Science, Service, Stewardship

# Geographic Variation in Pacific Herring Growth in Response to Regime Shifts in the North Pacific Basin

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# Outline

- Study justification
- Methods
- Model Results
- Conclusions

# Introduction

- Detecting and modeling the response to regime shifts and climate variability is one of the most significant sampling and modeling challenges presently faced by the ocean research community.

- Significant and coherent changes in the state of the ocean, across large geographic areas such as the whole North Pacific basin, should be manifested in regional marine ecosystems, especially higher trophic level biological populations.

# Objectives

- Investigate latitudinal variation and temporal patterns in Pacific herring growth in response to climatic variability and regime shifts within the North Pacific basin using mechanistic numerical simulation modeling

- Analyze model output to quantify important relationships and associations controlling marine ecosystem productivity.
  - to identify regime shifts within and among locations
  - perform comparisons to determine if herring

# Null Hypothesis

The same fish species, in eight different locations, will show similar biological responses when modeled with a common lower trophic level and fish bioenergetics model, location-specific HTL bioenergetic growth models, and a common basin-scale climate forcing.

# Methods: Analysis Tools

• Trends in monthly temperature, zooplankton densities, and fish growth (i.e. changes in wet weight between ages 4 and 5-Age5dww), were detected using variables expressed as anomalies.

• A five year moving average was calculated to remove high frequency interannual variability.

• Data were also examined using Principal Component Analysis (PCA) and variables (SST, zooplankton density and change in fish weight) were examined using Cluster Analysis.

# Methods: Model Configuration

- NEMURO.FISH nutrient-phytoplankton–zooplankton lower trophic level model. NPZ dynamics were simulated from 1948-2002.

- Embed in a 3D circulation model of the North Pacific (i.e. 3D-NEMURO) that provided zooplankton prey.

- Force a higher trophic level fisheries bioenergetics growth model of Pacific herring.

- Implement at eight different locations within the North Pacific basin where herring populations are know to reside and where observation data exist.

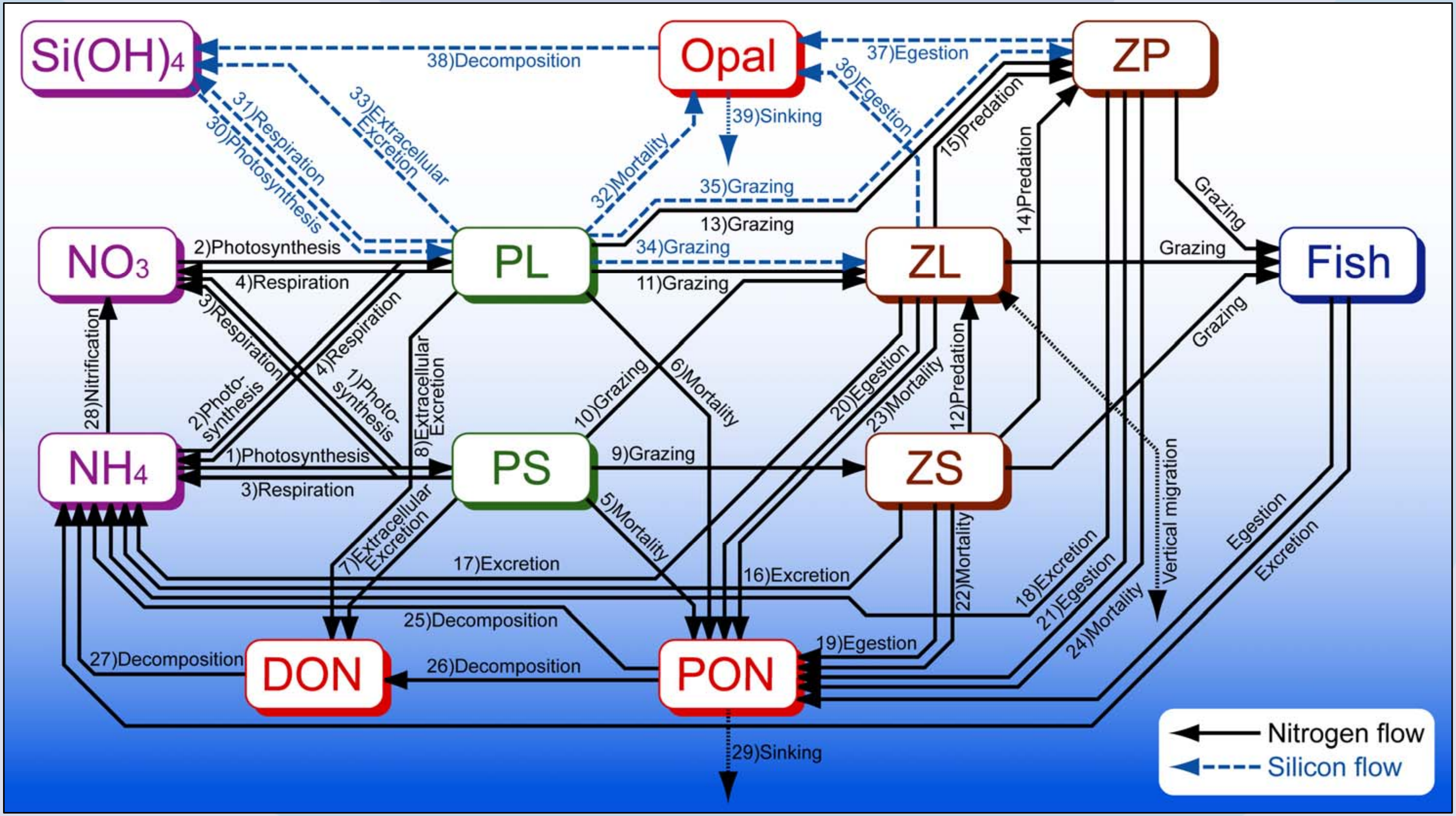
# Methods: Model Configuration

• Extract NEMURO-predicted monthly values for water temperature, and small, large, and predatory zooplankton densities at our eight locations.

