Chapter 4
Biological Environment

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Chapter 4. Biological Environment

This chapter addresses the biological resources and habitats found on Dungeness National Wildlife Refuge (NWR or Refuge). However, it is not an exhaustive review of all species and habitats. The chapter begins with a discussion of biological integrity (historic conditions and ecosystem function), as required under the Refuge Administration Act. The bulk of the chapter is then focused on the presentation of pertinent background information for habitats used by each of the Priority Resources of Concern (ROCs) and other benefitting species designated under the CCP. That background information includes descriptions, locations, conditions, and threats (stresses and sources of stress) to the habitats and/or associated ROCs. This information was used to develop goals and objectives for the CCP (see Chapter 2).

4.1 Biological Integrity, Diversity, and Environmental Health

The National Wildlife Refuge System Administration Act, as amended, 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. The BIDEH policy (601 FW 3) defines *biological integrity* as "the biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities." *Biological diversity* is defined as "the variety of life and its processes, including the variety of living organisms, the genetic differences among them, and communities and ecosystems in which they occur." *Environmental health* is defined as the "composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment." 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.

The Refuge System policy on BIDEH (601 FW 3) also provides guidance on consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on the Refuge and in associated ecosystems that represents BIDEH.

4.1.1 Historic Conditions

Dungeness NWR is located along the southern shore of the Strait of Juan de Fuca within the Salish Sea of Washington State. 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), San Juan Archipelago, and the Strait of Georgia (See Figure 1-1).

Dungeness and Graveyard spits were formed following the last glaciation in the Vashon Era ten to twenty thousand years ago. After the withdrawal of the glacier, the coastline of the Strait of Juan de Fuca was characterized by prominent headlands and embayments. In the course of time, tidal currents and waves filled the embayments with material eroded from the headlands. A dominant eastward-flowing longshore current aided by prevailing westerly and northwesterly winds caused an eastward drift of material, which formed the current barrier beach (USFWS 1986). Prior to Euro-American 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 currents, and local sea level.

Historic vegetation types in the nearshore areas of the Refuge were comprised of sandy feeder bluffs, coastal spit and strand (i.e., barrier beach), tidal lagoons and associated salt marsh and mudflats located at the base of both Dungeness and Graveyard spits (Figure 4-1) (USC&GS 1855a, Collins 2005, Todd et al. 2006). Additionally, early bathymetric maps show extensive areas of "thick grass," kelp or eelgrass, located within Dungeness Bay and Harbor (Figure 4-2) (USC&GS 1855b). Dungeness Spit was described early in the 1900s in the U.S. Coastal and Geodetic Survey (USC&GS) Topographic sheet (T-Sheet) General Description (Dibrell 1908) as a:

> "narrow reach of sand rising a few feet above high water with occasional grassy areas in the widest parts and practically covered with drift wood… (From the spit origin, the bluff) recedes inland to the eastward and slopes down into a low flat upon which is built the village of Dungeness. Considerable marshy land is found along the shore line here, the village being built on ground about 5 feet above high water…"

Prior to Euro-American settlement, the area surrounding the Refuge and the Olympic Peninsula generally was heavily forested to the saltwater edge, except for occasional meadows, prairies, open water, and wetland areas. Western redcedar and Douglas-fir were the dominant conifer tree species. Western hemlock was scattered in all native conifer stands. The climax forests were renowned for producing trees of impressive size. Deciduous hardwoods were found within the conifer stands, primarily in riparian zones such as stream corridors and wetlands, including red alder, bigleaf and vine maples, willow, and black cottonwood. Pacific madrona, a broadleaf evergreen, was also found at lower and drier elevations. The presence of glacial materials from the Vashon glaciation and of the Olympic rain shadow has resulted in a particularly unusual vegetative community in some dry coastal areas within the vicinity of the Refuge where drought-tolerant plants such as prickly-pear cactus, Rocky Mountain juniper, and lodgepole pine are present.

The area surrounding the Refuge has a long history of human habitation. Evidence of prehistoric occupation shows that people inhabited the region as early as 12,000 years ago – not long after the Vashon ice sheet had departed (Bergland 1984, also see Section 5.1, Cultural Resources). In the late 1700s when the earliest European explorers came into the Strait of Juan de Fuca, they found native villages and camps along the shores and bays, indicating that bands of people moved between preestablished sites according to the seasons and availability of food resources. The S'Klallam Tribes have inhabited the Olympic Peninsula for thousands of years. They lived off the land collecting shellfish in Dungeness Harbor, fishing for salmon in Dungeness Bay and building temporary camps on the spit for use while gathering.

4.1.2 Habitat Alterations since Presettlement Times

The BIDEH of the Salish Sea ecosystem, including and surrounding the Refuge, have undergone dramatic alterations since Euro-American settlement. The most discernible changes are related to: (1) the conversion and development of large portions of coastal areas into agriculture, residential, commercial, and industrial lands; (2) human-caused wildlife disturbance; (3) the introduction of contaminants and marine debris into the aquatic environment; (4) the loss of native species accompanied by a large influx of nonnative and invasive plants and animals into the system; and (5) climate change. Additional landscape-level changes such as the alteration of fire regimes and logging are also addressed in subsequent sections.

Figure 4-1. Historic Vegetation of the Dungeness Unit Based on 1855 USC&GS T-Sheet

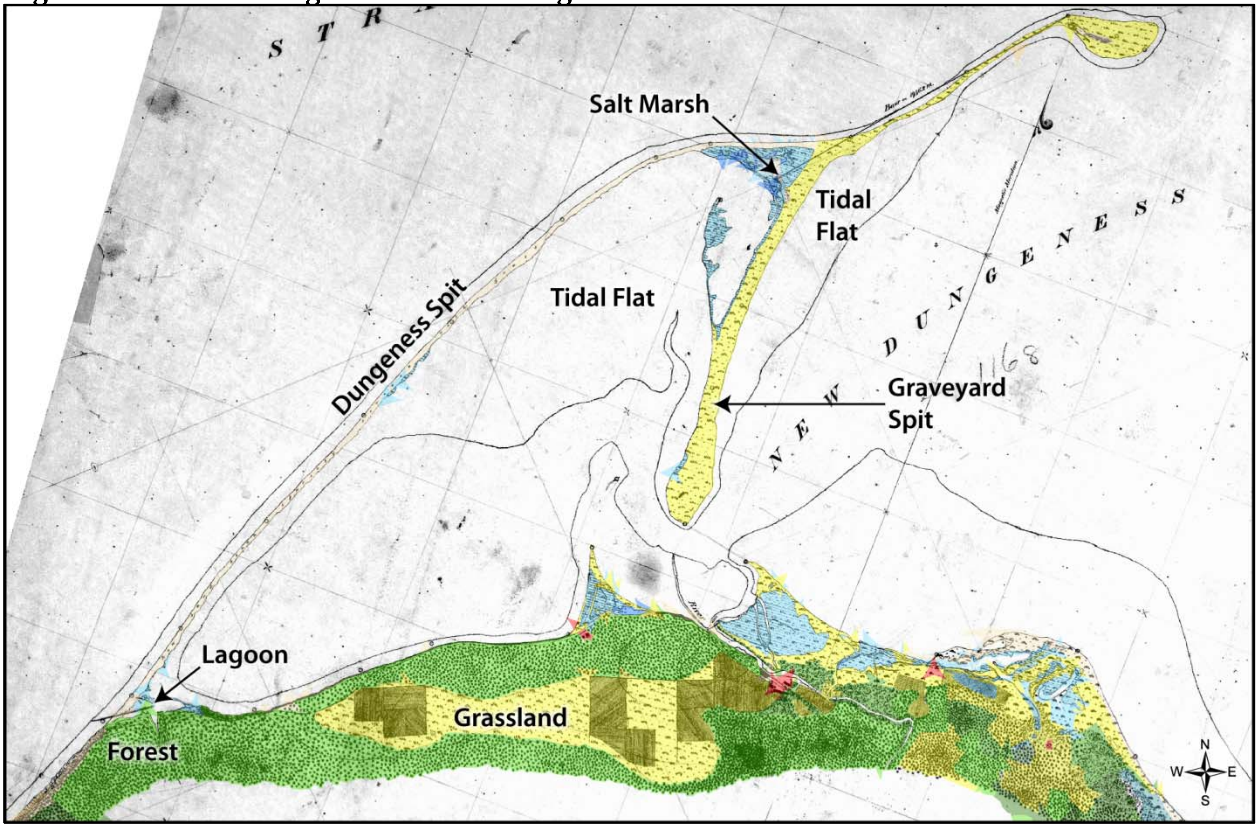
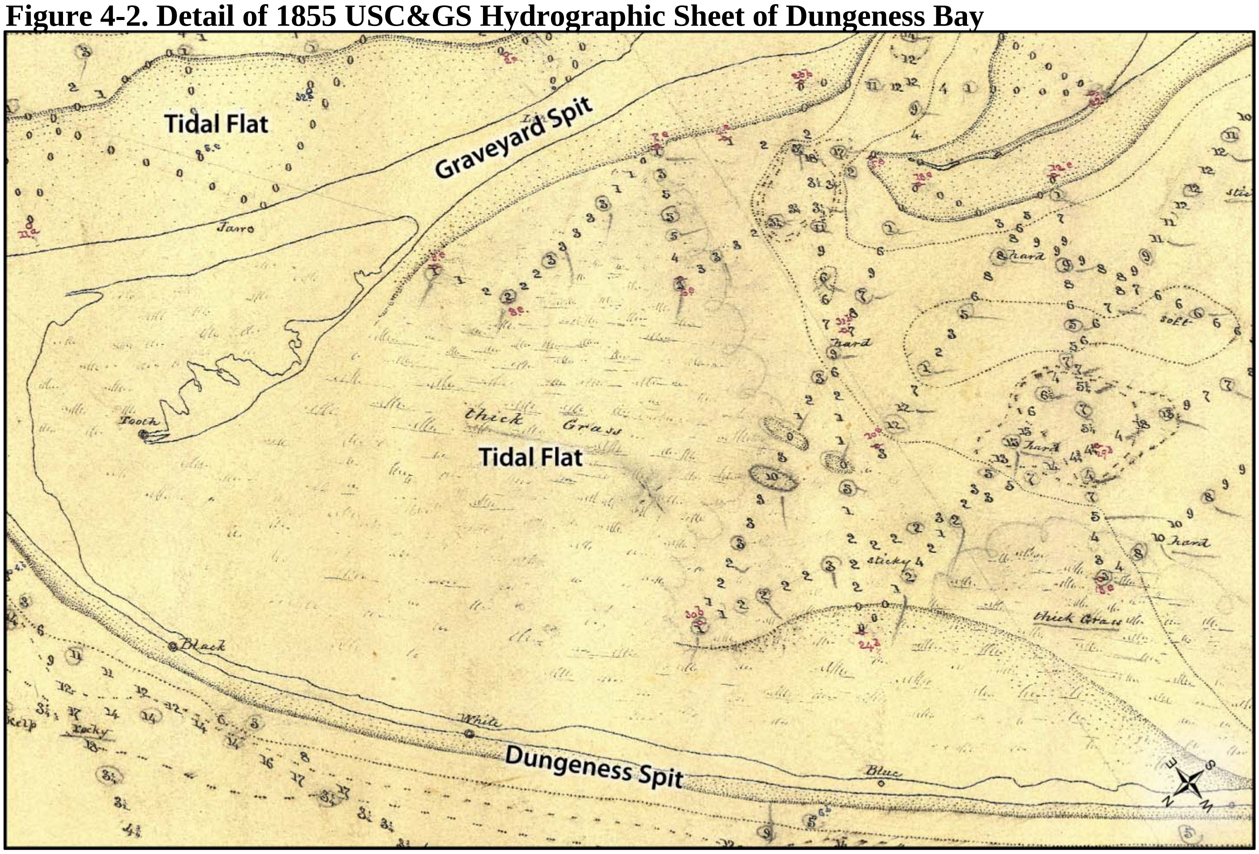


Figure 4-2. Detail of 1855 USC&GS Hydrographic Sheet of Dungeness Bay



The back sides of maps are blank to improve readability.

Many of the habitat changes and the spread of nonnative and invasive species were underway before the Refuge was established. This section discusses the connection between some of these main landscape-level changes with the current vegetation and wildlife on the lands and waters managed by the Refuge. This summary is not a complete analysis of all factors related to changes in native vegetation, fish, and wildlife.

Habitat Loss or Degradation due to Conversion and Development

The first European settlers arrived within the vicinity of the present-day Refuge in 1851. Habitat conversion for human use within the Salish Sea has been rapid since the mid-late 1800s and continues today, bringing profound and widespread alterations to the watersheds and shorelines of the region. 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). In addition, 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 2003, Thom et al. 1994). Armoring increases longshore currents and diverts sediments into deeper waters thereby reducing the natural deposition of sediment and driftwood to barrier beaches.

Construction of the New Dungeness Light Station was completed in 1857 and the light became the first in operation along the Strait of Juan de Fuca. From 1942 to 1946, there was a small naval station on Graveyard Spit. Old concrete foundations, cisterns, and rubble still remain (USFWS 1997a). Washington State Parks loosely maintained a small State Park on the end of Graveyard Spit. The areas was abused and overrun with people. Careless campers left fires unattended resulting in habitat damage. There was also a direct conflict with wildlife using the area. State Parks abandoned the site in the early 1980s (USFWS 1986).

A tidal lagoon and marsh located at the base of Dungeness Spit was evident in both the 1855 and 1907-1908 T-Sheets, though the channel openings were shown in different locations in the 50 years that separated the two maps (USC&GS 1855a, Todd et al. 2006). A narrow ravine and small stream enters at this location, and at the time of the 1907-08 T-Sheet, a railroad grade ran down the ravine leading to a “wharf” that crossed the lagoon and extended about 500 meters (more than ¼ mile), paralleling the inside of the spit. Today, two dikes or old roadbeds, possible remnants of the old railroad grade or wharf, alter the hydrology of this tidal lagoon.

Human-caused Wildlife Disturbance

This is a pervasive threat which has been identified as a conservation concern for wildlife by many of our partners (Floberg et al. 2004, WDFW 2005, Mills et al 2005, Tessler et al 2007, USFWS 2005b, USFWS 2007a). The Olympic Peninsula 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. On the Refuge, visitation ranged from 76,000 – 80,000 visitors per year for the last five years. The majority of use occurs primarily from May through September. Public use closures have been set in place to protect the integrity of habitat and reduce introduction of invasive species. For example, Graveyard Spit is closed to protect fragile coastal strand plant communities from trampling, inadvertent introduction of invasive plant species, and illegal fires as well as to provide a refugia for wildlife. The majority of invasive plant species in nearshore habitats of the Refuge can be found within the area surrounding the New Dungeness Light Station and an abandoned Navy facility on Graveyard Spit, areas of historically high public use.

Oil Spills, Other Contaminants, and Derelict Gear

Nearshore habitats of the Refuge are particularly at risk of contamination from oil spills and rogue creosote-covered logs. The U.S. Coast Guard determined that Dungeness Spit is one of the top five high-risk areas in the U.S. for oil related spill events due, in part, to its prominent location within the Strait of Juan de Fuca and proximity to the high level of shipping traffic within the Salish Sea (Melvin et al. 2001). Approximately 15 billion gallons of oil are shipped through the Strait of Juan de Fuca each year on over 1,000 tankers (WDOE 2009b). Any spill from these tankers could potentially be devastating to Refuge wildlife and habitats. Recognizing this threat, Refuge staff has participated in drills testing implementation of the Strait of Juan de Fuca Geographic Response Plan within Dungeness Bay and Harbor. In addition, nonpoint source oil tarballs or slicks periodically wash up and impact wildlife. These chronic sources of contaminants may be products of vessels illegally pumping bilges, recreational outboard motors, and improper use of petroleum products in marinas.

