Climate Projections for Islands Trust Area

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Photo: Tree eclipsed sun, Carla Funk

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Introduction

Rising temperatures, changes to seasonal precipitation patterns and more extreme weather events are challenging the unique ecosystems of the Salish Sea. With a mandate to preserve and protect the islands, it is important for Islands Trust to understand how climate change will continue to challenge terrestrial and aquatic ecosystems, and use this information to inform the Islands Trust Conservancy's conservation planning initiatives and property securement and management actions.

This summary report provides climate projections and potential impacts for the Islands Trust Area to support decision-making around how to adapt future acquisition and stewardship of land to appropriately consider climate change. The first section offers key indicators of temperature and precipitation that display how conditions are expected to change within the Islands Trust Area's land, waters and surrounding ocean in the 2050s and 2080s.[1] The second section describes how these projected changes are expected to impact biodiversity, as well as terrestrial, aquatic and oceanic ecosystems.

Methodology

This summary report provides regional and site-specific past and future values for climate indicators based on an ensemble of 12 global climate models developed by the Pacific Climate Impacts Consortium (PCIC) that describe climate projections. The climate projections presented in this summary report are based on a "business as usual" greenhouse gas emission scenario, using the Representative Concentration Pathway of 8.5 (RCP8.5) within these models.

The projection data was accessed from two different sources:

1. Regional data from PCICs database. This source includes the data for Region 1, and maps for the Area which are offered throughout this summary report. This data is not publicly available.
2. Site-specific data accessed through the web portal climatedata.ca.[2] This data is for each region in the data tables.

In many cases, there are two sources of data for Region 1 (PCIC and Climatedata.ca), resulting in two entries for Region 1 data in each table. Additionally, PCIC data includes climate indicators that were not available on climatedata.ca: growing season length, warmest winter day, seasonal precipitation, maximum 5-day total precipitation, 1-in-20 wettest day, 95th and 99th percentile wettest days, and dry spells. In these instances, Region 1 data is provided, and maps of the whole Area, where available. Maps are available only for the 2050s timeframe.

[1] These time periods were chosen based on available data.
[2] Information about modelling can be found here: https://climatedata.ca/about/

For more information on the methodology used to develop these climate projections, please refer to the Capital Regional District (CRD) Climate Projection report.[3] A detailed glossary of terms to support interpretation is available at https://climatedata.ca/glossary/.

The Islands Trust Area was divided into four regions based on available data and local climatic differences. The four 'regions' are summarized in Table 1 and displayed in Figure 1.

Table 1: Island Trust Area region descriptions.

		Site	Source
Region 1	Southern Gulf Islands (CRD)	Southern Region	PCIC Database – Region 1 data including Saturna, Mayne, Galiano, N /S Pender, Saltspring, Sidney, Moresby, and surrounding islets
	Saltspring Island	Saltspring Island	climatedata.ca – Location specific data PCIC Database – Regional maps
Region 2	Gabriola & Thetis Islands	Mudge Island	climatedata.ca – Location specific data PCIC Database – Regional maps
Region 3	Howe Sound	Gambier Island	climatedata.ca – Location specific data PCIC Database – Regional maps
Region 4	Northern Gulf Islands	Denman Island	climatedata.ca – Location specific data PCIC Database – Regional maps

[3] Capital Regional District, 2017, "Climate Projections for the Capital Region", 59 pgs, available at https://www.crd.bc.ca/docs/default-source/climate-action-pdf/reports/2017-07-17_climateprojectionsforthecapitalregion_final.pdf.

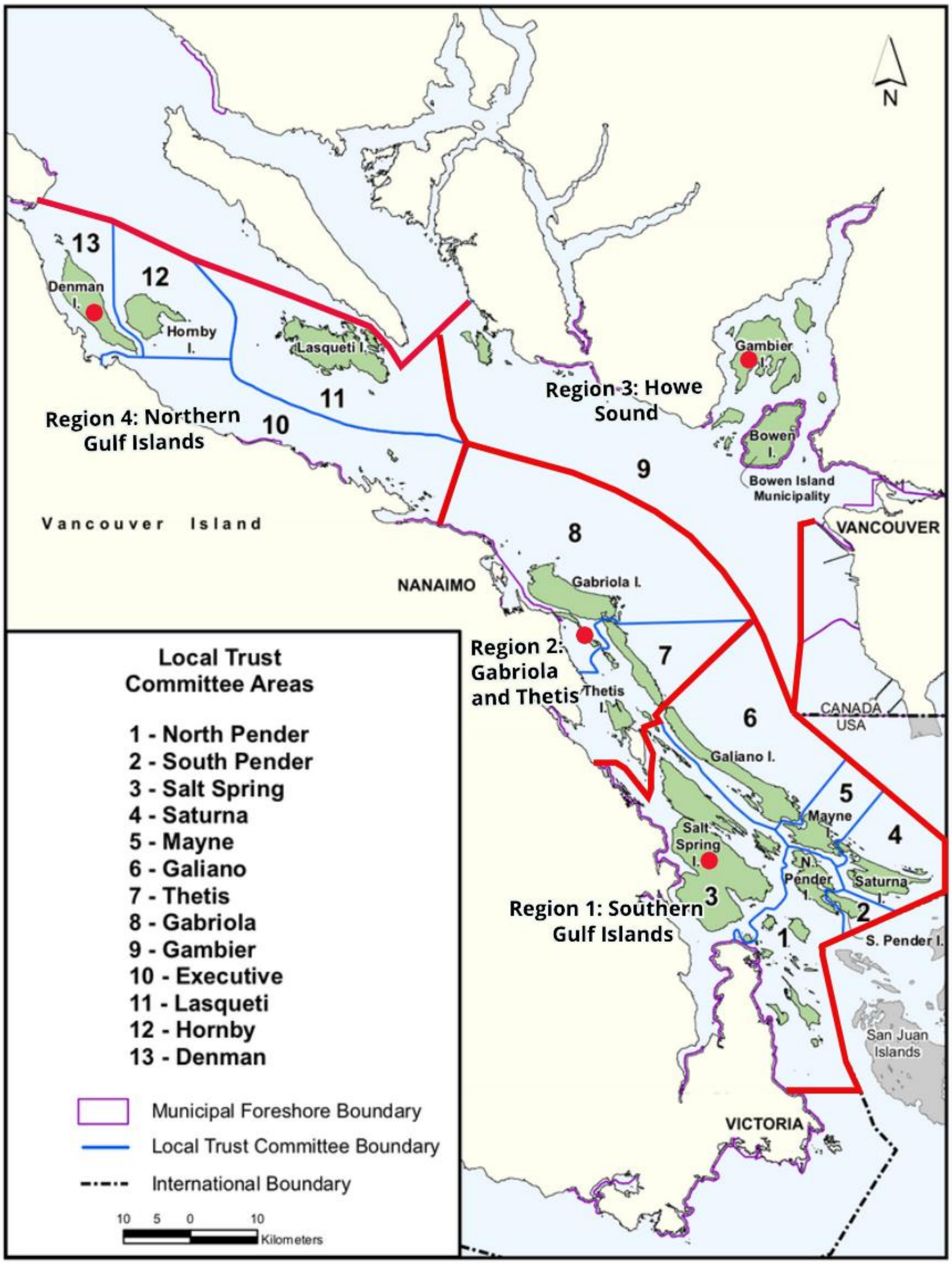

Figure 1: Island Trust Area divided into Regions used for climate projection analyses. Red dots indicate the location of the PICS data sites, given in table 1 above.

Climate Indicators for Islands Trust Area

Summary

In general, rising temperatures, changes to seasonal precipitation patterns and more extreme weather events are already affecting the Islands Trust Area, and we can continue to expect:

- Warmer summer temperatures, with hotter and more extreme heat days in summer.
- Warmer nights and a longer growing season.
- Warmer winter and summer temperatures.
- Less rain and longer droughts in the summer months.
- More precipitation and intense storms.
- Rising sea levels.
- Increasing acidity and temperatures, and reduction of oxygen levels in global ocean waters.

Projections Indicators

The following indicators were selected based on data availability and their applicability to future securement and stewardship of land. For each indicator, plain language definitions are given, along with average annual (or seasonal) projected values for the 2050s, and the 2080s, for each of the four regions in the Islands Trust Area, when available.

Summer Temperature Indicators

- 1.1 Annual hottest day
- 1.2 Days over 25°C
- 1.3 Days over 30°C
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- 1.5 Growing Season Length

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- 3.6 Dry spells

Ocean Indicators

- 4.1 Sea Level Rise
- 4.2 Surface temperature
- 4.3 Ocean acidification
- 4.4 Deoxygenation

Climate Projection Tables Details

In the tables below, climate indicators are provided in column A. Past values are in column B. Average values for climate projections derived from 12 global climate models are presented for 2050 and 2080 in columns C, and D, along with the range (upper bound and lower bound) of the models below in brackets. Projections are based on a RCP8.5 (business as usual) climate scenario and do not anticipate impacts of reduction of global emissions. The following terms in the projection tables are explained below:

- **Past** refers to the average value over a 30-year period between 1970-2000. These values are based on historical and measured data.
- **2050** refers to the projected average value over the 30-year period between 2040-2070.
- **2080** refers to the projected average value over the 30-year period 2070-2100.
- **Percent Change** refers to the average percent change from the baseline past value.
- **(Range)** refers to the 10^{th} and 90^{th} percentile values given by the 12 models.

Summer Temperature Indicators

1.1 Annual Hottest Day

About this Indicator: Hottest day refers to the highest daytime high temperature of the year, usually experienced during the summer months. The annual high for each year is an indicator of extreme temperatures and is averaged over a 30-year period. This measure helps us predict what to expect for annual hotter temperatures.

Projections:

- The past average annual hottest day temperature varied from 30 to 32°C for the Islands Trust Area, with the Northern Gulf Islands region experiencing slightly hotter temperatures, and the Howe Sound and the Southern Gulf Islands regions experiencing slightly cooler temperatures.
- Temperature of the Annual Hottest Day will increase to about 33 to 34°C by the 2050s, and to 35 to 36°C by the 2080s.

