

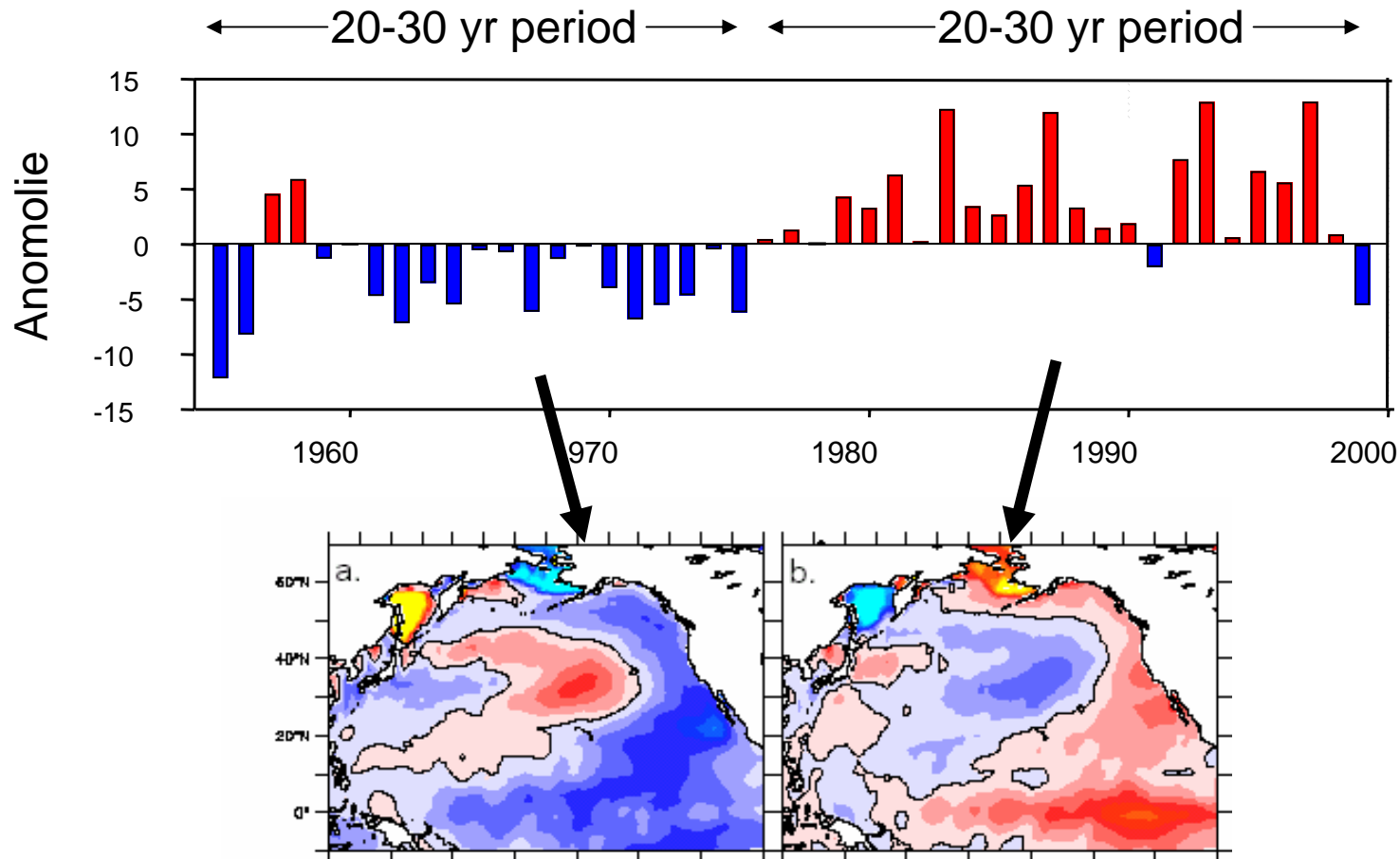
# Recent High Frequency Variability in the PDO: Impacts on the California Current Ecosystem and Salmon

NOAA Fisheries  
Northwest Fisheries Science Center  
Seattle, WA & Newport, OR, USA

Ed Casillas and Bill Peterson



Atmospheric and Ocean Phase shifts are tracked by the Pacific Decadal Oscillation (PDO): negative values = cool phase; positive values = warm phase.



