# Biological responses to recent climate variability on the eastern Bering Sea shelf

**Franz Mueter**

**School of Fisheries and Ocean Sciences, Juneau Center**

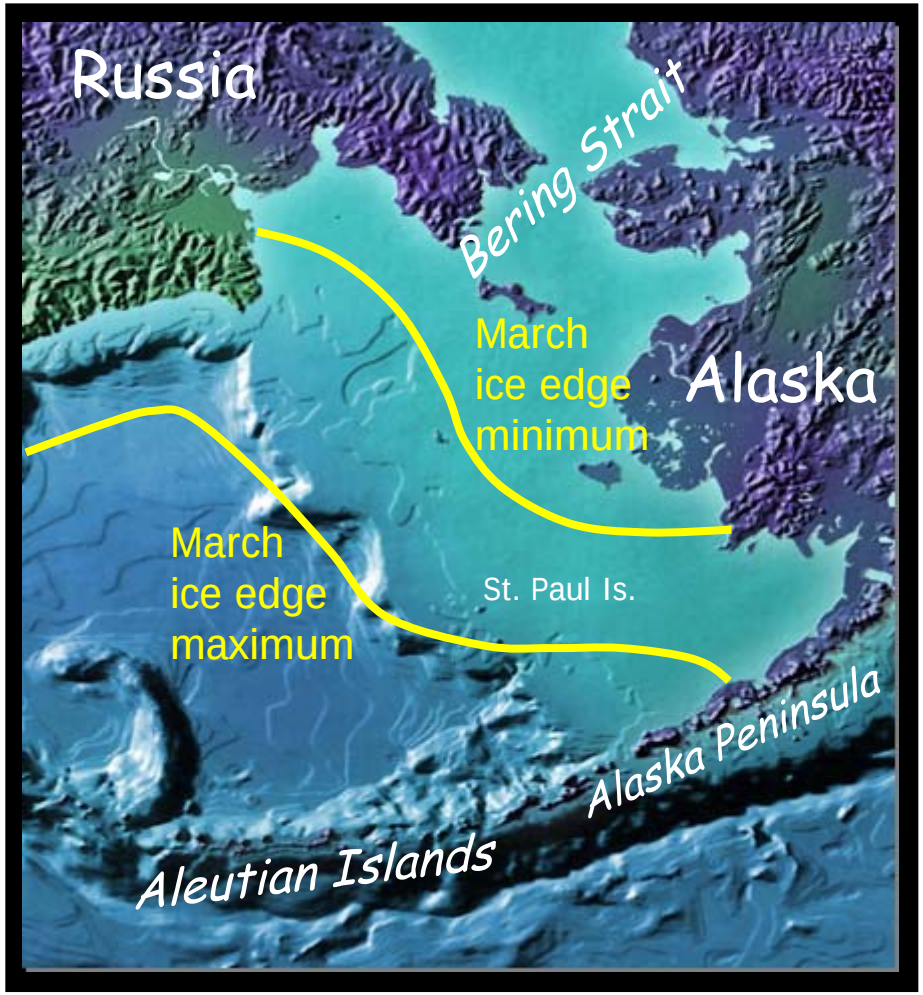
**University of Alaska Fairbanks**

**fmueter@alaska.edu**

Bering Sea

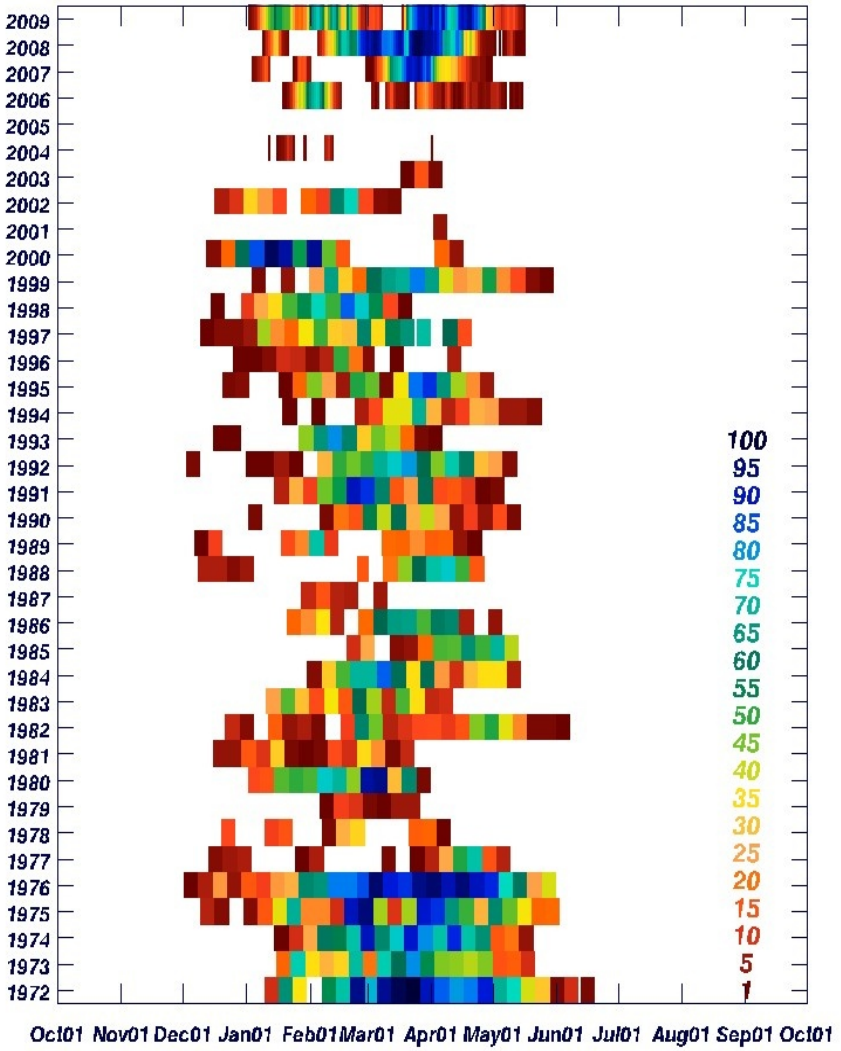
# The Eastern Bering Sea: a rather cold "hot spot"

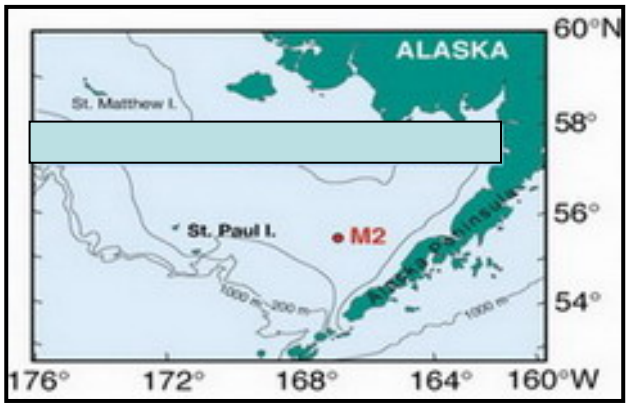
- Seasonally ice covered
- Large seasonal variability
  - 1700 km advance / retreat
- Large interannual variability due to changes in temperature and winds
- Decoupled from (multi-year) sea ice variability in the Arctic!



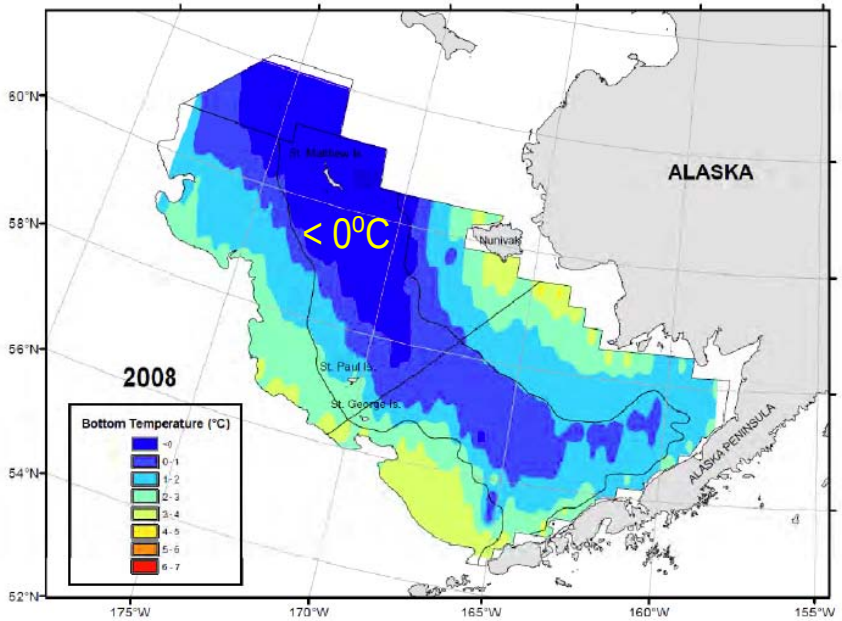
# Sea ice and the “cold pool”

