Detecting Climate Change in Pacific Arctic Plankton

Carin Ashjian

Woods Hole Oceanographic Institution

WOODS HOLE OCEANOGRAPHIC INSTITUTION

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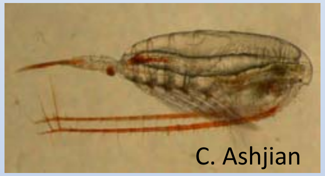
How might plankton change?

- Change in composition
  - Change in dominance (relative abundance, size composition) of endemic (Arctic) species
  - Increased proportion of non-endemic (Pacific) species
  - Ultimately, successful recruitment of non-endemic species

- Change in abundance
  - Increase/decrease of micro- and meso- zooplankton in response to changes in timing and quantity of primary production
  - Increase/decrease in abundance associated with other changes in the environment (e.g., warmer water, faster rates)
  - Increase/decrease in abundance associated with physical processes such as eddies, filaments, current pathways and transport

What determines the range of organisms and how might climate change change this?

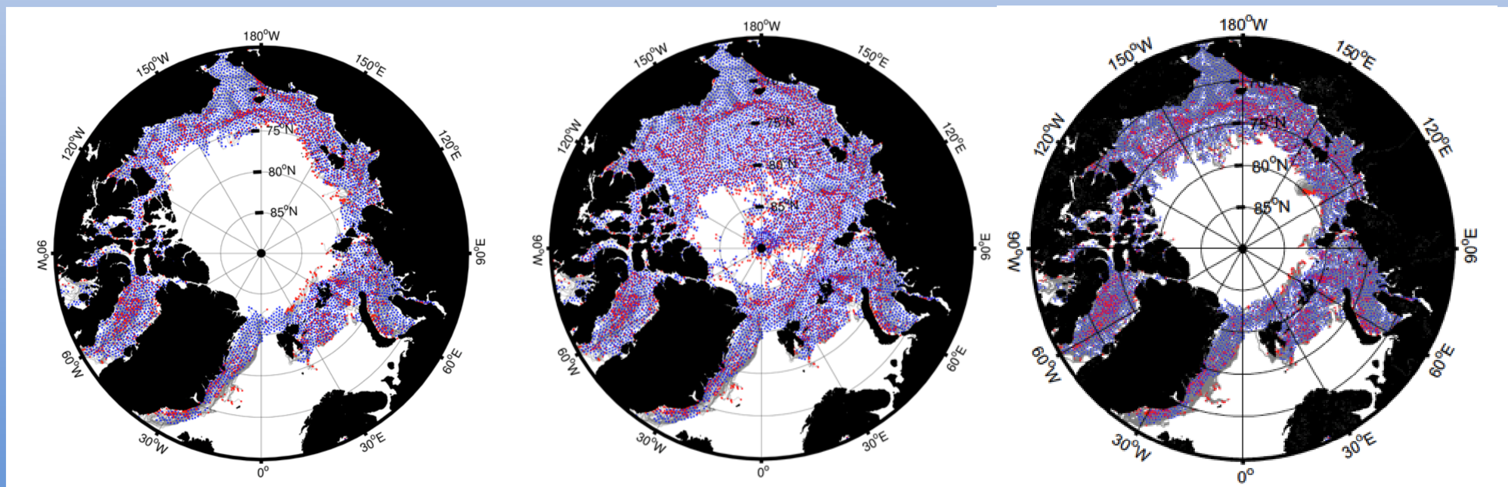


Arctic Copepod *Calanus glacialis*

Present Temperature and Growth Season Length

Temperature Increased 2° C

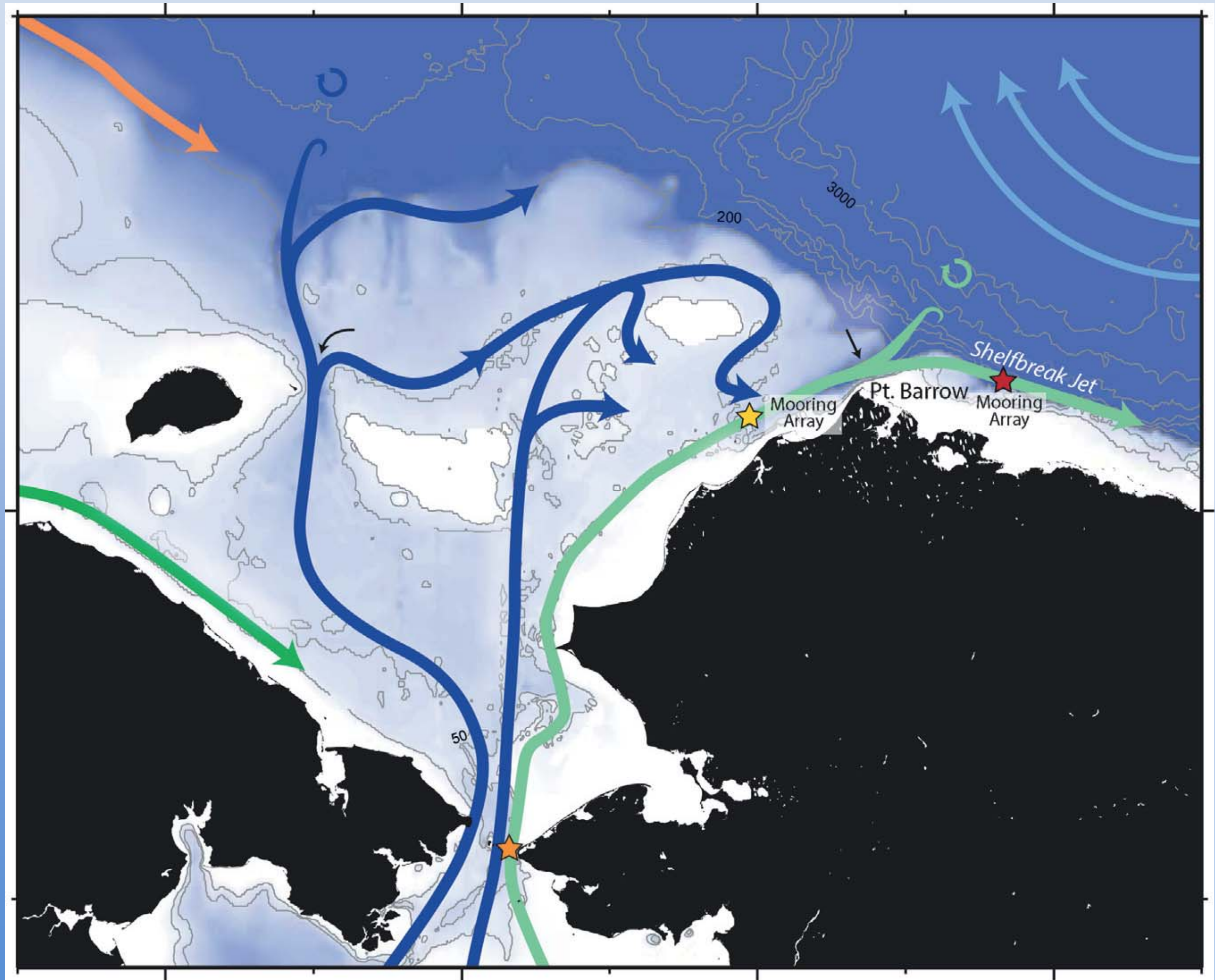
Growth Season Lengthened 2 Weeks



- A 2° C temperature increase greatly expands the potential range over which this species can persist. Lengthening of the growth season has a somewhat lesser effect

Ji, Ashjian, Campbell, et al. 2012. Progress in Oceanography 96: 40-56.