# NE Pacific Ecosystem Response To PDO

## Negative PDO

- SST Cooler
- Secondary Productivity – Alaska↓, PNW↑
- Salmon Abundance - Alaska↓, PNW↑

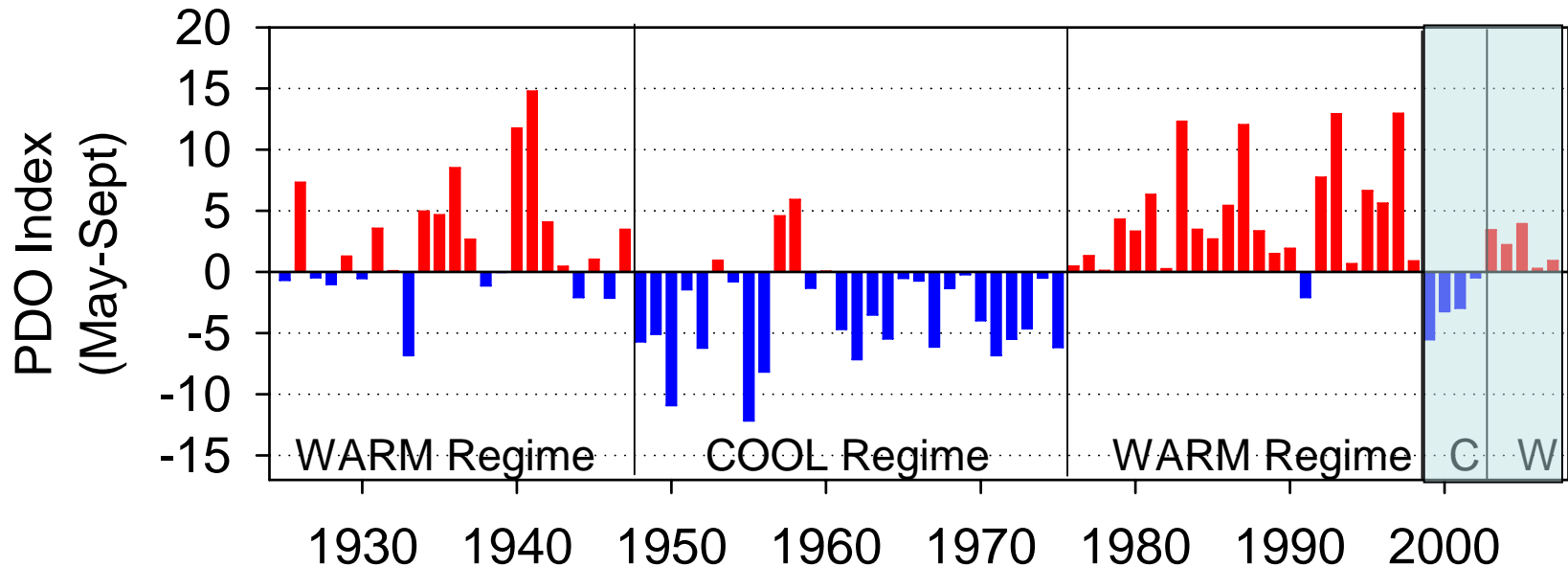
## Positive PDO

- SST Warmer
- Secondary Productivity – Alaska↑, PNW ↓
- Salmon Abundance - Alaska↑, PNW ↓

# Issue Being Addressed

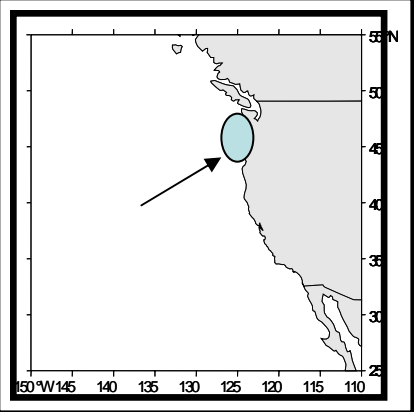
- Physical and biological elements of the ecosystems appear stable during each long term phase (cool or warm regime) of the PDO
- Question - If large scale regime shifts occur at a greater frequency (shorter duration), is the ecosystem able to respond accordingly?
- Because Global Warming could affect duration and variability in large scale forcing; do managers of fishery resources need faster responding forecasting tools?
- ANSWER – Yes and Yes

