



# North Coast and Cascades Network Climate Monitoring Report

*Ebey's Landing National Historical Reserve and San Juan  
Island National Historical Park; Water Year 2011*

Natural Resource Data Series NPS/NCCN/NRDS—2013/569



**ON THE COVER**

The Royal Marine Blockhouse at English Camp, San Juan Island Historical Park, with Garrison Bay in background.  
Photograph by: Bill Baccus

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

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## Executive Summary

Climate and weather events define the ecological characteristics found in national parks and are key to understanding and interpreting changes in natural resources. Everyday park operations including fire management, natural resource activities, maintenance of park infrastructure, and visitor use are influenced by weather. Monitoring weather and maintaining climate records provides essential information to support park operations and monitor park resources.

This report summarizes climate data collected within and adjacent to Ebey's Landing National Historical Reserve (EBLA) and San Juan Island National Historical Park (SAJH) from the 2011 water year. It is part of a set of climate summary reports from six national and Historical parks in the North Coast and Cascades Network. Published in the National Park Service's Natural Resource Data Series, annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. We intend that the primary audience for this document will be National Park staff, especially decision makers, planners, and interpreters; partners; and interested public.

Temperature and precipitation data are presented from four weather stations located on three islands in the northwest corner of Washington State. Data from San Juan Island (SAJH) were recorded using automated instruments operated by the National Park Service and the Federal Aviation Administration. Data from Orcas and Whidbey Island (EBLA) are provided by the National Weather Service Cooperative Observer Program (COOP). For two stations with long term records, the Coupeville COOP Station on Whidbey Island and the Olga COOP Station on Orcas Island, monthly average temperatures and monthly total precipitation are reported and compared to the 30-year normal. For the stations within or adjacent to park units, daily and monthly air temperature and precipitation data are reported. Accumulated growing degree days are presented for the Friday Harbor Airport (American Camp, SAJH) and Coupeville (EBLA).

Water year 2011 had near normal annual temperatures and slightly above normal precipitation. At Coupeville and Olga, temperatures were 0.1 and 0.6 warmer than normal respectively. While annual temperature was near normal, there were large monthly deviations which balanced on a seasonal basis. Seasonal deviations were more pronounced in the case of precipitation. Spring months were much wetter than normal, while summer was much drier than normal. Total annual precipitation at Coupeville (EBLA) was 22.9 inches, 107% of normal. Total precipitation at English Camp (SAJH) was 25.3 inches.

## Acknowledgments

The National Park Service relies on several cooperating agencies to help support and maintain a long-term climate monitoring program as part of the North Coast and Cascades Network climate monitoring program. These agencies include:

- Federal Aviation Administration and Department of Defense – Automated Surface Observing Systems
- National Interagency Fire Center – Remote Automated Weather Stations Program
- National Weather Service – National Weather Service Cooperative Observer Program

Data management is critical to provide for the availability and analysis of climate data. We rely on the North Coast and Cascade Network Data Managers, specifically John Boetsch, Bret Christoe and Ruth Jenkins, the Western Regional Climate Center, and the National Climate Data Center for climate data management.

We thank the following park staff for their assistance: Ken Arzarian, Maintenance Supervisor and Rob Palmer, Park Ranger at San Juan Island National Historical Park, for emergency maintenance of the English Camp weather station.

## Acronyms

ASOS	Automated Surface Observing Systems
COOP	Cooperative Observer Station
EBLA	Ebey's Landing National Historical Reserve
FAA	Federal Aviation Administration
GDD	Growing Degree Days
I&M	Inventory and Monitoring
NCCN	North Coast and Cascades Network
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWS	National Weather Service
PNW	Pacific Northwest
RAWS	Remote Automated Weather Stations
SAJH	San Juan Island National Historical Park
USDA	United States Department of Agriculture
WRCC	Western Regional Climate Center

## Glossary

**ASOS:** The Automated Surface Observing Systems program is a joint effort of the National Weather Service, the Federal Aviation Administration, and the Department of Defense. The program operates a network of automated weather stations at airports nationwide, for the purpose of supporting weather forecast activities and aviation operations.

**Climate:** Complete and entire ensemble of statistical descriptors of temporal and spatial properties comprising the behavior of the atmosphere. These descriptors include means, variances, frequency distributions, autocorrelations, spatial correlations and other patterns of association, temporal lags, and element-to-element relationships. The descriptors have a physical basis in flows and reservoirs of energy and mass. Climate and weather phenomena shade gradually into each other and are ultimately inseparable (Davey et al. 2006).

**Climate Normals:** A long-term average value of a meteorological parameter (i.e. temperature) for a certain area. For example, "temperatures are normal for this time of year" means that temperatures are at or near the average climatological value for a given time period. Normals are usually taken from data averaged over a 30-year period (e.g., 1971-2000 average), and are concerned with the distribution of data within limits of common occurrence.

**Degree Days:** A measure of the departure of the mean daily temperature from a given standard (e.g. one degree-day for each degree (°F) of departure above (or below) the standard during one day. Degree-days are accumulated over a "season" at any point during which the total can be used as an index of past temperature effect upon some quantity, such as plant growth, snow accumulation, etc.)

**Growing Degree Days (GDD):** A measure of heat accumulation over time, which is derived from the cumulative sum of daily air temperatures above a baseline value (e.g. 40°F is used in this report as the baseline value) over a specified time period. GDD is commonly used to understand rates of plant growth and the timing of plant and animal life cycles.

**Fall:** The season of the year which is the transition period from summer to winter occurring as the sun approaches the winter solstice. Fall includes the months of September, October, and November.

**NWS-COOP:** An extensive network of manually operated weather stations overseen by the National Weather Service. Many Cooperative Observer Program weather sites were established in the late 1800's and as such, provide the best long term data for understanding local climates. At each station, an observer records daily maximum and minimum temperature, as well as total rain and snowfall.

**Period of Record:** The total span of time that climate data have been collected at a specific location. The longer the period of record, the more likely the climate data will not be biased by singular weather events or cyclic climate anomalies such as those associated with the Pacific Decadal Oscillation.

**RAWS:** A network of remote automated weather stations that provide real-time weather data to assist land management agencies in monitoring fuels, rating fire danger and predicting fire behavior. RAWS stations are all operational during summer months, but many at lower elevations operate on a year round basis.

**Spring:** The season of the year comprising the transition period from winter to summer occurring when the sun is approaching the summer solstice. Spring includes the months of March, April and May.

**Summer:** The warmest season of the year during which the sun is most nearly overhead. Summer includes the months of June, July, and August.

**Water Year:** The Water Year (or Hydrologic Year) is most often defined as the period from October 1st to September 30 of the following year. It is called by the calendar year in which it ends. Thus, Water Year 2011 is the 12-month period beginning October 1, 2010 and ending September 30, 2011. The period is chosen so as to encompass a full cycle of precipitation accumulation.

**Weather:** Instantaneous state of the atmosphere at any given time, mainly with respect to its effects on biological activities. As distinguished from climate, weather consists of the short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, precipitation, humidity, wind, sky condition, visibility, and cloud conditions (Davey et al. 2006).

**Winter:** Typically the coldest season of the year during which the sun is farthest from overhead. Winter includes the months of December, January and February.





