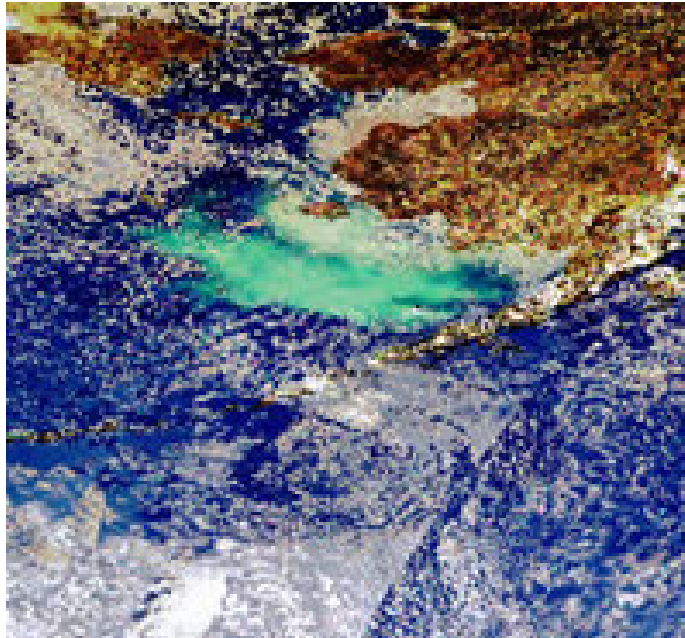
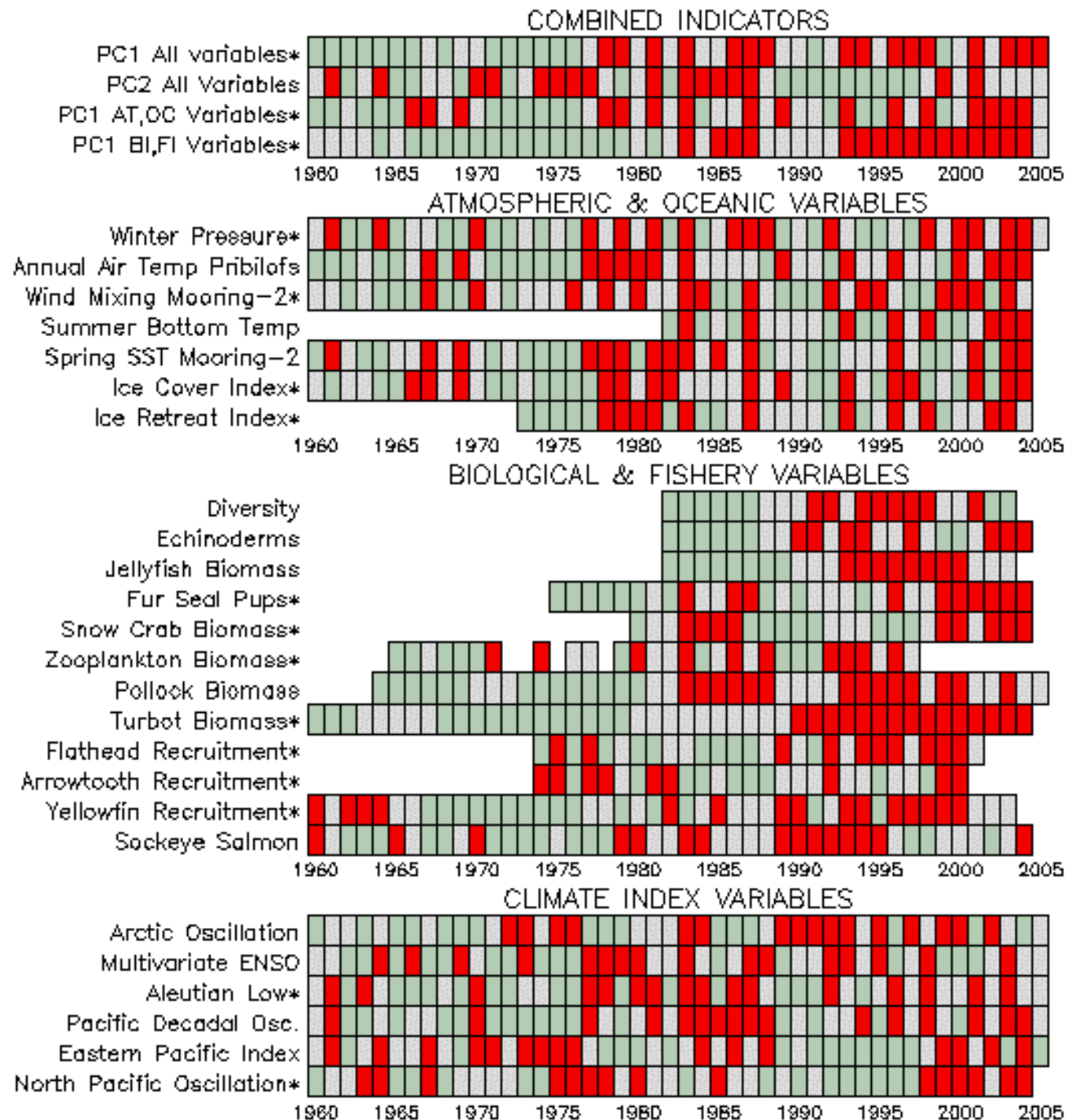


