. Beaches include both Pocket Beaches and Barrier Beaches, depicted on Map 10.

Sand beaches occur at scattered locations on Island County marine shorelines, especially along the west and south shores of Whidbey Island. Cobble beaches occur throughout the county marine shorelines on both Whidbey and Camano Islands. Beaches and other marine habitats along the Admiralty Inlet (Whidbey's western shorelines south of Admiralty Head) and Saratoga Passage (Whidbey's eastern shorelines south of Crescent Harbor and Camano's western shorelines) are designated Marine Stewardship Areas (Island County, 2011 – see Island County Marine Resources Committee website for more information: http://www.islandcountymrc.org/MSAs.aspx). The shorelines of Smith and Minor Islands are designated as an Aquatic Reserve by WDNR (WDNR, 2011 – more information available at: http://www.dnr.wa.gov/ResearchScience/Topics/AquaticHabitats/Pages/aqr_ac_smith_minor_island_rsrve.aspx).

Ecological functions of beaches include (Williams and Thom 2001; Williams et al. 2004; WDFW 2004; NWF, 2007):

- Forage fish spawning substrate;
- Habitat and refuge for intertidal fish and wildlife,
- Habitat/substrate for intertidal vegetation;
- Nutrient cycling;
- Primary production; and
- Shellfish habitat.

3.4.2 Tidal Flats

Tidal flats are gently sloping, intertidal and shallow subtidal areas with unconsolidated sand or mud substrates. Sand and mud flats frequently contain a number of channels formed by hydrologic processes that transport and distribute water, sediments and organic material, and provide some refuge for fish and invertebrates, especially during low tides. Sand and mud flats typically occur at mouths of rivers and streams where relatively large supplies of sediment are deposited as currents slow, and in embayments and depositional areas where wave and current energies are low (Map 5).

The shallow flats and inlets of the Island County nearshore are highly productive habitats, supporting high primary productivity and a diverse assemblage of benthic invertebrates and fish (SPSSRG 2004). Algal production on the surface of tide flats is an important source of food for prey items of salmonids and other fish (Redman et al. 2005).

Nutrient cycling on tidal flats and particularly the exchange of inorganic nutrients between benthic sediments and benthic infauna can be an important source of nutrients for algal growth and algal based food webs (Simenstad et al. 1991; Dethier, 2006). Tidal flats also provide habitat and foraging areas for a number of fish, including juvenile Chinook and chum salmon, as well as English sole, starry flounder, sand sole, speckled sanddab, and staghorn sculpin (Simenstad et al. 1991). Tidal flats are important habitat for waterfowl and shorebirds, providing foraging and rest stops of fall and spring migrations (NWF, 2007; Buchanan, 2006).

In Island County, sand and mud flat habitats occur in lower energy environments at the head of the major bays, such as Dugualla Bay, Cultus Bay, and Livingston Bay, Penn Cove, Triangle Cove, and Holmes Harbor (NWF, 2007; WDFW, 2008; WDNR, 2010).

3.4.3 Eelgrass and Kelp Beds

Eelgrass (*Zostera marina*) is a native marine rooted seagrass that forms extensive meadows or beds on gravel, fine sands or mud substrates in the lower intertidal and shallow subtidal zones of protected or semi-protected shorelines (Bulthuis 1994; Thom et al. 1998; Shaffer, 2003; Mumford, 2007). The eelgrass zone in Puget Sound is typically confined to areas between tidal elevations of +1 meter to -2 meters relative to mean lower low water (MLLW) (Thom et al. 2001, Simenstad 2000; Shaffer, 2003; Mumford, 2007).

Eelgrass ecosystems are highly productive, providing a source of organic matter to intertidal and shallow subtidal food webs. Eelgrass plants produce large amounts of organic carbon that is consumed directly by grazers, as well as forming the basis for complex detrital food webs (Williams and Thom, 2001; Mumford, 2007). Juvenile salmon, as well as a number of other animals depend on eelgrass habitat structure for refuge from predators. Eelgrass leaves provide physical structure that absorbs and dampens the energy of waves and currents, providing some buffering for adjacent habitats. Pacific herring use eelgrass for spawning substrate and for protection while eggs and juveniles mature (Williams and Thom, 2001; Mumford, 2007).

