Chapter 3
Physical Environment

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Chapter 3. Physical Environment

3.1 Climate and Climate Change

3.1.1 General Climate Conditions

The climate at Dungeness National Wildlife Refuge (NWR) is a mild, mid-latitude, west coast marine type. Because of the moderating influence of the Pacific Ocean, extremely high or low temperatures are rare. Summers are generally cool and dry while winters are mild but moist and cloudy with most of the precipitation falling between November and January (USDA 1987, WRCC 2011a). Annual precipitation in the region is low due to the rain shadow cast by the Olympic Mountains and the extension of the Coastal Range on Vancouver Island (Figure 3-1). Snowfall is rare or light. During the latter half of the summer and in the early fall, fog banks from over the ocean and the Strait of Juan de Fuca cause considerable fog and morning cloudiness (WRCC 2011a).

Climate Change Trends

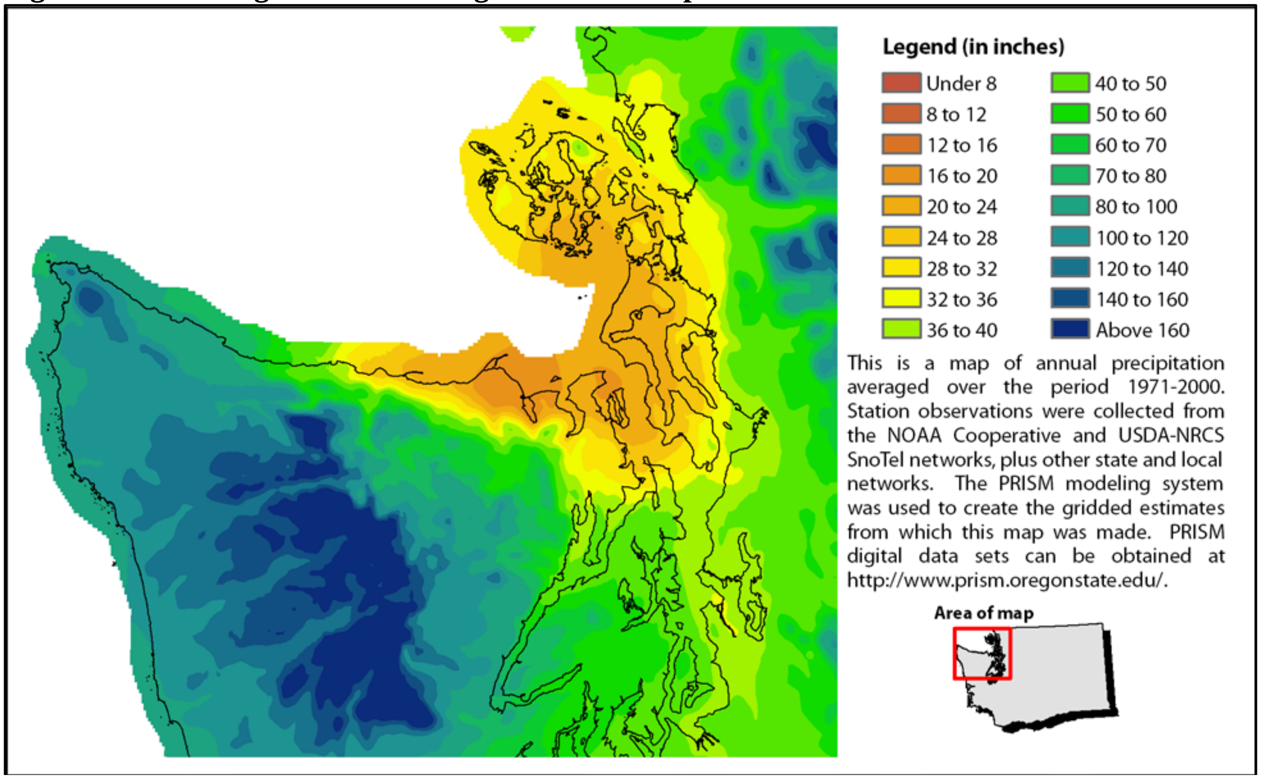
The greenhouse effect is a natural phenomenon that assists in regulating and warming the temperature of our planet. Just as a glass ceiling traps heat inside a greenhouse, certain gases in the atmosphere, called greenhouse gases (GHG), absorb and emit infrared radiation from sunlight. The primary greenhouse gases occurring in the atmosphere include carbon dioxide (CO_2), water vapor, methane, and nitrous oxide. CO_2 is produced in the largest quantities, accounting for more than half of the current impact on the Earth's climate.

A growing body of scientific evidence has emerged to support the fact that the Earth's climate has been rapidly changing and the magnitude of these alterations is largely due to human activities (IPCC 2007a, NAS 2008, USGCRP 2009). Increasingly, the role of human activities in the concentrations of heat-trapping greenhouse gases have increased significantly over the last several hundred years due to human activities such as deforestation and the burning of fossil fuels (Ibid).

Although climate variations are well documented in the Earth's history, even in relatively recent geologic time (e.g., the Ice Age of approximately 10,000 years ago), the current warming trend differs from shifts earlier in geologic time in two ways. First, this climate change appears to be driven primarily by human activity which results in a higher concentration of atmospheric GHG. Second, atmospheric CO_2 and other greenhouse gases, levels of which are strongly correlated with the Earth's temperature, are now higher than at any time during the last 800,000 years (USGCRP 2009). Prior to the start of the Industrial Revolution in 1750, the amount of CO_2 in the atmosphere was about 280 parts per million (ppm). Current levels are about 390 ppm and are increasing at a rate of about 2 ppm/year (DOE 2012). The current concentration of CO_2 and other greenhouse gases as well as the rapid rate of increase in recent decades are unprecedented in the prehistoric record (Ibid).

The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). The term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007b). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (Ibid).

Figure 3-1. Washington State Average Annual Precipitation from 1971 to 2000

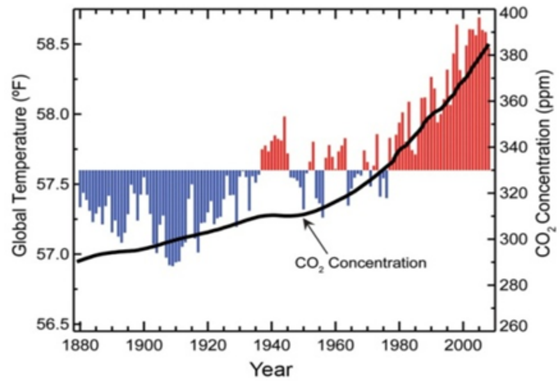


Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s (Figure 3-2). Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (e.g., IPCC 2007b and Solomon et al. 2007). In the Pacific Northwest, increased greenhouse gases and warmer temperatures have resulted in a number of physical and chemical impacts. These include changes in snowpack, stream flow timing and volume, flooding and landslides, sea levels, ocean temperatures and acidity, and disturbance regimes such as wildfires, insect, and disease outbreaks (USGCRP 2009). All of these changes will cause major perturbations to ecosystem conditions, possibly imperiling species that evolved in response to local conditions.

Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is "very likely" (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007b, Solomon et al. 2007). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), who concluded that it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

In the Northern Hemisphere, recent decades appear to be the warmest since at least about A.D. 1000, and the warming since the late 19th century is unprecedented over the last 1,000 years. Globally, including 2011, all 11 years in the 21st century so far (2001 to 2011) rank among the 13 warmest years in the 130-year instrumental record (1880 to present) according to independent analyses by NOAA and NASA. 2010 and 2005 are tied as the warmest years in the instrumental record and the new 2010 record is particularly noteworthy because it occurred in the presence of a La Niña and a period of low solar activity, two factors that have a cooling influence on the planet. However, in general, decadal trends are far more important than any particular year's ranking.

Figure 3-2. Global Annual Average Temperature and CO_2 from 1880-2008 (NOAA 2012a)



Global annual average temperature (as measured over both land and oceans). Red bars indicate temperatures above and blue bars indicate temperatures below the average temperature for the period 1901-2000. The black line shows atmospheric carbon dioxide (CO_2) concentration in parts per million (ppm). While there is a clear long-term global warming trend, each individual year does not show a temperature increase relative to the previous year, and some years show greater changes than others.[33] These year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and the eruption of large volcanoes.

Trends in global precipitation are more difficult to detect than changes in temperature because precipitation is generally more variable and subject to local topography. However, while there is not an overall trend in precipitation for the globe, significant changes at regional scales can be found. Over the last century, there have been increases in annual precipitation in the higher latitudes of both hemispheres and decreases in the tropical regions of Africa and southern Asia (USGCRP 2009). Most of the increases have occurred in the first half of the 20th century and it is not clear that this trend is due to increasing greenhouse gas concentrations.

Just as important as precipitation totals are changes in the intensity, frequency, and type of precipitation. Warmer climates, owing to increased water vapor, lead to more intense precipitation events, including more snowstorms and possibly more flooding, even with no change in total precipitation (Dominguez et al. 2012). The frequency of extreme single-day precipitation events has increased, especially in the last two decades. Paradoxically more droughts and heat waves have occurred because of hotter, longer-lasting high pressure systems.

3.1.2 Air Temperatures

There is no climate/weather station established on Dungeness NWR; however, temperature data have been consistently collected since October 1980 at the Sequim 2 E station (number 457544) located approximately 7 miles east of the Refuge. The proximity of this station to the Refuge provides valuable regional data. Table 3-1 provides a summary of the period of record.

As a result of the ocean's proximity, winter minimum and summer maximum temperatures are moderated. On average, 91.7 days per year experience minimum temperatures at or below freezing while 0.1 days per year experience temperatures at or below 0°F (WRCC 2011b). The coldest weather is usually associated with an outbreak of cold air from the interior of Canada. The first occurrence of freezing temperatures is usually in October (WRCC 2011c). The date of the last freezing temperatures in the spring ranges from the latter half of April to the first half of May (WRCC 2011d). Also, it is only in the extreme occurrences that temperatures have been recorded to exceed 90°F (WRCC 2011b).

Table 3-1. Air Temperature Summary near Dungeness NWR (WRCC 2011b)

Temperatures (°F)	**Sequim 2 E Oct. 1980 – Dec. 2010**
Average Monthly Temperature – High	57.6
Average Monthly Temperature – Low	39.3
Monthly Mean Winter Temperature – High	47.0
Monthly Mean Winter Temperature – Low	31.2
Monthly Mean Summer Temperature – High	68.6
Monthly Mean Summer Temperature – Low	49.0
Daily Maximum Extreme – High	94
Daily Maximum Extreme – Low	63
Daily Minimum Extreme – High	39
Daily Minimum Extreme – Low	-3

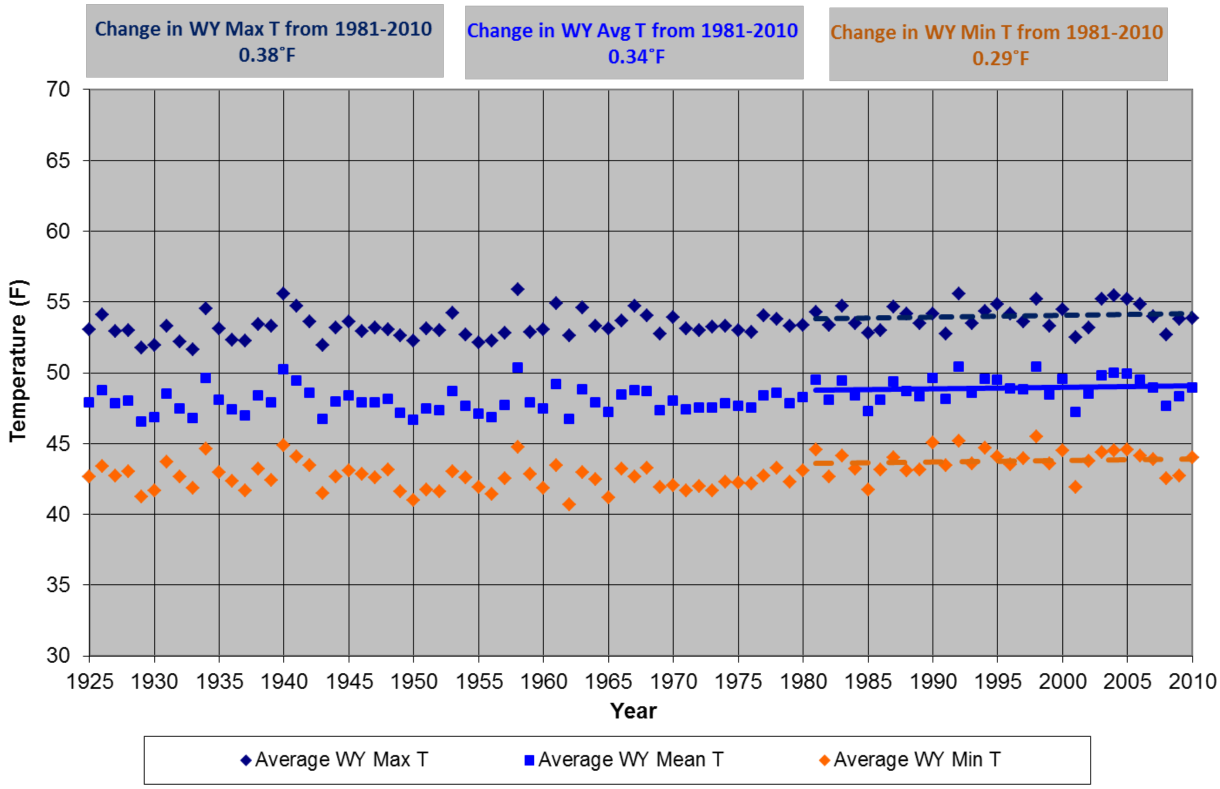
Mote (2003) observed that the Pacific Northwest region experienced warming of approximately 1.5°F during the 20th century. Fu et al. (2010) found that in Washington State from 1952 to 2002, annual mean air temperature increased 1.1°F (daily mean), 0.43°F (daily maximum), and 1.67°F (daily minimum), on average. For trends local to the Refuge we turn to the United States Historical Climatology Network (USHCN) which provides a high-quality data set of daily and monthly records of basic meteorological variables from 1,218 observing stations throughout the continental U.S. The data have been corrected to remove biases or heterogeneities from non-climatic effects such as urbanization or other landscape changes, station moves, and instrument and time of observation changes. The closest station is Port Angeles and trends are provided in Table 3-2 and Figure 3-3. The average yearly temperature change has increased 0.34°F over the past 30 years, and more striking are the seasonal trends which show warmer winters, summers, and falls than the yearly trends, and cooler springs (Table 3-2).

Table 3-2. Seasonal Temperature Trends, 1981-2010 (USHCN 2012)

Port Angeles, WA United States Historical Climatology Network Observation Station			
Monthly Absolute Change	Maximum Temp.	Average Temp.	Min. Temp.
Winter (Dec-Feb)	+1.36°F	+0.63°F	-0.11°F
Spring (March-May)	-0.60°F	-0.48°F	-0.36°F
Summer (Jun-Aug)	+0.46°F	+0.69°F	+0.93°F
Fall (Sept-Nov)	+0.36°F	+0.56°F	+0.77°F

The graph below illustrates a sample of these temperature trends using monthly data. The most recent 30-year period is calculated using the slope of the linear trendline, and temperature change is shown as an absolute change over the 30-year period. A water year is defined as the 12-month period from October 1, for any given year, through September 30 of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months.

Figure 3-3. Water Year Temperature 1925-2010 at Port Angeles, WA (USHCN 2012)



Future Trends

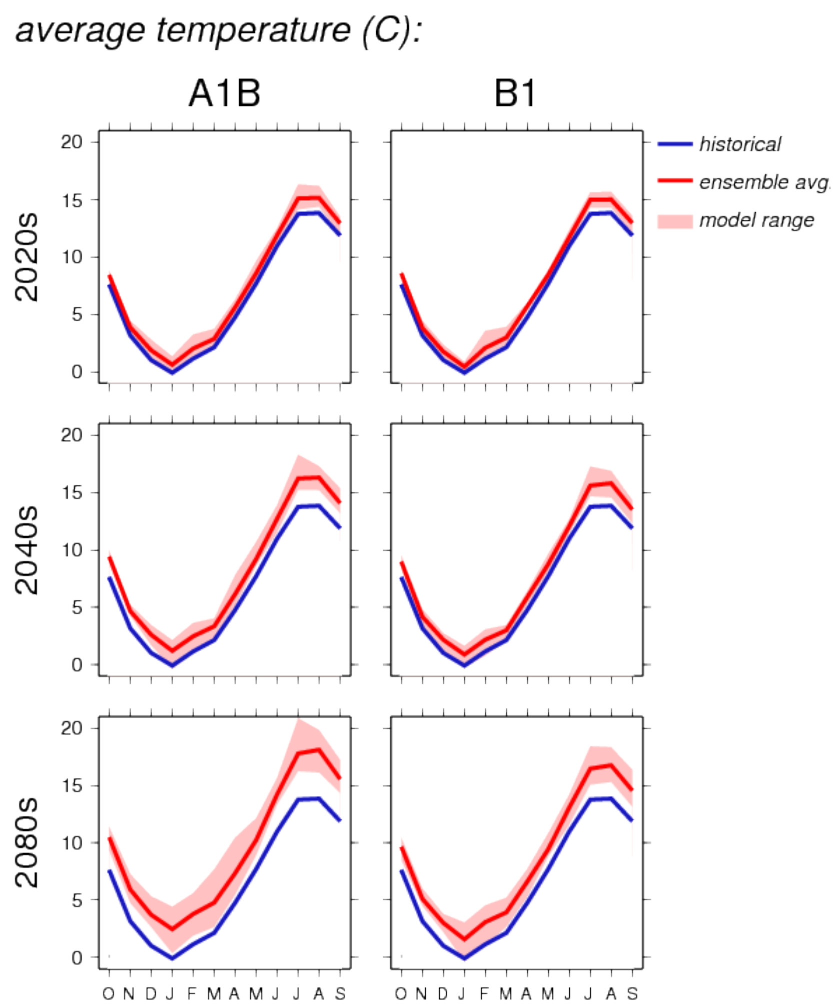
Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Meehl et al. 2007, Ganguly et al. 2009, Prinn et al. 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007c, Meehl et al. 2007, Ganguly et al. 2009, Prinn et al. 2011).

The statistical downscaling of an ensemble of 20 global climate models and two carbon emissions scenarios for each model run projects average annual temperature for the Pacific Northwest to increase 2.0°F (1.1°C) by the 2020s, 3.2°F (1.8°C) by the 2040s, and 5.3°F (3.0°C) by the 2080s, relative to the 1970-1999 average temperature (Mote and Salathé 2009 and 2010). The projected changes in average annual temperature are substantially greater than the 1.5°F (0.8°C) increase in average annual temperature observed in the Pacific Northwest during the 20th century. Seasonally, summer temperatures are projected to increase the most. The emissions scenarios modeled included the A1B scenario, which assumes moderate greenhouse gas emissions in the future, and the B2 scenario, which assumes low greenhouse gas emissions in the future. Actual global emissions of greenhouse gases in the past decade have so far exceeded even the highest IPCC emissions scenario (A2), which was not included in Mote and Salathé (2009 and 2010) or Salathé et al. (2010). Consequently, if these emissions trends continue the climate projections referenced herein likely represent a conservative estimate of future climatic changes.

The two regional climate simulations (Salathé et al. 2010) using a dynamical downscaling method with two global climate models (the CCSM3 and ECHAM5 – to specify boundary climate conditions within the region) support the warming increases described above, with small variations – one model slightly higher and one slightly lower. Both regional climate models project increases in heat wave frequency and the frequency of warm nights throughout the State of Washington.

Figure 3-4 shows these modeled, downscaled temperature projections for the Dungeness-Elwha watershed (HUC 17110020) (Hamlet et al. 2010).

Figure 3-4. Projected Temperature Changes for the Dungeness-Elwha Watershed under Two Emission Scenarios (Hamlet et al. 2010)



Note: A1B is a higher emission scenario than B1. Current rates are higher than both A1B and B1.

3.1.3 Precipitation

The prevailing wind direction across the Olympic Peninsula from the southwest means that storms frequently drop their moisture on the west side of the Olympic Mountains. Consequently, the relatively low precipitation at Dungeness NWR is the result of its location in the “rain shadow.” The rain shadow is an area that extends east from Port Angeles towards Everett and north into the San Juan Islands (Bach 2004).

The discussion below includes data from the climate station closest to Dungeness NWR, located in Sequim. An average of 8.12 inches, or roughly 50 percent of the annual precipitation, at this station occurs during late fall and winter in the months of November, December, January, and February. By comparison, the summer months of June, July, and August receive an average of 2.11 inches, a scant 13 percent of the annual precipitation. Additionally, the rate of rainfall within the rain shadow differs from other areas on the Olympic Peninsula. This area frequently receives drizzle or light rain while other localities are experiencing light to moderate rainfall (WRCC 2011a). On average, 5 days per year experience more than 0.50 inch of precipitation and 1 day greater than 1.00 inch (WRCC 2011e). Snow events are infrequent. However, snowfall increases with distance from water and rise in terrain. Consequently, the snow is a major source of water for the Dean Creek system, which passes through the Dawley Unit. Precipitation data for Sequim are summarized in Table 3-3.

Table 3-3. Precipitation Summary near Dungeness NWR (WRCC 2011e)

Precipitation (inches)	**Sequim 2 E Oct. 1980 – Dec. 2010**
Average Annual Precipitation	16.02
Average Annual Snowfall	1.5
Average Monthly Snowfall Range (winter)	0.2 to 0.9
Highest Annual Snowfall	13.7 (1989)
Highest Monthly Snowfall	25.0 (Dec. 1996)
Wettest Year on Record	20.51 (1997)
Driest Year on Record	11.35 (1994)
Wettest Season on Record	9.18 (winter 1997)
Driest Season on Record	0.41 (summer 2003)

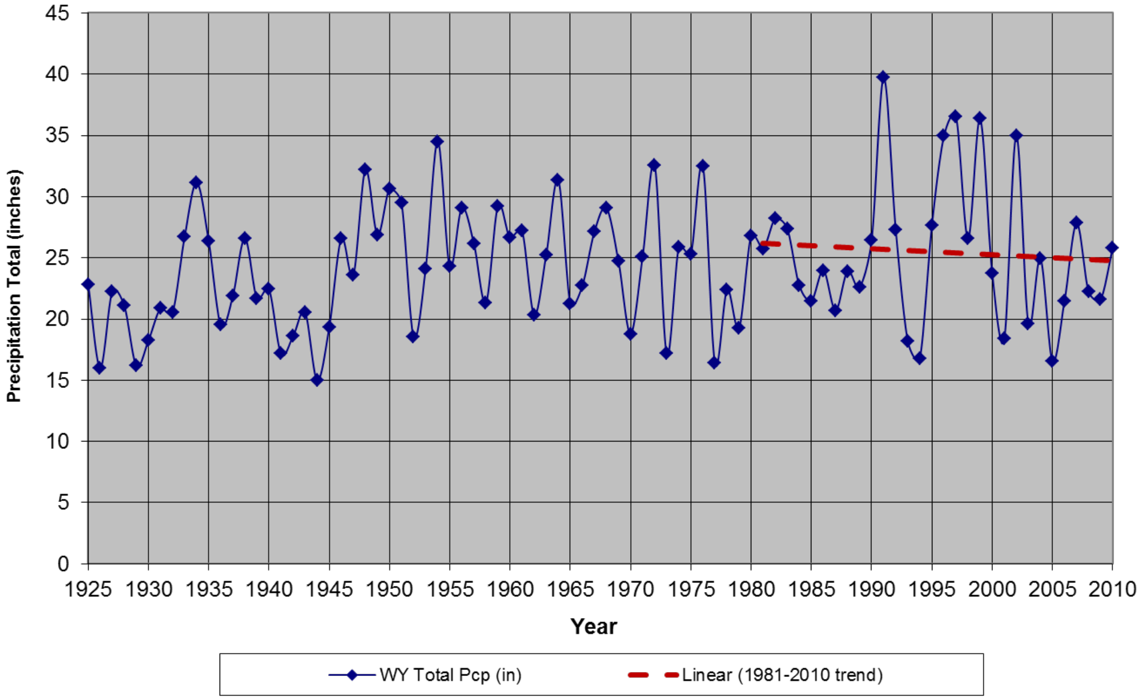
Longer-term precipitation trends in the Pacific Northwest are more variable than temperature and vary with the period of record analyzed (Mote et al. 2005). The Pacific Northwest experiences wide precipitation variability based on geography and seasonal and year-to-year variability (Salathé et al. 2010). Looking at the period 1920 to 2000, total annual precipitation has increased almost everywhere in the region, though not in a uniform fashion. Most of that increase occurred during the first part of the record with decreases more recently (Mote et al. 2005).

Precipitation trends from the Port Angeles USHCN observation station shows the average yearly precipitation change has decreased more than 5% over the past 30 years, with more striking decreases in the winter and increases in the summer (Table 3-4 and Figure 3-5).

Table 3-4. Seasonal Precipitation Trends, 1981-2010 (USHCN 2012)

Port Angeles, WA, United States Historical Climatology Network Observation Station	
Monthly Precipitation	30-year Change % from 1981 Value
Winter (Dec-Feb)	-17.1%
Spring (March-May)	14.3%
Summer (Jun-Aug)	-4.1%
Fall (Sept-Nov)	-1.6%

Figure 3-5. Water Year Total Precipitation 1925-2010 at Port Angeles, WA (USHCN 2012)

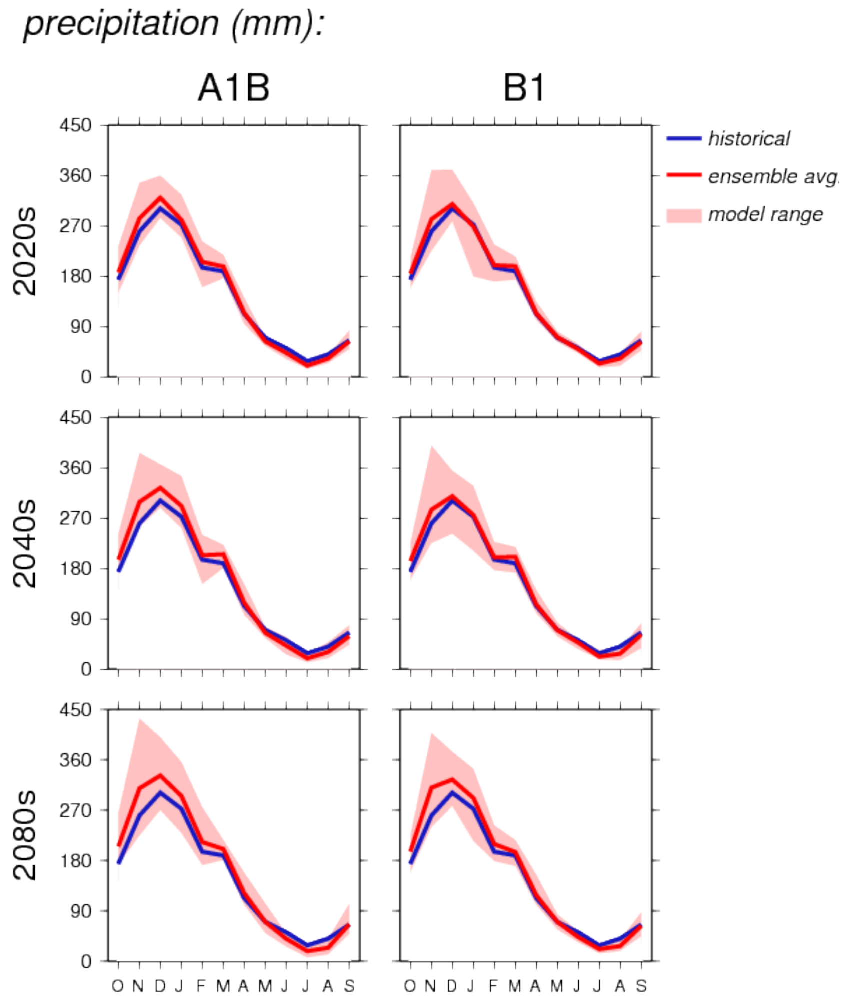


Future Trends

On a global scale, warmer temperatures are predicted to lead to a more vigorous hydrologic cycle, translating to more severe droughts and/or floods (IPCC 1996). Observations of Pacific Northwest precipitation trends through the 20th century indicate a region-wide increase of 14% for the period 1930-1995. Sub-regional trends ranged from 13%-38% (Mote 2003). However, these trends are not statistically significant and depend on the time frame analyzed. Thus, decadal variability has dominated annual precipitation trends. Cool season precipitation variability, though, has increased (Hamlet and Lettenmaier 2007).

Using data derived from the statistical downscaling of 20 global climate models, projected changes in annual precipitation within the Pacific Northwest throughout the twenty-first century, averaged over all models, are small (+1% to +2%) though individual models produce changes of as much as -10% or +20% by the 2080s. Some models project an enhanced seasonal cycle with changes toward wetter autumns and winters and drier summers (Mote and Salathé 2010). However, even small changes in seasonal precipitation could have impacts on streamflow flooding, summer water demand, drought stress, and forest fire frequency. Additionally, researchers have consistently found that regional climate model simulations yield an increase in the measures of extreme precipitation. This finding suggests that extreme precipitation changes are more related to increased moisture availability in a warmer climate than to increases in climate-mean precipitation (Leung et al. 2004, Salathé et al. 2010). Salathé et al. (2010) project increased extreme precipitation events in the State of Washington, with stronger increases in the northwestern portion of the state. The fraction of precipitation falling on days with precipitation exceeding the 20th century 95th percentile is projected to increase throughout the state. It is important to note that the one conclusion shared by researchers is that there is greater uncertainty in precipitation projections than that of temperature predictions and models (Leung and Qian 2003, CIG 2004, Salathé et al. 2010). Figure 3-6 shows these modeled, downscaled precipitation projections for the Dungeness-Elwha watershed (HUC 17110020) (Hamlet et al. 2010).

Figure 3-6. Projected Precipitation Changes for the Dungeness-Elwha Watershed under Two Emission Scenarios (Hamlet et al. 2010)



Note: A1B is a higher emission scenario than B1. Current rates are higher than both A1B and B1.

3.1.4 Wind

During the spring and summer, the semi-permanent low-pressure cell over the North Pacific Ocean becomes weak and moves north beyond the Aleutian Islands. Meanwhile, a high-pressure area spreads over the North Pacific Ocean. Air circulates in a clockwise direction around the high-pressure cell bringing prevailing westerly and northwesterly winds. This seasonal flow is comparatively dry, cool, and stable (WRCC 2011a).

In the fall and winter, the high-pressure cell weakens and moves southward while the Aleutian low-pressure cell intensifies and migrates southward as well. It reaches its maximum intensity in midwinter. Wind direction switches to primarily southwesterly or westerly prevailing winds. The air mass over the ocean is moist and near the temperature of the water. As it moves inland, it cools and condenses, bringing the beginning of the wet season (WRCC 2011a).

Wind data collected hourly from an automated station at the William R. Fairchild International Airport in Port Angeles, located 14.5 miles west of the Dungeness NWR, have been used to draw generalizations about wind activity in/on the Refuge (Table 3-5). Average wind speeds have been calculated on hourly data collected from 1996 to 2006. The highest average wind speeds occurred during the summer months of June and July. The calmest months were during the fall months of October and November.

Prevailing wind direction, defined as the direction with the highest percent of frequency, was calculated from hourly data during 1996 to 2006. Westerly winds occur from March through October, switching to southwesterly winds in November, and then to west-southwest during January, and southwest winds in February.

Table 3-5. Wind Data Summary for Port Angeles (WRCC 2011f)

	Port Angeles
Prevailing Wind Direction	W
Average Annual Wind Speed	5.2 mph
Average Monthly Wind Speed Range	4.2 (Jan., Oct., Nov.) – 6.6 (Jun., Jul.) mph

The open waters of the Strait of Juan de Fuca periodically allow very strong winds to develop, particularly during mid-latitude cyclone events (Reed 1980). Wantz and Sinclair (1981) published estimates of extreme winds in the Northwest. They estimate that speeds within the vicinity of Dungeness NWR sustained for an average of one minute and recurring on average every two years are as high as 50 mph, while fifty-year events would produce winds of approximately 68 mph. Peak gusts would be about 32% higher.

As a rule, tornadoes are infrequent in Washington and generally small in the northwestern part of the United States. The National Climatic Data Center maintains a database that provides information on the incidence of tornadoes reported in each county in the United States. This database reports that 107 tornadoes were reported in Washington from 1950 to 2011. No tornadoes have ever been reported in Clallam County (NCDC 2011).

3.1.5 Climate Cycles in the Pacific Northwest

Two climate cycles have major influences on the climate and hydrologic cycles in the Pacific Northwest: the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). In El Niño years, average sea surface temperatures in the central and eastern equatorial Pacific Ocean are warmer than average and easterly trade winds in the tropical Pacific are weakened. A La Niña is characterized by the opposite – cooler than average sea surface temperatures and stronger than normal easterly trade winds. These changes in the wind and ocean circulation can have global impacts to weather events. The ENSO influence on Pacific Northwest climate is strongest from October to March. During an El Niño event, the winters tend to be warmer and drier than average. La Niña winters tend to be cooler and wetter than average. Each ENSO phase typically lasts 6 to 18 months and the shift between the two conditions takes about four years (CIG 2011a, Conlan and Service 2000).

Like ENSO, the PDO is characterized by changes in sea surface temperature, sea level pressure, and wind patterns. The PDO is described as being in one of two phases: warm and cool. During a warm phase, sea surface temperatures near the equator and along the coast of North America are warmer while in the central north Pacific they are cooler. During a cool phase, the patterns are opposite. Within the Pacific Northwest, warm phase PDO winters tend to be warmer and drier than average while cool phase PDO winters tend to be cooler and wetter than average. A single warm or cool PDO phase lasts 20-30 years. The triggering cause of the PDO phase shift is not understood.

The potential for temperature and precipitation extremes increases when ENSO and PDO are in the same phases and thereby reinforce each other. When ENSO and PDO are in opposite phases, their opposite effects on temperature and precipitation can cancel each other out, but not in all cases and not always in the same direction (CIG 2011a).

Future Trends
Based on the evidence of the history of ENSO and PDO events, it is likely that these cycles will continue to occur far into the future. However, the potential influence of anthropogenic climate change on ENSO and PDO is unknown because more information is needed by the experts.

3.2 Hydrology

3.2.1 Refuge Hydrology

The circulation of Salish Sea region, which includes the Straits of Georgia, Juan de Fuca, and Puget Sound, is driven by tidal currents, the surface outflow of freshwater from river systems, and the deep inflow of saltwater from the ocean. The two major fresh water sources affecting the Refuge, the Dungeness River and Dean Creek, originate from the Olympic Mountains.

The headwaters of the Dungeness River begin in the steep alpine watershed of Olympic National Park. The Dungeness River and its tributaries drain about 200 square miles (322 square kilometers) and contain over 546 miles (879 kilometers) of river (Thomas et al. 1999). The Dungeness River flows generally north for about 32 miles, crossing the broad alluvial fan of the Sequim-Dungeness peninsula and into Dungeness Bay. The Dungeness and Graveyard Spits separate Dungeness Bay and Harbor from the Strait of Juan de Fuca.

Dungeness Spit is a narrow, high-energy spit which extends approximately 5 miles northeasterly into the Strait of Juan de Fuca. Graveyard Spit is a broader, sheltered spit which extends south 1.4 miles from and in the lee of Dungeness Spit at a point about 3 miles out, creating a narrow channel between its southern terminus and the mainland. Graveyard Spit separates Dungeness Bay into two parts: the outer Bay and the inner Bay. The inner portion of Dungeness Bay, also known as Dungeness Harbor, has a surface area of 1.8 square miles or 1,151.5 acres (Rensel 2003).

