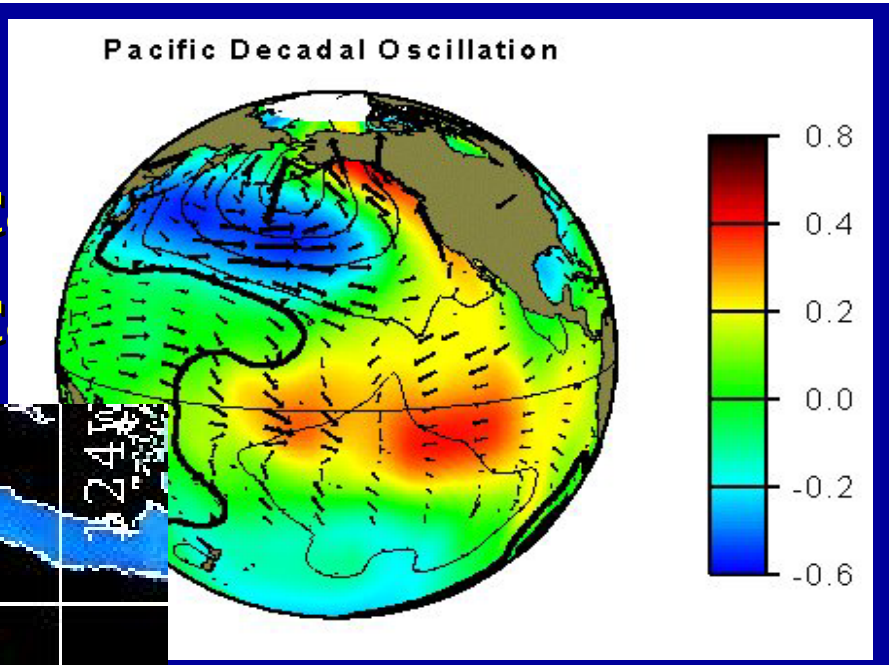
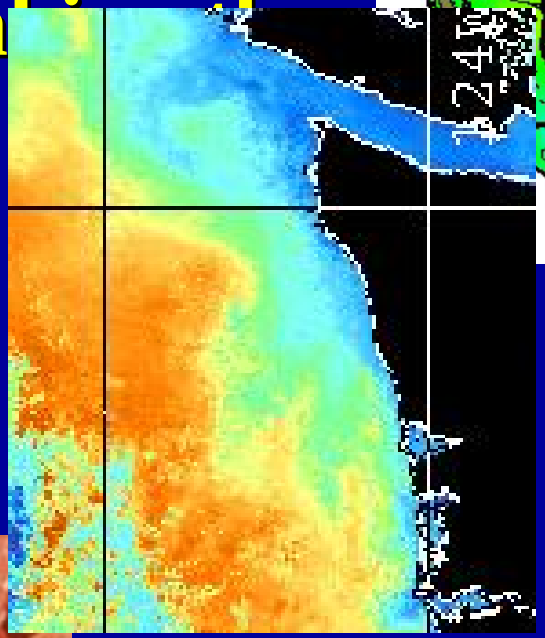
To upscale or downsc
bridging disparate sc
time in lin





rsity of Washington

JISAO/SMA Climate Impacts Group

PICES/CLIVAR Workshop Oct 23, 2004

The PDO oversold?

The precautionary approach to the PDO

Skip M[c]Kinnell
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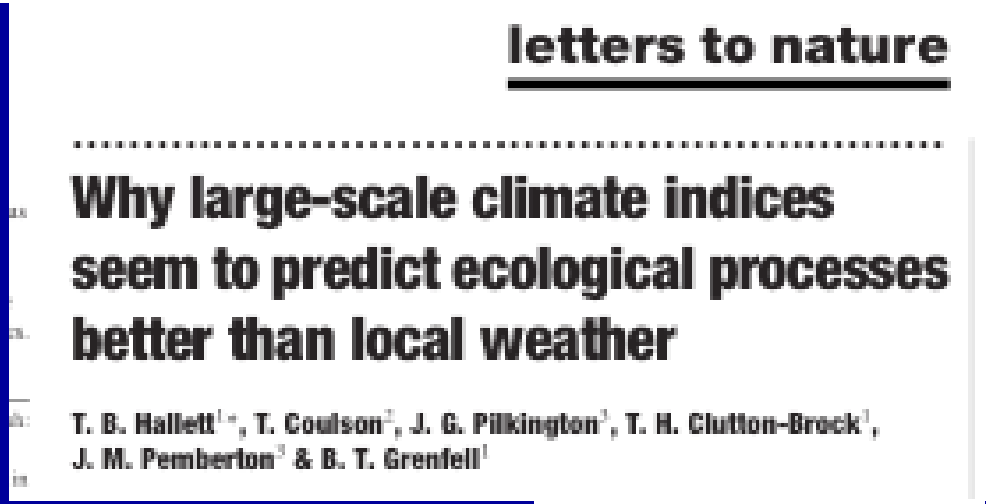
Dr. Skip M[c]Kinnell is Deputy Executive Secretary of PICES. During one of his former lives, he studied the relationship between various forms of macronekton and the sea. The abundance and diversity of scientific topics crossing his desk still manages to trigger some curiosity about what we think we know about any number of topics and how and why we came to think it. The topic of this article was inspired by some rather stimulating discussions with Jim Overland (PMEL, Seattle), and Steven Bograd (PFEL, Pacific Grove) at the PICES North Pacific Ecosystem Status Working Group meeting in Victoria in August 2003 and the recent paper by Bond et al. (2003).

- There's more to North Pacific SST variability at interannual-to-decadal time scales than two phases of the leading EOF (the PDO pattern)

PICES Press (2004): Vol 12, no. 1

The scale issue



letters to nature

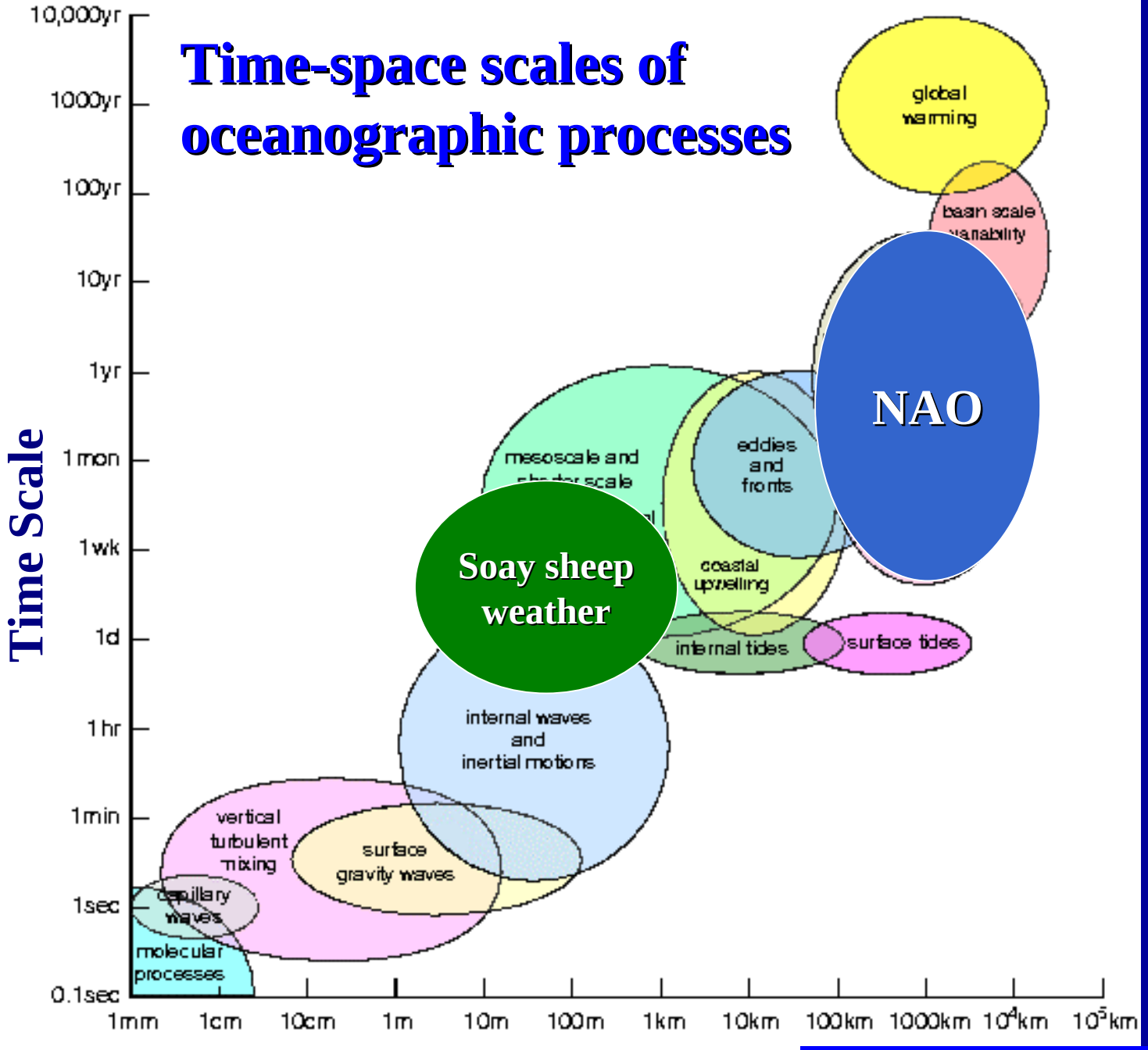
Why large-scale climate indices seem to predict ecological processes better than local weather

T. B. Hallett[1]*, T. Coulson[2], J. G. Pilkington[3], T. H. Clutton-Brock[3], J. M. Pemberton[3] & B. T. Grenfell[1]

Vol 430, 1 July 2004

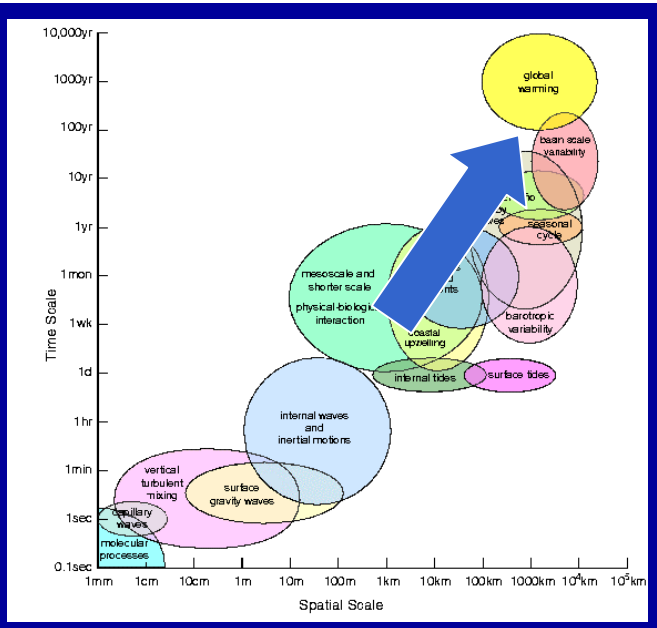
- Soay Sheep population dynamics are better correlated with the NAO than with “local climate”?
  - local weather events drive winter mortality: yet cold temperatures, high winds, and heavy rainfall all appear as causal factors ***in different years***
  - ***One-dimensional view of climate (e.g. temperature) is simply too narrow to capture climate impacts on Soay sheep, and the NAO index (roughly) captures many dimensions***