Table 2: Annual Hottest Day

			2050s (°C)		2080s (°C)	
		Past (°C)	**Average**	**Range**	**Average**	**Range**
Region 1	Southern Gulf Islands (CRD)	30	33	(32 to 34)	36	(34 to 38)
	Saltspring Island	31	34	(32 to 37)	36	(33 to 40)
Region 2	Gabriola & Thetis Islands	32	33	(32 to 37)	36	(33 to 40)
Region 3	Howe Sound	31	33	(31 to 36)	35	(32 to 38)
Region 4	Northern Gulf Islands	32	34	(31 to 37)	36	(32 to 39)

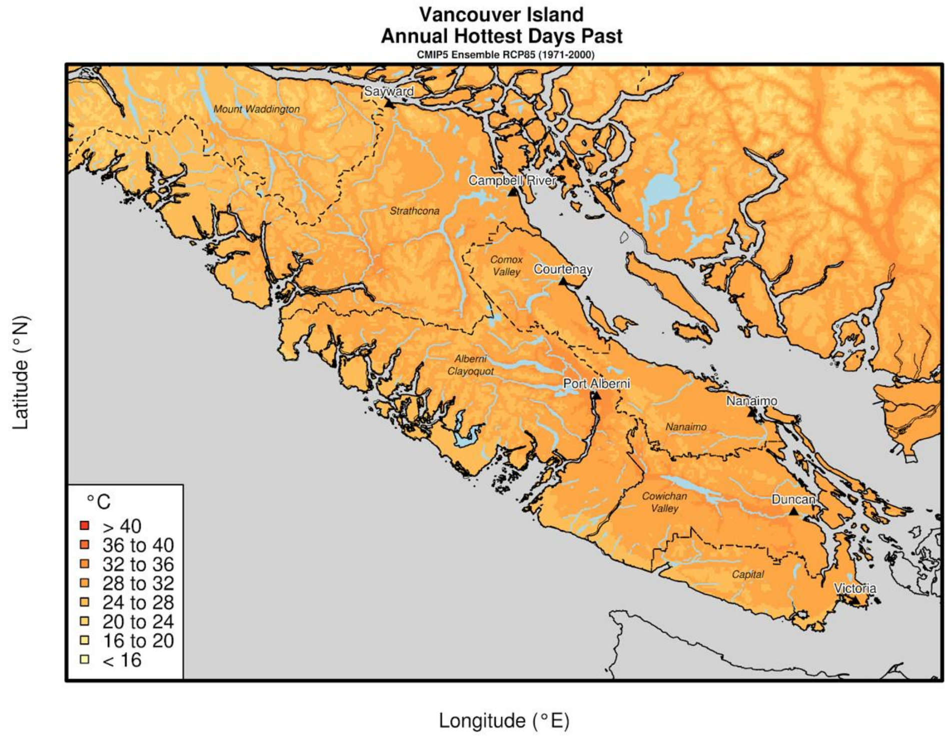

Figure 2: Annual Hottest Day - Past

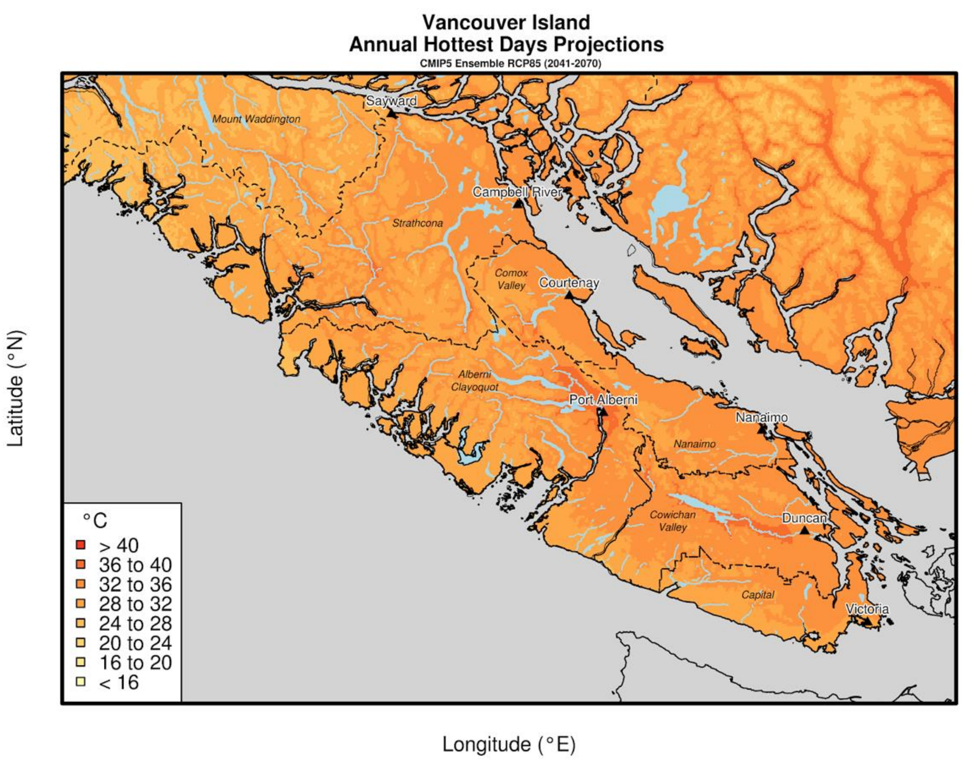

Figure 3: Annual Hottest Day - Future (2050s)

1.2 Days over 25°C

About this Indicator: This is the number of days when daily maximum temperature is greater than 25°C and gives an indication of the number of days with 'summer-like' temperatures. Values are calculated based on a 30-year average.

Projections:

- The past number of days over 25°C each year varied from 17 to 23 for the Area, with the Southern Gulf Islands and Howe Sound regions on average experiencing fewer summer days and the Northern Gulf Islands and Gabriola & Thetis regions experiencing more.
- The number of days per year over 25°C is projected to increase by approximately 30 days by the 2050s, and by about 60 days by the 2080s. Total days are offered in the tables below.

Table 3: Days over 25℃

		Past (days)	2050s (days)		2080s (days)	
			Average	Range	Average	Range
Region 1	Southern Gulf Islands (CRD)	17	54	(40 to 68)	82	(57 to 107)
	Saltspring Island	19	46	(29 to 70)	81	(58 to 113)
Region 2	Gabriola & Thetis Islands	23	54	(34 to 75)	89	(62 to 122)
Region 3	Howe Sound	18	47	(27 to 72)	84	(58 to 108)
Region 4	Northern Gulf Islands	21	55	(34 to 74)	91	(60 to 120)

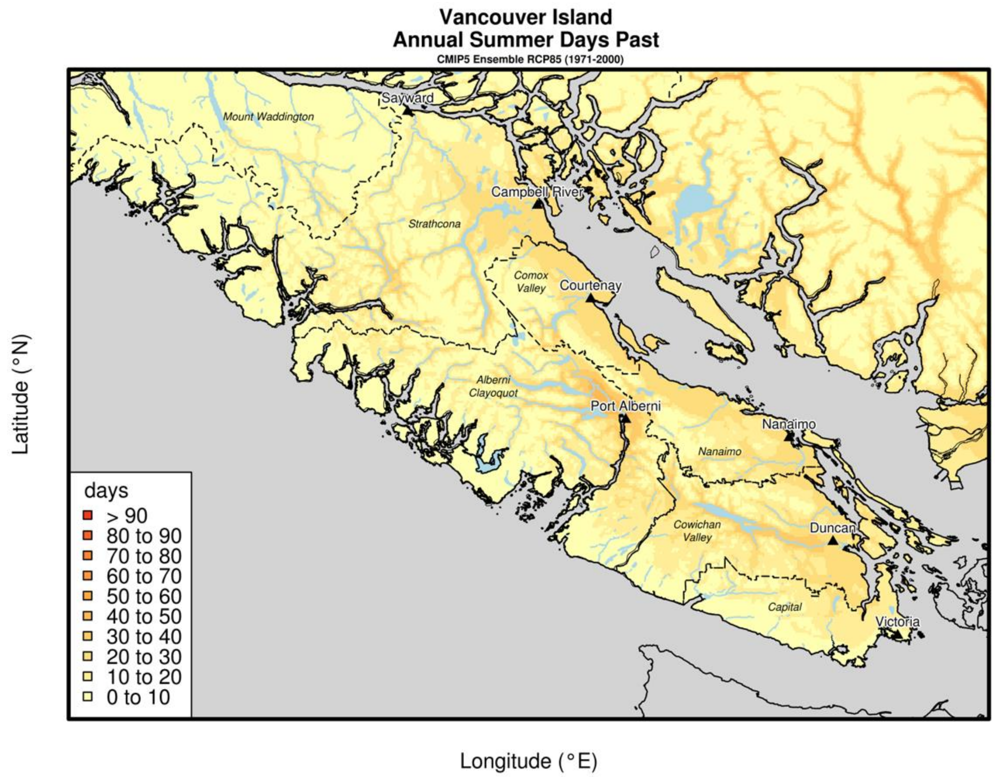

Figure 4: Days over 25℃ - Past

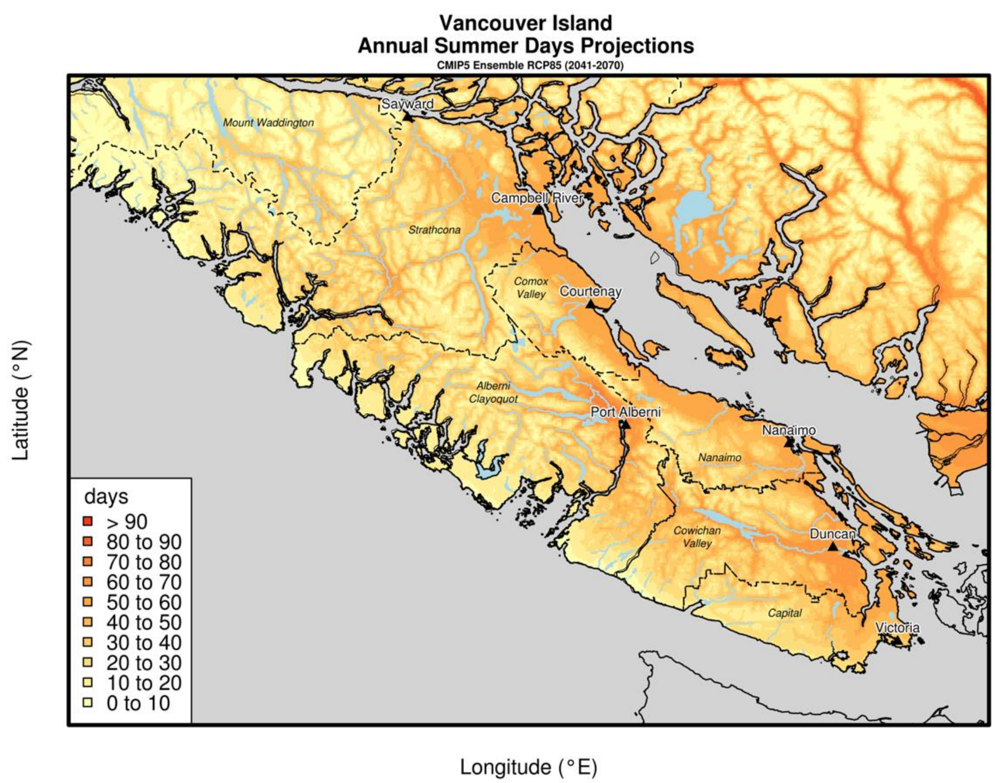

Figure 5: Days above 25℃ - Future (2050s)

1.3 Days over 30°C

About this Indicator: This is the number of days when daily maximum temperature is greater than 30°C and gives an indication of the number of higher temperature summer days.

