Ocean Warming: what's heating up the Sound?

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What is happening?

According to the National Oceanic and Atmospheric Administration (NOAA), 2019 was the second warmest year on record since 1880 (Figure 1). Globally, the average temperature from combined land and ocean surface was 0.95°C above the twentieth-century average.

The globally averaged ocean-only temperature for 2019 was 0.77°C above average, also the second highest year on record. Many of the major oceans, including the Pacific Ocean, had record high sea-surface temperatures recorded in 2019.[1] This pattern continues a trend that is being seen year after year. On average, Canada is warming at twice the speed of the rest of the world, with warming in Northern Canada occurring even faster.[2]

Diver on the Annapolis. (Credit: Eli Wolpin)

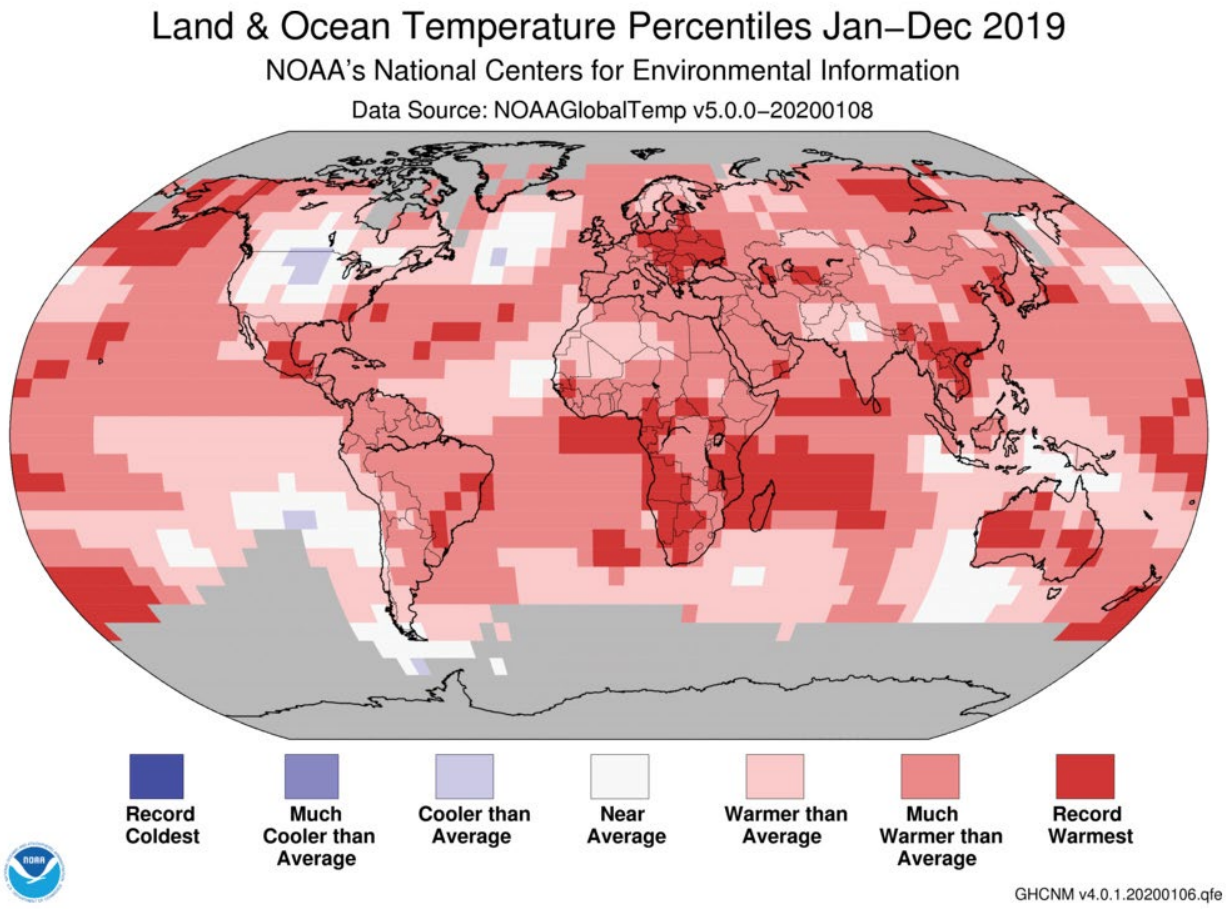


Figure 1. Land and ocean temperature percentiles from January to December 2019, compared to averages for the twentieth century. Source: NOAA National Centers for Environmental Information.