# PDO: May-Sep Average, 1925-2007

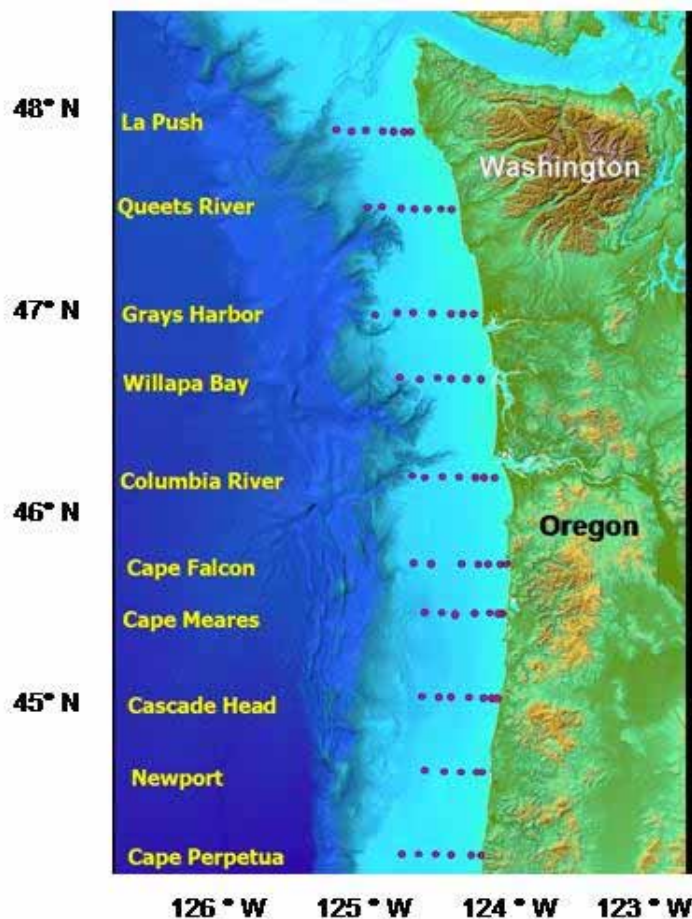


- At no time since 1900, nor during the Warm-Cool-Warm regimes was there a sign change longer in duration than 16 months (1957-58 El Niño), and there was never a period of PDO with an opposite change in sign for more than 8 months within a given year.
- However, we have had two shifts of four years duration recently: 1999-2002 and 2003-2006, **thus we have a natural experiment to test the question**

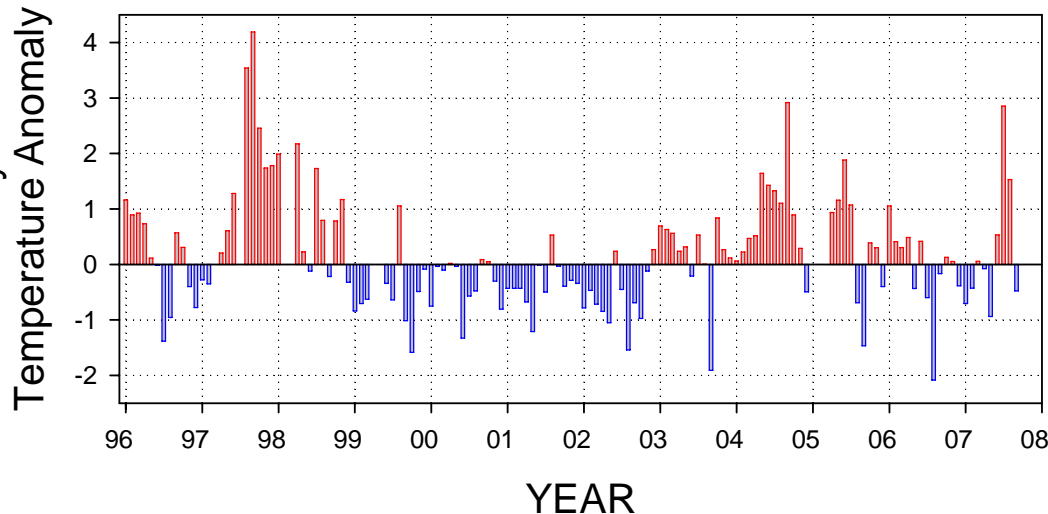
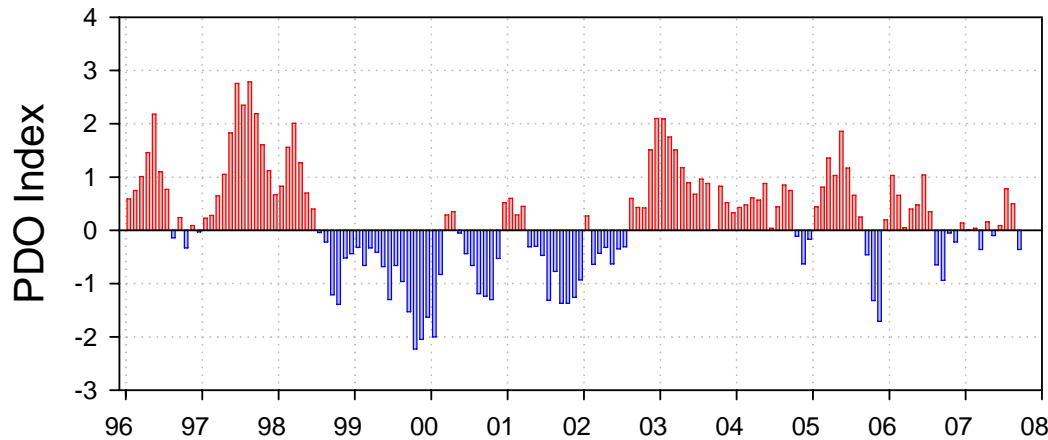
# Plankton, Salmon and Pelagic Fish Sampling