In Island County, eelgrass beds are found in numerous locations, with the most extensive beds being found on the east shore of Whidbey Island, and the west shore of Camano Island (Island Co., 2010; WDNR, 2010) (Map7). In addition to *Zostera marina* (the common and native eelgrass species), *Zostera japonica*, a non-native eelgrass also occurs in areas of Island County. Both native and non-native eelgrass beds provide habitat value for fish, but *Zostera japonica* has also been invasive in some shellfish areas in the state, adversely affecting shellfish harvesting. In such cases, there are tradeoffs between habitat values that must be considered when deciding whether to try to eradicate or tolerate the invasive species.

Kelp and other macrophytic brown algae can form dense, highly productive undersea forests that support many species of fish and marine mammals. Juvenile salmon and forage fish may preferentially use kelp stands in nearshore habitats (Shaffer 2003; Mumford, 2007). Dense kelp forests also dissipate wave energy and provide sheltered habitat for resting/rafting seabirds and other animals within the kelp forest or adjacent surface waters. Kelp forests are composed primarily of bull kelp (*Nereocystis luetkeana*) and other large brown algae, including the introduced Sargassum (*Sargassum muticum*). These plants are attached to the marine bottom

with holdfasts and require rocky or coarse substrates. Distribution is limited to areas with appropriate substrates, light penetration to the bottom and moderate wave/current energy.

In Island County kelp beds are located primarily on the west shore of Whidbey Island and adjacent to Smith and Minor Islands (Mumford, 2007; Island Co., 2010; WDNR, 2010) (Map 7).

3.4.4 Salt and Brackish Marsh

Salt marshes and brackish marshes are habitats that occur in areas with tidal inundation. Salt marshes typically occur at elevations at and above mean higher high water (MHHW) in areas where sediment supply and accumulation are relatively high. Therefore, salt marshes can occur in bays, along sand spits sheltered from waves and currents and most commonly on river and stream deltas. Marsh vegetation traps and stabilizes sediments. Marshes provide complex, branching networks of tidal channels where juvenile salmonids feed and take refuge from predators, as well as providing habitat connections to riverine and marine environments (Hood 2005).

Estuaries are embayments (bays) or semi-enclosed inland waters with freshwater inputs that serve as transition zones between marine and freshwater environments. Estuaries include the zone at the mouth of a stream dominated by the discharge of freshwater, and generally extend from the point of tidal influence seaward to the point where freshwater influences no longer dominate.

The ecological functions and biological resources of salt and brackish marshes include:

- Detrital based food webs;
- In-situ production of invertebrate prey items of importance to nearshore fish and birds (e.g., salmonid prey);
- Tidal channels provide refugia and foraging areas for fish and invertebrates; and
- Primary production.

The remaining salt marsh habitat in Island County is generally coincident with closed coastal lagoons, bays, and pocket estuaries such as Livingston Bay on Camano Island and Cornet Bay, Dugualla Bay, Crocket Lake, and Holmes Harbor on Whidbey Island.

On Whidbey Island, about 4,000 acres of historic salt marshes, such those at Useless Bay, were converted to farmland through diking before the 1960's (White, 1980), and most of that land remains in agricultural use.

Island County is located adjacent to some the most productive river estuaries in Puget Sound, including the Skagit, Stillaguamish, and Snohomish. These highly productive areas along with the numerous bays and smaller estuaries located along Island County's marine shorelines make it an important foraging and sheltering area for many fish and wildlife species. Eight species of salmonids use nearshore and estuarine habitats of Island County during juvenile life stages (SRP, 2005). Numerous bald eagle nesting territories and waterfowl concentration areas occur in shoreline areas and in coastal lagoons and lakes (WDFW, 2008).

