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# How will climate change affect estuarine nursery quality? Findings from a spatially explicit bioenergetics model in the Nisqually River Delta

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# HOW WILL CLIMATE CHANGE AFFECT ESTUARINE NURSERY QUALITY? FINDINGS FROM A SPATIALLY EXPLICIT BIOENERGETICS MODEL IN THE NISQUALLY RIVER DELTA

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## BACKGROUND & STUDY AREA

Climate change is expected to negatively affect estuarine nursery quality for juvenile salmon and other sensitive species. Sea-level rise, increasing ocean temperatures, and drought conditions in glacial and rain-fed systems will interact in complex ways to reduce the accessibility, complexity, and suitability of the estuarine habitat mosaic for juvenile fishes (Harley et al. 2006).

The Nisqually River Delta is a macrotidal estuary situated at the terminus of the Nisqually River between Olympia and Tacoma, Washington (47° 4′ 48″ N, 122° 42′ 20″ W ; Fig. 1). The Delta is comprised of numerous habitat types that vary in salinity, inundation frequency and duration, and vegetative cover (Ballanti et al. 2017, Davis et al. 2019). At the mouth of the delta, roughly 85 km of tidal channels wind through emergent salt marsh (5–30 psu), including 39 km of channels in subsided and sparsely vegetated restoring marsh habitat (Ellings et al. 2016).