Time-space scales of oceanographic processes



http://www.coas.oregonstate.edu

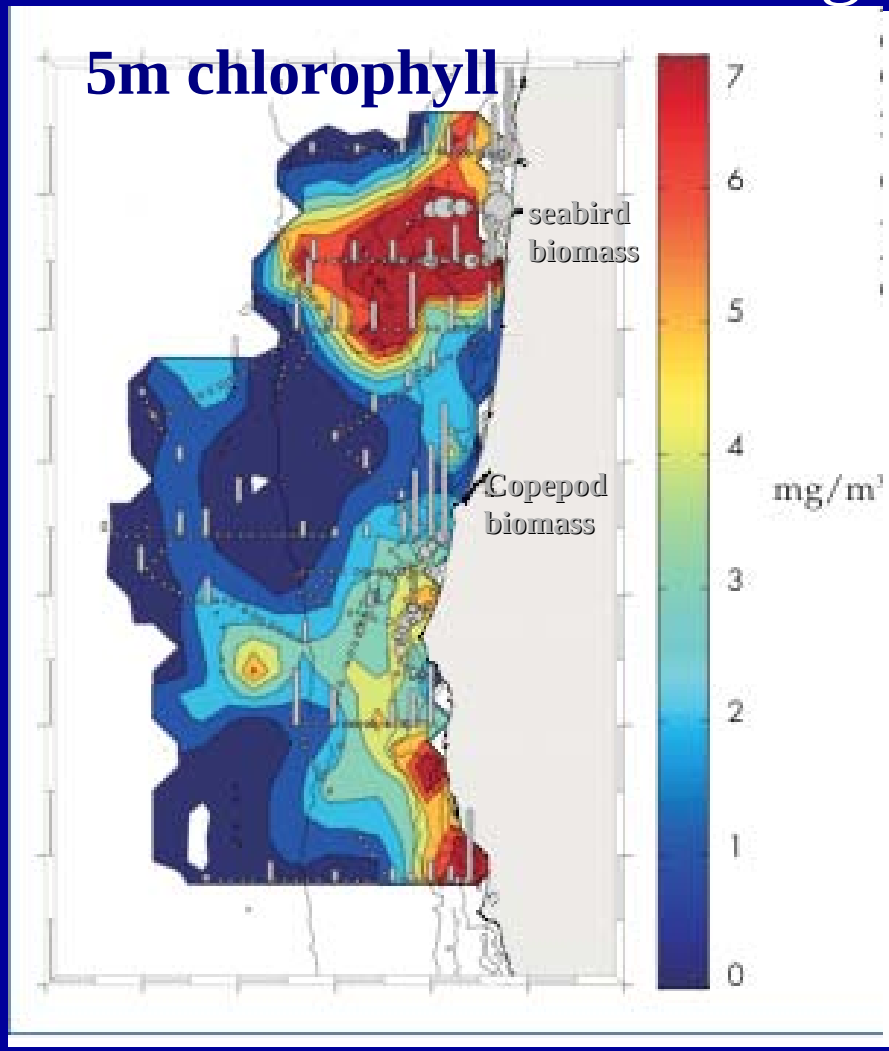
Upscaling

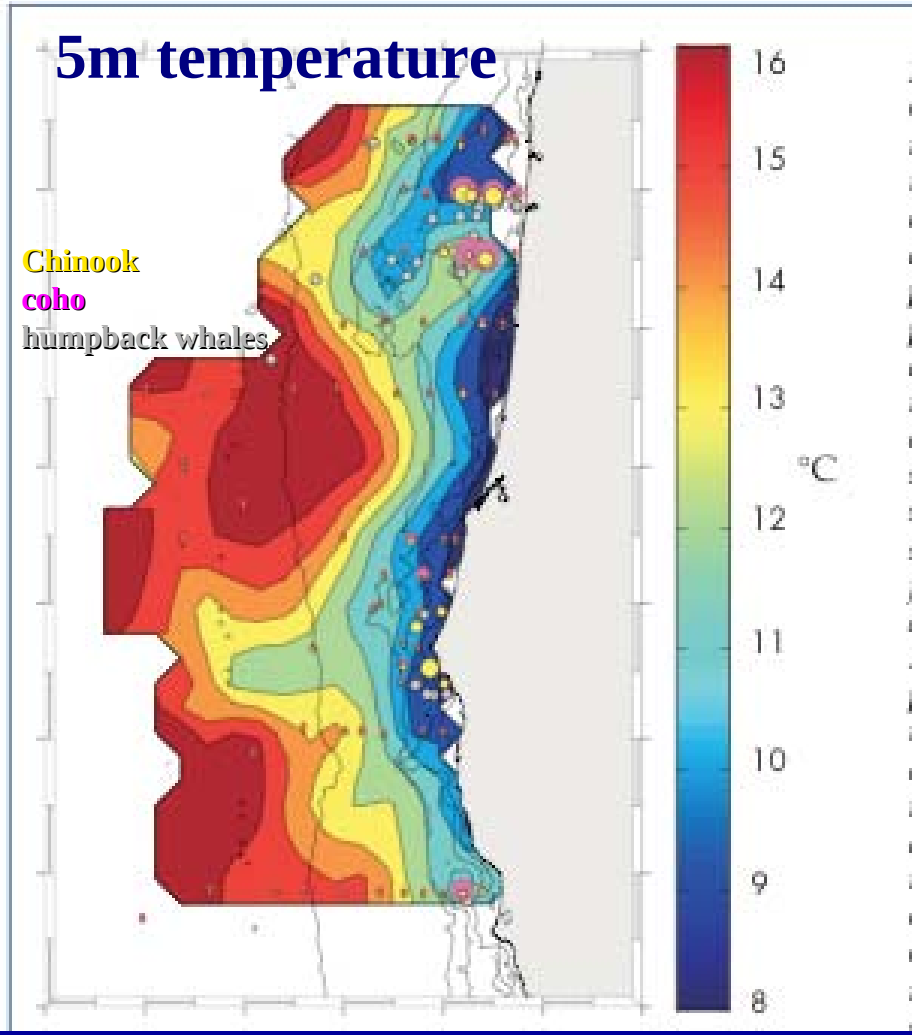


- **Philosophy**: use local/regional ecosystem measures to guide data analysis
  - **Don't limit data analysis to previously defined patterns or indices!**
  - Instead, let the local/regional ecosystem data guide you
- **Techniques**:
  - Case studies, compositing, one-point correlations, regressions
  - After important local/regional environmental indices are identified, quantify relationships to larger scales

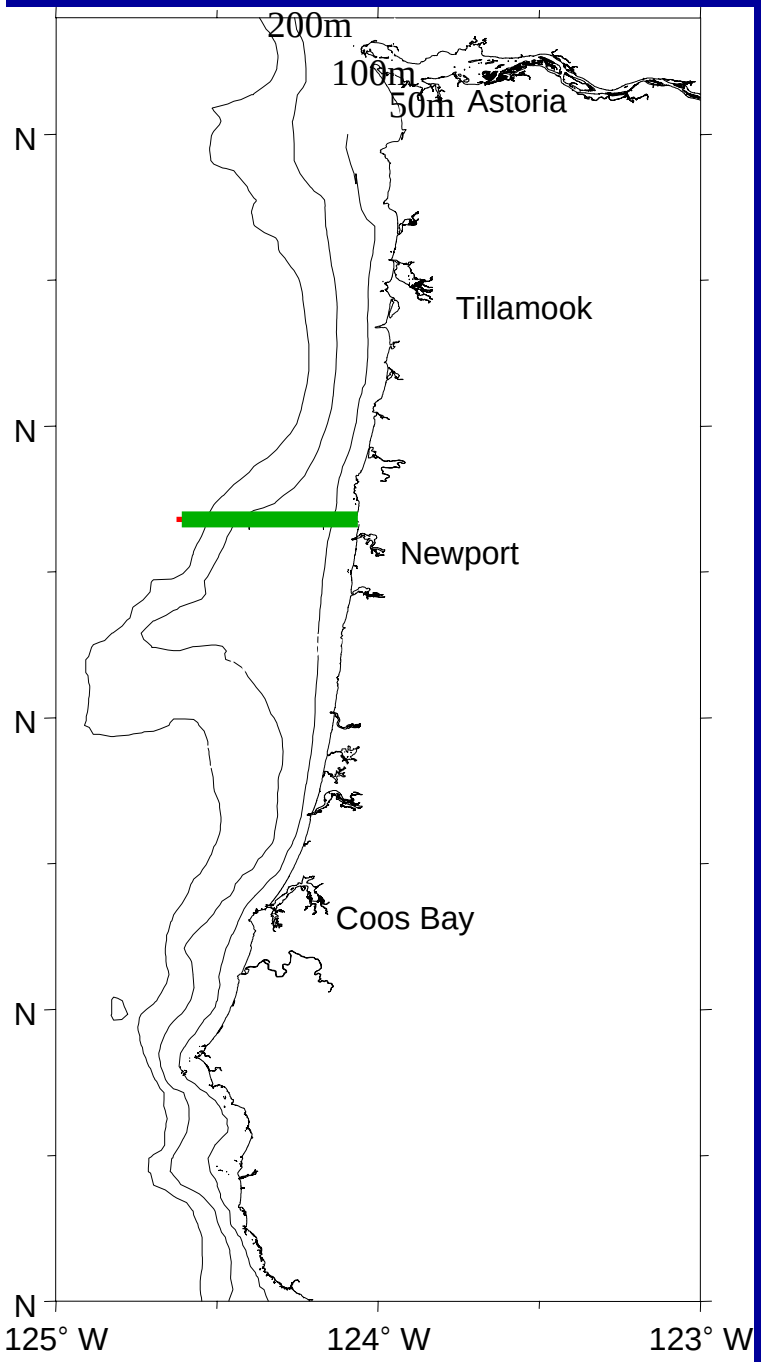
Case Study:August 2000 mesoscale survey data

