

AL GORE GOES TO CAPITOL HILL TO TESTIFY ABOUT GLOBAL WARMING...



Seattle Post-Intelligencer, January 30, 2009



The Climate Change Challenge for Pacific salmon (and *salmon people*)

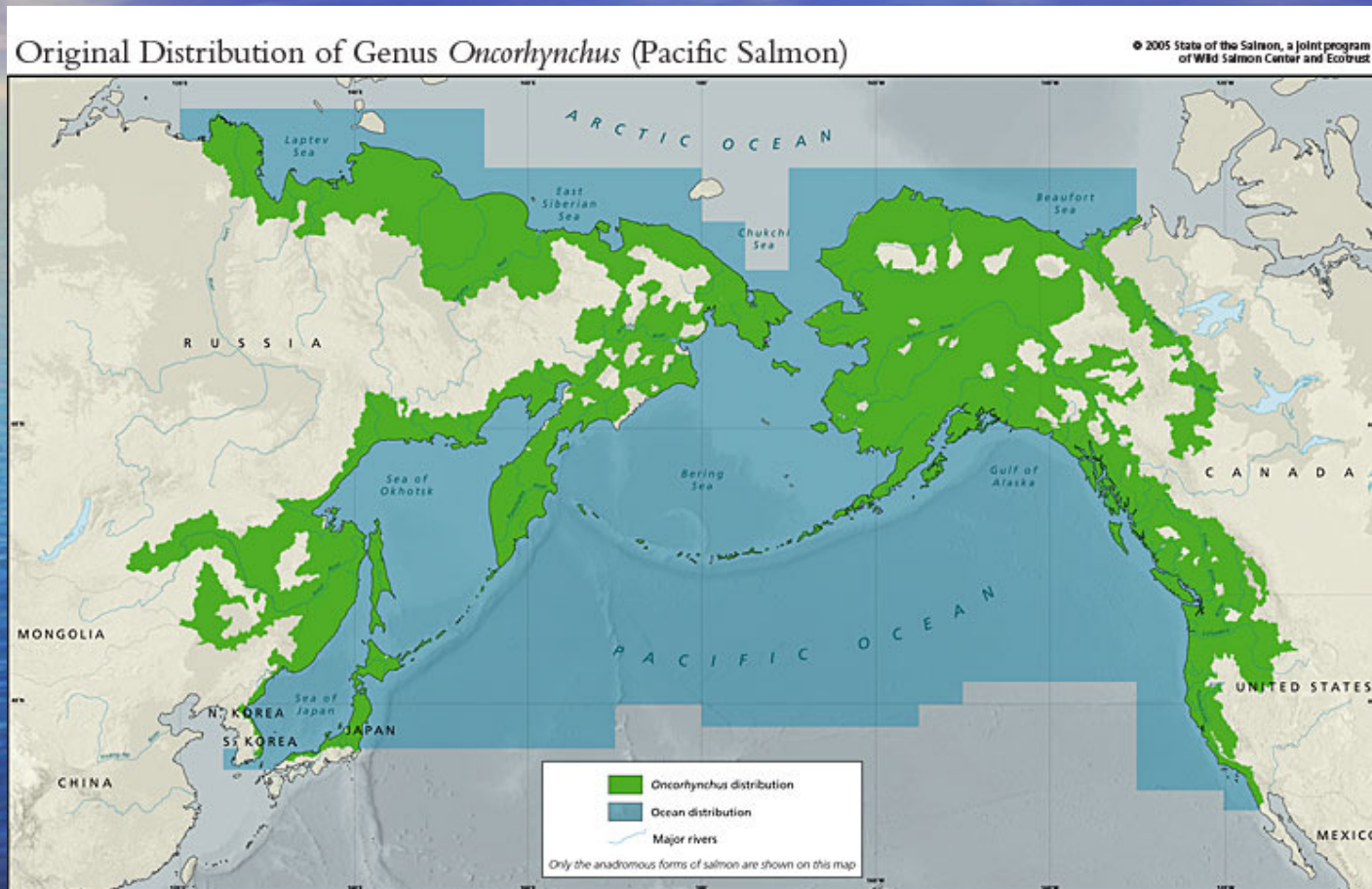
Nate Mantua, PhD

**University of Washington Climate Impacts Group,
School of Aquatic and Fishery Sciences, and
US Forest Service PNW Station**

State of the Salmon 2009
Vancouver, BC Canada
February 3, 2009

Historic Distribution of Pacific salmon

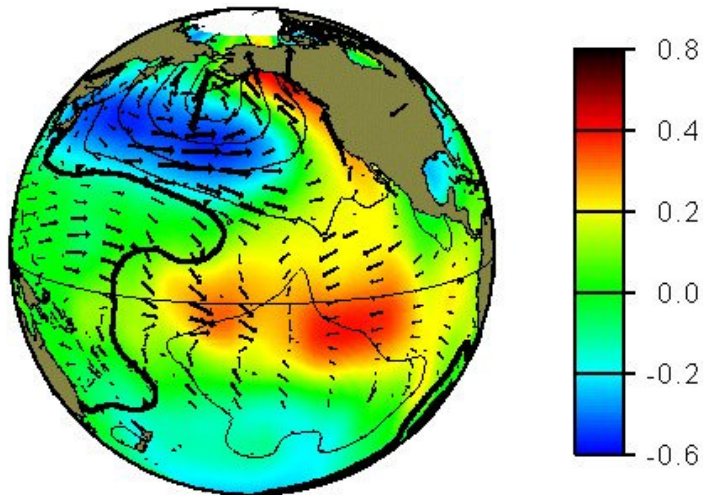
(source: stateofthesalmon.org)



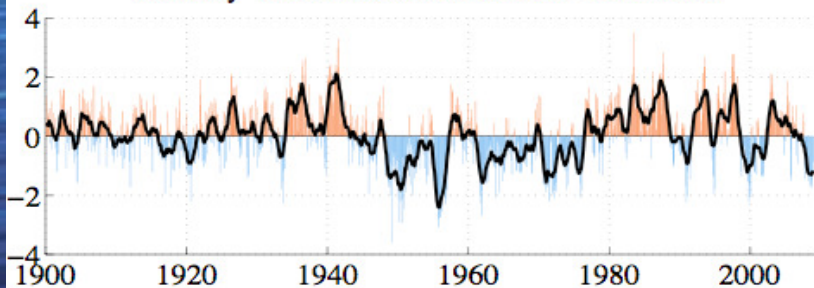
Biogeography of salmon is partly determined by climate

Climate variability has a powerful influence on salmon production -- just a 1 to 2°C swing in ocean temperatures is associated with a doubling of salmon biomass between “warm” and “cool” eras of the Pacific Decadal Oscillation

