The Oscillating Control Hypothesis
Reassessment in view of New Information from the Eastern Bering Sea

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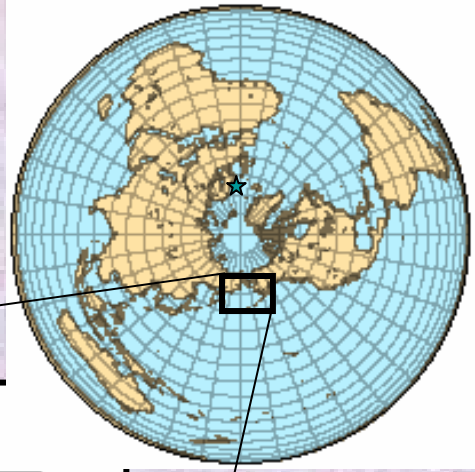
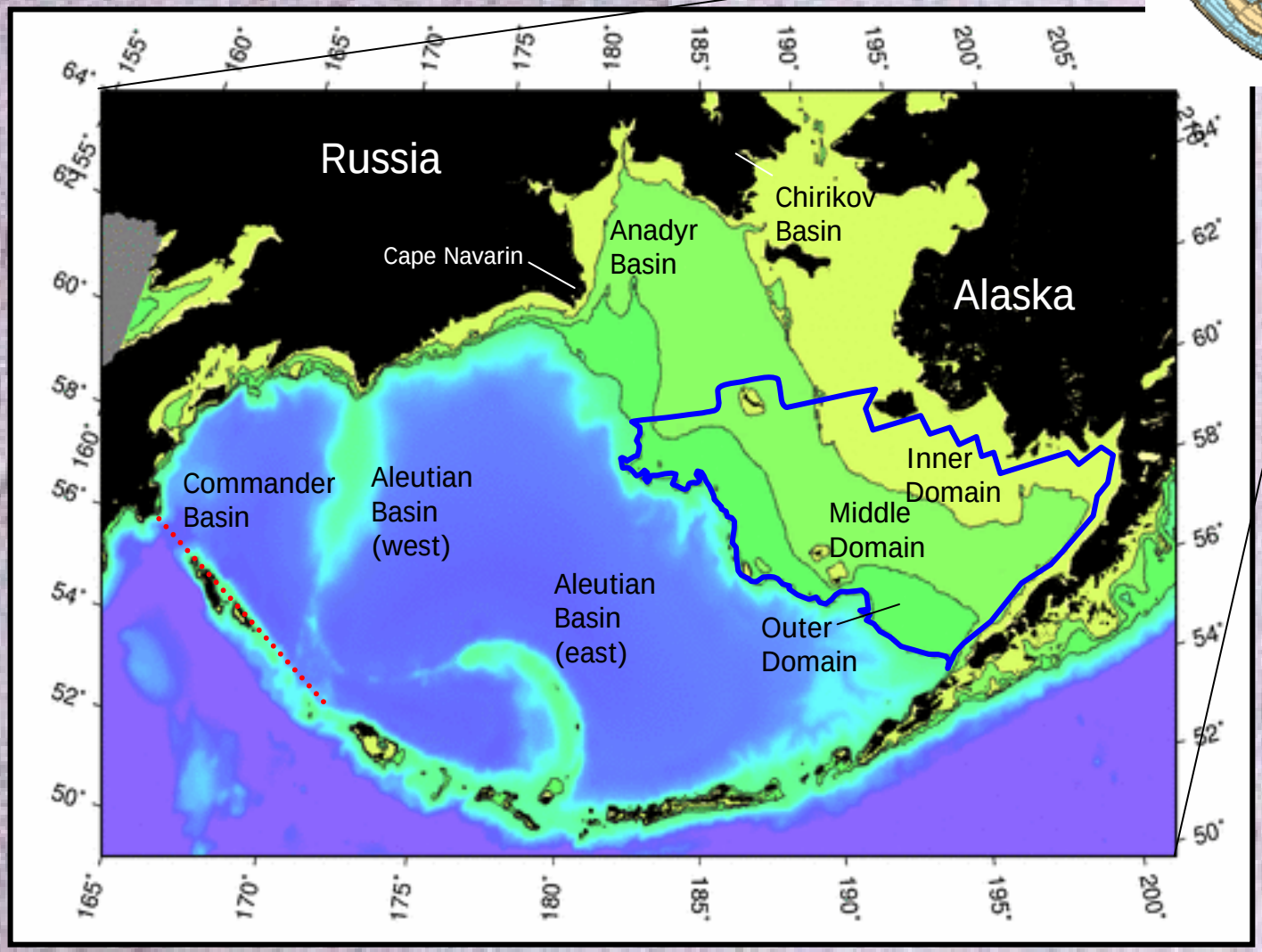
Where I want to go in this talk

- Walleye Pollock one of USA's most important Fisheries
- Recently, big drop in pollock biomass in Eastern Bering Sea
- Gap in production of strong year classes
- What fuels production of young pollock?
- Role of Sea Ice
- Long-term consequences