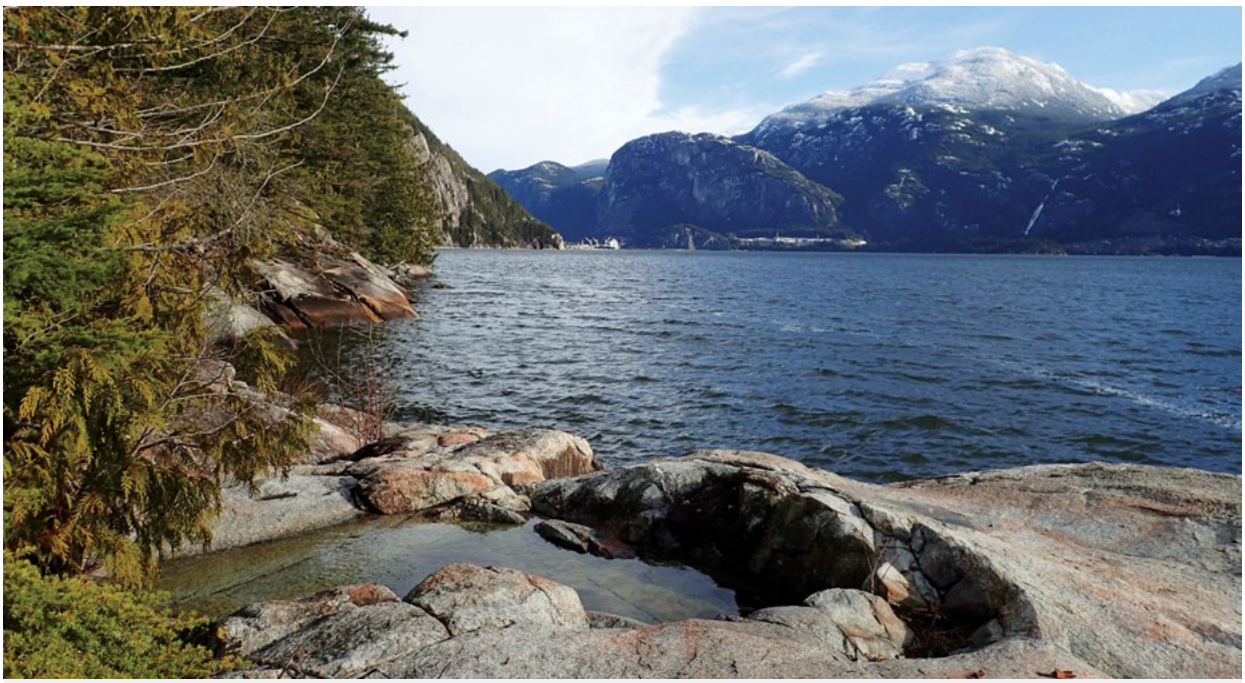
What is the current status?

Locally, there are two data sources relevant to identifying changes associated with ocean warming: 1) a weather buoy located in the Strait of Georgia; and 2) Squamish River flow data.[3] The weather buoy is maintained by Environment and Climate Change Canada, located on Halibut Bank in the Strait of Georgia. This buoy provides data on ocean warming relevant to the Átl'ka7tsem/Txwnéwu7ts/Howe Sound region. Since 1990, this buoy has provided, with some gaps, hourly sea surface temperature (SST) data, among other meteorological observations, e.g., air temperature. These 30 years of data have been analyzed to provide a yearly cycle of SSTs (upper panel, Figure 2) to examine how conditions at the boundaries of Átl'ka7tsem/Txwnéwu7ts/Howe Sound can influence the marine environment within the Sound.