- Sample in May, June and September (50 stations) since 1998
- Sample Columbia River and Willapa Bay every 10 days from April through July (AT NIGHT) at ~ 10 stations; since 1998
- Sample off Newport every two weeks, since 1996
- Have historical data on hydrography and zooplankton from 1970s and 1983; salmon abundance data from 1981-1985 but only some of these data are part of this talk



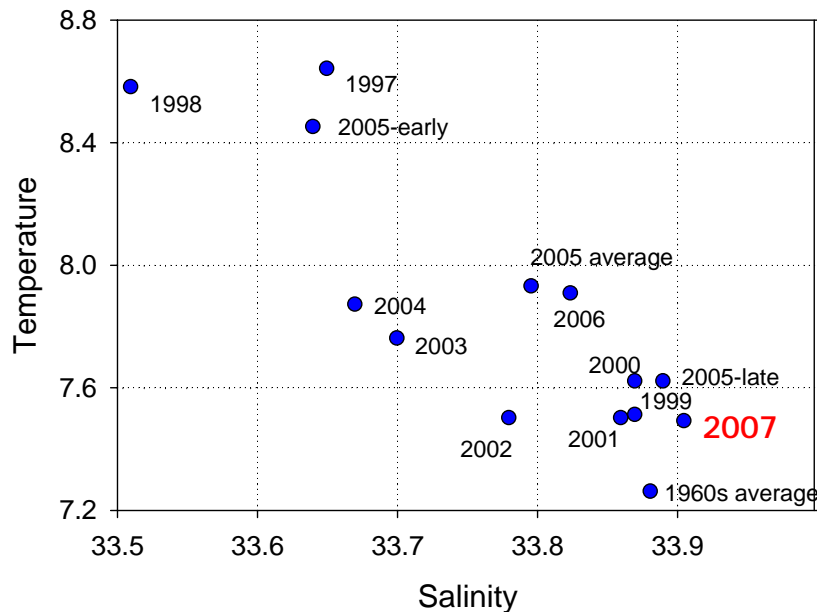
# PDO and SST (off Newport)



- PDO and SST highly correlated, as they should be.
- However there are time lags between PDO sign change and SST response of 3-5 months.
- Suggests PDO is an advective signal along the Oregon coast

# Different Water Masses in the Ca Current Ecosystem

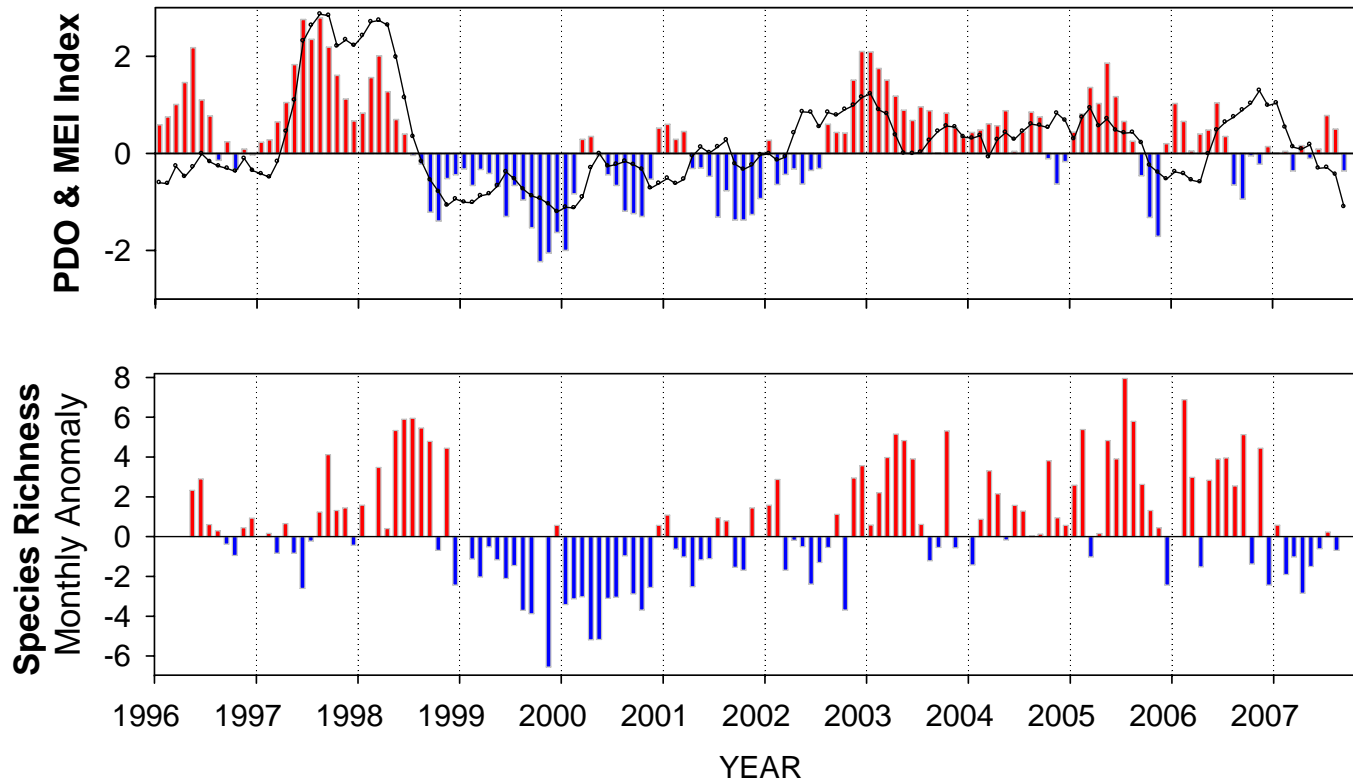
Temperature and Salinity averaged for May-September at station NH 05  
50 m water depth



