Chapter 4. Refuge Biology and Habitats

This chapter addresses the biological environment of the Protection Island and San Juan Islands National Wildlife Refuges (NWRs); however, it is not an exhaustive overview of all species and habitats. The chapter begins with a discussion of biological integrity, as required under the National Wildlife Refuge Administration Act, as amended. The biological integrity (601 FW3) analysis section introduces the biological environment by describing the native wildlife and vegetation that occur on the two Refuges in comparison to the surrounding landscape. The bulk of the chapter is then focused on the presentation of pertinent background information for the priority habitats and species that the Refuge Complex personnel will actively manage to accomplish biological conservation and/or restoration. The priority habitats and species are collectively known as the 'priority resources of concern' designated under this CCP. Background information includes description, location, condition, trends, key ecological attributes, and threats associated with each priority resource of concern. The information presented herein was used by the CCP team to develop goals and objectives for each of the priority resources of concern.

4.1 Biological Integrity Analysis

The National Wildlife Refuge System Improvement Act of 1997 directs the Service to ensure that the biological integrity, diversity, and environmental health (BIDEH) of the Refuge System are maintained for the benefit of present and future generations of Americans. In simplistic terms, elements of BIDEH are represented by native fish, wildlife, plants, and their habitats as well as those ecological processes that support them. National Wildlife Refuge System Policy on BIDEH (601 FW 3) also provides guidance on the consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuges and associated ecosystems that represents BIDEH on each refuge. Through the consideration of BIDEH, the refuges will provide habitat for all appropriate native species. Refuge management priorities may change over time, and since the CCP is designed to be a living, flexible document, changes will be made as needed and at appropriate times as identified by refuge personnel.

Protection Island NWR is located in the southeast corner of the Strait of Juan de Fuca approximately 2 miles from the mouth of Discovery Bay. Approximately 70% of the island's roughly 370 acres consists of an upland plateau surrounded by very high, steep-sloped sandy bluffs. Currently, about 80% of the plateau is covered by grassland and 20% by mixed coniferous forest. Sediment derived from the steep unvegetated bluffs along the north and south shorelines and transported by longshore currents to the ends of the crescent-shaped island results in two sand and gravel spits: Kanem Point on the southwest and Violet Point on the southeast.

The San Juan Islands NWR is located within the San Juan Archipelago, at the convergence of the Strait of Juan de Fuca and the Strait of Georgia. Geologically, the 83 small rocks, islands, and reefs comprising the Refuge contain extensive exposures of sedimentary, metamorphic, and/or volcanic bedrock which are occasionally overlain with glacial and alluvial deposits, particularly on the larger islands. The combination of these soil characteristics, near-drought conditions during the summer months, and highly variable topography and aspect results in a diverse assemblage of plant communities and ecological systems that range from xeric to mesic (Franklin and Dyrness 1988).

The BIDEH of the ecosystems, including and surrounding the Refuges, have undergone dramatic alterations since pre-settlement times. The most discernible changes are related to: a) the conversion and development of large portions of coastal areas into agriculture, housing, commercial, and industrial lands; b) human-caused wildlife disturbance; c) the introduction of contaminants into the aquatic environment; d) fisheries bycatch and marine debris; e) the alteration of fire regimes; f) the loss of native species accompanied by a large influx of non-native and invasive plants and animals into the system; and g) climate change. This section discusses the connection between these main landscape-level changes with the current vegetation and wildlife on the lands and waters occupied by the Refuges. This summary is not a complete analysis of all factors related to changes in native vegetation, fish and wildlife. For the purposes of this document, we define the Salish Sea as encompassing the Strait of Juan de Fuca, Puget Sound (Olympia north to Deception Pass and west to Hood Canal), and the Strait of Georgia (See Figure 1.1). This area effectively defines the ecosystem that encompasses the refuges. We use this term wherever relevant; however, it is a relatively new term and spans international boundaries. Therefore, throughout this chapter, we may refer to the sections of the Salish Sea listed above when a study, survey, or other source reports only for that section.

4.1.1 Habitat Loss or Degradation

Habitat conversion for human uses within the Salish Sea, which includes Protection Island and the San Juan Islands, has been rapid since the mid-late 1800s and continues today, bringing profound and widespread alterations to the watersheds and shorelines of the region. Logging and the milling of logs were among the earliest and more defining aspects of early settlement. Lower floodplains and tidal wetland areas were diked and drained in order to become prime locations for agricultural settlement. Major river delta areas such as Seattle and Tacoma were converted into centers of industrial and urban development. Today, over 40% of the region has been converted to urban or agricultural uses while most of the remainder is in production forestry (Floberg et al. 2004).

Furthermore, as residential, commercial, and industrial development occurs in close proximity to water, spit features and other low-lying sediment depositional areas along the shoreline were modified by armoring (bulkheads consisting of rock, concrete, and timber), large revetments (sloped face to protect a bank or shore structure, usually constructed of rock), causeways (fill corridors that extend across embayments), groins (cross-shore structures designed to trap sediment), overwater structures, fill, and dredging (Johannessen and MacLennan 2007). Approximately 34 percent, or 805 miles, of the shoreline inventoried by the Washington State ShoreZone Inventory has undergone such modifications (WDNR 2001). Shore modifications, almost without exception, impact the ecological functioning of nearshore coastal systems. The proliferation of these structures has been viewed as one of the greatest threats to the ecological functioning of coastal systems (PSAT 2003a, Thom et al. 1994).

4.1.2 Human-caused Wildlife Disturbance

Many of our partners have identified this threat in their plans and have identified similar strategies to ours to address this threat (USFWS 2005, WDFW 2005, Evens and Kennedy 2007, Mills et al 2005, NMFS 2008, Tessler et al 2007, USFWS 2007). The counties containing the Refuges (San Juan, Jefferson, Whatcom, Skagit, and Island) have experienced rapid (>50% increase) human population growth over a twenty year period from 1980 to 2000 (WSDOT 2009). Additionally, this area has become an increasingly popular tourist destination, particularly during the summer months. As a result, activities such as fishing, boating, recreational aviation, camping, and other economic and recreational activities have increased within the coastal areas. These activities often cause stress, reduced productivity, and increased predation of seabirds and pinnipeds associated with the Refuges (Rojek et al. 2007). Please refer to the Priority Resources of Concern sections for further discussion and detailed descriptions of habitat, associated wildlife, and disturbance factors.

4.1.3 Oil Spills and Other Contaminants

These two Refuges are particularly vulnerable to the threat of oil spills. Shipping lanes for cargo ships and large oil transport vessels that carry crude oil to refineries are located throughout the Salish Sea with primary ports in Seattle, Tacoma, Olympia, Port Angeles, Everett, Bellingham, Anacortes, Washington, and Vancouver, B.C. Tanker traffic alone through this area carries over 15 billion gallons of oil each year (WDOE 2009). Such high vessel presence increases the risk of oil spills that can cause devastation to the marine ecosystem. Additionally, other sources of hydrocarbon pollution from diesel, gasoline, kerosene, lubricant and various industrial oils are just as toxic to wildlife but can occur at a much smaller scale and may not be properly tracked (USFWS 2005).

In addition to the threat of oil spills, over the past 150 years human activities around the Salish Sea have introduced a variety of persistent, bioaccumulative toxic chemicals into the environment at levels that can be harmful to both humans and wildlife. These toxic chemicals include heavy metals such as lead, mercury, and copper, as well as organic compounds such as polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), dioxins, furans, phthalates, and polybrominated diphenyl ethers (PBDE). These contaminants enter the aquatic environment through a variety of sources and human activities including industrial and municipal discharges, groundwater seepage, atmospheric deposition, and resuspension of sediments (PSAT 2003b). While primarily concentrated in areas around urban or industrial developments, these contaminants affect a much larger area of the ecosystem. When organisms live in or eat within these areas of contamination, not only are they directly harmed but they also accumulate contaminants in their tissues and transfer them throughout the food web. In addition, ballast water and other waste dumping from ocean vessels increase contaminant load in the Salish Sea (Puget Sound Water Quality Action Team 2000).

4.1.4 Fisheries Bycatch and Marine Debris

With the growth of fisheries within the Salish Sea, the incidences of interactions between fisheries and seabirds and pinnipeds have increased. Seabird mortalities due to gillnet fisheries have been documented in Washington (Thompson et al. 1998). Additionally, the proliferation of derelict (lost or abandoned) fishing gear or nets is becoming a problem in the Salish Sea. Derelict gear poses an entanglement hazard to invertebrates, fish, waterfowl, seabirds, and marine mammals (Natural Resource Consultants 2004, Evens and Kennedy 2007, Natural Resource Consultants 2008, Northwest Straits Initiative 2008). During one study of 4 derelict nets in the Puget Sound, seabirds (88% of which were cormorants) were caught at a rate of 0.24 per day. At this rate, researchers calculated that each net could entangle approximately 7 seabirds per month. Compound that over the estimated 3,800 derelict nets distributed throughout the area and up to 26,600 seabirds per month could be lost to this threat (Natural Resource Consultants 2008). Seals have also been observed with wounds and scarring from entanglement with derelict gear and interactions with aquaculture (net pen) operations.

4.1.5 Alteration of Fire Regimes

The predominant pre-Euroamerican settlement vegetation on lowlands west of the Cascades, from the Willamette Valley of Oregon north to the Georgia Basin of southwest British Columbia, was a mosaic of grasslands, oak and conifer savannas, and various types of wetlands (Chappell and Crawford 1997, Sinclair et al. 2006). Oak woodlands and dry Douglas-fir forests were found in dry sites with shallow bedrock or deep, gravelly glacial outwash soils, and high growing season moisture stress (Chappell et al. 2001, Natureserve 2009). Historically, fire was a major component of these habitats.

In addition to occasional lightning strikes, fires were intentionally set by Native Americans to maintain food staples such as camas and bracken fern, prevent oak-dominated stands from converting to Douglas-fir forests, keep tree densities lower, and maintain grassy, as opposed to shrubby, understories. Although there is no definitive documentation of fire history, evidence suggests that many, if not most, grasslands and savannas burned every few years. Fire frequency within forests and woodlands probably ranged from frequent (every few years) to moderately frequent (once every 50-100 years), and reflected low-severity and moderate-severity fire regimes (Chappell et al. 2001a). The exclusion of fire from most of these habitats over the past 100-130 years has resulted in profound changes. In the absence of fire, trees show a tendency to encroach upon grasslands and savannas, eventually converting these areas to mixed conifer forests and woodlands. Fire suppression, along with factors such as invasive non-native species, grazing, and urban and agricultural conversion, has greatly reduced the amount of native grassland to just a small fraction of the pre-Euroamerican settlement extent. Estimates of remaining prairie vary from 10% of the pre-settlement extent in south Puget Sound (Crawford and Hall 1997), to less than 5% (including savannas) in southwest British Columbia (Garry Oak Ecosystem Recovery Team cited in Sinclair et al. 2006), to 1% in the Willamette Valley (Wilson et al. 1995).

4.1.6 Influx of Exotic, Invasive, and Other Species of Management Concern

Two of the largest threats to the wildlife and habitat of the Refuges are invasive plants and pest animals. Invasive plant species displace native vegetation, altering the composition and structure of vegetation communities, affecting food webs, and modifying ecosystem processes (Olson 1999). Introduced native and non-native wildlife can be in direct competition or prey on native wildlife for food, shelter, and breeding areas and often cause existing native species populations to decline or become extirpated. Ultimately, both plant and animal invasive species can result in considerable impacts to native wildlife and the habitat upon which they depend.

Invasive marine algae, plants, and wildlife

The ballast water of ships is a vector for the transport of marine invasive species (Carlton and Geller 1993) which threatens the conservation and sustainable use of biological diversity (Bax et al. 2003). These are some of the newest and least understood threats to the Refuges due to difficulties in monitoring and jurisdictional controls. Plants such as Japanese eelgrass, common cordgrass and the algae *Sargassum* seaweed have been recorded within the Salish Sea. Many of these species have infested large areas along the outer coast of Washington and removal has been costly. Other species of algae such as Japanese kelp and *Caulerpa* have not yet been found in the Salish Sea. To date, none of the species listed in Puget Sound Marine Invasive Species Monitoring Program - Target Species List (Eissinger 2009) are known to exist on or near any of the Refuge islands. Marine invertebrates are also a threat to Refuge resources that have not been well understood. The Refuge staff has begun monitoring for European green crab and plans to expand monitoring efforts to include tunicates, particularly at the Protection Island marina. The Service is required to maintain the marina on Protection Island and any infestation of these tunicates will impact native marine wildlife which may then affect Refuge trust resources. The effects of these threats are similar to that of oil spills, marine debris, and derelict fishing gear in that they occur mainly outside Refuge jurisdictional boundaries, but still affect Refuge resources.

Invasive, non-native terrestrial plants and animals

Non-native invasive plants on the Refuges include European beachgrass, Canada thistle, Himalayan blackberry, cheatgrass, Kentucky bluegrass, English ivy, field bindweed, and Scotch broom. This list is not all inclusive and includes only the most problematic species; many other exotic plants have been introduced.

Herbivores and predators of management concern

Native and non-native mammals that have the potential to negatively affect seabird populations and their habitats on the Refuges include black-tailed deer, European rabbits, rats, red fox, feral cats, domestic cats and dogs, river otters, racoons, and mink.

Black-tailed deer are native and abundant from the Cascade crest west toward the coast range (WDNR 2009, WDFW 2009). However, there are no historic records of black-tailed deer on Protection Island (Richardson 1961, USFWS 1985). Three adult deer were first observed on the island in 1991 (Hayward and Henson 2008). Due to a high reproductive rate and lack of natural predators on Protection Island, this number has increased to a high estimate of 100 deer in 2008/2009 (J. Hayward pers. comm.). The most current estimate as of February 2010 consists of approximately 70 deer (P. Davis pers. comm.). Black-tailed deer use all habitat types present on Protection Island including forest, grassland, bluff, and shoreline. Refuge staff have also observed black-tailed deer on refuge islands in the San Juan Archipelago. For information on the effects of deer under current management, see Section 4.8.5 and the rationale for objective 2.1.

European rabbits are one of the fastest colonizing mammals in the world, primarily because of their high reproductive rate (Hall and Gill 2005). European rabbits do occur on the larger islands within the San Juan Archipelago; however, the only sign of rabbit presence on a refuge island has been rabbit pellets on Nob Island within the San Juan Islands NWR (Murphy pers. comm.). Rabbits can compete with seabirds for nesting burrows and change vegetation at colony sites, affecting the reproductive success of seabirds (Courchamp et al. 2003).

Predation, particularly by non-native predatory mammal species such as rats, has been documented to have devastating effects on nesting seabird populations throughout the world (Kadlec 1971, Jehl 1984, Atkinson 1985, USFWS 1993, Ashmole et al. 1994, Gaston 1994). Predator impacts on seabirds may include direct predation of eggs, young, and adults; reproductive failure due to disturbance during the nesting season; and detrimental alteration of habitat, including destruction of nesting burrows. These impacts can result in complete abandonment of nesting colonies.

4.1.7 Climate Change

A growing body of scientific evidence has emerged demonstrating that the world's climate is changing and that changes in atmospheric composition due to human activity are the drivers for global warming (Bierbaum et al. 2007, IPCC 2007). Average annual air temperatures on the earth's surface have increased by 1.3 degrees F since the mid-19th century. Furthermore, the increasing trend in global temperatures over the last 50 years is approximately twice the trend of the previous 50 years. From 1995 to 2006, global surface temperatures have been the warmest on record since 1850 (IPCC 2007). The global climate system, in turn, controls regional and local-scale climate conditions within the Pacific Northwest. Projected impacts to the region encompassing the refuges include changes in seasonal temperatures, precipitation, extreme weather events, oceanic conditions, and sea level rise.

Climate change may have drastic effects on these refuges, but due to the complexity of the issue and unknown severity of change, the magnitude of the effects of climate change on the BIDEH of the refuges during the term of this CCP cannot be predicted. Climate change will further exacerbate all of the environmental stressors imposed by the threats listed in this and the following sections as they will likely be additive or synergistic. The anticipated effects of climate change on the Priority Resources of Concern are addressed in the following sections.

4.2 Priority Resources of Concern Selection and Analysis

4.2.1 Priority Resources of Concern Selection

In preparing this plan, the Service reviewed other local, regional, and national plans that pertain to the wildlife and habitats of Protection Island and San Juan Islands NWRs (see Appendix C). The Service also sought input from Washington State conservation agencies, non-governmental organizations, and the general public. The refuges' purposes, as stated in the enabling legislation for each refuge (see Chapter 1), were carefully reviewed, as was the refuges' contribution to maintenance of BIDEH (Appendix C) within the ecoregion. As a result of this information gathering and review process, a comprehensive list of potential resources of concern was developed. From this list, those species and habitats that are most representative of refuge purposes and habitats, BIDEH, as well as other Service and ecosystem priorities, were chosen as priority resources of concern (habitat types) and focal resources (plant and animal species). Habitats selected as priority resources of concern include shoreline, bluff, grassland/savanna/herbaceous bald, forest and woodlands, and wetlands (see Table 4.1). The International Terrestrial Ecological System Classification, under development by NatureServe and its natural heritage program members, was used to describe and map refuge vegetation types (see Figures 4.1, 4.2, and Appendix C) which fall under the more general refuge habitat types.

Priority resources of concern and focal resources consist of habitats and species whose conservation and enhancement will guide refuge management into the future. Potential management actions will be evaluated on their effectiveness in achieving refuge goals and objectives for the priority resources of concern. However, many native species that are present on the refuges will also benefit. They are referred to here as other benefiting species. See Appendix C for a completed list of priority resources of concern, focal resources, and other benefiting species.

4.2.2 Priority Resource of Concern Analysis

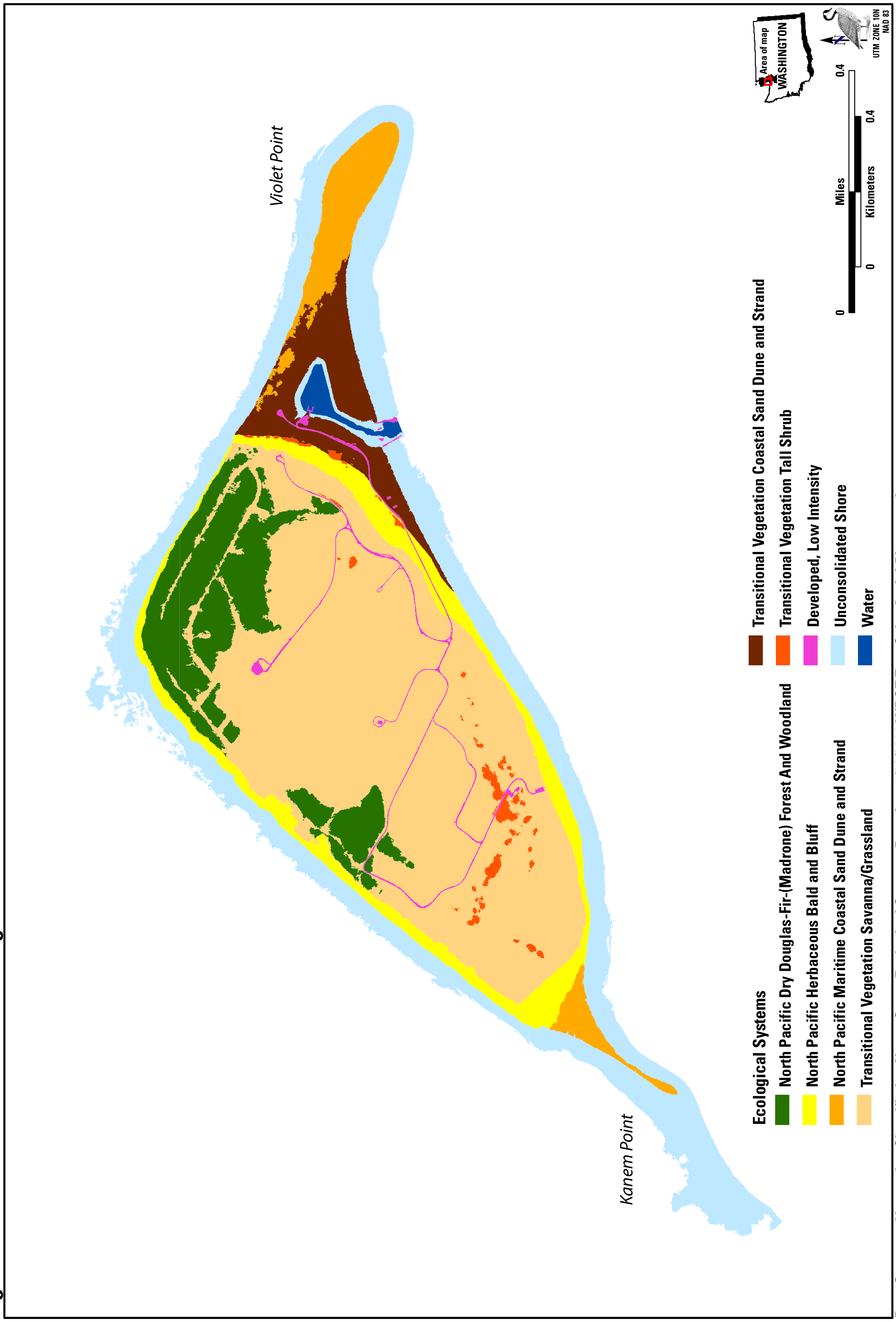
In the following sections, information is provided on the location, condition, associated wildlife, key ecological attributes, and threats for each priority resource of concern. There will be a description of location and condition of each priority resource of concern on Protection Island and San Juan Islands NWRs within the context of the Salish Sea ecosystem. Next, focal resources and other benefiting species are listed in the associated wildlife section. A preliminary analysis is then presented in the form of key ecological attributes. Key ecological attributes represent those aspects of the environment, such as ecological processes or patterns of biological structure and composition, that are key to sustaining the long-term viability of the resource. These key ecological attributes are further divided into measurable indicators that strongly correlate with the status of the attribute. The team developed desired conditions that were based on scientific literature review, consultation with species or area experts, and the team's professional judgment. Desired condition levels for each measurable indicator were used to help design objectives for the priority resource of concern as presented in Chapter 2. The last section includes a discussion on threats. Threats are defined as something that destroys, degrades, or impairs a priority resource of concern by impacting a key ecological attribute of that resource. Additionally, different threats place varying degrees of pressure on the environmental system and can become cumulative. Threats are of major concern and are addressed within this plan. A similar analysis is presented for focal resources (seabirds, marine mammals, etc.) following the analysis for priority resources of concern.

Table 4.1. Priority Resources of Concern, by Refuge Unit.

Refuge Unit	Shoreline	Sandy Bluff	Grassland/ Savanna/ Herbaceous Bald	Forest/ Woodland	Wetland
Protection Island NWR					
Protection Island	x	x	x	x	
San Juan Islands NWR					
1. Small Island	x				
2. Rum and Rim Islands	x		x	x	
3. Fortress Island	x		x		
4. Skull Island	x				
5. Crab Island	x				
6. Boulder Island	x		x		
7. Davidson Rock	x				
8. Castle Island	x		x		
9. 3 Unnamed Islands (Blind Island)	x		x		
10. Aleck Rocks	x		x		
11. Swirl Island	x		x		
12. Unnamed Rock	x				
13. 4 Unnamed Islands	x		x		
14. 3 Unnamed Islands	x				
15. Hall Island	x		x		
16. Unnamed Island	x				
17. Secar Rock	x				
18. Unnamed Island (Round Rock)	x				
19. 3 unnamed Islets	x		x		
20. 13 unnamed Islets	x		x		
21. Mummy Rocks	x				
22. Islets and Rocks associated with Deadman Island	x				
23. Shark Reef	x				
24. Harbor Rock	x				
25. Unnamed Rock (North Pacific Rock)	x				
26. Half Tide Rocks	x				
27. 7 Unnamed islands	x				
28. Low Island	x				
29. Pole Island	x		x		
30. Barren Island	x		x		
31. Battleship Island	x		x	x	
32. Sentinel Rock	x				
33. Center Reef	x				
34. Gull Reef	x				
35. Ripple Island	x		x	x	
36. Unnamed Reef (Shag Reef)	x				
37. Unnamed Island (Little Cactus Isl.)	x		x		
38. Gull Rock	x		x		
39. Flattop Island	x		x	x	
40. White Rocks	x		x		
41. Mouatt Reef	x				
42. Skipjack Island	x		x	x	

Refuge Unit	Shoreline	Sandy Bluff	Grassland/ Savanna/ Herbaceous Bald	Forest/ Woodland	Wetland
43. Unnamed Island	x				
44. Clements Reef	x				
45. Unnamed Island	x				
46. Parker Reef	x				
47. The Sisters (Lone Tree Island)	x		x		
48. The Sisters (Little Sister Island)	x		x		
49. Unnamed Island	x				
50. Tift Rocks	x		x		
51. Unnamed Rock (Reef Point)	x				
52. Turn Rock	x				
53. Shag Rock	x				
54. Flower Island	x		x		
55. Willow Island	x		x	x	
56. Lawson Rock	x				
57. Pointer Island	x				
58. Black Rock	x				
59. 3 unnamed rocks (Spindle Rock)	x				
60. Brown Rock	x		x		
61. Unnamed Rock	x				
62. South Peapod Rock	x		x		
63. Peapod Rocks	x				
64. North Peapod Rock	x		x		
65. Eliza Rock	x				
66. Viti Rocks	x		x		
68. Unnamed rock (Bird Rock)	x				
69. Unnamed Islands	x				
70. Low Island	x		x		
71. Nob Island	x		x	x	
72. Unnamed Island	x		x		
73. Unnamed Island	x		x		
74. Unnamed Rocks	x				
75. Smith Island	x	x	x		x
76. Minor Island	x				
77. Matia Island	x		x	x	x
78. Puffin Island	x		x	x	
79. Turn Island	x		x	x	
80. Four Bird Rocks	x				
81. Three Williamson Rocks	x		x		
82. Colville Island	x		x		
83. Buck Island	x		x		
84. Bare Island	x		x		

Figure 4.1 Protection Island Current Vegetation



Data Sources: Vegetation Classified to NatureServe Ecological Systems Based on 7/30/2003 WDOT True Color Aerial Photography

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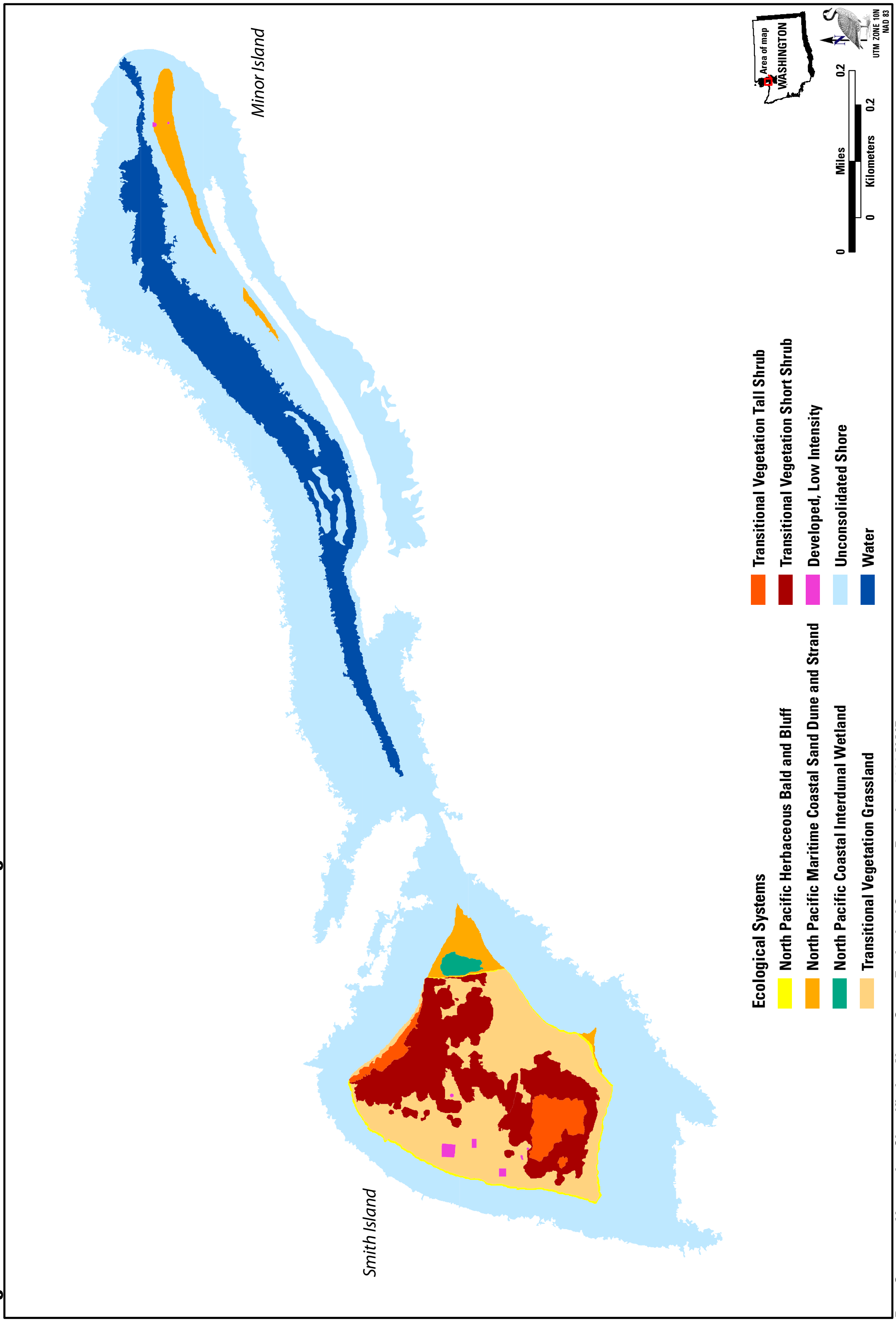
Figure 4.2 Smith and Minor Islands Current Vegetation



Data Sources: Vegetation Classified to NatureServe Ecological Systems Based on 2006 NAIP

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4.3 Shoreline

4.3.1 Description and Location

This habitat type comprises sandy/gravelly (unconsolidated) shoreline, including spits, rocky (consolidated) shoreline, and associated rocky cliffs. Sandy/gravelly shoreline is defined by having substrata consisting of components smaller than cobble (10" diameter), including gravel, sand, mud, and organic materials (Dethier 1990). The North Pacific Maritime Coastal Sand Dune and Strand ecological system is associated with sandy/gravelly shoreline and spits. For more information, see Appendix C. Rocky shoreline is defined by having substrata composed of bedrock, boulders (rocks greater than 10" diameter that are large enough not to be rolled by moderate wave action), and/or hardpan. Steep, rocky cliffs can be associated with rocky shoreline and are generally devoid of vegetation with occasional wind-swept shrubs, succulents, and grasses growing from fissures.