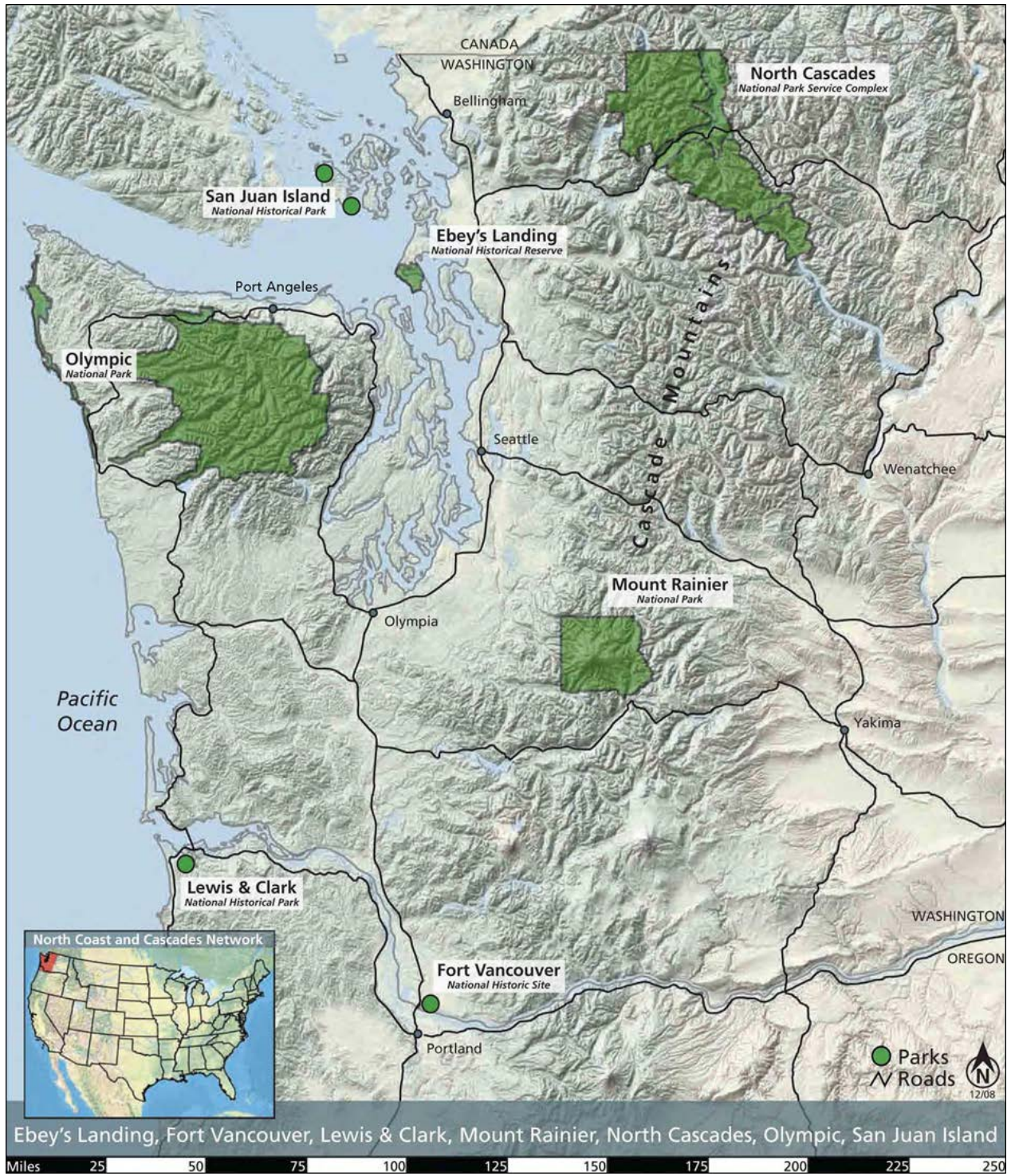
## Introduction

Climate is a dominant factor driving the physical and ecologic processes affecting the North Coast and Cascades Inventory and Monitoring Network (NCCN) (Davey et al. 2006). Trends in precipitation and temperature influence how an ecosystem and its organisms function. The quantity and timing of rainfall and snow can affect the productivity and health of forests (Nakawatase and Peterson 2006), the amount of water flowing in streams (Hamlet et al. 2007) or inundating wetlands. Likewise, temperature can influence many aspects of ecosystems, such as the quantity and timing of plant growth in forests and prairies (Cayan et al. 2001). Through direct and indirect methods, climate affects the behavior and reproduction of terrestrial and aquatic animal species (Crozier et al. 2008), such as the distribution and migratory behavior of bird communities (Marra et al. 2005) or the thermal stress experienced by intertidal organisms along areas of rocky coastline (Tomanek and Helmuth 2002). Disturbance events such as forest fires, windstorms, and floods are strongly related to climate (Littell and Gwozdz 2011). These events have a major impact on park landscapes and their associated ecosystems.

Given the importance of climate, it has been identified as a primary vital sign by all 32 Inventory and Monitoring (I&M) networks within the National Park Service (Gray 2008). The NCCN monitors climate in order to: understand variations in other park resources being monitored, compare current and historic data to understand long-term trends, and provide data for modeling impacts to park facilities and resources in the future (Lofgren et al. 2010). Climate data derived from the NCCN climate network will play an important role in understanding and interpreting the physical and ecological Vital Signs monitored within NCCN parks.

The NCCN climate monitoring program capitalizes on weather stations operated by partnering agencies. The NCCN climate monitoring program compiles data from over 60 weather stations in and adjacent to the parks, 15 of which are operated by the National Park Service. Although a wide variety of climate parameters are measured as part of the NCCN climate program, this report focuses on two key parameters: precipitation and air temperature.

This report summarizes climate data collected at four weather stations located in and adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park during the 2011 water year, and is part of a set of climate summary reports from six national and historical parks in the NCCN (Figure 1). Annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. National Park staff, especially park managers, scientists, and interpreters, partners, and interested public are the primary audience.



**Figure 1.** North Coast and Cascades Network National Parks (NCCN).

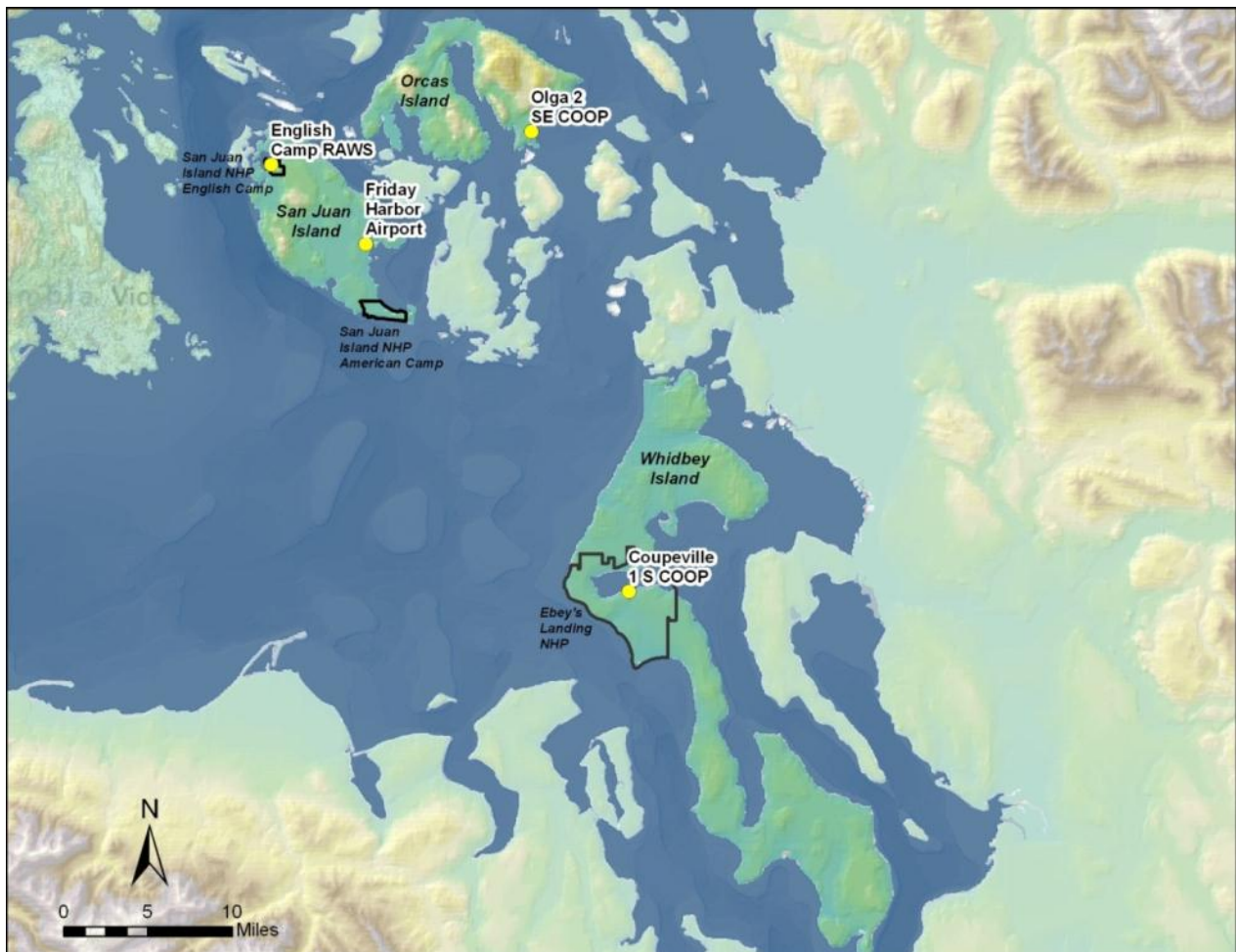
# Methods

## Station Locations

This report incorporates data collected from weather stations operated by the National Park Service, the Federal Aviation Administration and the National Weather Service (Table 1).

