

Future Temperature and Salinity in Puget Sound, Washington State, Under CMIP6 Climate Change Scenarios

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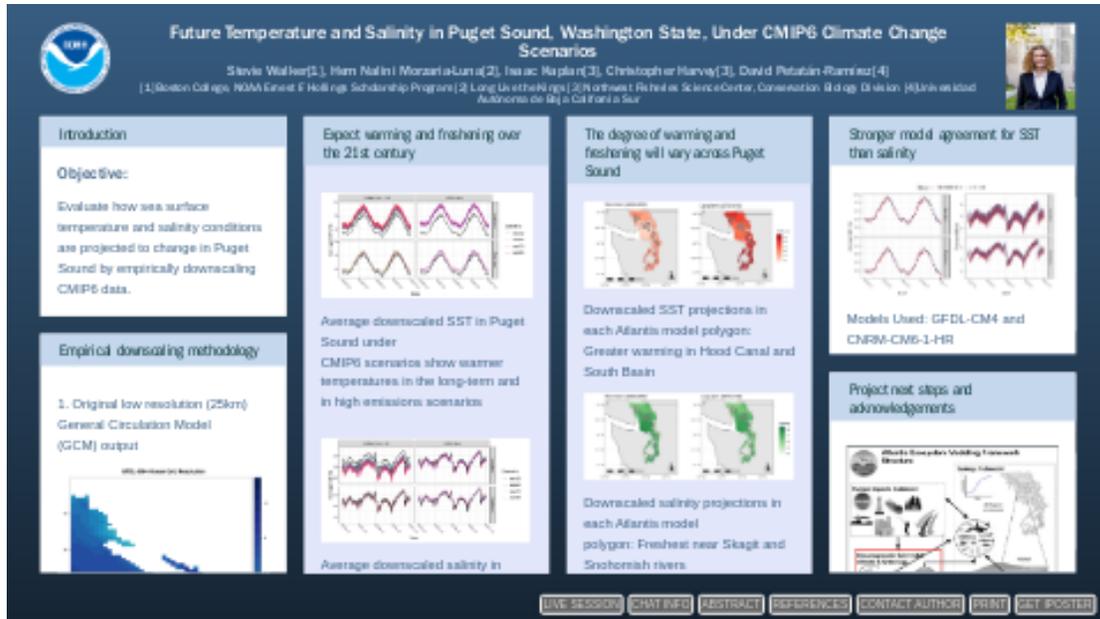
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November 23, 2022

Abstract

In Washington State, climate change will reshape the Puget Sound marine ecosystem through bottom-up and, top-down processes, directly affecting species at all trophic levels. We applied analytical approaches to better understand future climate change effects on temperature and salinity in Puget Sound. We used empirical downscaling techniques to derive high resolution time series of future sea surface temperature and salinity, based on scenario outputs of two coarse resolution General Circulation Models, GFDL-CM4 and CNRM-CM6-1-HR, which were created as part of the CMIP6 - Coupled Model Intercomparison Project Phase 6. We calculated long-term averages for historical simulations, calculated anomalies for future years, and applied a delta-downscaling approach to a Regional Ocean Modeling System (ROMS) time series, yielding short (2020–2050) and long-term (2070–2100) forecasts. Downscaled output for Puget Sound showed temperature and salinity variability between scenarios and models, but overall there was strong model agreement. Model variability and uncertainty was higher for long-term projections. Spatially, we found regional differences for both temperature and salinity: including higher temperatures in the South Basin and higher salinity in the North Basin. Caveats to our methodology include the assumption that variable relationships are static and cannot represent interactions between large scale and local change, but this study is a first step to translating CMIP6 outputs to higher resolution predictions of future conditions in Puget Sound. The climate projections for Puget Sound oceanography will be used to drive the Atlantis ecosystem model for Puget Sound, an end-to-end ecosystem modeling approach that represents all trophic levels and evaluates the species-level impacts of climate change. This project is part of a Washington State Sea Grant funded project, “Evaluating the effects of Southern Resident orcas recovery actions and external threats in the marine ecosystem of Puget Sound.”

