# State of the Physical, Biological and Selected Fishery Resources of Pacific Canadian Marine Ecosystems in 2023

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# 7. LAND TEMPERATURE AND HYDROLOGICAL CONDITIONS OVER B.C. IN 2023

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## 7.1. Highlights

- In 2023, B.C. experienced record warm annual, summer and fall temperatures and well below-normal annual precipitation.
- Snowpack was generally below-normal through the winter, rapidly decreasing to well below-normal by June 1st due to early snowmelt across the province.
- In late summer and fall, severe drought conditions were experienced nearly everywhere in B.C., coinciding with record warm temperatures and below-normal precipitation.
- The trend in annual mean temperature in B.C. is positive and can be distinguished from natural variability over the analyzed period, 1950-2023. Annual precipitation, however, exhibits no significant trend over that period.

## 7.2. Introduction

Temperature and precipitation can provide valuable insight into seasonal conditions in B.C. that have important impacts on B.C.'s coastal waters in the Pacific Ocean. This section describes the seasonal evolution of weather and snowpack conditions across B.C. in 2023 to help complement information from coastal and oceanic data analyses. In this effort, we use monthly temperature and precipitation pseudo-observations from a global atmospheric reanalysis and both manual and automated monthly measurements of snow water equivalent from the B.C. River Forecast Center.

## 7.3. Description of the data

### *7.3.1. Temperature and Precipitation*

Observations of temperature and precipitation made at B.C. weather stations have been compiled on an ongoing basis since 2010 under the Climate Related Monitoring Program (CRMP). The dataset consists of observations from the CRMP partners: the provincially run networks, BC Hydro, the Capital Regional District, Metro Vancouver, and Rio Tinto. The dataset also includes data from Environment Canada's observing network and, in aggregate, spans the years 1872 to present. Due to a combination of factors (staffing changes at PCIC and unanticipated delays in the transfer of data from certain networks), the spatial coverage of the station dataset for 2023 was insufficient for its exclusive use in this year's analysis. Instead, we made use of the fifth generation European Centre for Medium-range Weather Forecasting Atmospheric Reanalysis Product (ERA5), which offers a gridded representation of the historical climate spanning 1950 to present at a horizontal resolution of approximately 30 km x 30 km over the globe.

Long-term records of mean monthly temperature and precipitation were used to calculate 30-year climate normals for each month of the year during the 1981 to 2010 reference period. Anomalies in monthly temperature and precipitation were then computed relative to these

normals for the entire 1950 to 2023 time series covering B.C. The time series of gridded anomalies were then spatially divided among the B.C. River Forecast Centre's 23 Snow Index Basin regions. Spatial averages were then taken across each region to form a monthly time series of regional anomalies. The monthly data were also aggregated into seasons and annual values to assess the longer time scale fluctuations in temperature and precipitation and to rank the anomalies by year. An example of the resulting annual anomaly data is shown in Figure 7-1 for annual mean temperature (left panel) and precipitation (right panel). The temperature and precipitation anomalies are expressed as percentiles among the number of observed seasons or years in the sample. We define the first percentile and number 1 ranking as the warmest/wettest over the 74-year period of 1950 to 2023 and the highest percentile as the coldest/driest with a ranking of 74. We define broad anomaly categories ranging from record cold/record dry, much below-normal, below-normal, near normal, above-normal, much above-normal, record warm/record wet. These categories are defined by the percentile bins 100th, 100th to 90th, 90th to 66th, 66th to 33rd, 33rd to 10th, 10th to 1st, and 1st.

### *7.3.2. Snow*

Monthly measurements of snowpack are made by the Ministry of Environment and Climate Change Strategy and BC Hydro through manual snow surveys and automated snow weather stations across the province. In addition, the Ministry of Forests River Forecast Centre compiles monthly snowpack data from early January through June. Snowpack in regions is compared with data from previous years to determine how the current year's accumulated snow amount compares with historical expectations. Historical data are available from 1997-2023. This is important because in most basins, early spring snowpack dictates the added potential (or lack thereof) for riverine flooding during the late spring melt season.

## 7.4. Status and trends

### *7.4.1. Temperature and Precipitation*

In 2023, average annual temperature was record warm across B.C. relative to the 1950 to 2023 record (Figure 7-1, left). All basins ranked in the top 5, with most basins ranking as the warmest year since 1950. Annual precipitation anomalies were well below normal, especially in the south, with the province ranking 4th driest in the entire record (Figure 7-1, right). The Upper Fraser West, Nechako, and Skagit basins all experienced their record driest year since 1950. The Northwest was the only basin that had above normal annual precipitation.

Winter was the only season that had near normal temperature for B.C. Temperatures increased throughout the year, reaching above normal in the spring and record warm in the summer and fall. The Liard and Peace basins experienced their warmest summer on record, while all other basins ranked within the top 7 warmest summers. In the fall, most basins continued to rank in the top 7 warmest years, but a few basins in southern B.C. were slightly less warm with above normal temperature anomalies. Record warm temperatures and below normal precipitation throughout summer and fall prompted severe drought conditions over much of B.C. (see below).