Rarely do temperatures exceed the 90th percentile; in fact, on any given day, we would expect three exceedances to occur in 30 years. When the temperature of the 90th percentile is exceeded for five straight days, this is considered a marine heat wave and is an extreme condition, like a heat wave on land.[4]

Most marine heat waves over the last four years occurred in 2016 (lower panel, Figure 2), which can be attributed to the lingering influence of the 2013–2015 marine heat wave in the northeast Pacific, known as "The Blob" (see Resources). In 2017 and for the first few months of 2018, cooler ocean conditions prevailed. However, in the spring of 2018, another warm period occurred, with record high SSTs observed in the summer. These observations provide evidence of marine heat wave activity in the summer and fall of 2018, comparable to that seen in 2016 (lower panel, Figure 2). Warm periods also occurred throughout the spring and summer of 2019.

Marine heat waves affect the ecosystem structure because the associated changes to the environment may support some species and suppress others. Discussion of why ocean warming is important can be found in Ocean Warming, Ocean Watch Howe Sound Edition [OWHS] 2017.



Warming water temperatures have many impacts both below water and above water. (Credit: Tracey Saxby)

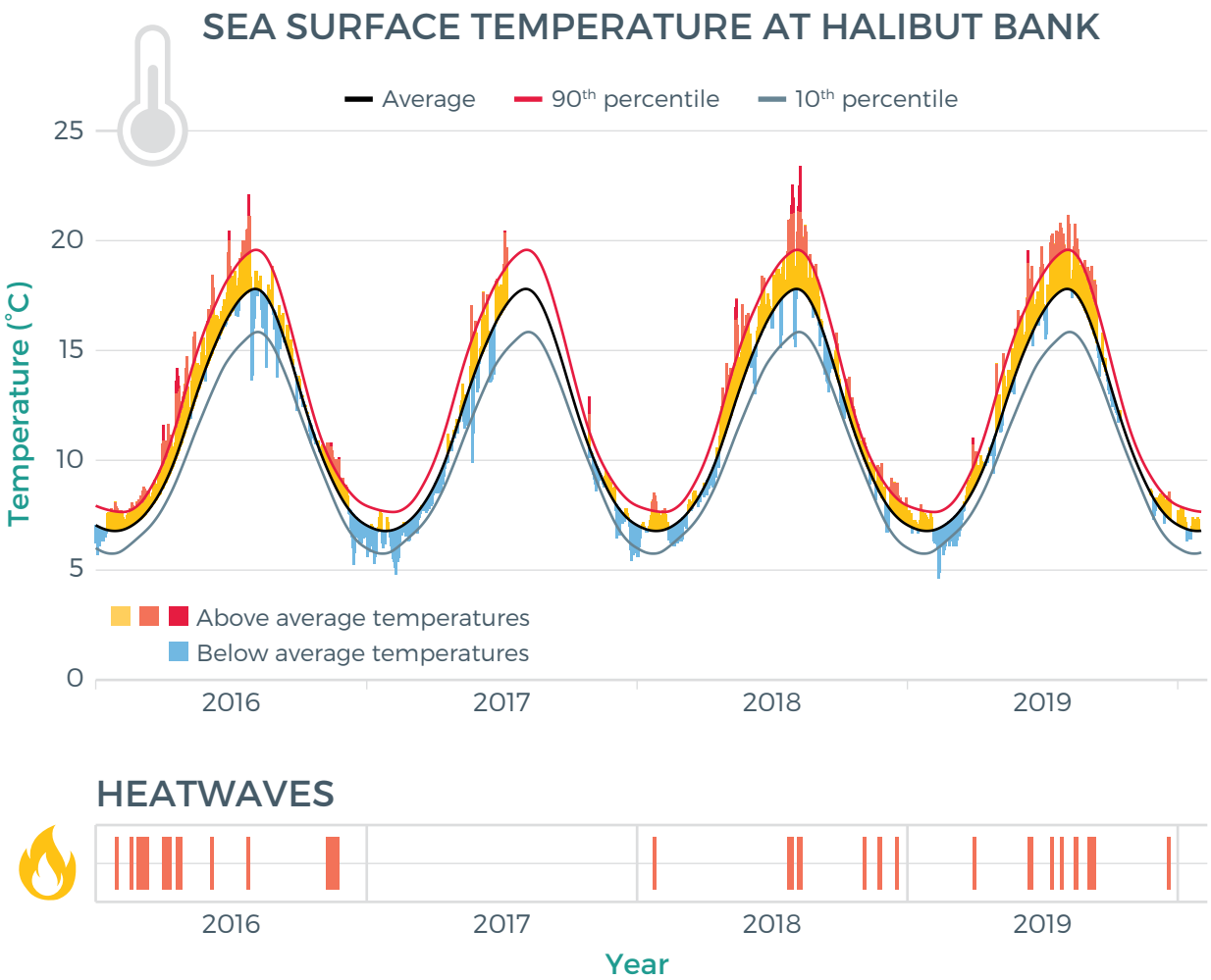


Figure 2. Upper panel: Daily sea surface temperatures (SSTs) recorded at Halibut Bank in the central Strait of Georgia since January 2016. Thirty years of data have been analyzed to provide a yearly cycle of SSTs, represented by the black line. The red line represents the 90th percentile. The blue line represents the 10th percentile. Thus, 80% of data falls in between the red and blue lines. Daily SST values that were higher than average from 2016 to 2019 are shown in yellow, orange and red. Daily SST values that were lower than average in this period are shown in blue. Note that there is some missing data in 2017 and 2019. Lower panel: Orange lines represent observed marine heat waves.

Additionally, the flow of fresh water into Átl'ka7tsem/Txwnéwu7ts/Howe Sound can influence its temperature. The Water Survey of Canada measures the flow of the Squamish River near Siyích'm/Brackendale, about 10 km from the head of Átl'ka7tsem/Txwnéwu7ts/Howe Sound. The Squamish River has the largest impact on this marine environment. It has a yearly discharge of 7.52 km^3, enough water to fill approximately three million Olympic sized swimming pools.