Salt marshes historically were extensive in both the Stillaguamish and Skagit estuaries adjacent to Camano Island. A significant portion of the marshland adjacent to Camano Island in Skagit and Snohomish Counties was converted to farmland through diking. There are plans being considered by Skagit and Snohomish Counties to remove dikes from some of these former marshlands.

3.4.5 Freshwater Wetlands

The state of Washington (WAC 173-22-030) defines wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands play an important role in the landscape, performing:

- Biogeochemical functions related to trapping and transforming chemicals and improving water quality in the watershed;
- Hydrologic functions related to maintaining the water regime in a watershed and reducing flooding; and
- Food web and habitat functions (Granger et al., 2005; Adamus et. al, 2006).

The majority of wetlands in Island County are freshwater palustrine wetlands – not associated with streams or lakes (Map 5). None of the county's freshwater wetlands are connected to rivers (absent in the county). Although few county wetlands are connected to streams directly, many likely are connected to aquifers, streams, or estuaries by subsurface flow. Most freshwater wetlands are on slopes or in depressions surrounded by sloping land, making them susceptible to the quality of runoff from their contributing area. Slightly more than half of the county's freshwater wetlands are seasonal. About 20 percent of the county's freshwater wetlands are dominated by trees or shrubs (Adamus et. al, 2007; Adamus, 2008b).

Wildlife use of wetland habitats includes breeding, nesting / denning, moving, foraging, and resting. The species using these habitats include wetlands specialists like waterfowl and some amphibians, species that spend part of their lives in wetlands, such as Pacific tree frog, yellow warbler and willow flycatcher, and those that travel through wetlands as they move about the landscape, such as deer, woodpeckers, owls, raccoons, etc.

3.4.6 Marine Riparian Vegetation

Marine riparian zones occur at the interface between upland and marine aquatic systems (Culverwell and Brennan 2003; Brennan and Culverwell 2004; Brennan, 2007). Marine riparian zones occur landward from tidal inundation, but may be in the area influenced by salt spray or storm waves. The type of marine riparian vegetation that occurs along the shoreline is influenced by a number of factors, including: geology (shoreform), type of soil, steepness and height of the shoreline or bluff, annual precipitation, adjacent land uses, and surface runoff processes.

Healthy marine riparian areas provide a range of important functions, including water quality protection, sediment stabilization and control, wildlife habitat, nutrient retention, microclimate regulation, food sources for juvenile fish, shade/cover, and woody debris to provide complex

habitat structure and stabilize beaches (Brennan and Culverwell 2004; Brennan, 2007). Areas with intact riparian vegetation can also help protect slopes and bluffs from erosion hazards, mitigate storm damage, and stabilize slopes. Plant root masses provide stability by holding the soil in place. In addition, evapotranspiration removes moisture from the soil and can prevent high soil moisture or saturated soil conditions, which can lead to landslides or erosion hazards (Brennan and Culverwell 2004). The extent to which riparian zones perform these functions is dependent on vegetation composition, vegetation density, and the area continuously covered with vegetation (e.g., width of buffer and length of shoreline with buffer) (Knutson and Naef 1997).

Brennan and Culverwell (2004) note the following characteristics of healthy nearshore riparian systems:

- Long linear shapes;
- High edge-to-area ratios;
- Microclimates distinct from those of adjacent uplands;
- Standing or flowing water present all or much of the year, or a capacity to convey or retain water;
- Periodic flooding, which results in greater natural diversity;
- Composition of native vegetation differing from upland (inland) systems (e.g., different species composition, abundance, diversity, and structure), and
- Support systems for terrestrial and aquatic biota.