Over the winter of 2022-2023, precipitation patterns were largely near normal over the province, with above normal precipitation seen in the Liard and North Thompson basins. Precipitation was below normal on Vancouver Island and the South Coast, and in most of the basins bordering the United States. By spring, most of the province was characterized by below normal precipitation: the Nechako, in particular, experienced its 4th driest spring on record. While most

of the basins bordering the United States were normal, the Northwest was unusually wet. Precipitation remained below normal for most of B.C. into the summer of 2023. The northwestern and southeastern basins bordering Alberta were normal, while Vancouver Island (4th driest), Haida Gwaii, and the Central Coast were well below normal. By fall, dry conditions spread to nearly all basins, with the exception of Haida Gwaii and Stikine (near-normal) and the Northwest which was anomalously wet (10th wettest). Eight basins recorded their 7th driest or drier fall season since 1950. Areas bordering the United States and Southern Alberta were slightly less dry, as were Vancouver Island and Skeena-Nass.

By the end of July, 84% of B.C. was rated Abnormally Dry or in Moderate to Exceptional Drought (Canadian Drought Monitor, 2023). This included 98% of B.C.'s agricultural lands. Moderate to Exceptional droughts persisted and increased to cover 88% of B.C. by the end of November. Most of the province experienced extreme low streamflow, low soil moisture, and a record-breaking wildfire season (Canadian Drought Monitor, 2023; BC Wildfire Service, 2023).

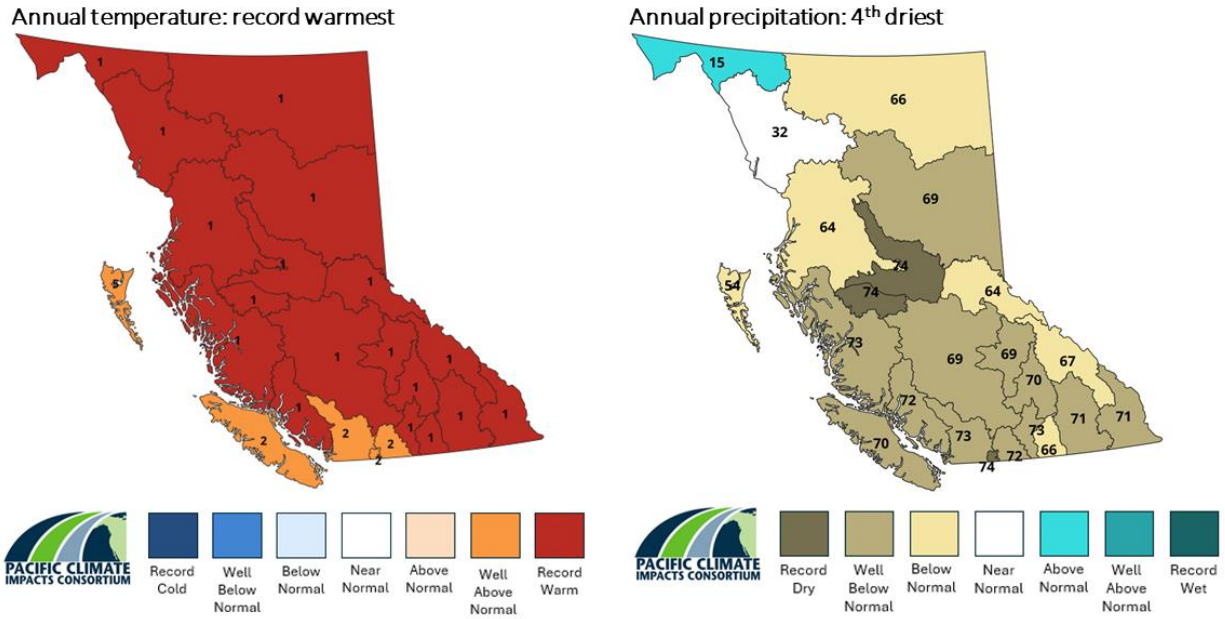


*Figure 7-1. Annual anomalies for average daily mean temperature (left panel) and total precipitation (right panel) for 2023 in B.C. Colour scale is based on percentiles as provided in the text. Labels on the map refer to ranking by year (1950 – 2023) with 1 being the warmest/wettest year and 74 being the coldest/driest year. Results are based on the ERA5 Reanalysis product from ECMWF, accessed via the KNMI Climate Explorer [https://climexp.knmi.nl/](https://climexp.knmi.nl/)*

Using the seasonal and annual temperature and precipitation anomalies, province-wide trends are calculated for the full ERA5 record spanning 1950 through 2023. Temperature trends are more easily detected due to the smaller spatial and interannual variability of temperature compared to precipitation data. The trends in mean daily temperature are positive and statistically significant ($p < 0.05$) annually and in all seasons (Table 7-1). The trends in precipitation are not statistically different from zero, except for a small decreasing trend in winter.

