

# Comparison of Northern Hemisphere ecosystems: Responses to recent oceanographic variability

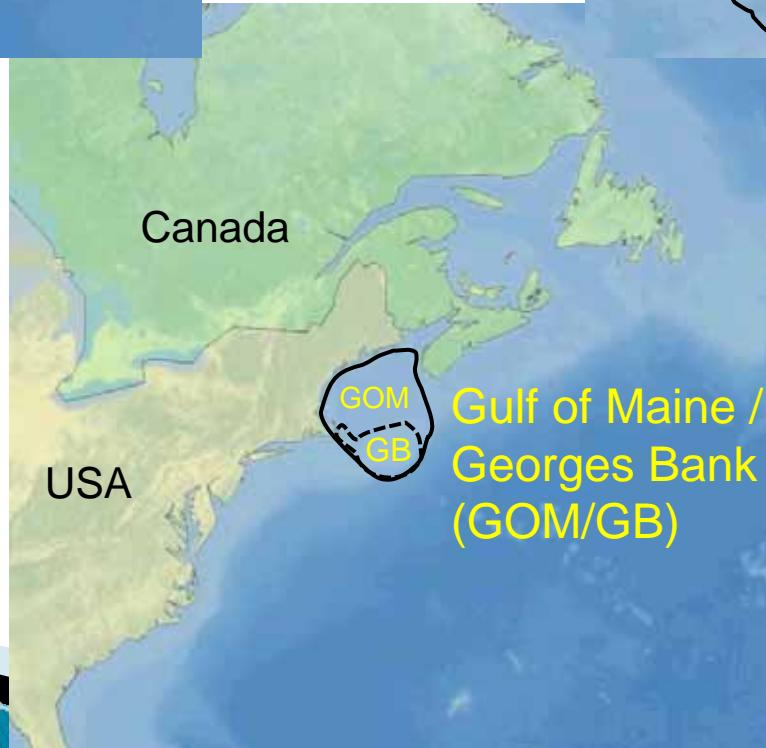
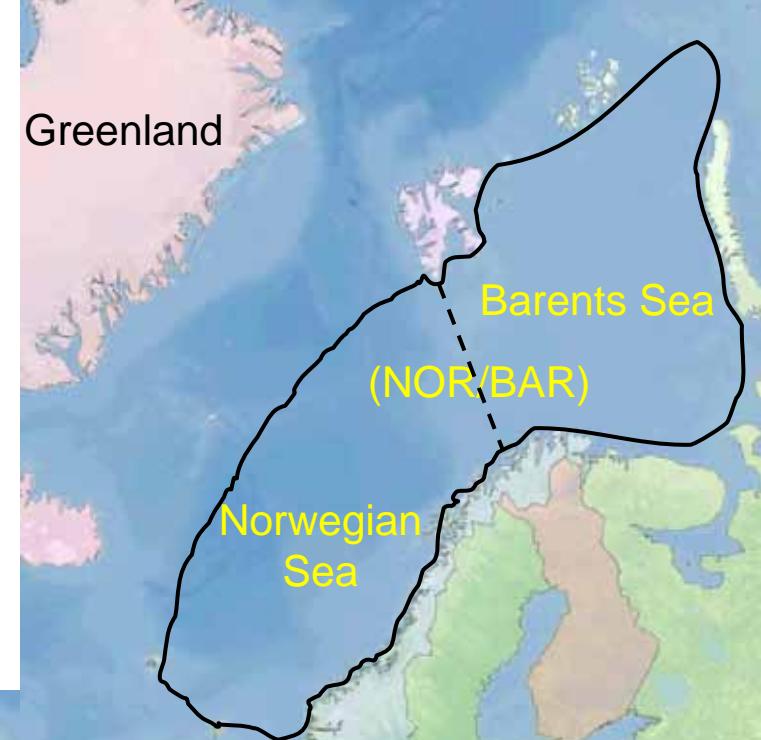
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Kevin Friedland, Jon Hare, George Hunt,  
Webjørn Melle, and Maureen Taylor



