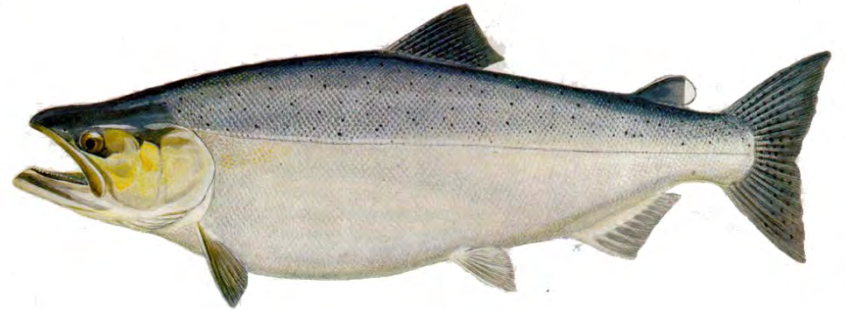
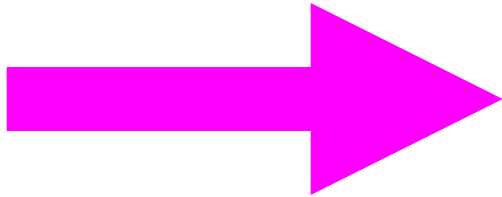


**Variability in North Pacific Ocean
Conditions: Assessing Habitat-
specific Vital Rates
and Thresholds for Fishes**

Stephen Brandt and Cynthia Sellinger
Department of Fisheries and Wildlife



Habitat Quality defined by species-specific vital needs





Essential Fish Habitat

NOAA Fisheries



National Marine
Fisheries Service



**Waters and substrate necessary for
spawning, breeding, feeding or growth**

EFH often defined geographically

Presence → Densities → Vital Rates → Production

What is good habitat for a pelagic fish in a spatially dynamic system?

**How do we define it, measure it and compare it
among species and in response to
environmental drivers?**

**Can habitat use be inferred from info on
habitat requirements?**

**What about temporal changes in habitat need
or availability?**



Pacific Northwest Chinook Salmon

- Spend most of their life (2-4 years) at sea
- Juvenile and Adult marine phase important to survival and reproductive potential
- What defines Marine Habitat Quality for Chinook Salmon??

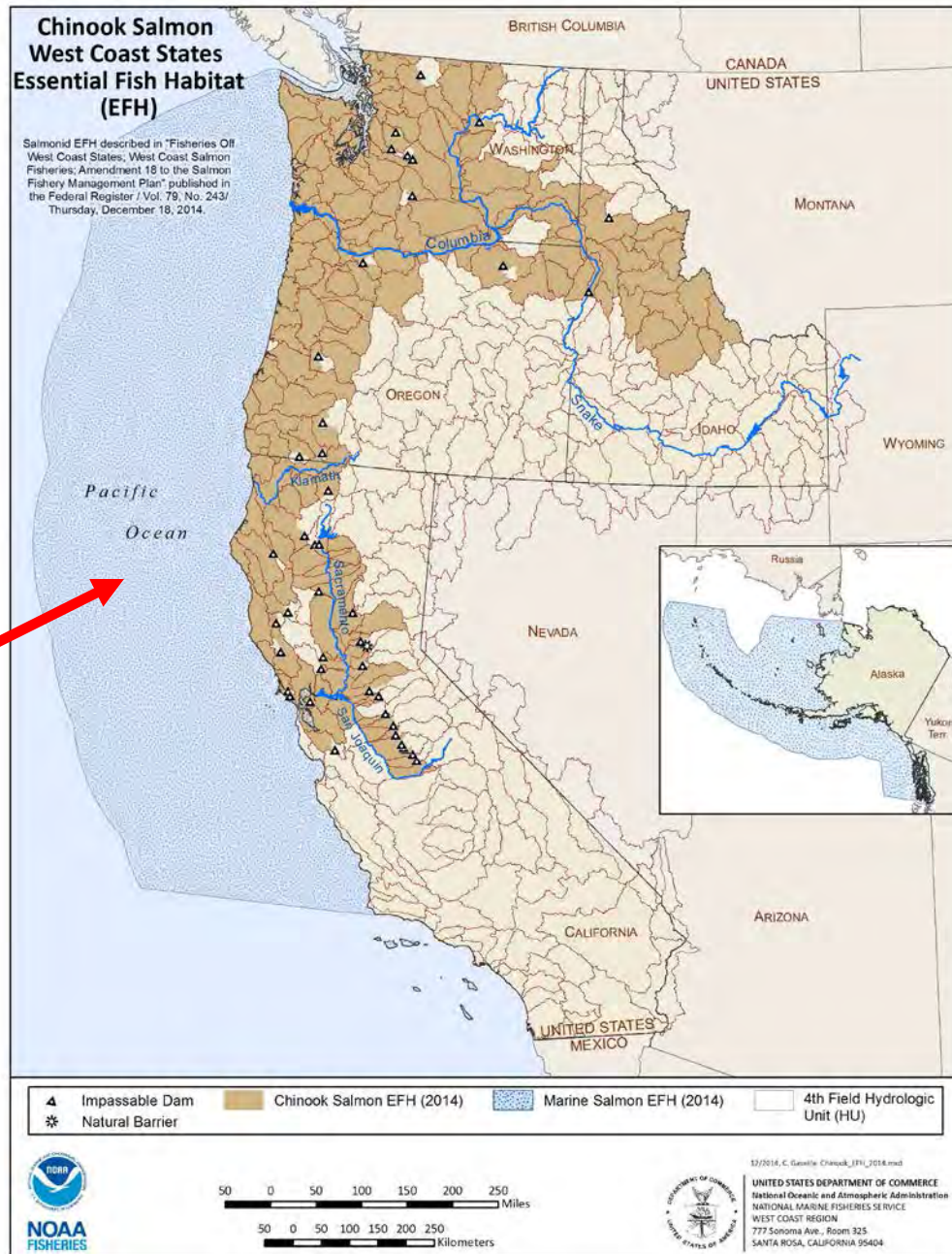
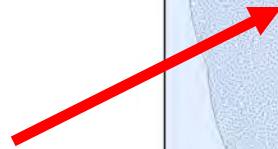


Adult fall Chinook salmon.

(Courtesy of Pacific Northwest National Laboratory)



Chinook Salmon EFH



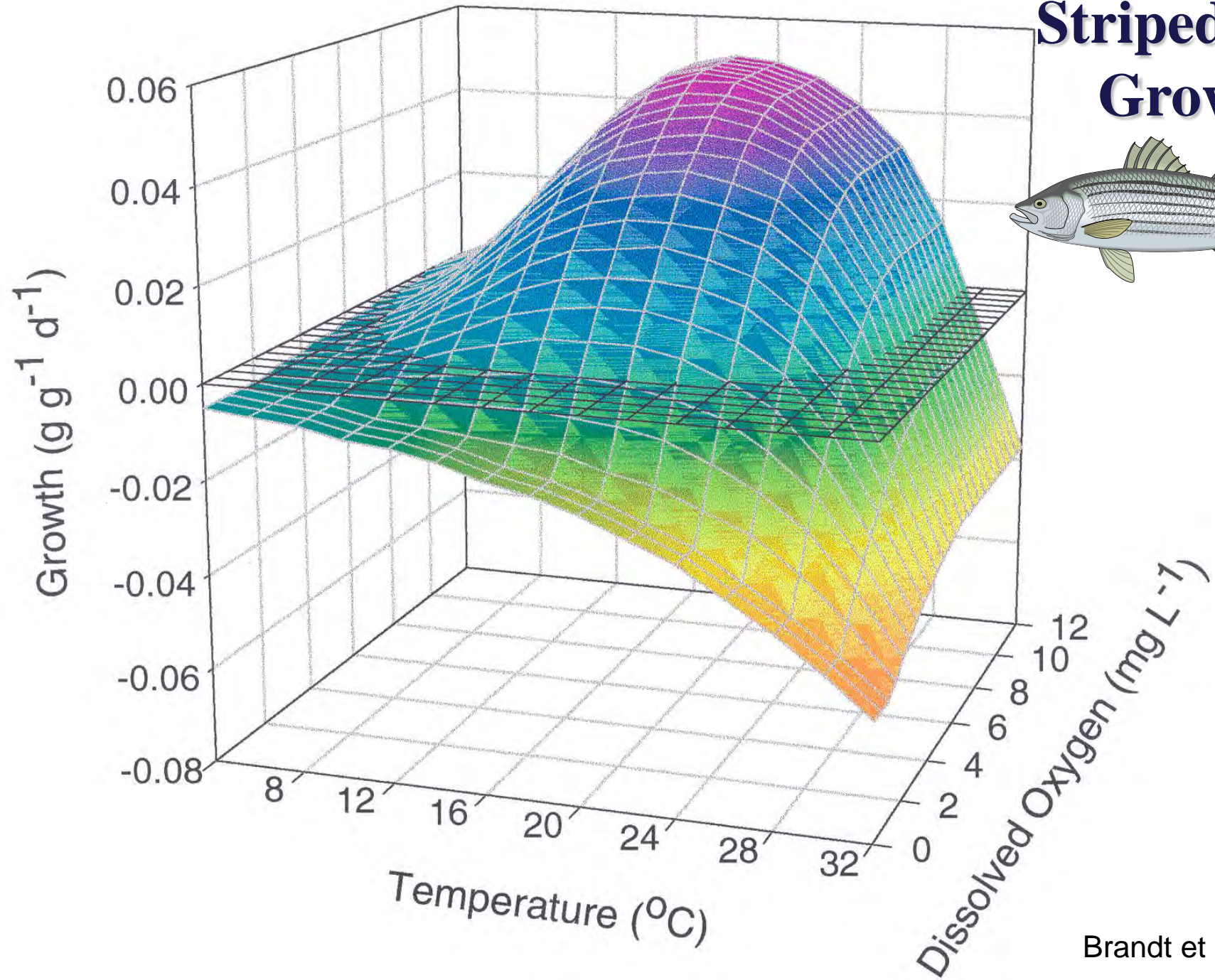
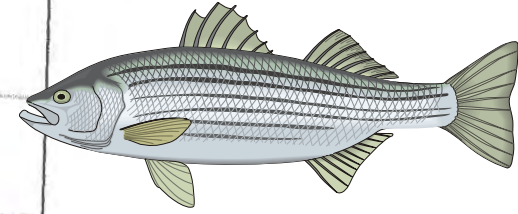
Habitat Quality = Growth Rate Potential

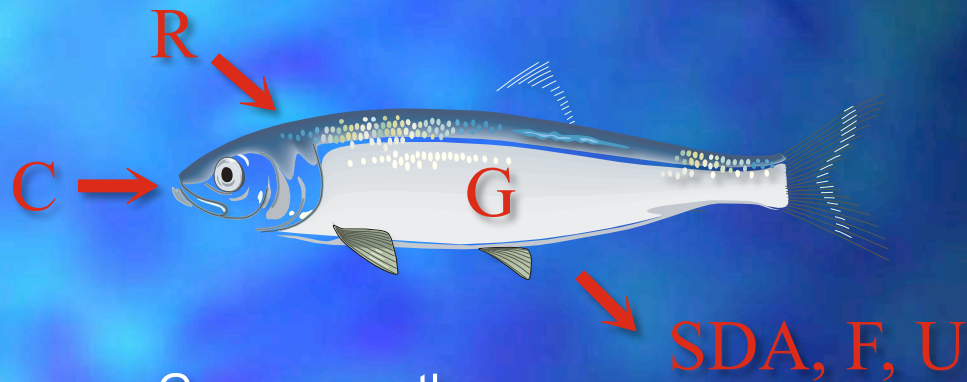
Expected daily growth rate of a fish if placed in a volume of water with known conditions such as prey type, prey size, prey density, temperature, oxygen and light

Why Fish Growth Rate?

- **Integrative Response of fish performance**
– related to survival and reproductive capacity
- **Based on fish's requirements and prevailing environmental conditions**
- **Differs among species and life stages**
- **Varies in time and space**
- **Nonlinear response**