The Bering Sea





< 50 m

50-100 m

100-200 m

Modified from: Aydin et al. (2002) and Mueter unpbl

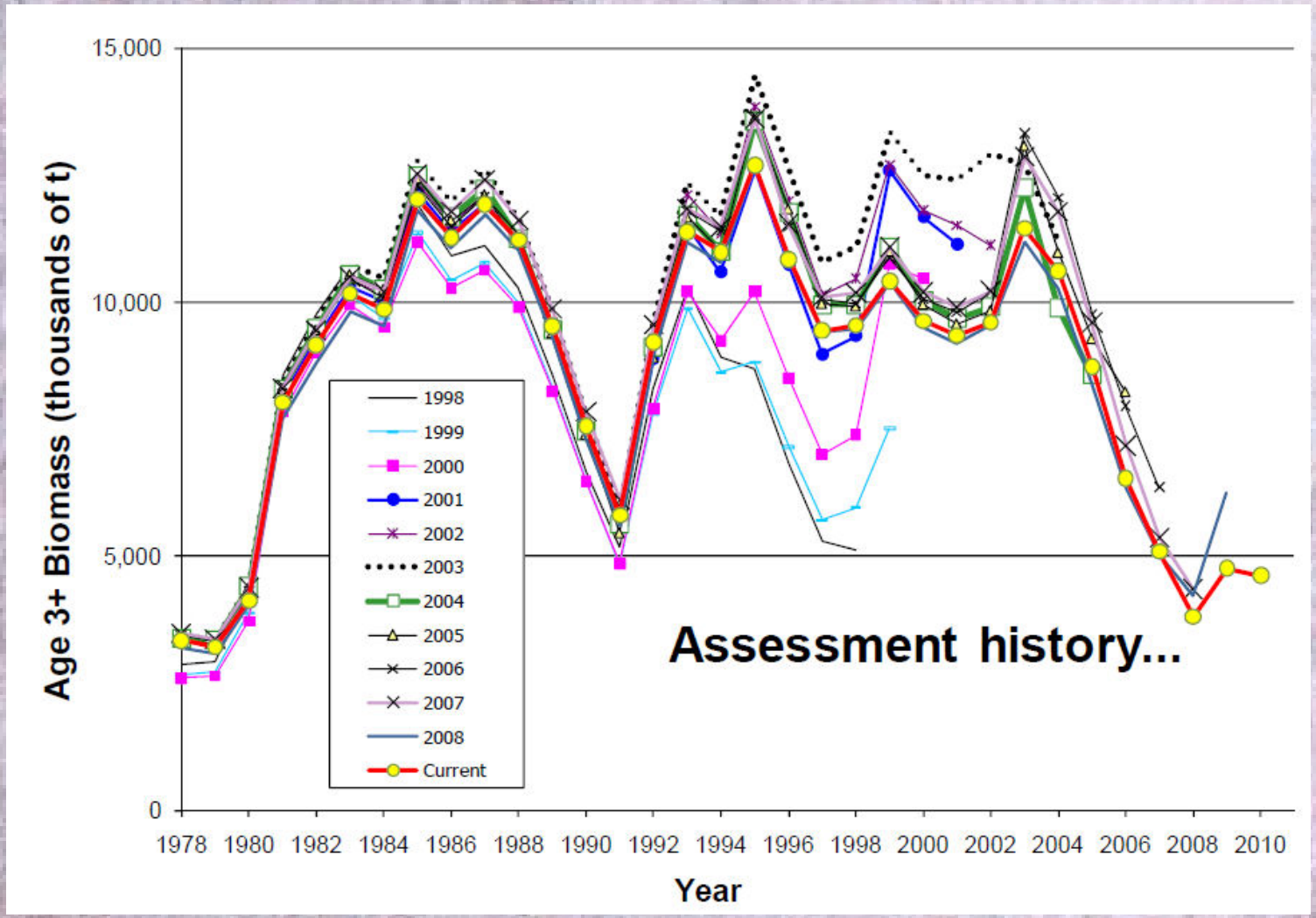
Importance of Walleye Pollock Fisheries

- **Number 1 species in USA by weight**
  - **2,298.1 million pounds; 28% of US fish catch**
- **Value $323,212, 000**
- **Dutch Harbor/Unalaska USA**
  - **Number 1 port for weight (612.7 million lb.)**
  - **Number 2 port for value ($195 million)**

A catch of juvenile pollock during a chartered hydroacoustic research cruise in Frederick Sound and Lynn Canal. (Photo by Johanna Vollenweider and David Csepp)