## Ice concentrations



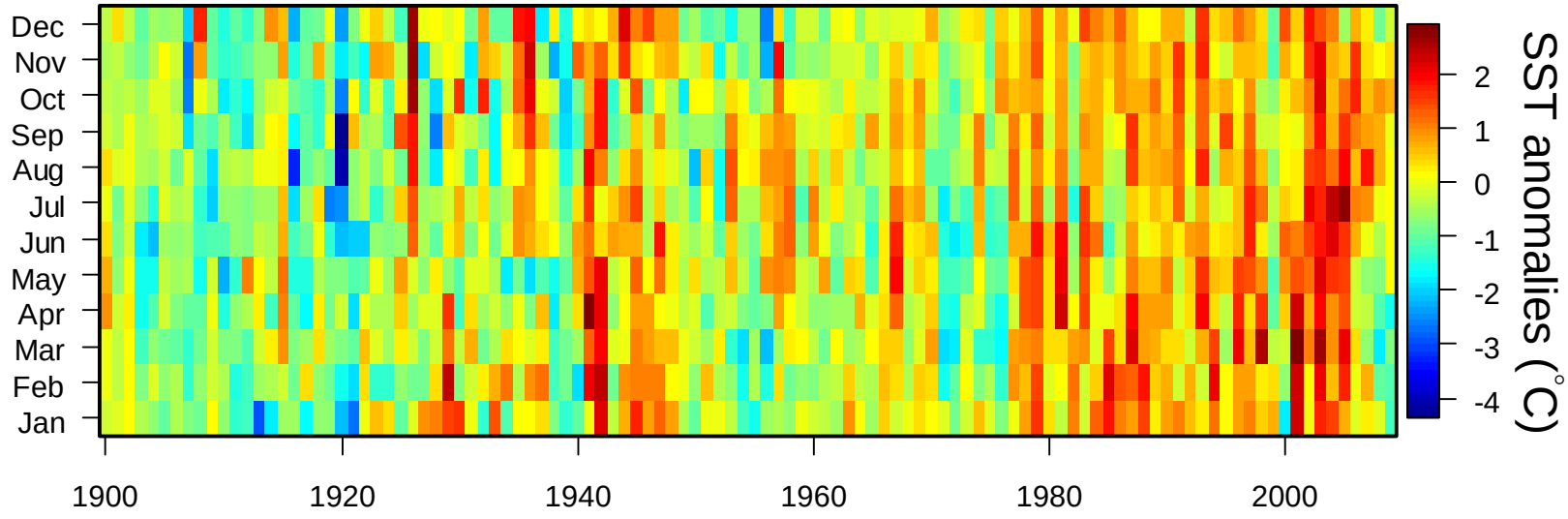



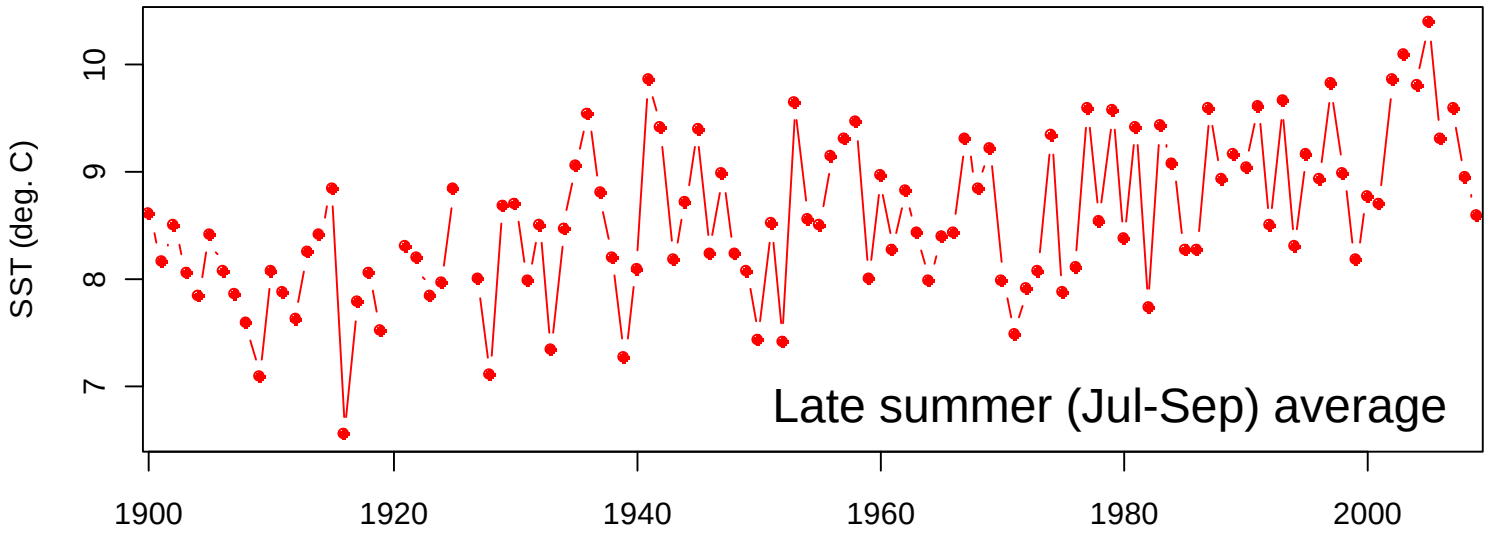

## Summer bottom temperatures



BEST-BSIERP Ecosystem Partnership

# Eastern Bering Sea SST anomalies




NOAA Extended Reconstructed SST (Smith et al 2008)