Striped Bass Growth

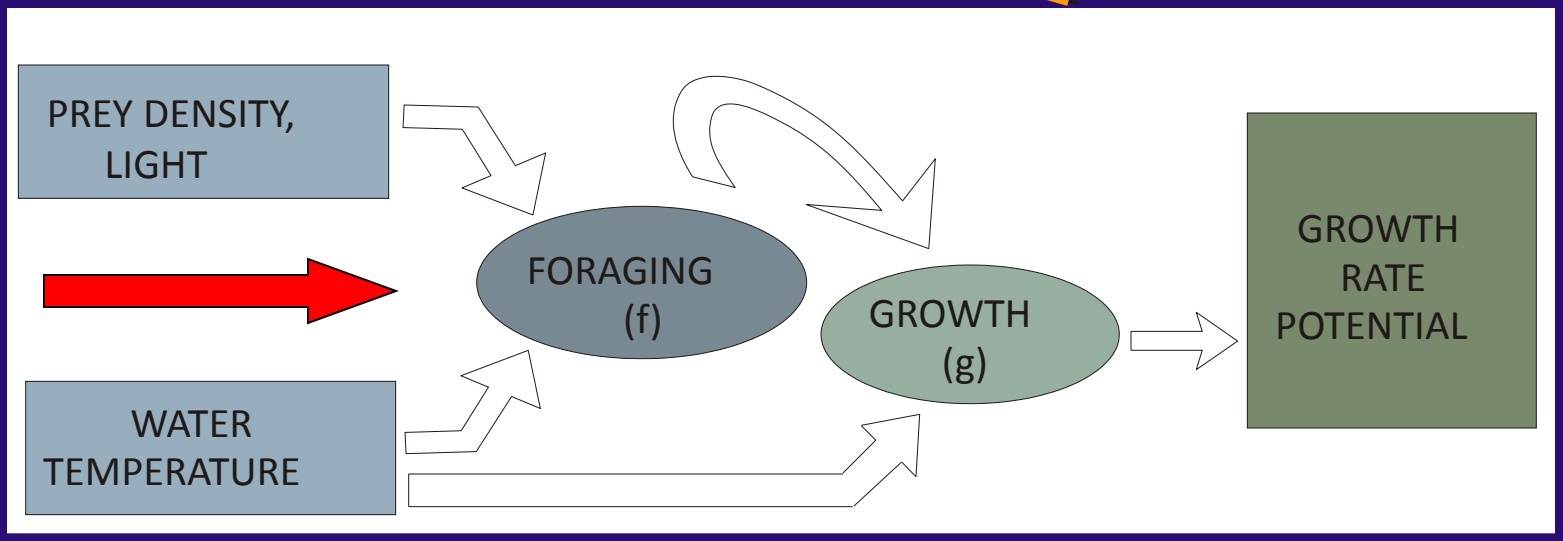
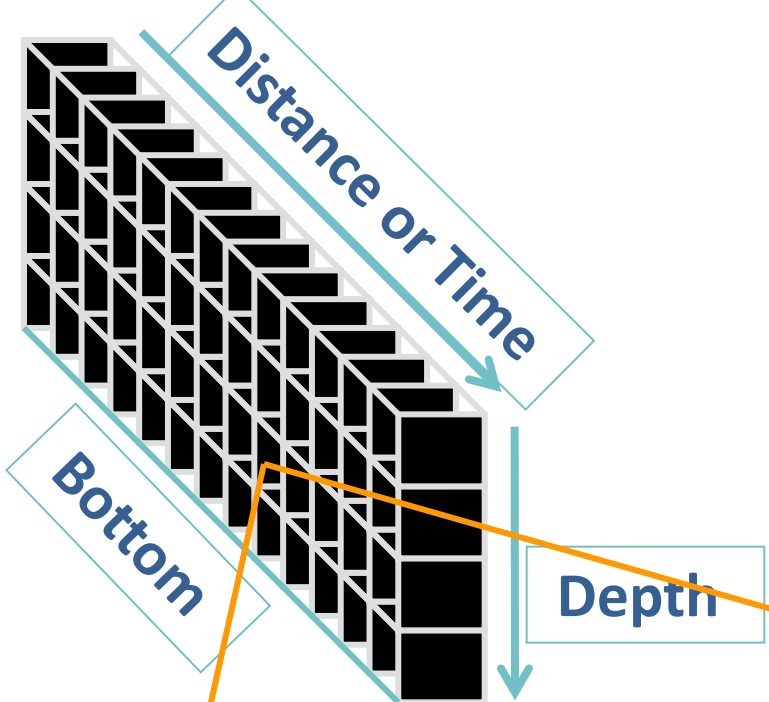




- G = growth
- C = consumption
- R = respiration
- SDA = standard dynamic action
- F = egestion
- U = excretion

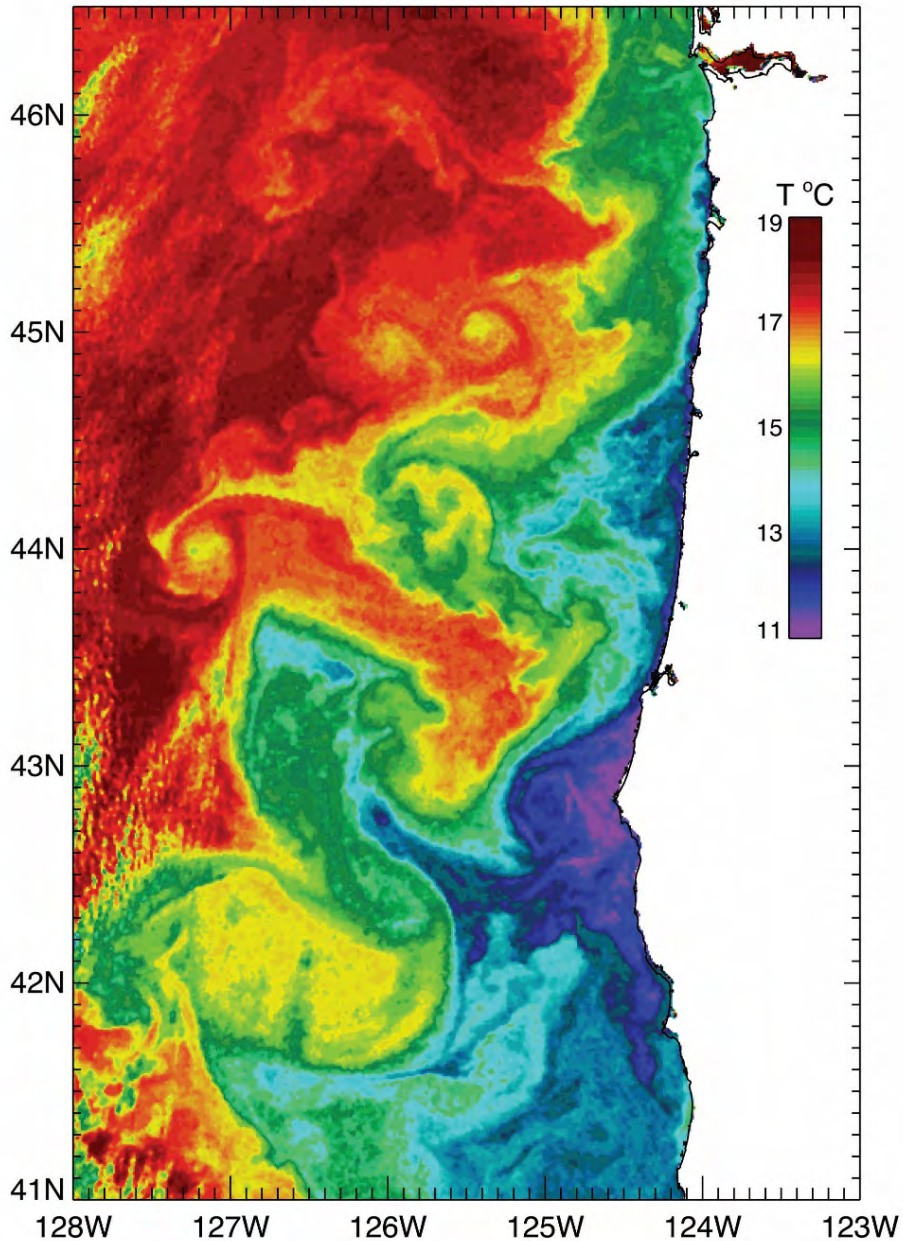
Consumption = Growth + Respiration + Wastes

Growth Rate Potential Spatial/Temporal Model



Sea Surface Temperature off NW Coast of America

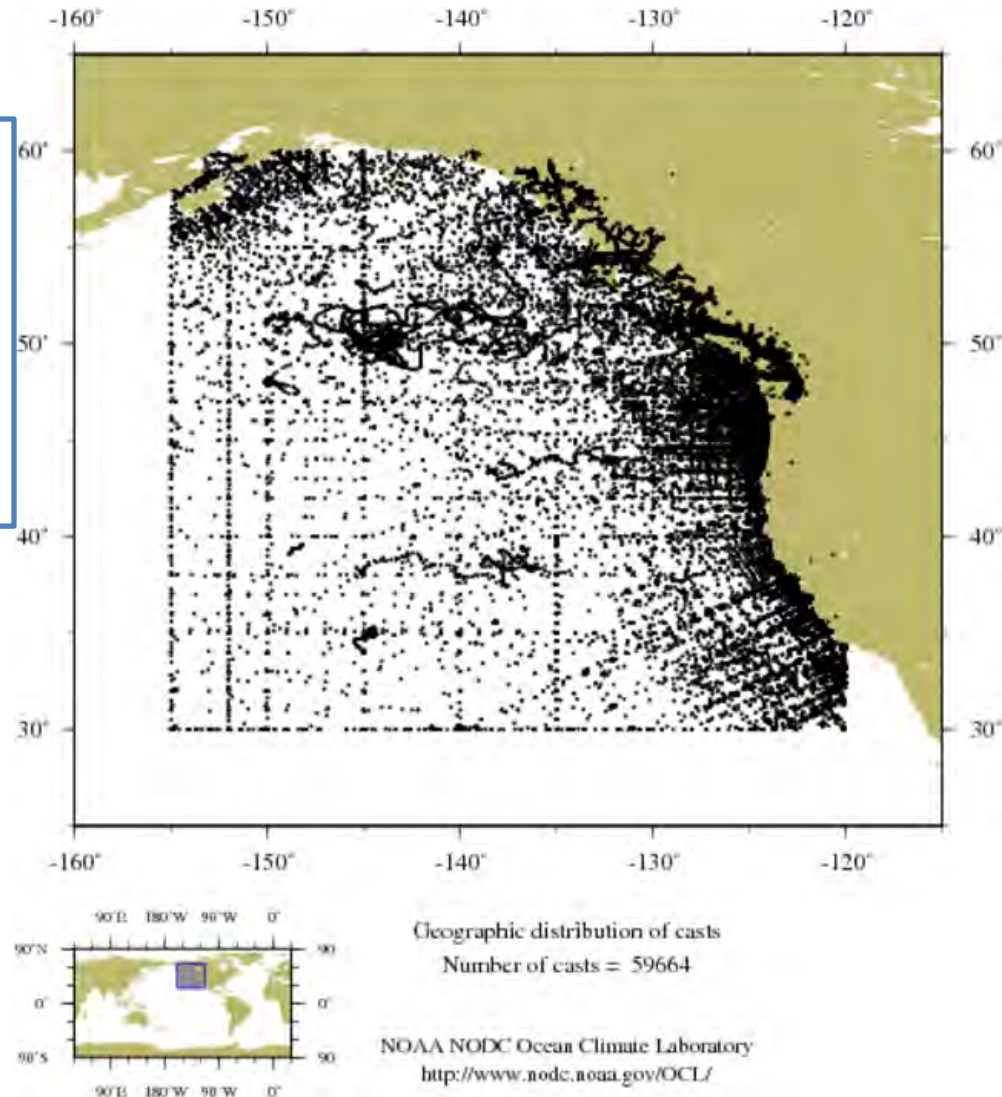
SST September 26, 1998



Large-scale Climatic cycles due to El Nino Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Climate Change

Salinity, Temperature and Oxygen Data

Data base =
37,838 CTD, XBT
casts for years
spanning
1929 - 2013

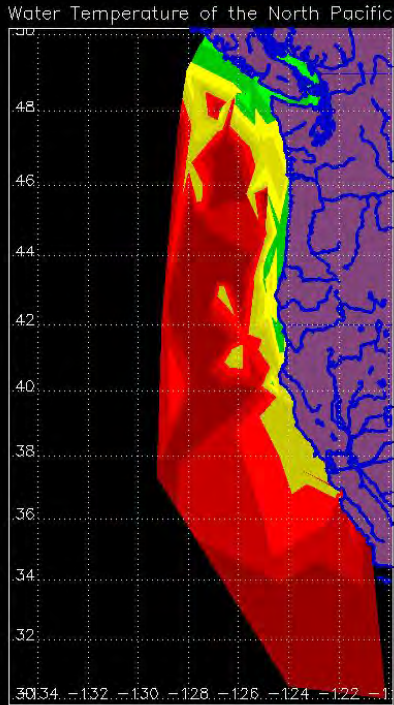


Fall Spatial Temperature Plots

Fall

Year = 1972

Min Depth = 0.000000
Max Depth = 10.0000

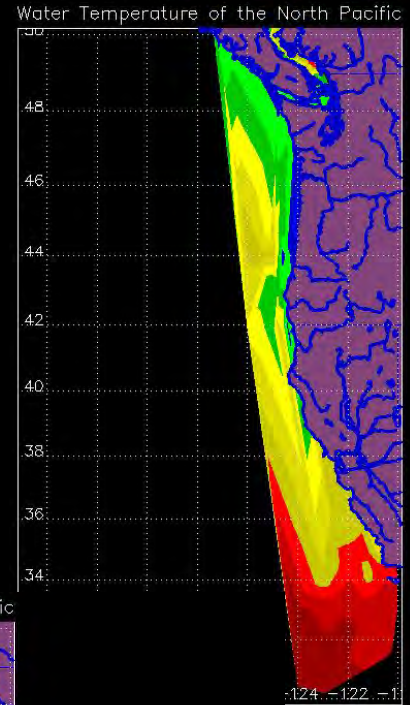


1972

Fall

Year = 2002

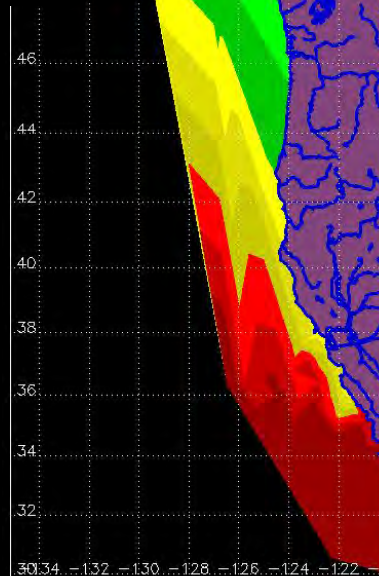
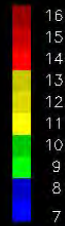
Min Depth = 0.000000
Max Depth = 10.0000