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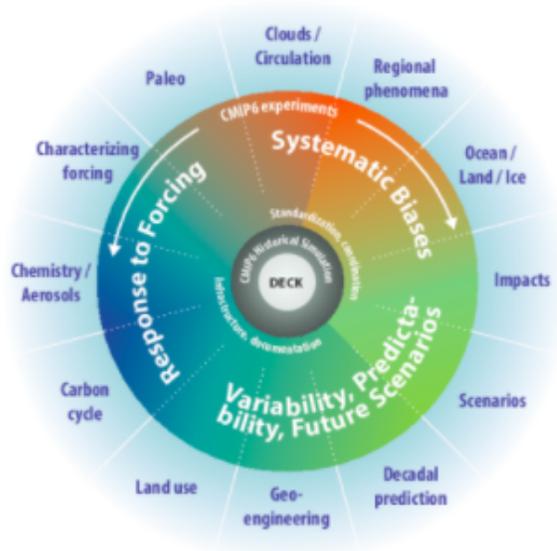


INTRODUCTION

Objective:

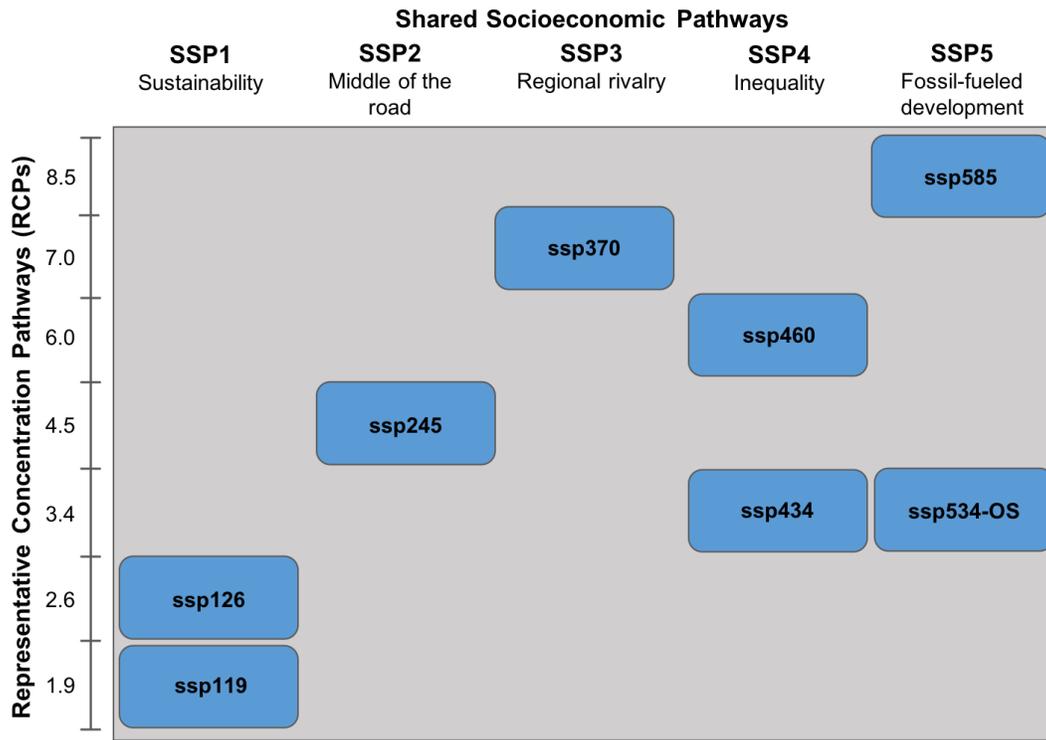
Evaluate how sea surface temperature and salinity conditions are projected to change in Puget Sound by empirically downscaling CMIP6 data.