Larger amounts of snow fall in the upper part of the Dungeness River drainage basin. This snow, along with glacier ice, is a major source of water to the Dungeness River system (BOR 2002). The river is a bimodal flow river, showing two peaks over the course of the year: a smaller peak associated with winter storm flows and a larger peak associated with snowmelt and runoff in the late spring and early summer (EDPU 2005). According to the Dungeness-Quilcene Water Resources Management Plan (Jamestown S'Klallam Tribe 1994), "there is relatively little storage in the upper watershed, so that current-year precipitation directly controls runoff… and the rain shadow location exacerbates the late-summer low flow." Where the river empties into Dungeness Bay, the river flow situation is even more complex due to irrigation diversion and hydraulic continuity between the river and the shallow aquifer (Simonds and Sinclair 2002).

Groundwater is recharged primarily by precipitation, the Dungeness River and irrigation water. Recharge from irrigation ditch leakage may be predominating over precipitation recharge in some areas of the lower Dungeness watershed. Flow is generally south to north, following the slope of the land with the exception of some confined aquifers where vertical movement up or down is attributed to an artesian effect.

Dean Creek is an intermittent stream draining about one square mile. The creek drains the east side of Burnt Hill and the northwest side of Lookout Hill, flowing behind the 7 Cedars Casino into the southwest corner of Sequim Bay. A short (0.25 mile) reach of the creek runs through the Dawley Unit beginning at river mile 0.6 from Sequim Bay. The headwaters of Dean Creek begin at an elevation of 690 feet, approximately four miles from its mouth. The creek is in a degraded condition, has been culverted in various locations, and experiences severe flooding (EDPU 2005).

Tidal salt marshes are found on both the northern and southern ends of Graveyard Spit. Barrier lagoons and mudflats are located within the Refuge in the interior of both spits. Refuge mudflats are also east of Graveyard Spit in Dungeness Bay. Small (< 0.10 acre) seasonal freshwater wetlands are located within the Dungeness and Dawley Units. For more information on refuge wetlands, see Chapter 4.

A historic tidal lagoon and marsh was located at the base of Dungeness Spit. Today, dikes or old roadbeds, possible remnants of the old railroad grade or wharf, alter the hydrology of this tidal lagoon.

3.2.2 Tides and Salinity

The nearest National Ocean Survey tidal benchmarks to Dungeness NWR are located in Port Angeles, approximately 13 miles west, and Port Townsend, approximately 18 miles east. Additionally, soundings collected in Dungeness Bay bathymetry in 2000 were analyzed and modeled to provide local tidal datums (Rensel 2003). Tidal benchmark information for Port Angeles and Port Townsend for the 1983-2001 period and tidal datums calculated for inner Dungeness Bay is summarized in Table 3-6. Historic records of tides and water levels from the Port Angeles and Port Townsend tide stations are summarized in Table 3-7. Data for each station include mean ranges, diurnal ranges, and the minimum and maximum water levels on record where available. The mean range is the difference in height between the mean high water and the mean low water. The diurnal range is the difference between the mean higher high water (MHHW) and the mean lower low water (MLLW) of each tidal day.

Table 3-6. Tidal Benchmark Summary for Port Angeles and Port Townsend, Washington and Tidal Datum Summary for Inner Dungeness Bay (NOAA 2011a, NOAA 2011b, Rensel 2003)

Station Information	Port Angeles Sta. ID 9444090	Port Townsend Sta. ID 9444900	Inner Dungeness Bay (05/2000)
Mean Higher High Water (MHHW) (ft)	7.07	8.52	7.55
Mean High Water (MHW) (ft)	6.52	7.84	6.89
Mean Tide Level (MTL) (ft)	4.23	5.17	N/A
Mean Sea Level (MSL) (ft)	4.25	4.99	4.59
Mean Low Water (MLW) (ft)	1.93	2.50	2.30
North American Vertical Datum 1988 (NAVD88)	0.43	N/A	N/A
Mean Lower Low Water (MLLW)	0.00	0.00	0.00

Table 3-7. Historic Tidal Data Summary for Port Angeles and Port Townsend, Washington (NOAA 2011c, NOAA 2011d)

Station Information	Port Angeles Sta. ID 9444090	Port Townsend Sta. ID 9444900
Mean Range (ft)	4.60	5.34
Diurnal Range (ft)	7.06	8.52
Mean Tide Level (MTL) (ft)	4.23	5.17
Minimum Water Level (ft below MLLW)	-4.83 (06/13/1982)	-4.22 (12/12/1985)
Maximum Water Level (ft above MHHW)	10.52 (01/02/2003)	11.73 (12/10/1993)

Tides are semidiurnal in Dungeness Bay, with higher high low, lower high and lower low tides generally occurring within a 24 hour 50 minute period. The mean tidal range, which relates to flushing ability, within the inner bay is approximately 4.4 feet. The water residence time in the inner bay averages about 40 hours. Details on tidal circulation can be found in Appendix A of *Dungeness Bay Bathymetry, Circulation and Fecal Coliform Studies* (Rensel 2003).

It is anticipated that the warming of Washington's temperate climate will contribute to fundamental changes along the coast, including but not limited to shifts in the timing and intensity of coastal storms, changes in precipitation and the delivery of freshwater inputs, sea level rise, and increased inundation of the shallow tidal basins. Regional coastal climate change may also result in changes in the intensity and timing of coastal upwelling, shifts in temperatures and dissolved oxygen concentrations, and alteration of the carbonate chemistry of nearshore waters. The combination of these changes will alter chemical concentrations in tidally influenced areas (Ruggiero et al. 2010). Dungeness Bay may experience changes in the salinity regime in response to changes in precipitation and snow melt in the watershed (resulting in changes in freshwater inflows) and increased intrusion of seawater associated with rising sea levels. However, the effect of climate change on salinity will vary with location and the magnitude of the relative sea level rise rate.

3.2.3 Sea Level Rise

Sea level rise on the Washington coast is the result of three major forces: global mean sea level rise driven by the melting of land-based ice, local dynamical sea level rise driven by changes in wind which pushes coastal waters toward or away from shore, and localized vertical land movements driven primarily by tectonic forces (Mote et al. 2008, McKay et al. 2011). Mean sea level is defined as the average sea level over a 19-year period, about which other fluctuations (e.g., tides, storm surges, etc.) occur (Smerling et al. 2005). Global mean sea level rise has been in the range of 1.3 to 2.3 millimeters per year (0.05 to 0.09 inch/year) between 1961 and 2003 (IPCC 2007a). But since 1993 the rate has increased about 50% above the 20th century rise rate to 3 millimeters/year (0.12 inch/year) (Bromirski et al. 2011), and the latest global satellite sea level observations have risen to 3.19 millimeters/year (0.13 inch/year) (NASA 2012). This acceleration is primarily the result of ice field and glacier melt-off (McKay et al. 2011). For example, the total global ice mass lost from Greenland, Antarctica and Earth's glaciers and ice caps between 2003 and 2010 was about 4.3 trillion tons (1,000 cubic miles), adding about 0.5 inch (12 millimeters) to global sea level in a seven year period (Jacob et al. 2012).

In addition, vertical land movements are occurring as the North American plate and the off-shore Juan de Fuca plate collide. Uplift, which may offset local sea level rise, occurs along the Washington coast while subsidence occurs off-shore. For example, while tide gauge data in Seattle reflect the global trend of about 2 millimeters/year (0.08 inch/year), at Neah Bay at the western end of the Strait of Juan de Fuca, relative sea level is falling because rapid uplift of the Olympic Peninsula outpaces global sea level rise. An interpolation of regional uplift rates based on an analysis of 29 tide gauges and 113 pairs of level lines provides an estimate of approximately 1-1.5 millimeters/year (0.04-0.06 inch/year) uplift in the vicinity of Dungeness NWR (Verdonck 2006).

Based on monthly mean sea level data from 1975 to 2006, the mean sea level trend at Port Angeles is 0.19 millimeter/year (0.007 inch/year) with a 95% confidence interval of ±1.39 millimeters/year (±0.054 inch/year), which is equivalent to a change of approximately +0.06 feet per century (NOAA 2011e). Data for Port Townsend were recorded from 1972 to 2006 and indicates a mean sea level trend 1.98 millimeters/year (0.077 inch/year) with a 95% confidence interval of ±1.15 millimeters/year (±0.045 inch/year), which is equivalent to a change of +0.65 feet per century (NOAA 2011e).

Future Trends

The IPCC Special Report on Emissions Scenarios (SRES) forecasted that global sea level would increase by approximately 12 inches (30 centimeters) to 39 inches (100 centimeters) by 2100 (IPCC 2001). However, more recent analyses (Chen et al. 2006, Monaghan et al. 2006) indicate that the eustatic rise in sea levels is progressing more rapidly than was previously assumed, perhaps due to the dynamic changes in ice flow omitted within the IPCC report's calculations. Vermeer and Rahmstorf (2009) suggest that, taking into account possible model error, a feasible range by 2100 might be 30 inches (75 centimeters) to 75 inches (190 centimeters) (Vermeer and Rahmstorf 2009).

Tebaldi et al. (2012) show that even seemingly low increases in sea level will have significant impacts in the short term when storm surges are taken into account. An analysis of historic data is combined with future projections of sea level rise to estimate future return periods for what today are considered 50-year and 100-year events. This magnifies sea level rise by a factor of five, on average, and dramatically increases the occurrence, or return periods, of storm surge events.

Rising sea levels may result in tidal marsh submergence (Moorhead and Brinson 1995) and habitat migration as salt marshes transgress landward and replace tidal freshwater and brackish marsh (Park et al. 1991). Changes in tidal marsh area and habitat type in response to sea level rise were modeled using the Sea Level Affecting Marshes Model (SLAMM 6), which accounts for the dominant processes involved in wetland conversion and shoreline modifications during long-term sea level rise (Park et al. 1989, Clough et al. 2010, Clough and Larson 2010). Within SLAMM, there are five primary processes that affect wetland fate under different scenarios of sea level rise: inundation, erosion, overwash, saturation, and accretion. There are currently several active projects involving the use of SLAMM 6 to estimate the impacts of sea level rise on the coasts and salt marshes of the Pacific Northwest (e.g., Glick et al. 2007).

For Dungeness NWR, SLAMM 6 was run using mean and maximum estimates from scenario A1B from the SRES. Under the A1B scenario, the IPCC AR4 (IPCC 2007a) suggests a likely range of 0.21 to 0.48 meter (0.7 to 1.6 feet) of sea level rise by 2090-2099 “excluding future rapid dynamical changes in ice flow.” The A1B-mean scenario that was run as a part of this project falls near the middle of this estimated range, predicting 0.40 meter of global sea level rise by 2100. The A1B-maximum scenario predicts 0.69 meter of sea level rise by 2100. To allow for flexibility when interpreting the results, SLAMM was also run assuming 1 meter, 1.5 meters, and 2 meters (3.3 feet, 4.9 feet, and 6.6 feet) of eustatic sea level rise by the year 2100. Pfeffer et al. (2008) suggests that 2 meters (6.6 feet) by 2100 is at the upper end of plausible scenarios due to physical limitations on glaciological conditions. Model results through 2025 for Dungeness NWR are presented in Table 3-8 (Clough and Larson 2010). All model results are subject to uncertainty due to limitations in input data, incomplete knowledge about factors that control the behavior of the system being modeled, and simplifications of the system.

Table 3-8. Predicted Change in Acreage of Land Categories at Dungeness NWR by 2025 Given SLAMM-modeled Scenarios of Sea Level Rise (Clough and Larson 2010)

		Sea Level Rise Scenarios*				
	Initial Condition	**A1B Mean (0.39 m by 2100)**	**A1B Maximum (0.69 m by 2100)**	**1 m by 2100**	**1.5 m by 2100**	**2 m by 2100**
Open Ocean	249.8	257.3	296.4	411.9	469.9	476.8
Tidal Flat	620.9	611.2	606.5	598.7	584.2	568.4
Undeveloped Dry Land	394.7	306.1	299.3	287.6	271.1	258.0
Estuarine Beach	145.5	146.6	146.5	146.4	146.2	145.9
Ocean Beach	130.1	204.0	170.1	62.9	16.7	19.6
Brackish Marsh	25.0	25.0	25.0	25.0	25.0	25.0
Saltmarsh	18.6	18.9	19.0	19.0	19.2	19.5
Swamp	7.8	7.8	7.8	7.8	7.8	7.8
Developed Dry Land	6.8	6.8	6.8	6.8	6.8	6.8
Estuarine Open Water	2.5	12.3	17.0	25.1	39.9	55.9
Inland Open Water	0.7	0.7	0.7	0.7	0.7	0.7
Transitional Salt Marsh	0.0	5.7	7.3	10.5	15.0	18.1

* 0.39 m = 1.3 feet, 0.69 m = 2.3 feet, 1 m = 3.3 feet, 1.5 m = 4.9 feet, and 2 m = 6.6 feet.

3.3 Ocean Chemistry

The ocean will eventually absorb most carbon dioxide released into the atmosphere as a result of the burning of fossil fuels and other sources. Current rates of carbon dioxide emissions are causing and an increase in the acidity of ocean surface waters and a decrease the saturation of calcium carbonate ($CaCO_3$), a compound necessary for most marine organisms' development of shells and skeletons (Hönisch et al. 2012). Oceanic absorption of CO_2 from fossil fuels may result in larger acidification changes over the next several centuries than any inferred from the geological record of the past 300 million years (with the possible exception of those resulting from rare, extreme events such as meteor impacts). In the past 300 million years, three analogous ocean acidification events have been identified and these events coincided with mass extinctions of marine organisms, however it should be noted that warming and corresponding oxygen depletion co-occurred during these events and contributed to the extinctions (Hönisch et al. 2012).

Virtually every major biological function of marine organisms has been shown to respond to acidification changes in seawater, including photosynthesis, respiration rate, growth rates, calcification rates, reproduction, and recruitment. Much of the attention has focused on carbonate-based animals and plants which form the foundation of our marine ecosystems. An increase in ocean acidity has been shown to impact shell-forming marine organisms from plankton to benthic mollusks, echinoderms, and corals (Doney et al. 2009). Many calcifying species exhibit reduced calcification and growth rates in laboratory experiments under high-CO_2 conditions. Ocean acidification also causes an increase in carbon fixation rates in some photosynthetic organisms (both calcifying and noncalcifying) (Doney et al. 2009, Smith and Baker 2008, OCBP 2008). These potential impacts to the marine food web may obviously negatively affect refuge resources such as seabirds, shorebirds, and salmonids. Localized acidification rates within Dungeness Bay have not been evaluated.

3.4 Topography and Bathymetry

The topography of Dungeness and Graveyard Spits is largely flat, with most areas below 15.0 feet North American Vertical Datum 1988 (NAVD88) in elevation (PSLC 2001). The spits are comprised of series of shallow dune ridges and troughs with accumulation of drift logs on the surface. As the narrowest portion of Dungeness Spit measures only approximately 50 feet wide, intermittent overwash events have been documented during and after large storms.

Tidelands of the second class located within Dungeness Bay and surrounding the spits are managed by the Service under a perpetual easement with the Washington Department of Natural Resources and include mud and sand flats exposed only at low tide. The average depth of the inner Dungeness Bay is 8.3 feet (Rensel 2003). Shallower areas occur at the north part of the inner bay, while the deepest areas are located just west of Graveyard Spit and northwest of Cline Spit. A comparison of bathymetry between 1967 and 2000 shows that the bay has become shallower over that time period (Rensel 2003).

Bluffs at the base of Dungeness Spit are approximately 90-100 feet high while bluffs west of the spit rise to about 130 feet. The forested areas within the Dungeness Unit are primarily between 90 to 130 feet NAVD88.

The northeastern portion of the Dawley Unit fronts Sequim Bay. The topography then generally slopes upwards from northeast to southwest. Dean Creek flows from south to north through the southeastern corner of the unit. Maximum elevations within the Dawley Unit are approximately 650 feet NAVD88.

3.5 Geology and Geomorphology

3.5.1 Regional Geologic Context

Dungeness NWR is located on the northeast coast of the Olympic Peninsula along the Strait of Juan de Fuca. South of the Refuge, the jagged peaks of the Olympic Mountains loom over a deep, forested labyrinth of canyons. The Olympic Mountains originated from subduction of the denser Juan de Fuca Plate of oceanic crust underneath the North American Plate of continental crust in an area known as the Cascadia Subduction Zone. This subduction caused the superficial rocks of the descending oceanic plate (an accretionary wedge) to be progressively scraped off and accreted to the continental margin (Tabor and Cady 1978). Due to the subduction and the accretionary wedge, there are two lithologic assemblages that can be found on the Olympic Peninsula: the peripheral and core rocks.

The peripheral rocks, part of the Coast Range Terrane, consist of oceanic crust that was accreted onto the continent by either the collision of an intra-Pacific seamount province or by backarc or forearc rifting at the North American plate margin (Wells et al. 1984, Clowes et al. 1978, and Babcock et al. 1992 cited in Brandon et al. 1998). The Coast Range Terrane is composed of a basal unit called the Crescent Formation and an overlying Eocene to lower Miocene marine clastic sequence known informally as the Peripheral sequence (Brandon et al. 1998). The Crescent Formation consists of thick basalt flows such as pillow lava that are cut by dikes and interbedded with pelagic limestone and mudstone (Brandon et al. 1998). On the present-day Olympic Peninsula, the peripheral rocks form a horseshoe-shaped belt that rings the core rocks on the northern, eastern, and southern sides of the peninsula.

The core rocks are known as the Olympic Subduction Complex and they encompass mélange scraped off the subducting Juan de Fuca plate and thrust, or underplated, on the bottom of the continental crust. This stacking of successive scrapes thus continually thickens and raises the older, top surface. As the subduction process at the Cascadia Subduction Zone continues, uplift occurs. At the same time, erosion eats away at the oldest, top sediments. Rocks of the Olympic Subduction Complex were first thrust above sea level about 12 million years ago and accretion and uplift presently outpace erosion in some parts of the range and so the Olympic Mountains are still rising, with the fastest rates occurring within the western part (Thackray and Pazzaglia 1994, Brandon et al. 1998).

Extensive glaciation over time has greatly shaped the Olympic Peninsula. The latest glaciation, the Fraser, lasted from about 23,000 to 11,000 years ago. The last major advance during the Fraser Glaciation occurred during the Vashon Stade, roughly 14,000 to 17,000 years ago (Hellwig 2010). At its maximum during the Vashon Stade, the margin of the Cordilleran ice sheet that influences the Olympic Peninsula originated in British Columbia, moved down through Georgia Strait on a base of advance outwash sands and gravels, proceeded south through the Puget Lowland to below the present city of Olympia (the Puget Lobe), and extended out the Strait of Juan de Fuca to beyond Cape Flattery (the Juan de Fuca Lobe).

The upper parts of watersheds draining into the Strait of Juan de Fuca were carved by alpine glaciers, which formed in the high mountain peaks of the Olympic Range and moved downstream. As the ice sheet retreated, widespread glacial deposits (outwash, drift, and till) were left behind. The lower watersheds were cut by glacial water outflows and formed gently sloping plains of glacial till and outwash. Since glaciation, landforms have been modified by mass wasting, surface erosion, and deposition.

3.5.2 Refuge Geology

Dungeness and Graveyard Spits are elongate spits primarily composed of well-sorted sand, gravel, and cobble which originate from erosion of adjacent mainland bluffs, alongshore sediment transport (shore-drift), and from washover deposits where the spits are narrow enough for overwash processes (Schwartz et al. 1987). The feeder bluffs are typically composed of Holocene-Pleistocene undifferentiated surficial (clay, silt, sand, gravel, till, diamicton, and peat) and landslide deposits (clay, silt, sand, gravel, and larger blocks deposited by mass wasting) that are at the edge of Pleistocene glaciomarine drifts (Schasse 2003). Net shore-drift patterns at the Dungeness Spit are driven primarily by fetch exposure. Sediment eroded from the glacial bluffs to the west is transported to the east, around the end of Dungeness and then along the recurve of Graveyard Spit. On the mainland, shore-drift converges from the east and west upon Cline Spit (Schwartz et al. 1987).

Using a comparison of historic maps of Dungeness Spit from dating 1855, 1926, and 1979 in conjunction with field surveys conducted in 1985, Schwartz et al. (1987) measured an eastward growth of the spit of about 1,900 feet (575 meters) over a period of record of 130 years. This elongation of Dungeness Spit was confined to that portion of the spit east of the junction with Graveyard Spit, as both Graveyard Spit and the west end of Dungeness Spit have remained relatively unchanged since the 1855 land survey. The study found an average elongation rate of 14.4 feet/year (4.4 meters/year) for the spit which agreed closely with 14.8 feet/year (4.5 meters/year) calculated by Bortleson et al. (1980). The volumetric increase in Dungeness Spit was estimated at about 65,305,000 cubic yards (1,850,000 cubic meters) from 1855 to 1985.

At the Dawley Unit, a portion of the unit adjacent to Dean Creek is underlain by Crescent Formation (middle and lower Eocene) basalt and basalt breccia. The lower part of Dean Creek, as it passes through the Refuge, is underlain with Vashon Stade advance glacial outwash, which is comprised of stratified, well-sorted sand, gravel, lacustrine clay, and silt laid down by meltwater during the glacial advance. The remainder of the unit occurs on Vashon Stade glacial till, which consists of unstratified, poorly sorted clay, silt, sand, gravel, and boulders directly deposited by the glacier (Schasse and Logan 1998).

3.6 Soils

All soil types and descriptions are mapped and described in the Soil Survey of Clallam County, Washington (USDA 2012). The principal soil types at the base of Dungeness Spit are Dick loamy sand (0 to 15 percent slopes) and Hoypus gravelly sandy loam (0 to 15 percent slopes). The Dawley Unit is made up of several soil types: Hoypus gravelly sandy loam (0 to 15 percent slopes, 15 to 30 percent slopes, and 30 to 65 percent slopes), Dick loamy sand (0 to 15 percent slopes), and Clallam gravelly sandy loam (15 to 30 percent slopes).

Dick loamy sand and Hoypus gravelly sandy loam are very deep, somewhat excessively drained soils formed in glacial outwash and found on outwash terraces. Permeability of these soils is rapid with a low water capacity. Consequently, runoff is slow. The effective rooting depth for both soils is 60 inches or more. Below a mat of organic material, the surface layer of Dick loamy sand is grayish brown and dark brown loamy sand about 3 inches thick. The next layer is brown sand about 19 inches thick. The upper 26 inches of the underlying material is light olive brown and yellowish brown, stratified sand to loamy sand, and the lower part to a depth of 60 inches or more is olive brown and dark yellowish brown, stratified gravelly sand to gravelly loamy sand. The surface of Hoypus gravelly sandy loam is typically covered with a mat of organic material 1 inch thick. The surface layer is very dark grayish brown gravelly sandy loam 3 inches thick. The upper 7 inches of the subsoil is dark brown gravelly sandy loam, and the lower 21 inches is dark yellowish brown very gravelly loamy sand. The upper 14 inches of the substratum is dark brown very gravelly sand, and the lower part to a depth of 60 inches or more is dark yellowish brown gravelly sand.

Clallam gravelly sandy loam is a moderately deep, moderately well drained soil formed in compact glacial till and found on hills. Permeability of this soil is moderate to the compact glacial till and very slow through it. Available water capacity is low. Runoff is medium, and the hazard of water erosion is slight. The effective rooting depth is 20 to 40 inches. Water is perched above the compact glacial till from January through April. Typically, the surface is covered with a mat of organic material 2.5 inches thick. The surface layer, where mixed to a depth of 6 inches, is dark brown gravelly sandy loam. The upper part of the subsoil is brown gravelly sandy loam about 4 inches thick, and the lower part is brown very gravelly sandy loam about 18 inches thick. Compact glacial till is at a depth of 28 inches. Depth to glacial till ranges from 20 to 40 inches.

3.7 Fire

3.7.1 Pre-settlement Fire History

Dungeness NWR is in the driest area in western Washington (please refer to the Precipitation section for further discussion). Consequently, prior to Euro-American settlement, the predominant vegetation on lowlands west of the Cascades, from the Willamette Valley of Oregon north to the Georgia Basin of southwest British Columbia, was a mosaic of grasslands, oak and conifer forests, savannas, and various types of wetlands (Chappell and Crawford 1997). These forests, savanna, grassland, and herbaceous bald ecosystems generally rely on fire to maintain their vegetative structure and species composition. In addition to lightning-caused fires, historical accounts have also established that Native Americans used prescribed burning to create habitat for game animals and to promote the growth of weaving materials and food (Agee 1993, Chappell et al. 2001). The historic frequency with which a given area burned depended directly upon the number of natural and human ignited fires. Other factors affecting fire frequency and fire intensity include plant community types, changes in topography (i.e., slope and aspect), varying fuel accumulations, and variation in seasonal precipitation. The advent of Euro-American settlement interrupted Native American land management practices and altered the natural fire regime by eliminating prescribed fires and suppression of natural fires.

The watershed of the Dungeness River has experienced repeated large, intense wildfires prehistorically as a result of a number of climatic patterns, including long-term temperature cycles, a rain shadow effect from the adjacent Olympic Mountains, jet stream patterns, and prevailing west-to-east winds (DAWACT 1995, BOR 2002). Large, intense, stand-replacement wildfires have swept across the watershed at intervals of approximately 200 years with surviving older trees generally restricted to higher elevations and along riparian corridors. Present data indicate that large, stand-replacing fires occurred in A.D. 1308, 1508, and 1701 in the Dungeness watershed (DAWACT

1995). The intervals between these fires was long enough to permit growth of a replacement stand and accumulation of both ground and ladder fuels within the forest (BOR 2002).

3.7.2 Post-settlement Fire History

In the areas dominated by Douglas-fir, such as on the mainland portion of Dungeness NWR and the Dawley Unit, the natural fire regime was probably similar to that described by Agee (1993) in coastal Douglas-fir forests. The majority of fires in the region are human-caused and starts occur during the dry summer months. A large, human-caused fire occurred in 1890 in the foothills between Port Angeles and Sequim, smoldered over the winter, and flared up again in 1891. Although not as extensive as the pre-historic fires, the 1890-1891 fire burned large areas of the lower Dungeness watershed. Numerous smaller fires have also occurred in the watershed with significant ones reported in 1860, 1880, 1896, 1902, 1917, and 1925. Few fires have occurred in the watershed since 1930, largely as a result of improved fire prevention techniques and increased levels of summer precipitation (DAWACT 1995, BOR 2002).

All known fires at Dungeness NWR were human-caused. The 1969 Dungeness Annual Narrative related the investigation of a fire started on June 3, 1969 when U.S. Coast Guard personnel were burning their garbage dump behind the residence. High winds caused the fire to quickly spread into the dry grass and driftwood affecting a total of 17 acres. Driftwood logs tend to smolder for weeks after the initial burn. The 1971 Dungeness Annual Narrative reported a fire at the junction of the main spit and Graveyard Spit on June 27 and 28, of that year. The 1983 Dungeness NWR Fire Management Plan states that between 1980 and 1983, two small unwanted fires originated on the spit from Native American campfires. In June 1989, the Ravine Fire burned 0.1 acre near the eastern boundary of the mainland portion of the Refuge. In June 1999, the Dungeness Fire burned 1 acre on Dungeness Spit, and a month later, the Lighthouse Fire burned 50 acres at the extreme end of the spit. The latter fire burned around New Dungeness Lighthouse with no damage.

3.8 Environmental Contaminants

3.8.1 Air Quality

The air quality may be affected by various activities on and adjacent to the Refuge including: marine vessels, industrial facilities, automobiles, and other human caused activities such as outdoor burning, wood stoves, and operation of various vehicles and machines (e.g., gasoline powered equipment, motorboats). The refuge staff uses various types of equipment and transportation methods to achieve the refuge habitat conservation projects and research. Habitat improvement projects and monitoring activities may include the use of tractors, heavy equipment, and/or the operation of trucks, boats, or other transport. Refuge visitors generally drive their automobiles to visit the various units of the Refuge and others operate motor boats within Dungeness Bay to fish or access the lighthouse.

3.8.2 Water Quality

A state is required to identify waters that do not meet that state's water quality standards under Section 303(d) of the Clean Water Act (CWA). These waters are considered "water quality limited" and placed on the state's 303(d) impaired waters list. Section 303(d) requires the state to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. TMDLs are the amount of each pollutant a waterbody can receive and not exceed water quality standards. Water quality standards for Washington include beneficial uses, narrative and numeric water quality criteria, and antidegradation policies. The Washington Department of Ecology (WDOE) assesses water segments according to parameters including bacteria, bioassessment, contaminated sediments, dissolved oxygen, pH, total phosphorus in lakes, temperature, total dissolved gas, toxic substances, and turbidity.

Dungeness Bay was listed as impaired in the 2008 303(d) reporting cycle for the following parameters: fish habitat and fecal coliform bacteria. A TMDL for fecal coliform was established in 2004 to address elevated fecal coliform levels that were impairing water quality and shellfish harvest. The Dungeness River has been identified as a source for nutrient loading and elevated fecal coliform problems from agricultural and residential runoff. Significant fecal coliform bacterial contamination and nutrient loading from animal waste were found on both commercial and small farms with high livestock concentrations and poor management. Existing on-site sewage disposal systems continue to have the potential to contribute bacterial contamination and nutrients to both surface and groundwater due to soil conditions and inadequate maintenance. Terminating near the Dungeness River delta and in several locations along the shoreline of the southern side of Dungeness Bay are outfalls for approximately 97 miles of irrigation ditches that divert water from the Dungeness River to agricultural and residential lands. These ditches are also likely contributing to the elevated fecal coliform problems in Dungeness Bay. Within 10 miles of the Refuge, there are five additional major subdrainages within the Dungeness River area watershed. These include McDonnell, Siebert, Bagley, Cassalery, and Gierin Creeks. There are approximately 546 miles of streams and tributaries in the overall watershed as identified in the 1993 Dungeness River Area Watershed Management Plan. Similar agricultural/residential runoff issues are likely associated with these drainages and are likely contributing to the existing problems with elevated fecal coliform bacteria.

Because of the shallow depth to groundwater, the lack of a confining layer in many areas, and porous soils, groundwater in this area is highly susceptible to nonpoint chemical contamination. In 1990, wells sampled by Clallam County showed levels of nitrate, although generally well below the drinking water standard, were elevated in some areas, and it was concluded that this was an upward trend. The source or sources for this contaminant is likely attributable to failing septic systems, livestock waste and agricultural/residential fertilizer usage combined with the presence of highly permeable soils and nearly 100 miles of irrigation ditches.

3.8.3 Contaminants

Considering the historical uses of Dungeness NWR and the Dawley Unit, environmental assessment studies have revealed some threats to the Refuge from contaminants. Some of these contaminant issues have already been addressed while others remain. Jurisdiction issues and other factors (e.g., exposure risks, funding, location, concentration, potential for movement of the hazard, and accessibility) influence the timing of remediation. Historical uses included military, navigational aids (lighthouse), residential, and commercial.

In 1857, prior to the establishment of the Refuge, a lighthouse station was constructed on the terminal end of Dungeness Spit. The United States Coast Guard (USCG) operated and maintained this facility in accordance with acceptable laws and practices during their years of operations. In 1974, the station was automated with aids to navigation. In March of 1994, the Coast Guard stationed the last keeper; then from March–September the USCG auxiliary staffed the lighthouse. September of the same year the lease for the maintenance and operation of the historical structures transferred to the newly formed New Dungeness Chapter of the U.S. Lighthouse Society (Society). In 2003, the New Dungeness Chapter separated from the Society and formed the New Dungeness Light Station Association. The agreement between the USCG and the New Dungeness Light Station Association was modified to reflect this change and continues today. As identified in this CCP, the Service proposes to acquire the lighthouse and surrounding land from the USCG when they excess this property. As part of that transfer the Service would work with the USCG on any unresolved contaminants issues concerning the lighthouse site. Several known issues have already been identified by the USCG through their own investigations.

In 2003, the USCG contracted Tetra Tech, Inc., to conduct a Phase I environmental site assessment also called an Environmental Due Diligence Audit (EDDA). The purpose of this audit was to "evaluate a particular property for potential environmental contamination and liabilities from past or present use of the site" in this case the New Dungeness Light Station. There were two underground storage tanks, and one above ground tank, on site which were removed in 1998 and soils tested for total petroleum hydrocarbons. The results were below the Model Toxic Control Act concentrations and no remediation was required.

The USCG, in 2009, contracted with Engineering/Remediation Resource Group, Inc. to conduct a Phase II (EDDA). The objectives were to evaluate (1) the presence and concentrations of lead in paint on the interior and exterior walls of the present site structures; (2) the concentrations of lead in soil around structures compared with background concentrations; (3) the presence of asbestos-containing material (ACM) inside site structures; (4) the presence and concentrations of petroleum hydrocarbons quantified as total petroleum hydrocarbons (TPH) and metals in the cisterns at the station; (5) the presence and concentration of petroleum hydrocarbons quantified as TPH in soil associated with former aboveground storage tanks (ASTs), former underground storage tanks (USTs), former fuel lines, and the present and former oil houses; (6) the concentrations of metals in soil around the current and former paint locker compared with background concentrations; (7) the presence and concentrations of polychlorinated biphenyls (PCBs) in soil in the vicinity of the transformer building; (8) the presence of mercury in the lighthouse lantern room; and (9) background metal concentrations. Based on the findings and recommendations of this report further sampling and remediation actions would be required.

In 2006, the Dawley rental house, located on the south side of Highway 101 and the mobile home west of the main residence, were sampled for Asbestos Containing Material (ACM) and Lead Based Paint (LBP). The test results were negative for all samples. The beach house along Sequim Bay, northwest of the Dawley main residence, was also sampled for ACM and LBP with test results showing positive for ACM but negative for LBP. There was an UST removed, also in 2006, near the garage west of the Dawley main residence and a vehicle oil changing rack. From both of these there was soil contamination by petroleum products that required the removal of 26 tons of soil from the UST and 5 tons from the rack areas. The Mellus Cabin, located in the Dungeness Unit, was surveyed for Asbestos Containing Material (ACM) and Lead Based Paint (LBP) in 2010 by the USFWS Regional Environmental Compliance Coordinator. A small area of interior floor tile contains low levels of ACM and there was no detection for LBP on any surface. The Dawley main residence was also surveyed at the same time for ACM and LBP. These compounds were detected at various levels and locations in and around the structure. For any of the structures that tested positive for either survey, the Service would be required to contract remediation services prior to any construction work.

The Dawley forest unit contains several small dump sites of waste construction material, household appliances, and other miscellaneous debris. In 2006, the Service conducted a Phase I and Phase II Environmental Site Assessment of the Dawley Unit revealing ACM in two locations. These sites were cleaned up by a contractor in 2009. No other containments, other than personal structural debris remains on the site.

Creosote pilings and rogue creosote logs are also a source of contamination for the Refuge and removal is an on-going management activity. Contamination by creosote is a concern because of the presence of toxic polycyclic aromatic hydrocarbons (PAHs) that can leach into water and sediments where they accumulate and impact marine and nearshore organisms. Sometimes levels of these compounds can reach above Washington State Department of Ecology sediment quality standards (Holman et al. 2009). In 2006, the Service partnered with the Washington State Department of Natural Resources and removed 150 tons of these logs from the Refuge. In 2011, a survey was again conducted for creosote rogue logs accumulation levels and locations. The U.S. Navy removed creosote treated sight target pilings from Dungeness Bay in 2010 that were on refuge tidelands.