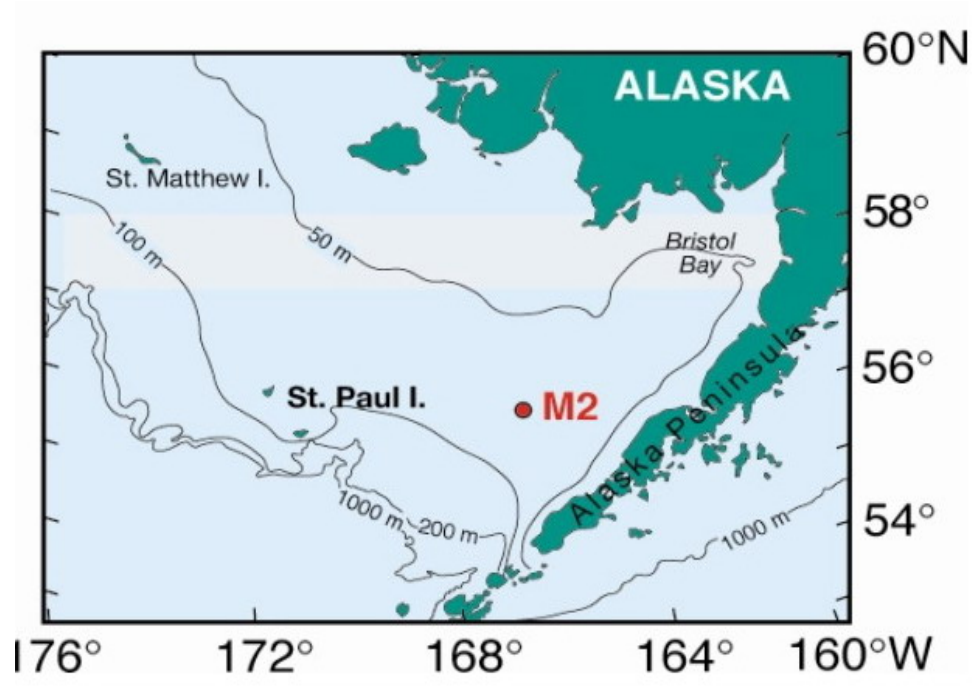
Multiple Indicators Track Major Ecosystem Shifts in the Bering Sea: A Persistent Warm Phase?

*James E. Overland, Jennifer Boldt, Phyllis J. Stabeno
Muyin Wang, and Patricia Livingston
NOAA-PMEL and AFSC, Seattle WA, USA*