River discharge changes with the seasons, with the greatest flows seen in early summer as a result of snowmelt that occurs during the spring. The typical Squamish River discharge pattern (Figure 3) shows low flows in winter with a steep increase in April to July from the snowmelt, and a longer decline in summer through fall.

The freshwater discharge at the head of Átl'ka7tsem/Txwnéwu7ts/Howe Sound influences stratification of water in the Sound. Water discharged from the river is not salty, which allows it to float on top of the heavier, saltier ocean water. Factors that influence mixing of these two layers depend on both river and ocean conditions, which can change during storm events as well as seasonally and from year to year.

During periods of low river discharge, there is less fresh water entering the Sound, and thus there will be a thinner, less saline surface layer that is more easily mixed, especially in the winter when there is more storm activity. Under these circumstances, water temperature at the surface will be similar to that found at depth.

When mixing of these two layers due to winds or currents is weak, a surface layer develops that holds the heat from solar warming, creating conditions favourable for phytoplankton blooms. Changes in timing of phytoplankton blooms affect the base of the food chain, potentially impacting the whole ecosystem (see Plankton, OWHS 2017).

For 2016–2019, the water discharge hydrograph for the Squamish River near Siyích'm/Brackendale shows an early summer peak, consistent with the influences of snowmelt and spring runoff (Figure 3). Since 2016, the annual volume of water flowing into Átl'ka7tsem/Txwnéwu7ts/Howe Sound from the Squamish River has decreased. All four years show a lower than average flow during the summer and early fall, with significant rainfall events occurring in late fall and early winter. However, there is considerable variation between years because the flow is driven by snowmelt, which peaks in early summer, and precipitation, which tends to increase in the last three months of the year.

While the oceanographic processes that influence mixing in Átl'ka7tsem/Txwnéwu7ts/Howe Sound are reasonably well understood, the factors that govern these processes are changing. The increasing water temperatures in the Strait of Georgia, and the early and rapid snowmelt that controls the Squamish River discharge, continue to challenge our ability to determine the environmental health of this region.