MENU

# Objectives

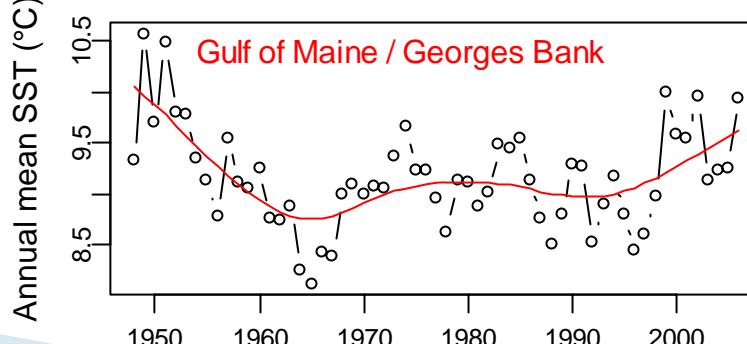
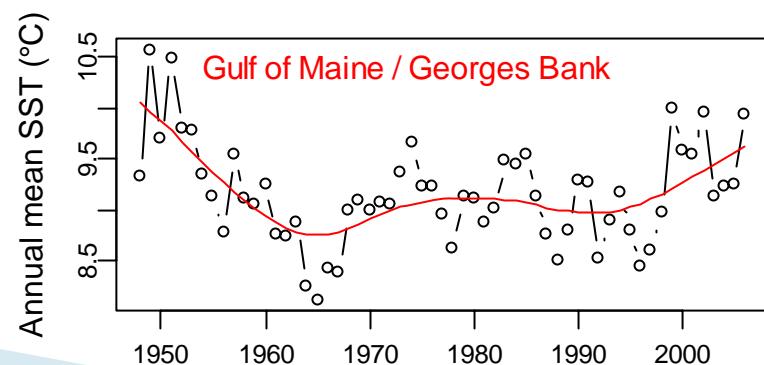
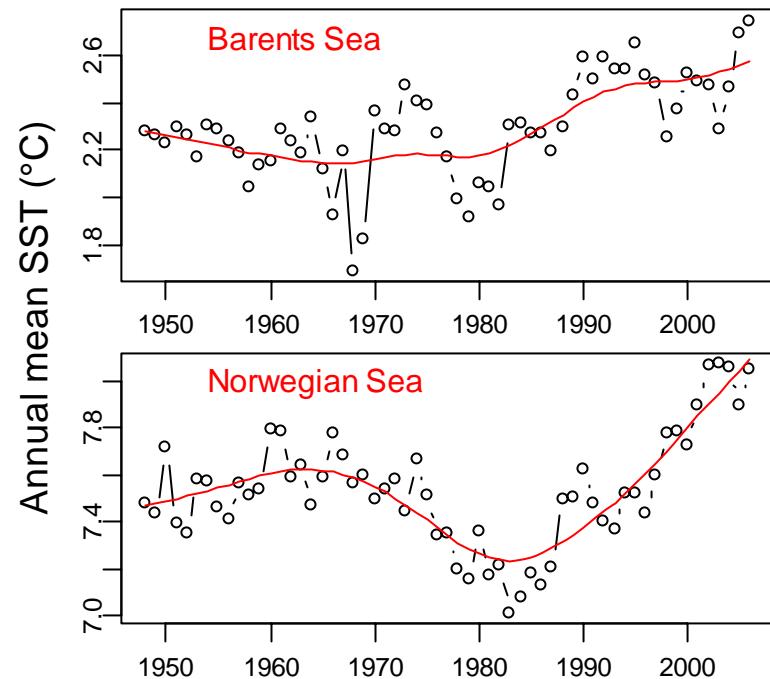
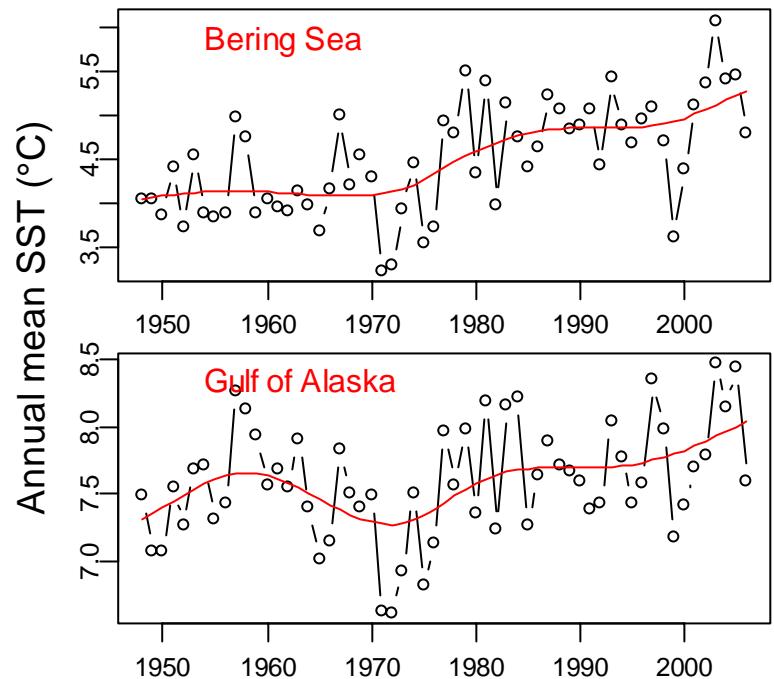
- ▶ Marine Ecosystems of Norway and U.S. project
- ▶ Comparison of Northern Hemisphere Marine Ecosystems
  - Environment (Drinwater et al. POC session)
  - Biota (this presentation)
  - Fisheries (Gaichas et al., this session)
- ▶ Identify similarities and differences in responses of biota to recent oceanographic variability
  - Focus on changes in productivity, abundance, and distribution in relation to SST variability



# Data sources

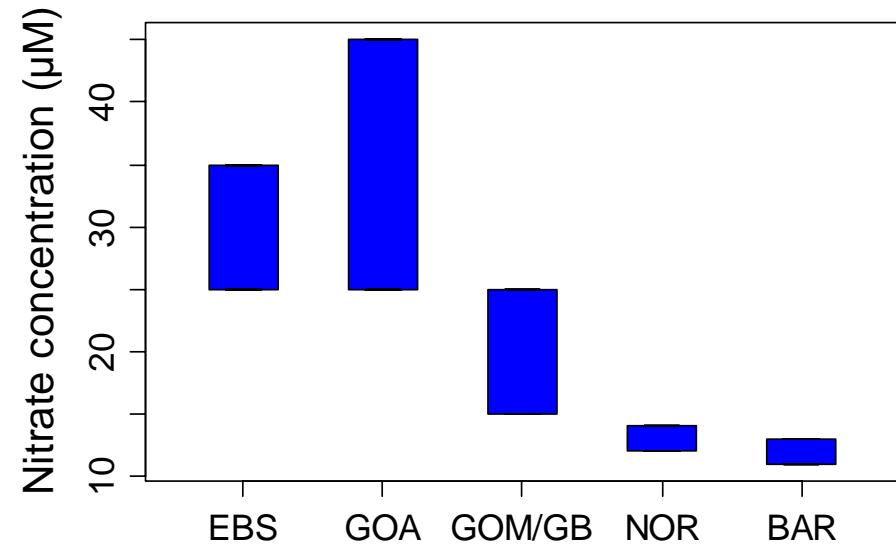
- ▶ Sea-Surface Temperatures
  - NOAA Extended Reconstructed, 1948-2006
- ▶ Nutrients
  - Published nitrate concentrations
- ▶ Primary Productivity
  - Monthly Chlorophyll *a*: SeaWiFS estimates
  - Monthly Net Primary Productivity
    - Behrenfeld & Falkowsky (1997) VGPM estimates
- ▶ Zooplankton biomass
  - Survey indices (Bering Sea, GOM/GB, Norwegian, Barents)
- ▶ Fish
  - Recruitment trends, biomass (stock assessments & survey data)
  - Distribution (literature review)
- ▶ Seabirds / Marine Mammals
  - Literature-based density estimates