http://bsierp.nprb.org

BEST-BSIERP Ecosystem Partnership

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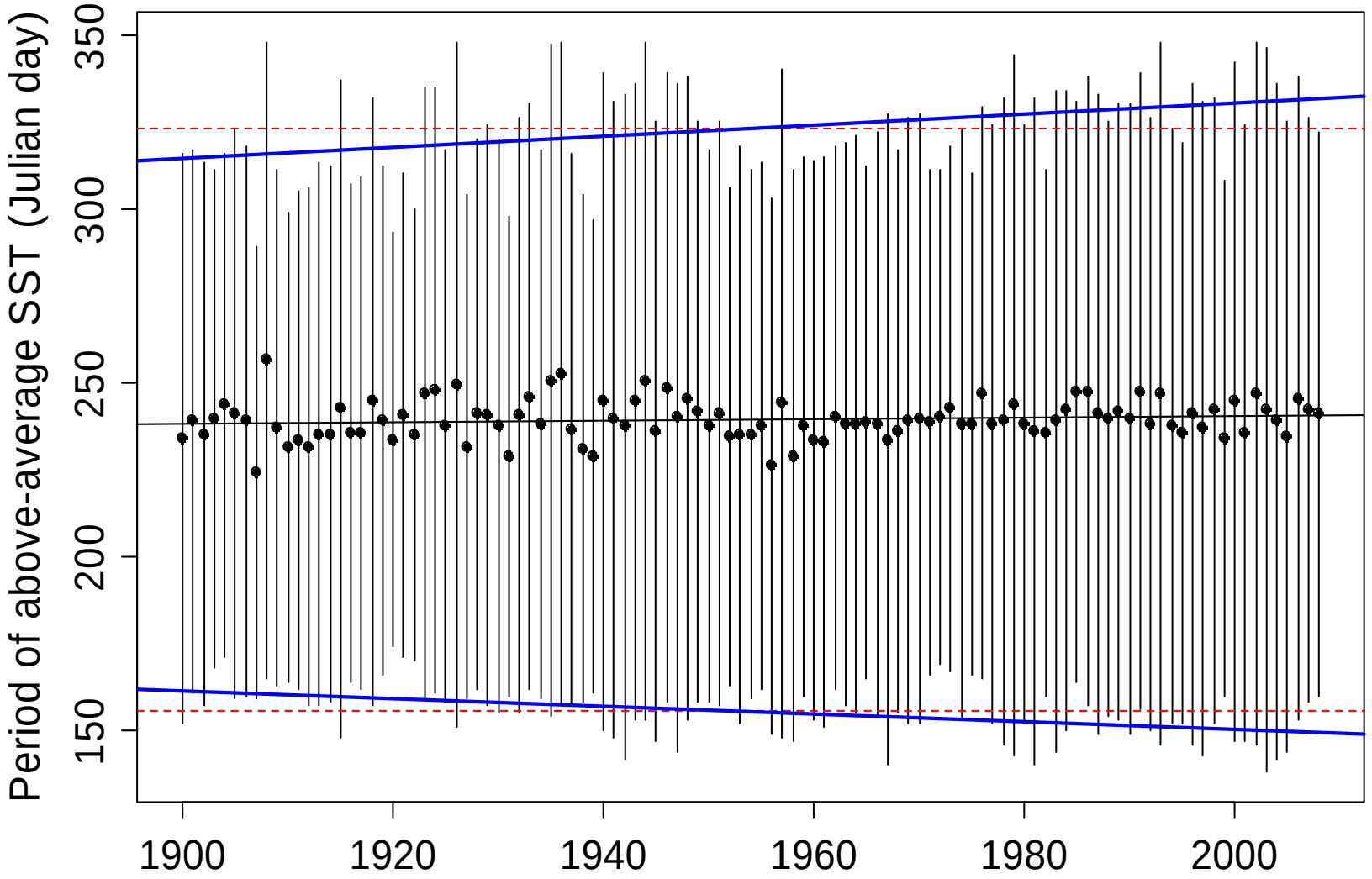
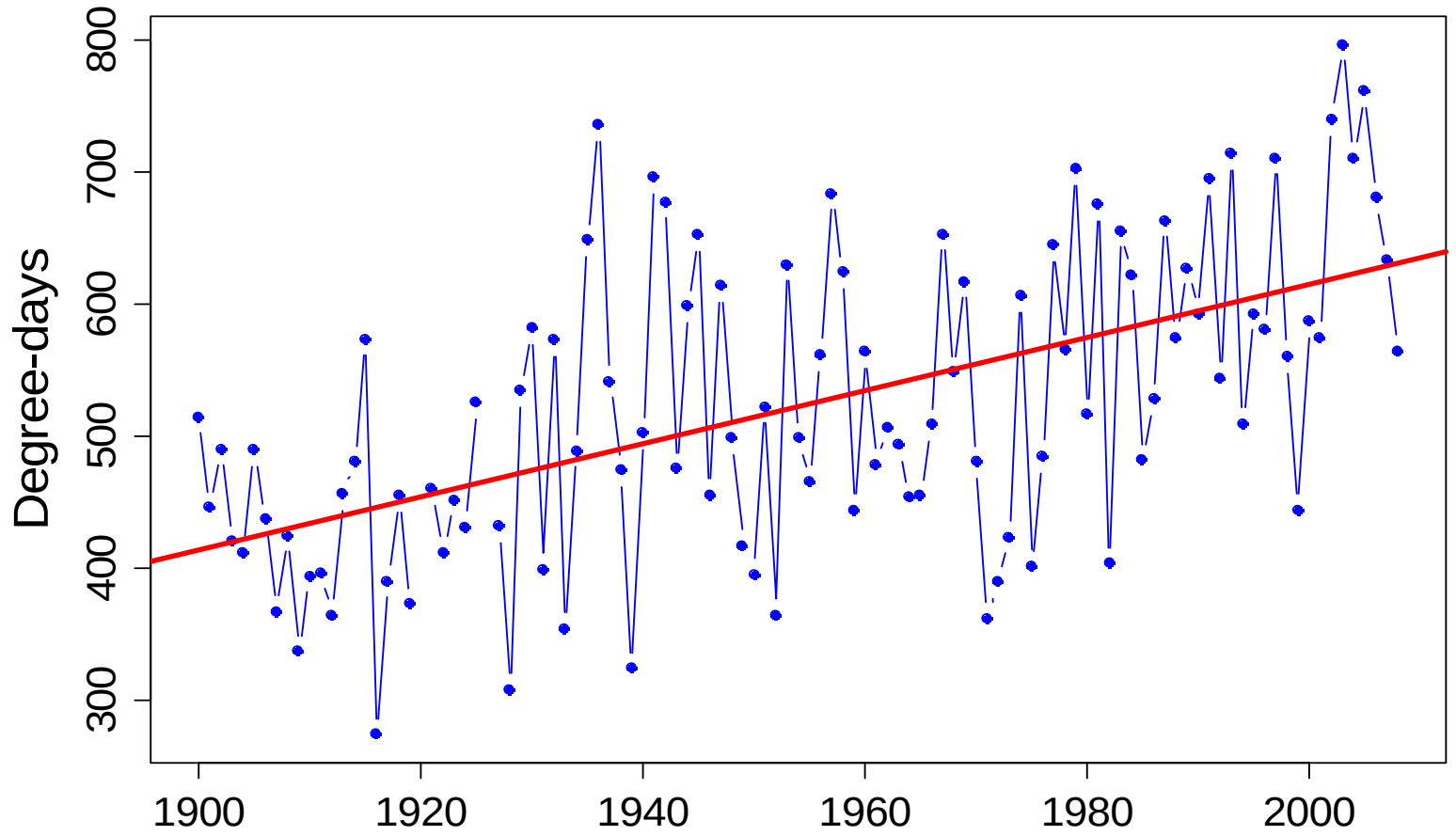
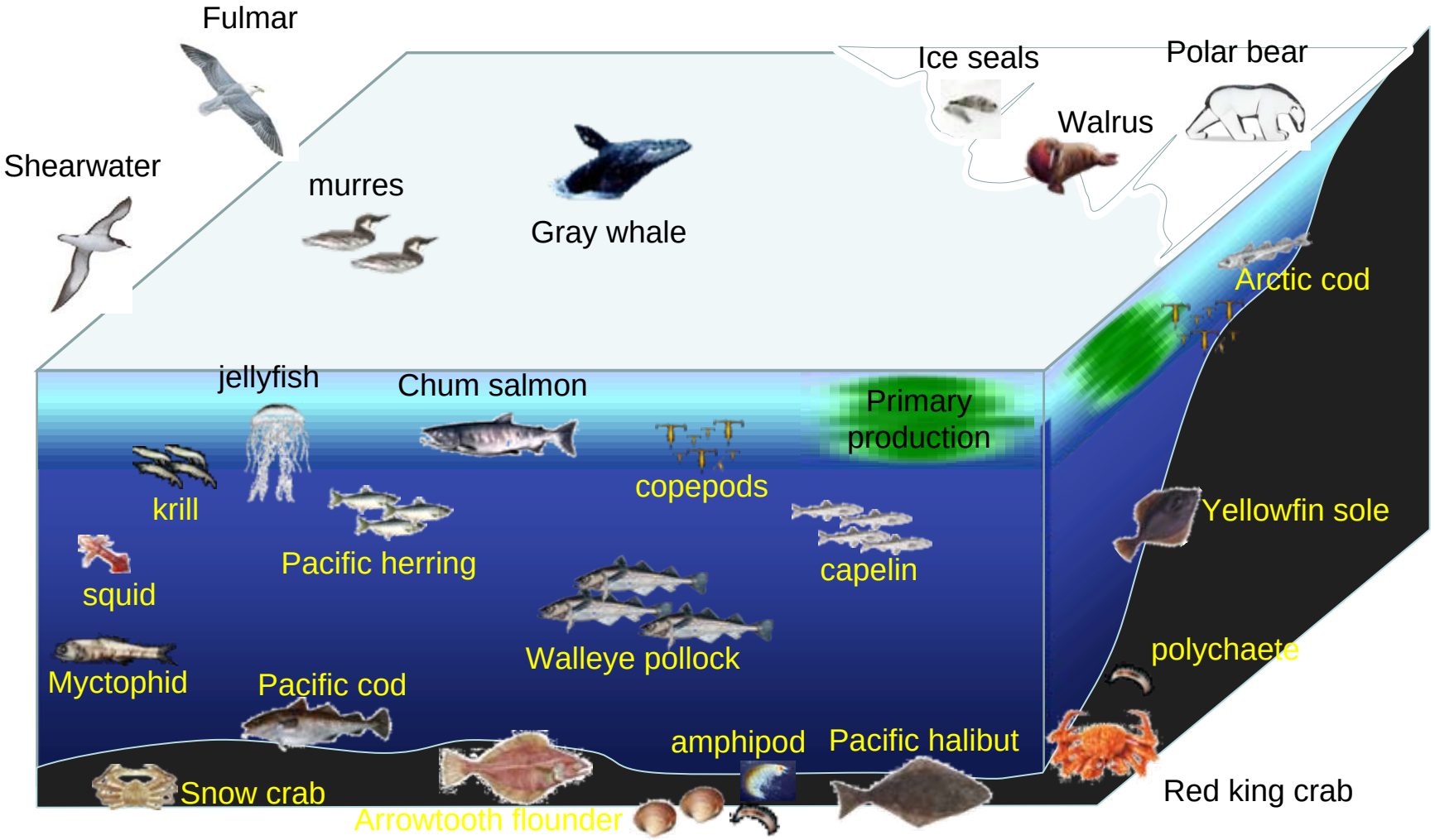
# Bering Sea summer season length