The amount of shoreline managed by the Service is roughly 4.7 miles at Protection Island and 34 miles in the San Juan Islands. Approximately 340 acres surrounding Protection Island from mean high tide to the mean low tide are managed by the Service under a WDNR aquatic lands lease. Additionally, the bedlands surrounding Protection Island extending to 600 feet beyond the extreme low tide line are withdrawn from "conflicting uses" for conservation purposes (WDNR 1988 Withdrawal Order 88 017).

Protection Island NWR
Sandy/gravelly shoreline comprises the entire perimeter around Protection Island. Kanem and Violet Point spits at the west and east ends of the island are formed by glacial deposits eroding from the high bluffs and transported by longshore currents. At the high water line, a backbone of driftwood helps to hold the sediment and provides beach nourishment.

The distribution of vegetation along the spits is affected by disturbance processes such as wave overwash during storm tidal surges, sand deposition, erosion, and lateral movement. Currently, on Violet Point, native species continue to dominate even when associated with introduced species such as European beach grass. Overall, Violet Point has higher native species richness and percent cover and lower introduced species richness and cover than the upland plateau (Cowles and Hayward 2008).

The tidelands surrounding Protection Island are considered intertidal mudflats. Since vascular plants are unable to persist due to the diurnal tidal flooding of salt or brackish water, algae are the dominant vegetation. Occasional small patch occurrences of eelgrass beds also border Protection Island (WDNR 2001).

San Juan Islands NWR
Sandy/gravelly shoreline occurs in the San Juan Islands Refuge as either spits or isolated pocket beaches. Smith (#75) and Minor (#76) Islands, located in the eastern Strait of Juan de Fuca, are connected by a low spit that is covered at high tide. Small portions of the spit that are not frequently overwashed by tidal storm surges have vegetation communities associated with the dune and strand ecological system dominated by American dunegrass and other forbs adapted to salty dry conditions. Isolated pocket beaches contained by rocky headlands and consisting of sandy and/or gravelly shorelines exist on Turn (#79) and Matia (#77) Islands as well as many other small islands.

Rocky shoreline occurs extensively within the San Juan Islands Refuge as most of the islands are small rocky benches or outcrops that are sparsely vegetated, unvegetated, or tidally inundated reefs. Reefs are usually underwater at high tide and only support marine algae. The substrate is usually bedrock, sometimes in conjunction with boulders. On sparsely vegetated islands, lichens and mosses cover the bare rock within the backshore area and are occasionally joined by forbs that occur on small glacial outwashes that collect in rock crevices and depressions. Common herbaceous species adapted to the low moisture, intense wind, and salt spray experienced by these small rocky outcrops include sea plantain, lance-leaved stonecrop, and sea thrift (Atkinson and Sharpe 1993).

Cliffs with rocky ledges, outcroppings, and crevasses can be found on Castle (#8), Hall (#15), Battleship (#31), Flattop (#39), Skipjack (#42), Little Sister (#48), Willow (#55), South Peapod (#62), Viti Rocks (#66), Matia (#77), and Puffin (#78) Islands.

4.3.2 Associated Wildlife

Focal resources for this habitat type include the pelagic cormorant, double-crested cormorant, pigeon guillemot, glaucous-winged gull, black oystercatcher, and marine mammals. Detailed information on these species can be found in the Seabird, Marine Mammals, and Black Oystercatcher sections of this chapter.

Other benefiting species include the brant, harlequin duck, Brandt's cormorant, black and ruddy turnstone, rock sandpiper, surfbird, dunlin, black-bellied plover and sanderling (migration and winter); wandering tattler and western sandpiper (migration); brown pelican (rare fall migrant); Heermann's gull, killdeer (breeding), and Caspian terns and peregrine falcon (breeding, though no known nests/eyries on refuges); great blue heron, river otter, herring, and sand lance (year-round).

4.3.3 Conditions and Trends

Prior to Euroamerican settlement, the condition of sandy/gravelly and rocky shorelines within the Salish Sea was primarily affected by natural processes and disturbances (i.e., accretion and erosion) and regional variations in geology, climate and precipitation, wave action, tidal range currents, and local sea level history. Currently, the condition of these shorelines is dramatically affected by human-caused modifications such as armoring and slope stabilization, groins and jetties, upland hydrologic changes, and fills. These modifications disrupt natural geomorphic processes, leading to altered accretion and erosion patterns.

Marine debris is a continuous source of pollution on the shorelines of both refuges. The only shoreline that is regularly cleaned is on Protection Island. The Smith Island shoreline is especially covered in marine debris. Creosote pilings that were used to build the docks on Protection and Matia Islands continue to leach contaminants into the shoreline sediment. In addition, some refuge shorelines have rogue creosote logs that have accumulated and continue to contaminate the sediment above the high tide.

Protection Island NWR
With the exception of the construction of a marina on Protection Island prior to refuge establishment, the refuge shorelines have not been directly modified. However, the disruption of geomorphic processes resulting from changes to off-refuge shorelines can indirectly affect the morphology of the refuge shorelines. Most of the shoreline showed little natural modification between 1956 and 1999 beyond what could be accounted for by differences in tides. However, exceptions include Kanem Point, which regressed 26 meters in length over this 43-year period due to erosion at the tip and narrowed slightly at the base below the bluffs. Violet Point increased from 915 to 957 meters in length and the wide beach that formerly spanned the region from the lagoon at the base of the Point north to the sea became vegetated due to filling and grading the area (Cowles and Hayward 2008). The marina was created by breaching Violet Spit and filling in the existing tidal wetland. The inner harbor shoreline lacks the amount of

woody debris and vegetation found on the spit shorelines. An extended user house was recently removed from the base of Violet Spit.

In addition to changes to the physical structure and stability of refuge shorelines, other recent anthropogenic impacts include altered vegetation communities and pollution. On Protection Island, European beach grass was planted by the 1920s to stabilize dunes. Other non-native species now found on the sand dunes, spits, and strand include grasses such as ripgut brome, common velvetgrass, Kentucky bluegrass, meadow barley, and orchard grass, and forbs including silver burweed and common sow thistle. However, now that agricultural and development activities on Protection Island have ceased, native species appear to be making at least a partial recovery (Cowles and Hayward 2008).

San Juan Islands NWR

The rate of erosion and subsequent supply of sediment on Smith Island continually affects the formation and maintenance of Minor Island. However, due to the resistance of the basalt bedrock and the lack of significant wave action, the other shorelines and rock cliffs within the San Juan Islands NWR have largely undergone negligible erosion and retreat.

Since refuge establishment, all shoreline habitats have been managed to minimize human-caused disturbance to nesting seabirds and other wildlife. Rocky cliffs are by their nature resistant to wave action erosion; however, projected sea level rise associated with climate change may reduce the quantity of this habitat in the future (Huppert et al. 2009).

4.3.4 Key Ecological Attributes

Table 4-2. Shoreline Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Physical Structure and Stability	1. Presence/absence of human-caused alteration of longshore currents or sedimentation processes (PI only) 2. Abundance and density of driftwood	1. No structural interference of shoreline development on PI (exception of the marina) 2. Continuous expanses of driftwood
Plant Community Structure and Composition	1. Presence of native, sparse, short grasses on spit habitat 2. Ratio of native to invasive species on spit habitat 3. Presence/absence of rare plant species on cliff habitats	1. <30% cover and 3- 4 feet in height of native grasses 2. <25% of invasive species 3. Presence of brittle prickly pear cactus
Security and Human Impacts	1. Human activity on or near cliffs, rocky, and sandy/gravelly shorelines 2. Presence/absence of rabbits or mammalian predators 3. Presence/absence of marine debris or creosote-covered materials	1. No trespass on all closed shorelines and minimal boat disturbance within 200 yards of closed refuge islands and shorelines. 2. No rats, rabbits, red fox, feral or domestic pets; few-to-no other mammalian predators 3. No marine debris or creosote on shorelines

4.3.5 Threats

Threats facing the shorelines of Protection Island and the San Juan Islands refuges include climate change-induced sea level rise, geologic events, invasive species, human intrusions and disturbance, and contaminants and marine debris.

Likely effects due to sea level rise and other climate-related factors include increased inundation, erosion, and overwash during storm events, leading to losses of shoreline habitats (Mote et al. 2008, Huppert et al. 2009). Additionally, climate-driven changes in ocean currents, sea temperatures, salinity, and the timing of resource availability have the potential to affect intertidal communities (Menge et al. 2008), eelgrass beds (Snover et al. 2005), seabirds, and marine mammals that use refuge shoreline and adjacent nearshore habitats.

Geologic events such as accretion and erosion affect the physical structure and stability of the refuge shorelines. Human-caused modifications such as armoring and slope stabilization, groins and jetties, upland hydrologic changes, and fills disrupt natural geomorphic processes, leading to altered accretion and erosion patterns which may degrade refuge shoreline habitat. Additionally, the presence of driftwood plays an essential role in maintaining the structure of refuge shorelines. Natural threats to the driftwood piles such as currents, decay, and fire in addition to human-caused threats such as collecting, moving, and illegal fires could also affect shoreline structure and stability. Fires, particularly, pose a serious threat as they have high potential to ignite vegetation and spread rapidly into adjacent habitats.

Non-native and invasive plant species threaten shoreline habitats by displacing the native sand dune, spit, and strand species, altering vegetation communities, and modifying ecosystem processes. Non-native and invasive plant and animal species directly compete with native species and often cause existing native species populations to decline or become extirpated.

Although the majority of the refuges' shorelines are closed to public access, human-caused disturbances and trespass still pose direct threats to seabirds and pinnipeds (refer to the Seabird, Black Oystercatcher, and Marine Mammal sections of this chapter for more information). Also, seabird nesting colonies and pinniped rookeries are extremely vulnerable to the effects of oil and other contaminants. Numerous oil tankers, cargo vessels, bulk carriers, and barges use the waters near the refuges as primary transportation routes. Any spill from these routes could potentially be devastating to populations of marine wildlife and habitat. In addition, non-point source oil tarballs, or slicks, periodically wash up and impact wildlife. Non-point chronic sources may be products of vessels illegally pumping bilges, recreational outboard motors, and improper use of petroleum products in marinas (USFWS 2005).

4.4 Sandy Bluffs

4.4.1 Description and Location

Sandy bluffs are classified under the North Pacific Coastal Cliff and Bluff ecological system, which includes bluffs composed of glacial deposits (NatureServe 2009). Steep, eroding coastal bluffs are composed of a sequence of glacial and interglacial sedimentary units (Dragovich et al. 2005) with occasional sparse cover of forbs, grasses, lichens, and low shrubs. The area occupied by the sandy bluff habitat type within the Protection Island and San Juan Island Refuges has not been surveyed and is difficult to quantify.

Protection Island NWR
On Protection Island, bluffs completely surround the upland plateau. Large portions of the vegetated bluffs above Kanem and Violet Points are covered with non-native grasses including European beach grass, ripgut brome, and meadow barley. Occasionally codominant native grasses include Idaho fescue and red fescue. Yarrow and gumweed are typical native forbs while non-native forbs distributed in patches along the bluffs include hedge mustard, alfalfa, sow thistle, bull thistle, and field bindweed.

San Juan Islands NWR
On Smith Island, bluffs rise directly landward of the beach on the northwest, west, and southwest sides. Between the upland grassland and the unvegetated portion of the bluffs, the shallow soil on the steeply sloped areas supports some grasses and forbs.

4.4.2 Associated Wildlife

Focal resources associated with sandy bluffs include the rhinoceros auklet and tufted puffin. For more detailed information on these species, see the Seabird section in this chapter. Other benefiting species that use this habitat type include the snowy owl (nonbreeding), swallows, and Canada goose (breeding).

4.4.3 Condition and Trends

Prior to Euroamerican settlement, the historic condition of the coastal bluffs on Protection Island NWR and Smith Island (within the San Juan Islands NWR) was largely driven by the natural, on-going process of erosion. The vegetated portions of the bluffs were likely dominated by native grasses such as Idaho fescue, California oatgrass, Lemmon's needlegrass, red fescue, and prairie junegrass and associated with a high diversity of forbs. Following Euroamerican settlement, practices associated with agriculture and development, including overgrazing, deforestation, and the introduction of non-native species (i.e., European beach grass), altered both the vegetative composition and erosional patterns of the islands.

Coastal bluff erosion is the result of numerous interacting variables, including first-order factors such as climactic conditions and sea level rise, and second-order factors such as geologic composition, surface and groundwater hydrology, and the relative rate of erosion at the bluff toe (Bray and Hooke 1997, Johannessen and MacLennan 2007). The cyclical process of bluff erosion is initiated when wave action removes material at the bluff toe creating an unstable bluff profile that eventually leads to landslides (mass-wasting) and the delivery of new material to the base of the slope (Emery and Kuhn 1982). Since Protection and Smith Islands both experience significant wave exposures along the Strait of Juan de Fuca, bluff erosion and recession rates are higher than at other less exposed areas of the Salish Sea.

Protection Island NWR
On Protection Island, early residents had reported rapid and extensive erosion of the northwest bluff (Cowles and Hayward 2008, Power 1976). This wasting may have resulted from unsustainable land uses, including overgrazing and deforestation. Since the 1950s, a slower rate of bluff erosion has occurred on the northwest margin where previous slide material was removed from the toe, leading to a steeper bluff profile. The northeast bluffs, which are nearly vertical and mainly bordered above by forest and woodland, showed little change. The southern bluffs, less steep and more protected from wave action, also showed little overall change (Cowles and Hayward 2008). During the 1800s, a road was built up the bluff overlooking Kanem Point. The road was used through the 1930s and has since eroded away, although some remnants can still be seen. During the 1960s, a dirt road was built at an angle up the bluff above Violet Point. Although still in use, it has already eroded away by half or more (Cowles and Hayward 2008). Otherwise, the overall physical structure of the vegetated portion of the bluffs overlooking both points has remained largely unchanged.

At a more localized scale, however, sheep overgrazing during the 1950s led to the formation of slide areas of loose soil and sand, which clearly adversely affected nesting seabirds (Richardson 1961). Since the early 1990s, black-tailed deer have been found on Protection Island. The abundance of deer steadily increased to approximately 80-100 animals by 2007/2008 and appears to have declined to about 70 in 2010 (P. Davis, pers. comm.). They have created deeply eroded pathways through the unstable slopes and caused auklet burrows to cave in; lain down on burrow entrances and thus effectively blocked adults from entering burrows to feed chicks; and caused disturbance to the gull colony on Violet Spit.

San Juan Islands NWR
At Smith Island, Keuler (1988) determined erosion rates of over 30 centimeters (11.8 inches) per year. The Smith Island lighthouse, built in 1858 about 200 feet away from the island's western edge, collapsed into the water in spring 1998 due to bluff erosion (Nelson 2009).

4.4.4 Key Ecological Attributes

Table 4-3. Sandy Bluff Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Physical Structure and Stability	1. Presence/absence of human structures (roads, residences, etc.) 2. Degree of slope and friability of soil	1. No human structures 2. Stable slopes and suitable soils for seabirds to build burrows in restored areas
Plant Community Structure and Composition	1. Percentage of vegetative cover at the beginning of the rainy season 2. Presence/absence of invasive shrubs 3. Ratio of invasive to native plants	1. At least 50% vegetative cover 2. No invasive shrubs (Scotch broom) 3. <25% invasive plants
Security and Human Impacts	1. Presence/absence of human activity on or near bluffs 2. Presence/absence of deer, rabbits, and mammalian predators	1. Low human activity 2. No non-native rats, rabbits, red fox, feral or domestic pets on any refuge islands; no deer on Protection Island.

4.4.5 Threats

Threats facing the sandy bluffs of Protection Island and Smith Island (within the San Juan Islands NWR) include climate change, mass-wasting, invasive species, and human intrusions and disturbance. Long-term climate change is expected to result locally in sea level rise, an increase in winter precipitation, and increased storm strength and frequency (Mote et al. 2008, Huppert et al. 2009). Among the key factors in bluff erosion are major storm events combined with high tides or elevated sea levels related to El Niño events (Shipman 2004). Storm events magnify the wave action on beaches and bluffs by increasing wave energy, wave height, and wind speed. Thus, sea level rise and the increase in storm severity and frequency will affect the future condition of the Protection and Smith Island bluffs by leading to larger and more frequent mass-wasting.

Introduced invasive plants (e.g., European beach grass, field bindweed) are a constant issue within the sandy bluff habitat. Many non-native species can directly outcompete native species by reducing light at the ground level and aggressively capturing water and nutrients. They also have the potential to alter ecosystem processes by producing nitrogen-enhanced litter, changing ground-level microclimates, altering fire regimes as a result of their flammability, enhancing soil moisture deficits, and other characteristics.

Human intrusions, disturbance, and trespass within sandy bluff habitat have the potential to fragment, degrade, or destroy the habitat through trampling and erosion, cause tremendous disturbance to wildlife (refer to the Seabird section in this chapter for more information), and introduce invasive plant species into closed areas of the refuges.

4.5 Savanna, Grasslands, and Herbaceous Balds

4.5.1 Description and Location

Savanna, grasslands, and herbaceous balds are associated with dry sites in lowland and mid-montane western Washington and Oregon. Approximately 200 acres of Protection Island NWR and a total of 41 islands within the San Juan Islands NWR currently have these habitats. These areas can be categorized into two ecological systems: Willamette Valley Upland Prairie and Savanna, and North Pacific Herbaceous Bald and Bluff (Natureserve 2009). The prairie and savanna system differs from herbaceous balds in the following respects:

- Prairies and savannas occur on relatively level terrain, primarily on deep, well-draining gravelly/sandy glacial outwash (Chappell and Crawford 1997, Crawford and Hall 1997, Chappell et al. 2001a, Natureserve 2009).
- Herbaceous balds typically occur in small patches on relatively shallow soils with an underlying restrictive layer of bedrock, and relatively dry topographic positions (e.g., on slopes) and can be intermixed with rock outcrops and fringed by areas of forest and woodland (Chappell et al. 2001a, Chappell et al. 2001b, Chappell 2006).

Protection Island NWR
On Protection Island, the Willamette Valley Upland Prairie and Savanna system is associated with the deep, coarse, well-draining Townsend series glacial outwash deposits constituting the majority of the undulating upland plateau. Currently, the prairie exists in a degraded state with rhizomatous exotic grasses dominating throughout the plateau (Cowles and Hayward 2008). Some native herbaceous component is still present in the least disturbed areas on the western and eastern fringes of the plateau.

The North Pacific Herbaceous Bald and Bluff system is found along the shallow soil, steep-sloped, grassy areas on the southern or western aspects between the upland grassland and bluffs. While some native plants are still present, these areas are currently dominated by European beachgrass, meadow barley, alfalfa, and ripgut brome.

San Juan Islands NWR
Similar to Protection Island, the upland plateau of Smith Island is primarily composed of glaciomarine drift and till (Dragovich et al. 2005). These well-draining substrates support a degraded prairie interspersed with early successional deciduous-dominated forest and woodland. Non-native grasses (i.e., orchard grass, cheatgrass, and ripgut brome), forbs (i.e., Canada thistle, bull thistle, and field bindweed), and woody plants (i.e., Himalayan blackberry) are found throughout the island, particularly in or near heavily disturbed areas.

Most of the other islands in the refuge are small rocky benches or outcrops that are unvegetated, tidally inundated reefs or only sparsely vegetated. The North Pacific Herbaceous Bald and Bluff ecological system can be found on these sparsely vegetated islands where lichens and mosses cover the bare rock and are joined by grasses and forbs that occur on small glacial outwashes that collect in rock crevices and depressions. On larger islands, grassy balds are common on southern and western exposures. Matia

Island, for example, has an extensive grassy bald lining its southern edge including areas with common camas and the white-flowered death camas. Rocky outcrop species frequently mix with bald species. Also, scattered trees such as Garry oak, Pacific madrona, Rocky Mountain juniper and/or Douglas-fir are present on Rum (#2), Boulder (#6), Castle (#8), Unnamed (#13), Battleship (#31), Ripple (#35), Flattop (#39), Skipjack (#42), Tift (#50), Flower (#54), Willow (#55), Nob (#71), and Unnamed (#73) islands in localized microsites that have greater late summer soil moisture. However, the majority of islands within the refuge are either too vulnerable to the erosion caused by wind and rain, too exposed, or too low in nutrient and moisture levels to support much more than lichens, mosses, and low, herbaceous vegetation.

4.5.2 Associated Wildlife

The following plants are considered focal resources for savanna, grasslands, and herbaceous balds due to high levels of conservation concern (e.g., Federal or state T&E listing): brittle prickly-pear cactus, golden paintbrush, California buttercup, and bear's foot sanicle. All but golden paintbrush can be found on refuge islands. Bennett (2007) has noted that refuge islands within the San Juan Islands exhibit significantly greater species richness of native plants and less introduced species than adjacent islands. Floristic surveys conducted in 2005 reveal that the brittle prickly-pear cactus, reputedly rare in Washington, occurs on refuge lands, including Rum (#2), Castle (#8), Boulder (#6), Blind (#9), and Aleck (#10). It has historically been found on Protection Island's Violet spit. California buttercup on Aleck (#10) and Castle (#8), and Bear's foot sanicle on Boulder (#6). Golden paintbrush is not known to occur on refuge lands, however habitat is available (2005 SJI Floristic Survey Results, Refuge Files).

Other benefiting species include the northern harrier, American kestrel, savanna sparrow, purple martin, and shrews; Vancouver groundcone, camas , slender crazyweed, Alaska alkaligrass, black lily, white meconella, erect pygmy-weed, sharpfruited peppergrass and northern adder's-tongue (WDNR 2004). The following rare butterflies are not known to occur on the refuges, but potential habitat is available, thus they are considered as other benefiting species for this plan: Taylor's checkerspot, island marble, and valley silverspot, and plant host species for these butterflies: mustard, verbena, plantain, Viola adunca, and paintbrush.

4.5.3 Conditions and Trends

The predominant pre-Euroamerican settlement vegetation on lowlands west of the Cascades, from the Willamette Valley of Oregon north to the Georgia Basin of southwest British Columbia, was a mosaic of grasslands, oak and conifer savannas, and various types of wetlands (Chappell and Crawford 1997, Sinclair et al. 2006). Estimates of remaining prairie vary from 10% of the pre-settlement extent in south Puget Sound (Crawford and Hall 1997), to less than 5 percent (including savannas) in southwest British Columbia (Garry Oak Ecosystem Recovery Team cited in Sinclair et al. 2006). Currently, these places have been degraded, fragmented, and lost entirely in many areas. Losses of prairie and savanna were primarily due to fire suppression, invasive non-native species, grazing, and urban and agricultural conversion (Chappell and Crawford 1997).

Small areas of herbaceous balds can be found scattered throughout the San Juan Archipelago. On a regional scale, herbaceous balds cover a small portion of the total area. However, this habitat is particularly significant for the conservation of biodiversity since these small areas tend to have high plant species diversity and support plant species that typically do not occur elsewhere (Chappell 2006). Additionally, some rare or threatened animal species, such as the island marble butterfly, are limited to this type of habitat.

Protection Island NWR
Historically, the dominant vegetation on the upland plateau of Protection Island consisted of native perennial bunch grasses and abundant and diverse forbs (Menzies 1792 in Newcombe 1923, GLO 1858, Clark 1995). The "few clumps of trees" within the grassland referred to by Captain George Vancouver in 1792 were likely scattered deciduous and/or coniferous trees that formed a savanna-like structure in small patches (Lamb 1984, Clark 1995).

However, the history of Euroamerican settlement, which began in the mid-1800s, has resulted in significant changes in vegetation cover and floristics within the former grassland and savanna areas. Farming, grazing, dune stabilization, and then attempted development of the upland plateau led to the introduction of numerous exotic species. Cowles and Hayward (2008) found that only 41 percent of the non-woody grassland species found in transects that they surveyed were native. The least disturbed areas of the grassland had some thriving areas of native species; however, aggressive exotic species such as quackgrass in plowed areas, ripgut brome in former pastures, Canada thistle, and orchard grass continued to persist. In the most disturbed areas, several introduced species of grass had established themselves along with some forbs such as false dandelion, black medic, and sheep sorrel. European beach grass, a non-native, occurred near the bluffs over Violet Point; lichens were most evident on ground graded for the airstrip where much mineral earth was exposed. In the former plowed fields, introduced species including field bindweed, quackgrass, orchard grass, and Kentucky bluegrass still dominate. However, blue wild rye, a native species, was also widespread and covered substantial areas of former pasture. Copses of native snowberry and Nootka rose still could be found scattered throughout the grasslands in areas of low disturbance.

San Juan Islands NWR
In large part due to its relative isolation and the general limitations placed on recreational use and visitation, the grasslands and herbaceous balds on most of the refuge islands, except for Smith Island, have not been significantly impacted by human use. Natural processes are allowed to predominate without human intervention and successional vegetative changes occur naturally. Consequently, some of the refuge islands still harbor rare or special status flora including Vancouver groundcone, slender crazyweed, Alaska alkaligrass, California buttercup, and bear's foot sanicle (Dunwiddie and Giblin 2005). However, the herbaceous bald habitats on the northern edge of Turn Island and the southern edge of Matia Island have been adversely affected by recreational use. The proliferation of unofficial trails has led to the reduction of vegetation cover, increase of non-native species, and in some cases, the creation of bare ground and surface erosion.

On Smith Island, grassland formerly occupied the south and east ends of the upland plateau while woodland composed of low conifers and woody vegetation occupied the center, north, and west ends (Menzies 1792 in Newcombe 1923, Vancouver 1792 in Blumenthal 2004, USCS 1854). However, a lighthouse station was established in 1858 with additional facilities, including 3 residences, a watch shack, pump house, cistern, dock, and other utility buildings (Skiff 2009). The T-Sheet of the area in 1870 shows a road leading up from the spit on the east end of the island to the lighthouse had also been built (USC&GS 1870). The dwarf trees and low woody vegetation were largely cleared in order to afford a clear horizon in every direction and to open up areas that were fenced for cultivation (USCS 1869). The light house was staffed from 1858 until 1957 when it was abandoned due to erosion. A new lighthouse was established and it was automated in 1976, which decreased the amount of human activity on the island. However, several introduced species of grasses and forbs continue to persist and thrive throughout the grassland areas of the island.

4.5.4 Key Ecological Attributes

Table 4-4. Savanna, Grassland, and Herbaceous Bald Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Disturbance Regimes	1. Areal extent, frequency, intensity, severity, and return interval of fire 2. Amount of fuel load	1. Every 3-5 years 2. Analysis not completed
Plant Community Structure and Composition	1. Proportion of shrub/tree cover 2. Proportion of native grasses 3. Ratio of native to non-native species 4. Presence/absence of butterfly host plants 5. Presence/absence of priority resource of concern plant species 6. Percent cover of invasive plants (Himalayan blackberry, Canada thistle, etc.) 7. Presence/absence of new noxious weed invaders (not currently present on these refuges)	1. <15-20% cover on PI; <30% on SJI 2. <50% cover of native grasses 3. <25% cover of non-native plant species 4. Larval and adult host plants established 5. One or more populations of priority resource of concern plant species 6. <10% cover of invasive plant species 7. No new noxious weeds
Security and Human Impacts	1. Presence/absence of human activity on or near grassland, savanna or herbaceous balds 2. Presence/absence of deer, rabbits, and mammalian predators	1. Low human activity 2. No non-native rats, rabbits, red fox, feral or domestic pets on any refuge islands; no deer on Protection Island.

4.5.5 Threats

Some of the threats to the savanna, grassland, and herbaceous bald communities on Protection Island and San Juan Islands Refuges include climate change, the lack of fire, invasive species competition with native plants and animals, and recreational use. Additional threats faced by the grasslands and herbaceous balds of the San Juan Islands Refuge potentially include overgrazing by native black-tailed deer, Canada goose, and European rabbits.

The warming trends within the Salish Sea leading to higher summer temperatures and anticipated minor precipitation increases (Mote and Salanthe 2009) will likely increase potential evapotranspiration, imposing water stress on native grassland and bald species. Increased stress on native grasses and forbs lowers productivity and decreases germination rates and seedling survival, making them more susceptible to invasion by invasive species. Additionally, warmer temperatures and summer drought may lead to an increased fire frequency and severity.

In pre-Euroamerican settlement times, fires were much more frequent and helped to maintain or expand the size of prairies and balds by killing small trees. In the absence of fire, trees show a tendency to invade, leading to conversion into forests and woodlands. The influence of fire in the development and maintenance of savanna, grassland, or bald communities likely was higher on larger islands such as Protection and Smith islands. Smaller islands probably had very little history of burning due to their size.

Currently, invasive species dominate the non-forested areas of the upland plateau on Protection Island. Invasive grasses are also present on all of the San Juan Islands refuge islands. Invasive species can outcompete native species and result in decreased population levels and degraded habitats.

The severity of threat due to recreational use varies depending on the type of recreation and the severity. Historically on Protection Island, vehicular use (including aircraft) within grasslands and balds caused soil compaction, erosion, and facilitated the spread of invasive species. Trails and trampling created similar impacts. Currently, Protection Island is closed to the public, therefore no recreational activities occur. Limited vehicle use by staff, a lifetime user, and researchers have only a small impact on these habitat types. However, any forms of recreational use would likely adversely impact wildlife populations (See the Seabird section of this chapter).

Prior to the introductions of two large subspecies into the region, Canada geese were not common nesters in the San Juan Islands. Their abundance today, especially during the breeding season, may impact special status plants and plant communities due to grazing and may increase the dispersal of non-native plants (Dunwiddie 2007, pers. comm.). However, due to the high probability of dispersal beyond the refuge boundaries, this threat is considered an ecosystem-wide issue. Further assessment and analysis of this threat is needed before management action can be taken.

