The Effect of Seasonal Sea Ice Cover on the Structure of the Eastern Bering Sea Pelagic Food Web

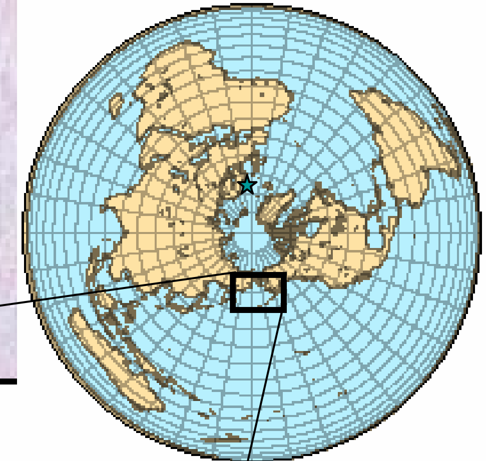
George L. Hunt, Jr.
University of Washington

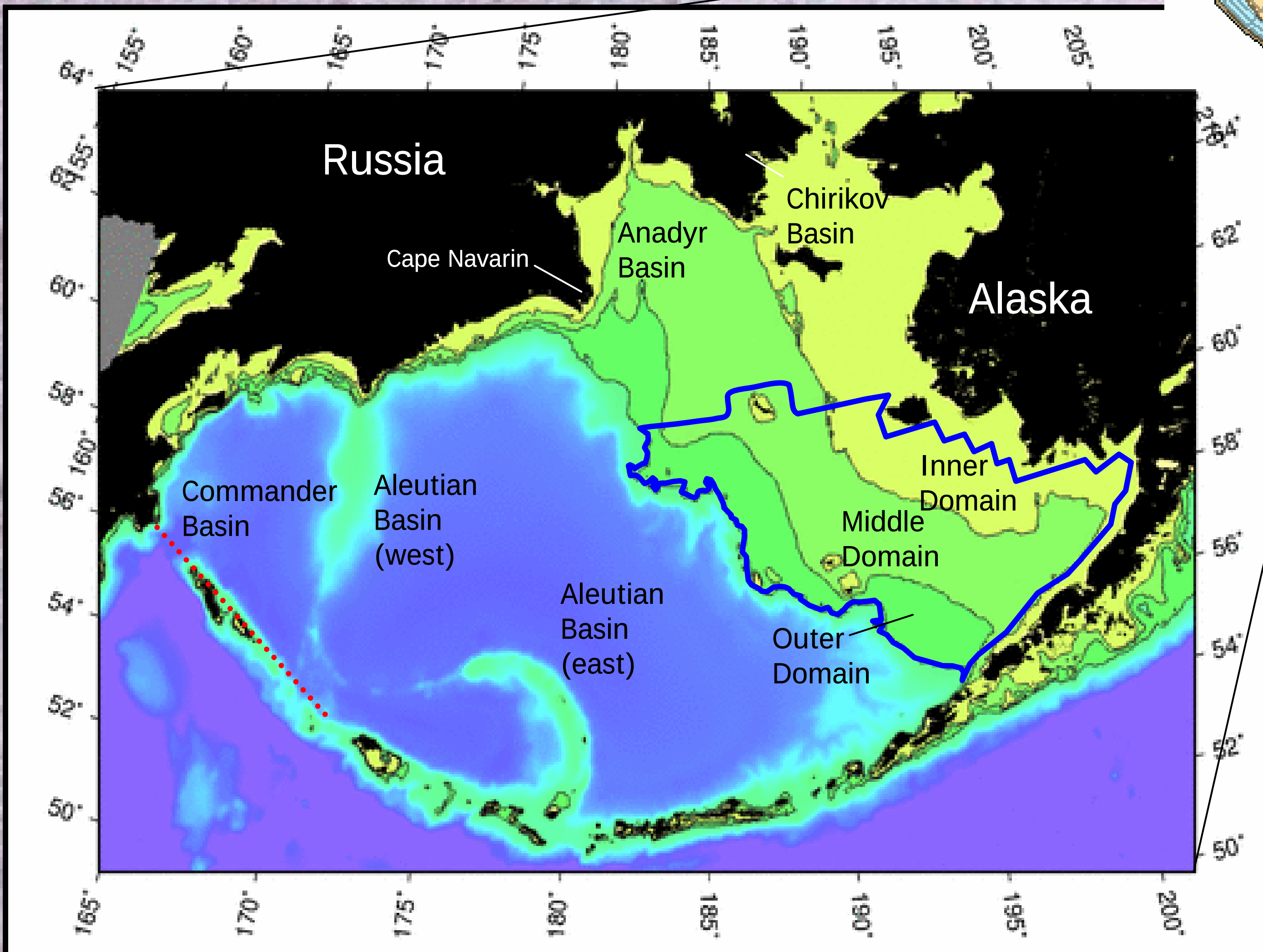
Jeffery M. Napp
NOAA Alaska Fisheries Science Center