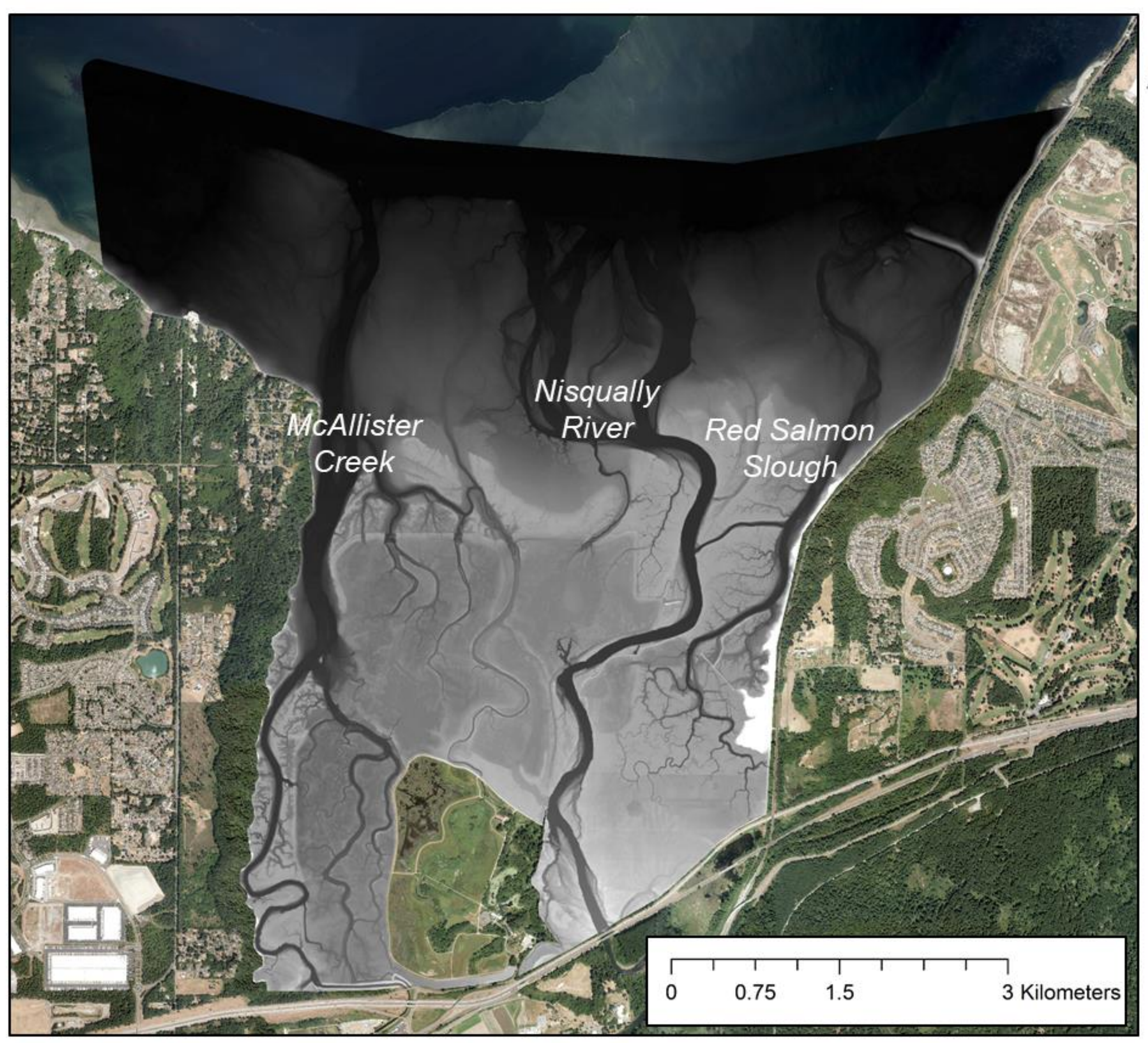


Figure 1. Map of the Nisqually River Delta, Washington. The grayscale DEM shows the spatial extent of the study area, for which growth was modeled for juvenile salmon from March 1 to July 31. Aerial imagery was flown in 2015 by GeoTerra Inc. (Eugene, Oregon).

## HOW WILL CLIMATE CHANGE AFFECT JUVENILE SALMON GROWTH IN THE NISQUALLY RIVER DELTA?

To answer this question, we integrated output from a marsh accretion model, a hydrologic model, and a spatially explicit bioenergetics model (Fig. 2). Based on previous research in the Delta, we hypothesized that juvenile salmon growth would be detrimentally affected by the loss of productive tidal marsh habitat and an increase in the amount of time water temperatures exceeded their thermal tolerance range.