The riparian habitats of Island County are included within the western hemlock zone (Franklin and Dyrness, 1988; ESA Adolfson 2008), as the undisturbed native forest was dominated by western hemlock, Douglas fir, western red cedar, shore pine, and grand fir. Other components of this zone that occur in Island County are Oregon white oak and madrona trees, and small areas of Puget Sound prairie. Deciduous tree species, including red alder, vine maple, and big-leaf maple, dominate in disturbed sites including shoreline bluffs and areas of human disturbance. The dry exposed south-facing slopes of Whidbey Island are occupied by a mix of grassland and open woodlands dominated by Douglas fir and madrona.

The backshore is also a component of the marine riparian zone. The backshore consists of a narrow band of stranded logs and salt-tolerant vegetation such as dune wildrye, saltgrass, and gumweed.

Many areas of marine shoreline in Island County have relatively intact marine riparian vegetation, with the potential to provide water quality, shoreline stabilization, and contribute large woody debris (LWD) functions to the nearshore. Areas with largely intact marine riparian vegetation are found throughout the county, but examples include Deception Pass State Park and southeastern Camano Island. Areas with little or no riparian vegetation include Naval Air Station Whidbey Island and southeast Penn Cove.

3.5 Fish and Wildlife Species

The terrestrial and aquatic habitats in Island County support numerous fish and wildlife species, included species listed as threatened or endangered under the state and/or federal Endangered Species Act (Table 3-4).

Table 3-4. Island County Listed Species

Common name	Scientific name	Federal Status	State Status	Critical Habitat
American White Pelican	*Pelecanus erythrorhyncos*	Species of Concern	Endangered	No
Bald eagle	*Haliaeetus leucocephalus*	Species of Concern	State Sensitive	No
Humpback Whale	*Megaptera novaeangliae*	Endangered	Endangered	No
Southern Resident Killer Whale	*Orcinus orca*	Endangered	Endangered	Yes
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	Threatened	Yes*
Northern goshawk	*Accipiter gentilis*	Species of Concern	Candidate	No
Northern Spotted Owl	*Strix occidentalis caurina*	Threatened	Endangered	No
Olive-sided Flycatcher	*Contopus cooperi*	Species of Concern	None	No
Peregrine falcon	*Falco peregrinus*	Species of Concern	State Sensitive	No
Pileated Woodpecker	*Drycopus pileatus*	None	Candidate	No
Purple martin	*Dryocopus pileatus*	None	Candidate	No
Sandhill crane	*Grus Canadensis*	None	Endangered	No
Slender-billed white-breasted nuthatch	*Sitta carolinensis aculeate*	Species of Concern	Candidate	No
Western grebe	*Aechmphorus occidentalis*	None	Candidate	No
Coastal cutthroat trout	*Oncorhynchus clarkii clarkia*	Species of Concern	None	No
Bull trout	*Salvelinus confluentus*	Threatened	Candidate	Yes
Puget Sound / Strait of Georgia coho salmon	*Oncorhynchus kisutch*	Species of Concern	None	No

Common name	Scientific name	Federal Status	State Status	Critical Habitat
Puget Sound Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	Candidate	No
Puget Sound steelhead	*Oncorhynchus mykiss*	Threatened	None	Yes
Pacific lamprey	*Lampetra tridentate*	Species of Concern	None	No
River lamprey	*Lampetra ayresi*	Species of Concern	Candidate	No
California wolverine	*Gulo gulo luteus*	Species of Concern	Candidate	No
Long-eared myotis	*Myotis evotis*	Species of Concern	None	No
Long-legged myotis	*Myotis volans*	Species of Concern	None	No
Pacific Townsend's big-eared bat	*Corynorhinus townsendii townsendii*	Species of Concern	Candidate	No
Steller sea lion	*Eumotopias jubatus*	Threatened	Threatened	No
Western gray squirrel	*Sciurus griseus griseus*	Species of Concern	Threatened	No
Northwestern pond turtle	*Clemmys marmorata marmorata*	Species of Concern	None	No
Oregon spotted frog	*Rana pretiosa*	Candidate	Endangered	No
Tailed frog	*Ascaphus truei*	Species of Concern	None	No
Van Dyke's salamander	*Plethedon vandykei*	Species of concern	Candidate	No
Western toad	*Bufo boreas*	Species of concern	Candidate	No

