Declines in mean body size have been identified in a wide range of exploited fishes, including several Pacific salmon species (REF). From a management perspective, such changes are particularly concerning if they result in reduced per-capita productivity (REF) or alter community dynamics (REF). Declines in body size are typically linked to reduced individual growth due to unfavorable environmental conditions (e.g. altered prey community, increased competition) or the removal of larger individuals in size-selective fisheries (REF). In the case of Pacific salmon, many populations have exhibited regionally coherent shifts in growth, age-at-maturity, and survival (REF), that are consistent with large-scale environmental drivers moderating interannual variation in traits such as body size. Unsurprisingly, identifying the specific conditions that drive this variability is of considerable interest, both as a means of improving forecasts and by bounding expected levels of future productivity.

Both bottom-up and top-down drivers may regulate salmon growth during marine residence. For example, changes in sea surface temperature may influence metabolic rate (REF), as well as the quantity and quality of prey available to salmon (REF). Salmon growth and survival is often associated with indices such as the Pacific Decadal Oscillation, North Pacific Gyre Oscillation, and ENSO, which integrate environmental conditions over relatively large spatial and temporal scales (REF). Although population-level responses to these temperature indices are regionally coherent, they often vary across the species range with northern populations responding positively to temperature increases and southern populations the opposite (REF). Wind stress indices, such as ALPI or upwelling metrics, may also be correlated with salmon growth by moderating nutrient transport to surface layers during winter and early spring (REF). Investigations into top-down effects are more limited and have largely focused on changes in the abundance of potential competitors during marine residence, which may result in density-dependent declines in growth or survival. In recent years, pink salmon abundance has garnered particular attention due to increased hatchery production that has been associated with reduced productivity and size-at-maturity across many Pacific salmon populations (REF).

Sockeye salmon spawning in British Columbia (i.e. the southern portion of the species’ range) have been the focus of much of this previous research due to widespread declines in productivity that have negatively impacted traditionally profitable commercial fisheries. On the whole, the productivity of these populations is negatively impacted by warmer ocean temperatures (REF), weak overwinter storms (REF), and abundant Alaskan pink salmon (REF), presumably due to reduced opportunities for marine growth. Yet predicting these populations’ response to future, potentially more extreme, environmental conditions is difficult. Even with the relatively long time series (more than 50 years) of stock-recruit data available for many sockeye salmon populations, it unclear whether they may exhibit non-linear responses to environmental processes that have been identified as important. Put more simply, are salmon dynamics normally regulated by factors such as sea surface temperature and interspecific competition or is this an artefact of rapid changes in these metrics?

To understand how sockeye salmon populations may behave in the future, we used a novel historical dataset to better understand how they responded in the past. Specifically we used age-structured, individual length data collected between 1914 and 1946 to examine two Pacific salmon populations’ response to abiotic and biotic drivers prior to widespread increases in sea surface temperature and hatchery propagation. These data originated from extensively sampled nearshore fisheries targeting Nass (northern British Columbia) and Rivers Inlet (central BC) sockeye salmon (*Oncorhynchus nerka*). Additionally we compare historical changes in Nass sockeye salmon body size to those observed in recent years using data collected during in-river sampling.

*Methods*

*Salmon data*

We used size data of individual salmon collected from two different sources. The first were compiled from Nass River and Rivers Inlet commercial gillnet fisheries operating between 1914 and 1946. These fisheries occurred in nearshore waters, with data collected (x). Returning adult sockeye salmon were sampled weekly and individual fork length (mm), weight (g), and sex were recorded. Although sampling occurred regularly from mid-June to late August in the majority of years, we excluded a subset of years due to insufficient sampling (Nass: 1915, 1920, 1922, 1924, 1938, 1945; Rivers Inlet: 1924, 1945). The second, contemporary dataset included data collected in the Nass Rivers fishwheel test fishery, operated by the Nisga’a First Nation between 1994 and 2017. Individuals were sampled daily and length and sex recorded. To account for differences in sampling location that would influence estimates of return timing, we assumed that individuals took seven days to travel from marine fishery locations to the fish wheel. This assumption is consistent with the Pacific Salmon Foundation’s Northern Boundary Sockeye Salmon run reconstruction model (REF).

Individual salmon were aged and scale annuli characteristics were used to distinguish between freshwater and marine residence using *x* nomenclature. For example, 1.2 individuals return to spawn 4 years after their parents spawn, having spent one year in the gravel, one year as a fry in freshwater, and two years at sea. Although a relatively large number of age classes were recorded, we constrained our analysis to dominant ages, i.e. those that were observed in every year in the historical dataset. For the Nass this included 1.2, 1.3, 2.2, and 2.3 individuals, while for Rivers Inlet only 1.2 and 1.3 individuals. Historical age data were generated by *x*, while contemporary aging analyses were conducted by Fisheries and Oceans Canada (1994-2004) or Alaska Department of Fish and Game (2005-2017) schlerochronology lab.

*Environmental data*

We tested the performance of a suite of environmental variables as predictors of changes in body size. Three of these are indices related to sea surface temperature. First, we incorporated monthly averages of raw sea surface temperature generated by… Interannual variability in sea surface temperature is often correlated with changes in the community composition of lower trophic levels (REF), as well as the growth and survival salmon (REF). We also included monthly indices of the Pacific Decadal Oscillation (PDO), the first principal component of variability in sea surface temperature poleward of 20°N (Mantua *et al.* 1997), retrieved from research.jisao.washington.edu/pdo/. The PDO captures long-term temperature trends, with positive anomalies frequently co-occurring with El Nino events (REF), as well as reduced salmon survival in southern regions and the opposite pattern among northern populations (REF). We generated a third monthly index using the second principal component of sea surface temperature variability poleward of 20°N (using the raw sea surface temperature data described above). Although less commonly used, this final index represents variation in temperature independent of the PDO that could represent anomalies with substantial biological impacts. The final abiotic covariate we incorporated was the Aleutian Low Pressure Index (ALPI), which represents the relative intensity of the low-pressure system centered over the north Pacific during winter (REF). ALPI reflects the relative intensity of both winter storms (REF) and the position of westerly winds (REF) that appear to moderate biological productivity by moderating spring upwelling (REF).

For each year we estimated the average from March to June, which represents the period

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M. & Francis, R.C. (1997) A pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society,* **78,** 1069-1079.