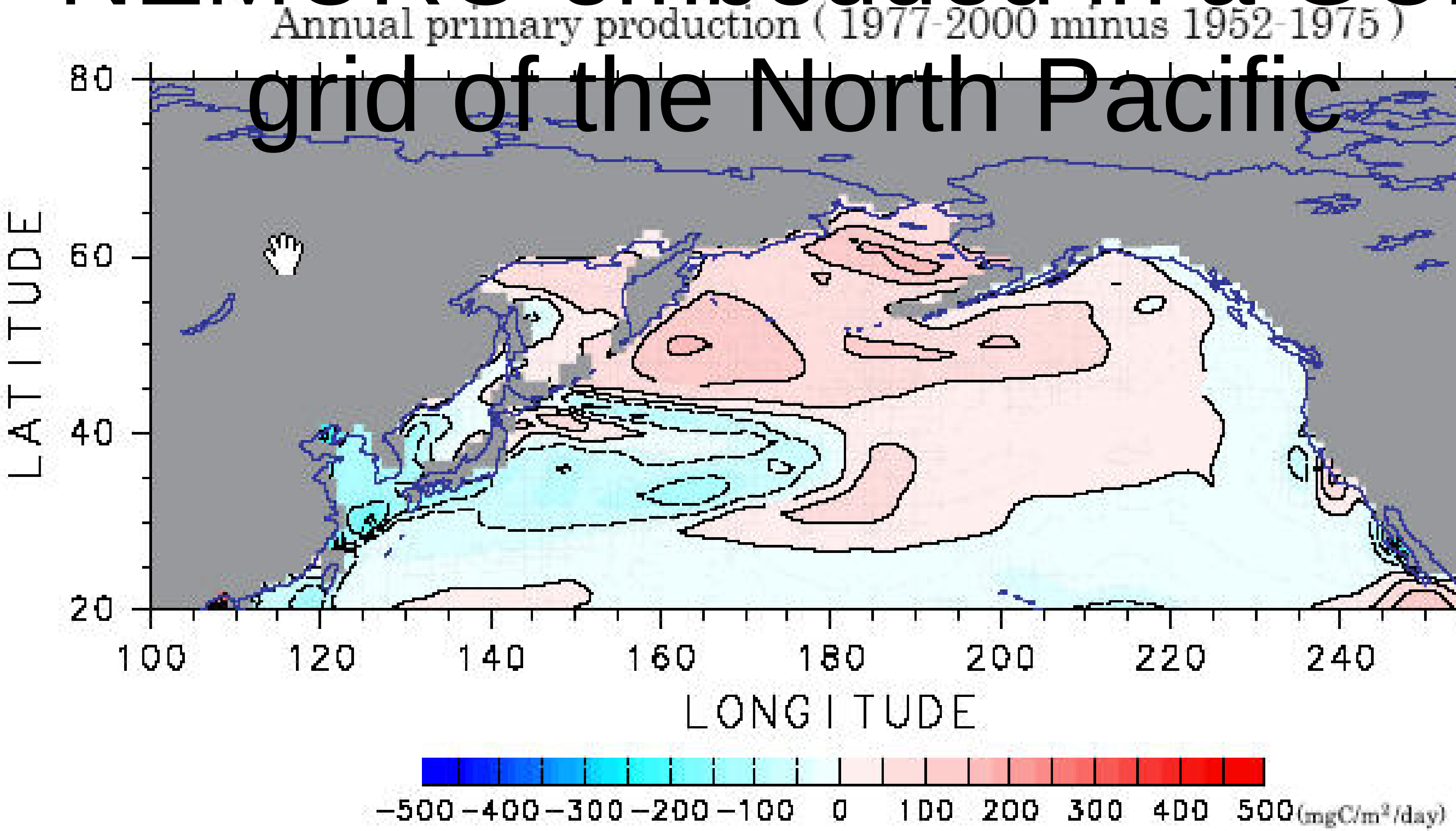
• Constructed time series by averaging the output over the top 100 meters of the water column to obtain single depth-averaged values of temperature and zooplankton densities for each month from 1948 to 2002 at each location.

• Calibrated the maximum consumption rate and feeding-related parameters for  the herring population at each location using climatological temperature and zooplankton densities so that steady-state weights-at-age matched observed averaged weights-at-age.