*None in Island County

3.5.1 Marine Mammals

A number of marine mammals occur in the nearshore and marine waters of Island County, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), Steller sea lions (*Eumatopias jubatus*) and Southern Resident killer whales, or Orcas (*Orcinus orca*). Humpback whales (*Megaptera novaeangliae)* may also occasionally occur occasionally in Puget Sound. From six to ten Grays return most years to northwestern Whidbey Island or southeastern Whidbey Island and Port Susan, Camano Island, feeding on ghost shrimp and tubeworms for several months. In recent years (2008-2009) more gray whales have been reported feeding in more areas around Whidbey Island, including Holmes Harbor and along Whidbey Naval Air Station and Joseph Whidbey State Park near Oak Harbor. They also appear to be arriving earlier - some in January - and staying later - some not leaving until July (http://www.orcanetwork.org/nathist/graywhales.html) (WDFW, 2009).

Marine mammal haulouts have been mapped by WDFW offshore of Camano Island in Skagit Bay, near Livingston Bay, Near Baby Point (East Whidbey), on Smith and Minor Islands, and on Double Bluff Point (West Whidbey).

3.5.2 Salmon Habitat and Use

Whidbey and Camano Islands are located at the junction of the Puget Sound and the Strait of Juan de Fuca, placing them in the migration corridors used by most Puget Sound juvenile and adult salmon and trout populations. The County is adjacent to some of the most productive salmon-producing rivers (Snohomish, Stillaguamish, Skagit) in Western Washington. While returning to their natal rivers to spawn, adult salmon move through the County's marine waters, historically providing some of the regions most significant commercial and sport fisheries. Salmon species utilizing Island County habitats include ESA listed Chinook, bull trout and Hood Canal summer-run chum, along with Coho, chum, pink, sea-run cutthroat, sockeye, and steelhead. Although complex and not yet fully understood, it is clear that each of these species have unique and varied life histories, cumulatively requiring a diverse range of marine and freshwater habitats.

Salmon habitat in Island County falls into three general ecosystem categories: marine waters, nearshore, and coastal streams. While salmon are known to spawn in several of the County's creeks, from a regional standpoint, Island County's major contribution to salmon productivity is its nearshore habitats. As fish move to and from their respective natal streams, Island County's nearshore habitats provide several critical functions including refuge from strong currents and waves, food production, shelter from predators, migration corridors, and areas with fresh and salt water mixing for physiological transitions. These habitat functions are especially important for juvenile salmon, whose time spent in the nearshore supports growth and physiological changes necessary for a successful transition to adult life in the ocean. Prior to fully committing to life in the marine environment, some individual juvenile salmon actually return to freshwater, temporarily inhabiting small coastal streams after leaving their natal rivers.

The nearshore habitat functions these fish depend on are formed and shaped by large-scale ecosystem processes (e.g., hydrologic inputs, sediment transport and accretion, tidal exchange, and nutrient cycling). Sediment transport and tidal processes shape a complex and dynamic landscape, forming a variety of habitats including: eelgrass meadows, marshes, salt marshes, mudflats, pocket estuaries, and sand/gravel beaches. These diverse habitats support the complex food webs that juvenile salmon depend upon. Freshwater creeks, although not used for spawning, supply prey in the form of terrestrial insects, and the productivity of these habitats is influenced by terrestrial riparian conditions.

3.5.3 Forage Fish

In Puget Sound, forage fish species constitute a significant part of the marine food web, being particularly important as prey for wildlife including salmonid fish, marine mammals, and seabirds (Fresh et al. 1981; Pentilla 1995; Bargmann 1998; Buchanan, 2006; Kriete, 2007). Three species comprise the main forage fish species: surf smelt (*Hypomesius pretiosus*), Pacific herring (*Clupea harengus pallasi*), and Pacific sand lance (*Ammodytes hexapterus*). Forage fish species use a range of nearshore and estuarine habitats for feeding, rearing, and spawning.