# Sea-surface temperature trends

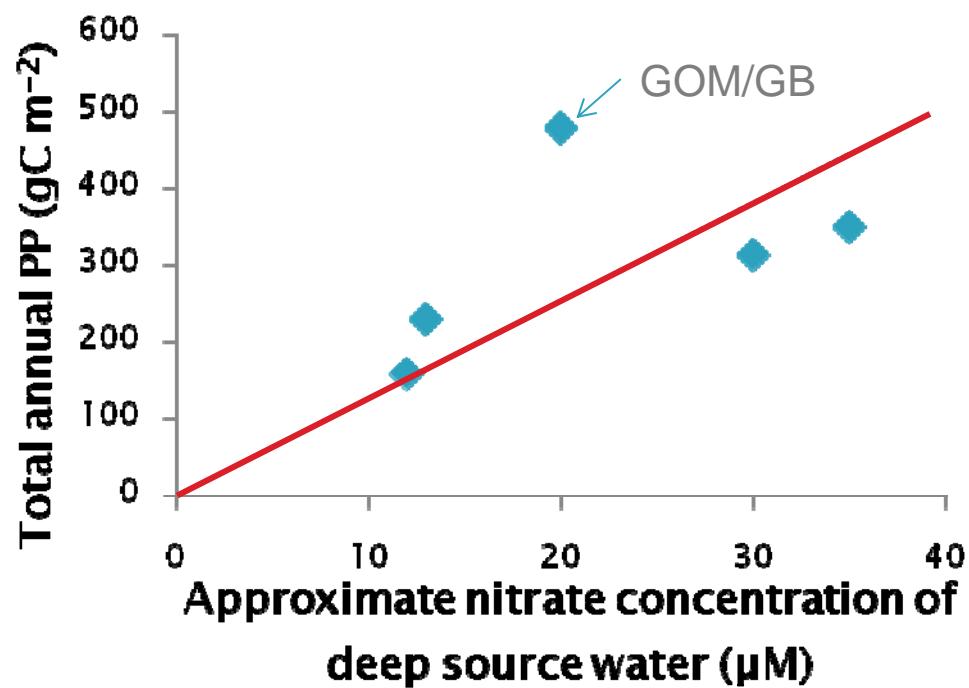


# Productivity increases with nitrate content of deep source waters

Approximate range

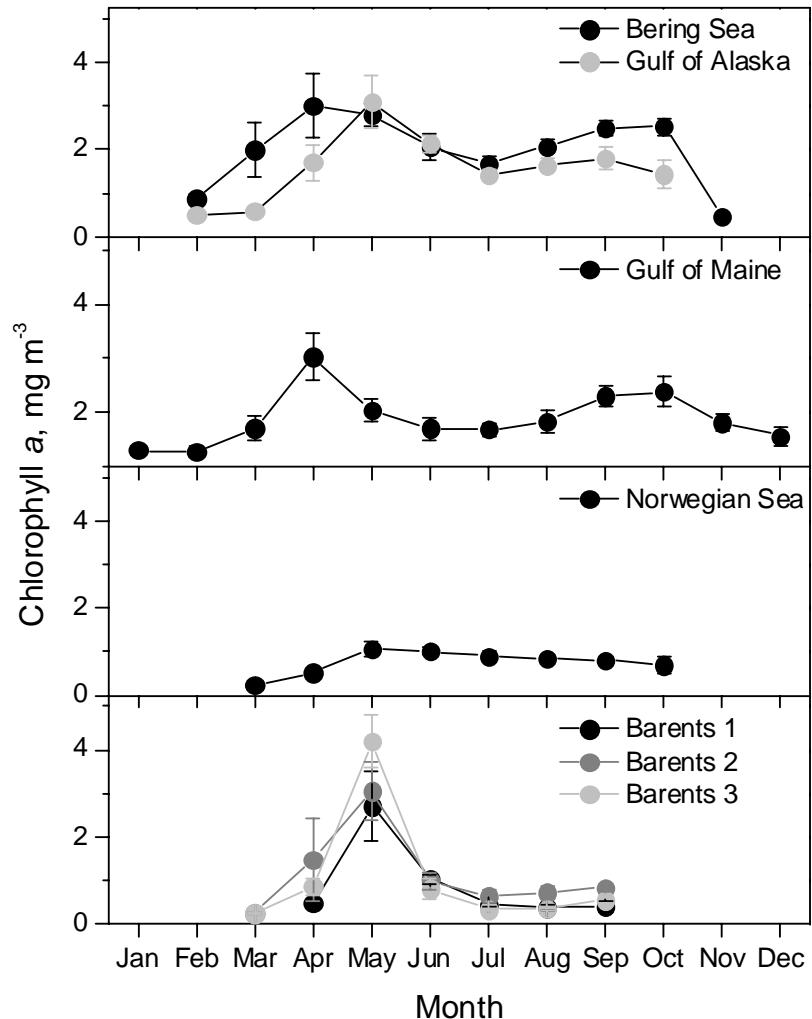


Nitrate in source waters and total annual primary production

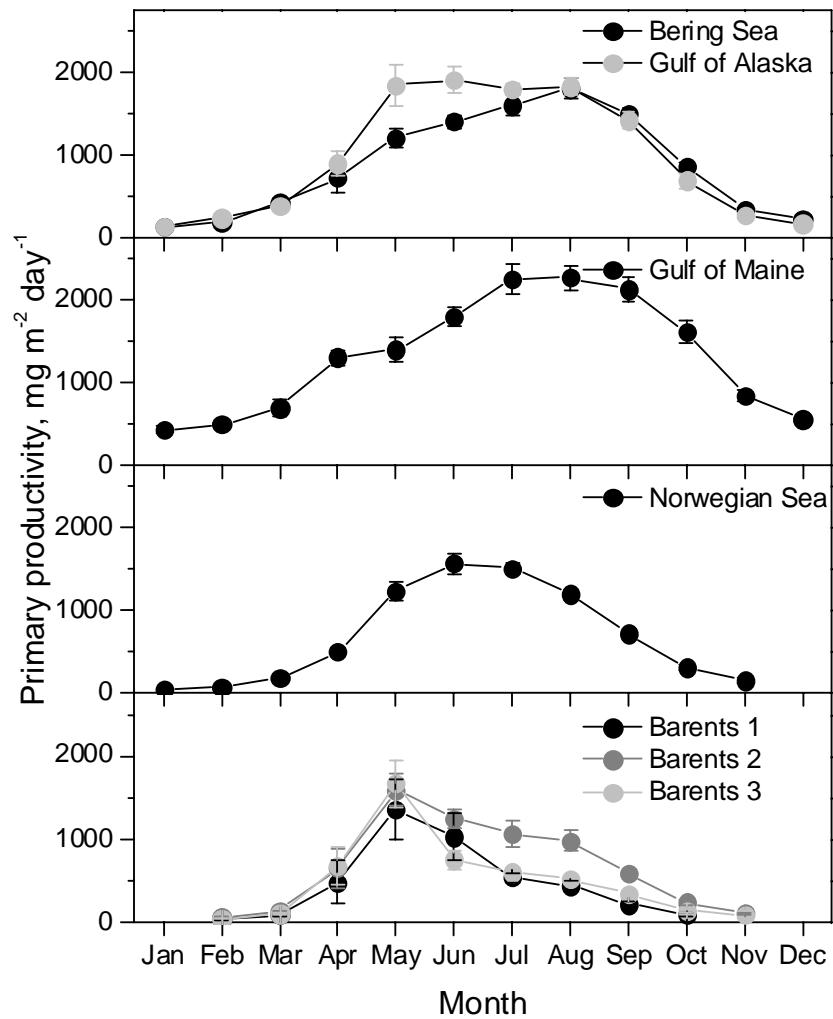


# Chl. *a* and Primary Productivity

Chlorophyll *a* concentration  