# NEMURO.FISH Model

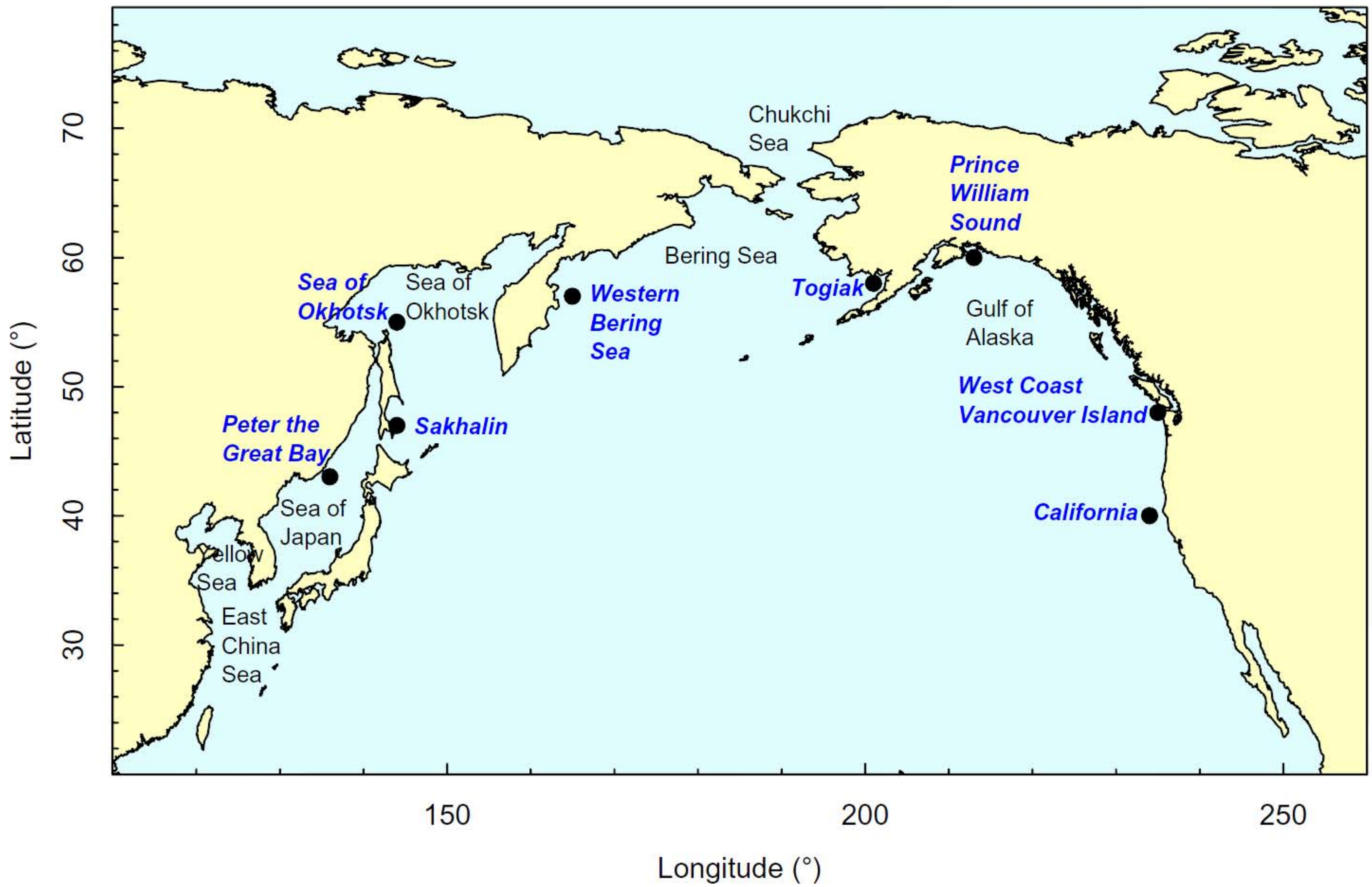


# Basin scale predictions of the state of the LTL ecosystem NEMURO embedded in a GCM grid of the North Pacific