Predominantly westerly currents have transported oil and/or oiled birds from recent oil spills in Port Angeles Harbor (e.g., T/V Arco Anchorage in 1985). Creosote-covered logs, derelict gear, and marine debris are similarly transported. Creosote is of conservation concern because it contains chemicals (notably polycyclic aromatic hydrocarbons or PAHs) that are considered “highly” or “very highly” toxic to fish and aquatic invertebrates according to the U.S. Environmental Protection Agency (USEPA 2008). Effects range from decreased productivity to low survival rates. Washington Department of Natural Resources removed 150 tons of creosote-covered logs from Dungeness Spit in 2006. During the same time frame, a study of creosote contamination on Dungeness Spit revealed that 2 of 9 creosote-covered logs contained PAH levels that exceeded Washington State Department of Ecology conservative standards (Holman and Lyons 2009). Studies have shown that PAHs tend to leach and remain in sediments with less oxygen such as those found in salt marshes, mudflats and the protected shore of barrier beaches (USEPA 2008, Holman and Lyons 2009). Therefore, removal is a priority for Refuge management. In 2006, contractors for the Northwest Straits Commission and Clallam County removed 42 derelict crab pots from Dungeness Bay and Harbor, 11 (26%) of which were still fishing (NRC 2006). This is particularly of concern off-Refuge, however could also be a problem in eelgrass beds on the Refuge.

Invasive Plants in Nearshore Systems

Exotic plant invasions are a serious threat to the biological integrity of any refuge. If unchecked invasive plant species can displace native vegetation, alter the composition and structure of vegetation communities, affect food webs, and modify ecosystem processes (Olson 1999).

Ultimately, invasive plant and animal species can negatively impact native wildlife. Although the Refuge is fortunate in that no single habitat type has been severely altered by any single invasive species, the threat posed by existing invasive species requires regular monitoring and responsive treatment. Introduced invasive plants (e.g., common cordgrass, Dalmatian toadflax, cheatgrass, etc.) are an issue within some of the nearshore habitats. Many nonnative plant species can directly out-compete native plant 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, and contributing toward soil moisture deficits.

The ballast water of ships is a vector for the transport of marine invasive species (Carlton and Geller 1993) which threaten the conservation and sustainable use of biological diversity (Bax et al. 2003). These are some of the newest and least understood threats to the Refuge due to difficulties in monitoring and jurisdictional controls. Plants such as Japanese eelgrass, common cordgrass (i.e., *Spartina* spp.) and the algae *Sargassum* 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, the only species listed in the Puget Sound Marine Invasive Species Monitoring Program's Target Species List (Eissinger 2009) found within the Refuge is common cordgrass.

Invasive Invertebrates in Nearshore Systems

Marine invertebrates with high reproductive capacity and wide environmental tolerances are a threat to Refuge resources. For instance, European green crabs prey on native Dungeness crabs, reduce populations of native clams, and out-compete native invertebrates for food resources where they have become established. Since 2001, Refuge staff have been monitoring for European green crab. To date none have been found on the Refuge or within the Salish Sea. However, one green crab was observed in the ballast water of a cargo ship in Port Angeles Harbor in 2011.

Invasive Plants in Upland Systems

Major invasive weeds that have invaded Refuge upland habitats include Bohemian knotweed, English holly, spurge laurel, Canada thistle, Scotch broom, and English ivy. These species occupy a small percentage of Refuge lands individually, but combined they have displaced native vegetation on the Refuge. More recently, Herb Robert has been found in several small patches of the Dawley Unit, along the upper most reaches of the main road (approximately <1/4 acre).

Climate Change

Predicted threats from climate change include increased inundation, erosion, and overwash, leading to loss of nearshore habitats due to sea level rise and an increase in the intensity and frequency of storm events (Mote et al. 2008). Additionally, climate-driven changes in ocean currents, sea temperatures, pH, 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 nearshore habitats on the Refuge.

Climate change may have drastic effects on the Refuge, 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 Refuge during the term of this CCP cannot be fully predicted. However, climate change will likely 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. It is important to note that these effects may not be readily apparent until a disturbance, such as fire, is introduced to the habitat. Once disturbance is introduced, it may become more readily apparent through vegetative response or regrowth. Additional effects of climate change on Refuge wildlife and habitats are addressed in Chapter 6 of the Draft CCP/EA (USFWS 2012a).

4.1.3 Early Refuge Management

Dungeness NWR was managed as an unfunded satellite within the Willapa NWR Complex until 1974. The Dawley Unit was willed to the Refuge in 1973; however, active management was not initiated until Cecil Dawley passed away in 2005 (USFWS 1997a). Dungeness NWR was transferred to Nisqually NWR and was staffed with a seasonal employee in 1974 and then a permanent employee in 1978. The emphasis on management was to protect resources and habitat; later, an additional emphasis was placed on interpretation and education. In addition, maintenance and visitor interpretation projects were bolstered by the help of volunteers, Northwest Youth Services and Youth Conservation Corps in 1977.

In 1982, the following wildlife-related management objectives were identified for the Refuge:

- To provide and preserve habitat for the enhancement of wintering waterfowl and other migratory birds with emphasis on brant;
- To protect and maintain natural habitat capable of supporting a diversity of wildlife;
- To cooperate with other agencies, educational institutions, private organizations, and individuals in providing technical assistance and research opportunities consistent with Refuge objectives and management needs.

By 1986, a Refuge Management Plan was developed to guide implementation of the management objectives listed above (USFWS 1986).

National wildlife refuges are the only lands in Federal ownership managed primarily for wildlife. In 1989, two U.S. congressional committees requested that the General Accounting Office (GAO) evaluate management of national wildlife refuges to see if they were being managed for their stated purposes. The GAO report found that refuges throughout the country were not meeting expectations. Many secondary uses were responsible for the destruction of wildlife habitats and diverting management attention from wildlife. Secondary uses are those activities that are not directly related to managing an area for wildlife. As a result of the report, refuge managers were interviewed to identify and review all secondary uses occurring on refuges to determine compatibility. A use was not compatible if it materially interfered with or detracted from the purpose(s) for which a refuge was established (Refuge Manual, Section 5 RM 20.6A).

In 1990, in cooperation with The Nature Conservancy, the Graveyard Spit Research Natural Area (RNA) was established. This RNA is recognized for its high-quality examples of a low intertidal, high salinity sandy marsh; a coastal spit with native vegetation and; a high salinity coastal lagoon. Establishing documentation provides guidelines for management of the RNA as an "area where natural processes are allowed to predominate without human intervention," and limits activities to research, study, observation, monitoring, and educational activities that are nondestructive, nonmanipulative, and maintain unmodified conditions (Refuge Manual, 8 RM 10.7). Currently, management in the RNA is limited to invasive species management (e.g., Dalmatian toadflax) and year-round closure to protect native strand plants and provide refugia for wildlife.

A lawsuit was filed on October 22, 1992 against the FWS by the national Audubon Society, Wilderness Society, and Defenders of Wildlife (Audubon et al. v. Babbitt, C92-1641), which alleged that the Service had, "violated the Refuge Recreation Act of 1962, the National Environmental Policy Act of 1969, and the Administrative Procedure Act in authorizing and allowing secondary uses of the National Wildlife Refuge System without ensuring that such uses are compatible with the purpose of the National Wildlife Refuge on which they occur, without ensuring that funds are available for the development, operation and maintenance of secondary recreational uses, and without considering the environmental impacts of such secondary uses pursuant to NEPA…"

The lawsuit resulted in a settlement agreement on October 20, 1993, which required another comprehensive review and evaluation of all secondary uses occurring on refuges, and the identification of uses found to be incompatible with refuge purposes. Compatibility determinations were to comply with the National Environmental Policy Act (NEPA) process and those uses found not to be compatible would either be modified to assure compatibility or eliminated by October 20, 1994.

An Environmental Assessment of the Management of Public Use for Dungeness National Wildlife Refuge was released in 1997 (USFWS 1997a). This document assessed 16 secondary uses of the Refuge (e.g., beach use, wildlife observation, etc.) to determine if they were compatible with the purpose of the Refuge. It found the following:

- Compatible as currently occurring: environmental education, tribal fishing, research, fishing enhancement, and permitted special uses.
- Compatible with modifications: hiking, wildlife observation, wildlife photography, nonmotorized and motorized boating, recreational fishing/shellfishing, jogging, beach use (e.g., swimming and other recreational beach activities) and horseback riding.
- Incompatible and no longer allowed: use of personal watercraft (e.g., Jet Skis and windsurfing).

In 1998, Dungeness NWR, San Juan Islands NWR, Copalis NWR, Quillayute Needles NWR, and Flattery Rocks NWR were combined into one complex known as Washington Maritime NWR Complex.

4.2 Selection of Priority Resources of Concern

4.2.1 Analysis of Resources of Concern

Refuge management priorities are derived from the National Wildlife Refuge System (Refuge System or NWRS) mission, individual refuge purpose(s), NWRS policy that identifies NWRS Resources of Concern, and the mandate to maintain the BIDEH of the Refuge. These mandates are consistent with the National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997. The management direction of Dungeness NWR is driven by Refuge purposes and statutory mandates, coupled with species and habitat priorities. The latter are identified in various USFWS conservation plans, as well as those developed by our state, federal, and private partners (USDI 2008). The Service also sought input from Washington State conservation agencies, nongovernmental organizations, and the general public. In developing ROCs, the team followed the process outlined in the Service's draft Identifying Refuge Resources of Concern and Management Priorities: A Handbook (USFWS 2009). As defined in the Service's Policy on Habitat Management Plans (620 FW 1), ROCs are:

> "all plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), System mission, or international, national, regional, state, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect 'migrating waterfowl and shorebirds.' Federal or

> State threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts (620 FW 1.4G)…"

Habitats or plant communities are resources of concern when they are specifically identified in refuge purposes, when they support species or species groups identified in refuge purposes, when they support NWRS resources of concern, and/or when they are important in the maintenance or restoration of biological integrity, diversity, and environmental health.

As a result of this information gathering and review process, a comprehensive list of potential resources of concern was developed (Appendix E).

4.2.2 Priority Resources of Concern Selection

Early in the planning process, the planning team cooperatively identified Resources of Concern (ROC) for the Refuge. Negative features of the landscape, such as invasive plants, may demand a large part of the Refuge management effort, but are not designated as ROCs. The step-by-step process to prioritize ROCs and management priorities for a refuge is displayed in Figure 4-3. The team then selected priority resources of concern from the ROC list. The main criteria for selecting priority resources of concern included the following requirements:

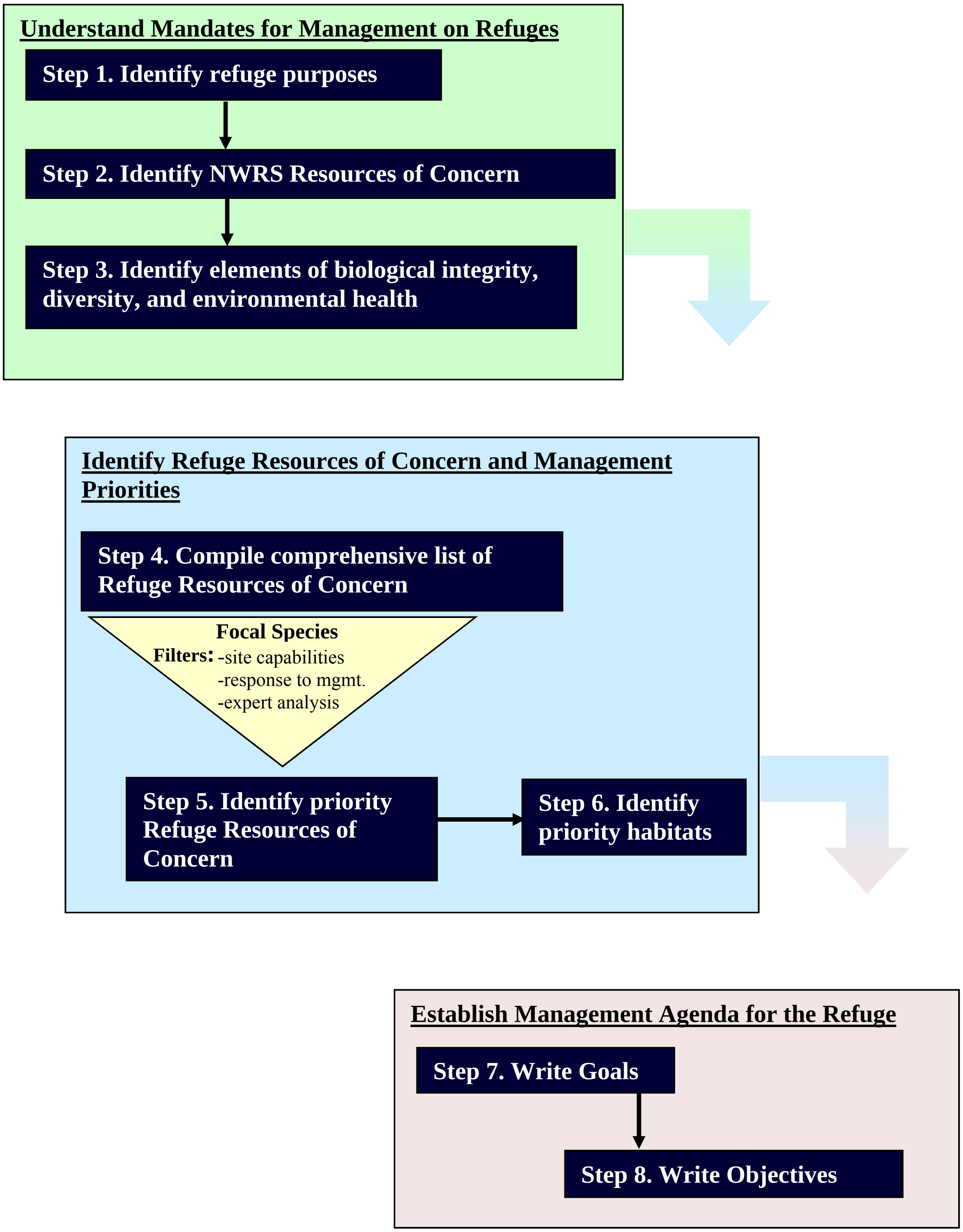
- The resource must be reflective of the Refuge's establishing purposes and the Refuge System mission;
- The resource must include the main natural habitat types found at the Refuge;
- The resource must be recommended as a conservation priority in the Wildlife and Habitat Management Review; or
- The resource must be federally or state listed, a candidate for listing, or a species of concern.

Other criteria that were considered in the selection of the priority resources of concern included the following:

- Species groups and/or Refuge features of special management concern;
- Species contributing to the biological diversity, integrity, and environmental health of the ecosystem;
- Species where it is feasible to estimate abundance and distribution (needed for future monitoring and adaptive management).

In developing its listing of priority resources of concern, the planning team selected not only species mentioned in establishing documents for the Refuge, but also species that captured the ecological attributes of habitats required by larger suites of species. The ecological attributes of habitats should meet the life history requirements of ROCs, and are therefore important to sustain the long-term viability of the priority resource of concern and other benefitting species. Ecological attributes of habitats include vegetation structure, species composition, age class, patch size and/or contiguity with other habitats; hydrologic regime; and disturbance events (e.g., flooding, fire). These provide measurable indicators that strongly correlate with the ability of a habitat to support a given species. Tables listing the desired conditions for habitat types found on the Refuge incorporate "desired" conditions that were based on scientific literature review and team members' professional judgment. These desired conditions for specific ecological attributes were then used to help design habitat goals and objectives, as presented in Chapter 2. However, not all ecological attributes or indicators were

Figure 4-3. Overview of the Process to Prioritize Resources of Concern and Management Priorities for a Refuge (USDI 2008)



deemed ultimately feasible or necessary to design an objective around. Other factors, such as the Refuge's ability to reasonably influence or measure certain indicators, played a role in determining the ultimate parameters chosen for each habitat objective. Thus, ecological attributes should be viewed as a step in the planning process.

Limiting factors were also considered in developing objectives. A limiting factor is a threat to, or an impairment or degradation of, the natural processes responsible for creating and maintaining plant and animal communities. In developing objectives and strategies, the team gave priority to mitigating or abating limiting factors that presented high risk to ROCs. In many cases, limiting factors occur on a regional or landscape scale and are beyond the control of individual refuges. Therefore, objectives and strategies may seek to mimic, rather than restore, natural processes. For example, pumps and water control structures may be used to control water levels in wetlands in areas where natural hydrology has been altered by hydropower operations and dike construction. The structure of plant communities utilized by ROCs can be created, rather than restoring the original native species composition. Mowing and/or grazing may be used to maintain a desirable vegetation structure, when restoring native grassland communities may be impractical. Through the consideration of BIDEH, the Refuge will provide for or maintain all appropriate native habitats and species. Refuge management priorities may change over time, and because the CCP is designed to be a living, flexible document, changes will be made at appropriate times.