Projections:

- In the past, the Area experienced 1 to 2 days over 30°C on average.
- Across the Islands Trust Area, annual number of higher temperature summer days will increase by about 5 to 8 by the 2050s, and by 20 to 30 days by the 2080s, with the Northern Gulf Islands experiencing the largest increase, and Howe Sound experiencing the lowest increase for the Area. Total days are offered in the tables below.

Table 4: Days over 30℃

		Past (days)	2050s (days)		2080s (days)	
			Average	**Range**	**Average**	**Range**
Region 1	Southern Gulf Islands (CRD)	n/a[4]	n/a	n/a	n/a	n/a
	Saltspring Island	2	7	(3 to 24)	22	(9 to 60)
Region 2	Gabriola & Thetis Islands	2	10	(3 to 24)	27	(11 to 66)
Region 3	Howe Sound	1	6	(2 to 23)	21	(8 to 60)
Region 4	Northern Gulf Islands	2	9	(3 to 24)	33	(10 to 60)

[4] There is no available data at a Southern Gulf Islands regional level from PCIC on this indicator.

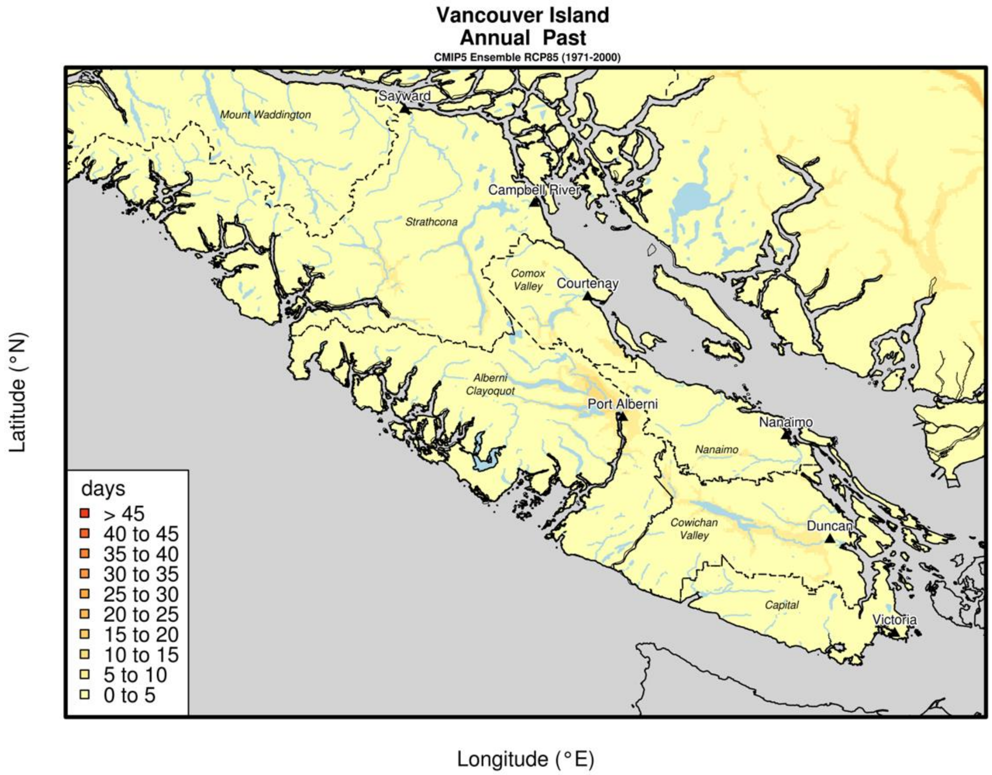

Figure 6: Days over 30℃ – Past

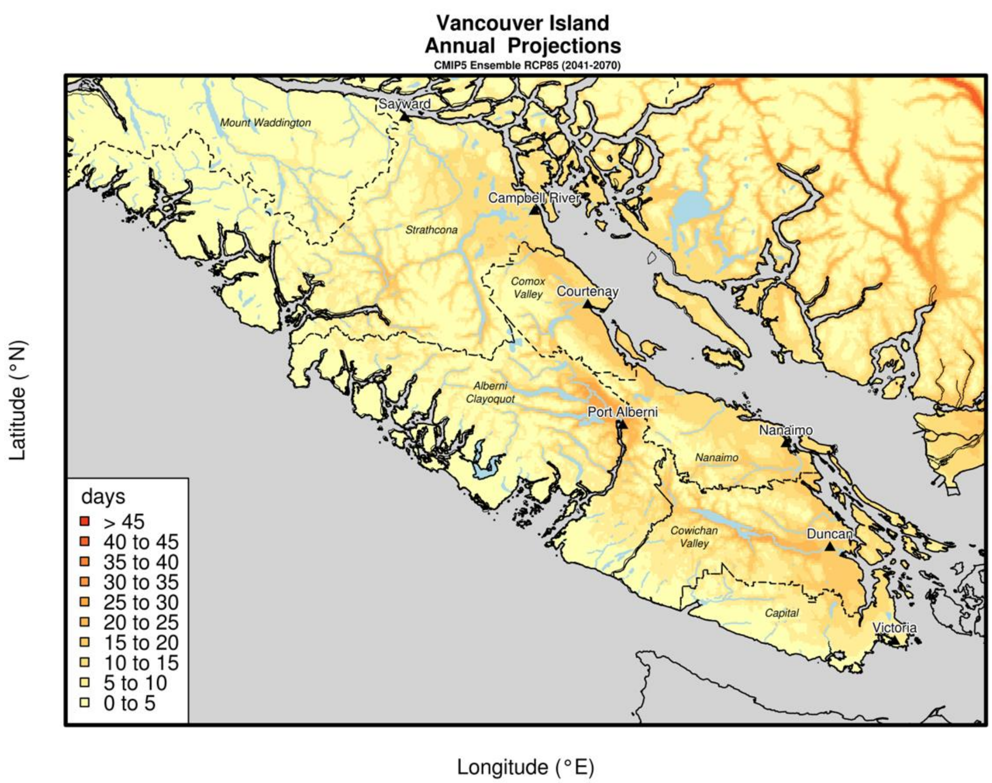

Figure 7: Days over 30℃ - Future (2050s)

1.4 Growing Degree-Days

About this Indicator: Growing degree-days is a measure of whether climate conditions are warm enough to support plant growth. When the daily mean temperature exceeds the threshold temperature, growing degree-days are accrued. A threshold temperature of 5°C was used, as it is generally used to calculate growing degree-days for forage crops in this region. This indicator also has relevance to native plants. For example, degree-days over 5°C have been used to model the geographic distribution of areas climatically suited to Garry oak ecosystems.[5]

Projections:

- The past growing degree-days varied from 1,900 to 2,100 for the Area.
- Growing degree-days will increase by about 45% by the 2050s, and by about 65% by 2080s, with the Northern Gulf Islands experiencing the largest increase, and Howe Sound and the Southern Gulf Islands (CRD) experiencing the lowest increase for the Area.

Table 5: Growing Degree-Days

		Past (degree-days)	2050s (degree-days)			2080s (degree-days)		
			Average	Range	Percent Change	Average	Range	Percent Change
Region 1	Southern Gulf Islands (CRD)	2,000	2,900	(2,500 – 3,300)	45%	3,500	(2,900 – 4,000)	75%
	Saltspring Island	1,900	2,700	(2,331 – 3,037)	42%	3,200	(2,800 – 3,900)	68%
Region 2	Gabriola & Thetis Islands	2,100	2,900	(2,500 – 3,200)	38%	3,400	(3,000 – 4,200)	62%
Region 3	Howe Sound	1,950	2,700	(2,400 – 3,100)	38%	3,200	(2,900 – 4,000)	64%
Region 4	Northern Gulf Islands	2,000	2,700	(2,400 – 3,000)	35%	3,200	(2,900 – 4,000)	60%

[5] Pellatt et. al. 2007. *Fire History and Ecology of Garry Oak and Associated Ecosystems in British Columbia*. Parks Canada. Available at https://www.researchgate.net.