The threat of oil spills is another concern that can affect all of the Refuge’s nearshore habitats. According to the Washington State Department of Ecology over 41 million gallons of oil are delivered over sensitive waterways every day in Washington. The Strait of Juan de Fuca is one of the most critical maritime highways for both the United States and Canada. Tanker traffic alone through this area carries over 15 billion gallons of oil each year (WDOE 2009a). The Refuge works with many partners on oil spill prevention, preparedness, and response programs to protect the natural shoreline and marine resources.

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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.” 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 pre-established 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 Pre-settlement 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 non-native 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

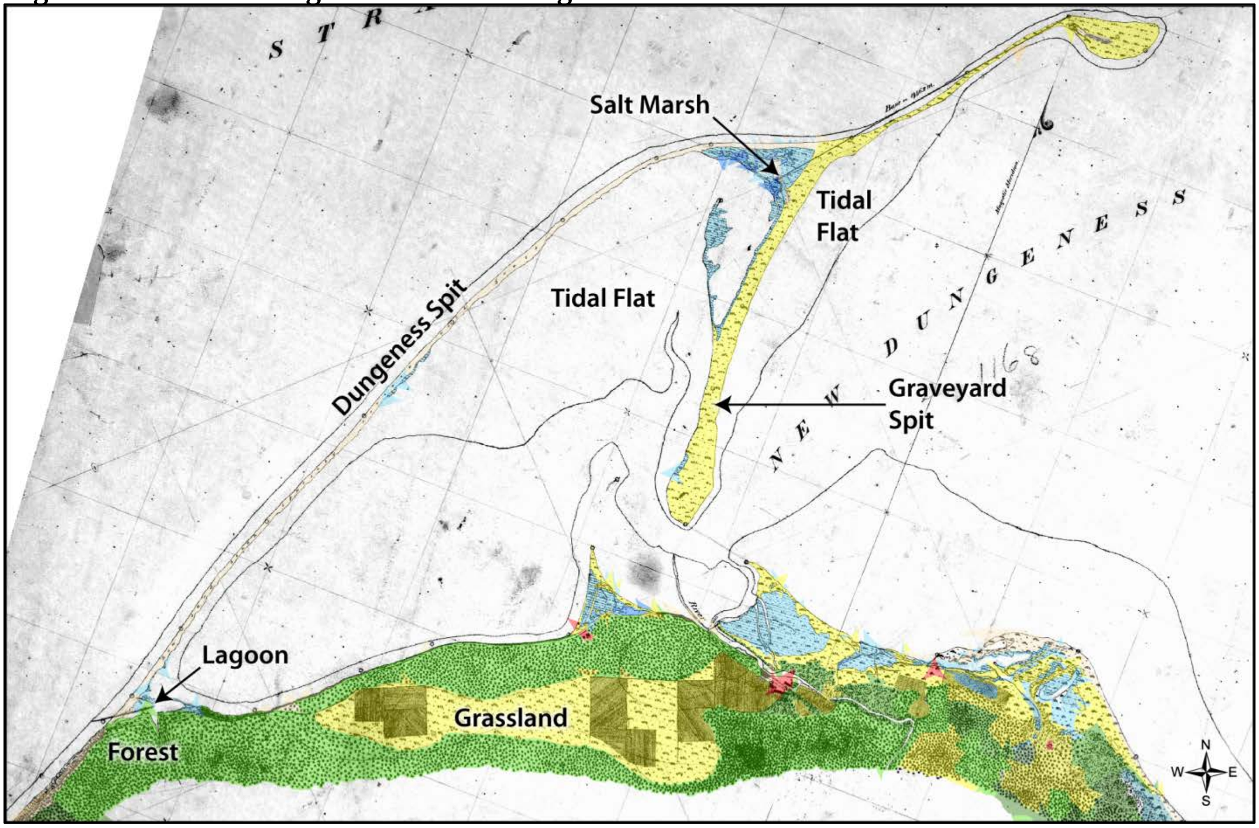
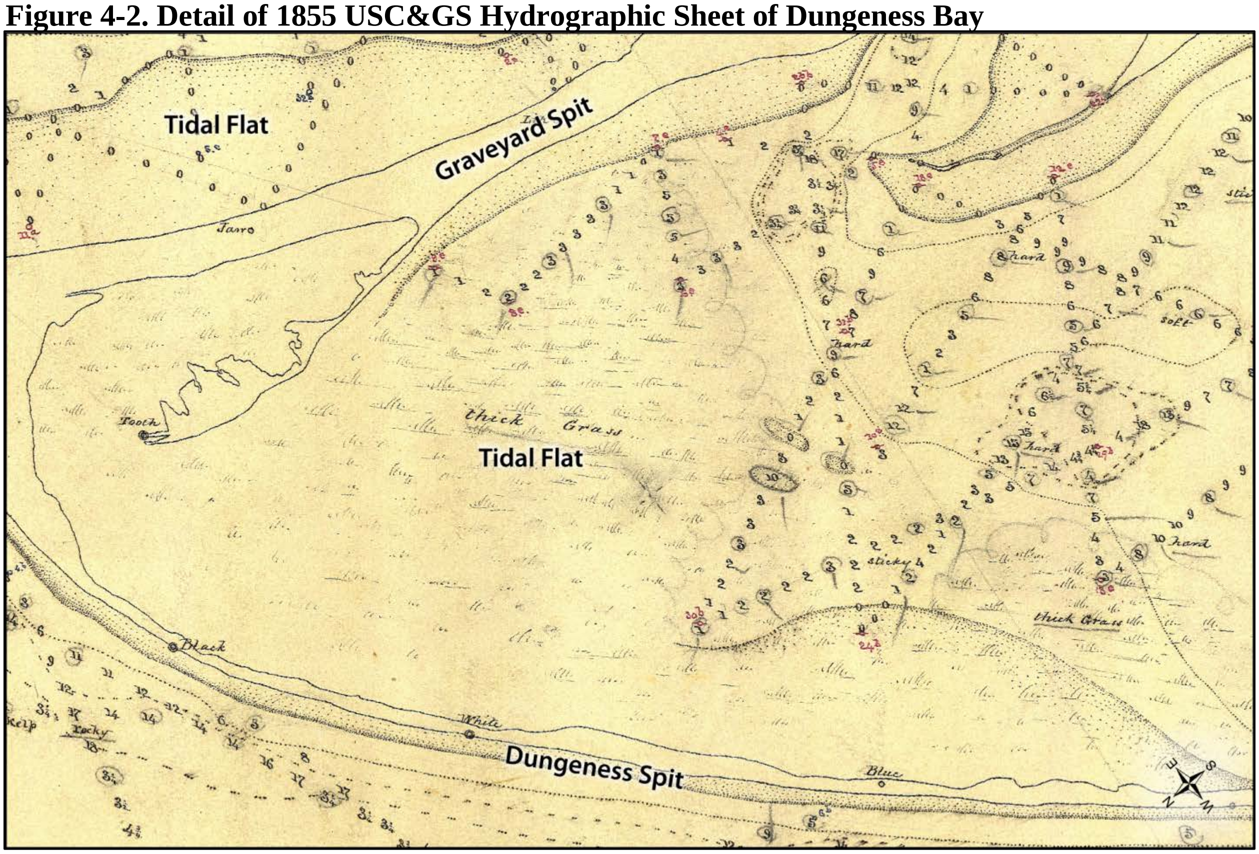


Figure 4-2. Detail of 1855 USC&GS Hydrographic Sheet of Dungeness Bay



The back sides of maps are blank to improve readability.

Many of the habitat changes and the spread of non-native 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 Lighthouse 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 Lighthouse 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, non-point 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 non-native plant species can directly outcompete 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 found within the Refuge as listed in the Puget Sound Marine Invasive Species Monitoring Program - Target Species List (Eissinger 2009) 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, significantly reduce populations of native clams, and outcompete 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.

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 non-destructive, non-manipulative, 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 proposes. 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.

A formal 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, non-motorized 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, non-governmental 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 ROCs 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 Resources of Concern (ROC) 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:

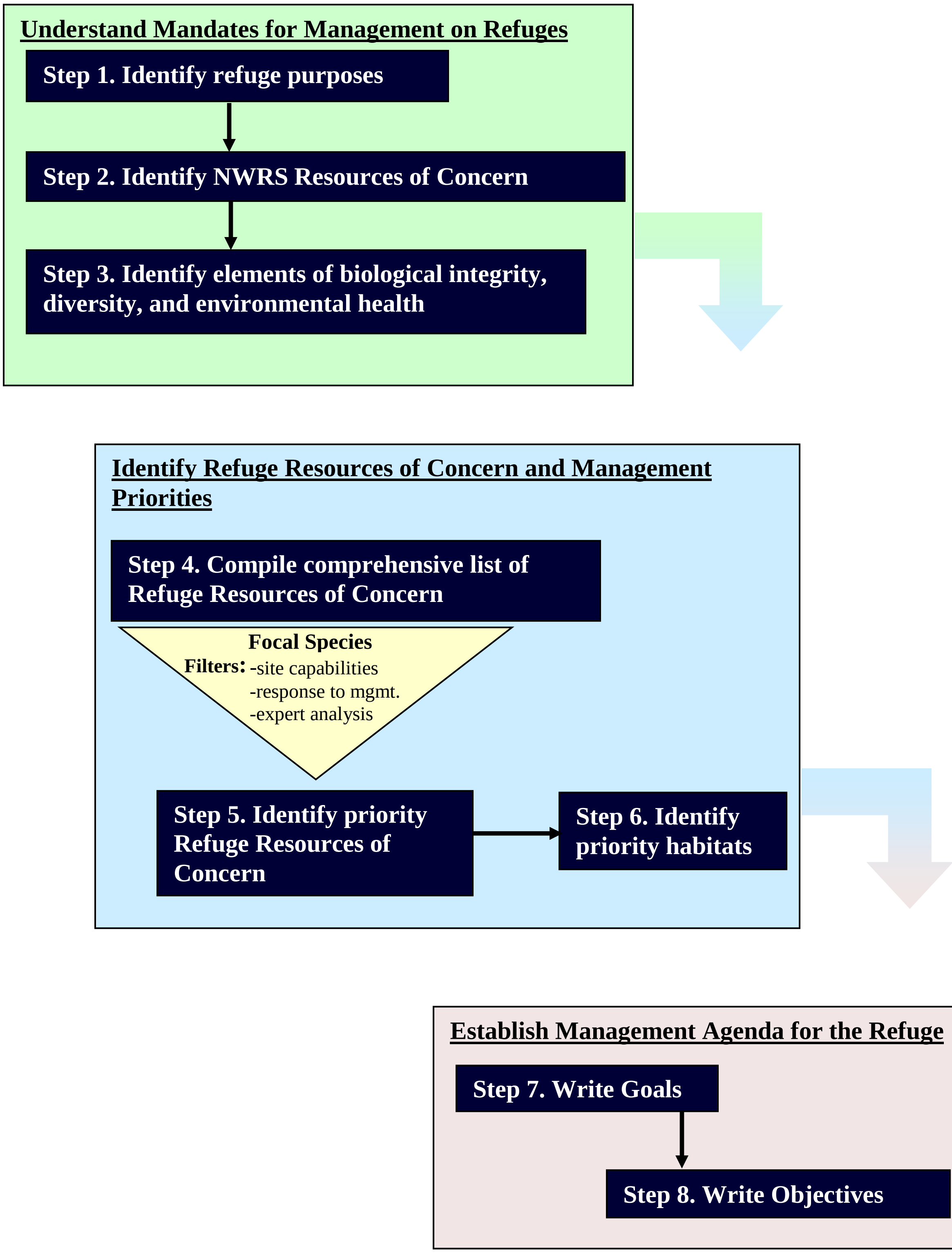
- The resource must be reflective of the refuge's establishing purposes and the Refuge System mission;
- The resource must include the main natural habitat types found at the refuge;
- The resource must be recommended as a conservation priority in the Wildlife and Habitat Management Review; or
- The 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 priority resources of concern (habitat types) habitats were selected as Priority Resources of Concern include: (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), 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 would be focused on attaining conditions required by the focal resource. Other species utilizing the associated habitat type would 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; 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 upper 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 and tip of Dungeness Spits support 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 saltmarsh 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 saltmarsh habitats (located along the northern and southern border of the RNA) support 100% cover and covers 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 current 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 saltmarsh 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 wave action within Dungeness Bay and freshwater influx from the Dungeness River. 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 saltmarsh 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 un-decomposed 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 would strive to follow guidelines set in place by the current Clallam County Shoreline Master Plan (SMP) restrict 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 would adopt the guidelines in the final SMP. In addition, no hard armoring (e.g., rip rap) would 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. Non-native 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 propose 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. Despite two surveys for eelgrass in 2003 and 2009 in Dungeness Bay, Japanese eelgrass has not been 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 non-native 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 will limit 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 mould-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 186 square kilometers or 18,600 hectares (72 square miles or 45,961 acres), which include beds on flat, narrow, and wide fringed areas (Berry et al. 2003). The report from 2009 showed that eelgrass covered 220 square kilometers (22,000 ± 3,600 hectares [85 square miles or 54,363 ± 8,895 acres]) 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 significant. 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 propose studies to assess variables associated with climate change stressors (e.g., accretion, salinity, driftwood recruitment, etc.) and steps 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 the section titled Oil Spills and Other Contaminants above.

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. Because sandy bluffs are so important to the maintenance of biological integrity and environmental health of associated nearshore habitats of the Refuge, BIDEH of sandy bluffs have been selected as the focal resource for the management of this habitat type. 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 Require-ment	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	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 Require-ment	Other Benefiting Species
		creosote-covered logs		
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, and silver burweed, yellow sand-verbena, red fescue, northern harrier, peregrine falcon, snowy owl, short-eared owl
Dunlin	Barrier Lagoons & 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	Year-round	Brant, American wigeon, northern pintail, mallard, green-winged teal, greater and lesser

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Require-ment	Other Benefiting Species
		MLLW); Low- to moderately high-energy environments (waves and currents); Absence of marine debris; Absence of human-caused wildlife disturbance from Oct 1-May 14 on the refuge portion of Dungeness Harbor and Bay		scaup, surf, white-winged and black scoters, common and barrows goldeneye, 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, non-noxious 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. Public use activities allowed on the Refuge include: fishing (saltwater), shell-fishing (clams and crabs), wildlife observation, wildlife photography, hiking, boating (no wake allowed), horseback riding, beach use (wading, beachcombing, 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 co-dominated 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 limited 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 and old-growth forest, but lack key mature and 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 non-forest 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 a significant threat 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 Require-ment	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	Year-round	Marbled murrelet, downy and hairy woodpeckers, red-breasted sapsucker, rufous hummingbird, bald eagle, sharp-

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Require-ment	Other Benefiting Species
		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 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		shinned and Cooper's hawks, northern saw-whet owl, Pacific-slope flycatcher, Hutton's vireo, northwestern crow, chestnut-backed chickadee, Bewick's 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 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 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 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 Stream Keepers 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 Require-ment	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°F-58°F); Well-oxygenated water, with dissolved oxygen levels >5	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

Focal Resources	Habitat Type	Desired Habitat Characteristics	Life History Require-ment	Other Benefiting Species
		parts per million; Instream presence of large woody debris		
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 non-native species (e.g., American bullfrog and non-native 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 Key Habitat Used below) and impacts from fires and timber harvest activities (stand replacement or removal of larger snags). Important processes include natural disturbance regimes (e.g., fire 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 Barrier Lagoon and Mudflat habitat section above), 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 Barrier Lagoons and Mudflats above.

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 with 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 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 non-migratory, 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 non-native predators and contamination are additional threats. Non-native 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 non-native 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 & 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); 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 the 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.

Surf smelt and Pacific sand lance spawning grounds are considered wide-spread 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). As a result, Pacific sand lance and surf smelt are considered Washington Species of Greatest Conservation Need within the State Wildlife Action Plan (WDFW 2005).

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 completing 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 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. These native 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 in 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 with only a few individual plants remaining in three separate clumps. These clumps were retreated in 2011. Monitoring would 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:
- Midwinter 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 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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Chapter 5
Human Environment

Chapter 5. Human Environment

5.1 Cultural Resources

5.1.1 Native American Overview

Prehistory
Jeanne M. Welch and R.D. Daugherty prepared a compilation of the prehistoric era on the Olympic Peninsula as part of their background information for a 1988 survey project on Dungeness NWR (Welch and Daugherty 1988). The following information is paraphrased from their report.

The five periods of occupation for the region proposed by Eric Bergland (Bergland 1984) cover approximately 12,000 years and include: Early Prehistoric, Middle Prehistoric Early Maritime, Prehistoric, Northwest Coast Pattern, and Historic. On the Olympic Peninsula, the prehistoric people are characterized as small groups of hunters and gatherers who moved around to utilize both terrestrial and maritime resources. This period on the peninsula is represented by the Manis Mastodon site (45CA218) which attests to the hunting of large game animals. It is likely that the onset of the Middle Prehistoric saw an increase in the use of maritime resources such as anadromous fish. By the Early Maritime period, proposed to have begun around 3,000 years before present (BP), the use of maritime resources was well established. It is likely that the cultural manifestations of these later prehistoric periods resembled those of the ethnographic period, but details such as the existence of villages with large, cedar plankhouses are uncertain.

During the Prehistoric Northwest Coast Pattern period, which began 1,000 years BP, chipped stone assemblages virtually disappeared while large plankhouse villages became prominent. As Welch and Daugherty note, however: “Bergland’s presumed appearance of cedar plank house villages at this time is based largely upon negative evidence and it may be that this type of settlement pattern is somewhat older, thus, there may have been many significant elements of continuity between the Early Maritime and Prehistoric Northwest Coast periods” (Welch and Daugherty 1988).

Ethnography
Ethnographically, the Refuge is located within the territory of the “Central Coastal” or “Straits” Salish Klallam people (Welch and Daugherty 1988). Tribal groups lived in large winter villages along the shoreline or at mouths of rivers to access the marine resources. The villages housed extended families. They utilized spits for gathering shell resources and as launch sites for fishing. Spits were also used for burial grounds (Kennedy 1981). During the summer season the villagers would break into smaller groups and move inland to gather plants and berries, and to hunt. Along with the Quinault, the Klallam were the only Coast Salish who hunted whales (Suttles 1990). Canoes made of red cedar were central not only to the survival of the Klallam as a source of transportation, but also featured in their burial practices. In 1868, Graveyard Spit was the site of a massacre of Tsimshian Indians that gave the spit its name. The massacre is discussed in more detail in Section 5.1.3.

Contemporary
The Klallam continue to occupy the Olympic Peninsula with tribal communities in three locations, consisting of the Port Gamble S’Klallam, the Lower Elwha S’Klallam, and the Jamestown S’Klallam, all of whom were signatories to the Point No Point Treaty of 1855. The transition from

ethnographic period to the establishment of the Bureau of Indian Affairs over their tribal structure has not been seamless. Initially, many Native Americans patented lands under the Indian Homestead Act, but policy changes reversed the trend toward private ownership. Suttles notes that “around 1875 the Dungeness people were forced off their traditional site and bought land nearby to establish the settlement of Jamestown…. Jamestown received federal acknowledgment in 1980” (Suttles 1990).

According to Jamestown S’Klallam tribal history, despite the fact that they were nearly reorganized into a larger S’Klallam tribe with the other two groups during the Indian Reorganization Act period (1935-1939), the tribe chose to stay on the land they had purchased in 1875 rather than relocate (Jamestown S’Klallam Tribe 2012). Among the consequences of this decision was the termination of their recognition by the federal government in 1953. The continuity and stability of their land base contributed to a sense of group identity and independence. The push for recognition lasted from 1974 until achieved on February 10, 1981.

Known Prehistoric Sites

While there are no prehistoric archaeological sites recorded on the Refuge, there has been very little systematic archaeological survey or testing conducted. A large portion of the approved boundary is tidelands, generally not a conducive environment for archaeological survey. Evidence of buried prehistoric archaeological use of the bluff above Dungeness Spit is unlikely because of the glacially deposited sediments. The dense forest stand generally precludes observation of the surface. However, the presence of known cultural resources in areas adjacent to the Refuge indicates that the potential exists for sites to be identified within refuge boundaries in future.

5.1.2 Euro-American Overview

Although first visited by explorers as early as 1790 when Captain Manuel Quimper inspected the area, the first Euro-American settlers came to the Dungeness area in 1851 while the region was still part of the Oregon Territory. The Washington Territory, which separated from Oregon Territory in 1853, established Clallam County in 1854 (Welch and Daugherty 1988). Within the next few years, a thriving community was established east of what is now the Refuge. Whiskey Flat was named as the county seat in an 1860 election, though two years later New Dungeness was designated as such. These two communities were located essentially in the same location; the latter was located above the former on the bluffs. By 1892, the present location of the town of Dungeness was established as the community center (Kennedy 1981). The heavily forested bluff margin northwest of the Whiskey Flat and Dungeness communities was not developed during the early historic period.

The New Dungeness Light Station, which began operating in 1857, was built by the Lighthouse Board at the behest of Congress. The lighthouse, located at the end of Dungeness Spit, is discussed in more detail in Section 5.1.3. Travel during the nineteenth century was primarily along the coastline by watercraft, few roads were constructed through the very dense, rugged terrain of the interior. The earliest road from Sequim to Port Angeles was not developed until 1890-1891. The timbered slopes and old growth forests supplied lumber to San Francisco during the gold rush along with the spruce trees needed for manufacture of World War I aircraft (Welch and Daugherty 1988). Lumber mills and shingle mills were established on nearly every water way around the peninsula as fluming logs down the rivers was the easiest method for getting the logs out of the mountains. The timber industry continued to be the largest economic employer into the twentieth century.

Agriculture and ranching is productive in pockets where micro-climates provide shelter from the very wet conditions of the Salish Sea. Cold weather crops such as potatoes, wheat, oats, peas, hay, and hops thrive. Located on the inland road system, Sequim was incorporated in 1913 and by 1914 the town had its own telephone franchise and electricity (Welch and Daugherty 1988).

Establishment of Dungeness NWR

The Refuge was established by Executive Order (E.O.) 2123 on January 20, 1915, by President Woodrow Wilson, for the purpose of preserving land "…as a refuge, preserve and breeding ground for native birds." The original 226.02 acres were known as the Dungeness Spit Reservation. The name was changed to Dungeness National Wildlife Refuge on July 25, 1940, by Presidential Proclamation 2416. Over the years, various tracts of land and tidelands have been acquired in fee title or easement within the approved refuge boundaries. Today, Dungeness NWR is 772.52 acres in size.

During World War II, the general area was used as an Army encampment, and a 147-acre tract on Dungeness Spit acquired in 1940 was reserved for use by the Navy until the requirement was terminated in 1955. Additional tracts were added in the following decades, including the Mellus and Dawley properties, both acquired in the early 1970s. However, very little development of the Refuge was undertaken until the 1980s when the parking lot, hiking trails, and interpretive signs were installed.

Dawley Unit

The Dawley Unit is a non-contiguous parcel of the Refuge, located near the base of Sequim Bay. Born in Sequim in 1915, Cecil L. Dawley engaged in numerous successful local business ventures both before and after his stint in the Army, which ended in 1945. He and his family lived in the home on the now-Dawley Unit from 1957, purchasing property and developing ponds and pens for his bird collection. Mr. Dawley donated 125 acres of uplands and bay frontage to the U.S. Fish and Wildlife Service in 1973. He continued to live on the property until his death in 2005. It was Dawley's specific intent that the land be preserved as a wildlife sanctuary.

Known Historic Sites

With the exception of the small inholding owned by the U.S. Coast Guard (USCG) at the end of Dungeness Spit, all parcels within the approved boundary of Dungeness NWR are currently owned under fee title or managed through easements, and consist primarily of tidelands and beach.

On those parcels where habitation is feasible, historic features associated with previous landowners can and do occasionally occur. Some upland habitat occurs in the bluff above Dungeness Spit and on the Dawley Unit. However, historic use of the bluff was isolated, with just a few homesteads and settlers in the nineteenth century. Use was limited until roads were established. In the 1940s, the military used the area for an encampment and training ground.

The bluff area is heavily forested, far from transportation corridors, and lacks productive agricultural values. Therefore, settlement and development of this area lagged behind property closer to the community centers. Based on previous surveys and background research, prehistoric, ethnographic, and early historic period archaeological resources are not expected in the bluff area.

5.1.3 Current Knowledge of Local Cultural Resources and Archeological Sites Occurring On Refuge lands

Graveyard Spit: 45CA238H – T31N R4W Section 24, 25 and T31N R3W Section 13, Dungeness 7.5-minute USGS quad

The 1969 National Register of Historic Places (NRHP) nomination form for Graveyard Spit describes the event that made Graveyard Spit significant at the local level:

> "On September 21, 1868, a party of Chimsean Indians consisting of 10 men, 8 women, and one child left Port Ludlow for Victoria. The Port Discovery Indians hearing of this, concocted a plan to murder and rob them, and started to Dungeness to obtain the assistance of the Sequim (Squim) and Dungeness Indians (in which they were successful). In the meantime, the Chimseans had camped on Dungeness Spit (Graveyard Spit) near the Lighthouse and erected a sail-tent to accommodate all 19; shortly after midnight, the Sklallams cut the tent ropes and let the tent fall on the sleeping Chimseans; when one party of the Sklallams drew their knives and spears and stabbed them through the tent indiscriminately; the other party of Sklallams seized their guns and revolvers, and shot and killed all excepting one women [sic] who secreted herself under a mat and thereby saved her life. Captain James G. Swan relates that the Indian woman was cared for by the wife of Benjamin Ranie of New Dungeness, a Chimsean. Later she was sent back to her home at Fort Simpson, Canada. With the woman went all the things recovered from the site and a lot of presents sent to the Chimseans, many of which were from the Clallam Indians. The British Columbia Colonist, the Seattle Intelligencer, the Port Townsend Weekly Argus, and the Olympia Territorial Republican for the year of 1868, tell of the massacre.
>
> From the report of the Secretary of Interior, 2nd session, 41st Congress, 1869-1870, No. 3414, Washington Government Printing Office, Washington Superintendency No. 1, T.J. McKenny, Superintendent of Indian Affairs, reports on August 14, 1869 to Bureau of Indian Affairs, on the Chimsean Indian massacre, saying some law should be passed for the punishment of the crimes of Indians committed among themselves. The offenders were arrested and required to work with ball and chain for 6 months on their reservation."

According to Jamestown S'Klallam history (Duncan 2012), the massacre was in retaliation for the theft by the Tsimshian:

> "… of one of Lame Jack's wives and his son. Stealing members from other tribes was a common practice. The stolen person may be sold or kept for slavery. When an offence occurred there could have been a payment made to counteract the wrong done to Lame Jack. As a payment did not occur then the S'Klallam saw revenge as the means to right the wrong done to a member of their Tribe. Revenge was another common practice of Coastal Indians. After a couple of years Lame Jack's wife and child made it back after having escaped their captors."

<u>Determination of Eligibility</u>: Graveyard Spit was nominated for the NRHP by the Clallam County Historical Society at a local level of significance in 1969. It does not appear that the nomination form was ever forwarded for consideration.

Status: Although not listed on the NRHP, the resource “is listed on the State Register by being recognized for its value and determined a significant cultural resource of the state” (DAHP 2012).

Dungeness Canoe: Found on Graveyard Spit near its southern tip
According to refuge records, a Native American canoe was recovered from Graveyard Spit in 1980. Although locals reportedly had known about its existence and location since the 1930s, it remained on the spit, susceptible to wildfires, winds, and illegal removal, prompting staff at the Refuge to urge for its recovery and protection. Experts estimated the age to ca. 1830s (150 years old in 1980) and considered it to be a significant find representing Pacific Northwest Indian craftsmanship (USFWS 1981). A Memorandum of Understanding (MOU) between the FWS and the Sequim-Dungeness Museum was prepared for conservation and permanent exhibition of the canoe.

Status: The canoe was transferred to the Jamestown S’Klallam Tribe on September 4, 1994 through an agreement with the Sequim Museum and Arts Center. It is currently on display at the Jamestown S’Klallam tribal cemetery.

New Dungeness Light Station: 45CA242H – T31N R3W Section 18 Dungeness 7.5-minute USGS quad
The New Dungeness Light Station is located near the end of Dungeness Spit in a small inholding owned by the U.S. Coast Guard. The NRHP nomination includes the following information about the property:

> “The New Dungeness Light station was the first federal navigational aid constructed north of the Columbia River. Lighted in December, 1857 (just a few weeks before the light on Tatoosh Island), the station consists of the original lighthouse with tower and a nearby keepers’ residence built in 1904. The Light station is situated at the tip of Dungeness Spit in the Strait of Juan de Fuca, and has served for nearly 140 years as a maritime beacon in an area plagued by strong storms, dense fog, and heavy commercial traffic. Although the tower was lowered in the early 20th century, the station retains excellent integrity and remains an enduring symbol of the historic lighthouses of Washington.”

Determination of Eligibility: The light station was determined to be significant at the state level and nominated to the NRHP in 1993. It was listed the same year (#93001338). The property was determined eligible under Criterion A – it was associated with events that have made a significant contribution to the broad patterns of our history, in this case the area of significance was Maritime History and the period of significance was 1857-1942.

Status: The property continues to be listed on the NRHP. It is currently managed on a day-to-day basis by the New Dungeness Light Station Association, a non-profit volunteer organization. It is scheduled for excessing by the U.S. Coast Guard, and as part of the CCP process, the Service proposes to work with the USCG to bring the light station property into the Refuge System either through interagency cooperative management agreement or property transfer. The Service would then work with the New Dungeness Light Station Association to develop an agreement for the continued management and maintenance of the light station facilities.

Mellus Cabin: T31N R4W Section 27 Dungeness 7.5-minute USGS quad
The Mellus Cabin was recorded in 2006 (Speulda 2006). Based on a review of maps and an understanding of the military timeline, it appears that the cabin was likely built sometime in the early 1950s. Walter B. Mellus purchased the parcel in 1940 with no improvements during a period when

the military presence may have limited his access to the area. He lived in the cabin along with a caretaker until his death in 1973, a year after the land had been sold to the U.S. Fish and Wildlife Service. Although the initial FWS inventory documented two cabins and an outhouse on the parcel, when it was recorded in 2006 only the original 10 x 23-foot cabin remained. The cabin was remodeled prior to acquisition by the FWS and was subsequently renovated in the 1980s to serve as temporary refuge staff housing. A garage was added in 1992. The Cabin currently serves as quarters for a full-time volunteer refuge caretaker.

Determination of Eligibility: It was determined that the Mellus Cabin does not meet NRHP eligibility criteria. The cabin was constructed after World War II and is not associated with any historic period, theme, or event. Mr. Mellus was not a prominent citizen in the area and does not appear in the historical record. The cabin's original appearance may have been rustic, but changes over the years destroyed the original characteristics. No archaeological materials were noted.

Status: Although slated for demolition since 2006, the cabin is still standing as of April 2012.

"Signal Station" Foundations and Debris: Graveyard Spit, Dungeness 7.5-minute USGS quad

The site consists of an assemblage of historic materials including cement foundations, pier blocks, septic tank, cistern, brick, tile, ceramic fragments, metal fragments, and some glass. Field notes taken in 2006 (Valentine 2006) indicate that a member of the local historical society referred to the location as a World War II-era signal station. However, this fact has not been confirmed. The site has not been formally recorded or evaluated.

Dawley Unit Structures: T29N R3W S2 Sequim 7.5-minute USGS quad

Several structures constructed over 50 years ago are located on the Dawley Unit, including the main residence and multiple outbuildings (See Section 5.2, Refuge Facilities)

None of these structures have been formally recorded, nor have they been evaluated for historic significance, a process which must be accomplished prior to any proposed demolition or remodeling.

5.1.4 Current Knowledge of Local Cultural Resources and Archeological Sites Located Near Refuge Lands

Known Cultural Resources Occurring Off-refuge

A record search documented several additional cultural resources—both prehistoric and historic, sites and isolates—that have been recorded within a one-mile radius of the refuge boundaries. While these sites do not fall under the jurisdiction of the FWS, they provide a context for settlement and commerce in the vicinity of the Refuge.

The closest sites to the Refuge are just east of the refuge boundary—the "New Dungeness" townsite (45CA231) and the Tse'esqut Village (45CA239)—located at the base of Cline Spit. Both sites were noted by Smith in 1907 and relate to the ethnographic period (Smith 1907). Historic property inventories have been prepared for several houses located in Sequim that are greater than 50 years old.

5.1.5 Previous Archaeological Research

Three previous archaeological surveys of the Dungeness NWR contain information about the setting and potential for cultural resources within the Refuge. In 1907, Harlan L. Smith and company documented numerous shell middens and burials in the vicinity of what is now Dungeness NWR. Smith’s survey encompassed the whole of the Gulf of Georgia and Puget Sound (Jesup North Pacific Expedition directed by Franz Boas of the American Museum of Natural History). According to Smith in his acknowledgments, William H. Thacker conducted reconnaissance on Smith’s behalf in the “San Juan group” during the summer of 1898. He continues, “In 1899 we examined the shell-heaps on Puget Sound, the Straits of Juan de Fuca as far west as New Dungeness” (Smith 1907). Site 45CA239 Tse’esqut Village, the ethnographically recorded site near New Dungeness Townsite is likely one of the sites described above.

In 1981, Robert Thomas and Hal Kennedy conducted an intensive surface survey of six sites proposed for development on the Dungeness NWR. Results of the investigations at these six locations were all negative, no cultural resources were identified (Kennedy 1981). Based on their research and review of other topographic areas similar to the bluff where they were surveying, Thomas and Kennedy prepared a list of categories of cultural resources that might be expected. These included isolated artifacts, burials, early archaeological sites (ca 60,000-8,000 years old), and ethnographically documented archaeological sites (Kennedy 1981).

They also noted that “Because soil conditions are related to glaciomarine and recessional outwash, buried archaeological sites would not be expected” (Kennedy 1981).

In 1988, Jeanne Welch and Dr. Richard Daugherty completed a survey and limited subsurface testing (augering) of the proposed enlargement of the parking lot at Dungeness NWR. No cultural resources were identified by this field effort.

Other archaeological investigations that have occurred at Dungeness NWR include survey for a vault toilet installation and environs (Raymond 1989, Valentine 1993), and the evaluation of the Mellus Cabin (Speulda 2006).

5.2 Refuge Facilities

The infrastructure and facilities discussed in this section include buildings, structures, roads, parking lots, trails, fences, signs, and utilities. Refer to Table 5-1 and Figure 5-1 for maps showing the locations of existing refuge facilities.

5.2.1 Public Entrances and Access Points

The primary public entrance point for the Refuge is through the entrance station located adjacent to the public parking area at the north end of Voice of America Road within the Clallam County managed Dungeness Recreation Area. Visitors can also access the Refuge from the horse trail entrance station located at the northern end of the County horse trail in the Dungeness Recreation Area. The County-owned Bluff Trail is accessible from five points along the public parking area and links the County trails with the Refuge but does not provide direct access to the refuge beach areas.

Boaters may access tideland areas, which are open seasonally May 15 through September 30, through the Dungeness Harbor and Bay. The only boat access to dry land areas within the Refuge is located adjacent to the New Dungeness Lighthouse. The boat landing zone is designated by two yellow posts and is directly south of the lighthouse on the south side of Dungeness Spit. Reservations are required to land and boaters are required to stay on the designated trail from the beach to the lighthouse as areas on either side are closed to the public to protect plants and wildlife.