# Growing Degree Days (> 4˚C)

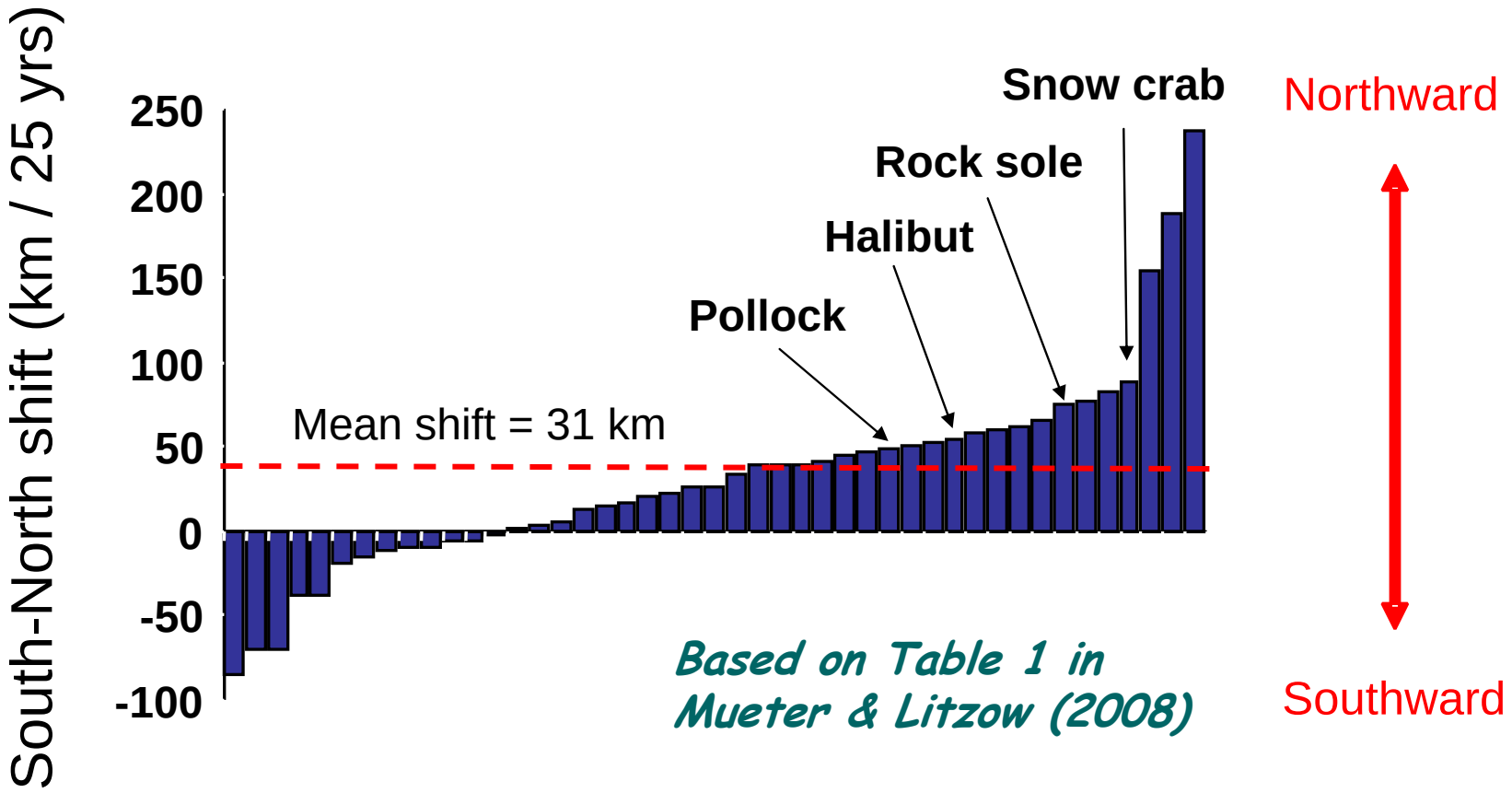


# The Bering Sea food web

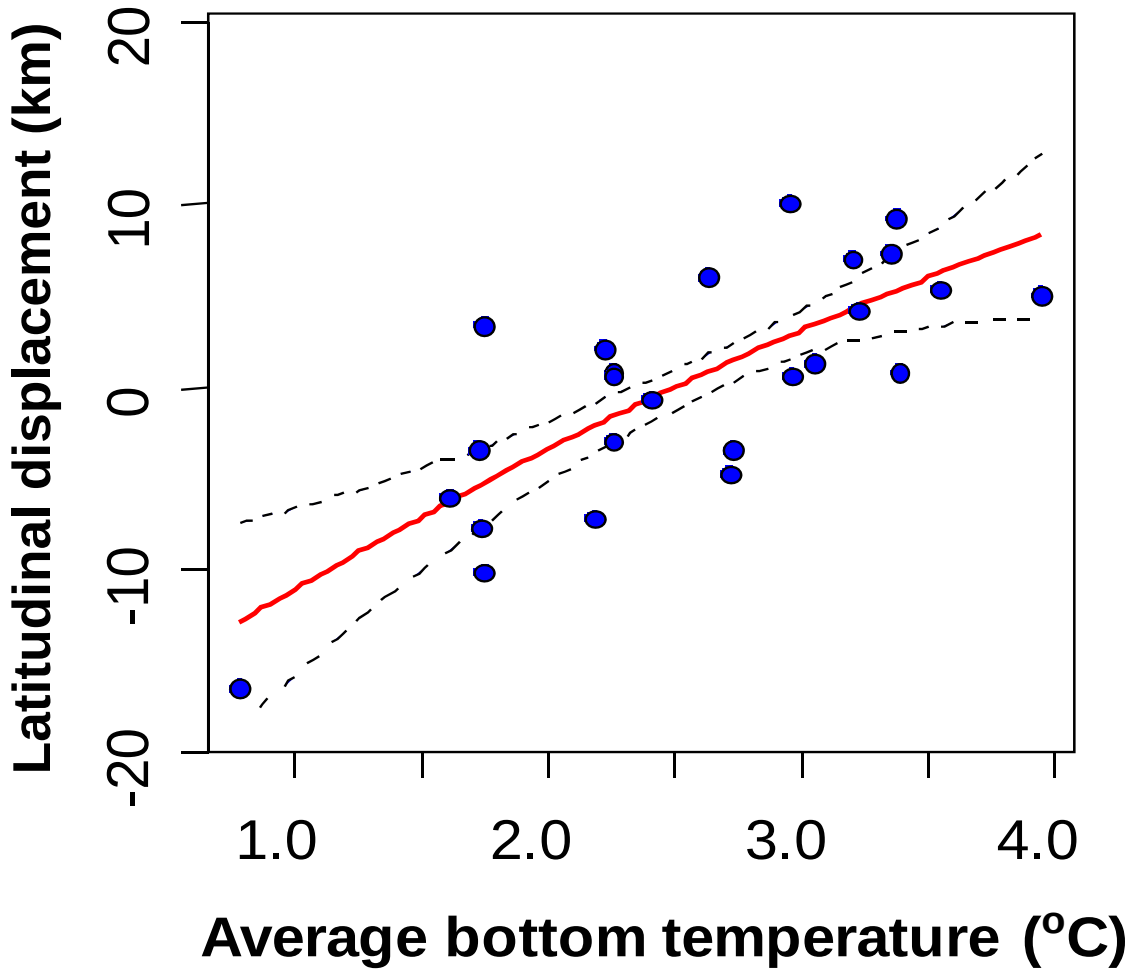


# Distribution

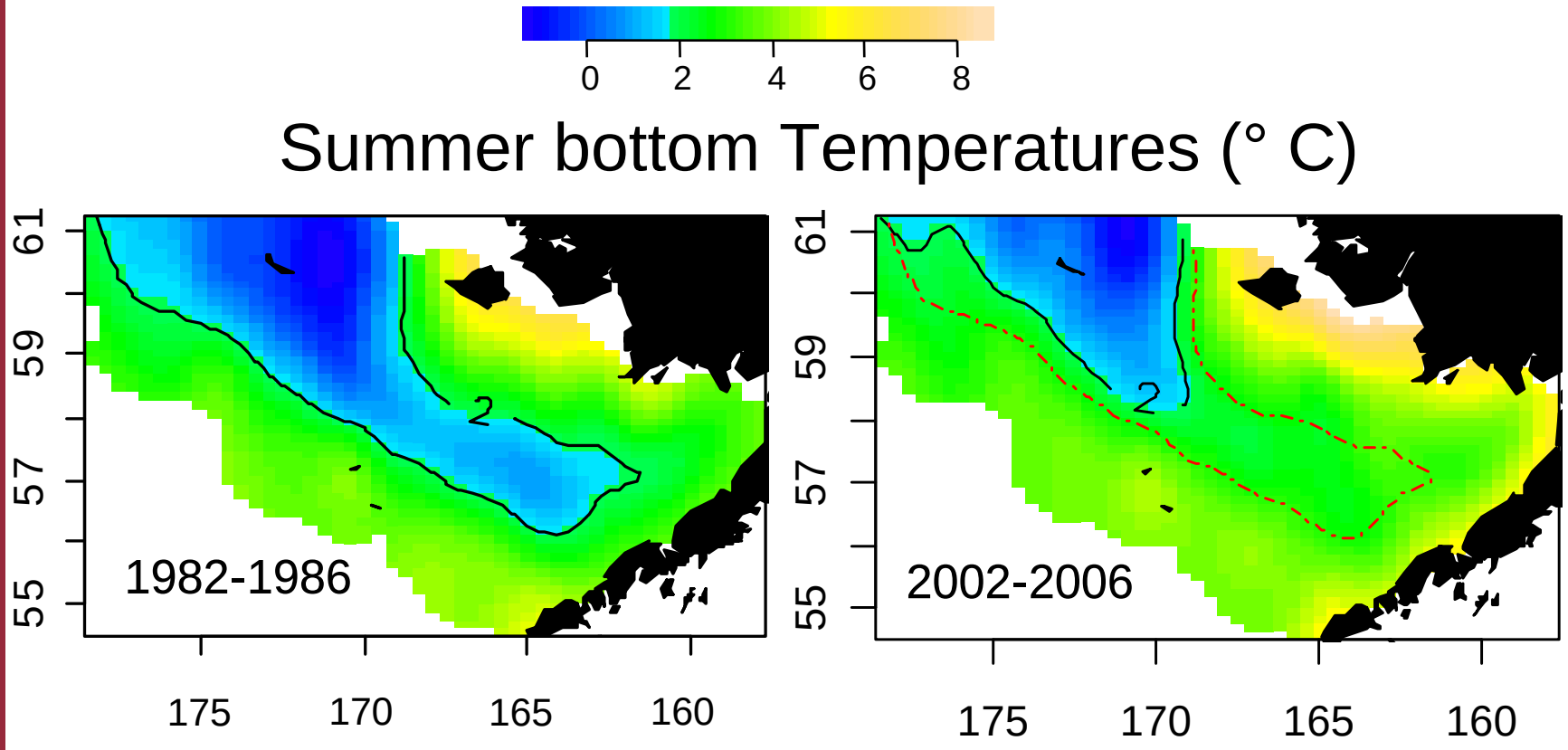
# North-South shifts in distribution, 1982-2006



# Distribution responds to temperature changes

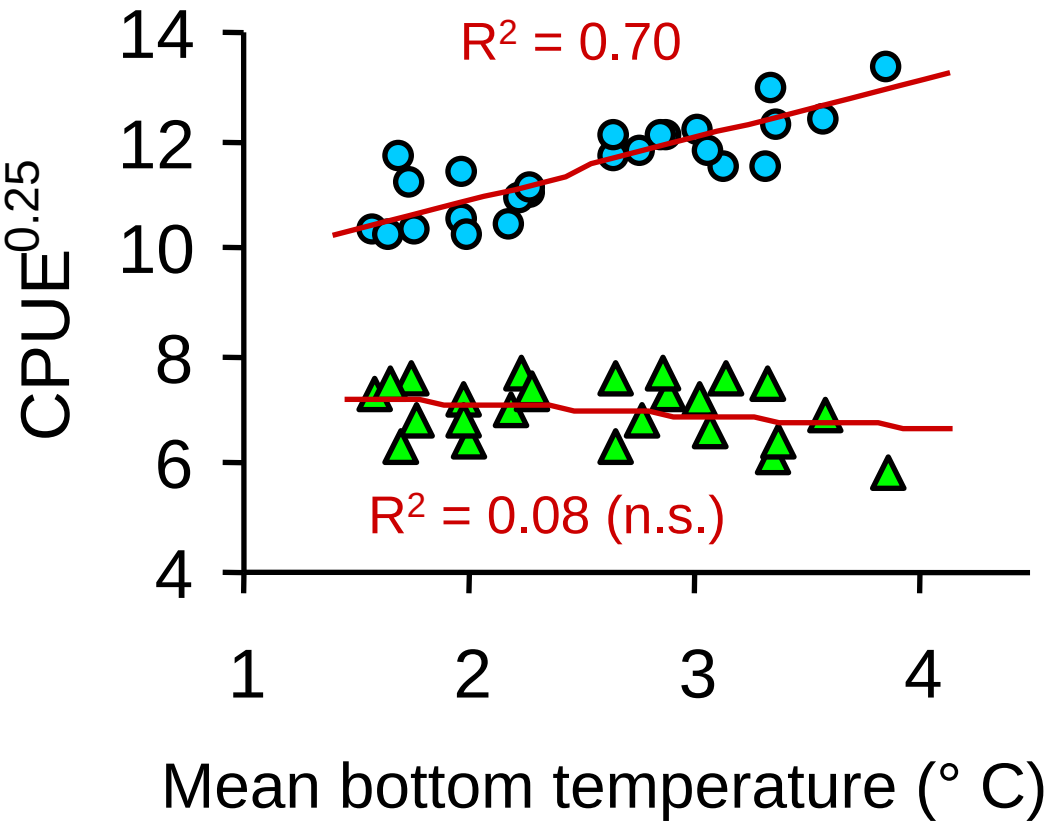


# Variable cold pool extent in the Southeast Bering Sea




Mueter & Litzow (2008)