A further distinction has been made within the priority resources of concern for plant and animal species which are labeled focal resources. Therefore, the following habitats were selected as Priority Resources of Concern: (1) Nearshore Habitats (North Pacific Coastal Cliff and Bluff, North Pacific Maritime Coastal Sand Dune and Strand, Temperate Pacific Intertidal Flat, North Pacific Maritime Eelgrass Bed, and Temperate Pacific Tidal Salt and Brackish Marsh), (2) Mixed Coniferous Forest (North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest and North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest), and (3) Wetlands (North Pacific Hardwood-Conifer Swamp and North Pacific Lowland Riparian Forest and Shrubland). Vegetation type descriptions according to the International Terrestrial Ecological System Classification under development by NatureServe and its natural heritage program members (refer to Appendix E for further discussion) are listed in parentheses. In addition, the following species were selected as Focal Resources for this CCP: Pacific harbor seal, American dunegrass and large-headed sedge (barrier beach), dunlin (barrier lagoon and mudflat), eelgrass (eelgrass beds), marine invertebrates (salt marsh), pileated woodpecker (mixed coniferous forest), and amphibians (wetlands).

In the following sections, information is provided on the ecological processes of formation and maintenance; regional distribution; condition and threats; key species supported; and management activities for each Priority Resource of Concern. A similar analysis is presented for focal resources (e.g., dunlin, harbor seal, etc.) following the analysis for Priority Resources of Concern.

Tables describing focal resources associated with a particular habitat type are included at the end of each Priority ROC section in Chapter 4. Definitions for the column headings are as follows:

- **Focal Resources:** Species or species groups selected as representatives or indicators for the overall condition of the priority resource of concern. In situations where the conservation target may include a broad variety of habitat structures and plant associations, several different conservation focal resources may be listed. In addition, species with specific "niche" ecological requirements may be listed as a focal resource. Management will be

focused on attaining conditions required by the focal resource. Other species utilizing the associated habitat type will generally be expected to benefit as a result of management for the focal resource.
- **Habitat Type:** The priority resource of concern utilized by the focal resource.
- **Desired Habitat Characteristics:** The specific and measurable habitat attributes considered feasible on the Refuge and necessary to support the focal resource.
- **Life History Requirement:** The general season of use for the focal resource.
- **Other Benefiting Species:** Other species that are expected to benefit from management for the selected focal resource. The list is not comprehensive.

4.3 Nearshore Habitats

4.3.1 Overview

The Puget Sound Nearshore Ecosystem Restoration Study defines nearshore as: a complex of estuaries, deltas, bays and inlets, lagoons, beaches, bluffs, rocky shores, intertidal flats, and shallow subtidal areas, accompanied by eelgrass beds, seaweeds, kelps, and other biological communities (PSNERP 2012). For purposes of this document, we have selected the following nearshore habitats as priority resources of concern on Dungeness NWR: sandy bluff, barrier beach, barrier lagoon and mudflat, eelgrass beds, and salt marsh.

Sandy Bluffs
This habitat type is classified within the North Pacific Coastal Cliff and Bluff ecological system (NatureServe 2010). Sandy bluffs are also referred to as “feeder bluffs” because they are continuously eroding and contributing sediment to “down-drift” beaches. They are often steep and composed of a sequence of glacial and interglacial deposits of fine sand to coarse gravel with occasional sparse cover of forbs, grasses, lichens, and low shrubs.

Sandy bluffs are the primary source of sediment for nearshore habitats within Puget Sound and they cover >60% of the shoreline in the Sound (Johannessen and MacLennan 2007). The key processes that form and maintain sandy bluff habitat are erosional through exposure to wind and waves, geologic composition (e.g., slope stability and drainage capacity) and surface and groundwater hydrology (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 or surface/groundwater weakens slope stability which eventually leads to landslides (mass-wasting). Either mechanism results in the delivery of new material to the base of the slope (Emery and Kuhn 1982). Key attributes include: physical structure and stability as indicated by the degree of slope and friability of soil; security and human impacts as indicated by the presence/absence of human activity on or near bluffs and presence of driftwood on the shoreline adjacent to bluffs; and plant community, structure and composition as indicated by percent of vegetative cover.

Dungeness NWR supports approximately ½ mile of sparsely vegetated, sandy bluff habitat along the Strait of Juan de Fuca. Since bluffs along the Strait of Juan de Fuca experience significant wind and wave exposure, bluff erosion and recession rates are higher than at other, less exposed areas of the Salish Sea. Slope failure rates are typically higher during winter months due to heightened storm intensity which acts to weaken bluffs with heavy precipitation and storm surges.

Barrier Beaches

Barrier beach habitats are associated with the North Pacific Maritime Coastal Sand Dune and Strand ecological system. This habitat type is defined as a relatively continuous ridge of sand and gravels raising a short distance above the high tide line. Barriers often form across embayments or other distinct coastal bends, and are represented by a variety of types such as spits, recurved spits, stream-mouth spits, bay barriers, or bay-mouth barriers (Shipman 2008). On this Refuge, barrier beach habitat consists of Dungeness and Graveyard spits. The lower shoreline component is traditionally referred to as "the spit" while the higher elevation portion of the barrier beach is referred to as strand. The shoreline is composed of substrata consisting of components of cobble size (10 inches in diameter) and smaller, including gravel, sand, mud, and organic materials (Dethier 1990).

Dungeness NWR is unique in that it contains one of the longest natural sand spits in the world. Dungeness Spit is 5.5 miles long and averages 300 feet wide (from Mean Low Water); however the narrowest portion measures approximately 50 feet wide during high tide. Dungeness Spit has an accretion rate of about 15 feet per year along the eastern tip (Schwartz et al. 1987). The beach substrate along the Strait (north) side of Dungeness Spit is in a constant state of flux shifting from primarily cobble in the winter months due to increased storm activity to a finer, sandier composite in the summer months. Graveyard Spit branches off of Dungeness Spit at approximately 3 miles from the mainland and extends due south. It is approximately 1.4 miles long and averages 475 feet wide. Cumulatively, Dungeness and Graveyard spits provide approximately fifteen miles of undeveloped shoreline. Above the high water line of Dungeness Spit, a backbone of driftwood helps to hold the sediment and provides beach stabilization. The interior of Graveyard Spit and tip of Dungeness Spit support a relatively stable native strand plant community. The composition of vegetation within this fragile plant community is affected by disturbance processes such as wave overwash during storm surges, sand deposition, and erosion.

Graveyard Spit was designated a Research Natural Area (RNA) in 1990 due to the intact plant community of native strand vegetation. The RNA consists of coastal lagoon, strand, and salt marsh habitats. Of the total, native strand habitat consists of 58 acres. The percent of plant cover within the strand habitat varies both from north to south and between the dune ridges and troughs. Dune ridges tend to support a higher percent cover (80-100%) while troughs support roughly 10-50%. Within the northern-most portion of the spit, percent cover appears to increase within the dune ridges and troughs adjacent to the abandoned Navy structures. The salt marsh areas (located along the northern and southern border of the RNA) support 100% cover and cover approximately 52 acres within the RNA.

Important processes include the natural erosion of sandy bluff habitat which is then transported by predominantly eastward-flowing longshore currents and prevailing westerly and northwesterly winds to down-drift nearshore habitats. The natural erosion of sandy bluffs is critical to the integrity of barrier beach habitat. Natural erosion supplies down-beaches with finer sediments on a gradual, protracted pace. Key ecological attributes include: natural deposition and erosion of sand, gravel, and driftwood; presence of native strand plants tolerant of dry salty conditions; absence of marine debris, man-made or natural fires; minimal to no impact from oil spills or creosote-covered logs; and no human-caused wildlife disturbance during seasonal and year-round closures. The deposition and retention of driftwood found along the "backbone" of Dungeness Spit serves an important role in stabilizing the upper portion of the beach by holding sediments in place, particularly during storm events that coincide with high tides. Native strand plants act in the same manner as driftwood within the more protected strand portion of this habitat type.

Barrier Lagoons and Mudflats

Barrier lagoons are tidal embayments that lack a significant freshwater source and are often associated with barrier beaches which protect them from wave action (Shipman 2008). Common elements include intertidal mudflats and high tidal, sandy flats. The mudflats of these lagoons are composed of fine silt combined with organic matter deposited by complex longshore currents along the Strait of Juan de Fuca and prevailing winds. Mudflats are found between Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW). They are often submerged, but are gradually exposed as the tide lowers. Since vascular plants are unable to persist on mudflats due to the diurnal tidal flooding of salt or brackish water, algae are the dominant vegetation, primarily sea lettuce. High tidal flats consist primarily of sandy shores with areas of salt marsh vegetation. The substrate of the sandy shores originates from erosion of nearby bluffs which is then transported by longshore drift or overwash. These low energy shorelines are often fringed by a thin ring of salt marsh vegetation where sufficient sediment is available in the upper intertidal zone.

Due to the protected nature of barrier lagoons, tidal processes predominate. These influence supply of sediment, water circulation, and salinity gradients. Barrier lagoons and mudflats consist of a substrate primarily composed of fine silt with a shallow-gradient benthic layer and minimal to no vegetation. This type of benthic layer is more conducive to marine invertebrate productivity and survival. Vegetation covering the benthic layers impedes oxygen and nutrient uptake for marine invertebrates and reduces foraging area and sight distances for dunlin. Other important processes include tectonic uplift or subsidence; isostatic rebound; prevailing winds, storm events; water and air temperatures.

Approximately 403 acres of barrier lagoon and mudflat habitats are found within the Refuge in Dungeness Harbor, the interior of both spits, and east of Graveyard Spit in Dungeness Bay. Approximately 47 of that acreage is barrier lagoon while 356 acres are intertidal mudflat. The mudflats east of Graveyard Spit are more exposed to freshwater influx from the Dungeness River and wave action compared to the areas west of Graveyard Spit. These tidelands of the second class are managed by the Service under a perpetual easement with Washington Department of Natural Resources.

Eelgrass Beds

Common eelgrass (eelgrass) is a rooted perennial vascular plant found in intertidal areas (Mumford 2007). Eelgrass is not a true grass, but a pondweed (Moore and Short 2006). Eelgrass completes its entire lifecycle underwater and low tide exposure is a limiting factor for distribution. Like many other plants eelgrass flowers in the spring; releases seeds in midsummer; the seeds overwinter in the substrate; and germinate in the spring (Churchill et al. 1985, DeCock 1980). Eelgrass can also spread vegetatively by rhizomes that branch forming tangled mats within the beds (Moore and Short 2006).

Important processes that influence eelgrass growth include water circulation (tides and freshwater inflow) as well as water temperature. These processes drive key ecological attributes such as salinity, water quality, sedimentation, and temperature. This plant prefers a high level of salinity with temperatures ranging from 41-46°F for optimal growth (59°F upper limit; Snover et al. 2005). Eelgrass can be found at depths ranging from +0.4 to -8.8 meters (+1.3 to -28.9 feet) within the Strait of Juan de Fuca with an average maximum depth of -3.5 meters (-11.5 feet), relative to MLLW, within the Puget Sound (Mumford 2007). Where conditions of water temperature, quality (nutrient and contamination levels), and light penetration (clarity) are optimal, the plants form continuous solid beds. As conditions and other environmental factors stress the plants, their coverage becomes patchier.

Approximately 314 acres of eelgrass beds are managed by the Service within the second class tidelands easement. The majority of these beds are located within Dungeness Harbor, due west of Graveyard Spit and south of Dungeness Spit. Additional beds can be found due east of Graveyard Spit in Dungeness Bay. The current acreage of eelgrass beds within the Refuge is estimated based on Wilson (1993) and Norris and Fraser (2009) and includes areas of sparse, patchy, and dense coverage. Thus, the actual footprint of eelgrass beds is smaller.

Salt Marsh

Salt marsh habitat is classified as Temperate Pacific Tidal Salt and Brackish Marsh (Estuarine Emergent Wetland). This system varies in location and extent with daily and seasonal dynamics of freshwater input balanced against evaporation and tidal flooding of saltwater. Salt marshes are confined to specific environments defined by ranges of salinity, tidal inundation regime, and soil texture. Summer dry periods result in decreased freshwater inputs and thus higher salinity levels. Characteristic plant species include American glasswort, seashore saltgrass, and seaside plantain. Due to high salinity levels, this system supports low plant species diversity.

Natural processes responsible for the formation of these marshes include the formation of the barrier beach which shelters the salt marsh from wave action and serves as a funnel for sediment in the water column to enter the marsh. Key ecological attributes that are responsible for the maintenance of these salt marshes include the hydrological regime and water quality. The hydrological regime in the salt marsh essentially determines the frequency of tidal inundation and therefore salinity of the marsh and plants that can tolerate that salinity as well as the rate of accretion or subsidence of sediment. Water quality is indicated by presence of creosote-covered driftwood and/or oil as well as the amount of other pollutants, temperature, and alkalinity.

Salt marshes are important components of the nearshore ecosystem due to the high nutrient concentrations resulting from decaying marsh vegetation. The resulting dissolved organic materials support especially high concentrations of phytoplankton (one-celled microscopic floating plants). In addition, nutrients are flushed from the marsh by tides and storms into adjacent nearshore habitats thereby enriching practically all nearshore habitats (Gosselink 1980). They also serve as a vital nursery area for commercially important species such as marine invertebrates (e.g., Dungeness crab) which seek these areas for refugia. Salt marshes filter pollutants from the water and break them down into less harmful forms (e.g., nitrogen) and buffer inland areas from the damaging effects of storm surges. Finally, salt marsh plants remove carbon from the atmosphere and store it in undecomposed materials in the soil.

Approximately 52 acres of salt marsh can be found on both the northern and southern ends of Graveyard Spit. In each salt marsh, one channel serves as the conduit for saltwater intrusion but the entire marsh is not typically flooded each day; inundation occurs only on the highest of high tides. Each salt marsh contains a bulwark of driftwood along their northern borders which adds to the organic material available for decomposition and provides cover for marine invertebrates. The predominant plant covering these marshes is American glasswort.

4.3.2 Regional Distribution, Conditions and Threats

Sandy Bluffs

Sandy bluffs constitute approximately 60% of Puget Sound shores; however one third of Puget Sound's shoreline has been effectively eliminated from this natural cycle through armoring.

Armoring is typically used to reduce erosion of bluffs adjacent to homes or important areas by placing sea walls or bulkheads parallel to bluff habitats (Johannessen and MacLennan 2007). Armoring has far-reaching negative effects on all nearshore habitats, primarily through the reduction of sediment deposition to sandy beaches. In addition, armoring can increase the wave energy reflected to down-drift beaches and bluffs, thereby increasing the potential erosion rates (Johannessen and MacLennan 2007).

Threats from climate change include sea level rise as well as the increase in the incidence and severity of storm events that can significantly erode the base (toe) of sandy bluffs and accelerate natural erosion. Bluff areas west of Dungeness Spit appear to be eroding at a rate of 0.5 to 3 feet per year on average but a single storm event or bluff failure can take as much as 28 feet of bluff at a time (ESA 2011). Thus, climate change is predicted to exacerbate erosion particularly when this threat results in elevated storm severity coinciding with elevated sea levels resulting in larger and more frequent mass-wasting events.

Development adjacent to bluffs and trespass within sandy bluff habitat have the potential to degrade or destroy the habitat through trampling and erosion as well as cause tremendous disturbance to wildlife and introduce invasive plant species into closed areas of the Refuge. No further development of Refuge lands is planned at this time; however replacement of the Dungeness caretaker cabin (Mellus Cabin) is an identified deferred maintenance project need. Should this project be funded within the time frame of this plan, we will strive to follow guidelines set in place by the current Clallam County Shoreline Master Plan (SMP) restricting building within 150 feet of the bluffs, as established for residential uses on Shorelines in the Natural Environment (WDEQ 1992). Currently, the County is developing the draft of a new Shoreline Master Plan. Once that plan has been approved by the County and the Washington Department of Ecology, the Service will adopt the guidelines in the final SMP. In addition, no hard armoring (e.g., rip rap) will be placed adjacent to bluffs on Refuge lands.

Barrier Beach

The natural erosion of sandy bluffs and presence of driftwood along the spit are critical to the integrity of barrier beach habitat. Natural erosion supplies down-drift beaches with fine sediments on a gradual, protracted pace. Increased armoring and increases in the incidences and severity of storm events as well as wave heights due to climate change can all lead to higher levels of erosion of barrier beaches. The driftwood found along the backbone of Dungeness Spit serves an important role in stabilizing the upper portion of the beach by holding sediments in place, particularly during high tide events that coincide with storms.