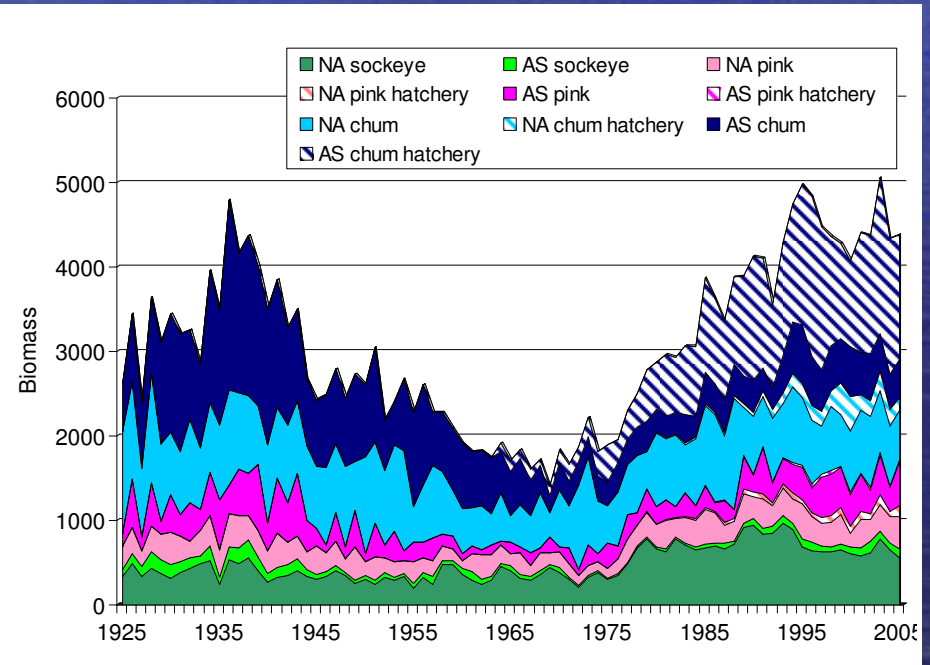
Pacific Decadal Oscillation (PDO)