4.6 Forest and Woodlands

4.6.1 Description and Location

Forests and woodlands currently occupy approximately 49 acres of Protection Island NWR and are found on 10 islands within the San Juan Islands NWR (see Table 4-1). These habitat types can be categorized into two ecological systems: North Pacific Dry Douglas-Fir (Madrone) Forest and Woodland, and North Pacific Maritime Dry Mesic Douglas-fir-Western Hemlock Forest. A third ecological system, North Pacific Oak Woodland, could possibly have existed on a couple of islands within the San Juan Islands NWR during the pre-Euroamerican settlement period (pre-1880).

Forests are defined as stands with crowns overlapping (generally forming 60-100% cover) whereas woodlands feature open stands of trees with crowns not usually touching (generally forming 25-60% cover). The canopy tree cover of woodlands may be less than 25 percent in cases where it exceeds shrub, dwarf-shrub, forb, and nonvascular cover, respectively (Anderson et al. 1998).

Protection Island NWR
On Protection Island, North Pacific Dry Douglas-Fir (Madrone) Forest and Woodland occurs in two stands that occupy the northern edges of the prairie-dominated upland plateau. The forest stands provide a natural windbreak from the prevailing wind direction. Common trees occurring with the Douglas-fir are Pacific madrona, shore pine, grand fir, and Douglas maple. Red cedar and western hemlock are also present but not dominant. Scouler's willow and Hooker's willow occur in some areas as understory tree species.

San Juan Islands NWR
On Matia Island, the North Pacific Dry Douglas-Fir-(Madrone) Forest and Woodland system occurs in a mosaic with North Pacific Maritime Dry Mesic Douglas-fir-Western Hemlock forest, typically occupying upper slopes or ridgetops, steeper areas, or faces with southern to western aspects. Generally, this system is found adjacent to the herbaceous balds on the southern edge of the island. In contrast, the North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest system is found on north-facing slopes and in

the protected interior valleys where cooler, humid, and low wind conditions occur. Old trees that predate Euroamerican settlement occur there as scattered individuals. These are primarily Douglas-fir, which is the dominant tree across most of the island. Sites where moisture is high, such as in the central valleys, are co-dominated by western red cedar, Douglas-fir, and grand fir, with significant amounts of sword fern in the understory. Some of the cedars are up to six feet in diameter with 3-4 foot diameter individuals of both cedar and Douglas-fir not uncommon (Dunwiddie 2007b). Western hemlock, bigleaf maple, and red alder also occur in these areas. North-facing slopes are occupied by western red cedar and Douglas-fir with a diverse, yet generally sparse understory typically including salal. Fire scars are common on both the cedars and Douglas-fir.

On Turn Island, the North Pacific Dry Douglas-Fir-(Madrone) Forest and Woodland system covers almost the entire interior of the island with the exception of remnant North Pacific Oak Woodland communities centered around the 8-12 Garry oaks growing as scattered individuals on the southern, western, and north-northeastern shores of the island in association with Douglas-fir, Pacific madrone, and Rocky Mountain juniper. Most of the oaks are <18” in diameter and most appear to be relatively healthy with fairly full, vigorous crowns. In most areas, the canopy (especially of Douglas-firs) is not yet so dense as to be severely competing with the oaks, madrones, and junipers. The understory is typically comprised of low shrubs including snowberry and orange honeysuckle, grasses including blue wildrye, Alaska brome, Alaska oniongrass, and forbs such as Pacific sanicle, yerba buena, and sea blush (Dunwiddie 2007a).

The North Pacific Dry Douglas-Fir-(Madrone) Forest and Woodland system also occurs on larger islands such as Flattop (#39), Skipjack (#42), Willow (#55), Smith (#75), and Puffin (#78) Islands. Small patches of woodland also occur on the Rum Islands (#2) and Battleship Island (#31). Other refuge islands where Garry oaks grow include Rum (#2), Flattop (#39), the easternmost refuge island of the Nob Island Group (#71), and Unnamed (#73) Islands. However, the dominance and density of oaks is too little for those areas to be truly considered oak woodlands. Rather, they are more like herbaceous balds that support limited numbers of oak woodland species. Additionally, it is unlikely that lightning-caused fires were common on any of these smaller islands due to their size and relative lack of burnable fuels. If fires did occur, they probably burned with low intensity and were restricted only to those individual islands. Although there is evidence that Native Americans burned oak savannas and grasslands on some of the larger islands in the San Juan archipelago, there is no evidence of any cases on the refuge islands.

4.6.2 Associated Wildlife

Bald eagles are considered focal resources for these habitat types and more detailed information can be found in the Bald Eagle section of this chapter. Other benefiting species that use forests and woodlands include downy, hairy, and pileated woodpeckers, olive-sided flycatchers, American kestrels, great horned owls, and bats.

4.6.3 Condition and Trends

North Pacific Dry Douglas-Fir Forest and Woodland

Protection Island NWR

The current forested areas on Protection Island are smaller, more fragmented, and have more hardwoods and other early seral stage species compared to the pre-Euroamerican settlement time period (Cowles and Hayward 2008). In 1868, the forest and woodland area on Protection Island was approximately 120 acres. The acres of pre-settlement forest on Protection Island were probably slightly higher than that, since by 1868 some selective logging and agricultural activities had already occurred (USC&GS 1868, Power 1976). By the 1930s, the logging activities and conversion to agriculture had decreased the forested area to 81 acres. The large continuous forest on most of the north edge of the island became divided into two distinct forest stands separated by grassland with a few small patches of trees. The northwest grove consisted primarily of conifers while the northeast grove contained a mixture of conifers, deciduous trees, and shrubs (Einarsen 1945). Between 1944 and the 1950s, at least two major fires burned most of the uplands and both Kanem and Violet Points, including buildings and forested land (Power 1976, Clark 1995). Subsequent photos of the forested areas (Richardson 1961, Larsen 1982) show large numbers of snags mixed with shorter, healthy trees. Probably as a result of the fires, by 1956, the northwest grove had shrunk by 5% and the northeast grove by 10%, with small patches connecting the two groves absent (Cowles and Hayward 2008). The space between the two groves is now primarily composed of sand dunes and grassland. By 1974, roads had cut through both the northwest and northeast groves while the western end of the northeast grove was cleared and leveled for the airstrip. After refuge establishment in 1982, the airstrip and roads within the forest area were removed and the forest over-and understory began to recover. By 1999, the forested areas gradually expanded in range and closed over the roads built through them with the northwest grove recovering to roughly 82% of its 1930s area and the northeast grove 97% of its former extent. However, the composition of both forested areas contain a larger proportion of deciduous trees and shrubs which represents an earlier state of succession than the 1930s forest (Cowles and Hayward 2008).

The current forest stands are relatively healthy but the recruitment of tree saplings may be limited due to deer herbivory and/or competition with non-native species. Another important factor in the quantity of forested areas on Protection Island is erosion of adjacent bluffs. While the northeast bluff has showed little change between 1956 and 1999, the northwest bluffs have eroded and slumped considerably (Cowles and Hayward 2008).

San Juan Islands NWR

Overall, the dry Douglas-fir forest and woodland on Rum (#2), Battleship Island (#31), Skipjack (#42), Willow (#55), Puffin (#78), and Turn (#79) Islands appear to be relatively unaltered in extent from the late 1880s and 1890s (USC&GS 1888, USC&GS 1889, USC&GS 1894 a,b,c, USC&GS 1895a,b). [NOTE: There was no data available for Flattop Island (#39).] In 1892, a homesteader settled on Matia Island and cleared a small area near the southeast cove for a home, orchard, garden, and livestock (Oldham 2005). The clearing likely temporarily reduced the extents of both the dry Douglas-fir forest and woodland and the dry-mesic Douglas-fir-Western Hemlock forest. However, after roughly 30 years, the settler passed away and the clearing slowly reverted back to forest.

Overall, the forests and woodlands on Turn Island appear to be in good condition. The understory is generally intact, and consists primarily of native shrubs, grasses, and forbs under the oaks. However, in the immediate vicinity of the campsites, exotic grasses and weeds dominate and provide a striking contrast with the understory elsewhere on the island.

On Smith Island, woodland composed of low conifers (likely Douglas-fir) and shrubs formerly occupied the center, north, and west ends of the upland plateau (Menzies 1792 in Newcombe 1923, Vancouver 1792 in Blumenthal 2004, USCS 1854). However, with the establishment of a lighthouse station in 1858, the dwarf trees and low woody vegetation were largely cleared in order to afford a clear horizon in every direction and to open up areas that were fenced for cultivation (USCS 1869). With the decline in human activity on the island since 1976 when the lighthouse was automated, the woodland has somewhat expanded; however, the vegetation remains transitional as willows, oceanspray, snowberry, wild rose, and grasses still dominate while the Douglas-fir remain stressed and marginal. Around many of the structures invasive species, such as field bindweed, Canada thistle, and orchard grass, have become the dominant vegetation.

North Pacific Maritime Dry Mesic Douglas-fir-Western Hemlock
San Juan Islands NWR
Overall, the dry mesic Douglas-fir-Western Hemlock forest on Matia Island appears to be in good condition. The area cleared by the homesteader in the late 1800s and early 1900s has since filled back in. The fruit trees are still present though. Additionally, the understory has few invasive species – primarily a few holly trees, and a patch of English ivy near the eastern shore. Neither of these invasive species is abundant.

The old-growth stands on Matia Island are unique in the San Juan Islands. While there are other old-growth forests in the islands, they are few and far between, and primarily consist of Douglas-firs. What is remarkable about this stand is the size and abundance of red cedars. This species is considerably less common that Douglas-fir in the San Juans, and most large cedars have been logged many years ago in areas where they once existed.

North Pacific Oak Woodlands
Prior to Euroamerican settlement, oak woodlands were found throughout the Salish Sea in dry sites with shallow bedrock or deep, gravelly glacial outwash soils, and high growing season moisture stress (Natureserve 2009). The historical range of oak woodlands was also greatly affected by Native Americans who used low-severity fire, pruning, and knocking to favor oak savannas and woodlands over mixed conifer forests and to influence stand configuration and tree shape (Cole 1977, McCarthy 1993). However, the advent of Euroamerican settlement interrupted traditional forest management practices and further altered plant community dynamics by eliminating prescribed fires, introducing invasive plants, and overgrazing. As a result, areas with remnant oak woodlands commonly undergo successional changes that result in plant communities that diverge from a historic composition. These changes include an increase in conifers, the proliferation of a shrub understory, higher oak densities, and an increasing abundance of non-native annuals and perennials in the herbaceous understory (Hosten et al. 2006).

Consequently, throughout its range, this Garry oak-dominated system is in precipitous decline. While it was historically much more abundant in the San Juan Archipelago, it was never likely to be abundant on refuge islands. Currently, the presence of the North Pacific Oak Woodlands system within the refuge is essentially limited to the perimeter of Turn Island. It is likely, however, that there once was a larger oak woodland on Turn Island and there may have been some full-sized oak trees on other small but forested refuge islands that currently have only a few shrub-sized oaks. The primary factors responsible for oak stands being converted to conifer stands on refuge islands such as Turn Island are natural succession and fire suppression, which encourage conifer growth. Elsewhere in the San Juan Archipelago some oak woodlands were undoubtedly lost to land development. On Turn Island, invasive species within the vicinity of the campsites, trail proliferation by the public, and grazing by deer all pose threats to the integrity of this habitat.

4.6.4 Key Ecological Attributes

Table 4-5. Forest and Woodland Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Disturbance Regimes	1. Areal extent, frequency, intensity, severity, and return interval of fire 2. Rate of regeneration (saplings/acre)	1. Analysis not completed 2. Analysis not completed

Key Ecological Attributes	Indicators	Desired Condition
Plant Community Structure and Composition	1. Percentage of canopy cover of trees on PI (e.g., total canopy openness/closure and gap proportions) 2. Amount of snags and woody debris 3. Ratio of cover of native to non-native understory species 4. Presence/absence of late-seral or old growth stands 5. Percentage of invasive species cover 6. Presence/absence of new noxious weed invaders (not currently present on these refuges)	1. >25 canopy cover 2. Analysis not completed 3. >50% cover of native understory shrubs (ocean spray, Nootka rose, etc.) 4. Presence of > 200 year-old trees 5. <10% invasive species cover 6. No new noxious weeds
Connectivity 1.	Presence/absence of shrub layer between forest patches	1. Gap between forest stands restored with shrubs to >50% shrub cover on PI
Security and Human Impacts	1. Presence/absence of human activity on or near forest and woodlands on Turn and Matia islands 2. Number of illegal fires on Turn and Matia 3. Presence/absence of human activity on or near forest and woodlands on PI and other closed islands 4. Presence/absence of deer, rats, rabbits, red foxes, feral or domestic pets	1. Limited access to within campsites and designated trails 2. 100% use of liquid fuel camp stoves 3. Low human activity 4. No non-native rats, rabbits, red fox, feral cats or dogs on any refuge islands; no deer on Protection Island.

4.6.5 Threats

Threats facing the forests and woodlands of Protection Island and the San Juan Islands Refuges include climate change, storm events, invasive species, insect or disease infestation, altered fire regime, herbivory, and human intrusions and disturbance.

For the forests and woodlands occurring on Protection Island and the San Juan Islands, the responses to climate change will vary according to regional and local topography, forest type, soil moisture, productivity rates, species distribution and competition, and disturbance regimes. However, based on the projected changes in the spatial and temporal patterns of temperature and precipitation associated with climate change, some general patterns can be described (adapted from Aldous et al. 2007):

- Species distributions are likely to change. Cool coniferous forests in the western part of the Pacific Northwest will contract and be replaced by mixed temperate forests over substantial areas (Mote et al. 2003). Douglas-fir appears relatively sensitive to low soil moisture, especially on drier sites (Case 2004; Hessl and Peterson 2004; Holman 2004 citations in UWCIG 2004).
- Increasing temperature will generally increase forest fire frequency and extent.
- Higher temperatures will increase rates of evapotranspiration, leading to greater water losses from forests.
- The change in seasonality of precipitation could lead to a drier growing season, increasing water stress.
- Warmer temperatures could lead to a change in the timing of reproduction, which may lead to asynchronies between flowering and pollinator activity, fruit ripening and foraging by fruit-

consumers, or predator behavior by pest-eating species.

- An increase in extreme weather events (e.g., wind storms) could change the frequency of disturbance, leading to a shift to forests that are younger and species that are faster-growing, shorter-lived, and more disturbance-tolerant.
- Warmer temperatures could increase development of insect and other pathogen outbreaks, as well as extend their growing season, potentially leading to an increase in the frequency and extent of outbreaks.
- Some tree species may experience an increase in productivity if carbon dioxide acts as a fertilizer and allows trees to increase their water use efficiency. However, this increased productivity, coupled with warmer temperatures, longer growing seasons, and prolonged drought, may also increase fire frequency and severity.

Introduced invasive plants (e.g., English ivy, English holly, Scotch broom) pose a significant threat to the native forest and woodland communities on the refuges. By outcompeting native species, these invasive plant species can alter vegetation communities and modify ecosystem processes. Non-native animal species such as feral cats and rats may prey on or compete with native wildlife species utilizing the forest and woodland habitat. Additionally, some invasive insects (e.g., winter moth, jumping gall wasp, oak leaf phylloxeran, and gypsy moth) and other invasive pathogens have the potential to cause serious damage to Garry oaks and other tree species. Other potential insects or diseases that could affect the refuges' forests and woodlands include aphids, scale and bark beetles, root rot, leaf cast, and other fungi. Sudden Oak Disease, caused by the fungus *Phytophthora ramorum*, has not yet been detected within Washington outside of nurseries; however, it should be considered a potentially significant threat.

Prior to Euroamerican settlement, oak woodlands were greatly affected by Native Americans who used low-severity prescribed burns to influence stand configuration and tree shape (Cole 1977, McCarthy 1993). Fire suppression within oak woodlands following Euroamerican settlement led to an increase in conifers, the proliferation of a shrub understory, higher oak densities, and an increasing abundance of non-native annuals and perennials in the herbaceous understory (Hosten et al. 2006). The continued lack of fire on Turn Island, the only refuge island containing remnant oak woodland, will likely lead to succession towards greater conifer dominance.

Due to lack of predation and hunting pressure, the population of black-tailed deer on Protection Island and within the San Juan Islands has also expanded to such densities that they are having an influence on vegetative cover. Typically, deer browsing helps to maintain herbaceous dominance by limiting sapling recruitment and retarding or delaying succession to forested habitats (Chappell 2006). However, deer browsing may impede the restoration of Protection Island's forest, and on the San Juan Islands Refuge, researchers are concerned that excessive deer browsing is threatening oak woodlands (Dunwiddie 2007a).

Human-induced wildfire is a potential catastrophic threat to the late-successional and old-growth forest on Matia Island. Additionally, other illegal activities such as firewood collection, trail proliferation, and general trespass have the potential to cause tremendous disturbance to wildlife and also have the potential for introduction of invasive plant species into closed areas of the refuge.

4.7 Wetlands

4.7.1 Description and Location

Wetlands currently occupy a total of 0.9 acres on two islands within the San Juan Islands NWR. The wetlands currently occurring on refuge-managed lands can be categorized into two ecological systems:

Temperate Pacific Freshwater Emergent Marsh and North Pacific Coastal Interdunal Wetland.

Protection Island
Prior to development of the marina on Protection Island in the late 1960s, an 8.9 acre North Pacific Coastal Interdunal Wetland existed on Violet Point. Daily and seasonal input of freshwater from the seeps coming down the slopes to the west of the spit likely affected the vegetation composition of the marsh. However, the marsh was filled in and graded during the construction of the marina and no longer exists.

San Juan Islands
Matia Island is unique among the smaller of the San Juan Islands in that it includes a 0.4-acre Temperate Pacific Freshwater Emergent Marsh dominated by cattails and slough sedge. The areas of open water between the cattails and shore are partially covered by duckweed. Other than these species, there appear to be few others growing in the water or on the vegetation mat (Dunwiddie 2007b). The wetlands are surrounded primarily by tall red alder.

Smith Island contains a 0.5 acre North Pacific Coastal Interdunal Wetland on its eastern spit in a wind-scoured depression. Pickleweed and other salt-tolerant wetland species occurs along the perimeter of a small shallow swale that receives limited freshwater input from seeps coming down from the west in addition to direct precipitation. Consequently, water levels vary seasonally, typically receding and occasionally drying up in the summer. The spit protects the wetland from wave action but is likely to allow irregular, limited saltwater intrusion, especially during storm or overwash events. Vegetation has not been surveyed; however, a variety of emergent wetland species have been noted by staff.

4.7.2 Associated Wildlife

Since this habitat type consists of no more than approximately 1 acre, no focal resources have been selected for wetlands; maintaining biological integrity will be the focus for management. However, there are several other benefiting species associated with this habitat type including dunlin, northern pintail, mallard, Canada goose, great blue heron, amphibians, and bats. Black oystercatchers and glaucous-winged gulls nest in adjacent habitats and may use the wetlands on Smith and Protection islands during their lifecycle.

4.7.3 Conditions and Trends

Protection Island NWR
The wetland no longer exists on the island, however small pools of water do form after hard rains during the winter months.

San Juan Islands NWR
The freshwater emergent marsh on Matia Island seems to be unaltered and appears to be in good condition. The tidal wetland on Smith Island also seems to be in good condition, however, staff are not sure if the natural hydrology of the area around the wetland has been altered.

4.7.4 Key Ecological Attributes

Table 4-6. Wetland Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Hydrologic Regime and Water Quality	1. Water source, depth, annual cycle, temperature, pH, alkalinity, conductivity, dissolved oxygen, and phosphorous	1. Analysis not complete
Disturbance Regimes	1. Frequency, depth and duration of saltwater intrusion and flooding of Smith Island wetland	1. Analysis not complete
Plant Community Structure and Composition	1. Inventory plant community composition. 2. Proportion of native plant species 3. Presence/absence of trees and shrubs	1. Analysis not complete 2. Analysis not complete 3. Analysis not complete
Native Species Representation	1. Presence/absence of aquatic invasive animals and plants.	1. Analysis not complete
Security and Human Impacts	1. Presence/absence of human activity on or near wetlands. 2. Presence/absence of rats, rabbits, or mammalian predators.	1. Low human activity. 2. No non-native rats, rabbits, red fox, feral or domestic pets on any refuge islands

4.7.5 Threats

The amount of water and, consequently, duration of wetland on Matia Island varies with precipitation. Therefore, the wetland could be sensitive to climate change and altered precipitation patterns. Sea level rise could also threaten the current plant communities if the freshwater table is pushed upwards by salt water intrusion, leading to a higher salinity within the marsh.

The current plant communities of the Smith Island wetland may be threatened by climate change and sea level rise, which would likely increase the amount of tidal inundation and salt water intrusion. Also, any significant erosion of the low spit would likely damage or eliminate the wetland. In the event of sea level rise, additional threats from invasive species (e.g., European green crab and common cordgrass) could alter the present plant community.

4.8 Seabirds

Seabirds spend most of their time on the ocean and return to land only to reproduce and raise their young. There are six species of seabirds that commonly nest on the refuges and were selected as focal resources. They are the rhinoceros auklet (RHAU), tufted puffin (TUPU), pigeon guillemot (PIGU), pelagic cormorant (PECO), double-crested cormorant (DCCO) and glaucous-winged gull (GWGU). Four of these species are emphasized in the refuge purposes for Protection Island NWR (Public Law 977-333), specifically: "The purposes of the refuge are to provide habitat…with particular emphasis on protecting the nesting habitat of…tufted puffin, rhinoceros auklet, pigeon guillemot and pelagic cormorant."

A number of seabirds that may be seen in the vicinity of the refuges are not covered in detail in this plan because they do not nest on refuge islands. For instance, common murres (COMU) may be seen flying or swimming near the refuges during late summer through spring periods, but they are not known to nest on the refuges or anywhere else in the inner waters of Washington (Speich and Wahl 1989). They frequently forage in the waters surrounding refuge islands during the non-breeding season. Marbled murrelets (MAMU) nest in old growth forests on the Olympic Peninsula, Washington, and Vancouver Island, British Columbia, but have never been found to nest on small islands in the San Juan Archipelago (Raphael pers. comm. 2005). Brandt's cormorants (BRCO) are typically observed in the Salish Sea during the breeding season, but very rarely breed here, thus they have not been selected as focal resources.

4.8.1 Description and Location

Many of the seabird species that breed on the refuges are fairly site-faithful, returning to the same colony site year after year if successful in fledging young the previous breeding season. Seabirds have very specific nesting requirements, primarily habitat free of predators and human disturbance, particularly for ground or crevice nesting species, and with suitable soils for burrow nesting species (USFWS 2005). Protection Island and San Juan Islands NWRs provide some of the last remaining undeveloped seabird nesting habitat in the Salish Sea. The suitability of larger islands within the San Juan Archipelago for seabird nesting has been reduced due to habitat loss and threats associated with development and disturbance. Subsequently, the largest colonies and the vast majority of breeding seabirds are found on small (<40ha;100ac) islands on- and off-refuge (USFWS 2005). Protection Island is an exception as it is a relatively larger island that supports the third largest RHAU colony in North America and the single largest gull as well as one of the larger pigeon guillemot colonies in the U.S. portion of the Salish Sea (Pearson et al. 2009, Roby and Adkins 2007, Cyra et al. 2007, J. Evenson pers. comm.). Protecting suitable seabird nesting habitat within these refuges is clearly a Service priority.

Rhinoceros Auklet

The breeding range of the rhinoceros auklet extends from the California coast northward around the Pacific Rim through the Aleutian Islands to northern Japan (Speich and Wahl 1989). The majority of the birds that breed in North America (>95%) are located on islands in southeast Alaska (12%), British Columbia (73%) and Washington (13%), with most birds concentrated in 8 colonies (USFWS 2005). Two of the 8 key colonies are located in Washington: Destruction Island on the outer coast and Protection Island NWR in the Strait of Juan de Fuca (USFWS 2005). Smith Island within the San Juan Islands NWR also has a relatively small auklet colony.

Through the breeding season, rhinoceros auklets forage or raft up around Protection Island and within the Strait of Juan de Fuca. Wahl and Speich (1994) reported that approximately 59 percent of the birds within the Strait were observed in that area from June through July in 1978. An additional 29 percent were observed foraging near Admiralty Inlet to the east of the island. This data represents a snapshot of distribution within the Salish Sea and may vary based on distribution of forage fish. In addition, from early August through early September, fledglings can be found in the waters surrounding Protection Island. They typically remain close to shore for several days before dispersing (U. Wilson pers. comm.). Outside the breeding season, auklets disperse widely. The Service Seabird Conservation Plan notes that some birds move south during post-breeding dispersal to important wintering areas off the coast of California. A portion can be found within the Salish Sea during the nonbreeding season, in places like southern Puget Sound; however, their breeding origin is unknown (USFWS 2005). This species is typically observed at sea in mixed feeding flocks of seabirds and sea ducks (Gaston and Jones 1998).

Auklets are present on colony from March through late September. Egg laying is generally initiated in early May; hatching spans mid-June through mid-July and fledging follows through August (Wilson 1977, Richardson 1961).

Tufted Puffin
Tufted puffins breed from California around the Northern Pacific Rim to Japan. Approximately 0.8 percent of the global population of TUPU breeds in Washington (Piatt and Kitaysky 2002). Breeding in the inner marine waters of Washington is currently limited to Protection and Smith islands. Speich and Wahl (1989) reported low numbers "In the inland waters...at Protection Island, Smith Island, and at Colville and Bare Islands." The last recorded incident of TUPU nesting on Puffin Island was in 1963 with 7 individuals observed in the area during the breeding season, but breeding status was not confirmed (Speich and Wahl 1989). In 1977, 6 TUPU were reported at Williamson Rock (Speich and Wahl 1989) and refuge staff observed 1 puffin flushed from Williamson Rock in 1985, but nesting status was not confirmed. Refuge staff reported 9 TUPU on Colville Island in 1983 and 5 in 1984. In 1984, staff observed a puffin flying into a burrow on Colville Island with fish. Recently, partners conducted a survey for TUPU on historical breeding islands in the San Juan Archipelago and reported no TUPU observed (S. Pearson pers. comm.).

TUPU arrive in April and are last observed in September. Egg laying through fledging spans from May through August (Piatt and Kitaysky 2002). This species winters offshore throughout the North Pacific.

Pigeon Guillemot
PIGU primarily nest in low abundance at many locations throughout the Salish Sea; however, they do concentrate at some sites such as Protection Island, where approximately 16 percent of the breeding population of the inner marine waters of Washington can be found each year (J. Evenson pers. comm.) This species nests on more than 1/3 of the islands in the San Juan Island NWR (Sanguinetti 2004). Refuge islands in the San Juan Islands NWR which historically supported >200 PIGU include Castle, Flattop, Skipjack, Matia, and Williamson Rock.

This species can be seen throughout the Salish Sea year-round, however it is unknown whether PIGU observed in the area during the nonbreeding season are the same individuals as those that breed here. PIGU can be found on the colony from April through September. Eggs are generally laid beginning in mid-May and fledgling runs through September (Speich and Wahl 1989).

Pelagic Cormorant
During the most recent comprehensive survey of the inner marine waters of Washington, three locations supported 75 percent of nests; all were located off-refuge on unprotected properties. In the 1980s, the largest refuge colony, on Protection Island, ranged from 150 to 300 nests (Speich and Wahl 1989, K. Ryan, pers. comm). Historically, Bare, Castle, Colville, Protection, Smith, Viti, and Williamson islands have supported at least 100 nests each through the early 80s (Speich and Wahl 1989). During the 2003 survey, refuge islands supported 12 percent of nests. However, the number of nests observed did not exceed 65 on any San Juan Islands NWR islands (Nysewander 2003a). In 2009, refuge staff observed PECO on or near Barren Island, Bare Island, Bird Rocks, North Pacific Rock, Sentinel Rock, South Peapod, Unnamed Island (# 36), Smith Island, Williamson Rocks, Viti Rocks, and Protection Island; however, breeding status was only confirmed for Bird Rocks, Williamson Rocks, Viti Rocks, Smith Island, and Protection Island.

PECO are on colony from April through October. Sensitive times include egg laying through fledgling which occurs from mid-May through September. They can be seen within the Salish Sea year-round.

Double-crested Cormorant
Similar to PECO, DCCO colony locations vary considerably. Historically, Colville, Williamson, and Bird Rocks have supported over 100 breeding birds, and Protection, Smith, Bare, and Viti have supported less than 50 (Speich and Wahl 1989). Results from surveys throughout the inner marine waters of

Washington in 2003 reveal that one location supported 67 percent of all nests observed in inner marine waters of Washington; however, this site is located off-refuge in a non-protected location. Five refuge islands (Smith, Protection, Viti, Williamson, and Hall) supported 33 percent (Nysewander 2003a). In 2009, refuge staff observed DCCO adults or nests on Bare Island, Bird Rocks, Barren Island, Crab Island, Gull Reef, Minor Island, North Pacific Rock, Smith Island, Small Island, Viti Rocks, and Williamson Rocks. DCCO can be found on colony from late March through mid-November with egg laying through fledgling occurring from April through October. They are resident within the Puget Sound.

Glaucous-winged Gull
This species is found year-round throughout the Salish Sea. A comprehensive aerial survey of gulls throughout the Puget Sound in 2007 indicates that the largest GWGU colony, with approximately 40 percent of gull nesting in the U.S. portion of the Salish Sea, is located on Protection Island (Roby et al 2007, Cyra et al. 2007) Within the San Juan Archipelago, 7 refuge islands supported approximately 50 percent of gull colonies. They include Hall Island (11%), Smith Island (10%), Bird Rocks (9%), Viti Rocks (8%), Minor Island (5%), Williamson Rock (3%), and Pointer Island (3% Cyra et al. 2007).

4.8.2 Condition and Trends

A large portion of breeding seabirds in the Strait of Juan de Fuca and San Juan Archipelago nest on the refuges where they find relatively undisturbed habitat (J Evenson pers. comm., P Sanguinetti pers. comm.). However, extensive development and the resulting habitat loss and increased predation on larger islands in the Salish Sea (i.e., Whidbey and San Juan Island) has lead to a decrease in the abundance of breeding seabirds on those islands. Further information on the conservation status of each species listed below can be found in Appendix C.