Kenneth O. Coyle
University of Alaska, Fairbanks

Phyllis J. Stabeno
NOAA Pacific Marine Environmental Laboratory

The Bering Sea





< 50 m

50-100 m

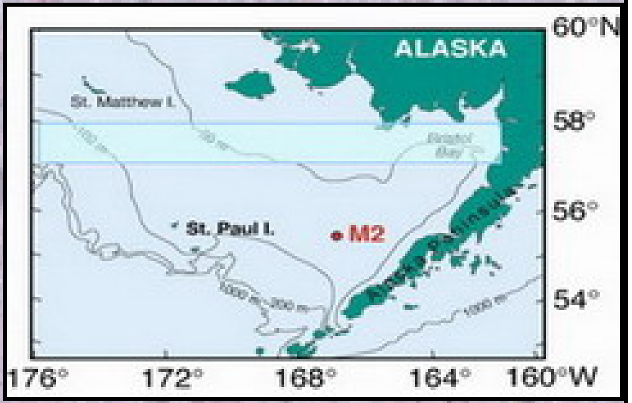
100-200 m

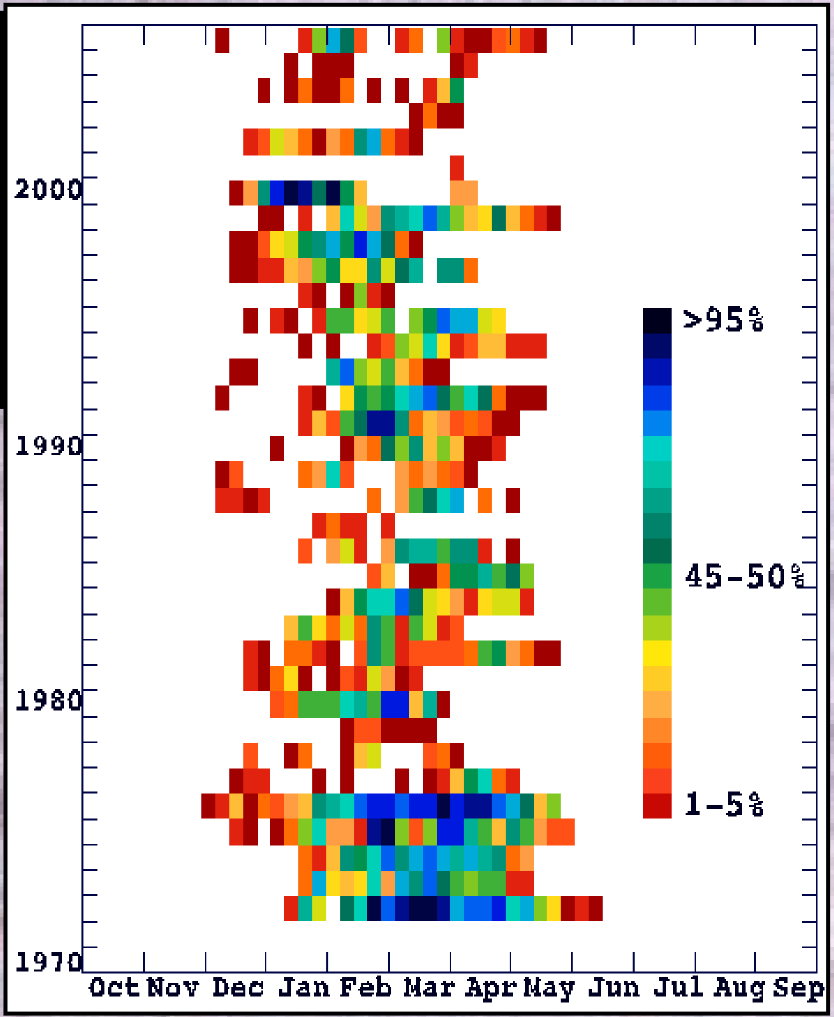
Modified from: Aydin et al. (2002) and Mueter unpbl

Issues to Discuss

- Sea ice cover is changing
- Timing of ice retreat affects bloom timing
- Timing of bloom affects zooplankton
- Zooplankton species requirements differ
- Events in spring set up summer conditions
- Role of prey availability vs. predation for pollock recruitment

Ice Coverage on the Southeast Bering Sea Shelf, 1972-2006





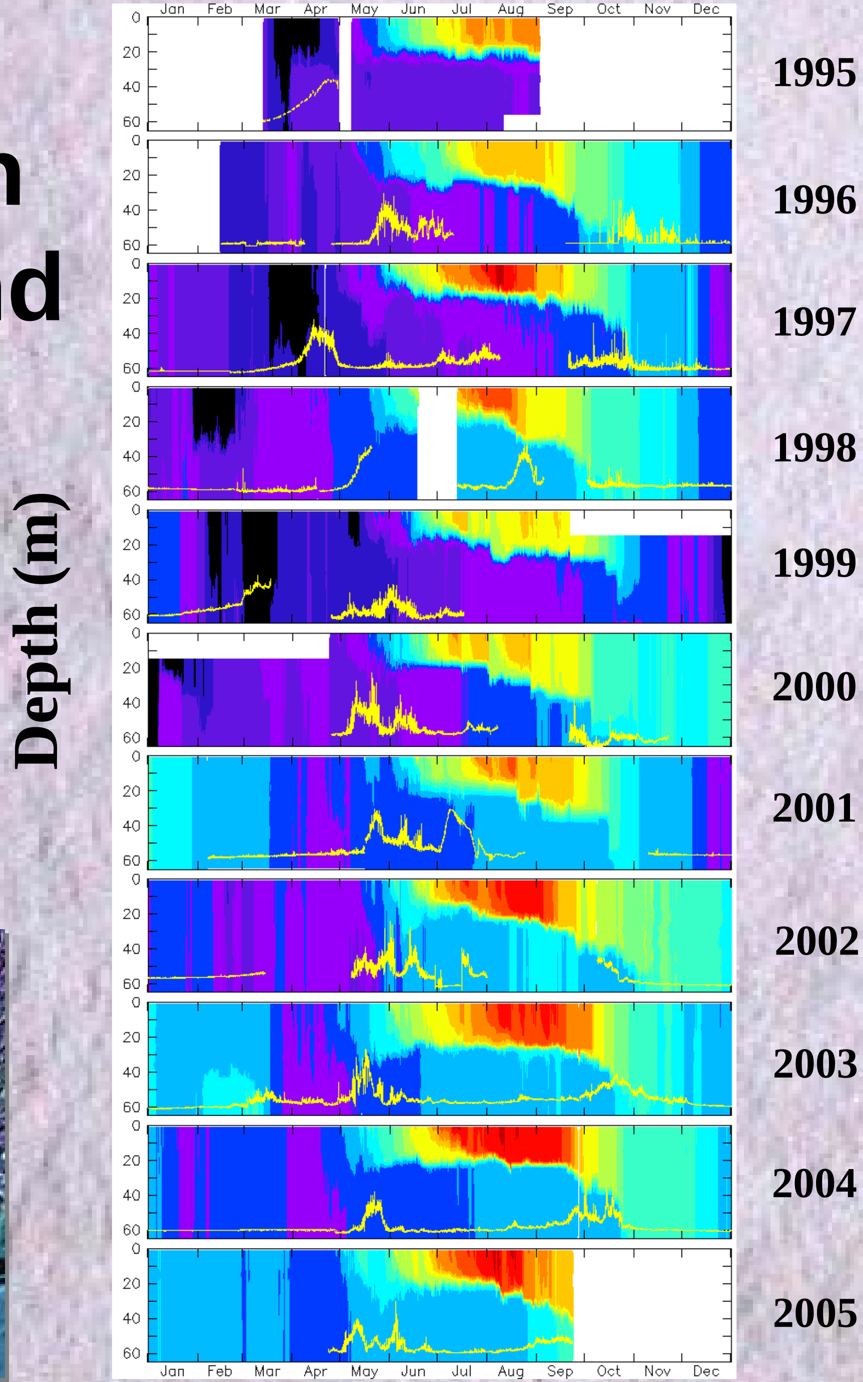
- Decreased ice cover since late 1970s
- Very little or no ice 2000-2005, increase since 2006

Courtesy of Jim Overland, PMEL

Interannual and seasonal variation in water temperature and fluorescence

<u>Mooring M2, middle shelf, 70 m depth</u>

Fluorescence at 11-13m (yellow line)



Figures courtesy of:
Phyllis Stabeno
NOAA-PMEL
Seattle, WA

Timing of Ice Retreat and Type of Spring Bloom

	Bloom Occurs at Ice Edge	Bloom Occurs in Open Water
Ice Gone by Mid-March	0	11
Ice remains after late March	7	1 ?