5.2.2 Administrative Buildings and Other Structures

Dungeness Unit Buildings and Structures

The Washington Maritime National Wildlife Refuge Complex headquarters is located at 715 Holgerson Road in Sequim, Washington. Public access is located at the north end of Voice of America Road in the Dungeness Recreation Area. The headquarters consists of an administrative building (3,756 square feet), shop building (3,848 square feet), and an equipment storage building (2,220 square feet), all completed in 2009.

Additional buildings and structures include the Mellus Cabin which is located in the forest on the bluff above the base of Dungeness Spit where the main and horse trails begin to descend to the beach. Although the property was purchased by Mr. Mellus in 1940, the cabin (750 square feet) was not constructed until sometime in the early 1950s (See Section 5.1.3). The Mellus Cabin is currently used as a volunteer office and as the refuge caretaker’s residence. There is a septic system associated with the residence. Adjacent to the Mellus Cabin is an equipment storage garage built in 1992 (400 square feet) and a pump house built in 1973 which services a well drilled in the 1940s.

In 2011, the Service constructed a new entrance station in the “Northwest” timber frame style adjacent to the public parking area at the main trailhead. The station includes two structures, a fee station, and an interpretive kiosk with an attached structure containing three public trash/recycle cans. The facility includes four wood outdoor benches and a metal bicycle rack. A garbage storage structure located near the public restrooms was also constructed in a similar style and includes a dumpster and three public trash/recycle cans. There is a second smaller fee station constructed in 1987 located at the horse trailhead.

There are two viewing decks totaling 1,300 square feet near the north end of the horse and main trails adjacent to the Mellus Cabin with benches and telescopes overlooking the Dungeness Spit. The upper deck is wheelchair accessible. The Refuge leases a public restroom facility and drinking fountain (425 square feet) built in 1973 from Clallam County. It is located next to the public parking area, also leased from Clallam County, adjacent to the main refuge entrance station and includes a 1,000 gallon twin vault septic system and drain field constructed around 2005 and located to the west of the building. However, that system is not able to handle the heavy use associated with the busiest visitor use days the Refuge experiences.

In 2011, the Service constructed an additional septic system for that facility on County property to increase capacity. A 2,000 gallon pump tank was added with a high capacity pump and aqua works controls. A much larger drain-field was added and includes ten 3 x 1 foot trenches, five measuring 60 feet in length and five measuring 70 feet in length. Pipe was installed in each trench which is designed to equally disperse effluent. The old system was left in place and a connecting valve was added to allow selection of the old or new system depending on needs.

Dungeness Unit – Other Infrastructure
Infrastructure at the Refuge Complex headquarters includes an on-site wastewater treatment/disposal system with two 1,000-gallon septic tanks, 250 linear feet of 4-inch diameter PVC effluent piping, and two 60-foot long gravel-less chamber drainfields, all installed in 2009. The domestic water system is tied to the Dungeness Recreation Area's domestic water which is supplied by a community water company. It is comprised of 800 linear feet of 3-inch diameter PVC pipe, a 500-gallon storage tank, booster pump/controls, 1-inch diameter flowmeter, pressure sustaining valve, and 240 linear feet of 2-inch diameter PVC piping to the office building. The electrical infrastructure includes underground utilities (15 KV underground power cable in 2-inch PVC conduit (137 linear feet off-site and 643 linear feet on-site)); 75 KVA transformer; CT enclosure; 2 electric meters; and two 2-inch diameter conduits with underground power to office, all installed in 2009.

Dawley Unit
There are 21 buildings, ponds and other substantial structures located on the Dawley Unit which is closed to all public access. In addition there is a 2,640 linear foot water distribution system to and from the large earthen impoundment pond south of Highway 101 constructed in 1964. Table 5-1 lists each structure including size, condition, and year constructed and/or deconstructed. Structure locations are identified by number on the associated map (Figure 5-1).

5.2.3 Fencing and Boundary Markers

Dungeness Unit Fences
Fencing on the Dungeness Unit falls into two general categories, split rail and plank rail. There is split rail and/or plank fencing surrounding most of the headquarters complex as well as delineating the refuge property from the County recreation area. There is also plank rail fencing delineating the area which is closed to public around the Mellus Cabin from the public trail. A few small fence sections also line both the main and horse trails to discourage visitors from creating illegal "social" trail shortcuts.

Split Rail Fencing
In 2009, contractors installed 953 linear feet of split rail fencing on the southern and eastern boundary of the headquarters complex as part of the new headquarters construction. That fence includes an electronic security gate at the north end of Holgerson Road. Later in 2009, refuge volunteers installed an additional 247 linear feet of split rail fencing in the staff parking area, around the new Complex office entrance, and at the entrance to horse trail. In 2011, 134 linear feet of split rail fence was added between the overflow parking area and the office path and behind the fee station.

Plank Rail Fencing
In 2011, contractors added 84 linear feet of heavy plank rail fencing between the office path and the main trail and an additional 30 linear feet between the entrance to the bluff trail and the parking space closest to the kiosk. This fence was very similar in style to the existing fence which fairly accurately delineates the boundary between the Refuge and the County Recreation Area. The primary difference is that the old fencing incorporated round creosote treated posts and the new fencing uses square untreated cedar posts. The old fence runs 1,389 linear feet from east of the garage building to the west end of the public parking lots and includes breaks or gaps for the horse and main trail, the refuge entrance station, the bluff trail entrance and four parking lot access points along the bluff trail.

The Mellus Cabin is separated from the main trail by 206 linear feet of plank rail fencing and there is 146 linear feet of fence separating the horse trail from the main trail adjacent to the cabin. Three additional sections of plank rail fence totaling 128 linear feet are located along the main trail and one measuring 33 linear feet is located in the forest near the middle section of the horse trail.

Dawley Unit Fences

The Dawley Unit has 920 linear feet of chain link fencing, mostly north and east of the three "natural" ponds and around the stone shed. That fence includes two double gates (one unhinged) and one single gate. There is another double gate separating the Olympic Discovery Trail from the main residence driveway. An additional 306 linear feet of wire fencing stretching from the mobile home to the stone shed was installed by the Discovery Trail during construction.

Saltwater Pilings

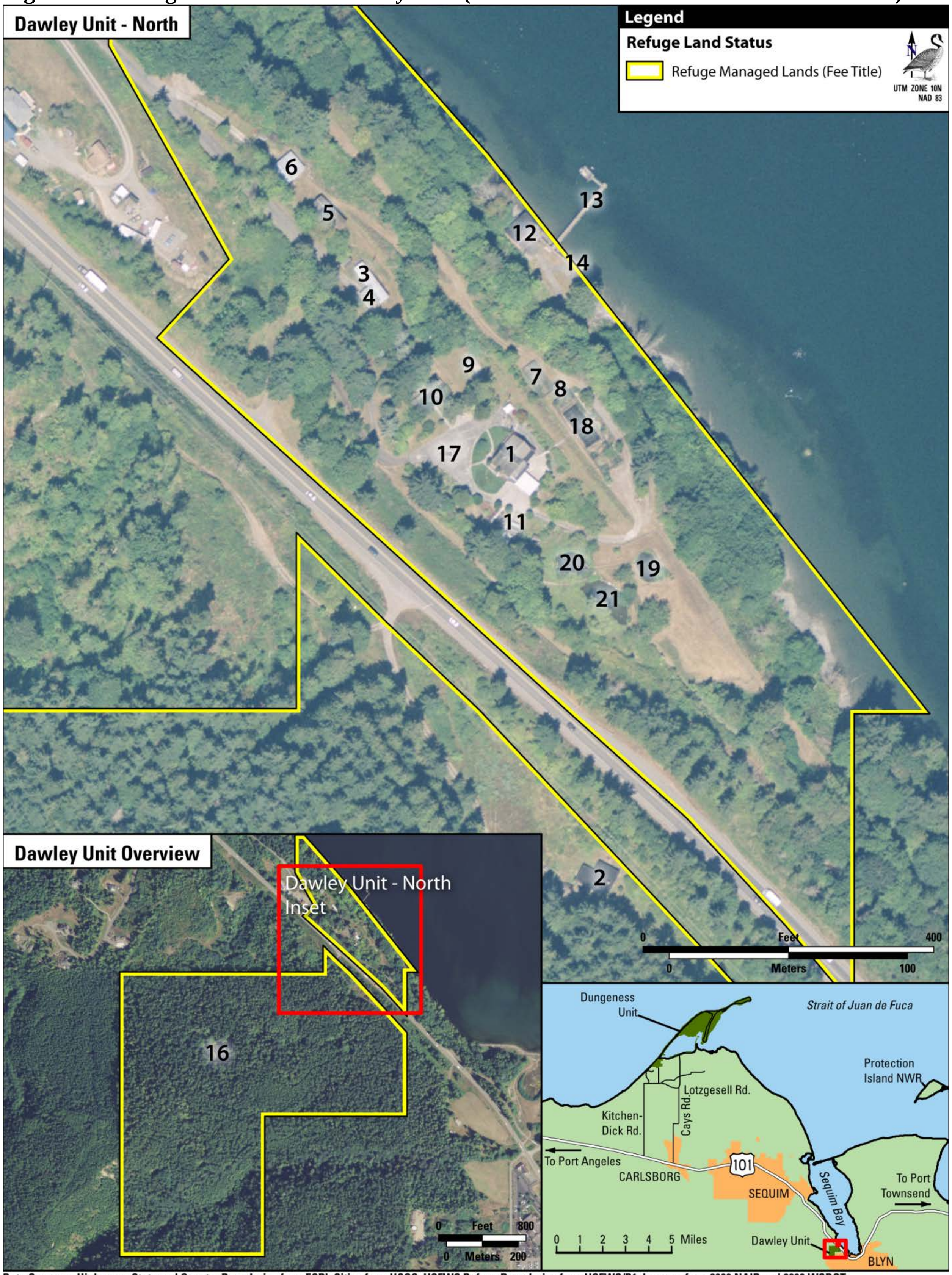
The Refuge currently maintains 13 plastic covered steel core pilings with regulatory signs demarcating the refuge boundary in Dungeness Bay and Harbor.

Table 5-1. Refuge Structures on Dawley Unit (refer to Figure 5-1 for locations)

Structure		Size, sq. ft.	Septic syst.	Yr. Built	Condition	Removed	Tract
1	Main residence	4,393	yes	1935	Fair		North
2	Old rental house *	896	yes	1964	Poor		South
3	Mobile home	808	yes	1974	Poor		North
4	& Small shed		no				
5	Large shed	720	no	1930	Poor		North
6	Metal garage	1,090	no	1990	Good		North
7	Aviary shed	990	no	1965	Foundation	2011	North
8	Small aviary	227	no	1963	Foundation	2011	North
9	Pentagon aviary	16	no	1975	Foundation	2011	North
10	Rectangle aviary	1200	no	1975	Foundation	2011	North
11	Stone shed	288	no	1939	Fair		North
12	Beach house	1,024	yes	1960	Poor		North
13	Wood dock	59.44	-	1952	Fair		North
14	Concrete bulkhead		-				
15	Pole barn	Unknown	no	1964	Collapsed		South
16	Impoundment	Large	-	1964	Good		South
17	Brick "well"	Very small	-		Fair		North
18	Concrete pond	Small	-		Breached	2011	North
19	"Natural" pond 1	-	-				North
20	"Natural" pond 2	-	-				North
21	"Natural" pond 3	-	-				North

* The Service currently plans to remove structure #2, old rental house, and decommission the associated septic system. Note: Removal may be associated with the Washington Department of Transportation's upcoming highway project.

Figure 5-1. Refuge Structures on Dawley Unit (refer to Table 5-1 for numbered references)



Data Sources: Highways, State and Country Boundaries from ESRI; Cities from USGS; USFWS Refuge Boundaries from USFWS/R1; Imagery from 2009 NAIP and 2003 WSDOT

The back sides of maps are blank to improve readability.

5.2.4 Roads and Trails

Dungeness Unit Roads
The Refuge Complex Headquarters compacted gravel access road located at the northern end of Holgerson Road is 490 feet long and was completed and chip sealed in 2009. It provides access to all three buildings at the headquarters and includes a staff parking area with room for approximately 7 vehicles. The parking area also includes a 12 x 36-foot concrete RV pad with water and electrical hook-ups and a sewage discharge connection.

Refuge visitors park in one of two parking lots leased from Clallam County at the north end of Voice of America Road in the Dungeness Recreation Area. The main lot is chip sealed and contains 63 vehicle spaces including two Americans with Disabilities Act (ADA) compliant parking spaces. The “overflow” lot is a mixture of compact gravel and chip seal and contains spaces for 12 additional vehicles including one concrete paver ADA compliant disabled parking space. There is an emergency and maintenance beach access road and right of way that traverses private property at the end west of Anderson Drive. That access includes a locked gate and is not available to the public.

Dawley Unit Roads
There is no public access to the Dawley Unit and no public roads. There is 1,164 linear feet of concrete roadway, 5,856 linear feet of gravel road, and 52,545 linear feet of dirt “skid” roads within the unit providing access to various locations.

Dungeness Unit Trails
Public access to the Refuge Complex headquarters from the refuge entrance station and parking area is via a 404 linear feet concrete paver walkway which incorporates an ADA compliant parking space. The main trail connects the entrance station to the Dungeness Spit and is 2,115 linear feet. It is constructed of compacted gravel and was re-surfaced and modified in 2011. The bluff trail is a dirt trail measuring 740 linear feet extending from the refuge entrance station to the western end of the public parking area. The horse trail is also a dirt trail measuring 3,110 linear feet. and connects to the Dungeness Recreation Area horse trail on the south end and to the refuge main trail on the north end. In 2009, the entrance to horse trail was relocated approximately 30 feet east to align with the County horse trail and to facilitate the installation of the brick paver path connecting the Refuge Office with the entrance station. The old horse trail entrance was rehabilitated.

Although they are not maintained hiking trails, refuge visitors can also hike on the beach on the Strait of Juan de Fuca side from the western refuge boundary to the lighthouse compound. The Dungeness Harbor side of the Spit from the base to the ½ mile marker is open to public hiking from May 15 through September 30.

5.2.5 Signs

The U.S. Fish and Wildlife Service maintains informational, interpretive, and regulatory signage in accordance with standard Service policy; however, due to the maritime nature of the Dungeness National Wildlife Refuge, a series of non-standard “large format” signs have been utilized on shoreline areas. These heavy duty signs measure approximately 5 feet wide by 4.5 feet tall. Such signs are used in particularly sensitive habitat areas susceptible to disturbance by watercraft and warn boaters to remain 200 yards from shore where possible to protect wildlife. The size allows for text large enough to be clearly legible from a distance. See Appendix H for a complete sign inventory.

5.3 Public Use Overview

National wildlife refuges are closed to public use unless specifically designated as open. The Refuge Recreation Act of 1962 authorizes recreational uses of refuges only when such uses do not interfere with the refuge's primary purposes and when funds are available for development, operation, and maintenance of those uses. The National Wildlife Refuge System Administration Act of 1966 further stipulates that all uses of a refuge must be compatible with the purpose(s) for which the refuge was established.

Dungeness NWR offers visitors a limited variety of recreation opportunities. The Refuge includes areas that are open for public use year-round and areas that are open only seasonally, depending on the needs of refuge wildlife. Some portions of the Refuge are closed to visitors year-round for the benefit of wildlife. The Dungeness NWR is divided into five public use zones. Table 5-2 provides a description of the zones as well as a summary of the areas open and closed to public uses and the types of uses that are allowed in each zone. Figure 2-3 also depicts the five public use zones. Public use activities currently occurring on the Refuge include:

- Fishing (saltwater)
- Shellfishing (clams and crabs)
- Wildlife observation
- Wildlife photography
- Hiking
- Boating (no wake allowed)
- Horseback riding
- Beach use (wading, beachcombing, other recreational beach uses)

Opportunities for environmental education and environmental interpretation also exist at the Refuge. While there is no hunting allowed on the Refuge, there is waterfowl hunting taking place on adjacent lands and waters (See Section 5.8, Regional Recreational Opportunities). There is also some waterfowl hunting occurring illegally on refuge waters (See Section 5.6.1, Illegal Refuge Uses).

The 1997 Final Environmental Assessment (EA) for the Management of Public Use for Dungeness National Wildlife Refuge established that personal water craft (jet skiing) and wind surfing are incompatible with refuge purposes (USFWS 1997a). Hiking, wildlife observation and photography, boating, recreational fishing, jogging, beach use and horseback riding were determined to be compatible with the modifications outlined in the EA. Environmental education, tribal fishing, research, and permitted special uses were also found compatible.

In July 2006 the Service published its Appropriate Refuge Use Policy (603 FW 1). Under this policy refuge managers are directed to determine if a new or existing public use is an appropriate refuge use. If an existing use is not appropriate, the refuge manager is directed to modify the use to make it appropriate or terminate it, as expeditiously as practicable. The existing uses of jogging and horseback riding were evaluated and our draft analysis has found that jogging is not appropriate due to wildlife disturbance and therefore and would no longer be allowed. We also have preliminarily determined that horseback riding should no longer be allowed due to safety concerns and user conflicts. See Appendix A, Appropriate Use Findings.

Table 5-2. Refuge Areas Open and Closed to the Public and Current Allowed Uses by Zone

Zone	Description	Open	Closed	Currently Allowed Activities
Zone 1	Beach facing the Strait of Juan de Fuca southwest of the spit base (first ½ mile of refuge beach adjacent to Clallam County Dungeness Recreation Area)	Year-round	N/A	Saltwater fishing, wildlife observation and photography, hiking, and recreational beach use (including jogging)
		Weekdays only: 5/15 to 9/30 Daily: 10/1 to 5/14	Weekends: 5/15 to 9/30	Horseback riding (reservations required)
	Bluffs above the beach	N/A	Year-round	N/A
Zone 2	First ½ mile of beach on Dungeness Spit facing the Strait of Juan de Fuca (west)	Year-round	N/A	Saltwater fishing, wildlife observation and photography, hiking, and recreational beach use (including jogging)
	First ½ mile of beach on Dungeness Spit facing Dungeness Harbor (east)	5/15 to 9/30 (foot access only)	10/1 to 5/14	Clamming/crabbing, wildlife observation and photography, and hiking
Zone 3	Dungeness Spit beach facing the Strait of Juan de Fuca (west and north) from the end of Zone 2 to the New Dungeness Light Station	Year-round	N/A	Saltwater fishing, wildlife observation and photography, and hiking
Zone 4	Dungeness Spit beach facing Dungeness Harbor and Bay, from the end of Zone 2 to the New Dungeness Light Station, the tip of Dungeness Spit, and Graveyard Spit, including a 100 yard buffer below the mean high-tide line	N/A	Year-round	N/A
Zone 5	Refuge waters and tidelands in Dungeness Harbor and Dungeness Bay beyond the Zone 4 100 yard buffer area	5/15 to 9/30 (boat access only)	10/1 to 5/14	Clamming/crabbing, wildlife observation and photography, and boating (no wake)

5.4 Wildlife-Dependent Public Uses

Wildlife-dependent public uses are voluntary, leisure time pursuits which require presence of or proximity to fish, wildlife, or wildlands. Wildlife-dependent uses in the National Wildlife Refuge System generally refer to hunting, fishing, wildlife observation and photography, and environmental education and interpretation. With the exception of hunting, all of these uses occur at Dungeness NWR.

Some uses are not wildlife-dependent but do facilitate the pursuit of wildlife-dependent activities. Examples of non-wildlife-dependent uses occurring at Dungeness NWR that may facilitate fishing or wildlife observation and photography include hiking, boating, and recreational beach uses such as wading, beachcombing, picnicking, or sunbathing. These uses are described in Section 5.5, Other Refuge Uses.

5.4.1 Fishing and Shellfishing

A limited amount of hook-and-line saltwater fishing occurs on the Strait of Juan de Fuca side of Zones 1, 2, and 3. These three zones are open year-round to fishing activities. Shellfishing occurs on the tidelands in Dungeness Harbor and Dungeness Bay in Zones 2 and 5. Both Zones 2 and 5 are open to shellfishing from May 15 through September 30. Visitors are allowed to access Zone 2 by foot only and Zone 5 by boat only. In Zone 5, shellfishing is restricted to beyond 100 yards from the mean high tide line. Shellfishing at the Refuge does not include oyster harvesting; all oysters in the area are privately owned. All Washington State fishing regulations apply to fishing and shellfishing activities on the Refuge. Use of the Refuge for fishing and shellfishing is limited because there are areas in the local vicinity that offer higher quality opportunities for these experiences. No developed facilities exist to support fishing or shellfishing.

5.4.2 Wildlife Observation and Photography

Wildlife observation and wildlife photography are the primary wildlife-dependent activities occurring on the Refuge. Visitors to Dungeness NWR can enjoy wildlife observation and photography opportunities in any of the areas open to public use. Wildlife observation and photography can occur year-round along the upland trails and the beach in Zone 1; along the Strait of Juan de Fuca in Zones 2 and 3; and seasonally in Zones 2 and 5. Access restrictions dictate that wildlife observation and photography can only occur via access on foot in Zones 1, 2, and 3; by boat in Zone 5; and by horseback in Zone 1. There are two observation decks with viewing scopes at Dungeness NWR. The upper deck is equipped with two viewing scopes and the lower deck with one. The observation decks are located approximately 3/8 mile from the parking area and can be reached by a designated trail.

5.4.3 Environmental Education and Interpretation

The Refuge is a popular outdoor classroom for local scout troops and school groups from grade school to university. Instructors arrange for educational field trips to the Refuge and these groups often assist the Refuge with service projects. Projects include removing Styrofoam, plastics, and other debris from the refuge lands. The Refuge does not offer formal education programs but does try to support instructors who use the refuge as a classroom.

There are limited numbers of interpretive panels and information at the Refuge. Interpretive panels are located in the kiosk area near the parking lot trailhead and along the trail. The Refuge also has an interpretive brochure for visitors' use. In addition, the Refuge takes advantage of volunteer subject matter experts to present interpretive programs about the refuge habitat resources and geomorphologic processes (i.e., spit formation). There is limited interpretive information about the human history of the refuge area and vicinity. The New Dungeness Light Station Association volunteers provide interpretive information to lighthouse visitors about the light station and its role in local maritime history; minimal refuge interpretation is presented at the light station. A panel with a map and some regulation information is located at the light station. Regulatory panels are also located off-refuge at the Dungeness Landing County Park and Cline Spit Community Beach boat launches.

Since 1990, Graveyard Spit has been a designated Resource Natural Area (RNA). Activities here are limited to research, study, observation, monitoring, and education; must be non-destructive and non-manipulative; and must maintain unmodified conditions. The natural processes must be allowed to predominate without human intervention. Public access to Graveyard Spit is not allowed; research arrangements and permits must be specifically granted by the Service.

5.5 Other Refuge Uses

In addition to wildlife-dependent public uses, refuges can sometimes offer experiences that are non-wildlife-dependent. Non-wildlife-dependent public uses are those voluntary, leisure time pursuits that do not require the presence or proximity of fish, wildlife, or wildlands. Examples of non-wildlife-dependent uses include swimming or wading, horseback riding, jogging, and hiking or recreational boating purely for the sake of hiking or boating, respectively. The non-wildlife-dependent uses allowed and occurring at Dungeness NWR are described below.

5.5.1 Hiking

Some non-wildlife-dependent uses on the Refuge enable visitors to enjoy wildlife-dependent activities. For example, public use of motorized vehicles is not allowed on the refuge lands; therefore, hiking allows visitors to engage in wildlife observation and photography. Hiking is enjoyed for the sake of hiking as an experience, as well. Hiking occurs along a designated upland trail and along the spit beach facing the Strait of Juan de Fuca. The upland trail begins at the parking area and meanders through the forest to an overlook on the bluff above Dungeness Spit. It continues down a steep hill to the spit, emerging from the forest at the interface of public use Zones 1 and 2. It extends another five miles as a beach walk along the Strait of Juan de Fuca, ending at the New Dungeness Light Station.

5.5.2 Boating

Boating is another example of a non-wildlife-dependent activity that can support wildlife-dependent recreation as well as be enjoyed for the sake of the activity itself. Parts of the Refuge are only accessible by boat and, like hiking, recreational boating can allow visitors to engage in wildlife observation and photography opportunities in those areas. Recreational boating is a necessary refuge use in order for refuge visitors to engage in shellfishing on the refuge tidelands in Dungeness Harbor and Dungeness Bay. During daytime low tides in the summer months, some visitors dig for clams in the tidelands west of Graveyard Spit. Boaters often set crabpots east of Graveyard Spit from September through April.

Powerboats are also used to visit the New Dungeness Lighthouse. There is a designated boat-landing zone near the lighthouse that is open year-round; reservations are required. The reservation system allows the Refuge to limit the number of boat landings in order to minimize wildlife disturbances.

The landing zone is a 100-yard wide area on the bay side of Dungeness Spit – it is the only area on the bay and harbor side of the spit in which boats are allowed to land within the 100-yard buffer zone. The designated landing is an unimproved section of beach with no facilities. Visitors are allowed to walk through a designated area in Zone 3 in order to access the lighthouse from the landing site.

Non-motorized boats are also common on the refuge waters. While small sailboats and canoes are occasionally used to visit the area in summer, kayaks have become a more popular means for visiting the area. Several kayak outfitters offer guided tours to Dungeness NWR and New Dungeness Lighthouse. The kayaks launch from Cline Spit and travel through refuge waters to the landing zone at the lighthouse. While most of the tours occur in the summer months, some are also offered in the winter months.

Although they are popular activities nearby, jet skiing and windsurfing are not allowed in the refuge waters. All waters within the refuge boundary are designated as no-wake zones. To protect wildlife, the Refuge has established a buffer that extends waterward for 100 yards from the mean high tide line.

Under the action alternatives, Alternatives B and C, boat landings at the designated lighthouse boat landing zone would be limited to 9 am to 5 pm.

5.5.3 Horseback Riding

Horseback riding is currently allowed in Zone 1 only and requires an advanced reservation through the Refuge Office. Riding is permitted, with the required reservations, on weekdays from May 15 through September 30 and daily during the remainder of the year. The reservation system is used to avoid overcrowding and to ensure public safety. Riders must use the designated horse trail from the parking area through the uplands to access the beach area west of the Dungeness Spit base (below the bluffs). Horseback riding use varies seasonally in the same trend manner as overall monthly refuge visitation. Peak horseback riding on the Refuge occurs in the summer months.

Through this planning process, horseback riding was re-evaluated based on the refined criteria outlined under the appropriateness policy. We have preliminarily determined that horseback riding should no longer be allowed due to safety concerns and user conflicts. For more information, see Chapter 2 and Appendix A, Appropriate Use Findings.

5.5.4 Jogging

Jogging is currently allowed in Zones 1 and 2. In Zone 1, jogging is allowed along the access trail and the beach facing the Strait of Juan de Fuca. In Zone 2, jogging is allowed on the Strait of Juan de Fuca beach. All foot traffic in Zone 3 is to be at a walking pace. Through this planning process, jogging was re-evaluated based on the refined criteria outlined under the appropriateness policy. Jogging did not satisfy the criteria for appropriateness and thus would no longer be allowed. For more information, see Chapter 2 and Appendix A, Appropriate Use Findings.

5.5.5 Other Recreational Beach Use

Other recreational beach use includes wading, beachcombing, picnicking, sunbathing, and other passive, non-consumptive uses not described above. These beach uses are allowed in Zones 1 and 2, along the beach facing the Strait of Juan de Fuca. These zones are the most accessible areas via the trail from the parking area.

In order to protect migrating birds and other wildlife from disturbance, jet skis, windsurfers, pets, bicycles, kites, Frisbees, boomerangs, and balls are not allowed on the Refuge. More information about illegal uses is provided in the next section.

5.6 Illegal Uses

5.6.1 Illegal Refuge Uses

The most frequent illegal uses occurring on the Refuge include non-payment of the required entrance fee and after hours and closed area trespass. Occurring less frequently are dog walking, bicycle riding, littering, climbing on closed bluffs, beach combing and collecting (including drift wood collection), and unauthorized boat landings and entry into closed waters. Additional incidental illegal uses include fishing (shellfish and finfish) out of season, water fowl hunting, camping and fires, graffiti and other vandalism. Non-wildlife-dependent recreational activities that disturb wildlife such as jogging in areas closed to that activity, kite flying and ball sports occasionally occur on the Refuge.

Illegal uses persist partly due to limited law enforcement presence and a lack of public awareness of the sensitivity of refuge wildlife to human disturbance. There is currently one dual-function Refuge Law Enforcement Officer assigned to cover all six refuges within the Washington Maritime National Wildlife Refuge Complex. Refuge staff coordinates with other Federal officers/agents and works with the U.S. Coast Guard as well as State, county, and local law enforcement offices.

5.7 Refuge Visitation

5.7.1 Visitation

The Refuge is a popular regional destination. However, determining actual visitation is problematic due the Refuge's "honor" system where visitors are required to enter the number of people in their party on their fee payment envelope and because there is no mechanism in place to count refuge boaters, except those that make reservations to land at the historic lighthouse. Some visitors simply do not fill out the required information and others illegally bypass the fee station altogether. As such, refuge visitation is estimated by adding an additional 15% to the total visitor count attained from fee envelopes to account for people who do not comply with the registration requirements and for boaters who do not land at the lighthouse and those that fail to make the required reservation.

It is estimated that visitation in 2011 approached 76,000 people and may have actually been significantly higher. Construction of the new entrance station during spring and summer of 2011 may have negatively impacted visitation which has ranged in the past five years from relative lows of about 76,000 visitors in 2009 and 2011 to a high of about 80,300 in 2010. Between 2007 and 2011, refuge visitation remained fairly steady (±5%) despite the onset of a severe economic recession suggesting the sluggish economy has not significantly impacted refuge recreation trends. This may be due, in part, to the relatively low user fee of $3 per day or $12 annually per 4 adults. By comparison, many other popular recreation site user fees in the region are significantly higher (See Table 5-3, Regional Recreation Site User Fees). The local area is also considered to be a retirement community and many of the regular visitors possess lifetime “Senior” or “Golden Age” passes which cover refuge entrance fees.

The Refuge usually experiences the highest visitation in the summer months from June through August. On average, this three month period accounts for nearly half of annual visitation. It is not unusual to have 600 or more visitors per day during the summer and very busy days may have over 900 people. The highest single day visitation on record was Sunday, September 4th, 2011, when 1,037 people were tallied entering the Refuge (USFWS 2012a).

In July 2011, visitor surveys were distributed to refuge visitors as part of a National Science Foundation funded research project involving Colorado State University, the National Park Service, the FWS, and the National Parks Conservation Association. Of the 150 respondents who filled out demographic information, 11% were ages 66 and up. The two largest age groups were from 46-55 (20%) and 56-65 (29%) (Davis et al. 2012). Demographic information for visitors to the nearby Olympic National Park (NP) provides additional insight into refuge visitation. Based on a visitor study conducted at Olympic NP in July 2000, most of the visitor groups (64%) were family groups. Seventy-seven percent of the park’s visitor groups were groups of two to four people (Van Ormer et al. 2001). Anecdotally, Dungeness NWR sees similar visitor group sizes and, particularly during the summer, a similar proportion of family groups.

While it is apparent that most visitors are seeking an outdoor recreation experience, it is difficult to quantify the number of visitors participating in each category. The most popular activities are hiking and wildlife and/or landscape viewing. Many people just want to see the Dungeness Spit and enjoy the panoramic views. Aside from the trails, the majority of visitors tend to congregate in the first ½ mile of the spit making it the busiest part of the Refuge’s beach area.

Visitor logs maintained at the New Dungeness Light Station suggest that approximately 10% of refuge visitors make the 11 mile round trip hike to see the historic lighthouse. Due to the difficulty of tracking visits by boat, it is unknown how many recreational boaters use refuge waters. However, it is estimated that on average, around 275 boats visit the lighthouse each year, most of those being kayaks. By far the majority of visitors, at least 99%, access the Refuge via the upland trails. Of those more than 98% enter on the main trail while only about 1% enters the Refuge via the horse trail. However, horse riders typically account for less than 12% of horse trail users averaging just 164 reservations annually between 2008 and 2010 (USFWS 2012a). Data from 2011 were not included as the horse trail was closed for about 3 months due to reconstruction of the main trail.
Education is also an important refuge activity. The Refuge is used as an outdoor classroom for environmental education by regional schools, organizations, and universities. Between 2007 and 2011, 117 educational use permits were issued for the Refuge covering 879 adults and 3,496 youths. On average, 23 permits covering 176 adults and 699 youths are issued annually. While specific curriculums vary, permits require that the course of study focus on the wildlife, plants, geology, marine environment, or history of Dungeness National Wildlife Refuge.

5.8 Regional Recreational Opportunities

Dungeness NWR is located on the North Olympic Peninsula which encompasses two counties, Jefferson and Clallam, and is bordered by the Pacific Ocean to the west, the Strait of Juan de Fuca to the north, Puget Sound to the east, and Olympic National Park and National Forest to the south. The area boasts an incredible array of bays, estuaries, lakes, rivers, waterfalls, glaciers, beaches, mountains, forests, wetlands, farmlands, and alpine meadows. It has a great diversity of natural habitats and nature based recreational opportunities. The North Olympic Peninsula is well known for its extensive hiking, biking, camping, boating, wildlife viewing, mountaineering, snow sports, hunting, fishing and diving opportunities. With so much land in public ownership, the recreational opportunities are quite extensive. The following abbreviated synopsis is intended to provide a general overview of regional recreation opportunities including those available in Clallam County and in the general vicinity of the Refuge. Furthermore, the North Olympic Peninsula is only a short drive and a ferry ride away from additional recreational opportunities available in the San Juan Islands; Victoria, British Columbia; and Canada's Vancouver Island.

The Olympic Peninsula encompasses more than 6,500 square miles (Richards 1984) with the Olympic National Forest (NF) and Olympic National Park (NP) comprising nearly one-third of the land area (Turner et al. 1996). See Table 5-4, Land ownership on the Olympic Peninsula, Washington. Currently Olympic NF includes 633,677 acres, and Olympic NP includes 922,650 acres. Of the more than two million acres of forests in Clallam and Jefferson counties, more than 50% is federally owned (RC&DC 2009). Both public and private lands are generally held in large blocks, and the majority of the nonfederal lands are managed for timber production by the state of Washington's Department of Natural Resources (WDNR) and by large private corporations. Most of that land is open for recreation including hunting. Small private ownerships comprise only 21% of the Olympic Peninsula (Turner et al 1996).

Wilderness

The United States Congress designated the Olympic Wilderness in 1988 (Washington Park Wilderness Act of 1988 - Public Law 100-668 (11/16/1988)). The area, managed by the National Park Service, now totals 876,669 acres and is Washington's largest Wilderness area. It is also one of the most diverse wilderness areas in the U.S. The heart of the Olympic Wilderness is made up of the rugged Olympic Mountains and some of the most pristine forests left south of the 49th Parallel. The temperate rainforest valleys of the west and south flanks of the mountains receive 140 to 180 inches of precipitation annually with Mt. Olympus (7,980 feet), the highest peak in the Olympic Mountains, receiving over 100 feet of snow annually (Wilderness.net 2012).

Mt. Olympus has the third largest glacial system in the conterminous U.S. next to Mt. Rainier and Mt. Baker, also in Washington State. The Olympic Wilderness also contains 48 miles of wilderness coast including beaches, rugged headlands, tide pools, seastacks, and coastal rainforests. Just over 600 miles of trails lead into the interior of the park. Olympic is one of the most popular wilderness destinations in North America, with nearly 40,000 overnight wilderness visitors each year (Wilderness.net 2012).