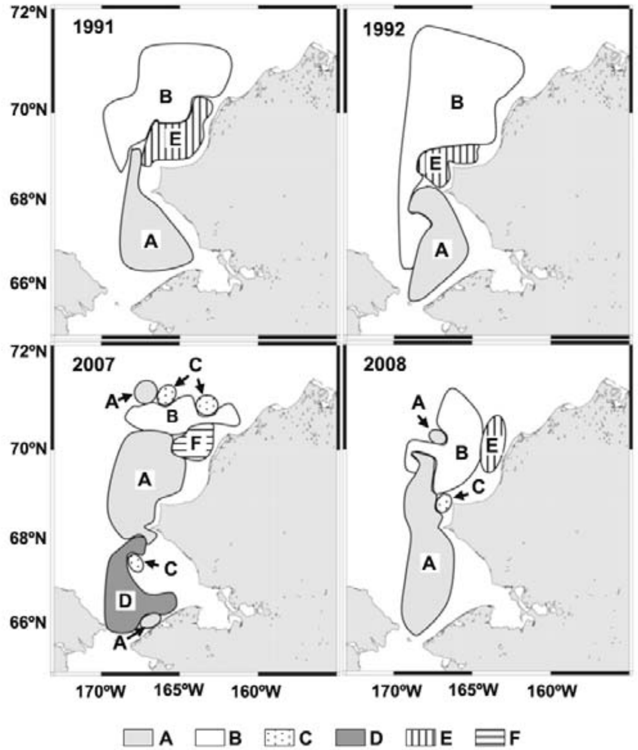
Chukchi Sea and ultimately Western Arctic plankton are critically impacted by input of Pacific Water and intrinsic plankton



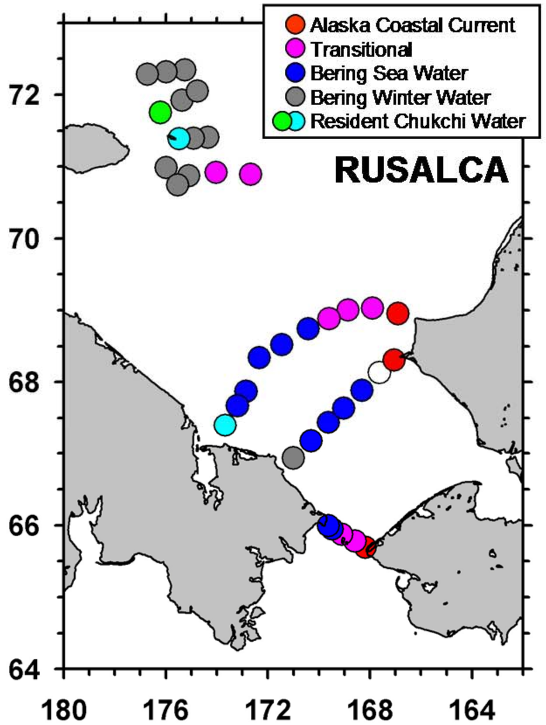
Brugler, Pickart, et al. 2014

Pacific Species already are present and likely always have been
- Abundance MIGHT be increasing (increased transport?)

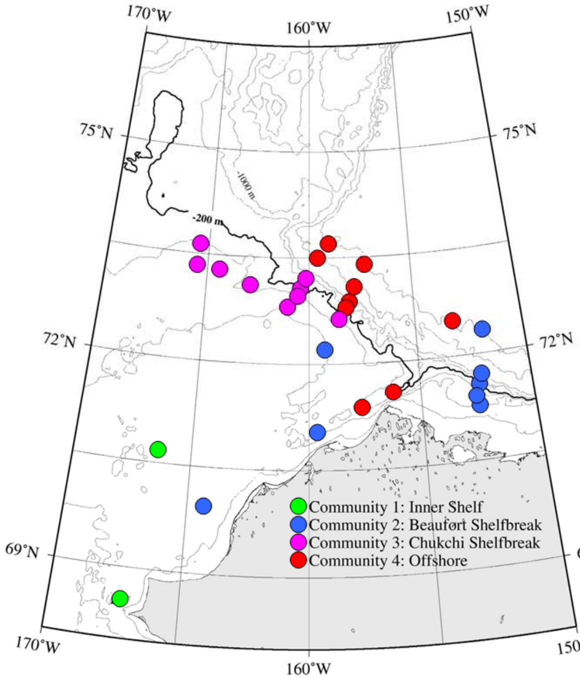
Groups A and D are Pacific types



Matsuno et al. 2011



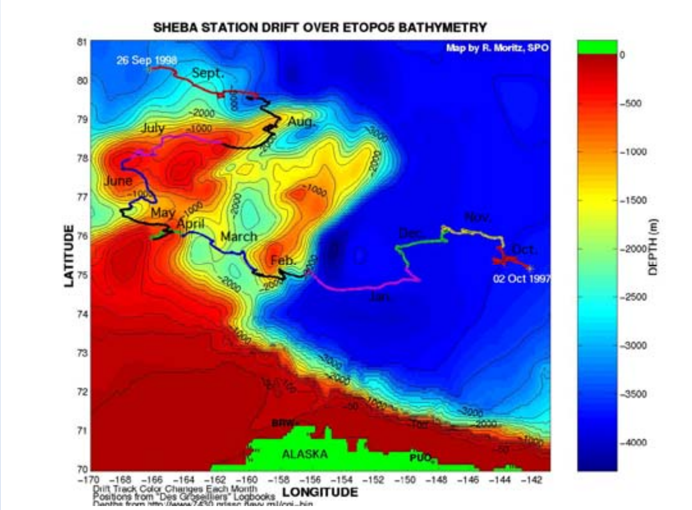
Hopcroft et al. 2010

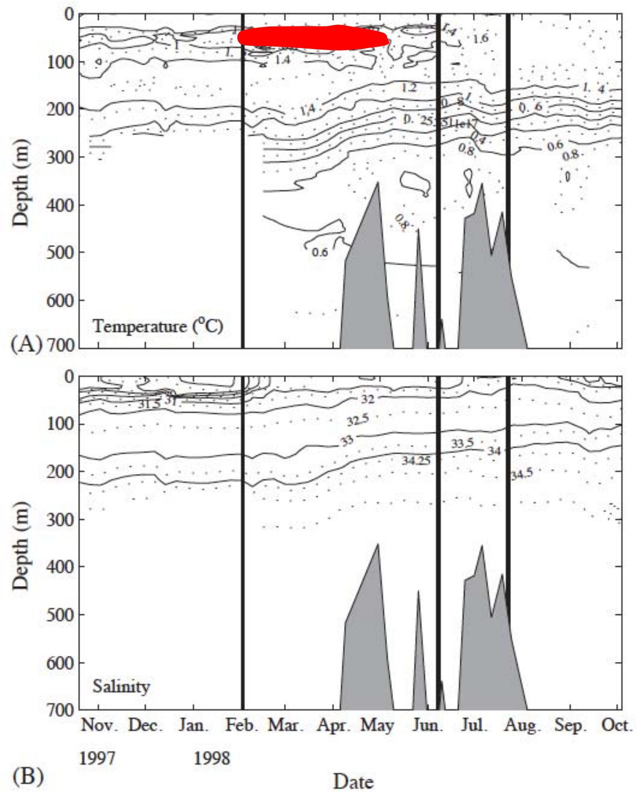


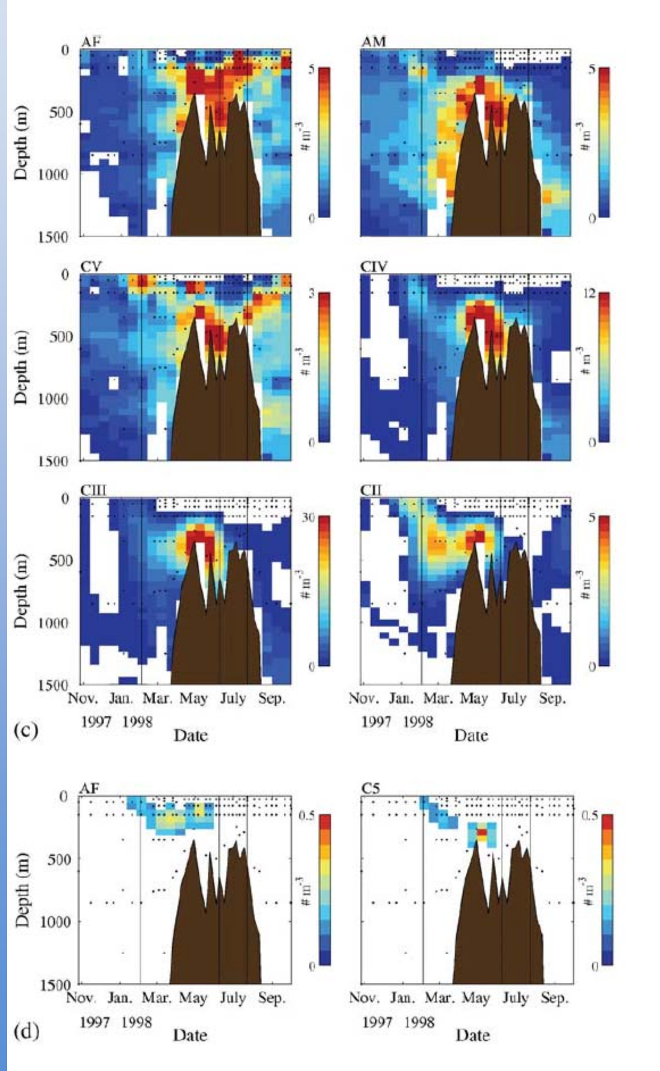
Ashjian and Plourde

Chukchi Sea is a flow through shelf –" River of Death" - for plankton if they cannot survive and persist in the Arctic environment

Pacific species are seen regularly north of Chukchi Sea but not highly abundant – will this increase in the future?