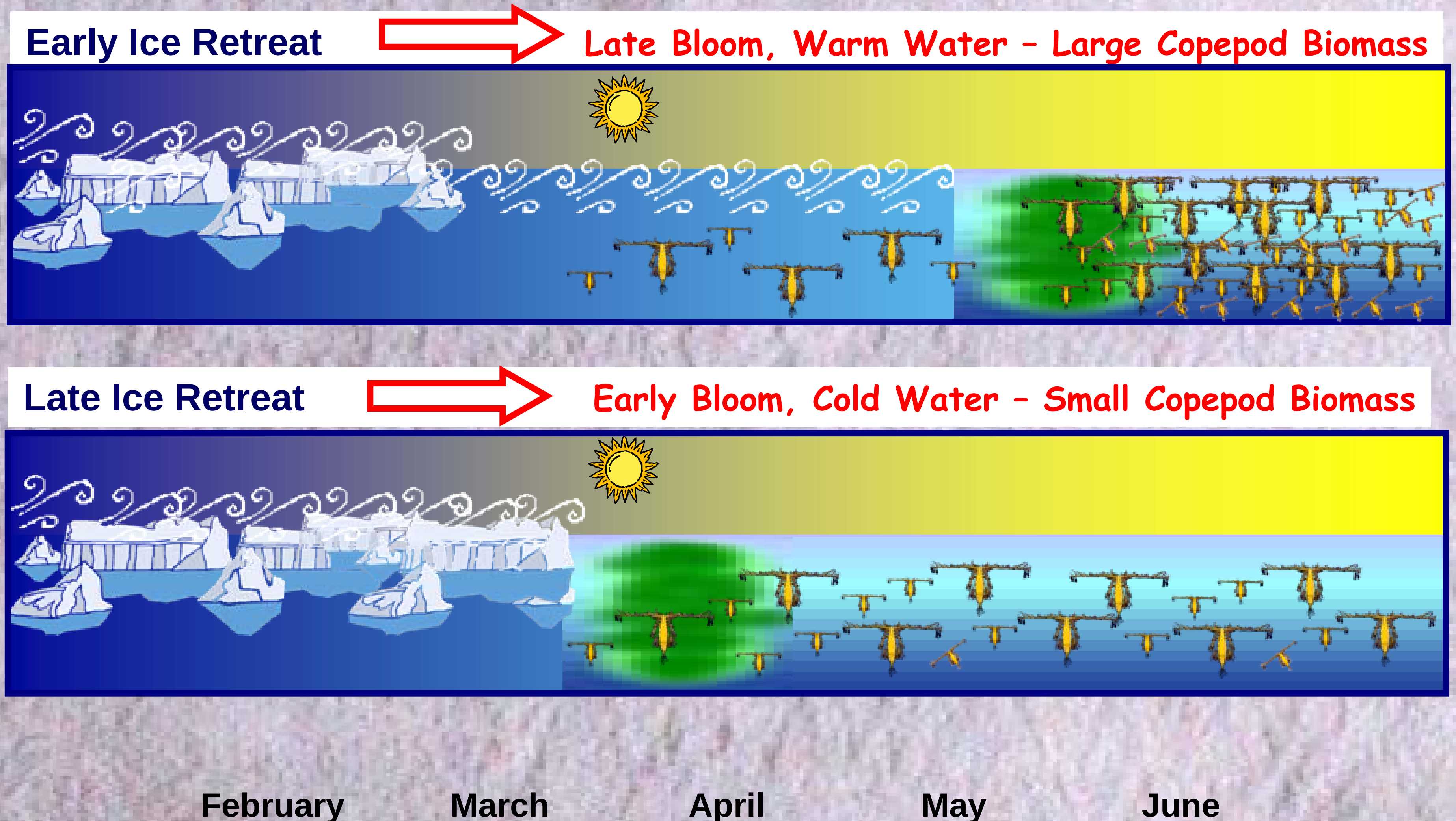
Hunt et al., 2002

Variation in Copepods (# m^{-3}) with Temperature, SE. Bering Sea

Variable	Year			
	1997	1998	1999	99 Change
Onset of Bloom	Mid-April	Early May	Late March	
Mean temp. °C	3.76	3.45	**0.32**	**-3.29** °C
Acartia spp.	961	711	**64**	**-92%**
Pseudocalanus	1168	893	**240**	**-77%**
Calanus marshallae	34	72	3.7	**-97%**
Calanoid nauplii	616	626	**322**	**-48%**
Oithona similis	99	219	28	**-82%**