Native plant species continue to dominate on Graveyard and Dungeness spits even when associated with introduced species. Graveyard Spit represents a very stable sand spit; however the following invasive species are currently under management control on the spit: Dalmatian toadflax and Himalayan blackberry. Nonnative and invasive plant species threaten this habitat type by displacing native vegetation, altering intact communities, and modifying ecosystem processes. Due to the fragile nature of strand habitat, soil disturbing management activities can increase the risk of additional invasive species issues.

Climate change also poses a serious threat to this environment. According to sea level rise modeling using Sea Level Affecting Marshes Model (SLAMM), within the time span of this plan, roughly half of the spit or ocean beach habitat (not including the strand component of barrier beach) is predicted to be lost based on the 1-meter (3.3-foot) global average sea level rise scenario (through 2025;

Clough and Larson 2010). In 100 years, 98% of this component of the barrier beach on Dungeness Spit is predicted to be lost to sea level rise based on the same 1-meter (3.3-foot) scenario (Clough and Larson 2010). There is some uncertainty in the results due to a lack of precise geospatial data used in the models. For this reason, we will perform studies to assess variables that affect sea level rise rate scenarios (e.g., sedimentation, geospatial extent of the spit and salt marshes, etc.).

Barrier Lagoons and Mudflats

Intertidal life is affected by light level, temperature change, amounts of oxygen, pH, salinity, and exposure to air and wind. These ecological attributes are primarily determined by current, wind, and tidal processes. Predominant threats include contamination by oil spills, creosote, and other chemicals; invasive species; and climate change. By their very nature, barrier lagoons are partially protected from oil spill contamination; however due to the limited tidal action within this habitat type, they are also more vulnerable to persistence of contaminants (for more information, see Section 4.1.2; USEPA 2008).

Plate tectonic processes are currently causing geologic uplift along the shoreline of the northern Olympic Peninsula. These processes further complicate predictions of the effects of sea level rise on the barrier lagoons and mudflats of Dungeness NWR. For instance, the historic (100 year) trend of 1.085 millimeters/year (0.04 inch/year) rise in sea level for the Dungeness area is lower than the global 100 year trend of 1.7 millimeters/year (0.07 inch/year) (Clough and Larson 2010) as a result of uplift. In addition, according to a study completed in 2000, a 35% reduction in water volume has occurred in Dungeness Harbor from 1967 through 2000 (Rensel 2003). Several natural factors have influenced this loss of capacity including deposition of sediment from the longshore drift originating from the Strait of Juan de Fuca and the Dungeness River. Subsequently, an increase of 6% has been observed in tidal mudflats in the harbor (Rensel 2003). However, recent SLAMM results for Dungeness NWR reveal that the area of mudflats may be reduced by 4-6% based on 1-meter to 1.5-meter (3.3-foot to 4.9-foot) global average sea level rise scenarios respectively within the time span of this CCP (Clough and Larson 2010). Effects of climate change that will impact intertidal organisms have already been reported in the Puget Sound including warmer sea surface temperatures, decreased summer precipitation and decreases in snow pack. Research has shown that sea surface temperatures in the Strait of Juan de Fuca during the 1990s were the warmest recorded in written history (since the 1840s; Snover et al. 2005). Increased sea surface temperatures affect the productivity and survival of plankton, the base of the nearshore food web.

The Service is conducting an early detection monitoring program for European green crab on the Refuge and surrounding environments; however this species has not been detected on or near the Refuge. Green crabs are considered very invasive and have a negative impact on native species through competition (with native crabs) and predation (with native clams, mussels, juvenile fishes and other species; Eissinger 2009). Common cordgrass was initially found within the barrier lagoon on Dungeness Spit in 2007 and approximately 27 square feet was removed. It has been found and removed each year since that time. In 2011, approximately 6 square feet was removed. Mechanical means of control have been sufficient to keep up with this infestation. This species can significantly alter mudflat habitat by raising the elevation of the benthic layer to elevations above high tide by trapping sediment in the water column. During two surveys for eelgrass in 2003 and 2009 in Dungeness Bay, Japanese eelgrass was not observed (Norris and Fraser 2009, Dowty et al. 2005). This species typically grows within the intertidal zone and can be found in Puget Sound; however, it is a nonnative plant.

Eelgrass Beds

In 1987, approximately 300 acres of eelgrass beds were delineated via remote sensing in the tidelands (Wilson 1988). During a follow-up survey in 1991, the total area had been reduced with the loss of all areas designated as "sparse," a 39% reduction in "patchy," and a 27% loss of "dense" eelgrass beds in Dungeness Harbor (the largest area of eelgrass in Dungeness NWR; Wilson 1993). The reasons for this decline vary, but a portion of the loss was attributed to the dynamic nature of intertidal areas and former eelgrass beds covered by sea lettuce (Wilson 1993).

Research has shown that sea surface temperatures within the Strait of Juan de Fuca have increased with the 1990s noted as the warmest decade on record since the 1840s; researchers expect the warming trend to continue (Snover et al. 2005). Climate change may induce temperature stress which limits growth of eelgrass. In addition, sea level rise may increase water depths to levels that will no longer be suitable for eelgrass. However, this is complicated by a gradual infill noted in Dungeness Harbor as well as mild geologic uplift occurring on the northern Olympic Peninsula (for more information, see Barrier Lagoons and Mudflats above). Another mortality factor that may become more of a threat due to climate change-related impacts is a wasting disease that affects eelgrass through a slime mold-like pathogen (*Labyrinthula*). *Labyrinthula* occurs naturally in eelgrass beds, but high levels have caused significant mortalities in eelgrass on the east coast of the U.S. and in Europe. This pathogen is present in the Puget Sound; however, it has not caused significant mortality. When eelgrass begins to stress, such as at lower salinities or with increased pollution, the *Labyrinthula* pathogen is stimulated and mortalities ensue (Muehlstein et al. 1991, Burdick et al. 1993). While lower salinities are not predicted, other environmental stressors related to climate change may combine with wasting disease leading to unanticipated effects.

The Washington Department of Natural Resources began to monitor eelgrass distribution throughout the Salish Sea in 2000. The Puget Sound Submerged Vegetation Monitoring Project: 2000-2002 Monitoring Report, provided an estimate of eelgrass beds covering Puget Sound of 72 square miles or 45,961 acres (186 square kilometers or 18,600 hectares), which include beds on flat, narrow, and wide fringed areas (Berry et al. 2003). The report from 2009 showed that eelgrass covered 85 square miles or 54,363 ± 8,895 acres (220 square kilometers or 22,000 ± 3,600 hectares) in the same areas (Gaeckle et al. 2011). This shows a slight increase in the overall Salish Sea eelgrass population, but a declining trend on more individual sites within the Salish Sea is troubling.

Salt Marsh

Over half of the nation's population live and work within coastal counties. The cumulative impact within the watershed surrounding salt marshes can be substantial. Loss or degradation (e.g., in-filling, channelizing, or reducing inflow) of salt marshes has been greatly minimized due to federal and state laws, yet a number of threats to salt marsh habitats still exist. Nonpoint-source pollution from runoff originating from roads (petroleum products from cars), farms, and lawns (pesticides and fertilizers) is difficult to control. Pollution may disrupt the food web in the salt marsh by killing some species while prompting others to greatly increase in number.

Due to the limited extent of salt marsh habitats on the Refuge, minimal change is predicted as a result of sea level rise within the time span of this plan (i.e., 2025 under the 1-meter and 1.5-meter [3.3-foot and 4.9-foot] rise scenarios in SLAMM; Clough and Larson 2010). Sea level rise can cause loss of the salt marsh through increased erosion and excessive flooding of marsh plants (Chabreck 1988). This threat can be minimized by natural accretion (accumulation of sediment and organic matter within the marsh) if it can keep pace with sea level rise. Studies of accretion rate within the Salish Sea have shown that salt marshes in this area have the capacity to keep up with sea level rise so long as the sediment supply remains similar to that received currently (Thom 1992). However, any significant erosion of the barrier beach would likely damage or eliminate the marshes. Model results using SLAMM can be improved, particularly by increasing the accuracy of the geospatial data used in the model (e.g., the south marsh is not delineated) and incorporating effects from other stressors due to climate change. As a result, we will perform studies to assess variables associated with climate change stressors (e.g., accretion, salinity, driftwood recruitment, etc.) and to improve the data used in local-scale sea level rise modeling.

For more information on the threat of oil spills and creosote-covered logs, see Section 4.1.2.

4.3.3 Key Species Supported

Sandy Bluffs

The concept of BIDEH, as defined by USFWS policy (601 FW 3.3), applies not only to species but also to habitats and those ecological processes that support them. Sandy bluffs are important to the maintenance of biological integrity and environmental health of associated nearshore habitats of the Refuge. Species supported by management of sandy bluffs include pigeon guillemot and glaucous-winged gulls.

Barrier Beach

Barrier beach habitat provides necessary haul out and pupping locations for harbor seals and the occasional northern elephant seal, particularly in the closed areas of the Refuge. Raptors such as northern harrier, peregrine falcon, bald eagle, and short-eared owl use the driftwood as hunting perches and/or shelter from the weather. Overwintering shorebirds (sanderling, dunlin and black-bellied plover) and harlequin ducks roost on the shoreline during the winter months. Breeding black oystercatchers, glaucous-winged gulls, Caspian and Arctic terns nest on the sandy shoreline particularly in the closed areas of the Refuge. Migrant birds such as the western and least sandpipers as well as Heermann’s, mew and western gulls can also be seen in small flocks in barrier beach habitat during the spring and fall migration. The interior portion of the barrier beach on Graveyard Spit has been recognized for its unique native strand community supporting an abundance of American dunegrass, large-headed sedge, red fescue, silver burweed and black knotweed, to name a few. Focal resources for barrier beach habitat include Pacific harbor seal, American dunegrass, and large-headed sedge.

Barrier Lagoons and Mudflats

Barrier lagoons and mudflats provide foraging habitat for dunlin, western and least sandpiper, sanderling, black-bellied plover, black oystercatcher, and glaucous-winged gulls. Brant, American wigeon, northern pintail, mallard, and green-winged teal roost in this habitat type between foraging bouts especially during migration and the winter months. Dungeness crab, anadromous and forage fish forage within this habitat type throughout the year. Dunlin has been selected as a focal resource for this habitat type.

Eelgrass Beds

Eelgrass beds, or meadows, support a fantastic array of life. Many species are very dependent on these plants for their very existence, while others are more loosely connected to this habitat. Species such as brant, snails, and urchins eat the leaves directly, Pacific herring spawn on the leaves, and highly productive bacteria in the sediment are protected and nourish many invertebrates (e.g., crab larvae) because of the oxygen pumped into the sediment by the roots of the eelgrass. Anadromous and forage fish are sheltered by the leaves and forage on invertebrates in the water column. Eelgrass beds provide important migrant staging and winter habitat for 1,000 to 3,000 brant composed predominantly of the black brant population. A small percentage of the intermediate or grey population can be found here. Other species of waterfowl such as northern pintail, mallard, and American wigeon are common during the winter months with abundance ranging from 500-1,500 per species. Eelgrass has been selected as the focal resource for management of eelgrass beds.

Salt Marsh

Salt marshes are among the most productive ecosystems on earth because they contribute greatly to the base of the food chain. In aquatic systems, this food chain starts with phytoplankton. These algae are consumed by minute floating animals called zooplankton; anadromous and forage fishes; and marine invertebrate larvae, to name a few. Because salt marsh productivity is often the key to the health of the surrounding estuary, marine invertebrates (e.g., Dungeness crabs) have been selected as focal resources of this habitat type. Other benefiting species that occasionally use the salt marsh include glaucous-winged gull, dunlin, mallard, American wigeon, northern pintail, great blue heron, northern harrier, and short-eared owl.

Table 4-1. Focal Resources Associated with Nearshore Habitats

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Requirement	Other Benefiting Species
Biological Integrity	Sandy Bluffs	Limit impervious surfaces within 150 feet of the top of the bluff; No public use of the bluff toe or face at any time; No hard armoring (e.g., rip rap) on shoreline adjacent to the bluff	N/A	Pigeon guillemot and glaucous-winged gull
Pacific Harbor Seal	Barrier Beach	Natural deposition and/or erosion of sand and gravel; Continuous ridge of sand and gravel rising a short distance above high tide; Materials derived from erosion of nearby sandy bluffs; Absence of marine debris; Presence of driftwood along the "backbone" of Dungeness Spit and the eastern side of Graveyard Spit; No human-caused wildlife disturbance during seasonal and year-round closures; Absence of man-made or natural fires; Minimal to no impact from oil spills or other contaminants; Minimal creosote-covered logs	Year-round	Northern elephant seal; sanderling; western and least sandpiper; dunlin; black oystercatcher; Heermann's, western, and glaucous-winged gulls; Caspian tern; harlequin duck; bald eagle; peregrine falcon; northwestern crow

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Requirement	Other Benefiting Species
American Dunegrass, Large-headed Sedge	Barrier Beach	Natural deposition and/or erosion of sand and gravel; Continuous ridge of sand and gravel rising a short distance above high tide; Materials derived from erosion of nearby sandy bluffs; Presence of native strand plants; Absence of marine debris; Presence of driftwood along the "backbone" of Dungeness Spit and the eastern side of Graveyard Spit; <1% total cover of Dalmatian toadflax and <20% total cover of cheat grass; No human-caused wildlife disturbance during seasonal and year-round closures; Absence of man-made or natural fires; Minimal to no impact from oil spills or other contaminants; Minimal creosote-covered logs	Year-round	Black knotweed, silver burweed, yellow sand-verbena, red fescue, northern harrier, peregrine falcon, snowy owl, short-eared owl
Dunlin	Barrier Lagoons and Mudflats	Absence of *Spartina spp.*; Substrate primarily composed of fine silt; Shallow gradient benthic layer (i.e., <10 cm [3.9 inches]); Absence of human-caused wildlife disturbance from Oct 1-May 14 on Refuge portions of Dungeness Harbor and Bay; no human-caused wildlife disturbance year-round to the lagoons within the spits; No creosote-covered logs on or near mudflats and the barrier lagoon habitats; Absence of marine debris	Winter, Migration	Black-bellied plover; black oystercatcher; western and least sandpiper; western and glaucous-winged gulls; bald eagle, northwestern crow; brant; American wigeon; northern pintail; mallard, green-winged teal; Dungeness crab; young salmon and forage fish
Eelgrass	Eelgrass Beds	Intertidal areas with muddy to sandy substrates; Depth range from +0.4 to -8.8 meters (+1.3 to -28.9 feet), average is -3.5 meters (-11.5 feet; relative to MLLW); Low- to moderately high-energy environments (waves and currents); Absence of marine debris; Absence of human-caused wildlife disturbance from Oct 1-	Year-round	Brant; American wigeon; northern pintail; mallard, green-winged teal; greater and lesser scaup; surf, white-winged and black scoters; common and Barrow's goldeneye;

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Requirement	Other Benefiting Species
		May 14 on the Refuge portion of Dungeness Harbor and Bay		Dungeness crab; young salmon and forage fish
Marine Invertebrates	Salt Marsh	Vegetation dominated primarily by glasswort (*Salicornia* spp.); Infrequent inundation except at highest high tides; Maximum of 40% coverage by driftwood; Absence of man-made or natural fires; Absence of creosote-covered logs; <1% invasive plant species (e.g., Common cordgrass) cover; No human-caused wildlife disturbance year-round	Year-round	Glaucous-winged gull, dunlin, mallard, American wigeon, northern pintail, great blue heron, northern harrier, short-eared owl

4.3.4 Refuge Management Activities

Due to the dynamic nature of tidal habitats, there are relatively few viable actions available for management of nearshore habitats. As a result, current management activities are focused on reducing or eliminating invasive species, human-caused wildlife disturbance, and/or threats from contaminants and fires within nearshore habitats.

Because invasive plants and animals currently represent the greatest threat to the Refuge's wildlife and habitat, control of invasive species is a high priority management activity. Invasive species such as common cordgrass and State and County-listed noxious weeds are managed according to IPM policies. In addition, nonnoxious weeds such as Himalayan blackberry, English holly, and English ivy, and introduced animals such as feral cats are under management control to the degree that funding permits. Common cordgrass was initially found within the barrier lagoon on Dungeness Spit in 2007 and approximately 27 square feet was removed. It has been found and removed each year since that time. In 2011, approximately 6 square feet was removed. Mechanical means of control have been sufficient to keep up with this infestation. The Service has been participating in an early detection monitoring program for European green crab with WDFW. Currently the green crab has not been detected in the Salish Sea.