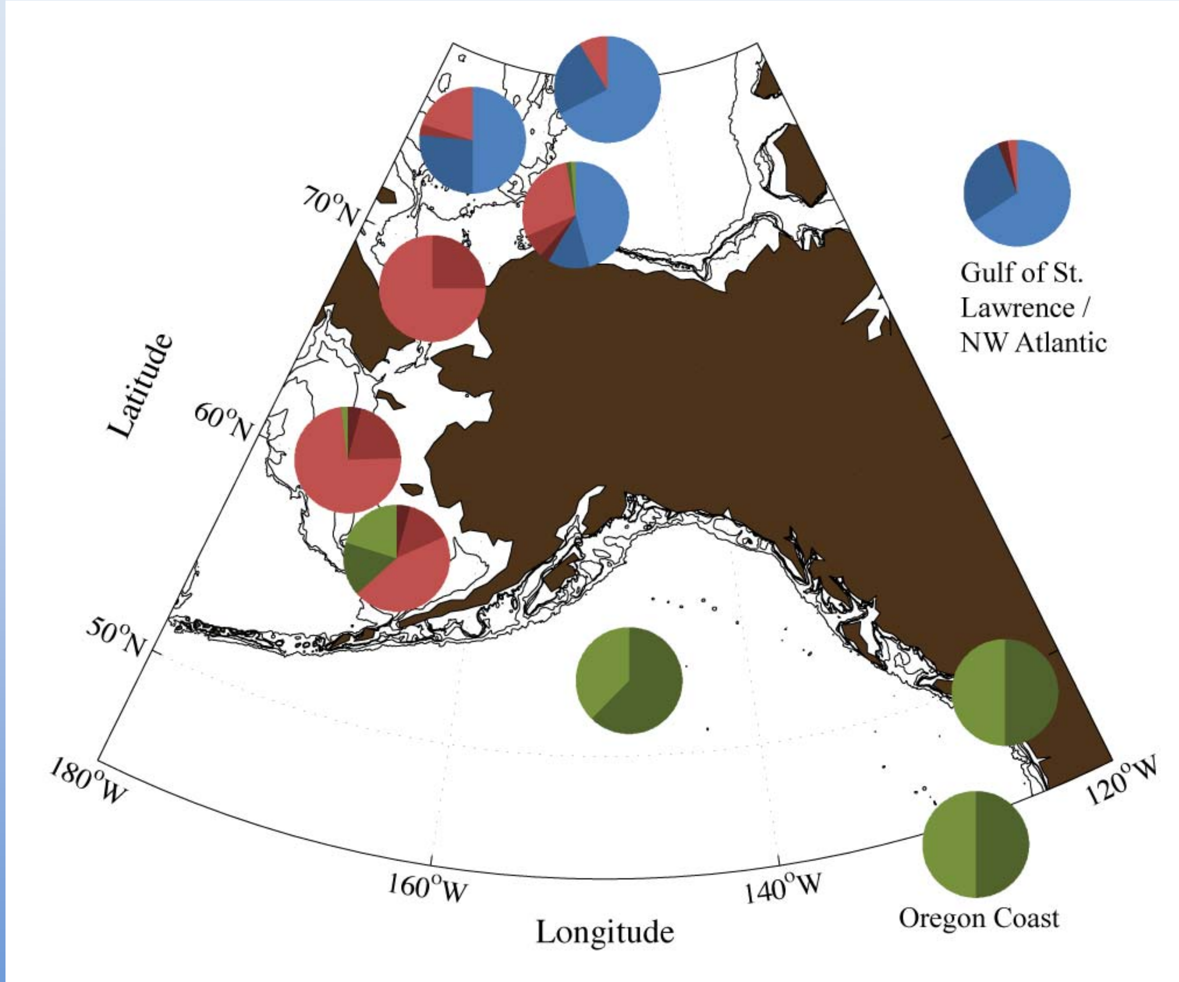


Metridia longa

Metridia pacifica

Ashjian et al. 2003

Calanus glacialis/marshallae: Population Genetics

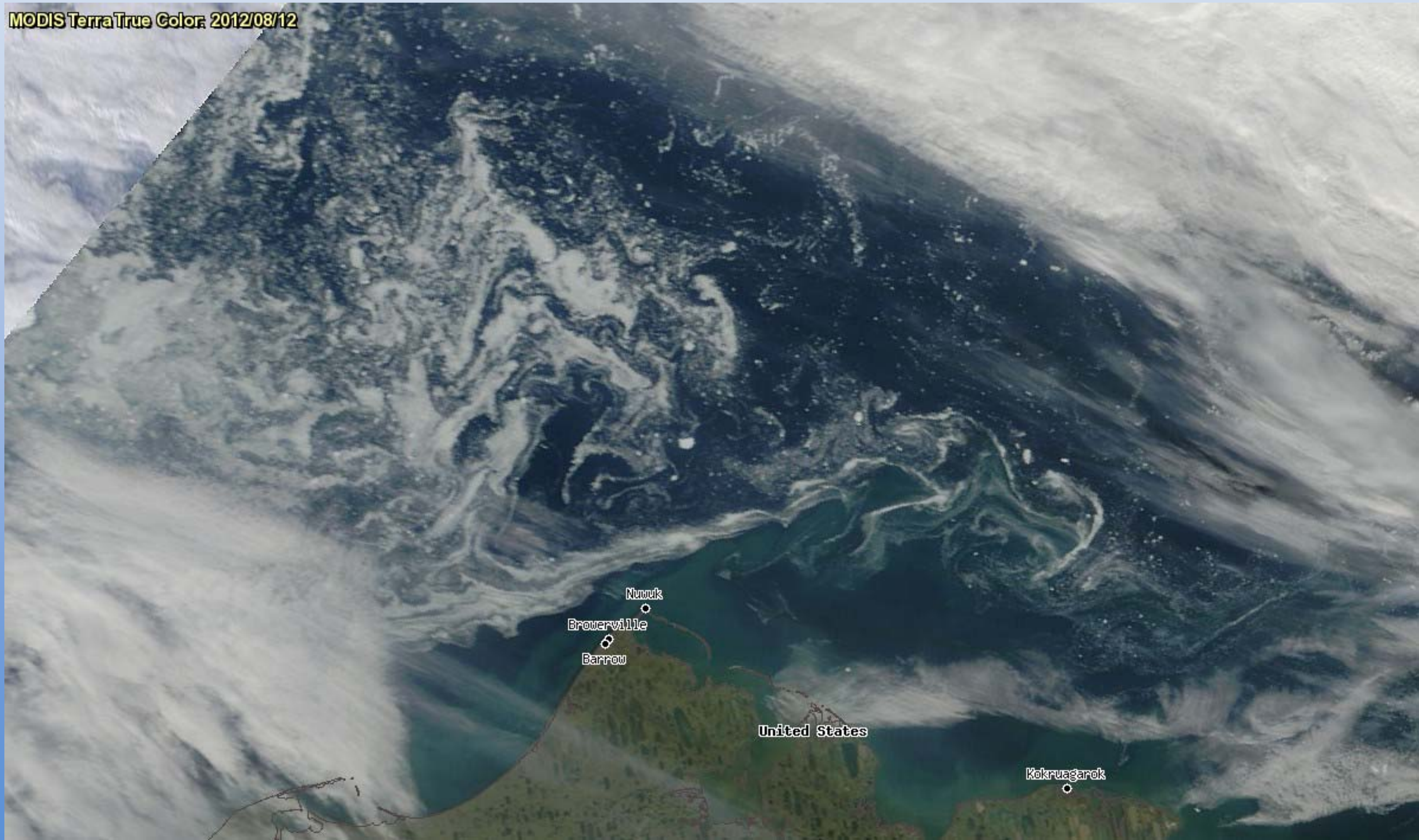


Mt COI gene sequences
Blues: Arctic *C. glacialis*
Reds: Bering *C. glacialis*
Greens: *C. marshallae*
(n = 1500)