2002

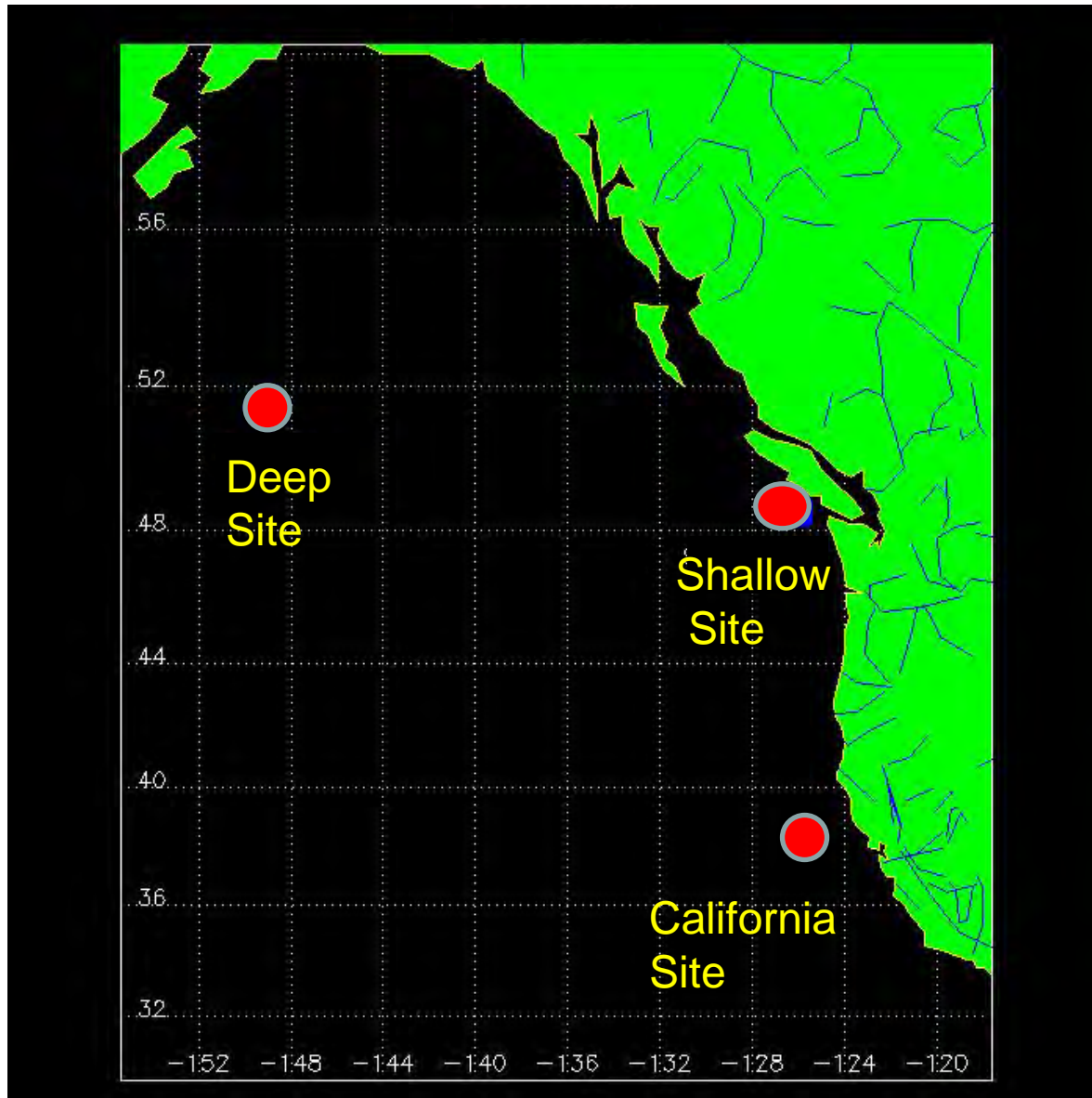
Temperature of the North Pacific

Max Depth = 10.0000

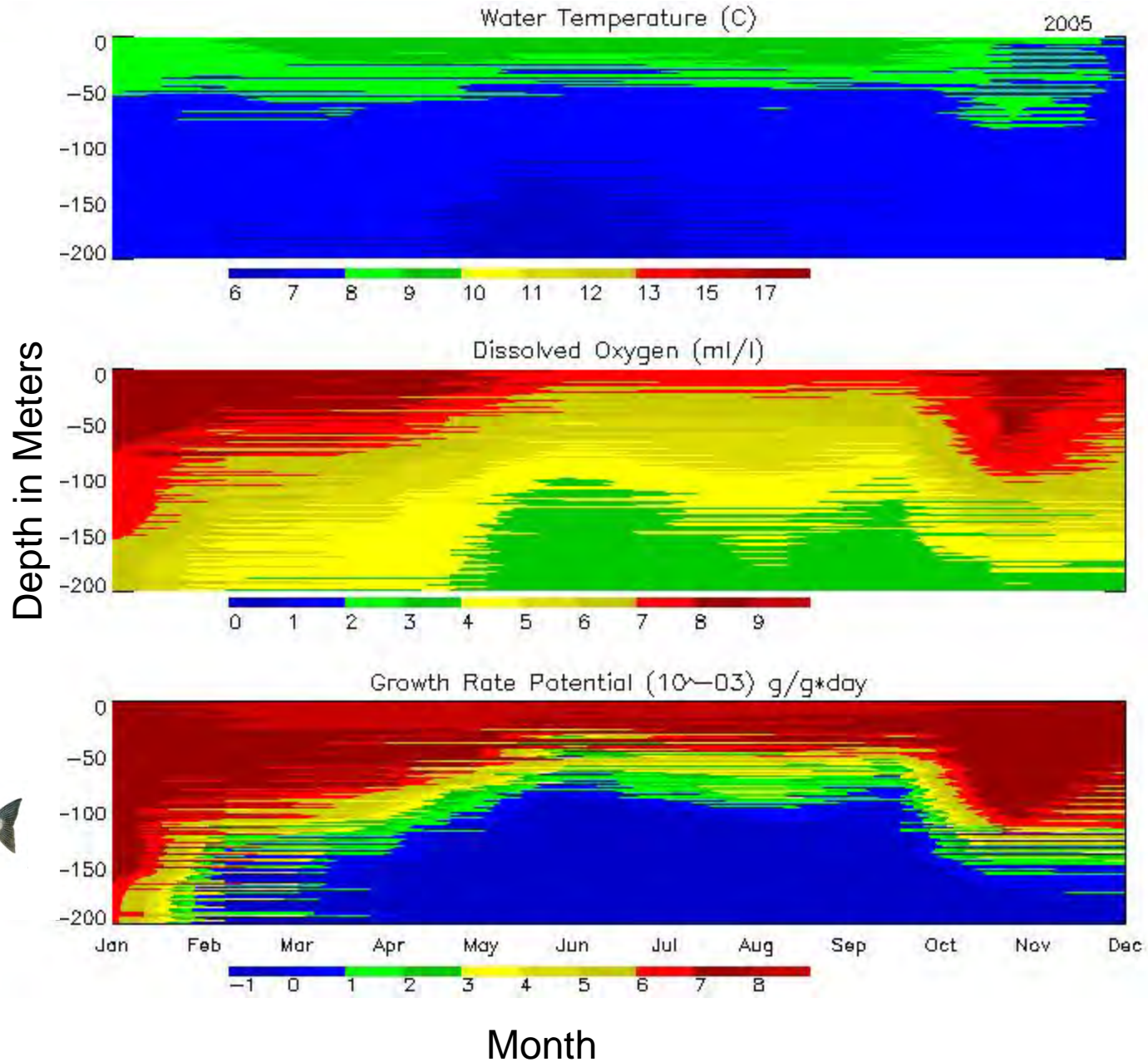


1984

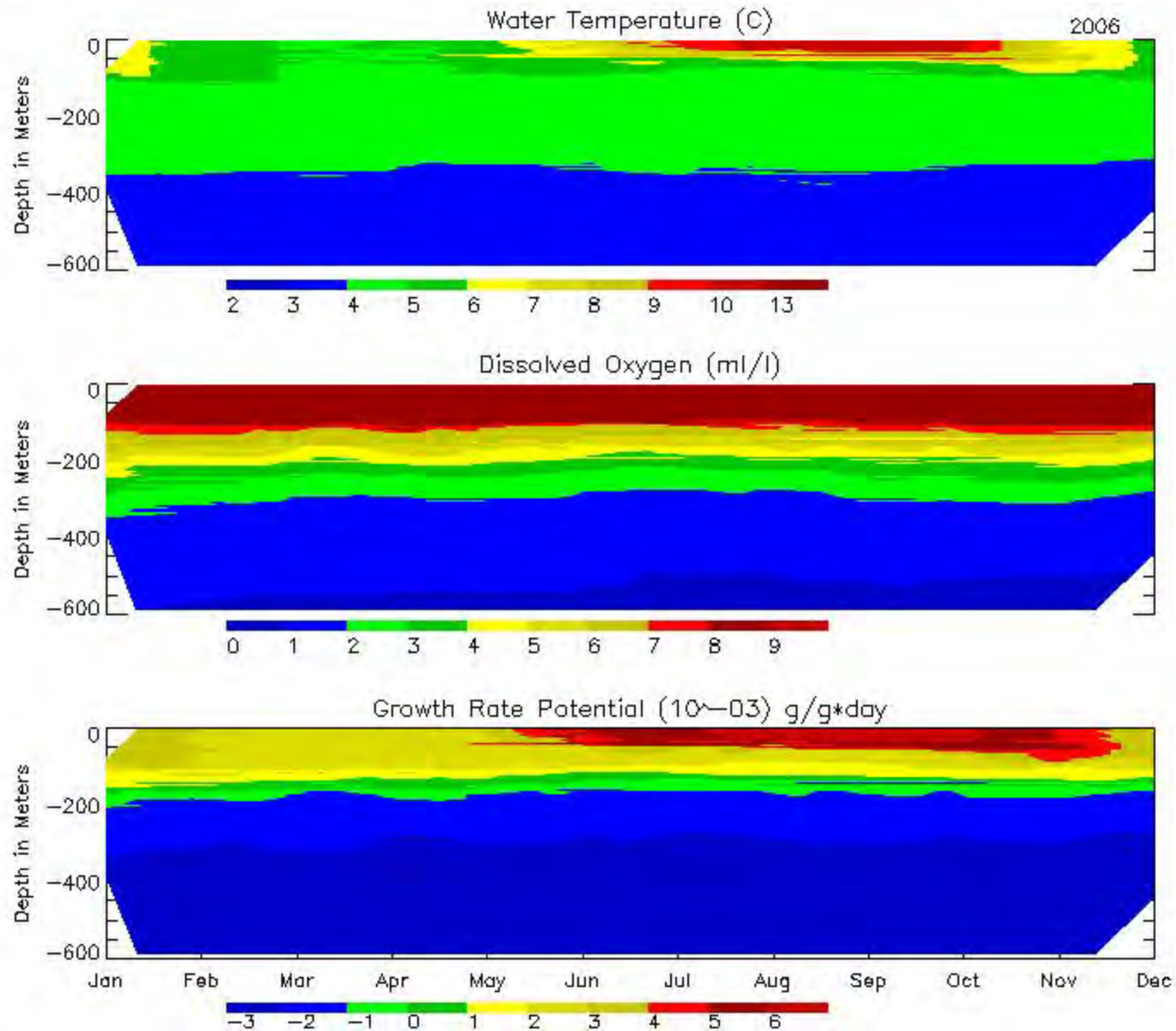
North Pacific Study Sites



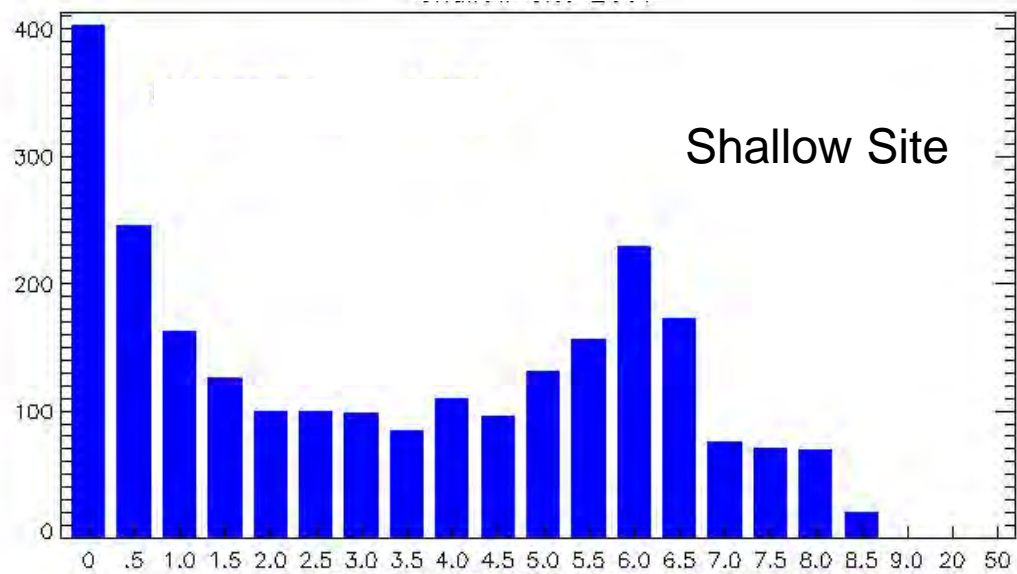
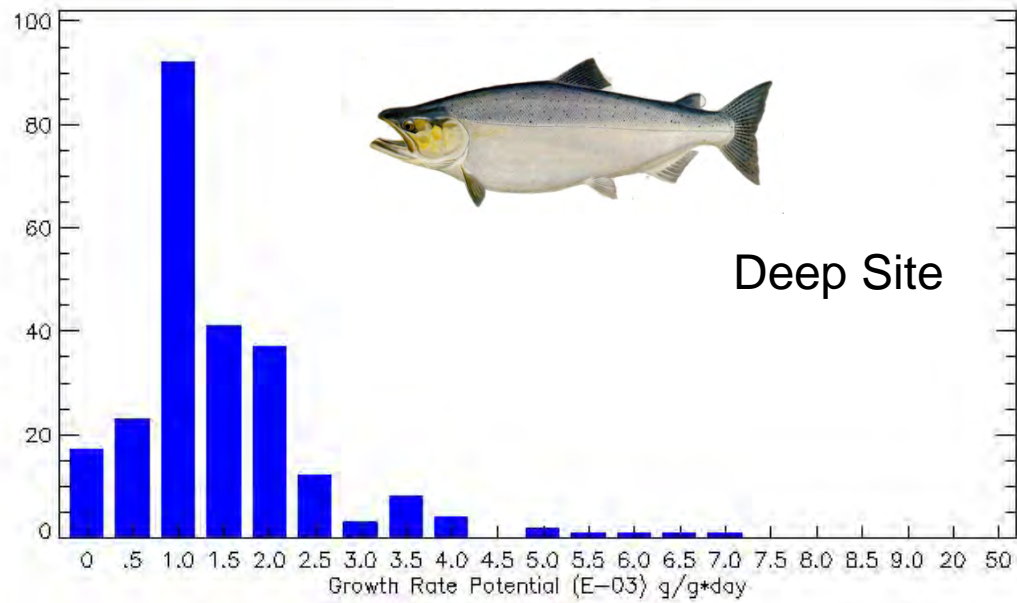
Shallow Site --2005