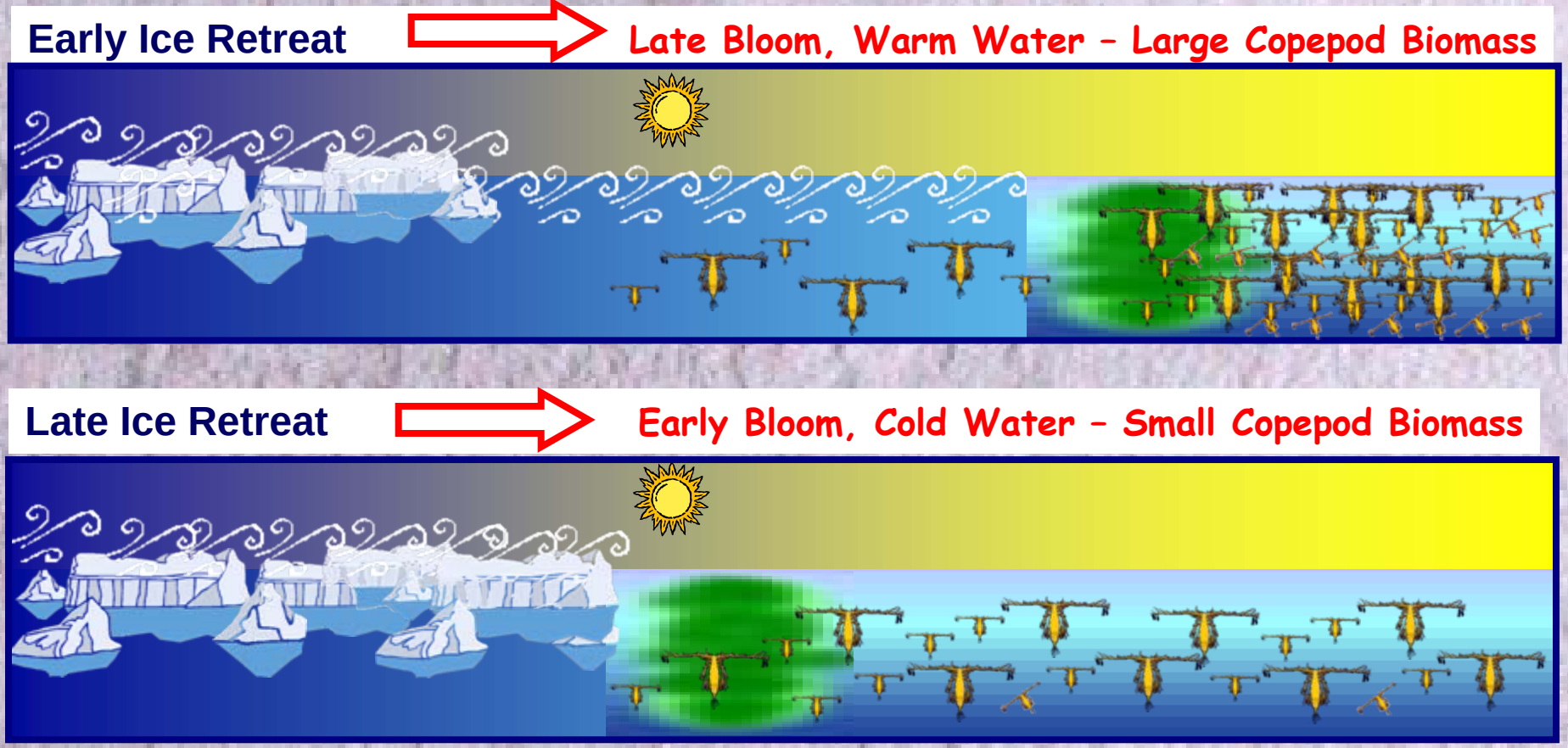
Source: NOAA Fisheries website

Pollock Modeled Biomass



Source: NPFMC 2010 SAFE, Dec 2009

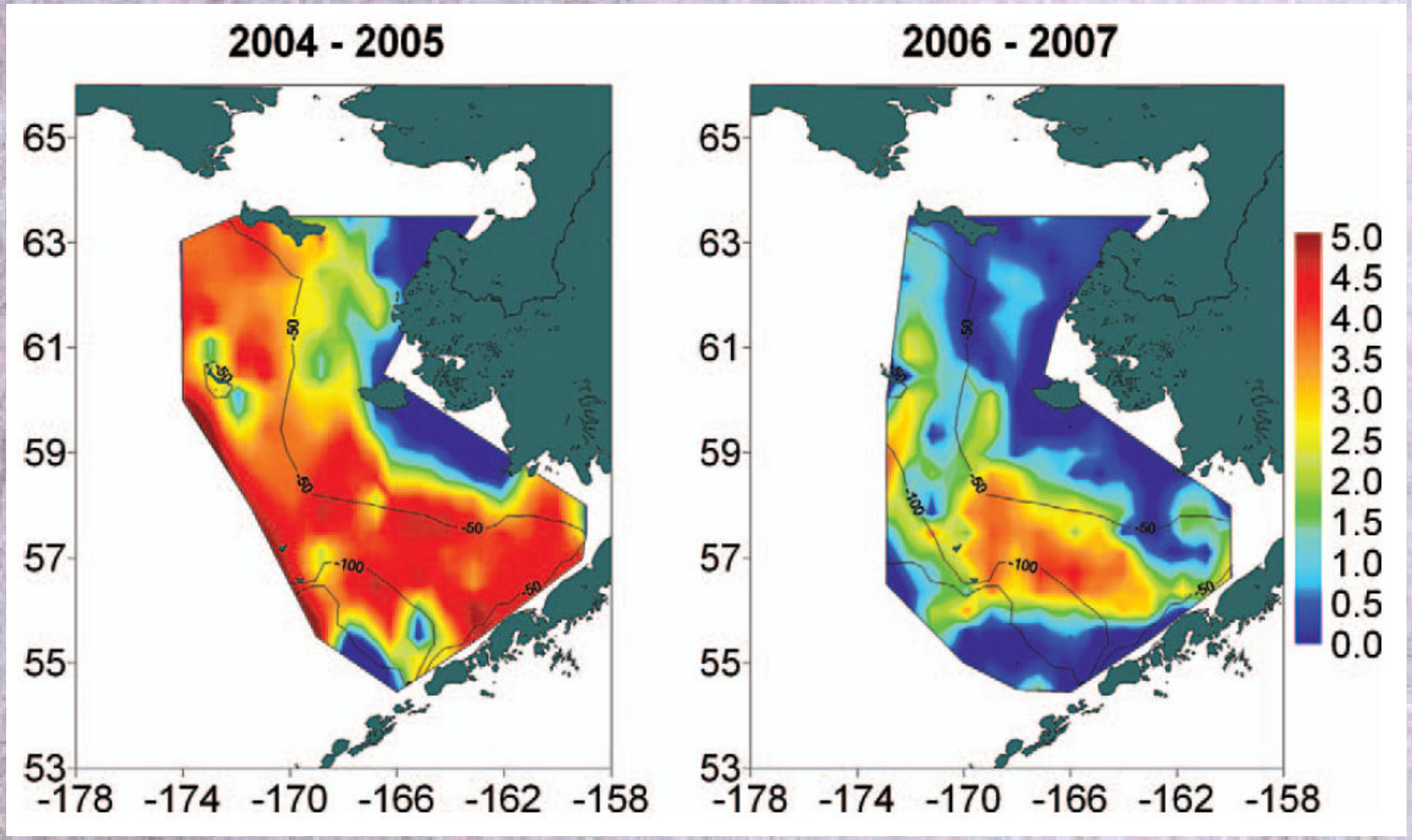
Ice, Wind, Bloom and Copepods



Hunt et al. 2002

Distribution of Age-0 Walleye Pollock

$\log_e$ transformed catch per unit effort (fish/m^3)



Moss et al., 2009 Trans .Amer. Fish. Soc.