monthly values for the PDO index: 1900–2008

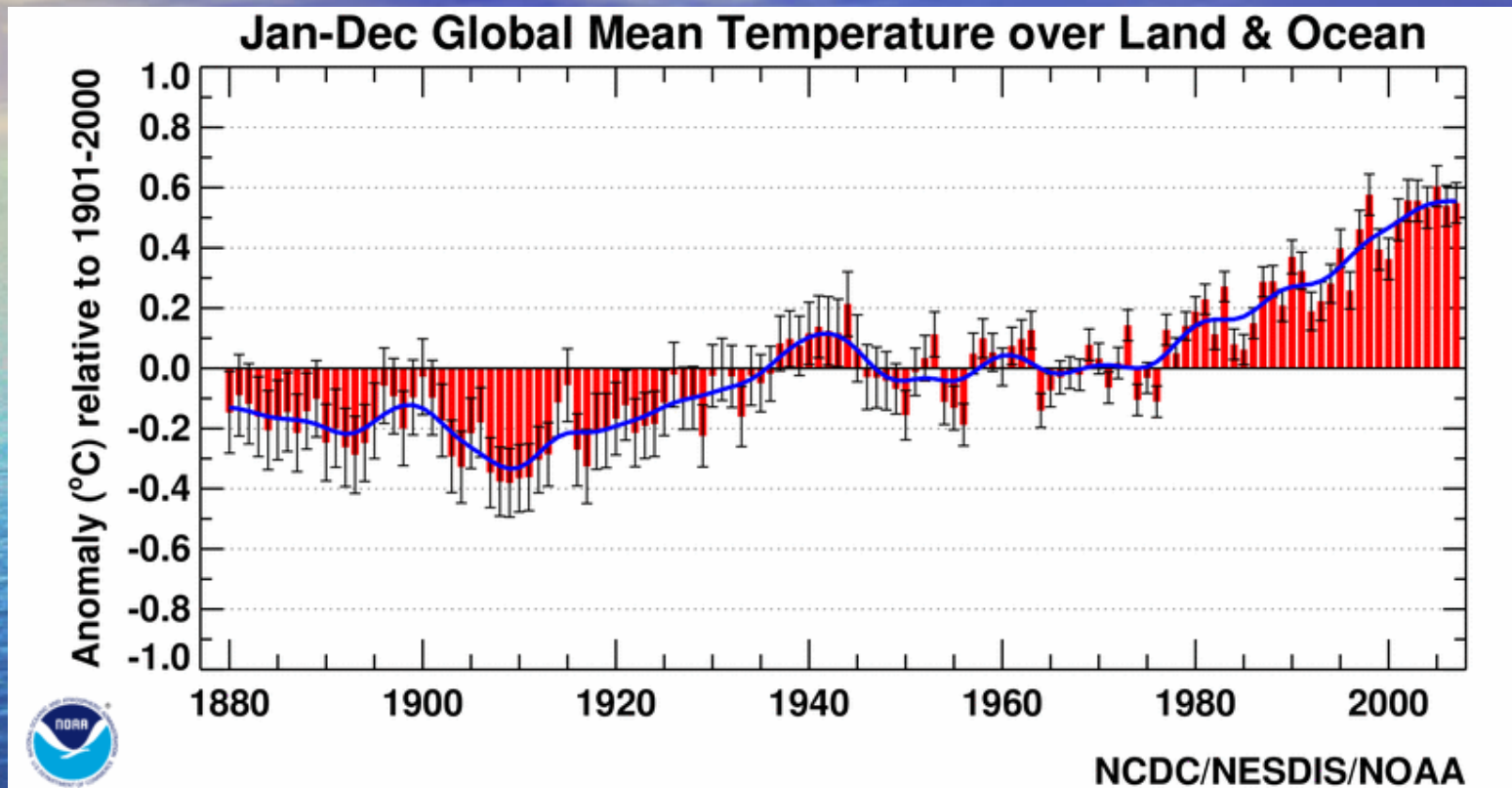


Total Pacific salmon biomass

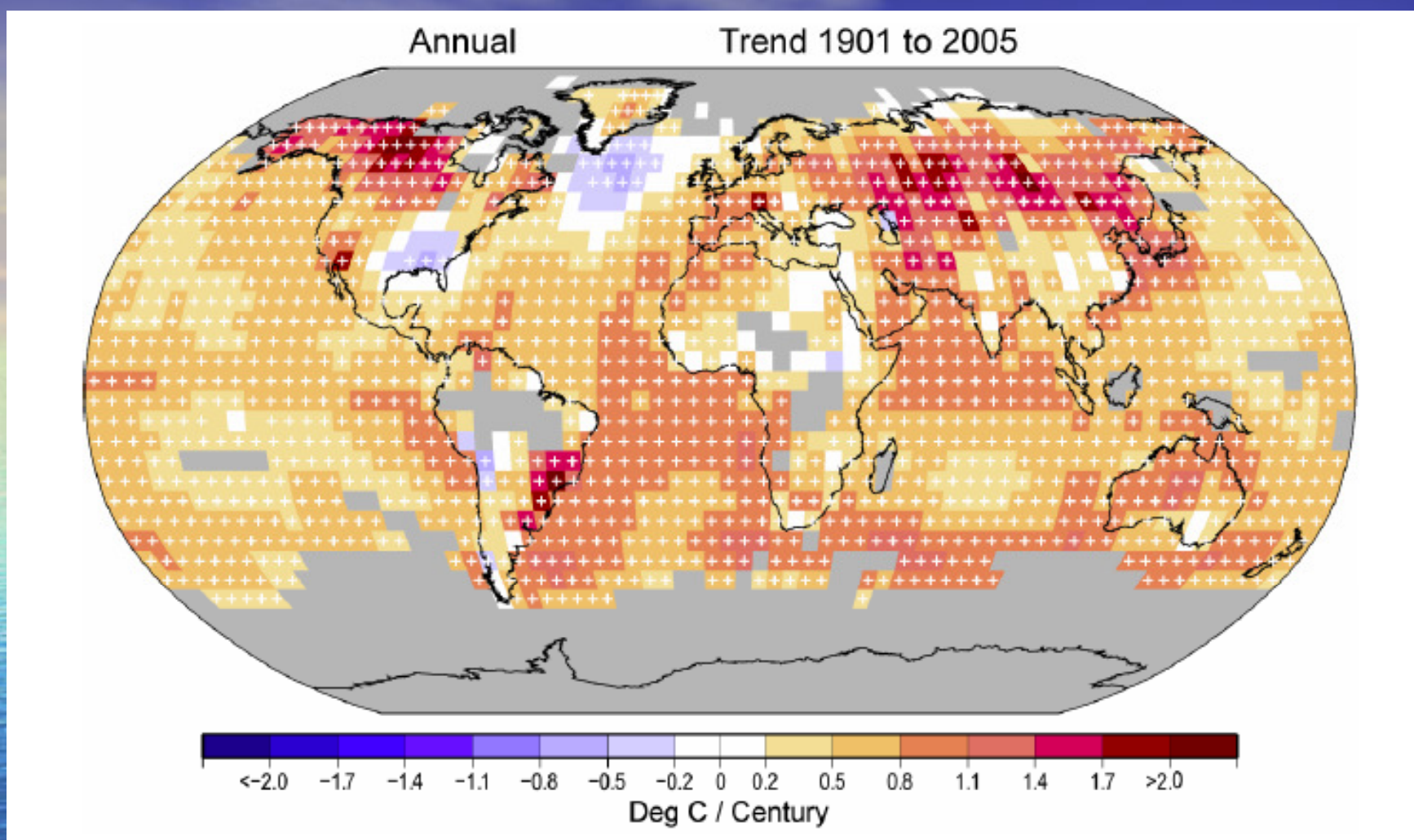


Data from Eggers; Figure from Schindler et al (2008): Fisheries

On top of regional climate variations, the planet has been warming...



The ten warmest years on record are in the period 1997-2008; and 2008 stands as the 8th warmest in the historical record (tied with 2001).

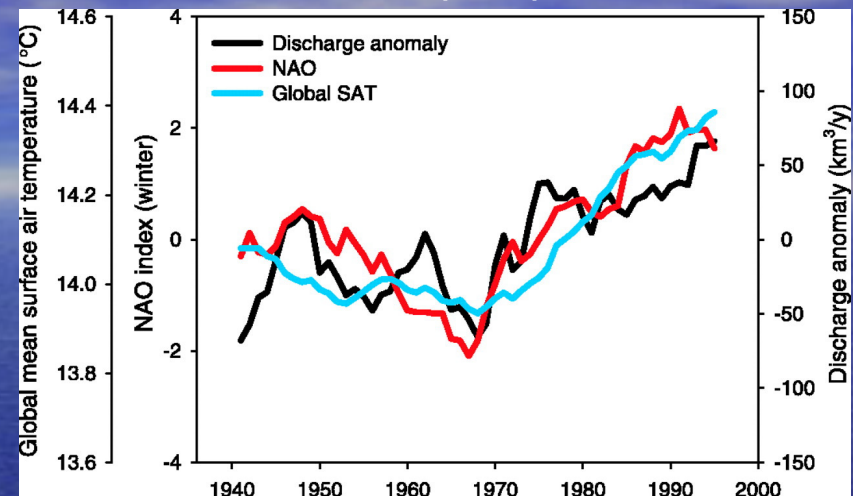


- There truly has been global warming in the past century, with just a few exceptions (North Atlantic and SE US).

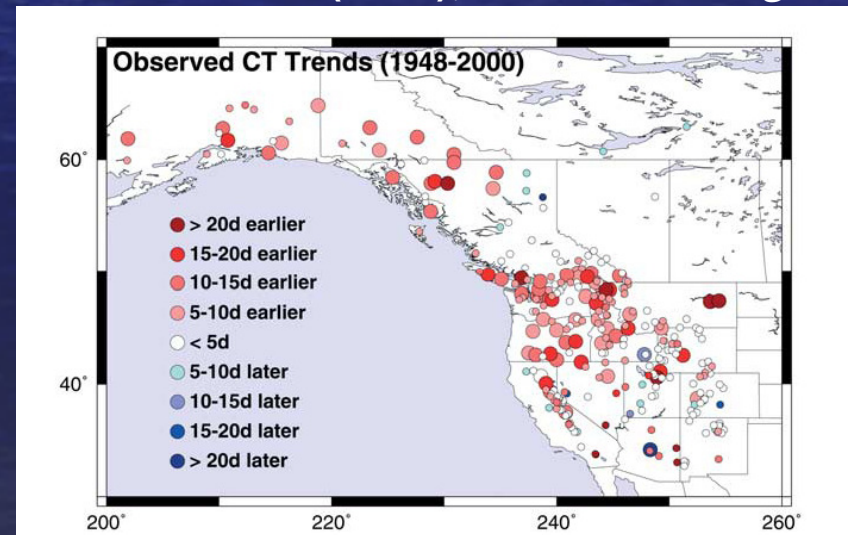
Hydrology has responded to recent climate trends

- Increasing streamflow for major Eurasian rivers in the Arctic tracked the North Atlantic Oscillation (NAO) index and global average temperatures
- Runoff timing for western N. America's snowmelt rivers advanced by a few days to a few weeks from 1948-2000 -- partly explained by PDO, but best explained by regional warming trends