*Table 7-1. Linear trends in seasonal and annual daily mean temperature and total precipitation based on ERA5, spatially averaged over B.C. Only trends that are significant at the 5% significance level are shown.*

| Trends over 1950-2023 | ANN | MAM | JJA | SON | DJF |
|---|---|---|---|---|---|
| Mean Temperature (°C decade-1) | +0.37 | +0.35 | +0.35 | +0.26 | +0.45 |
| Precipitation (mm decade-1) | – | – | – | – | −22 |

### *7.4.2. Snow*

B.C.'s snowpack was below normal during the winter of 2022-2023, except at the end of the season when snowpack returned to near normal (March 1 was at 90-109% of normal). The Okanagan, Boundary, and Lower Thompson basins had above normal snowpack all winter (>110%; January 1st to May 1st), then rapidly decreased to < 50% of normal snowpack by June 1st. Due to above normal temperatures and below normal precipitation in the spring followed by record warm temperatures in the summer, early snowmelt occurred province wide. This led to an early melt freshet at the Fraser River at Shelley in the southern Peace Basin (M. Schnorbus, private communication) and high flows and flooding in the Central and Southern interior in May (River Forecast Center, 2023).

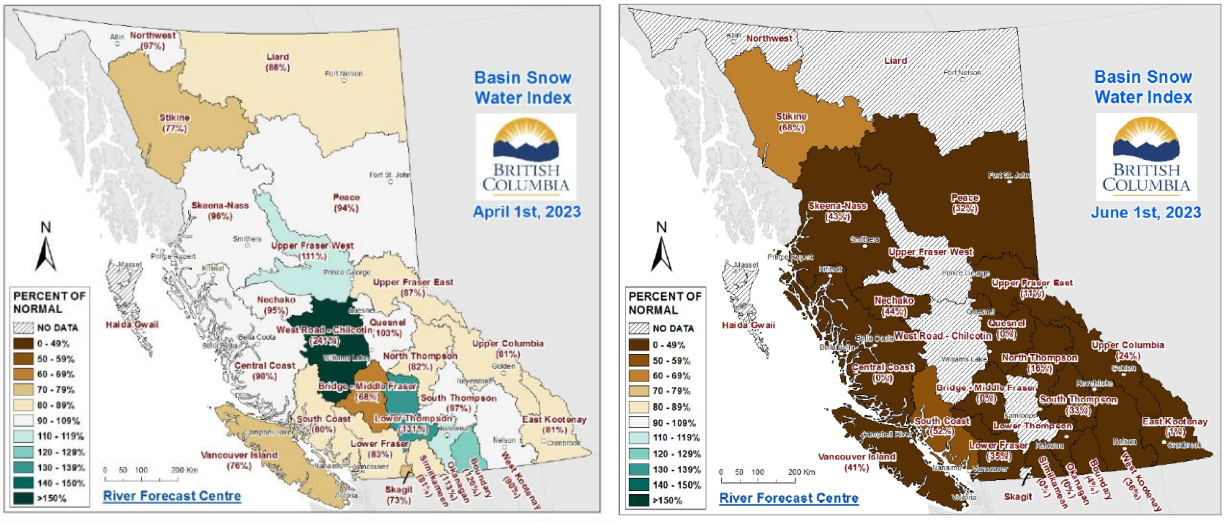


*Figure 7-2. Anomalies in B.C. snowpack for April (left) and June (right), 2023. Maps are produced by the B.C. Ministry of Forests River Forecast Centre (River Forecast Centre 2023).*

## 7.5. Factors causing trends and implications

In 2023, B.C. was record warm with well below normal annual precipitation. B.C. was warmer and drier than normal in all seasons except winter. Record-breaking temperatures occurred in the summer and fall for B.C. as a whole and specifically in the Liard (summer), Peace (summer), and Stikine (fall) basins. Precipitation was near normal in the winter and the province became drier throughout the year, with the most basins ranking well below normal in the fall. The combination of record-breaking temperatures and below normal precipitation led to severe drought conditions that persisted well into the fall. This coincided with a record-breaking wildfire season in 2023.

The observed anomalous temperatures in 2023 are consistent with ongoing warming in B.C., as indicated by trend analysis of the 1950 to 2023 record (Table 7-1). Annual mean temperatures in B.C. have risen by 0.37ºC decade$^{-1}$ on average over the last 74 years. B.C. followed global temperature trends with 2023 being the warmest year on record (Copernicus Climate Bulletin, 2024).

In 2023, ocean temperatures transitioned from a La Niña pattern into what became a strong El Niño in March of 2023. As El Niño is associated with above average temperatures and below average precipitation in B.C., this state change may have contributed to the early snowmelt and the temperature and precipitation patterns seen throughout the spring, summer, and fall.

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