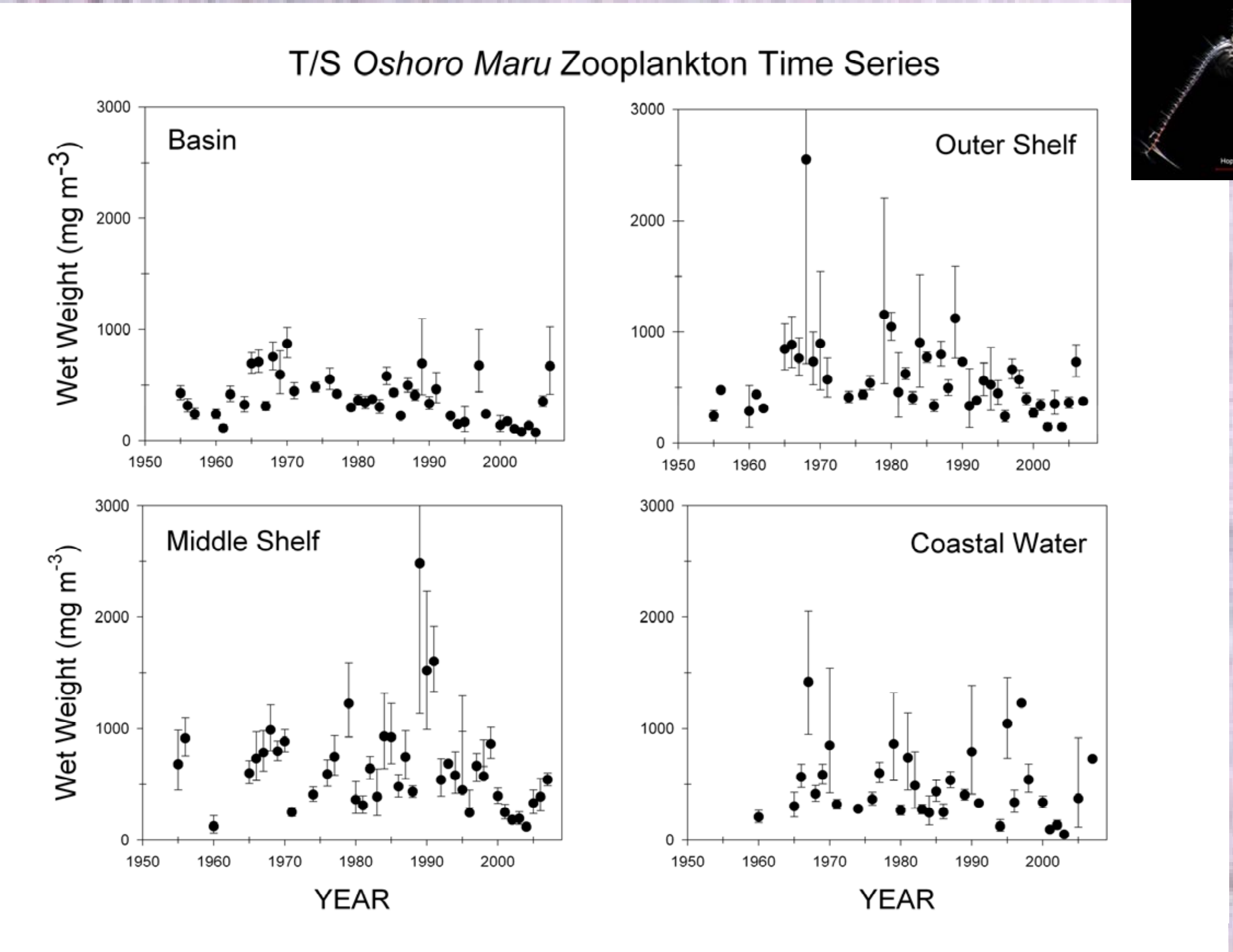
Coyle & Pinchuk, 2002

Ice, Wind, Bloom and Copepods



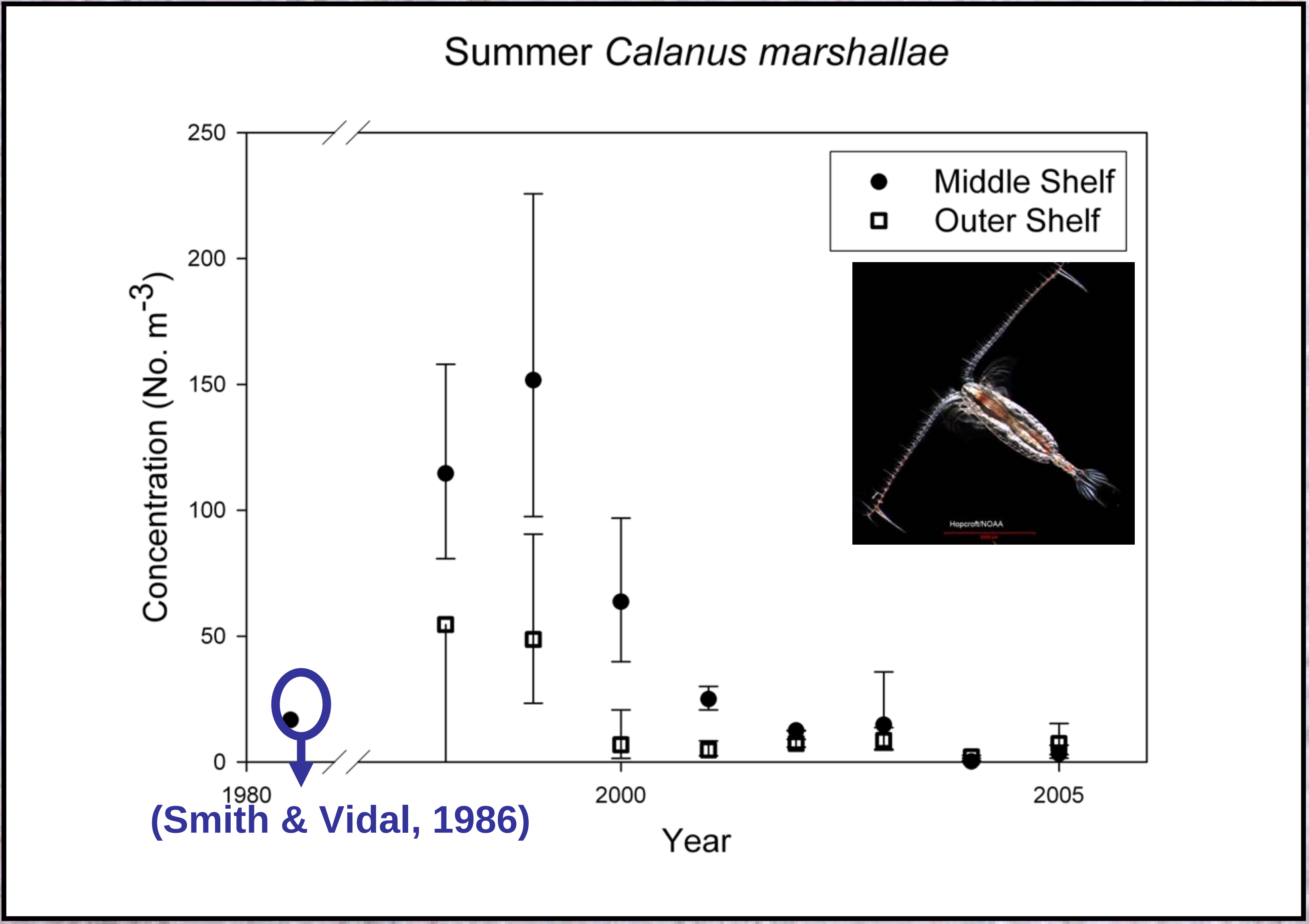
Hunt et al. 2002

Widespread Plankton Decline & Recovery

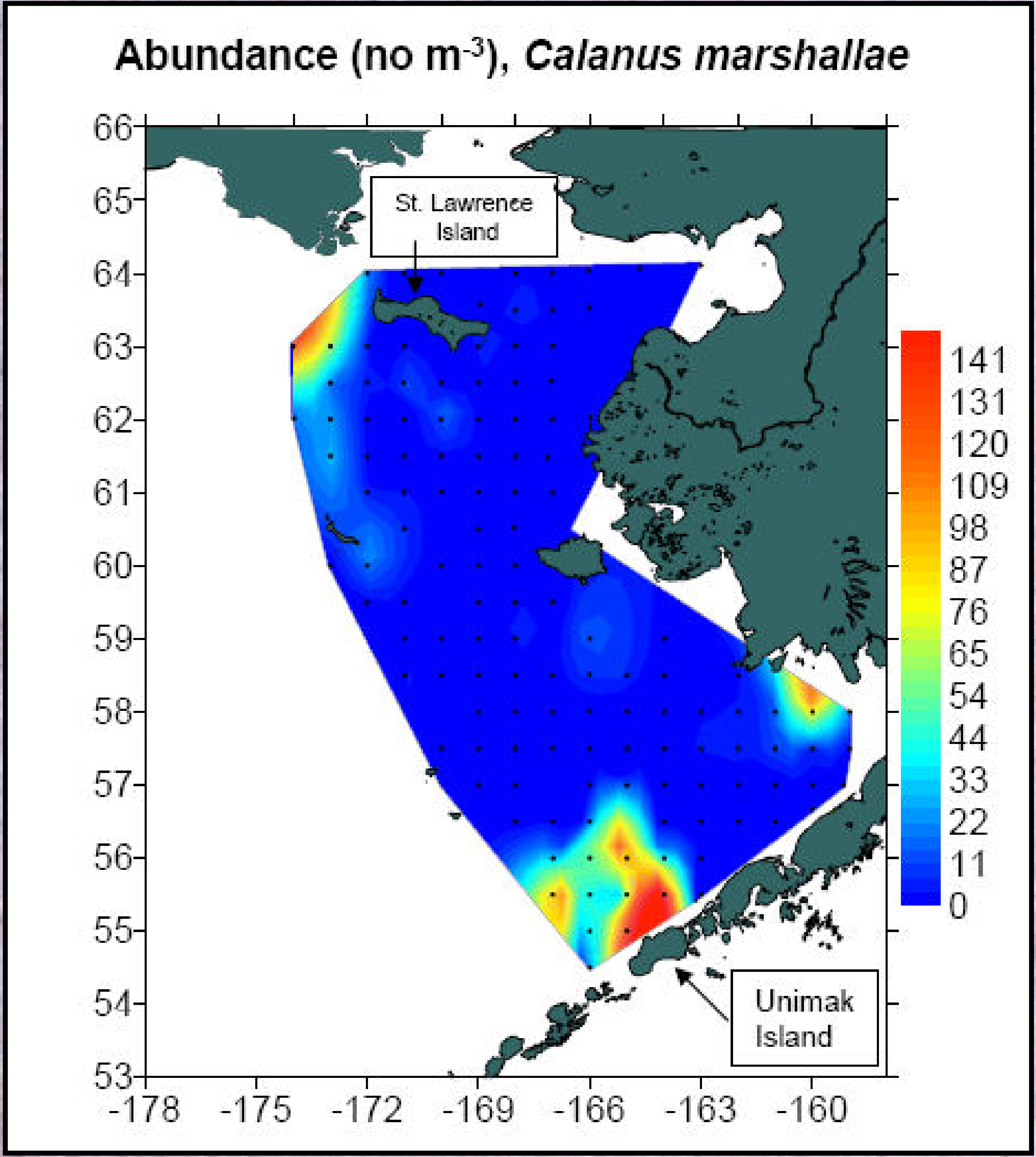


J. Napp / N. Shiga

Copepod Abundance



Courtesy of Napp and Shiga



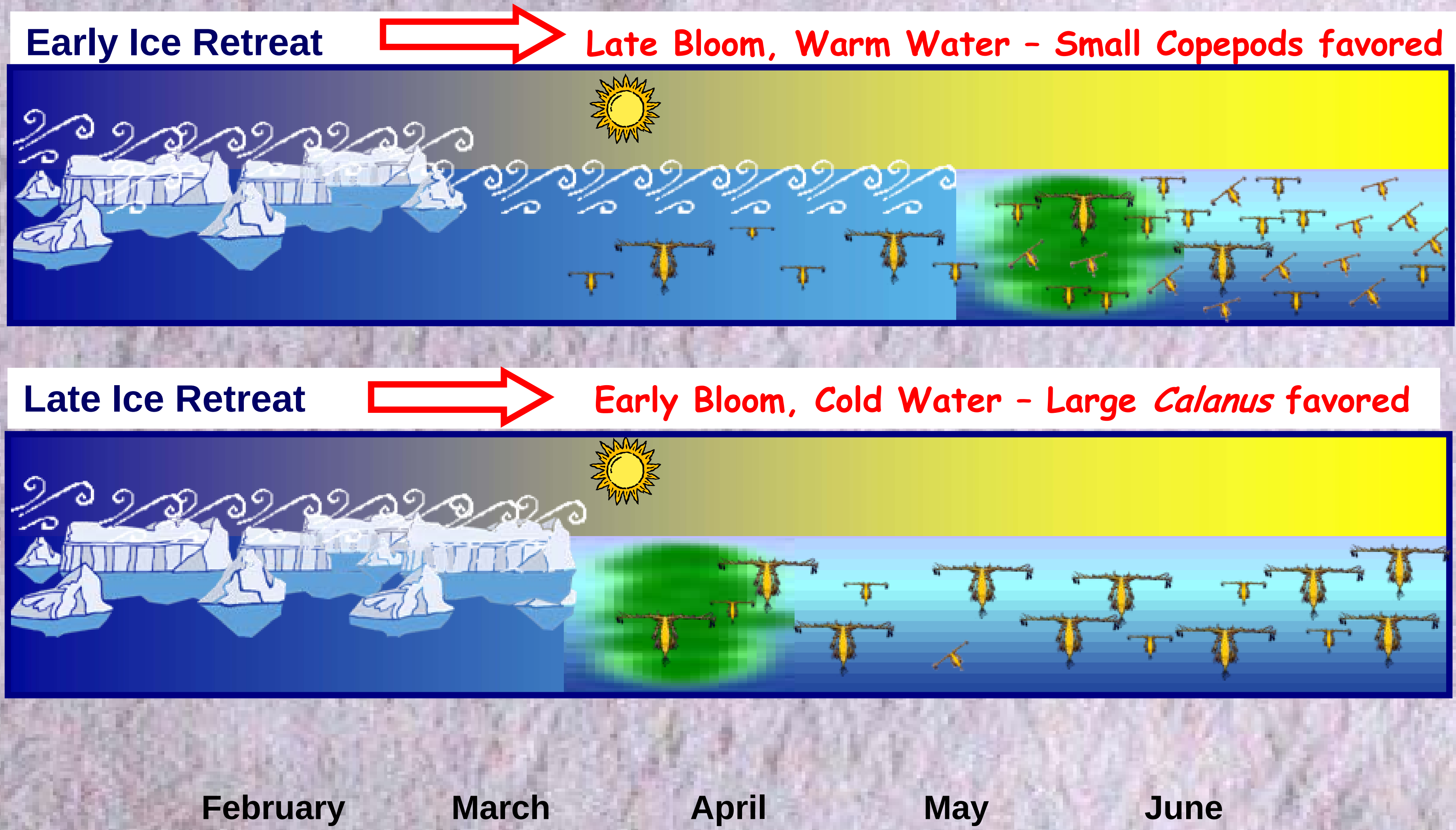
Coyle et al., 2008

Middle Shelf Copepods (No. m^{-3})

Summer 1999 vs. 2004

Data Type (from Coyle et al. 2008)	1999 (Cold)	2004 (Warm)	P value
Oithona similis	348	1633	0.000
Pseudocalanus spp.	404	1211	0.000
Acartia spp.	277	507	0.264
Centropagus abdominalis	0	$(2.96)^{-03}$	0.177
Calanus marshallae	44	$(8.13)^{-04}$	0.000
Calanoid nauplii	161	2.69	0.015