Public use closures have been set in place to protect the integrity of habitat and reduce introduction of invasive species. The sandy bluff, Graveyard Spit and the tip of Dungeness Spit are closed year-round; the tideland areas and the first half mile of the bay side of Dungeness Spit are closed seasonally from October 1 through May 14. Under the management direction in this CCP, public use activities on the Refuge will include saltwater fishing, shell-fishing (clams and crabs), wildlife observation, wildlife photography, hiking, no-wake boating, jogging, horseback riding (should alternative access be obtained per compatibility determination), beach use (wading, other recreational beach uses), environmental education, and environmental interpretation.

Refuge staff actively coordinates with the Washington Department of Ecology and others in preparing Area Geographic Response Plans and conducting periodic drills to test preparedness for oil spill response. Staff also participates in local marine resource committees and water quality action teams to address water quality issues within Dungeness Bay and Harbor, such as reduction of contaminants recently through removal of creosote-covered logs and removal of derelict crab pots in 2006. In addition, fire suppression techniques follow the Fire Management Plan completed for the entire Complex in 2004 which includes the prevention of catastrophic wildfire to promote the retention of driftwood and vegetation on the barrier beaches.

4.4 Mixed Coniferous Forests

4.4.1 Overview

This habitat type occurs in a mosaic of two ecological systems: North Pacific Maritime Dry Mesic Douglas-fir-Western Hemlock Forest and North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest. Sites where moisture is high are codominated by western redcedar, Douglas-fir, Western hemlock and/or grand fir, with significant amounts of sword fern in the understory. Red alder is found as an overstory tree in some forests where clear-cut harvest formerly occurred, along riparian areas, and as an understory tree in younger conifer forests and areas of recent disturbance. Understory shrub and herbaceous vegetation in these forest types typically include salal, oceanspray and sword fern.

Forests currently occupy approximately 180 acres of Dungeness NWR. There are approximately 57 acres of second-growth forest within the Dungeness Unit and 123 acres of second-growth within the Dawley Unit. A relatively homogenous stand of Douglas-fir is located along the western boundary of the Dungeness Unit with DBH ranging from 10-20 inches and canopy cover ranging from 40-70%. This stand supports few short snags (up to 20 feet) and a dense understory composed primarily of oceanspray and salal. To the north and west, the forest becomes a more complex stand of second-growth dominated by Douglas-fir, western hemlock, and western redcedar. This forest supports a mosaic of snags; downed woody debris; broken-top or candelabra-shaped trees; live trees of various heights and diameters; as well as a varied understory dominated by sword fern, oceanspray and salal. The Dawley Unit supports a similar stand as that found within the north and west of the Dungeness Unit.

There are approximately 5 acres of hardwood forest adjacent to the second-growth conifer forest along the southeast corner of the Dungeness Unit. Vegetation in this habitat consists primarily of red alder with an understory of red elderberry, Oregon grape, false lily-of-the-valley and sword fern. Canopy cover is roughly 75-95% with average tree heights of 50-60 feet. A small (<0.10 ac) seasonal palustrine wetland and adjacent small depressions that hold standing water in wet winters can be found within the center of this stand.

Historically, a moderate-severity fire regime involving occasional stand-replacement fires and more frequent moderate-severity fires created a complex mosaic of stand structures across the landscape. Currently, logging also plays a key role. Key attributes in maintaining or enhancing mixed coniferous forest include the presence of fire as a management tool, forest structure (e.g., diversity of tree species, canopy cover and layers, shrub and forb understory snags and downed woody debris), connectivity to adjacent forested habitats, and minimizing human-caused wildlife disturbance.

4.4.2 Regional Distribution, Conditions and Threats

Forests in western Washington have been extensively managed for timber production; today, 3% of forests in this area are considered old-growth (WDFW 2005). Managed forests are typically composed of Douglas-fir and western hemlock. Harvest of old-growth and mature forests for commercial timber and paper production has resulted in loss of species diversity and forest complexity on most of the landscape due to planting of even-aged, monotypic stands, and short harvest rotations.

The first saw mill on the northern Olympic Peninsula was established in Port Ludlow in 1852. However, logging activity expanded when a steam mill was completed in Port Gamble in 1853. By the end of its first full year in operation, the mill had cut more than 3.5 million board feet in the mid- to late-1800s. From 1915 to 1980, the Milwaukee Road operated the rail line from Port Townsend to Port Angeles and then west to connect with several logging railroads. The primary cargo carried by the railroad was Olympic Peninsula timber. Logging peaked in the 1980s prior to enactment of environmental legislation limiting timber harvest.

The forest stands within both units are currently second-growth with remnant patches of mature forest, but also lack key old-growth forest characteristics such as downed woody debris and snags. In addition, both stands support small (<5 acre) red alder stands located in near or around small wetlands. Blow down is a recurring natural event, particularly within the Dungeness Unit which is exposed to significant wind events along the Strait. Historically, occasional intense winter windstorms occurred with a frequency of once or twice every few decades, although their frequency has increased during this decade. Major stand-replacement fires impacted much of the Olympic Peninsula in the early 1500s and 1700s. There are signs of fire scars and areas of dense regrowth (180 trees/acre vs. 50-100 trees/acre found in typical stands) within the Dawley Unit, but there is no record of the event. Mistletoe has been found in the northwest section of the Dawley Unit.

Threats facing the forested habitats on Dungeness NWR include altered fire regime, climate change, invasive species, insect or disease infestation and human-caused wildlife disturbance. Response to climate change will vary according to regional and local topography, forest type, soil moisture, productivity rates, species distribution and competition, and disturbance regimes. Many of the effects of climate change may not be readily observed until a disturbance mechanism, such as fire, occurs. Once disturbance alters the landscape, vulnerable species may not be able to regenerate in altered stand-level environments such as low summer soil moisture levels. 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. Douglas-fir appears relatively sensitive to low soil moisture, especially on drier sites.
- Increasing temperature will generally increase forest fire frequency and extent by increasing rates of evapotranspiration leading to a decrease in fuel moisture.
- The change in seasonality of precipitation could lead to a drier growing season, increasing water stress and higher mortality of forest vegetation unable to adapt.
- 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 more fast-growing, short-lived, and 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.

Human-induced wildfires, as well as fire suppression, are potential catastrophic threats to forested habitats. Conversion of habitat to residential and nonforest uses has accelerated forest fragmentation. Additionally, illegal activities such as firewood collection, trail proliferation, and general trespass have the potential to cause disturbance to wildlife and also have the potential for introduction of invasive plant species into closed areas of the Refuge. Introduced invasive plants (e.g., English ivy and holly) pose threats to forested habitats on the Refuge. Potential insects or diseases that could affect the Refuge's forests include aphids, scale and bark beetles, root rot, leaf cast, and other fungi.

4.4.3 Key Species Supported

The focal species for Mixed Coniferous Forests is the pileated woodpecker. Mixed coniferous forests provide nesting habitat for downy and hairy woodpeckers; red-breasted sapsucker; rufous hummingbird; bald eagle; sharp-shinned and Cooper's hawks; Pacific-sloped flycatcher; northwestern crow; chestnut-backed chickadee; Bewick's wren; golden-crowned kinglet; Townsend's warbler; spotted towhee; and pine siskin, to name just a few. Other species such as varied thrush visit during the winter months. American black bear, bobcat, elk, deer, and ermine can be found here year-round. Many bats and amphibians are associated with mixed coniferous forests including Townsend's big-eared bat; Keen's, long-eared and long-legged myotis; ensatina and northwestern salamander.

Table 4-2. Focal Resources Associated with Mixed Coniferous Forests

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Requirement	Other Benefiting Species
Pileated Woodpecker	Mixed Coniferous Forest	Multi-aged, multi-layered, multi-species canopy consisting of Douglas-fir, western redcedar, western hemlock, and bigleaf maple; Natural gaps in the canopy that promote regeneration of the dominant tree species; 8 dominant (old-growth and mature) trees 100-200+ years old with tree diameters >32 inches DBH/ acre; 12 sub dominant trees with >16 inches DBH/acre; >4 snags	Year-round	Marbled murrelet; downy and hairy woodpeckers; red-breasted sapsucker; rufous hummingbird; bald eagle; sharp-shinned and Cooper's hawks; northern saw-whet owl; Pacific-slope flycatcher; Hutton's vireo; northwestern crow; chestnut-backed chickadee; Bewick's

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Requirement	Other Benefiting Species
		of >20 inches DBH and >15 feet tall/acre; 4 pieces of downed woody debris >24 inches diameter and > 50 feet long/acre; Density range of 50-100 trees/acre; <10% of invasive species (e.g., spurge laurel, English ivy, English holly) in the forest structure		wren; golden-crowned kinglet; varied thrush; orange-crowned and Townsend's warbler; spotted towhee; pine siskin; Townsend's big-eared bat; Keen's, long-eared and long-legged myotis

4.4.4 Refuge Management Activities

Since becoming part of the National Wildlife Refuge System, there have been very limited management actions within the forested habitat of either unit. Both units were harvested selectively prior to acquisition by the Refuge. Active IPM has occurred in both units primarily in control of English holly and English ivy. Additional invasive species under control on the Dawley Unit include spurge laurel. Although no fires have been noted within the forested habitats in recent history, the Refuge ascribes to a full fire suppression policy.

4.5 Wetlands

4.5.1 Overview

Seasonal Freshwater Wetlands
A small (< 0.05 acre) seasonal palustrine wetland is located in the uplands of the Dungeness Unit. This linear wetland is dominated by slough sedge and water hemlock. It is capable of supporting two pools with 8-10 inches of standing water. This wetland is likely formed over a high water table with either clay or compacted soil forming a barrier to drainage. A similar 0.05 acre wetland is located on the Dawley Unit; however, this wetland is deeper and holds water longer into the summer.

This habitat is driven largely by precipitation and, to a minimal extent, snow melt. Key ecological attributes include water quality (sedimentation, pH, alkalinity, dissolved oxygen and phosphorous, etc.) and hydrologic regime (annual precipitation cycle and temperature), plant community structure (presence/absence of invasive species, density of vegetation, etc.), and absence of human-caused wildlife disturbance.

Instream and Riparian Forest
A short (0.25 mile) reach of Dean Creek runs through the Dawley Unit beginning at river mile 0.6 from Sequim Bay. The western half of this intermittent creek is dominated by cascades (ranging from 1-6 feet tall) with some small pools (approximately 3 feet in diameter) and averages 3 feet wide (during spring runoff). Most of the small pools are ~1-1.5 feet deep; however, there are a few larger pools that are deeper. The eastern half of the creek as it runs through the property is primarily made up of ripples with little pooling. The creek widens to approximately 8 feet with an average depth of 1

foot. The banks of the creek are very steep and highly erodible with a primary substrate of loose gravel.

A limited amount of lowland riparian forest occurs along Dean Creek. Riparian and wetland forests are highly variable in their composition, size, and structure. Functioning floodplains are influenced by high-flow events that shape stream channels and riparian vegetation through a process of pulse disturbances. The high density of edges contributes to habitat and species diversity and productivity.

This system is driven by the amount and timing of snow melt and precipitation. Key ecological attributes include water quality (sedimentation, pH, alkalinity, dissolved oxygen and phosphorous, etc.) and hydrologic regime (annual precipitation cycle and temperature), plant community structure (presence/absence of invasive species, density of vegetation, etc.), and absence of human-caused wildlife disturbance.

Ownership of the property includes water rights to Dean Creek dating back to 1960 for irrigation and domestic water uses.

Managed Wetland
A small (0.39 acre) impoundment is located within the center of the Dawley Unit. This impoundment is capable of holding up to 8 feet of water. It is surrounded by shrubs, trees and understory vegetation on three sides and an earthen dam on the southern edge which is dominated by forbs and grasses. A small (8 feet in diameter) island is located near the northern edge of the impoundment.

Water levels are maintained largely by a man-made, gravity fed system which delivers water from Dean Creek to the impoundment. Water is also supplied by runoff and precipitation. Key ecological attributes include water quality (sedimentation, pH, alkalinity, dissolved oxygen and phosphorous, et.) and hydrologic regime (annual precipitation cycle and temperature), plant community structure (presence/absence of invasive species, density of vegetation, etc.), and absence of human-caused wildlife disturbance.

4.5.2 Regional Distribution, Conditions and Threats

Seasonal Freshwater Wetlands
The condition of these two wetlands is unknown; however, they appear to be healthy as indicated by the presence of amphibians, native vegetation, and aquatic invertebrates.

The amount of water and consequently the duration of the seasonal wetlands vary with the level of precipitation and temperatures throughout the year. Therefore, these wetlands could be threatened by climate change-induced alteration of temperature and precipitation cycles. In fact, wetlands are predicted to be the most vulnerable to climate change of all aquatic systems (Lawler and Mathias 2007) due to predicted effects.

Instream and Riparian Forest
Clallam County Streamkeepers rates Dean Creek as Highly Impaired due to development in the upper reach, poor bank stability, stream bed scour, low flows, and barriers to passage for aquatic species. The main road adjacent to the western section of this habitat has steep cut banks and signs of slope failure. However, partially submerged downed woody debris, falls and ripples are present throughout this reach.

Because the stream flow is determined largely by the amount of snowpack, timing, and rate of melt, climate change has the potential to heavily impact instream habitat conditions. Climate change has already affected the hydrologic cycle in Washington with earlier and more extreme spring floods and reduced spring/summer flows. From 1948-2003, the total annual inflow of freshwater into the Puget Sound declined by 13% due to changes in precipitation (Snover et al. 2005). In addition, temperatures have increased by 2.7° F since 1950 in the Puget Sound (Snover et al. 2005). These changes have resulted in lower summer stream levels, increased incidences of flooding events, particularly in the winter months, and increased incidences of streambed scour. Lawler and Mathias (2007) predict a variable increase in precipitation in the winter months with a decrease in the summer months.

Further, development or logging of adjacent uplands and potential erosion also pose a serious threat to water quality in instream habitats.

Managed Wetland
The condition of the impoundment appears to be healthy as indicated by the presence of amphibians, native vegetation, and aquatic invertebrates. It is surrounded by forested habitat on all sides which adds nutrients to freshwater inflow. Suitability for amphibians is limited due to lack of submerged woody debris and a water control structure to manage for shallow water.

4.5.3 Key Species Supported

Seasonal Freshwater Wetlands
The focal resources for this habitat type are amphibians (Pacific chorus frog, rough-skinned newt, and northwestern salamander with a potential for long-toed salamander, western toad and red-legged frog). Bat species associated with seasonal freshwater wetlands for foraging include: Keen’s and long-legged myotis.

Instream and Riparian Forest
Focal resources for these habitats include instream amphibians (potential for Cope’s giant and Olympic torrent salamanders, and Cascades and coastal tailed frogs). Bat species associated with instream habitats for foraging include Townsend’s big-eared and silver-haired bats and long-legged myotis. Historically, Dean Creek likely supported coho salmon and steelhead trout; however due to the low flow at the mouth of the creek and several barriers to passage, presence is highly unlikely.

Managed Wetland
The focal resources for this habitat type are amphibians (red-legged frog, Pacific chorus frog, rough-skinned newt, and northwestern salamander with a potential for long-toed salamander, and western toad). Mallard, great blue heron, wood duck, and Canada goose occasionally forage and rest in the impoundment during the nonbreeding period. Wood ducks historically nested within the wood duck boxes placed around the impoundment; however, these have since aged beyond repair. Bat species associated with wetlands for foraging include: Keen’s and long-legged myotis.