**Table 1.** Weather stations referenced in this report.

Station Name	Station Type	Location	Elevation (ft)	Forest Zone	Period of Record
Coupeville 1S	COOP	Whidbey Island	50	Lowland Prairie	1895 to Present
English Camp	NPS	San Juan Island	60	Lowland Forest	2008 to Present
Friday Harbor	ASOS	San Juan Island	108	Lowland Prairie	1999 to Present
Olga 2 SE	COOP	Orcas Island	80	Lowland Forest	1891 to Present



**Figure 2.** Location of weather stations referenced in this report.

## Weather Station Measurements

Weather stations within the NCCN are managed by a variety of different agencies, each with a specific purpose. For this reason, instrumentation, method and period of collection may vary between sites. Table 2 describes the parameters measured at each station, highlights the data which are presented in this report, and indicates which data are available by request from the NCCN.

**Table 2.** Parameters measured at weather stations included in this report. **X** indicates the parameter is measured and data are presented in this report; **X** indicates parameter is measured and data are available on request.

Station Name	Managing Agency - Station Type	Air Temp	Rh	Precipitation	Snow fall	Sky Condition	Solar Radiation	Wind Speed & Direction	Fuel Temperature	Fuel Moisture
Coupeville 1S	NWS COOP <sup>1</sup>	X		X	X					
English Camp RAWS	NPS <sup>2</sup>	X	X	X			X	X	X	X
Friday Harbor Airport	ASOS <sup>3</sup>	X	X	X	X	X		X		
Olga 2 SE	NWS COOP <sup>1</sup>	X		X	X					

<sup>1</sup> National Weather Service Cooperative Stations (NWS COOP) stations rely on a standard array of manually operated weather instruments. Parameters are measured and recorded daily.

<sup>2</sup> National Park Service (NPS) stations utilize a standard array of automated weather instruments which are measured at 5 minute intervals and output as hourly averages.

<sup>3</sup> ASOS utilize a standard array of automated weather instruments in support of weather forecasting and aviation operations. Parameters are measured every 60 seconds, and output as hourly averages. These stations are managed and operated by the Federal Aviation Administration, National Weather Service and United States Department of Defense.

## Data Quality Assurance and Control

The NWS COOP station and ASOS station data used in this report are acquired directly from the managing agencies. Quality assurance and control is provided by these agencies and is described in the NCCN Climate Monitoring Protocol (Lofgren et al. 2010).

The daily data used in this report from the English Camp RAWS station are derived from hourly data which have been evaluated through automated queries and manual display and graphing. If more than two hours of data for a given day are flagged, identified as suspect, or missing, no daily value is generated or presented.

Similarly, monthly values are only generated and presented for stations where five or fewer daily values are flagged as suspect or missing. The exception is missing precipitation values. Daily precipitation quantities may be substituted from another nearby weather station for the purposes of reporting monthly and annual totals. This will only occur when nearby data are available and a known correlation exists between these sites. In these cases where estimates are generated from

nearby stations, data are footnoted and a description of the quantity and source of data replacement is given.

### ***Water Year 2011 Data Quality***

Data were compromised at the English Camp, SAJH station when the tipping bucket rain gage malfunctioned on September 26, 2010. Consequently, five days of data for Water Year 2010 and 37 days in Water Year 2011 were lost. For the purposes of providing annual and monthly precipitation totals in this report, missing data were replaced with data from the Friday Harbor Airport.

A single error was found in the maximum air temperature data retrieved from the Friday Harbor Airport. A maximum air temperature of 98.6°F was recorded on December 7, 2010. This temperature is well out of the reasonable range for this time of year and is quite different from values recorded at nearby stations (e.g. English Camp recorded 52.5° F). This data value was removed from the dataset for all derived summaries in this report.

### **Data Reporting**

Data in this report are based on the hydrologic or water year and organized by month and seasons. Ecosystems in the Pacific Northwest are dominated by two distinct hydrological periods, a wet season generally beginning in late October and ending in June, and a drought season which extends from July to September. While a calendar year divides the wet winter season, the use of a water year (October 1 to September 30) closely reflects the timing and seasonality of many physical and ecological processes that are driven by climate, such as soil saturation, forest evapotranspiration, emergence and flowering of plants, and the migratory timing of bird species.

Seasons in this report are distinguished based on National Weather Service (NWS) standards for the Northern Hemisphere. The NWS defines December, January, and February as winter; March, April, and May as spring; June, July, and August as summer; and September, October, and November as fall.

This report provides monthly averages of daily average temperatures and monthly total precipitation for four stations listed in Table 2. Monthly averages of daily maximum and minimum temperatures are presented for three weather stations in or directly adjacent to parks. The data are presented in Fahrenheit and inches to easily facilitate use and interpretation by the public and park staff. Two stations with long term records, the Olga COOP on Orcas Island and the Coupeville COOP within Ebey's Landing, are compared to the 30-year climate normal (1971-2000). Air temperature extremes (maximum and minimum daily) are given for Coupeville and English Camp.

More detailed daily data are presented for two sites: 1) the park-operated (RAWS) weather station at English Camp on the west side of San Juan Island, and the Coupeville COOP. Daily data include precipitation, temperature, and accumulated growing degree days (AGDD). It should be noted that daily precipitation records are not always comparable between locations because total daily rainfall is tallied differently among weather stations. For example: at COOP sites such as Coupeville, total rainfall is tallied daily, usually in mid-morning. Total recorded rainfall for December 12 would actually be the sum of rainfall from 9:00 AM on December 11 to

9:00 AM on December 12. In contrast, at English Camp, a site with an automated weather station, rainfall is tallied hourly and then totaled at midnight, ending the 24 hour period. In this case, recorded December 12 rainfall would tally all rain between 12:01 AM December 12 to midnight on December 12. If the majority of the rain fell during the day of December 11, a COOP station would record December 12 as having high precipitation, whereas an automated site would record December 11 as the day with the high rainfall.

Daily growing degree-days (GDD) are a measure of accumulated heat commonly used to predict plant development rates. GDD is calculated in this report using the following formula:

$$\text{GDD} = T_{\text{AVG}} - T_{\text{BASE}}$$

$$\text{If } T_{\text{AVG}} < T_{\text{BASE}} \text{ then GDD} = 0$$

where  $T_{\text{AVG}}$  is the daily average air temperature (calculated by adding the daily maximum and minimum values, divided by two), and  $T_{\text{BASE}}$  is the temperature below which the process of interest (e.g. plant growth) does not progress (McMaster 1997). When using GDD to understand rates of plant growth, the value of  $T_{\text{BASE}}$  varies depending on the species and growth stage (Wang, 1960). Literature sources document a range of base temperatures used to calculate GDD (Gordon 1993, Miller 2001). These typically range from 32°F for the hardiest of graminoids (Frank 1989, McMaster 1988), to warmer base temperatures of 40 and 50°F for less hardy grasses, forbs and woody perennials (Briggs 2000, OSU 2013). To best represent the prairie species monitored at SAJH, and a variety of commercial crops grown at EBLA, this report calculates GDD with a base temperature of 40°F.

Accumulated growing degree-day values (AGDD) are presented for Friday Harbor (SAJH) and Coupeville (EBLA). AGDD was calculated by adding daily GDD values from March 1 to September 30. The March through September time period was selected as it best represents the growing season for this region.