Discharge to Arctic Ocean (Eurasia)
Peterson et al. (2002); *Science*



Runoff Timing Trends
Stewart et al. (2005); *Climatic Change*



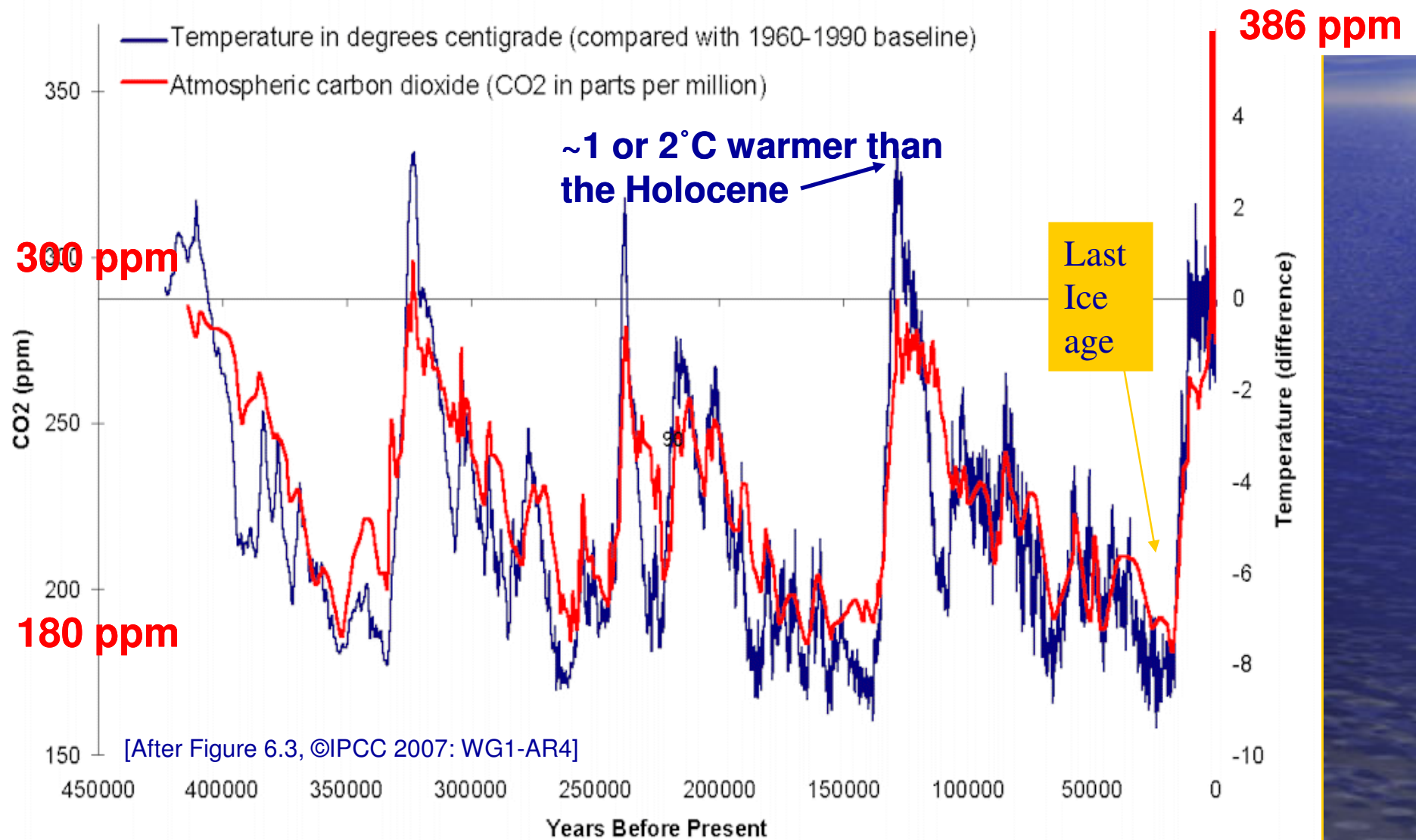
Muir Glacier/Muir Inlet, Glacier Bay Alaska



Glaciers, globally, have been retreating, including most glaciers in the western North America. For some, like the Muir Glacier, the retreat has been dramatic: a 12 km retreat and 800 meters of thinning since 1941

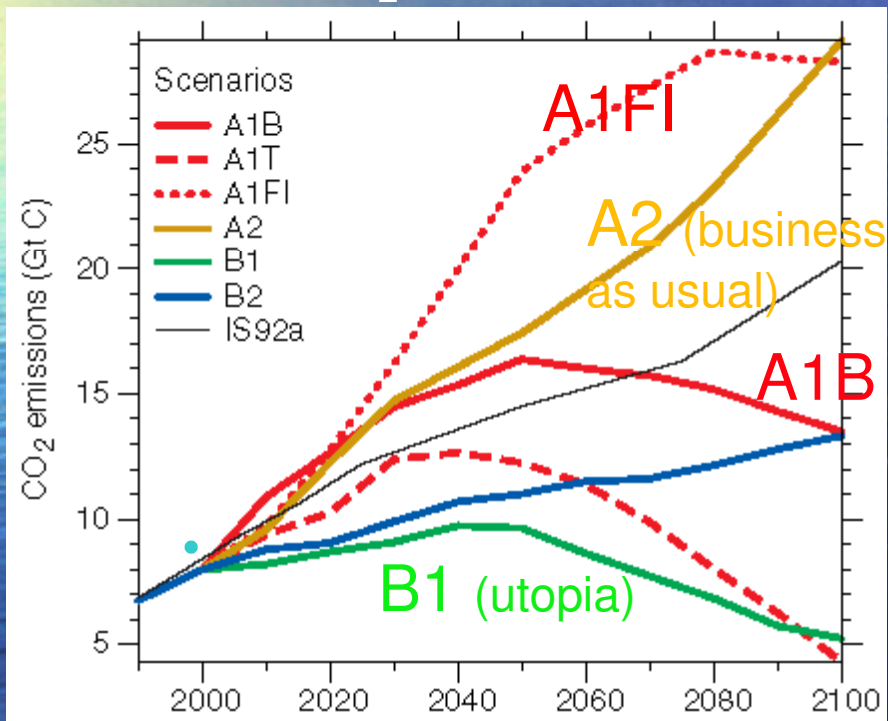
http://nsidc.org/data/glacier_photo/special_high_res.html

The evolutionary history of salmon has been forged, in part, by dramatic glacial/interglacial climate cycles

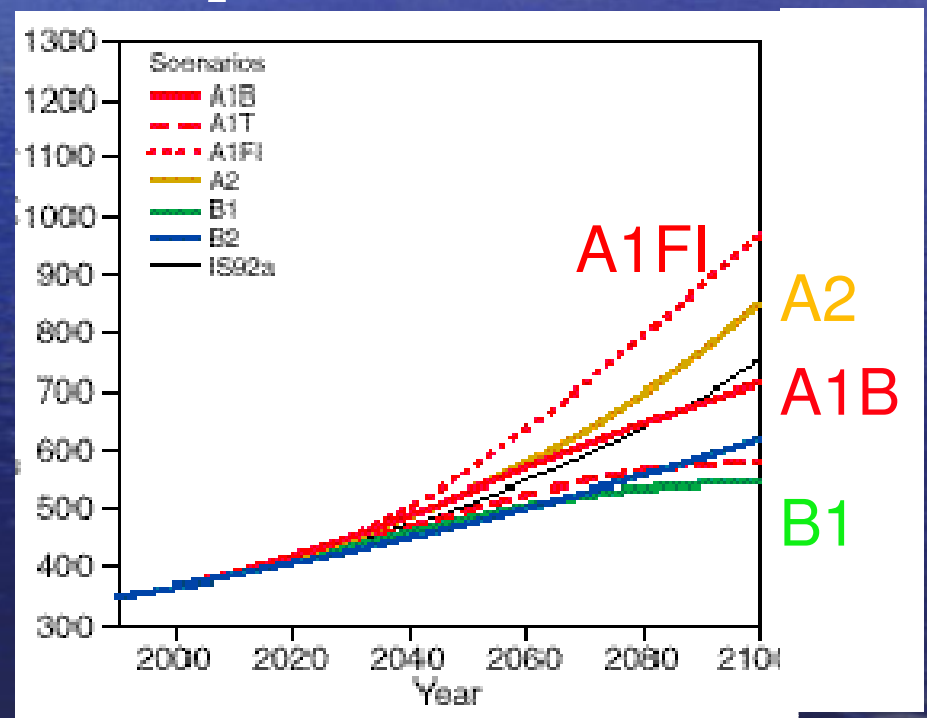


How much Carbon Dioxide will be released into the atmosphere?