Synthesis reveals details of the physical and ecological structure





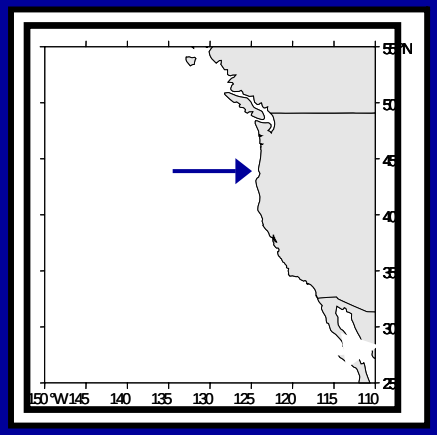
Batchelder et al, 2002: GLOBEC CCS program, Oceanography



NH-Line Hydrographic and Zooplankton Time Series

Bi-weekly Sampling:

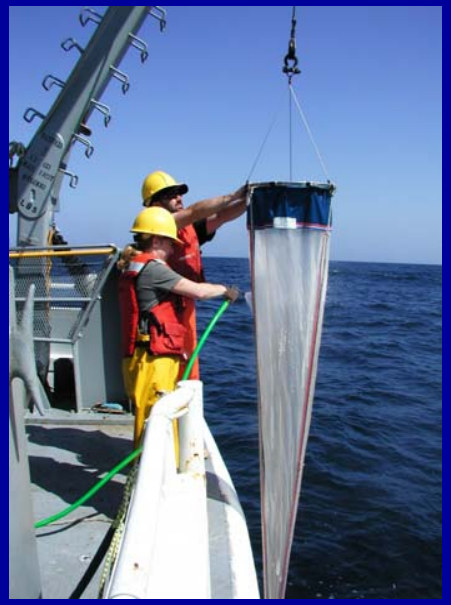
- **1969 – 1973** (Miller, Pearcy, Peterson)
- **1983** (Miller, Batchelder, Pearcy, Brodeur)
- **1990-1992** (Fessenden and Cowles)
- **1996 – present** (Peterson et al.)



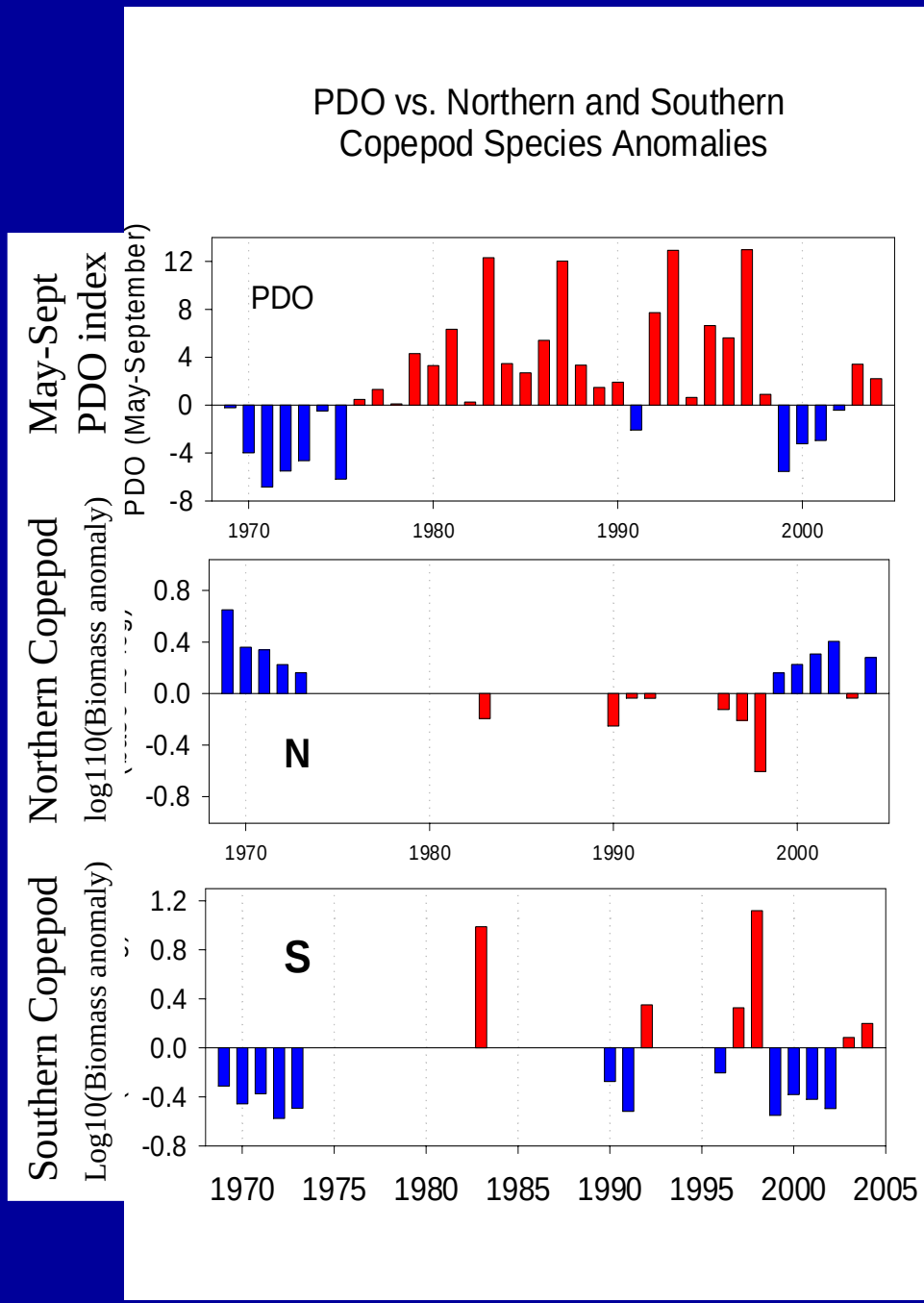
Provided by Bill Peterson

Sampling methods

- Water sampling with CTD, Niskin Bottles, and buckets for hydrography, chl-a and nutrients
- Mesozooplankton with ½ m 200 um net towed vertically
- Euphausiids with 70 cm 505 um net towed obliquely



Provided by Bill Peterson



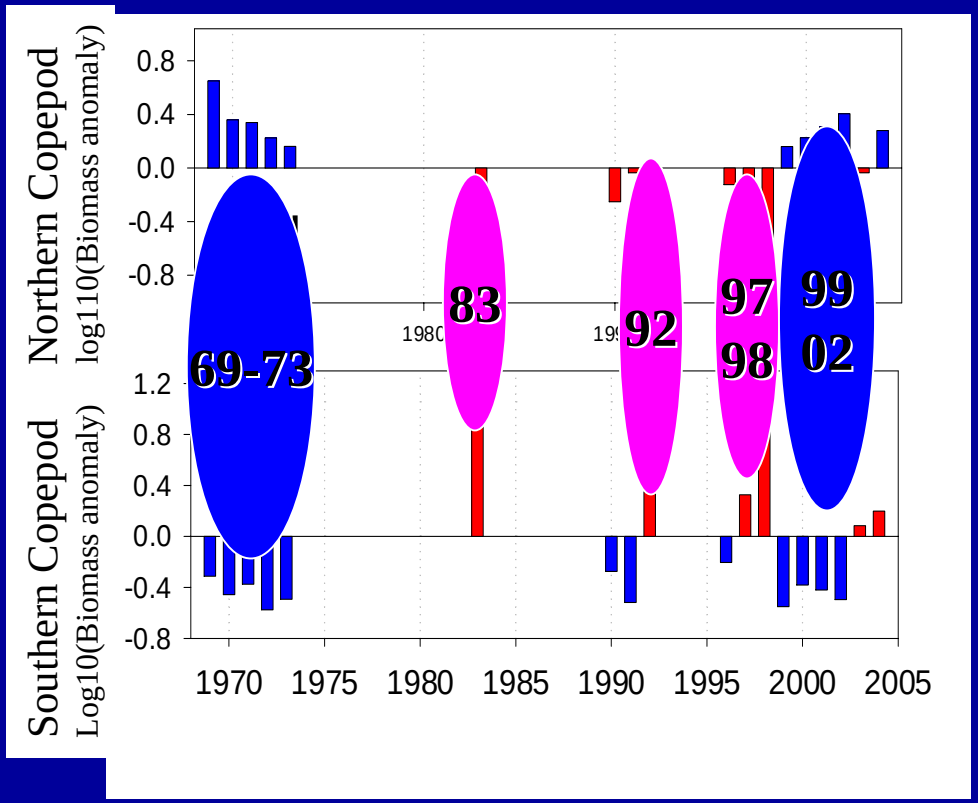
a pattern is evident…

When PDO is negative, ("cool phase") cold water or northern species have high biomass whereas the warm water southern species have low biomass

and vice versa…

The changes are rapid and approach order of magnitude differences among years.

Provided by Bill Peterson



The upscaling view: a pattern is evident…

There is a strong inverse relationship between northern (boreal) and southern (subtropical) copepod species

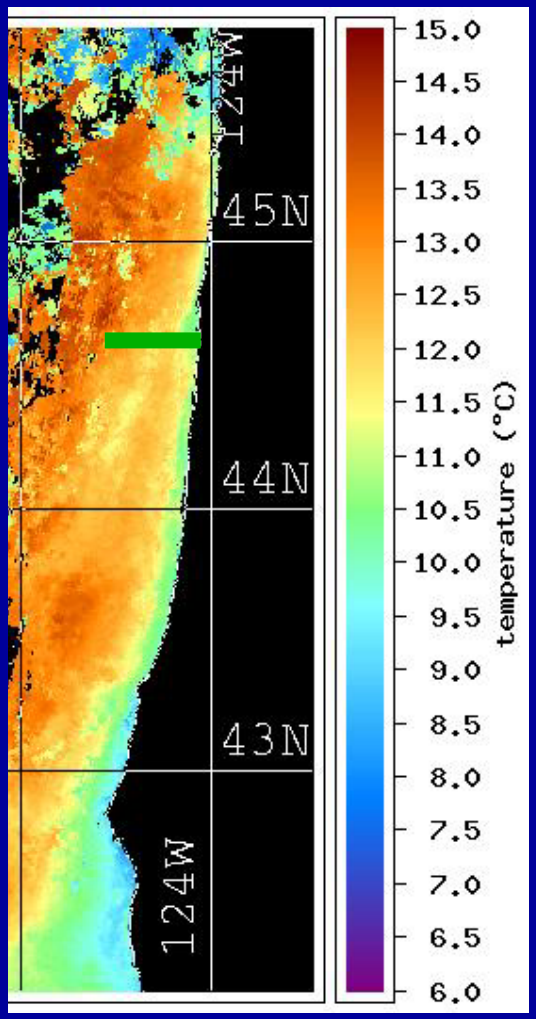
changes are rapid and approach order of magnitude differences among years.

Why?