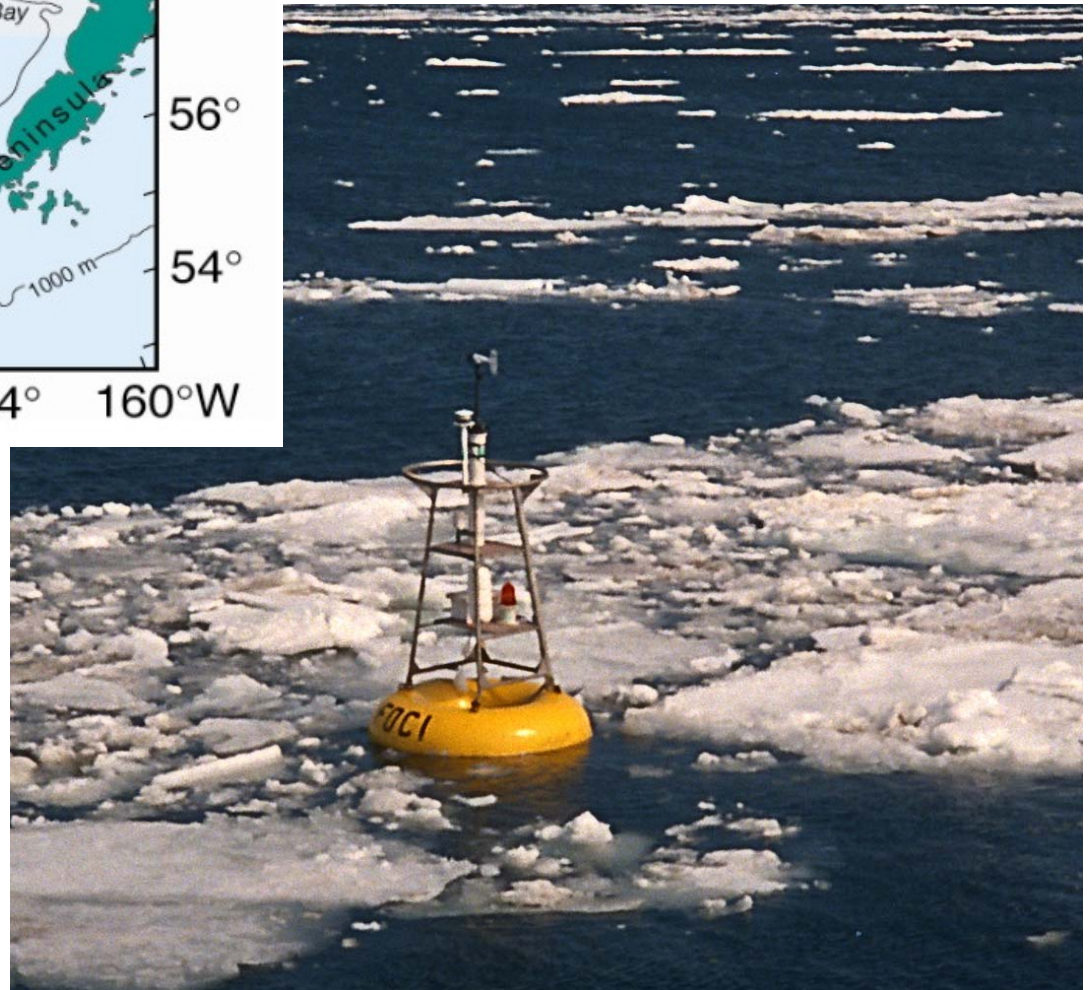


Bering Indicators

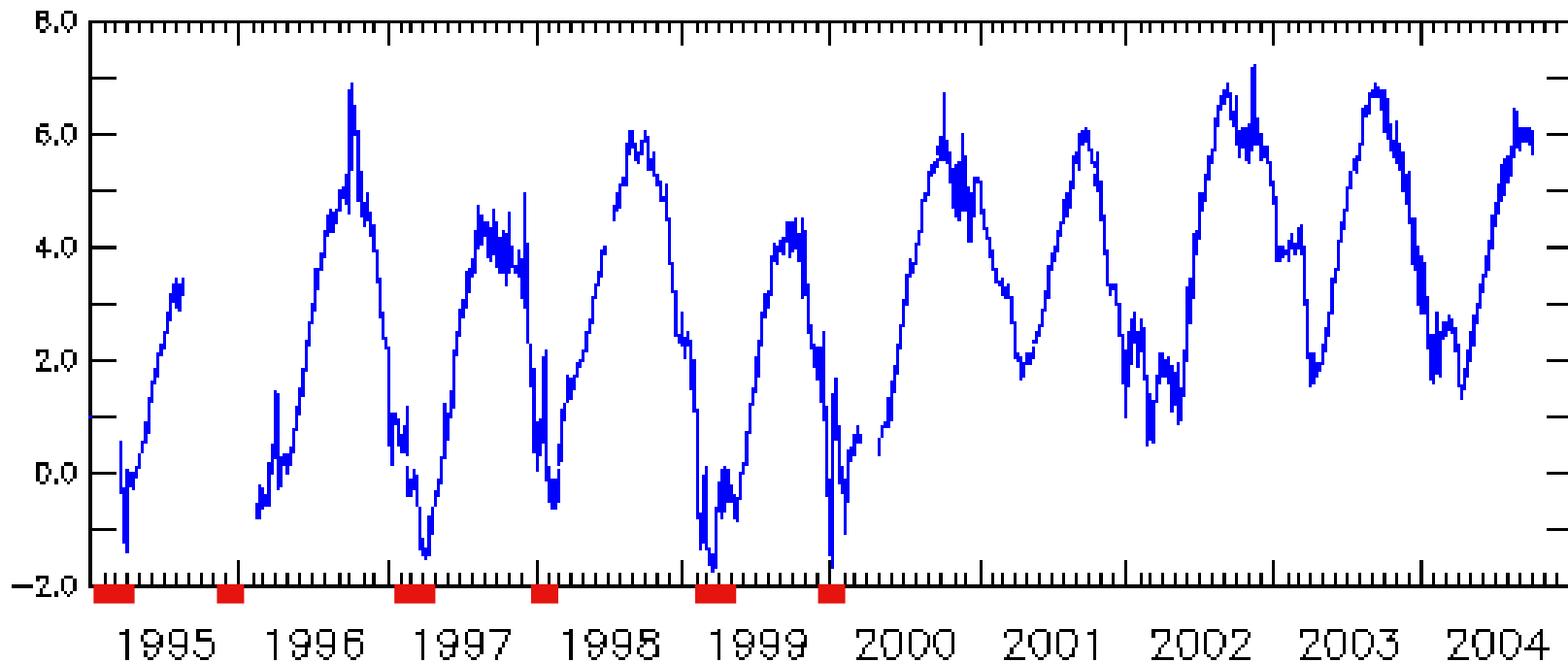




Mooring 2 (M2) and its Location in Bering Sea



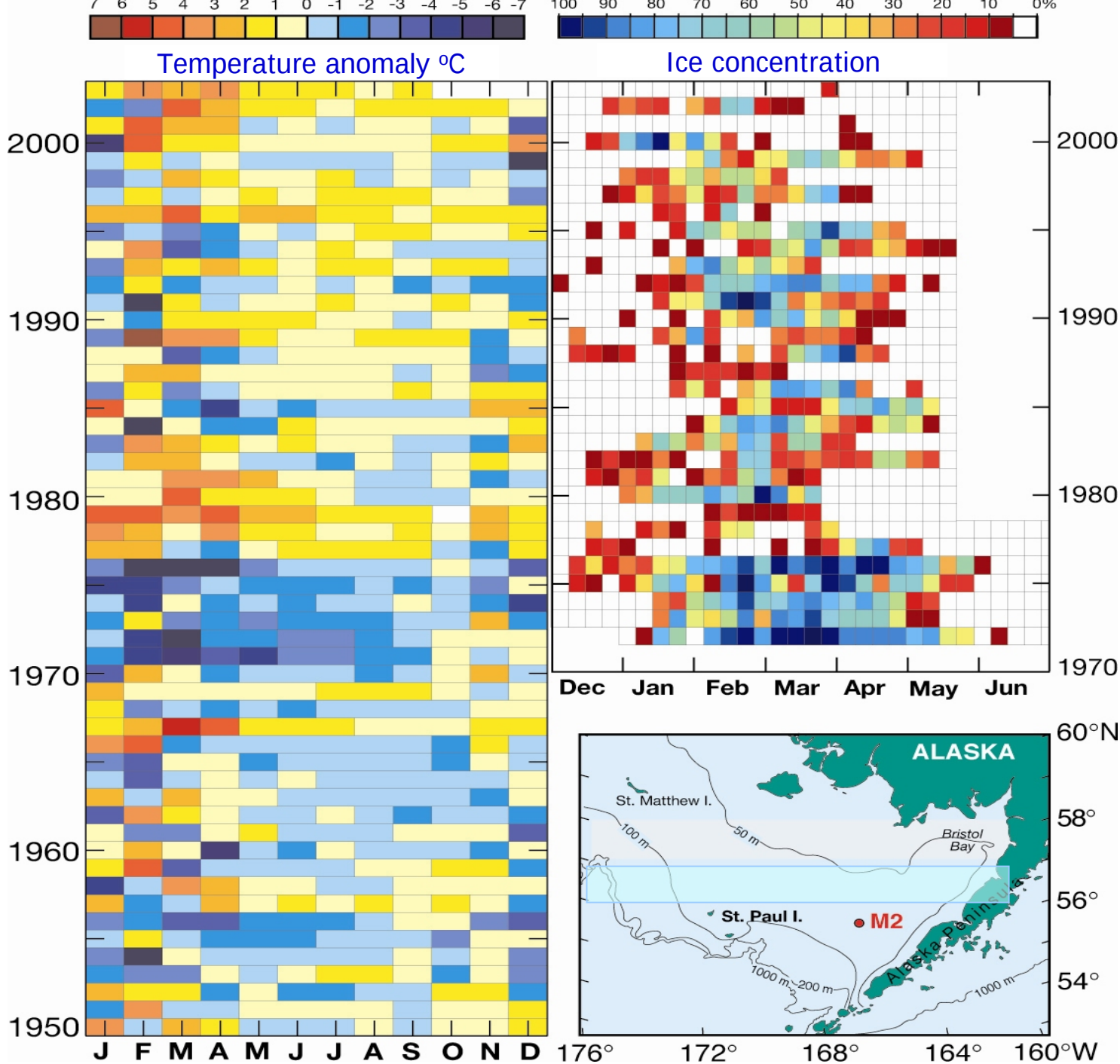
Vertically Averaged Water Temperature (°C) at M2

