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Canada's 2020 Report on Recent Pacific Salmon Abundance and Ecosystem Trends

by

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ABSTRACT

The planet is warming due to anthropogenic climate change. Climate change has emerged as a key overarching driver of changes in Canadian Pacific Salmon ecosystems, and the declining trends of many of these salmon species. Other factors that are contributing to salmon trends that include habitat changes, disease, invasive species are embedded within this overall climate change context. Catch for Canadian Pacific Salmon has been reduced significantly in recent decades to compensate for declines in salmon productivity and abundances. A number of these salmon populations are facing imminent threats of extinction, particularly in central to southern British Columbia.

CANADA'S PACIFIC SALMON TRENDS

Fisheries & Oceans Canada (DFO) manages five species of Pacific Salmon: Sockeye, Chinook, Coho, Chum and Pink. In 2020, Sockeye returns were poor, continuing the low abundance trends observed for this species in recent years, particularly in central to southern latitudes of British Columbia (BC) (Grant et al. 2019; NPAFC 2019; Grant et al. 2020; Hyatt et al. 2020). The last two years for Canadian Sockeye exhibited particularly low returns. Fraser Sockeye as one example, exhibited two record low return years in 2019 (486,000) and 2020 (292,000), compared to a long term average of 7.2 million from 1950 to 2020 (Grant et al. 2020). Sockeye populations in the Taku River of the Northern BC-Alaska transboundary region did not experience the same poor returns as other sockeye populations in 2020.

Total returns of Chinook in 2020 were again poor, which continued the recent trend of generally low abundances (Grant et al. 2019; NPAFC 2019). Some exceptions in 2020 included Chinook populations on the east coast of Vancouver Island. Coho marine survival remained low relative to the 1980s. Chum salmon generally exhibited poor returns in 2019 and 2020, in contrast with their recent positive trend (Grant et al. 2019; Grant et al. 2020). Pink salmon returns in 2020 were also mixed but generally better than other species. Pink salmon have also exhibited generally better trends over the past decade, particularly for odd year cycle lines (Grant et al. 2019; NPAFC 2019; Irvine et al. 2014).

A total of 21 Canadian Pacific salmon populations have been placed in DFO's poor (Red) status zone, using Fisheries & Ocean's (DFO) Canada's Wild Salmon Policy (WSP) methods (DFO 2015, 2016, 2018). Canada's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has independently assessed 26 of these populations as Endangered or Threatened, meaning they are facing an imminent threat of extinction (COSEWIC 2016, 2017, and 2018).

Catch for all five DFO-managed Pacific Salmon species (Sockeye, Chinook, Coho, Chum and Pink) have been reduced to compensate for declines in salmon returns in recent decades. Catch includes commercial, recreational and subsistence fisheries. Catch averaged 24 M from 1925–1993, and dropped to an average of 13 M from 1994-2014, and 4 M from 2015-2020. Catches in the last two years were extremely low, where the 2019 catch was 2 M and 2020 catch was three M (Figure 1).

GLOBAL CLIMATE CHANGE AND SALMON FRESHWATER AND MARINE ECOSYSTEM

The planet is warming (Figure 1) due to human-caused greenhouse gas emissions (IPCC 2014; IPCC 2018). Average land-ocean temperature has risen by 1°C over the last century (IPCC 2018), and the last six years were the warmest on record (NOAA 2020a). Global temperatures are projected to rise 1.5°C to 3.7°C above the 1850–1900 average by the end of this century. We are already approaching the 1.5°C global limit of warming that the IPCC recommends as critical if we are to avoid significant issues related to food, water, and other life support systems on the planet (IPCC 2014, 2018, UNEP 2019). Canada's warming is double the rate of the global average (Bush and Lemmen 2019).

Pacific salmon productivity and growth are impacted by this global climate shift through changes in their freshwater and marine environments (Holsman et al. 2018, IPBES 2018, Boldt et al. 2019, 2020, Bush & Lemmen 2019, Grant et al. 2019, 2020, 2021).