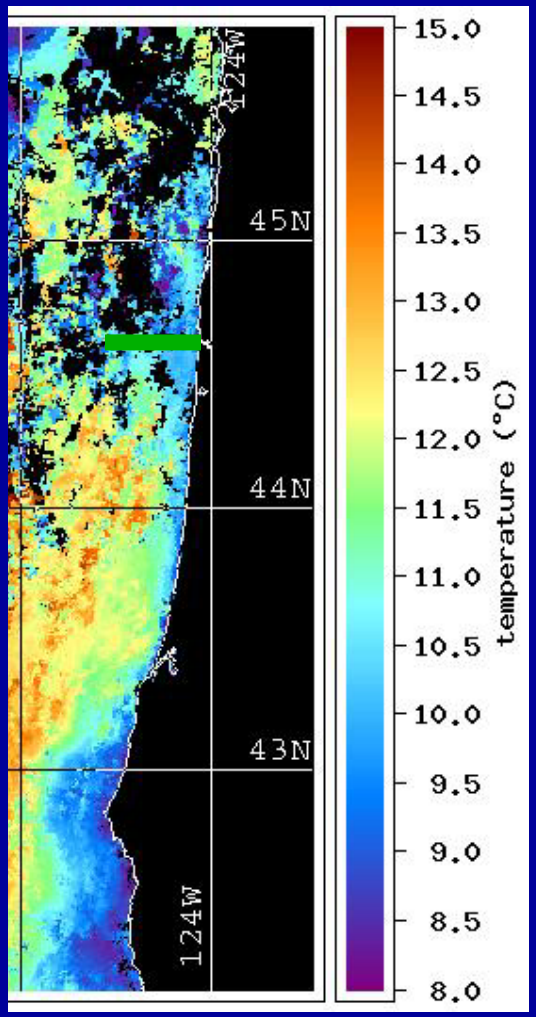
• an exploratory analysis using upscaling

Modified from Bill Peterson's original

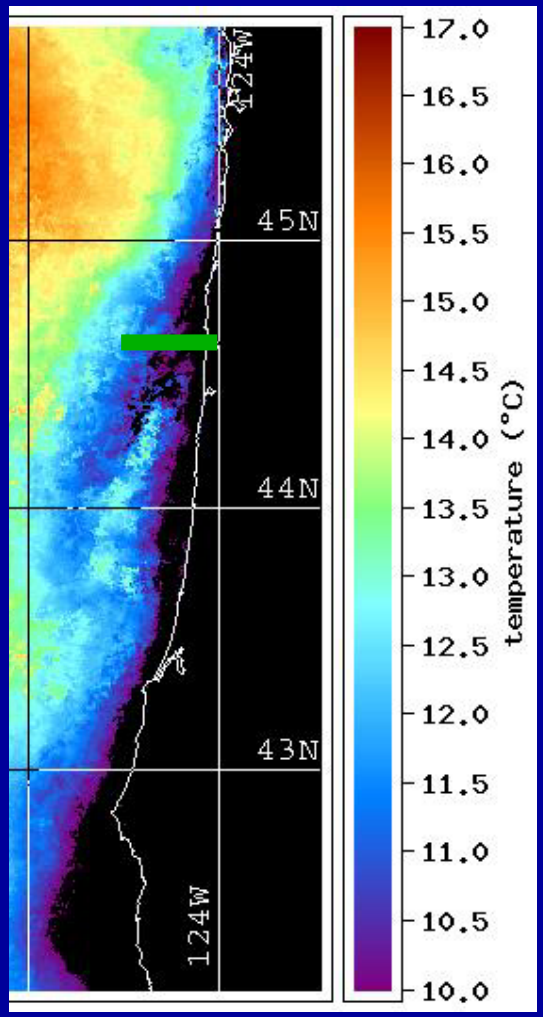
Satellite SST 1-month composites, 1km resolution



June 1998



June 1999

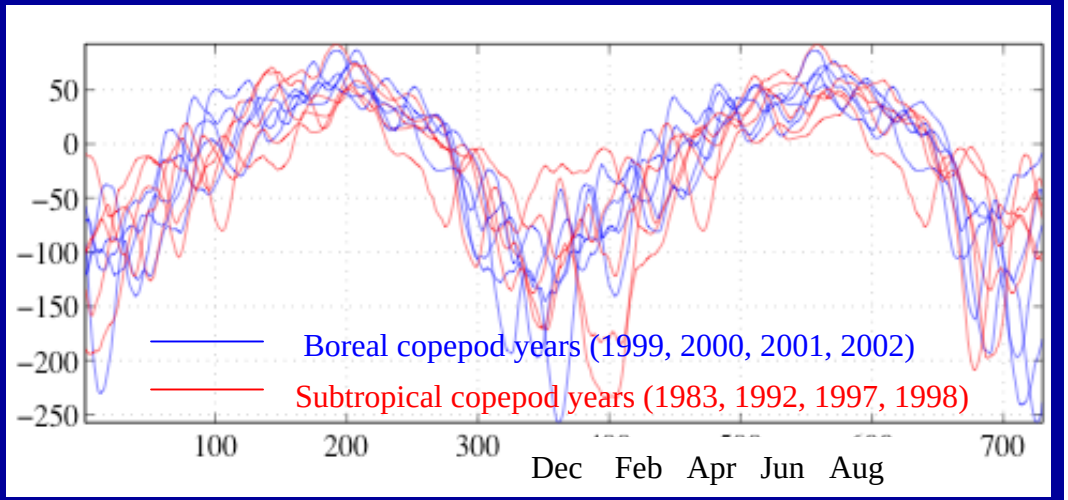


June 2002

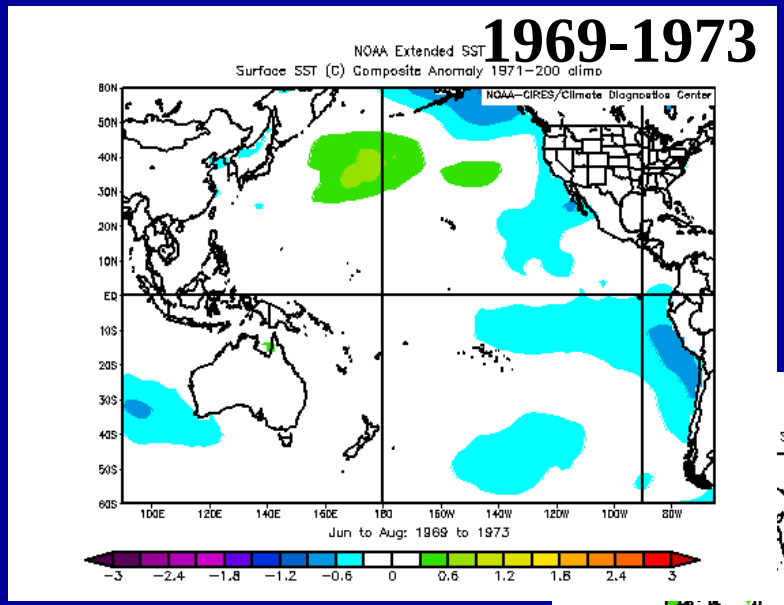
Links with event-scale processes

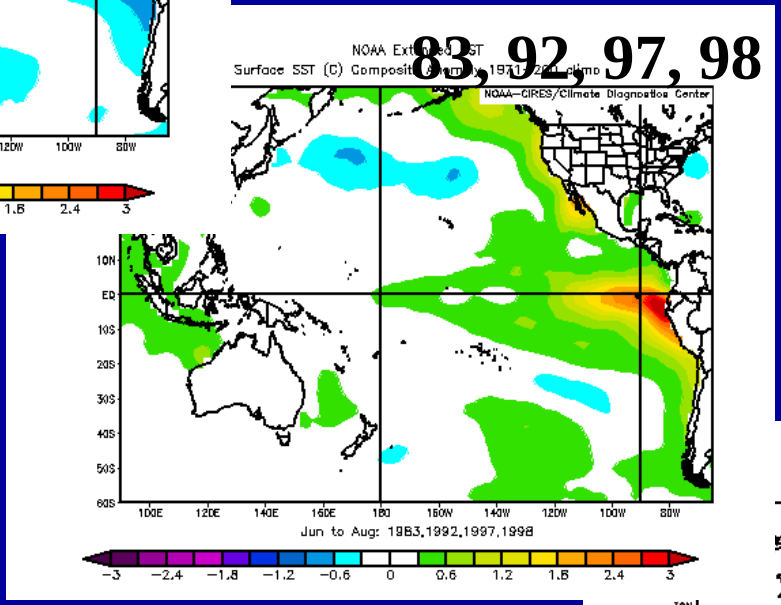
- "local" ecosystem observations can be used for evaluating the statistics of any process for which there is data
  - Eddies, frontal structures
  - Upwelling and/or downwelling wind events
  - Alongshore transport
  - Spring and fall transition dates

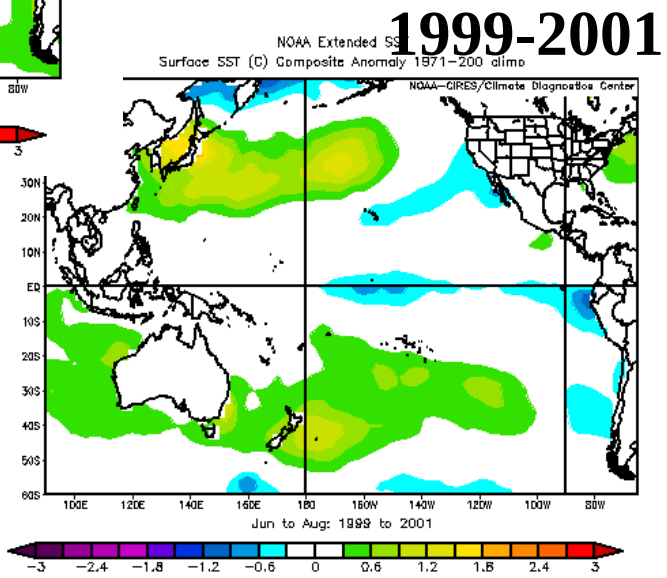
10 day average Bakun index at 45N, 125W



JJA Composites:
1 degree lat-lon gridded SST anomalies



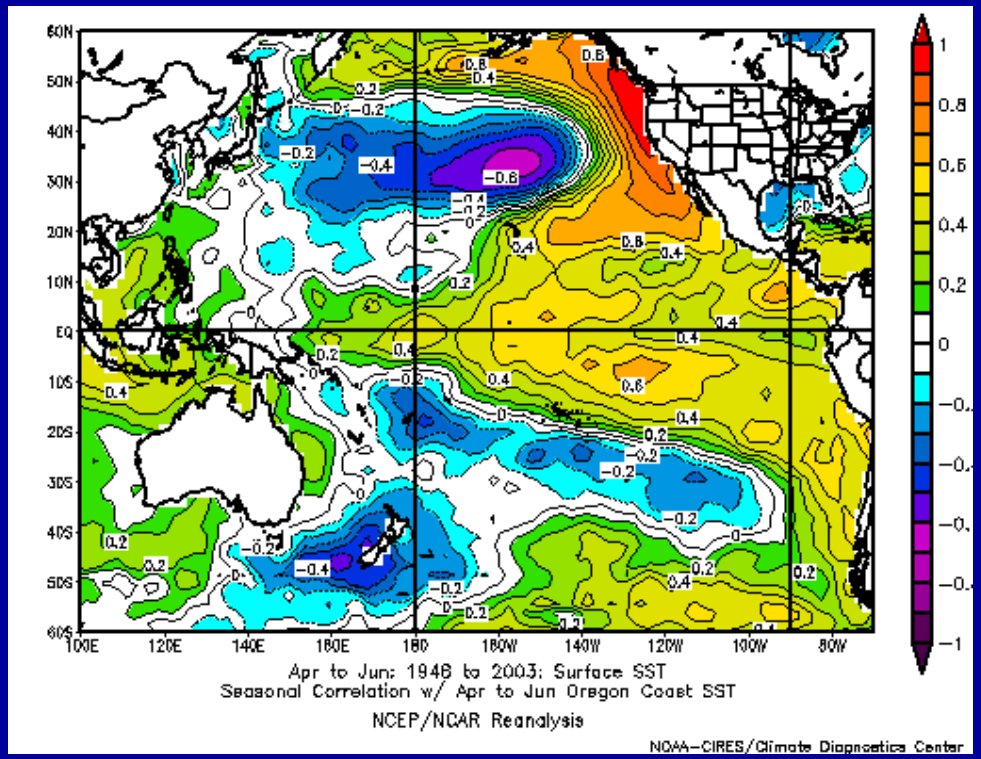




One-point correlation maps

(see Wallace and Gutzler 1981)