Additional samples for genetic sequencing generously provided by B. Frost, G. Parent, B. Peterson, and A. Pinchuk

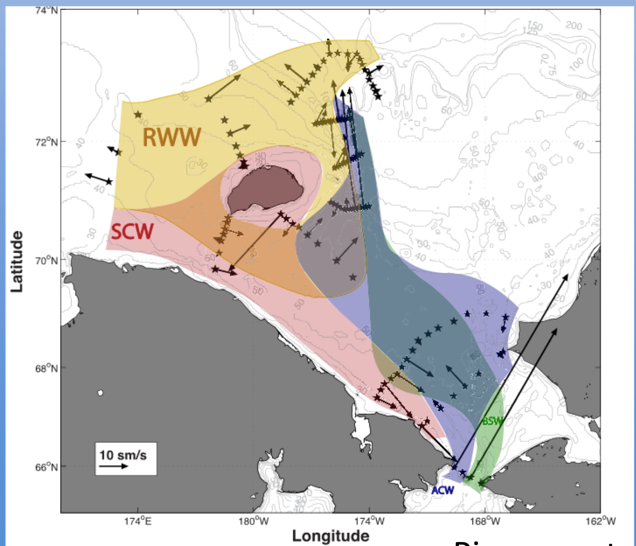
- Arctic and Bering populations of *C. glacialis*
- *C. glacialis* is the dominant form in the Bering Sea
- *C. marshallae* is mostly restricted to the southern Bering Sea
- Northward extension from population centers consistent with predominant current flow

Physical features are critical to determining the distributions of plankton

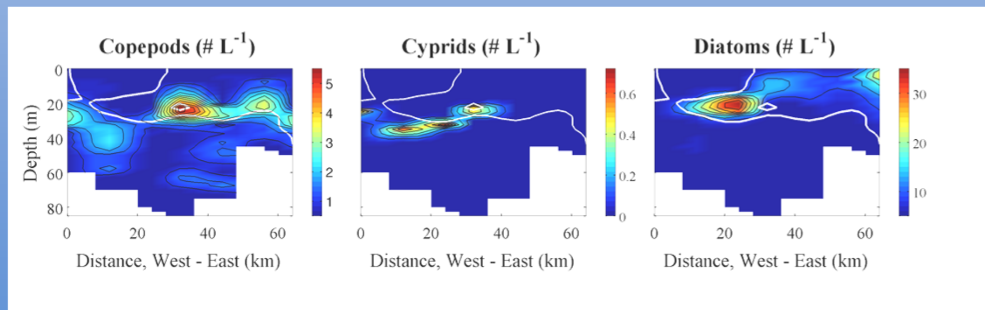


How can we detect importance of physical processes in driving biological distributions?

- Geographic Distributions: Water column plankton distributions associated with water masses
- Feature associated distributions: Vertically discrete coupled biological-physical data

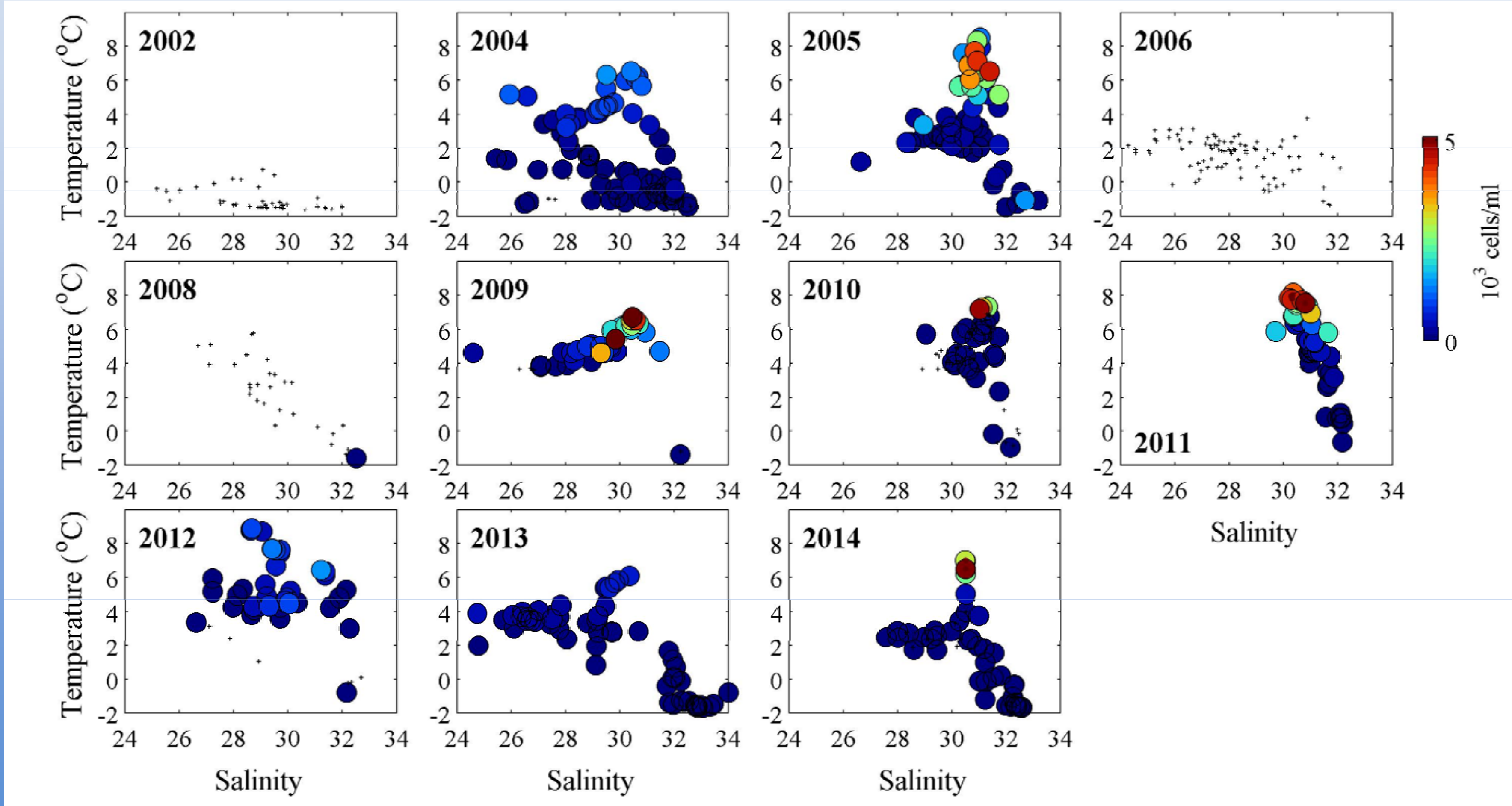


Pisareva et al.