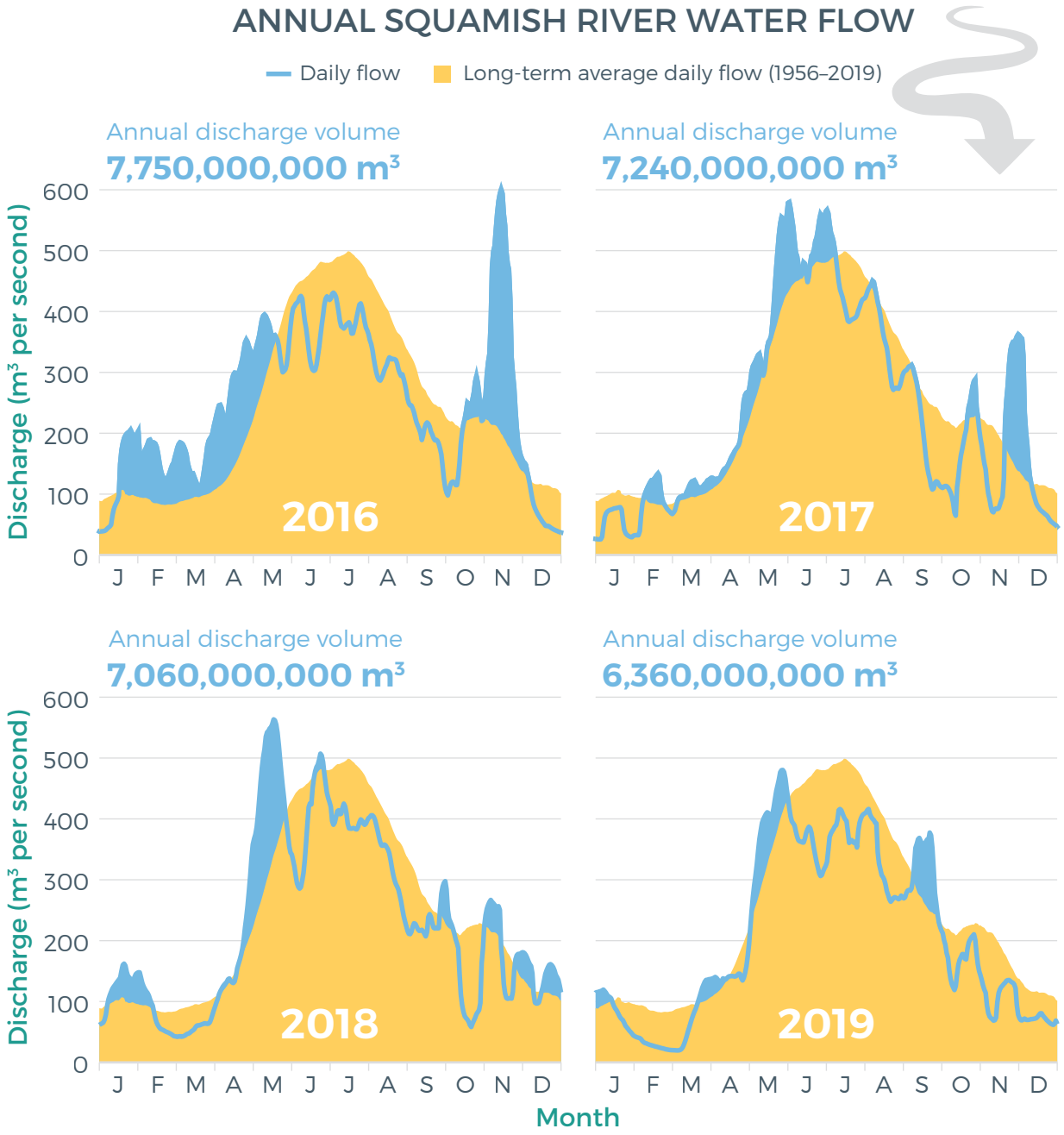


Figure 3. The water discharge hydrograph for the Squamish River near Siyích'm/Brackendale for the years 2016–2019 (blue); the orange area represents the long-term average daily discharge based on data since 1956[i].

i) The long-term average is based on data from 1956 up until the year prior to the year shown, i.e., for the 2016 graph, the long-term average was based on data from 1956 to 2015.