British Columbia warmed by 1.4°C between 1948 to 2016 (White et al. 2016), well above the global average. Correspondingly, river temperatures have been higher. For example, peak summer water temperatures in the Fraser River increased by greater than 1.8 °C in the forty years preceding 2010 (Patterson et al. 2011). Temperatures increasingly are exceeding upper thermal optimums for salmon in summer months, affecting upstream salmon migration, egg incubation and juvenile rearing (D. Patterson, personal communication, 2019) although exact exposures to warm temperatures vary by system and salmon population. Temperature effects on salmon have been compounded in recent years by early losses of snowpack in snow-dominated hydrological systems, and drought conditions. Increasing frequency of drought in recent years has lowered river flows, potentially blocking access to spawning habitat, stranding salmon, and increasing their exposure to predators.

Agriculture, mining, urbanization, forestry, and other human land-use activities have long been altering salmon freshwater habitats through deforestation and water extraction. This can lead to even warmer river temperatures, greater changes to river flows, and more erosion and landslides, than those caused by climate change alone (Pike et al. 2008, 2010; Cloutier et al. 2016). These habitat effects are more localized, and contribute to variability in the observed salmon trends across populations and CUs. For example, in recent years there have been several major landslides in Pacific Salmon watersheds that are further compounding the impacts of climate change on salmon populations (Guthrie et al. 2012, Gaboury et al. 2015; Government of B.C. et al. 2019, 2020). The Big Bar landslide on the Fraser River is particularly concerning, as it has blocked upstream access to critical Sockeye, Chinook, and Coho spawning areas since 2019. Work is on-going to remove this blockage, and monitoring of fish passage and health is being conducted (Government of B.C. et al. 2019, 2020).

Canadian Northeast (NE) Pacific Ocean coastal sea-surface-temperatures (SST's) increased linearly by 0.86°C over the past 100 years, resulting in changes to ocean conditions and marine food webs recently (Chandler et al. 2020, Boldt et al. 2020). Temperatures also increasing throughout the water column, down to the ocean bottom (Cheng et al. 2020). In addition, recent unprecedented marine heatwaves were present in the NE Pacific Ocean from late-2013 to 2021 (Ross 2017; Ross and Robert 2018, 2019, 2020; Hannah et al. 2019). These heat waves were characterized by temperatures that were 3-5°C above seasonal averages, and extended down to depths of 100 m (Bond et al. 2015). A strong El Niño event occurred in late 2015 to early 2016, further increasing temperatures during this period to the hottest observed throughout the 137-year time-series. In recent years (2020/21), a cooler La Niño event occurred, contributing to cooler coastal waters in BC/Yukon, though warmer heatwaves persisted in the broader NE Pacific.

Heatwaves are caused by global climate change, and are expected to increase in frequency, intensity, and extent of occurrence in the future (Frölicher et al. 2018; Cheung and Frölicher 2020; Laufkotter et al. 2020). These ocean conditions have negatively affected many physical and biological ocean processes relating to salmon growth and productivity.

Warm ocean temperatures may be harmful to salmon through their effect on zooplankton composition, a key pathway potentially linking reduced salmon productivity to temperatures in the NE Pacific Ocean (Mackas et al. 2007). Warmer temperatures cause shifts in the distribution of southern prey species northward, to occupy habitats previously too cold for them (Mackas et al. 2004). Shifts in salmon prey species composition have been observed in waters along the West and North Coast of Vancouver Island, and broadly in the NE Pacific. This includes shifts to smaller, lipid-poor, boreal copepod species, which dominated lower levels of the salmon food web in these warmer years (see Table 16-2 in Galbraith & Young 2019; Galbraith & Young 2020). These southern species are considered poorer quality food for salmon. In cooler years, larger, lipid-rich, boreal and subarctic copepods typically dominate zooplankton composition in the NE Pacific (Galbraith & Young 2020); these larger species are considered better quality food for salmon. Within the Strait of Georgia, where some Canadian salmon populations first enter the ocean, shift in zooplankton abundances have been linked to changes in ocean survival for Chinook and Coho species (Perry et al. 2021).

Changing ocean conditions may be further influenced by increases in salmon numbers rearing in the North Pacific, which may affect salmon growth and survival through density-dependent mechanisms (Ruggerone and Irvine 2018; Connors et al. 2020).