# Changes in the cold pool area




Subarctic taxa

Arctic taxa

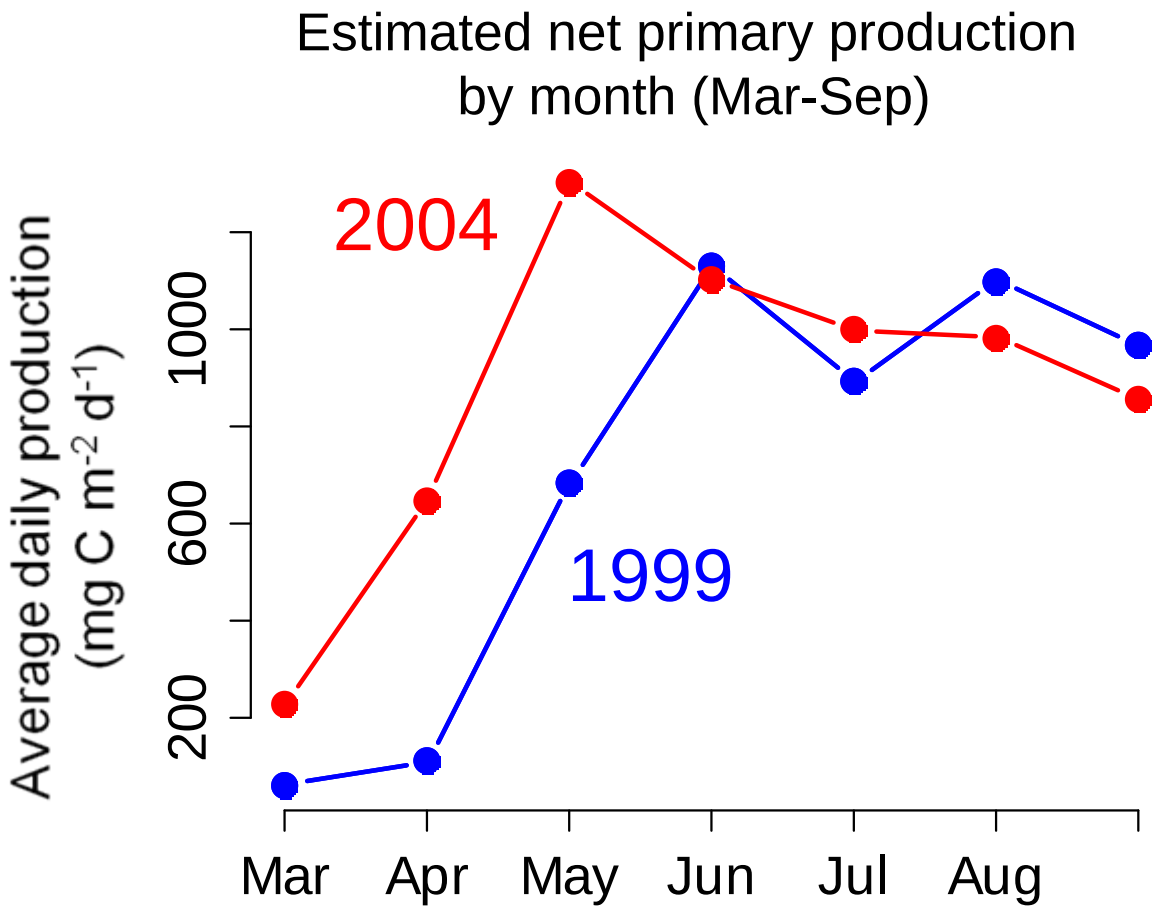
*Mueter & Litzow (2008)*

# Summary: Distribution

- Northward shift of numerous species on EBS shelf in response to warming
- Increase in biomass of subarctic fish and crustaceans on middle shelf
- Retreat and / or decline of Arctic species (e.g. snow crab)
- Expansion of subarctic groundfish into northern Bering & Arctic unlikely in next 30-50 years