Table 4-3. Focal Resources Associated with Wetlands

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Requirement	Other Benefiting Species
Amphibians	Seasonal Freshwater Wetlands	Conditions vary from dry in late summer to as high as 3 feet in spring; Up to 80% short emergent vegetation (e.g., *Scirpus*, *Carex*, and *Juncus* spp.); Up to 10% cover of downed woody debris from the shoreline into the wetland; Absence of aquatic invasive plants and animals (e.g., American bullfrog, purple loosestrife, or Bohemian knotweed).	Year-round	Mallard, great blue heron, long-toed salamander, western toad, red-legged frog, Keen's and long-legged myotis
Instream Amphibians	Instream	Intact riparian corridor providing stream surface shade of 60-80%; Overstory riparian vegetation characterized by red alder, bigleaf maple, Douglas-fir, and western redcedar; Understory riparian vegetation characterized by Pacific rhododendron, salal, salmonberry, sword fern; <10% cover of invasive plants; Low amounts of fine sediments; Cool temperatures (<73°F) with a preferred temperature range (40-58°F); Well-oxygenated water, with dissolved oxygen levels >5 parts per million; Instream presence of large woody debris.	Varies	Cope's giant and Olympic torrent salamanders; Cascades and coastal tailed frog; coho (potential); steelhead (potential); Townsend's big-eared and silver-haired bats; long-legged myotis
Amphibians	Managed Wetland	Up to 80% short emergent vegetation (e.g., *Scirpus*, *Carex*, and *Juncus*); <20% of tall emergent vegetation (e.g., cattail); 10% cover of partially submerged, downed woody debris along the shoreline; <30% cover of shrubs and trees on the shoreline (e.g., salmonberry, redcedar, and hemlock saplings); Absence of invasive and nonnative species (e.g., American bullfrog and nonnative fish).	Year-round	Mallard, great blue heron, long-toed salamander, western toad, red-legged frog, Keen's and long-legged myotis

4.5.4 Refuge Management Activities

The impoundment was created at the Dawley Unit prior to acquisition by the Refuge. It appears to have been maintained by Mr. Dawley to support wildlife (a small nesting island and wood duck nesting boxes can be found in the impoundment). In addition, this structure may also support water levels in a nearby spring box which is part of the water delivery system for an adjacent residential parcel down slope. Consequently, high water levels are maintained by an existing water control valve which does not allow for maintenance of shallow water. Additional management includes control of woody vegetation on the dike along the southern shoreline of the impoundment to maintain the dike's structural integrity.

The only management action within the instream habitat has been limited water withdrawal to maintain water levels in the impoundment. No management activities have been implemented within the small seasonal wetlands on either unit.

4.6 Pileated Woodpecker

4.6.1 Overview

Pileated woodpeckers can be found year-round on the Olympic Peninsula. This species has been selected as a focal species for this plan because it plays a key role in the creation of habitat for other forest wildlife (e.g., owls, forest carnivores, etc.) through cavity excavation activities. Cavity excavation also facilitates creation of new snags and downed woody debris, a key component that is currently lacking in the forest structure of the Dawley Unit. Partners in Flight have identified this species as indicative of large snags located in multi-layered, mature forest (Altman 1999). Key attributes include forest structure and composition (see Section 4.6.3, Key Habitat Used, below). Important processes include natural disturbance regimes (e.g., fire, windthrow, and flood intervals) particularly as they maintain a mosaic of mature to old-growth forested habitat with a variable age class of appropriately sized snags.

Foraging activity has been observed on both units within small, remnant stands of mature forest.

4.6.2 Regional Distribution, Conditions and Threats

This species is a fairly common resident within suitable habitat throughout Washington. However, distribution is limited to elevations that support large trees for nesting, roosting and foraging. In addition, suburban landscapes with a higher percentage of forested habitats had higher densities of pileated woodpeckers in the rapidly urbanizing region around Seattle, WA (Blewett and Marzluff 2005). Historic distribution has declined concurrently with the loss of mature and old-growth habitat. This species is listed as Sensitive by the State.

Threats include loss of habitat, especially the decrease in density of large snags (>21 inches DBH) and large hollow trees, as well as loss of mature to old-growth forest mosaic with a size sufficient to support the species. Timber harvest has the most significant impact on habitat in the western U.S. Forest fragmentation and removal of large-diameter live and dead trees reduce habitat suitability and makes birds more vulnerable to predation. In addition, burning slash piles as a fuel reduction treatment after harvest effectively eliminates habitat (logs, snags and stumps) for prey species (e.g., carpenter ants). Bull et al. (2005) found that foraging activity was more abundant in untreated stands or in stands where fuels were reduced mechanically, largely because carpenter ants were more abundant in these stands when compared to the harvested and burned stands. Pileated woodpeckers have continued to use a 15-hectare (37-acre) old-growth stand for nesting and roosting before, during, and after it was selectively logged with a treatment that reduced fuel loads and accelerated regeneration because all green trees of any size and all snags and logs >37 centimeters (14.6 inches) DBH were retained; only small-diameter dead wood was removed (Bull and Jackson 2011).

4.6.3 Key Habitat Used

This species requires larger snags (5-18 snags >21 inches DBH and >25 feet tall/acre) or decadent trees (live trees with dead or broken tops) in early to moderate stages of decay for foraging, roosting and nesting (Mellen-McLean 2011). They occupy a relatively large home range size (minimum of 2,100 acres) within mature to old-growth, mixed coniferous forests.

4.7 Dunlin

4.7.1 Overview

Dunlin are one of the most abundant migrant shorebirds in the northern hemisphere. Within the Refuge, highest abundance is found along the inner side of Dungeness Spit and the coastal lagoon of Graveyard Spit where this species forages and roosts during low tide. Dunlin are the most abundant shorebird in this area during the winter months (Nov-Feb) with numbers regularly reaching 4,000 on the Refuge (Sue Thomas, pers. obs.). Numbers are somewhat reduced during spring with estimates ranging from 675-1,220 (Apr-May; Evenson and Buchanan 1997). Limited abundance (typically no more than 40) of roosting birds can be found along the outer side of Dungeness Spit and on the driftwood of the salt marshes during high tide.

Environmental processes important to dunlin include those that affect their preferred habitat type (coastal lagoon and mudflat) including continual, natural erosion of sandy bluff habitat and longshore drift sufficient to maintain the deposition of fine sediment to mudflats and driftwood logs (roosting substrate).

4.7.2 Regional Distribution, Conditions and Threats

Dunlin are one of the northernmost overwintering shorebirds on the Pacific coast. The race found in this area breeds on the Yukon-Kuskokwim Delta (Fernandez et al. 2010). Distribution within the Puget Sound appears to be fluid with flocks frequently moving between several estuaries within the Sound as a response to disturbance, predation, and/or availability of foraging resources. They can be found within the Salish Sea from mid-October to early-May.

The population estimate for dunlin in North America is 1,525,000 with estimates for the *pacifica* subspecies ranging from 500,000 to 600,000; however, confidence in this population estimate is low (Fernandez et al. 2010). The *pacifica* subspecies is listed in the U.S. Shorebird Conservation Plan (Brown et al. 2001) as a subspecies of high concern. Due to a long life span (up to 14 years) and low reproductive output (fledging success estimated at roughly 36%), and limited migration stop-over locations, this species is particularly vulnerable to threats.

Human-caused wildlife disturbance is perhaps the single, most pervasive threat to dunlin in the Salish Sea due to increasing tourism and residential development. Any disturbance, however brief, can reduce the amount of time spent foraging and increase energetic demands through flight. These effects are compounded in the spring staging period when dunlin have a particularly short period of time in the spring to fatten up for the long flight back to their Arctic breeding grounds. If they do not manage to acquire sufficient reserves to arrive on the breeding grounds, lay and incubate eggs, reproductive success will be negatively affected. On the nonbreeding grounds, adult survival is the key limiting factor for this species. Dunlin typically lose body mass over winter and researchers believe this is due to the need to balance good physical conditioning necessary to escape predation, with the high energy costs of foraging (Warnock and Gill 1996). If continually disturbed during this time, dunlin may not be able to consume enough prey to survive, particularly through severe winter storm events, given the low body mass maintained during this time period (Buchanan 2006). If disturbed too frequently in one location, they will avoid that site even if suitable habitat is available.

Due to the vulnerability of this species' preferred habitats (see description of Barrier Lagoon and Mudflat in Section 4.3), dunlin are considered highly susceptible to oil spill contamination. Oil spills can result in direct mortality due to plumage fouling and toxicity, or indirect threats due to reduced invertebrate food resources. Creosote contamination can reduce the abundance of invertebrate food resources as well. A high abundance of forage species is especially important for dunlin prior to migration because an inability to build up fat reserves here can reduce survival and/or reproductive success on the breeding grounds.

Habitat loss and degradation resulting from changes in the influx of freshwater and nutrients; shoreline armoring and changes in deposition of sediment and nutrients; and encroachment of mudflats by invasive plant species (e.g., Common cordgrass; Fernandez et al. 2010) or aquaculture all pose serious threats to dunlin, particularly on the wintering grounds. In fact, the subspecies has experienced a 30-91% loss of wintering grounds throughout its range (Warnock and Gill 1996). This can result in reduced foraging efficiency and overwintering survival as a result of increased density at remaining sites.

Predicted threats associated with climate change include sea level rise inundating low lying coastal habitats such as mudflats and increased frequency and intensity of storms and wave heights, which will negatively affect dunlin due to their vulnerability during the overwintering period and potentially further reduce habitat suitability. For more information, see description of Barrier Lagoons and Mudflats in Section 4.3.

4.7.3 Key Habitat Used

Dunlin primarily forage on mudflats and coastal lagoons. Specifically, they prefer substrates composed of fine silt virtually devoid of vegetation. Dunlin will forage in water up to 2 inches deep. Their main prey includes polycheate worms and tiny, shrimp-like amphipods and tanaids (Warnock and Gill 1996). During high tide they typically roost on the sandy beach and driftwood found on the Refuge, but in a considerably lower abundance.

4.8 Pacific Harbor Seal

4.8.1 Overview

The most abundant, widespread marine mammal on the Refuge is the Pacific harbor seal (harbor seal). They primarily use the barrier beach to pup or molt. Coming on shore is referred to as "hauling out" and is typically dependent on time of day and tidal height. Pinnipeds also haul out to sleep and conserve energy. Within the Salish Sea, they 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).

Key attributes include protection from human-caused wildlife disturbance at haulouts; habitat free of contaminants and marine debris; degradation or loss of habitat; and reduction in food supply. Important processes include ongoing, gradual erosion of bluffs and longshore drift to maintain haulout beaches and processes that affect prey (see Section 4.10, Anadromous and Forage Fish).

4.8.2 Regional Distribution, Conditions and Threats

Harbor seals can be found throughout the northern hemisphere in nearshore waters of the Atlantic and Pacific Ocean. They are nonmigratory, but long distance movements among sites in the North Pacific have been documented (Calambokidis and Baird 1994).

Until 1960, Washington State managed this species through a "bounty" and it was severely depleted until it was protected by the Marine Mammal Protection Act. Currently, the population estimate for Washington is approximately 22,380 (NOAA Fisheries 2011). In Washington and Oregon, harbor seals are divided into two stocks: coastal and inland. Based on summer haulout counts, the population estimate for the Strait of Juan de Fuca is approximately 2,000 seals, which is considered "optimum sustainable population" (Jeffries et al. 2003). Haulout numbers can range from 100-500 seals, particularly near the tip of Dungeness Spit and along the shorelines of Graveyard Spit, all areas closed to public use (Jeffries et al. 2000). This species exhibits strong site fidelity to their usual haulout locations during pupping and molting seasons (Suryan 1998).

The primary threats to harbor seals in the Salish Sea are human-caused wildlife disturbance and habitat contamination. Although harbor seals react differently to disturbance depending on their degree of previous experience, age, sex, location, and life cycle stage, they are all vulnerable to human-caused wildlife disturbance (Sanguinetti 2003). For instance, 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); the most typical cause of abandonment is due to human-caused wildlife disturbance. Within 30-40 days, pups double their birth weight prior to weaning. Without adequate time to nurse, weight gain is impaired and pup mortality rates increase. Some pups are found within the public use area of the Refuge. Typically the mother is nearby foraging or waiting for visitors to pass. The mother will not approach the pup until humans have left the area. This often results in the misconception that the pup has been abandoned. If people remain with the pup for long periods of time, the pup will weaken due to lack of nourishment and stress. If left alone, the mother may return to shore and coax the pup back into the water and to a more protected site.

Seals are popular ecotourism targets, which can multiply the number of disturbances in a day. Increasing ecotourism combined with an increasing human population and marine recreation in the Salish Sea pose a threat to pinnipeds in the area. Several studies have noted that pinnipeds have a disproportional, negative response to approach by kayaks in contrast to other recreational vessels (Szaniszlo 2001, Grella et al. 2001) potentially due to the stealthy, low profile approach of a kayak. In fact, Calambokidis et al. (1991) noted that harbor seals in the southern Puget Sound were disturbed by kayaks at a significantly greater distance than other boats. Persistent human-caused wildlife disturbance can change haul-out patterns.

Catastrophic events, such as oil spills or persistent contaminants, present a threat to harbor seals. High concentrations of chlorinated hydrocarbons (e.g., PCBs) have been noted in harbor seals of the Puget Sound. These contaminants can accumulate in the blubber and lead to birth defects or premature births (Calambokidis et al. 1991). In addition, curious juvenile seals can become entangled in derelict gear or become inadvertently captured in active fishing nets and aquaculture (net pen) operations.

Predicted effects due to climate change include loss of protected haulout habitat to rising sea levels; changes in sea-surface temperatures adversely affecting foraging resources and potentially increasing instances of bacterial infections.

4.8.3 Key Habitat Used

This species primarily uses the barrier beach habitat to haulout. 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% of their time onshore (Jefferies et al. 2003). Mother-pup pairs usually segregate from main haulout groups (Kroll 1993) and can be found anywhere along the shoreline of the barrier beach. The barrier beach surrounding Graveyard Spit is considered a nursery area (Jeffries et al. 2000).

4.9 Amphibians

4.9.1 Overview

Four species of amphibians are known to occur on Refuge lands: red-legged frog, rough-skinned newt, northwestern salamander, and Pacific chorus frog. These species can be found primarily within the forested and wetland habitats of the Dungeness and Dawley units. An additional eight species have the potential to occur on Refuge lands but have not been confirmed: ensatina; Cope’s giant, Olympic torrent, long-toed and western red-backed salamanders; Cascades and coastal tailed frogs and western toad.

4.9.2 Regional Distribution, Conditions and Threats

Pacific chorus frog, northwestern salamander red-legged frog, and rough-skinned newt are common in western Washington. The remaining species have the potential to occur on the Refuge because the Refuge occurs within their ranges and appears to provide suitable habitat.

Very little information is available on historic distribution or trends of amphibians. However, since there can be significant year to year variation in population size, long-term monitoring is necessary to determine population trends (Graham and Powell 1999, Paton 2002). In addition, abundance varies widely in relation to annual variation in weather. Consequently, assessment of management practices is challenging for these species.

Degradation, fragmentation, and loss of habitat all pose serious threats to amphibians. Many amphibians are long lived and reach sexual maturity after many years of growth. As a result, adult survival is considered a limiting factor for amphibians. In addition, their dispersal or migration distance is relatively limited to the immediate area around their breeding ponds, streams, or forests. For these reasons amphibian populations are relatively isolated and habitat buffers are increasingly important. Buffers provide cover, protection from siltation, filtration of pollutants, and protection from trampling. Suitable buffers can also mitigate changes in the microclimate around breeding ponds or streams. For instance, tree cover will reduce harmful UV rays and also decrease evapotranspiration of soil moisture. Human disturbance from road and trail construction, timber harvest and fire management may result in fragmentation of terrestrial habitat and breeding ponds (Graham and Powell 1999, Paton 2002). Logging activities should be scheduled to occur during the winter months to minimize soil compaction and litter layer disturbance (Graham 1997, Paton 2002).

Introduction of invasive or nonnative predators and contamination are additional threats. Nonnative species can have devastating effects on amphibian abundance. American bullfrogs are an introduced species in the Pacific Northwest and compete with native frog species and consume native amphibians. Since American bullfrog tadpoles require two years to mature, seasonal wetlands can be drawn down in July at least every two years and screens put in place at the outlet to isolate American bullfrog tadpoles for removal. In addition, the presence of nonnative fish such as trout can significantly reduce frog and toad tadpoles and amphibian larvae (Tyler et al. 1998).

Because their skins are permeable, amphibians are more susceptible to airborne contaminants and disease. In the Pacific Northwest, amphibians are sensitive to UV-B exposure as well. Possible effects of exposure to UV-B include increased mortality and incidence of deformities, slowed growth, and skin darkening (Belden and Blaustein 2002). The effects of climate change on amphibians are uncertain; however, impacts are anticipated as a result of changes in key habitat attributes (e.g., reduced soil moisture, increased temperatures, and changes in prey species phenology).