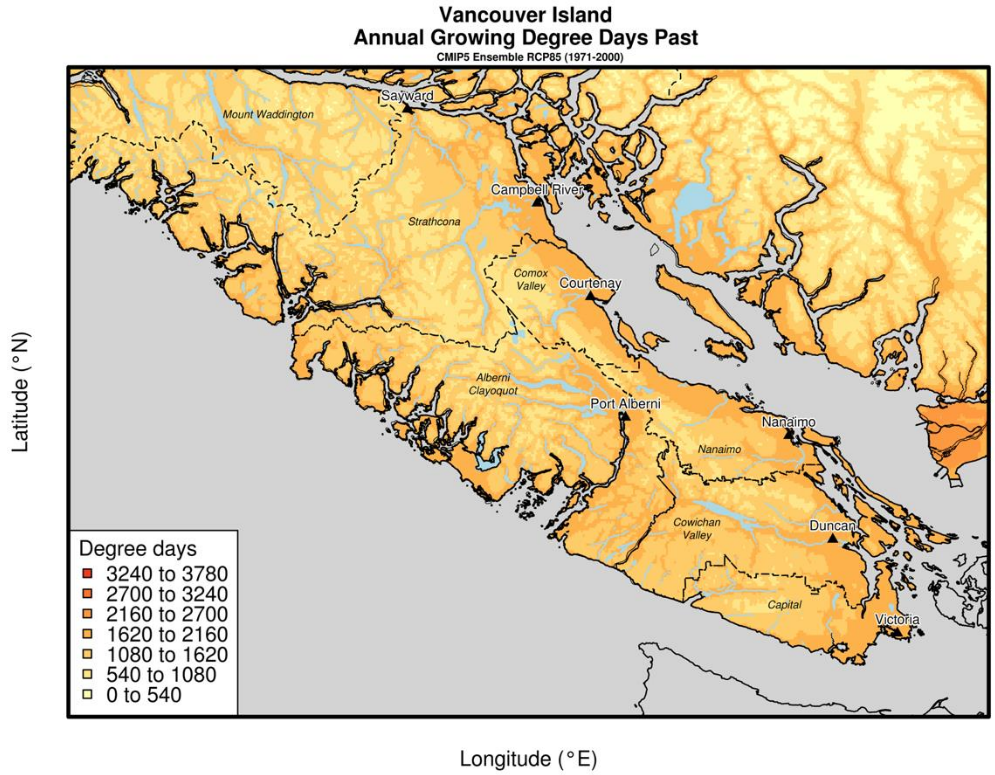

Figure 8: Growing Degree-Days - Past

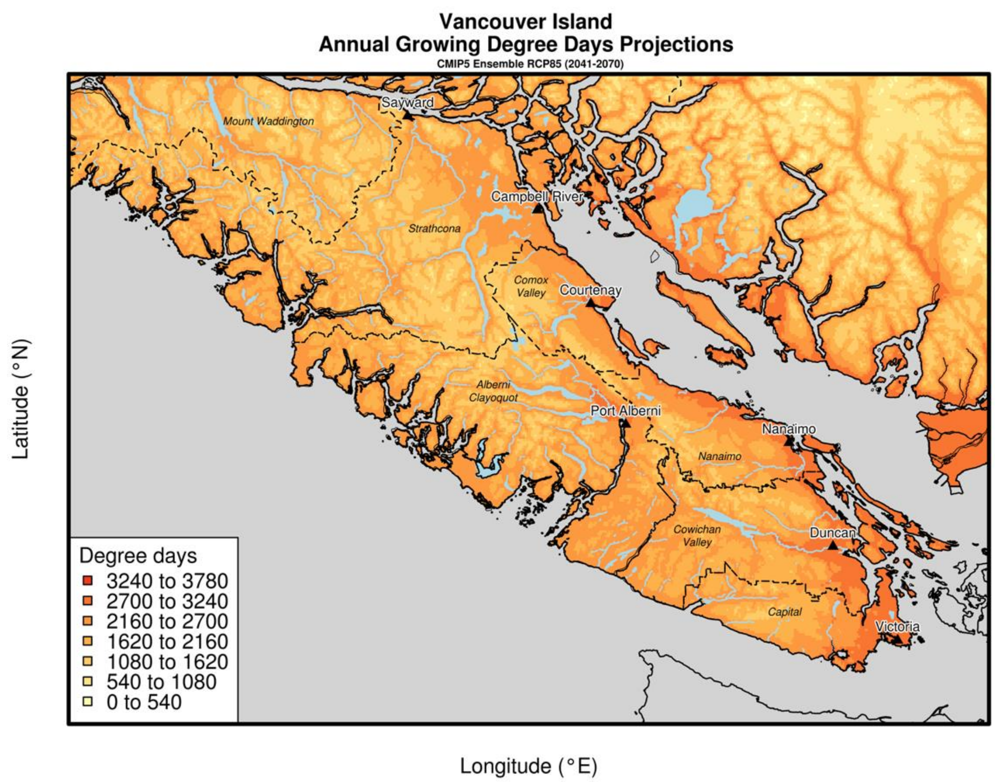

Figure 9: Growing Degree-Days - Future (2050s)

1.5 Growing Season Length

About this Indicator: Growing season length is an annual measure that counts the number of days between the first span of at least 6 days with a daily average temperature greater than 5°C and the first span after July 1 of 6 days with temperature less than 5°C. While each plant species has unique environmental cues to start and end its annual growth cycle, this growing season metric is a widely used general indicator of the timing of plant photosynthetic activity, and indicates the length of the growing season for typical plants or crops.

Projections:

- The past growing season length was on average 300 days in the Southern Gulf Islands.
- Growing season length will increase by 15% in the 2050s, and by 20% in the 2080s.

Table 6: Growing Season Length

		Past (days)	2050s (days)			2080s (days)		
			Average	Range	Percent Change	Average	Range	Percent Change
Region 1	Southern Gulf Islands (CRD)	300	345	(340 - 350)	15%	360	(355 – 360)	20%

Winter Temperature Indicators

2.1 Warmest Winter Day

About this indicator: Warmest winter day is the highest temperature recorded during the winter months, in an average year. Winter is considered to be the months of December, January, and February.

Projections:

- The past warmest winter day ranged from 4 to 8°C.
- Warmest winter temperatures will increase for the Southern Gulf Islands to about 9°C by the 2050s, and to 11°C by 2080s.
- Regional data are available only for the Southern Gulf Islands (CRD). The remainder of the Warmest winter day projections for the other regions have been estimated from the maps (Figure 10 and Figure 11).

Table 7: Warmest Winter Day

		Past (°C)	**2050s (°C)**		**2080s (°C)**	
			Average	**Range**	**Average**	**Range**
Region 1	Southern Gulf Islands (CRD)	7	9	(8 to 10)	11	(10 to 13)
	Saltspring Island	(4-8)	(8-12)	n/a	n/a	n/a
Region 2	Gabriola & Thetis Islands	(4-8)	(8-12)	n/a	n/a	n/a
Region 3	Howe Sound	(4-8)	(8-12)	n/a	n/a	n/a
Region 4	Northern Gulf Islands	(4-8)	(8-12)	n/a	n/a	n/a

Note: Site-specific data is not available as climatedata.ca does not provide data on warmest winter day indicator. The range for Past and 2050s average the values based off the maps below.

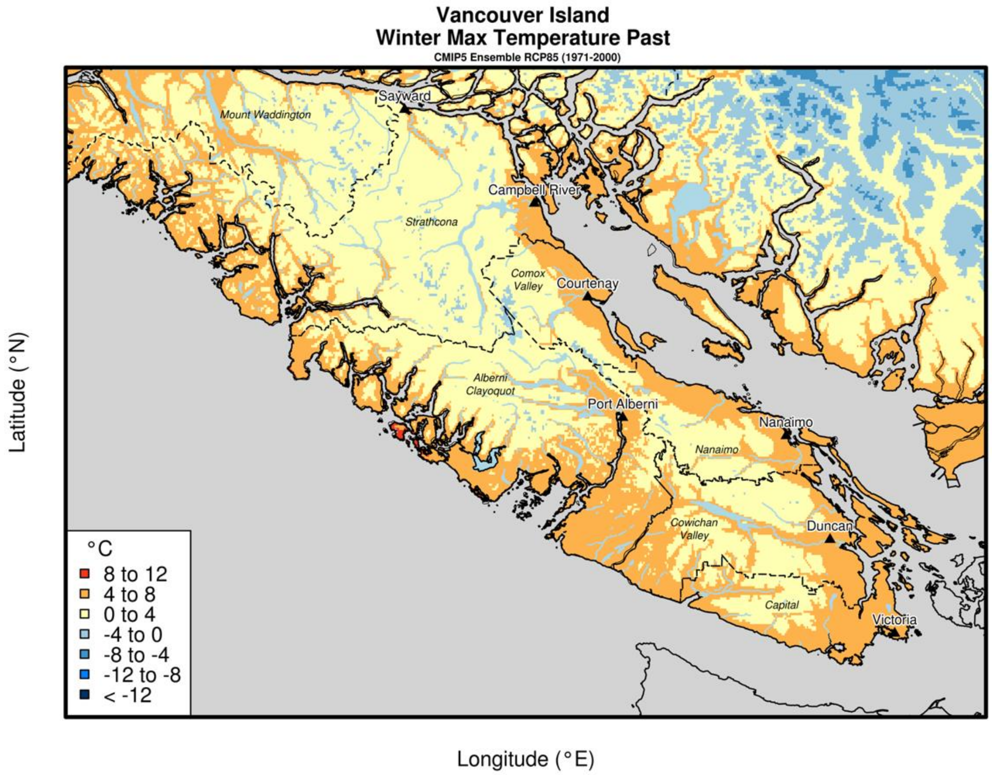

Figure 10: Warmest Winter Day – Past

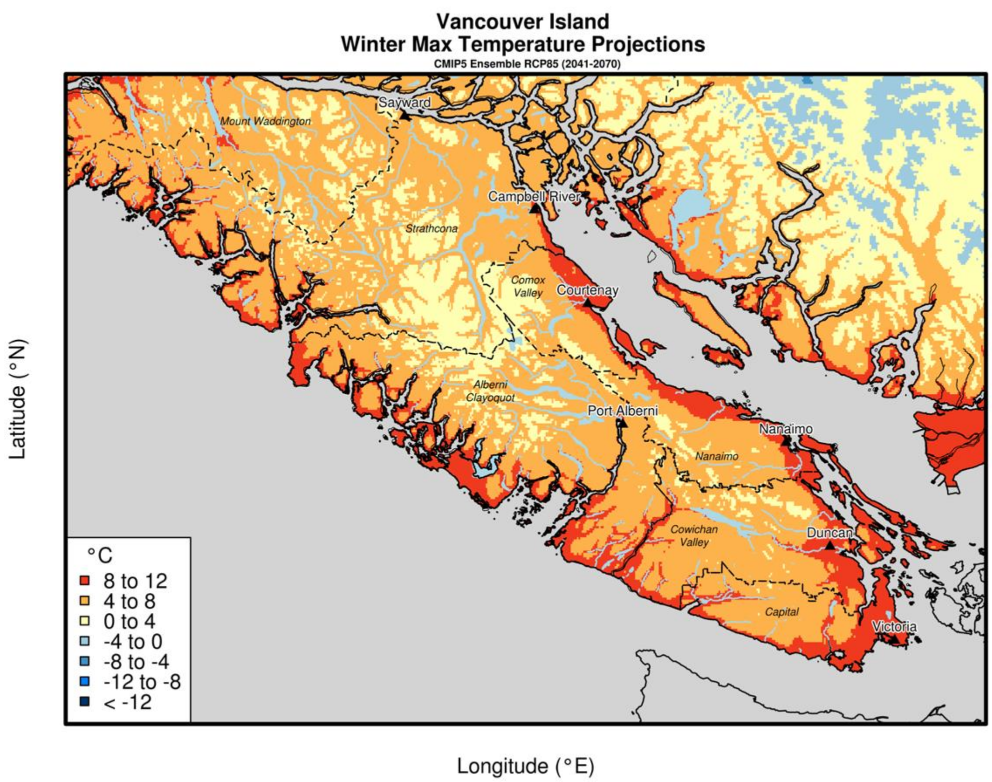

Figure 11: Warmest Winter Day - Future (2050s)

2.2 Coldest Day

About this indicator: Coldest day is the lowest minimum temperature value in this time period, usually experienced at nighttime during winter months.

Projections:

- The past coldest day in the region was on average -8°C.
- Average annual coldest day temperatures will increase by about 3°C by the 2050s, and by about 7°C by 2080s.