Year Class Strength Variable

Source: NPFMC 2010 SAFE, Dec 2009

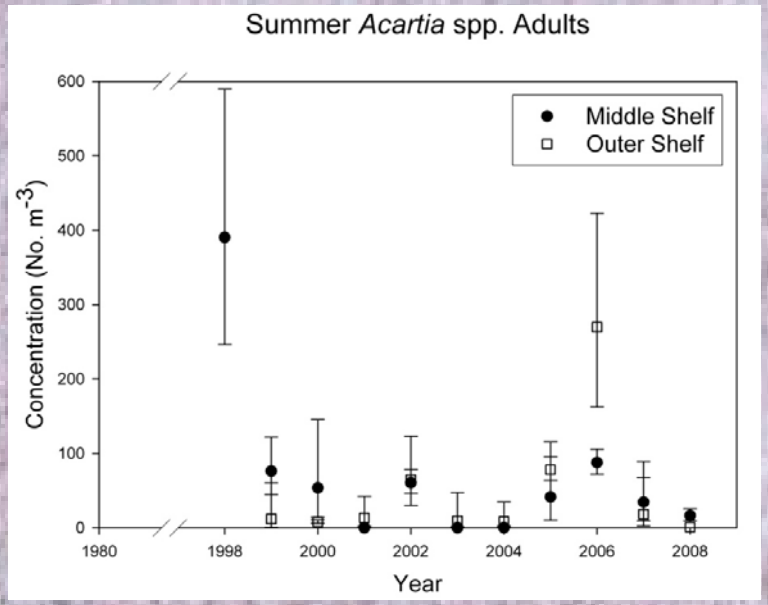
What were the Assumptions?

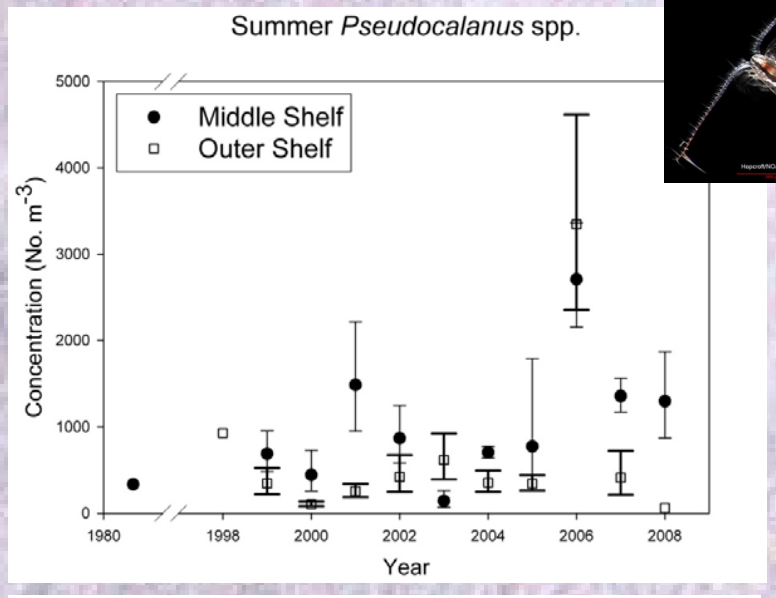
- Warm water good for copepod survival and growth
- Euphausiids were always available
- Warm water good for age-0 pollock feeding and growth
- Fast growing age-0 pollock will have a greater survival to age-1

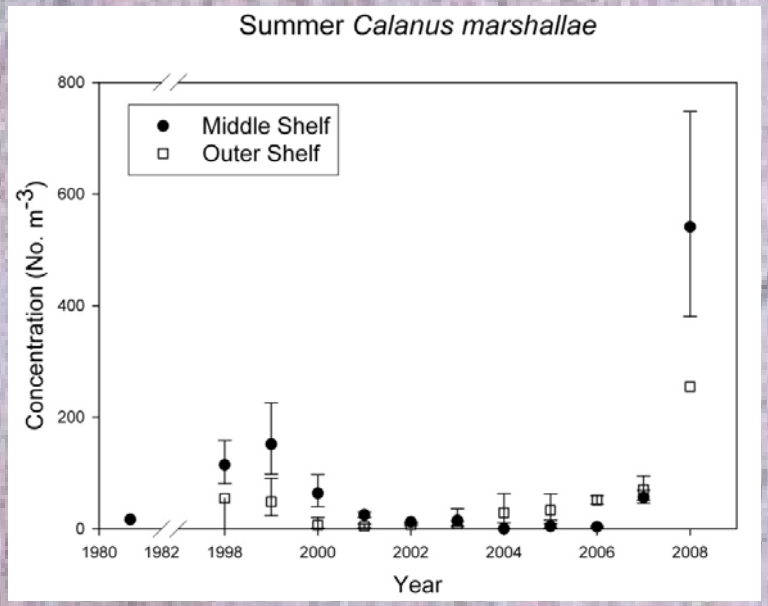
The Reality Check

- **The warm years did not lead to big year-classes of pollock**
- **Baier and Napp 2003 showed that *Calanus marshallae* needed an early bloom in cold water**
- **Perhaps warm years were good for small copepods but not for the big *C. marshallae* or for euphausiids**
- **So- some bad assumptions! NEW DATA NEEDED**