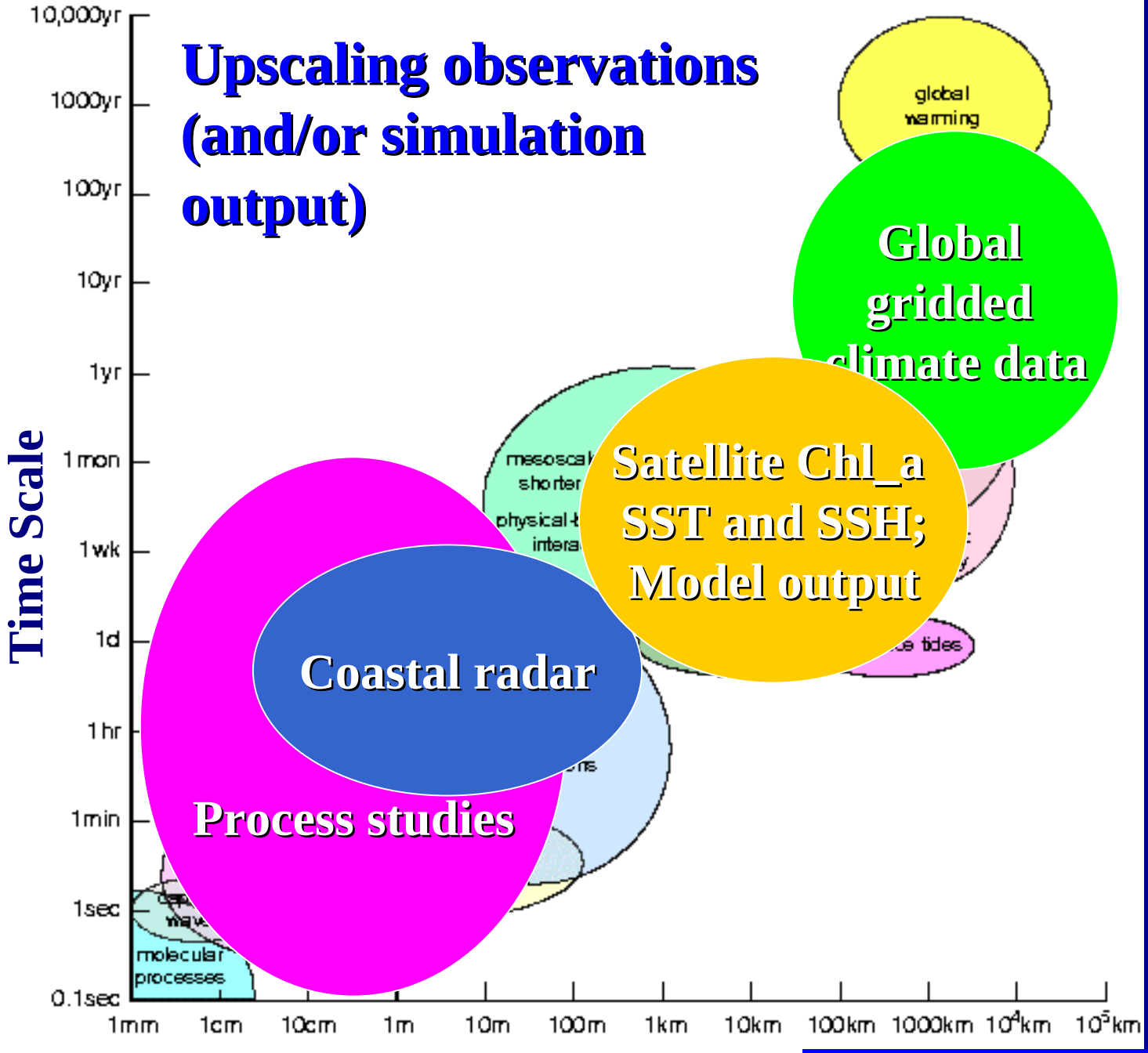
- Correlate gridpoint data from broad regions with a time series of interest
  - At right, the reference time series is AMJ SST at 45N, 125W



the meso-scale and large-scale context

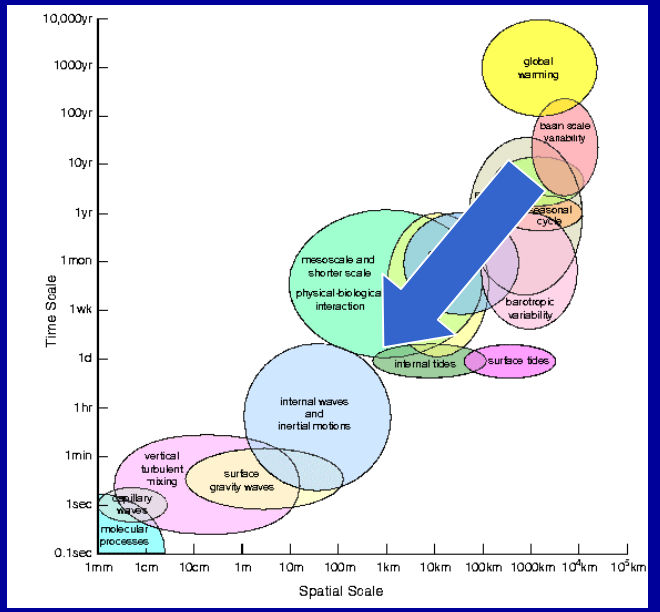
- Remote sensing products now provide a wealth of spatial information for ocean surface fields
  - SST, Chl_a, SSH, windstress, surface currents …
- ARGO profiling floats + simulation models provide subsurface information
- Atmospheric reanalysis data provide the regional to global circulation context

Upscaling observations (and/or simulation output)



http://www.coas.oregonstate.edu

Downscaling



Philosophy: Developing relatively high-resolution details from relatively coarse-resolution, larger-scale information

Applications:

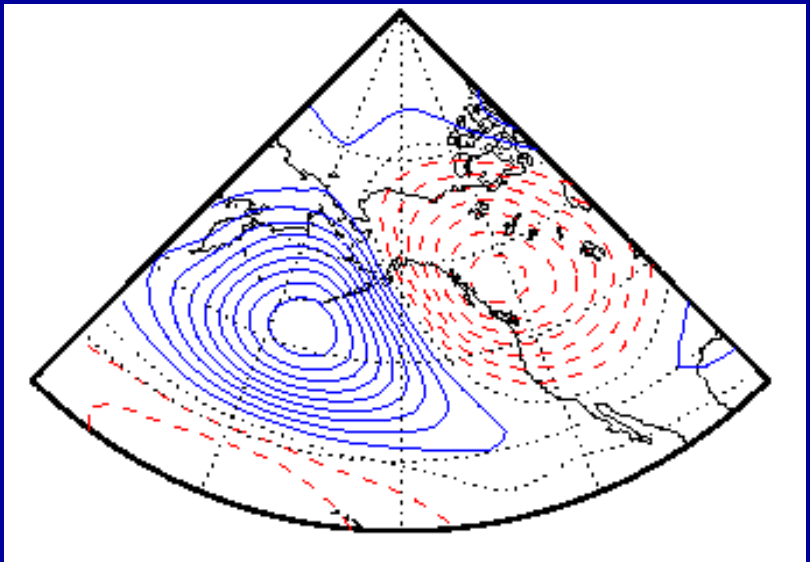
- translating global gridded data or model outputs at 10^2km scales into regional/mesoscale outputs at 10^0-10^1km scales
  - global climate model output for seasonal climate forecasts and/or global warming scenarios

Methods

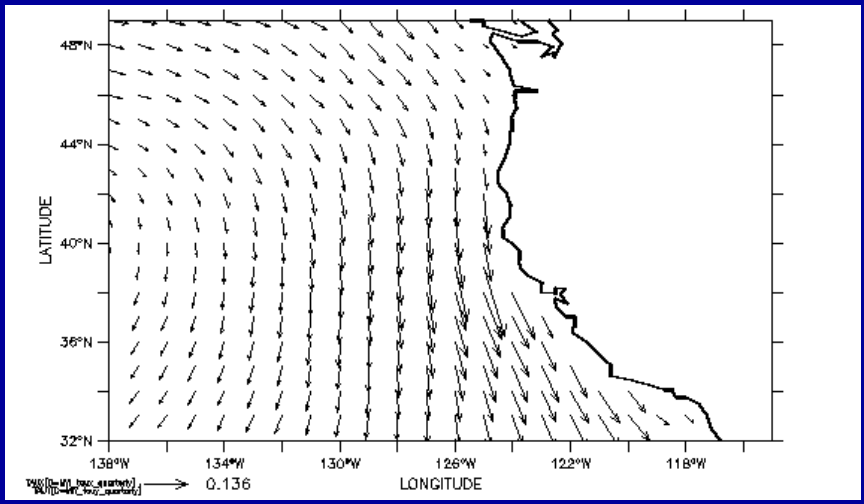
- Statistical
  - Empirically relate large-scale patterns to mesoscale patterns
  - Fast but lack details
- Physical
  - Nested mesoscale model
  - Computationally intensive but provides details from physical principles