# Results

## Temperature

Mean annual temperatures were at or slightly above normal at weather stations within or adjacent to EBLA and SAJH. Coupeville, at 50.2°F, was normal, and Olga, at 50.0°F, was 0.5° above normal for the 2011 water year (Table 3). The annual average daily maximum air temperature was highest at Coupeville, at 57.2°F, while English Camp had the lowest annual average minimum daily temperature, at 40.8°F (Table 4). Despite the near normal annual temperatures, monthly values vacillated between positive and negative deviations, balancing seasonally with a few notable patterns during spring and summer months.

October was warmer than normal and this trend continued into early November. The first week in November was unusually warm, however a prolonged cold period including below freezing temperatures shifted the month to below normal (-1.1 and -2.3°F at Coupeville and Olga, respectively). Conditions reversed themselves again in December, with temperatures 2.6 and 3.0°F above normal at Coupeville and Olga, respectively (Figure 3 and 4).

A more consistent pattern appeared at weather stations in February with all sites reporting below normal temperatures. March had slightly above normal temperatures, but temperatures were below normal in April and May (Figure 3 and 4). It is noteworthy that while Washington State experienced one of its coldest April through June periods extending back to 1895 (NOAA 2011, OWSC 2011), the temperature departure at the island parks was quite moderate (-1.2 and -0.7°F at Coupeville and Olga, respectively) when compared to parks on the mainland. By comparison, Quillayute at OLYM was 2.5°F below normal (Baccus et al. in press) while Longmire at MORA was 3.6°F below normal during this period (Lofgren 2013).

Summer temperatures at Coupeville were near normal, however at Olga summer months averaged 1.5°F above normal. This was again in contrast with mainland park weather stations that experienced temperatures well below normal (Baccus et al. in press, Lofgren 2013). Consistent with sites around western Washington, September was much warmer than normal (+2.2, +4.0°F at Coupeville and Olga, respectively) (Figure 3 and 4).

There were two prolonged cold periods in Water Year 2011, the most extreme in late November and a milder event in late February (Figure 5). Coupeville recorded an absolute low of 14°F on November 24 (Table 5). On November 23 and 24, English Camp recorded its absolute low of 16.1°F (Table 6). The dates of absolute maximum temperatures were not associated with any particular summer period and varied between sites. An indication of the cool summer of 2011 is that no measured site experienced an hourly maximum temperature above 80°F. The highest recorded temperature was 79°F at Coupeville, recorded on 4 separate days in the months of July and September.

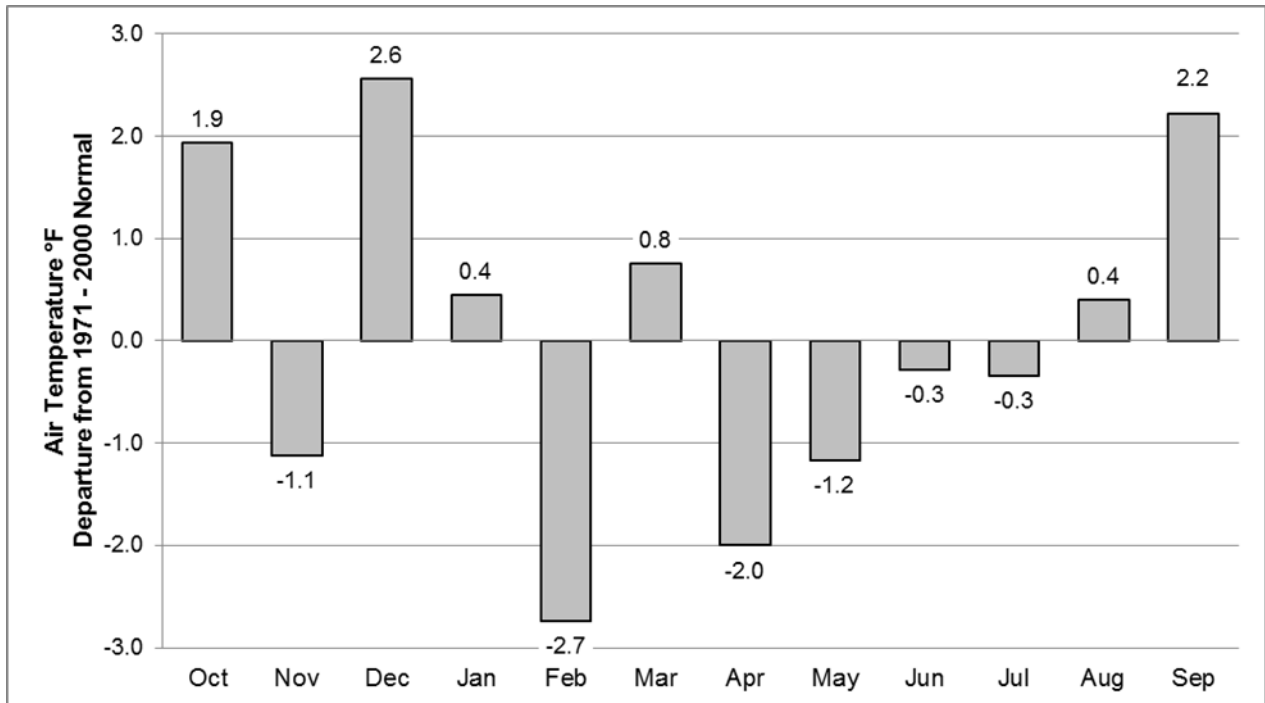
**Table 3.** Average monthly air temperatures (°F) from weather stations within or adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park Water Year 2011.

Season	Month & Year	Coupeville	English Camp	Friday Harbor	Olga
Fall	October 2010	52.2	48.6	51.1	52.0
	November 2010	43.0	39.5	42.6	41.6
Winter	December 2010	42.7	40.3	43.1	42.8
	January 2011	40.5	37.1	41.2	40.4
	February 2011	39.4	36.5	39.1	38.5
Spring	March 2011	45.9	42.4	45.5	46.0
	April 2011	46.9	42.1	45.0	45.5
	May 2011	52.5	48.1	50.5	52.1
Summer	June 2011	57.3	54.7	56.7	58.0
	July 2011	60.7	58.7	58.4	59.9
	August 2011	62.0	60.0	59.6	62.6
Fall	September 2011	59.6	57.3	59.2	60.8
<b>Water Year</b>		50.2	47.1	49.4	50.0
<b>Normal (1971 to 2000)</b>		50.2	-----	-----	49.5

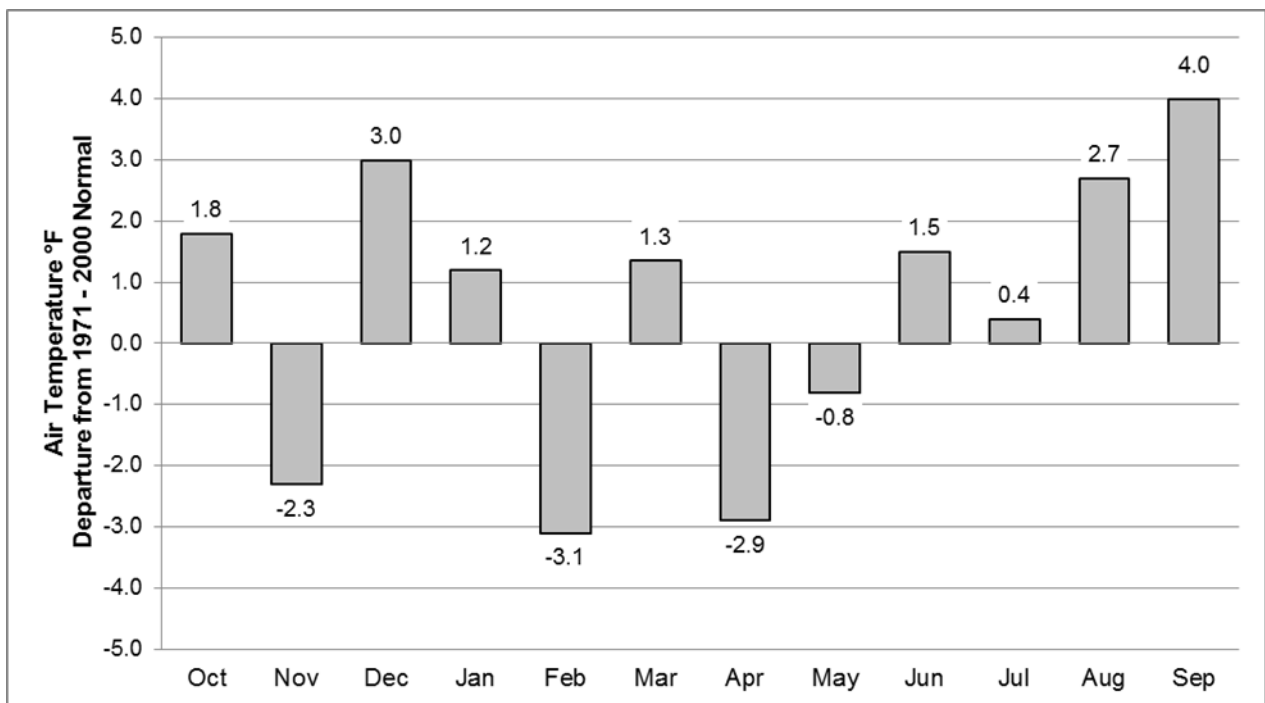
**Table 4.** Average maximum and minimum daily air temperature (°F) for each month from weather stations within or adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park in Water Year 2011.