Recreation on Washington Department of Natural Resources (WDNR) Lands

WDNR seeks to provide outdoor recreation opportunities to the public throughout Washington State. Recreation on WDNR-managed lands includes hiking, hunting, fishing, horseback riding, camping, off-road vehicle (ORV) driving, mountain biking, and boating. The agency provides trails and campgrounds in a primitive, natural setting. Most recreation on these lands takes place in the 2.2 million acres of forests that WDNR manages as state trust lands. WDNR manages 1,100 miles of trails, 143 recreation sites, and a wide variety of landscapes across the state (WDNR 2012).

WDNR’s Olympic Region, which surrounds the Olympic Peninsula, offers a variety of quality recreation experiences. The region has 10 campgrounds, 4 designated multi-use trails with approximately 40 miles of trails for hiking, horseback riding, mountain biking, motorcycling, and ORVs or 4x4s, as well as numerous other trails for non-motorized activities. The majority of the campgrounds have river or lake access for boating, fishing, and other water activities. The region is located near the Olympic National Park, Hoh Rain Forest, Olympic National Forest, Olympic Experimental State Forest, as well as the many coastal beaches in the region. The region encompasses approximately 371,000 acres of state forest, agriculture, urban and conservation lands (WDNR 2012). See Table 5-5, North Olympic Peninsula Parks and Recreation Areas.

Clallam County Parks

Clallam County manages parks in various parts of the County, primarily oriented around water. Recreation opportunities in the agency’s twenty parks include camping, fishing, boating, hunting, hiking, horse riding, picnicking, scuba diving, and beachcombing. The 216 acre Dungeness Recreation Area borders the Refuge and offers camping (February 1 through September 30), picnic sites (including a group picnic area), hiking, horseback riding, limited hunting, and allows pets on leashes (Clallam County Parks 2012a).

There are two other County Parks, Cline Spit and Dungeness Landing, adjacent to the Refuge. Both offer public restrooms, tidelands, and free boat launches. Cline Spit is approximately 2 acres in size and has a boat ramp for boats 17 feet long and smaller that provides access to inner Dungeness Bay. The park includes 240 linear feet of public tidelands. Dungeness Landing is 5.6 acres with 13 additional acres of tidelands along the outer Dungeness Bay. Park features include a covered birding platform, a high water boat launch, and spectacular views of the historic New Dungeness Lighthouse and the Refuge (Clallam County Parks 2012b). See Table 5-5, North Olympic Peninsula Parks and Recreation Areas.

Birding

From ocean beaches to the Olympic Mountains, the North Olympic Peninsula offers some of the best birding opportunities in the Pacific Northwest. Mild winters support large numbers of ocean birds, including waterfowl. Spring and fall are migration times and offer great diversity in species. Due to diverse habitat, from rainforest to tidelands, many species remain as summer residents (OPAS 2012). In addition to the Refuge, the following viewing sites are recommended by the local Audubon Chapter.

- Gardiner Beach, Diamond Point & Discovery Bay
- South Sequim Bay / Blyn & Jimmycomelately Creek
- John Wayne Marina
- Washington Harbor, Schmuck Road, & Port Williams/ Marlyn Nelson County Park
- Dungeness Bay & 3 Crabs
- Dungeness Recreation Area
- Sequim’s Railroad Bridge Park & Dungeness River Audubon Center
- Olympic National Forest: Upper waters of the Dungeness & Gray Wolf Rivers
- Olympic National Park & Hurricane Ridge
- Ediz Hook & Port Angeles Harbor
- Elwha River Estuary
- Salt Creek County Park
- Neah Bay & Cape Flattery

Wildlife Viewing

Exceptional opportunities to view the region's rich wildlife abound. One of the newest is the Whale Trail, a network of marine mammal viewing sites in the Pacific Northwest (Figure 5-2). The Whale Trail is being developed by a core team of partners including NOAA Fisheries, the Washington Department of Fish and Wildlife, People for Puget Sound, the Seattle Aquarium, the Olympic Coast National Marine Sanctuary, the Whale Museum, and Coast Watch Society. Thus far it includes 8 sites on the Olympic Peninsula, 32 sites in total located in city, county, and state parks; Tribal lands; and the Washington State Ferries (Whale Trail 2012).

Figure 5-2. One of Four Whale Trail Signs along Highway 112 on the Olympic Peninsula

Photo Credit: USFWS

Olympic Coast National Marine Sanctuary (OCNMS or Sanctuary)

The Sanctuary includes 2,408 square nautical miles of marine waters off the rugged Olympic Peninsula coastline. The Sanctuary extends 25 to 50 miles seaward, covering much of the continental shelf and several major submarine canyons. The Sanctuary protects a productive upwelling zone - home to marine mammals and seabirds. Along its shores are thriving kelp and intertidal communities teeming with fishes and other sea life. Twenty nine species of marine mammals reside in, or migrate through the Sanctuary. Gray whales, sea otters, harbor seals, and Steller's and California sea lions can be spotted from land at many locations along the coast at some time during the year. Other whales including humpback whales can be seen from boats as they feed miles offshore. The Sanctuary receives more than three million visitors annually, many attracted by Olympic National Park and other natural and cultural amenities (NOAA 2012a). The Sanctuary surrounds all the islands comprising Flattery Rocks, Quillayute Needles, and Copalis NWRs.

Waterfowl Hunting

While there is no hunting allowed in the Refuge, there are public and private recreational hunting opportunities nearby. On October 16, 2010, the Washington Department of Fish and Wildlife (WDFW) opened a new public waterfowl hunting area on the Lower Dungeness Unit west of the mouth of the Dungeness River off of East Anderson Road near Sequim. The 140 acre unit is open for waterfowl hunting on Wednesdays, Saturdays, and Sundays throughout the hunting season under a three-year agreement with Dungeness Farms Inc. As part of that agreement WDFW granted exclusive public access to Dungeness Farms to a parcel off Three Crabs Road (WDFW 2010). In addition, the State of Washington allows waterfowl hunting on State owned waters adjacent to the Refuge.

Western Washington Pheasant Release Program

The major goal of the pheasant program in western Washington is to provide an upland bird hunting opportunity. The program also encourages participation from young and older-aged hunters. Because the cool, wet climate of western Washington combined with the lack of grain farming limits naturally sustained pheasant populations, 30,000 to 40,000 pheasants are released each year on about 25 release sites. The only release site in Clallam County is the Dungeness Recreation Area (DRA) which currently allows pheasant hunting between the first weekend in October and November 30 on Saturdays, Sundays, and holidays (WDFW 2012b). The DRA also allows waterfowl hunting Saturdays, Sundays, and holidays throughout the waterfowl season. However, after completion of Clallam County's Master Plan for DRA, the hunting program has been determined to no longer be a compatible activity and will likely be phased out after 2013 (Clallam County Parks 2008).

Public Hunting on Private Lands

Since about 50% of Washington is in private ownership, many public hunting opportunities rely on landowners opening their lands. In Washington, hunters must obtain landowner permission to hunt on private land. Since 1948, WDFW has worked with private landowners across the state to provide public access through a negotiated agreement. Landowners participating in a WDFW cooperative agreement retain liability protection provided under state law (RCW 4.24.210). Landowners receive technical services, materials for posting (signs and posts), and in some cases monetary compensation. During the 2010-2011 hunting season, there was one Private Lands Program cooperator in Clallam County providing 216 acres of hunting area (WDFW 2012a).

Horse Riding

Low rainfall and mild winters in the Dungeness Valley make the area ideal for year round equestrian activities and there are several popular places to ride horses near the Refuge. The Dungeness Recreation Area provides equestrian trails which are open daily except Saturdays, Sundays and holidays during the hunting season. Riders can access the Refuge's horse trail from the County equestrian trail. Clallam County also offers equestrian trails at Robin Hill Farm County Park. The Park features 195 acres of wetlands, thick forests, and large grassy meadows. There are approximately 2.5 miles of horseback riding trails through forests and rolling grasslands. Riders can also access the Olympic Discovery Trail from the Park.

The Olympic Discovery Trail provides approximately 53 miles of hiking and biking trails in the lowlands between the Olympic Mountains and the Strait of Juan de Fuca. The trail will eventually span 126.2 miles from Port Townsend to the Pacific Ocean. Many parts of the trail have a horse track alongside. This may be a wide, dirt or packed gravel shoulder or a separated path. Between Sequim and Port Angeles horses are allowed from the west side of the Dungeness River Bridge to east side of the Morse Creek Bridge, although there is not an adequate horse track from Lake Farm Road to Morse Creek. Horse trailer parking and unloading is available at Robin Hill Farm County Park (PTC 2012).

Table 5-3. Regional Recreation Site User Fees

<table>
<tr><th colspan="2">Site/Agency</th><th>Daily Fee</th><th>7 Day Fee</th><th>Annual Fee</th><th># of Visitors Covered</th></tr>
<tr><td colspan="2">Dungeness NWR</td><td>$3</td><td></td><td>$12</td><td>4 adults or immediate family</td></tr>
<tr><td colspan="2">Clallam County Parks</td><td>Free *</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Jefferson County Parks</td><td>Free *</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Sequim/Port Angeles Parks</td><td>Free</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">WDFW</td><td>$10 ($11.50**)</td><td></td><td>$30 ($35**) ***</td><td>Occupants of Private Vehicle</td></tr>
<tr><td colspan="2">WDNR</td><td>$10 ($11.50**)</td><td></td><td>$30 ($35**)</td><td>Occupants of Private Vehicle</td></tr>
<tr><td colspan="2">WA State Parks</td><td>$10 ($11.50**)</td><td></td><td>$30 ($35**)</td><td>Occupants of Private Vehicle</td></tr>
<tr><td colspan="2">Olympic NF</td><td>$5</td><td></td><td>$30</td><td>Occupants of Private Vehicle</td></tr>
<tr><td rowspan="2">Olympic NP</td><td>Vehicle</td><td></td><td>$15</td><td>$30</td><td>Occupants of Private Vehicle</td></tr>
<tr><td>Individual</td><td></td><td>$5</td><td>$30</td><td>Per Person</td></tr>
<tr><td colspan="2">Makah Recreation Permit</td><td></td><td></td><td>$10</td><td>Occupants of Private Vehicle</td></tr>
<tr><td colspan="2">Olympic Game Farm</td><td>$11/$12</td><td></td><td></td><td>Per Person</td></tr>
</table>

* Fees charged for camping
** Price including dealer and transaction fees
*** Hunters, fishers, and trappers get a Vehicle Access Pass as part of their annual license fee, excluding annual shellfish license.

Table 5-4. Land Ownership on the Olympic Peninsula, Washington

Ownership	Mi^2	Km^2	%
Private	4,664	7,506	45
National Park Service	2,262	3,640	22
U.S. Forest Service	1,578	2,540	15
Washington State	1,267	2,039	12
Tribal	608	978	1
County	28	45	<1
U.S. Department of Defense	10	16	<1
U.S. Fish and Wildlife Service	1	2	<1
Bureau of Land Management	1	1	<1

Source: Ratti et al. 1999.

Table 5-5. North Olympic Peninsula Parks and Recreation Areas

Ownership	Size
Federal	
Olympic National Park	922,650 acres
Olympic National Forest	633,677 acres
Dungeness National Wildlife Refuge	772.5 acres, > 50% open to the public permanently or seasonally
WDNR Recreation Areas in Clallam County	
Bear Creek Campground	
Foothills ORV Trailhead and Trails	
Little River Trailhead and Trails	
Lyre River Campground	
Murdock Beach Access	
Sadie Creek Trailhead, Vista & Trail	
Striped Peak Vista, Trailhead and Trail	
WDNR Recreation Areas in Jefferson County	
Copper Mine Bottom Campground	
Cottonwood Campground	
Hoh Oxbow Campground	
Minnie Peterson Campground	
South Fork Hoh Campground	
Upper Clearwater Campground	
Willoughby Creek Day Use Area	
Yahoo Lake Campground	
WA Department of Fish and Wildlife Lands	
Bell Creek Unit	89 acres
Chimacum Unit	109 acres
Elwha Unit	62 acres
Lower Dungeness Unit	148 acres + 73 acres of easement
Morse Creek Unit	133 acres
Snow Creek-Salmon Creek Unit	156 acres
South Sequim Bay Unit	22 acres
Tarboo Unit	Not available
WA State Parks	
Anderson Lake SP	480 acres
Bogachiel SP	123 acres
Damon Point SP (WDNR Owned)	61 acres
Dosewallips SP	425 acres
Fort Flagler SP	784 acres
Fort Worden SP & Conference Center	433 acres
Grayland Beach SP	412 acres
Griffiths-Priday Ocean SP	364 acres
Mystery Bay SP	10 acres
Ocean City SP	170 acres
Old Fort Townsend SP	367 acres
Pacific Beach	10 acres
Pillar Point SP	4.3 acres

Ownership	**Size**
Sequim Bay SP	92 acres
Shine Tidelands SP	13 acres
Triton Cove SP	29 acres
Clallam County Parks	
Camp David Jr.	9.5 acres
Clallam Bay Spit Community Beach CP	33 acres
Cline Spit CP	2 acres
Dungeness Landing CP	5.6 acres + 13 acres of tidelands
Dungeness Recreation Area	216 acres
Freshwater Bay CP	21.07 acres
Jessie Cook Scriven CP	5 acres
Lake Pleasant Community Beach	< 2 acres
Mary Lukes Wheeler CP	10 acres
Panorama Vista (WDNR Owned)	3 miles of tidelands
Port Williams (Marlyn Nelson CP)	1 acre
Quillayute River CP	13 acres
Robin Hill Farm CP	195 acres
Salt Creek Recreation Area	196 acres
Three Waters CP	8.5 acres
Verne Samuelson Trail CP	1.5 mile trail
Olympic Discovery Trail	120 miles planned

5.9 Regional Recreation Rates and Trends

5.9.1 Outdoor Recreation Participation Rates Statewide

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

The report identified 15 major categories of outdoor recreation, subdivided into 114 activity types or settings. Of these 15 major categories, walking/hiking is the number one activity with 74% of Washington residents participating in some type or setting of walking and/or hiking. Nature activity is the third most popular recreation, with 54% of residents enjoying some form of this activity. The report indicated observing/photographing nature and wildlife has a participation rate of 29% and that visiting interpretive centers has a participation rate of 15% among statewide residents (See Table 5-6, Major activity group participation in 2006).

The most frequently occurring recreational activities in 2006 included walking without a pet (3.5 million times), observing or photographing wildlife or nature (3.1 million times), walking with a pet (2.7 million times), jogging or running (2.3 million times), and playground recreation (2.2 million times). The most frequently mentioned activities that Washingtonians wanted to do more of in the 12 months following the survey interview included sightseeing (46.9%), picnicking or cooking outdoors

(39.4%), hiking (33.5%), tent camping with a car or motorcycle (33.4%), and swimming or wading at a beach (28.4%) (RCO 2007).

Table 5-6. Major Activity Group Participation in 2006

Ranking of Major Activity Areas Activity Area	Population %
Walking/Hiking	73.8
Team/Individual Sports, Physical Activity	69.2
Nature Activity	53.9
Picnicking	46.8
Indoor Community Facility Activity	45.1
Water Activity	36.0
Sightseeing	35.4
Bicycle Riding	30.9
Off-road Vehicle Riding	17.9
Snow/Ice Activity	17.5
Camping	17.1
Fishing	15.2
Hunting/Shooting	7.3
Equestrian Activity	4.3
Air Activity	4.0

Source: RCO 2007.

5.9.2 Forecast for Regional Recreation Demand and Key Recreation Needs

Overall, outdoor recreation in most categories continues to increase at high growth rates. In their 2003 report, the IAC projected future participation in 13 of 14 major outdoor recreation use categories over periods of 10 and 20 years. Nine of these activities were projected to experience double digit growth (IAC 2003). These most recent estimates of recreation trends were based on the National Survey on Recreation and the Environment Projections for the Pacific Region (NSRE), which includes Washington State. The IAC adjusted the NRSE projections as necessary based on age group participation, estimates of resource and facility availability, user group organization and representation, land use and land designations, and "other factors," including the economy and social factors. Table 5-7, Projected Participation Increases for Selected Outdoor Recreation Activities, shows the percent change expected for Washington State by activity as reported by IAC.

In an earlier assessment conducted by the IAC, trails and environmental education were identified as the two highest outdoor recreation needs in the state (IAC 1995). In their subsequent report in 2002, the IAC encouraged USFWS to find the resources with which to ensure that regulatory processes are as efficient as possible while protecting important natural resources, and to consider their findings in the development and implementation of management plans (IAC 2003). Many outdoor activities generally permitted on refuges are expected to show increases of 20 to 40 percent over the next 20 years. The exception is hunting, in which participation is expected to fall at about that same rate. This CCP considers the recommendations of the IAC and specifically addresses the increasing need for environmental education and maintaining access to trails.

Hiking/Walking

On average in 2006, of the various walking and hiking activities, Washington residents expressed the greatest interest in doing more hiking (34.2%) in the next 12 months. Of all age groups, parents of children under 10 expressed the highest level of interest in the child doing more walking and hiking in general (33.8%). Females showed higher levels of interest than males in doing more walking with pets (18.5%) or without pets (32.5%). Males were more likely than females to want to do more climbing or mountaineering (9.8%). Washingtonians 50 and older were the most likely to express an interest in doing more walking without a pet (30.4% of those 50 to 64 and 34.6% of those 65 or older) (RCO 2007).

Wildlife Observation and Photography

Washington State offers some of the most fantastic and unique opportunities to view and photograph wildlife in the U.S. In particular, the north Olympic Peninsula offers endless opportunities to experience wildlife including rare seabirds such as tufted puffins, rhinoceros auklets, and black oystercatchers. The region's rich waters are home to large numbers of marine mammals, including seals, porpoises, and whales, as well as a myriad of other creatures. It is estimated that nearly 40 percent of Washington residents participated in nature and wildlife observation and photography in 2006 (RCO 2007), although the actual percentage may be well over that (IAC 2003).

The RCO's 2006 Outdoor Recreation Survey reported such activity occurred more than 35 million times that year (RCO 2007). Participation in nature-related activities is growing in popularity in Washington and is expected to increase significantly in coming years (IAC 2003). On average in 2006, just over a quarter of Washington residents wanted to do more observation or photography of wildlife or nature in the next 12 months (25.8%). Females wanted to visit nature or interpretive centers more and at higher rates than males. Parents of children under 10 indicated their children would like to do more visiting of nature or interpretive centers, gathering or collecting things in nature settings, and nature activities in general at rates higher than older residents indicated for themselves (RCO 2007).

Sightseeing

On average in 2006, 47.7% Washington residents wanted to do more sightseeing in general in the next 12 months. Females expressed this desire more frequently (51.2%) than did males (44.1%). Residents 50 to 64 years old wanted to do more sightseeing (in general) at a significantly higher rate (35.0%) than did those under 20 (18%). More than one quarter of Washingtonians (27.3%) mentioned wanting to do more of a specific type of sightseeing (RCO 2007).

Fishing

Whether due to the perception, or actual declines in available fish, data showed a steady decline in the sale of state fishing licenses in the 10 years prior to the release of the Assessment of Outdoor Recreation in 2003 (IAC 2003). However, in 2006, about the same number of Washington residents wanted to do more fishing from a bank, dock, or jetty in the next 12 months (18.7%) as wanted to do more fishing from a private boat (18.5%). With the exceptions of fishing for shellfish and fishing from a bank, dock, or jetty, males showed greater levels of interest in doing more fishing than females. Compared to other regions, residents in the San Juan Islands and the Peninsulas (Olympic and Kitsap) showed the greatest interest in doing more fishing for shellfish (28.1% and 20.4%, respectively) (RCO 2007). Future participation in fishing will depend to a large degree on the success of habitat preservation and restoration efforts now underway statewide (IAC 2003).

Hunting

Hunting is overwhelmingly practiced by men with about 6 percent of state residents participating in peak season prior to the RCO's report released in 2008. License sales appear to be steady, but are shrinking as a percent of population. Consistent with national trends, increased participation is highly unlikely as the state's population continues a general rural-to-urban migration (RCO 2008). Despite the trend, in 2006, Washington residents expressed interest in doing more firearms activity of any type (11.2%) and for more hunting and shooting in general (9.9%) in the next 12 months. Males were more likely than females to express an interest in doing more of all hunting or shooting activities (RCO 2007).

Equestrian Activity (horse riding)
On average in 2006, nearly one quarter of Washington residents wanted to do more horseback riding in general in the next 12 months (23.8%). This interest was more prevalent among females (27.1 %) than among males. It was also more prevalent among children under 10 (30.7%) and tweens and teens (33.2%) than among older Washingtonians (RCO 2007).

Table 5-7. Projected Participation Increases for Selected Outdoor Recreation Activities

Activity	Estimated Change, 10 years (2003-2013)	Estimated Change, 20 Years (2003-2023)
Walking	23%	34%
Hiking	10%	20%
Nature Activities (outdoor photography, wildlife observation, gathering and collecting, gardening, and visiting interpretive centers)	23%	37%
Fishing	-5%	-10%
Hunting / Shooting	-15%	-21%
Sightseeing (includes driving for pleasure)	10%	20%
Camping – developed (RV style)	10%	20%
Canoeing/kayaking	21%	30%
Motor Boating	10%	No Estimate
Equestrian	5%	8%
Non-pool swimming	19%	29%

Source: IAC 2003.

5.10 Socioeconomics

5.10.1 Population and Area Economy

Dungeness NWR is located in Clallam County on the northern coast of the Olympic Peninsula in the state of Washington. The nearest city is Sequim, which has a population of 6,273 (U.S. Census Bureau 2012). Table 5-8 shows the population and area economy. The county population increased (11 percent) from 2000 to 2010, compared with a 14 percent increase for Washington and a 10 percent increase for the United States as a whole. County employment increased by 11 percent from 2000 to 2010, compared to a smaller employment increase in Washington (8 percent) and the United States (5 percent). Per capita income in Clallam County increased by 16 percent between 2000 and 2010, while Washington and the United States both increased by 4 percent.

Table 5-8. Dungeness NWR: Summary of Area Economy, 2010

	Population*		Employment*		Per Capita Income*	
	2010	**Percent change 2000-2010**	**2010**	**Percent change 2000-2010**	**2010**	**Percent change 2000-2010**
Clallam County	71.5	11%	35.4	11%	$37,614	16%
Washington	6,743.0	14%	3,793.6	8%	$43,933	4%
United States	309,330.2	10%	173,767.4	5%	$41,198	4%

Source: USDC 2012.
* Population & Employment in thousands; Per Capita Income in 2011 dollars.

The largest industry sectors for Clallam County are ranked below by employment (Table 5-9). The largest employer is the State and local government, followed by food services and drinking places.

Table 5-9. Industry Summary for Clallam County

Industry	Employment	Output	Employment Income*
State and Local Government	6,595	$372,059	$328,490
Food Services and Drinking Places	1,943	$102,033	$32,448
Health Practitioner Offices	1,021	$96,458	$37,634
Retail Stores - General Merchandise	862	$64,504	$29,199
Real Estate	862	$101,261	$6,424
Nonresidental Construction	807	$115,562	$26,454
Retail Stores - Food and Beverage	801	$61,328	$24,672
Nursing	799	$31,168	$21,344
Commercial Logging	770	$187,995	$18,734
Civic, Social, Professional, and Similar Organizations	661	$27,812	$11,817

Source: Implan 2008.
* Dollars in thousands.

5.10.2 Local Community

The Dungeness NWR is located approximately 6 miles northwest of Sequim, WA (pronounced "squim"). The area is famous throughout the Pacific Northwest for its low rainfall and sunny skies. Known as "Sunny Sequim" or "the Blue Hole," Sequim lies in the rainshadow of the Olympic Mountains, and boasts an average annual rainfall of less than 17 inches. In recent years the Sequim area, or Dungeness Valley's, consistently sunny weather, unusual for Western Washington, has drawn many new residents from across the United States that want to enjoy the benefits of a more temperate climate, less crowded landscape, and a welcoming community. The Sequim area has become an attractive retirement community, with the average age of Sequim rising to the near 60s during the past 20 years (MySequim 2012). Despite recent declines in job growth, -0.59 % from October 2010 to September 2011 and a comparatively high unemployment rate of 11.6% (Sperling's

2011), Sequim continues to be an attractive place to retire and the fastest growing community in Clallam County (CLR 2010) ensuring an increasing demand for outdoor recreational opportunities.

5.10.3 Refuge Impact on the Local Economy

Visitors to Dungeness NWR spend money on food, lodging, equipment, transportation, and other expenses, which creates jobs within the local economy. Additionally, refuge budget expenditures, including those provided through the Refuge Revenue Sharing Act, also result in economic impacts to the local community. The effects on the local economy associated with consumer expenditures on refuge-related recreation and effects associated with refuge budget expenditures are explored in detail in Chapter 6 of the CCP.

Chapter 6 Environmental Consequences

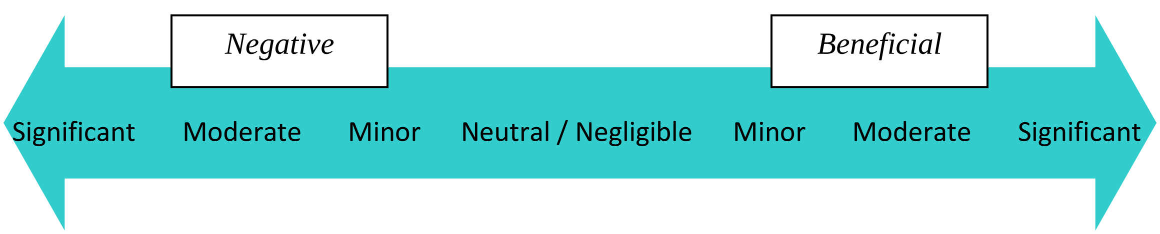
Sue Thomas/USFWS

Chapter 6. Environmental Consequences

This chapter provides an analysis of the environmental consequences of implementing the alternatives described in Chapter 2. Impacts are described for the main aspects of the environments described in Chapters 3 through 6, including physical, biological, cultural, and socio-economic resources. The alternatives are compared “side by side” under each topic, and both the adverse and beneficial effects of implementing each alternative are described. The overall cumulative effect on the environment from implementing the various alternatives is summarized in Section 6.7. More detailed assessments of the Refuge’s cumulative effects for relevant impact topics are presented section by section. The information used in this analysis was obtained from relevant scientific literature, existing databases and inventories, consultations with other professionals, and professional knowledge of resources based on field visits, and experience.

Table 6-1 provides an overview of the long-term effects under each alternative by indicator. The effects related to implementing each alternative are described in terms of the change from current conditions (i.e., the environmental baseline). Alternative A, the “no action” alternative would continue present management actions. However, the consequences of implementing Alternative A may have beneficial, neutral, or negative effects. For example, the continued use of IPM techniques under Alternative A to control invasive species would have a minor positive impact on native habitats and species.

Although the analysis shows that none of the alternatives would be expected to result in significant effects, some positive (beneficial) or negative effects are expected. The qualitative terms moderate, minor, and negligible are used to describe the magnitude of the effect. To interpret these terms, moderate is a higher magnitude than minor, which is of a higher magnitude than negligible. The word neutral is used to describe a negligible or unnoticeable effect compared to the current condition.



The terms identified below were used to describe the scope, scale, and intensity of effects on natural, cultural, and recreational resources.

- **Neutral/Negligible.** Resources would not be affected, or the effects would be at or near the lowest level of detection. Resource conditions would not change or would be so slight there would not be any measurable or perceptible consequence to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource.
- **Minor.** Effects would be detectable but localized, small, and of little consequence to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource. Mitigation, if needed to offset adverse effects, would be easily implemented and successful.
- **Moderate.** Effects would be readily detectable and localized, with consequences to a population, wildlife or plant community, recreation opportunity, visitor experience, or

cultural resource. Mitigation measures would be needed to offset adverse effects, and would be extensive, moderately complicated to implement, and probably successful.

- **Significant (major).** Effects would be obvious and would result in substantial consequences to a population, wildlife or plant community, recreation opportunity, visitor experience, or cultural resource within the local area and region. Extensive mitigating measures may be needed to offset adverse effects and would be large scale in nature, complicated to implement, and may not have a guaranteed probability of success. In some instances, major effects would include the irretrievable loss of the resource.

Direct effects are generally caused by a particular action and occur at the same time and place as the action. Indirect effects are reasonably foreseeable effects caused by the proposed action, but occur later in time.

Time and duration of effects have been defined as follows:

- **Short-term or Temporary.** An effect that generally would last less than one year or season.
- **Long-term.** A change in a resource or its condition that would last longer than a single year or season.

Table 6-1. Summary of Effects under each CCP Alternative by Indicator

	Alternative A (No Action)	Alternative B (Preferred)	Alternative C
EFFECTS TO THE PHYSICAL ENVIRONMENT			
Hydrology	Minor negative effect as roads and the impoundment are maintained on the Dawley Unit.	Minor positive effect due to the rehabilitation and stabilization of roads on the Dawley Unit, possible removal of USCG road access dike, and enhancements to the hydrology of the impoundment.	
Soil	Minor negative effect as roads and the impoundment are maintained on the Dawley Unit.	Minor positive effect due to the rehabilitation and stabilization of roads on the Dawley Unit, possible removal of USCG road access dike, enhancement of native habitats, and additional protection of the shoreline and bluff.	
Air quality	Neutral effect as management activities continue.	Negligible effect as impacts from habitat management and public use are temporary and localized.	
Water quality	Minor negative effect as roads are maintained on the Dawley Unit.	Neutral to minor positive effect due to the rehabilitation and stabilization of roads on the Dawley Unit, habitat management, and removal of small dump site at Dawley Unit. The positive effects are partially offset by increase in public use, which leads to increased risk of pollution.	
EFFECTS TO HABITATS AND ASSOCIATED SPECIES			
Nearshore habitats	Overall minor negative to negligible effects on nearshore habitats are expected with current public use areas.	A minor positive effect would occur for nearshore habitats and associated species due primarily to the increased acreage of invasive species management, expanded removal of marine debris and contaminants, removal of dike road, and additional research and monitoring.	
Mixed coniferous forests	Minor beneficial effects would continue under this alternative with the removal of invasive species and fire	A minor to moderate positive effect would occur due to habitat enhancement activities (e.g., thinning, snag creation, or prescribed fire), the rehabilitation of stabilization of roads, and the removal of a small dump	

	Alternative A (No Action)	Alternative B (Preferred)	Alternative C
	suppression	site on the Dawley Unit; enhancement of the main trail fire break on the Dungeness Unit; and additional forest assessment and monitoring.	
Wetlands	Neutral effects are expected due to the minimal management of these habitats.	Minor positive effects are expected under these alternatives due to slope stabilization of the main Dawley Unit access road, impoundment management, and greater understanding of the resources and associated species.	
EFFECTS TO FISH AND WILDLIFE			
Pileated woodpecker	Minor beneficial effects due to fire suppression in forested habitats and minimal overlap with public use areas.	Minor to moderate beneficial effects under Alternatives B and C resulting from forest enhancement strategies that would improve habitat over the long term within the Dawley Unit. Some additional acreage proposed for minimal management techniques (e.g., plant berry producing shrubs) under Alternative C. However, these proposed management techniques would not likely benefit this species or their foraging habitat.	
Dunlin	Negligible to minor negative effects are expected to continue under Alternative A given low staffing levels to enforce public use closures.	Minor beneficial effects are expected under Alternatives B and C due to increased enforcement of public use closures and an increase in habitat management actions that benefit the species over the long term.	
Pacific harbor seal	Negligible to minor negative effects to harbor seals given issues with trespass into closed areas necessary for haulout.	Minor beneficial effects are anticipated for Alternatives B and C due to increased outreach regarding disturbance and enforcement efforts in closed areas.	
Amphibians	Negligible effects given no directed management practices along with no overlap with public use.	Minor beneficial to negligible effects are expected due to the moderate, short-term negative effects of management actions which would be offset by minor to moderate long-term beneficial effects of improved habitat quality and no overlap with public use	
Anadromous and forage fish	Negligible to minor negative effects given minimal directed management, particularly for potential anadromous fish located within Dean Creek downstream of the Dawley Unit.	Overall, minor beneficial to negligible effects can be inferred from management practices and minimal overlap with public recreational use.	
Threatened, endangered and sensitive species	Given very limited or no occurrence on the Refuge, overall effects to listed species are expected to be negligible.		
EFFECTS TO CULTURAL AND PALEONTOLOGICAL RESOURCES			
Cultural resources	Negligible overall effect as cultural resource management practices are the same as present.	Minor beneficial short-term and moderate beneficial long-term effects from implementing actions to complete evaluation/documentation of historic structures, creation of a GIS layer for cultural resources, and improved communication with stakeholders.	
Paleontological resources	Neutral effect as paleontological resource management practices would continue.		
SOCIAL EFFECTS			
Overall visitation	Moderate positive effect. Minor rise in visitation due	Minor short and moderate long-term beneficial effects due to enhanced outreach efforts and increased	

	Alternative A (No Action)	Alternative B (Preferred)	Alternative C
	to demographic trends and the increase in demand for a variety of outdoor recreational opportunities.	opportunities for wildlife-dependent recreation, interpretation, and education.	
Opportunities for quality wildlife observation and photography	Negligible to minor negative impact. Jogging adversely impacts wildlife. The potential for user conflicts and safety concerns offset benefits to allowing horseback riding facilitated wildlife observation and photography.	Minor beneficial effect. Short-term minor benefits, mostly from removing horseback riding and jogging. Long-term moderate benefits from removing horseback riding and jogging, habitat improvements, new orientation materials, and offering structured wildlife walks and programs. The elimination of horseback riding would result in a moderate benefit to pedestrians by reducing the potential for user conflicts and safety issues.	
Opportunities for quality environmental education and interpretation	Negligible effect. No actions would be taken to provide additional new opportunities for environmental education or interpretation.	Moderate beneficial short- and long-term effects from new interpretive panels; new orientation materials; additional interpretive programs and an increased staff and volunteer commitment; and moderate long-term benefit from the addition of and environmental education/outreach specialist who would offer education programs to primary and secondary level school groups on and off the Refuge.	
Opportunities for quality fishing and shellfishing	Negligible overall effect. No actions would be taken improve fishing and shellfishing opportunities.	Negligible short-term and minor beneficial long-term effects resulting from increased outreach and additional habitat management practices resulting in improved fish and shellfish stocks.	
Opportunities for quality non-wildlife-dependent public uses	Negligible overall effect. No actions would be taken to provide additional new opportunities.	Minor to moderate negative effects due to changes in non-wildlife-dependent recreation opportunities (primarily the removal of horseback riding and jogging).	
Illegal uses	Neutral to minor negative effect. Illegal uses could experience a minor increase due to demographic trends and rising demand for outdoor recreation. Existing staff, volunteer, signage, enforcement, and outreach may not be sufficient to prevent these illegal uses from occurring.	Negligible short-term and moderately beneficial long-term effects from increased staff and volunteer presence, improved signage, increased enforcement, and accelerated outreach efforts.	
OTHER EFFECTS			
Human health	Negligible effects.		
Environmental justice	Negligible effects.		
Economic	Minor positive effect due to demographic trends and rising demand for outdoor recreation leading to increased visitation.	Moderate positive effect due to increased visitation and refuge budget expenditures on habitat and public use management.	

6.1 Effects Common to All Alternatives

Integrated Pest Management (IPM). Potential effects to the biological and physical environment associated with the proposed site-, time-, and target-specific use of pesticides on refuge lands would be evaluated using scientific information and analyses documented in "Chemical Profiles" (Appendix G). These chemical profiles provide quantitative assessment/screening tools and threshold values to evaluate potential effects to species groups (birds, mammals, and fish) and environmental quality (water, soil, and air). Any pesticide use must be approved through a Pesticide Use Proposal (PUP). PUPs (including appropriate Best Management Practices) would be approved where the chemical profiles provide scientific evidence that potential impacts to refuge biological resources and the physical environment are likely to be only minor, temporary, or localized in nature.