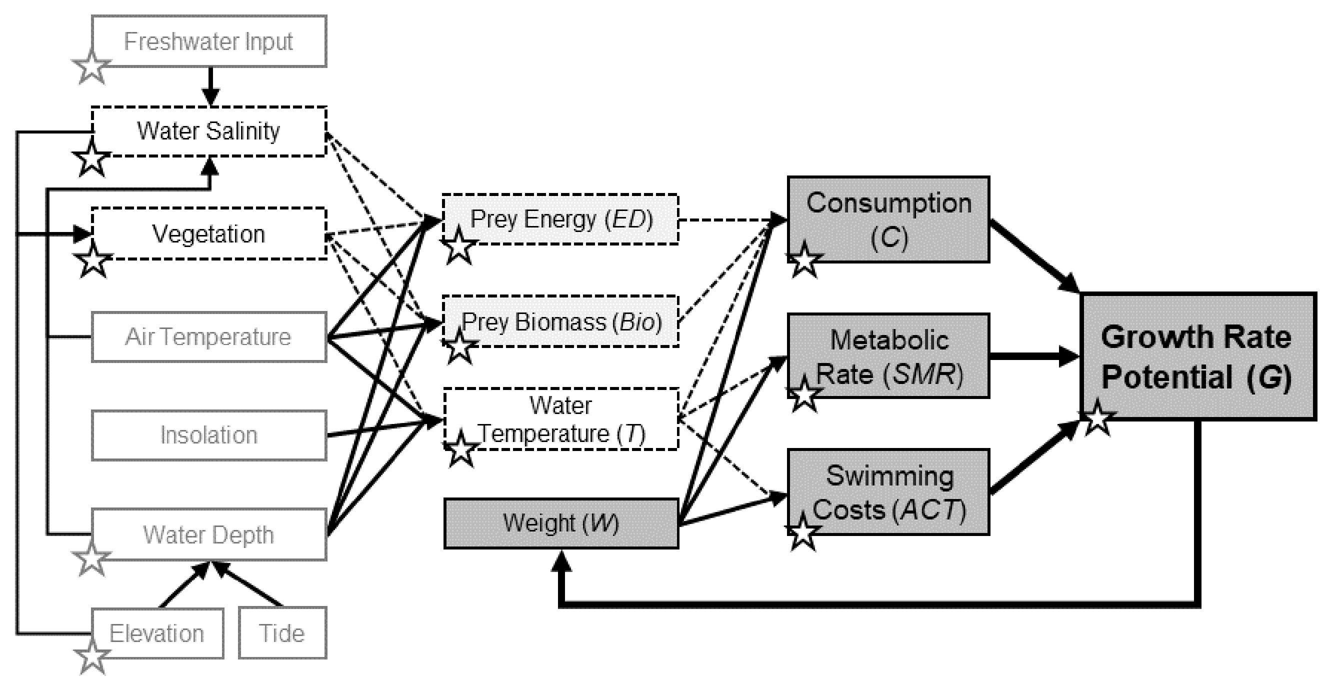


Figure 2. Conceptual diagram of data inputs used in a spatially explicit bioenergetics approach. Shaded squares indicate bioenergetics model components. Stars indicate spatial data layers. From Davis et al. (2021).

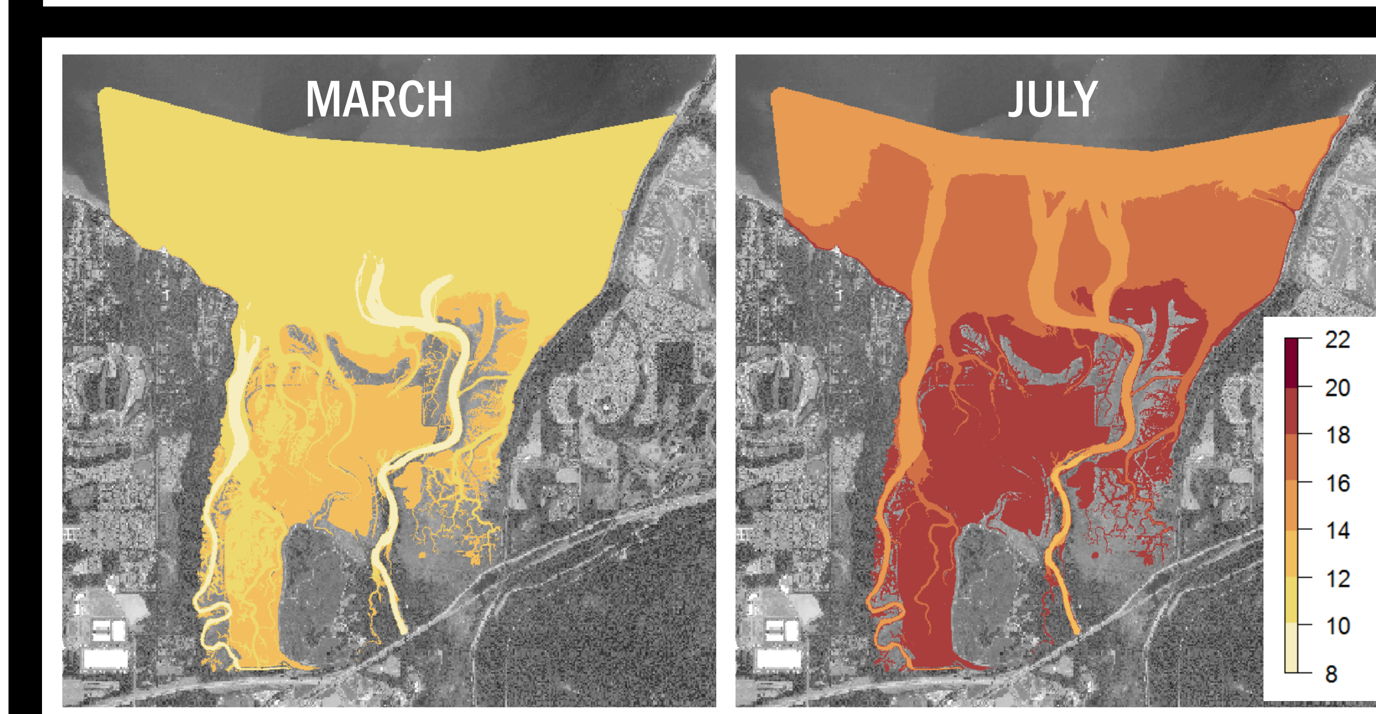


Figure 3. Predicted water temperatures (°C) at mean high water (2.8 m NAVD88) in March (left) and July (right) under present day conditions. Adapted from Davis et al. (2021).