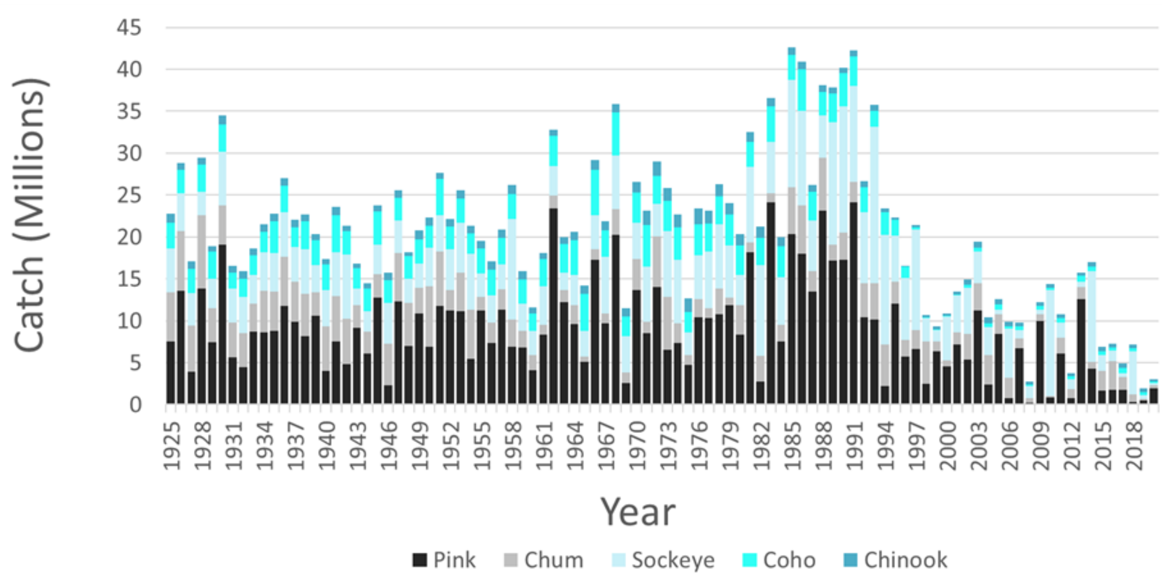

Figure 1. Commercial catch of Canadian Pink, Chum, Sockeye, Coho and Chinook Salmon (Grant et al. 2019c; NPAFC statitics: https://npafc.org/statistics/). Average catch from 1925–1993 was 24 million, from 1994–2014 was 13 million, and from 2014–2020 was five million.

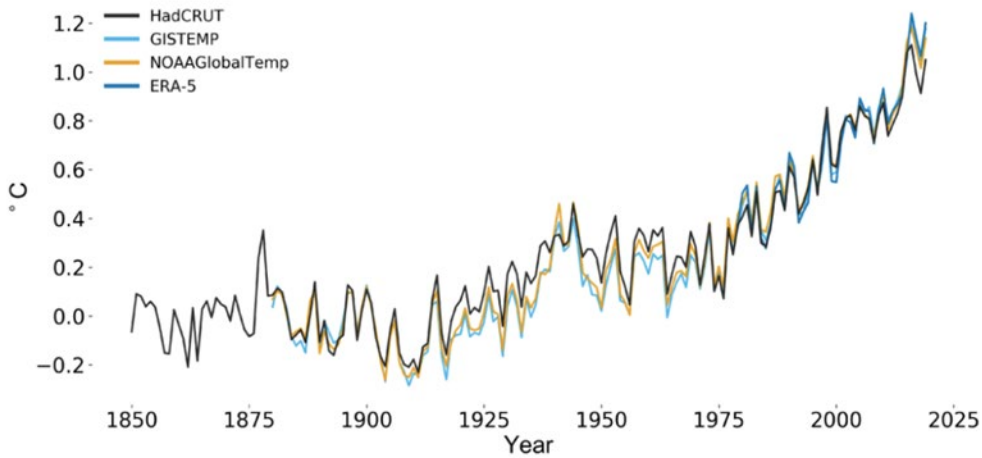

Figure 2. Global annual mean temperature difference from pre-industrial conditions (1850–1900). Canada's temperature increases are double this global rate of warming, typical of countries occupying northern latitudes.

Source: Met Office Hadley Centre and the Climatic Research Unit at the University of East Anglia, UK (HadCRU) presented in World Meteorological Organization, 2020. WMO Statement on the State of Global Climate Change in 2019 (WMO-No. 1248), Figure 1, Page 6).

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