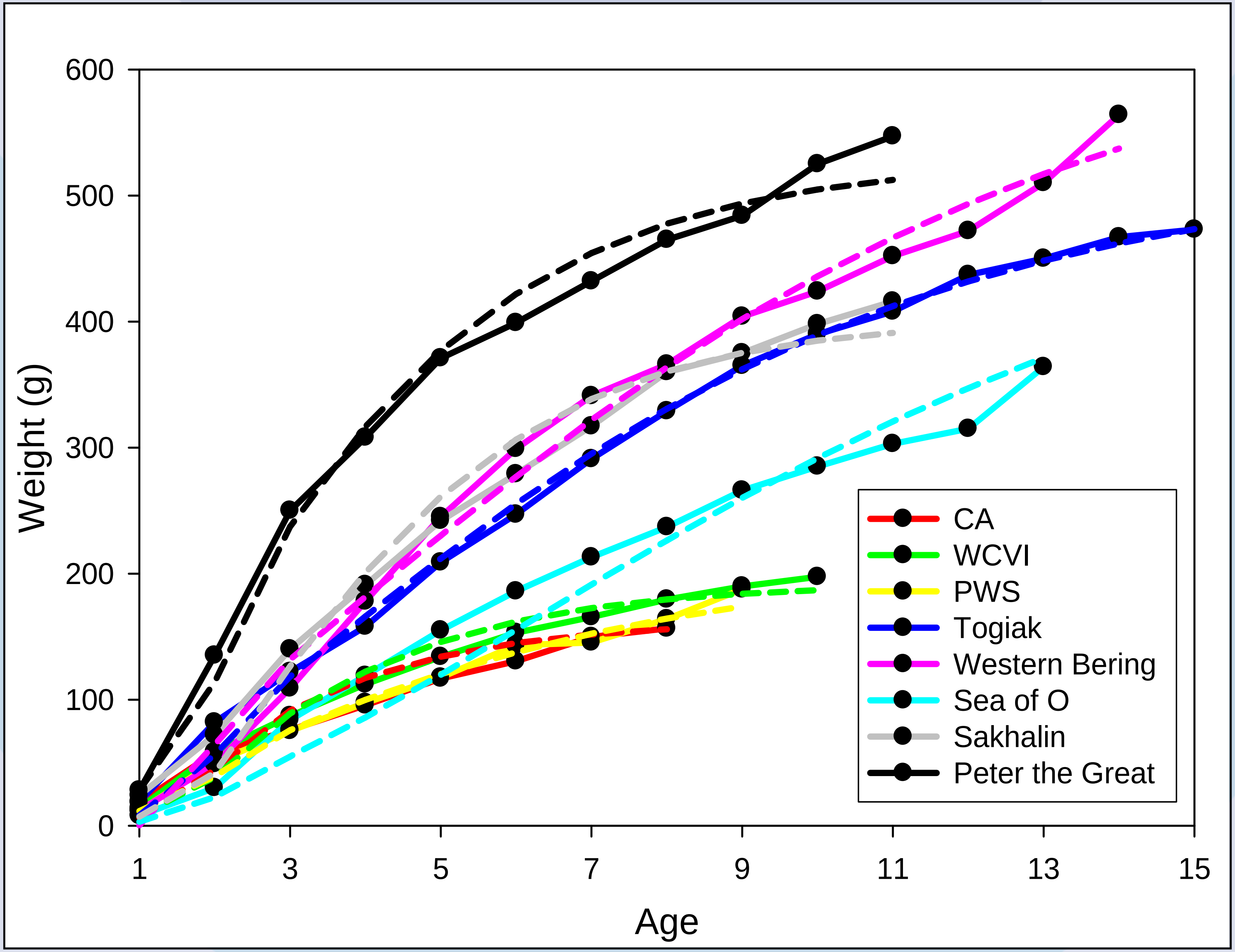



***Source: Noguchi  et al. 2007. Ecological Modeling.***

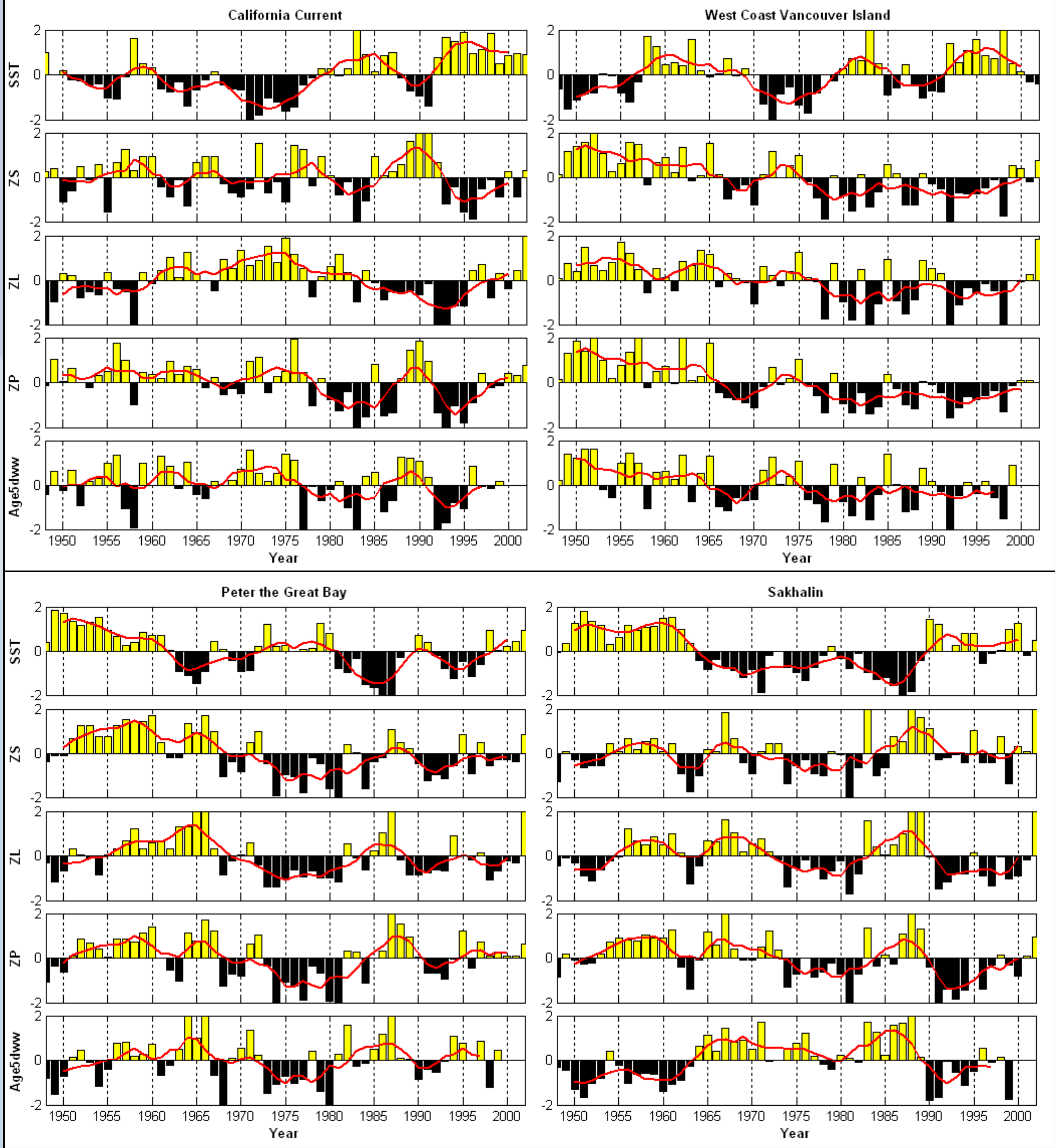
# Herring Populations Compared



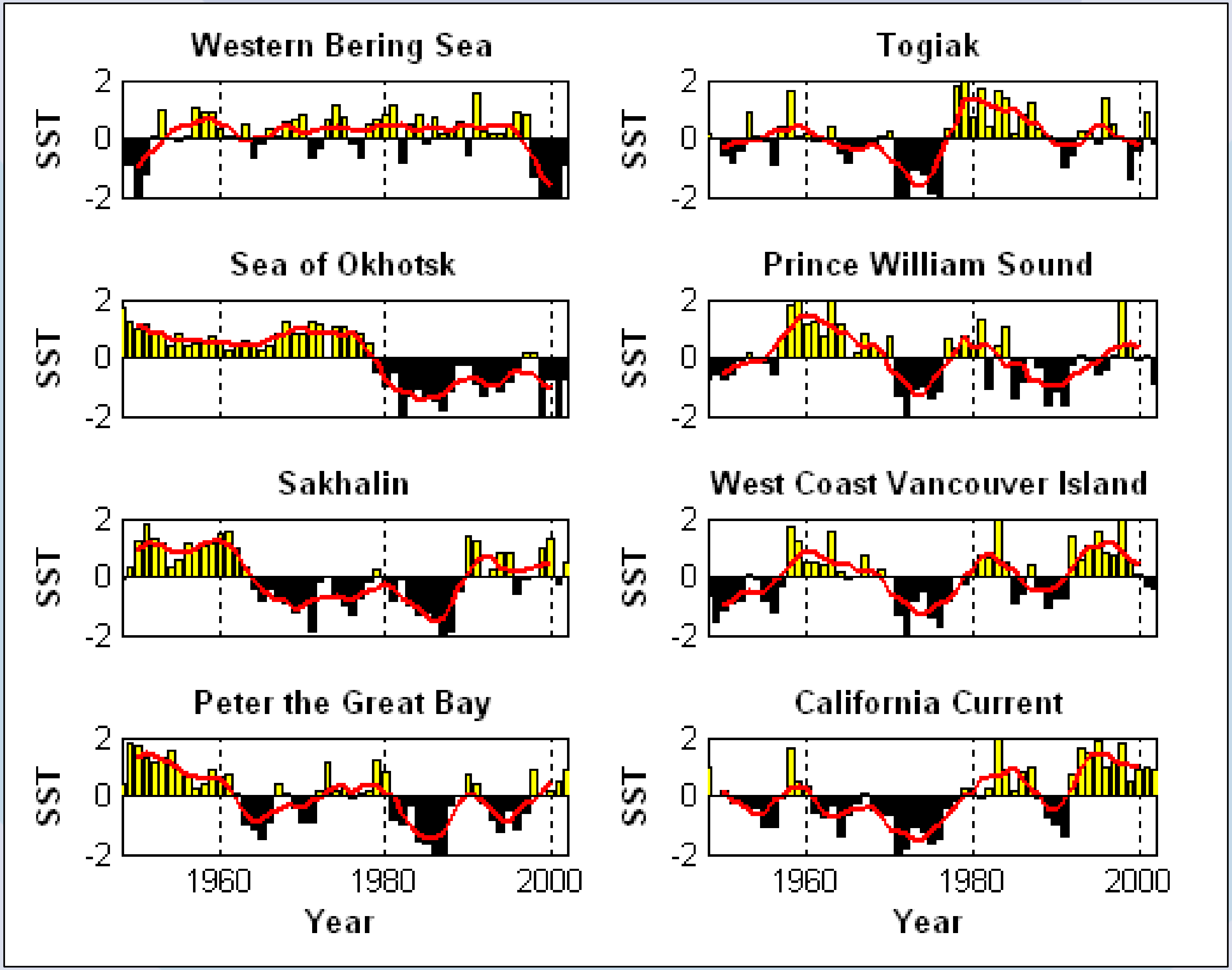