CO₂ Emissions

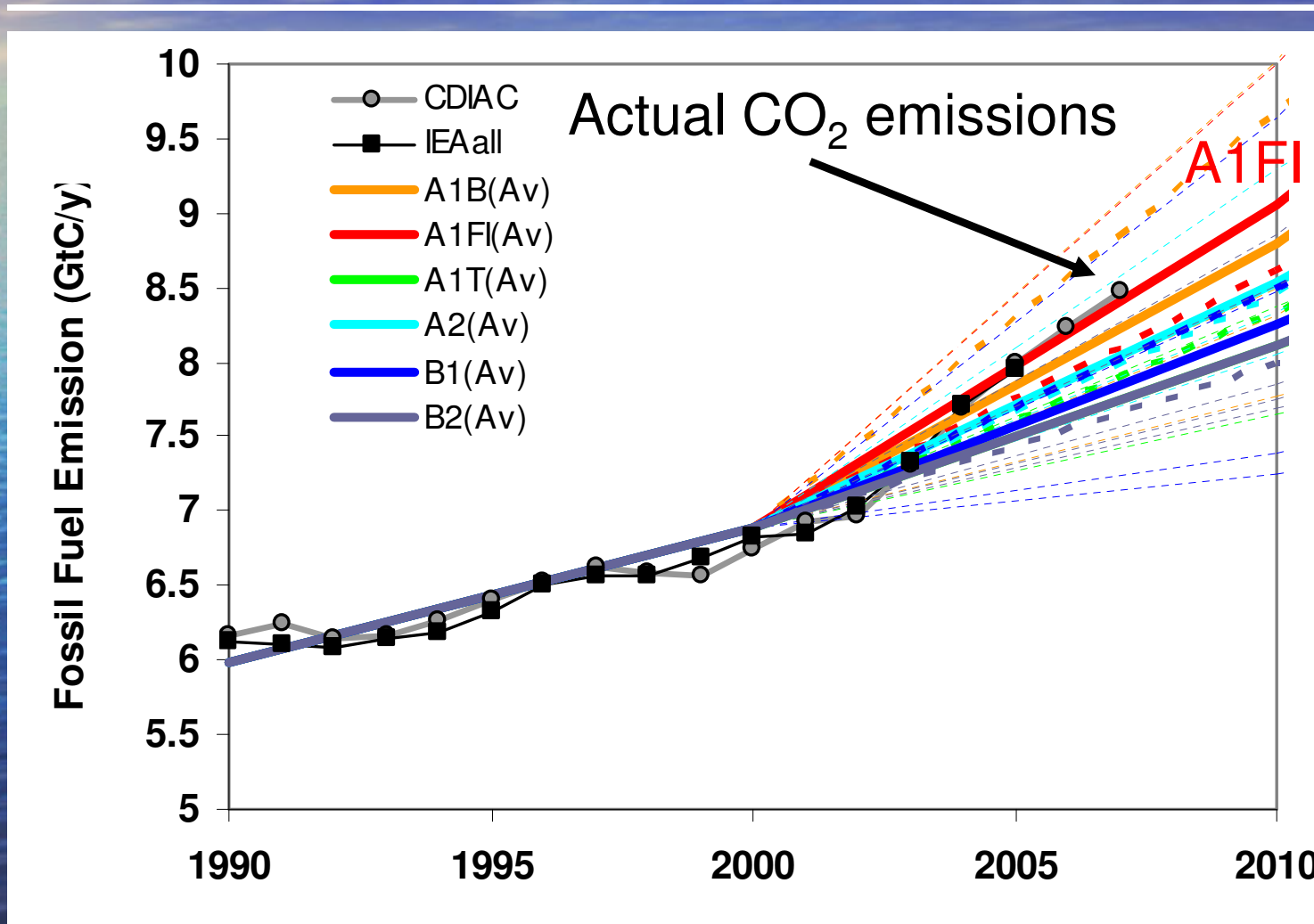


CO₂ Concentrations

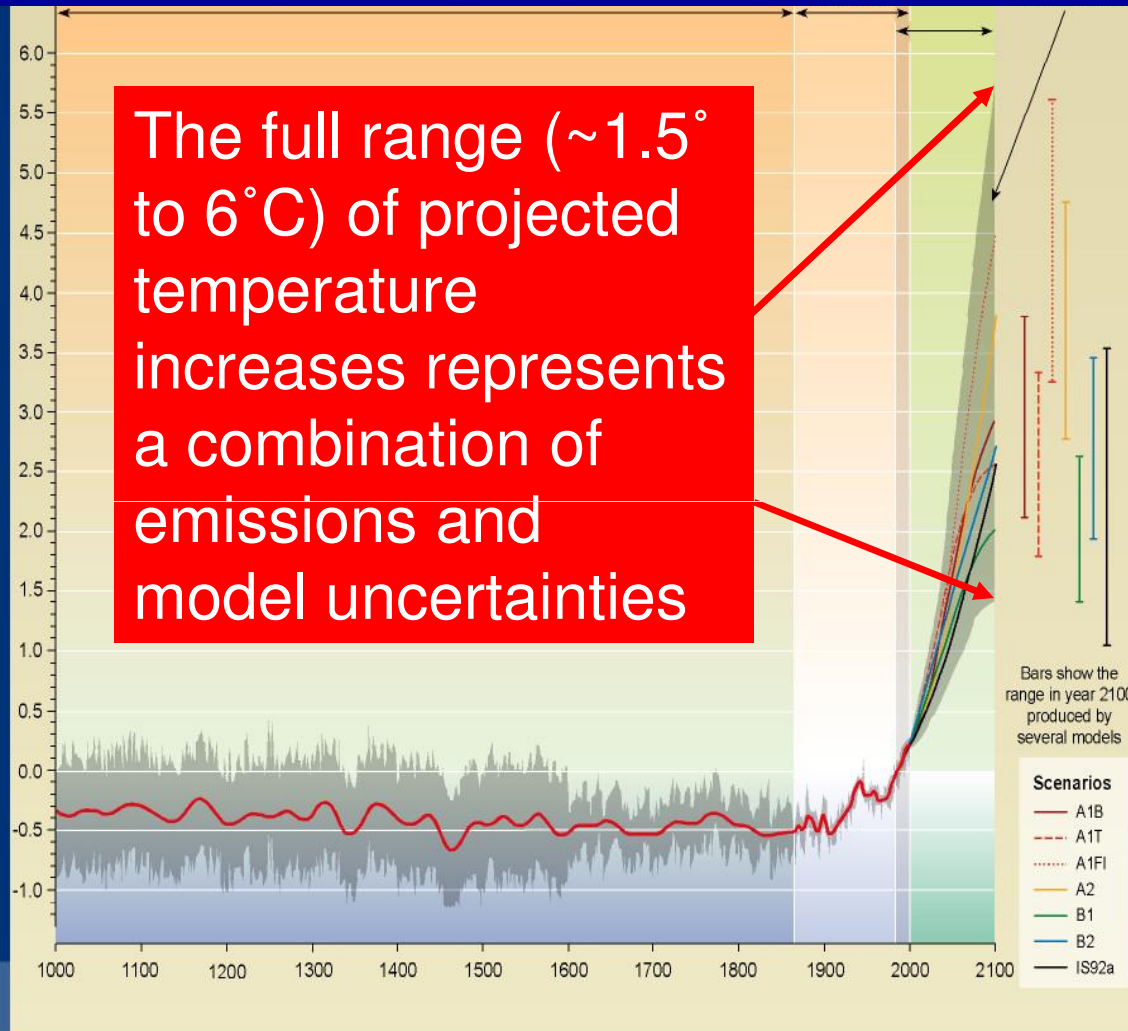


Estimates depend on population and economic projections, future choices for energy, governance/policy options in development (e.g., regional vs. global governance)