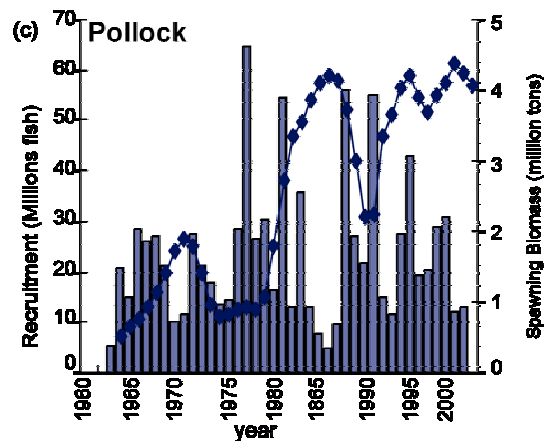
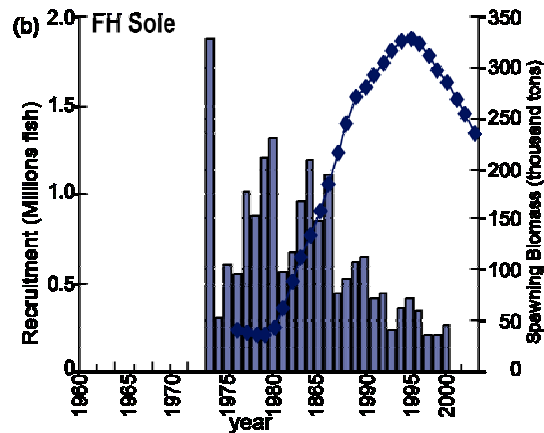
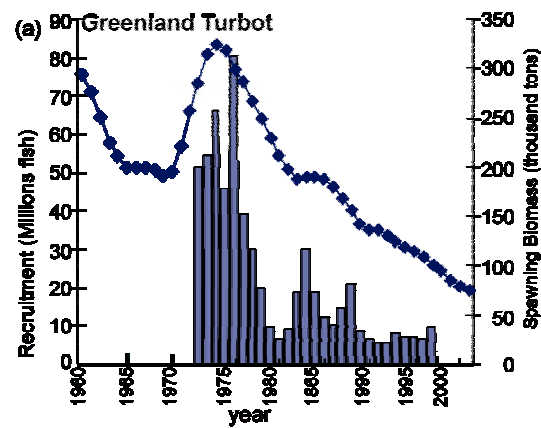