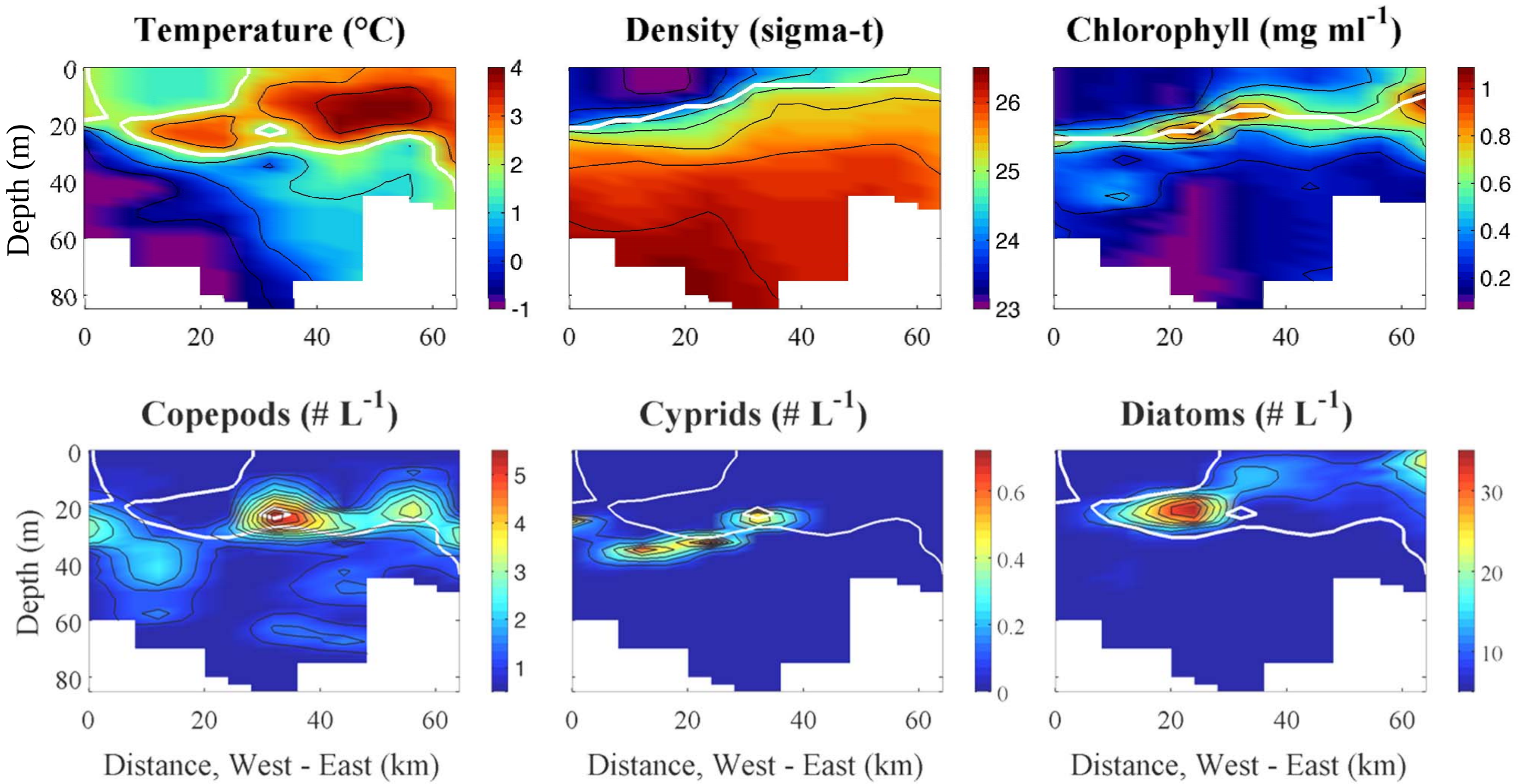


Ashjian et al.

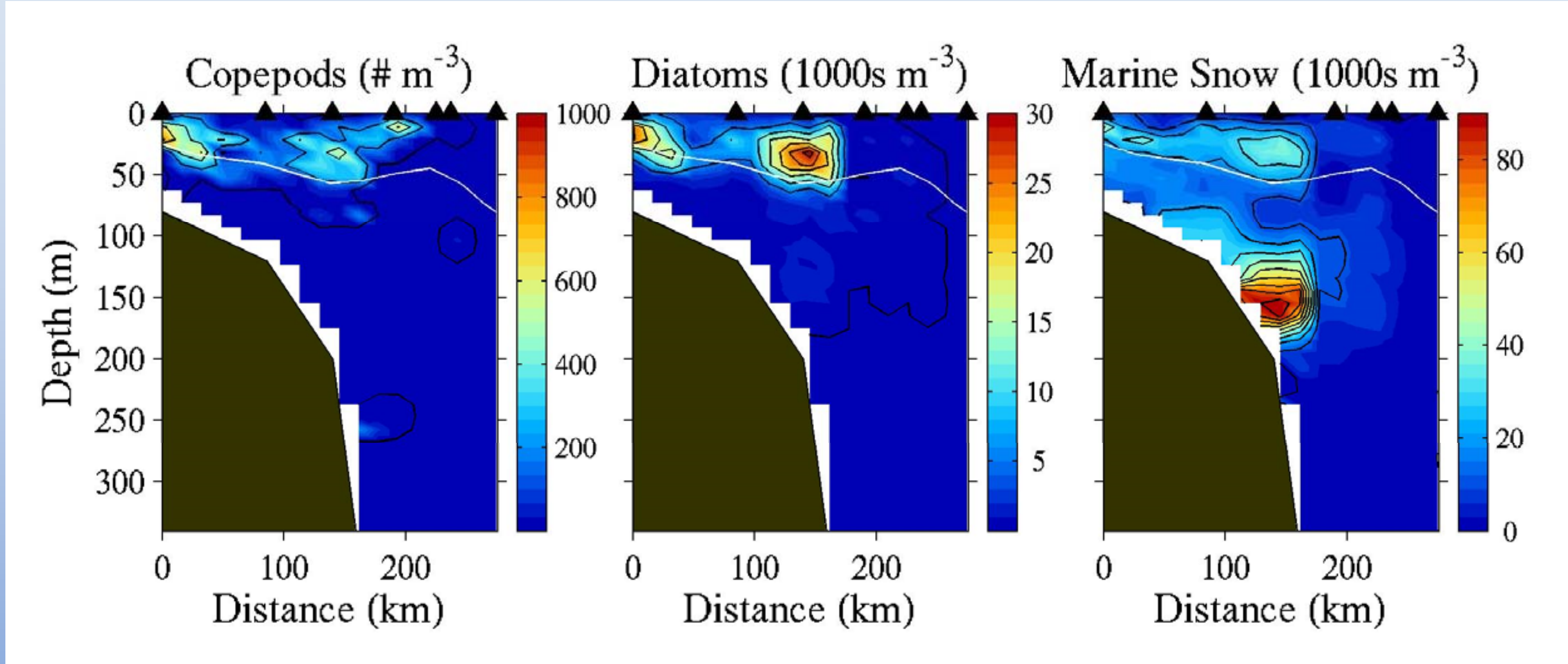
Synechococcus only highly abundant in Pacific Water near Barrow



Example of physical features and plankton distributions :Video Plankton Recorder data from a transect across Herald Canyon in 2009