# Primary production

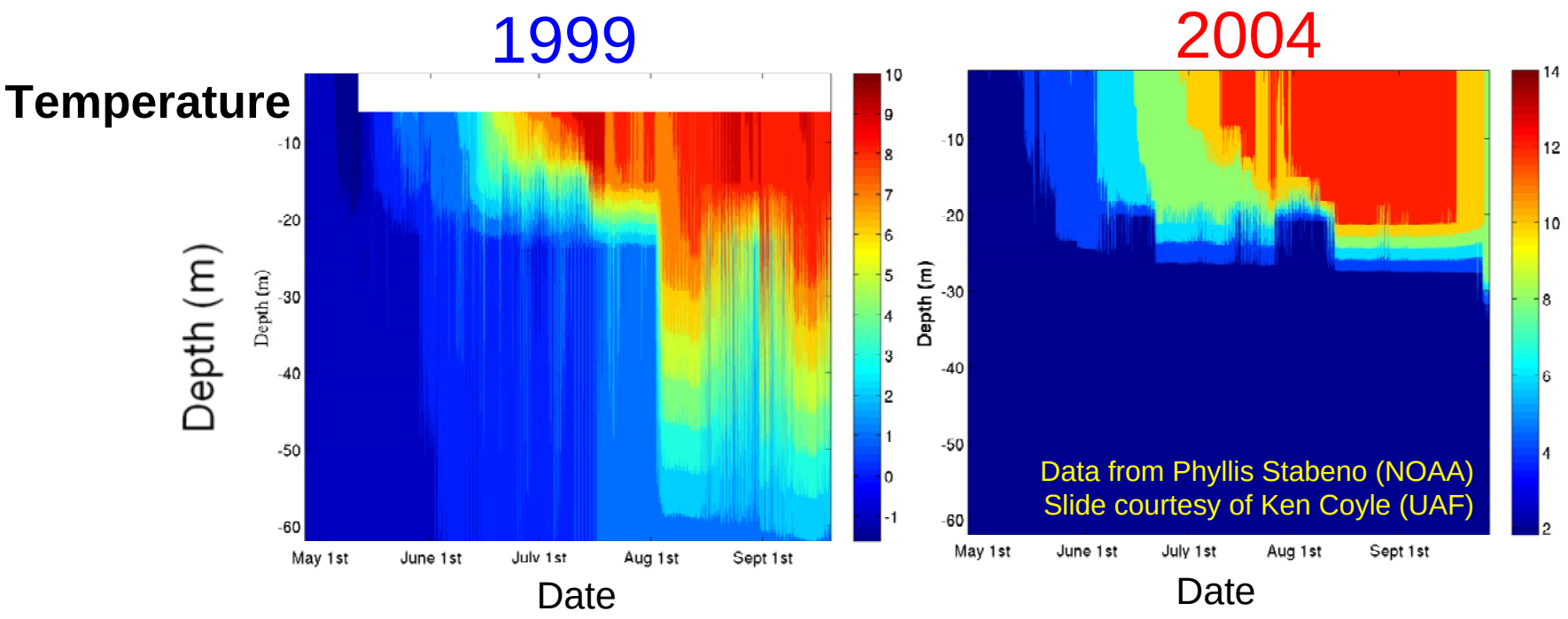
# Earlier spring bloom → more production?




From Carbon-based production model (CbPM)
Behrenfeld et al (2005)

Available at:
http://web.science.oregonstate.edu/ocean.productivity/

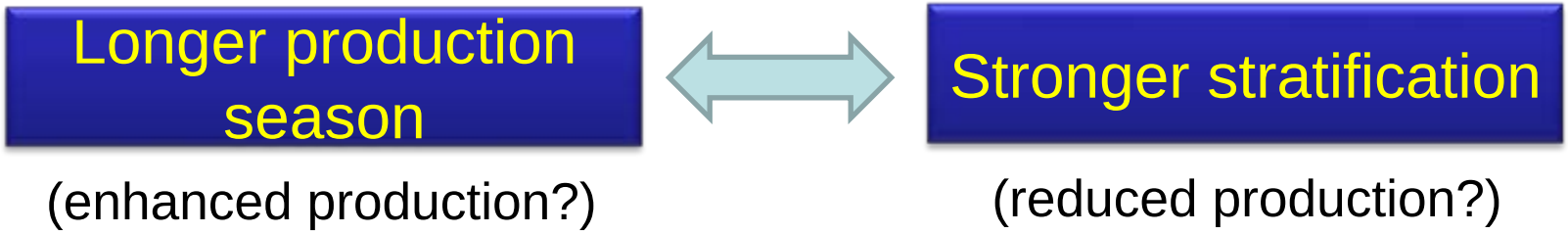
# Stronger summer stratification → less production?




- Reduced primary production in summer 2004
- Reduced abundance of large copepods (food for young pollock & cod) in warm summers of 2002-2005

