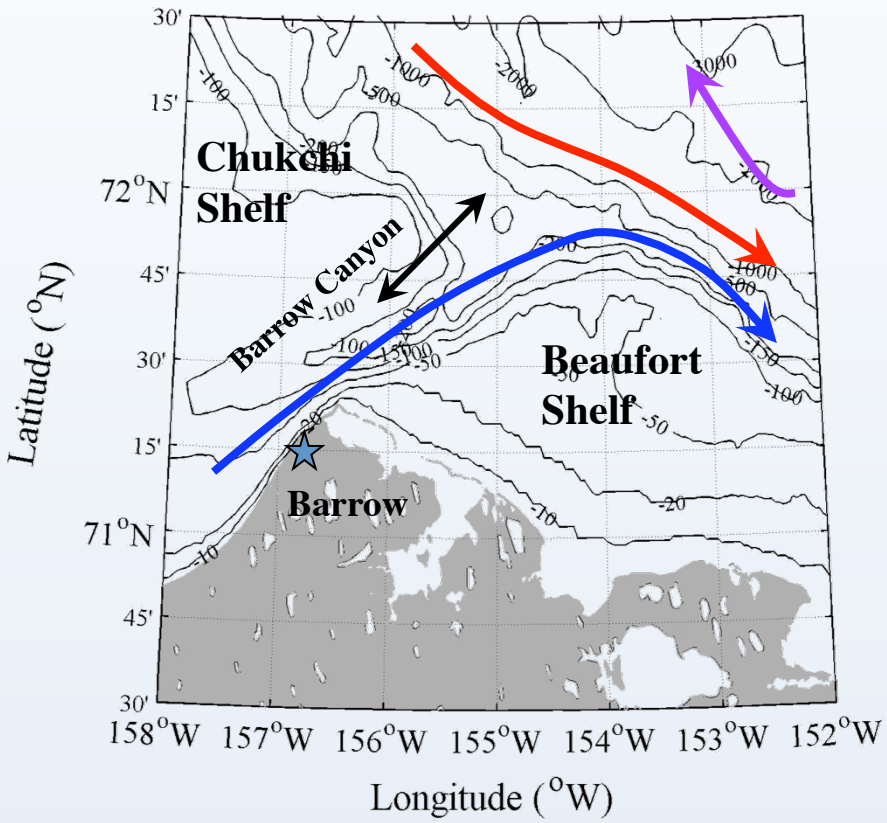
Inter-annual Variability in Physical and Biological Characteristics Across Barrow Canyon in August-September 2005-2015

Carin Ashjian (WHOI), Robert Campbell (URI), Stephen Okkonen (UAF), Philip Alatalo (WHOI), Frank Bahr (WHOI)

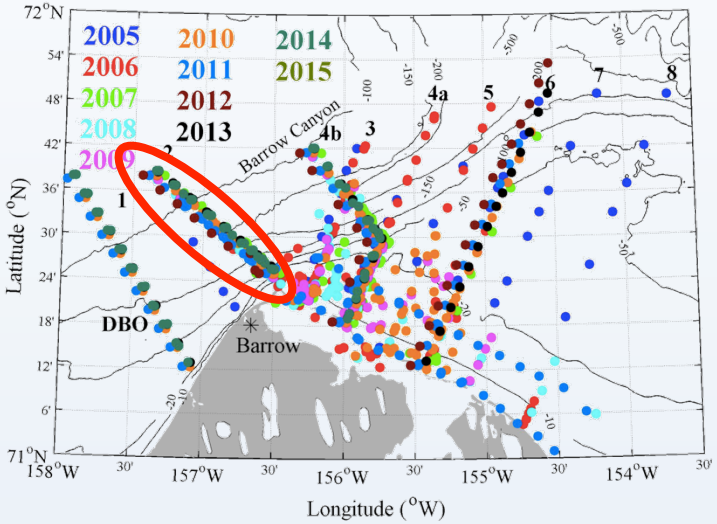
Why Barrow?



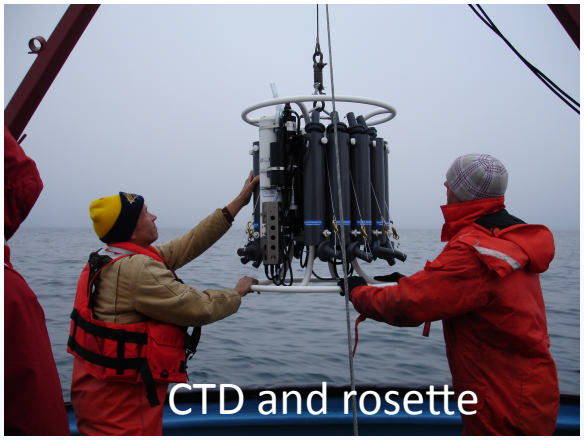
Alaskan Coastal Current flows to NE through Barrow Canyon