(SeaWiFS)



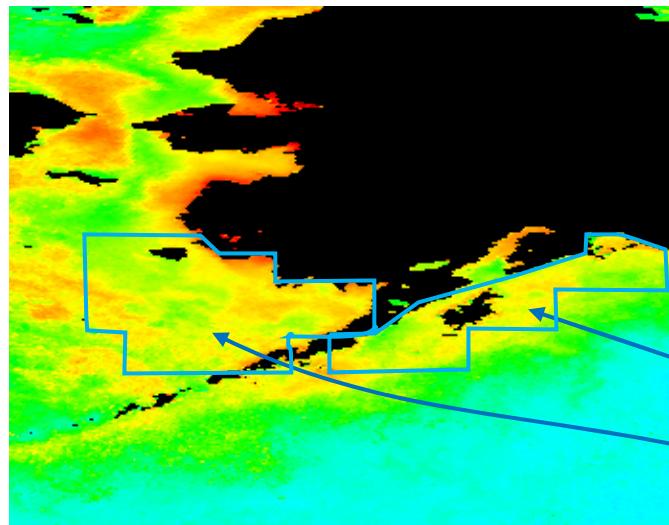
Net primary productivity  
(VGPM\* estimates)



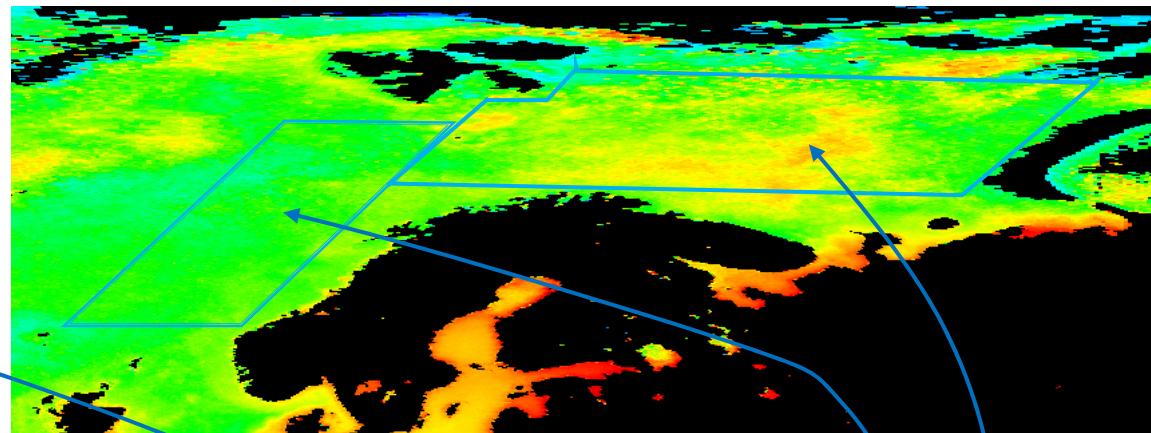
\* Based on Behrenfeld & Falkowski (1997) VGPM algorithm

# SeaWiFS climatology - Chl. *a* (Apr-Jun)

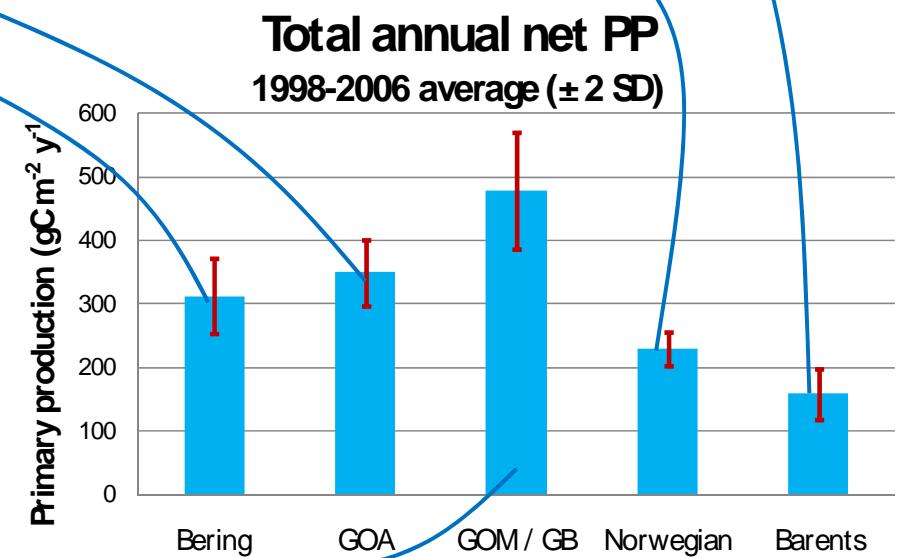
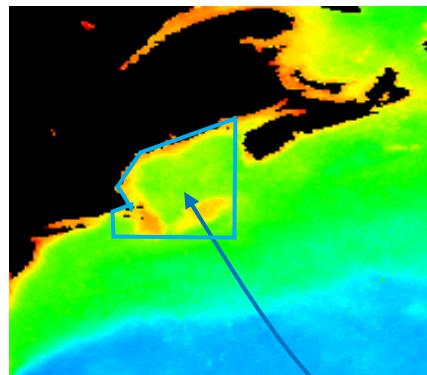
Bering Sea / Gulf of Alaska