July Copepod Abundance







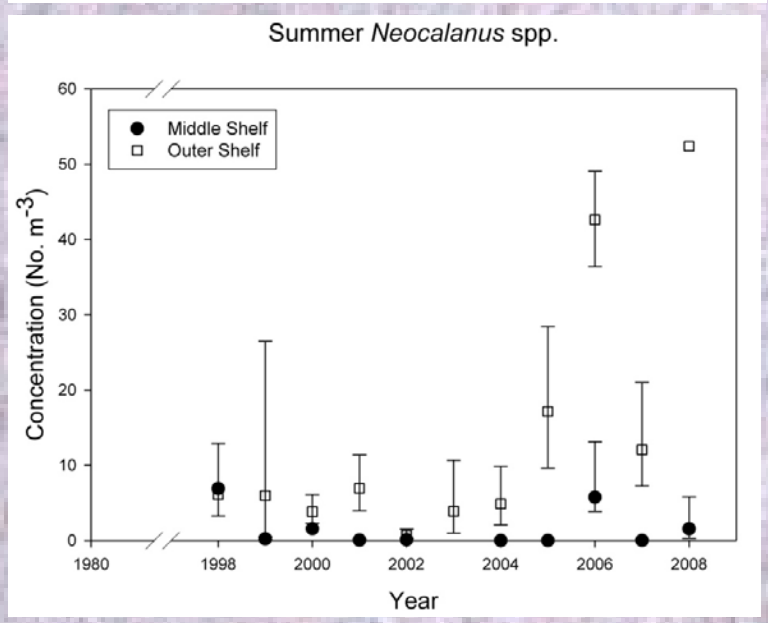
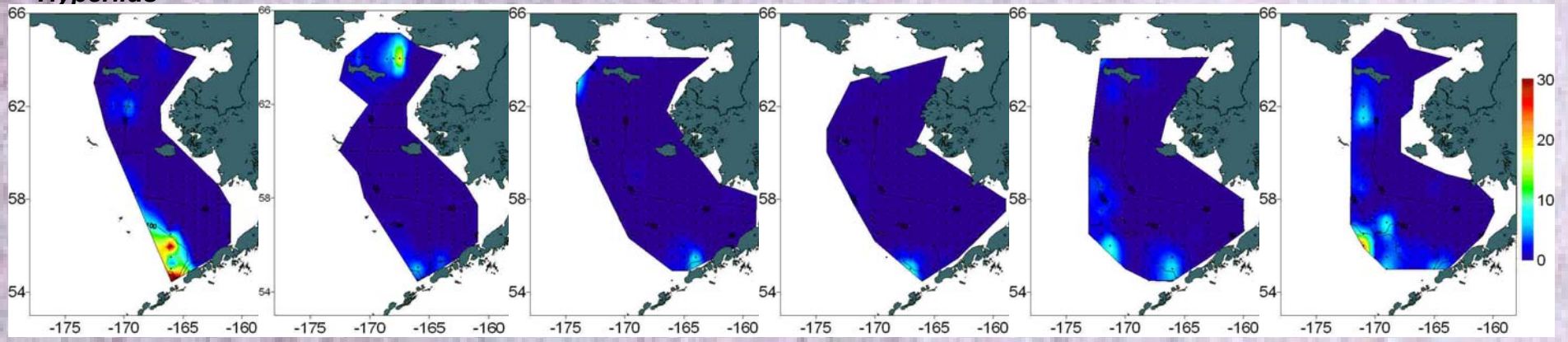


Figure Courtesy of J. Napp, NOAA AFSC

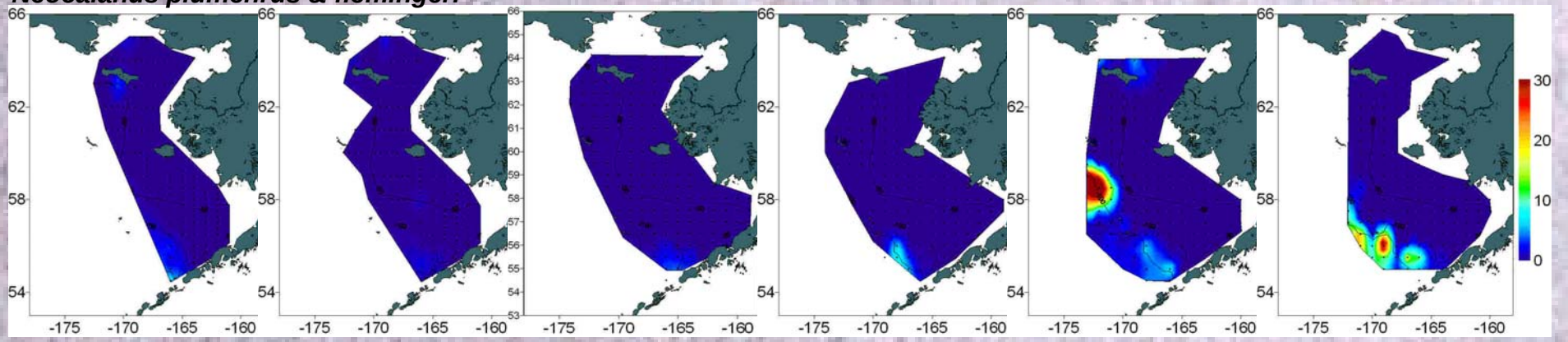
Large zooplankton abundance (# per m³), Bongo Tow, 505 µm mesh net