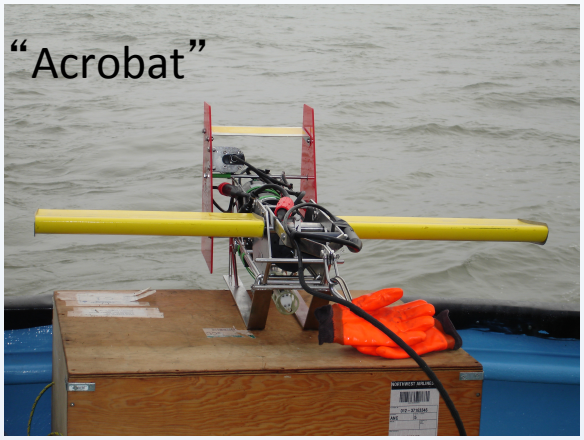
- Important feeding hotspot for bowhead whales
- Bowhead whales are key for local Iñupiat subsistence hunting
- At the juxtaposition of the Chukchi Sea, Beaufort Shelf, and Canada Basin
- Dynamic region where change could be detected
- Downstream of a former oil and gas exploration and exploitation region
- Distributed Biological Observatory line

GOAL: Describe inter- annual variability across Barrow Canyon using data from over a decade of sampling



- Sampling using the 43' *R/V Annika Marie* from mid-August to mid-September 2005-2015
- Transect sampled each year during the third week of August


CTD and rosette


"Acrobat"