Season	Month	Coupeville COOP Ebey's Landing		English Camp San Juan Island		Friday Harbor San Juan Island	
		Average Daily Max Air Temp °F	Average Daily Min Air Temp °F	Average Daily Max Air Temp °F	Average Daily Min Air Temp °F	Average Daily Max Air Temp °F	Average Daily Min Air Temp °F
Fall	October 2010	59.1	45.4	57.0	43.1	57.8	44.4
	November 2010	48.2	37.8	44.7	35.5	47.4	37.8
Winter	December 2010	47.3	38.1	44.9	37.0	47.0	39.5
	January 2011	45.5	35.7	41.5	33.5	45.4	37.0
	February 2011	45.1	33.6	42.5	32.2	44.7	33.5
Spring	March 2011	52.1	39.7	49.6	37.2	50.5	40.5
	April 2011	54.3	39.5	51.0	35.6	52.2	37.8
	May 2011	60.0	45.0	57.9	39.9	58.0	43.0
Summer	June 2011	64.9	49.7	65.5	46.0	64.2	49.1
	July 2011	69.5	51.8	70.1	50.2	68.0	48.7
	August 2011	71.7	52.3	73.0	50.2	70.0	49.2
Fall	September 2011	69.2	50.1	69.0	49.6	69.1	49.3
<b>Water Year</b>		57.2	43.2	55.6	40.8	56.2	42.5

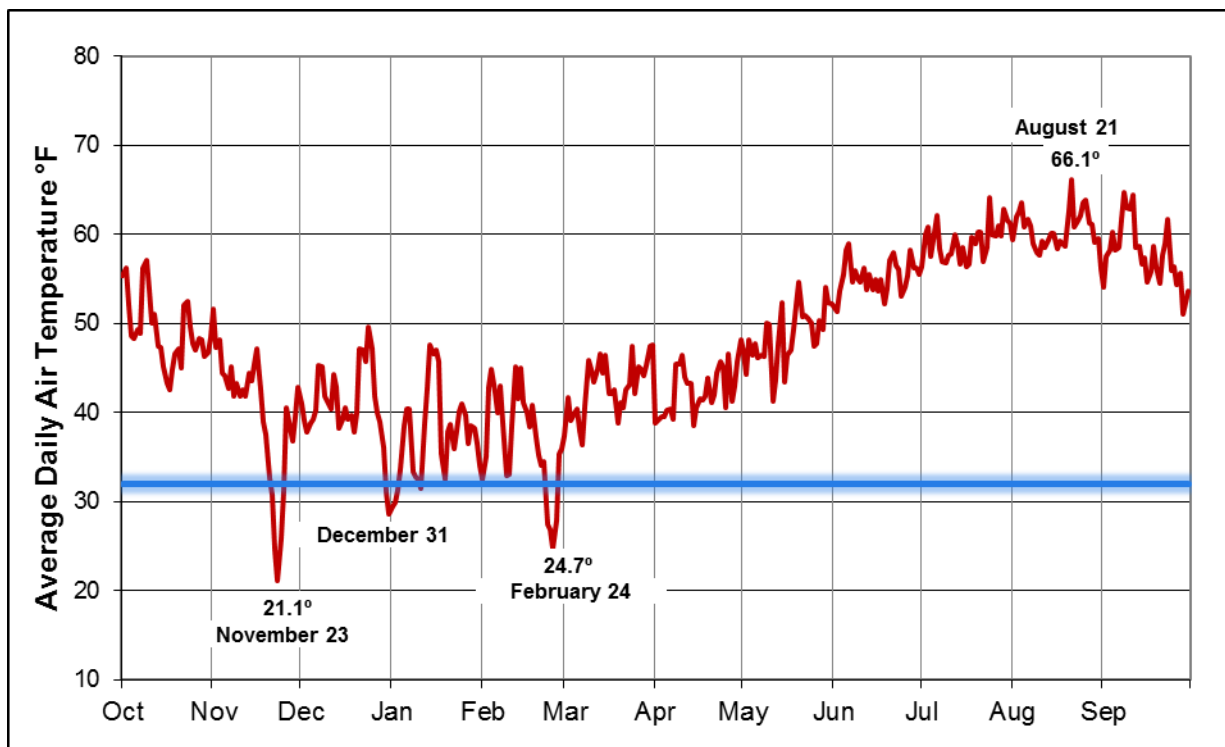




**Figure 3.** Comparison of average monthly temperature (°F) for Coupeville, WA (Ebey's Landing National Historical Reserve and San Juan Island National Historical Park) in Water Year 2011 against monthly averages for the climatological normal 1971-2000.



**Figure 4.** Comparison of average monthly temperature (°F) for Olga, WA (Orcas Island) in Water Year 2011 against monthly averages for the climatological normal 1971-2000.



**Figure 5.** Daily average air temperature (°F) at English Camp, WA, Water Year 2011. Blue line indicates 32°F, the freezing point of water.

**Table 5.** Air temperature extremes at Coupeville, WA (Ebey's Landing National Historical Reserve and San Juan Island National Historical Park), Water Year 2011.

Date	Max Air Temp °F <sup>1</sup>	Date	Min Air Temp °F <sup>1</sup>
July 24, 2011	79	November 24, 2010	14
September 8, 2011	79	November 23, 2010	17
September 11, 2011	79	November 25, 2010	19
September 23, 2011	79	November 22, 2010	21
July 25, 2011	78	December 31, 2010	22

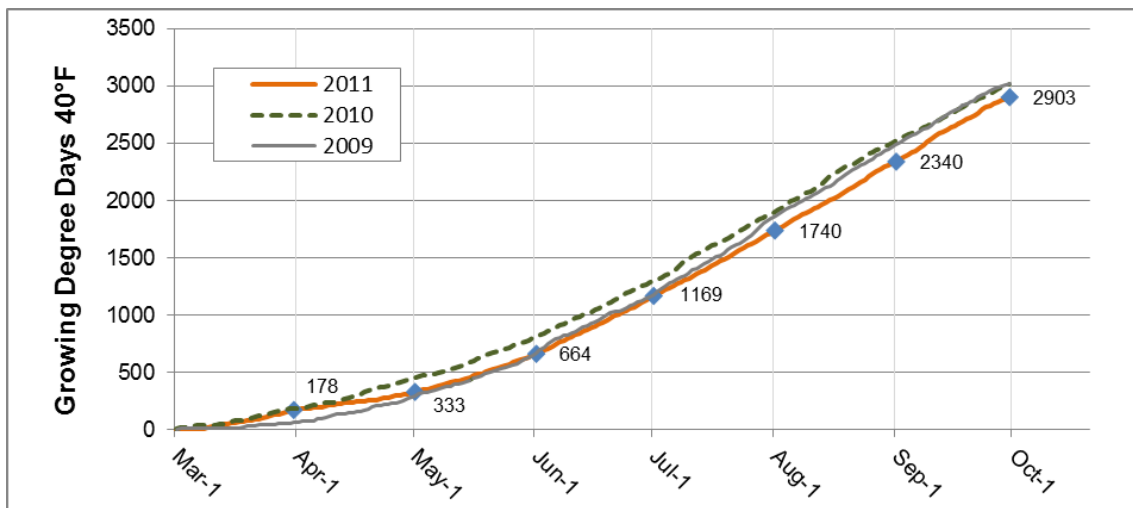
<sup>1</sup> Extreme temperatures at Ebey's Landing are presented in whole numbers due to the precision and recording practices at manually operated NWS COOP stations. Standard practice at these sites is to record daily temperatures to the nearest whole number.