- 2007 a “cool” year, similar to 1999-2002
- 1997-1998 + early 2005 were warm and fresh
- 2003-2006 intermediate T and S

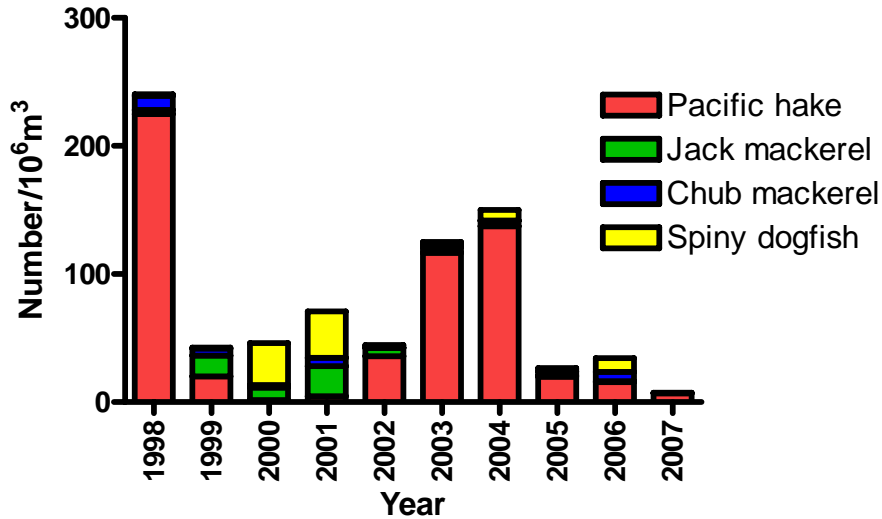


# PDO and copepod species richness anomalies



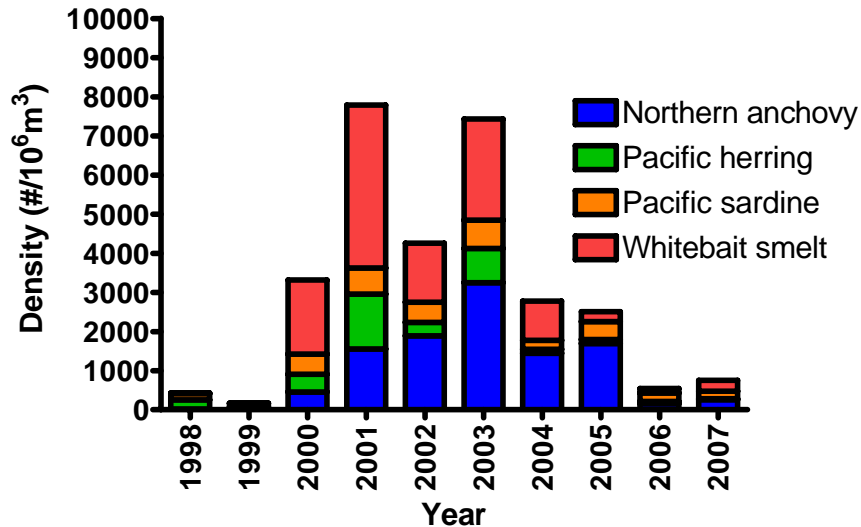
Monthly anomalies of number of copepod species in samples. Low number of spp when PDO negative; high number of spp when PDO is positive. Noteworthy that species richness was low in 2007 but PDO was positive (and SST warm) but rest of the water column was very cold and salty. Implication: use SST with care!!! Some suggestion that copepods track the MEI better, especially in 2007.