Downscaling example

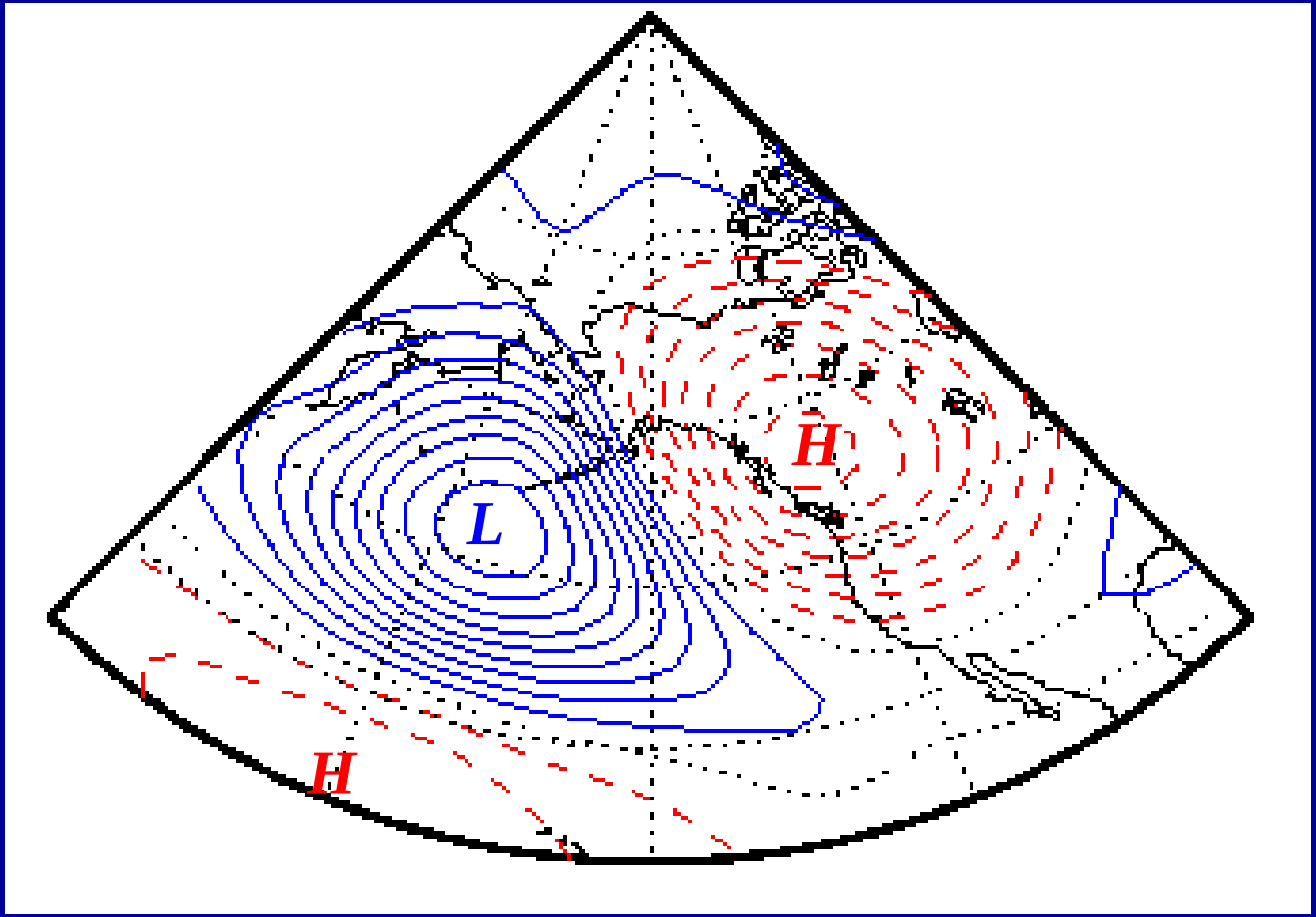
Large scale circulation patterns



Quickscat surface windstress
1/2 degree grid, Aug 2000



500 mb height anomalies during warm phases of PDO: the *Pacific North America* pattern



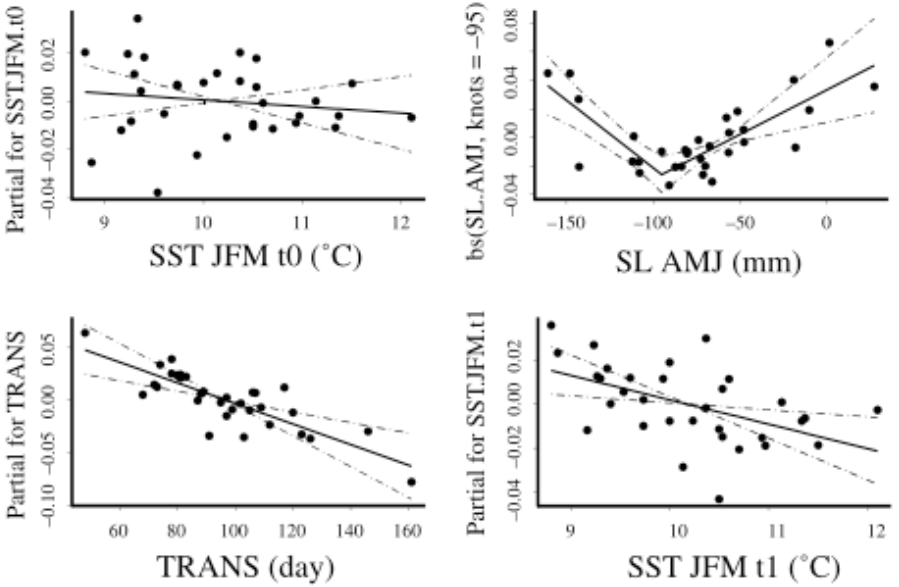
Contours every 5 meters

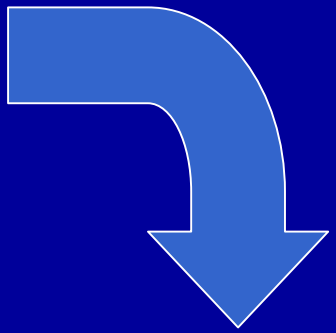
The upscaling-downscaling link

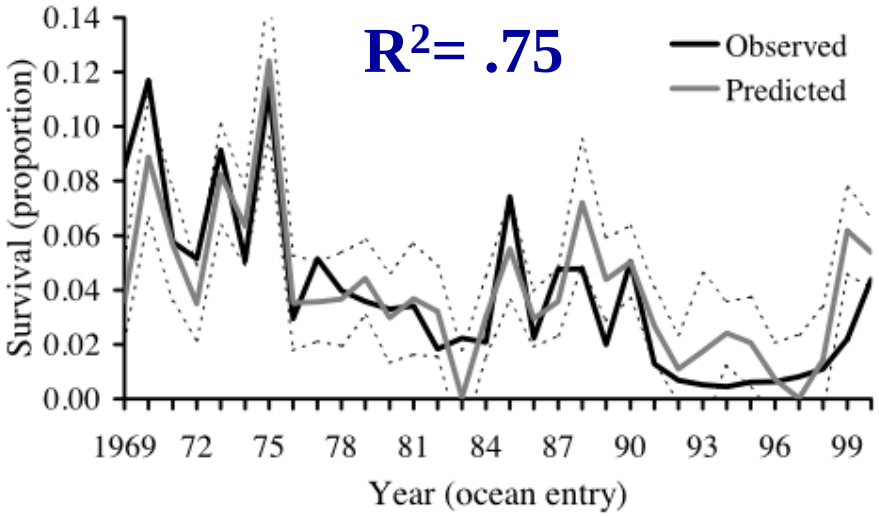
- Once key environmental processes are identified, they can be “indexed” and linked to larger scale phenomenon
  - A Bakun upwelling index at one location with an ENSO index, or an Aleutian Low
  - Because predictability for ENSO is (more or less) known, this provides a means for assessing the predictability of the Bakun index
  - Because the historic variability of the AL is also known, that history can help explain part of the history of the Bakun index of interest, and how much or how little the AL

An upscaling study:
4 index *Ocean Conditions Model* "hindcasts" for OPI coho marine survival, 1969-1998

Logerwell et al. 2003, Fish. Oc.