Courtesy Phyllis Stabeno

2°C increase in winter after 2000 above freezing point

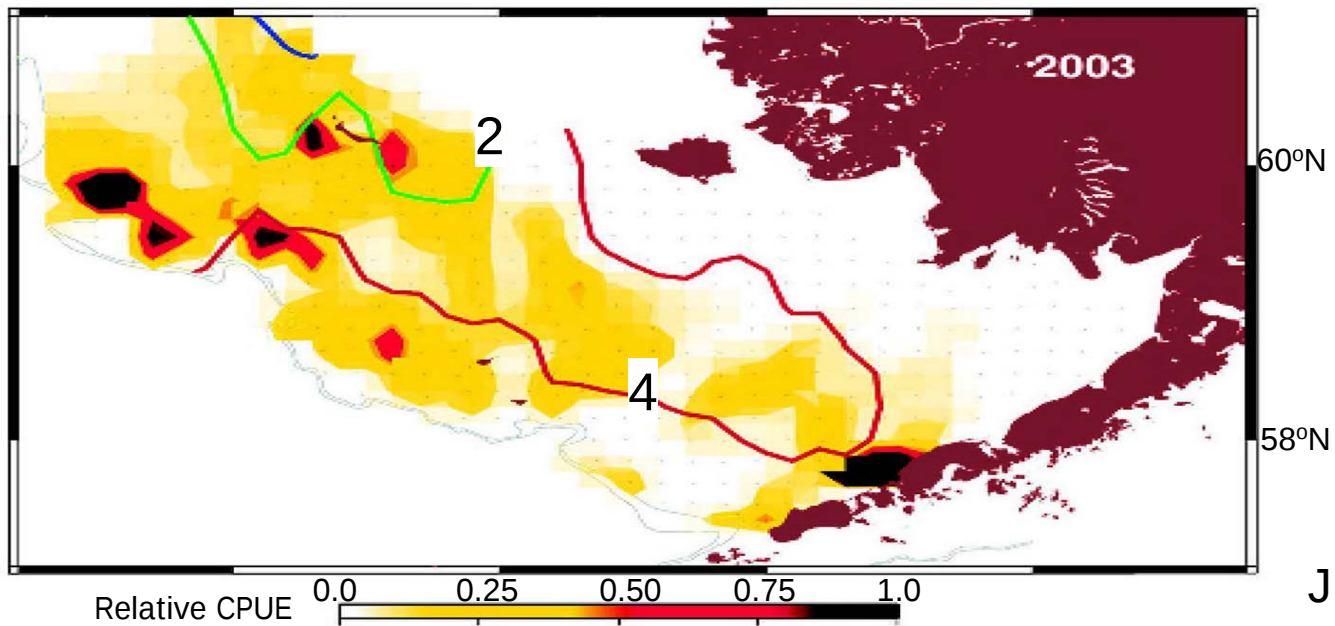
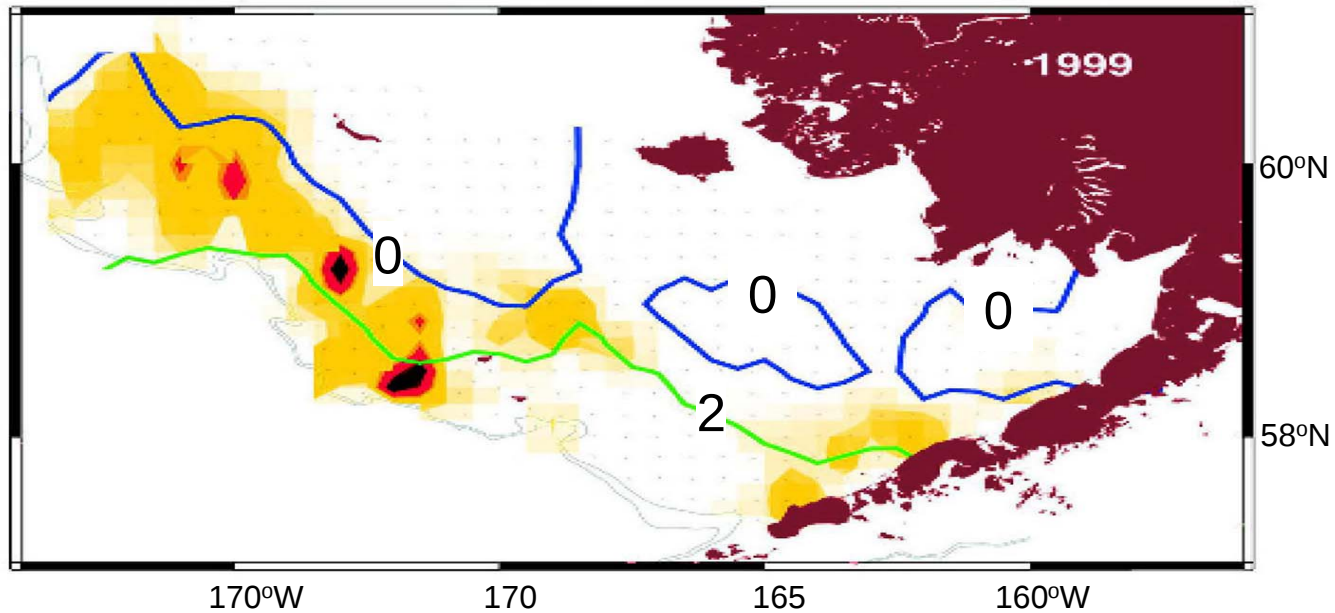
Surface Air Temperature Anomaly at St. Paul