**Table 6.** Air temperature extremes at English Camp, San Juan Island National Historical Park, Water Year 2011.

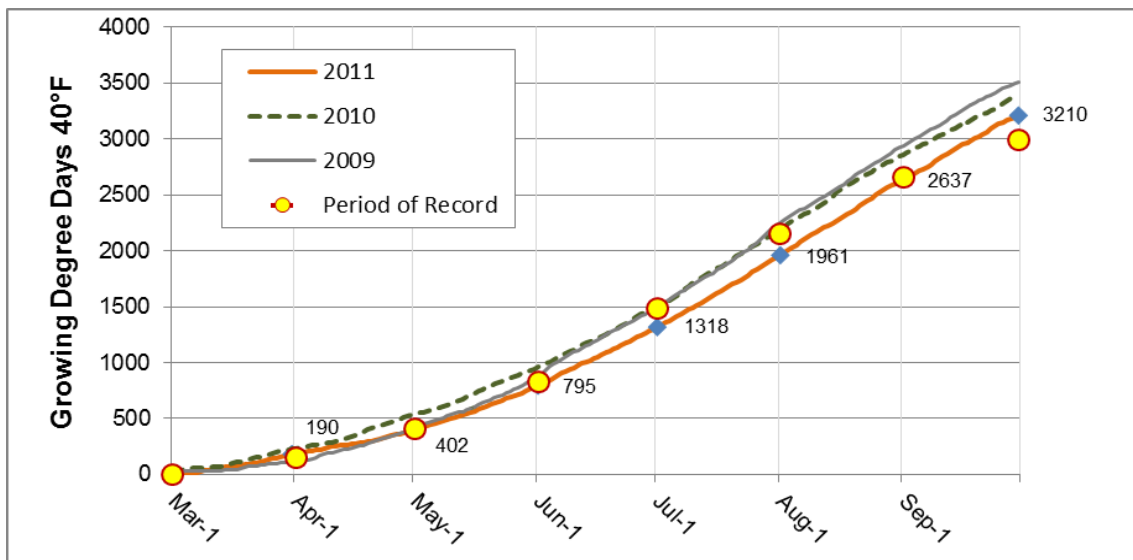
Date	Max Air Temp °F	Date	Min Air Temp °F
August 20, 2011	78.6	November 23, 2010	16.1
August 21, 2011	76.8	November 24, 2010	16.1
September 8, 2011	75.9	February 26, 2011	19.3
July 24, 2011	75.9	February 25, 2011	20.7
September 11, 2011	74.8	November 22, 2010	21.4

## Growing Degree Days

Accumulated growing degree days (AGDD) is a measure of heat accumulation, derived from the cumulative sum of growing degree days (GDD) over a specified time period. In Water Year 2011, the AGDD above 40°F from March 1 to September 30 at Friday Harbor Airport and Coupeville was 2903 and 3210, respectively (Figures 6 and 7). When compared to prior years, AGDD was similar at Friday Harbor and Coupeville. At Coupeville, the longer climate record (1895 to 2011) allowed AGDD values to be compared to a long term mean. At Coupeville, AGDD remained at or above the mean until late spring when the cooler than average months of May, June and July AGDD values dropped below the period of record average. On July 1, AGDD was 88% of the long term average. On August 1, AGDD had risen slightly to 91% of average. By the end of September, warmer than usual temperatures raised AGDD to 107% of average (Figure 7).



**Figure 6.** Accumulated Growing Degree Days (40°F) from March 1 to September 30, at Friday Harbor, WA, Water Year 2011.



**Figure 7.** Accumulated Growing Degree Days (40°F) from March 1 to September 30, at Coupeville, WA, Water Year 2011 and compared to previous years and the period of record 1895 to 2011.

## Precipitation

Annual precipitation in Water Year 2011 was slightly above normal at weather stations within or adjacent to EBLA and SAJH. Coupeville received the lowest amount of precipitation with 22.9 inches, 107% of normal. Olga received 29.8 inches, 106% of normal (Table 7 and Figure 8). English Camp and Friday Harbor, on San Juan Island, received 25.3 and 24.6 inches, respectively (Table 7). Precipitation is typically higher at Olga than SAJH or Coupeville (EBLA) because it is farther east of the Olympic Mountain's rain shadow (Figure 2), and this was the case in Water Year 2011 (Figure 8). Olga received the highest monthly amount of precipitation five months out of the year (Figure 9).

October and November 2010 were drier than normal. Coupeville and Olga were 74 and 71% of normal, respectively (Figures 10 and 11). Winter months were wetter than normal, especially the month of January which was 155% of normal at Coupeville and 143% of normal at Olga. Spring months were even wetter, averaging 178% at Coupeville and 169% of normal at Olga. The greatest departure from normal for the water year in terms of precipitation was in May, with 214 and 208% of normal at Coupeville and Olga, respectively (Figures 10 and 11).

**Table 7.** Total monthly precipitation (inches) from weather stations within or adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park, Water Year 2011.

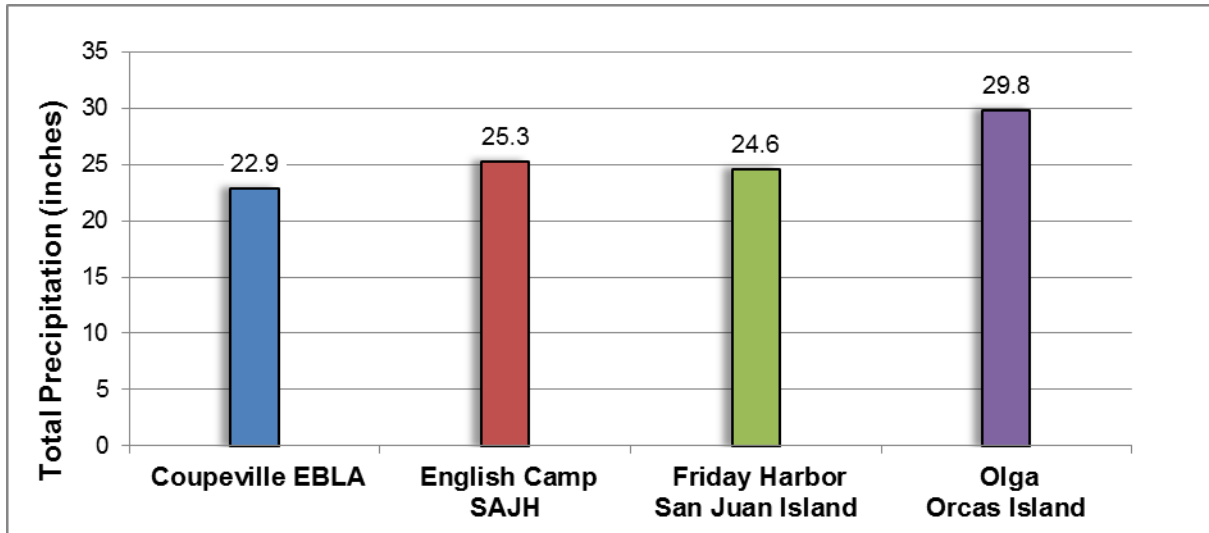
Season	Month & Year	Coupeville	English Camp	Friday Harbor	Olga
Fall	October 2010	0.9	1.3 <sup>a</sup>	1.3	1.6
	November 2010	2.7	1.7 <sup>a</sup>	2.1	3.3
	December 2010	2.4	5.8	5.1	5.5
Winter	January 2011	3.9	4.8	4.3	5.5
	February 2011	1.7	1.8	2.0	2.1
	March 2011	3.1	3.0	2.6	2.9
Spring	April 2011	2.6	2.2	2.4	3.2
	May 2011	3.8	2.6	2.8	3.6
	June 2011	0.5	0.2	0.6	0.4
Summer	July 2011	0.9	0.6	0.6	0.7
	August 2011	0.2	0.3	0.3	0.3
Fall	September 2011	0.3	1.0	0.6	0.7
<b>Water Year</b>		22.9	25.3 <sup>a</sup>	24.6	29.8
<b>Normal (1971 to 2000)</b>		21.4	----	----	28.2

<sup>a</sup> Precipitation data are missing for 36 days from October 1 to November 6, 2010. Daily data was substituted from Friday Harbor ASOS station to derive monthly and yearly totals.