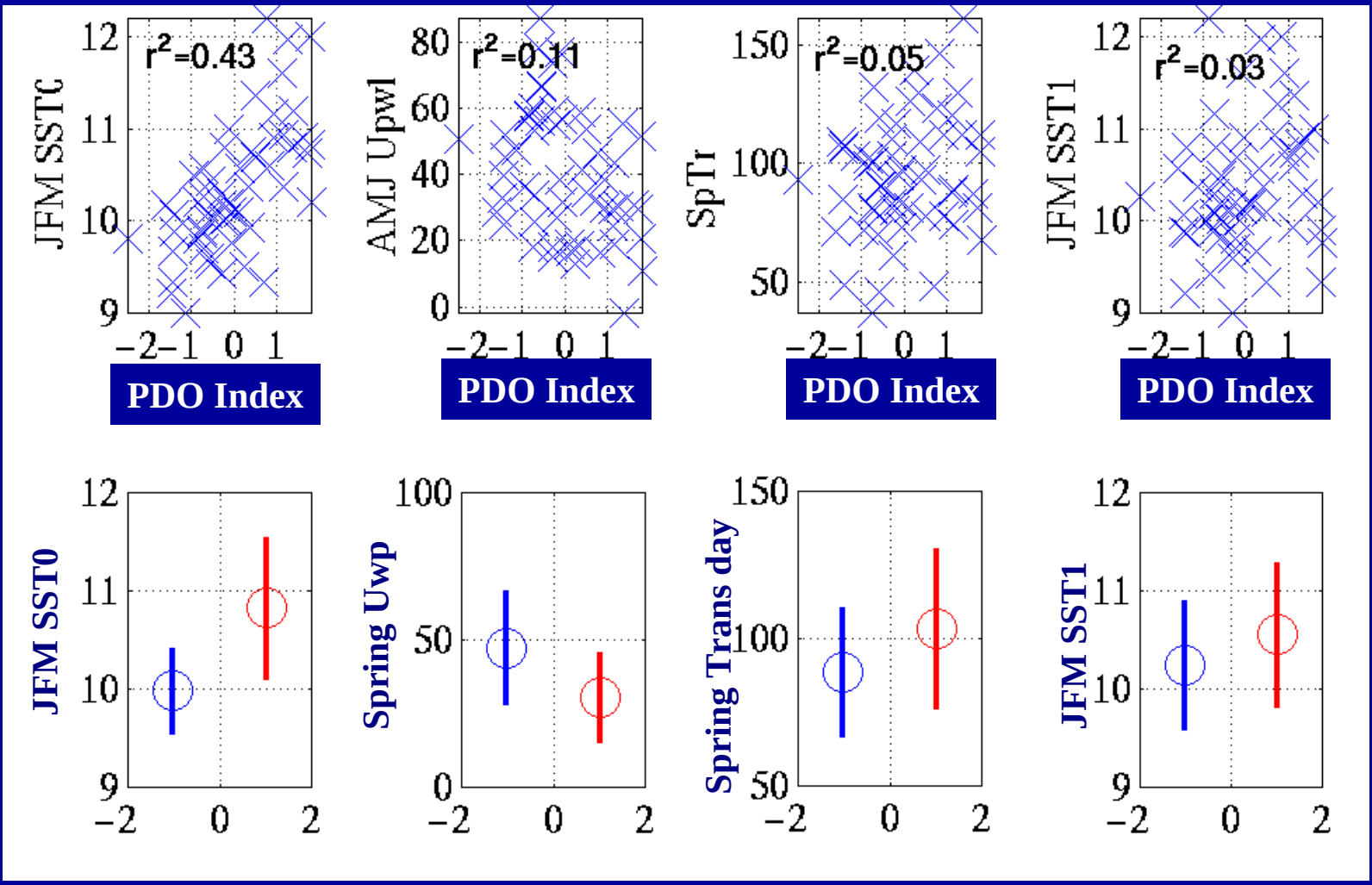




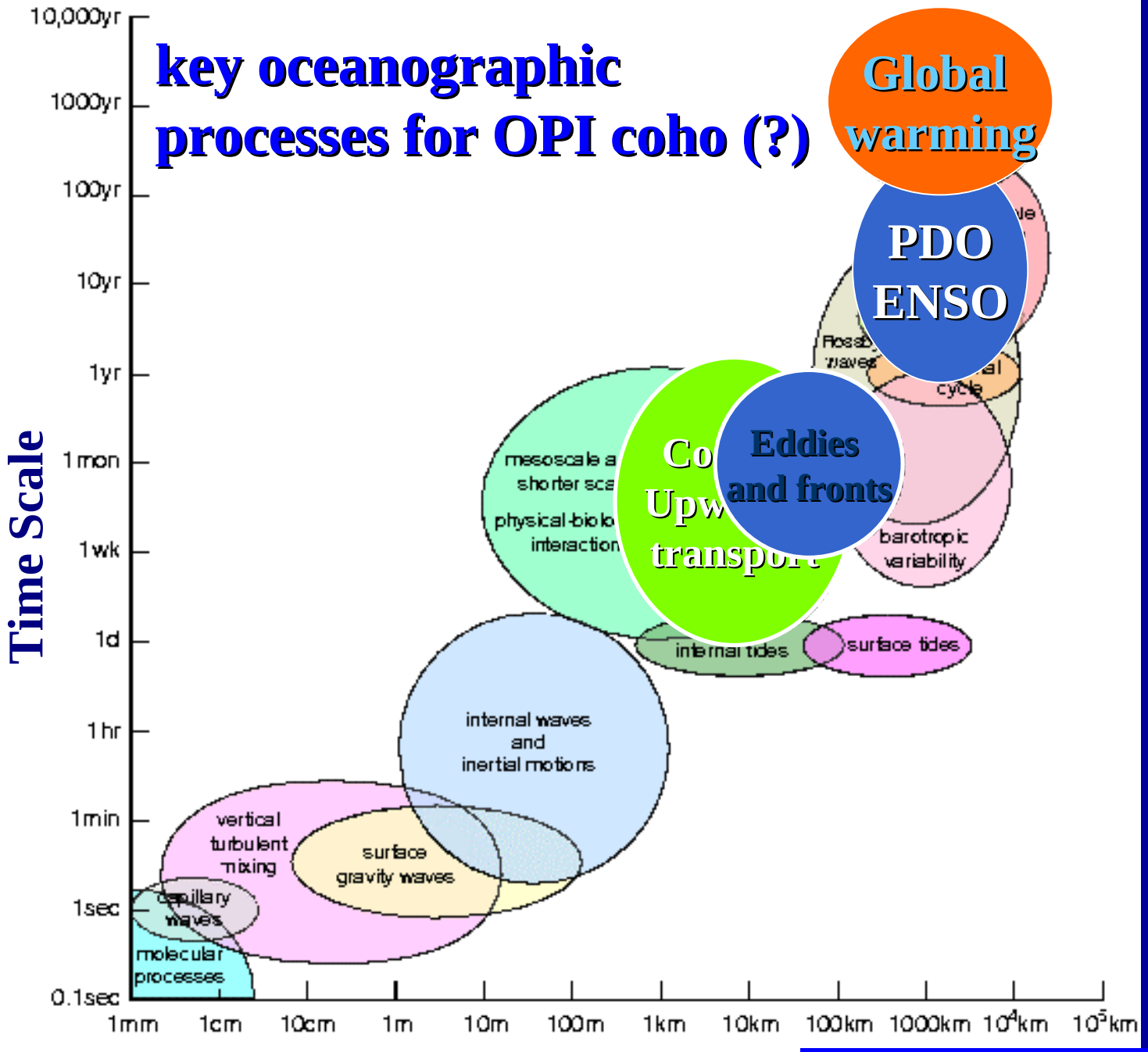


"Ocean Conditions" =
F(wtr/spring stratification (SST), spring transition date, transport and upwelling (SL), and first winter SST)

Coastal Oregon regional indices and large-scale July-June PDO index:1948-2003

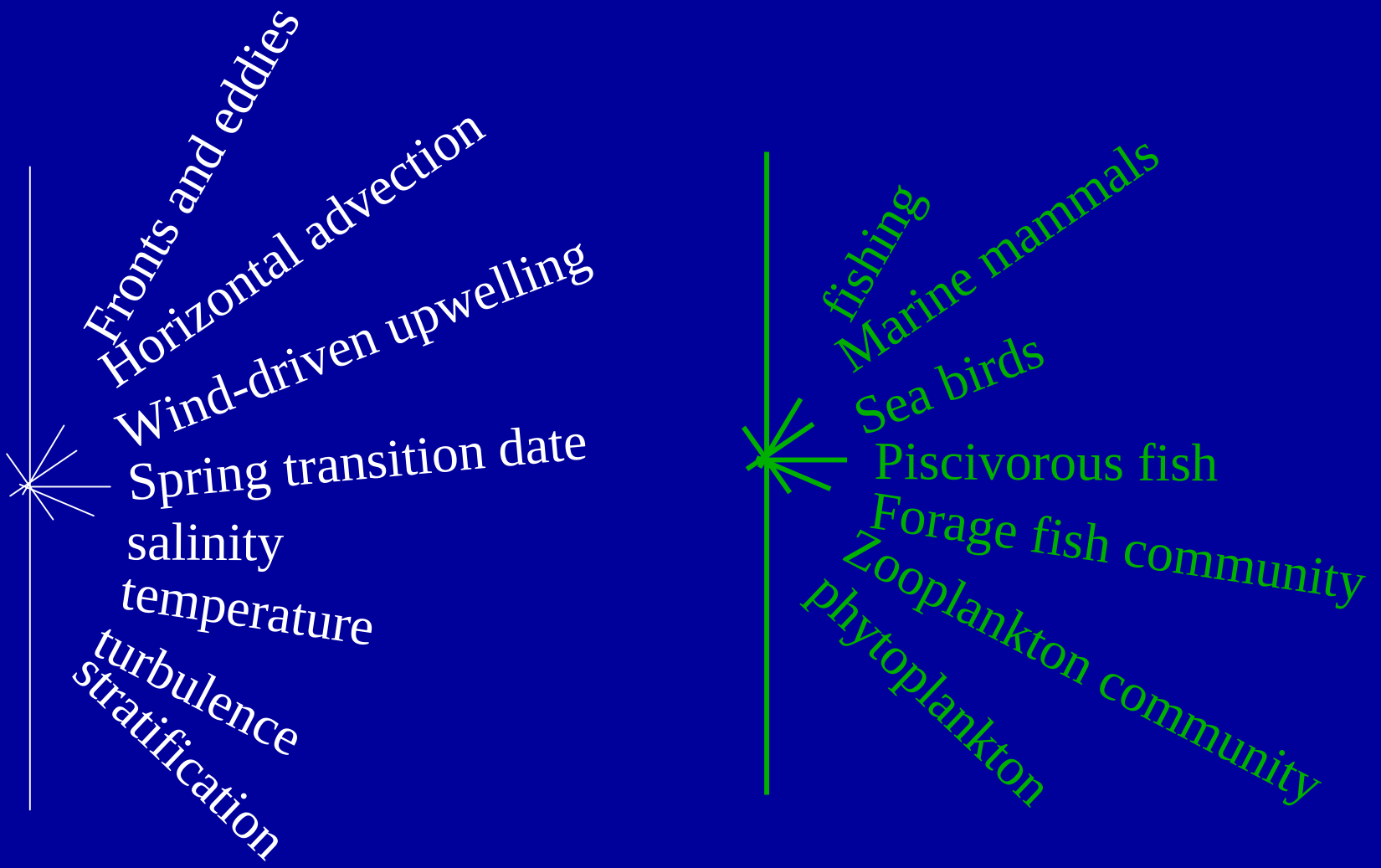


key oceanographic processes for OPI coho (?)



http://www.coas.oregonstate.edu

“ocean habitat” and “ecosystems” are both biotic and abiotic at the same time



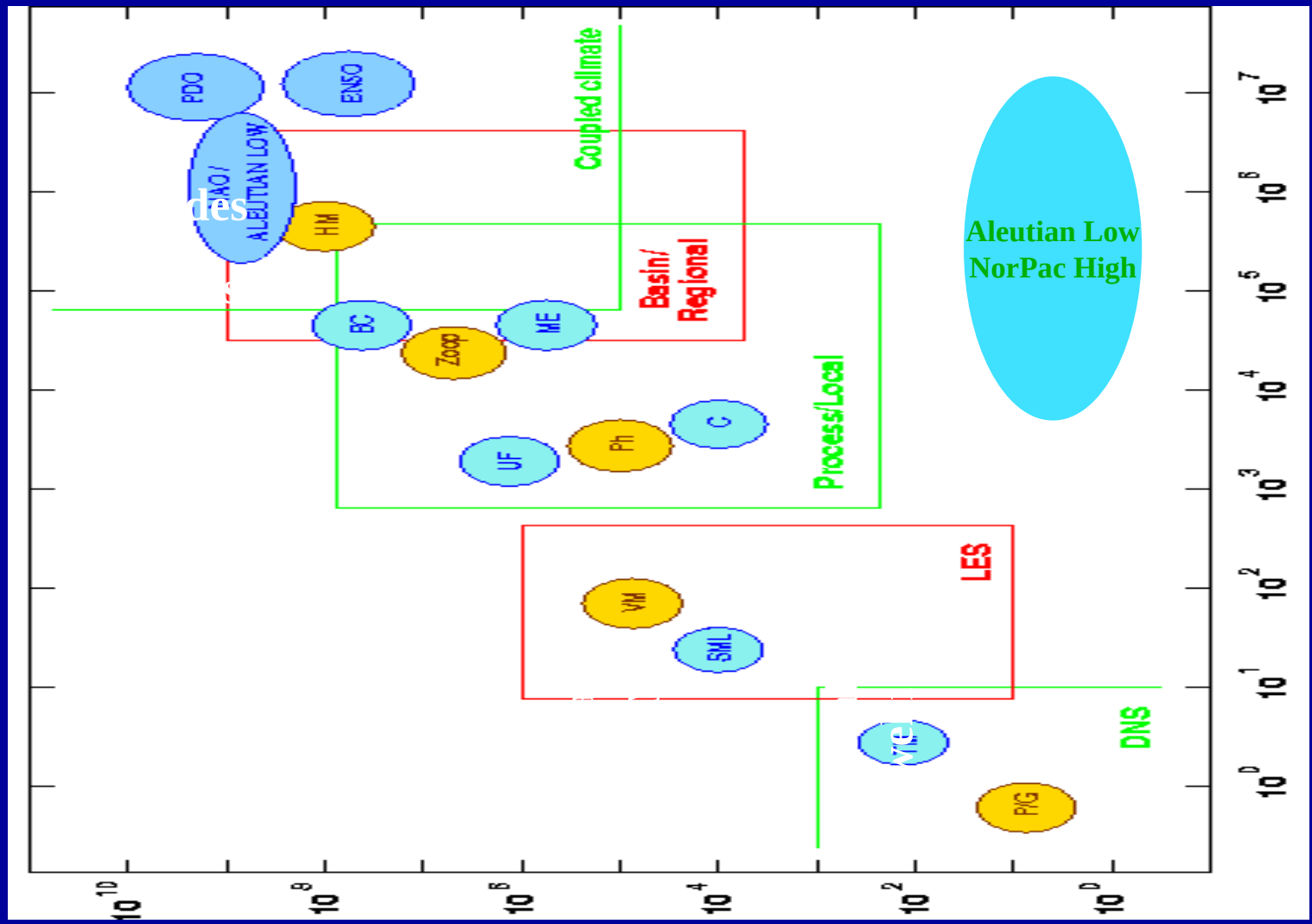
The abiotic environment + **the biotic environment**