# Calibrated Herring Growth



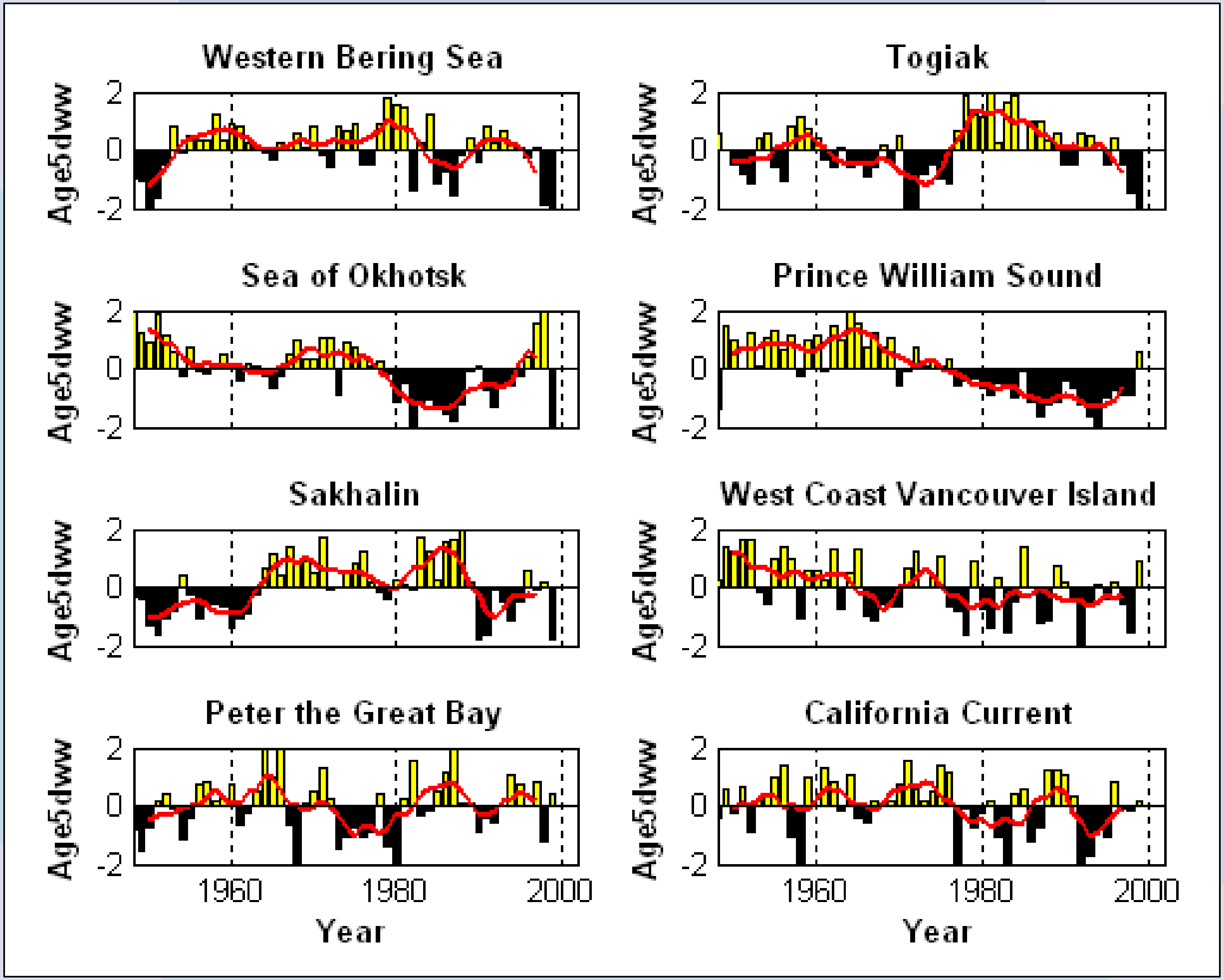
# Trends in Time Series Anomalies of Model Output for 4 Different Locations of the North Pacific



