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
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)

Source: NOAA Fisheries website
Pollock Modeled Biomass

Source: NPFMC 2010 SAFE, Dec 2009
Early Ice Retreat  →  Late Bloom, Warm Water - Large Copepod Biomass
Late Ice Retreat  →  Early Bloom, Cold Water - Small Copepod Biomass

February  March  April  May  June

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 m^3), Bongo Tow, 505 μm mesh net

- **Hyperiids**
- **Neocalanus plumchrus & flemingeri**
- **Calanus marshallae**
Ice, Wind, Bloom and Copepods

Early Ice Retreat → Late Bloom, Warm Water – Mostly Small Copepods

Late Ice Retreat → Early Bloom, Cold Water – Large *Calanus* favored

February March April May June

Modified from Hunt et al. 2002
Diets of Age-0 Pollock

Theragra chalcogramma
Small copepod
Pteropod
Polychaeta
Other zoop
Mysid
Large copepod
Fish
Euphausiid
Decapod
Cnidaria
Chaetognath
Amphipod
Ammodytes hexapterus
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.