Along with the selective use of pesticides, PUPs would also describe other appropriate IPM strategies (biological, physical, mechanical, and cultural methods) to eradicate, control, or contain pest species in order to achieve resource management objectives.

The effects of non-pesticide IPM strategies to address pest species on refuge lands would be similar to those effects described elsewhere within this chapter, where they are discussed specifically as habitat management techniques to achieve resource management objectives on the Refuge.
Based on scientific information and analyses documented in "Chemical Profiles," most pesticides allowed for use on refuge lands would be of relatively low risk to non-target organisms as a result of low toxicity or short-term persistence in the environment. Thus, potential impacts to refuge resources and neighboring natural resources from pesticide applications would be expected to be minor, temporary, or localized in nature, except for certain mosquito treatments necessary to protect health and safety. (See Appendix G for additional information on Integrated Pest Management.)

6.2 Effects to the Physical Environment

Topics addressed under the physical environment section include direct and indirect effects to hydrology, geology/soils, air quality, and water quality.

6.2.1 Effects to Hydrology

Effects from Habitat Management Practices
Under Alternative A, the minimal maintenance of existing roads within the Dawley Unit could have minor negative long-term effects to hydrology as forest roads can alter runoff processes and influence sediment transport, sediment delivery, and mass-wasting (refer to Coe 2004 for a literature review). The proposed rehabilitation of 0.58 (Alternative B) or 0.16 (Alternative C) mile of unneeded logging spur roads could result in minor positive benefits to hydrology since these strategies would directly eliminate or reduce the amount of roads within the Dawley Unit and their detrimental hydrological effects. Additionally, the slide stabilization at mile point 1.2 along the main Dawley Unit access road proposed under both action alternatives would reduce the amount of sediment entering into Dean Creek from the Refuge.

Under the action alternatives, minor positive long-term effects to hydrology could take place if the U.S. Coast Guard road access dike at the base of Dungeness Spit is determined to be on refuge land and subsequently removed, restoring tidal flow to a historic tidal marsh and lagoon. If dike removal were to proceed, then minor short-term negative effects of the restoration process include local erosion and sediment inputs.

On the Dawley Unit, the previous land owner developed a 0.20 acre impoundment for fire suppression, irrigation, and waterfowl use. Under all alternatives, the Refuge would exercise water rights to Dean Creek by maintaining and utilizing the existing water delivery system to the impoundment. These withdrawals could continue to cause negligible to minor adverse impacts to the quantity and timing of stream flow at Dean Creek. Under Alternatives B and C, the objective is to enhance the value of the impoundment as a freshwater wetland to benefit amphibians and other species (see Section 6.3.3). Strategies under these action alternatives could include the installation of a water control structure and contouring of the benthic layer to maintain a conservation pool. These activities would result in short-term negative impacts to hydrology due to direct impacts such as local erosion and sediment inputs. Also, short-term minor to moderate effects to water quantity are possible as all or a portion of the volume of water may need to be drained. Over the long term, the proposed management of the impoundment would result in a neutral to minor positive impact. Although the utilization of a water delivery system deviates from natural and historic hydrologic conditions, the manipulation of water level in the impoundment would be intended to emulate natural freshwater wetland hydrology.

Effects from Research and Monitoring Strategies

Under Alternatives B and C, research and monitoring strategies involving hydrology include: studying hydrological flows and tidal elevation/cycles within salt marsh habitat, conducting a roads inventory and condition assessment, assessing instream habitat, and conducting a wetlands inventory (Dawley Unit) and hydrological assessment (Dawley and Dungeness Units). Implementation of these monitoring strategies has the potential to indirectly benefit refuge hydrology by informing adaptive management decisions that affect all refuge habitats. In particular, the hydrological assessment at the Dawley Unit could lead to minor positive effects as the results would define the relationship between the impoundment and the domestic water source and indicate the feasibility of modifying the impoundment water levels to improve freshwater wetland habitat.

Effects from Public Recreational Use

Access associated with public recreational uses under all alternatives would likely to cause negligible impacts to hydrology.

Overall Effects

Overall, considering all programs and across the entire Refuge, implementing Alternative A would represent a minor negative effect to refuge hydrology due primarily to the maintenance of roads within the Dawley Unit and their detrimental effects. Alternatives B or C would represent a minor positive effect to refuge hydrology since these roads would be rehabilitated and stabilized.

6.2.2 Effects to Soil

Effects from Habitat Management Practices (not including prescribed fire)

Currently, a portion of the slope adjacent to the main Dawley Unit access road is sliding into the riparian habitat and potentially into the instream habitat of Dean Creek. Furthermore, other forest roads, including former logging spur roads, continue to erode and deliver sediment to the creek. Consequently, implementation of Alternative A would lead to minor negative impacts. Under Alternatives B and C, 0.58 or 0.16 mile, respectively, of roads would be rehabilitated, resulting in minor positive benefits since the amount of erosion and sedimentation would be reduced. The slide stabilization along the main access road proposed under both action alternatives would also, in the long term, reduce the amount of erosion and sedimentation. However, in the short term, the probable use of heavy machinery to stabilize the slope would lead to moderate negative effects due to soil removal, slope modification, and/or compaction.

Also, under the action alternatives, the potential removal of the dike road at the base of Dungeness Spit would restore natural tidal flows and tidal wetland function, which would improve soil quality in the long term as soil organic matter content increases. The use of forest management techniques in the Dawley Unit forest are expected to improve soil quality in the long term as more stable native ground cover becomes established and organic matter increases. However these and other habitat management actions (e.g., recontouring the impoundment) may also have short-term adverse impacts such as erosion, compaction, and some loss of soil organic matter.

Shoreline 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). However, armoring has far-reaching negative effects on all nearshore habitats, primarily through the reduction of sediment deposition to sandy beaches. Also, armoring can increase the wave energy reflected to down drift beaches and bluffs, thereby increasing the potential erosion rates (Johannessen and MacLennan 2007). Under Alternatives B and C, the Service would coordinate with partners (e.g., State, County, and Tribes) to prevent or reduce shoreline armoring, especially to the west of Dungeness NWR. Additionally, the further restriction on development adjacent to bluffs on refuge lands would decrease the amount of impervious surfaces upslope which in turn can reduce the amount of runoff causing erosion. These strategies would have moderate positive impacts on refuge soils as feeder bluffs on- and off-refuge would be allowed to naturally erode, nourishing the beach and spits.

Under all alternatives, full fire suppression and the prohibition of driftwood collection on the spits would have moderate positive impacts as driftwood found along the “backbone” of Dungeness and Graveyard Spits serves to stabilize the upper portion of the beach by holding sediments in place.

Effects from Prescribed Fire

The Service anticipates the use of prescribed fire as a management tool on the Refuge under Alternatives B and C, primarily in the Dawley Unit mixed coniferous forest. The step-down forest management plan will describe in greater detail the effects to soil based on the specific management actions developed. The Service is currently finalizing a draft of the Complex’s Fire Management Plan which describes fire management units with the Refuge Complex and outlines a programmatic management plan. Some basic comments about effects to soils can be made by looking at the Common Effects of Prescribed Fire on Habitat Types on U.S. Fish and Wildlife Refuges in the Pacific Region Version 3 – Final 2012 (USFWS 2012b). Because of the diversity of fire behavior in mixed coniferous forests, the effects of prescribed fires on soil can vary tremendously. The potential effects range from negligible if the fire is of short duration and intensity to minor if there is an increased fire duration and fuel load which increases the negative effect on underlying soils. In many mixed conifer stands, mechanical treatments often precede burning (Harrod et al. 2009). In many of these situations, pile burning is prescribed either alone or in concert with broadcast prescribed fire. The effects of pile burning on underlying soil heating are well studied and reviewed elsewhere (DeBano et al. 1998). In short, piles can generate substantial heat and combust soil organic matter, alter soil structure, and increase the hydrophobic nature of proximal soil. Pile burning can also lead to subsequent non-native species invasion in these localized soil disturbances. At a broad scale, these activities are often minor (piles typically cover less than 5 percent of the burned landscape); however, in aggregate the effects of piles can be of concern.

Mitigation methods to limit soil impacts from prescribed burning could be utilized (e.g., burning during the wet end of the prescribed burning window and raking or similar measures to disrupt the residual forest floor). Additional approaches to mitigation include: scattering severity across the landscape with small areas ignited conservatively, or removing slash from units prior to burning. Pile burning effects can be minimized if the small piles are burned over wet soil, where the soil moisture would resist temperature rise (DeBano et al. 1998). Removing woody slash, while often costly, can diminish high-severity fires in mixed conifer forests. Slash removal can range from hand removal to mechanical yarding, with concomitant financial and environmental costs and benefits for each end of the spectrum. Fire prescriptions would be written to avoid overly hot fires that can scorch soils. Through effective planning and use of mitigation methods by which prescribed burns are controlled, the impacts would be adverse but not significant. Thus, the negative impacts to soil from burning would be minor and temporary.

Effects from Public Recreational Use
Under all alternatives, the public use closure areas serve to protect refuge soils from erosion and compaction. In areas open to foot traffic, impacts to soil health are minor and limited since refuge visitors are restricted to predefined footprints such as trails (including main, horse and bluff trails); the beach within Zones 1, 2, and 3; or observation decks. Under current management, Alternative A, horseback riding has the potential to cause soil compaction and erosion (Bainbridge 1974, Hammitt and Cole 1987, Hendee et al. 1990); however, these impacts are negligible due to the low volume and predefined footprints (horse trail and the beach within Zone 1). The removal of horseback riding under Alternatives B or C would result in a negligible or barely measurable positive impact to soil health within a limited footprint (i.e., horse trail).

Overall Effects
Considering all programs and across the entire Refuge, implementation of Alternative A would result in a minor negative effect to refuge soils due primarily to the maintenance of roads within the Dawley Unit and their detrimental effects. Alternatives B or C would represent a minor positive long-term effect since these roads would be rehabilitated and stabilized, native habitats would be enhanced, and the shoreline and bluffs would receive additional protection.

6.2.3 Effects to Air Quality

Effects from Habitat Management Practices
All alternatives include strategies to reduce the risk of fire. Information on wildfire risk and suppression options as well as sensitive habitats to be considered in planning for fire risk reduction and suppression actions, is contained in the step-down Fire Management Plan for Dungeness NWR, in draft concurrently with this CCP. Effects from these fire management strategies are expected to have negligible beneficial effects to air quality by reducing smoke particulates entering the local airshed.

Under Alternatives B and C, prescribed fire would be implemented as a tool for habitat management, primarily in the Dawley Unit mixed coniferous forest, and would result in moderate short-term negative effects on air quality in a localized area. Impacts to air quality would occur from the actual burning activities, but also from emissions associated with equipment used to facilitate and manage the prescribed burn for fire control purposes. Emissions associated with equipment for prescribed burning is assumed to be minimal in comparison with the emissions associated with the actual prescribed burn and is not discussed in detail. Through effective planning and methods by which prescribed burns are controlled, emissions associated with prescribed burns can be limited to such a degree that ambient air quality standards are not exceeded, and impacts would be adverse but not significant. Any prescribed burning would be conducted in accordance with all state, local, and Service policies and regulations.

The step-down forest management plan will describe in greater detail the effects to air quality based on the specific management actions, including prescribed burning, developed. General anticipated effects are that lighter, fine fuels (i.e., grasses) have a lower impact on air quality than heavy fuel found in forested habitat. Conducting prescribed burns may also benefit air quality in the long term by preventing larger uncontrolled wildfires which affect air quality to a greater extent. Since the prescribed fire use is limited and of short duration, the expected long-term effects on the air quality are neutral.

Habitat management activities such the use of forest management techniques in the mixed coniferous forests of the Dungeness and Dawley Units (Alternatives B and C) might also cause a slight short-term negative effect on air quality as a result of exhaust and dust from mechanized equipment operation. In addition, the use of IPM may involve techniques which can be expected to produce slight negative short-term air quality impacts from gas and diesel powered equipment and possible pesticide or herbicide drift. Since any emissions or drift would rapidly dissipate, this effect is determined to be extremely localized and negligible to minor.

The enhancement of native habitat types such as the mixed coniferous forest under Alternatives B and C would have a long-term positive effect on air quality as plants grow by producing oxygen, and taking in carbon dioxide and storing it in plant fibers as carbon.

Effects from Public Recreational Use

Throughout the life of the CCP/EA, minor to modest increases in visitation are expected due to population growth. The expansion of public use and outreach programs under the action alternatives are expected to also increase refuge visitation. However, cumulatively, these increases in visitation would be temporary and localized and therefore not degrade air quality to any noticeable degree.

Overall Effects

Overall, effects to air quality should be neutral under all alternatives. None of the alternatives would be expected to have significant long-term effects to air quality compared to current management. Some temporary minor negative impacts to local air quality may result from refuge management actions.

6.1.4 Effects to Water Quality

Effects from Habitat Management Practices

Under all alternatives, the Service is committed to working with partners in order to perform rapid response to oil spills or other contaminant events in Dungeness Bay and Harbor in accordance with the Strait of Juan de Fuca Geographic Response Plan. In addition, under all alternatives, the Service would continue marine debris removal and would coordinate with partners such as the Clean Water Working Group to monitor and address water quality issues within the bay. These strategies would provide moderate positive impacts in the event of contamination or water quality issues.

Minor short-term impacts to water quality could occur under all alternatives, stemming from the control of invasive plant species and short-term sedimentation associated with habitat maintenance or enhancement activities (e.g., forest management practices, slide stabilization, or forest road rehabilitation under the action alternatives). In situations where mechanical and cultural invasive plant control methods are ineffective, the Refuge may use approved herbicides in accordance with the Refuge's IPM program. Although mechanical removal has the potential to expose soils to wind and water erosion, this activity would be limited, largely due to the use of hand tools and would focus on individual plant removal, rather than the removal of large areas of vegetation. Therefore, the continuation of this control method is not expected to introduce substantial amounts of additional sediments into the local wetlands or rivers. The use of herbicides or pesticides to control invasive plants or animals also poses several environmental risks, including drift, volatilization, persistence in the environment, water contamination, and harmful effects to wildlife. Although there are a large number of acres on the Refuge potentially subjected to herbicide treatment, the potential for such risks are considered minimal due to the types of herbicides used (non-persistent) and the precautionary measures taken during application (see Appendix G, IPM Program). Effects would not be considered significant under any alternative.

Under Alternative A, the slide at mile point 1.2 along the main Dawley Unit access road would continue to exist, contributing sediment to Dean Creek and reducing water quality. Under Alternatives B and C, slide stabilization would provide minor positive impacts as the amount of sediment entering into Dean Creek from the Refuge would be reduced.

Under Alternatives B and C, the removal of a small dump site on the Dawley Unit could lead to the presence of fewer environmental contaminants and a minor benefit to water quality.

Effects from Research and Monitoring Strategies

As described in the Compatibility Determination appendix (Appendix B), all research and monitoring activities would need to comply with measures to limit the risk of contaminants entering the refuge environments and therefore they would have a negligible effect.

Water quality monitoring strategies are described under Alternatives B and C. Implementation of these monitoring strategies has the potential to indirectly benefit refuge water quality by informing adaptive management decisions.

Effects from Public Recreational Use

Under all alternatives, a minor to moderate overall increase in refuge visitation is expected due to population growth and the public use and outreach programs. Refuge visitors would generally drive their automobiles to visit the Refuge. Others could operate motor boats to participate in fishing or to access the lighthouse. Thus, under all alternatives, there could be an increased risk for fuel or oil spills and pollution potentially leading to a minor negative effect.

Overall Effects

With the proposed alternatives, the overall water quality, water chemistry, temperature, and risk of contaminant release would experience a neutral to minor positive effect. Some localized, short-term negative effects might occur associated with various invasive species removal efforts or other habitat management activities, although they would be offset by implementing Best Management Practices. The likely increase in visitation would lead to a corresponding increased risk for spills and pollution. However, the impacts of public recreational use would be offset by habitat improvements, including the slide stabilization in the Dawley Unit.

6.3 Effects to Wildlife and Habitats

6.3.1 Effects to Nearshore Habitats and Associated Species

Effects from Habitat Management Practices
The nearshore habitats will be discussed together due to their association and dependence of geological, hydrological, and wildlife interactions. Under Alternative A, the nearshore habitats are under a variety of management actions to protect and maintain these habitats. These include monitoring for invasive species, removal of marine debris, derelict fishing gear, and some creosote-covered logs while maintaining closures as needed. Under Alternatives B and C, the Service would increase protection from invasive species on sandy bluffs, maintain habitat health by removing creosote-covered logs and marine debris on additional acres, remove a dike road within the barrier lagoon and mudflats (if determined to be within refuge boundaries), and monitor climate change effects on all nearshore habitats within the Refuge.

Under all alternatives, moderate beneficial effects would be expected by addressing and/or preparing for hazards from oil spill, harm to wildlife from marine debris and derelict fishing gear as well as invasive species issues. In Alternatives B and C, there could be minor benefits from the increase in invasive species monitoring within the sandy bluff habitat, expanded removal of creosote-covered logs, and monitoring of environmental factors that are climate change related stressors. The removal of creosote-covered logs has varied potential impacts, negligible to positive, depending on which specific habitat, location, and the amount under consideration. The potential long-term environmental effects of the leaching of the chemical compounds found in creosote are well documented and discussed in Section 3.8. Past activities associated with removal have had a negligible effect from equipment (e.g., ATV, saws and helicopter) or manual labor to remove the logs. For impacts to associated species see Effects to Dunlin (Section 6.2.5) and Harbor Seals (Section 6.2.6).

Effects from Research and Monitoring Strategies
In Alternative A, limited monitoring would occur within the nearshore habitat (e.g., invasive species, water quality, sediment transport, and deposition). Under Alternatives B and C, monitoring climate change related stressors and other environmental stressors would greatly assist management in identifying and prioritizing management needs. As a result, the action alternatives would have a minor to moderate positive effect on nearshore habitats and associated species while Alternative A would have a minor negative to negligible effect on nearshore habitats.

Effects from Public Recreational Use
All of the alternatives of the nearshore habitats have full or partial public closure or other forms of restrictions on activities to protect the habitat and the wildlife that uses them. Public use management that benefits these habitat types involves public education and outreach on the sensitivity and connectedness of the different habitats; use closures; the prohibition of driftwood removal; limited boat access; and prohibition of fires. This management provides a minor beneficial effect under all alternatives.

Overall Effects
Overall, considering all programs, implementing Alternative A would result in negligible to minor negative effects. A minor positive effect would occur for nearshore habitats and associated species under both Alternatives B and C due to the increased acreage of invasive species management,

expanded removal of marine debris and contaminants, removal of dike road, and additional research and monitoring.

6.3.2 Effects to Mixed Coniferous Forests and Associated Species

Effects from Habitat Management Practices
Acres available by alternative: Each of the alternatives would maintain and protect all or enhance portions of the existing 180 acre mixed coniferous forests on the Refuge. Under Alternative B, within the Dawley Unit there would be enhancement on 40 acres. An additional 30-40 acres of planting native shrubs would occur under Alternative C. Under all alternatives, weed control and fire suppression would occur. Both of these management strategies are critical for maintaining or protecting the habitat value of these forests. Alternatives B and C propose maintaining the trails by selective woody debris removal on the Dungeness Unit. In addition, on the Dawley Unit, certain roads would be removed while others would be maintained, a dump site would be removed, and thinning of variously sized trees to advance mature to old-growth characteristics would improve the forested habitat condition. The NEPA process for the step-down forest management plan, identified in Objective 1.2 under Alternatives B and C, would examine in detail the benefits from specific management techniques (e.g., thinning, creating snags, or prescribed fire).

Effects from management practices: Alternative A has a minor benefit due to the removal of invasive species and fire suppression. Under both Alternatives B and C, the increase of the fire break buffer along the main Dungeness trail may affect some of this habitat, but it would serve to better protect the forest from a stand replacement fire. Working along either side of the trail would require the removal of small dead and downed material. A minor amount of habitat degradation from these vegetation removal activities and from trail use and trail maintenance (e.g., trail clearing, grading) may be expected. However, it is expected that these effects would be temporary and localized.

Under Alternatives B and C the use of prescribed fire in this habitat would be determined more specifically by the step-down forest management plan; however, some general effects can be anticipated. Low intensity ground fires would have short-term negative impacts to invertebrates and some wildlife foraging on these invertebrates. Pile burns would have less of an effect to the habitat but more on localized soil as discussed in Section 6.2.3, Effects to Soil. From ground fire, above ground species would recover faster, due to the presence of regenerating vegetation and the addition of small-diameter trees killed by the fire becoming snags and forest floor litter. Those species found in the litter layer would take a little longer to recover. Overall, the long-term effect of prescribed fire would be negligible to minor.

For weed species that are or become established, mechanical, chemical, and biological control methods would be evaluated (see Appendix G for descriptions of general weed control methods). Chemical usage would be subject to provisions of the refuge IPM Plan (Appendix G) including provisions that the most effective pesticide available with the least potential to degrade environmental quality (soils, surface water, and groundwater) and least potential effect to native species would be acceptable for use on the refuge. A chemical profile analysis would be completed for each approved pesticide in which a risk quotient of active ingredients would be compared to a predefined Level of Concern rating for surrogate species, as established by the EPA. All applications of herbicides would conform to the specific pesticide label requirements.

Employment of this chemical approach would result in a potential minor negative effect from chemical exposure. However, un-quantified risks may still occur via factors not assessed under current protocols, species-specific sensitivity that differs from surrogate species sensitivity; exposure through inhalation, exposure through ingestion of pesticide-contaminated soil, and other factors (see Appendix G).

Effects from Research and Monitoring Strategies
Little to no information is currently available on the forest condition and composition as well as amphibian or bat species occurrence on the Refuge. A forest assessment and monitoring for these species would greatly assist management in identifying and prioritizing management needs. As a result, Alternatives B and C would have a minor to moderate positive effect on forested habitats and associated species while Alternative A would have minor negative to neutral effects on forested habitats.

Effects from Public Recreational Use
Since the Dawley Unit and a vast majority of the Dungeness Unit are closed to public recreational use (only the trails on the Dungeness Unit are opened to the public) recreational use effects under all alternatives would be limited to a narrow area along these trails and would be negligible. Enhancement of the main trail fire break would serve to improve public safety by maintaining a better escape route and reducing fuel load along the trail where tossed cigarettes could start a fire. Effects from the existing horseback riding use (Alternative A) to the habitat in the form of trampling, soil compaction, and the potential introduction of exotic plant species are considered negligible. The removal of horseback riding under Alternatives B or C would result in a negligible impact to forest health. Human activities on the forest trails may result in direct effects on wildlife through harassment, a form of disturbance that can cause physiological effects or varying levels of behavioral modification (also see Appendix A, Appropriate Use Findings, and Appendix B, Compatibility Determinations). These wildlife disturbance considerations were folded into the design of the interpretive trail, which helps keep people on the trail. Therefore, overall, negligible effects are expected from the permitted public activities.

Overall Effects
In summary, minor beneficial effects are anticipated for Mixed Coniferous Forests and Associated Species under Alternative A due to the removal of invasive species and continued wildfire suppression. Under Alternatives B and C, a minor to moderate positive effect would occur due to habitat enhancement activities (e.g., thinning, snag creation, or prescribed fire), the rehabilitation of stabilization of roads, and the removal of a small dump site on the Dawley Unit; enhancement of the main trail fire break on the Dungeness Unit; and additional forest assessment and monitoring. However, it would take many years, beyond the life of this CCP, to achieve the desired old-growth forest characteristics.

6.3.3 Effects to Wetland and Associated Species

Effects from Habitat Management Practices
Acres available by alternative: Currently, the only management action under Alternative A for the freshwater wetlands has been limited invasive species removal at the impoundment. Under Alternatives B and C, less than 0.1 of an acre of seasonal freshwater wetlands, 0.25 mile of riparian and instream habitat, and 0.39 acre of impoundment would be protected and maintained against invasive species using IPM methods. Under Alternatives B and C, slope stabilization in the riparian

corridor and mapping the bathymetry, installing a new water control structure, water level manipulation, and vegetation within and along the edge of the impoundment are proposed management actions.

Effects from management practices: For weed species that are or become established, mechanical, cultural, biological, and chemical control methods would be evaluated (see Appendix G for descriptions of general weed control methods). Chemical usage would be subject to provisions of the refuge IPM plan (Appendix G). Among other provisions, this plan provides direction that the most efficacious pesticide available with the least potential to degrade environmental quality (soils, surface water, and groundwater) as well as the least potential effect to native species would be acceptable for use on the Refuge. Each approved pesticide would undergo a chemical profile analysis; active ingredients would be analyzed for their risk quotient and this value compared to a Level of Concern for surrogate species, as established by the Environmental Protection Agency (EPA). All applications of herbicides would conform to the specific pesticide label requirements.

Employment of this approach with herbicides would result in a moderate to minor risk from chemical exposure. However, un-quantified risks may still occur via factors not assessed under current protocols, such as intermingling of unlike chemicals in the field; species-specific sensitivity that differs from surrogate species sensitivity; exposure through inhalation, exposure through ingestion of pesticide-contaminated soil, and other factors (see Appendix G).

In the event of either accidental or intentional introduction of non-native fish or amphibians, mechanical, biological, and chemical controls methods would be evaluated (see Appendix G).

The effects of a portion of the slope sliding into the riparian habitat and potentially into the creek habitat would require some engineered controls that would impact mainly the riparian habitat. Although no method of stabilization has yet been selected, heavy equipment use would be anticipated. Therefore, a moderate negative amount of habitat degradation (during soil or vegetation removal, slope modification, and soil compaction) may be expected in this habitat type. Effects from stabilization techniques selected would be addressed in the step-down forest management plan.

Mapping the benthic layer of the impoundment and installing a new water control structure would have negligible effects to the water quality (stirred up sediments) and short-term minor to moderate effects to quantity (may need to drain all or a portion of the volume of water). Any planned work would be for times of the year where impacts to the native fauna or other needs would be minimized (e.g., non-breeding season). Amphibians may be displaced for a short period and other wildlife may need to feed or drink elsewhere. The vegetation management within and along the banks of the impoundment would result in a minor beneficial effect.

In summary, the use of specified habitat management techniques would help maintain wetland habitat structure, plant diversity, native plant composition, and native wildlife. Minor disturbance and damage could occur as a result of using these habitat management techniques, but these effects would be temporary and shortly eclipsed by enhanced habitat structure and composition. Overall, the actions under Alternatives B and C represent a moderate positive effect to wetland habitat quality for associated species.

Effects from Research and Monitoring Strategies

Little to no information is currently available on hydrology, condition, or composition of this habitat type on the Refuge. Similarly, there is an information gap concerning amphibian or bat species occurrence on the refuge within wetlands. Under Alternatives B and C, inventory efforts aimed at understanding the natural hydrologic processes of the refuge wetlands and associated species would result in minor benefits by providing staff with a better understanding about the natural processes of these wetlands.

Effects from Public Recreational Use
These wetlands are very small with no public access. Although the areas are considered closed there have been trespassing issues in the past. If trespassing resulted in the introduction of a non-native species (e.g., bull frogs) there would be an impact on native associated species (e.g., amphibians). Minor to moderate negative effects could be anticipated from unpermitted public recreational use.

Overall Effects
Overall, neutral effects are expected under Alternative A with the continuation of current management. Considering all three habitats and management actions, implementing Alternative B or C would represent a minor positive effect to wetland habitat quality for associated species, primarily due to the slope stabilization of the main Dawley Unit access road, impoundment management, and greater understanding of the resources and associated species.

6.3.4 Effects to Pileated Woodpeckers

Effects from Management Practices
Strategies currently followed under Alternative A have a minor positive effect for this species, primarily fire suppression tactics which help preserve standing dead and downed woody debris necessary for forage species (e.g., carpenter ants). Forest habitat management strategies in Alternatives B and C are expected to result in long-term minor beneficial impacts through snag creation and management to accelerate development of larger trees. Alternatives B and C differ in the size of active habitat management project areas on the Dawley Unit; however the core 40 acres remain the same in both alternatives. Management actions within the additional 30-40 acres proposed under Alternative C would be negligible for this species (e.g., planting berry producing shrubs). Forest management within the core 40 acres of Alternatives B and C would involve traditional use of logging techniques to open dense conifer stands with either removal of excess material, or piling. Broadcast burning would be the least favorable burning technique for the site due to the negative effect this has on pileated woodpecker forage species. Minor negative effects from disturbance and damage to forested habitats from management could occur as a result of using these techniques, including ground disturbance and potential weed spread. Specific management prescriptions would be identified in a separate step-down management plan with accompanying NEPA review. Road removal would have negligible effects on this species due to the limited staff use of the roads in the Unit at present.

Effects from Research and Monitoring Strategies
Although pileated woodpeckers have been observed in both units, little to no information is currently available on their magnitude of use. Periodic breeding bird surveys would benefit pileated woodpeckers by providing information before and after enhancement activities for use in adaptive management. Under Alternatives B and C, a forest assessment would provide more detailed information for use in planning forest enhancement activities in areas typically used by this species. Overall, minor beneficial to negligible effects are anticipated as a result of monitoring and research.

Effects from Public Recreational Use

Potential negative effects of public use are largely limited to the two trails through the forested habitat on the Dungeness Unit. The forested habitat within the Dawley Unit and all off-trail areas within the Dungeness Unit would remain closed to public use under all alternatives. Within these areas, minor negative effects from disturbance may be expected due to trespass. Of the wildlife-dependent public uses proposed, wildlife photographers tend to have the largest disturbance impacts (Klein 1993, Morton 1995, Dobb 1998). While wildlife observers frequently stop to casually view species, wildlife photographers are more likely to approach wildlife (Klein 1993) to get that perfect photograph. Other compounding factors include the potential for photographers to remain close to wildlife for extended periods of time in an attempt to habituate the wildlife subject to their presence (Dobb 1998) and the tendency of casual photographers, with low-power lenses, to get much closer to their subjects than other activities would require (Morton 1995), including wandering off trails. This usually results in increased disturbance to wildlife. The requirement that visitors remain on forest trails restricts the general visitor and photographers' accessibility which minimizes wildlife disturbance. This strategy would continue to be implemented under all alternatives in the CCP. Given the relative degree of fragmentation of this forested unit and minimal use by the species, these activities are expected to have a minor negative to negligible effect on pileated woodpeckers.

In addition, jogging has the potential to cause increased levels of disturbance to wildlife when compared to walking. Animals show greater flight response to humans moving unpredictably than to humans following a distinct path (Gabrielsen and Smith 1995) and rapid movement by joggers is more disturbing to wildlife than slower moving hikers (Bennett and Zuelke 1999). This activity would no longer be allowed on refuge lands under Alternatives B and C resulting in a minor beneficial effect.

Overall Effects
Strategies currently followed under Alternative A have negligible effects for this species given no direct management of habitat yet minimal overlap with public use areas. Minor to moderate beneficial effects under Alternatives B and C are expected resulting from forest enhancement strategies in the Dawley Unit that would improve habitat over the long term within the Dawley Unit. Some additional acreage proposed for minimal management techniques (e.g., planting berry producing shrubs) under Alternative C yet, proposed management would not likely benefit this species or their foraging habitat.

6.3.5 Effects to Dunlin

Effects from Management Practices
Minor beneficial effects are expected under all alternatives from management practices for dunlin over the long term. They include the use of appropriate IPM techniques to control invasive species such as *Spartina*; working with partners to address water quality issues in Dungeness Bay and Harbor; rapid response to oil spills which involves practice deployments; and marine debris removal in mudflats and lagoons. Removal of *Spartina* may have a minor negative effect on dunlin prey species that inhabit refuge mudflats through localized soil disturbance; however if left untreated, *Spartina* can reach a density that precludes dunlin foraging on the mudflat. Maintaining mudflats and lagoons, where marine debris and contaminated materials collect, in a cleaner state would continue to provide beneficial effects to dunlin and their forage species. Total wildfire suppression tactics for all wildfires and continued prohibition of driftwood collection would help preserve the accumulated woody debris on the barrier beach. This effectively results in a moderate beneficial effect because it

reduces the potential for overwash or breaching thereby protecting the mudflat habitat inland of the barrier beach from increased wave action and scouring.

Effects from Research and Monitoring Strategies
Negligible to minor beneficial effects are anticipated as a result of monitoring and research in nearshore habitats. Overall minor beneficial effects are expected in association with surveys for overwintering shorebirds as well as studies of mudflat habitat quality. Overall negligible to minor negative effects of surveys from human-caused disturbance are expected given the limited duration of survey efforts. They would be scheduled whenever possible to avoid disturbance.

Effects from Public Recreational Use
Human-caused wildlife disturbance is perhaps the single, most pervasive threat to over-wintering dunlin in the Salish Sea. Any disturbance, however brief, can reduce the amount of time spent foraging and increase energetic demands through flight. Given the low body mass maintained during this time, if continually disturbed dunlin may not be able to consume enough to survive through severe winter storm events (Buchanan 2006). Under all three alternatives, public access would remain limited to the outer side of Dungeness Spit during the winter season to provide undisturbed habitat for overwintering dunlin. A small portion of the dunlin using the Refuge can be found along this portion of the barrier beach. They would experience a minor negative effect from human-caused wildlife disturbance. Of greater concern is trespass into closed areas particularly adjacent to mudflats within Dungeness Harbor and Bay. These trespass incidents could have minor to moderate negative effects on dunlin. Overall, beneficial effects would be slightly greater under Alternatives B and C due to the allocation of greater enforcement of closed areas.

The presence of people observing or photographing wildlife at Dungeness NWR has the potential to cause minor negative effects to dunlin on the barrier beach under all alternatives. For more specific information, see Section 6.3.4, Effects to Pileated Woodpeckers.

Jogging also has the potential to cause increased levels of disturbance to dunlin particularly if the activity is continued beyond zones in which it is allowed. It has been determined that animals show greater flight response to humans moving unpredictably than to humans following a distinct path (Gabrielsen and Smith 1995) and rapid movement by joggers is more disturbing to wildlife than slower moving hikers (Bennett and Zuelke 1999). While jogging is limited to the forested trails and the first half mile of the barrier beach in Alternative A, the Complex is aware that some visitors disregard signs indicating area restrictions on this use. Such unauthorized use creates the potential for greater disturbance to dunlin such as running past the ½ mile point on the barrier beach. This area is used more often by dunlin than the first ½ mile which increases the potential for impact resulting from joggers not following regulations. Under Alternatives B and C, jogging would not be allowed on any area with the Refuge resulting in a minor beneficial effect to dunlin.

Negligible to minor negative impacts from vehicle use of the barrier beach is expected on dunlin through temporary displacement of those individuals that roost on the outer side of the spit. In addition, as a solitary and stationary activity, fishing tends to be less disturbing to wildlife than vehicle access or motorized boating and is not anticipated to have an effect on dunlin (Tuite et al. 1983).

Overall Effects
Negligible to minor negative effects are expected to continue under Alternative A given trespass issues in closed areas. Minor beneficial effects are expected under Alternatives B and C due to

increased enforcement of public use closures and an increase in habitat management actions that benefit the species over the long term.

6.3.6 Effects to Harbor Seals

Effects from Management Practices
Under all alternatives, harbor seals would experience moderate beneficial effects similar to those described for dunlin (above).