Ice, Wind, Bloom and Copepods

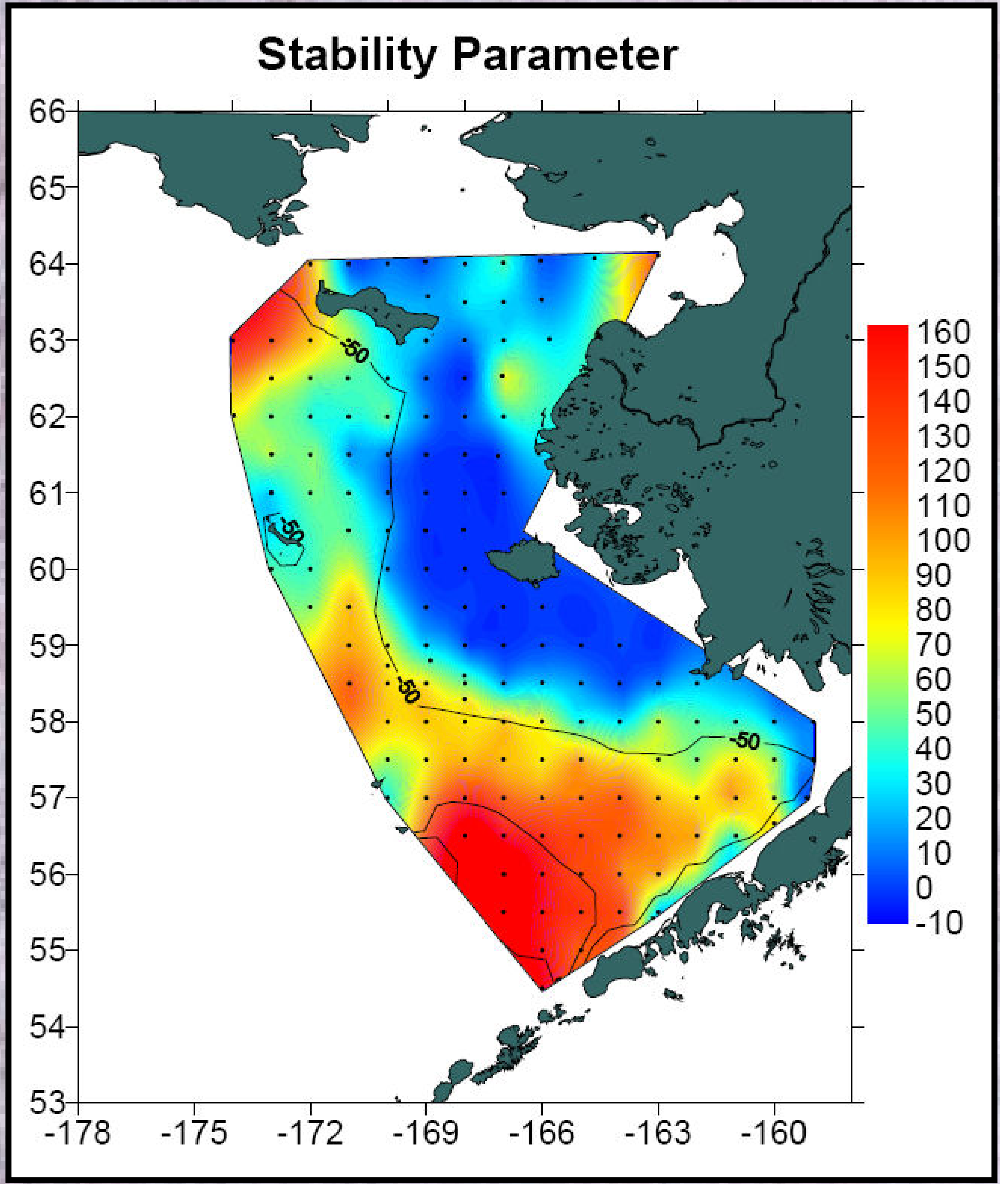


Modified from Hunt et al. 2002

Stratification at M2, 1999 vs. 2004

Data Type (From Coyle et al. 2008)	1999 (Cold)	2004 (Warm)	P value
Temperature, (ºC) Upper Mixed Layer	7.0	12.6	0.000
Temperature, (ºC) Bottom Mixed layer	2.0	3.2	0.000
Salinity, (PSU) Upper Mixed Layer	31.6	31.8	0.000
Salinity, (PSU) Bottom Mixed Layer	31.7	32.0	0.000
Stability Parameter (J m^{-3})	**34.9**	**98.4**	**0.000**

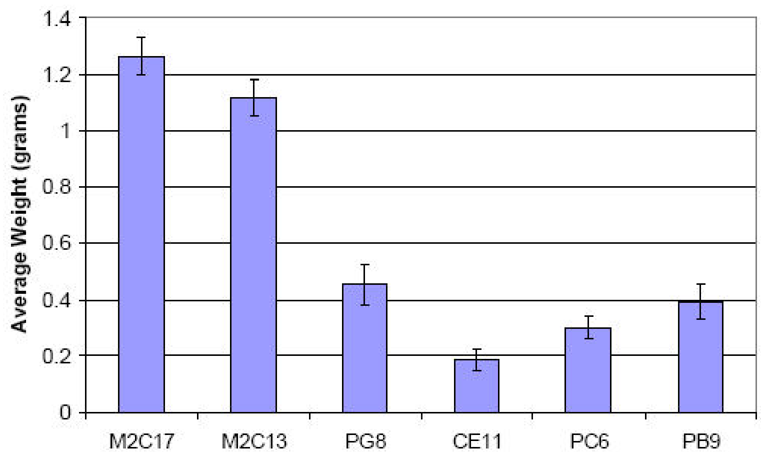
Water Column Stability
August-September 2004



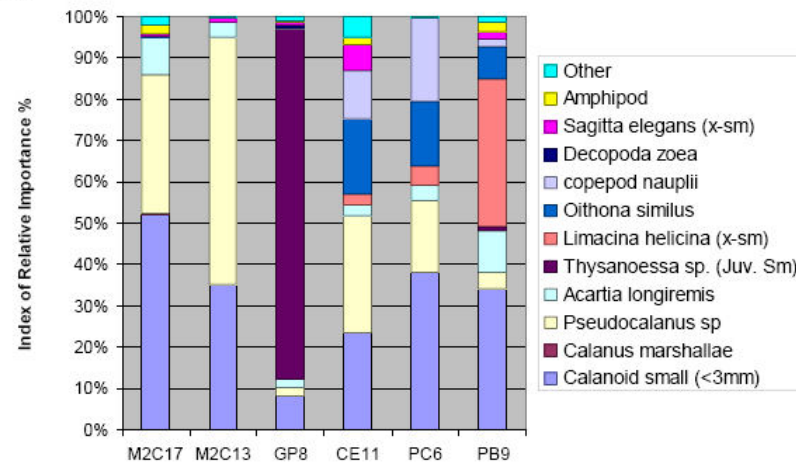
Parameter calculated by Ken Coyle from BASIS Data. Figure from Coyle et al., 2008