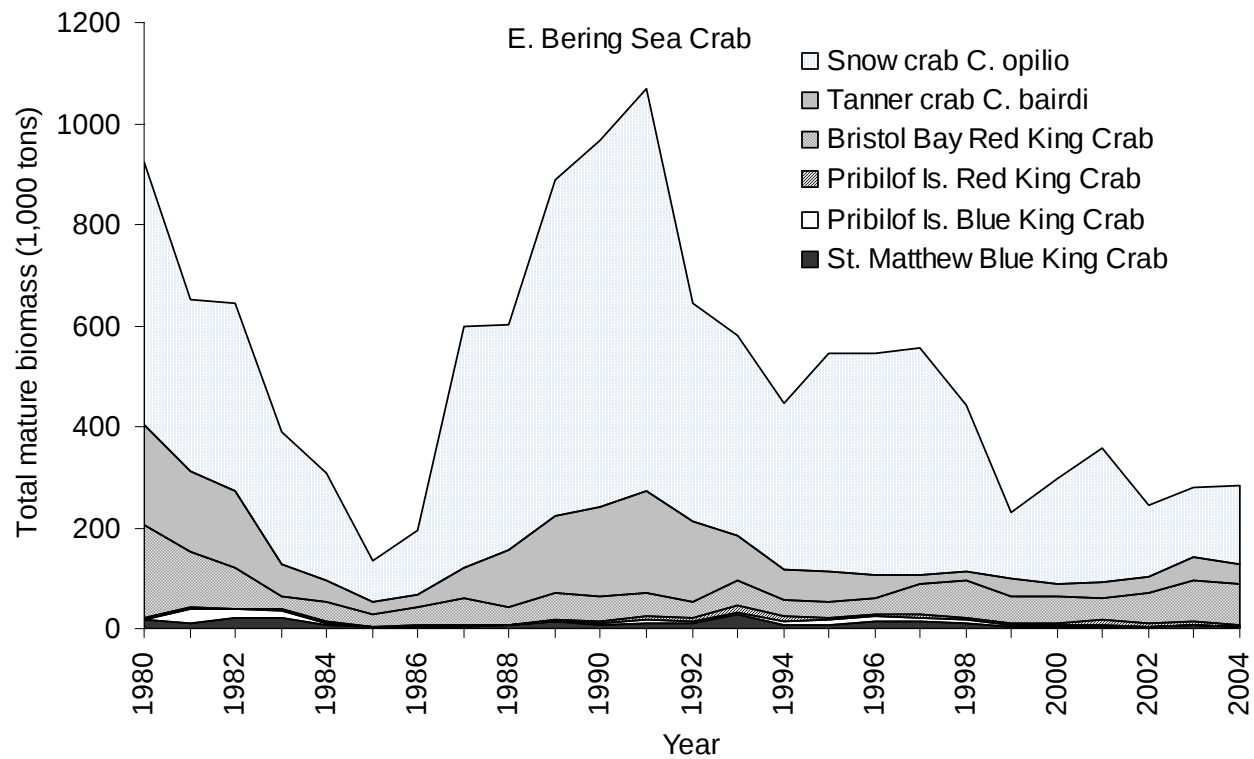


**Three
different
fisheries
responses
to the 1977
regime shift**

Pollock and Bottom Temperature

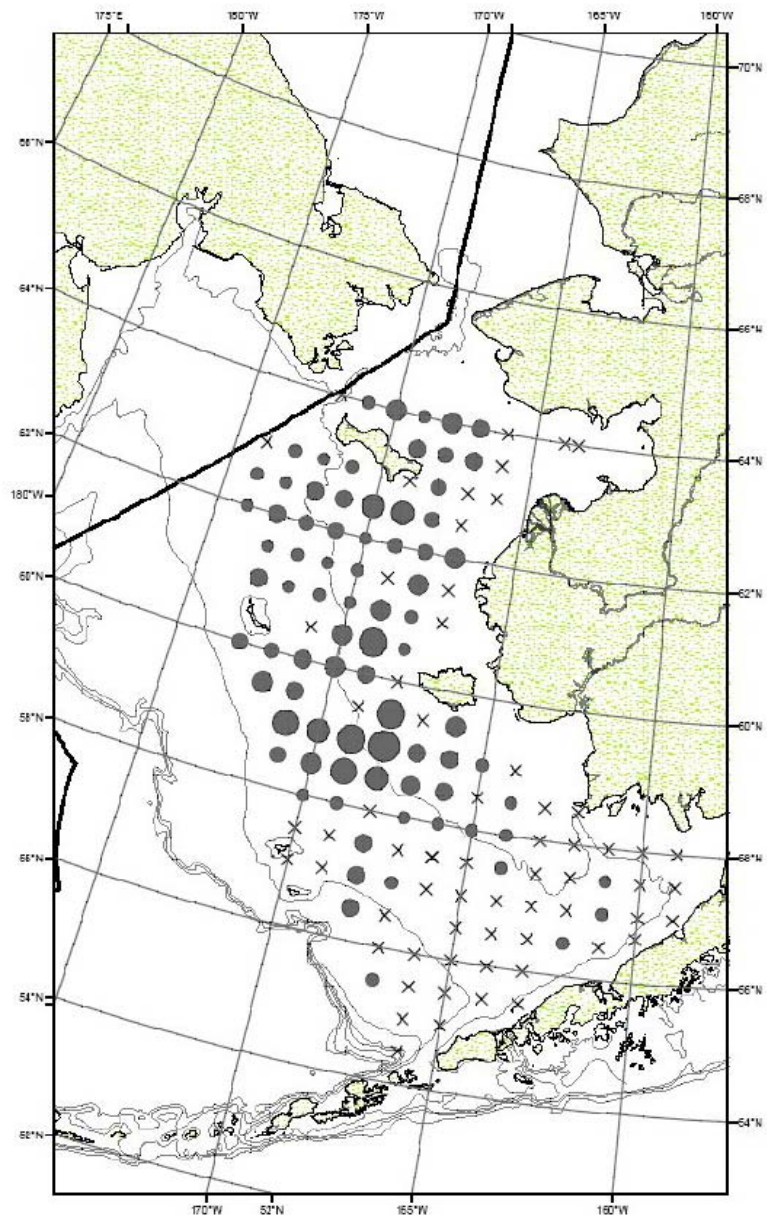
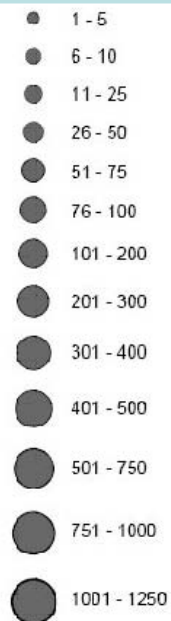