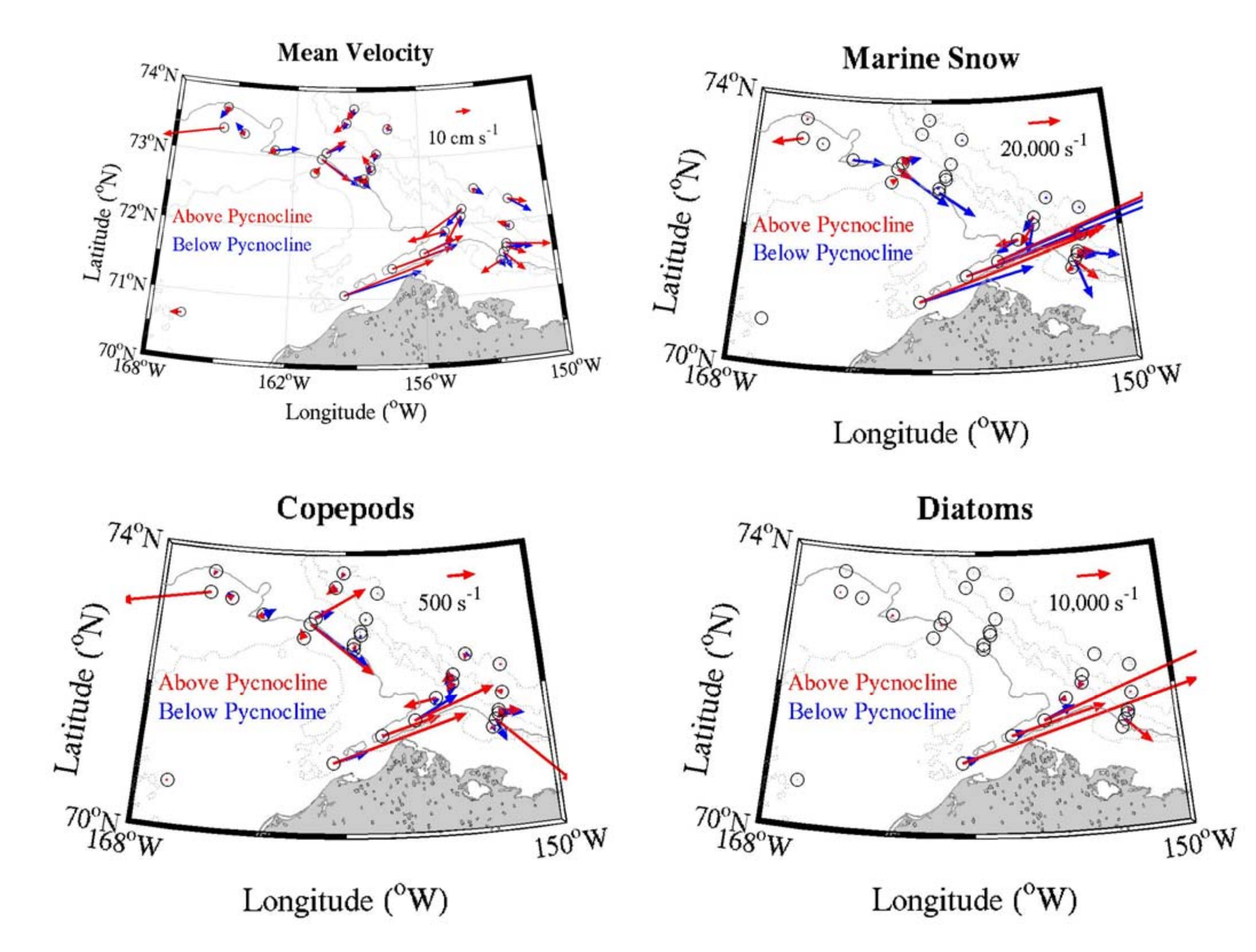


VPR Data from a Transect Along Barrow Canyon in 2002



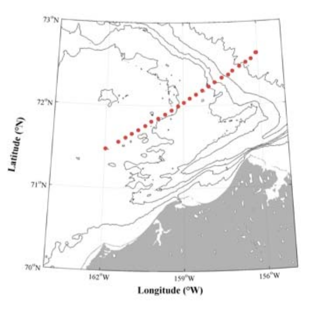
Ashjian et al. 2004

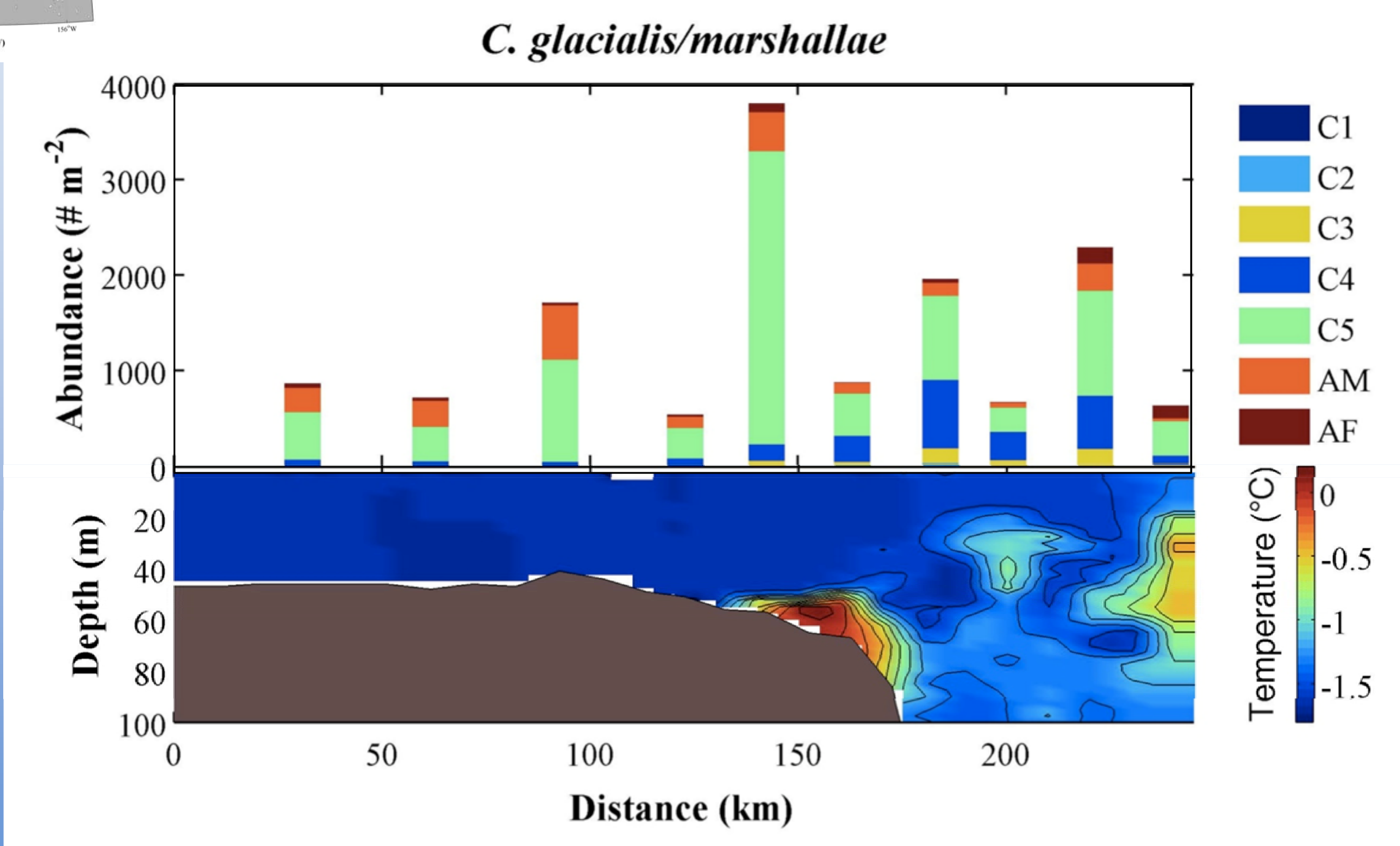
Vertical distribution of plankton and particles coupled to ADCP vectors reveals direction and magnitude of movement and differences in transport with depth