2002 2003 2004 2005 2006 2007

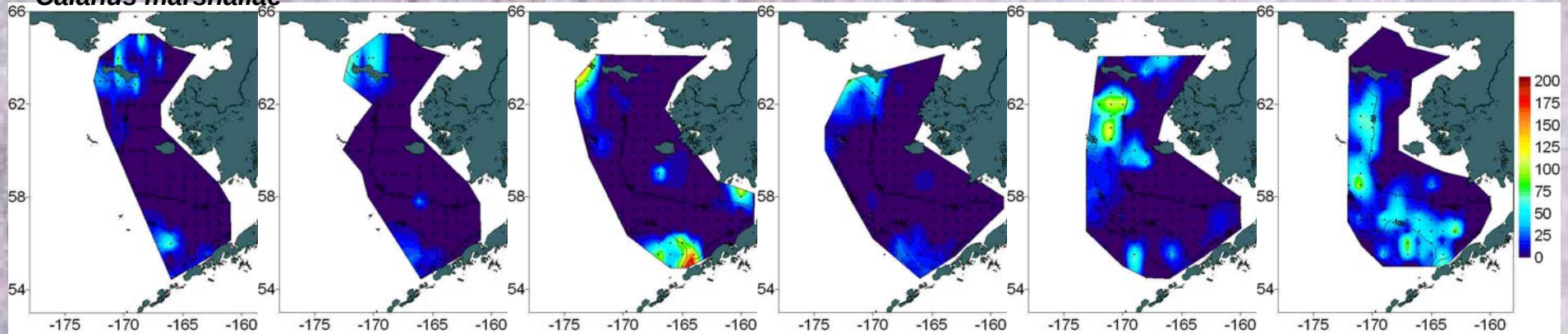
Hyperiids



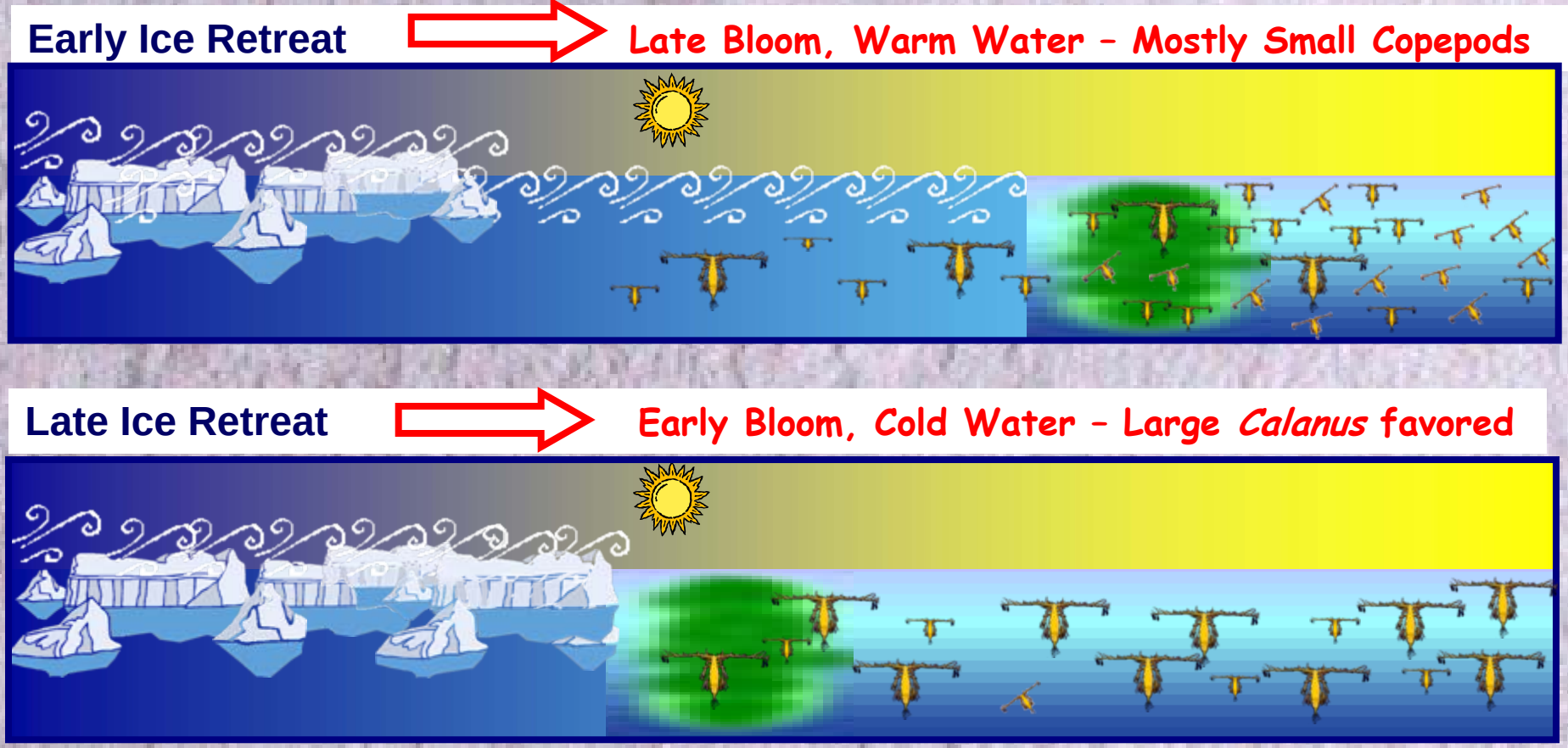
Neocalanus plumchrus & flemingeri



Calanus marshallae

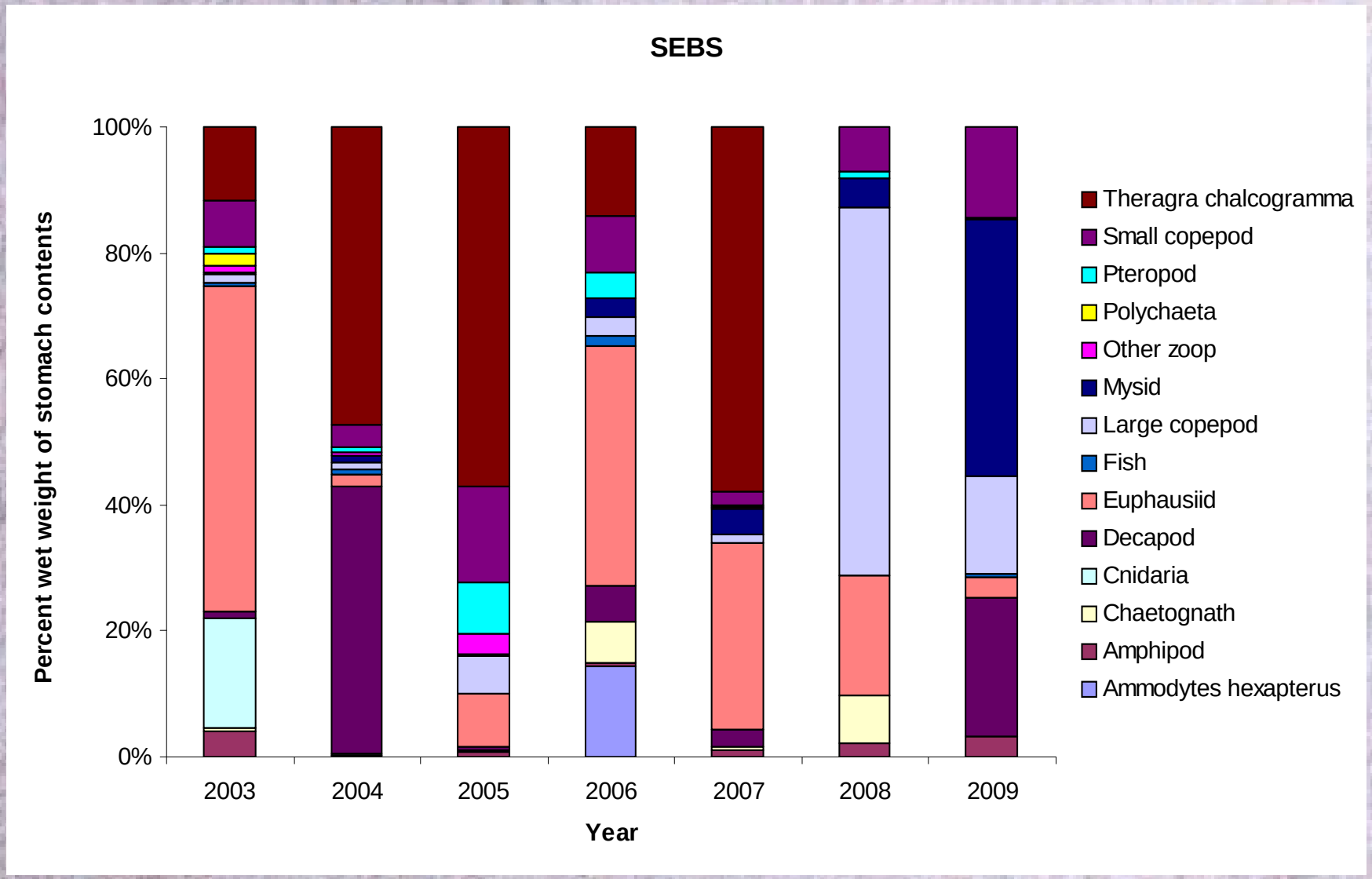


Ice, Wind, Bloom and Copepods



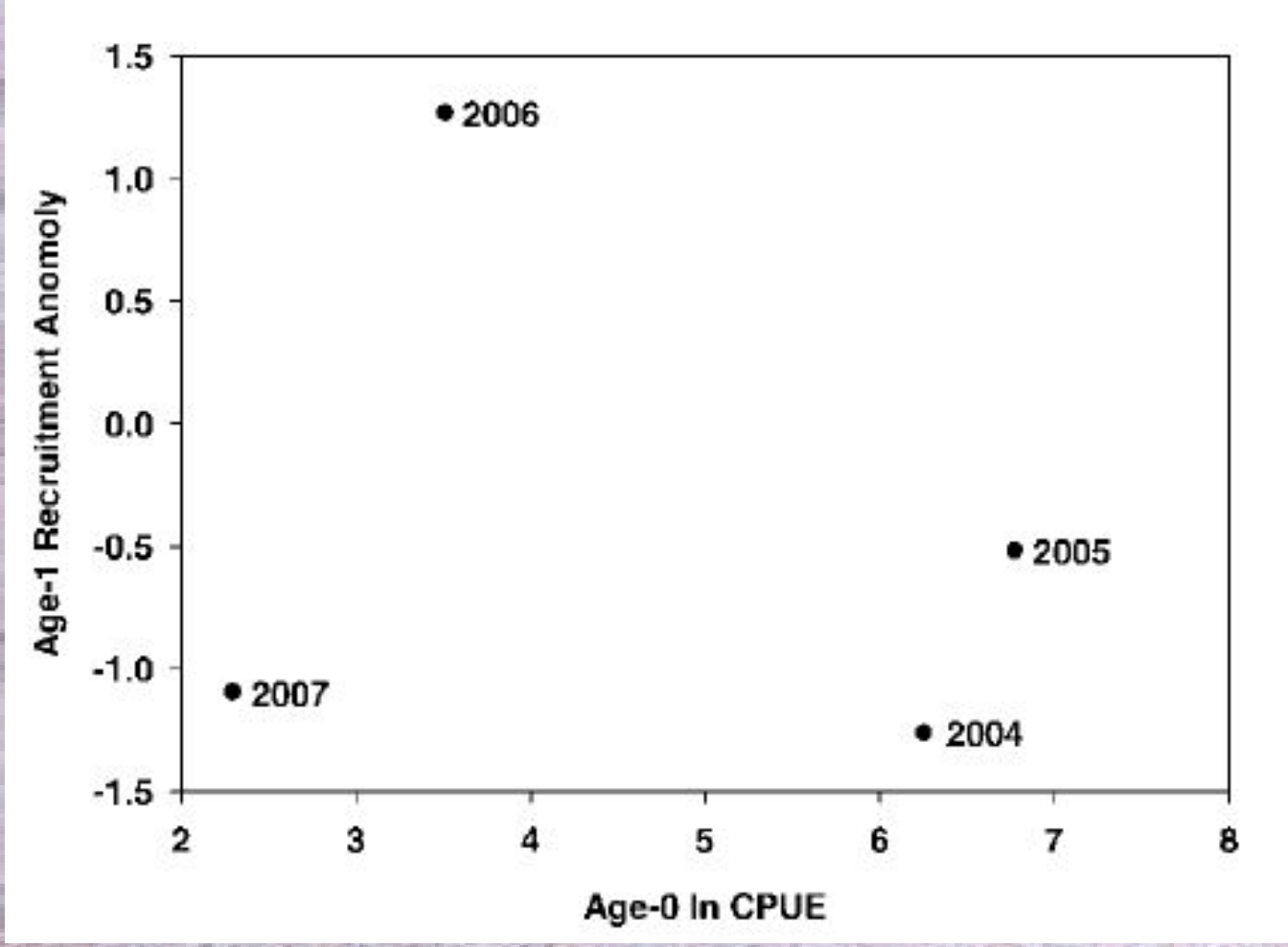
Modified from Hunt et al. 2002

Diets of Age-0 Pollock



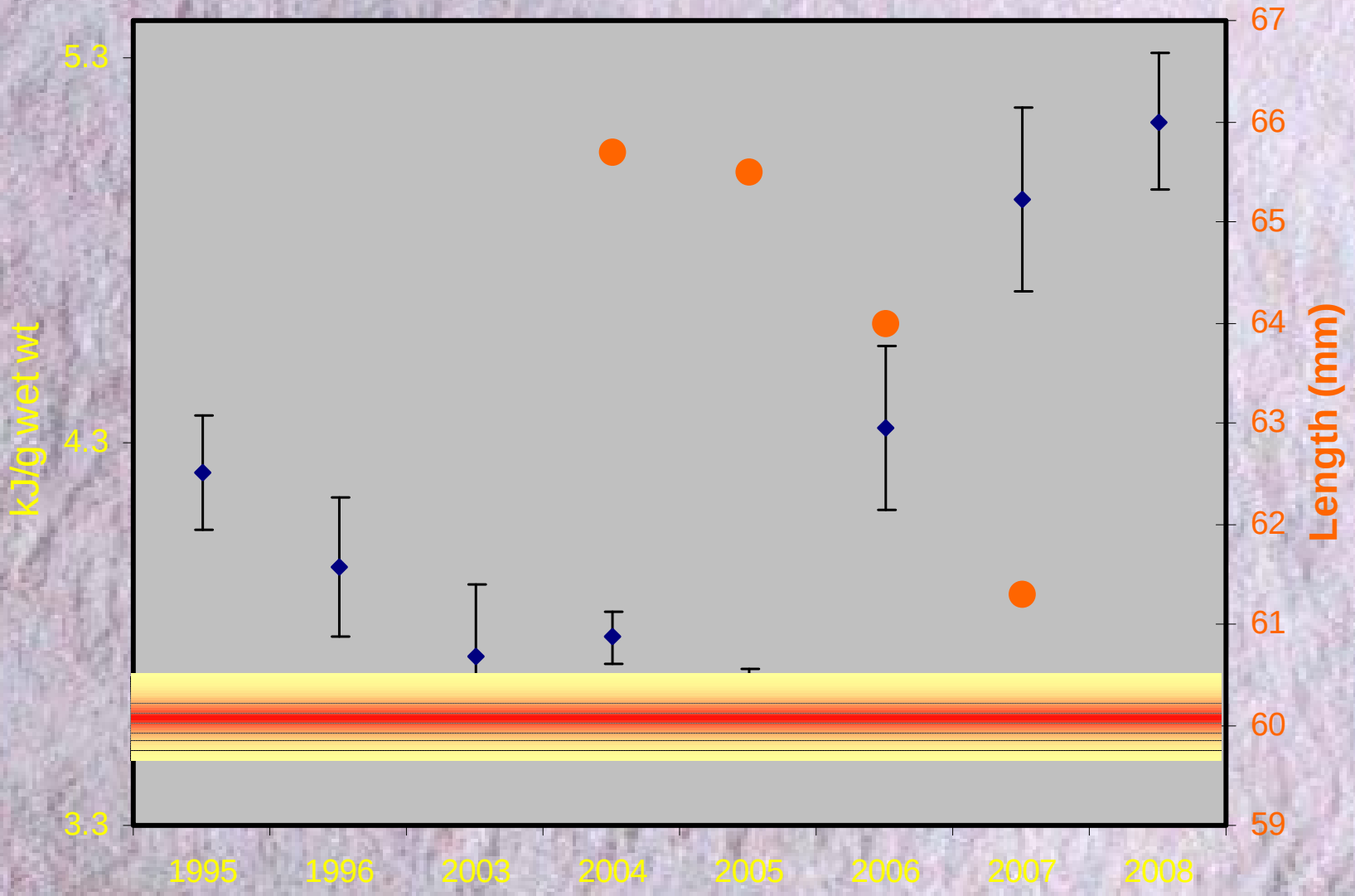
Slide courtesy of Ed Farley

Abundance of Age-1 Pollock VS. Age-0 Abundance the prior year



From Moss et al., 2009

Age-0 Pollock Energy Density and Length BASIS (2004 to 2008)



Slide courtesy of R. Heintz

New Since 2002

- **Mueter- Pollock recruitment dome-shaped with respect to temperature**
- **Moss et al.- Early pollock survival & growth better in warm years; growth weak in cold years**
- **Baier & Napp- Need early bloom, cool water to have big zoops (*C. marshallae, T. raschii)***
- **Moss et al- Need sufficient energy to survive winter; size & energy density of age-0s critical**
- **Predation on age-0 pollock greater when large zoops scarce in summer**

Conclusions

- Variations in timing of ice retreat affect the availability and size of copepods in spring- warm springs have mostly small copepods, but good early survival of age-0 pollock.
- High numbers of age-0 pollock in summer do not necessarily lead to high numbers of age-1 pollock the next year
- In warm years, there is a lack of large crustacean zooplankton in summer, age-0 pollock have low energy density, and there is enhanced cannibalism
- In warm years, summer lack of large zooplankton may result from their failure to recruit in the spring