Coupled Model Intercomparison Project Phase 6 (CMIP6)



The data we used come from the Coupled Model Intercomparison Project Phase 6, which standardizes the best general circulation models and has many different model intercomparison components. Data used come from ScenarioMIP.

ScenarioMIP

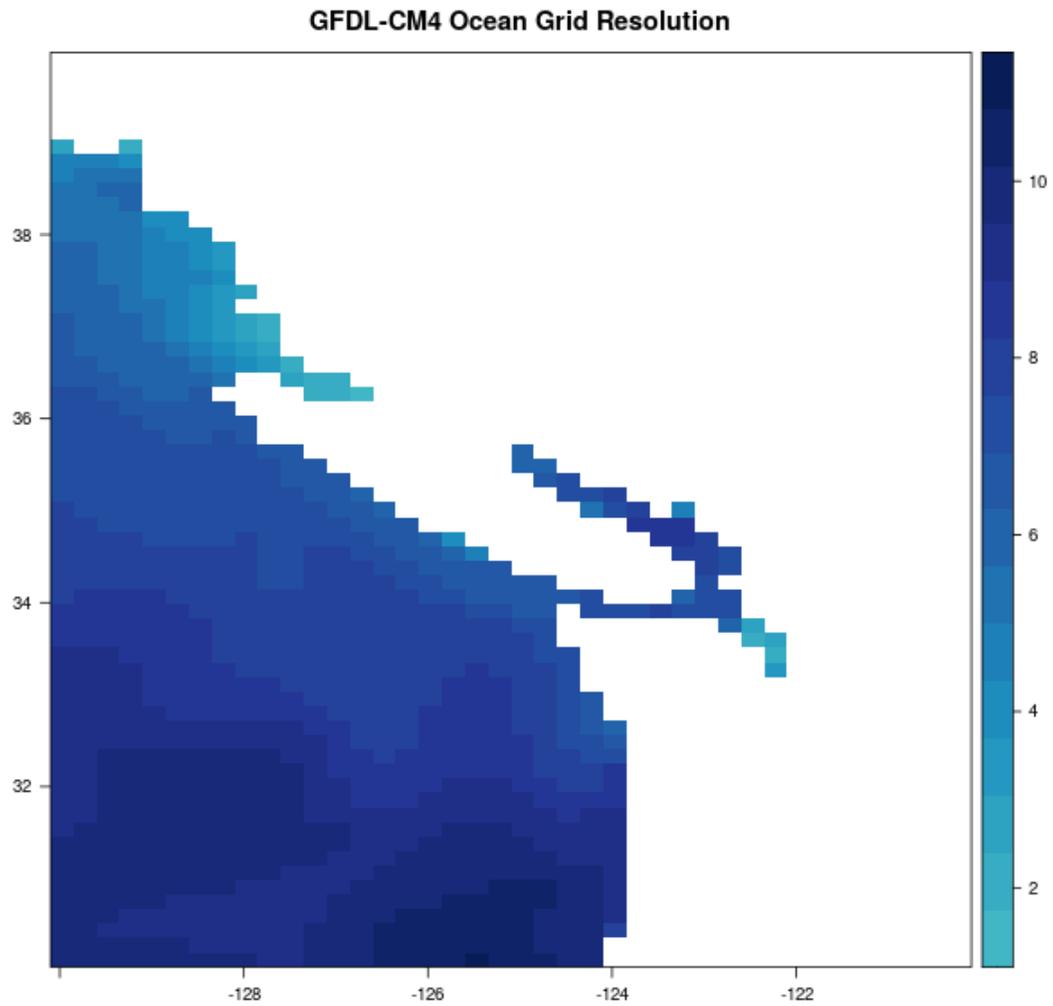


One major advancement in CMIP6 are updated climate change scenarios that integrate different societal outcomes, the SSPs, with different emissions scenarios, the RCPs.

These scenarios range from sustainable, low-emissions outcomes (ssp126) to business-as-usual, high-emissions outcomes (ssp585) over the 21st century.