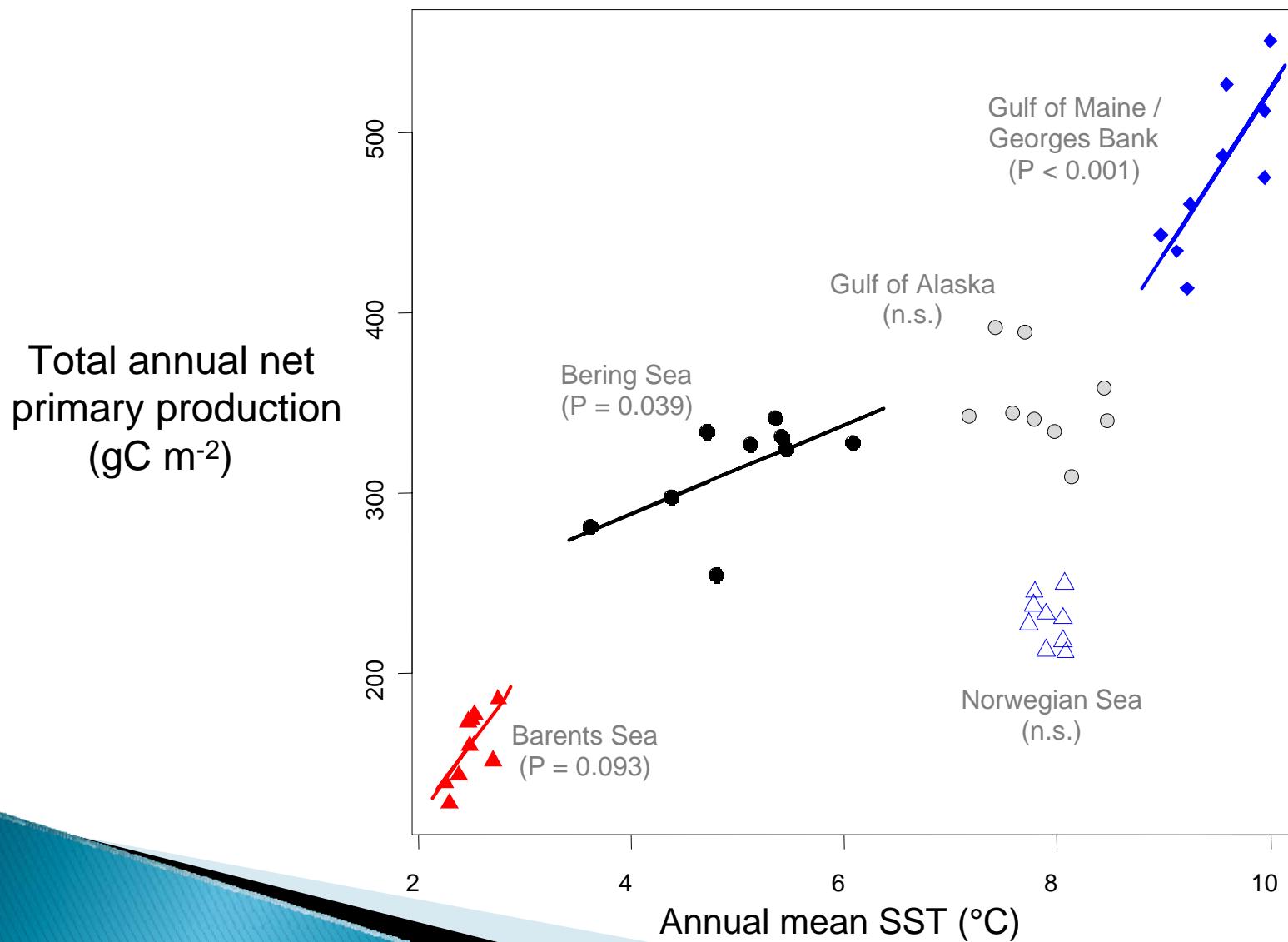
Norwegian Sea / Barents Sea



Gulf of Maine /  
Georges Bank

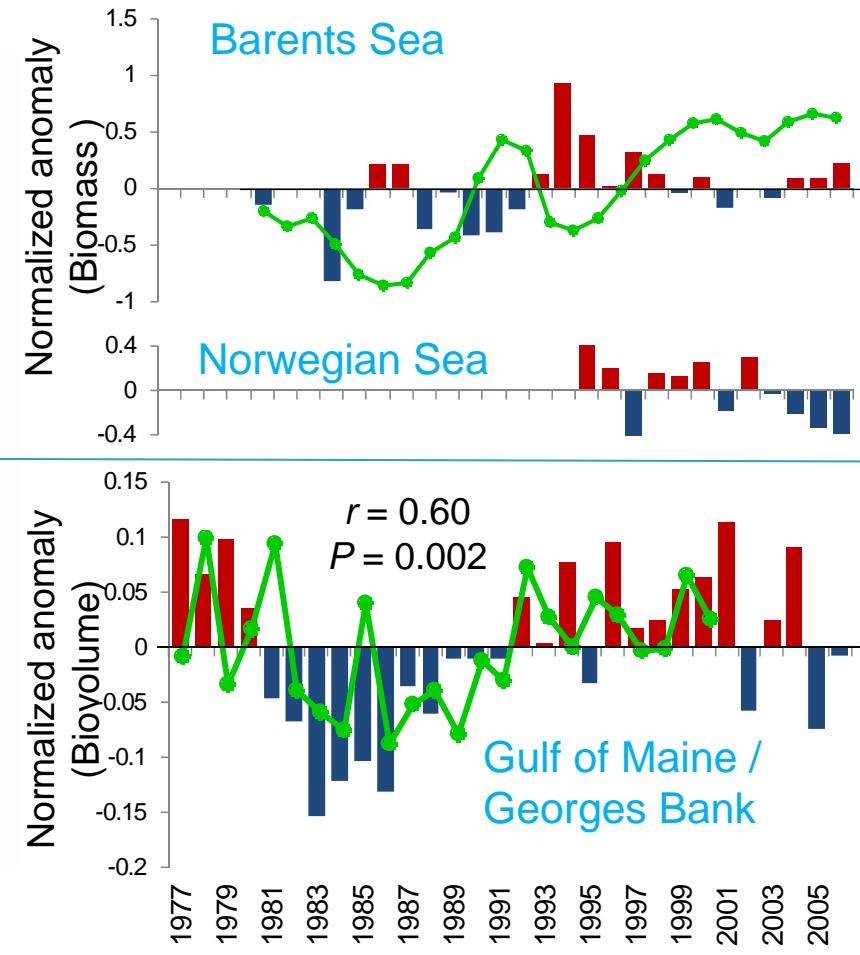
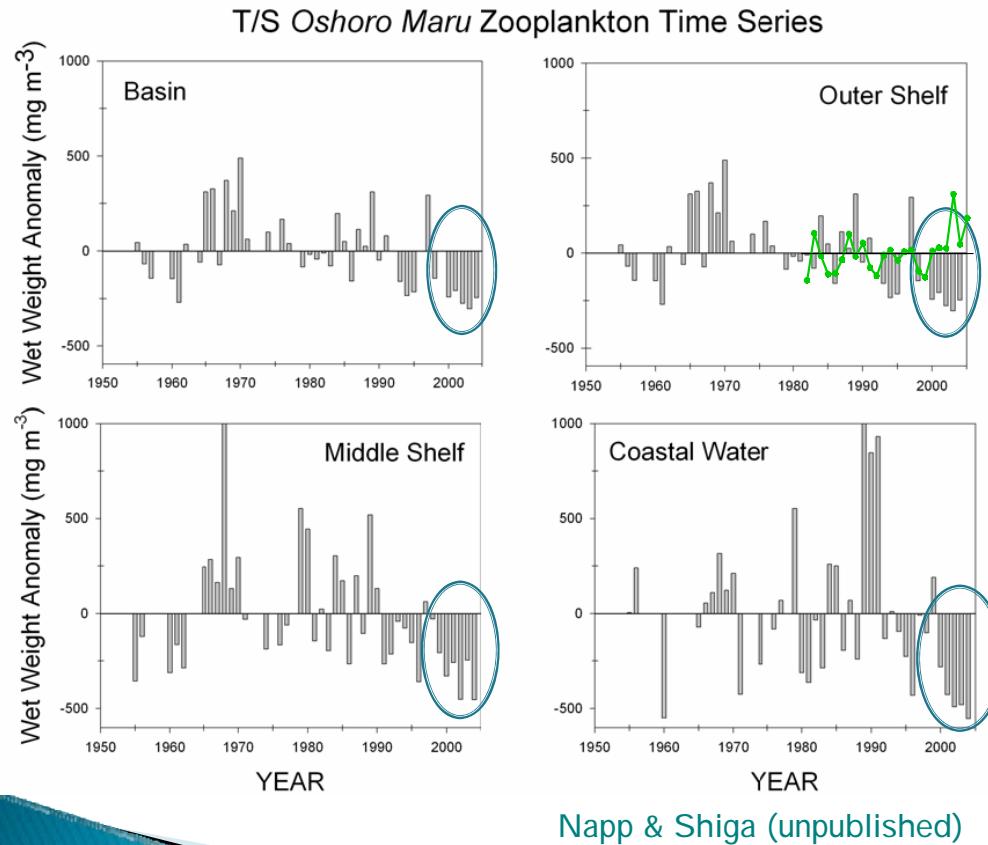