Effects from Research and Monitoring Strategies
Overall harbor seals would experience minor beneficial effects due to monitoring and research. They would benefit from surveys for creosote covered logs, marine debris and derelict fishing gear as these surveys would provide information to assess their impact and better direct removal programs. Research on environmental factors that are climate change related stressors would provide information on how best to reduce manageable stressors which may be the only feasible method to help mitigate climate change for harbor seals.

Effects from Public Recreational Use
Given the overlap in habitat use, the concerns of public use, particularly wildlife observation, photography, vehicular access and jogging on harbor seals are very similar to those of dunlin. The impact of these activities would depend upon the distance from the animal to the disturbance, the duration of the disturbance and the individual's degree of acceptance of disturbance. Adult harbor seals tend to avoid shorelines that receive substantial human activity; however pups are less predictable and a few will likely continue to appear on high use portions of the barrier beach each year. Minor to moderate negative effects are expected to continue for those pups (typically less than 10/year) that haul out within high use areas of the barrier beach during peak summer months. Under Alternatives B and C, harbor seals and their pups would experience fewer human-caused disturbances as a result of increased staff presence encouraging wildlife observation and photography at a distance that minimizes disturbance; maintaining temporary closures in portions of high use areas when seal pups are on the beach; and better enforcement of seasonal closures. Additionally, the removal of horseback riding under Alternatives B and C could result in slightly more positive effects than in Alternative A due to the potential for fewer human-caused disturbances. Minor beneficial effects would be slightly greater under Alternatives B and C due to the allocation of greater staff time.

Minor to moderate negative effects from motorized boating can occur even at low densities, given their noise, speed, and ability to cover extensive areas in a short amount of time. Both motorized and non-motorized boating activities can alter distribution; reduce use of particular habitats or entire areas by marine mammals; alter feeding behavior and nutritional status; and cause premature departure from areas. For instance, boating close to shore may disturb harbor seals hauled out on the beach.

Overall Effects
Negligible to minor negative effects are expected to harbor seals under Alternative A given issues with trespass into closed areas necessary for haulout. Minor beneficial effects are anticipated for Alternatives B and C due to public use closures and increased enforcement efforts.

6.3.7 Effects to Amphibians

Effects from Management Practices

The Service is currently not managing wetland habitats for amphibians under Alternative A. However indirect effects under Alternative A include minor negative effects to instream amphibians from a slide located off of the main road above Dean Creek which has subsided just shy of the creek. Habitat management strategies associated with Alternatives B and C that would provide minor to moderate beneficial impacts include slide stabilization in the instream habitat for amphibians. The Service would contribute to maintaining instream habitat primarily through slide stabilization and road decommissioning. All forested habitat management would be implemented outside of the immediate drainage area for Dean Creek and any effects would be addressed in a separate step-down management plan.

Negligible to minor negative effects to amphibians could be inferred within the impoundment under Alternative A because it is not maintained at an optimal water level for this species group. Habitat management strategies associated with Alternatives B and C that would provide minor to moderate beneficial impacts include management of the impoundment specifically for amphibians through installation of a new water control structure to allow for low water levels; potential benthic layer contouring; and maintenance of sufficient submerged vegetation and partially submerged downed woody debris around the perimeter of the impoundment to support egg deposition. In addition, permanent wetlands can provide habitat for bullfrogs and non-native fish, which could potentially create moderate negative impacts on some native amphibians. This would be mitigated by periodic surveys for these predators and control if found. A potential short-term minor negative effect may be anticipated (depending on the species present) as a result of recontouring the benthic layer in the impoundment. This would be mitigated by the use of seasonal restrictions on management activities.

Under all alternatives, there would be minor to moderate beneficial effects to forest-dwelling amphibians from total wildfire suppression tactics. Under Alternatives B and C, the prohibition on collection of downed wood would provide minor beneficial effects for forest-dwelling amphibians as downed wood of all sizes can provide shelter. Removal of roads and small dump sites would provide minor beneficial effects to forest dwelling amphibians particularly if conducted during periods of low movement within forested habitats (species dependent). Forest management practices may provide minor negative effects to forest amphibians from disturbance to the soil however minor to moderate beneficial benefits over the long term from habitat improvements such as retention of larger downed woody debris would outweigh minor, temporary negative effects. Again, further formal NEPA analysis will be completed in conjunction with the step-down forest management plan.

Effects from Research and Monitoring Strategies

Minor beneficial effects could be inferred for amphibians from monitoring and research. Little to no information is currently available on amphibian abundance or distribution on the Refuge. Baseline data would assist staff in developing habitat management actions during periods of low use or movement. Periodic amphibian surveys would further benefit these species by providing information after recontouring the impoundment and forest enhancement activities have occurred to assess the effects of these actions on amphibians and inform adaptive management.

Effects from Public Recreational Use

Under all alternatives, wildlife observation and photography, both priority public uses, would continue. The impact of these activities on amphibians within the forested habitats of Dungeness Unit are expected to be negligible to minor given the limited overlap in public use on forested trails. The forested and wetland habitats within the Dawley Unit and all off-trail areas within the Dungeness Unit would remain closed to public use under all alternatives which would continue to provide a moderate beneficial effect on amphibians and their habitats.

Overall Effects
Negligible effects are expected from Alternative A given no directed management practices yet no overlap with public use. Overall minor beneficial to negligible effects are expected from Alternatives B and C given the limited apparent occurrence; minimal overlap with public use; and balance between moderate short-term negative effects of management actions and minor to moderate long-term beneficial effects of improved habitat quality.

6.3.8 Effects to Anadromous and Forage Fish

Effects from Management Practices
Under all alternatives, effects to anadromous and forage fish in nearshore habitats would be similar to effects described for dunlin (i.e., IPM, oil spill response, marine debris removal). Minor negative effects due to temporary damage could occur in forage fish spawning habitat as a result of using hand removal techniques on *Spartina*, but these effects would be temporary and localized and eclipsed by protection of preferred habitat structure. In addition, actions taken to protect eelgrass would have minor to moderate beneficial effects on salmonids and Pacific herring because eelgrass provides shelter for juvenile salmonids, spawning substrate for Pacific herring spawning and prey species for salmonids.

Effects to anadromous fish from forest and instream habitat management would be similar to those listed for amphibians in the same habitats and would be fully analyzed in a separate step-down forest management plan. Some short-term, minor negative impacts to instream habitat would be experienced under alternatives B and C from slide stabilization; however it is unlikely that anadromous fish reside in this reach of Dean Creek due to barriers to passage below the Refuge. Regardless, any anadromous fish downstream of the Unit would experience minor beneficial benefits over the long term from activities that reduce input of sediment in the creek such as removal of the slide, road removal, and full fire suppression. Best management practices, including appropriate seasonal timing for forest management activities that disturb soils and use of the IPM approach to address weeds (see Appendix G), would be considered to minimize negative effects.

Effects from Research and Monitoring Strategies
Anadromous and forage fish would experience minor beneficial effects due to monitoring and research. Overall, surveys for creosote covered logs, marine debris, and derelict fishing gear would provide a negligible to minor beneficial effect as these surveys would provide information to assess their impact and better direct removal programs. Research on environmental factors that are climate change related stressors would provide information on how best to reduce manageable stressors which may be the only feasible method to help mitigate climate change for fish.

If present, anadromous fish would benefit from a survey to determine presence/absence in Dean Creek on the Dawley Unit. In addition, a road inventory, forest assessment and hydrologic study of the Dawley Unit would benefit any anadromous fish present within Dean Creek as it would provide information for management to better design the forest management plan (e.g., provide seasonal or spatial restrictions on work, eliminate unused forest roads within a defined distance of the riparian area, etc.).

Effects from Public Recreational Use
Related impacts for fish stocks associated with Tribal and recreational fishing in Dungeness Harbor and Bay are estimated annually. Working as co-managers of the fishery, the State of Washington and Tribes consider those impacts when developing annual fishing agreements and associated regulations. Because fishing regulations are established to provide a sustainable fish resource, negative impacts to fish populations from fishing are expected to be minor to negligible.

Negligible to minor negative effects may be anticipated from boating activities as a result of scour of eelgrass beds. Boating activities have the potential to increase sedimentation and contamination from limited oil or gas spills. A very minor to negligible negative effect of shellfishing may be anticipated for forage fish stocks from harvest methods on spawning areas. Shellfishing on the Refuge is not currently very active as there are more productive areas with easier access nearby. All other public use management would be expected to have an overall negligible effect to anadromous and forage fish. The Dawley Unit would remain closed to public use under all alternatives; therefore no effects are anticipated from public use.

Overall Effects
Negligible to minor negative effects are experienced under Alternative A given minimal directed management, particularly for potential anadromous fish located within Dean Creek downstream of the Dawley Unit. Minor beneficial effects can be inferred under Alternatives B and C for anadromous and forage fish from management practices and minimal overlap with public recreational use.

6.3.9 Effects to Threatened, Endangered, and Sensitive Species

Listed species receive special consideration in terms of refuge management. Federally listed species are trust resources that require additional consultation whenever an activity conducted by or permitted by the Refuge may have an effect on these species or their habitats. A total of 5 federally listed species are known to occur on or adjacent to the Refuge.

Table 6-2. Threatened, Endangered, and Sensitive Species within the Vicinity of the 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 on Graveyard Spit
Western Snowy Plover	*Charadrius alexandrinus nivosus*	Threatened	Occasional observations according to historic records on Dungeness and Graveyard spits
Puget Sound Chinook	*Oncorhynchus tshawytscha*	Threatened	Probable use of nearshore habitats
Hood Canal Summer Chum	*Oncorhynchus keta*	Threatened	Probable use of nearshore habitats

Effects from Management Practices
Marbled murrelets are known to occur adjacent to the Dawley Unit. Critical habitat is found within state lands to the south of the Unit; however the Unit is not included within critical habitat designation and does not currently support suitable habitat. Given the status of this species and the presence of critical habitat to the south of the Unit, murrelets would be considered within the NEPA process covered during development of the step down forest management plan for the Dawley Unit.

Limited observations of snowy plover have been noted on Dungeness NWR with up to 6 individuals observed on Dungeness and Graveyard spits in May-June of 1995. One plover was reported in the spring of 1996 and another was observed by refuge staff during the spring of 2012. Targeted surveys in 1995, 2011, and 2012 during the breeding season did not result in confirmed breeding perhaps due to lack of suitable breeding habitat. In addition, this species has not been reported on the Refuge historically (Refuge Narratives from 1977-1992) through more recent bird survey efforts (1992/1993 Shorebird Survey), or within information contained in the species listing package. Critical habitat is not designated on the Refuge; in fact the Refuge does not occur within the range of the listed population and habitat quality appears to be marginal due to a high density of native strand plants. Given the limited occurrence of this species, effects are considered negligible.

One sand-verbena moth was captured in a light trap on Graveyard Spit in 2002. This species is currently a candidate for listing under the Endangered Species Act and no critical habitat has been designated. According to the description of preferred habitat within the listing package, habitat quality appears to be marginal with a high density of native strand plants and a low density of this species' sole host plant, yellow sand verbena. Invasive species removal may provide a minor benefit by creating open sand habitat preferred by yellow sand verbena.

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 Effects to Anadromous and Forage Fish above). The Refuge falls within designated critical nearshore habitat for both ESUs.

Effects from Research and Monitoring Strategies
Given the low occurrence rate of these species, effects from monitoring and research are expected to be negligible.

Effects from Public Recreational Use
Given the low occurrence rate of these species typically in closed areas of the Refuge, effects from public recreational use are expected to be negligible. This particularly applies to species for which limited occurrences have either been off-refuge (marbled murrelet) or suitable habitat and limited occurrences are located in closed areas (sand-verbena moth). Negligible to minor negative effects are expected from public recreational use for snowy plover given the very limited (4) observations and suitable habitat which mainly occurs in closed areas. Minor negative effects from human-caused wildlife disturbance could be inferred for plovers using the outside of the barrier beach habitat; however suitable habitat along this stretch is extremely limited given the dynamic nature of longshore currents and storm events which reduces the amount of fine sediment typical of sandy beach habitat favored by this species.

Overall Effects
Given very limited or no occurrence on the Refuge, overall effects to listed species occurring on or near the Refuge are expected to be negligible under all Alternatives.

6.4 Effects to Cultural and Paleontological Resources

6.4.1 Effects to Cultural Resources

The National Historic Preservation Act (NHPA) of 1966, as amended, establishes the Federal government's policy on historic preservation and the programs through which that policy is implemented. Historic preservation is defined as the protection, rehabilitation, restoration, and reconstruction of sites, buildings, structures, and objects significant in American history, architecture, engineering, and archaeology.

Title I, Section 106, of the NHPA requires Federal agencies having direct or indirect jurisdiction over a proposed Federal or federally-assisted undertaking in any state to take into account the effect of the undertaking on any historic property. Regulatory procedures for complying with Section 106 are found in 36 CFR Part 800. All ground disturbing activities proposed for the Refuge and for any parcels that might be acquired in future, as well as alterations to significant historic structures or infrastructure, would be subject to compliance with Section 106 of the NHPA, which may include pedestrian survey and other identification efforts as appropriate.

Prior to implementing undertakings, the applicable cultural resource compliance investigation would be undertaken. If significant cultural resources are found, appropriate procedures and protocols would be followed to protect them. Whenever possible, resources would be avoided or mitigated. Mitigation options, in addition to site avoidance by relocating or redesigning facilities, may include data recovery, using either collection techniques or in-situ site stabilization procedures or other measures as appropriate.

An impact to cultural resources would be considered significant if it adversely affects a resource listed in or eligible for listing in the National Register of Historic Places (NRHP). In general, an adverse effect may occur if a significant cultural resource would be physically damaged or altered, isolated from the context considered significant, or affected by project elements that would be out of character with the significant property or its setting.

Section 110 or the NHPA requires Federal agencies to create a program to identify and protect historic properties. This program includes the nomination of eligible properties to the National Register of Historic Places (NRHP); the designation of a qualified agency historic preservation officer; conducting agency programs and activities so that preservation values are considered; and the authority of Federal agencies to include the costs of preservation activities within overall project costs during undertakings. Many opportunities exist to comply with Section 110, including but not limited to the development of interpretive materials and exhibits, refuge-based cultural heritage curriculum and resources for use both on- and off-refuge, and a systematic program for recording and evaluating the Refuge's cultural resources. These opportunities also present excellent prospects for partnerships with tribal communities and historical societies. The myriad ways in which the Refuge's rich cultural history can be shared with refuge audiences should be considered during any planning project or undertaking on the Refuge.

The Service is committed to protection of known and unknown cultural resources. Alternatives B and C under Objective 8.1 would implement actions to complete evaluations and documentation of historic structures including their eligibility to the National Register of Historic Places. These alternatives would initiate the development of a GIS layer for cultural resources inventory while ensuring appropriate measures to protect sensitive information. The Refuge would also develop partnerships with the Tribes for cultural resources inventory, evaluation, and project monitoring, consistent with the regulations of the NHPA. While the short-term effects would be negligible, there would be moderate beneficial long-term effects for evaluation, monitoring, and preservation of cultural resources.

While the Refuge currently has only limited coordination with Jamestown S'Klallam and Makah Tribes regarding the Native American Graves Protection and Repatriation Act (NAGPRA), under Alternatives B and C, the Service would further identify Native American Tribes, Groups, and direct lineal descendants that may be affiliated with the refuge lands. The Refuge would also open a consultation process with affiliated Tribes, Groups, and direct lineal descendants and develop formal procedures to follow for intentional and inadvertent discoveries including identifying specific persons to contact for the purposes of NAGPRA. Although the short-term effects would be negligible, there would be moderate beneficial long-term effects from improving communication with stakeholders and satisfying refuge obligations outlined in NAGPRA.

Effects from Habitat Management Practices

Habitat management practices could have inadvertent negative effects on cultural resources. For example, ground disturbance created during habitat enhancement efforts could damage undocumented sites and/or their historical context. However, by developing a GIS layer for cultural resources to be used in conjunction with other GIS layers, the chances of such an occurrence would be reduced. Additionally, prior to implementing any ground disturbing projects, the applicable cultural resource compliance investigation would be undertaken. If cultural resources are found, appropriate procedures and protocols would be followed to protect them. Whenever possible, resources would be avoided or mitigated. Mitigation options, in addition to site avoidance, would include data recovery, using either collection techniques or in-situ site stabilization protection. Therefore Alternatives B and C would be more likely to have a negligible short-term effect and a moderately beneficial long-term effect to resource protection.

Effects from Public Recreational Use

As with effects from habitat management, cultural resources can be compromised by public recreational uses under all alternatives although nearly all of the Refuge's identified cultural resources are in areas closed to the public. Documenting known cultural resource sites within a GIS layer would offer an additional layer of protection from public uses. Increased cultural resources interpretation and education proposed under Alternatives B and C may have a minor beneficial effect as these programs can foster an awareness and appreciation for cultural resources and native cultures.

Overall Effects

Compliance with cultural resource investigation protocol prior to conducting ground disturbing actions, and subsequent compliance with procedures if cultural resources are found, would ensure that negative impacts to cultural resources from implementation of any of the Alternatives are negligible. In general, Alternatives B and C would help to strengthen long-term protection and preservation of all cultural resources in the Refuge and ensure compliance with both NHPA and NAGPRA. While the overall short-term effects would be negligible, the long-term effects would be moderately beneficial as the cumulative effects to known refuge cultural resources and yet to be discovered resources are recognized. Additionally, the Refuge could experience moderately beneficial effects from strengthening partnerships with affiliated Tribes, Groups, and direct lineal descendants.

6.4.2 Effects to Paleontological Resources

Paleontological resources, like cultural resources, are found above and below the surface of the ground. Also, similar to cultural resources, they are impacted by ground-disturbing activities including erosion, digging, and public uses that alter their stability and integrity. Under all alternatives, the collection and curation of paleontological resources would be managed under the Department of the Interior's Museum Property program and the Paleontological Resources Protection Act (PRPA). Negative impacts to paleontological resources would be minimized by conducting a systematic survey prior to any ground-disturbing activity and mitigating potential negative effects. Consequently, the overall effects to paleontological resources across all alternatives are neutral.

6.5 Social Effects

The Social Effects section assesses how management actions under each alternative could affect quality opportunities for each of the Refuge System's priority public uses currently occurring or proposed for Dungeness NWR (i.e., wildlife observation, photography, interpretation, environmental education, and fishing). The section also includes an assessment of the change in refuge user numbers expected under each of the alternatives.

6.5.1 Changes in Visitation

As an overview to assessing the social and economic effects of Alternatives A, B, and C, it is important to understand the broader context of the Refuge within the region and how recreational demand and public use are expected to change over time. A growing visitor presence on the Refuge can be expected in the future. Many of the public use opportunities currently provided are very popular within the state, and are forecasted to attract increasing amounts of participants in the coming years. A 2002 report by Washington State's Interagency Committee for Outdoor Recreation (IAC) estimated the percent of change in the number of people participating in recreational activities in the future compared to current levels. For example, according to the report, it is estimated that "nature activities" including outdoor photography and wildlife observation, will increase 30 percent during the next 15 years. In 2006, observing and photographing wildlife and nature was reported as a recreational activity by at least 39 percent of Washingtonians (RCO 2007).

According to the Banking on Nature report (Carver and Caudill 2007), in 2006, 38 percent of visitors to Dungeness NWR were considered residents to the area (defined as living within a 30-mile radius of the Refuge). The local Sequim area continues to be an attractive place to retire and the fastest growing community in Clallam County (CLR 2010). As a result, refuge visitation will likely increase as the local population increases. Alternatives that add or improve outreach, interpretation, education, and wildlife-dependent recreation opportunities would likely generate additional visitation increasing refuge use above the IAC's estimates.

There are a several community outreach alternatives that would affect refuge visitation. Currently, staff and volunteers attend one or two public events each year including the Audubon Center's Dungeness River Festival and the Sequim Lavender Festival and staff deliver up to two presentations about the Refuge annually within the community. Alternatives B and C would increase community events attended to at least three per year. Alternative B would increase presentations about the Refuge to five annually and Alternative C would increase presentations to three annually. Because the Refuge is already very well known in the community, the increased exposure would have a negligible effect in the short term and a minor to moderate beneficial effect on refuge visitation in the long term.

The Refuge also conducts outreach via the Internet and sporadic media outreach. Alternative B would increase coordination with media outlets including publishing at least two articles about the Refuge annually while also targeting the boating and aviation communities. Alternative C is similar except that the goal would be to publish at least one article about the Refuge annually. While these alternatives are ultimately intended to help people understand how they can reduce disturbance to wildlife, the increased exposure would generate interest in the Refuge resulting in a negligible increase in visitation in the short term and a moderate increase in the long term.

Under Alternative A, boats are allowed to land at the lighthouse daily from sunrise to sunset by advanced reservation and the number of landings is limited to no more than 20 per day. On average about 275 boats, mostly kayaks, take advantage of this opportunity. Because the landing zone at the lighthouse is intended only to give visitors access to the historic structure and not as an entry point into the Refuge, Alternatives B and C would limit landings to between 9am and 5pm to coincide with the lighthouse public hours. These alternatives would both have a negligible short- and long-term effect on visitation.

Overall Effect
In addition to minor increases in visitation under all alternatives due to demographic trends and a rising demand for outdoor recreation, the overall effect on refuge visitation from increased community outreach and increased wildlife-dependent recreational opportunities due to habitat management practices would be negligible in the short term, but the effect would be moderately beneficial in the long term under both Alternatives B and C.

6.5.2 Effects to Opportunities for Quality Wildlife Observation and Photography

The Refuge currently offers unstructured opportunities to observe and photograph wildlife along approximately 1 mile of trails (including main, horse and bluff trails) and on approximately 5.5 miles of beach (Zones 1, 2, and 3). There are also two observation decks with viewing scopes. Under Alternatives B and C, the Refuge would develop partnerships with interest groups to create naturalist guided wildlife observation and photography walks. Under Alternative C, at least 3 guided wildlife walks and/or programs would be offered annually. Under Alternative B that would increase to at least 5 offerings annually. Under both Alternatives B and C, these additional opportunities would have a minor beneficial effect on opportunities to observe and photograph wildlife in the short and long term.

Horseback riding is an existing use on the Dungeness NWR that can facilitate wildlife observation, but is not necessary to achieve it. Under Alternative A, horseback riding is permitted, with the required reservations, on weekdays from May 15 through September 30 and daily during the remainder of the year on the horse trail (approximately 3,110 linear feet), the lower main trail where the horse trail meets the main trail to the beach (approximately 500 linear feet), and west on the refuge beach towards Clallam County Park lands (approximately 1/2 mile). Through this planning process, horseback riding was re-evaluated based on the refined criteria outlined under the appropriateness policy. We have preliminarily determined that horseback riding should no longer be allowed due to safety concerns and user conflicts (see Appendix A, Appropriate Use Findings). Consequently, by not allowing horseback riding under Alternatives B and C, pedestrians engaged in compatible, wildlife-dependent activities such as wildlife observation and photography would experience a minor benefit due to fewer safety concerns and user conflicts.

Under Alternative A, jogging is allowed on refuge trails, on the beach to the west refuge boundary, and on the Spit to the first ½ mile marker (Zone 1 & Strait-side of Zone 2). Jogging has the potential to cause increased levels of disturbance to wildlife when compared to walking. Animals show greater flight response to humans moving unpredictably than to humans following a distinct path (Gabrielsen and Smith 1995) and rapid movement by joggers is more disturbing to wildlife than slower moving hikers (Bennett and Zuelke 1999). This activity does not meet the Appropriateness criteria established in the Refuge Administration Act (see Appendix A). Therefore, this activity would no longer be allowed on refuge lands under both Alternatives B and C resulting in less wildlife disturbance and a minor beneficial effect to opportunities for quality wildlife observation and photography. In particular, opportunities to encounter species such as dunlin and bald eagles as well as a variety of forest birds such as chickadee and towhee could improve with the removal of jogging.

Effects from Habitat Management Practices

There are a number of habitat management alternatives that could increase wildlife viewing and photographic opportunities through improvements in habitat quality and production. They include monitoring and the use of appropriate IPM techniques for controlling invasive species such as *Spartina*, working with partners to address water quality issues in Dungeness Bay and Harbor, rapid response to oil spills, marine debris and creosote-covered log removal, fire suppression, and removal of the dike road within the barrier lagoon and mudflats. Increasing the fire break buffer along the main Dungeness trail would serve to better protect the forest from a stand replacement fire. These practices would have a minor to moderate beneficial effect to opportunities for quality wildlife observation and photography through improved habitat quality and the resulting increased wildlife production.

Overall Effects

The overall effects to opportunities for quality wildlife observation and photography from removing horseback riding, jogging, habitat improvements, and offering structured wildlife walks and programs would be beneficial under both Alternatives B and C. The benefits in the short term would be minor, mostly from removing horseback riding and jogging. The effects would be moderate in the long term as wildlife programs are developed and habitat is improved.

The current management under Alternative A would provide opportunity for horseback riding facilitated wildlife observation and photography; however, these benefits are offset by safety concerns and the potential for user conflicts, particularly in the areas where horseback riding and pedestrian use overlap. Thus, overall, Alternative A would result in a negligible to minor negative impact to wildlife observation and photography.

The removal of horseback riding under Alternatives B and C would eliminate the opportunity for horseback riding facilitated wildlife observation and photography; however this could also reduce the potential for user conflicts and safety issues thereby potentially improving the experience for other refuge users. The vast majority of refuge users are pedestrians versus on horseback. Thus, this alternative would provide minor benefits for the overall wildlife observation and photography programs. See Appendix A, Appropriate Use Findings.

6.5.3 Effects to Opportunities for Quality Interpretation and Environmental Education Experiences

New interpretive panels installed late in 2011 have greatly increased opportunities for interpretation of wildlife and habitat, geology, and cultural resources on the Refuge. Visitors can now experience these passive displays in a new interpretive kiosk at the entrance station and along the trail to the Dungeness Spit. There are 6 additional interpretive panels awaiting installation on the upper Spit overlook. The displays are designed to facilitate both refuge interpretation and support education programs and would have a moderate short- and long-term effect on quality interpretation and environmental education experiences.

Currently the Refuge averages just 1 formal interpretive program annually focusing on wildlife and habitats, Dungeness Spit geomorphology, and/or refuge-related cultural resources. Under Alternative C, that would be increased up to 3 programs annually and up to 5 programs annually under Alternative B. In both Alternatives B and C, an environmental education/outreach specialist position would be created and tasked with offering guided interpretive programs. The specialist would partner with Tribe(s) to provide at least 1 Native American cultural program per year and would offer education programs to primary and secondary level school groups on and off the Refuge. Because it is unlikely that the environmental education/outreach specialist position would be created immediately upon implementation of this plan, both Alternatives B and C would have a minor beneficial short-term and a moderate long-term effect on quality interpretation and environmental education experiences on the Refuge.

From about April 1 through September 30, the “busier” season, visitors arriving at the entrance station between 8 am and 7 pm are usually greeted by trained volunteers and given a brief orientation. Currently volunteers spend about 1,000 hours, and staff spends about 210 hours annually providing visiting groups with a more in depth introduction to the Refuge. These introductions generally include information about refuge wildlife including observation and photography opportunities, geology, and cultural history. Alternative C would increase that time commitment to 315 hours for staff and 1,100 hours for volunteers and Alternative B would increase it to 520 hours for staff and 1,200 hours for volunteers. The increase would have a minor to moderate beneficial effect to quality interpretation and environmental education experiences.

Effects from Habitat Management Practices
While interpretation and education opportunities could arise from habitat management practices**,** the direct effects would be negligible. However, there would be a minor beneficial effect from being able to interpret management practices and restoration techniques and from including such information in formal refuge environmental education programs such as those presented by the environmental education/outreach specialist.

Overall Effects
Under Alternative A, negligible effects to interpretation and environmental education are expected as no actions would be taken to provide new opportunities. Under Alternatives B and C, the overall effects to quality interpretation and environmental education experiences would be moderately beneficial due to the addition of new interpretive panels; new orientation materials; additional interpretive programs and an increased staff and volunteer commitment; and the addition of environmental education/outreach specialist who would offer education programs to primary and secondary level school groups on and off the Refuge.

6.5.4 Effects to Opportunities for Quality Fishing and Shellfishing

The effects to opportunities for quality fishing and shellfishing are expected to negligible in the short term and beneficial (minor) in the long term. Under Alternatives B and C for both fishing and shellfishing there would be no changes to refuge access. The only changes being considered are the addition of refuge map and regulation panels at the Cline Spit and Dungeness Landing boat launches and the inclusion of refuge-specific information in the Washington State sport fishing rules pamphlet. It is possible that these changes could serve to “advertise” fishing and shellfishing opportunities in the Refuge resulting in a small increase in the number of visitors participating in these activities. However, it is more likely that these changes would have a minor beneficial effect of reducing illegal use of the Refuge.

Effects from Habitat Management Practices
All habitat management alternatives are intended to improve habitat quality and increase fish and shellfish stocks. In most cases the short-term effects would be negligible; however, the long-term effects would range from minor to moderately beneficial for stocks and therefore equally beneficial for fishing and shellfishing opportunities. For example, actions taken to protect eelgrass would have minor to moderate beneficial effects on salmonids and Pacific herring because eelgrass provides shelter for juvenile salmonids, spawning substrate for Pacific herring spawning and prey species for salmonids. In turn, those increased stocks would benefit recreational harvest opportunities. However, in the short term there could also be a negative minor effect due to temporary damage in forage fish spawning habitat as a result of management practices such as invasive species removal techniques. But these effects would be temporary and localized and eclipsed by protection of preferred habitat structure.

Effects from Monitoring and Research Strategies
Anadromous and forage fish stocks would experience minor beneficial effects due to monitoring and research and from surveys for creosote covered logs, marine debris and derelict fishing gear. These benefits should translate into increased fishing and shellfishing opportunities.

Overall Effects
Under Alternative A, a negligible overall effect is expected as no actions would be taken improve the quality of fishing and shellfishing opportunities. Overall, the effects to fishing and shellfishing under Alternatives B and C in the short term would be negligible; however, there could be a minor beneficial long-term effect for visitor opportunities to enjoy these uses in the long term as well as a moderate short- and long-term reduction in illegal use of the Refuge.

6.5.5 Effects to Opportunities for Non-wildlife-dependent Public Uses

Boating is an example of a non-wildlife-dependent activity that can support wildlife-dependent recreation as well as be enjoyed for the sake of the activity itself. Boats are also used to visit the New Dungeness Light Station. The designated boat landing area on the beach directly south of the lighthouse is the only place boats are allowed to land in the Refuge and is intended to provide visitors who wish to visit the historic lighthouse with an alternative to hiking the spit. Under current management, boat landing hours are from sunrise to sunset. Under the action alternatives, B and C, boat landing hours would be limited to 9 am to 5 pm, matching the hours of visitation for the lighthouse. Since the boat landing area is not intended to be an alternate access point for Dungeness

Spit (or areas adjacent to the landing close to reduce wildlife disturbance) but rather the means towards facilitating visitation of the lighthouse, the effects of reducing the boat landing hours under Alternatives B or C would be negligible.

Horseback riding is currently allowed in a limited area (horse trail and Zone 1) by reservation only. Under Alternative A, the use is permitted daily October 1 - May 14, and weekdays only May 15 - September 30. The review of horseback riding under the appropriateness policy preliminarily determined that horseback riding should no longer be allowed on the refuge due to safety concerns and user conflicts. Since other opportunities to engage in this activity locally exist (e.g., Dungeness Recreation Area, Robin Hill Farm County Park, and Olympic Discovery Trail) and because this activity is currently only permitted in a limited area within the Refuge, the effects of implementing Alternatives B or C would result in a minor to moderate negative impacts to this non-wildlife-dependent use.

The existing use of jogging was evaluated under the appropriateness policy and found to be inappropriate and therefore not permissible. As such, both Alternatives B and C would remove this non-wildlife-dependent use from the Refuge. Because this activity would continue to be allowed in the adjacent 216 acre Dungeness Recreation Area, is currently only permitted in a small area within the Refuge (Zone 1 & Strait side of Zone 2), and is not considered to be a significant use of the Refuge, the short- and long-term effects of implementing the action alternatives would be negligible.

General non-wildlife-dependent beach recreation (use) is loosely defined to include: wading, picnicking, and sunbathing but does not include any kind of sports such as ball playing, kite flying, or Frisbee throwing which are not allowed in the Refuge. The included activities are limited to a small area (Zone 1 and Strait-side of Zone 2) and are not considered to be a significant use of the Refuge but are rather viewed as incidental to wildlife-dependent recreation. Under all alternatives, impacts to this use are likely to be neutral.

Effects from Habitat Management Practices, Research and Monitoring
The effects to opportunities for non-wildlife-dependent public uses from habitat management practices, research, and monitoring would be negligible in the short and long term. Management practices such as reducing fuel loads (woody debris) along trails and other trail maintenance could impact visitors due to area closures and detours but the effects to actual opportunities would be negligible as would any additional closures necessitated by monitoring and research.

Overall Effects
Overall, there would be a neutral effect on opportunities for non-wildlife-dependent uses under Alternative A since there would be no changes in the management of these uses. Under Alternatives B and C, minor to moderate negative overall effects to non-wildlife-dependent uses would occur primarily due to the removal of horseback riding. However, removing user conflicts and safety concerns caused by horseback riding and wildlife disturbance caused by jogging from the Refuge may prove to have a minor positive effect on pedestrian-based wildlife viewing and photography (see Section 6.5.2).

6.5.6 Effects to Illegal Uses

Illegal uses of the Refuge occur to varying degrees and include pets, bicycles, resource collecting, fires, discharging firearms, closed area and after hours trespass including camping, kite flying, fireworks, ball playing and Frisbee throwing. Currently the Refuge utilizes regulatory information distributed via the website, publications, interpretive panels, and regulatory signage. Law enforcement officers and other staff and volunteers also inform visitors about regulations and allowable activities. Alternatives B and C would increase law enforcement patrols as well as replace and improve regulatory and guidance signage at the lighthouse boat landing zone and on the end of Dungeness Spit.

Effects from Habitat Management Practices, Research and Monitoring
Habitat management practices, research, and monitoring would have a negligible direct effect on most illegal uses except that additional illegal resource harvesting could result from improved habitat conditions and an increase in associated wildlife. However, an indirect consequence of active management is a greater field presence of staff and volunteers which creates higher visibility which serves as a deterrent thereby having a moderately beneficial effect on reducing illegal uses.

Overall Effects
Under Alternative A, the existing staff, volunteer, signage, enforcement, and outreach may not be sufficient to prevent these illegal uses from occurring, particularly in light of the potential for a minor increase in these uses due to demographic trends and rising demand for outdoor recreation. The overall effects to illegal uses would negligible in the short term as the changes prescribed under Alternatives B and C would not be implemented immediately due to budgetary limitations and maintenance and staff priorities; however, the overall long-term impacts would be moderately beneficial.

6.5.7 Effects to Human Health

In addition to the effects described in the air and water quality sections (Sections 6.2.3 and 6.2.4); use of herbicides and/or pesticides in management strategies for invasive species control could have the potential to impact human health. However, it is expected that all people performing applications of these chemicals would follow instructions and wear appropriate protection to avoid dangerous contact with or respiration of the materials. Also, since many of the areas potentially requiring invasive species treatment are closed to public access, there would be little risk of the public coming into contact with herbicides or pesticides used in refuge management (also see Appendix G).

Management strategies under all alternatives to work with partners to remove marine debris and to monitor and address water quality issues within Dungeness Bay and Harbor could provide negligible to minor positive impacts to human health. Additionally, public health could be enhanced through participation in the public use and recreation opportunities provided under all alternatives. Therefore, overall, negligible to minor positive impacts to human health are expected as a result of any of the management alternatives.