Recent emissions are outpacing even the most intense (A1FI) fossil fuel scenario established by the IPCC's 2000 special report on emissions scenarios



We are in the early stages of an era of rapid climate and environmental change

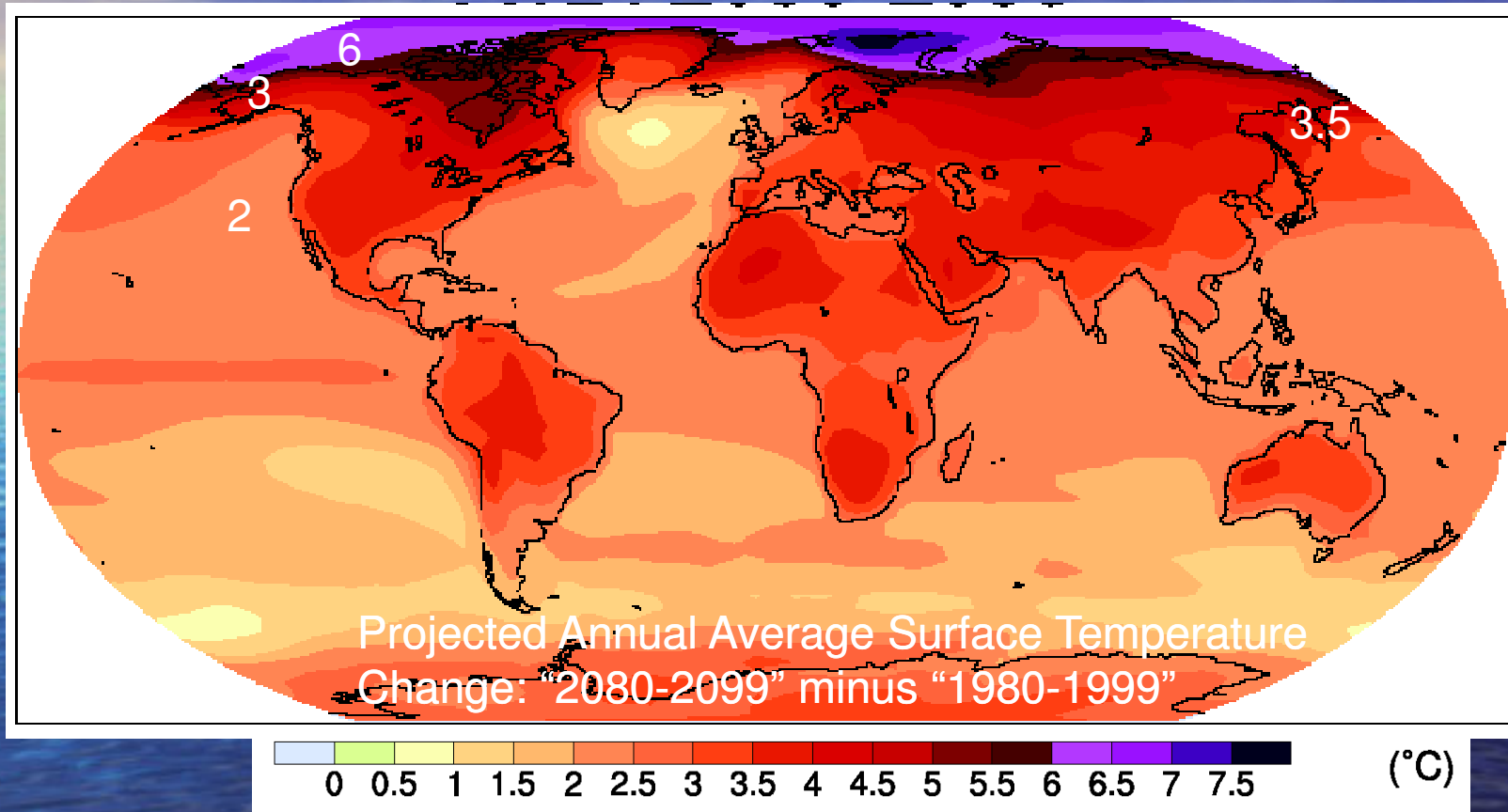


+6°C

+1.5°C

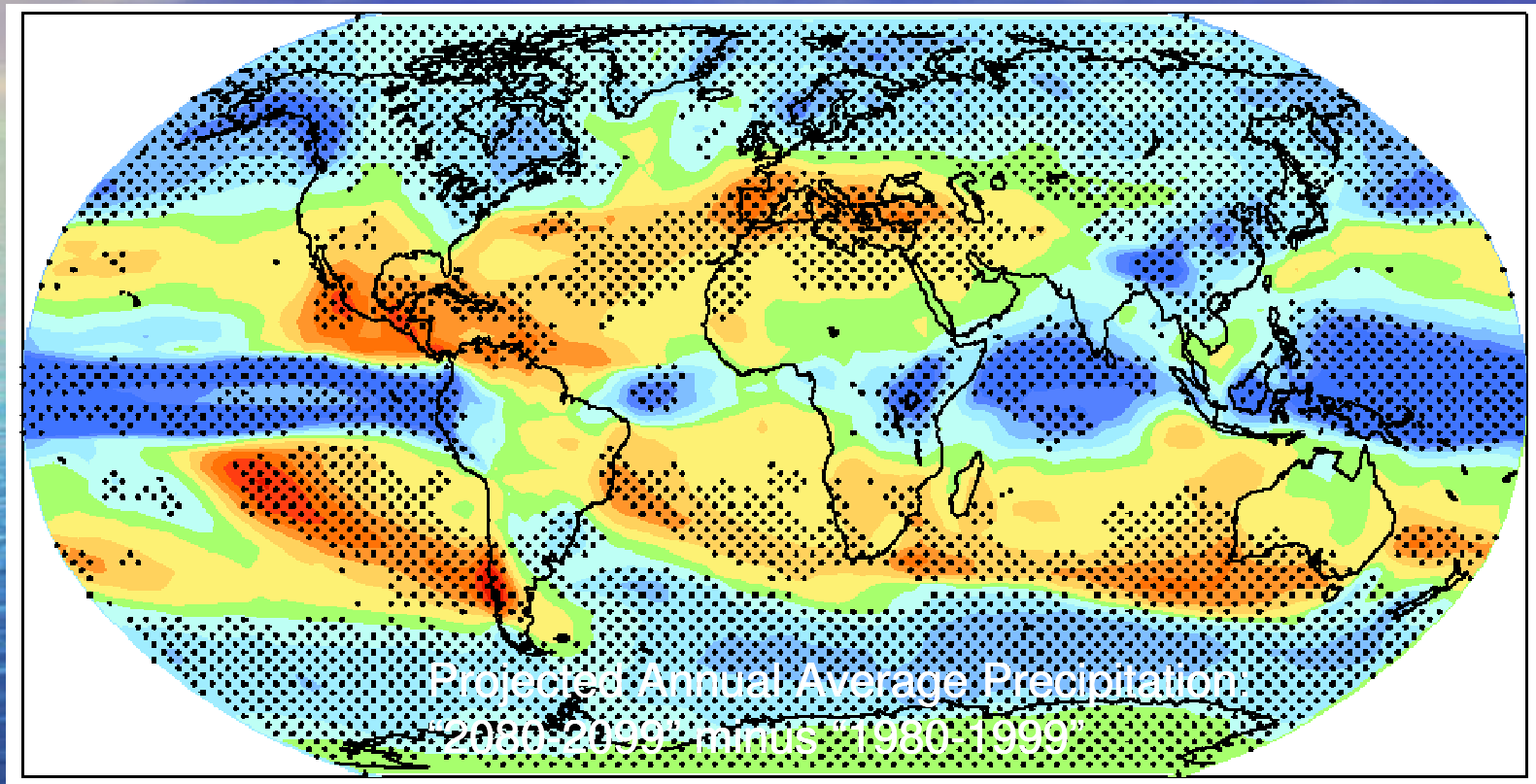
SYR - FIGURE 9-1b

By the end of this century, average surface temperatures for most places may be warmer than at any time in the past million years, or more