**Predator Densities off the Columbia River**

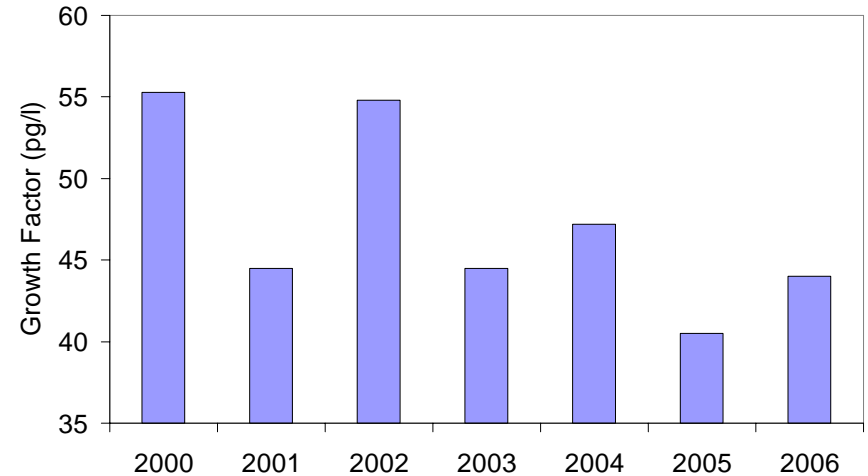


Variation in Other Biological Factors of the California Current Ecosystem During the 1998-2007 Period