Rhinoceros Auklet

Approximately 66 percent of the estimated global population (1 million) breeds in North America (USFWS 2005). Because this species nests underground and is active on the colony primarily at night, determining trends in RHAU populations is logistically difficult. Table 4-7 shows the range of abundance on Protection Island (both on- and off-refuge). It should be emphasized that this data represents the historical range of abundance of RHAU on the island only. Different methodologies, survey areas, and data analysis do not allow for a direct comparison of estimates, therefore the trend is unknown. The previous refuge biologist reported a noticeable decline in numbers on Protection Island after the Tenyo Maru oil spill in 1991 (K Ryan pers. comm. per Wilson). Currently, Protection and Smith Islands support the only known RHAU colonies within the inner marine waters of Washington State.

Table 4-7. Range of Abundance of Breeding RHAU on Protection Island

Year surveyed	Estimated # RHAU	Source
1854	Colony present but no estimate provided	Speich and Wahl 1989
1956-1959	3000-4000 breeding pairs	Richardson 1961
1973	9,200 breeding pairs	Frazer 1973 in Speich and Wahl 1989 (Robel reported 12,50 br pr in 1973)
1976a	27,549 burrows 17,108 breeding pairs	Wilson 1977
1983	27,059 burrows	Thompson et al. 1985
1985	17,000 breeding pairs	USFWS 1985
2000	12,000 breeding pairs	Wilson unpublished data cited in

		Wilson 2005
2008	54,113 ± 9,390 burrows 35,715 ± 6,757 breeding pairs	Pearson et al. 2009

Number of burrows x 62% occupancy in 1976 = estimate of breeding pairs (Wilson 1977)

Breeding RHAU on Smith Island have not been counted since 1979 when the estimated abundance was 2,388 individuals (Speich and Wahl 1989). Refuge narrative reports have noted estimates of 3,000 RHAU in 1983 and 1984 and 1,200 in 1986 on Smith Island. In 1983, burrows were also observed on Bare Island, however, surveyors were unable to verify whether they were active or occupied by RHAU or TUPU.

Tufted Puffin
The North American population estimate for TUPU is approximately 2,460,000 breeding birds (Piatt and Kitaysky 2002). Of that, approximately 1 percent breeds in USFWS Region 1. During the past 15 years, declines of 3-21 percent per year have been estimated for California, Oregon, and Washington (USFWS 2005). These trends may reflect a response to decadal changes in large scale ocean currents. Because the species nests in burrows that are difficult to access and breeding colonies are often located in inaccessible areas, current population estimates and information on productivity is lacking (USFWS 2005).

Speich and Wahl (1989) estimate approximately 45 tufted puffins were located on Protection Island and 8 on Smith Island during the breeding season in the late 70s and early 80s. Galusha et al. (1987) reported approximately 50 puffins observed on or around Protection Island in 1984. Very little current information is available for this species; however, incidental observations in 2008 account for approximately 37 birds on Protection Island and up to 34 birds on Smith Island (S Pearson pers. comm.). Breeding status was not determined, but some of the birds observed were exiting burrows near the top of the sandy bluffs of each island.

Pigeon Guillemot
The status of PIGU in the Salish Sea is unknown (USFWS 2005). The North American population estimate is 88,000 breeding birds (USFWS 2005). Confirmation of status is hindered by lack of comprehensive overall historic data collected throughout the Salish Sea with which to compare the 1999-2003 surveys. Recent surveys of PIGU in the inner marine waters of Washington State produce an estimate of 16,000 birds within 425 colonies (Evenson et al. 2002). The most current estimate of PIGU breeding on Protection Island is approximately 1,500 (J. Evenson pers comm.). This represents the second largest concentration of PIGU in the Salish Sea.

Pelagic Cormorant
The global population estimate is 400,000, with approximately 29,000 in Washington (USFWS 2005). Overall populations appear to be stable, however reproductive success declines during El Niño events (USFWS 2005). PECO colonies may move from year to year, particularly after years of colony or nest failure. This results in a high annual variation in abundance between years. Protection Island supports one of the largest colonies in the inner marine waters of Washington with the other three large colonies located off-refuges. This colony supported 906 individuals (breeding status not confirmed) in 1984 (Galusha et al. 1987), although abundance has since declined and the colony has been abandoned in recent breeding seasons. The cause of abandonment is unknown; it may be due to predation, disturbance, or simply reflect a natural shift in colony sites. Protection Island is one of the few larger colony sites that has some federal or state protective status associated with it.

Double-crested Cormorant
This species is expanding its range and abundance throughout the U.S. A recent survey of the U.S. Pacific Coast colonies in 2003, including the inner marine waters of Washington, reported an increase in abundance since 1991(25,600 pairs in 2003 vs. 12,200 pairs in 1991, USFWS 2005). Results from the surveys in 2003 show that sites supporting DCCO in high abundance are located off-refuge, yet historically a large portion of the breeding birds in the Salish Sea nested on refuge islands. It is unknown if this reflects a population change or a shift in nesting outside of the survey area (Nysewander 2003a).

Glaucous-winged Gull
The North American breeding population size is approximately 380,000 breeding pairs (USFWS 2005). Protection Island and the San Juan Archipelago are located at the northern end of the Glaucous-winged Gull/Western Gull hybrid zone (Bell 1998). In fact, researchers believe it is the largest breeding site for Glaucous-winged Gull x Western Gull hybrids, thus, this refuge serves as a particularly important resource for the study of vertebrate hybridization (J. Hayward, pers. comm.).

Historically large GWGU colonies, including Buck Island, Colville Island, Gull Rock, Puffin Island, Skipjack Island, Sisters Islands, and White Rock, have disappeared. It is unknown if this reflects a shift in the breeding population to urban areas or other factors, such as mammal predation, disturbance, or landfill remediation and closure in the past throughout the Salish Sea.

During the first 10 years of refuge establishment, the GWGU colony on Protection Island steadily increased, and then steadily decreased through 2006. During the 2005 breeding season, an almost complete reproductive failure was reported on the largest colony, Violet Spit. This failure appeared to be in response to changes in vegetation and bald eagle predation (Galusha 2005). Researchers believe that this has caused the bulk of the gull colony on the spit to shift towards the bluff and marina where human presence may serve to reduce the abundance of eagles at any given time (J. Hayward and J Galusha pers. comm.).

4.8.3 Ecology

According to the Birds of North America species accounts, the breeding seabirds on these two refuges are relatively long-lived (up to 17 years) and begin breeding typically around their third year. Annual reproductive output is relatively low, with RHAU, TUPU, and PIGU laying 1 or 2 eggs, while GWGU, DCCO, and PECO will lay from 1 to 4 eggs (Ewins 1993, Gaston and Dechesne 1996, Hatch and Weseloh 1999, Piatt and Kitaysky 2002, Hobson 1997, Verbeek 1993). In addition, if disturbed, many of these species will abandon eggs or young, thereby further reducing reproductive output for the year. With such low clutch sizes and long life spans, adult survival is an important component of the status of each species.

Rhinoceros Auklet
Important characteristics for RHAU nesting habitat include soil, slope, elevation, and vegetation. They are further defined below:

Soils- Leschner (1976) noted that few generalizations about habitat preference can be made because of the variation in slope, substrate, vegetation, and weather conditions throughout the geographical range of the rhinoceros auklet. Nevertheless, the one common feature to all known rhinoceros auklet colonies is a well-developed soil into which they excavate burrows. Throughout their range and with few known exceptions, RHAU nest on islands with well-developed soils into which they dig burrows with their feet and beaks (Leschner 1976, Speich and Wahl 1989, Richardson 1961). On Protection Island, burrows averaged 2 to 2.4 meters with a range of 1 to 5.2 meters (Richardson 1961). A firm, sandy soil with some roots holding it together near the surface is preferred. RHAU burrows are often near the surface of the ground and can easily be collapsed (Sowls et al. 1980, Leschner 1976).

Slope- On both Protection and Smith Islands auklets do not burrow in the level open grass interior portion of the islands (Leschner 1976). This is primarily because the slope aids take-off. Birds burrowing on level areas must walk to the edge before departing (Leschner 1976). Richardson (1961) found burrows as far as 100 to 200 yards back from the bluffs. Wilson and Manuwal (1986) found that burrow density was significantly correlated with angle of slope on Protection Island. From 1956-1959 the majority of the burrows were located on or just above the steep slopes (37 degrees to 45 degrees) of Protection Island, presumably to avoid trampling by domestic livestock (Richardson 1961). In 1975 and 1976 the colony expanded with 85 percent of burrows located on the more moderate southeastern and southwestern bluffs (Wilson and Manuwal 1986). In 1983 the colony was estimated to be approximately the same size as in the mid-1970s, but there was another shift in density of burrows with higher densities on the gentler slopes than the bluffs (Thompson et al. 1985). The reason for this shift was unknown, however Thompson noted that two factors may be important: 1) over time, burrowing may deteriorate the soil and thus habitat in localized areas, and 2) the colony may be expanding into areas in which the soil has stabilized and vegetation regenerated after 70 years of overgrazing by sheep (Newcomb 1940, Richardson 1961, Wilson 1977). Whatever the case, this shift appears to have continued in 2008 (Pearson et al. 2009). In 2008, the largest extent of the colony was located on the south-facing slopes, although dense expanses of burrows are still located along the western bluff.

On Smith Island where moderate slopes are not available, most of the RHAU burrows are located in the flat grass-covered upper edge of the island, avoiding the very steep bluffs (Wilson and Manuwal 1986). Staff have noted that most burrows are located within the first 100 feet from the edge of the bluffs.

Elevation- On Protection Island, Richardson (1961) noted that auklets drop several feet when taking off from land and most burrows were located 30 feet or more above the level of the beach even where suitable nesting slopes extended to the bottom. Very few burrows were located as low as six feet above and 12 feet back from the mass of logs and flotsam marking the limit of highest water. Auklets leaving from these burrows scrambled through the flotsam to take off from the water. Auklets with burrows above the two wide spits did not tend to nest so low on the slope (Richardson 1961).

Vegetation- Vegetation primarily serves to stabilize the soil above-ground from erosion and roots stabilize the soil for burrowing activity. Range-wide, RHAU colonies can be found in many different habitat types under a variety of vegetative communities. On Protection and Smith islands, RHAU dig their burrows under dense grasses. Rhizomatous grasses with well developed root systems appear to provide the best stability for burrow construction on the island.

RHAU are wing-propelled, pursuit divers that typically forage in mixed flocks in waters greater than 20 meters deep (Wahl and Speich 1994). In the Salish Sea, their diet consists of small fish, such as herring and sandlance (Wilson and Manuwal 1986).

Tufted Puffin

The upper level of sandy bluffs on Protection and Smith Islands provide high quality nesting habitat for TUPU. This species digs burrows on Protection and Smith Islands and congregates in mixed foraging flocks on the water around the islands. TUPU are diurnal and feed on small fish, such as herring, salmon smolt, smelt, and sandlance.

Pigeon Guillemot
PIGU will nest in a variety of habitats and forage close to land. On the rocky islands of the San Juan Archipelago, they nest in cavities and crevices. On Protection Island, the majority of guillemots nest in the driftwood on Kanem and Violet Spits, but they also dig burrows in sandy bluffs composed of clay, sand, or some combination. On Protection Island, these burrows tend to be near the top of the bluffs. This species feeds on small fish, such as blennies and sand lance. They often forage in small groups or pairs.

Pelagic Cormorant
Pelagic cormorants nest in small colonies on rocky ledges on steep cliffs. They also use human-created structures, such as channel buoys, which offer small cubbyholes or ledges. Some colonies are placed on larger, off-refuge islands, such as Henry Island near Roche Harbor, where ledges are completely inaccessible to humans. Cormorants are very sensitive to disturbance and will abandon the colony if disturbed during the breeding season. They are also sensitive to shifts in sea conditions, such as those that occur during El Niño events, and will abandon nesting if an adequate food supply is not available. PECO are typically solitary away from the colony and forage by diving for small fish along the rocky shore.

Double-crested Cormorant
On the refuges, DCCO build platform nests of sticks on rocky ledges, cliffs, and islands. Like PECO, DCCO will use human-created structures such as buoys, towers, and large signs. Although they build on the upland, the nests are placed so that the birds can easily access the surrounding water. Biologists believe that cormorants are laying later in the year and some colony locations have changed in response to eagle disturbance and predation (D. Nysewander pers. comm.). DCCO can be observed roosting on shorelines and shoreline pilings throughout the islands. They also dive for small fish among submerged rocks.

Glaucous-winged Gull
An invasion of non-native plant species (i.e., beach grass) has rendered sections of Violet Spit that once supported the highest abundance of gull nests as unsuitable. Closer to the marina, a remnant population of native plants remain that are associated with the strand assemblage with low vegetative density and ample open spaces between plants. Researchers have noted that gull nests located in or near dense vegetation are more susceptible to bald eagle depredation (80%) while those located in more open, strand habitats appear to be more successful (15%, J. Galusha, pers. comm.). This is due, in part, because the open space allows mobbing gulls better access to eagles that are on the ground.

In addition, research in other colonies has shown that a high degree of variability in topography (i.e., relatively small hillocks or divots in the sand or woody debris) around nests provides concealment from predation and natural screens from nearby nests (Good 2002). These components are particularly important in areas with high disturbance and predation pressure, such as Violet Spit, where disturbance or predation from bald eagles, other gulls, and deer can limit reproductive success (Hayward and Henson 2008, Galusha et al. 2005). Components of strand communities that support successful gull productivity include: 1) sparse <30% grasses; 2) interspersed with gum weed and other natural forms of screening for nests such as driftwood. Restoration should be conducted in a manner that maintains the cohesion of the colony because the colony is less likely to shift to new, disjointed areas (J. Galusha, pers. comm.).

4.8.4 Key Ecological Attributes

Table 4-8. Seabird Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Population Levels	1. # of breeding RHAU 2. # of breeding TUPU 3. # of breeding PIGU 4. # of breeding PECO 5. # of breeding DCCO 6. # of breeding GWGU	1. RHAU - maintain current population on PI 2. TUPU - reestablishment in SJs 3. PIGU - Increase 4. PECO - Increase 5. DCCO - Maintain 6. GWGU - Habitat management to maintain on the spits of PI
Clean Habitat	1. Presence of marine debris on shoreline and derelict gear in the water 2. Presence of creosote pilings and rogue logs 3. Presence of oil or other contaminants on shorelines	1. No marine debris on shoreline or derelict gear in waters 2. No creosote pilings on PI and Matia. No creosote rogue logs on Smith, PI, and other islands when observed 3. No oil or other contaminants on shorelines
Security and Human Impacts	1. Presence/absence of human activity on or near seabird breeding areas 2. Presence/absence of deer, rabbits or mammalian predators	1. Access limited to essential activities (research or management) 2. No non-native rats, rabbits, red foxes, feral or domestic pets on any refuge islands; no deer on Protection Island

4.8.5 Threats

Because seabirds typically have a long life span and low productivity, threats that limit productivity and increase adult mortality are of the highest conservation concern. Known and potential threats to seabird populations include habitat degradation, climate change, disturbance and trampling, fisheries interactions, oil contamination, predation, and competition (USFWS 2005). Many of the threats below are linked. For instance, the larger islands within the inner marine waters of Washington, such as Whidbey and San Juan Islands, have been extensively developed leading to habitat alteration, higher threats of human disturbance, and introduced mammalian predators. These islands no longer support substantial seabird breeding colonies.

Habitat Loss and Degradation
Greater than 50 percent of the U.S. seabird population lives within 50 miles of the coastlines, and loss of habitat along the coast has been significant (USFWS 2005). Since 1889, approximately 70 percent of estuarine wetlands and 50 to 90 percent of riparian habitat throughout Washington have been lost. Habitat conversion, fragmentation, and degradation are pervasive threats throughout the Salish Sea and can compound the remaining threats below. For instance, removal of driftwood for fires or creation of driftwood structures degrades important nesting habitat for PIGU. Without abundant driftwood, chicks have less natural screens for use in camouflage from predators. Flight obstructions such as power lines and towers also deteriorate habitat quality, particularly for seabirds that access colonies at night. They can prove fatal to both fledglings and adults especially when placed on or near colonies.

On Protection Island, black-tailed deer are impacting auklet habitat and directly and indirectly affecting RHAU. RHAU burrows are 1-5 m long, often near the surface of the ground, and are susceptible to collapsing. This may cause the egg or chick to be crushed or abandoned, and this species rarely re-nests. As a result, disturbance or trampling of burrows can reduce reproductive success. Burrows collapsed by deer hoofs and deer bedding down in the colony, at times on top of the entrance to a burrow, have been observed by staff and researchers. In addition, deer have created deeply eroded pathways through the unstable slopes and are foraging in most of the suitable burrow nesting habitat. Cumulative impacts could negatively impact RHAU habitat on the island. This species of deer is native to the region, but with the recent high density of approximately 70 deer/0.5 mi^2, vegetative damage would be expected. Several studies in the literature have noted that the impacts of deer on vegetation and soil substrates increase substantially with an increase in the density of deer (Albon et al. 2007, Gillingham 2008).

Impacts to burrows from deer have only recently been noted by staff, however, historical instances of ungulate trampling have occurred on the island. In 1958, Richardson (1961) found trampling by domestic sheep on the island's slopes led to the formation of many slide areas of loose sand and soil. Observations included unstable slopes and auklet burrows buried under slides or caved in by hoofs. During the 1958 and 1959 auklet breeding seasons, about 46 percent of the 76 burrows in the study area were buried by slides from trampling by sheep.

Human-caused Disturbance

Seabirds are very sensitive to disturbance during the nesting period (Speich and Wahl 1989). Cormorants are particularly susceptible to human disturbance during the nesting season and will desert eggs or young if disturbed. Disturbance can be caused by low-flying aircraft or boats approaching too closely to colony islands (Hatch and Weseloh, 1999). Studies of seabird colonies in California have revealed that most aircraft disturbance occurs when flyovers are less than 1,000 feet above sea level, and boat disturbance occurred within 164 feet from shore and was most pronounced when boats remained in the area for extended periods (Rojek, et al. 2007). Boaters anchoring too closely to the islands, or those who have landed on an island and walked through a colony, have also caused colonies to fail. In fact, reports from biologists suggest that DCCO and PECO colonies on Viti Rocks have failed over the past several years. The cause of this failure possibly relates to bald eagle predation and harassment of breeding birds, but declines in forage fish stocks may also have played a role. Since this island is located near frequent boat traffic routes and rockfishing areas, biologists also suspect some degree of disturbance from recreational boating may have contributed to the failure (D. Nysewander, pers. comm.) In addition, on many of the navigational markers within the Salish Sea, GWGU and PECO nests are removed during maintenance.

Increased ecotourism and shoreline development within the Salish Sea create additional threats to breeding seabirds. TUPU are a favored species to see and ecotourism companies schedule cruises during the breeding season. With increasing human populations around the Salish Sea and ecotourism, boating is becoming an increasing source of disturbance. Fast boats are especially dangerous to alcids since the birds are slow to take to the wing and slow fliers. This is particularly of concern near Protection Island during the fledgling period when juvenile auklets are learning to fly and dive (U. Wilson, pers. comm.).

Climate Change

Habitat specialists, such as seabirds, face increased threats from climate change since they have a very restricted range during the breeding season. For instance, terns and gulls are vulnerable to loss of habitat and reproductive failure due to sea level rise and increased incidences of storm events because they typically nest on low-laying spits or sandy shorelines. Climate change will further exacerbate all of the threats listed in this section as they will likely be additive. Increased incidences of El Niño events, sea surface warming and ocean acidification, due in part to climate change, are already affecting seabird species by altering forage fish distribution (Walther et al. 2002, Wormworth and Mallon via climaterisk.net). Cormorants and alcids (e.g., guillemots) are expected to be highly susceptible to population declines due to a mismatch in life cycle events with prey as a result of climate change (Wormworth and Mallon via climaterisk.net). For instance, in 2005, seabird colonies failed along the west coast when a 2-month delay in northerly winds delayed coastal spring upwelling of nutrient rich waters. Delayed upwelling resulted in the lack of phytoplankton and subsequently a lack of fish foraging on the phytoplankton near seabird colonies. Without fish, a major prey species for seabirds, many seabird colonies failed along the Pacific coast (Wormworth and Mallon via climaterisk.net).

Environmental conditions in the Salish Sea are already changing with total annual temperatures increasing by 13 percent and annual inflow of freshwater from precipitation and snow melt decreasing. This change has lead to increased instances of harmful algal blooms and areas of low dissolved oxygen. This, in turn, will reduce plankton, the foundation of the food web in the Salish Sea (Snover et al. 2005). Reduced abundance of plankton will reduce forage fish for seabirds. Since seabirds, especially cormorants, will not nest or colonies will fail in years of low food resources, climate change has the potential to greatly reduce productivity and potentially the adult survival of seabirds breeding on these refuges. On Protection Island, researchers have found that higher temperatures associated with El Niño events decrease hatching success and increase egg cannibalism (Hayward 2010).

Fisheries Interactions

Interactions with fisheries results in several different threats. Mortalities have been documented in Washington gillnet fisheries especially for RHAU and COMU, but PIGU and MAMU have also been affected (Thompson et al. 1998). Declines of RHAU on Protection Island are suspected to be caused, in part, by mortality in gill nets. Regulating the use of a visible mesh panel and eliminating dawn fishing has reduced bycatch in some fisheries and should be encouraged in all active gillnet fisheries in the Salish Sea (Melvin et al. 1999). Entanglement in derelict (lost or abandoned) gear or nets is increasingly becoming a problem in the Salish Sea. Cormorants appear to be most susceptible to this threat. During one study of 4 derelict nets in the Puget Sound, seabirds (88% of which were cormorants) were caught at a rate of 0.24 per day. At this rate, researchers calculated that each net could entangle approximately 7 seabirds per month. Compound that over the estimated 3,800 derelict nets distributed throughout the area and up to 26,600 seabirds per month could be lost to this threat (Natural Resource Consultants 2008). Additional threats include overfishing, which reduces prey species for seabirds, and disturbance from aquaculture fisheries off refuge islands, such as geoduck diving.

Oil Contamination

There are 6 oil refineries in the Salish Sea and approximately 15 billion gallons of oil are moved through the area each year on over 1,000 tankers (WDOE 2009). Other sources of ‘oil’ pollution stem from diesel, gasoline, kerosene, lubricant, and various industrial oils that are just as toxic to wildlife but can occur at a much smaller scale (e.g., leaky bilges) and may not be properly tracked (USFWS 2005).

Species particularly at risk of contamination are those that roost, haul out, or feed in large flocks or rafts near shipping lanes and ports. Protection and Smith Island and many other important seabird nesting colonies in the San Juan Islands NWR (e.g., Williamson and Bird Rocks) are directly adjacent to the vessel traffic routes into the Salish Sea. Breeding RHAU, TUPU, PIGU, and cormorants are highly vulnerable to oil spills because they tend to forage in large rafts near colony sites (Speich and Wahl 1989). In fact, RHAU was the second most common species killed in the Apex Houston oil spill off central California (Page et al. 1990). Further, oiled birds that return to the nest can then transfer oil to eggs or chicks. Laboratory tests have shown that this significantly reduces hatching and fledgling success (Speich and Wahl 1989). The Nestucca (1988) and Tenyo Maru (1991) oil spills off the coast of Washington are considered as contributing factors to the decline in the common murre breeding population (USFWS 2005).

Predation
Predation targets both adult survival and productivity. This threat is especially prevalent on seabird colonies where seabirds nest in and on the ground and have not evolved a mechanism for predator avoidance. In fact, over 40 percent of island bird extinctions world-wide have been caused by introduced species (Courchamp et al. 2003). Potential introduction of cats, rats, raccoons, or other predators into Washington colonies is a primary concern (Speich and Wahl 1989). Raccoons have eliminated seabird colonies on two islands in B.C. and caused serious decline on two additional islands (Golumbia et al. 2008).

Avian predators are also of concern. Mortality has been documented at breeding colonies from bald eagles, peregrine falcons, and other avian predators (Harfenist and Ydenberg 1995, Thayer et al. 2000, Wilson and Manuwal 1986). Hayward and Henson (2008) observed both indirect and direct mortality of gulls due to eagle disturbance on Protection Island. As the population of eagles rebounds, incidences of seabird mortality may increase. Gulls in turn, prey on RHAU and BLOY chicks. Hayward and Clayburn (2004) noted dead RHAU fledglings in gull territories east of the marina and channel on Protection Island where they were killed and eaten by gulls.

Competition
Competition for food resources and nesting areas can have serious effects on reproductive success of seabirds. Some species compete for nesting space. For instance, rabbits will compete for burrows and can change vegetation at colony sites (Courchamp et al. 2003). Rabbits were introduced to San Juan Island and have drastically changed the vegetative community on the island. TUPU are less susceptible to competition with rabbits since their burrows are typically found within very steep bluffs or cliffs. However, TUPU may decline at some locations as a result of reestablishment and recovery of RHAU since the two species compete for burrows (USFWS 2005). Other species compete with seabirds for food in the form of kleptoparasitism. Gulls and raptors are known to steal fish from seabirds returning to the colony to feed chicks (Gaston and Deschesne 1996, Speich and Wahl 1989). RHAU almost always enter and leave colonies at night when feeding chicks (Speich and Wahl 1989). This predominantly nocturnal behavior may have evolved as a means of reducing kleptoparasitism or simply to exploit different prey species (Wilson and Manuwal 1986). Wilson (1993) noted that the presence of gulls nesting near auklet burrows did not affect auklet burrow use, breeding success, or egg-laying dates, although chick growth was slower than that of chicks in gull-free areas.

4.8.6 Information Gaps/Research Questions

Seabirds
- What additional limitations could climate change impose on breeding seabirds or what limitations will be exacerbated by climate change?
- Is there additional high-quality seabird nesting habitat worth protecting through acquisition or easement?
- Is availability of forage fish a factor in the decline of seabirds? How far away do they forage? What is the condition of forage resources?
- Was establishment of Cherry Point oil refinery a factor in the disappearance of seabird colonies on islands in the northern portion of the archipelago (e.g., puffins on Puffin Island) or the crash of the herring fishery north of Lummi Island?
- Are there mammalian predators or herbivores impacting focal resources on any of the San Juan NWR islands?

Rhinoceros Auklet
- What is the current estimate of RHAU nesting on Smith Island?

- What is the population trend of RHAU nesting on PI and Smith Island?
- Is it feasible to restore and establish other colonies of RHAU in the San Juans?
- Is the area of PI occupied by the RHAU colony shifting (using more of the upland) and if so, why?
- What is the best vegetation cover for RHAU nesting habitat?

Tufted Puffin
- What are the current estimates of TUPU nesting on the refuges?
- Is it feasible to restore and establish other colonies?

Pelagic and Double-crested Cormorants
- What has caused the decrease in nesting of PECO and DCCO on PI?

Glaucous-winged Gull
- Why did the large GWGU colony stop nesting on Colville Island?

4.9 Bald Eagles

4.9.1 Description and Location

The enabling legislation for the development of the Protection Island NWR lists the protection of nesting habitat for bald eagles as one of its establishing purposes. Thus, they have been selected as a focal resource for this CCP. Three nests and one breeding pair of eagles can be found on Protection Island, and many bald eagles forage or roost on the island. In fact, a peak count of 50 bald eagles was counted in one day during the breeding season of 2007 on Protection Island (Hayward and Henson 2008).

The following table shows current territory counts for San Juan, Island, and Jefferson counties as well as the number of refuge islands encompassed by eagle territories (J. Stofel pers. comm.). However, bald eagles use all the islands as perches or roosts.

Table 4-9. Bald eagle nesting territories that encompass refuge islands, by county.

County	County total	# Territories that encompass refuge islands
San Juan	122	8
Island 81		1
Jefferson 91		1

During the 2009 San Juan Island NWR Summer surveys, 57 bald eagles were observed on refuge islands throughout the San Juan Archipelago and another 19 were observed on Smith and Minor Islands.

Nest building begins in early January, egg laying and incubation runs from late January through May, hatching and rearing young from February through July, and young fledging from May through August (USFWS 2007). Abundance decreases shortly after the breeding season when breeding birds move north during the fall to feed on salmon runs in British Columbia and SE Alaska and return in January (WDFW 2001).

4.9.2 Condition and Trends

The bald eagle has undergone significant changes in population. Early 19th century reports describe the bald eagle as common in the Pacific Northwest (Buehler 2000). By the mid-1900s, the bald eagle population was decimated by human persecution and pesticide contamination. In 1978, the species was listed as threatened throughout the contiguous United States under the Endangered Species Act of 1973. Legal protections under the Endangered Species Act, Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c), and Migratory Bird Treaty Act (16 U.S.C. 703-712) combined with the ban of DDT have led to a dramatic recovery of the bald eagle. In 2007, the bald eagle was removed from the Endangered Species List.

In Washington State, bald eagle-occupied territories increased from about 100 in 1980 to about 650 in 1998 (WDFW 2001). There are approximately 700 resident pairs and abundance swells up to 4,000 during winter in the state (WDFW 2001). Since receiving protection under the Endangered Species Act and the Bald and Golden Eagle Protection Act, bald eagle abundance has increased in the San Juan Archipelago (R Milner pers. comm.). Abundance of this species also has increased on Protection Island with as many as 50 observed at one time (Hayward and Henderson 2008). As a result, predation by eagles has increased and may be limiting abundance of other native wildlife, including cormorants and gulls (Galusha et al. 2005). However, due to concerns for maintaining recovery levels and continued protection provided by the Bald and Golden Eagle Protection Act, no management actions will be taken against eagles.

4.9.3 Ecology

Bald eagles build nests in large trees or snags that can support nests that may weigh more than 1,000 pounds. However, on islands where trees are limited, they can place their nests on the ground. Eagles may build additional nests and alternate use between years. They exhibit strong nest site fidelity and will return yearly to the same terriritories.

Hayward et al. (2010) found that the main prey species for bald eagles nesting on Protection Island are gull eggs and chicks as well as dead harbor seal pups and afterbirths.