Table 8: Coldest Day

		Past (°C)	2050s (°C) Average	2050s (°C) Range	2080s (°C) Average	2080s (°C) Range
Region 1	Southern Gulf Islands (CRD)	-8	-4	(-5 to -2)	-2	(-3 to 0)
	Saltspring Island	-7	-3	(-6 to 0)	0	(-4 to 4)
Region 2	Gabriola & Thetis Islands	-8	-2	(-6 to 0)	0	(-4 to 4)
Region 3	Howe Sound	-9	-4	(-7 to 0)	0	(-4 to 4)
Region 4	Northern Gulf Islands	-8	-4	(-7 to 0)	-1	(-4 to 3)

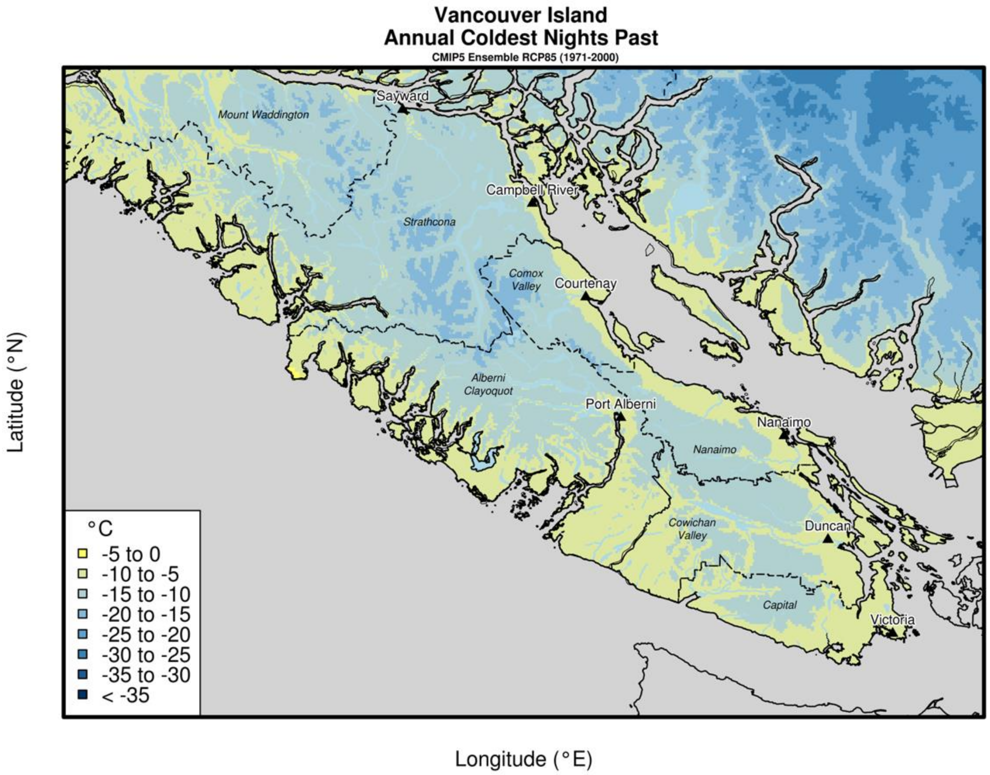

Figure 12: Coldest Day – Past

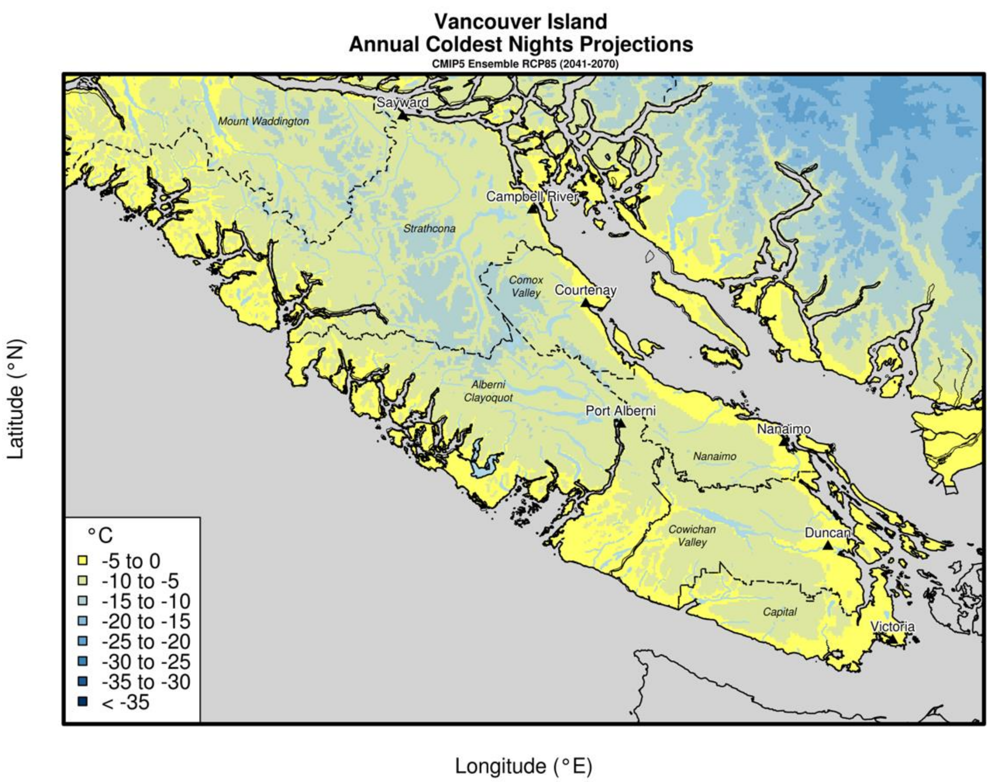

Figure 13: Coldest Day - Future (2050s)

2.3 Frost Days

About this indicator: Frost Days is the number of days when daily minimum temperature is less than 0°C and indicates when conditions are below freezing, usually overnight.

Projections:

- The past average annual number of frost days varied from 40 to 50 for the Area.
- This number will decrease by just over 30 days by the 2050s, and frost days will nearly never occur by the 2080s.

Table 9: Frost Days

		Past (days)	2050s (days)		2080s (days)	
			Average	Range	Average	Range
Region 1	Southern Gulf Islands (CRD)	40	9	(4 to15)	3	(0 to 8)
	Saltspring Island	45	9	(0 to 27)	1	(0 to 13)
Region 2	Gabriola & Thetis Islands	40	7	(0 to 26)	1	(0 to 10)
Region 3	Howe Sound	40	9	(0 to27)	1	(0 to 11)
Region 4	Northern Gulf Islands	50	9	(1 to 30)	2	(0 to 16)

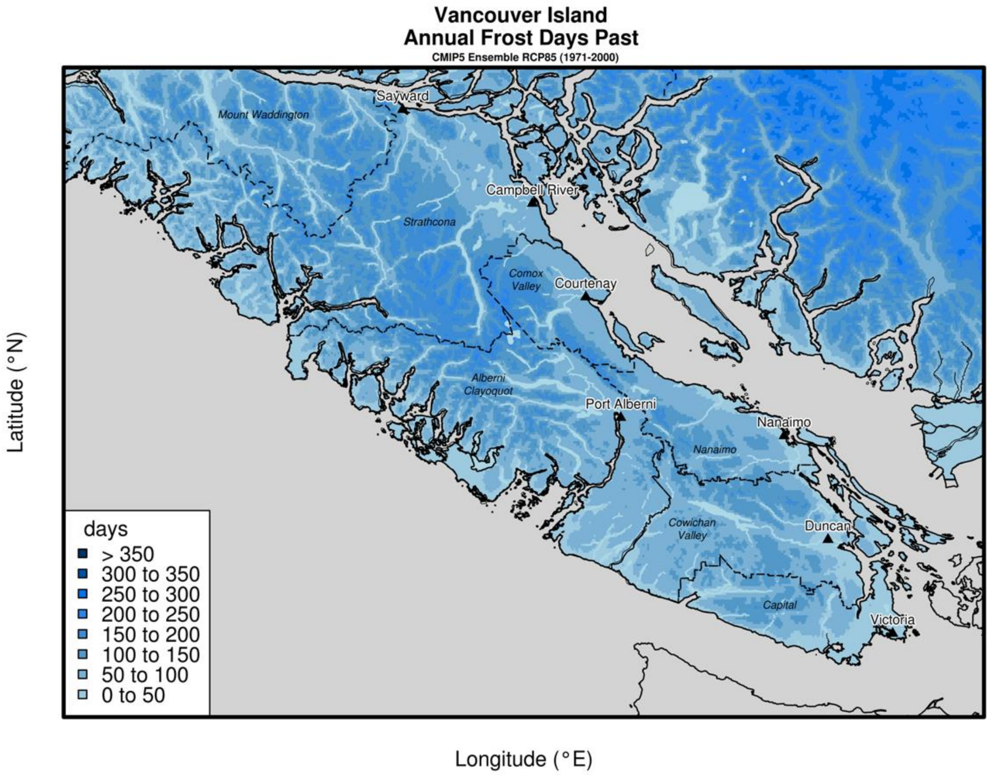

Figure 14: Frost Days - Past

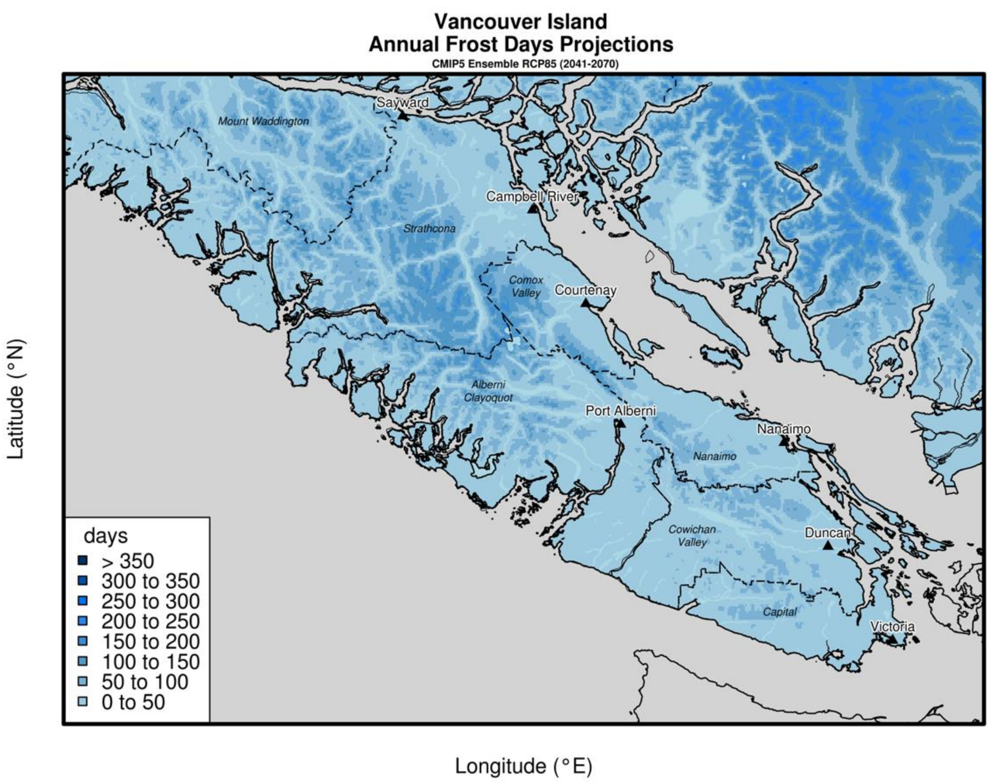

Figure 15: Frost Days – Future (2050s)

2.4 Ice Days

About this indicator: Ice days refers to the number of days when the daily maximum temperature does not exceed 0°C.