**Forage Fish Densities off the Columbia River**

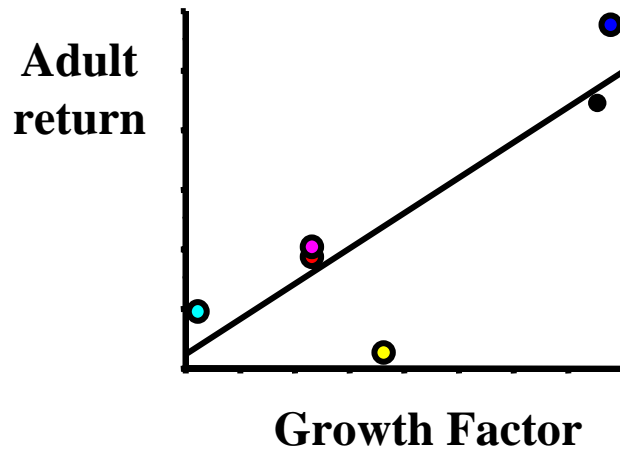


**Coho Salmon Growth Condition**

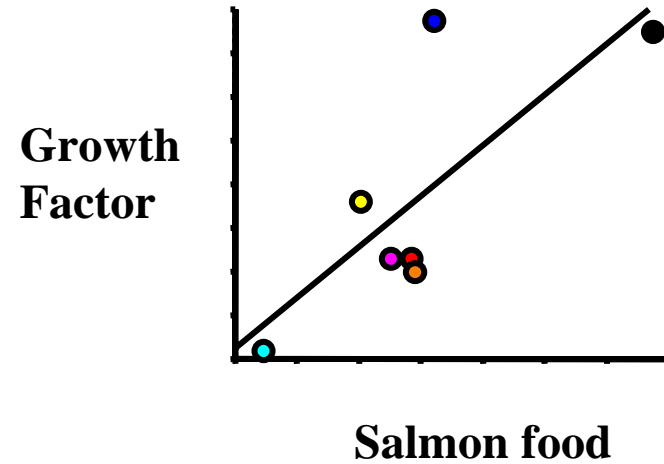


# Are Growing Conditions Important To Salmon?

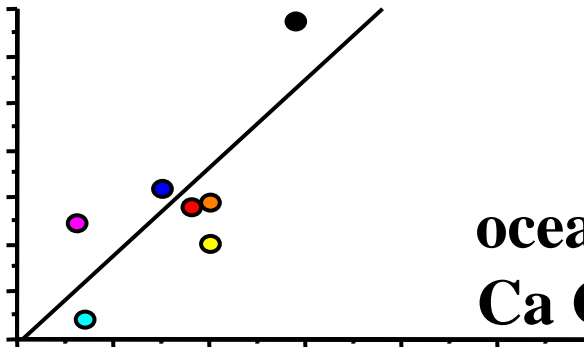
Survival relates to growth



Growth relates to food



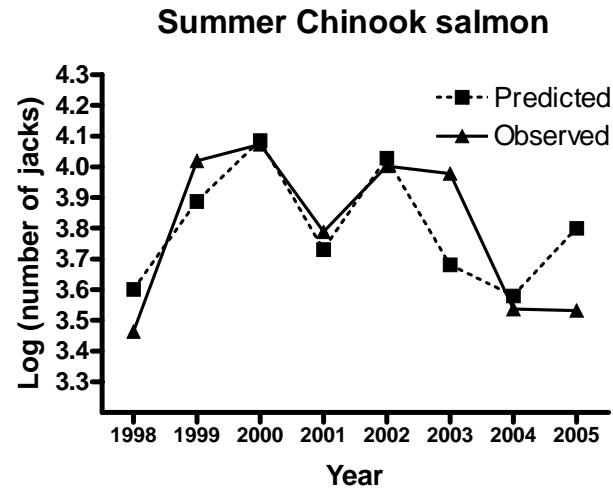
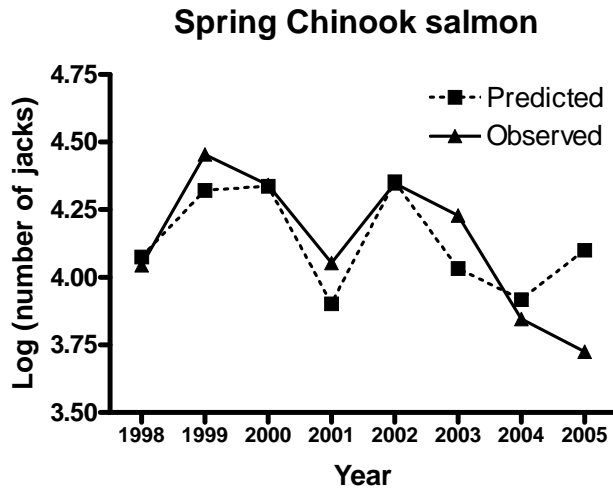
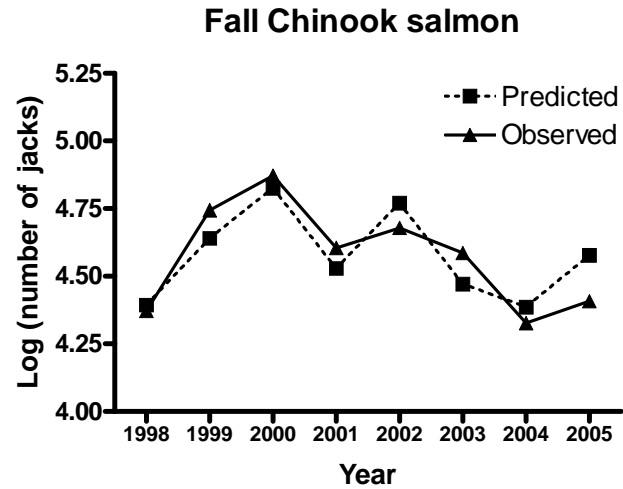
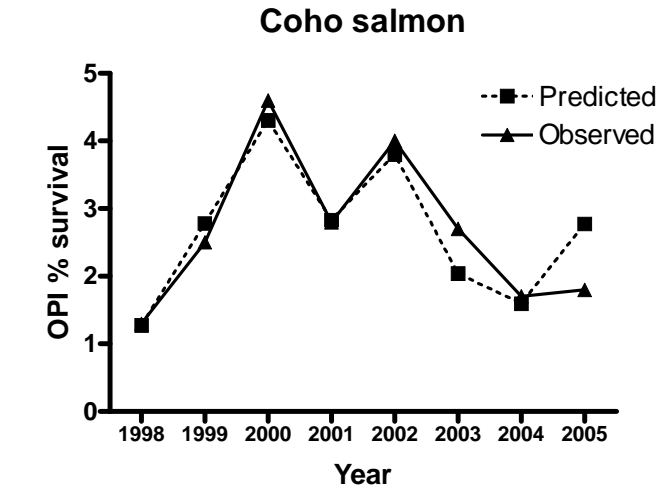
Salmon food