4.9.3 Key Habitat Used

Most amphibians spend a large part of their life near streams and wet environments within the forested habitats. Northwestern and long-toed salamanders, western toad, red-legged and Pacific chorus frogs, and rough-skinned newt require wetlands or ponds with tall emergent vegetation or downed woody debris to provide some degree of structure within the shallow water margin to support eggs. In addition, these species all require rotting logs, rodent burrows, and moist crevices found in downed woody debris of forested habitats during the remainder of their life cycle. There are four species of amphibians endemic to the Northwest that breed and deposit eggs in small streams (less than 6 feet or 2 meters wide). Dean Creek has the potential to support four of these secretive species: Cope’s giant and Olympic torrent salamanders and Cascades and coastal tailed frogs. These species require rocky, fast flowing streams with cool, oxygenated water and forested canopy cover that provides shade and leaf litter which nourishes aquatic invertebrate prey. In addition, many other species of amphibians use riparian habitats as corridors for movement. Amphibians typically require more than one habitat type for their life history needs. For instance, many amphibians lay their eggs in ponds, the larva develop and metamorphose in those same ponds. They then spend their adult life in the forests within a ½ mile of those ponds, returning in later years to lay eggs and the cycle continues. Thus, providing suitable corridors between habitat types is important, particularly to maintaining adult survival. Ensatina and western red-backed salamanders differ in that they rely exclusively on forested habitats with no wetland component to their life history needs. Woody debris, bark piles, and snags all provide important habitat components for these species, particularly in mature or old-growth forests.

While home ranges of salamanders tend to be very small, on the order of a few meters to a few dozen meters in diameter, some salamanders will disperse up to several hundred meters. Frogs and toads can move up to 1.5 miles; however, frogs especially appear to prefer to remain close (<700 meters [2,297 feet]) to their breeding sites (NatureServe 2011).

4.10 Anadromous and Forage Fish

4.10.1 Overview

Anadromous Fish

Anadromous fish spend most of their life at sea and return to freshwater habitats to breed. The Dungeness River is home to various populations of chinook, chum, bull trout, pink, and coho salmon; and steelhead and cutthroat trout (Shared Salmon Strategy 2007). Three populations are particularly dependent on nearshore habitats within Dungeness Bay and Harbor during the juvenile rearing period: Puget Sound chinook (Dungeness chinook), Hood Canal/Strait of Juan de Fuca summer chum (Dungeness summer chum) and Puget Sound/Strait of Georgia chum (Dungeness fall chum; Shared Salmon Strategy 2007). The remaining populations migrate through the estuary on route to more open waters in the Salish Sea or the Pacific Ocean and will not be covered in detail here. Chinook typically emerge from the river in early spring and spend up to a year rearing in the estuary. Timing of emergence from the river varies for chum based on life history stage and environmental conditions; however, they typically rear in the estuary for a few weeks before dispersing to other nearshore environments to continue development (Fresh 2006).

Important processes that affect anadromous fish use of nearshore habitats on the Refuge include gentle to moderate tidal circulation (maintains fine sediment and eelgrass) as well as precipitation and watershed drainage (influences salinity, temperature levels, sediment transport and contaminant levels). Due to their reliance on nearshore habitats, processes that affect these habitats are also important to salmonids, particularly those occurring in eelgrass beds and salt marshes which provide a high proportion of the prey species for juvenile salmonids and concealment from larger predators. Not only do juvenile salmonids rely on nearshore habitats for rearing, but all populations use the nearshore environment during some stage of their life cycle to undergo the physiological changes necessary to transition between predominantly freshwater and saltwater environments (e.g., emerging juveniles or returning adults). Key attributes of nearshore environments for anadromous fish include water temperature and salinity levels (affects development and transition from a freshwater “parr” to a saltwater “smolt”); presence of fine-grained substrates (promotes diverse food and cover) as well as a variety of habitat types (shallow sandy beach for prey, deeper water habitats for refugia as salmonids develop, eelgrass for cover); and absence of contaminants or altered nutrient input. The effects of these key attributes differ widely based on the species, population, size (fry vs. yearling) and life history strategy (rear in the estuary for up to a year vs. rearing in freshwater for 6 months; Fresh 2006). Further, limited information is known about how these components are affected by each attribute (Fresh 2006, Shared Salmon Strategy 2007).

Approximately 0.25 mile of Dean Creek runs through the Dawley Unit beginning at river mile 0.6. The lower 0.5 mile of this intermittent creek potentially supports coho, winter steelhead and cutthroat trout. Unknown species of resident fish have been noted in the stretch of Dean Creek that runs through the Refuge; however, no record of anadromous fish exists for the Refuge (EDPU 2005). According to the Elwha-Dungeness Watershed Plan (EDPU 2005), impassable fish barriers are located at river mile 0.5 and 1.2, effectively blocking return of any historic stocks found on Dean Creek. The plan also notes that fish passage can be severely limited at the confluence with the bay during the spawning period due to extreme low flows which often go underground near the bay.

Forage Fish
Nearshore habitats provide vital habitat for forage fish (Pacific herring, surf smelt, and Pacific sand lance) during their life cycle. They spawn within Dungeness NWR annually and larvae spend a portion of their first year drifting in the water column. Pacific herring spawn on marine benthic vegetation which drives processes and key attributes. For all of these species, key attributes are directly related to habitat needs. Pacific herring require healthy beds of eelgrass while surf smelt and Pacific sand lance require maintenance of sandy spawning beaches through functioning drift cells and sediment input from sandy bluffs and barrier beaches (Penttila 2007).

The known Dungeness/Sequim Bay Pacific herring stock spawning grounds are located in the west end of Dungeness Harbor encompassing a small portion of the eelgrass beds on Refuge lands. They typically spawn within Dungeness Bay from mid-January through the end of March. Surf smelt and Pacific sand lance can be found on the inside of the barrier beach of Dungeness and Graveyard spits as well as the southern shore of Dungeness Bay and Harbor. The surf smelt spawning season within Dungeness Bay occurs from May through February while Pacific sand lance can be found here from November through February (PSWQAT 2001). Pacific sand lance remain in the area during their first year of life.

4.10.2 Regional Distribution, Conditions and Threats

Anadromous Fish
The Endangered Species Act considers status of salmonids by evolutionary significant units (ESU). An ESU is a population or group of populations of Pacific salmon that is substantially reproductively isolated from other populations and that represents an important component of the evolutionary legacy of the species.

The boundary of the Puget Sound chinook salmon ESU extends from the Nooksack River in the north to southern Puget Sound, includes Hood Canal, and extends westerly out the Strait of Juan de Fuca to the Elwha River (Shared Salmon Strategy 2007). The proportion of this ESU originating in the Dungeness River has access to the historic spawning range, though return rates are low (200 spawners currently vs. an estimated capacity of 699) and reaches of the Gray Wolf River are underutilized (Shared Salmon Strategy 2007). This ESU appears to migrate north to the Canadian coastline via the east or west side of Vancouver Island (Shared Salmon Strategy 2007). Return rates vary from 3-6 years and they exhibit a high degree of natal stream fidelity. The status of the Puget Sound chinook ESU is listed as threatened and the status of the Dungeness population is listed as critical as indicated by the Salmon Stock Inventory compiled by WDFW (see http://wdfw.wa.gov/mapping/salmonscape/index.html). The return rate of Dungeness chinook has been less than 200 adult fish for the past 20 years compared to an estimated historic abundance of 8-9,000 (Shared Salmon Strategy 2007). Productivity has increased from 0.12 in 1986-1990 to 0.70 from 1994-1998, yet it is still below 1.0, the amount necessary to maintain the population. Approximately 83% of the population originates from hatchery-raised stock (Shared Salmon Strategy 2007).

There are two populations of chum that use the nearshore habitats of Dungeness NWR for rearing, including summer and fall chum. Limited population-specific information exists for summer vs. fall chum. However, due to the listed status, the Hood Canal summer chum ESU distribution is well defined and includes all naturally spawned populations of summer-run chum salmon in tributaries to the Hood Canal, Discovery Bay, Sequim Bay, and the Dungeness River. Reports of chum spawning in the Dungeness River are collected from incidental observations taken during surveys for chinook and pink salmon. They are typically observed in the lower Dungeness River, but have been noted as high as the Dungeness Hatchery. There are no data prior to 1980 that indicate the presence of a summer chum stock in the Dungeness River (http://wdfw.wa.gov/webmaps/salmonscape/sasi/full_stock_rpts/2528.pdf). Chum are known to migrate to the North Pacific and Bering Sea, spend 2-4 years at sea, and return to natal spawning grounds. Some evidence exists that this species is less faithful to natal streams. The status of the Hood Canal summer chum ESU is listed as threatened. According to the Shared Salmon Strategy (2007), the Hood Canal summer chum experienced a severe drop in abundance in the 1980s, and returns decreased to all-time lows in 1989 and 1990 with less than a thousand spawners each year. Recently, trends have shown a slight increase in naturally spawning stocks through 2002. The status of the Dungeness River component of this ESU is unknown as there have been no systematic surveys conducted for this species in this river. Researchers note that their numbers are so low that they may not represent a self-sustaining stock but could be strays from other stocks (http://wdfw.wa.gov/webmaps/salmonscape/sasi/full_stock_rpts/2528.pdf). The status of the Puget Sound/Strait of Georgia fall chum is not warranted for listing, while the status and trends of the Dungeness population of fall chum is unknown due to a lack of systematic surveys.

Forage Fish
Pacific herring spawning stocks have been surveyed annually since the mid-1970s. Pacific herring spawning beaches within the Puget Sound are geographically distinct and location does not vary among 20 known sites which includes Dungeness Bay. The Dungeness/Sequim Bay Pacific herring stock is listed as depressed; however, this stock may be the same as the Strait of Juan de Fuca regional stocks which are listed as critical.

Pacific sand lance and surf smelt are considered Washington Species of Greatest Conservation Need within the State Wildlife Action Plan (WDFW 2005). Pacific sand lance and surf smelt spawning grounds are considered widespread in the area with new beaches discovered each year. For more information see http://wdfw.wa.gov/conservation/phs/list/. Very little is known about the historic distribution, condition, or trends of Pacific sand lance and surf smelt within the Puget Sound due to the lack of a cost-effective survey methodology (Penttila 2007).

Threats
Threats to forage and anadromous fish relative to nearshore habitats include habitat loss or degradation, environmental contamination, degradation of water quality (salinity, temperature, and nutrients) and climate change. As with all nearshore habitats and species, shoreline armoring is the primary, persistent threat to these species. Essentially, armoring interferes with natural erosion from

bluffs to nearby shoreline and drift cells, this in turn reduces the input, particularly of fine-grained sediment, to spawning beaches. Pacific herring and juvenile salmonids are susceptible to any limitations in eelgrass beds as they are essential to providing a rich mix of prey species and cover. One critical period of time in the life cycle of Pacific herring is the period approximately one week after hatching, at which point larvae drift in the water column. If they do not encounter sufficient plankton to survive, the entire year class of that stock may be at risk (Stick and Lindquist 2009). This is particularly significant considering that Pacific herring live for only 4-5 years (PSWQAT 2001). In addition, aquaculture practices threaten the persistence of eelgrass beds and therefore Pacific herring spawning grounds.

Impacts from climate change are more difficult to predict for salmonids due to differences in adaptive strategies which vary by species, population, life history stage, etc. However, change in temperature is a well-known threat. A small increase in temperature can change migration timing, reduce growth, and increase the susceptibility of fish to toxins, parasites, and disease (Shared Salmon Strategy 2007). In fact, the distribution of salmon is in part dictated by temperature tolerances with most adult salmon unable to survive in water over 70° F (Lawler and Mathias 2007). Both rearing and completion of the physiological transition are affected by salinity and temperature levels with tolerance varying by species, population, time of year, and life history strategy (Fresh 2006). In addition, changes in salinity and temperature can change the composition of prey species as well as degrade habitat (reduce the supply of dissolved oxygen). Sea level rise threatens Pacific sand lance and surf smelt spawning habitat particularly if the rate of loss does not allow sufficient time for the upper intertidal zone to migrate into the backshore zone, or other impediments to migration exist such as armoring. This in turn threatens juvenile salmonids because forage fish are a primary source of prey to some life stages.

All fish are vulnerable to oil spills either directly or indirectly through habitat degradation and mortality of prey species (e.g., phytoplankton and zooplankton). Excessive nutrient input can be just as harmful as oil or contaminant spills leading to increases in algal blooms which, in turn, lead to decreased dissolved oxygen, decreased light levels, and increases in water temperatures.

4.10.3 Key Habitat Used

Anadromous Fish
Adult and juvenile salmon can be found within the matrix of nearshore habitats (e.g., eelgrass beds, mudflats, marshes, and shallow water adjacent to barrier beaches) year-round depending on the species and time of year. Chum spend more of their life history in marine waters than any other Pacific salmon species. Juvenile chum migrate to saltwater almost immediately after emerging from gravel, thus their continued survival depends on healthy estuarine environments. In Dungeness Bay and Harbor, this species typically spends a few weeks in the eelgrass beds. Pocket estuaries and small channels that end in the upper sections of salt marshes can be important for chinook fry rearing in the nearshore habitats. One limiting factor to fish distribution in these habitats is water temperature. As temperatures rise above 59°F, salmonids will limit their use. As juvenile chinook increase in size, they move deeper into the waters of the adjacent nearshore environment.

Forage Fish
Pacific herring spawn almost exclusively on marine benthic vegetation (e.g., eelgrass beds). In fact, Penttila (2007) indicates that Pacific herring spawning habitat is the critical life history element that can be identified and managed. The most important component is the presence of marine vegetation,

primarily eelgrass. The key element of both surf smelt and Pacific sand lance spawning habitat is the availability of a suitable spawning substrate. For surf smelt, this exists from approximately 7 feet to extreme high water and consists of sand or gravel of 1-7 millimeters (0.04-0.28 inch) (Penttila 2007). Pacific sand lance prefer a smaller grain size from 0.2-0.4 millimeters (0.01-0.02 inch) (Penttila 2007).

4.11 Threatened, Endangered, and Sensitive Species

One goal of the Refuge System is "To conserve, restore where appropriate, and enhance all species of fish, wildlife, and plants that are endangered or threatened with becoming endangered." In the policy clarifying the mission of the Refuge System, it is stated, "We protect and manage candidate and proposed species to enhance their status and help preclude the need for listing." In accordance with this policy, the CCP planning team considered all species with Federal or State status, and other special status species in the planning process. Table 4-4 lists species that are federally endangered, threatened, or candidate species and that are known to occur on or near Dungeness Refuge. A discussion of the federally listed species follows the table in Section 4.11.2.

A total of 5 federally listed species are known to occur on or adjacent to the Refuge. Marbled murrelet is known to occur adjacent to the Dawley Unit; however, the unit currently does not support suitable habitat. Limited observations of western snowy plover and sand-verbena moth have been noted on Dungeness Spit (see below), but habitat quality appears to be marginal. Two species of anadromous fish likely occur within the nearshore habitats of the Dungeness Unit including Puget Sound chinook and Hood Canal summer chum (see Section 4.10, Anadromous and Forage Fish, above).

Table 4-4. Federally Listed Species Known to Occur on or Adjacent to Dungeness Refuge

Common Name	Scientific Name	Federal Status	Current Occurrence on Refuge
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Adjacent to Refuge
Sand-verbena moth	*Copablepharon fuscum*	Candidate species	One collected in 2002
Western snowy plover	*Charadrius alexandrinus nivosus*	Threatened	Occasional observations according to historic records
Puget Sound chinook	*Oncorhynchus tshawytscha*	Threatened	Probable use of nearshore habitats
Hood Canal summer chum	*Oncorhynchus keta*	Threatened	Probable use of nearshore habitats

4.11.1 Habitat Needs, Conditions, and Threats of Federally Listed, Proposed, or Candidate Species

Marbled Murrelet
The marbled murrelet is a small diving seabird that breeds along the Pacific coast of North America. In the Pacific Northwest, it forages almost exclusively in the nearshore marine environment (mainly within a few kilometers of shore), but flies inland to nest in mature to old-growth conifers. Behavior

indicative of marbled murrelet nesting has been documented to occur adjacent to the Dawley Unit; however, the unit does not currently provide suitable habitat (B. Ritchie, pers. comm.).

The range of the marbled murrelet extends from Bristol Bay, Alaska, south coastally through British Columbia, Washington, Oregon, to northern Monterey Bay, California. Limited anecdotal information exists on the historic distribution and numbers of this species throughout its range. In the Puget Sound, marbled murrelets were considered "common," "abundant," or "numerous" as summarized in Speich et al. (1992).