Age-0 Pollock Mass and Diets August 1999-2004

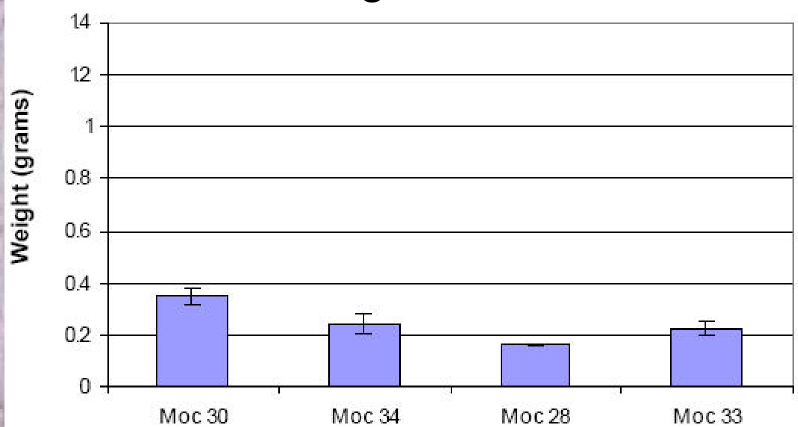
Mass August 2004 M2 & Pribilofs



Diets August 2004 M2 & Pribilofs

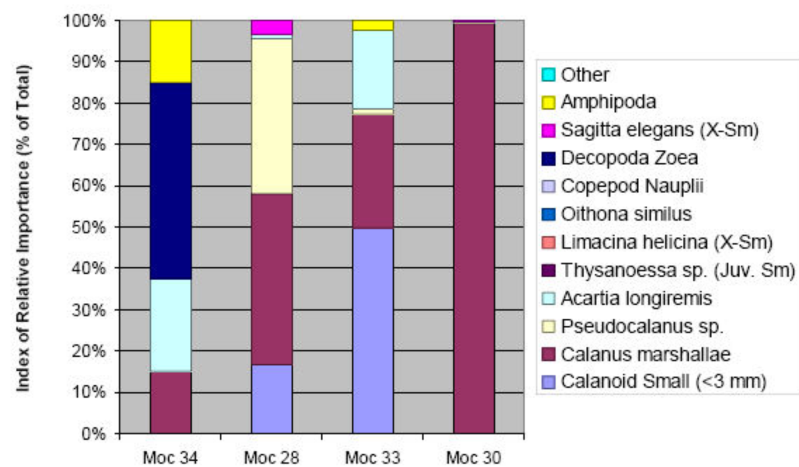


Mass August 1999 at M2



Collection Site

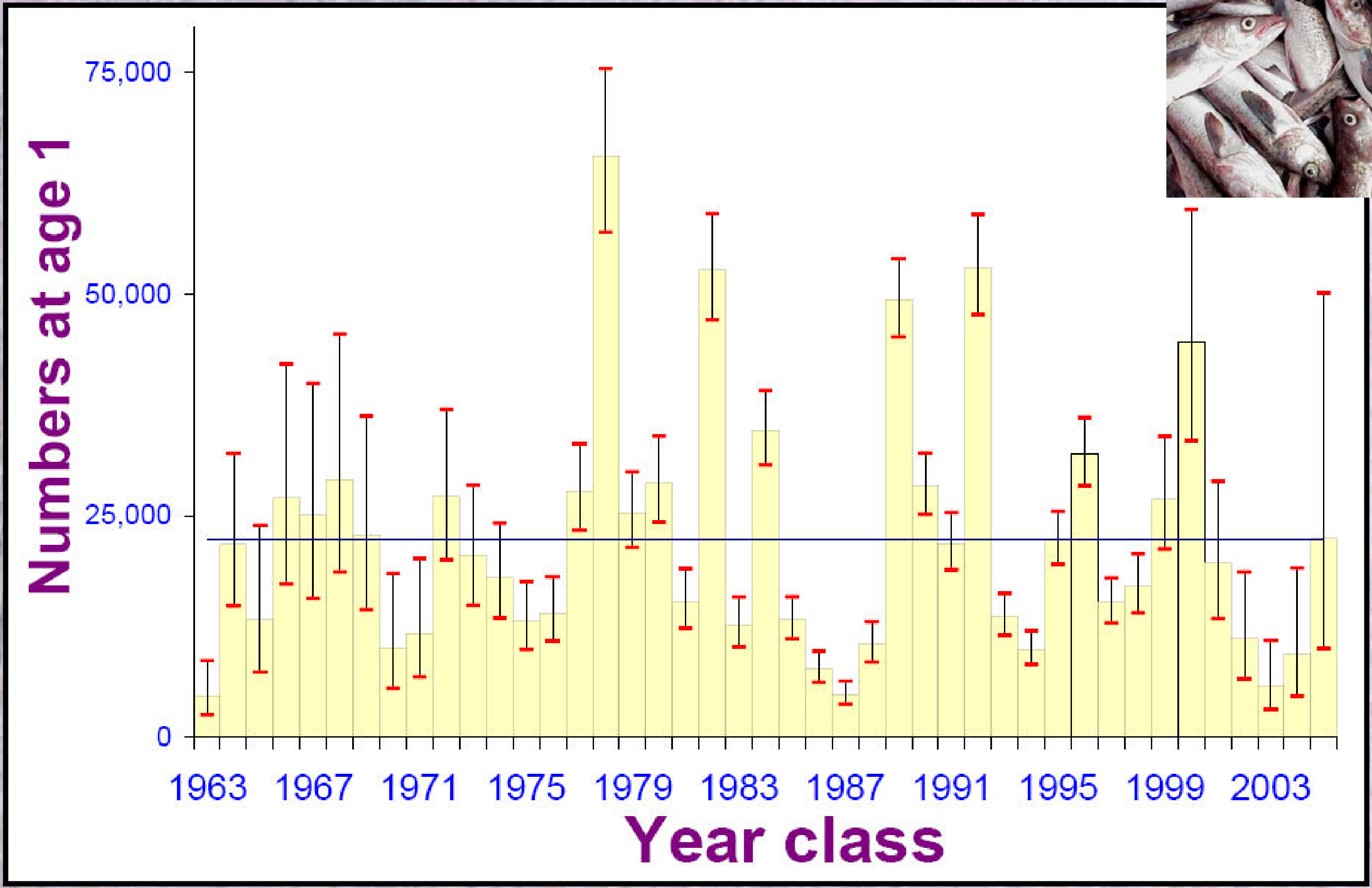
Diets August 1999 at M2



Collection site

Coyle et al. 2008

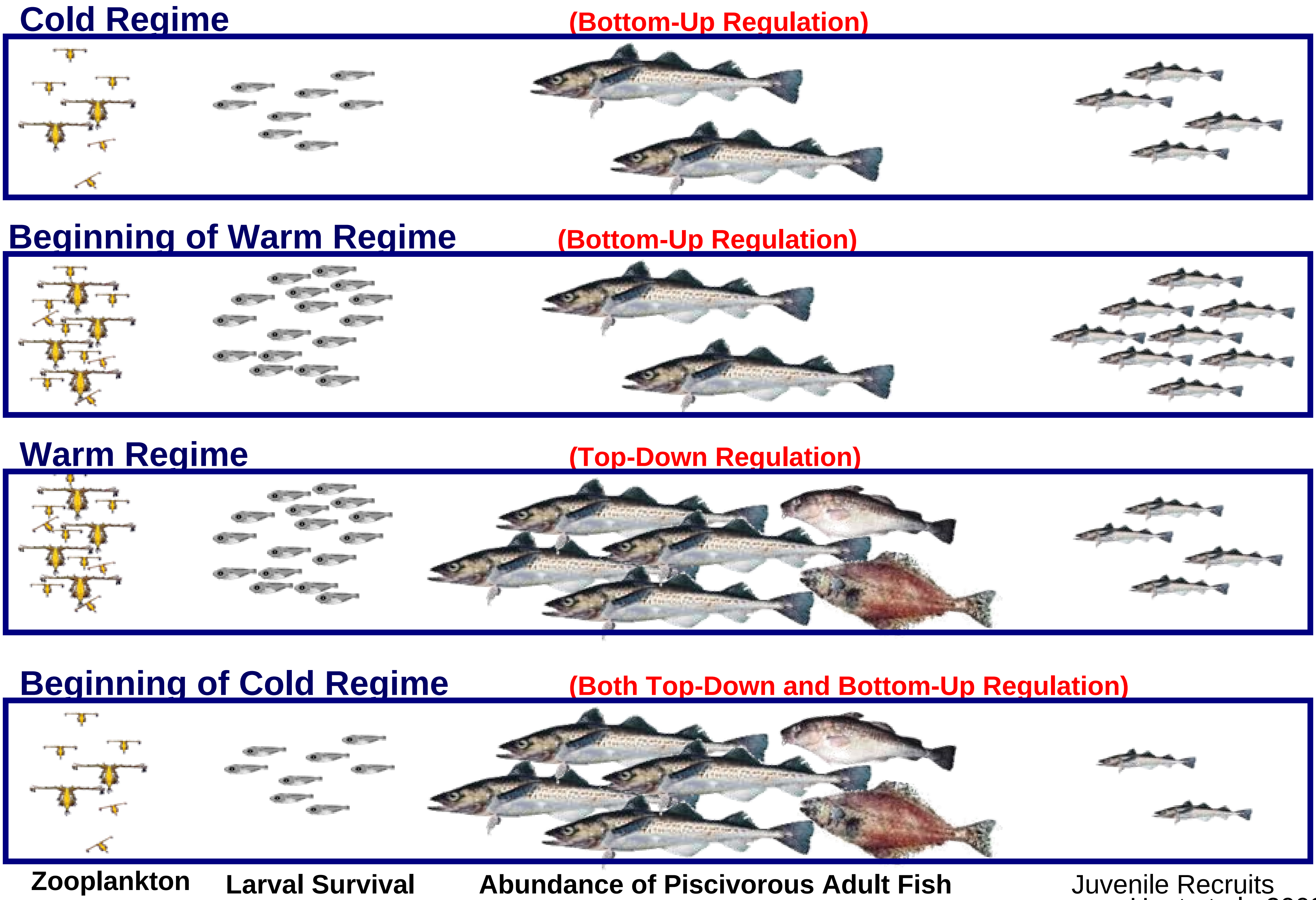
Walleye Pollock Age-class Strength



Numbers of age-1 pollock, in millions of individuals

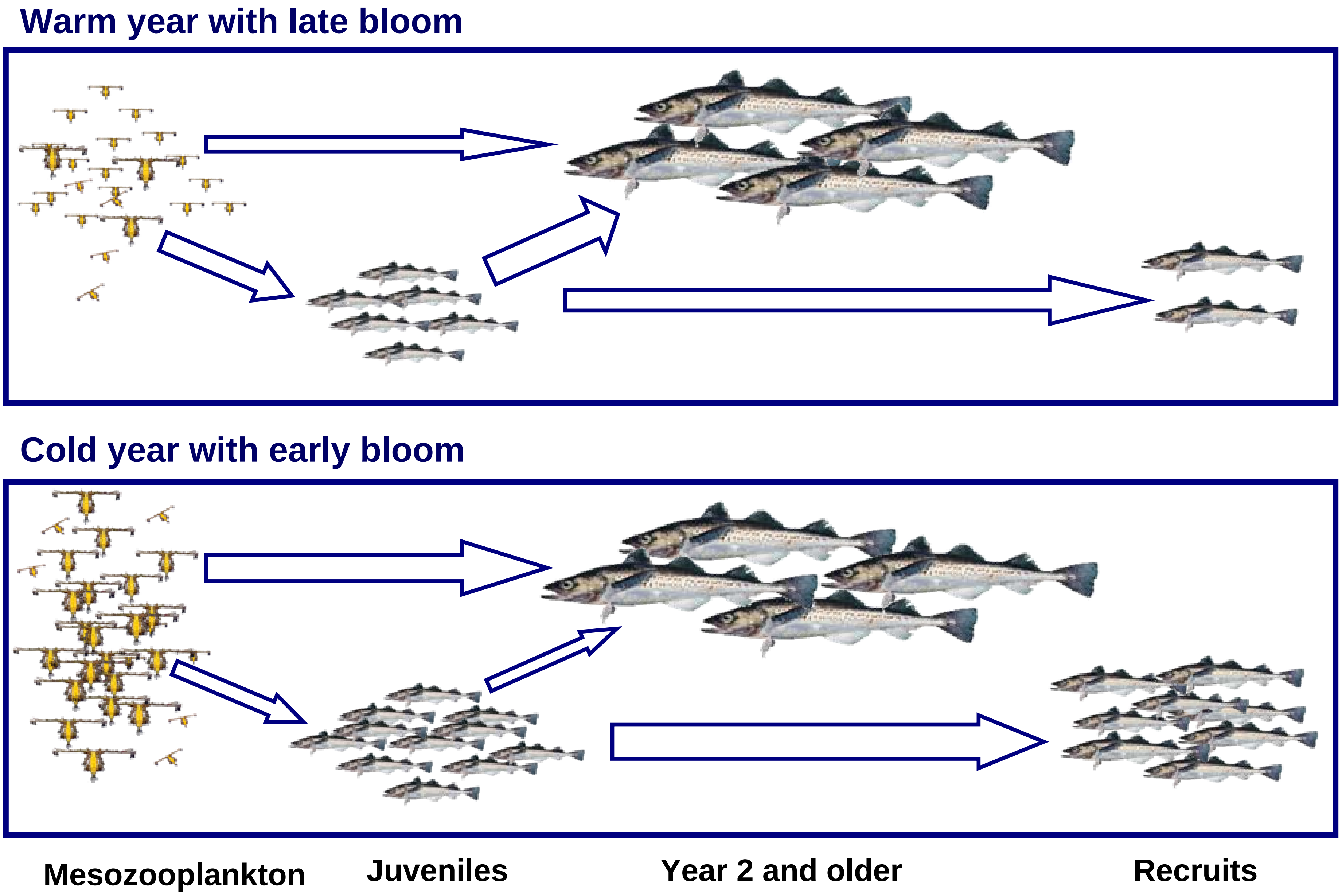
Courtesy Ianelli et al. 2007 SAFE

Oscillating Control Hypothesis



Hunt et al., 2002

Prey Switching Hypothesis (Cooney *et al.* 2001)



Issues Discussed

- **Changing sea ice cover**
- **Early ice retreat > late bloom in warm water**
- **Timing of bloom affects zooplankton**
  - **Large *Calanus marshallae* needs early bloom**
  - **Small shelf species do best with late bloom**
  - **Thus timing of bloom affects size of zooplankton available**
- **Events in spring set up summer conditions including stratification and types and amount of prey available**
- **Lack of large zooplankton affects survival of both age-0 and age-1 pollock**
  - **Hypothesize if no large zooplankton on shelf in summer, then increased cannibalism (and predation) of age-0 and age-1 pollock**
  - **Hypothesize lack of large zooplankton in late summer may affect over-winter survival of juvenile pollock (Mueter and Coyle talk to follow)**