Projections:

- In the past, there were approximately 2-3 ice days a year, on average.
- By the 2050s there will be a very low chance of an ice day, and by the 2080s, temperatures will almost never remain below freezing all day.

Table 10: Ice Days

		Past	2050s (days)		2080s (days)	
		(days)	Average	Range	Average	Range
Region 1	Southern Gulf Islands (CRD)	3	1	(0 to 2)	0	(0 to 1)
	Saltspring Island	3	0	(0 to 2)	0	(0 to 1)
Region 2	Gabriola & Thetis Islands	2	0	(0 to 1)	0	(0 to 0)
Region 3	Howe Sound	3	1	(0 to 2)	0	(0 to 1)
Region 4	Northern Gulf Islands	2	0	(0 to 1)	0	(0 to 0)

Note: The maps were not useful for this measure, as the degree of change was too small to be viewed for this region.

Precipitation Indicators

3.1 Seasonal Precipitation

About this indicator: Seasonal precipitation is all precipitation summed over the season, including rain and snow water equivalent. This is a high-level indicator of how precipitation patterns can be expected to change.[6]

Projections:

- The past summer precipitation total was about 80 mm for the Southern Gulf Islands, and between 100 – 200mm for the other regions.
- For the Southern Gulf Islands, summer precipitation will decrease by approximately 20% (to ~70 mm) in the 2050s and by 27% (to ~61 mm) in the 2080s.
- For the Southern Gulf Islands, Fall precipitation will increase by approximately 15% in the 2050s and by 25% in the 2080s.

Table 11: Seasonal Precipitation for Region 1: South Gulf Islands (CRD)

	Past (mm)	2050s (Percent change)		2080s (Percent change)	
		Average	Range	Average	Range
Summer	84	-19%	(-44 to 3)	-27%	(-51 to -5)
Fall	272	13%	(5 to 29)	24%	(9 to 47)
Winter	388	4%	(-2 to 12)	15%	(2 to 27)
Spring	174	7%	(-5 to 15)	10%	(-1 to 25)

[6] Seasons refer to Summer (June, July, August), Fall (September, October, November), Winter (December, January, February), Spring (March, April, May).

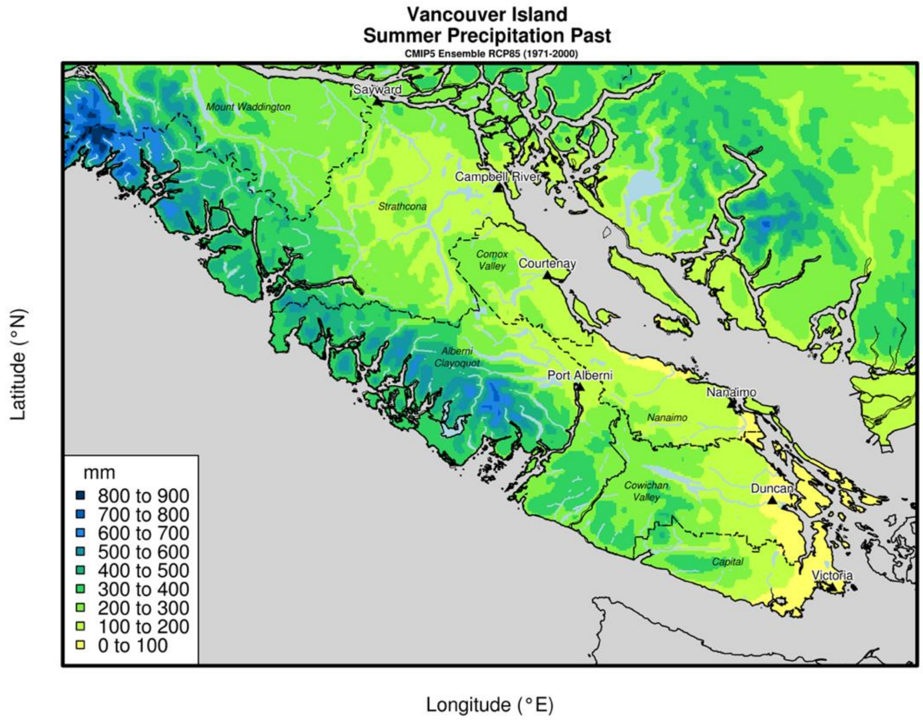

Figure 16: Summer Precipitation - Past

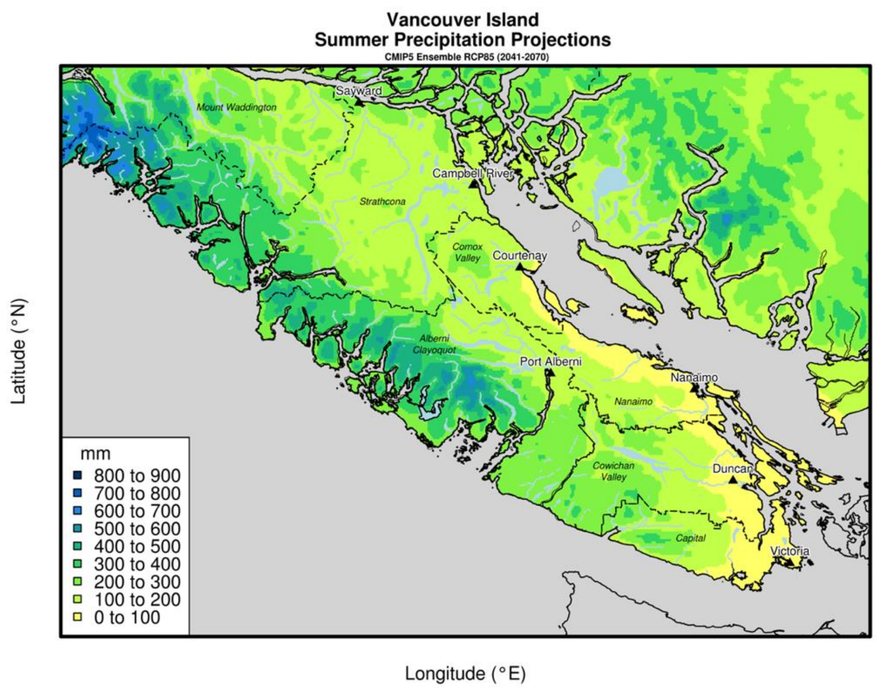

Figure 17: Summer Precipitation – Future (2050s)

Note that for the other seasons, maps are not shown as they do not show interpretable changes within the Islands Trust Area as the scale of the maps is too large relative to that of predicted changes.

3.2 Maximum 1-Day Total Precipitation

About this indicator: Single-day annual maximum precipitation describes the amount of precipitation that falls on the wettest day of the year, on average.

Projections:

- The wettest single day of the year will see an average of 15% more rain by the 2050s, and up to 35% more by the 2080s for the Southern Gulf Islands.
- Howe Sound and the Northern Gulf Islands will see an approximate increase of just over 10% by the 2050s, on average, and approximately 15% by the 2080s.
- The southern portion of this Area will see a larger percentage change in precipitation than the northern.

Table 12: Maximum 1-Day Total Precipitation

		Past (mm)	2050s Average (mm)	2050s Range (mm)	2050s Percent change	2080s Average (mm)	2080s Range (mm)	2080s Percent change
Region 1	Southern Gulf Islands (CRD)	42	49	(43 to 58)	17%	56	(47 to 64)	35%
	Saltspring Island	42	49	(39 to 76)	17%	51	(42 to 60)	21%
Region 2	Gabriola & Thetis Islands	41	47	(34 to 71)	15%	50	(38 to 57)	22%
Region 3	Howe Sound	70	77	(60 to 107)	10%	83	(63 to 106)	18%
Region 4	Northern Gulf Islands	60	68	(48 to 89)	13%	67	(53 to 89)	12%

3.3 Maximum 5-Day Total Precipitation

About this indicator: Five-day annual maximum precipitation describes the largest amount of rain that falls over a period of 5 consecutive days in the year.

Projections:

- The wettest five-day total precipitation event in the summer will see a decrease in rain of approximately 7% by the 2050s, and 8% more by the 2080s;
- The wettest five-day total precipitation amount in Fall will increase by approximately 15% in 2050s and 35% in the 2080s.

Table 13: Maximum 5-Day Total Precipitation for Region 1: Southern Gulf Islands

	Past (mm)	2050s			2080s		
		Average (mm)	Range (mm)	Percent Change (%)	Average (mm)	Range (mm)	Percent Change (%)
Summer	29	27	(20 to 31)	-7	26	(18 to 31)	-8
Fall	70	81	(67 to 105)	16	93	(79 to 111)	33
Winter	83	89	(85 to 95)	7	97	(84 to 105)	17
Spring	42	47	(38 to 54)	12	49	(43 to 54)	16

3.4 1-in-20 wettest day

About this indicator: The 1-in-20 wettest day is the day so wet that it has only a 1-in-20 chance of occurring in a given year. That is, there is a 5% chance in any year that a 1-day rainfall event of this magnitude will occur. This indicator measures total annual precipitation during heavy precipitation events, which is a combination of both how often these events occur (frequency) and the size of these events (magnitude).

Projections:

- More precipitation is expected to fall during the 1-in-20 (or 5% chance) wettest day extreme storm events in the future. Larger 1-in-20 wettest day events could mean over 30% more rain falling during these events, on average, by the 2050s.
- There are expected to be more 1-in-20 day events in the future, which is indicated by the volume of precipitation.
- Note: Due to variability and timing of precipitation displayed through the seasonal precipitation indicator (3.1 above), more storms may not lead to more stormwater retention, groundwater and surface water recharge.