EMPIRICAL DOWNSCALING METHODOLOGY

1. Original low resolution (25km) General Circulation Model (GCM) output



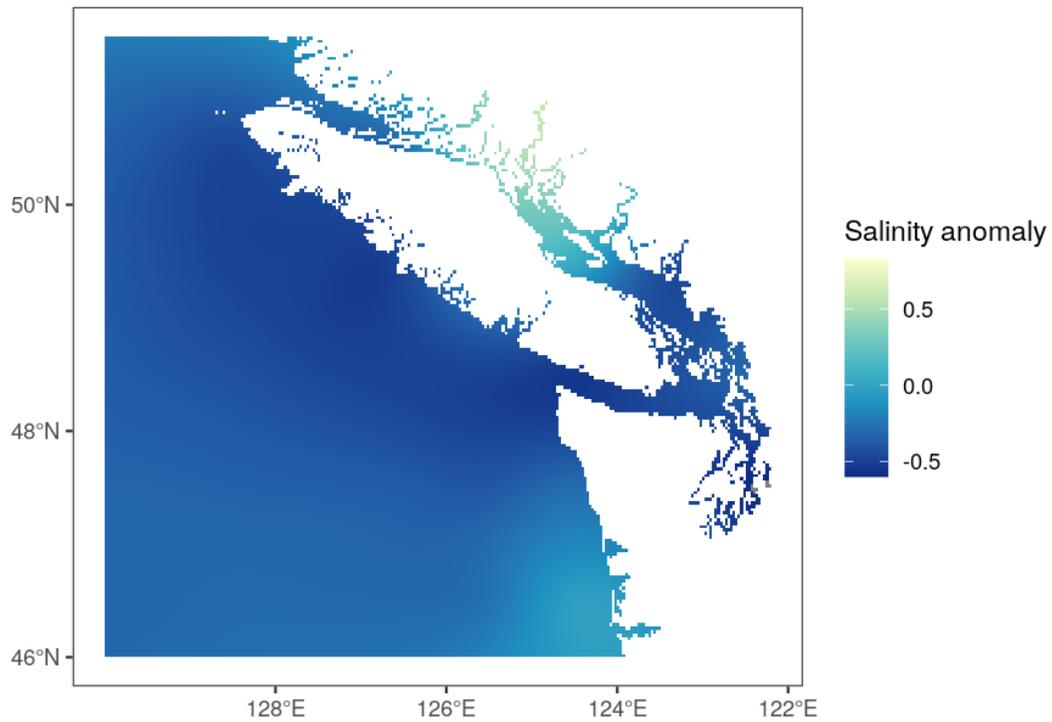
a) Calculated model hindcast (1984-2014)

b) Calculated model forecasts

i) Short-term (2020-2050)

ii) Long-term (2070-2100)