Deep Site --2006

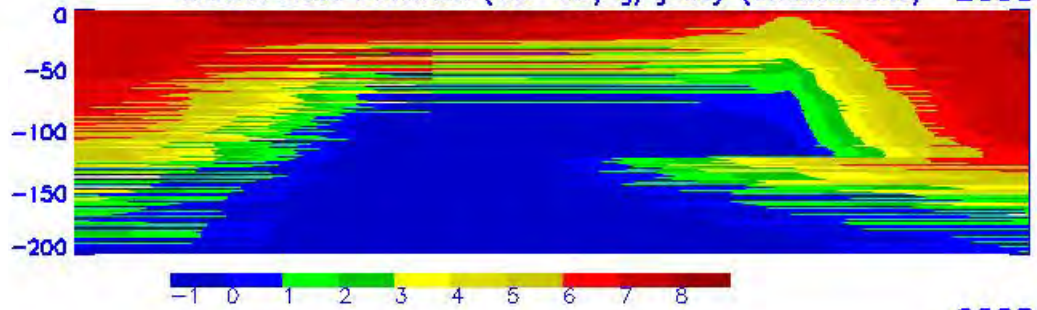


2007

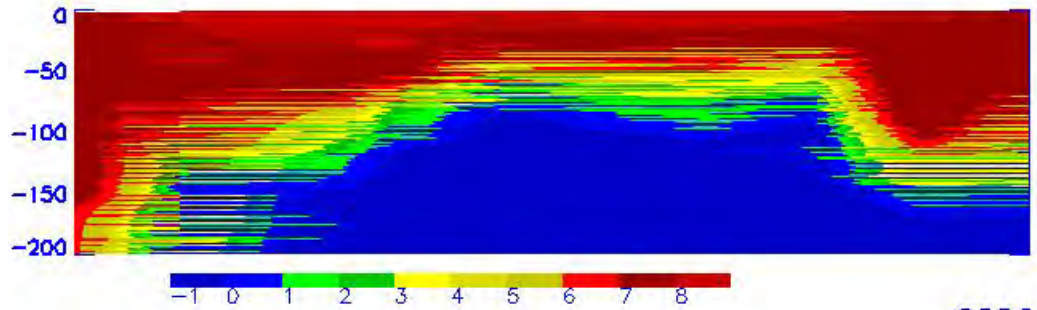


Salmon Growth Rate Potential

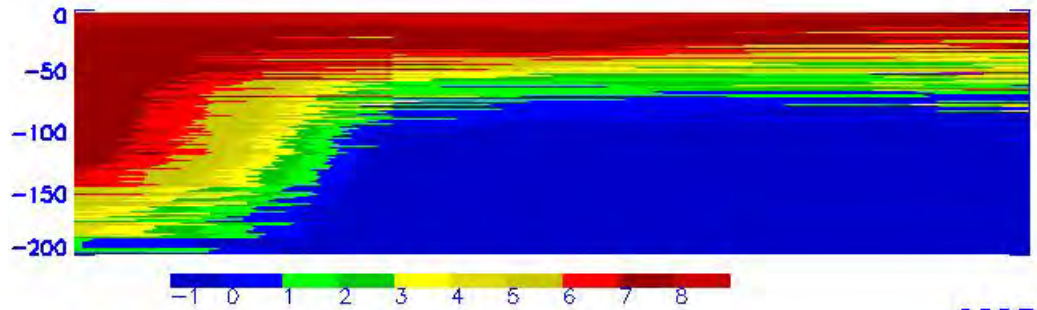
Growth Rate Potential (10^{-03} g/g*day (Shallow Site) 2003



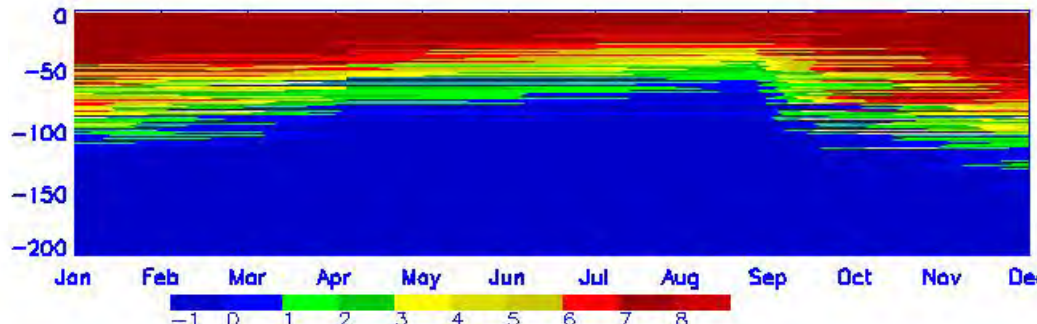
2005



2006



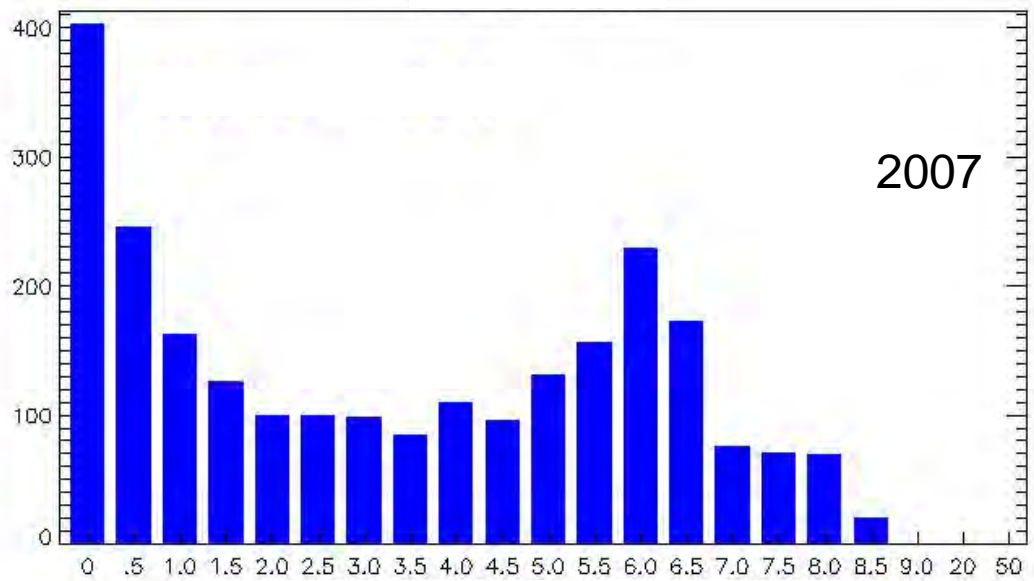
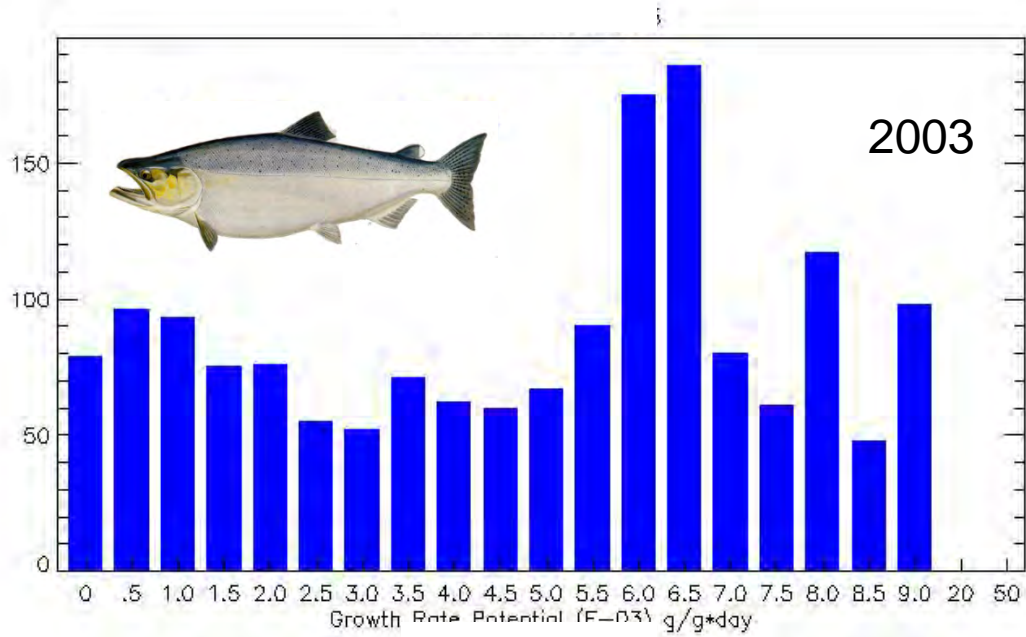
2007



Depth in Meters

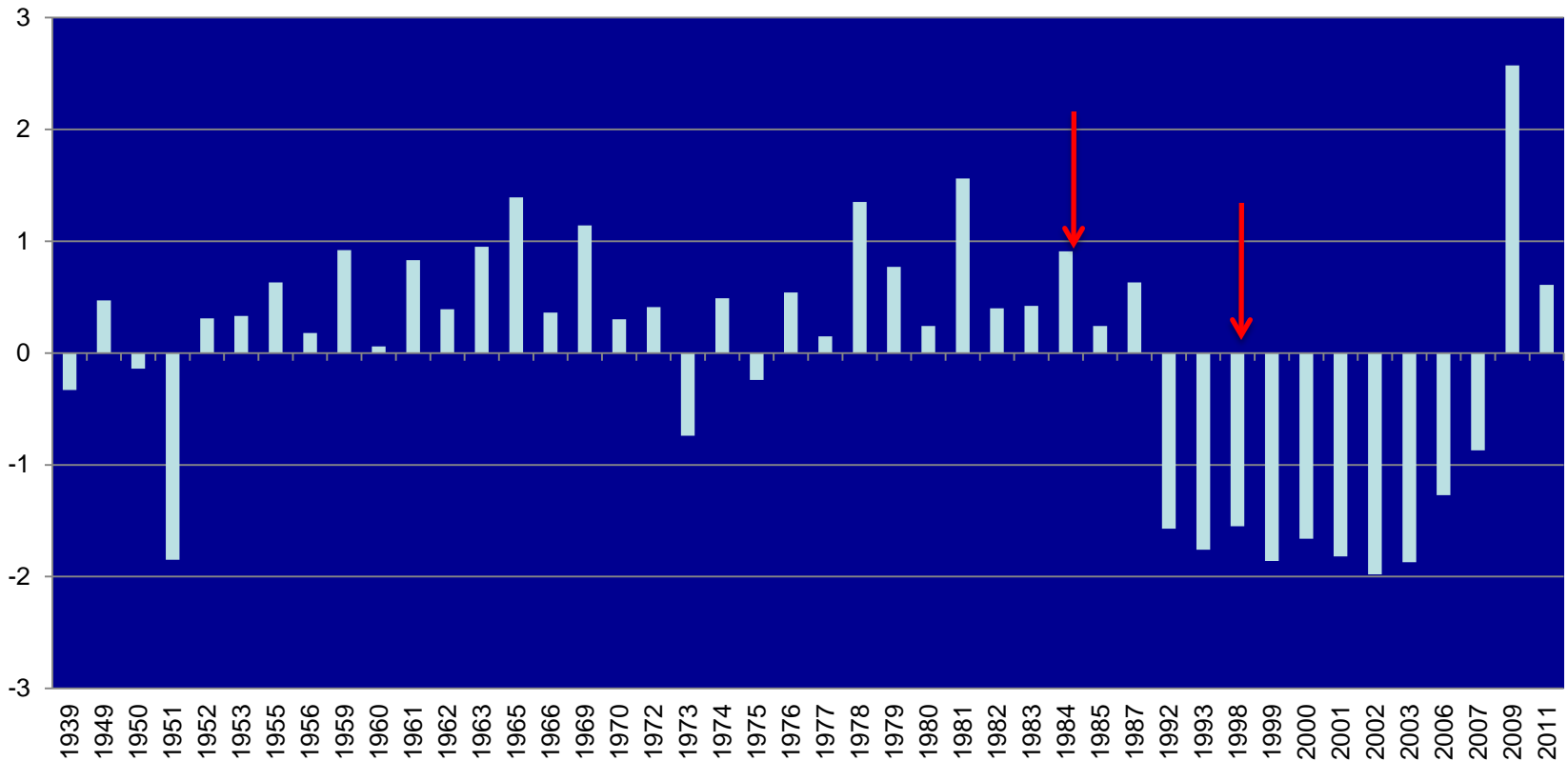
Chinook Salmon
Growth Rate Potential
Across Different
Years