4.9.4 Key Ecological Attributes

Table 4-10. Bald Eagle Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Population Levels	1. # of occupied nests 2. # bald eagles observed using refuges	1. Have an occupied nest in each of the ten current territories 2. Maintain # of bald eagles using refuges maintain what?
Clean Habitat	1. Marine debris observed on refuge shorelines 2. # of oil or other pollutant spills 3. Creosote pilings and rogue logs on refuges	1. No marine debris observed on shorelines 2. No incidence of spills 3. No creosote pilings and creosote rogue logs on refuges

Key Ecological Attributes	Indicators	Desired Condition
Security and Human Impacts	1. # of incidents of trespass or other non-authorized, human-caused disturbance at nest sites 2. # of motorized and non-motorized craft within 330 feet of nest sites during breeding season 3. # of aircraft operating within 1,000 feet of a nest during breeding season 4. # of incidents of intentional harming or killing eagles	1. Eliminate non-authorized, human-caused disturbance to nest sites. Reduce need for Coast Guard emergency maintenance to signal towers during the breeding period 2. No watercraft within 330 feet of nest sites 3. No aircraft, except by refuge authorization, within 1,000 feet of a nests during breeding season 4. No incidents of harming or killing eagles

4.9.5 Threats

Bald eagles nesting or over-wintering in the Salish Sea face the same threats as seabirds. They include:

- Disturbance by human activities such as boats and low-flying aircraft approaching too closely to nests during critical time periods: courtship and nest building, egg laying, incubation and hatching.
- Decreased food supply brought on by changes in prey availability from over-harvesting or climate change; human development that reduces suitable feeding sites,
- Habitat loss, particularly around nest sites, through human-caused fires on refuge islands or increasing development on islands adjacent to refuge islands.
- Mortality or reduced production through contamination from catastrophic events such as oil spills or exposure to persistent sources of contaminants such as pesticides and creosote on pilings and rogue logs.
- Mortality or injury from entanglement in marine debris or derelict gear.
- Harassment or illegal take of eagles and their parts by uneducated public, disgruntled anglers, or others.

According to the National Bald Eagle Management Guidelines (USFWS 2007), buffer zones around a nest shall be maintained in the following ways to avoid disturbance:

- If the activity will be visible from the nest, maintain a buffer of 660 feet
- For activities not in sight of a nest, maintain a buffer of 330-660 feet depending upon the activity and whether there is a similar activity within 1 mile of the nest (e.g., an activity that the eagles have become accustomed to).

These guidelines will be followed on all refuges in order to avoid disturbance to eagles, a violation of the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act.

4.10 Black Oystercatchers

4.10.1 Description and Location

The Black Oystercatcher (BLOY) is a large shorebird that ranges from the Aleutian Islands to Baja, California. The BLOY is a rocky intertidal obligate species that can be found in the Salish Sea year-round. During the last comprehensive survey of 95 islands in the inner marine waters of Washington in 2003, 40 islands within the San Juan Islands NWR supported approximately 80 percent of breeding pairs (Nysewander 2003b).

Wintering distribution and seasonal movements are poorly understood, however, birds breeding in the San Juan Archipelago appear to be resident. A tracking study to determine if breeding birds do remain on or near their territories year-round is currently underway in the San Juan Archipelago. During the winter months, BLOY tend to aggregate in groups of tens to hundreds. Winter flocks stay relatively close to their general breeding areas, and some individuals may maintain territories year-round (Nysewander 1977, Hartwick and Blaylock 1979).

4.10.2 Status and Trends

The global population is estimated at between 8,900 and 11,000 birds (median = 10,000; Morrison et al. 2006). This estimate, however, is based largely on observations from seabird surveys that do not specifically target black oystercatchers. These surveys are not optimal for detecting oystercatchers because they are focused on large seabird colonies, not the widely distributed islets and rocky intertidal areas where oystercatchers commonly occur. In addition, they are conducted later in the breeding season when oystercatchers are less vocal and visible. The population trends for BLOY in the inland marine waters appear to be stable (Salo 1975, Speich and Wahl 1989, Golumbia et al. 2009) at approximately 350–400 total individuals with at least 250 breeding birds (Tessler et al. 2007). BLOY nests on Protection Island have decreased from 13 to a low of 4 since refuge establishment in the 1980s. This is believed to be due to an increase in glaucous-winged gulls and bald eagles (P. Sanguinetti, pers. comm.).

4.10.3 Ecology

Rocky islands, islets, and headlands are favored breeding habitats, although birds will occasionally nest on gravel beaches in Washington. There are several islands that support 2 or more nesting territories. With few exceptions, all of the refuge islands are within a breeding territory of a black oystercatcher pair and used for nesting, foraging, or both. BLOY favor rocky shorelines in areas of high tidal variation to forage. They forage exclusively on intertidal macroinvertebrates (e.g., limpets and mussels, Tessler et al. 2007). Because they are so dependent on marine shorelines, the black oystercatcher is considered a sensitive indicator of the health of the rocky intertidal community.

Highly territorial, breeding birds exhibit strong site fidelity to nesting sites. Typically three eggs are laid in May. Incubation ranges from 26-28 days, and nestlings are generally observed from mid-June through late July. Fledgling occurs approximately 40 days after hatching with chicks remaining in the adults' territory through as late as October. One brood is raised per season; however, when a clutch is lost, pairs can lay up to two replacement clutches, which tend to be smaller than initial clutches (Andres and Falxa 1995). Age of first reproduction is believed to be five years, and their life span ranges from 9-15 years (Andres and Falxa 1995). Once individuals reach breeding age, it is generally assumed that they attempt to breed every year.

4.10.4 Key Ecological Attributes

Table 4-11. Black Oystercatcher Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Condition
Population Levels	1. # of refuge islands with nests 2. # of BLOY nests 3. # of BLOY observed foraging on islands	1. Maintain or slightly increase 2. Maintain or increase #s on smaller islands; increase nests on larger islands, such as Matia, Turn, and PI 3. Determine winter concentrations on refuge islands
Clean Habitat	1. Marine debris observed on refuge shorelines 2. # of oil or other contaminant spills 3. Creosote pilings and rogue logs on refuges	1. No marine debris observed on refuge shorelines 2. No incidence of spills 3. No creosote pilings and creosote rogue logs on refuges
Security and Human Impacts	1. # of incidents of trespass or other non-authorized, human-caused disturbance at nest sites 2. # of incidences of disturbance caused by boats approaching too closely to nest sites	1. Eliminate non-authorized, human-caused disturbance to nest sites 2. Minimal boat disturbance within 200 yards of closed refuge islands and shorelines

4.10.5 Threats

Black oystercatcher populations are ultimately regulated by the availability of nesting and foraging habitat, and quality habitat is more or less saturated at the moment (Tessler et al. 2007). Habitat quality in this sense depends in part on predation risk; some otherwise suitable habitat may remain unoccupied in areas exposed to high densities of avian or mammalian predators (i.e., main islands of the San Juan Archipelago).

Climate Change
Due to a restricted breeding range and habitat specialization, oystercatchers are highly vulnerable to climate change through habitat loss and/or changes in intertidal prey abundance or distribution. In addition, oystercatchers are vulnerable to reproductive failure due to nest flooding as a result of increased incidences of storm events because they typically nest on low-lying gravel beaches or rocky shorelines. Climate change may further exacerbate all of the threats listed in this section as they will become additive. For instance, the predicted increase in the severity and number of storm events caused by climate change may lead to an increased threat of a contaminant spill in the Salish Sea.

Contaminants
Oil spills such as the Exxon Valdez in 1989 can have immediate impacts on local black oystercatcher populations, and persisting contamination can slow recovery by depressing breeding efforts and chick survival (Andres 1997). Up to 20 percent of BLOY breeding in the area of the Exxon Valdez spill were killed by oiling (Andres and Falxa 1995). Oystercatchers and their prey may be at risk from low-level contamination by diesel fuel, gasoline, oil residues, and other contaminants along shorelines resulting from tankers or cargo ships expelling water from their ballast tanks and increased recreational activities (Tessler et al. 2007).

Predation and Competition
Predation is a primary cause of mortality to oystercatcher eggs and chicks (Tessler et al. 2007, Morse et al. 2006). In a study of productivity at four breeding areas in Alaska from 2003 to 2006, predation accounted for 48 percent of all egg losses where a cause could be positively identified. Because 27 percent of all egg losses were of unknown cause, egg depredation could be even higher. Small chicks are particularly vulnerable to predation during the first two weeks after hatching (Andres and Falxa 1995). Pinnipeds hauling out on land may also cause decreased reproductive success by crushing eggs and chicks and causing oystercatchers to leave nest sites during incubation or brooding periods (Warheit et al. 1984).

Human Disturbance
Growing pressure from recreational activities and development in and around breeding areas can negatively impact oystercatcher productivity. For instance, expanding use of the Salish Sea by commercial and private vessels may increase the probability that nests will be flooded by large wakes, especially when vessel traffic coincides with periods of the highest tides. Increasing human presence may directly impact oystercatcher productivity at the nest site through accidentally trampling nests and eggs, or indirectly affect them through interference with foraging, parental care, or causing nest abandonment. It is important to note that these threats are cumulative, since isolated incidences of low levels of recreation have been shown to have no effect on oystercatcher productivity in Kenai Fjords National Park (Morse et al. 2006). However, when taken as whole, increased incidences of human disturbance at the nest site combined with increases in nest flooding may decrease productivity and subsequent population growth of oystercatchers in the Salish Sea.

In addition, recreational uses of the refuges can attract predators to campgrounds, picnic areas, and nearby shorelines in search of garbage. There are no oystercatchers nesting on Turn Island, despite the presence of suitable habitat. This may be the result of predation or because some of the best habitat for oystercatcher nesting is used as a landing area for the campground and accessible to dogs daily during the breeding season.

4.11 Marine Mammals

NOAA Fisheries and the Service share responsibility for implementing the Endangered Species Act (ESA) of 1973. NOAA Fisheries has jurisdiction over the four species of seals or pinnipeds that occur on the refuges (Steller and California sea lion, harbor and northern elephant seal) under the Marine Mammal Protection Act (MMPA) of 1972. However, the Service manages land these species use to pup, molt, or haul out. For this reason, four marine mammal species were selected as focal resources for this plan.

Although many species of marine mammals can be observed in the waters surrounding the refuge islands, four species regularly use the refuge shorelines and rocks: harbor seals (*Phoca vitulina*), northern elephant seals (*Mirounga angustirostris*), California sea lions (*Zalophus californianus*), and Steller (Northern) sea lions (*Eumetopias jubatus*). Although all pinnipeds forage on fish, they must come to shore at various times to breed, have pups, or molt (shed hair and top layer of skin). Coming on shore is referred to as "hauling out" and a social group of seals on shore is often referred to as a "haulout." Pinnipeds also haul out to sleep and conserve energy.

4.11.1 Description and Location

Harbor seal
The most abundant, widespread marine mammal on the refuges is the harbor seal. Protection Island and Smith/Minor Island both have large haulouts, often peaking above 500 seals. Refuge wildlife surveys

have documented harbor seals hauled out on most of the islands within the San Juan Islands NWR. The highest count of adult harbor seals (725 seals) was on Minor Island in 2009. Other islands with high counts of adult harbor seals (>200) included White Rock, Clements Reef, Puffin Island, the North Peapod, Unnamed (# 63, Peapod Rocks), South Peapod and Bare Islands. Harbor seal pup counts >35 were recorded on Flattop Island, Unnamed (#45), Lone Tree Island, Puffin Island, and Colville Island.

Harbor seals are present year-round, but haul out in greatest numbers during their summer/fall pupping and molting season. Pupping season begins in mid-June, peaking from mid-July through August, with some pups born as late as the end of September (Calambokidis et al. 1978).

Elephant seal
A few elephant seals have been documented to breed and pup on Protection Island and Smith Island. Like harbor seals, elephant seals also use the refuge islands to breed and molt, but their seasons are very different. They can be found on Protection or Smith and Minor islands year-round. Breeding males arrive on Protection and Smith/Minor Islands in November or December, with females following in December. Pups are born late December through January. Breeding occurs from January through early February. Adult females and juveniles molt from March through June. Adult males molt from May through September. Juveniles will haul out again from July through January (LeBoeuf and Laws 1994).

California sea lion
The inland waters of Washington State are a foraging area for California sea lions. They do not breed in Washington State and primarily are present from September to May. Only male California sea lions are observed in the Salish Sea. They tend to haul out on rocky shorelines in the Straits and can often be seen on refuge islands that serve as navigational markers.

Steller sea lion
Primarily coastal, Steller sea lions (or Northern sea lions) haul out in small numbers in the inner waters of Washington State. They have been observed hauled out within the San Juan Islands NWR on Peapod Rocks (#s 62-64), which are in Rosario Strait (Jeffries pers. comm.). Refuge staff have observed non-breeding Steller sea lions on Eliza Rock (#65) and Bird Rocks (#80) within the San Juan Islands NWR (Sanguinetti 2004).

4.11.2 Condition and Trends

Harbor Seal
Until 1960, Washington State managed seal abundance through a “bounty.” This species’ population was severely depleted until protected by the MMPA. The population for Washington is estimated at more than 35,000 (NOAA Fisheries 2004). Based on summer haulout counts, the population estimate for the San Juan Islands is 5,000 seals and the population for the Strait of Juan de Fuca is estimated at 2,000 seals (Jeffries et al. 2003). The Strait of Juan de Fuca and San Juan Islands harbor seal populations have reached “optimum sustainable population.” Population growth in the Strait of Juan de Fuca has slowed, but San Juan Island’s population may still be increasing (Jefferies et al. 2003). Research partners reported a large number (>60) of harbor seal pup deaths in 2005 on Smith and Minor Island, but did not indicate the causes of death.

Northern Elephant Seal
This species was almost extinct by 1900. However they have recovered and the species population is estimated at 150,000. Northern elephant seals are rapidly colonizing new areas in the Pacific Northwest (LeBoeuf and Laws 1994) and are reestablishing themselves in the Northern Puget Sound. In 1977, a molting tagged female was identified at Discovery Bay near Protection Island (Everitt et al. 1980), while

the first elephant seal to be observed on Protection Island was reported in 1989 and appeared to be in molt. The recent increase or reestablishment of their breeding range includes small colonies on Protection and Smith/Minor Islands. In 2004, a peak year for breeding, three pups were born on Protection Island. In 2006, 1 pup was born on Protection Island, but it died with the cause of death unknown.

California Sea Lion
The California sea lion population estimate for the west coast of the U.S. is roughly 167,000 to 188,000 (NOAA Fisheries 2004). In 1995, a peak count of 1,100 animals was reported for the Everett area (NOAA Fisheries 2004). No trend data available.

Steller Sea Lion
The Steller sea lion is listed as a threatened species under the ESA. The current population estimate for the eastern distinct population segment is between 46,000-58,000. Declines are due, in part, to decreasing fish stocks.

4.11.3 Ecology

Harbor Seals
This species exhibits strong site fidelity to their usual haulout locations during pupping and molting seasons (Suryan 1998). They use both rocky and sandy/gravely shorelines for haulouts. Haulout locations are vital to seals during molt and rearing of young. This species feeds primarily on fish including rockfish, cod, herring, flounder, and salmon (Eder 2002).

While harbor seals typically pup during the summer months, they can pup at any time of the year. Pups are born on land and can swim immediately, but they remain close to their mothers. The first hours after pupping are critical for the pup to imprint on the mother. Without proper imprinting, the mother will not recognize the pup if separated. Abandonment of pups was found to be the primary cause of pup mortality at Grays Harbor (Stein 1989).

During pupping, mother seals haulout for longer periods of time to care for their pups (Stein 1989, Watts 1991, Kroll 1993). Mothers with nursing pups can spend more than 90 percent of their time onshore (Huber et al. 2001 as reported in Jefferies et al. 2003). Mother-pup pairs usually segregate from main haulout groups (Kroll 1993).

Elephant Seals
Elephant seals spend the majority of their life cycle at sea and return to land only to breed, pup, and molt. They use sandy/gravely shorelines to haul out and are known for digging sand and flipping it over their backs to regulate their internal temperatures. The largest of the pinnipeds, the males weigh, on average, 4,000 lbs. in contrast to the average female's 1,800 lbs. (Wynne 1992). The males are easily recognized by their distinctive proboscis (snout). Elephant seals feed on a variety of marine life including squid, octopus, and large fish (Eder 2002).

This species has a drastic molt where the upper layer of epidermis peels off in patches (Reidman 1990). Molting season is determined by gender and age. Elephant seals fast during their time at shore and conserve energy by lowering their metabolic rate. As a result, they spend most of their time sleeping and moving very little (Reidman 1990). Pups are very dependent on their mothers and are unable to swim until weaned at approximately 27 days (Reidman 1990). On Protection Island, elephant seals breed and pup on the shores and upland of Violet Spit. Pups on Minor Island have been lost to winter storms.

California Sea Lion
This species hauls out on rocky shorelines and navigational buoys or markers. Only non-breeding males are observed in the inner marine waters of Washington. California sea lions feed on a wide variety of fish, squid, and octopus; however, within the Puget Sound they consume several different species of salmon. They tend to mix with Steller sea lions and can be difficult to differentiate.

Steller Sea Lion
Steller sea lions use rocky shorelines and navigational buoys or markers to haul out. This species feeds opportunistically, often including octopus, squid, and a variety of fish (herring, rockfish, and greenling, Eder 2002). Steller sea lions mix with California sea lions and can be difficult to differentiate.

4.11.4 Key Ecological Attributes

Table 4-12. Marine Mammal Ecological Attributes, Indicators, and Condition Parameters. HASE=Harbor seal; ELSE=Elephant seal; CASE=California sea lion; STSE=Stellar sea lion

Key Ecological Attributes	Indicators	Desired Condition
Population Levels	1. # of seals using refuge 2. Count of HASE pups in summer survey 3. # of ELSE born 4. # of ELSE weaned	1. HASE - existing ELSE - increase CASE - existing STSE - increase 2. Maintain 3. Maximize 4. Maximize
Clean Habitat	1. Marine debris on shoreline 2. Creosote-covered logs, oil, or other contaminants on shorelines	1. Marine debris removed from the Salish Sea 2. Provide quality haulouts with no incidence of contamination or marine debris
Security and Human Impacts	1. Incidents of human-caused injury or mortality	1. Public is educated about lone pups and pups are left alone 2. Provide quality haulouts with no incidence of human-caused injury or mortality 3. Maintain low levels of disturbance on PI 4. Reduce disturbance incidences in the SJs

4.11.5 Threats

Although pinnipeds react differently to disturbance depending on their degree of previous experience, age, sex, location, and life cycle stage, they are all highly vulnerable to human-caused disturbance (Boren et al. 2003, Sanguinetti 2003, Hoover-Miller 1993). Seals and sea lions are popular ecotourism targets, which can multiply the disturbance instances in a day. Increasing ecotourism combined with an increasing human population and marine recreation in the Salish Sea pose a threat to stable and declining populations of pinnipeds in the area. Several studies have noted that pinnipeds have a disproportional, negative response to approaches by kayaks in contrast to other recreational vessels (Szaniszlo 2001, Grella et al. 2001) potentially due to a kayak's stealthy, low-profile approach (Hoover-Miller et al. 2003).

Disturbance can interrupt nursing or cause pups to be separated from their mothers (Fisheries and Oceans Canada 2002). Also, well-meaning but misinformed people will remove pups that have been temporarily left by their mothers. Persistent human-caused disturbance can reduce fitness or increase mortality, especially during molt or nursing. Seals and sea lions repeatedly forced into the water during these time periods expend more energy maintaining their body temperature and must then spend more time in the water foraging. Pups repeatedly forced into the water have less time to nurse, which decreases blubber production. This increases the potential for mortality once pups are weaned and must rely on stored energy in blubber to survive while learning to forage. Elephant seal pups are particularly at risk because they cannot swim until weaned. During this period, if the mother is disturbed and retreats to the water, the pup is vulnerable to predation. In addition, they are unable to retreat from natural or catastrophic disturbances such as fire or oil spills. Finally, all seal and sea lion pups are at risk of being crushed by adults stampeding to the water when disturbed at a haulout.

Fisheries interactions also pose direct and indirect threats to marine mammals. Seals and sea lions are susceptible to intentional killing or harassment by humans because of the marine mammals' perceived fishery impacts. Roughly 3-6 dead sea lions are reported each year in the Puget Sound due to gunshot wounds. However, this number rose to 7 in 2007, including one threatened Steller sea lion (Rasmussen 2007). While each species forages on different fish, California sea lions pose a management challenge because they forage on salmon. Unfortunately, other pinnipeds in the area are persecuted in the mistaken assumption that they are also depleting commercially viable fisheries. Seals and sea lions in the Puget Sound are also killed in net fisheries and through entanglement in derelict gear (Natural Resource Consultants 2004). Seals have been observed with wounds and scarring from entanglement with derelict gear and interactions with aquaculture (net pen) operations. Over-fishing is a threat to pinnipeds to varying degrees depending on species and forage fish affected.

Pinnipeds are susceptible to catastrophic events, such as oil spills. Due to their restricted distribution within the Salish Sea, elephant seals are particularly susceptible to oil spills. In addition, persistent contaminants, such as PCBs and dioxin, accumulate in pinniped blubber and create elevated levels in inland harbor seals (Ross et al. 2004).

Additional threats to pinnipeds include an increased potential for inter-species transfer of diseases, such as canine distemper. This threat is particularly relevant on refuge islands which allowed dogs access (i.e., Matia, Turn, and those close to the main islands in the archipelago). Climate change may produce several threats: exacerbating the threat of oil spills; loss of protected haulout habitat due to rising sea levels; increases in the severity and incidences of storm events; and changes in sea temperatures adversely affecting availability of food supply. Finally, rising ocean temperatures or El Niño events may increase the potential for bacterial infections.

4.11.6 Information Gaps

- Use of the San Juan Islands by Steller sea lions (abundance, distribution, phenology).
- Determine the number of elephant seal use days throughout the year, especially on Smith Island. What is their survival rate and site fidelity to refuge islands?
- What are the migration patterns of the harbor seals? Are the Smith Island stocks more closely aligned to PI or to the San Juans? Do the seals move into the Georgia Strait in the winter? Or into the Hood Canal?

4.12 Herbivores and Predators of Management Concern

Herbivores and predators of management concern are defined in this document as native or non-native species whose expanding abundance or potential presence represents a threat to native wildlife or plants, especially breeding seabirds. There are several native and introduced species on refuge islands that pose a threat to healthy populations of our focal resources, their habitats, or native plant revegetation efforts. They include black-tailed deer, European rabbits, raccoons, mink, otters, Canada geese, and avian predators. Rats, red fox, and feral or domestic pets are not known to exist on refuge islands; however, they pose a threat and therefore are addressed in this section.

Species found within island habitats are particularly vulnerable to extinction. Approximately 93 percent of bird species or subspecies that have become extinct since the 1800s were found on island habitats (Courchamp et al. 2003). A primary contributing factor to these losses has been the successful establishment of alien species. Native species, not typically found on islands, can have just as much of an impact on island nesting species as non-native species. This is due, in part, because many island nesting species have not developed defenses to avoid or life history traits to accommodate disturbance or predation. Further, non-native species introduced to seabird nesting islands may become prey to sustain native predators during the non-nesting season (Courchamp et al. 2003, Mills et al. 2005). In extreme cases, ecosystems have not recovered to historical conditions even after invasive or native species were removed (Ebbert & Byrd, 2002, Courchamp et al. 2003).

4.12.1 Black-tailed Deer

Black-tailed deer are abundant in Northwest Washington with a Washington Natural Heritage Program ranking of ‘demonstrably secure’ both globally and by state (WDNR 2009). They are native from the Cascade crest west toward the coast range. Throughout the state, deer occupy nearly all ecological zones, from alpine to valley and have adapted to varied climate regimes. Their average life span is five years and few deer live longer than ten years. In general, does breed in their first or second year and two fawns are common.

Historically, this species constituted the highest number of deer harvested in Washington State with an average annual harvest of about 14,000 individuals (WDFW 2008). According to models developed by WDFW, the black-tailed deer population estimate has nearly doubled over the last 5 years within WDFW’s Coastal Region (6), which includes the Olympic Peninsula (WDFW 2009). They occur in high numbers on the Quimper and Miller Peninsulas, the closest landmasses to Protection Island, and are capable of swimming approximately 1.5 miles from the tip of either peninsula to the island. Black-tailed deer use all habitat types present on Protection Island.

There are no historic records of black-tailed deer on Protection Island. From 1956-59, Richardson (1961) made 18 trips to the island and reported that the only native mammals on the island were Townsend chipmunks and a shrew. In addition, the Protection Island Master Plan (USFWS 1985) makes no mention of deer in the species list. Three adult deer were first observed on the island in 1991 (Hayward 2008). Due to a high reproductive rate and lack of natural predators on Protection Island, this number has increased to a high estimate of 100 deer in 2008/2009 (J. Hayward pers. comm.). Current estimates are approximately 70 deer (P Davis pers. comm.). With approximately 360 acres (0.562 mi^2) on the island, that abundance is equivalent to 124 deer/mi^2,which is considered a very high density (A. Clark pers. comm.). According to ungulate biologists, 10-30 deer/mi^2 is considered normal along the Columbia River of Washington. No hunting has been allowed on the refuge since designation and there are no natural predators (e.g., mountain lion, bear, coyotes). In the absence of hunting and predators, population growth is limited only by habitat capacity. Refuge staff have also observed black-tailed deer on refuge islands in the San Juan Archipelago. For more information on the effects of deer under current management, see section 4.8.5 and the rationale for objective 2.1.

4.12.2 European Rabbits

Rabbits are one of the fastest colonizing mammals in the world, primarily because of their high reproductive rate (Hall and Gill 2005). European rabbits do occur on the larger islands within the San Juan Archipelago but have not been observed on refuge islands. However, there is an unconfirmed report of rabbit pellets on Nob Island (Murphy pers. comm.).

4.12.3 Canada Geese

The abundance of Canada geese within the San Juan Archipelago has increased over the years and effects of trampling and suspected introduction of non-native plant species to refuge islands have been noted. Research in Canada's Gulf Islands has shown impacts of geese to island vegetation. We have reports from vegetative surveys conducted on refuge islands that confirm the existence of nesting Canada geese and note some effects to vegetation (Bennett 2007). The Service considers this an ecosystem-wide issue due to the high probability of dispersal of geese and beyond the scope of this CCP. As such, this issue must be addressed by all appropriate conservation partners. Increased presence of refuge staff on the islands as identified in the CCP will provide opportunities to monitor goose abundance and assess impacts to native vegetation on refuge islands.

4.12.4 Mammalian Predators

Non-native mammalian predators in this area include rats, red fox, dogs, and cats. Rats are present on approximately 80 percent of the world's islands and are responsible for at least 50 percent of global extinctions and countless local extinctions (Dolan and Heneman 2007). They can be found primarily on the larger, developed islands of the San Juan Archipelago and are non-native; however, they have not been reported on refuge islands. Rats have not been observed on Protection Island either, but they could potentially colonize the island via a ship wreck or by accessing the island on authorized or unauthorized vessels. Red fox are non-native west of the Cascades in Washington and were introduced on San Juan Island in the early and mid-20th century (Aubry 1984, R. Milner pers. comm., WA GAP). There have been no reports of red fox on refuge islands, although fox are common on San Juan Island. Dogs and feral and domestic cats are not native in the Salish Sea. Dogs have been allowed on two refuge islands that support camping (Turn and Matia islands), but feral and domestic cats are not known to occur on refuge islands.

Native mammalian predators include raccoons, river otters, and mink. Raccoons can be found on islands within the San Juan Archipelago, but they have not been observed on Protection Island. River otters have been observed on both refuges, and mink have been noted on islands within San Juan Islands NWR. Both species are native to this area, although there are reports of mink introductions to the San Juan Archipelago in the early 20th century for fur farming (R. Milner pers. comm.). Due to the close proximity of islands within the San Juan Archipelago, these species could be virtually ubiquitous to the islands.

4.12.5 Avian Predators

Native avian predators include crows, ravens, gulls, peregrine falcons, and bald eagles. These species occur throughout the Salish Sea. No management actions have been identified for control of avian predation and limited information is available on the effects of native avian predators on the refuges.

4.13 Paleontological Resources

4.13.1 Geological Background

During the late Jurassic and early Cretaceous periods, numerous blocks of exotic terranes were added to the western edge of the North American continent to form Washington, British Columbia, and Oregon. These terranes consist mostly of rock sequences that formed far from their current location. They include volcanic island rocks and fossiliferous marine sediments that originated elsewhere in the Pacific Ocean. Jurassic and Cretaceous fossils from these rock sequences occur in the north-central and northwestern part of Washington.

Marine fossiliferous sandstone and siltstone of Cenozoic age cover most of Washington west of the Cascades Mountains. The Olympic Mountains consist of marine sedimentary rocks uplifted about 10 million years ago. The Cascade volcanic chain began to form in the mid-Cenozoic and has been active ever since. During the late Cenozoic, the Cordilleran Ice Sheet covered the northern third of the state and alpine glaciers covered the higher elevations of the Cascade and Olympic Mountains.

A variety of rock units ranging in age from early Paleozoic to late Cretaceous are exposed in the San Juan archipelago. These rock units are separated by faults and fault zones. The San Juan faults are part of a broader fault system that extends 80 km eastward into the North Cascade Mountains.

The landscape of the Puget Lowland and Juan de Fuca Strait is largely the product of repeated glaciations by the Cordilleran Ice Sheet during the Pleistocene Epoch (~ 2 million years ago to ~11,000 years ago). Dated samples of wood, peat, and shell from southern British Columbia and northern Washington provide age control on the growth and decay of this sector of the Cordilleran Ice Sheet during the last (Fraser) glaciation (Clague and James 2002). Starting about 22,000 years ago, the ice sheet first started to form in the Coast Mountains and on Vancouver Island of British Columbia, but did not extend south of the international border. This advance was followed by a period of climatic amelioration and glacier retreat about 19,000 to 18,000 years ago (Hicock et al.1982). Shortly after 18,000 years ago, the Cordilleran Ice Sheet started to advance again. After passing Vancouver Island, it advanced southward as two lobes. At its maximum extent 14,500 years ago, the Puget Lobe filled the Puget Lowland, where it was nearly 1000 m thick over Seattle, and its southern edge extended south to its maximum position near present-day Olympia (Thorson 1980). At about the same time, the Juan de Fuca lobe moved westward along the Strait of Juan de Fuca, where the ice sheet covered southern Vancouver Island, filled the Strait of Juan de Fuca, and rose against the Olympic Mountains to an elevation of 840 m. Retreat of both lobes began shortly after 14,500 yr BP, and by 12,000 yr BP the northeastern Olympic Peninsula and northern Puget Lowland were ice free.