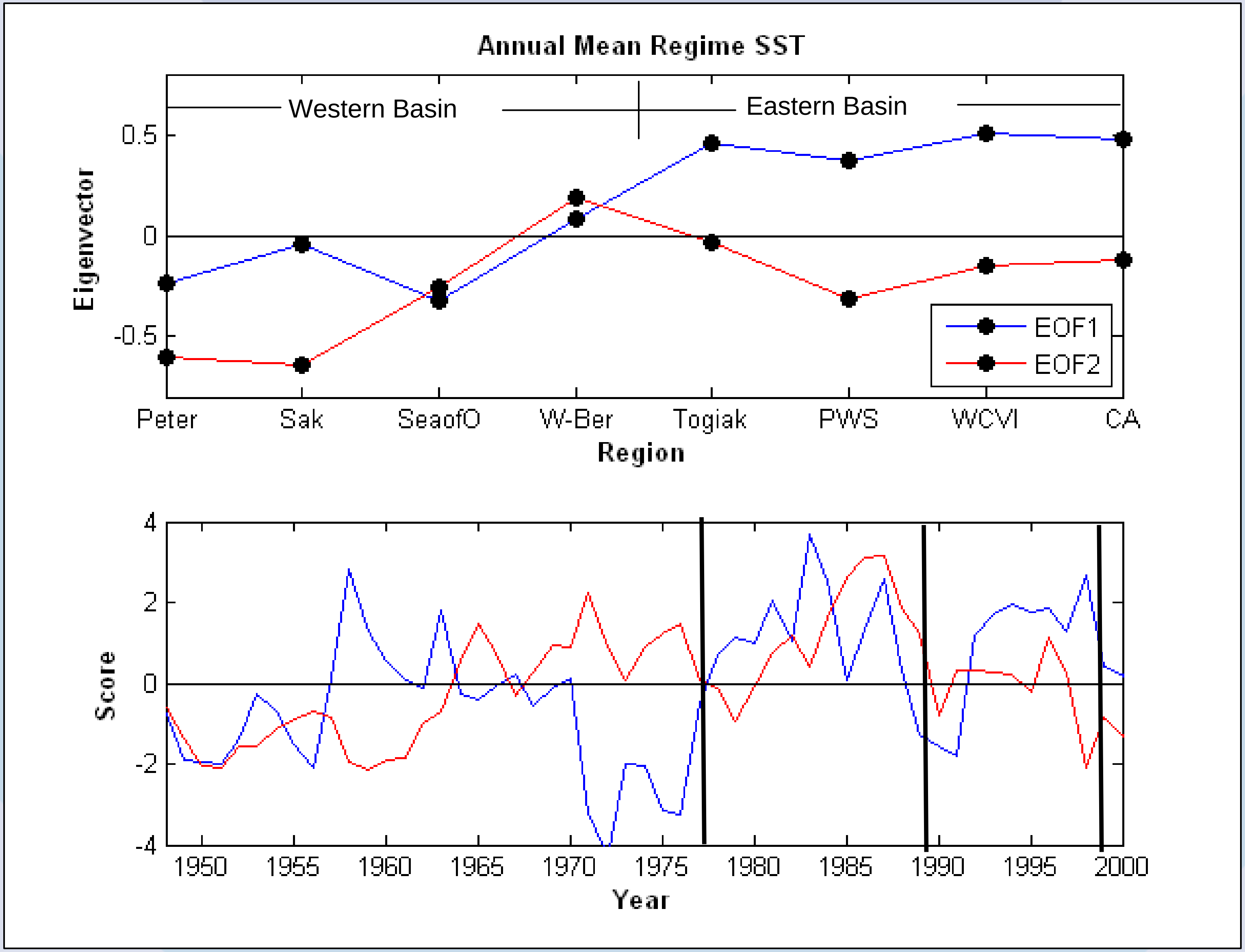
# Trends in SST Time Series Anomalies in 8 Different Locations of the North Pacific