Salmon Growth Rate Potential

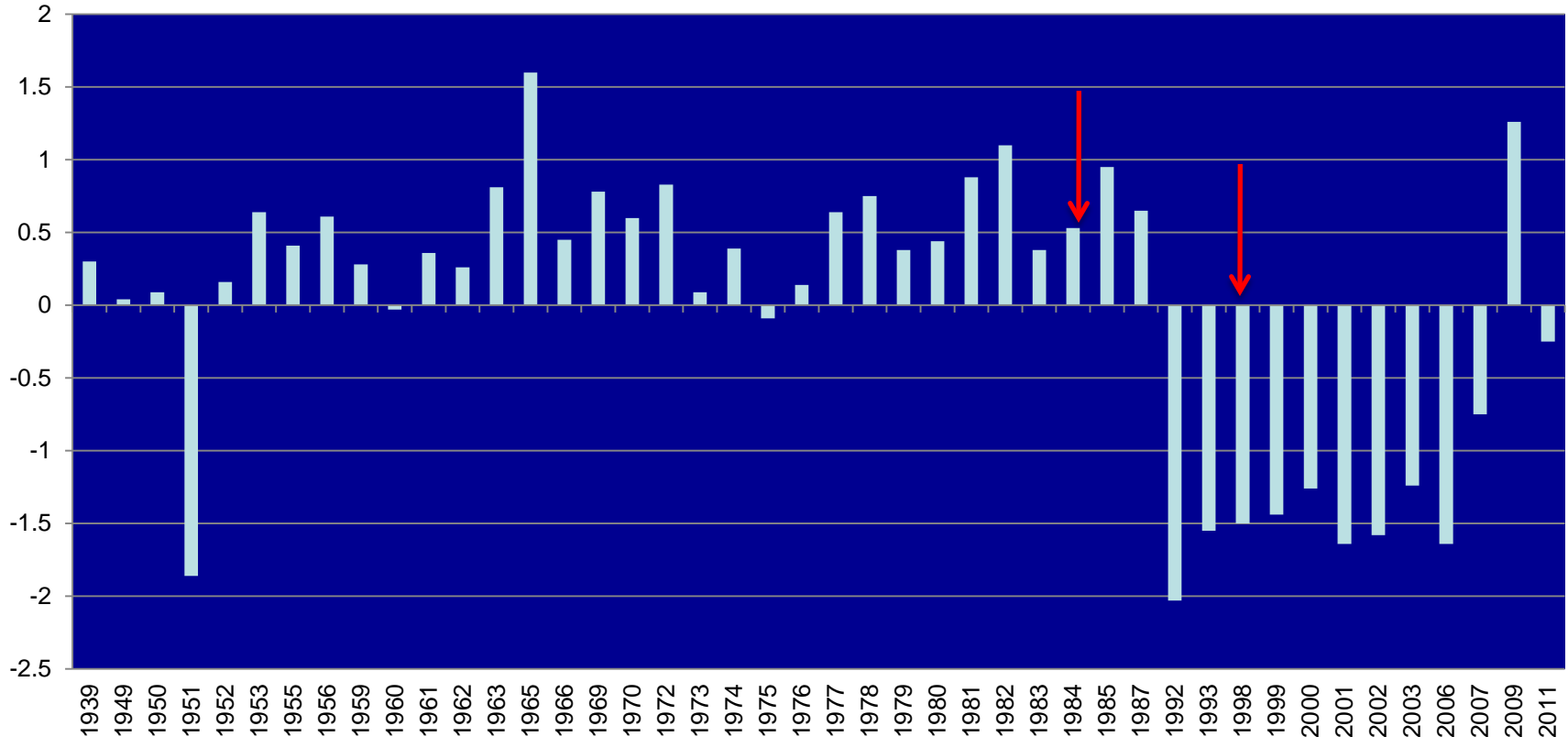
Time Series California Water Temperature