Table 14: 1-in-20 wettest day

		Past (mm)	2050s (mm)		2050s (Percent change)
			Average	Range	Average
Region 1	Southern Gulf Islands (CRD)	67	87	(65 to 119)	32%

3.5 Wettest Days

About this indicator: The 95th and 99th percentile wettest days precipitation indicator describes the number of days when precipitation exceeds a threshold set by the annual 95th (wettest days) and 99th (very wettest days) percentile of wet days during the baseline period (1971–2000). This measure indicates how many days will experience these heavy rain events, and very heavy rain days.

Projections:

- The amount of precipitation in 95th percentile wettest days will increase by approximately 30% by the 2050s, and 63% by the 2080s.
- The amount of precipitation in 99th percentile wettest days (the very wettest days) will increase by approximately 68% by the 2050s, and 138% by the 2080s.
- These increases are a product of more frequent heavy event days (more big storms), and wetter wet days (more rain falling during storms).
- It is likely that precipitation will be concentrated into the wettest days. The wettest days of the year could occur anytime from September to May. Historically, total precipitation has been highest in the winter months, but this may shift to the fall in the future.

Table 15: Region 1 - Southern Gulf Islands Wettest Days

	Past (mm)	2050s			2080s		
		Average (mm)	Range (mm)	Percent Change (%)	Average (mm)	Range (mm)	Percent Change (%)
Wet Days (R95P)	201	260	(206 to 317)	30	327	(281 -386)	63
Very Wet Days (R99P)	62	102	(71 to 137)	68	145	(108 - 200)	138

3.6 Dry Spells

About this indicator: Dry spells are a measure of the number of consecutive days where daily precipitation is less than 1 mm. The value denotes the longest stretch of dry days in a year, typically in summer. This number does not indicate extreme droughts, as it is averaged over the 30-year period.

Projections:

- Dry spells lasted between 20 and 30 days in the past, on average.
- Dry spells will increase to 30 – 35 days by the 2050s for the Southern Gulf Islands region, and to approximately 37 days by 2080s, on average.

Table 16: Region 1 - Southern Gulf Islands (CRD) Dry Spells

		Past (days)	2050s (days)		2080s (days)	
			Average	Range	Average	Range
Region 1	Southern Gulf Islands (CRD)	27	33	(29 to 38)	37	(31 to 43)
Region 1	Saltspring Island	(25 – 30)	(30 – 35)	n/a	n/a	n/a
Region 2	Gabriola & Thetis Islands	(25 – 30)	(30 – 35)	n/a	n/a	n/a
Region 3	Howe Sound	(20 – 25)	(20 – 25)	n/a	n/a	n/a
Region 4	Northern Gulf Islands	(20 – 25)	(20 – 25)	n/a	n/a	n/a

Note: Site specific data is not available for this indicator from climatedata.ca. The range for Past and 2050s average values are calculated based off the maps below.

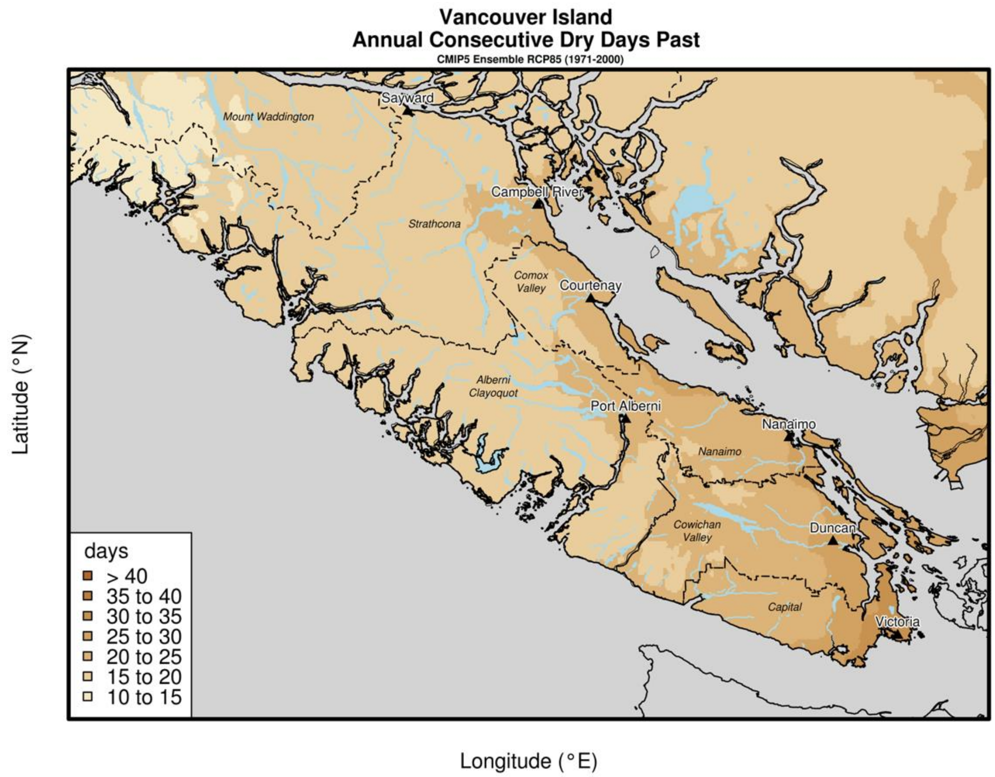

Figure 18: Dry Days - Past

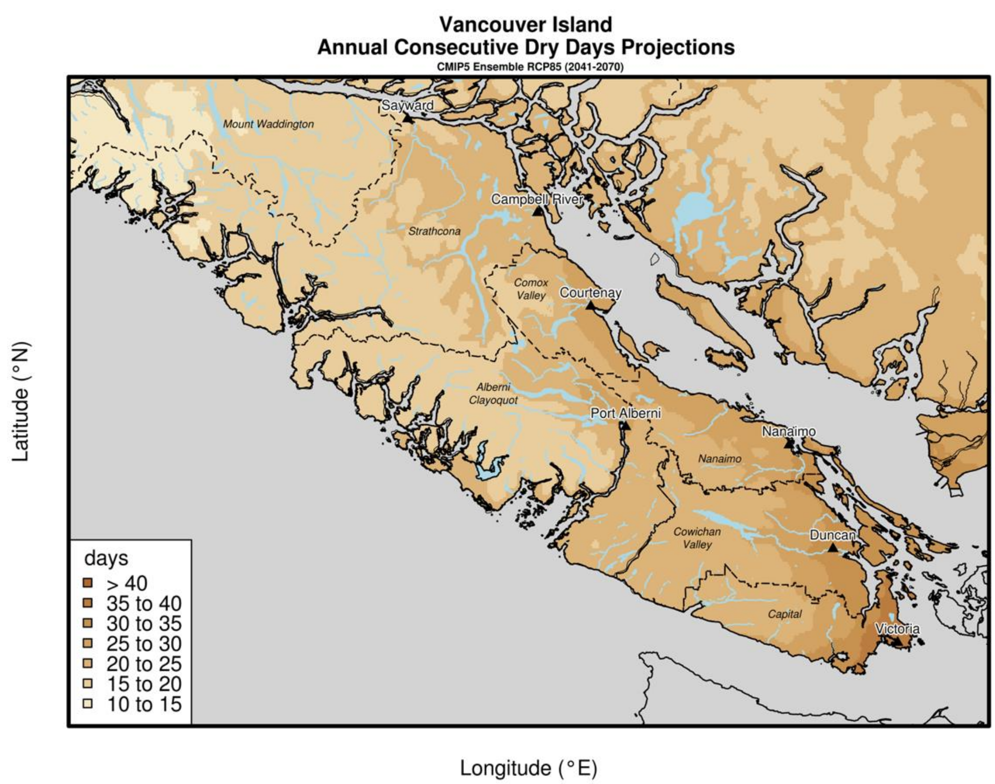

Figure 19: Dry Days - Future (2050s)

Ocean Indicators

4.1 Sea Level Rise

About this indicator: Sea level rise identified for coastal B.C. reflects the combined impacts of climate change and vertical land movements. Relative sea-level changes are displayed below, and are the changes in sea level that are observed or experienced relative to the solid surface of the Earth. The coast of B.C. is still rising from a geological process called post-glacial rebound—the rising of land due to past thinning and retreat of the massive ice sheet that once covered much of the province. In addition, the shifting of the tectonic plates generates vertical land motion in coastal B.C. causing parts of Vancouver Island to rise, and subduction in the Georgia Strait. These factors result in a difference in sea level rise across the region.

Projections:[7]

- Recent technical guidelines published by the Provincial government projected a sea level rise of half a metre by the year 2050, one metre by 2100 and two metres by 2200. Detailed local projections are offered in the bullets below.
- The past sea level rise varied from -0.3cm in North Saanich to 0.8cm in Vancouver.
- There will be an increase in sea level rise to between 15 and 20 cm in the 2050s, to between 34 and 42 cm in the 2080s.[8]

Table 17: Sea Level Rise

	Past 2007 (cm)	2050s (cm)		2080s (cm)	
		Average	Range	Average	Range
North Saanich	-0.3	15	(5 to 25)	34	(13 to 54)
Vancouver	0.8	20	(10 to 30)	42	(21 to 62)

Note: The table above is based on relative sea-level projections, for more information see James et al., 2015, report referenced in footnote 7 below.

[7] Sea level past level and projected rise is sourced from James et al, 2015. For more information see report: James, T.S., Henton, J.A., Leonard, L.J., Darlington, A., Forbes, D.L., and Craymer, M., 2015. Tabulated values of relative sea-level projections in Canada and the adjacent mainland United States; Geological Survey of Canada, Open File 7942, 81 p. doi:10.4095/297048.

4.2 Ocean Surface Temperatures

About this indicator: Ocean surface temperatures indicate the temperature in the top 100m of the ocean. Note that this indicator does not include local variability that may come from the influence of freshwater lenses on the ocean surface. For example, the Fraser River temperatures are predicted to increase and will likely have an impact on the east side of the Southern Gulf Islands, but this nuance is not included in this indicator.

Projections:

- The average global ocean surface temperature has increased at a rate of 1.1°C per century between 1971 and 2010, according to the Intergovernmental Panel on Climate Change (IPCC).[9]
- For the Strait of Georgia, the mean water temperature could be 1.5–3 °C warmer by the end of the 21st century.[10]
- Climate models project that average global ocean surface temperature will increase by 0.6°C to 2°C in the top 100m of the sea by the end of 2100. [11]

4.3 Ocean Acidification

About this indicator: Ocean acidification is the ongoing decrease in the pH of the ocean due to uptake of Carbon Dioxide from the atmosphere.