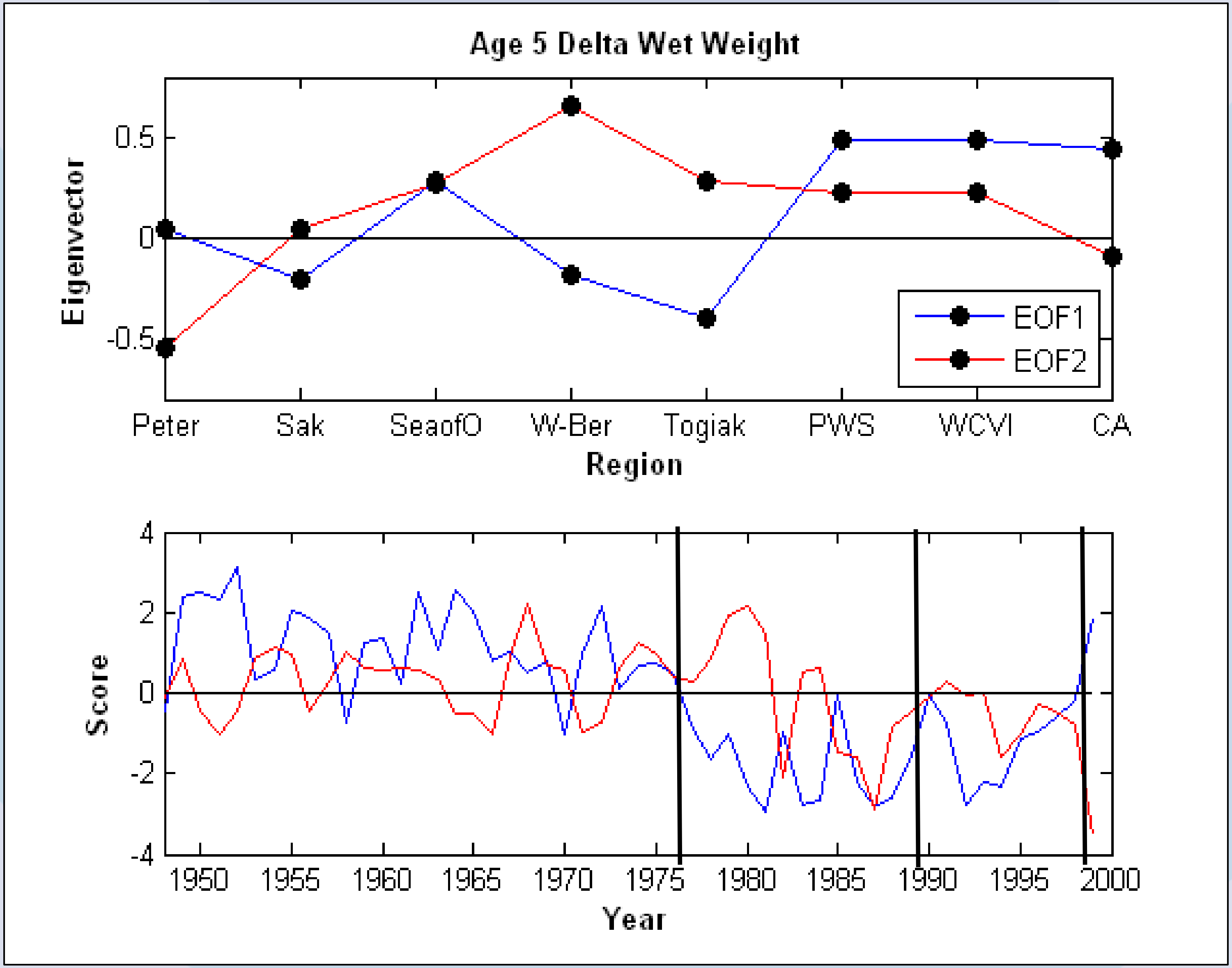
# Trends in Age5dww Time Series Anomalies in 8 Different Locations of the North Pacific



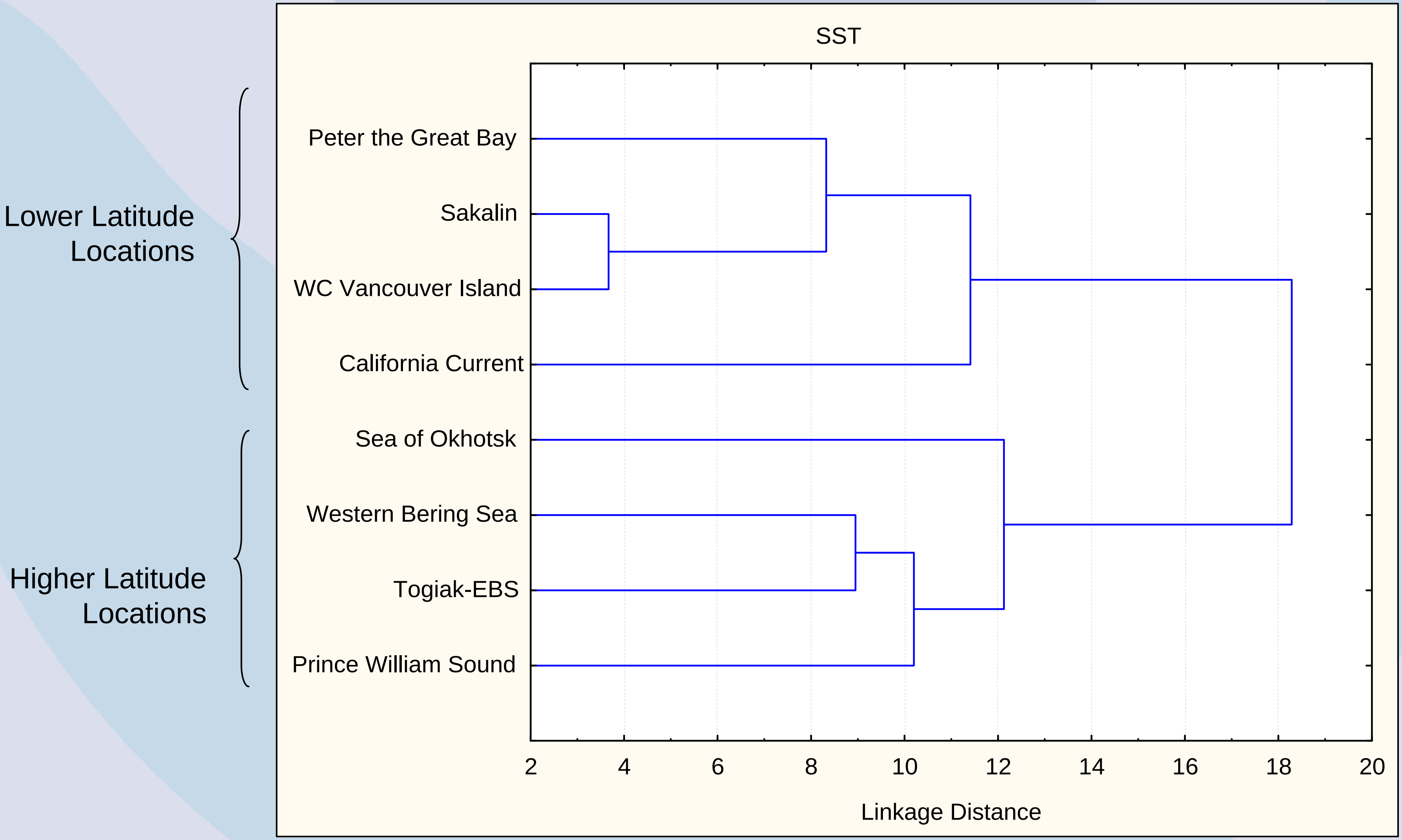
# Principal Component analysis of SST in 8 Different Locations of the North Pacific