# Effect of SST on primary production, 1998–2006



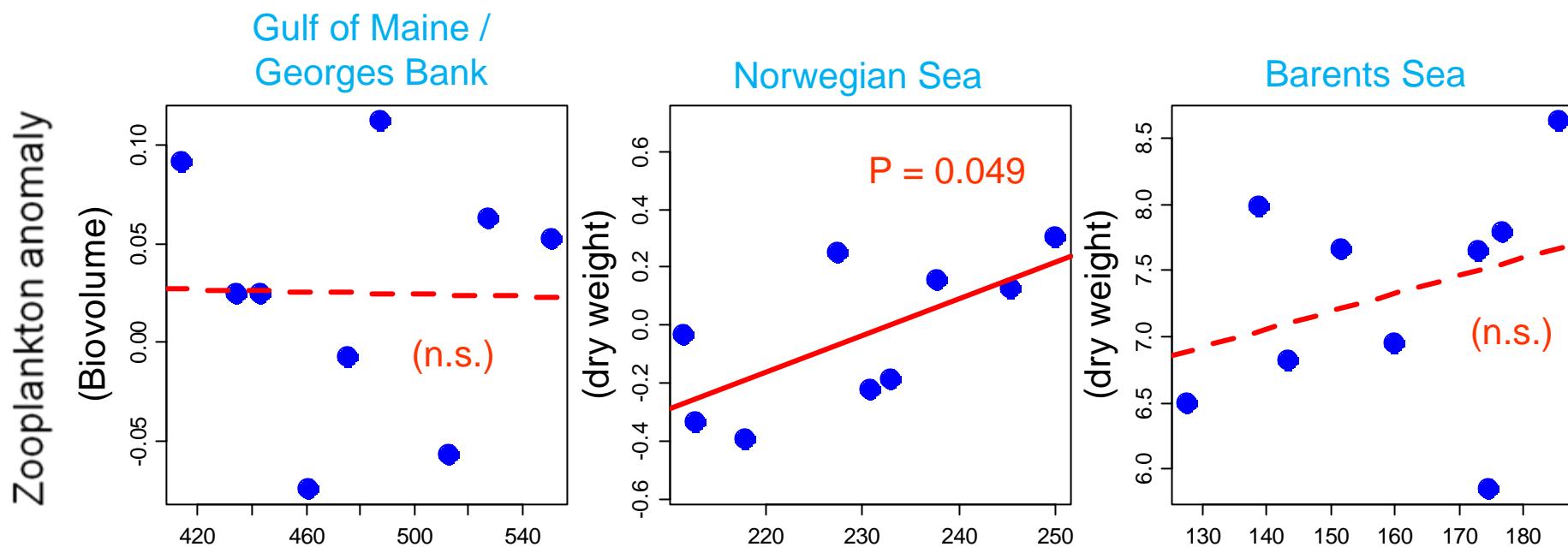
# Zooplankton anomalies: Evidence of top-down and bottom-up control

## Bering Sea



Based on Valdés et al. (2006)