Ashjian et al. 2005

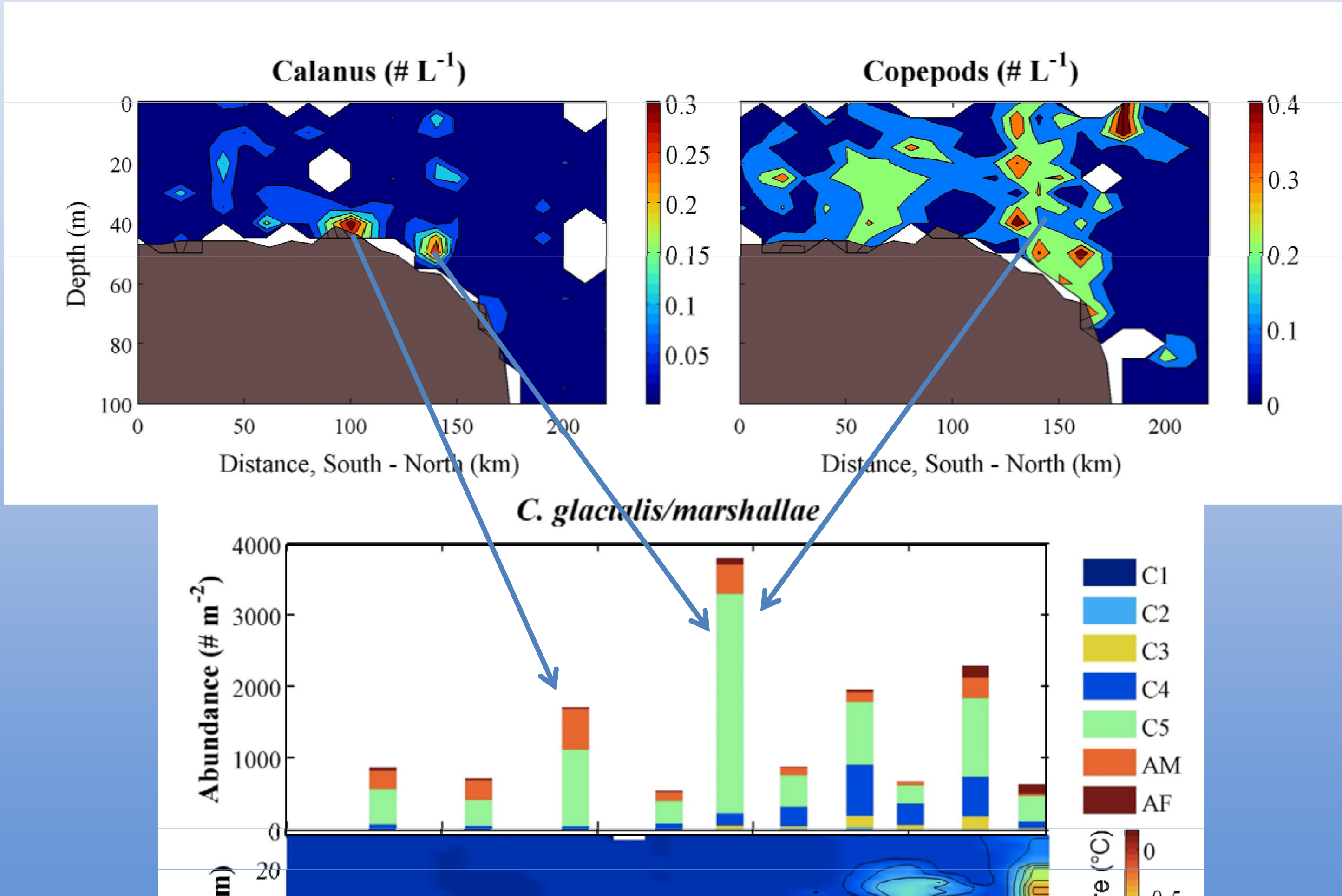
Calanus along the Hanna Shoal Transect



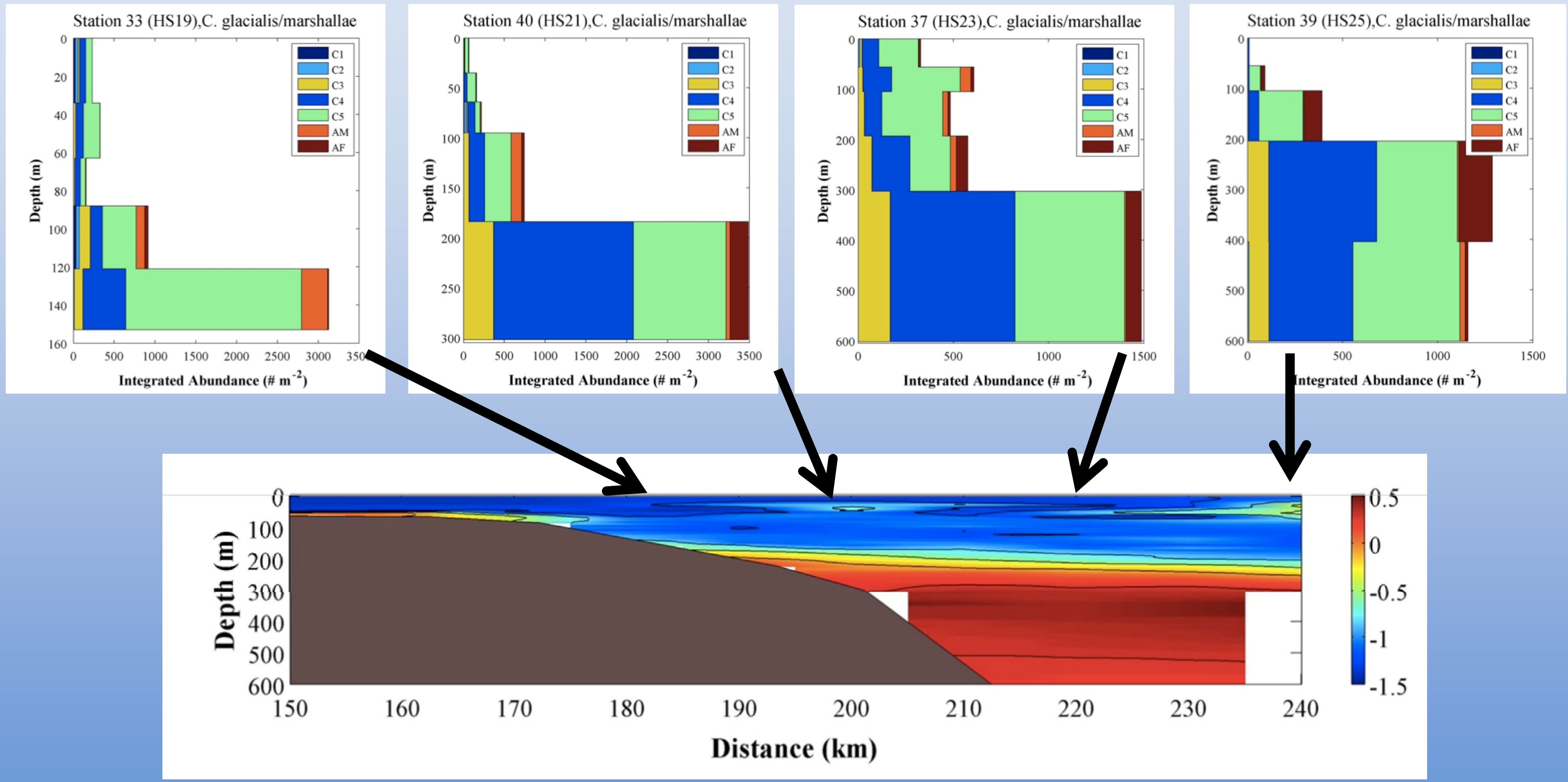


- Proportions of Copepodid 3 & 4 increased at the shelf break and in the basin, where warmer water was found at depth
- There appear to be two populations: Chukchi shelf and Basin, with 1 and 2-yr life cycles, respectively

Vertical distributions from a Video Plankton Recorder reveal additional information

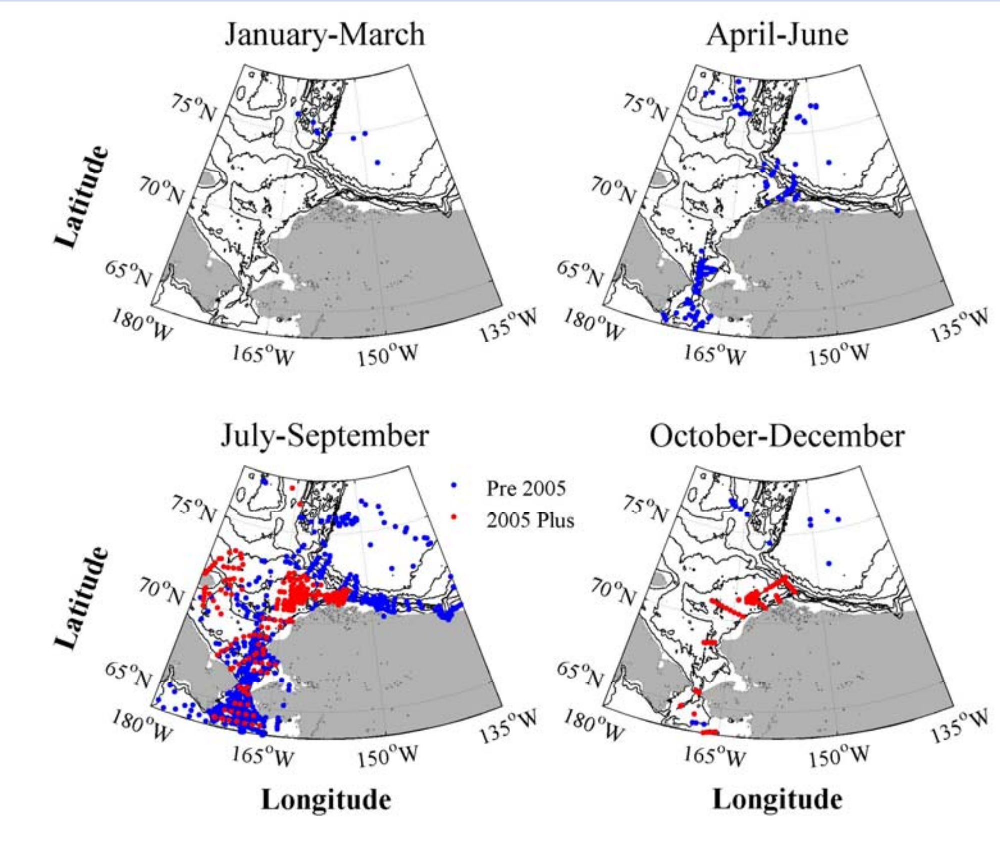


Vertical Distribution of *Calanus* from a Multinet



- Most *Calanus* were at depth, in the warm Atlantic Water in the basin or near the bottom in warm water at the shelf break – this is typical of a population thinking about diapause

How can we detect change?