J Ianelli

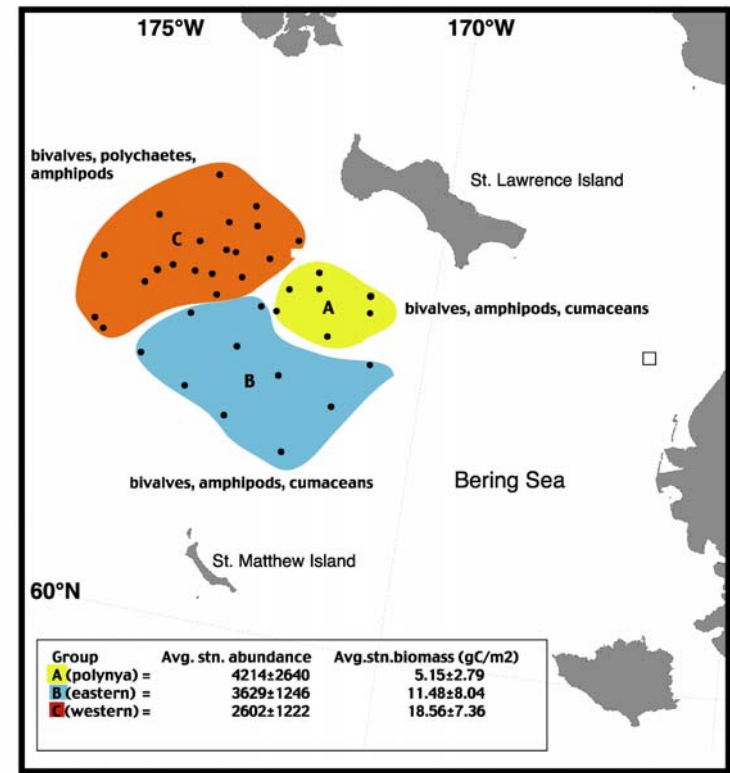
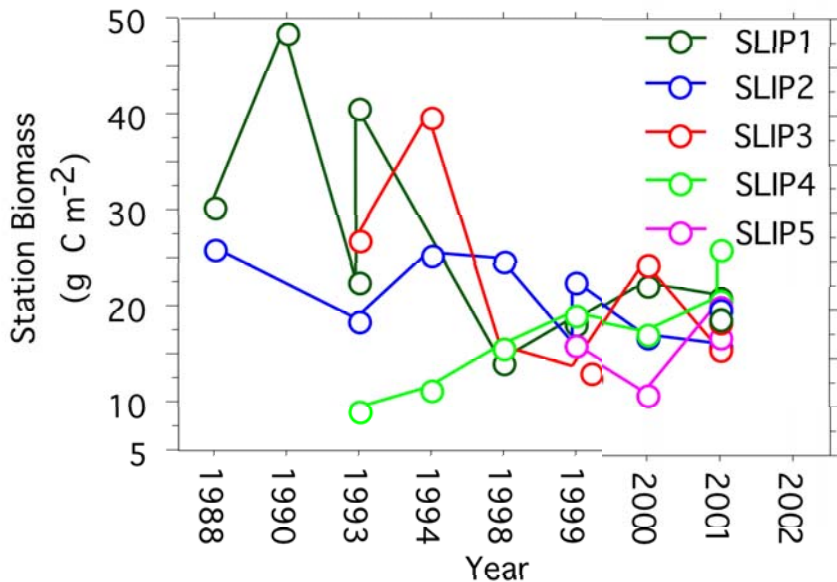
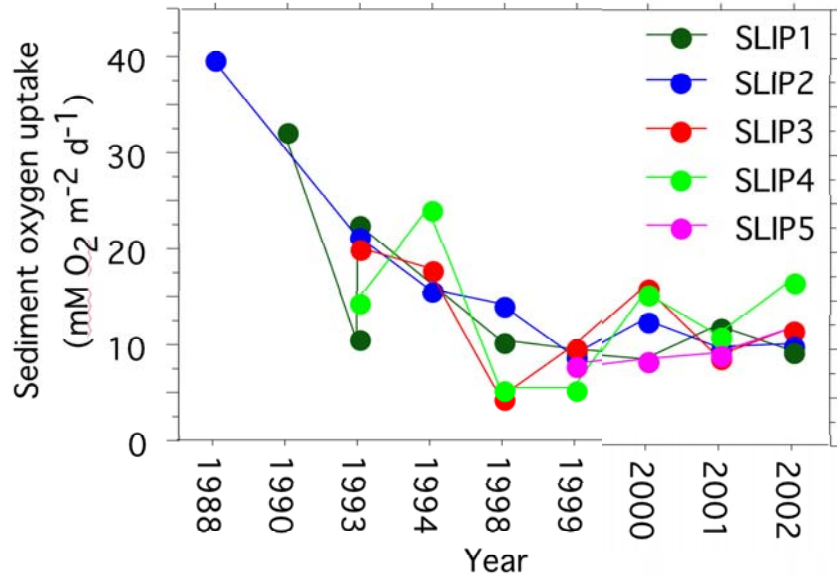


Major Increase in Pink Salmon in the N. Bering Sea in 2004

Jack Helle (NMFS)



Loss of Benthic Productivity In N. Bering (J Grebmeier)



[Simpkins et al., Polar Biology, 2003]

Benthos south of St. Lawrence Island

- decline in late 1990s in both productivity (sediment oxygen uptake) and overall benthic standing stock
- changes in dominant bivalve from *Macoma calcareo* to *Nuculana radiata*

Walrus decline in the northern Bering and Chukchi Seas



[M. Webber-USFWS]



Clam food
in walrus →
stomachs

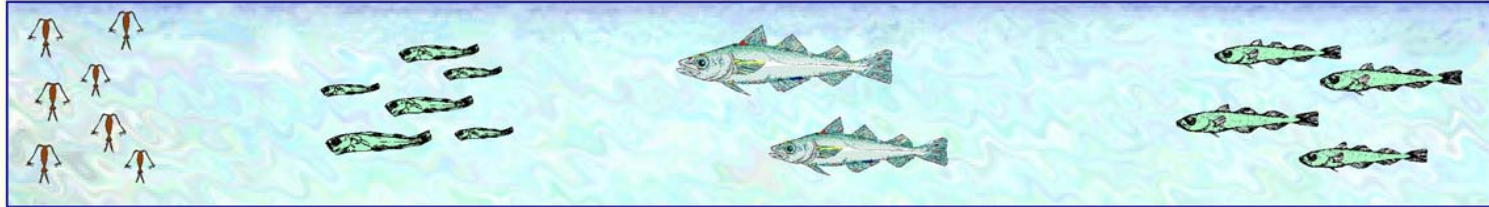


[photos courtesy G. Sheffield]