2. High resolution (0.1km) interpolated anomaly results
Long-term (2070-2100) GFDL-CM4 ssp585

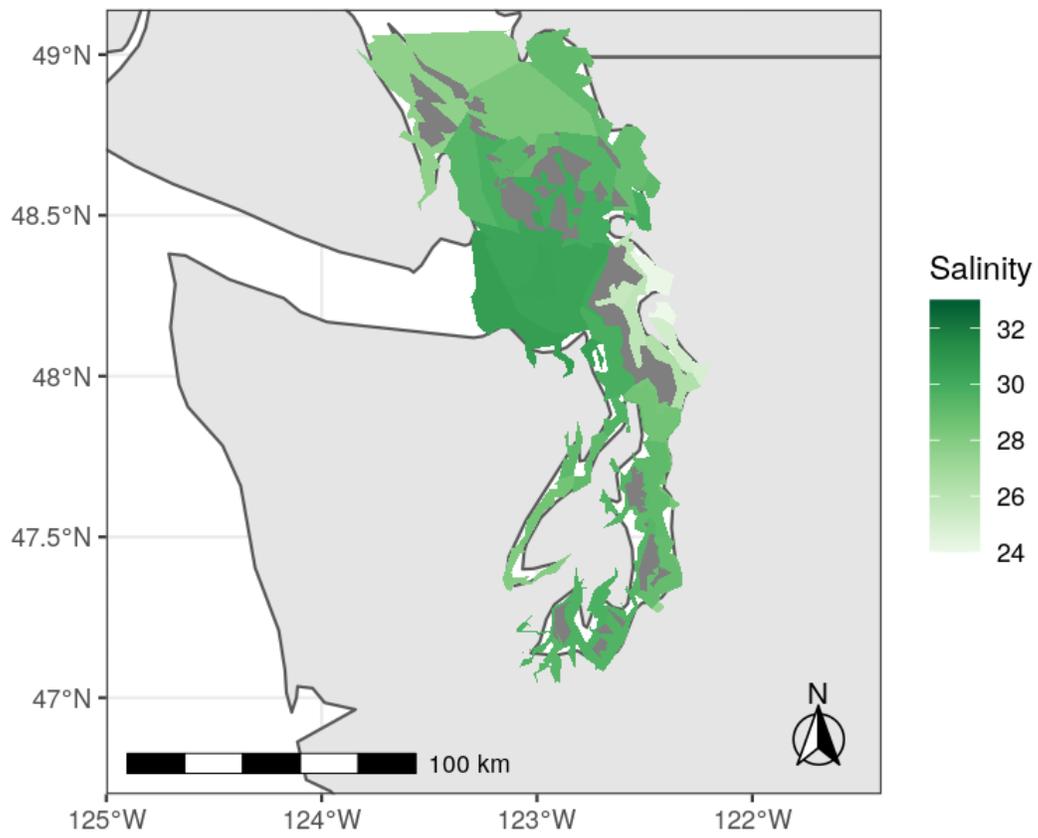


c) Calculate the SST and salinity anomalies (Δ) for short and long term

d) Interpolate to a 0.1km resolution

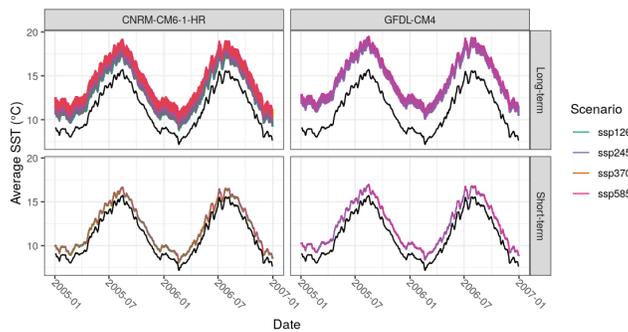
3. Overlaid interpolated results to Regional Ocean Modeling System (ROMS) data

Long-term (2070-2100)