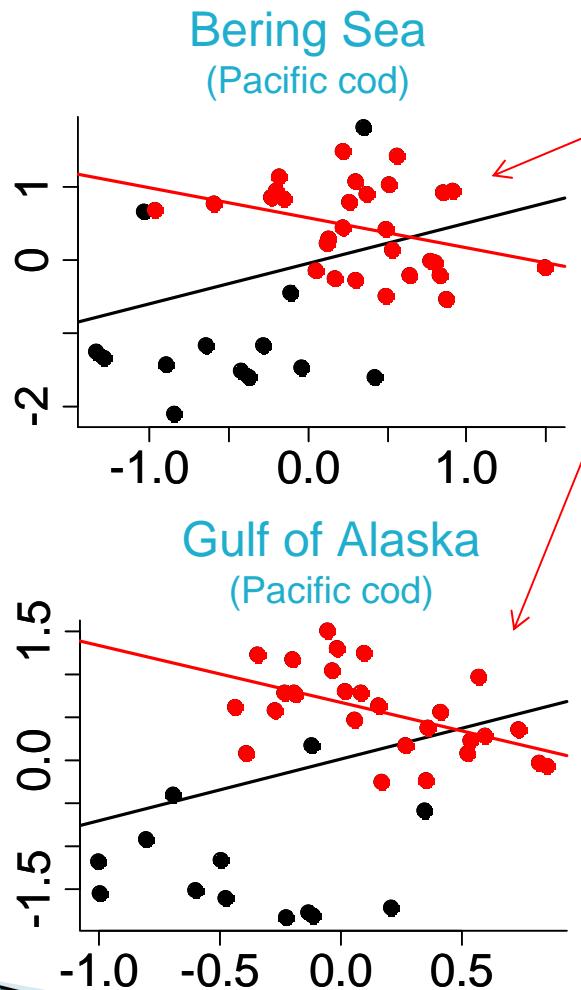
# Prim. Production and zooplankton 1998 - 2006



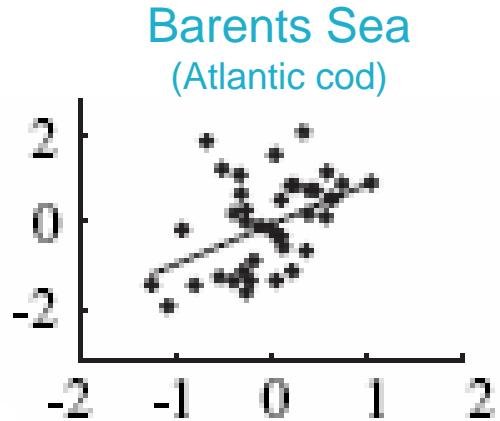
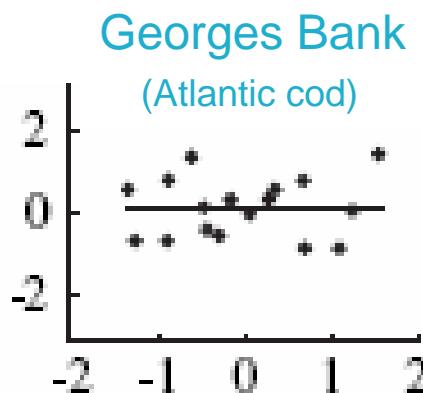
➡ No apparent relationship between total annual production and zooplankton indices, except in Norwegian Sea

# Fish: SST & cod recruitment

Log(Recruitment) anomaly



SST anomaly



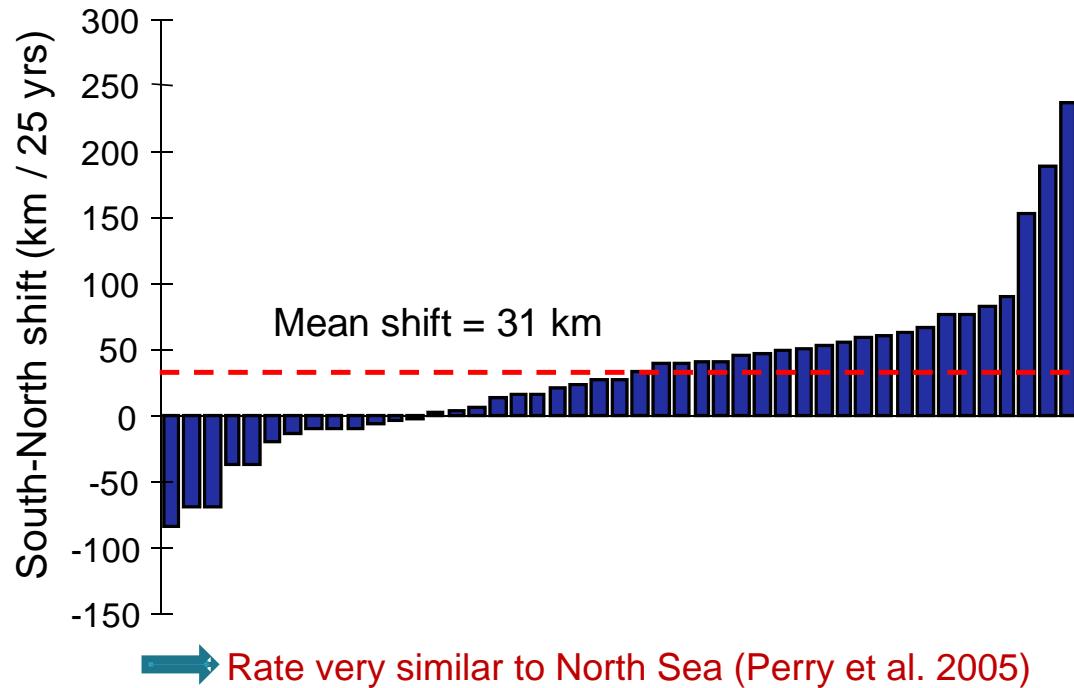
Georges Bank and Barents  
Sea figures from:  
Planque & Frédou (1999)