Average of 21 climate models forced by Scenario A1B.
Multiply by ~1.5 for A1FI and ~0.7 for B1

Climate models predict a *robust* increase in precipitation over northern latitudes (>45 N), but drying for the subtropics



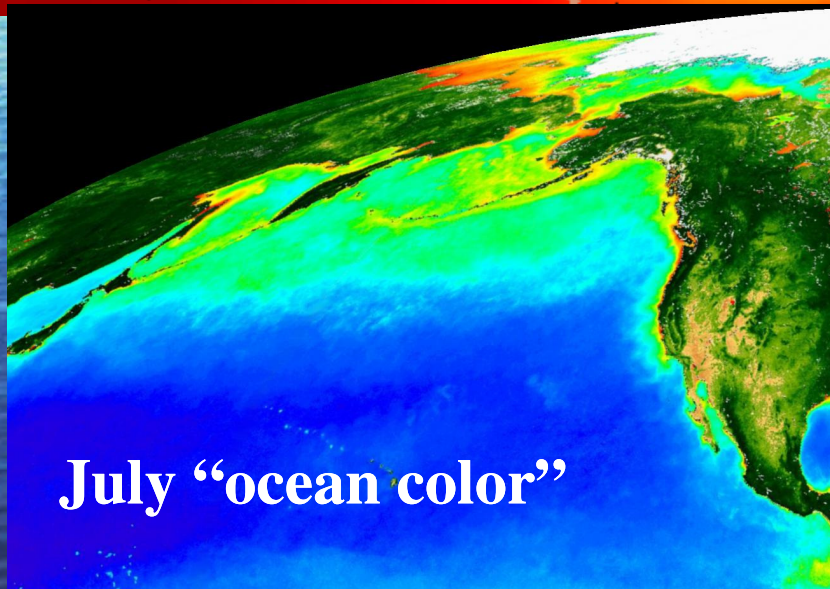
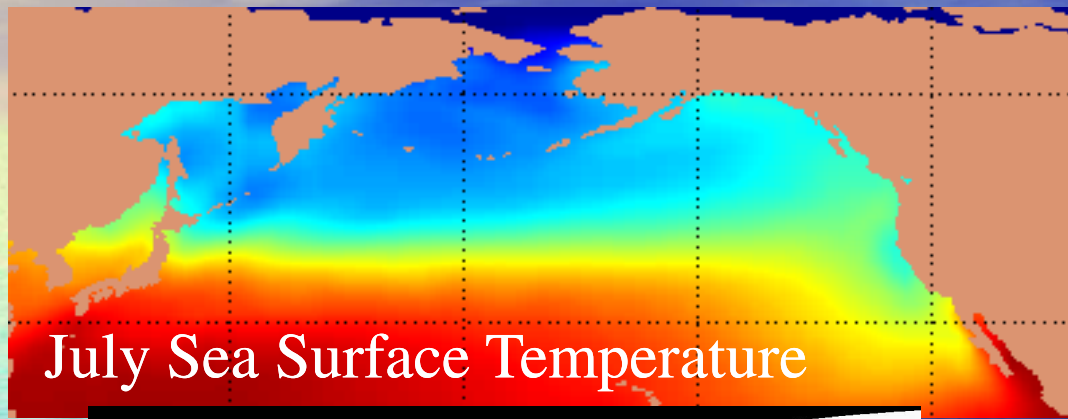
Scenario A1B

Stippling is where the multimodel average change exceeds the standard deviation of the models

Consequences of a warmer climate for salmon watersheds

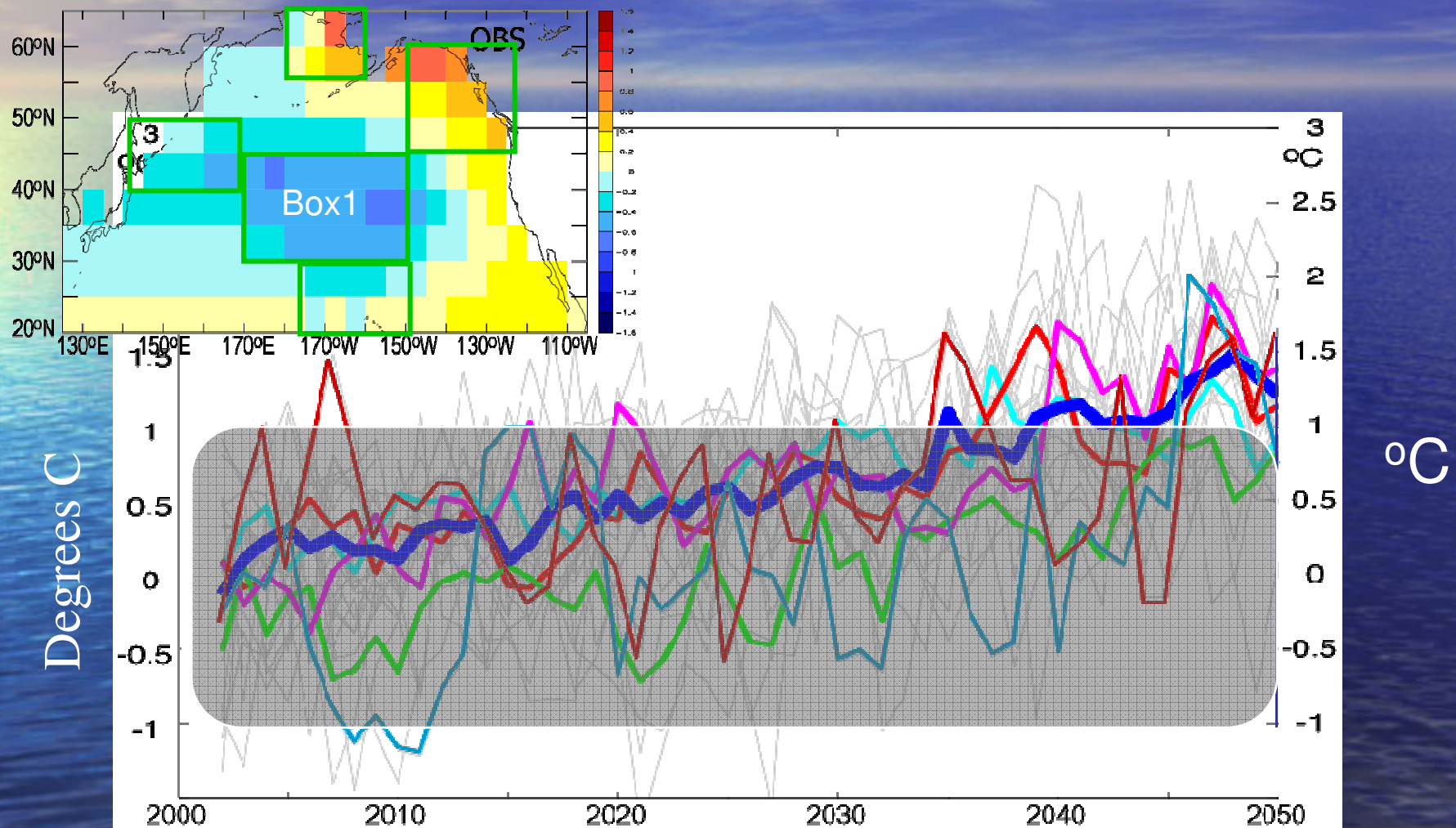
- Increased precipitation intensities
 - more rain and less snow for “near-freezing” locations
- Altered streamflows
 - Higher in winter, lower in summer
- Longer, hotter, drier summers
- Major changes in disturbance regimes (fires, floods, vegetation changes, etc.)
- Increased conflict over water
 - mostly negative impacts in lower/warmer latitudes, and many (?) positive impacts in higher/colder latitudes (at least up to a point)