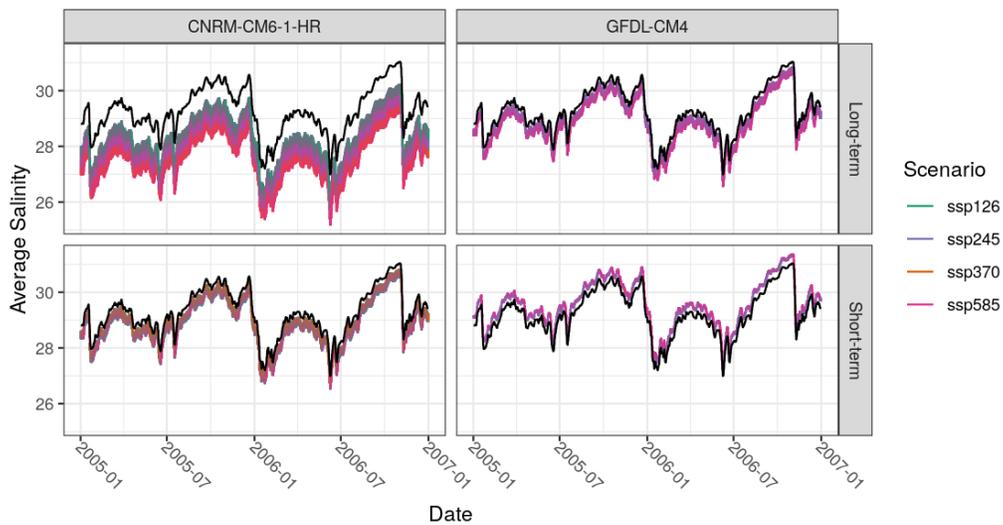


- e) Overlaid interpolated results to ROMS data within each Atlantis model polygon
- f) Developed final downscaled SST and salinity projections

EXPECT WARMING AND FRESHENING OVER THE 21ST CENTURY

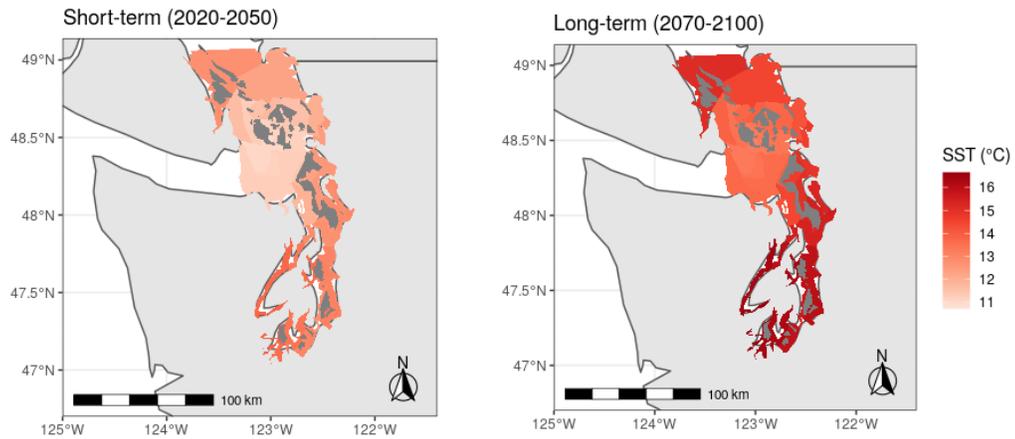


Average downscaled SST in Puget Sound under CMIP6 scenarios show warmer temperatures in the long-term and in high emissions scenarios

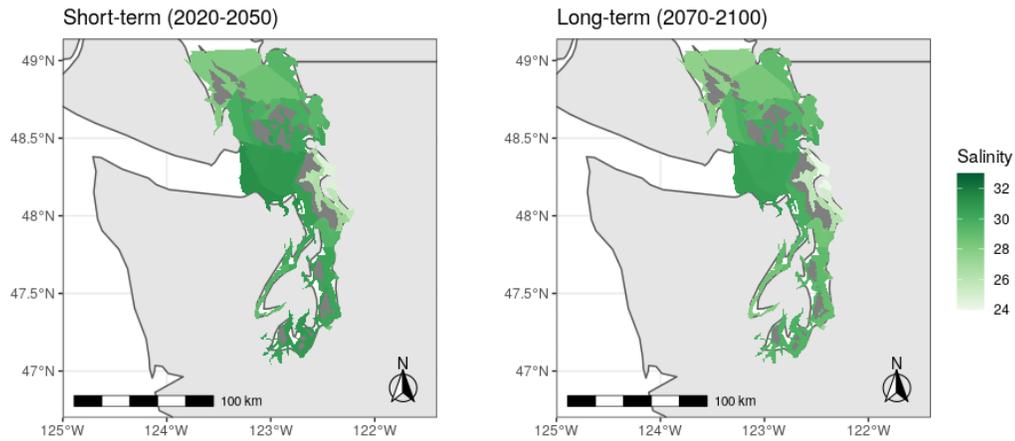


Average downscaled salinity in Puget Sound under CMIP6 scenarios show stronger freshening in the long-term and high emissions scenarios