6.5.8 Effects to Environmental Justice

The concept of environmental justice has been around since the early 1990s and arose from a need to ensure that negative environmental activities from industry or government projects would not endanger local communities. The U.S. Environmental Protection Agency (USEPA) oversees environmental justice compliance and defines environmental justice as: “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (USEPA 2010).

All federal actions must address and identify, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations, low-income populations, and Indian Tribes in the United States. Since CCP implementation of any of the alternatives is expected to result in generally positive effects on the human environment, all alternatives pose little risk of disproportionate adverse effects on human health or economics to low income or minority groups. Therefore, negligible effects related to environmental justice are anticipated under all CCP alternatives.

6.6 Economic Effects

6.6.1 Approach to Estimating Economic Effects

From an economic perspective, Dungeness National Wildlife Refuge provides a variety of environmental and natural resource goods and services used by people either directly or indirectly. The use of these goods and services result in economic impacts to both local and state economies. The various services the Refuge provides can be grouped into five broad categories: (1) Maintenance and conservation of environmental resources, services and ecological processes; (2) Production and protection of natural resources such as fish and wildlife; (3) Protection of cultural and historical sites and objects; (4) Provision of educational and research opportunities; and (5) Outdoor and wildlife-related recreation. People who use these services benefit in the sense that their individual welfare or satisfaction level increases with the use of a particular good or service.

One measure of the magnitude of the change in welfare or satisfaction associated with using a particular good or service is economic value. Economic value is the economic trade-off people would be willing to make in order to obtain some good or service. It is the maximum amount people would be willing to pay in order to obtain a particular good or service minus the actual cost of acquisition. In economic theory this is known as net economic value or consumer surplus. In the context of this report, estimates of the economic value of particular recreational activities are used to determine the aggregate value of recreational use of Dungeness National Wildlife Refuge.

Aside from the effect on the individual, use of the good or service usually entails spending money in some fashion. These expenditures, in turn, create a variety of economic effects collectively known as economic impacts. Economic impacts refer to employment, employment or labor earnings, economic output, and federal, local, county, and state tax revenue that occur as the result of refuge activities. To estimate the total economic activity, employment, employment income and federal and state taxes generated by refuge activities, this report uses IMPLAN, a regional input-output model and software system. The following is a list of terms and definitions that are commonly used in economic impact analysis (Minnesota IMPLAN Group, Inc. 2004 and Miller and Blair 1985):

> Economic output includes three types of effects: direct, indirect, and induced effects. Direct effects are the expenditures associated with a particular activity (such as refuge recreation visits and management activities). "Indirect effects result from changes in sales for suppliers to the directly-affected businesses (including trade and services at the retail, wholesale and producer levels). Induced effects are associated with further shifts in spending on food, clothing, shelter and other consumer goods and services, as a consequence of the change in

workers and payroll of directly and indirectly affected businesses" (Weisbrod and Weisbrod 1997). The indirect and induced effects represent any multiplier effects. Both job income and tax revenue are derived from total economic output (aggregate sales). For example, labor costs are paid out of total sales revenue for a company as are taxes. To add taxes and job income to output would double-count economic impacts.

Jobs and job income include direct, indirect and induced effects in a manner similar to economic output. Employment includes both full and part-time jobs, with a job defined as one person working for at least part of the calendar year, whether one day or the entire year.

Tax revenues are shown for business taxes, income taxes, and a variety of taxes at the local, state, and national level. Like output, employment, and income, tax impacts include direct, indirect, and induced tax effects.

A comprehensive economic profile (baseline) of the Refuge and estimates of the economic effects of alternative management strategies would address all applicable economic effects associated with the use of refuge-produced goods and services. However, for those goods and services having nebulous or non-existent links to the market place, economic effects are more difficult or perhaps even impossible to estimate. Some of the major contributions of the Refuge to the natural environment, such as watershed protection, maintenance and stabilization of ecological processes, and the enhancement of biodiversity would require extensive on-site knowledge of biological, ecological, and physical processes and interrelationships even to begin to formulate economic benefit estimates. This is beyond the scope of the analysis within this CCP.

This section focuses on a limited subset of refuge goods and services, primarily those directly linked in some fashion to the marketplace, such as recreation use and refuge budget expenditures. It should be kept in mind that the emphasis on these particular market-oriented goods and services should not be interpreted to imply that these types of goods and services are somehow more important or of greater value (economic or otherwise) than the non-market goods and services previously discussed.

For this effects analysis section, two types of economic impacts are addressed: (1) impacts associated with annual consumer expenditures on refuge-related recreation and (2) impacts associated with refuge budget expenditures. The economic impacts are presented as annual impacts over a 15 year time period. For Alternatives B and C, the analysis presents the impacts that would result assuming that all management objectives are implemented and achieved. Note that funds are not currently present to implement all objectives and strategies identified; however the analysis for Alternatives B and C assumes that funding would manifest.

6.6.2 Recreational Activities

Dungeness NWR receives visitors from across North America and the world. The majority of refuge visitors live in the local area. The spending by recreational visitors when visiting the Refuge impacts the local economy by creating jobs and generating tax revenue.

Economic impacts for the recreation baseline and Alternatives are addressed in this section. Two types of information are needed to estimate the economic impacts of recreational visits to the Refuge: (1) the amount of recreational use on the Refuge by activity; and (2) expenditures associated with recreational visits to the refuge. Recreational use (i.e., visitation and the distribution of resident visitors and non-resident) is estimated by refuge staff. Expenditure patterns used in this report were obtained from the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USFWS 2007c). These expenditures include travel-related expenses, such as food, lodging, transportation, and other travel-related miscellaneous expenses. With this information, total expenditures for each activity can be estimated. These expenditures, in turn, can be used in conjunction with regional economic models to estimate industrial output, employment, employment income and tax impacts associated with these expenditures. The economic impact area for recreational activities is defined as Clallam County, which is located on the northern coast of the Olympic Peninsula in the state of Washington. It is assumed that visitor expenditures occur primarily within this area.

The economic impacts from recreation expenditures estimated in this report are gross area-wide impacts. Information on where expenditures may occur locally and the magnitude and location of resident and non-resident expenditures (resident and non-resident relative to the geographical area of interest) is not currently available. Generally speaking, non-resident expenditures bring outside money into the area and thus generate increases in real income or wealth. Spending by residents is simply a transfer of expenditures on one set of goods and services to a different set within the same area. In order to calculate net economic impacts within a given area derived from resident expenditures, much more detailed information would be necessary on expenditure patterns and visitor characteristics. Since this information is not currently available, the gross area-wide estimates are the maximum impact for the net economic impacts of total resident and non-resident spending in the five-county area. The economic impacts of non-resident spending represent a real increase in wealth and income for the area (for additional information, see Kaval and Loomis 1993).

Alternative A (Baseline): Recreational Activities

Under Alternative A, there would be no changes to the recreational activities offered at the Refuge. All programs would continue to follow current management goals. Dungeness National Wildlife Refuge would continue to offer a variety of non-consumptive public uses, including hiking, photography, interpretation, and environmental education.

Table 6-3 shows the visitation for Dungeness NWR. The Refuge had 112,151 visits in 2011. Pedestrian visits represented 56 percent of all visits. Opportunities for interpretation include the Refuge's large volunteer group who meet and greet visitors and the numerous interpretive panels at various locations. Other recreation includes horseback riding and jogging. In addition to recreation visits, the Refuge also had about 500 environmental education visits. The environmental education program consists mainly of student field trips led by refuge staff.

Table 6-3. Alternative A: FY2011 Visitation

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	41,029	22,093	63,122
Auto Tour	0	0	0
Boat Trail/Launch Visits	153	153	306
Bicycle Visits	0	0	0
Photography	125	125	250
Other Recreation	113	38	150

Activity	Residents	Non-Residents	Total
Interpretation	30,875	16,625	47,500
Environmental Education	105	418	523
Fishing:			
Freshwater	0	0	0
Saltwater	240	60	300
Total Visitation	**72,639**	**39,512**	**112,151**

Alternative A (Baseline): Regional Economic Analysis
Visitor recreation expenditures for Alternative A are shown in Table 6-4. Environmental education opportunities for residents do not contribute to the local economic impacts because the events typically do not bring visitors who are spending money toward travel-related goods and services. Total annual expenditures were about $1.8 million with non-residents accounting for about $1.2 million or 66 percent of total expenditures. Under Alternative A, these annual expenditures are expected to continue.

Table 6-4. Alternative A: Visitor Recreation Expenditures (2011 dollars in thousands)

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	$342.1	$671.5	$1,013.6
Boat Trail/Launch Visits	$1.3	$4.7	$5.9
Photography	$1.6	$5.7	$7.3
Other recreation	$0.5	$0.6	$1.0
Interpretation	$257.4	$505.3	$762.8
Total Non-Consumptive	**$602.8**	**$1,187.8**	**$1,790.6**
Fishing:			
Total Fishing	$4.5	$3.7	$8.3
Total Expenditures	**$607.4**	**$1,191.5**	**$1,798.9**

Input-output models were used to determine the economic impact of expenditures on the Refuge's local economy. It is assumed that visitor expenditures occur primarily within Clallam County. Table 6-5 summarizes the local economic effects associated with recreation visits. Economic output totaled $2.5 million with associated employment of 25 jobs, $753,000 in employment income and $331,000 in total tax revenue.

Table 6-5. Alternative A: Local Economic Effects Associated with Recreation Visits (2011 dollars in thousands)

	Residents	Non-Residents	Total
Economic Output	$868.4	$1,647.2	$2,515.6
Jobs	9	16	25
Job Income	$262.5	$490.3	$752.8
State & Local Tax Revenue	$58.3	$114.9	$173.2
Federal Tax	$54.9	$103.1	$157.9

Alternative B: Recreational Activities
Table 6-6 shows the visitation that would occur if Alternative B is fully implemented. Approximately 134,150 visits would be related to a variety of recreational opportunities, interpretation programs, and environmental education. Pedestrian and interpretation visits would continue to represent the majority of all visits. Under this alternative, visitors would have more opportunities for cultural history programs and wildlife/plant geology walks. Horseback riding would no longer be permitted under Alternative B. In addition to recreation visits, the Refuge also would support 700 environmental education visits.

Under Alternative B, recreation visits are projected to increase by 20 percent, compared to Alternative A. Similar to Alternative A, nearly all recreational visitors would participate in non-consumptive activities. Less than 1 percent of visitors would participate in fishing.

Table 6-6. Alternative B: Projected Annual Refuge Visitation

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	47,125	25,375	72,500
Auto Tour	0	0	0
Boat Trail/Launch Visits	163	163	325
Bicycle Visits	0	0	0
Photography	193	83	275
Other Recreation	0	0	0
Interpretation	39,000	21,000	60,000
Environmental Education	280	420	700
Fishing:			
Freshwater	0	0	0
Saltwater	280	70	350
Total Visitation	**87,040**	**47,110**	**134,150**

Alternative B: Regional Economic Analysis
Visitor recreation expenditures associated with a fully implemented Alternative B are shown in Table 7. Total annual expenditures would be about $2.2 million with non-residents accounting for about $1.4 million or 66 percent of total expenditures. Expenditures associated with non-consumptive activities would account for 99 percent of all expenditures, followed by fishing at less than 1 percent.

Table 6-7. Alternative B: Visitor Recreation Expenditures (2011 dollars in thousands)

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	$392.9	$771.3	$1,164.2
Boat Trail/Launch Visits	$1.4	$4.9	$6.3
Photography	$2.4	$3.8	$6.2
Other Recreation	–	–	–

Activity	Residents	Non-Residents	Total
Interpretation	$325.2	$638.3	$963.5
Total Non-Consumptive	**$721.9**	**$1,418.3**	**$2,140.2**
Fishing:			
Total Fishing	$5.3	$4.4	$9.6
Total Annual Expenditures	**$727.2**	**$1,422.6**	**$2,149.8**

Input-output models were used to determine the economic impact of expenditures on the Refuge's local economy under Alternative B. The estimated economic impacts are expected to occur in Clallam County. Table 6-8 summarizes the local economic effects associated with recreation visits. Under Alternative B, economic output would total $3.0 million with associated employment of 29 jobs, $900,000 in employment income and $396,000 in total tax revenue.

Table 6-8. Alternative B: Local Economic Effects Associated with Recreation Visits (2011 dollars in thousands)

	Residents	Non-Residents	Total
Economic Output	$1,040.3	$1,967.5	$3,007.9
Jobs	11	19	29
Job Income	$314.5	$585.6	$900.1
State & Local Tax Revenue	$69.9	$137.2	$207.1
Federal Tax Revenue	$65.7	$123.1	$188.8

Alternative C: Recreational Activities

Table 6-9 shows the visitation that would occur if Alternative C is fully implemented. Approximately 129,105 would be related to a variety of recreational opportunities, interpretation programs, and environmental education. Pedestrian and interpretation visits would continue represent the majority of all visits. Under this alternative, visitors would have more opportunities for cultural history programs and wildlife/plant geology walks. Horseback riding would no longer be permitted under Alternative C. In addition to recreation visits, the Refuge also would support 700 environmental education visits.

Under Alternative C, recreation visits are projected to increase by 15 percent, compared to Alternative A. Similar to Alternative A, nearly all recreational visitors would participate in non-consumptive activities. Less than 1 percent of visitors would participate in fishing.

Table 6-9. Alternative C: Refuge Visitation

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	45,500	24,500	70,000
Auto Tour	0	0	0
Boat Trail/Launch Visits	163	163	325
Bicycle visits	0	0	0

Activity	Residents	Non-Residents	Total
Photography	161	69	230
Other Recreation	0	0	0
Interpretation	37,375	20,125	57,500
Environmental Education	280	420	700
Fishing:			
Freshwater	0	0	0
Saltwater	280	70	350
Total Visitation	**83,759**	**45,347**	**129,105**

Alternative C: Regional Economic Analysis
Visitor recreation expenditures estimated for Alternative C are shown in Table 6-10. Total annual expenditures would be about $2.1 million with non-residents accounting for $1.4 million or 66 percent of total expenditures.

Table 6-10. Alternative C: Visitor Recreation Expenditures (2011 dollars in thousands)

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	$379.4	$744.7	$1,124.1
Boat Trail/Launch Visits	$1.4	$4.9	$6.3
Photography	$2.0	$3.1	$5.2
Other Recreation	–	–	–
Interpretation	$311.6	$611.7	$923.3
Total Non-Consumptive	**$694.4**	**$1,364.5**	**$2,058.8**
Fishing:			
Total Fishing	$5.3	$4.4	$9.6
Total Annual Expenditures	**$699.7**	**$1,368.8**	**$2,068.5**

Input-output models were used to determine the economic impact of expenditures on the Refuge's local economy. The estimated economic impacts are expected to occur in Clallam County. It is assumed that visitor expenditures occur primarily within this local area. Table 6-11 summarizes the local economic effects associated with recreation visits. Under Alternative C, economic output would total nearly $2.9 million with associated employment of 28 jobs, $866,000 in employment income and $381,000 in total tax revenue

Table 6-11. Alternative C: Local Economic Effects Associated with Recreation Visits (2011 dollars in thousands)

	Residents	Non-Residents	Total
Economic Output	$1,000.4	$1,892.3	$2,892.7
Jobs	10	18	28
Job Income	$302.4	$563.2	$865.6
State & Local Tax Revenue	$67.2	$131.9	$199.2

	Residents	Non-Residents	Total
Federal Tax Revenue	$63.2	$118.4	$181.6

Summary of Recreational Visitation Impacts
Tables 6-12 and 6-13 provide a summary of the potential economic impacts related to recreational visitation for each alternative. Table 12 summarizes the annual average for each Alternative when fully implemented. Table 6-13 summarizes the annual change for recreation visitation for Alternatives B and C, compared to Alternative A.

Under Alternatives B and C, recreation visitation would increase after the management alternative is fully implemented. As a result, economic output, jobs, job income, and tax revenue would increase.

Table 6-12. Annual Economic Effects Associated with Recreation Visits (2011 dollars in thousands)

	Alternative A	Alternative B	Alternative C
Recreation Visits	112,151	134,150	129,105
Expenditures	$1,798.9	$2,149.8	$2,068.5
Economic Output	$2,515.6	$3,007.9	$2,892.7
Jobs	25	29	28
Job Income	$752.8	$900.1	$865.6
State & Local Tax Revenue	$173.2	$207.1	$199.2
Federal Tax Revenue	$157.9	$188.8	$181.6

Table 6-13. Change in Average Annual Recreation Visits and Expenditures Compared to the Baseline (Alternative A) (2011 dollars in thousands)

	Alternative B	Alternative C
Recreation Visits	+21,999	+16,954
Economic Output	+$492.3	+$377.1
Jobs	+4	+3
Job Income	+$147.3	+$112.8
State & Local Tax Revenue	+$33.9	+$26
Federal Tax Revenue	+$30.9	+$23.7

6.6.3 Refuge Budget

Annual costs reflect refuge spending of base funds allocated each year. These are also known as recurring costs and are usually associated with day-to-day operations. Non-salary expenditures are primarily fixed costs such as utilities, office supplies, boat and vehicle gas and maintenance, facility maintenance, aircraft costs for seabird and marine mammal surveys, printing of refuge brochures, and other expenses.

Table 6-14 shows that average annual expenditures would be about $646,000 for Alternative A, and about $1.7 million for Alternatives B and C. The estimated expenditures for Alternatives B and C assume that the alternatives are fully funded as described in the CCP. Increased needs identified in the CCP include increased species surveys, monitoring, research, habitat manipulation, signage, and materials for environmental education and interpretation.

Table 6-14. Dungeness National Wildlife Refuge Average Annual Expenditures (2011 dollars in thousands)

Expenditure:	Alternative A	Alternative B	Alternative C
Salary	$365.4	$417.8	$417.8
Non Salary	$280.2	$1,268.0	$1,255.0
Total	**$645.6**	**$1,685.8**	**$1,672.8**

Table 6-15 shows the economic impact of average annual (salary and non-salary) expenditures. Impacts associated with annual expenditures would continue to occur throughout the 15 year timeline of the CCP if the Alternative is fully funded. Under Alternative A, the Refuge's annual expenditures would generate approximately $523,000 in economic output, 5 jobs, $251,000 in job income, and $84,000 in tax revenue. Economic impacts for Alternatives B and C would be similar. Annual expenditures under Alternatives B and C would generate economic output of about $1.4 million, 12 jobs, $650,000 in job income, and $192,000 in total tax revenue.

Table 6-15. Local Annual Economic Effects Associated with Average Annual Refuge Budget (2011 dollars in thousands)

	Alternative A	Alternative B	Alternative C
Economic Output	$523.4	$1,366.6	$1,356.1
Jobs	5	12	12
Job Income	$250.8	$654.8	$649.7
State & Local Tax Revenue	$23.8	$62.2	$61.7
Federal Tax Revenue	$50.0	$130.5	$129.5

Table 6-16 shows the change in economic impacts associated with the refuge budget compared to the baseline (Alternative A). Once fully funded, annual expenditures for Alternatives B and C would each increase by about $1.0 million, compared to Alternative A (Table 6-16). Under Alternatives B and C, economic impacts associated with annual expenditures would increase by about $832,000 to $843,000 in economic output, 7 jobs, and about $400,000 in job income. Alternative B would have slightly larger economic impacts than Alternative C.

Table 6-16. Change in Annual Expenditures Compared to the Baseline (Alternative A) (2011 dollars in thousands)

	Alternative B	Alternative C
Annual Expenditures	+$1,040.2	+$1,027.2
Economic Output	+$843.2	+$832.7
Jobs	+7	+7
Job Income	+$404.0	+$399.0
State & Local Tax Revenue	+$38.4	+$37.9
Federal Tax Revenue	+$80.5	+$79.5

6.6.4 Refuge Revenue Sharing Payments

Under provisions of the Refuge Revenue Sharing Act (Public Law 95-469), the Service would annually reimburse Clallam County for tax revenue which is lost as a result of the Services acquisition of private property. This law states that the Secretary of the Interior (Secretary) shall pay to each county in which any area acquired in fee title is situated, the greater of the following amounts:

- An amount equal to the product of 75 cents multiplied by the total acreage of that portion of the fee area that is located within such county.
- An amount equal to three-fourths of one percent of the fair market value, as determined by the Secretary, for that portion of the fee area that is located within such county.
- An amount equal to 25 percent of the net receipts collected by the Secretary in connection with the operation and management of such fee area during such fiscal year. If a fee area is located in two or more counties, however, the amount for each county shall be apportioned in relationship to the acreage in that county.

The appraisal estimate value is based on the current local land values at the time of the appraisal. The most recent Refuge Revenue Sharing Act payment to Clallam County of $7,723 was based on the 2007 Refuge Revenue Share Appraisal and may also be representative of federal budgetary constraints determined annually by Congress. Appraisals of refuge lands are conducted every five years and the 2007 appraisal evaluated approximately 213 fee title acres. Table 6-17 shows payments made to Clallam County from FY 2003 to FY 2010. The Revenue Sharing payment from 2006 to 2010 has declined due to government funding deficits.

Forecasting revenue sharing payments is complex. Actual payments are a function of the appraised value and appropriations. The Refuge Revenue Sharing Act requires Service lands be reappraised every five years to ensure that payments to local governments remain equitable. However, some payments are less than the legislated amounts due to governmental funding deficits. Congress may appropriate, through the budget process, supplemental funds to compensate local governments for any shortfall in revenue sharing payments. The final calculation for the payment to local governments depends on the total amount of funds available from revenue receipts collected on refuges nationwide and any appropriations. As a result, payments fluctuate based on the revenue receipts and appropriations. Forecasting revenue sharing payments is beyond the scope of this analysis.

Table 6-17. Revenue Sharing Payments made to Clallam County, 2003-2010 (2011 dollars)

Year	Payment
2003	$29,350
2004	$28,588
2005	$27,651
2006	$11,540
2007	$16,310
2008	$12,186
2009	$11,492
2010	$7,967

6.6.5 Summary of Economic Impacts

This section summarizes the economic impacts generated by refuge management activities for each alternative. Table 6-18 summarizes the economic impacts in Clallam County for Alternative A. Under Alternative A, refuge activities would generate an estimated $3.0 million in economic output, 30 jobs, $1.0 million in job income, and $197,000 in state and local tax revenue. These economic impacts under Alternative A represent less than one percent of total income and total employment in the local area economy.

Table 6-18. Summary of Annual Economic Impacts for Alternative A (2011 dollars in thousands)

	Economic Output	Jobs	Job Income	State & Local Tax Revenue	Federal Tax Revenue
Recreation Visits	$2,515.6	25	$752.8	$173.2	$157.9
Budget	$523.4	5	$250.8	$23.8	$50.0
Total	**$3,039.0**	**30**	**$1,003.6**	**$197.0**	**$207.9**

Table 6-19 summarizes the economic impacts for Alternative B. Under Alternative B, refuge activities would generate an estimated $4.4 million in economic output, 41 jobs, $1.6 million in job income, and $589,000 in tax revenue. These economic impacts under Alternative B represent less than one percent of total income and total employment in the local area economy.

Table 6-19. Summary of Annual Economic Impacts for Alternative B (2011 dollars in thousands)

	Economic Output	Jobs	Job Income	State & Local Tax Revenue	Federal Tax Revenue
Recreation Visits	$3,007.9	29	$900.1	$207.1	$199.2
Budget	$1,366.6	12	$654.8	$62.2	$130.5
Total	**$4,374.5**	**41**	**$1,554.9**	**$269.3**	**$329.7**

Table 6-20 summarizes the economic impacts for Alternative C. Under Alternative C, refuge activities would generate an estimated $4.3 million in economic output, 40 jobs, $1.5 million in job income, and $572,000 in tax revenue. These economic impacts under Alternative C represent less than one percent of total income and total employment in the local area economy.

Table 6-20. Summary of Annual Economic Impacts for Alternative C (2011 dollars in thousands)

	Economic Output	Jobs	Job Income	State & Local Tax Revenue	Federal Tax Revenue
Recreation Visits	$2,892.7	28	$865.6	$199.2	$181.6
Budget	$1,356.1	12	$649.7	$61.7	$129.5
Total	**$4,248.8**	**40**	**$1,515.4**	**$260.9**	**$311.1**

6.7 Cumulative Effects

Cumulative effects can result from the incremental effects of a project when added to other past, present, and reasonably foreseeable future projects in the area. Cumulative impacts can result from individually minor but cumulatively significant actions over a period of time. This analysis is intended to consider the interaction of activities at the Refuge with other actions occurring over a larger spatial and temporal frame of reference.

The Council on Environmental Quality (CEQ) regulations for implementing the provisions of NEPA define several different types of effects that should be evaluated in an EA, including direct, indirect, and cumulative. Direct and indirect effects are addressed in the resource-specific sections of this draft CCP/EA. This section addresses cumulative effects.

The CEQ (40 CFR § 1508.7) (CEQ 1997) provides the following definition of cumulative effects:

> "The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions."

It should be noted that the cumulative effects analysis has essentially been completed by virtue of the comprehensive nature in which direct and indirect effects associated with implementing the various alternatives was presented. The analysis in this section primarily focuses on effects associated with reasonably foreseeable future events and/or actions regardless of what entity undertakes that action.

6.7.1 Effects from Reasonably Foreseeable Future Refuge Activities

As described in Chapter 4, cumulatively, there has been a substantial modification to native habitats surrounding the Refuge over the past 150 years. Many of these modifications have resulted in the loss or degradation of important habitats including coastal sand dune and strand, eelgrass beds, tidal salt and brackish marsh, riparian forest, and late-successional Douglas-fir-western hemlock forest. The losses of these habitats, alteration of disturbance regimes, and introduction of non-native species have altered ecosystem processes. A variety of government and non-government agencies, including the U.S. Fish and Wildlife Service, National Park Service, U.S. Forest Service, State of Washington, Tribes, Counties, and private landowners have protected a number of areas within the Salish Sea. However, alterations and loss of native habitats continue at a landscape scale as challenges such as human development and climate change pose complex and persistent threats. Within this context, region wide biological integrity may be at risk. Over time, the Refuge, although relatively small and isolated from other natural lands, may become increasingly valuable for the persistence of native wildlife. Active improvement of refuge habitats would increase or maintain the value of refuge lands and waters for a wide variety of native fish and wildlife, and biological diversity. All of the alternatives would protect and maintain refuge habitats valuable to wildlife. Additionally, the Service would improve the availability and quality of wildlife-dependent recreation, contributing to increased regional recreational opportunities.

Compared to Alternative A, Alternatives B and C present the potential for more benefit to conservation of native species and to recreational users, because under these alternatives the Service would actively enhance larger blocks of wildlife habitat and enrich public use programs. Also, the action alternatives emphasize additional wildlife and habitat monitoring (e.g., population of focal species), which would enrich the ability of the Service to evaluate the consequences of management actions and perform adaptive management.

In concert with other protected lands, the Refuge has an important role to conserve resident, threatened, and rare species, as well as migratory wildlife species, and to provide places where the public can enjoy and appreciate nature. Implementing the CCP would have overall beneficial effects to habitats, species, and the American public. In the context of all of the factors (both natural and human-caused) that negatively affect habitats and species (e.g., food availability, human disturbance, and contaminants) the positive contributions associated with CCP implementation do not represent a major (significant) effect.

6.7.2 Potential Effects from Climate Change

According to the Climate Impacts Group at the University of Washington: "Even subtle changes in Pacific Northwest precipitation and temperature have noticeable impacts on the region's mountain snowpack, river flows and flooding, the likelihood of summer droughts, forest productivity and forest fire risk, salmon abundance, and quality of coastal and near-shore habitat" (CIG 2011b). However, the complexity of ecological systems and interactions of species results in a large amount of uncertainty on the exact effect of climate change on species, habitats, and ecosystems (Parmesan et al. 2011). These effects require localized research and such as climate species and habitat sensitivity analyses and vulnerability assessments. The following paragraphs attempt to identify the potential effects of warming on refuge-specific habitats and biota, utilizing the available science and predictions, combined with awareness of refuge-specific conditions. By necessity this brief assessment is incomplete and represents professional judgment rather than hard science. All predicted effects should be treated as hypotheses and tested over time using scientific methods.

General Species Response: Climate change effects on species' ranges, phenology, and physiology have been well documented at global and regional scales including altered species distributions, life histories, community composition, and ecosystem function (Parmesan 2006, Rosenzweig et al. 2008, Schneider and Root 2002, Lovejoy and Hannah 2005, McLaughlin et al. 2002). Rising temperatures and shifts in precipitation patterns may also affect other ecological interactions, such as spring flowering times, the timing of bird migration, or the emergence timing and patterns for insect and pollinator species, and many other factors (Geyer et al. 2011). These include the potential for complex cascading direct and indirect effects such as those described by Martin and Marin (2012). Wetland, riparian and aquatic species are perhaps the most vulnerable of these effects in the Northwest (Lawler et al. 2008). In particular, amphibians are considered to be some of the most susceptible animals to climate change, partly because the microhabitats they depend on may be some of the most affected systems, and partly because they have limited abilities to disperse across a fragmented landscape (ibid.).

Projecting potential biological response at the population level is complex: in a warmer climate, plant and animal species may respond by occupying different parts of the landscape; rare or endangered species may become less abundant or extinct; insect pests, invasive species and harmful algal blooms may become more abundant (Akcakaya et al. 2006, Pereira et al. 2010). Declines in abundance of species may be caused directly by physiological stress related to changes in temperature, water availability, and other environmental shifts, and/or indirectly by habitat degradation and negative interactions with species that are benefited by climate change (diseases, parasites, predators, and competitors), but it remains difficult to model how species' ranges and population abundance (increasing or declining) can be projected from a suite of inter-related climate related variables (Fordham et al. 2012). Researchers are improving models and undertaking new vegetative and species response modeling. The Refuge would monitor the results of coastal and marine species sensitivity analyses (in progress, Dr. Deborah Reusser, USGS, lead researcher, funded by the North Pacific Landscape Conservation Cooperative) and a north Pacific birds sensitivity analyses (in progress, PRBO-Conservation Science, funded by the North Pacific Landscape Conservation Cooperative).

Effects of Extreme Precipitation Events: Generally, evidence is beginnig to emerge that for some types of events, notably heatwaves and precipitation extremes, global increases in events are linked to climate change (Coumou and Rahmstorf 2012). Regionally, increases in the intensity of future extreme winter precipitation are projected for the western United States by Dominguez et al. (2012). These researchers project an area-averaged 12.6% increase in 20-year return period (or “20-year rainfall events”) and 14.4% increase in 50-year return period daily precipitation (or “50-year rainfall events”—a return period is an estimate of how long it will be between rainfall events of a given magnitude).

Near-coast regions are vulnerable to extreme events known as atmospheric rivers or more commonly as “pineapple express” events. These are long and narrow bands water vapor brought to the West Coast from the south Pacific’s extratropical cyclones or the “warm conveyor belt.” They are characterized by high water vapor content falling as large amounts of precipitation as the West Coast’s mountain ranges are encountered. Extreme precipitation, devastating floods, and debris flows occur, especially when heavy rain occurs on preexisting snowpack (Neiman et al. 2008).

Such flood and debris events can alter the Refuge’s habitats, and potentially carry contaminants from upstream flooding.

Effects of warming to hydrology and lowland habitats: Projected changes in precipitation are subject to high levels of uncertainty. However, even small changes in seasonal precipitation could have impacts on streamflow flooding, summer water demand, drought stress, and forest fire frequency. The refuge lands themselves currently receive the vast majority of their annual precipitation as rainfall; however, the watersheds feeding the Dungeness River and Dean Creek currently receives a significant quantity of its annual precipitation in the winter as snow. Generally, a large shift in the form of winter precipitation from snow to rain has been observed and is projected to continue over the long term for the Pacific Northwest, with lower elevation basins affected before upper elevation basins (Mote et al. 2005, Nolin and Daly 2006). Snowfields act as a reservoir that collects freshwater during the wetter winter months and releases this water during the drier summer months, effectively distributing water more equitably across the seasons. As long-term temperatures continue to increase into the future, higher winter flows with earlier snowmelt and runoff peaks will occur along with lower summer stream flows. Additionally, rivers and streams in both rain-fed and snow-dominated basins will likely be warmer in the future, which could increase evapotranspiration and reduce water quality (Isaak et al. 2011). Warmer streams and rivers may also facilitate the expansion of the ranges of warm-water fish species (Lawler et al. 2008), pathogens, and invasive species (see below) and worsen conditions for cold-water species (Lawler et al. 2008).

Lawler et al. (2008) stated that of all aquatic systems, wetlands “will likely be the most susceptible to climate change” with drying, warming, and changes in water quality predicted.

Sea Level Rise and Ocean Acidification: The projected effects of potential sea level rise and ocean acidification are covered in Sections 3.2.3 and 3.3.

Invasive Species and Pathogens: The increase of invasive species and pathogen risks due to climate change includes a variety of factors. For example, invasive species have a broader climate tolerance and larger geographic ranges, and characteristics that favor rapid range shifts that would be hastened by changing climatic conditions. Also climate change may alter transport and introduction mechanisms, establish new invasive species, alter the impact of existing invasive species, and other risk factors (Hellman et al. 2008, Rahel and Olden 2008, Willis et al. 2010).

Forest Ecosystems: Fire, insect and disease disturbances are already significantly affecting forest ecosystems in the Pacific Northwest, and these are forecast to continue and accelerate throughout the region (Waring et al. 2011). Generally, insects and diseases will expand northward in latitude, toward the coast and upward in elevation in a warming climate.

Wildfires will likely increase in all forest types in the coming decades. Warmer and drier summers leave forests more vulnerable to fire, while wetter winters provide abundant fuel in the form of grasses and shrubs. Wildfire frequency in western forests has increased fourfold during the period 1987-2003 as compared to 1970-1986, while the total area burned increased six-fold (Westerling et al. 2006). This study demonstrated that earlier snowmelt dates correspond to increased wildfire frequency. Trouet et al. (2006) confirm that these increases in area burned are tied to climate conditions despite forest suppression management practices such as thinning. As shown above, virtually all climate-model projections indicate that warmer springs and summers will occur over the region in coming decades. Prolonged dry and hot periods are generally required for large fires (Gedalof et al. 2005) and future conditions will likely make these periods, and resultant wildfires, more likely.

6.7.3 Other Reasonably Foreseeable Events and Activities

Development and population growth: Utilizing the State of Washington's Office of Financial Management (OFM) High Series Population Forecast, the population of Clallam County is projected to grow from 71,404 in 2010 to a projected 84,458 by 2025, an increase of 13,054 (OFM 2012). This population growth will continue to place stress upon the ecosystems within the surrounding area of the Refuge, both through direct loss of remaining habitats, and indirectly through fragmentation and degradation of the area's remaining parcels of wildlife habitat and demands on water. The Dungeness NWR CCP can do nothing to stem this trend but refuges and other tracts of habitats will become even more important as repositories of biodiversity.

Increased tanker ship traffic: The Strait of Juan de Fuca may see increased tanker ship traffic if proposed oil pipelines or a coal terminal are developed on the coast of British Columbia. This increased traffic would increase the potential for oil or other contaminate spills impacting shore and marine habitats.

Clallam County Shoreline Master Program: Clallam County is updating its Shoreline Master Program (SMP), which regulates land use and development within 200 feet from rivers, lakes, streams, and marine shores. Shorelines in Clallam County are protected by the Washington State Shoreline Management Act (SMA) and by the Clallam County SMP. Protection of geomorphic processes of "feeder" bluffs west of Dungeness NWR is critical to the continued maintenance and growth of Dungeness Spit.