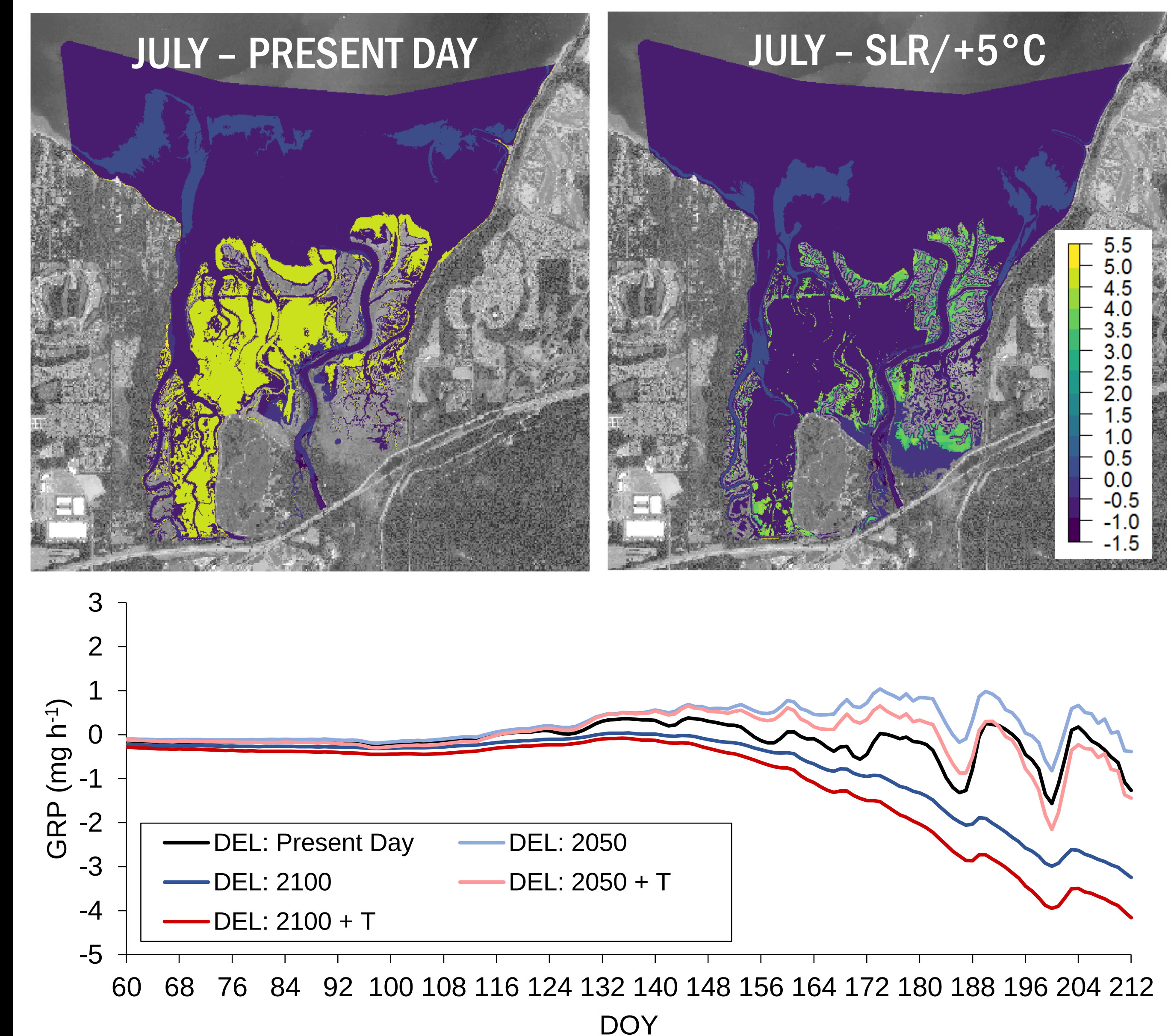


Figure 4. Modeled delta-wide growth rates under present day conditions and a high sea-level rise/temperature scenario. From Davis et al. (2021).

## RESULTS & IMPLICATIONS

Unmitigated sea-level rise led to a 30% reduction in end-of-season weights and increasing water temperatures compounded these effects such that the average daily growth rate of an individual fish decreased by an additional 5–50% when compared to the effects of sea-level rise alone. Our findings indicate that rising tidal levels and increasing ocean temperatures may reduce the quality of the estuarine habitat mosaic for out-migrating salmon.

### LITERATURE CITED

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