# Summary: Primary production

- Response of net primary production to warming is highly uncertain



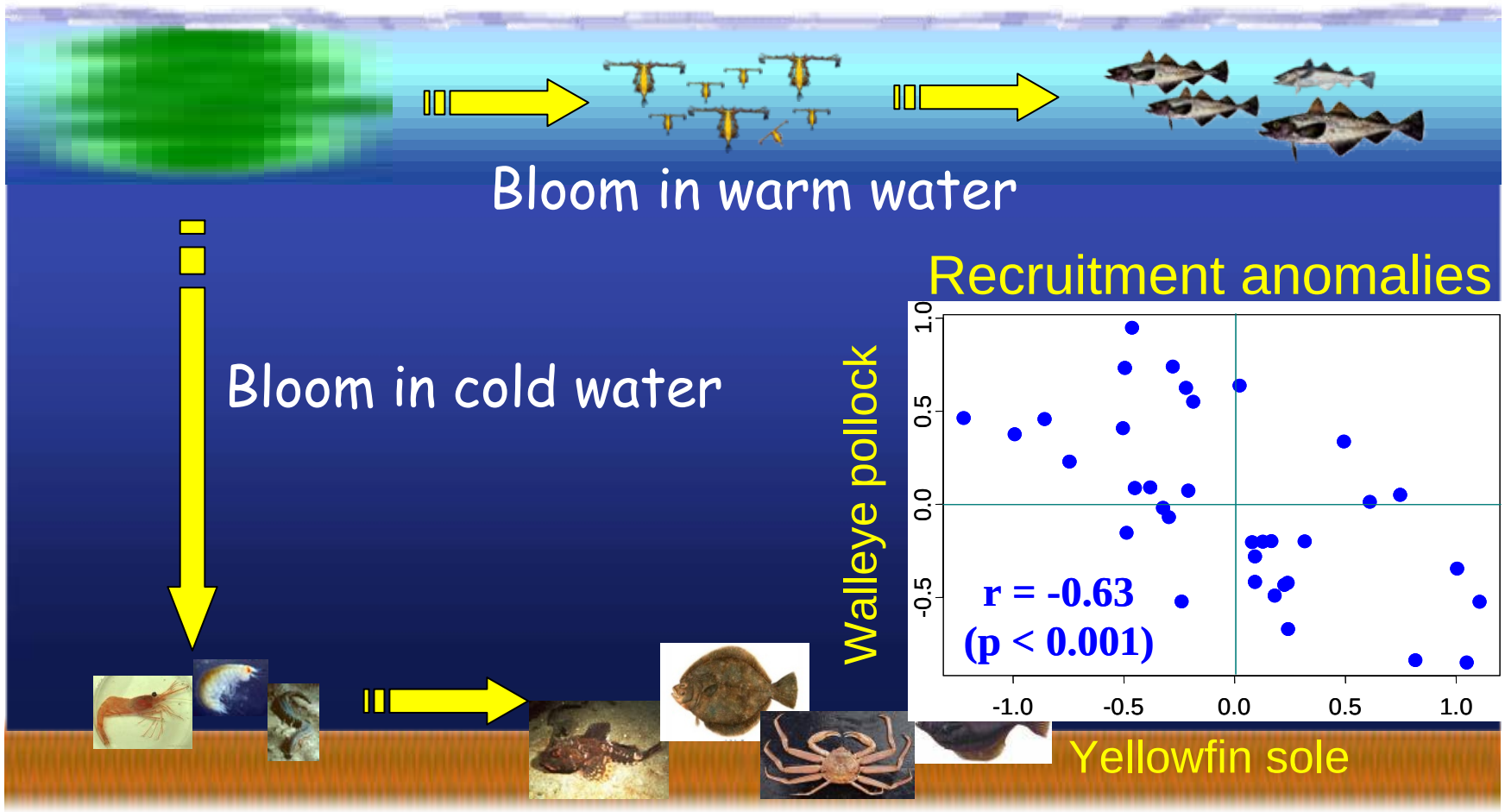

- Currently cannot predict whether the EBS ecosystem will become more or less productive in response to continued warming

Effects on the

productivity and abundance of

commercial fish populations

# Different pathways of production




From Mueter et al (2006)

# Summary: Recruitment

- Previous evidence for many fish populations in northern seas (including Bering Sea) that recruitment tends to increase with temperature
- In the EBS, a series of poor recruitments of cod and pollock in 2001-2005 may be linked to unusually warm and strongly stratified conditions, which were associated with absence of large-bodied zooplankton over much of the shelf

→ see Hunt et al, Monday (P1-D1)

# Likely impacts of a warming future on Bering Sea fish & fisheries

- Fish will move North!
- Changes in primary production uncertain
  - Possible increase in annual production (??)
- There will be winners and losers!
- Changes will be disruptive to fisheries and fishing communities
- Expect surprises!

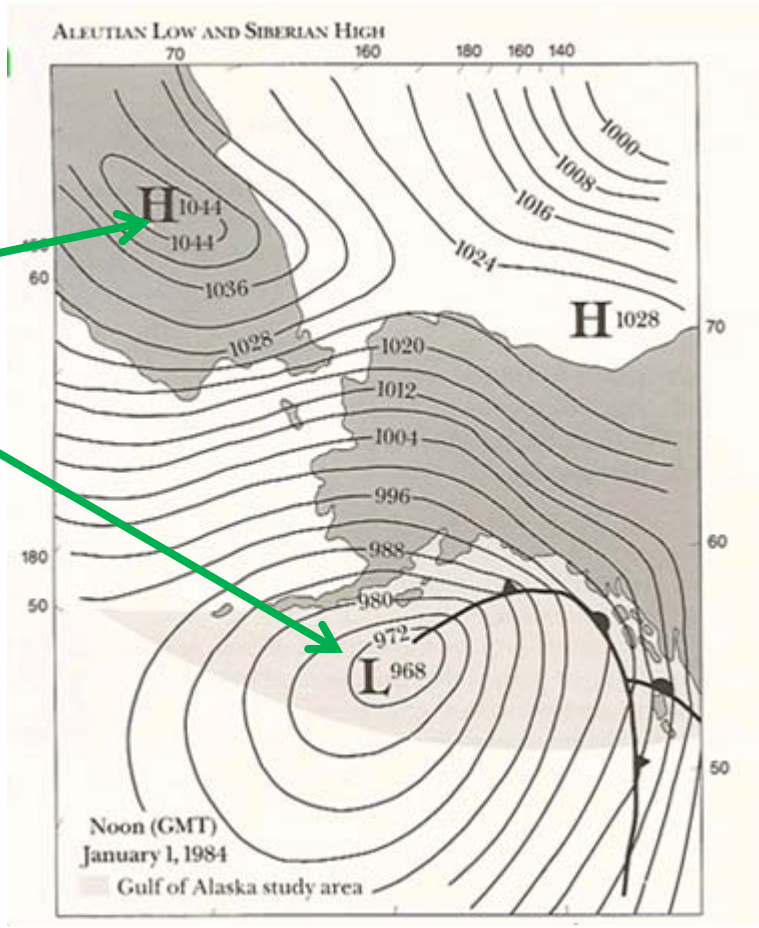
# Bering Sea Climate Variability

- Bering Sea climate variability linked to two major weather systems:

  Siberian High

  Aleutian Low

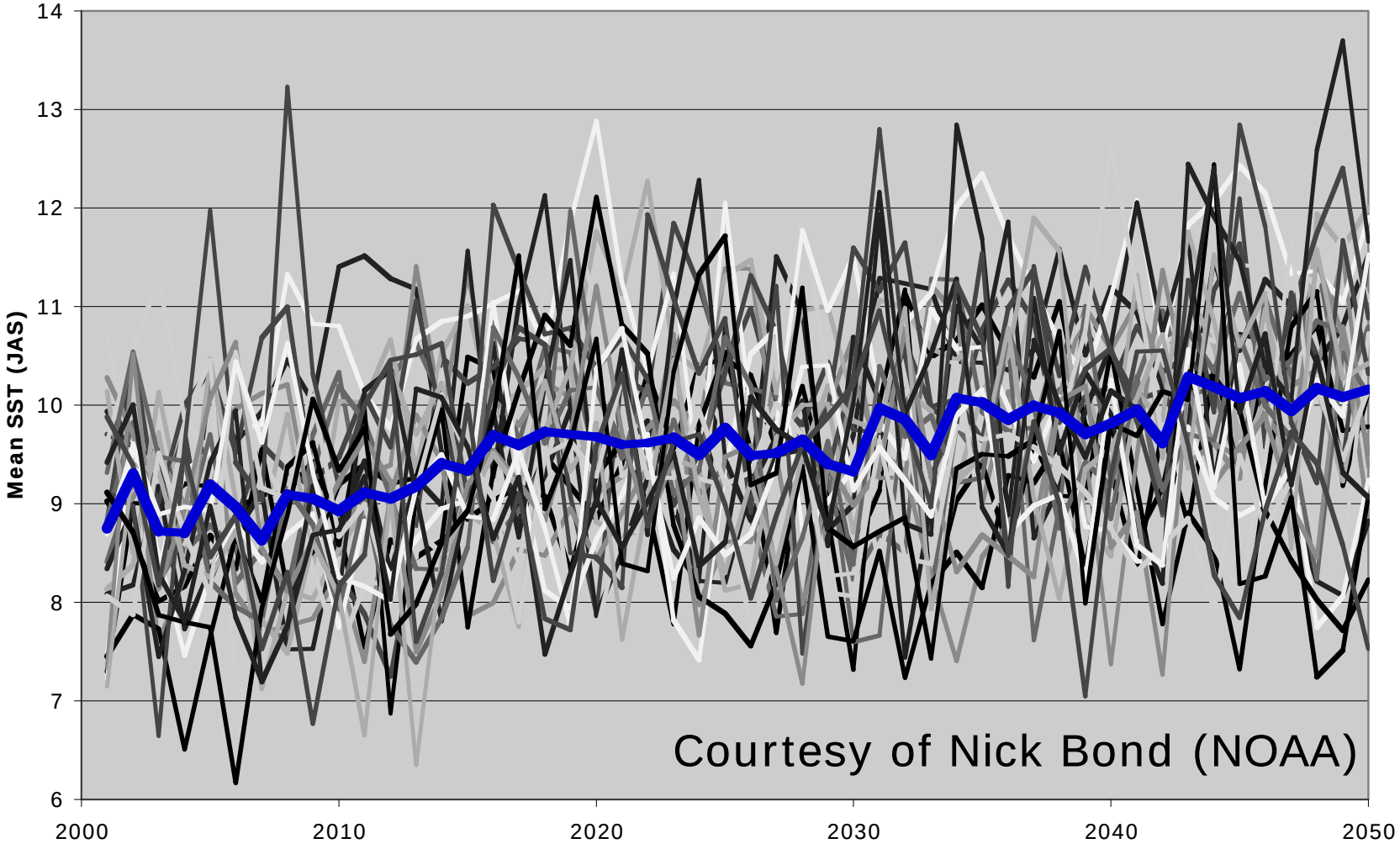
- Strength & Position determine:
  - Wind patterns / Storm tracks
  - Temperature condition
  - Ice conditions