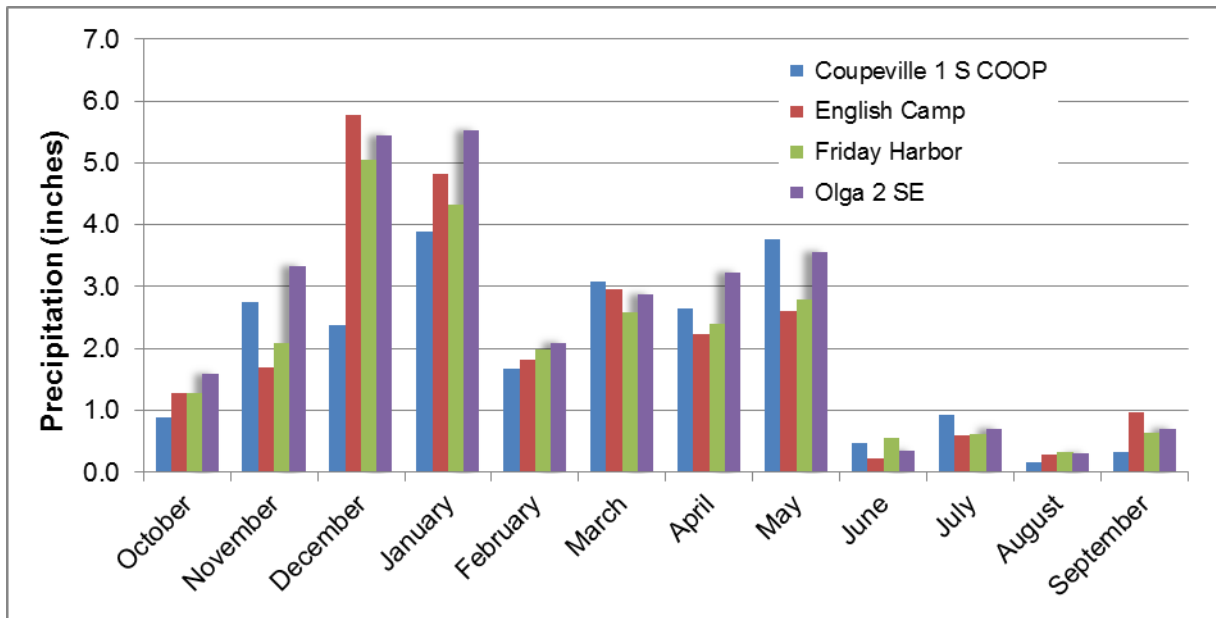
By contrast, summer months were quite dry, averaging 49% and 43% of normal at Coupeville and Olga respectively (Figures 10 and 11). This was especially the case during the months of June and August. Beginning in late July there was a prolonged period of drought (54 days at Coupeville, 47 days at English Camp and Olga). During this period, a single rain event occurred on August 22, which accounted for all the precipitation in the month of August. The dry period ended abruptly on September 17 with a series of rainfall events, however this month remained

drier than normal, receiving 0.3 and 0.7 inches of rain (25% and 53% of normal) at Coupeville and Olga, respectively.

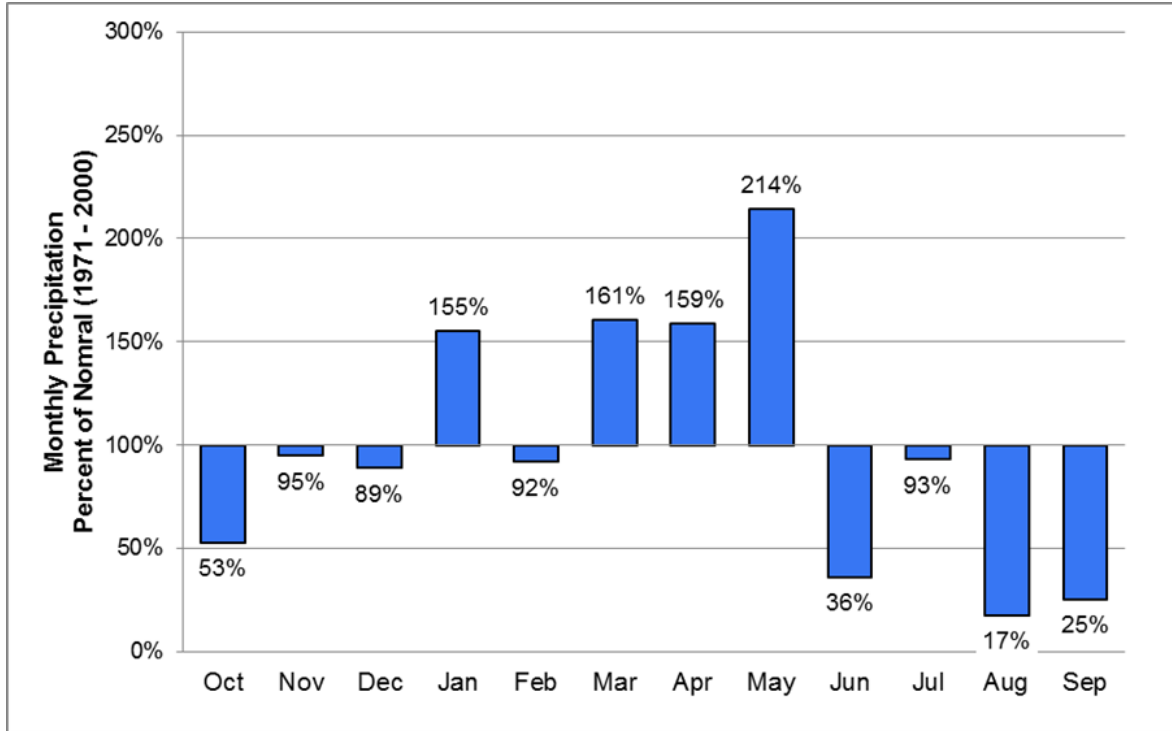
The wettest period was between December 8 and 12, 2010, when English Camp received 4.49 inches of precipitation over a five day period. The wettest single day occurred on December 12, 2010, with English Camp receiving 1.88 inches of rain (Figure 12). The wettest day at Coupeville was reported on May 15, 2011, a total of 1.25 inches (Figure 13). Coupeville received 1.01 inches on December 12 (Table 8).



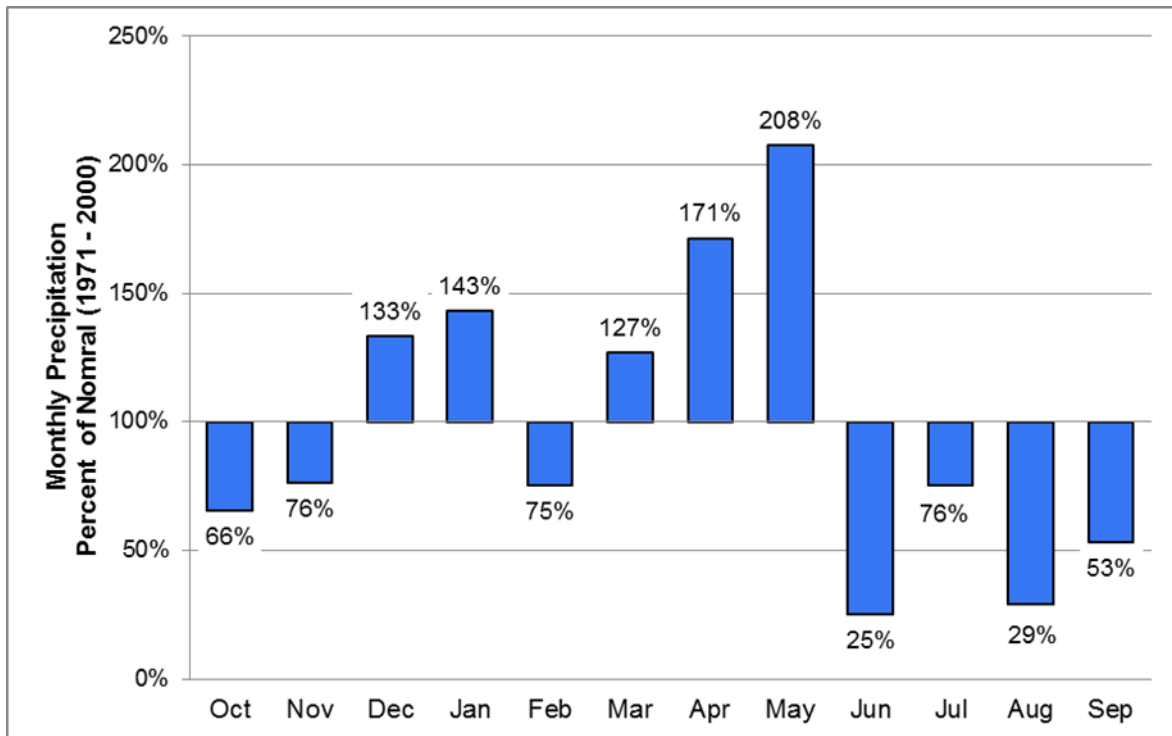
**Figure 8.** Total precipitation (inches) recorded at weather stations within or adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park, Water Year 2011.