The marbled murrelet is federally listed as a threatened species in California, Oregon, and Washington. The current overall estimate for the listed population is >18,000. Trend data indicate an annual decline of between 2.4% to 4.3% (Falxa et al. 2009). The combination of low demographic potential, small population size, and increased threats from human-caused habitat destruction or degradation could lead to extirpation of the marbled murrelet in portions of its range. This species reaches breeding maturity in two to four years (De Santo and Nelson 1995); however, they have a low rate of reproductive success. Murrelets may not nest every year, especially when food resources are limited (Nelson 1997). Breeding pairs produce a single offspring during reproductive years. The life span of marbled murrelets is unknown, but other members of the Alcid family live from 5-32 years (De Santo and Nelson 1995).

The Federal Recovery Plan for the Marbled Murrelet (USFWS 1997b) identifies the primary cause of population decline as loss of older forests. This species requires suitable canopy structures primarily found in mature and old-growth forest stands for nesting. Habitat degradation or fragmentation resulting in increased densities of nest predators and reduced prey availability also limit long-term productivity and survival of this species. Predation rates at marbled murrelet nests have been found to be extremely high in some areas. Corvids are thought to forage using visual cues and have been identified as primary marbled murrelet nest predators. A more complex forest has larger canopy mass in multi-dimensions that can help to conceal the location of nests from such visual predators (Rudnicky and Hunter 1993, Wilcove 1985, Yahner and Cypher 1987). Adult mortality caused by predation, impacts from the effects of oil spills, entanglement in fishing gear, chronic water pollution, aquaculture, and disturbance at nesting and foraging sites have also been identified as potential limiting factors.

While the Dawley Unit does not currently provide suitable habitat, appropriate habitat management over the next 50-75 years may produce habitat with a high probability of recruitment due to the proximity of marine foraging habitat as well as occupied territories immediately to the south. Stands that lie further from feeding areas require the adults to expend more energy to provision the nest. Newly fledged chicks may have a greater likelihood of successfully reaching the marine waters if their nest is closer to the shoreline. Suitable nesting habitat adjacent to or near an occupied stand offers more opportunities for population expansion. This may also help maintain localized breeding productivity if a catastrophic event such as a wildfire or wind storm destroys a nesting stand. Within the range of the listed population, marbled murrelets are found in the vicinity of large tracts of older forests and within 50 miles of marine waters. Marbled murrelet nests are often located in the largest trees in the stand (Jordan and Hughes 1995, Singer et al. 1995) which typically require 200 to 250 years or more to attain necessary attributes (USFWS 1996). However, younger stands with an abundance of dwarf mistletoe, or stands with numerous older legacy trees remaining from a previous stand can develop characteristics of nesting habitat at a younger age. Nest site selection is highly dependent upon the availability of potential nesting surfaces, or platforms (Nelson 1997). The minimum requirements of suitable nesting platforms are defined by the recovery plan as large diameter branches (>4 inches) at > 33 feet above the forest floor within trees of 28 feet DBH or greater (USFWS 1997b). Potential nesting platforms can be found in the form of large lateral limbs; branches creating a fork with the space between bridged by canopy litter; a high incidence of dwarf mistletoe infestation which creates witches brooms; or an abundance of canopy defects due to damage caused by environmental conditions (ice, lightning and wind storms), insects, or other processes that create growth abnormalities. Nest limb diameters in Washington range from 14 to 50 centimeters (5-20 inches); limb heights from 20 to 53 meters (66-174 feet) with the majority of nests located in the upper half of the tree crown (Hamer and Nelson 1995).

Other factors which appear to contribute to the suitability of habitat for marbled murrelet nesting are cover, stand size, and location on the landscape. Cover directly above and adjacent to the nest appears to be an important attribute. Occupied stands in Washington have a mean canopy cover of 81% (Hamer 1995) and 87% of all nests in the Pacific Northwest had greater than 74% immediate overhead cover (Hamer and Nelson 1995). Stand size may influence the quality of the stand by affecting the amount of available interior habitat, nest predation and disturbance levels. Reduced levels of predation were shown to occur where nests were higher in a tree, farther from a recently disturbed edge, and in mature stands with higher and deeper canopies (Naef 1996). Nelson and Hamer (1995) noted that marbled murrelet reproductive success was correlated to distance from an edge with all but one successful nest greater than 55 meters (180 feet) from an edge.

Sand-verbena Moth

The Sand-verbena moth is a nocturnal moth that was first described in 1996 from specimens collected near Sidney, British Columbia, and Whidbey Island, Washington (COSEWIC 2003). Currently, the moth's known global population is restricted to the Salish Sea (Wild Earth Guardians and the Xerces Society 2010). It has been recorded at 10 sites throughout its range (4 sites in Canada and 6 sites in Washington) one of which is Graveyard Spit. One moth was collected on the spit in 2002.

This species is currently a candidate for listing in the United States and is listed in Canada as Endangered under the Species at Risk Act. Since the moth was first described in 1996, trends are unknown. However, the listed population in Canada is estimated to total less than 10,000 (COSEWIC 2003) and a rough estimate of the U.S. population has been noted as "likely just a few thousand, but possibly more than 10,000" (Wild Earth Guardians and the Xerces Society 2010). The primary threat to this species is limited habitat availability, particularly for its sole obligate host plant, yellow sand-verbena. Vegetation stabilization as a result of natural succession on strand habitat often results in more dense cover of native strand plants. Yellow sand-verbena requires "chronic natural disturbance to maintain open sand areas…or new sand deposition…" (Wild Earth Guardians and the Xerces Society 2010). Additional reasons for loss of habitat are due to human development, coastal erosion, and invasive plant species (e.g., European beachgrass). Climate change poses a serious threat to this species' habitat because it is predicted to increase the intensity and number of storm events which in turn could lead to increased coastal erosion particularly of low-lying barrier beaches. Ultimately, sea level rise could limit habitat availability.

The sand-verbena moth requires large (>500 square meters or 0.1 acres), dense (>25% cover) patches of yellow sand-verbena. Yellow sand-verbena in turn requires open sand habitat free of competition from other plants (COSEWIC 2003). The host plant, and therefore sand-verbena moth, are typically found within 5 meters (16 feet) of the high tide line, rarely >50 meters (164 feet) (COSEWIC 2003).

Western Snowy Plover
The western snowy plover is a subspecies of the snowy plover with an isolated breeding population found only along the Pacific Coast from Midway Beach, Washington, to Bahia Magdalena, Baja California, Mexico. Currently, distribution of this species in Washington is limited to Midway Beach and Leadbetter Point (Pearson et al. 2010). Up to 6 individuals were observed on Dungeness Spit in May and June of 1995; one was observed in May of 1996 and a final observation was reported on Dungeness Spit in April, 2012.

This population was listed as threatened under the ESA in 1993. A recent population estimate suggests that the population in Washington is declining and is not maintained by local production (Nur et al. 1999). According to the USFWS (2007b) habitat degradation caused by urban development and introduced beachgrass; human-caused wildlife disturbance; and expanding predator populations have resulted in a decline in active nesting areas and in the size of the breeding and wintering populations. In Washington, egg predators, inclement weather, shoreline modification, dune stabilization, and recreational activities have been attributed to reduced nest success and have been cited as the causes of local population declines (WDFW 1995). Lafferty (2001) found that disturbances to wintering snowy plovers are 16 times higher at a public vs. a protected beach. Humans, dogs, American crows, and other birds were the main sources of disturbance. Human-caused wildlife disturbance has been shown to negatively affect hatching rates, chick survival, and feeding rates for various plover species (Lafferty 2001, Dowling and Weston 1999; Flemming et al. 1988).

The coastal population of snowy plover nests primarily above the high tide line on a variety of nearshore habitats including sparsely vegetated barrier beaches (USFWS 2007b). In winter, snowy plovers are found on beaches used for nesting as well as on beaches where they do not nest (USFWS 2007b). Dungeness and Graveyard spits do not appear to provide suitable habitat for nesting due to the density of native strand vegetation covering all but limited overwash locations on the tip of Dungeness Spit.

4.12 Invasive and Nuisance Species

One of the most striking attributes of invasive plants and animals are their impacts on refuge natural resources. Invasive plant species displace native vegetation, altering the composition and structure of vegetation communities, affecting food webs, and modifying ecosystem processes, which result in considerable impacts to native wildlife.

4.12.1 Exotic and Invasive Plant Species

Many invasive plant species infest and degrade the terrestrial habitats on the Refuge. Several plant species were introduced as ornamental plants (e.g., Bohemian knotweed and Dalmatian toadflax) and have escaped and spread into barrier beach, grassland, forest, and riparian habitats. Some highly invasive species (e.g., common cordgrass and Canada thistle) can produce monotypic stands that completely displace native and desirable plant communities. Native plant communities provide essential habitat that supports high priority species and species groups on the Refuge (e.g., migratory birds). The Refuge's overall strategy to manage invasive plants is based on an IPM approach. Mechanical, physical, and chemical methods are used to control invasive plants as a basis for achieving desirable habitat conditions. Many factors affect efficacy of control efforts for invasive plants. For species with the largest infestations within the Refuge (e.g., Canada thistle), IPM strategies involve treating new spot infestations while working to eradicate the main infestation areas.

There are twelve species of plants found on the Refuge (Table 4-5) which are classified by the Washington Department of Agriculture as noxious weeds.

Table 4-5. Washington Department of Agriculture Noxious Weeds Found on Dungeness Refuge

Common Name	Scientific Name
Common Cordgrass	*Spartina angelica*
Bohemian Knotweed	*Polygonum x bohemicum*
Herb Robert	*Geranium robertianum*
Dalmatian Toadflax	*Linaria dalmatica*
Oxeye daisy	*Leucanthemum vulgare*
Poison Hemlock	*Conium maculatum*
Scotch broom	*Cytisus scoparius*
Spurge Laurel	*Daphne laureola*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
Common (English) Ivy	*Hedera helix*
Himalayan Blackberry	*Rubus armeniacus*

The plants listed below are of the highest priority for the Refuge and are part of invasive species management.

Common Cordgrass
Found along the shoreline on the northeast side of Graveyard Spit. The Refuge has worked with the Washington Department of Agriculture since 2008 on the monitoring and removal of this invasive species. Currently, abundance of common cordgrass is considered very low.

Bohemian Knotweed
Originally found at the Dawley Unit residential area in 2009, treatment was initiated in 2010 resulting in only a few individual plants remaining in three separate clumps. These clumps were retreated in 2011. Monitoring will continue for the next several years to ensure that the plants have been eradicated

Dalmatian Toadflax
This species is found within the RNA of Graveyard Spit in an area associated with former military structures. It is unknown when this species first appeared, but it was listed in the Washington Native Plant Society's inventory of plants for Dungeness Spit in 1986. It may have arrived with a hiker or camper before the area was closed to the public in the early 1990s. Refuge staff and volunteers began eradication efforts in 2001 which has continued to the present time.

Control Efforts
An IPM approach is used, which includes a variety of tools such as mechanical/physical control, cultural control (e.g., crop rotation, prescribed fire, and weed-free mulch), biological control, pesticides, habitat restoration, and protocols preventing new introductions (see Appendix G, Integrated Pest Management Plan). Control efforts are planned annually, and Pesticide Use Proposals

(PUPs) are submitted to regional and/or national IPM coordinators for approval. All annual chemical applications are recorded and entered into the national PUPs database. Mechanical, physical, and chemical methods have been used to combat invasive plants in a variety of habitats. Pulling, cutting, and digging of shrubs, annual and biannual forbs have been very effective in our small patches. Cut-stump, injection, broadcast, and spot spray chemical applications have been used to treat the largest shrubs and perennial forbs.

4.12.2 Exotic Wildlife Species

Currently, there is no documentation of known exotic wildlife occupying Refuge lands. Refuge staff and volunteers have been monitoring for European green crab since 2001; however, none have been captured to date. Within the freshwater wetlands and the impoundment, American bullfrogs are considered a species of concern but no sign of American bullfrogs has been observed.

Occasionally, feral and domestic cats, and trespass dogs have been recorded on the Refuge. They prey on small mammals, birds, reptiles, and amphibians. In fact, domestic cats are considered the primary cause of extinction for 33 species of birds, worldwide, since the 1600s (Winter and Wallace 2006). It is estimated that these cats kill one billion birds annually in the United States (Dauphine and Cooper 2008). These predators are of management concern and are treated under the Refuge's IPM plan (See Appendix G).

4.13 Wildlife and Habitat Research, Inventory, and Monitoring

A Wildlife Inventory Plan was drafted in 1985 for all refuges under management of the Puget Sound NWRC which included Dungeness NWR. This plan recommended formal and opportunistic survey efforts to be implemented at Dungeness NWR for waterfowl (aerial brant surveys), shorebirds (point counts), raptors (area searches for peregrines and bald eagles), and marine mammals (aerial harbor seal surveys). Upon completion of this CCP, Refuge staff will begin development of an updated Inventory and Monitoring Plan for the Washington Maritime NWRC, to include Dungeness NWR.

The following is a list of surveys, research, and monitoring projects that have been conducted on the Refuge since it was established, including surveys identified in the original Inventory Plan. Many of these efforts consist of collaborations between the Service, other State and Federal agencies, nongovernment organization (NGOs) and universities. This list may not be inclusive.

Surveys and Scientific Assessments:
- Mid-winter Waterfowl Survey
- Winter/spring brant surveys
- Fall/winter shorebird surveys
- Snowy plover breeding season survey
- Taylor's checkerspot habitat assessment
- Bald eagle and peregrine falcon surveys
- Eelgrass inventory and mapping
- Common cordgrass inventory
- European green crab surveys
- Dalmatian toadflax inventory
- Water quality monitoring

- Forage fish spawning survey
- Sand-verbena moth survey
- Creosote-covered driftwood inventory
- Creosote assessment in Puget Sound beaches
- Water circulation study in Dungeness Bay and Harbor

Research projects:
- Brant and harbor seal disturbance study
- Caspian tern breeding success
- Benthic macroinvertebrate community monitoring
- Harbor seal genetic sampling and disease screening
- Salmonid distribution and habitat use in Dungeness Bay

Citizen science projects:
- Coastal Observation And Seabird Survey Team (COASST)
- Microplastics monitoring
- Project Feederwatch
- Christmas Bird Count
- Bird-a-thon

4.14 Paleontological Resources

4.14.1 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.

The landscape of the Puget Lowland and Strait of Juan de Fuca 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 began 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. 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 1,000 meters (3,280 feet) 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 (2,756 feet). Retreat of both lobes began shortly after 14,500 years Before Present (yr BP), and by 12,000 yr BP the northeastern Olympic Peninsula and northern Puget Lowland were ice free.

4.14.2 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 and Webb et al. 1989 cited 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 approximately 37 miles southeast of Dungeness NWR) 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 cited 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.

Dungeness NWR

In 1989, a two-foot section of a mastodon tusk was discovered by a visitor at the base of the bluff near the sanitary facilities on Dungeness Spit and turned over to the Refuge's manager (Raymond 1989). An April 1990 incident report notes that a visitor found what was identified as a mammoth tooth on Dungeness Spit approximately ½ mile out on the outer beach (Strait side). The tooth was turned over to a Refuge volunteer. According to the project leader (K. Ryan, personal communication 21 February 2012), there are some paleontological specimens being curated in the Refuge office. Whether they are the above-described specimens has not been verified, but it is likely that they are.

In March 1994, a Sequim resident examining the cliff of glacial till after a storm discovered the stump end of a mammoth tusk. The find was confirmed by paleontologist Bruce Crowley of the Burke Museum. The specimen was reported to be 6 feet long. According to USFWS Regional Cultural Resources Team records, a loan agreement was prepared for long-term curation of the tusk at the Burke Museum. The agreement is long-expired, and no additional action has been taken regarding the item. A newspaper article prepared at the time of the discovery noted that the "mammoth tusk appears to be entombed in a 100,000 year-old layer of glacial debris and clay known to contain a lot of fossils and to be possibly associated with volcanic mud flows" according to amateur paleontologist Richard Dobbs, who discovered the fossil (Seattle Times, accessed online at http://community.seattletimes.nwsource.com/archive/?date=19940329&slug=1902831, 21 Feb 2012).

Although no other known specimens have been documented, the possibility of finding paleontological resources on the Refuge is considered high. The collection and curation of paleontological resources should be managed under the Department of the Interior's Museum Property program and the Paleontological Resources Preservation Act (PRPA) of 2009.

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