Thus, during periods of low freshwater discharge from the Squamish River (i.e., summer and early fall over 2016–2019), there would likely be a decrease in water mixing, potentially resulting in an increase in water temperature in the Sound. Conversely, the large rainfall events observed over these four years would have led to an increase in water mixing in the Sound. Simultaneously, marine heat wave activity has been seen in the summer and fall of 2016, 2018 and 2019 in the Strait of Georgia, which would influence the ocean temperature in Átl'ka7tsem/Txwnéwu7ts/Howe Sound. Together, these data indicate that the ocean temperature in Átl'ka7tsem/Txwnéwu7ts/Howe Sound has been warmer than average in recent years, which has implications for species and communities in the region.

What has been done since 2017?

The table below reports on progress made on recommended actions from the previous 2017 article, where identified. Many of these require ongoing action.

2017 ACTION	ACTION TAKEN
INDIVIDUAL AND ORGANIZATION ACTIONS	
Help prevent climate change by producing fewer greenhouse gases. Adopt policies and practices within your organization.	There is little data available on an individual level. However, incentives to decrease the costs of electric vehicles are available in B.C. https://pluginbc.ca/incentives/vehicle-incentives/#izev
GOVERNMENT ACTIONS AND POLICY	
Protect any cold water "refugia" within rivers. Strengthen regulations that protect riparian areas along streams to keep warming to a minimum.	Squamish River Watershed Society, together with DFO and Sḵwx̱wú7mesh Úxwumixw/Squamish Nation, have carried out revegetation in the Squamish estuary area. West Vancouver Streamkeepers, Squamish Streamkeepers, and Bowen Island Fish and Wildlife Club all carry out habitat restoration on salmonid streams. Some funding for some of these groups comes from various government organizations.

What can you do?

A detailed overview of recommended actions relating to climate change is included in *The path to zero carbon municipalities* (OWHS 2020). In some cases, no progress was identified on previous recommended actions; these remain listed below. Additional actions marked as NEW also follow.

Individual and Organization Actions:

- Eat sustainable seafood to foster healthy and resilient fish populations.
- NEW Support political action to reduce fossil fuel impacts (use and technology).

Government Actions and Policy:

- Incorporate latest climate change hazard assessments into emergency response planning.
- Implement the Wild Salmon Policy as it recognizes that diversity among salmon populations will be critical in helping salmon populations adapt to future climate conditions.
- NEW Fund protection and revegetation of riparian areas to create shade along streams, helping to keep warming to a minimum.
- NEW Fund continual monitoring of ocean temperatures.

Methods

Global data were accessed from the NOAA website (see References). Sea surface temperature data specific to the Átl'ka7tsem/Txwnéwu7ts/Howe Sound region were accessed via a weather buoy located on Halibut Bank in the Strait of Georgia, operated by Environment Climate Change Canada. Flow data for the Squamish River were accessed via the Water Survey of Canada website.

Resources

This list is not intended to be exhaustive. Omission of a resource does not preclude it from having value.

El Niño patterns contributed to a long-lived marine heat wave in the North Pacific. 2016. Available at: https://swfsc.noaa.gov/news.aspx?ParentMenuId=54&id=21991 Accessed August 9th 2019.

Ocean heat waves like the Pacific's deadly "Blob" could become the new normal. 2019. Available at: https://www.sciencemag.org/news/2019/01/ocean-heat-waves-pacific-s-deadly-blob-could-become-new-normal Accessed August 12th 2019.

References

1 NOAA. State of the Climate: Global climate report – September 2019 [Internet]. 2019. Available from: https://www.ncdc.noaa.gov/sotc/global/201909

2 Bush E, Lemmen D. Canada's Changing Climate Report [Internet]. Ottawa: Government of Canada; 2019. p. 444. Available from: www.ChangingClimate.ca/CCCR2019 ISBN: 978-0-660-30222-5

3 Environment and Natural Resources Canada. Discharge for Squamish River near Brackendale (08GA022) [Internet]. Water survey of Canada. 2019. Available from: https://wateroffice.ec.gc.ca/report/historical_e.html?stn=08GA022

4 Hobday AJ, Alexander L V., Perkins SE, Smale DA, Straub SC, Oliver ECJ, et al. A hierarchical approach to defining marine heatwaves. Prog Oceanogr. 2016;141:227–38.