4.13.2 Paleontological Resources

Paleontological resources, also known as fossils, are the remains or traces of prehistoric plant and animal life that are found in the geologic formations in which they were originally buried, typically within units of limestone, sandstone, mudstone, and shale. Paleontological resources are considered to be nonrenewable and sensitive scientific and educational resources.

The major laws protecting paleontological resources on Service lands are the National Environmental Policy Act of 1969 (NEPA), the Paleontological Resources Preservation Act of 2009 (PRPA), and various sections of Service regulations.

Fossil record in Northwest Washington

Because of their large size and taphonomic durability, mastodon and mammoth remains (mostly molars) are the most commonly reported Pleistocene vertebrate fossils in Washington (Barton 1998). Unlike mastodons, which were not elephants, mammoths (genus *Mammuthus*) were large, specialized elephants that were common during the Pleistocene epoch. This genus first evolved in the early Pliocene (4.0 to 5.0 Ma) of Africa, and by the early Pleistocene (ca. 1.7 Ma), mammoths had spread throughout Asia and into North America (Shoshani and Tassy 1996, Webb et al. 1989 in Barton 1998). Mammoths were obligate herbivores with a dietary preference for grasses and sedges, herbs, and meadow-bog mosses, ferns and aquatic plants.

In western Washington, mammoth finds are heavily concentrated in the central and northern Puget Lowland. The earliest mammoth finds recovered from western Washington were discovered at Scatchet Head on Whidbey Island (located 45 km southeast of Protection Island) around 1860, but these were destroyed in the San Francisco earthquake and firestorm of 1906 before they could be identified to species level (Lawson 1874, in Barton 1998). Another specimen from the same locality was recovered in the 1880s and is currently part of the University of California Berkeley paleontology collections. This specimen is clearly from a Columbian mammoth. Of two species of mammoth found in Washington (*M.imperator* and *M. columbi*), Barton (1998) states that the Columbian mammoths are by far the most common. Of 31 previously reported finds that could be analyzed to species level in the Puget Lowland, 27 proved to be from Columbian mammoths (Barton 1998). The Columbian mammoth formally became the Washington state fossil in 1998.

Protection Island

A search of the paleontology online collection at Burke Museum of Natural History and Culture was completed in May 2009. The records search identified five specimens (B2424, B2436, B2448, B2451, B2452) that were collected from Protection Island, but specific location is unknown. These resources are all foraminifera (shells) dating to the recent period/epoch. The paleontological site nearest to the refuge on Protection Island is one containing mammoth remains identified in the Zella M. Schultz Seabird Sanctuary. Other unprovenienced bones have been collected from other areas of the island as well. In addition, a collection of 164 fossils (mostly unidentifiable) from Protection Island, which includes a mammoth tooth, is curated at the offices of the Washington Maritime NWR Complex. In 2008, a partial skull of a giant beaver (*Castoroides*) including incisors was located but has not been formally recorded.

Paleontological materials (mammoth tusks and a tooth) have been recovered from Dungeness National Wildlife Refuge, located approximately 15 km to the west of Protection Island. Another nearby paleontological site which is also known for its archaeological importance is the Manis Mastodon site located in Sequim, Washington, approximately 15 km southwest of Protection Island. Mastodon (*Mammut americanum*) and bison (*Bison sp.*) bones, caribou antlers (*Rangifer sp.*), and pollen, fruits, and seeds were recovered from a colluvial brown, gravelly, silty sand with organic detritus grading upward to sandy silt. Radiocarbon dates from fossil pollen and seed assemblages suggest the fossils are 11,000 – 12,000 yr BP (Petersen et al. 1983).

San Juan Islands

Although paleontological resources have yet to be identified on the refuge, they are common within the broad vicinity of the San Juan Islands, with associated ages ranging from the Paleozoic Era to the Holocene Epoch. A search of the paleontology online collection from the Burke Museum of Natural

History and Culture indentified 60 fossils that have been collected from the San Juan Islands, specifically Sucia, Waldron, and Spieden islands. The specimens, primarily mollusca and foraminfera, were collected from sandstone, shaly sandstone, and glacial drift deposits from the Pennsylvanian (n=1) and Cretaceous (n=25) Periods and the Pleistocene (n=32) and Holocene (n=2) Epochs, ranging in age from 320 million years to 10,000 years old.

Other known paleontological resources within the San Juan Islands include those at Deadman Bay on San Juan Island, where crinoid debris and fragments of other fossils can be found in limestone pods. Crinoids appeared during the Lower Ordovician roughly 490 million years ago and underwent several major radiations during the Paleozoic Era. Triassic age (~200 million years) conodont fauna, which are elongate worm-like organisms, were identified at Limestone Point on the northwest coast of San Juan Island (Savage 1984). On Lopez Island, brownish-red mudstones containing foraminifera dating to the mid-Cretaceous (~100 million years) were discovered in a road-cut by Danner (1966). This site is important because it provides the youngest dates of the rocks in the San Juan fault system.

A *Bison antiquus* cranium and partial skeleton dating to 11,760 ± 70 14C yr BP was located in lacustrine sediments below peat on Orcas Island. These resources were found unconformably above emergent Everson Glaciomarine Drift (>12,000 14C yr BP), which often contains fossil marine shells. Several bison finds in similar contexts on Orcas and Vancouver Islands, dating between 11,750 and 10,800 14C yr BP, have also been found and indicate an early postglacial land mammal dispersal corridor with reduced water barriers between mainland and islands (Wilson et al. 2009).

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Chapter 5. Human Environment

5.1 Cultural Resources

5.1.1 Native American Overview

This section provides an overview of the known archaeological and ethnographic uses of the San Juan Islands Archipelago region in which the San Juan Islands NWR is located. It is excerpted from a cultural resource overview prepared by SWCA (2007) of the study area, which includes all lands in and within one mile of the congressionally authorized boundaries of the San Juan Islands NWR. Protection Island was not included within the study area for the 2007 cultural resource overview, although much of the general history is applicable to that island as well. Information specific to Protection Island is summarized from an overview prepared by Daugherty (1988).

Protection Island: Prehistoric and Early Historic Period - Protection Island is located off the northeast coast of the Olympic Peninsula. Ethnographic sources indicate that the area was occupied by the Chemakuan-speaking Chemakum people (Daugherty 1988). According to early ethnographer Frederick Hodge, the Chemakum fought with their Salish neighbors, including the Klallam, and their numbers dwindled significantly (Hodge 1907). The ethnohistoric record assigns Protection Island to the territory of the Klallam Indians, who ranged over most of the southern shore of the Strait of Juan de Fuca in the early historic period. The Klallam followed a seasonal subsistence strategy which included winter villages comprised of cedar plankhouses and summer settlements with smaller and more informal structures (Daugherty 1988: 46). Their subsistence activities included fishing for salmon and other fish, hunting both marine and terrestrial mammals, and gathering plant materials.

San Juan Islands: Prehistoric Period - Native Americans have long utilized the diverse resources (e.g., water, fish, wild game, plants, living areas, and burial areas) present in the San Juan Islands to maintain many of their cultural lifeways and spiritual connections to the land. Previous archaeological investigations have demonstrated the presence of human occupation in the region for a minimum of 11,500 years.

Several cultural models have been developed in order to explain the history and cultural development of Native American peoples in the San Juan Islands. In this region, cultural sequences have been divided into five general time periods or phases: Paleo-Indian Period; Cascade or Island Phase; St. Mungo, Mayne, and Locarno Beach Phases; Marpole Phase; and San Juan Phase. These periods are based on cultural change in the region, including shifts in the organization of subsistence patterns, land-use, and technological developments (SWCA 2007).

Ethnographic Period - A number of researchers have compiled extensive ethnographic accounts for the San Juan Islands. Much of the following ethnographic account relies on Wessen's (1988) ethnographic overview of the study area conducted for the National Park Service, Stern's (1934) ethnographic study of the Lummi, and Suttles' (1951) unpublished Ph.D. dissertation and subsequent ethnographic accounts (Suttles 1990a).

During the ethnographic period, multiple Native American groups occupied the San Juan Islands Archipelago. The inhabitants of the San Juan Islands belong to a more general group of people who speak Central Coast Salish languages (Stein 2000, Suttles 1990a, Wessen 1988, 2006). The Salish is a broad language family that ranges from Montana to the Pacific Coast (Wessen 1988), and during the ethnographic period, Central Coast Salish was spoken from Western Washington to parts of British Columbia. The inhabitants of the San Juan Islands belong to one of five language groups of the Central Coast Salish, called the Northern Straits Salish (Suttles 1990a, Wessen 1988).

The Northern Straits Salish occupied an area that included the southeastern part of Vancouver Island, the San Juan Islands, and portions of the southern Gulf Islands and mainland shore. The Northern Straits Salish were further divided into seven tribes with distinct but similar dialects. These groups included the Lummi, the Samish, the Saanich, the Sooke, the Semiahmoo, the Swinomish, and the Songish (Boxberger 1980, N.D. Suttles 1990a). Of the seven tribes of the Northern Straits Salish, five occupied the San Juan Islands, including the Lummi, the Samish, the Saanich, the Swinomish, and the Songish (Suttles 1990a, Wessen 1988).

In addition to different language dialects, an extensive marine-based economy distinguished the Northern Straits Salish from other Coastal Salish groups. Reef-netting for salmon, particularly sockeye, was a practice unique to the people living in the San Juan Islands Archipelago (Ames and Maschner 1999; Stein 2000; Suttles 1990a; Wessen 1988, 2006). In mid-July, sockeye salmon entered the Strait of Juan de Fuca and swam up to the San Juan and Gulf Islands and into the Fraser River. Large nets were suspended between two canoes along routes taken by the salmon and were situated with anchor lines in order to guide the fish into the nets (Suttles 1990a, Wessen 1988). Reef-netting enabled Native American groups to collect large quantities of salmon at one time. It was practiced until the 1890s when commercial fisheries took control of the resource locations (Boxberger 1980, Marino 1990, Kopperl 2006, Suttles 1951).

The economic, social, and political organization of the inhabitants of the San Juan Islands was similar to other Central Coast Salish groups, characterized by complex and overlapping local lineal groups. Families held the rights to knowledge and access of reef-netting and other resource locations, as well as ceremonial rights and practices, all of which were passed down for generations. Locally, residential groupings of the Central Coast Salish included the family, household, local group, winter village, tribe, and language group (Suttles 1990a, Wessen 1988).

The Native American groups occupying the San Juan Islands during the ethnographic period practiced a seasonal subsistence and settlement pattern. The diversity of subsistence resources on the islands included camas, deer, elk, salmon, herring, fruit, and shellfish. These resources were accessible at various islands during particular times across the seasons. Multiple families gathered in winter villages with multiple large split-cedar plank longhouses with either gable or shed roofs (Wessen 1988). In the early spring, groups left their winter villages and divided into smaller camps occupying mat lodges, rectangular-framed structures covered in cattail rush and cedar bark mats, and procured duck, herring, shellfish, camas bulbs, bird, halibut, and spring salmon (Wessen 1988). Both the camas bulbs and the fish were dried and processed for storage.

During the summer months, the smaller Native American groups converged into larger communities or reef-net camps to prepare for the reef-netting season. The summer camps contained large-pole drying racks, which were used to dry large amounts of sockeye salmon (Wessen 1988). In addition to fishing, deer and elk were hunted and fruits, shellfish, and sea urchins were collected (Suttles 1990a, Wessen 1988).

In the fall, the summer camps once again divided into smaller groups and collected and processed clams for storage, hunted deer, elk, and duck, and fished for cod. There has been discussion that most Native American groups temporarily left the San Juan Islands during the fall for riverine salmon weir camps on the mainland and Vancouver Island (Wessen 1988). Wessen (1988) argues that all but the Lummi and the Samish departed the San Juan Islands directly after reef-netting season. In some instances, Lummi and Samish groups moved into camps on the mainland leaving only a few small groups behind on the San Juan Islands. In late November, when the riverine salmon season was over, all Native American groups returned to the winter village with food that had been processed and stored, thus commencing the subsistence cycle over again.

Indian Reservation Era - In the late 18th century, Europeans had started exploring the San Juan Islands and the surrounding region. Disease, traders, missionaries, and new technology had severe impacts on the Native American people living on the islands at the time. Population numbers declined dramatically due to introduced infectious diseases such as smallpox. As a result, surviving Native Americans relocated their winter villages from the islands to the mainland. Stein (2000), Wessen (1988), and Schalk (1998) suggest that by approximately A.D. 1850, no winter villages remained on the San Juan Islands.

The Treaty of Oregon in 1846 divided the region into British and American jurisdictions, and subsequent governmental treatment and recognition depended upon which side of the boundary the Native American groups were located. British and Americans both started procuring tribal lands and established treaties with Native American groups that were within their own jurisdiction but were not living within the disputed area of the San Juan Islands (Suttles 1990a, Wessen 1988).

In 1853, Isaac Stevens became the governor of Washington and the superintendent of Indian affairs. One of his tasks as the head of Indian Affairs was to convince Native American groups to sign treaties, referred to as the Stevens Treaties. He aimed to quickly consolidate multiple tribes onto a limited number of reservations (Richards 2005). Two of Stevens' treaties, the Point Elliot Treaty and the Treaty of Point No Point, pertain to tribes and lands located within the study area. In 1855, Stevens, along with 82 chiefs and headsmen of various Native American tribes in the Western Washington region including the Lummi and the Samish, signed the Treaty of Point Elliott (Marino 1990, Wessen 1988).

By signing the treaty, the Lummi subsequently ceded all of their lands to the U.S. Government and were required to move onto reservation lands. The reservation included lands around their primary village, the Lummi Peninsula, uninhabited Portage Island, and specific fish weir sites. The reservation was also shared with the Samish and Nooksack (Kopperl 2006, Suttles 1990a, Wessen 1988). In 1875, the Samish were forced to abandon their village on Samish Island. Instead of relocating to the reservation, they moved to Guemes Island and established a new village which was later abandoned in the 20th century (Wessen 1988, Suttles 1990a).

Despite signing the Treaty of Point Elliott, Native Americans continued to struggle with maintaining their rights and access to subsistence locations. In the late 19th to early 20th century, the Lummi struggled to keep lands and rights obtained through the treaty. In the 1890s, they lost the use of the reef-netting sites at locations such as Point Roberts and Lummi Island due to heavy competition from non-Indian commercial fishing companies. Additionally, logjams and flooding prevented access to their village (Boxberger 1980, Marino 1990, Suttles 1954).

5.1.2 Euroamerican Overview

Protection Island: Early Exploration: The first Europeans recorded visiting the island in 1790, when Spanish explorer Manuel Quimper sailed into the Strait of Juan de Fuca for the first time; the island was dubbed Isla de Carrasco after his ensign, Juan Carrasco. It was renamed Protection Island by Captain George Vancouver, who visited in May 1792 and described the landscape "as enchantingly beautiful as any of the most elegantly finished pleasure grounds in Europe" (Meany 1907: 87). Suckley (1859), an early naturalist, referred to Protection Island as a favored breeding ground of the rhinoceros auklet.

Euroamerican Settlement: The lands of Protection Island were patented by the United States from the public domain to private ownership through presidential actions from 1861 to 1865. Settlers first moved onto the island with their cattle, sheep, and horses, and planted alfalfa, barley, and potatoes during the mid-to late-1800s. Over the next 100 years, several different families attempted to live on and farm the island without success. Heavy grazing caused extensive damage to the native vegetation and severe erosion on the slopes.

From 1937-42, a ring-necked pheasant research project released at least two cats on the island to observe the effect of this predator on the isolated pheasant population (Einarsen 1945). Although sheep were not on the island during this period, much of the habitat was still recovering from past overgrazing. About 30 percent of the island was intensively farmed for wheat, alfalfa, and potatoes at this time.

With the onset of World War II, the U.S. Government assumed control of the island and established a Coast Artillery battery as a measure to protect the straits. After WWII, Protection Island passed through several ownerships. The major land use during this time was farming, with various other uses such as hunting and research. In 1969, subdividing and development of the island for homes was initiated. Eventually 580 lots were sold and owners began building houses and barging camp trailers to the island. There was no electric or telephone service and drinking water had to be transported from the mainland. Although the developers did stop the overgrazing, the increased human presence and new activities, such as lot development, road construction, and gravel pits, destroyed some valuable rhinoceros auklet breeding habitat and impacted other species. Due to the lack of a drinking water source, the development came to a halt in 1972. In 1982, Congress established the island as a National Wildlife Refuge, and by 1985 many of the lots had been acquired by the Service from willing sellers. A 48-acre parcel at the southwestern tip of the island was established as the Zella M. Schultz Seabird Sanctuary.

San Juan Islands: Early Exploration: During the late 18th century, the strait originally discovered by and named for 16th century Spanish sailor Juan De Fuca (1592), was explored by numerous expeditions, including those of English Captain Charles Barkley (1787) and Spanish Ensign Manual Quimper (1792) (Suttles 1990a, Wessen 1988). In 1791, Francisco de Eliza, who gave the San Juan Islands their name, explored the southern end of the Strait of Georgia and the San Juan Islands (Wessen 1988). In the following year, English Captain George Vancouver sailed through the islands as well. None of these early explorers provided accounts of Native American groups in the San Juan Islands. It has been suggested that early European contact had great impacts on Native American people on the islands. In the 18th and 19th centuries, epidemics decimated Native American populations and may have reduced their numbers to 20% of the original population (Wessen 1988, Suttles 1990a).

In addition to disease, other events impacted Native American groups in the region during this time period. In the early to middle 19th century, both missionaries and trading companies pursued opportunities in the region. Hudson’s Bay Company established two large trading posts in the region, Fort Langley in the Fraser Delta and Fort Victoria on Vancouver Island. Traders employed Native Americans as trappers, fishermen, mill-hands, loggers, farm hands, sailors, and middlemen in the fur trade. They also sold items such as fish, shellfish, and fruits to non-Native American peoples (Suttles 1990a). While it appears that trading companies did little directly on the islands, they still impacted Native Americans within the region, including the San Juan Islands, by instituting changes in their subsistence and settlement patterns (Wessen 1988).

Missionaries also had a great impact on the area. In 1841, the first Catholic missionary, Modeste Demers, settled at Fort Langley (Suttles 1990a, Wessen 1988). This marked the beginning of the missionary movement into the area which continued throughout the late 1800s. Many Native Americans converted to these new religions, thus altering their social and religious structures. While there are no accounts of missionaries traveling to the San Juan Islands, this does not necessarily mean that people living in the San Juan Islands never had contact with them.

During the 19th century, American and British interests grew in the region and tensions continued to rise between the two nations over the occupation of the San Juan Islands, leading to the signing of the Oregon Treaty in 1846 (National Park Service n.d., Vouri 2004). This treaty gave the US control over land south of the 49th parallel and also divided the water channel that separates Vancouver Island from mainland Washington. However, the treaty failed to recognize that the channel splits into two straits, the Haro and the Rosario, with islands in between them. No references of the San Juan Islands were provided, and due to a dramatic increase in military presence from both countries in the area, tensions built on this omission.

Eventually, conflict escalated between the two nations and reached its climax during the "Pig War," discussed in detail in the overview along with other major historical events in the region (SWCA 2007). In 1872, the Treaty of Washington was signed and the boundary was set through the Haro Strait, giving the US control of the San Juan Islands and setting the boundary between America and Canada.

There was a general lack of settlement or other development within the San Juan Islands NWR during the historic period. One story of interest which occured on an island within the refuge is that of the "Hermit of Matia Island" (Elvin Smith, 1835-1921), who made his way west after the Civil War and settled on Matia Island. He sustained himself on the island with fishing and raising chickens, sheep, and rabbits, traveling by boat only periodically to Orcas Island for supplies. In 1921, he and a friend disappeared on the return leg of one of these supply trips, and though fragments of the boat were later found, their bodies were never recovered.

5.1.3 Current Knowledge of Local Cultural Resources, Archaeological Surveys On and Nearby Refuge Lands

Protection Island: Apart from the emergency removal of a human burial in 1980 (see below), only one intensive survey and cultural resource overview has been conducted on Protection Island (Daugherty 1988). A project-specific survey prior to the removal of several structures on the northwest face of the island was conducted in 2001 with negative results.

San Juan Islands: Washington State's Department of Archaeology and Historic Preservation (DAHP) Geographic Information System (GIS) database indicates that 165 inventories have been previously conducted in the study area as of March 2007. A complete listing of these studies is included in the Overview (SWCA 2007, Appendix A). Of the 165 inventories, five occurred on one or more of the islands within the San Juan Islands NWR. Two of the inventories (NADB 1331698 and 1332069), which encompassed the San Juan Islands NWR, were part of a series of assessments conducted by the University of Washington of archaeological sites on State Parks property. Another archaeological inventory (NADB 1331172) was conducted on 189 sites containing shell deposits. The survey examined distribution patterns for sites perceived to relate to economic activities or human behavior. Many of the 189 sites were previously recorded by the University of Washington field schools; although 82 new sites were recorded within the San Juan Islands Archipelago.

A fourth inventory was conducted at least partially within the San Juan Islands NWR (NADB 1332339). The survey attempted to relocate and document 271 known prehistoric archaeological sites on 32 islands in the San Juan County section of the archipelago as well as obtain micro-environmental samplings of previously unexamined settings. An additional 51 new archaeological sites were also recorded during the survey efforts. A fifth inventory within the San Juan Islands NWR (NADB 1333658) took place solely on Smith Island. The survey was conducted on a small section of Smith Island for the installation of a Hyper-Fix Navigational Beacon Antenna, during which only a few historic artifacts were located (Stilson 1987). The project area was located within the NRHP-listed Smith Island Light Station site boundaries.

A more intensive survey of Smith and Minor Islands conducted by SWCA in 2008 covered 64 acres and culminated in a review of the structures associated with the light station in order to assess and update their determinations of historic significance (see below).

5.1.4 Archaeological Sites on and Nearby Refuge Lands

Protection Island:
No significant cultural resources were identified as a result of the intensive 1988 surface survey within the boundaries of the refuge, although a prehistoric site (never formally recorded) and a paleontological site containing mammoth remains were documented within the Zella M. Schultz Seabird Sanctuary.

Also in the vicinity of the sanctuary, a human burial encased in sediments that had slumped from the top of a bluff was removed from the base of the bluff in 1980. The skull and a long bone were transferred to Washington State University. In her reminiscence of eight years spent on the island as a young girl, Mrs. Doris Prim Hufford noted that she and her siblings “found many arrowheads and spear points: the Indians used to have many feasts but there were no graves” (Hufford MSS 66, n.d.). Daugherty notes that the thriving population of the camas plant on the island would make likely the presence of aboriginal camas ovens. He also notes that subsurface testing an evaluation could reveal remains of historic or prehistoric utilization of the island in areas that have not been previously disturbed.

A National Register Nomination form was prepared for Protection Island in 1970. The Period of Significance was cited as the 18^{th} century, specifically 1792, and the Areas of Significance included: Historic Aboriginal, Agriculture, Conservation, and Military. Apparently, the form was submitted for consideration, but no action was taken. Therefore, there are no listed historic properties on Protection Island.

San Juan Islands:
The DAHP GIS database search indicated that 457 archaeological sites have been recorded within the sections containing and proximate to the study area, including 418 pre-contact or “prehistoric” sites, 13 sites with both prehistoric and historic components, 15 historic sites, and 11 archaeological sites of unknown component (SWCA 2007, Appendix A and Table 2). Seven of the 457 archaeological sites and 28 historic properties found within the study area are located on 5 different islands within the San Juan Islands NWR. Other features are typically earthworks, like trenching or depressions, mounds or hearth remnants. In addition to the 457 archaeological sites, 28 historic properties were located within the study area in the DAHP WISAARD GIS database (SWCA 2007 Appendix D). In this context, historic properties are resources that are eligible for or listed on the National Register of Historic Places (NRHP). Only one of the 28 historic properties in the study area is located within the San Juan Islands NWR, and that is the light station located on Smith Island, discussed in more detail below.

5.2 Refuge Facilities

The infrastructure and facilities discussed in this section include buildings, roads, trails, recreational and docking facilities, regulatory and interpretive signs, and other physical structures. Refer to Chapter 2, Alternative A, Figures 2.1, 2.2, and 2.3 for maps which show the location of existing facilities on Protection Island NWR and Turn and Matia Islands in the San Juan Islands NWR.

5.2.1 Entrance and Access Points

Protection Island: Protection Island has a single, non-public, access point located in the man-made armored harbor (two rock jetties totaling approximately 500 ln. ft.) on the southeast end of the island. The facility consists of a concrete boat ramp and a two-dock floating pier (131 ln. ft. with 40 ln. ft. gangway) system capable of accommodating four small vessels . There are no other landing facilities on the island. Accessing the island via the shoreline is not allowed.

San Juan Islands: Matia and Turn are the only islands in the San Juan Islands NWR open to the public. Both are open year-round, however, the majority of Matia is designated as wilderness and is closed to public entry. All other islands in the Refuge are closed year-round to provide undisturbed habitat for wildlife.

Matia Island: The primary and only Federally-approved access point for upland areas on Matia Island is Rolfe Cove, on the northeast side of the Island adjacent to the 2-acre, non-wilderness, recreation area maintained as a State marine park by Washington State Parks and Recreation Commission (WSPRC). Larger vessels can moor to one of 2 seasonal buoys or land on a seasonal dock if space is available (approximately

70 ln. ft. of dock space including 2 sides and 60 ln. ft. gangway). The dock and buoys are available approximately April through September. Installation and removal times vary due to weather and scheduling. Smaller vessels such as kayaks can land on the dock or on the adjacent beach.

Although boaters may access other Matia coves from the water, they are not allowed to access upland areas from these "pocket" coves. Island visitors are not allowed to access the water outside Rolfe Cove from upland areas. However, the presence of a number of unauthorized "social" trails in wilderness areas suggests visitors are accessing the Island from coves located on the north, west, and south sides of the island and are accessing closed areas from the wilderness loop trail.

Turn Island: Unlike Matia Island, visitors may currently land anywhere that is suitable on Turn Island. While there are no docking facilities, the State does maintain 3 seasonal mooring buoys just off the north beach.

5.2.2 Roads and Trails

Protection Island: Protection Island has approximately three miles of primitive dirt roads. The main road begins at the marina, ascends the bluffs on the south side of the island, and circles the island's high plateau. There are three small arterials extending from the main road which provide access to a private residence and the island caretaker's cabin, the research station bunkhouse, and the east overlook.

There is a 4,000 square foot parking area associated with the marina where vehicles used by refuge staff, researchers, and extended users are located. Vehicles are brought to the island by an infrequent supply barge.

San Juan Islands: There are only two islands with foot trails in the San Juan Islands NWR. Matia Island has a 1.2 mile wilderness loop trail which circles the island's interior, and Turn Island has a 0.9 mile loop trail which circles the island's outer perimeter. Also, both islands have several short trails which access camping, picnic, and restroom areas.

5.2.3 Administrative Buildings and Other Infrastructure

Complex Headquarters: Management of Protection Island NWR and San Juan Islands NWR is carried out from the Washington Maritime National Wildlife Refuge Complex headquarters located at 715 Holgerson Road, Sequim, Washington. The headquarters consists of an administrative building (3756 sq. ft.), shop building (3848 sq. ft.), and an equipment storage building (2220 sq. ft).

Protection Island: There are a total of twelve buildings on the island. See table 5.1. Seven are directly related to island management. One building functions as a research station/bunk house and another is a shop/storage area for the research station. There is a 140-ft. well, 33,000 gallon water tower, and 10,200 linear feet of water distribution systems. The office, maintenance shop/garage, and fire cache/storage building are all located on the lower level of the island, approximately 10 feet above sea level.

Table 5.1 Protection Island NWR Buildings

Refuge Maintained Buildings		Size: Sq. Ft.	Location	Condition
1	Maintenance shop/garage	864	South lowlands	Very good
2	Office	468	South lowlands	Poor
3	Fire cache/storage	240	South lowlands	Poor
4	Pump/well house	80	Central uplands	Fair
5	Research station/bunkhouse	768	East uplands	Fair
6	Research storage/shop	120	East uplands	Poor

7	Caretaker's cabin	1280	South uplands	Good
8	Caretaker's cabin car port	312	South uplands	Fair
9	Caretaker's cabin generator shed	80	South uplands	Fair
Buildings not maintained by the Refuge				
10	Private residence	800	South uplands	Fair
11, 12	Unoccupied residences (2)	1700 total	Central uplands	Poor

Because most of the electrical power consumed on the island is supplied by gasoline generators, there is a need to upgrade island infrastructure to include more solar power. Currently, the caretaker's cabin and research station/bunkhouse utilize solar power; however, these small systems supply only a portion of the energy requirements.

San Juan Islands: There are no buildings maintained by the Refuge in the San Juan Islands NWR. However, there are camping and picnic facilities, including composting toilets, on Matia and Turn Islands which are maintained by the WSPRC. These include picnic tables and fee collection equipment such as pipe safes and registration envelope dispensers. Matia has a double composting toilet and Turn has two single composting toilets.

5.2.4 Signs

A complete sign inventory for both Protection Island NWR and San Juan Islands NWR can be found in Appendix D of this document. The U.S. Fish and Wildlife Service maintains both informational and regulatory signage in accordance with standard Service policy; however, due to the nature of these island refuges, a series of non-standard signs has been adopted. These include "large format," heavy duty signs approximately 5 feet wide by 4.5 feet tall. Such signs are used in particularly sensitive habitat marine areas susceptible to disturbance by watercraft. These signs may be either white or brown and typically warn boaters to remain 200 yards from shore to protect wildlife. The size allows for text large enough to be clearly legible from a distance.

Protection Island: Signs on Protection Island include six "large format," 200-yard boater warning signs, a large sign that reads "Protection Island NWR, Established August 26, 1988", a reflective "Marina Closed" sign, various standard 11-inch x 14-inch "Closed Area" signs to warn residents and researchers of sensitive habitat and dangerous areas, and a sign maintained by the Washington Department of Fish and Wildlife which designates the Zella M. Schultz Seabird Sanctuary. See Protection Island NWR sign plan, Appendix D.