thoughts on scale interactions

1. There are obvious limitations in large scale perspectives on biophysical interactions
   - All biophysical interactions are local/regional
2. "**Upscaling**" is a simple but powerful approach for identifying processes linking climate w/biota
3. "**Downscaling**" is important for understanding environmental and ecosystem *history*, *predictions* and *predictability*
4. combining upscaling and downscaling perspectives offers a promising approach to better understanding environmental influences on ecosystems
5. Habitat is multidimensional, and includes both biotic and abiotic aspects of "*the neighborhood*"

Space-Time Scales of Ocean Processes

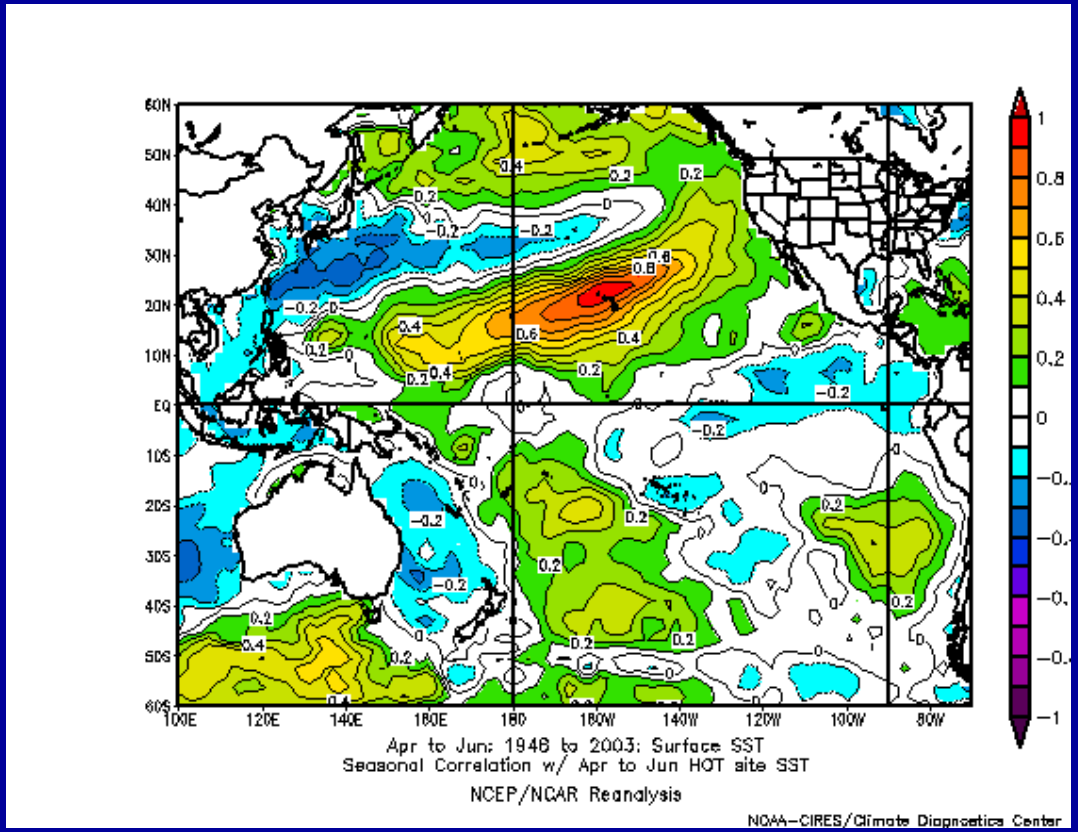
(Mantua et al. 2002, U.S GLOBEC issue of Oceanography)



Created by Dale Haidvogel

One point correlation map
1 degree gridded SST data: 1948-2004

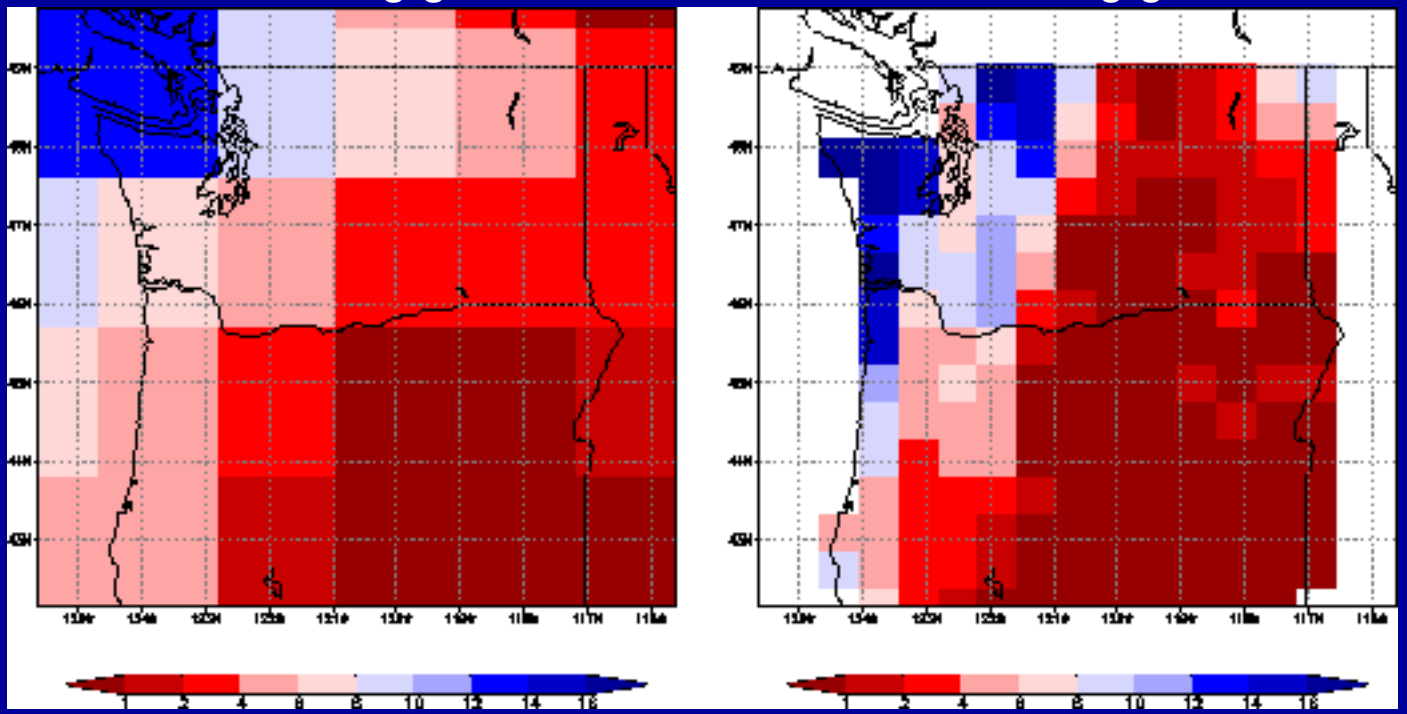
Base grid point is near the HOT site



Mean Precipitation, January 1990

Global Model
~2.5 deg grid

Observed
~ 0.5 deg grid

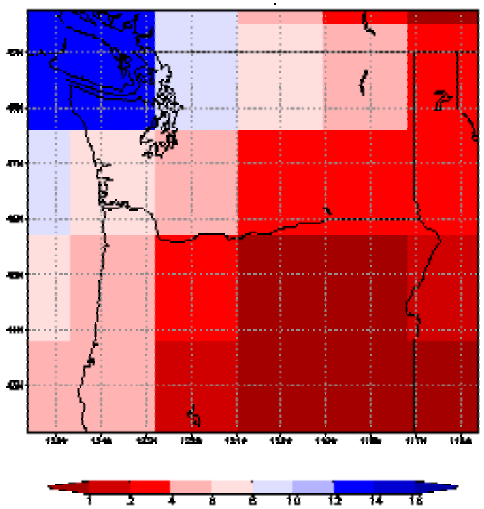


From NCEP Reanalysis

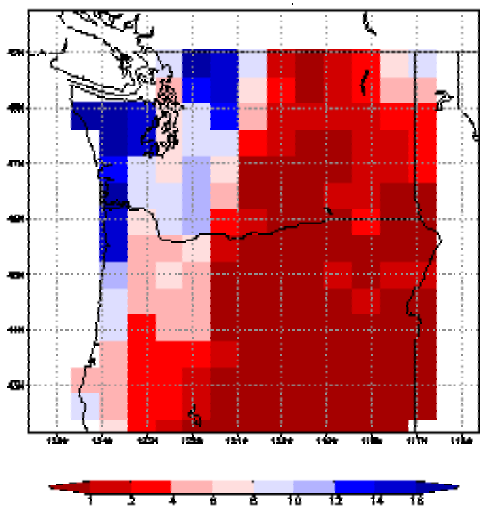
Salathe 2004

Mean Precipitation, January 1990

Global Model



Observed



Produced by an empirical model that maps large scale circulation patterns (2.5 deg grid) onto regional (0.5 deg grid) precipitation patterns

Widman et al. 2003, J. Climate

Downscaled