Surf smelt and Pacific sand lance both spawn within a limited range of tidal elevations in the upper intertidal zones of beaches, and have specific habitat requirements including substrate size and type (Pentilla 1978, 1995). Eelgrass beds are important spawning substrate for Pacific herring; adhesive eggs are deposited on leaf blades of eelgrass and to a lesser extent on a variety of marine algae (Lemberg et al. 1997; Pentilla 1995; Mumford, 2007). Due to the spawning requirements of these species, suitable spawning habitat for forage fish is limited, and these species are particularly vulnerable to changes in beach morphology (relative depth, exposure), beach sediment characteristics (substrate size - sediment sources, transport, or deposition), and nearshore riparian vegetation cover (WDFW 2000, 2004). Manmade structures such as bulkheads and docks and piers have been identified as a threat to forage fish spawning areas by shading and blocking natural sediment transport processes (PSNERP, Marine Forage Fishes in Puget Sound).

Documented forage fish spawning beaches in Island County are concentrated on the east shore of Whidbey Island and most beaches on Camano Island outside of the estuarine-influenced areas along the island's northeast shoreline (English Boom to Livingston Bay). Limited forage fish spawning is also documented along the west shores of Whidbey Island (Map 6 in Appendix A).

3.5.4 Waterfowl and Marine Birds

Both resident and migratory seabirds and waterfowl are associated with Island County shorelines. Commonly occurring seabirds or waterfowl include loons (*Gavia* spp.), cormorants (*Phalacrocorax* spp.), mergansers (*Mergus* spp.), grebes (*Aechmophorus* spp.), herons and egrets (*Ardeidae*), geese (*Branta*), brants (*Branta bernicla*), gulls (Larinae), sandpipers (Scolopacidae), and ducks (dabbling and diving) (Buchanan 2006). In addition, a number of bird species identified as state priority wildlife species are associated with and forage along shorelines of Island County, including bald eagles (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), and great blue heron (*Ardea herodias*) (WDFW, 2008; Buchanan, 2006).

Waterfowl concentrations in Island County are associated with bays and estuarine areas. Major areas include Cranberry Lake, Dugualla Bay, Crocket Lake, Lake Hancock, Deer Lagoon, and the Skagit and Skykomish delta areas of Camano Island (WDFW 2008).

3.5.5 Shellfish

Cobble to fine sand beaches and sand and mud flats are important habitat for many shellfish species. Intertidal and subtidal areas that support the native Dungeness crab (*Cancer magister*) occur abundant in the northern portions of Puget Sound, often associated with estuaries and eelgrass beds (Stevens and Armstrong 1984). Geoducks (*Panopea abrupta*) occur offshore in

fine substrates of mud or soft sand, and typically burrow up to 2-3 feet deep into the substrate. A number of hardshell clams, including butter clams (*Saxidomus gigantean*), native littleneck (*Protothaca staminea*), manila clams (*Venerupis philippinarum),* horse clams *(Tresus capax* and *T. nutallii*), and Pacific blue mussels (*Mytilus trossulus*) also inhabit the intertidal shorelines. Olympia oyster (*Ostreola conchaphila*) and non-native Pacific oysters (*Crassostrea gigas*) are common in Island County. Other nearshore shellfish include a number of filter feeders that remove plankton from the water column - cockles (*Clinocardium nutallii*), softshell clams (*Mya arenaria*) and detritivores that feed on organic detritus on the surface of sediments – clams (*Macoma* spp.). Shellfish resources in Island County are important as the basis for commercial, recreational, and tribal harvesting, particularly for hardshell clams, oysters, and geoducks.