Average = 9.00 °C

Time Series California Dissolved Oxygen

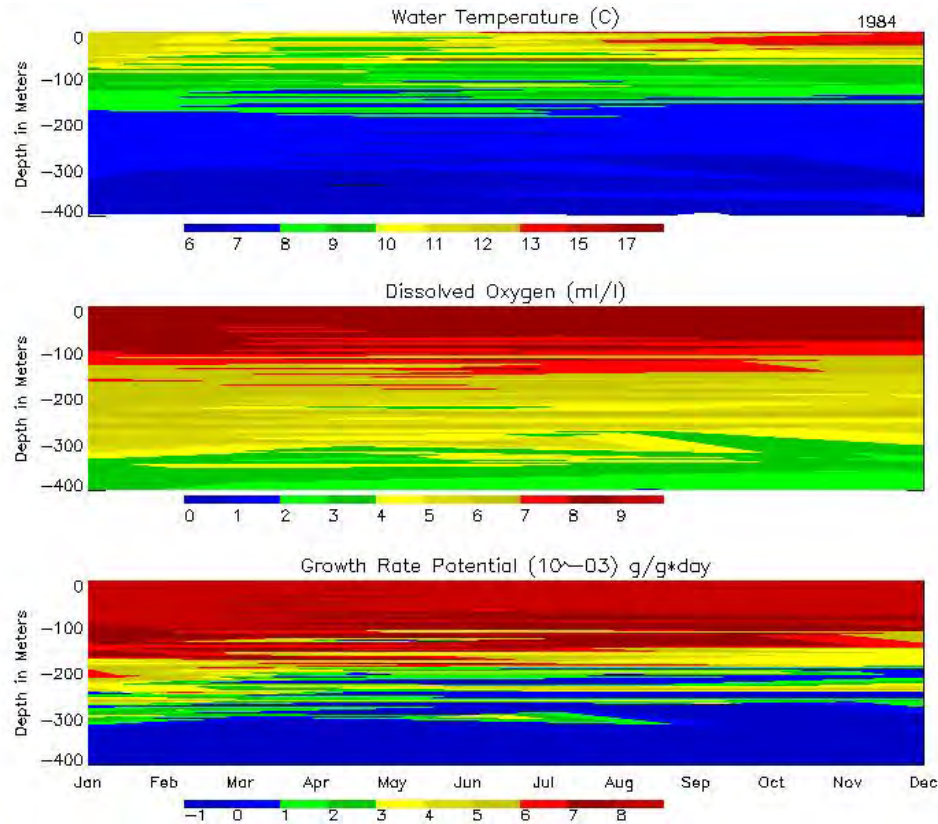
California DO



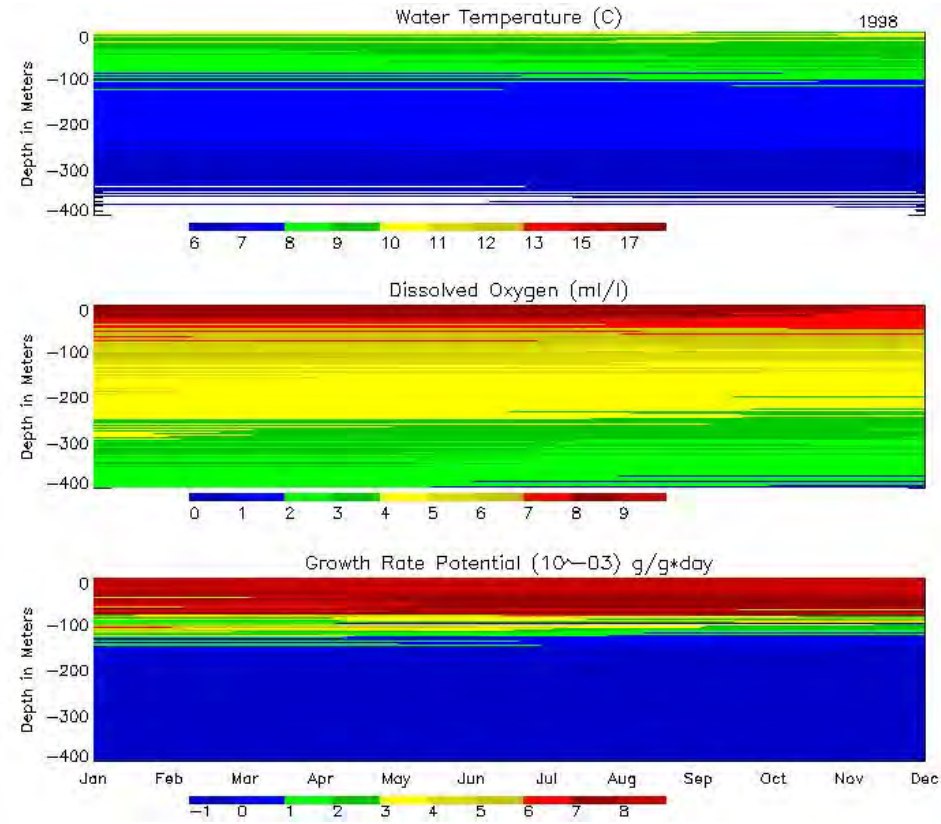
Average = 3.62 mg/l

Annual Differences between Warm and Cold year

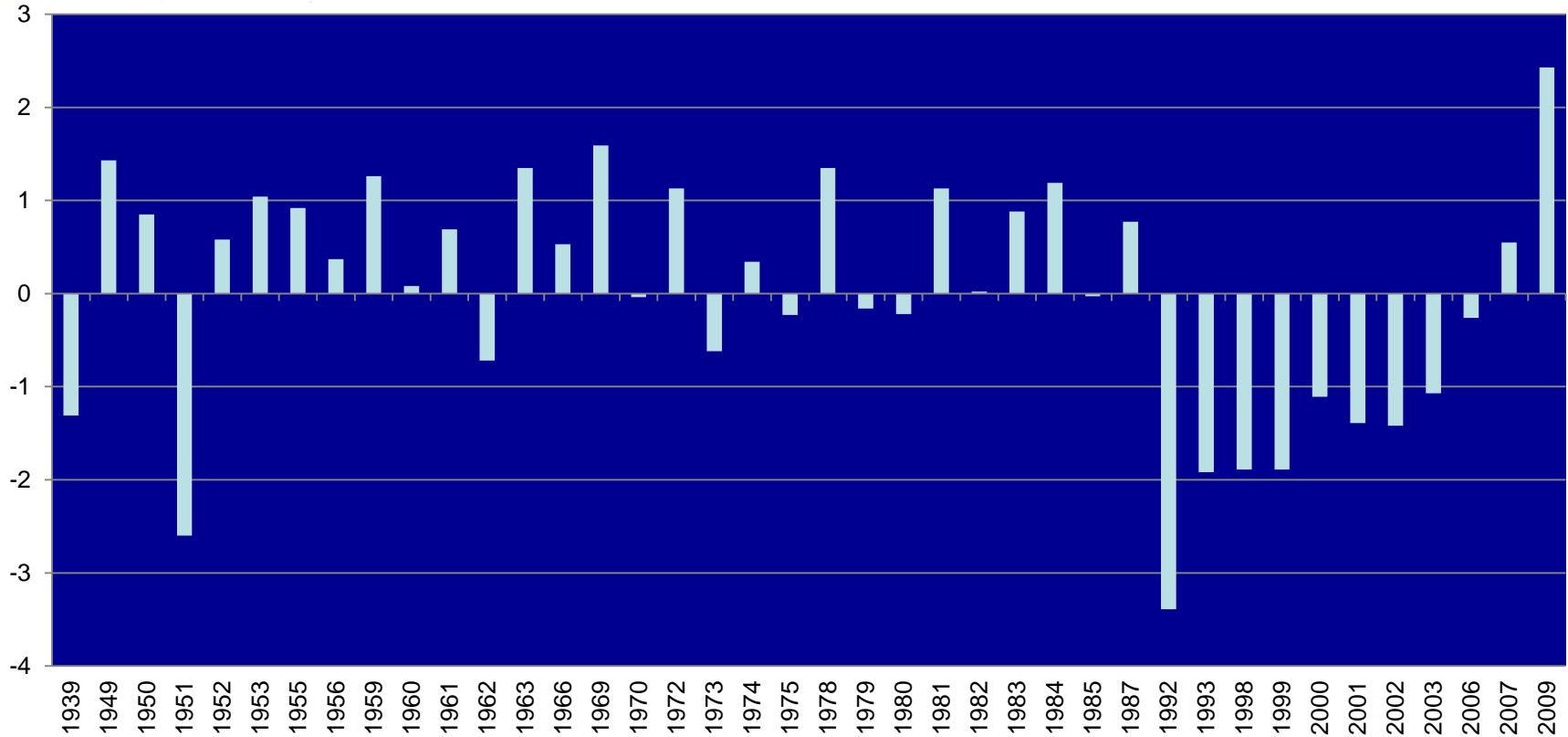
California 1984



California 1998

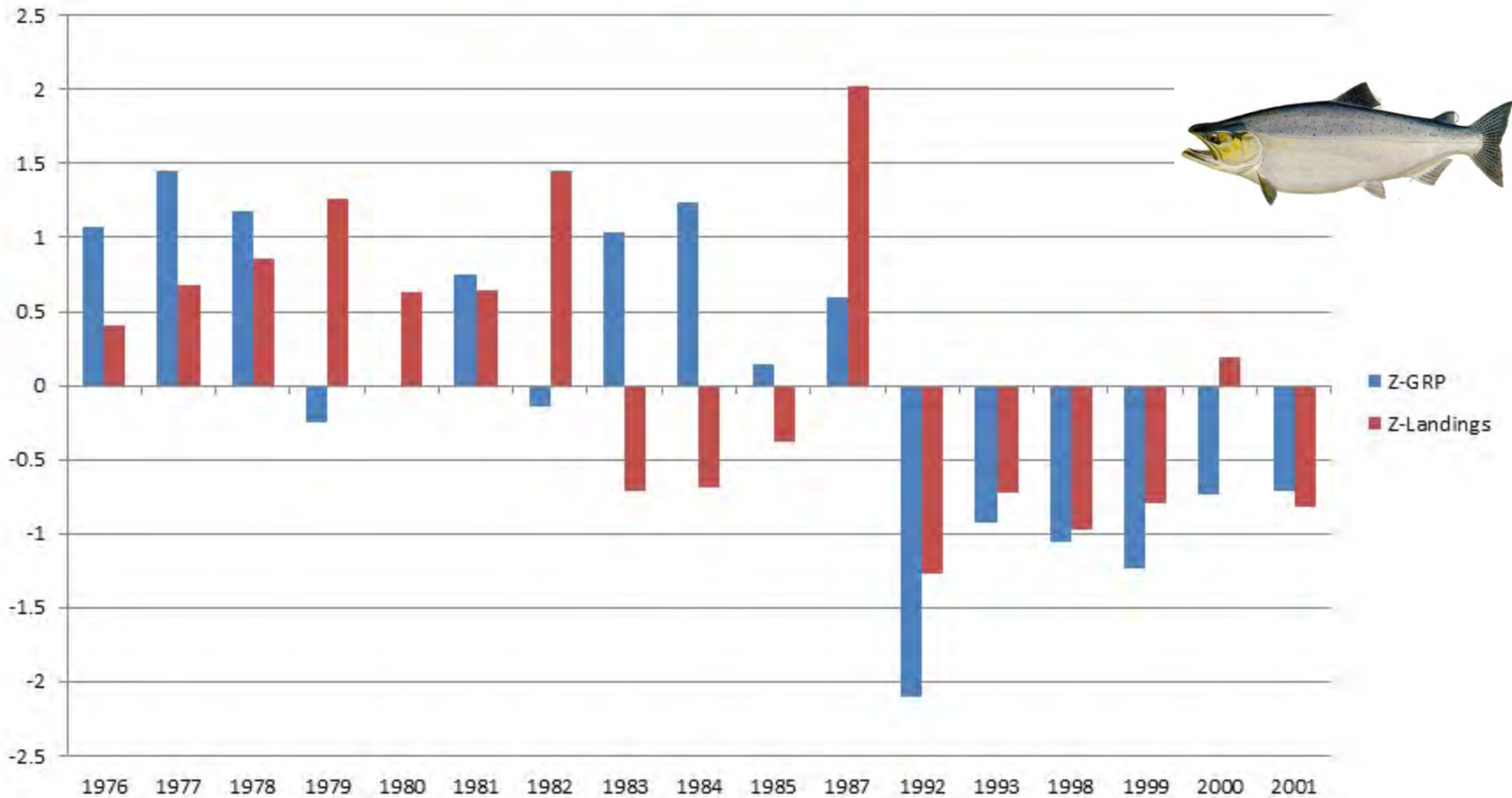


Chinook Salmon Growth Rate Potential



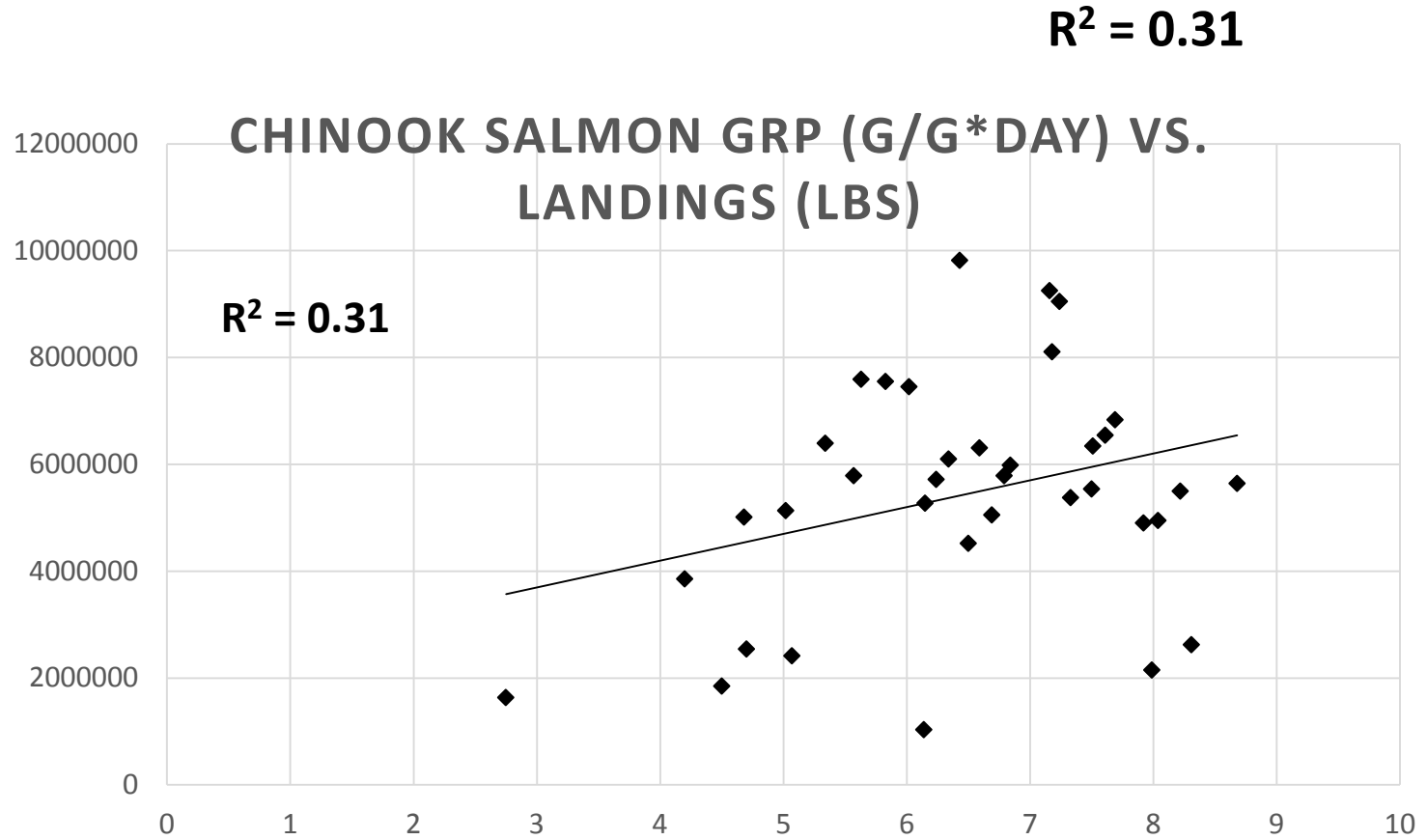
Average = 6.00×10^{-3} g/g*day

Growth Rate Potential and Statewide Catches of Chinook Salmon



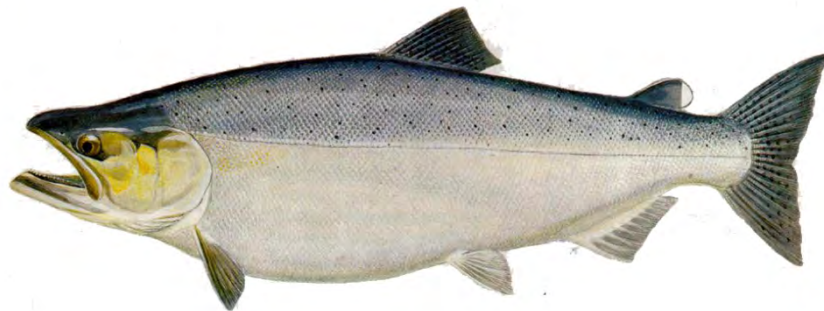
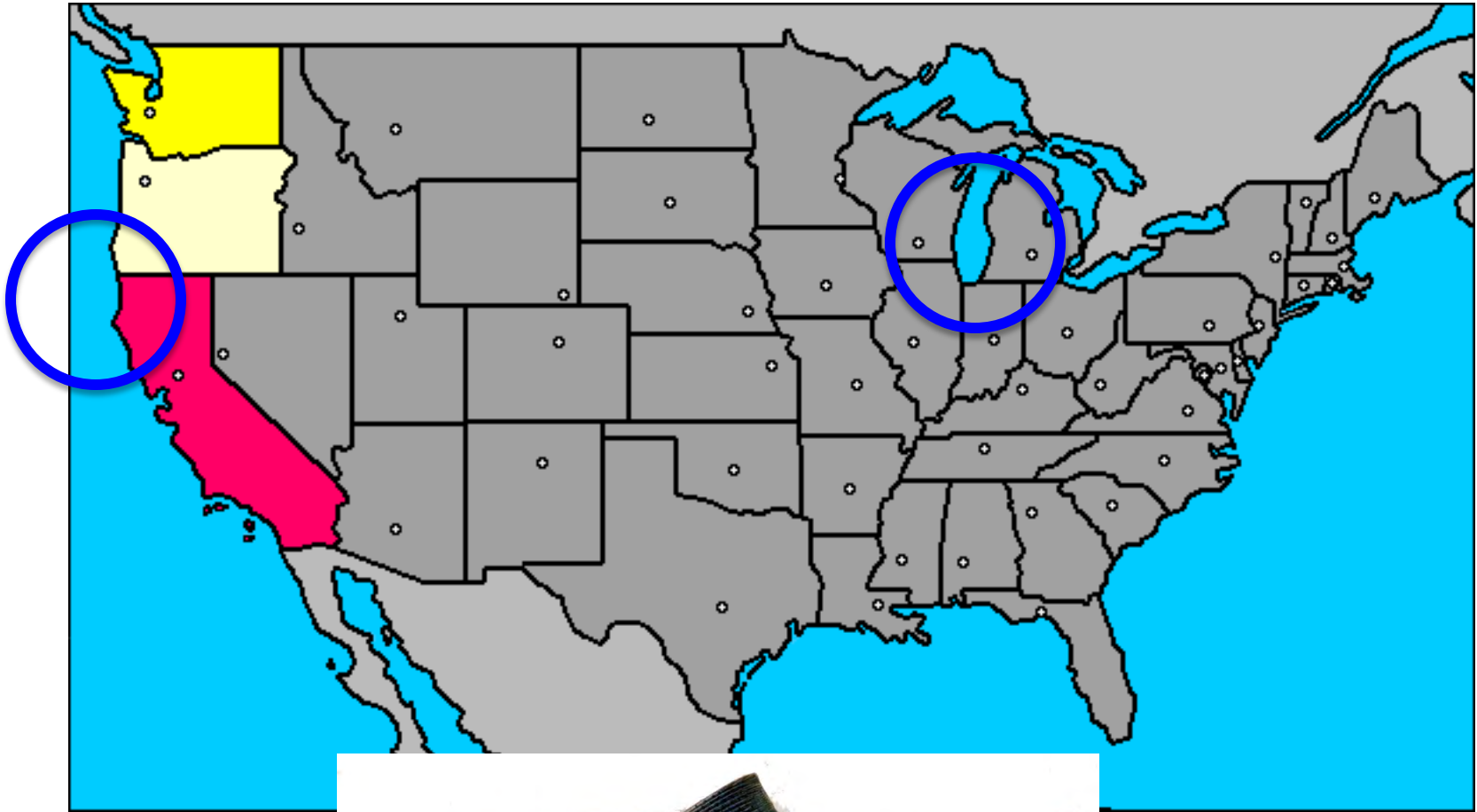
Wilcoxon Rank Sum Test $p = 0.5$ —Same mean distribution
 $R^2 = .474$

LANDINGS



GROWTH RATE POTENTIAL

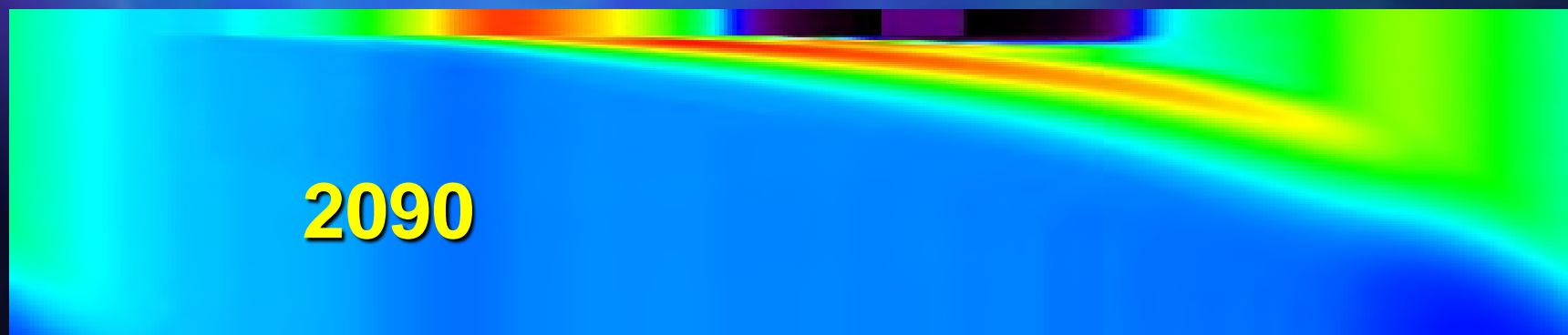
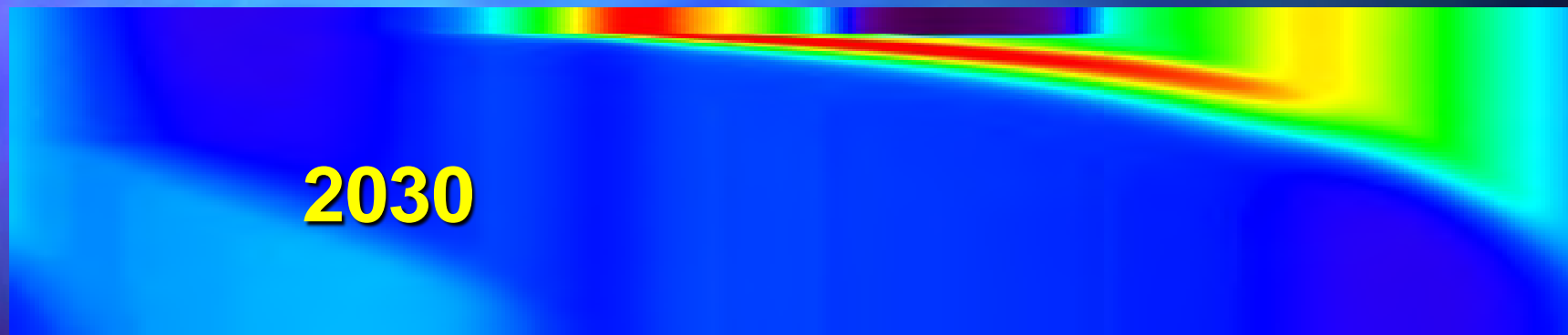
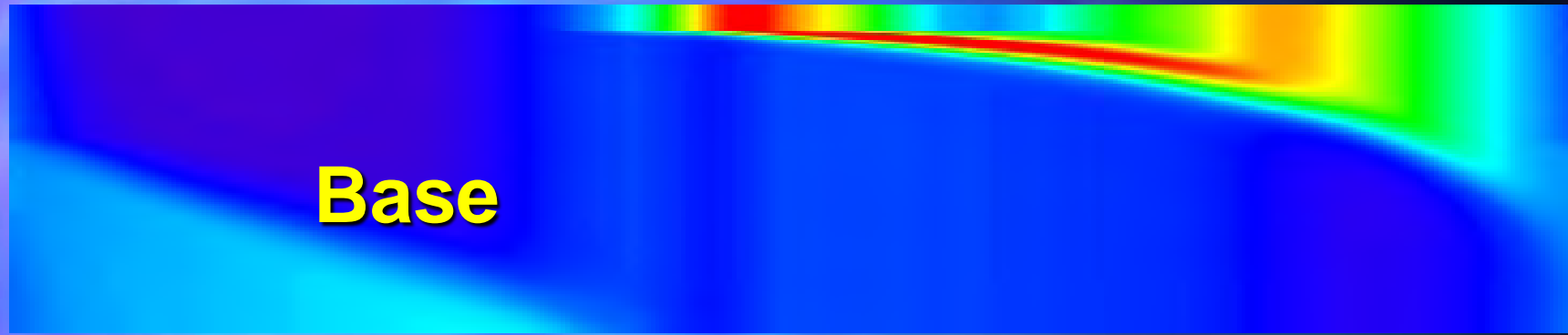
Climate Change Impacts on Chinook Salmon