Projections:

- There is an overall global trend towards decreasing pH levels in the oceans, resulting in acidification.
- Since the industrial revolution, ocean pH has dropped from 8.2 to 8.1, and is expected to decrease to an average of ~7.7 pH level by 2091-2100.[12]

[9] Intergovernmental Panel on Climate Change. 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WGIAR5_SPM_brochure_en.pdf

[10] Riche O, Johannessen S, Macdonald R. 2014. Why timing matters in a coastal sea: Trends, variability and tipping points in the Strait of Georgia, Canada. Journal of Marine Systems. 2014 vol: 131 pp: 36-53. https://www.sciencedirect.com/science/article/pii/S092479631300225X

[11] British Columbia Ministry of Environment. (2016). Indicators of Climate Change for British Columbia: 2016 Update. Ministry of Environment, British Columbia, Canada.

[12] Canadian Centre for Climate Modelling and Analysis, Environment Canada, 2013.

4.4 Ocean Deoxygenation

About this indicator: Ocean deoxygenation is the expansion of oxygen minimum zones in the world's oceans as a consequence of anthropogenic emissions of carbon dioxide.

Projections:

- Research published in 2014 projects declining dissolved oxygen levels for the Northeast Pacific Ocean.[13]
- This century, dissolved oxygen is expected to decrease in the global ocean by 1–7%.[14]
- Changes to oxygen levels are occurring rapidly in the North Pacific Ocean, where oxygen has already decreased by 22% at depths of between 100 and 400 m during the last 50 years.[15]
- In the North Pacific Ocean, oxygen has decreased at a rate of 0.39–0.70 µM $year^{-1}$ or an integrated rate of 123 mmol m^{-2} $year^{-1}$. Canada's Pacific coast has experienced loss rates of 0.5 to 1.0 µM per year measured below the surface mixed layer.[16]

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[13] T.A. Okey, H.M. Alidina, V. Lo, S. Jessen, Effects of climate change on Canada's Pacific marine ecosystems: a summary of scientific knowledge, Rev Fish Biol Fisheries. 24 (2014) 519–559. doi:10.1007/s11160-014-9342-1.

[14] Keeling RF, Kortzinger A, Gruber N (2010) Ocean deoxygenation in a warming world. Ann Rev Mar Sci 2:199–229. doi:10.1146/annurev.marine.010908.163855

[15] Batten S, Chen X, Flint EN, Freeland HJ, Holmes J, Howell E, Ichii T, Kaeriyama M, Landry M, Lunsford C, Mackas DL, Mate B, Matsuda K, McKinnell SM, Miller L, Morgan K, Peña A, Polovina JJ, Robert M, Seki MP, Sydeman WJ, Thompson SA, Whitney FA, Woodworth P, Yamaguchi A (2010) Status and trends of the North Pacific oceanic region, 2003–2008. In: McKinnell SM, Dagg MJ (eds) Marine ecosystems of the North Pacific Ocean, 2003–2008. PICES Spec Publ 4:56–105

[16] Crawford WR, Pena MA (2013) Declining oxygen on the British Columbia Continental Shelf. Atmos Ocean 51(1):88–103. doi:10.1080/07055900.2012.753028

Regional Impacts

The projected changes to the climate presented throughout this summary report will have multiple impacts on the Islands Trust Area. This section provides an overview of the types of impacts we can expect as a result of the changing climate and is in no way an exhaustive snapshot of impacts. The impacts were gathered from a meeting with Islands Trust Conservancy staff, and research from neighbouring regions with similar ecological impacts.[17] Climate change will impact the Islands Trust Area in complex ways, as species that reside here are part of an interdependent system. Species may experience benefits from one change and stress from another and the variability and instability of climatic factors will stress all species and ecosystems.

Expected Impacts to Ecosystems and Biodiversity

The changing climate will create undue stress to ecosystems and species which will ultimately impact biological diversity, species ranges and species health. Due to increased variability and higher temperatures, the Islands Trust Area can expect strains to sensitive habitats. Further, warmer temperatures will increase the likelihood of spread of invasive species and pests and pathogens, all of which have the potential to compromise native species.

Significant impacts to aquatic, marine and terrestrial species will come as a result of the changing climate. The Islands Trust Area can expect to see new species migrating to the region. The region can also expect the presence and range of some species (e.g. Western redcedar) to decline and contract, respectively, as the local climate becomes less suitable, with the potential for other species, such as Garry oak, to expand their range.

Specific threats to ecosystems and biodiversity include:

Earlier springs and longer growing season

Early springs and a longer growing season may cause species' reproductive and biological cycles to be out of sync with new conditions. The timing of pollination may be negatively affected, causing changes to occur within insect populations, and impacting the fruiting of plants. Finally, the changing climate in spring could increase pests and the introduction and spread of disease. For example, invasive species such as House Sparrows, rats, and domestic rabbits may be able to raise greater numbers of successful young.

The ability of native and non-native plant species to change the timing of life-cycle events may alter the extent and outcome of invasive species spread as climate changes. Non-native species are typically better able to adapt their lifecycles to temperature changes than native species. For example, recent studies show that non-native plants are better able than native species to flower earlier in response to earlier warm temperatures. Climate change may therefore promote invasion success and population persistence.[18]

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[17] Cowichan Valley Regional District. (2017). Climate Projections for the Cowichan Valley Regional District. 46 pgs.

[18] For a recent field trial, see MA. Zettlemoyer, EH. Schultheis, JA. Lau. Phenology in a warming world: differences between native and non-native plant species. *Ecology Letters*, 2019; DOI: 10.1111/ele.13290

Warmer, drier summers

In general, the Islands Trust Area can expect to see a shortage of water during the summer months, increase in heat stress for plants, impacts on growth rates and a reduced quality of forage crops. Hotter, drier summers will increase risk of wildfires. This will result in ecosystem stress, stress of upland forest water-holding capacity, soil exposure, and erosion.

Increased summer temperatures could curb summer growing and, depending on precipitation patterns, result in a shift in growth to spring and fall with a potential dormant period in the summer due to drought. Further, the Islands Trust Area can expect stress on aquatic species due to decreased summer streamflow and warmer water temperatures, with potential severe consequences for freshwater aquatic invertebrates and fishes and estuaries. Warmer temperatures may increase invasive weed and algae growth, and will result in lower dissolved oxygen levels, putting further stress on important marine shoreline ecosystems such as eelgrass and kelp beds. Further, soil microfauna will be impacted, particularly fungi. We may see big shifts in the abundance and timing of mushrooms, and impacts to survival of different types of plants based on changes to their symbiotic relationships. The changes to moisture and temperature will also likely shift decomposition rates which will affect soils.

Changing precipitation regimes

Longer drought periods followed by more intense precipitation will significantly impact soil chemistry and capacity to absorb and retain water. As a result, the Islands Trust Area can expect increased risk of slope failure, overland flooding, streambank collapse, and the transport of silt to water bodies. Changes to water quality and levels will also likely result in:

- Scouring of streams could result of loss of eggs and juveniles (fishes, amphibians) and of larval stages of aquatic insects
- Reduced quality of drinking water, requiring additional chemical and filtration systems
- The loss of property as it sloughs away during large events
- Compromised soil conditions and root systems, increasing risk of tree blow-down.

Warmer, wetter winters

Warmer, wetter winters will increase demand on resources for species that typically overwinter on the Islands. The Islands Trust Area can anticipate a shift in migration patterns, with some migrating birds becoming year-long residents. Further, small mammals and snakes that typically hibernate may remain active. Changing activity patterns may cause shifts in predator prey relationships, for example, more fish and amphibian eggs may be eaten as demand for resources increases and predators are more active during winter.

Growth and development of plants is also likely to change. For instance, the season of algal blooms is likely to be extended. Both native and introduced plant species that typically require or experience dormancy may not go dormant. Life cycles of insects, both native and non-native, may be significantly altered, especially those that require one or more over-wintering stages. Additionally, cyclical species' death, for example of pests and pathogens that currently die or become inactive during the winter, may not occur as temperatures do not go below a certain level in winter.

It is important to note that the Islands Trust provides respite to tourists during the warmer winter months. Warmer winters may also shift tourism patterns, resulting in increased tourism in the winter, which may put more strain on ecosystems if the spectrum of use for natural spaces increases.

Warmer more acidic ocean conditions

Ocean acidification, as a result of warmer temperatures, will impact growth of nearshore species such as eelgrass beds, and kelp beds, as well as the ability of molluscs such as clams and oysters to make shells. Warmer more acidic ocean conditions will also increase algal blooms and affect the ability of deep water species, such as glass sponge, to thrive[19]. These stresses may change populations and movement patterns of keystone species such as eelgrass, bull kelp and sea stars, with potentially disproportionately large impacts to intertidal ecosystems, salt marshes and estuaries.

Increase in the intensity of storms combined with sea level rise

An increase in the intensity of storms, combined with sea level rise may result in loss of shoreline property. Further, salt water intrusion into freshwater can be expected, possibly increasing the presence of salt marshes but also shifting dynamics of estuaries and surface freshwater. Shoreline erosion will also create:

- Impacts to archeological sites
- Impacts to traditional harvesting such as loss of clam beds
- Impacts to trail management, access to beaches, restoration prescriptions, shoreline infrastructure (e.g. stairs)
- Increase in turbidity will impact eelgrass beds and kelp

[19] See article for more details: https://thetyee.ca/News/2018/05/08/Glass-Sponges-Climate-Change-BC-Ocean-Environment/

Recommendations

This summary report marks a first step for the Islands Trust Conservancy's pathway towards understanding and managing the challenges posed by the changing climate. Early recommendations that have come out of discussions with staff include:

- Take a no-regrets approach to climate action. The time for change is now.
- Explore further how key ecosystems and species will be impacted by the projected change in climate.
- Engage in new work to explore specific impacts as they pertain to each ecosystem and signature species. For example, Garry oak, Douglas-fir, wetlands, shoreline, intertidal, and riparian.
- Update property management policies and procedures as required to plan for management activities based on shifting cycles. For example, potential alteration of breeding timing for birds may require changes to the timing of management activities such as trail building and danger tree removal.
- Use this information in existing and future planning processes.
- Explore the best way to communicate the content of this summary report with various audiences, including the public and partners.
- Work with neighbouring regional districts to align research and work on climate change and climate action.
- Work with First Nations to gain insight into their climate change work and climate actions and look for opportunities to share resources and work together.