Food relates to ocean conditions in the Ca Current Ecosystem

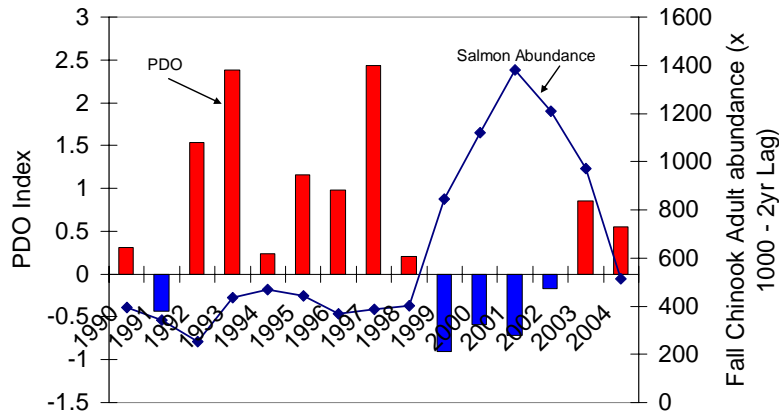
April upwelling

# Predatory/Forage Fish Interaction Affects Salmon Survival

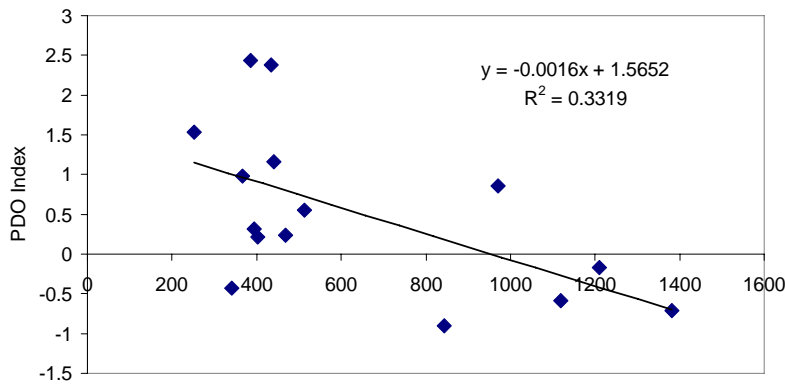
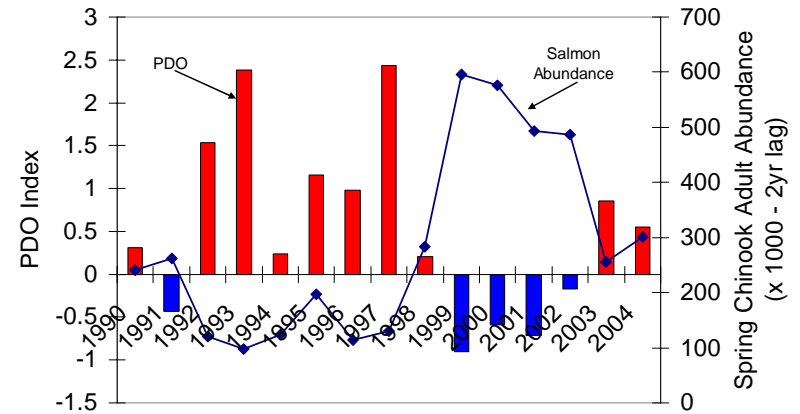


# Salmon Abundance in the Ca Current Reacts Quickly to change in PDO sign

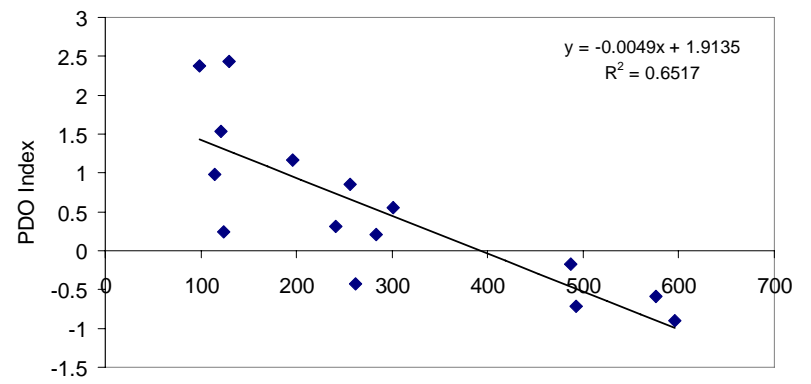
## Fall Chinook



## Spring Chinook



Fall Chinook Adult Abundance (x 1000 - 2 yr Lag)



Spring Chinook Abundance (x1000)

# Findings

- Physical and biological features of the California Current ecosystem appear to change rapidly to phase shifts in the large scale forces reflected in the PDO
- Marine survival of salmon similarly appears to reflect rapid changes in ocean conditions of the northern California Current ecosystem
- Because Global Warming could affect duration and variability in large scale forcing, managers of fishery resources will need faster responding forecasting tools?
- An example of one such forecasting tool documents current ocean conditions and potential impact of salmon survival 1 to 2 years ahead of their actual return (See webpage [www.nwfsc.noaa.gov](http://www.nwfsc.noaa.gov))

# Ocean Index – Forecasting Future Salmon Returns

	Juvenile migration year				Forecast of adult returns	
	2000	2005	2006	to June 2007	Coho 2007	Chinook 2008
<b>Large-scale ocean and atmospheric indicators</b>						
PDO	■	■	■	■	●	●
MEI	■	■	■	■	●	●
<b>Local and regional physical indicators</b>						
Sea surface temperature	■	■	■	■	●	●
Coastal upwelling	■	■	■	■	●	●
Physical spring transition	■	■	■	■	●	●
Deep water temp. & salinity	■	■	■	■	●	●
<b>Local biological indicators</b>						
Copepod biodiversity	■	■	■	■	●	●
Northern copepod anomalies	■	■	■	■	●	●
Biological spring transition	■	■	■	■	●	●
Spring Chinook--June	■	■	■	■	--	●
Coho--September	■	■	■	■	●	--

[www.nwfsc.noaa.gov](http://www.nwfsc.noaa.gov) (look for ocean indicator link)