Chinook Salmon Growth

-0.02

0.09



Jan

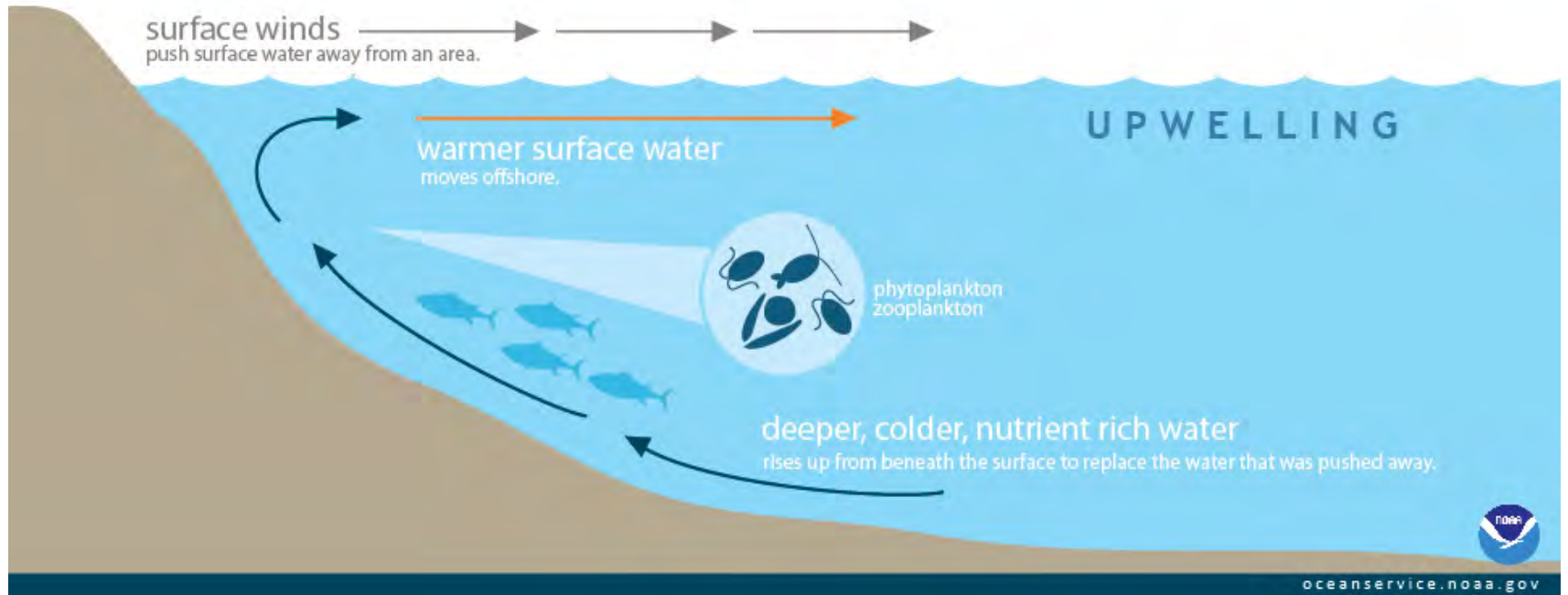
July

Dec

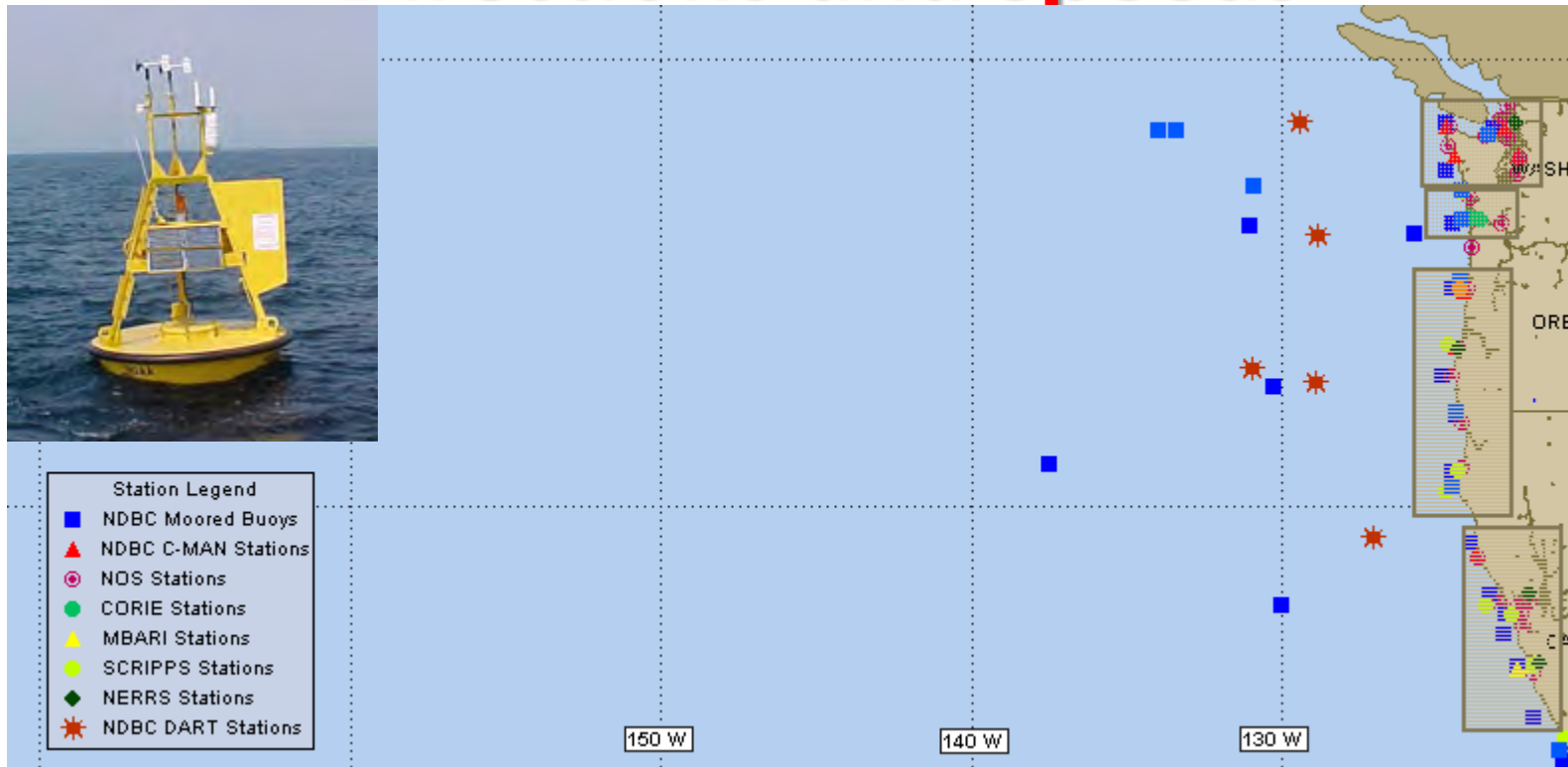
0

150

2002 Upwelling Event



NOAA Data Buoy Locations for Wind Directions and Speeds



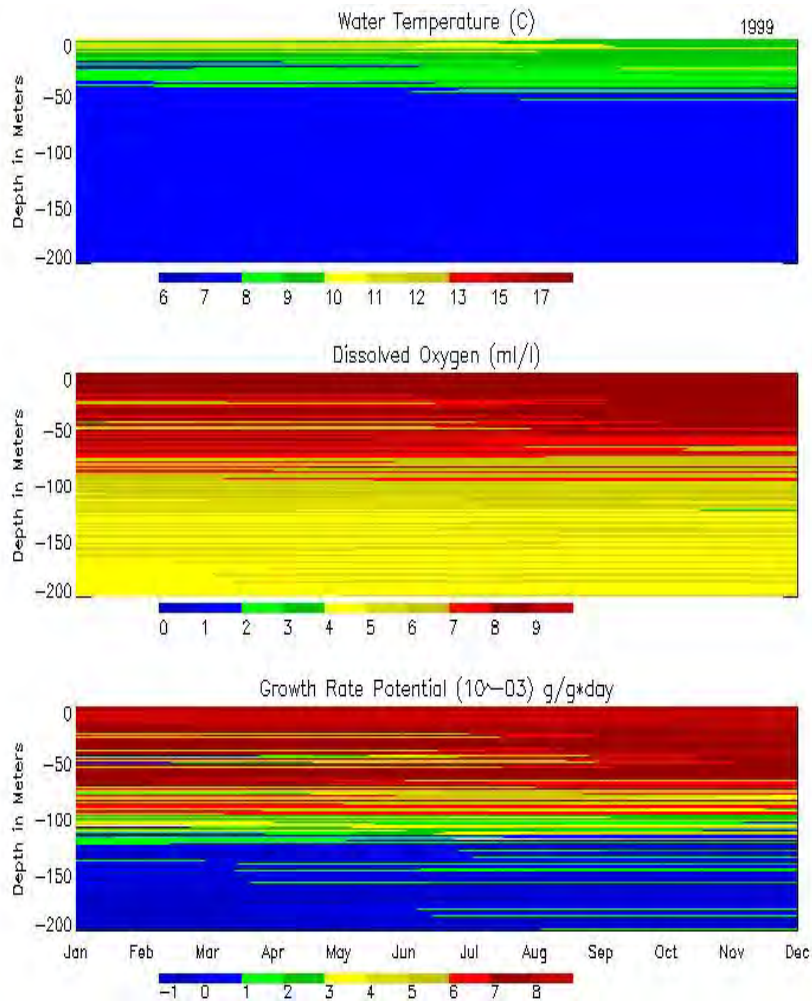
Obtained Wind Speeds and Directions from 27 NOAA Moored Data Buoys with years ranging from 1972 - 2014

Nearshore Hypoxia from 2002 Upwelling

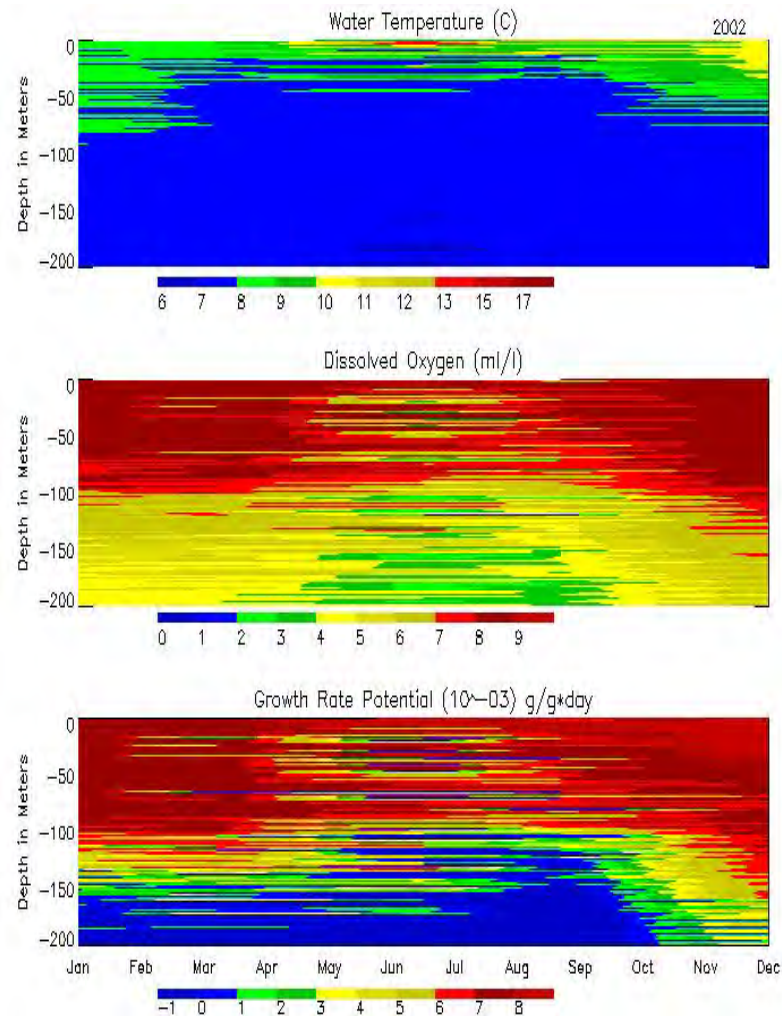
- Development of inner-shelf (<70m) hypoxia
- Between July and September, bottom dissolved oxygen (DO) concentrations of 0.2 – 1.6 ml/l were found.
- DO deficient bottom water occupied 40m of the water column.
- Large numbers of dead fish and invertebrates washing ashore in the affected area.