THE DEGREE OF WARMING AND FRESHENING WILL VARY ACROSS PUGET SOUND

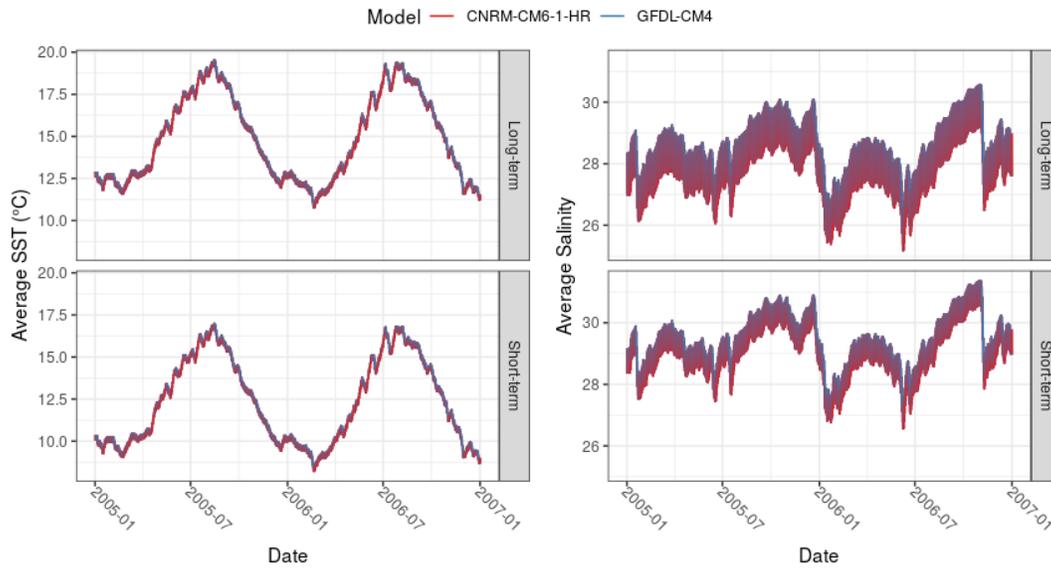


Downscaled SST projections in each Atlantis model polygon: Greater warming in Hood Canal and South Basin



Downscaled salinity projections in each Atlantis model polygon: Freshest near Skagit and Snohomish rivers

STRONGER MODEL AGREEMENT FOR SST THAN SALINITY



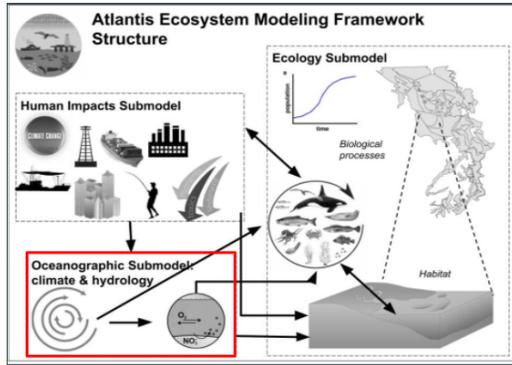
Models Used: GFDL-CM4 and CNRM-CM6-1-HR

SST shows strong agreement between both models for both short term and long term projections.

Salinity shows more variability between models, especially in the long term.

This is likely due to internal model variability.

PROJECT NEXT STEPS AND ACKNOWLEDGEMENTS



Downscaled results will be applied to the Atlantis ecosystem model for Puget Sound, which is currently being created as part of the Washington Sea Grant project "Evaluating the effects of Southern Resident orcas recovery actions and external threats in the marine ecosystem of Puget Sound".



These climate projections will help inform the vital signs for Puget Sound and make better policy recommendations for species conservation.

Project Contact

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Acknowledgements

- Parker MacCready (UW)
- NOAA Ernest F. Hollings Scholarship Program
- Microsoft Azure AI for Earth

ABSTRACT

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