Shellfish beds perform a number of important ecological functions including nutrient cycling, stabilizing substrate, enhancing water quality (filtering and retention), creating and maintaining habitat structure (e.g., oyster reefs), and providing food for a wide variety of marine invertebrates, birds, fish and mammals. As filter feeders, shellfish consume large quantities of plankton and particulate organic matter, cleaning the water column of organic matter (and any pathogens or pollutants that are present). Shellfish species occupy a range of substrate types from mud to gravels, with each species having a preferred or optimal substrate size for larval settling and adult growth (Dethier 2006). Siltation can negatively impact larval shellfish by smothering, and adult shellfish through interfering with filter feeding. Shellfish are therefore sensitive to changes in sediment dynamics, especially increased erosion and inputs of fine sediments or changes in substrate type or size (Dethier 2006). Because shellfish filter the water column, they retain and concentrate pathogens and pollutants in the water – although this helps improve water quality, contaminated shellfish can negatively impact people and other animals that eat shellfish.

In Island County, shellfish beds and commercial and recreational harvest beaches are found in Port Susan Bay, Penn Cove, and Admiralty Bay, among others (WDFW 2008, WA DOH Annual Growing Area Review for Island County, July 2010).

3.5.6 Land Use and Land Cover

The ecosystems of Island County have been heavily modified by human activity, but land uses remain largely rural in character. The land uses in the county are tabulated in Table 3-5. Forest cover, ubiquitous before European-American settlers arrived, has been diminished but remains a major component of land cover. Almost all forested land has been logged at least once in the past century, and much forest land is occupied by relatively young forest stands. Agriculture is also a predominant land use. The majority of agricultural uses are pasture and hay, but there are also row crops grown in some areas.

Table 3-5. Land Uses in Island County

Land Use	ShorelinePlanning Area	County
Agriculture	9.6%	8.2%
Commercial	3.2%	1.9%
Cultural, Entertainment, and Recreational	0.5%	0.4%
Forest or Timber	1.3%	10.1%
Mining	0.0%	0.8%
NA	1.6%	3.1%
Parks and Open Space	5.1%	1.4%
Residential	40.0%	43.1%
Tidelands	11.0%	0.9%
Transportation, Communication, and Utilities	0.4%	0.3%
Vacant	27.2%	29.7%
Grand Total	100.0%	100.0%

Source: Island County 2010

Residential uses are the most common use throughout county, and also in shoreline areas. Commercial uses include the three incorporated areas and in the Freeland area comprise 1.9 percent of the land area in the county, but 3.2 percent of the shoreline planning area. The federal military bases include administrative, airfield, and housing uses a similar in character to the urban areas. They also include open areas used for military exercises. In the rural areas of more intense development, allowed densities range from 0.33 units/acre to 2.5 units/acre. These areas comprise 7.8 percent of the land area of the county and approximately 16 percent of the shoreline area.

3.6 Implications of Sea Level Rise

Sea level rise is expected to affect many of the habitat areas described above. Sea level rise will result in landward migration of the shoreline due to wave action and the addition of sediment from associated bluffs (Johannessen and MacLennan, 2007). Sand beaches associated with estuaries (e.g Arrowhead Beach on Camano) are particularly vulnerable to sea-level rise, and losses of 50 percent could occur in this century (NWF, 2007). Sea level rise is expected to affect tidal sand and mud flats, resulting in expected expansions in estuary areas (e.g. Port Susan Bay) and conversion of freshwater and estuarine marshes to tidal flats (NFS, 2007).

Rising sea level will cause salt marshes to move landward, and cause saltwater intrusion into fresh marshes, likely increasing the extent of salt marsh in Island County. Rising sea level near freshwater wetlands could cause salt intrusion from groundwater, and the introduction of saline surface water, both of which would cause the conversion of freshwater wetlands to brackish or estuarine wetlands (NWF, 2007). Rising sea levels could also result in a shift to more salt-tolerant species in areas affected by salt water surface or groundwater intrusion or salt spray (NWF, 2007), and could result in local shifts in habitat use patterns by shorebirds, fish, and other wildlife species to adjust to changing habitat conditions.