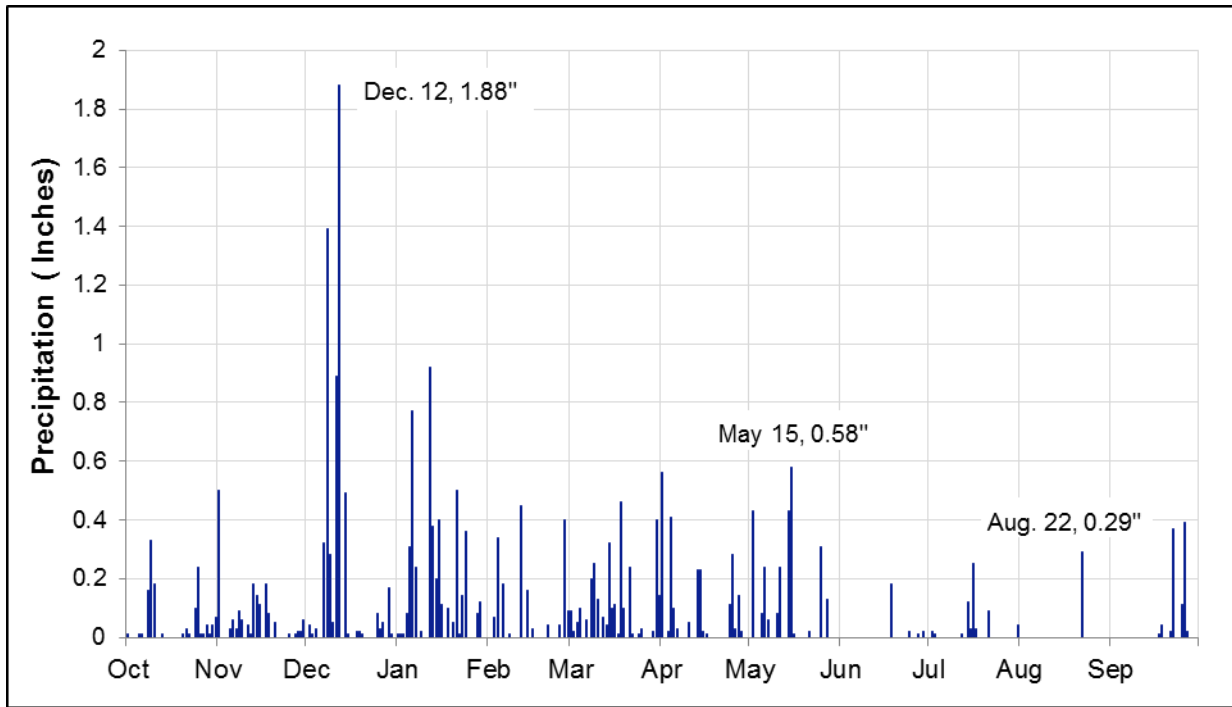
**Figure 9.** Comparison of monthly precipitation values for four stations within or adjacent to Ebey's Landing National Historical Reserve and San Juan Island National Historical Park, Water Year 2011.



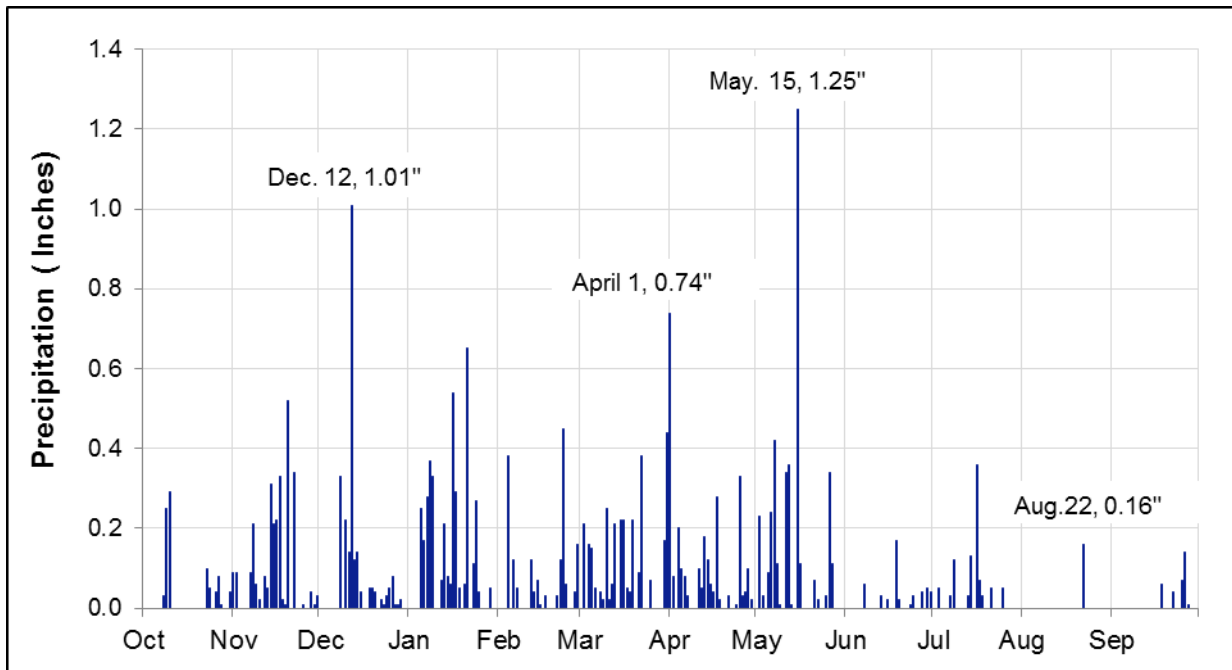
**Figure 10.** Comparison of total monthly precipitation (inches) at Coupeville, WA in Water Year 2011 against the climatological normal 1971-2000.



**Figure 11.** Comparison of total monthly precipitation (inches) at the Olga, WA in Water Year 2011 against the climatological normal 1971-2000.



**Figure 12.** Daily precipitation (inches) at English Camp, WA (San Juan Island National Historical Park), Water Year 2011.



**Figure 13.** Daily precipitation (inches) at Coupeville, WA, Water Year 2011.

**Table 8.** Daily precipitation extremes (inches) at Coupeville (Ebey’s Landing National Historical Reserve) and English Camp (San Juan Island National Historical Park), Water Year 2011.

<b>Coupeville, WA (EBLA)</b>		<b>English Camp, WA (SAJH)</b>	
<b>Date</b>	<b>Daily Precipitation Inches</b>	<b>Date</b>	<b>Daily Precipitation Inches</b>
May 15, 2011	1.25	December 12, 2010	1.88
December 12, 2010	1.01	December 8, 2010	1.39
April 1, 2011	0.74	January 12, 2011	0.92
November 20, 2010	0.52	December 11, 2010	0.89
March 31, 2011	0.44	January 6, 2011	0.77



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