Many exploited marine fish species have exhibited considerable variation in body size through time, which can reduce fisheries yields (REF) and alter the dynamics of ecological communities (REF). Declines in mean body size may be linked to reduced individual growth due to unfavorable environmental conditions (e.g. altered prey community, increased competition) or fisheries that selectively remove larger individuals. Persistent changes in body size are well documented in Pacific salmon species, with previous studies identifying declines in the mean size of multiple Chinook and coho salmon populations. Although the mean size of many of these stocks has rebounded recently (Ricker paper, Jeffrey paper), such widespread changes in physical characteristics suggest that environmental conditions can constrain management actions intended to recover populations. Indeed salmon populations often exhibit coherent shifts in growth, age-at-maturity, and survival at large spatial scales (REFS). There is widespread interest in identifying the primary drivers of this variability as a means of improving natural resource management (e.g. bounding expected levels of population productivity (REF) and improving forecasts of recruitment).

In the case of Pacific salmon, previous studies examining interannual variation in size have focused on both bottom-up and top-down drivers. The first are physical processes that directly or indirectly regulate conditions for growth. These include basin-scale temperature indices such as the Pacific Decadal Oscillation, North Pacific Gyre Oscillation, and ENSO that represent multi-year trends, as well as direct observations of SST (REF). Increases in temperature may be correlated with declines in body size due to greater metabolic expenditure (REF) or changes in prey quantity and quality (REF). Wind stress indices may also be incorporated as a proxy for prey availability by representing changes in nutrient transport to surface waters. Investigations into top-down effects have largely focused on changes in the abundance of potential competitors during marine residence, which may result in density-dependent declines in growth. Increased pink salmon abundance due to enhancement appears to be a particularly consistent driver of declines in the growth and survival of several salmon species.

Pacific salmon populations within a region typically exhibit coherent responses to shared environmental drivers, with divergent patterns occurring across geographic boundaries. For example, responses to the timing of spring phytoplankton blooms, sea surface temperatures, pink salmon abundance, and inter-decadal oceanographic regimes consistently vary among Pacific salmon populations in northern and southern portions of their geographic ranges.

Such patterns can provide important clues about how salmon will respond to future environmental changes and

Most Pacific salmon species exhibit variation in age-at-maturity. While maturation schedules are likely influenced by genetic factors, there is also evidence to suggest individuals delay return migrations when growth conditions are poor. Therefore, increases in the proportion of individuals returning at older ages could obscure declines in marine growth rates.

Pacific salmon, like many other exploited fishes, exhibit considerable variability in size-at-maturity and abundance. Identifying the processes that drive this variability is of considerable interest to management, both as a means of improving forecasts and by bounding expected levels of future productivity.

Growth during marine residence plays a critical role in Pacific salmon population dynamics by moderating juvenile survival and size-at-maturity. Furthermore Pacific salmon populations often exhibit coherent trends in productivity, suggesting environmental processes occurring at relatively large spatial scales regulate interannual variation in survival or growth. Identifying and incorporating such processes into management actions may prove helpful, 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. For example, changes in sea surface temperature can influence metabolic rate (REF), as well as the quantity and quality of prey available to salmon. 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). Wind stress indices, such as ALPI, may also be correlated with growth by moderating nutrient transport to surface layers (REF). Investigations into top-down effects 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).

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