Applying GRP to Upwelling Events

Oregon 1999



Oregon 2002



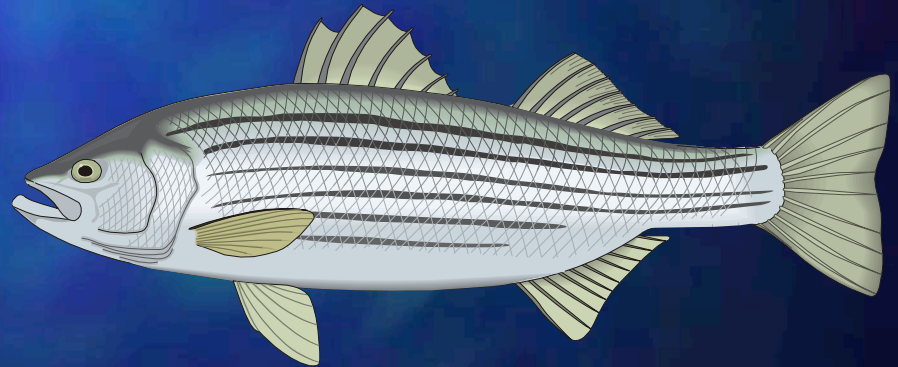
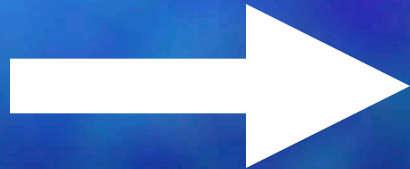
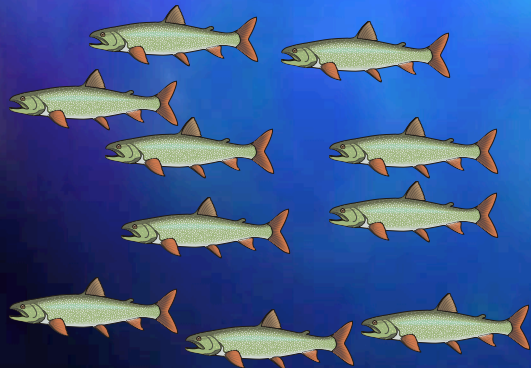
Consumption

Function of:

Predator Consumption Capabilities

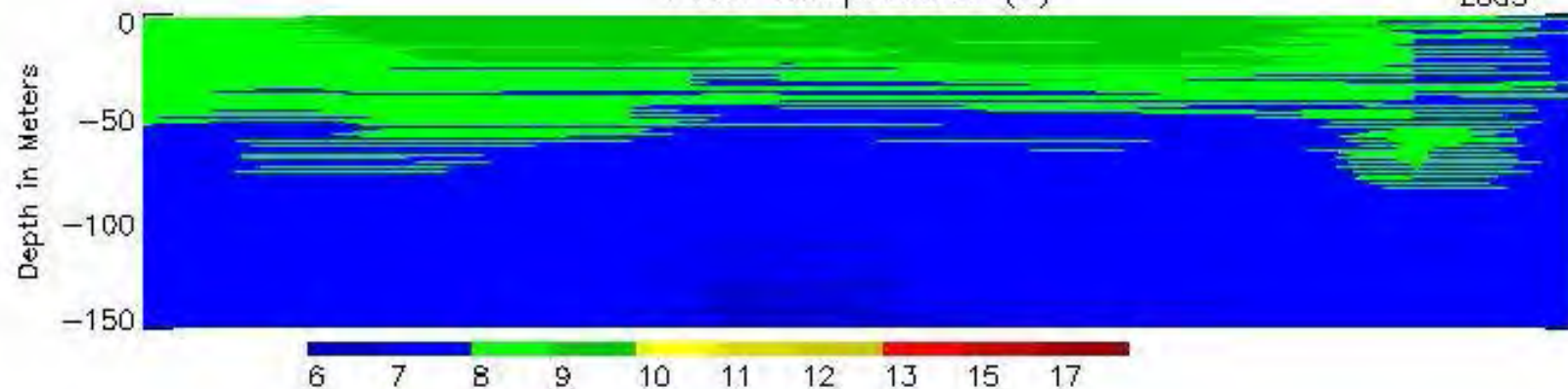
- predator size, foraging capabilities, temperature, oxygen, light

Prey density

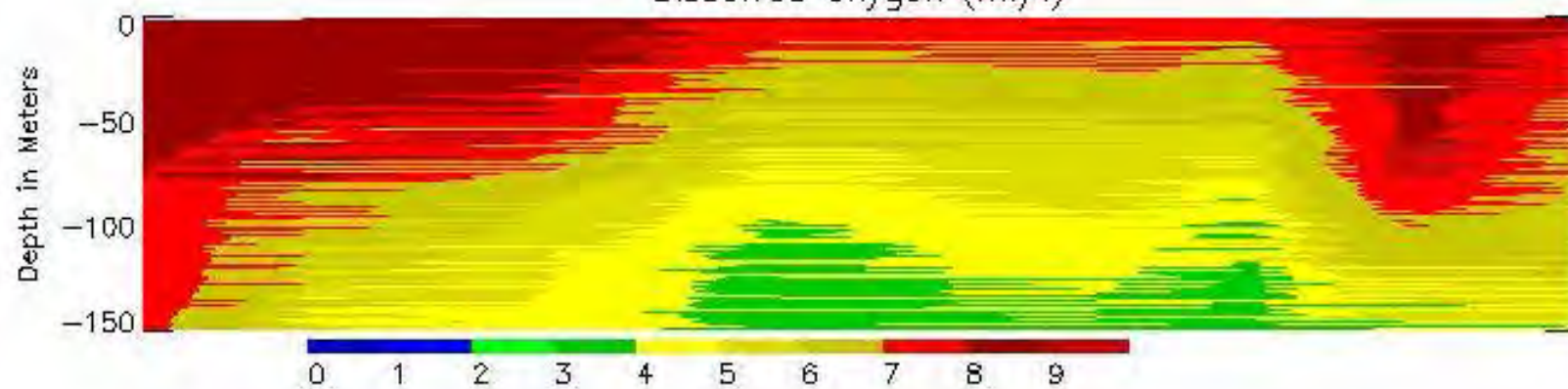
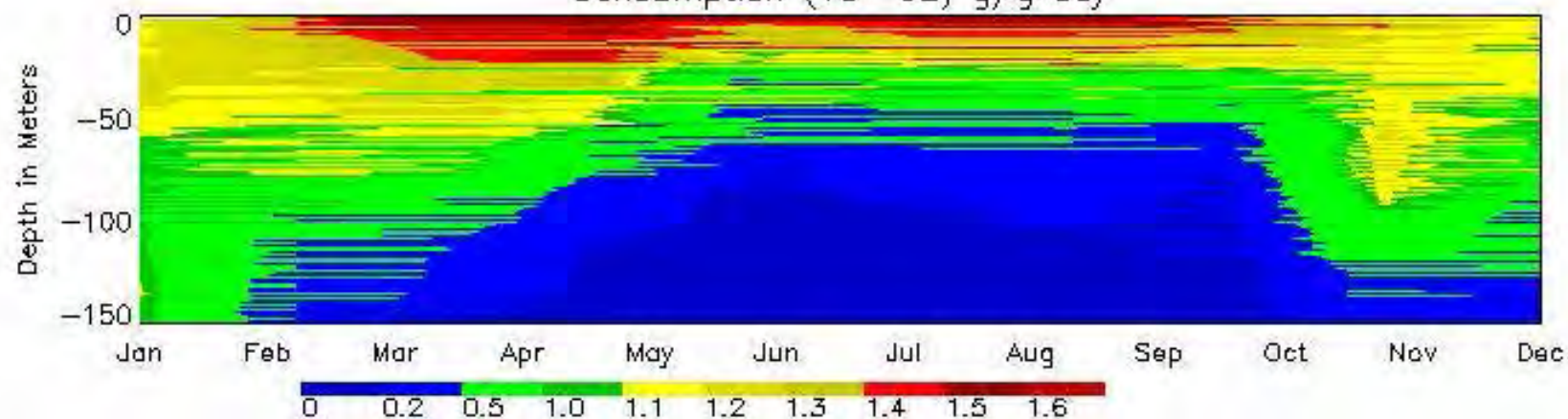


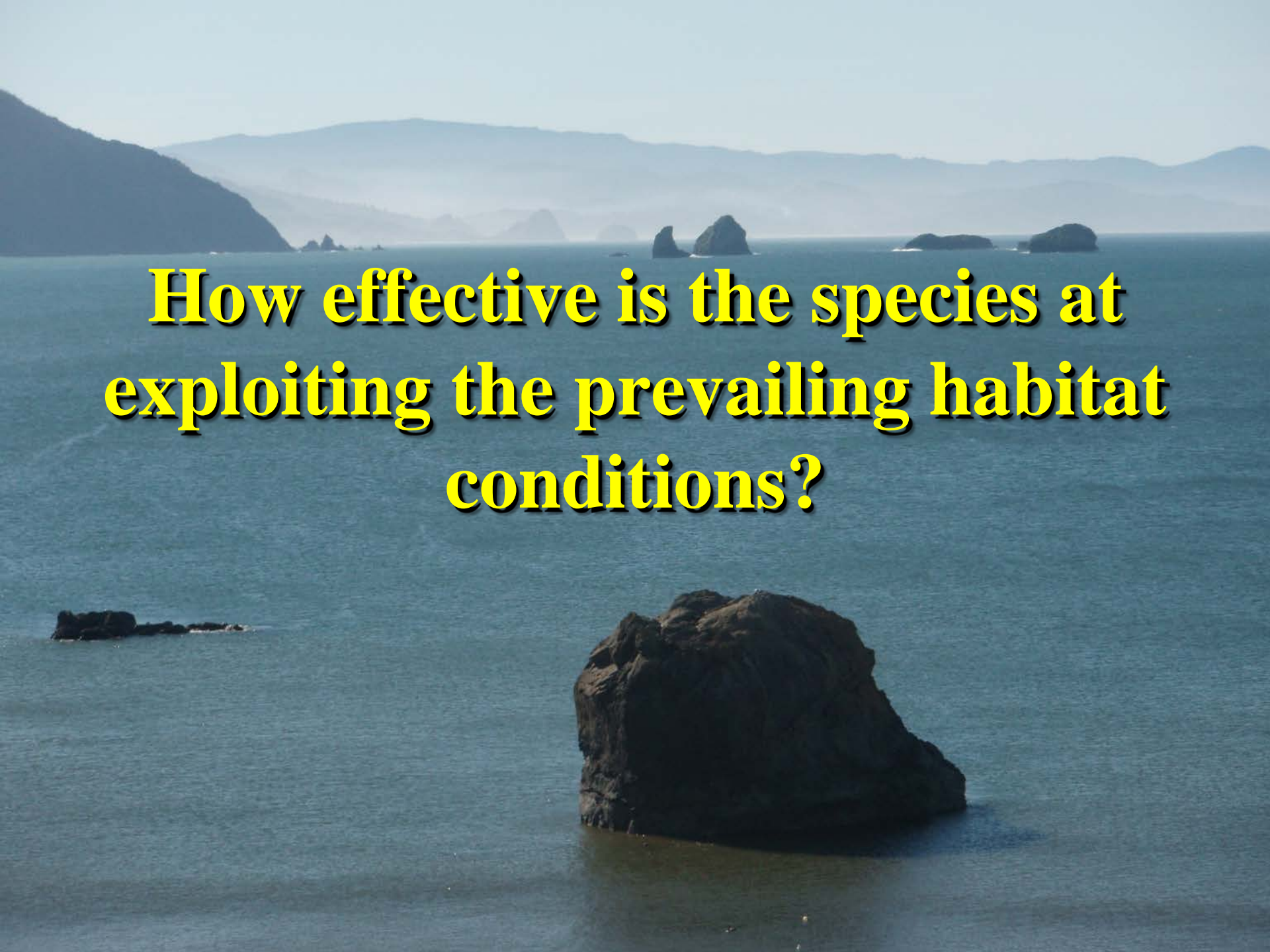
Water Temperature (C)

2005



Dissolved Oxygen (ml/l)

Consumption (10^{-02}) g/g*day

A scenic view of a coastline with blue water, dark rock formations, and hazy mountains in the background. The text is overlaid in the center of the image.

**How effective is the species at
exploiting the prevailing habitat
conditions?**

Growth Rate Potential

- Measure of habitat conditions
- Quality defined by fishes energetic needs and foraging abilities
- Independent of fish distribution

Observed Growth

- Measure of response of fish to habitat conditions
- Depends on fish behavior and distribution (actual or modeled)

Take-Home Messages

- **Nonlinearity – Correlations**
- **Spatial Scales – average across habitats**
- **Time Scales (events – climate)**
- **Time Duration (seasonal scope for growth)**
- **Fish physiology and vital needs filter environmental conditions and thresholds**
- **Habitat choice options**
(Habitat quality = Habitat use but is a predictor)

Future Research

- **Expand Space to 3D Maps of Habitat Quality for Chinook in the NW Pacific Ocean**
- **Examine multiple year life in the sea**
- **Link to Observing and global circulation models to forecast changes in Chinook Essential Fish habitat**
- **Sensitivity to prey densities**
- **Thresholds or regions of persistent habitat quality**
- **Add albacore**

Questions?

Support from;
NOAA-CSCOR NGOMEX
National Academy of Sciences