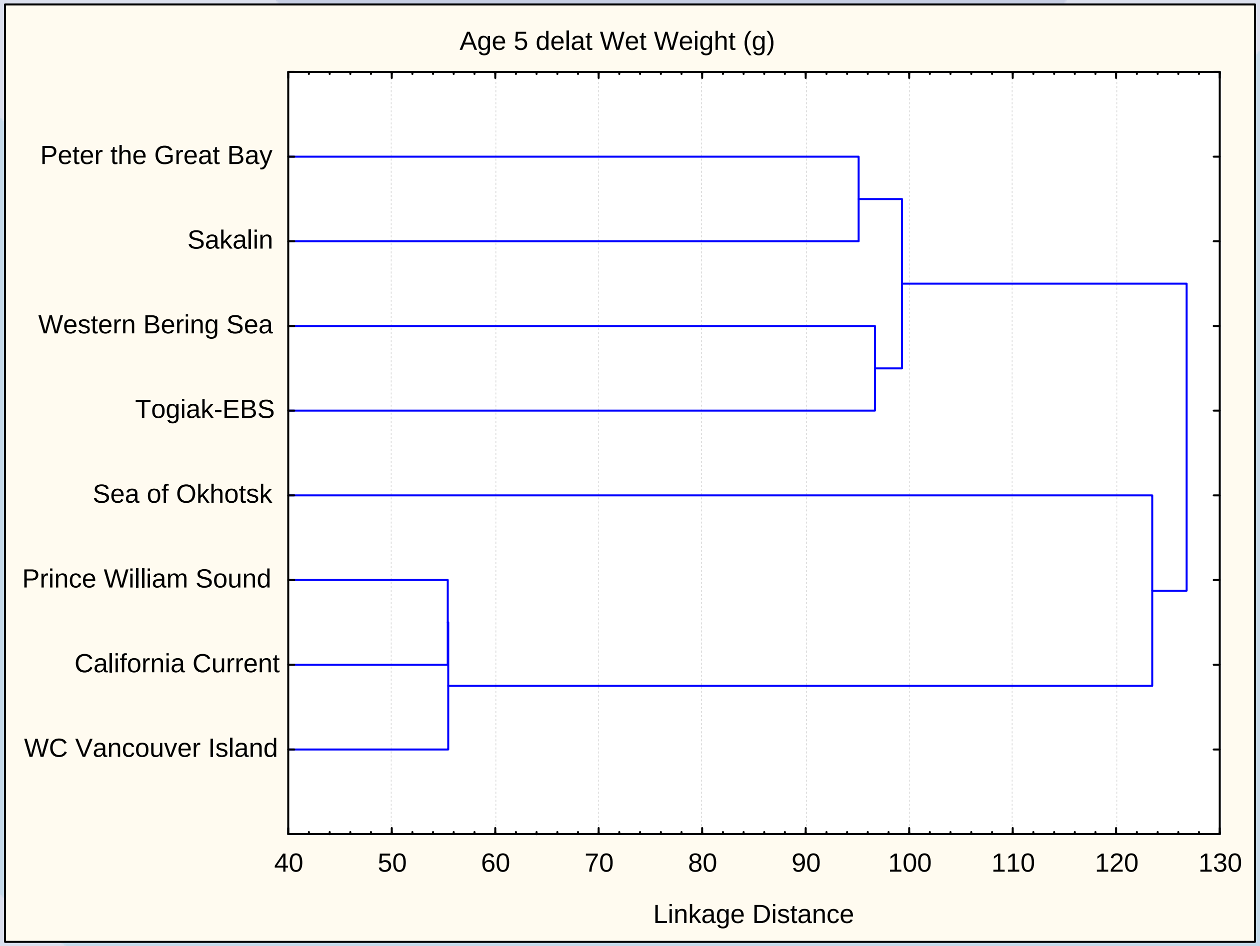
# Principal Component analysis of Age5dww in 8 Different Locations of the North Pacific



# Cluster Analysis Results by Location for SST



# Cluster Analysis Results by Location for Age 5 delta Wet Weight



# Conclusions

- Herring growth appears to be driven by bottom-up processes.

- Herring populations at eight locations each show a unique response to similar model forcing indicating the importance of local conditions.

- East-west differences in herring growth response may be due to the influence of different expressions of the PDO within the North Pacific basin.

- SST seems to be inversely associated