# Fish: SST & distribution

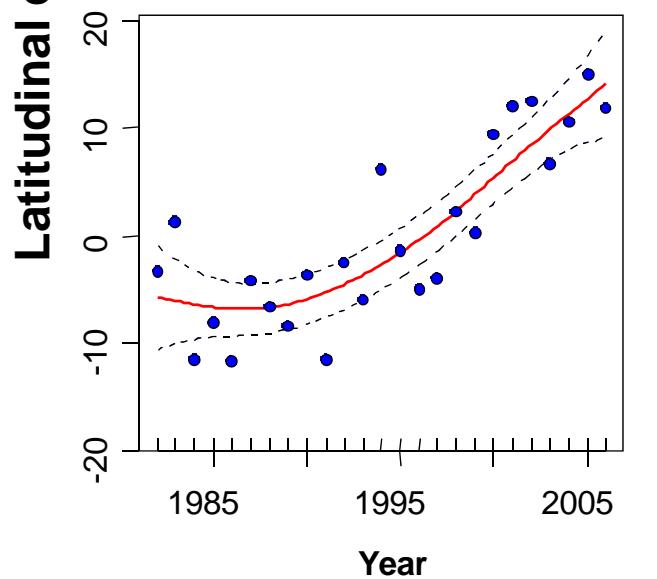
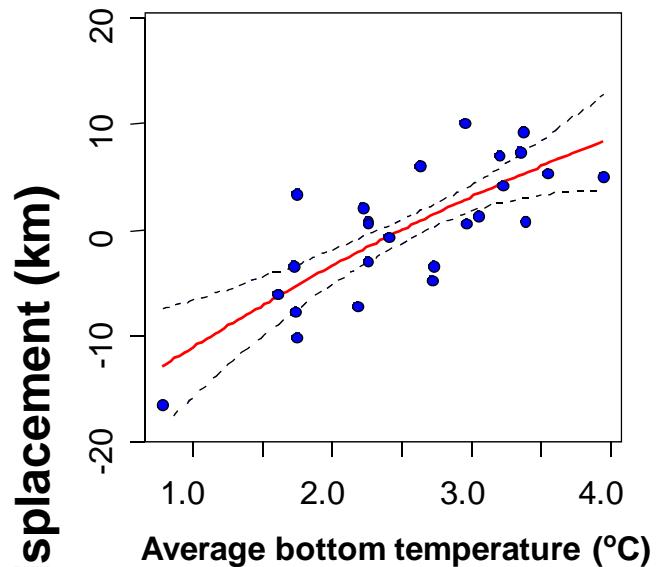
- ▶ Atlantic
  - Northward shifts of herring, capelin, cod with increasing temperature (e.g. Rose 2005)
  - Shifts in spawning location (capelin, herring)
  - Northward shifts in numerous demersal species in response to recent warming (North Sea, Perry et al. 2005)
- ▶ Pacific:
  - Northward shifts of numerous demersal species in response to recent warming (Bering Sea, Mueter & Litzow, in press)

# Recent changes in distribution of demersal fish and invertebrates in the Bering Sea

Northward shift in center of distribution  
from 1982-2006



From: Mueter & Litzow (In press)

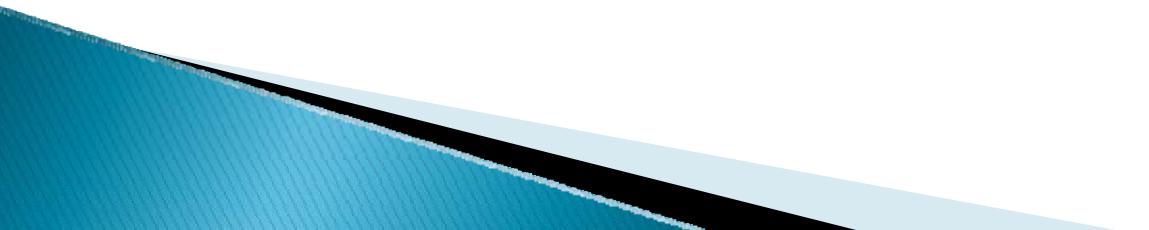


# Summary & conclusions (1)

- ▶ Recent warming trend in all regions
- ▶ Annual primary production increases with nitrate content in source waters
- ▶ Primary production increases with SST between regions and within 3 of the regions (Bering, Barents, and GOM / GB)
- ▶ Low zooplankton biomass in recent years in the Bering Sea and Barents Sea
  - Inverse relationship between fish and zooplankton suggests top-down control

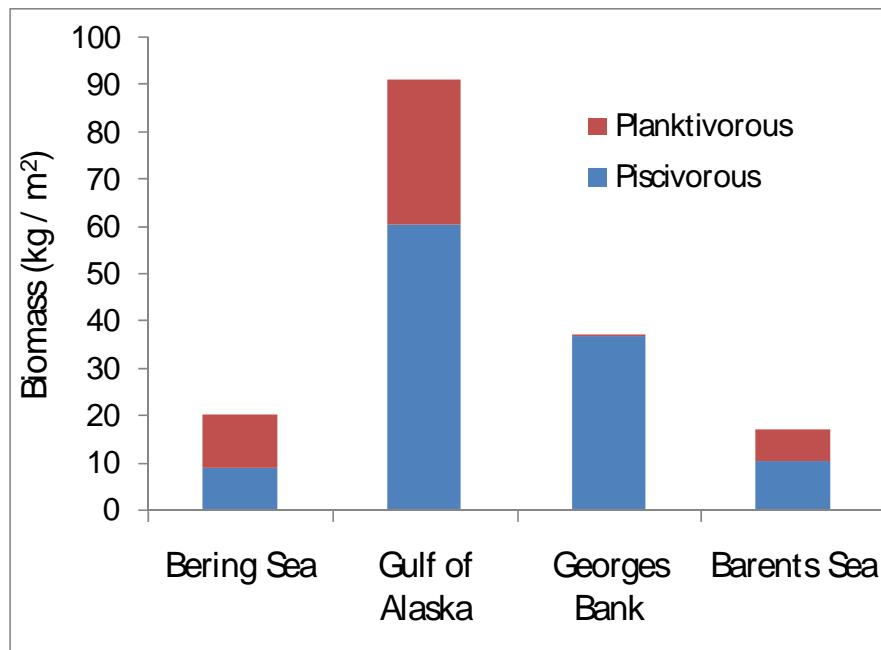
# Summary & conclusions (2)

- ▶ Decadal-scale changes in GOM/GB zooplankton
  - Positive relationship between fish and zooplankton suggests bottom-up control
- ▶ Effect of temperature on recruitment differs among regions and species.
  - Previously documented positive effect of SST on Pacific cod appears to have reversed in current “warm regime”
- ▶ Northward shifts in distribution of fish with increases in temperature
  - Bering Sea shift only partly explained by temperature



# Seabirds & mammals

Seabird densities



Mammal densities