Matia and Turn Islands: Currently there are no interpretive Service signs located on either Matia or Turn Islands, the only areas open to the public in the San Juan Islands NWR. However, each island does have minimal informational signage such as the island name with agency logo and minimal standard regulatory signage. The WSPRC maintains signage on both islands which provides general information such as camping and fee information.

San Juan Islands NWR, closed islands: The majority of rocks and islands within the Refuge are marked. Areas that are marked generally have standard Service 11-inch x 14-inch "Closed Area" signs in tandem with similar sized "blue goose NWR" signs. However, 15 islands are marked with "large format," 200-yard boater warning signs. Due to the harsh marine environment a great majority of these signs are worn and need replacing. In addition, see San Juan Islands NWR sign plan, Appendix D, for a complete inventory.

Two standard signs are prevalent within the Refuge. Currently these signs measure 11-inch x 14-inch and read either: "NATIONAL WILDLIFE REFUGE, UNAUTHORIZED ENTRY PROHIBITED" or "AREA BEYOND THIS SIGN CLOSED, All Public Entry Prohibited". Due to the need to place signs outside of dynamic boundary areas such as shorelines, the latter text is often rendered confusing and inappropriate for island units which are completely closed. In addition, due to their size, they are legible only after an individual has trespassed and as such are visually inadequate.

5.3 Research

Research activities have taken place on Protection Island NWR and the San Juan Islands NWR for many years, some prior to the Refuges' establishments. Over 80 research projects reported in published or grey literature have been conducted since the late 1930's with the majority since the mid-1980's. Primary research has been focused on glaucous-winged gulls, rhinoceros auklets, pigeon guillemots, and bald eagles.

5.3.1 Research Activities Prior to Refuge Establishment

The Oregon Cooperative Wildlife Research Unit of the U.S. Fish & Wildlife Service conducted ring-necked pheasant studies on Protection Island from 1937 through 1942 for the purpose of accumulating information as a guide to their management in the Northwest. A long-term bird banding operation of glaucous-winged gulls was conducted by the Western Bird Banders Association. Gulls were banded in the trans-boundary area of Canada and the U.S. starting in 1940 and continuing thru 1973. Banding on Colville Island in the San Juan Islands NWR was carried out for the longest period of any U.S. gull colony, followed by Protection Island.

In the 1960's, a Cooperative Agreement between the Bureau of Sport Fisheries and Wildlife and the University of Washington allowed the University's Friday Harbor Lab to conduct research studies on marine resources on tide flats and shorelines of Colville, Jones, Matia, Turn and Smith Islands. In 1967, Colville Island was removed from the agreement to reduce potential adverse impacts to glaucous-winged gulls nesting there. Glaucous-winged gull and bird population studies were conducted on Colville, Four Bird Rocks, Three Williamson Rocks, Flower Island, Pointer Island and Ram Island by researchers from Walla Walla University.

During the 1970's, glaucous-winged gull studies and bird population studies continued on Colville Island, Williamson and Bird Rocks, and on Protection Island by staff and students of Walla Walla University. Additional bird population studies were conducted in 1970 on Flower, Pointer, and Ram Islands by the University.

National Oceanic and Atmospheric Administration (NOAA) biologist Clifford H. Fiscus conducted research on harbor seals on Smith and Minor Islands and on Protection Island as part of NOAA's Marine Ecosystem Analysis (MESA) Project from 1977 to 1979. Funded by NOAA and EPA, the MESA Project set out to record the distribution and abundance of a wide range of marine species and habitats over the northern portion of Washington State's inland waters. Fiscus's study characterized marine mammal populations and their habitats vulnerable to petroleum-related activities. Regular surveys were used to determine times and places for breeding, feeding, and rearing of young as well as timing of entrance and departure of seasonal pinniped migrants.

Also as part of NOAA's MESA Project, a SUP was issued to Stephen M. Speich in 1978 and 1979 to conduct low level aerial surveys to characterize the distribution, abundance, and time of occurrence of all the breeding and non-breeding birds in the Strait of Juan de Fuca, San Juan Islands, and the Strait of Georgia. Dr. David Manuwal and Terry Wahl also participated in the study.

5.3.2 Protection Island NWR Research Activities

Dr. Joseph G. Galusha, Walla Walla University, began his work in 1979 and to-date has had 21 graduate and 11 undergraduate students work on projects. A majority of his work has dealt with glaucous-winged gulls. Research topics include time budgets while in the colony; spatial aspects of territorial behavior; parent-chick recognition, social behavior of gulls living in different habitats; behavior of resident and intruder gulls; behavior and survival of families of differing size; egg-laying chronology and reproductive success of glaucous-winged gulls; and social facilitation of chicks and parents while on territory. He also studied the impacts of an increasing bald eagle population on the glaucous-winged gull colony, and conducted periodic total gull colony censuses. Dr. Galusha and his students studied pigeon guillemot breeding success and daily time budgets of this species as it relates to human disturbance. Northwestern crow population and breeding success and double-crested cormorant colony utilization and flight patterns were also studied.

Thomas A. Lee, Walla Walla University, also conducted research on the natural history and aspects of behavioral ecology of the Northwestern Crow on Protection Island.

Dr. James L. Hayward, Andrews University, has conducted a number of research studies and investigations on the Refuge since 1987. Ten graduate and 22 undergraduate students of his have worked on projects primarily studying glaucous-winged gulls, including: eggshell taphonomy, bone growth and developmental bone histology, egg-laying synchrony, reproductive success, pellet counts, prediction of habitat occupancies by gulls in relation to environmental factors, and impacts of bald eagles on gull behavior. In addition, Dr. Hayward's research topics include great-horned owl pellet contents; historical changes in island structure and vegetation, prediction of harbor seal haul-out times, Protection Island food web, and a Protection Island flora and vegetation map.

Steve Jeffries, WDFW, has conducted marine mammal studies on Protection Island NWR and the San Juan Islands NWR since the 1990's. Studies have included harbor seal and elephant seal census, food habits, health monitoring (blood and tissue samples), contaminant research, and mortality event investigations.

Scott Pearson, WDFW, **Peter Hodum**, University of Puget Sound, **Michael Schrimpf**, **Jane Dolliver** and **Julia Parrish**, University of Washington, and **Thomas Good**, NOAA Fisheries, have studied long-term changes in seabird diet and the potential impacts of these changes on seabird populations since 2006. Work on Protection Island has focused on rhinoceros auklets and included burrow counts, burrow density, occupancy rates, and associated habitat variables.

Lee Robinson, Refuge volunteer, has conducted long-term monitoring of pigeon guillemots on Protection Island. This work began as part of the Puget Sound Ambient Monitoring Program in 1994. Nest boxes were established and are monitored throughout breeding and chick rearing. Data on chick weight and wing length measurements are collected.

Ulrich Wilson, retired Refuge wildlife biologist, conducted long-term rhinoceros auklet research that spans over 25 years. Studies included burrow use, breeding success, chick growth, chick survival, diet studies, population estimates from burrow counts, and effects of El Niño events on Protection Island rhinoceros auklets. He also investigated DDE, PCB's, cadmium, lead, and mercury concentrations in rhinoceros auklets from Washington State.

Brent Norburg from NOAA's National Marine Mammal Laboratory and WDFW was issued SUPs to conduct research on harbor seals on Protection Island NWR and San Juan Islands NWR. This research included radio-tagging harbor seals, food habits, pupping phrenology, and population assessment.

Western Heritage, Inc., of Olympia, Washington, conducted cultural resource surveys on Protection Island in 1988.

5.3.3 San Juan Islands NWR Research Activities

Joe Bennett, University of British Columbia's Center for Applied Conservation Research, has conducted research in support of his doctoral thesis, "Determinants of plant community composition in coastal meadow ecosystems of Vancouver Island and adjacent islands," on a number of Refuge islands in the San Juan Archipelago. Floristic surveys and soil samples were collected to assess drivers of savanna ecosystem composition and vulnerabilities.

John Calambokidis of the Cascadia Research Collective, a non-profit research organization, has been issued SUPs to continue work begun in the 1970s to determine long-term trends in concentrations of chlorinated hydrocarbon contaminants in harbor seals and other environmental components (mussels and sculpins) at Smith and Minor islands. In 1977, John conducted research on habits, behavior, and population dynamics of harbor seals on Smith and Minor Islands. He has been particularly interested in harbor seal pup mortality on the islands, which some years have totaled 60+ animals. John has also assisted Steve Jeffries**,** WDFW, with his work on marine mammals.

R. Wayne Campbell, British Columbia Provincial Museum, Victoria, B.C., conducted a nest use survey of double-crested cormorant colonies on the Sisters Islands, Viti Rocks, and Bird Rocks in 1976.

Dr. Mark Dybdahl, University of Washington's Friday Harbor Laboratories, conducted research in the San Juan Archipelago in the 1990s, which included a census and some collection of tide pool copepods.

David Giblin, University of Washington Herbarium, Burke Museum of Natural History, and **Peter Dunwiddie**, TNC, began a systematic effort to collect, archive, and disseminate floristic information concerning the smaller islands (<100 hectares) of the San Juan Archipelago in 2005, 2006, and 2009. Preliminary results show that the small islands in the San Juan Archipelago harbor substantial numbers of rare plant populations. In addition, due to the lack of residential or agricultural development, several small islands harbor some of the most pristine examples of Puget Sound prairies in the region. These surveys have generated important baseline data in light of anticipated vegetative changes in response to climate change.

Dr. David A. Manuwal conducted studies on dispersal of rhinoceros auklets from disturbed natal colony sites on Smith and Minor Islands and Protection Island.

Ruth Milner, WDFW, lead a research project entitled "Post-breeding movement of the black oystercatcher in the North Puget Sound – VHF Tracking Study". This study extends the VHF tracking portion of a larger 2007 study of black oystercatcher movements between breeding, stopover, and over wintering sites at Prince William Sound, Middelton Island, Stephens Passage near Juneau, Alaska, Kodiak NWR, and along the west coast of Vancouver Island.

On a larger scale, this effort will increase our understanding of how animals breeding in different segments of the black oystercatcher's range behave in winter and is important to the effective management of this species (e.g., oil spill response, habitat conservation, and monitoring response to disturbance). Some of the birds captured for this study came from islands within San Juan Islands NWR. Sue Thomas (USFWS), Dave Nysewander, Joe Evenson and Tom Cyra (WDFW) also participated in this study. Ruth was also issued an SUP in 2007 to ground truth a west-coast-wide aerial survey of gulls. That SUP allowed access to Hall Island, Gull Rock, Three Williamson Rocks, and Peapod Rocks in the San Juan Islands NWR.

Dave Nysewander and **Joe Everson**, WDFW, have conducted pigeon guillemot and black oystercatcher censuses on the San Juan Islands NWR since the 1990's. Their recent surveys have been conducted using amplified black oystercatcher calls, a study technique they developed.

Richard Knight, Coordinator of the Washington Eagle Study for the Washington Department of Game, was issued an SUP in 1980 to visit active eagle nests, band and mark young, take blood samples for heavy metal and PCB analysis, and collect food habit data.

Steven Speich was issued an SUP in 1983 to survey the breeding marine birds of the San Juan Islands to determine breeding status, stage of nesting, status of tufted puffins and rhinoceros auklets, and to describe the habitat.

Research on Refuge lands requires submission of a research proposal, which is reviewed by Refuge staff, and if approved, a Special Use Permit with special conditions to ensure compatibility is issued to conduct the study.

5.4 Refuge Recreation

5.4.1 Open and Closed Areas

Protection Island: All of Protection Island National Wildlife Refuge is closed to the public year-round.

San Juan Islands: Turn and Matia Islands are the only units open to the public within the San Juan Islands National Wildlife Refuge. The remaining 81 rocks, reefs, and islands are closed to public entry year-round to provide undisturbed habitat for wildlife. Currently the whole of Turn Island and 2 acres on Matia Island are managed as State Marine Parks under a Memorandum of Understanding (MOU) with the WSPRC. Of all the State Parks in Washington, Matia and Turn are the only ones located on a National Wildlife Refuge (WSPRC 2007a). These unique Refuge units are the only places in northwest Washington State where boating visitors can experience island wildlife and their habitat on a National Wildlife Refuge. Both islands are accessible year-round.

Matia Island: The 2-acre recreation/camping area located adjacent to Rolfe Cove and a 1.2 mile wilderness loop trail are the only areas open to the public on Matia Island. The remaining 140 acres of the island are designated as a National Wilderness Area. Except for the 1.2 mile loop trail, the wilderness area is closed to the public to provide undisturbed habitat for wildlife. Visitors are required to stay on the trail and are not allowed to access other areas from the trail. The wilderness trail offers a unique glimpse of protected old-growth island forest habitat present in only a few places in the region.

The nearest safe harbor to Matia Island is Sucia Island State Marine Park, approximately 1.3 nautical miles to the west (Carlten Tripod 2009). However, Sucia Island and its associated smaller islands comprise a large, busy park offering a very different experience at 564 acres, including two docks (660 feet of space), 48 mooring buoys, and 55 campsites (WSPRC 2009).

Turn Island: There are currently no closed areas on Turn Island and boaters may access all beaches; however, future management strategies may include closing some areas to benefit wildlife and vegetation. Turn Island's close proximity to busy Friday Harbor makes it an ideal destination for those seeking an easily accessible island experience. At just 35 acres, Turn Island is relatively small, but offers safe and easy access for small boats. Unlike Matia Island, Turn is not designated as wilderness. However, much of the island is relatively undisturbed, so whether wandering the wide open beaches or hiking the island's

0.9 mile perimeter loop trail, there is a very good possibility of encountering some of the island's protected wildlife.

Because Turn Island has no docking facilities, larger vessels looking for dock access often bypass Turn, instead choosing to head for the much larger Jones Island State Marine Park approximately 6 nautical miles to the north (Carlten Tripod 2009). At 188 acres, Jones Island has 320 feet of seasonal dock, 7 mooring buoys, and 21 campsites including the ability to accommodate large groups (WSPRC 2009).

5.4.2 Annual Recreation Visits

Matia Island is remotely located at the far northeast corner of the San Juan Islands Archipelago which is a popular tourist destination. Many refuge visitors likely come from the nearest large population center, Bellingham, Washington. Bellingham is approximately 17 nautical miles to the east (Carlten Tripod 2009) and has a population of more than 77,000 people (CityData.com 2009). However, Matia Island receives visitors from across the region and beyond.

According to data collected by the WSPRC, it is estimated that Matia Island received 1,868 day use and 2,228 overnight use visitors in 2008 (WSPRC 2008a). However, recorded figures are likely to be much lower than the actual visitation numbers due to limitations of survey timing and techniques. Matia figures are calculated by recording the number of boats in the approved landing area in Rolfe Cove multiplied by a factor of 5.25 to determine a day count. These figures do not account for vessels landing in other areas. WSPRC staff members suggest the actual figures could be as much as four times higher (USFWS 2007a).

Turn Island is located approximately two nautical miles southeast of Friday Harbor, Washington, the most populous city in the San Juan Islands with just over 2,000 residents and also the primary transportation hub for the Islands (CityDate.com 2009). It is estimated that Turn Island received 10,248 day use and 3,061 overnight use visitors in 2008 (WSPRC 2008a). As with Matia Island, recorded visitation figures for Turn Island may be less than 25 percent of the actual number of visitors using the island (USFWS 2007a).

WSPRC's data for visitation between 2002 and 2007 can be interpreted to indicate visitation overall remained fairly steady for both islands (WSPRC 2008a). However, WSPRC staff indicates that kayak visitation increased on Turn Island during that time while it remained fairly stable on Matia Island. Staff members also indicate that larger vessel use of Matia may be declining (WSPRC 2007c). This could be, in part, due to the limited docking space available in Rolfe Cove, combined with the nearby alternative, Sucia Island, which offers considerably more docking facilities.

5.4.3 Wildlife Observation and Photography

Wildlife observation and photography are primary uses of Matia and Turn Islands. However, refuge wildlife, especially birds, can also be viewed and photographed from the water near other refuge islands, including Protection Island NWR. There are numerous commercial ecotourism charters operating in both areas. Wildlife observation and photography is covered more in the following section titled Regional Recreation Opportunities and Trends.

Matia Island: Matia Island presents a unique opportunity to walk and camp among old growth trees and listen to the sounds of wildlife and waves in one of the most beautiful and peaceful settings in the Salish Sea. The 1.2-mile wilderness loop trail provides limited wildlife viewing and photography opportunities, as well as a peaceful respite from the busier 2-acre recreation area. The wilderness loop trail begins and ends in the 2-acre recreation area and is not intended to provide access to other parts of the Island. In addition to wildlife viewing and photography, and walking the wilderness trail, Matia provides opportunities to experience wildlife by day and at night while camping in one of the 6 primitive sites.

Turn Island: Turn Island has a 0.9-mile perimeter trail which provides visitors with opportunities to view and photograph wildlife. This short walking trail encircles the island passing through a variety of wildlife habitat from rocky shorelines to meadows to mixed forests. Future plans for this trail include the addition of interpretive information and some changes to protect sensitive vegetation. In addition to the loop trail, Turn Island has an extensive open beach area suitable for observing aquatic species and landing small craft. The shoreline outside of the beach areas is available for wildlife viewing and photography from the water but is not suitable for landing vessels. In addition to wildlife viewing, photography, and walking the loop trail, Turn currently provides opportunities to experience nature by day and at night while camping in one of the 13 primitive sites.

5.4.4 Environmental Education and Interpretation

Protection Island NWR: The primary education opportunities on Protection Island NWR are in association with volunteers and college students conducting or assisting with research projects.

San Juan Islands NWR: Currently the San Juan Islands NWR has no formal environmental education or interpretation programs, and many visitors are not fully aware that Matia and Turn are part of a national wildlife refuge. Additionally, information provided via travel websites and elsewhere often neglects to mention that these islands are part of the National Wildlife Refuge System. Future plans for both islands include increasing interpretation opportunities with the goal of helping visitors understand and appreciate their unique value as island national wildlife refuges.

5.4.5 Hunting and Fishing

Currently there is no hunting on refuge lands; for information regarding nearby hunting see section 5.6.1 below. There are no fish-bearing water resources on any of the refuge islands. There are, however, fishing opportunities in the marine waters that surround refuge islands. For more information about nearby fishing, see section 5.6.2 below.

5.4.6 Camping

In 1960, WSPRC began planning and installing camping and picnicking facilities on Matia and Turn Islands as provided for under MOU's with the Service. It was determined that *"Seasonal use of the islands by wildlife affords an opportunity for controlled recreation use without limiting the function of the islands as wildlife sanctuaries; thus, the Bureau of Sport Fisheries and Wildlife* (USFWS) *has concurred in the development of docking and picnicking facilities at designated locations"* (Laythe 1959 pers. comm.). Since that time, camping, picnicking, restroom, and boating facilities have been developed and maintained by the WSPRC.

Currently, camping is allowed year-round on a "first-come, first-served" basis. Camping fees are $12 – 14 per night, no reservations required. All fees are collected by the WSPRC. Additionally, mooring buoys are $10 per night and overnight dock fees on Matia are 50 cents per foot, $10 minimum.

Matia Island: Matia has 6 primitive campsites and one additional picnic site, all with picnic tables. In addition, Matia has a composting public toilet, 2 seasonal mooring buoys, and a seasonal dock located in Rolfe Cove.

Turn Island: Turn has 13 primitive campsites and a picnic site, all with picnic tables. In addition, Turn has 2 composting toilets and 3 seasonal mooring buoys.

Camping affords visitors an opportunity to view wildlife at times when animals are particularly active, such as dawn and dusk, and to experience the sounds of wildlife at night. In addition, visitors who have traveled by human-powered craft may be afforded safe refuge to rest, and to allow wind and inclement weather to abate.

5.4.7 Pets

WSPRC regulations currently allow pets on leashes in the campground areas on Turn and Matia Islands. Visitors, however, routinely allow pets off-leash and on trails and other areas where they are not allowed. Pets other than authorized hunting dogs and service animals are not typically allowed on national wildlife refuges because they disturb and/or prey on wildlife; decrease the presence of wildlife; decrease opportunities to view wildlife; can be involved in disease transmission to or from wildlife; and can be a safety hazard to humans or the pets themselves.

5.4.8 Unauthorized Refuge Uses

Protection Island NWR
Due to the frequent presence of refuge staff, volunteers, and researchers on Protection Island, unauthorized activities are uncommon.

San Juan Island NWR
Pets are frequently observed off-leash on Turn and Matia Islands. People and their pets also trespass on closed refuge islands. Impacts of pets are described above under 5.4.7. People disturb driftwood on closed islands to build makeshift sculptures. Disturbing driftwood impacts the wildlife values of this important habitat component. Wildlife such as shorebirds, seabirds, and marine mammals require areas of sanctuary where they can rest, nest, and forage free from human disturbance. The presence and activities of people and/or their pets can make otherwise suitable wildlife habitat unavailable to these species. These activities are in violation of chapter 50, section 26.21, of the Code of Federal Regulations.

Matia Island: The shoreline perimeter around Matia Island is closed, with the exception of Rolfe Cove. However, due to the inviting nature of Matia Island's many "pocket" coves and the lack of clear regulatory signs, a number of unauthorized "social trails" have developed through closed areas leading from the wilderness loop trail to bluff areas and beaches around the Island. These areas are important habitat for sensitive species, such as eagles, cormorants, and black oystercatchers, which may be harmed by disturbance. Wildlife such as marine mammals, shorebirds, and seabirds will avoid shorelines that are frequented by people. This otherwise suitable habitat becomes unavailable to these species due to human activities.

Unauthorized wood cutting and collection occurs on Matia Island even though open fires are not allowed and cooking grills have been removed by the WSPRC. Unauthorized fire rings, where materials such as driftwood and cut tree branches are burned, are evidence that refuge regulations are sometimes ignored. An important reason for prohibiting open fires is that Matia Island is considered to be at high risk of catastrophic wildfire. The incredible old-growth forest on Matia Island might never fully recover its habitat and aesthetic values if a stand-replacing forest fire occurred.

Turn Island: WSPRC has reported that Turn Island has among the highest number of incidents of unauthorized activities among all of the marine state parks. Refuge staff are concerned that Turn Island has become a destination for non-wildlife dependant recreation inappropriate for a National Wildlife Refuge and incompatible with the refuge purpose. Its close proximity and easy access to Friday Harbor makes it popular with visitors, including those exhibiting undesirable behaviors. Unauthorized wood cutting and collection also occurs on Turn Island, even though open fires are not allowed and cooking grills have been removed by the WSPRC. Unauthorized cutting and collecting of firewood is resulting in damage to native vegetation. Uncontrolled "social trails" have been created on fragile slopes and meadows.

5.4.9 Law Enforcement and Resource Protection

There is one dual function officer assigned to cover all of the six refuges in the Washington Maritime National Wildlife Refuge Complex. That officer is based out of the Refuge Complex headquarters located at the Dungeness National Wildlife Refuge near Sequim, Washington. As a result of the geographic distances, and their remoteness, Matia and Turn Islands are patrolled very infrequently, less than 5 days per year.

The Service entered into an MOU with WSPRC in 1959. This MOU with WSPRC was in response to "uncontrolled public use" which "created litterbug and sanitation problems" (Laythe 1959 pers. comm.) and was designed to convey authority to WSPRC to manage and regulate recreational activities, including camping and picnicking, on the non-wilderness portion of Matia Island and on the whole of Turn Island. As a result of that and subsequent modified MOUs, WSPRC has served as the primary law enforcement agency on Turn and Matia Islands. In a 2007 meeting, WSPRC staff indicated that Turn Island typically has a much higher law enforcement incident rate than other State Marine Parks (USFWS 2007a).

5.5 Other Refuge Uses

5.5.1 Proprietary Uses

United States Coast Guard
The U.S. Coast Guard operates and maintains a number of aids to navigation structures on or immediately adjacent to refuge islands in the San Juan Islands and Protection Island. Nineteen of these are covered under a 2005/2006 MOU. Also see Appendix A and Appendix E.

NOAA
The National Oceanic and Atmospheric Administration's National Data Buoy Center established the Coastal-Marine Automated Network (C-MAN) for the National Weather Service in the early 1980s. A C-MAN Station (S1SW1) was established on Smith Island in 1984. The development of C-MAN was in response to a need to maintain meteorological observations in U.S. coastal areas. Such observations, which had been made previously by USCG personnel, would have been lost as many USCG navigational aids were automated under the Lighthouse Automation Modernization Program.

C-MAN station data typically include barometric pressure, wind direction, speed and gust, and air temperature; however, some C-MAN stations are designed to also measure sea water temperature, water levels, waves, relative humidity, precipitation, and visibility. The station on Smith Island is mounted on a tower and is powered by marine batteries charged with solar cells. Standard meteorological data has been collected since 1984 and continuous wind data since 1997.

5.5.2 Non-proprietary Uses

Island Oil Spill Association, San Juan County
Island Oil Spill Association (IOSA) is a unique, community-based, private non-profit organization that provides a range of responsive services including initial assessment, containment and clean-up, and oiled wildlife rescue. The association is volunteer-based with more than 200 trained responders. It is fully recognized by the U. S. Coast Guard as a Federal Oil Spill Response Organization and by the Washington State Dept. of Ecology as an Approved Primary Response Contractor. It has field-tested and developed 54 geographic response plans to protect the most sensitive resources in the San Juan Islands area. The refuge has worked with this group by providing anchoring points on Fortress, Crab, and Blind Islands to help with the deployment of containment booms.

Low Island – Yellow Island Marine Research Preserve
Working with the University of Washington Friday Harbor Lab and The Nature Conservancy, the refuge has permitted the placement of two signs on Low Island. These signs inform the public that the area around Low and Yellow Islands is a marine research preserve and a no fishing area.

5.6 Regional Recreational Opportunities

5.6.1 Hunting

The quantity of **waterfowl hunting** near the refuges is low in comparison to the rest of Washington State (Davison 2008 pers. comm.). Dabbling ducks such as mallards, wigeons, and pintails are hunted primarily by local residents on bays, inlets, ponds, lakes, and other public and private wetland areas. However, due to an increasing interest in hunting sea ducks including scoters, harlequin, and long-tailed ducks, the North Puget Sound area has become a "destination" for sea duck hunting (WDFW 2007, WDFW 2008b**,** Nysewander 2008 pers. comm.). Sea duck hunting guides in the area attract a growing clientele of domestic and international hunters (Davison 2008 pers. comm.) interested in a "once-in-a-lifetime" opportunity to hunt these unique species of ducks (Peninsula Sportsman 2008, Wings and Waves 2008). Most of the sea duck hunting seems to occur from areas close to the mainland (outfitters and guides operate out of Quimper Peninsula and Skagit Valley area shorelines). Boats typically used for sea duck hunting are not well equipped to make the often challenging crossing from the mainland to the islands.

Island County has the highest sea duck harvest numbers in the state (WDFW 2008b). Skagit and Whatcom Counties are also among the highest while Jefferson County has lower sea duck harvest averages. In San Juan County, 2007 was the first year that any sea duck harvests were reported since mandatory reporting started in 2004. If interest in sea duck hunting continues to grow, it is likely to increase in this county as well (WDFW 2008b). As resident goose populations rapidly increase in the San Juans, goose hunting opportunities are increasing because more private landowners are opening their properties to hunters (Davison 2008 pers. comm.).

There are limited opportunities for **deer hunting** near either refuge. In the vicinity of Protection Island NWR, there is a small amount of public land open to deer hunting in the northern portions of Quimper and Miller Peninsulas and in the Sequim vicinity. In addition, a few nearby private landowners allow hunting on their properties (Schirato 2008 pers. comm.).

Island County allows public hunting on three of their Whidbey Island properties near Greenbank and Penn Cove (Guthrie 2008 pers. comm.). In the San Juan Islands area there are high concentrations of deer, but most land is privately owned (WDFW 2008a) and San Juan County requires hunters on private land to carry written permission from the landowner to hunt (San Juan County Code 9.08.040). Because public hunting is limited and the best opportunities are on private lands, primarily local residents engage in these nearby deer hunting opportunities (Milner 2008 pers. comm.).

5.6.2 Fishing

There are numerous charter operators in the region that specialize in fishing throughout the San Juan Islands area. A handful of charters operate out of harbors within the San Juan Islands while others operate from harbors in nearby Anacortes and Bellingham. In addition, the waters around the San Juan Islands offer endless opportunities to fish from private vessels. While lingcod and other bottomfish are the most common targets, fishing for salmon is also popular. Unlike the San Juan Islands, few charter fishing operations are based near Protection Island. However, the area is popular with local sport fishers.

It is estimated that more than 10% of the state's residents participate in recreational saltwater fishing from private vessels while less than 2% do so from charter vessels (RCO 2007). The peak sport fishing season in the San Juan Islands begins in May for most species and continues through September. Lingcod, with a very short peak season occurring in May and June, is one of the most popular species. Other species with peak seasons from May through September as well as generally good fishing during the non-peak months support a year-round draw for the industry. The peak month for participating in saltwater fishing from charter vessels is May, while the peak month for fishing from private vessels is July (RCO 2007).

5.6.3 Diving

There are many popular dive sites throughout the San Juan Islands and associated areas. Attractions in the San Juan region often include diving the steep vertical island and rock edges, commonly known as walls. There are a few wrecks that also attract divers. WSPRC manages three underwater state parks in the region and many of the marine parks that they manage offer shore diving opportunities. Several commercial operators offer diving charters throughout the island waters. Purchases related to diving needs and services contribute to the local economies, but likely not as strongly as sea kayaking, and certainly not as strongly as whale watching. Some of the well-known and/or frequented sites are listed in Table 5.2.