The salty side of Pacific salmon habitat



Salmon feed and mature in productive cool-fresh-nutrient rich *subarctic* waters from northern Japan to California -- coastal upwelling extends this habitat south to S. Cal.

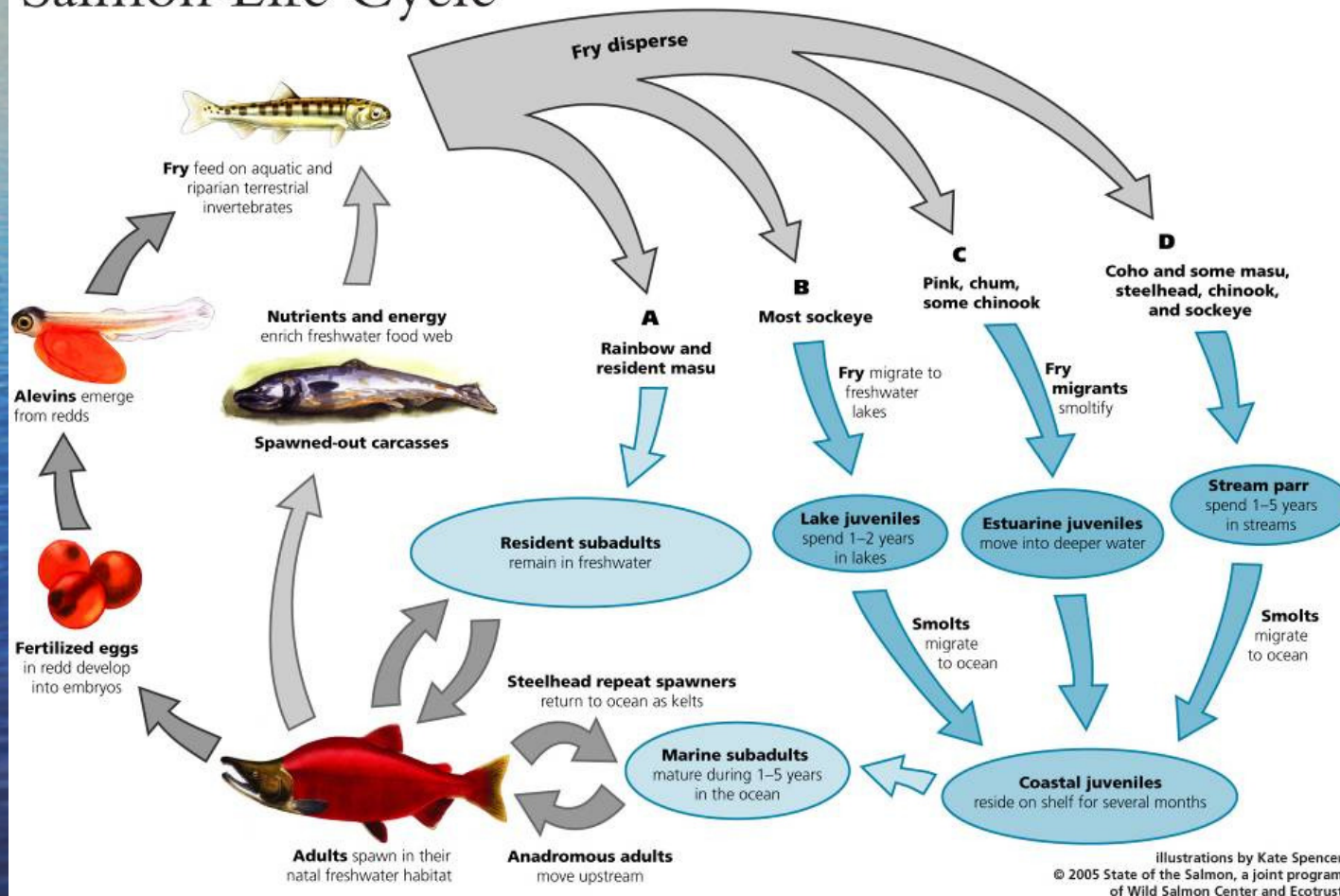
The future will not present itself in a simple, predictable way, as natural variations will still be important for climate change in any location



Overland and Wang *Eos Transactions* (2007)

Because of the complexity of habitat, salmon life histories and local adaptations, there will be a diverse suite of climate change impacts that varies for different stocks, watersheds, and sub-basins

Salmon Life Cycle



Ocean Acidification: the other CO₂ problem

Sources

Land-use change
200 Pg C
(42%)

Fossil emission
280 Pg C
(58%)



Sinks

Atmospheric accumulation
190 Pg C
(40%)

Terrestrial sink
166 Pg C
(35%)

Ocean sink
124 Pg C
(26%)

Ocean pH has already dropped by 0.1 units (30% more acidic); increased CO₂ uptake is expected to reduce upper ocean pH by ~0.5 units by 2100, which would be the largest change in pH to occur in the last 20-200 million years



What are the biological implications of ocean acidification?



- Reduced calcification rates for hard-shelled organisms
- increased physiological stress for many other species causing reduced tolerance to other environmental fluctuations
- Shifts in phytoplankton diversity and changes in food webs
- **High potential for changes to fitness and survival, but this is poorly understood**

(Slide provided by Dick Feely, NOAA)

Larson

LOOKOUT
AHEAD

We're still
accelerating --
but it's time to
back our way
down this
mountain...

LOOKOUT!



Responding to the Climate Change Challenge

- To reduce the risks of catastrophic climate change and ocean acidification, greenhouse gas concentrations must be reduced
 - We can do this by reducing emissions and/or extracting gases from the atmosphere
- Salmon are facing rapid rates of environmental change and they will need to adapt
 - As the primary drivers of change in salmon ecosystems, our actions will shape their potential for adaptation