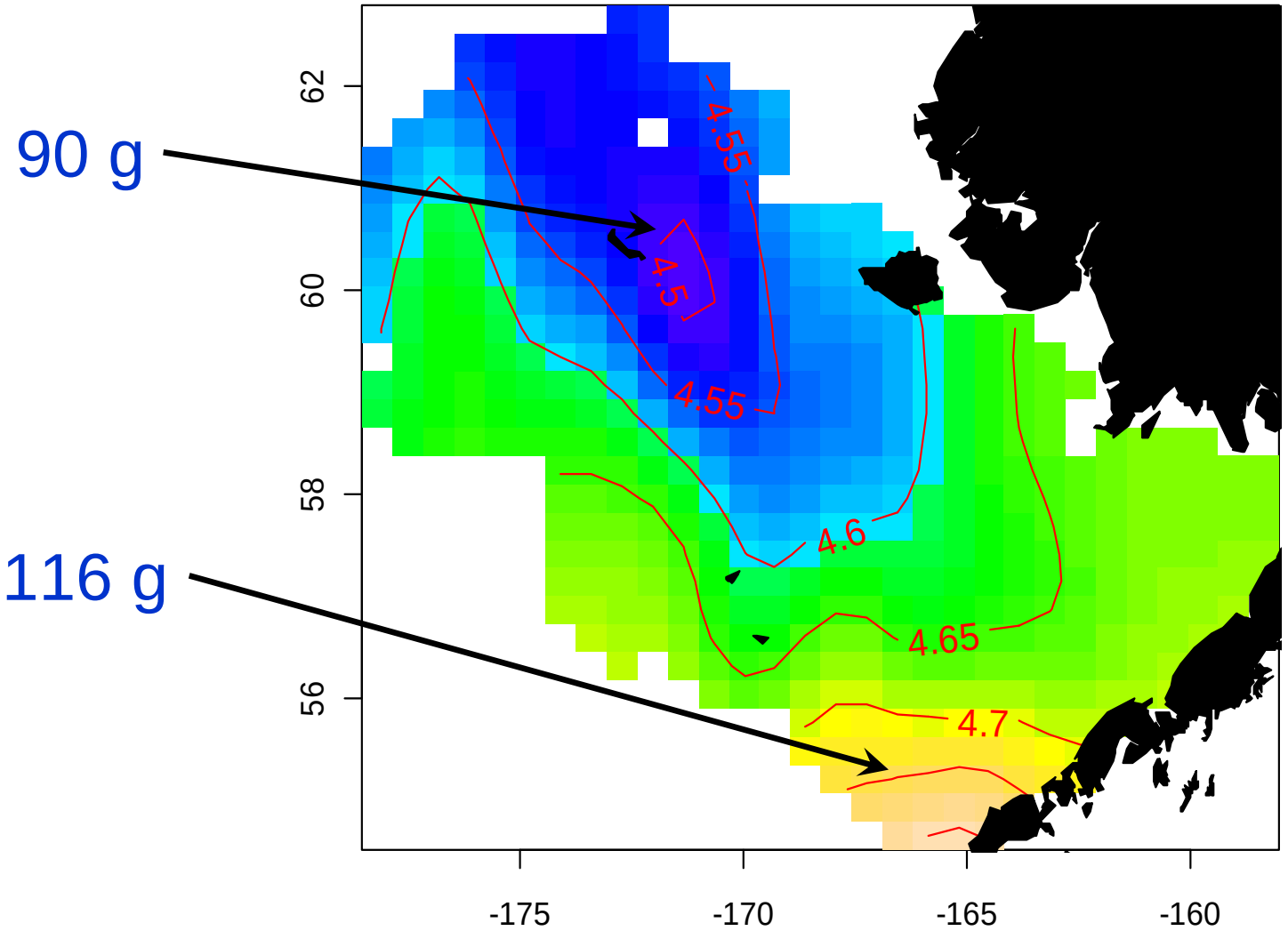

From Wilson & Overland (1986)

# SST projections, 2000-2050

Bering Sea (July – September) SST – IPCC B1 Scenario



# Pollock condition (weight-at-length anomaly) : Spatial pattern



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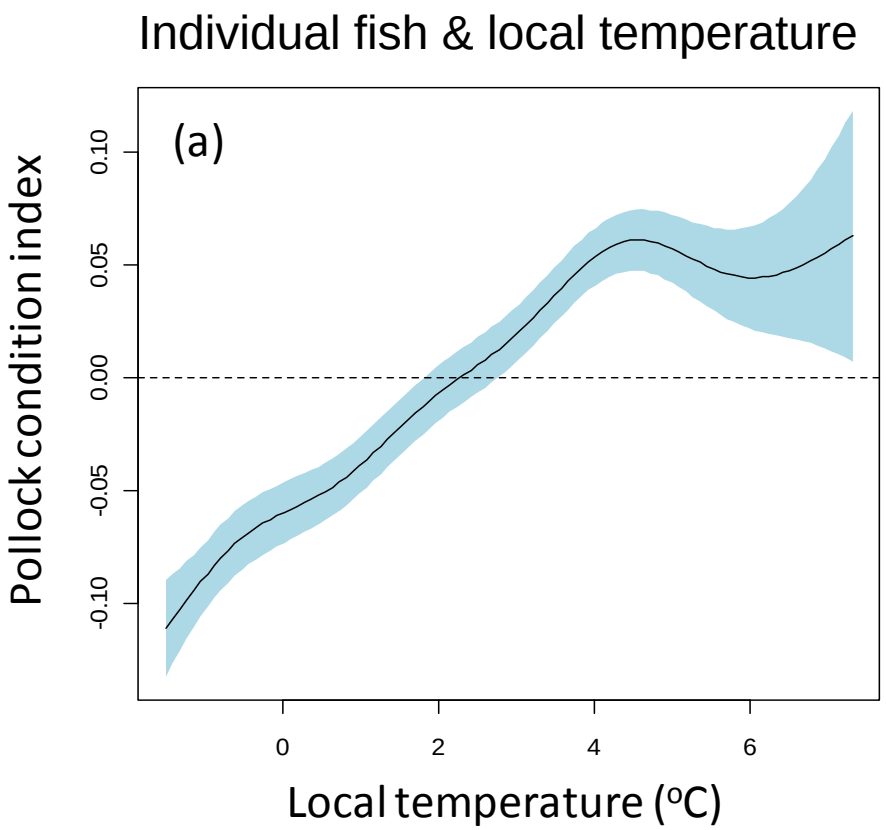


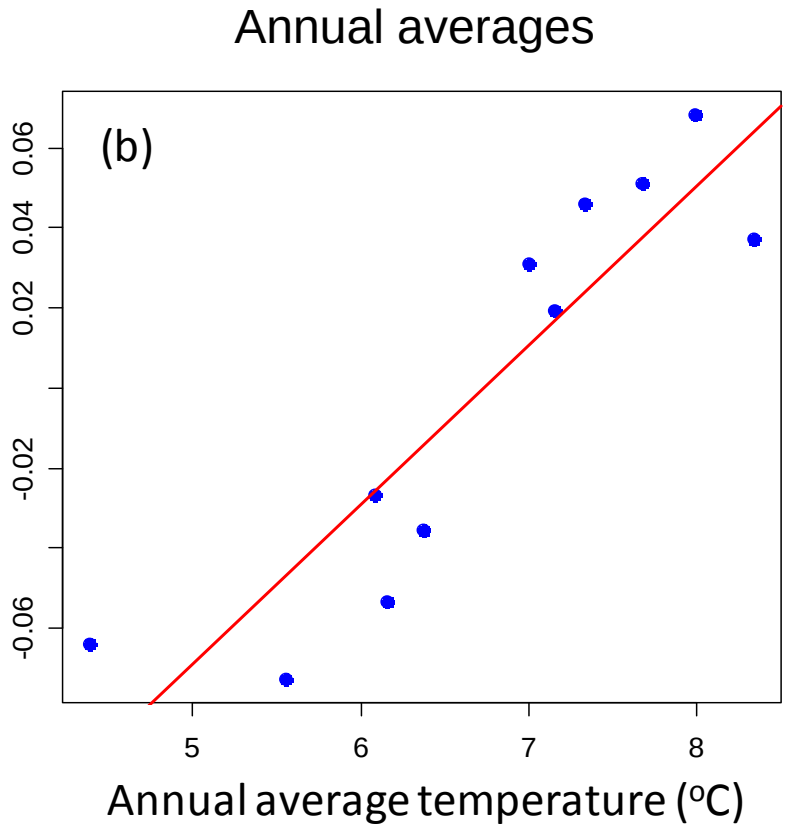

# Summary: Condition

- Strong evidence that condition of pollock and cod positively is higher when local temperatures are higher
- Condition of small fish (ages-1&2) is higher on average in warm years