Ashjian et al. in PacMARS report (Cooper et al., 2015)

- Compare abundance, distribution, and composition
- Difficult because of paucity of older data from proposed study area and of sampling inconsistencies (GEAR INCOMPATIBILITY) between older data and present data
- Data available for Western Arctic:
  - Older, ice camp work
  - SHEBA (1997-1998), SBI, 2004 Ocean Exploration, Araon expeditions, Japanese expeditions, 2014 SubIce Cruise (Chukchi)

Detection of Change

Greater zooplankton abundance and biomass

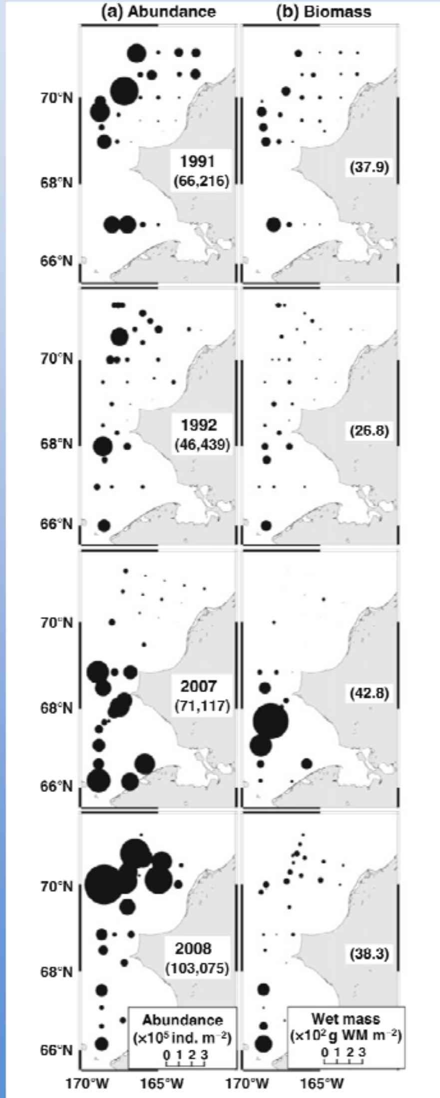
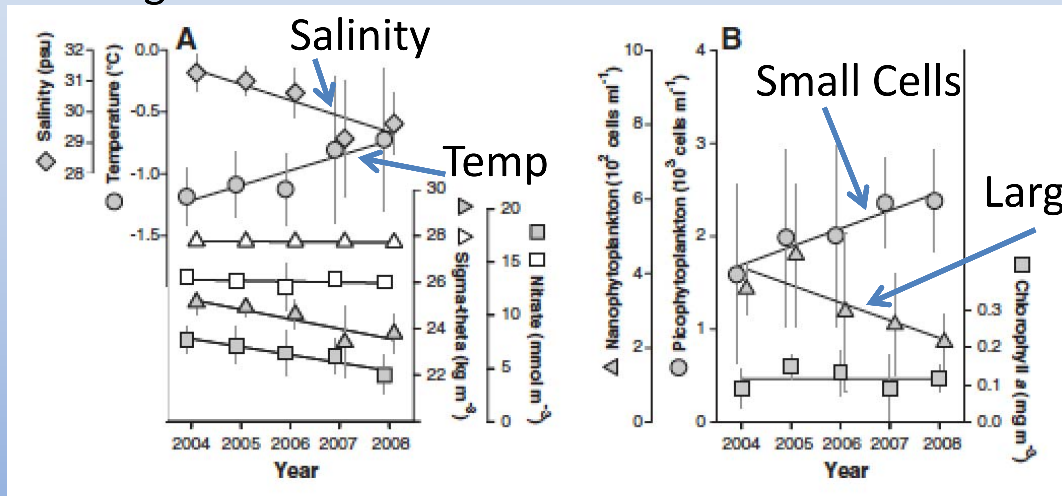


Fig. 4 Geographic distribution of the zooplankton abundance (**a**) and biomass (**b**) in the Chukchi Sea during July–August of 1991, 1992, 2007, and 2008. Values in the *parentheses* indicate mean values of each year

Matsuno et al. 2009

More small cells in Canada Basin with warming and freshening

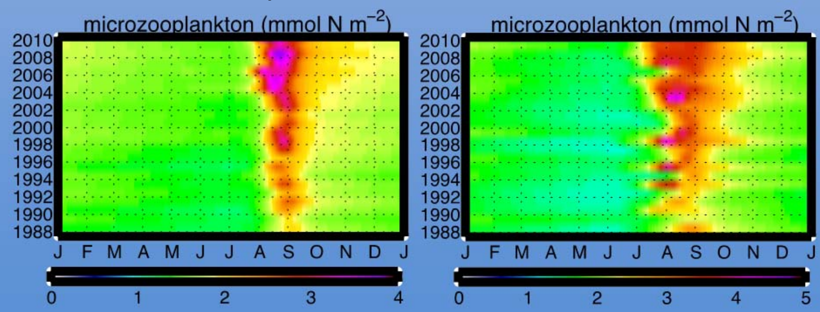


Li et al. 2009

Modeled microzooplankton increases

Arctic Deep Basin

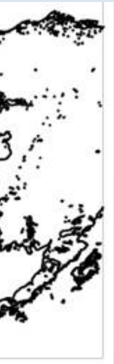
Beaufort Sea



Spitz, Zhang et al. (unpub.)

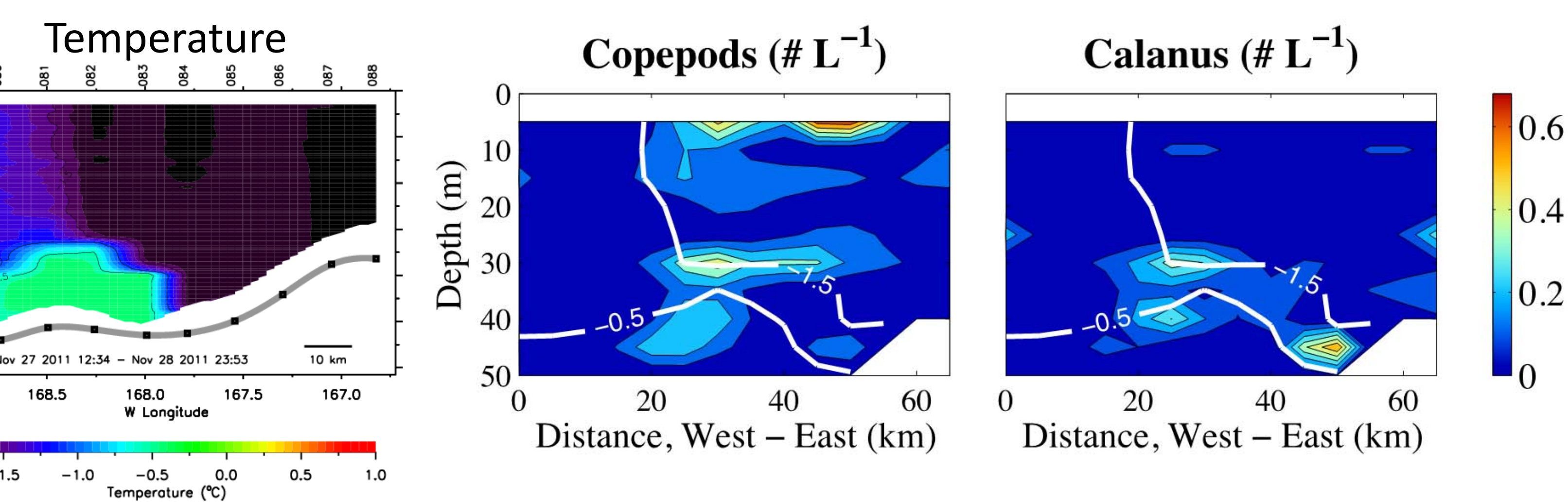
Take – Home Messages

- Both integrated and vertically discrete abundances are mportant to describe importance of physical processes nd characteristics in determining plankton istributions
- Look for regions where physical mechanisms are mportant to mixing of plankton and identify how this appens
- Strive for similarity in sampling methodology between observing teams to permit direct comparison
- Check out available earlier data for region of transect o define sampling methodology



Vertical Distribution of Copepods

(Data from Video Plankton Recorder)



lanus spp. were found primarily in the lower water column, particularly
ove the warmer Bering Sea while non-*Calanus* copepods were found both
depth and near the surfaceNote – this is an underestimate of *Calanus*