Oscillating Control Hypothesis

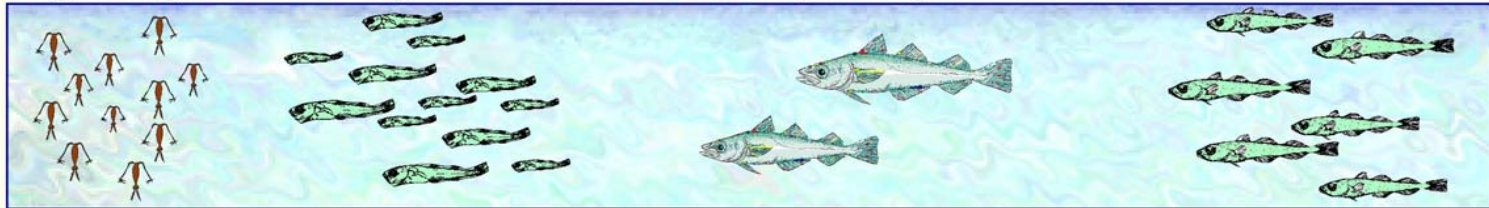
Cold Regime

(Bottom-Up Regulation)



Beginning of Warm Regime

(Bottom-Up Regulation)



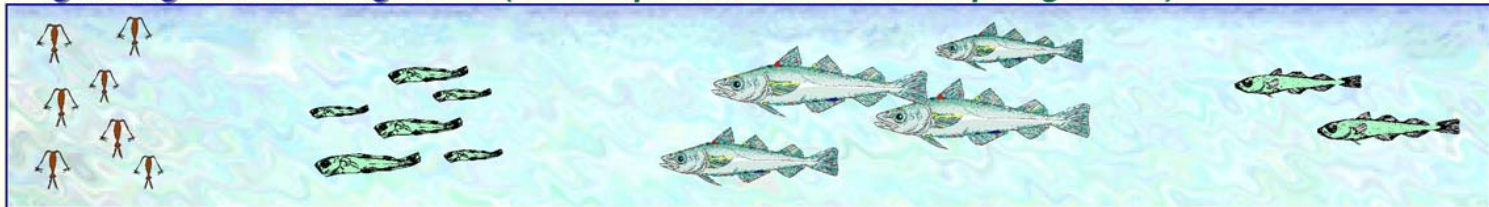
Warm Regime

(Top-Down Regulation)



Beginning of Cold Regime

(Both Top-Down and Bottom-Up Regulation)



Zooplankton

Larval Survival

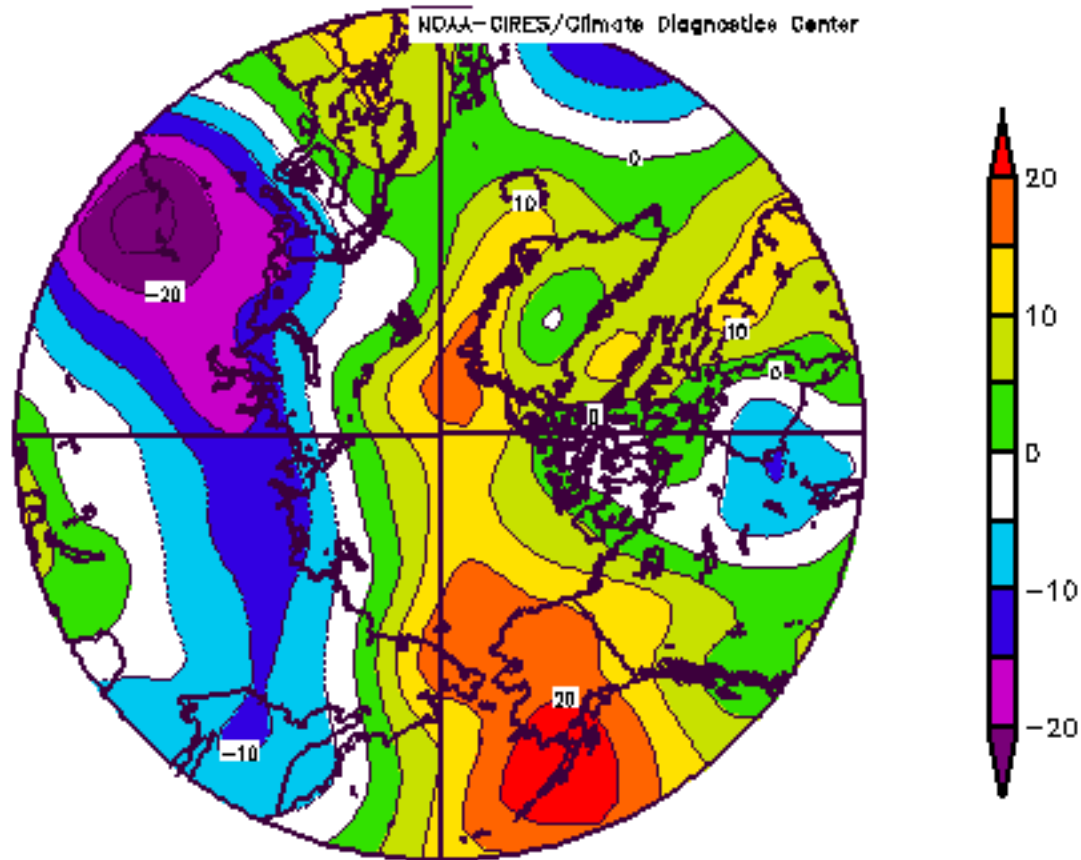
Abundance of Cannibalistic Adults

Juvenile Recruits

Geopotential Height Anomaly for Spring 2000-2005

NCEP/NCAR Reanalysis
850mb Geopotential Height (m) Composite Anomaly 1958-1996 climo

NOAA-CIRES/Climate Diagnostics Center



Mar to May: 2000 to 2005



Bering Sea Summary

- Balance of the Bio-physical Evidence Shows Bering Sea Changes
 - Switched from long-term (170 yr) stable cold Arctic ecosystem to sub-Arctic ecosystem after 1976
 - Last six years: Continued warm ocean and atmosphere; little or no ice in south Bering
- Stuck in “warm phase” due to Arctic climate change?