Table 5.2, Nearby Popular Diving Locations

<table>
<tr><th colspan="2">Shore diving locations near PINWR</th><th>Boat diving near PINWR</th></tr>
<tr><td>Port Townsend</td><td>• North Beach Park
• Fort Worden State Park</td><td rowspan="2">• None</td></tr>
<tr><td>Whidbey Island</td><td>• Fort Casey Underwater State Park (Keystone)</td></tr>
<tr><th colspan="2">Shore diving locations near SJINWR</th><th>Boat diving near SJINWR</th></tr>
<tr><td>Lopez Island</td><td>• Odlin County Park
• Spencer Spit State Park
• Agate Beach County Park</td><td rowspan="5">• Pea Pod Rocks *
• Cone Islands
• Brown Rock
• Brown Rock
• Henry Island
• Spieden Island
• Turn Island *
• Doe Island
• Frost island
• James Island
• Long Island
• Patos Island
• Sucia Island
• Iceberg Island
• Bell Island
• Matia Island *
• Waldron Island
• Jones Island</td></tr>
<tr><td>Orcas Island</td><td>• Doe Bay
• West Beach
• Lover's Cove</td></tr>
<tr><td>San Juan Island</td><td>• Reuben Tarte Picnic Area
• San Juan County Park
• Lime Kiln Point State Park
• Deadman Bay
• Eagle Cove
• South Beach
• Smallpox Bay</td></tr>
<tr><td>Stuart Island</td><td>• Turn Point</td></tr>
<tr><td>Whidbey Island</td><td>• Washington Park
• Rosario Beach
• Burrows Pass</td></tr>
</table>

Sources: Fischnaller 2000. Northwest Diver 2007. Pratt-Johnson 1994, San Juan Islands Directory 2007, Washington State Parks and Recreation Commission 2007b

Note: * indicates Service-managed lands where diving activities may be impacting refuge wildlife.

5.6.4 Wildlife Observation and Photography

Wildlife Observation and Photography
Washington State offers some of the most fantastic and unique opportunities to view and photograph wildlife in the U.S. In particular, the areas around Protection Island and the San Juan Islands offer endless opportunities to experience rare sea birds such as tufted puffins, rhinoceros auklets, and black oystercatchers. These rich waters are home to large numbers of marine mammals, including seals, porpoises, and whales, as well as a myriad of other creatures. It is estimated that nearly 40 percent of Washington residents participated in nature and wildlife observation and photography in 2006 (RCO 2007), although the actual percentage may be well over that (IAC 2003). The Washington State Recreation and Conservation Office's 2006 Outdoor Recreation Survey reported such activity occurred more than 35 million times that year. Participation in nature-related activities is growing in popularity in Washington and is expected to increase significantly in coming years (IAC 2003).

San Juan Islands
There are many opportunities for wildlife observation near the refuge. While many of the commercial wildlife observation charters focus specifically on whales, most offer seabird viewing when opportunities arise. The majority of the charter operators are members of the local whale spotting network and Whale Watch Operators Association which includes at least 30 operators. But there are at least another dozen operators who are not members of the association. Most companies offer whale watching cruises along the west side of San Juan Island, although they will go just about any place where whales are present. In addition, destinations for seabird and marine mammal viewing include Spieden, Cactus, Flattop, Goose, Long, Yellow, and O'Neill Islands and Whale and Sentinel Rocks. Whether commercial or private, marine mammal and seabird observation and photography are popular activities throughout the islands.

Whale watching and sightseeing guided tours serve more than 50,000 – and possibly as many as 100,000 – visitors to the islands each year. Of those completing the 2005 and 2006 San Juan Islands Visitors Bureau exit surveys, between 38 and 51 percent marked whale watching as the favorite part of their trip. Whale watching is second only to dining and shopping for activities in which visitors completing the surveys engaged. Whale watching and sightseeing is likely one of the top economic resources for the region.

Protection Island
The Port Townsend Marine Science Center offers opportunities to view seabird colonies on their cruises around Protection Island. Observers are also likely to catch a glimpse of seals hauled out to rest along the shores of Protection Island. In addition, Protection Island waters are a popular destination for private vessels including kayaks, sailboats, and power boats. Although the island is closed to the public and vessels are required to remain a minimum of 200 yards from shore to minimize disturbances, there are ample opportunities to view seals and seabirds in the waters around the island and onshore, especially with the aid of binoculars.

5.6.5 Environmental Education and Interpretation

Walla Walla University offers summer marine biology courses at its Rosario Beach Marine Laboratory in Anacortes; students attending these summer courses routinely examine the marine flora and fauna present in the San Juan Islands. For the past 10 years, Professor Jim Nestler has incorporated data produced by students studying inter-tidal areas around Swirl Rocks in annual marine invertebrate surveys.

A variety of other natural and cultural education and interpretation programs and facilities are available near the refuges (See Table 5.3). They are primarily managed by the WSPRC, the National Park Service, and the Port Townsend Marine Science Center. Unfortunately the lack of funding in recent years has reduced or eliminated the environmental education opportunities at several State Parks Environmental

Learning Centers in the region (Graham 2007 pers. comm.). This trend of reduced services at State Parks is likely to continue at least into the near future due to budget reductions (Niel 2009 pers. comm.)

Table 5.3, Area Environmental Education & Interpretation Opportunities

Facility by Location	Focus	Features
San Juan Island		
Lime Kiln Point State Park	▪ Whale watching ▪ Local history	▪ Lighthouse tours ▪ Self-guided, signed interpretive trail ▪ Interpretive center ▪ Seasonal guided walks and marine mammal programs
American Camp **San Juan Island National Historical Park**	▪ Local history	▪ Visitor center ▪ Environmental education programs ▪ Signed interpretive walks ▪ Encampment re-enactments ▪ Wildlife viewing
English Camp **San Juan Island National Historical Park**	▪ Local history	▪ Royal marine barracks contact center ▪ Environmental education programs ▪ Signed interpretive walks ▪ Encampment re-enactments ▪ Wildlife viewing
Orcas Island		
Camp Moran **Moran State Park**	▪ Wetlands ▪ Old growth forest ▪ Forest ecology	▪ Nature programs for youth ▪ Kayaking ▪ Backpacking
Moran State Park	▪ Local history ▪ Beach ecology ▪ Old growth forest ▪ Forest ecology	▪ Jr. Ranger program ▪ Interpretive story of Robert Moran ▪ Low tide beach walks ▪ Self-guided interpretive trail with signage ▪ History talks ▪ Family nature crafts ▪ Guided hikes to waterfall and through old growth forest ▪ Campfire program
Blake Island		
Blake Island State Park	▪ Native plants ▪ Trimble Estate history	▪ Signed nature trail ▪ Historic interpretive signage
Whidbey Island		

Facility by Location	Focus	Features
Bowman Bay Interpretive Center **Deception Pass State Park**	▪ Wetlands and sand dunes ▪ Samish Indian Nation story ▪ Discovery and naming of Deception Pass and Whidbey Island	▪ Maiden of Deception Pass story pole ▪ Historic interpretive signage ▪ Frequent weekend and evening lectures and slide shows
Port Townsend		
Port Townsend Marine Science Center **Fort Worden State Park**	▪ Marine ecosystems ▪ Intertidal ecosystems	▪ Protection Island wildlife cruises ▪ Touch tanks ▪ Marine exhibit ▪ Natural history exhibit
Fort Worden State Park	▪ Local military history	▪ Coastal Artillery Museum ▪ Commanding Officer's Quarters ▪ Rothschild House
Marrowstone Island		
Fort Flagler State Park	▪ Local military history	▪ Military museum ▪ Historic buildings

Sources: Washington State Parks and Recreation Commission 2008b, National Park Service 2008, Personal Communications: Linda Sheridan and John Graham, Washington State Parks and Recreation Commission.

5.6.6 Camping

There are more than 400 public campsites within 15 miles of Turn and Matia Islands (See Tables 5.4 for Matia and 5.5 for Turn). Another 400 private campsites are available on San Juan, Orcas, Lopez, and Canoe Islands (Doe Bay Resort 2007, Lucas 2004, Mitchell Bay Landing 2007, Mueller and Mueller 1985, NW Source 2007, San Juan County Parks 2005, San Juan Islands Directory 2007, TheSanJuans.com 2007, SanJuansSite.com 2007). Many of these campgrounds are accessible from the saltwater shoreline, but a few are located off the water.

The Washington State Parks and Recreation Commission (WSPRC 2007b) and the Washington Department of Natural Resources (WDNR) manage 7,006 acres for parks and recreation within San Juan County including Moran State Park, Washington's largest state park (San Juan County 2005). These State-managed properties include 282,886 linear feet of shoreline, 368 camping sites, and 108 day-use sites (San Juan County 2005).

San Juan County manages 3 camping facilities with a total 112 campsites (San Juan County 2005). These three parks total approximately 152 acres with 11,195 linear feet of shoreline (San Juan County 2005). The County also manages several day-use only park facilities.

Table 5.4, Designated Public Camping Facilities Within 15 Miles of Matia Island

Campground	Miles to Matia	Acres	Saltwater Shoreline (linear feet)	Campsites	Mooring Buoys	Firepits	Water	Toilets	Hiking Trails	Setting
Sucia Island Marine State Park	1.5	564	77,700	55	48	▪	▪	▪	▪	Forest, rock cliffs
Clark Island Marine State Park	4	55	11,292	7	9	▪		▪		Forest, sandy beaches, rock outcrops
Patos Island Marine State Park	6	207	20,000	7	2	▪		▪	▪	Forest, sandy beaches, rock outcrops
Moran State Park	5	5,252	-	151	-	▪	▪	▪	▪	Old growth forest, lodge pole pine forest, freshwater lakes and shoreline
Obstruction Pass Park	9	80	450	11	3	▪		▪	▪	Forest, tide pool shoreline
Doe Island Marine State Park	9	6	2,000	5	-	▪		▪	▪	Forest, rock outcrops
Lummi Island DNR	12	ND	ND	10	1	▪		▪	▪	Forest
Pelican Beach DNR (Cypress Is.)	12	*	*	*	*	▪		▪	▪	Forest
Cypress Head DNR (Cypress Is.)	14	*	*	*	*	▪		▪	▪	Forest
Strawberry Island DNR	13	*	*	*	*	▪		▪		Forest
TOTALS 6		**,164**	**77,700**	**246**	**63**					

ND = No Data
DNR = WA Department of Natural Resources
*These numbers are included in Table 3.
Sources: Mueller and Mueller 1995, NW Source 2007, San Juan County Parks 2007, San Juan Islands Directory 2007, TheSanJuans.com 2007, SanJuansSite.com 2007, Washington State Department of Ecology 2007, Washington State Department of Natural Resources 2007, Washington State Parks and Recreation Commission 2007b.

Table 5.5, Designated Public Camping Facilities Within 15 Miles of Turn Island

Campground	Miles to Turn Island	Acres	Shoreline (linear feet)	Campsites	Mooring Buoys	Firepits	Water	Toilets	Hiking Trails	Setting
South Beach County Park (Shaw Is.)	2	60	4,610	11	-	▪	▪	▪	▪	Woods
Blind Island State Park	2	3	1,280	4	4	▪		▪		Rocky, scrub-shrub
Odlin County Park (Lopez Is.)	4	80	3,960	30	Y	▪	▪	▪	▪	Old growth forest, forest, sandy beach, steep cliffs
Griffin Bay State Park (San Juan Is.)	4	15	340	4	2	▪	▪	▪		Woods, grassy meadow
Jones Island Marine State Park	6	188	25,000	21	7	▪	▪	▪	▪	Forest, sandy beaches, rock outcrops

Campground	Miles to Turn Island	Acres	Shoreline (linear feet)	Campsites	Mooring Buoys	Firepits	Water	Toilets	Hiking Trails	Setting
Spencer Spit Marine State Park (Lopez Is.)	8	138	7,800	50	12	▪	▪	▪		Saltwater marsh
San Juan County Park (San Juan Is.)	8.5	12	2,700	20	Y	▪	▪	▪		Gravel beach, rocky bluffs, woods
Posey Island Marine State Park	11	1	1,000	2	-	▪		▪		Woods, rock island
James Island Marine State Park	11	113	12,335	13	4	▪		▪	▪	Forest, rock outcrops, cliffs
Strawberry Island	11	ND	ND	3	-	▪		▪		Forest
Pelican Beach (Cypress Is.)	12	ND	ND	3	6	▪		▪	▪	Forest
Cypress Head (Cypress Is.)	14	ND	ND	9	4	▪		▪	▪	Forest
Stuart Island Marine State Park	14	153	33,030	22	22	▪	▪	▪	▪	Forest, meadow, sandy beaches, rocky shores
TOTALS 7		**63**	**92,055**	**192**	**61+**					

ND = No Data
Sources: Mueller and Mueller 1995, NW Source 2007, San Juan County Parks 2007, San Juan Islands Directory 2007, TheSanJuans.com 2007, SanJuansSite.com 2007, Washington State Department of Ecology 2007, Washington State Department of Natural Resources 2007, Washington State Parks and Recreation Commission 2007b.

5.6.7 Beaches and Beach Activities

There are many public beaches throughout the San Juan Islands and along the shores of the Quimper and Miller Peninsulas. Among local residents, beachcombing and other beach-related activities are popular. In a recent survey of residents of San Juan and Island counties, beachcombing was ranked third out of fourteen water activities most engaged in by survey participants (RCO 2007). In the same survey, swimming or wading at fresh or saltwater beaches was ranked second (RCO 2007). This survey is discussed in greater detail in the regional recreation rates and trends section below. Although all of the beaches on refuge islands are closed to the public, except Rolfe Cove on Matia Island and a small portion of the Turn Island shoreline, there are many open beaches near refuge islands. See the table titled Beaches in the Vicinity of Protection Island NWR and San Juan Islands NWR, Appendix D.

5.6.8 Boating

Many areas with boat access throughout the San Juan Islands, Quimper Peninsula, and Whidbey Island provide a variety of regional access options. Most of the marinas provide some guest moorage and many of the public parks and campgrounds offer mooring buoys and/or anchorages. Limited boat launches are scattered throughout the main islands. Powerboat cruising, sailing, and kayaking are all popular means of boating throughout the archipelago.

Motorized boating (including sailboats that typically have auxillary motors)
Motorized boat users visit the refuge from locations throughout the region, including the major metropolitan areas around Seattle, Washington, and Vancouver and Victoria, B.C. Popular mainland departure locations close to refuge islands include marinas, harbors, and parks in the northeast Olympic Peninsula, Anacortes and Bellingham areas. In the San Juan Islands area, motorized boat traffic

concentrates at towns (e.g., Friday Harbor), harbors (e.g., West Sound), and resorts (e.g., Rosario and Lopez Islander). From these locations, motorized boaters explore a variety of campgrounds and beaches throughout the San Juan Archipelago.

Human-powered boating (including kayaks and canoes)
Human-powered boaters also visit major harbors and parks throughout the mainland and San Juan Islands, but often prefer launch sites and destinations not frequented by motorized boaters. Smaller state and county parks are popular with human-powered boaters, especially sites associated with the Cascadia Marine Trail. Short loop trips near cities are especially popular (e.g., Deception Pass and Cypress Island) while paddlers with more time look for more remote places such as Stuart or Sucia Islands. The nature of human-powered boating allows for access to many undeveloped areas that are popular for picnicking, beachcombing, clamming, and other informal activities.

Sea kayaking in the San Juan Islands is a favorite local pastime and the area is considered one of the top ten sea kayaking destinations in the United States (GORP 2008). The islands are highlighted as a choice autumn destination for sea kayaking (Bune 2001). Olinger (2008) describes the San Juan Islands as "…a plethora of jewels that touring buffs fervently take to in good and sometimes even bad weather." With islands close together, paddlers can enjoy time both on the water and the shoreline throughout a day of paddling (GORP 2008). In addition, the local marine wildlife, unsurpassed scenery, and charm of their quiet isolation and small villages make the islands a coveted destination of many paddlers (GORP 2008).

Among local residents, kayaking is a popular activity. In a recent survey of residents of San Juan and Island counties, kayaking/canoeing/rowing was ranked 4th out of 14 water activities most engaged in by survey participants (RCO 2007). In the same survey, the statewide rank for this activity category was only slightly lower, at 5th place, indicating that hand-powered boating opportunities are not just a locally preferred sport, but rather are valued across the state. This survey is discussed in greater detail in the regional recreation rates and trends section below.

Commercial outfitters
There is no shortage of commercial kayaking outfitters serving the San Juan Islands. More than 25 outfitters, most located within the immediate islands area, offer San Juan Islands paddling trips. Kayak outfitters and guides favor the west side of San Juan Island, as this is also primary whale watching territory. Many offer overnight camping trips to Stuart Island as this is (relatively) easily accessed from the west side of San Juan Island.

There is also a common paddle route from Stuart Island along Spieden Island and through the Cactus Islands en route to Jones Island. Jones Island is another common overnight camping stop for multi-day paddles. Many of these trips return to San Juan Island at Friday Harbor. Outfitters out of Anacortes tend to guide trips through the eastern islands as the outer islands are quite some distance to paddle if a mother ship is not utilized. Outfitters are reluctant to report the numbers of visitors served each year, but it is safe to say that this activity is very popular.

> *"The primary goal of the Cascadia Marine Trail is to secure camping areas every 5 to 8 miles for the safety of non-motorized boaters traveling on Puget Sound waters. The length of Puget Sound shoreline, according to various sources, is between 1,800 and 2,300 miles. The trail will be considered complete at a point in time when there are between 225 and 460 campsites."* Washington Water Trails Association.

Cascadia Marine Trail is one of the premier water trails for human-powered boaters in the United States. Designed for kayaks, canoes, and other non-motorized, beachable boats, the water trail offers unsurpassed views of Northwest scenery and wildlife while providing access to pullouts, campsites, and other public amenities along the way (WSPRC 2008c). Since 1993 thousands of state residents and visitors have traveled on the water trail that extends the length and width of the Salish Sea from the state capitol in Olympia to the Canadian border (WWTA 2008).

The Cascadia Marine Trail is an inland sea National Recreation Trail and is designated as one of 16 National Millennium Trails by the White House (WWTA 2008). There are over 50 campsites along the trail that can be accessed by boating from many public and private launch sites or shoreline trailheads (WWTA 2008). Within the San Juan Islands, there are many campgrounds along the trail, including:

- Blind Island State Park
- Griffin Bay
- James Island State Park
- Jones Island State Park
- Obstruction Pass
- Odlin County Park
- Point Doughty
- Posey Island State Park
- San Juan County Park
- Shaw County Park
- Spencer Spit State Park
- Stuart Island State Park

5.6.9 Hiking Trails

The National Park Service manages several miles of trails at San Juan Island National Historical Park. The WSPRC and WDNR manage approximately 47 miles of trails in San Juan County, including 33 miles within Moran State Park (San Juan County 2005). San Juan County manages a minimal number of walking trails at a few county parks.

5.6.10 Other Recreation

Geocaching is becoming a popular activity throughout the islands. There are several known locations throughout the area where caches are located (Geocaching 2007). Other recreation occurring on the main islands includes bicycling and visiting historic places.

5.7 Regional Recreation Rates and Trends

The Washington State Recreation and Conservation Office (RCO), formerly the Interagency Committee for Outdoor Recreation (IAC), advises the State on matters of outdoor recreation. The RCO conducts inventories of outdoor recreation sites and opportunities, conducts studies of recreational participation and preferences, and periodically releases documents related to overall state outdoor recreation. The most recent release is the 2006 Outdoor Recreation Survey (formerly, the State Comprehensive Outdoor Recreation Planning Report – SCORP Report).

5.7.1 Washington Tourism

In 2008, visitors to Washington spent $15.7 billion and travel spending accounted for 3.8% of all jobs statewide. Tourism is one of the top 5 industries in the state (VS 2009) and continues to be a critical element for the viability of local communities. Local economies where Protection Island NWR and the San Juan Islands NWR are located rely heavily on visitors. For example, in San Juan County alone, more than 10% of all jobs were directly attributed to the travel industry (WSTC 2008). Tourism accounted for

28% of all state and local tax dollars generated countywide in 2006, making it a key segment of the area's economy. In addition, local tourism in San Juan County continues to grow faster than almost every other county in the state (SJIVB 2006).

5.7.2 Outdoor Recreation Participation Rates

The most recently released survey report (RCO 2007) identified 15 major categories of outdoor recreation, subdivided into 114 activity types or settings. Of these 15 major categories, walking/hiking is the number one activity with 74 percent of Washington residents participating in some type or setting of walking and/or hiking. Nature activity is the third most popular recreation, with 54 percent of residents enjoying some form of this activity. The report indicated observing/photographing nature and wildlife has a participation rate of 29 percent and that visiting interpretive centers has a participation rate of 15 percent among statewide residents.

The RCO also reported regional data for the same activity categories. "The Islands" region is comprised of Island and San Juan counties. There were 320 people surveyed in The Islands region and they engaged in a total of 94,526 outdoor activity occurrences over the course of the year 2006. The highest average participation rates were in sightseeing and nature activities, 35 and 23 percent, respectively. The next most popular category, water activities, had a 16 percent average participation rate. The other categories all ranged between 12 and 15 percent.

5.7.3 Forecast for Regional Recreation Demand and Key Recreation Needs

Note: The following information is from the Washington State Recreation and Conservation Committee (RCO), formerly known as the Interagency Committee for Outdoor Recreation (IAC).

Overall, outdoor recreation in most categories continues to increase at high growth rates. In a recent technical report (IAC 2003), IAC projected future participation in 13 of 14 major outdoor recreation use categories over periods of 10 and 20 years. Nine of these activities will experience double digit growth.

These most recent estimates of recreation trends were based on the National Survey on Recreation and the Environment Projections for the Pacific Region (NSRE), which includes Washington State. IAC adjusted the NRSE projections as necessary based on age group participation, estimates of resource and facility availability, user group organization and representation, land use and land designations, and "other factors," including the economy and social factors. Table 5.6 shows the percent change expected for Washington State by activity as reported by IAC.

The 1995 assessment identified trails and environmental education as the two highest outdoor recreation needs in the state. Many outdoor activities generally permitted on refuges are expected to show increases of 20 to 40 percent over the next 20 years. The exception is hunting, in which participation is expected to fall at about that same rate.

Table 5.6, Projected Participation Increases for Selected Outdoor Recreation Activities

Activity	Estimated Change, 10 years (2002-2012)	Estimated Change, 20 Years (2002-2022)
Walking	23%	34%
Hiking	10%	20%
Nature Activities (outdoor photography, wildlife observation, gathering and collecting, gardening, and visiting interpretive centers)	23%	37%
Fishing	-5%	-10%
Hunting / Shooting	-15%	-21%
Sightseeing (includes driving for pleasure)	10%	20%
Camping – developed (RV style)	10%	20%
Canoeing/kayaking	21%	30%
Motor Boating	10%	No estimate
Equestrian	5%	8%
Non-pool swimming	19%	29%

Source: IAC 2003.

In addition, the newly designated San Juan Islands Scenic Byway, which includes routes on both Orcas Island and San Juan Island (San Juan Islands Visitors Bureau 2008), may draw more recreation-seeking visitors to the vicinity of the San Juan Islands National Wildlife Refuge.

5.8 Socioeconomics

5.8.1 Socio-economic Baseline Setting

The study area for estimating the economic effects of the recreational use of the refuges is defined as Island, Jefferson, San Juan, Skagit, and Whatcom counties. The Protection Island NWR is wholly contained within Jefferson County, which was established in 1852. Port Townsend is the county seat and the only incorporated city within the county.

The San Juan Islands NWR is predominantly located in San Juan County with some islands located in neighboring Island, Skagit, and Whatcom counties. San Juan County was established in 1873 and contains 176 named islands and reefs (with up to 743 at low tides). The largest islands in the county are San Juan, Orcas, Lopez, and Shaw, all of which are served by the Washington State Ferry System. The nearest major population centers are Victoria and Vancouver, B.C., and Seattle, Washington. The county seat is Friday Harbor, located on San Juan Island.

Smith and Minor islands, the two most southern islands of the San Juan Islands NWR, are located in Island County. Island County was established in 1852 and consists of two large islands (Whidbey and Camano) and several smaller islands. The county seat is located on Whidbey Island at Coupeville. The largest city is Oak Harbor, also on Whidbey Island.

Eliza Rock, Viti Rocks, and Three Williamson Rocks, the eastern-most features of the San Juan Islands NWR, are located in Skagit County. Skagit County was established in 1883. Mount Vernon is the largest city and the county seat. Other incorporated cities within Skagit County include Anacortes, Burlington, Concrete, Hamilton, La Conner, Lyman, and Sedro Woolley.

The Whatcom County boundary lies at the eastern edge of the San Juan Islands NWR. The county was established in 1854. The largest city, Bellingham, is the county seat. Other major communities within the county include Lynden, Everson, Ferndale, Sumas, Nooksack, and Blaine.

5.8.2 Population Data and Trends

Growth Rate

Between 1980 and 2000, all five area counties, Island, Jefferson, San Juan, Skagit, and Whatcom, grew at a rate well above the Washington State average and substantially above the rate for the United States. The one exception is from 1990 to 2000, when Island County grew at a rate slightly less than that for the state. The other four counties experienced a higher rate of growth during the 1990 to 2000 period than in the 10 years prior (U.S. Census 2007a; 1995; 1993b).

Density

Based on the 2000 census data, of the five-county area containing the refuges, Island County has the highest density at 344 people per square mile, nearly four times greater than the state density of 88.6 people per square mile. Jefferson County density is only 14.3 people per square mile, about 1/6 of the state density. Less extreme are San Juan, Skagit, and Whatcom counties with 80.4, 59.4, and 78.7 people per square mile, respectively (U.S. Census 2007a; 2007b).

Age Distribution

In general, the five counties follow the state trend with the majority of the population falling between the ages of 18 and 65 years old. The next highest percentage age group in the state is persons under 18 years of age (23.6 percent). Island, Skagit, and Whatcom counties have similar percentages (22.5, 23.5, and 21.5, respectively), while Jefferson and San Juan counties differ in the trend. Jefferson and Skagit counties have a higher percentage of retiree-age population (21.5 and 21.1, respectively). In all cases, county and state, the lowest age category percentage is those under 5 years old (U.S. Census 2007a; 2007b).

5.8.3 Low Income and Minority Populations

Each of the five counties has a smaller percentage of minority population (86.5 – 95.0 percent) than the overall United States percentage (75.1 percent) and the Washington State percentage (81.8 percent). The percent of people below the poverty level in the five counties varies from below to above (7.0 percent - 14.2 percent) the national and state values (12.4 percent and 10.6 percent, respectively) (U.S. Census).

5.8.4 Economic Base of the Surrounding Area

Employment

Among all five counties, the largest employment sectors in both 2000 and 2005 were in construction, manufacturing, retail trade, health care and social assistance, and accommodations and food services. Business sectors experiencing the most growth between 2000 and 2005 varied by county. In Island County, the highest positive percentage change (growth) was seen in the professional, scientific, and technical services sector (29.59 percent) and the highest negative percentage change (decline) was in the unclassified establishments sector (-91.89 percent), followed by finance and insurance (-29.53percent). The most growth in Jefferson County was seen in the real estate and rental and leasing sector (55.56 percent) and the largest decline in transportation and warehousing (-28.95 percent). In San Juan County, the highest growth was seen in the finance and insurance sector (99.13 percent) and the largest decline in the transportation and warehousing sector (-21.11 percent). Between 2000 and 2005, Skagit County experienced the most employment growth in the wholesale trade sector (89.03 percent) and the most employment decline in the arts, entertainment, and recreation sector (-33.07 percent). Whatcom County saw its highest employment growth in the health care and social assistance sector (40.14 percent) and its sharpest decline in the management of companies and enterprises sector (-74.82 percent).

Overall, employment growth in Island, Skagit, San Juan, and Whatcom counties outpaced state growth from 2000 to 2005. Washington State experienced an overall 2.15 percent growth in employment between 2000 and 2005. Island, Skagit, San Juan, and Whatcom counties experienced 5.35, 13.36, 7.03, and 14.14 percent growth, respectively, during the same time period. Jefferson County experienced a 0.64 percent growth in employment from 2000 to 2005, nearly one-fourth of the state growth during that same time frame (U.S. Census 2007a).

Personal Income and Employment Earnings

In general, per capita personal incomes (PCPI) for Island, Jefferson, Skagit, and Whatcom county residents from 1979 to 1999 mirror the Washington State trend. However, San Juan County had a much higher growth rate. From 1979 to 1989, San Juan County PCPI increased more than 45 percent compared to the next highest rate of 17 percent and 13 percent for Island and Whatcom counties respectively. However, from 1989 to 1999, PCPI increases in the four other counties were similar to San Juan County. When PCPI growth is combined for both decades, San Juan County experienced a 112 percent increase while the four other counties sustained more moderate increases between 64 and 80 percent averaging 71.4 percent, just above the Washington State average of 69.82 percent and below the U.S. average of 76.6 percent for the same 20 year period (U.S. Census 2006; 1993a).

5.8.5 Recreation and Economic Uses of Refuges

The economic significance of refuge visits nationally has been estimated to be nearly $1.4 billion (2004 US dollars [2004 USD]) (Caudill and Henderson 2005). Caudill and Henderson (2005) report approximately $154,000 (2004 USD) from USFWS Region 1 (including Washington, Oregon, California, Idaho, and Nevada at the time of publication) contributed to the national economic significance figure. More localized studies and modeling of the economic impacts to local communities from the San Juan Islands and the Protection Island NWRs has not been undertaken. Some generalizations about recreation impact on the local socioeconomics can be drawn based on other readily available information.

Matia and Turn Islands are the only refuge islands which allow camping and day use. Visitation records from 1986 through 2004 indicate that each of these two islands averages between 8,000 and 11,000 day and overnight visitors each year. Over time, the two islands have consistently been used by more visitors for day-use activities than for overnight camping.

In addition to Turn and Matia, all of the islands comprising the San Juan Islands and Protection Island NWRs provide vessel-based wildlife viewing opportunities for visitors to the area. Some of the most popular uses of the surrounding waters include whale and wildlife watching tours. Other regionally important recreation occurring in the waters surrounding both refuges includes recreational boating, including motorized and personal watercraft, deep-sea sport fishing, and underwater diving. Other water-dependent recreation known to occur on islands within the San Juan Archipelago, but not necessarily on those that are part of the refuges, include beach-related activities (beachcombing, picnicking, hiking, etc), waterfowl hunting, interpretation and environmental education activities, and some geocaching.

The San Juan Islands Visitors Bureau conducts occasional surveys of people visiting the islands. Tourism is a major economic base for the islands. While Washingtonians make up more than 20 percent of the visitors to the islands, nearly half the visitors surveyed are from other parts of the Unites States. A small percentage of those surveyed arrived by personal watercraft or by airplane but the vast majority of visitors to the islands rely on the Washington State Ferry system. Approximately 75 percent of the visitors surveyed were there for leisure.

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