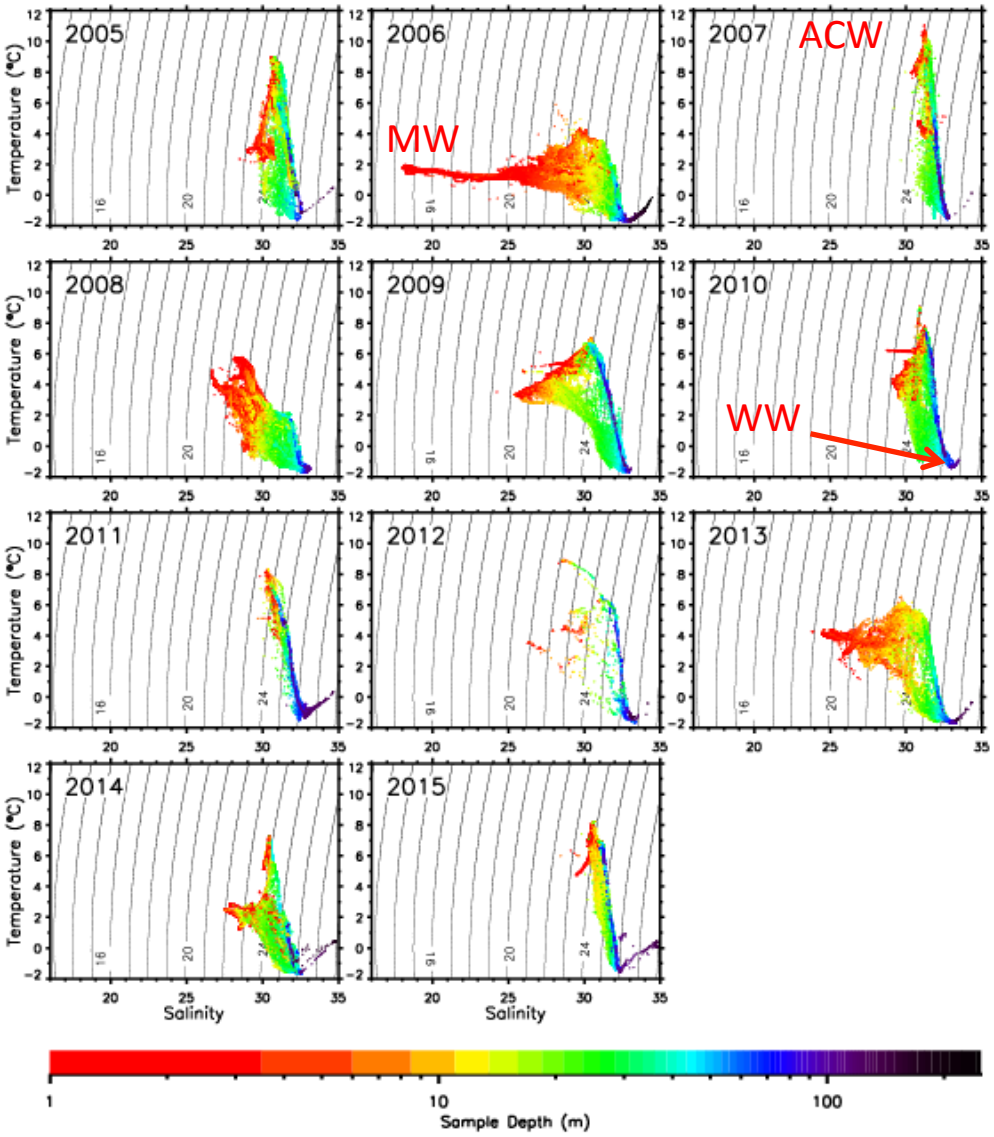

Deploying Acrobat

Oceanographic Measurements

- Water column temperature, salinity, density, chlorophyll fluorescence, ADCP velocities
- Upper 50 m water temperature, salinity, density, optical backscatter, chlorophyll and CDOM fluorescence
- Chlorophyll, nutrient, FCM microbes, microzooplankton concentrations at 0, 10, 40 m and near bottom
- Mesozooplankton abundances
- Marine mammal (and sometimes seabird) watch

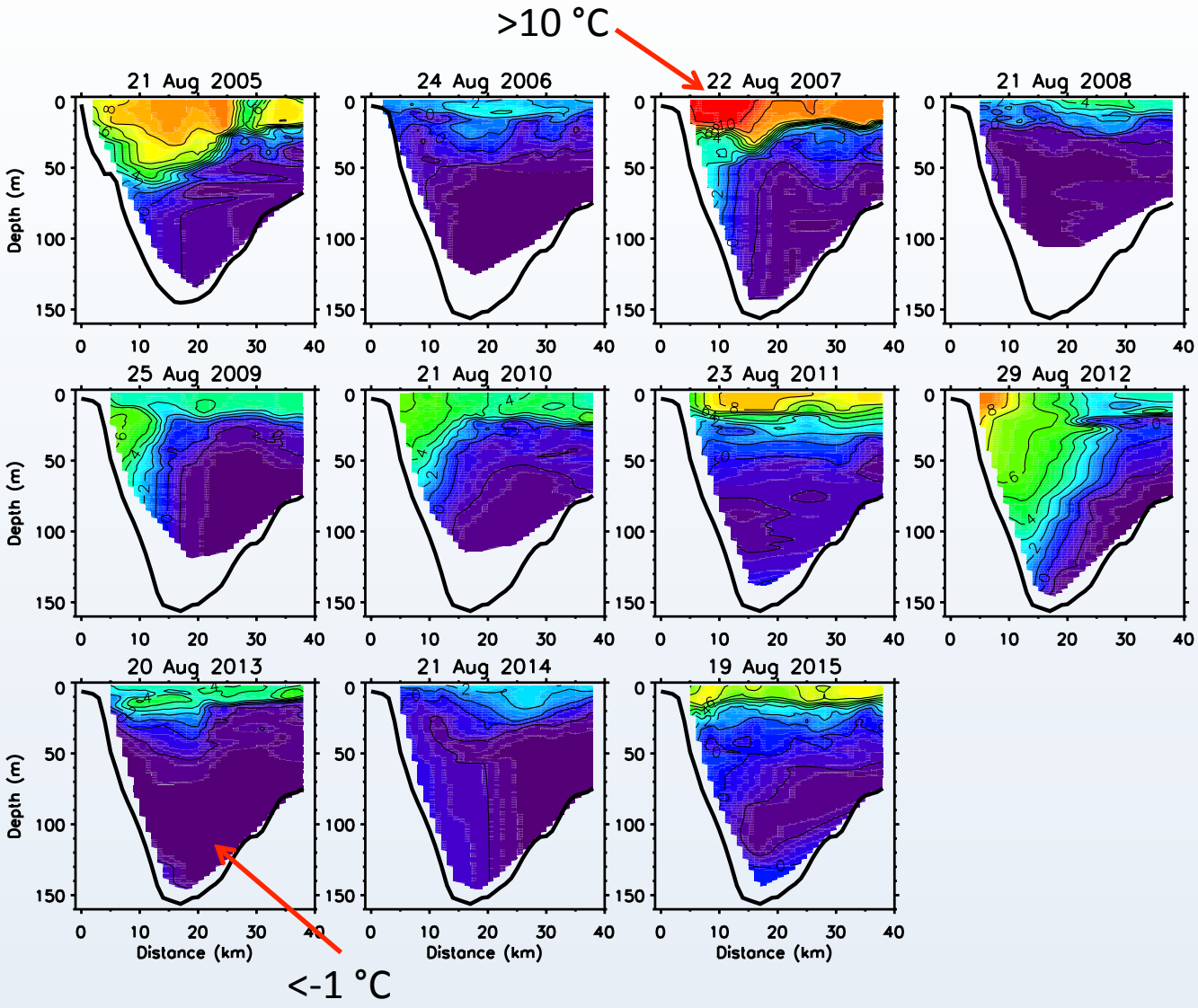

Nets

Temperature and salinity variable between years



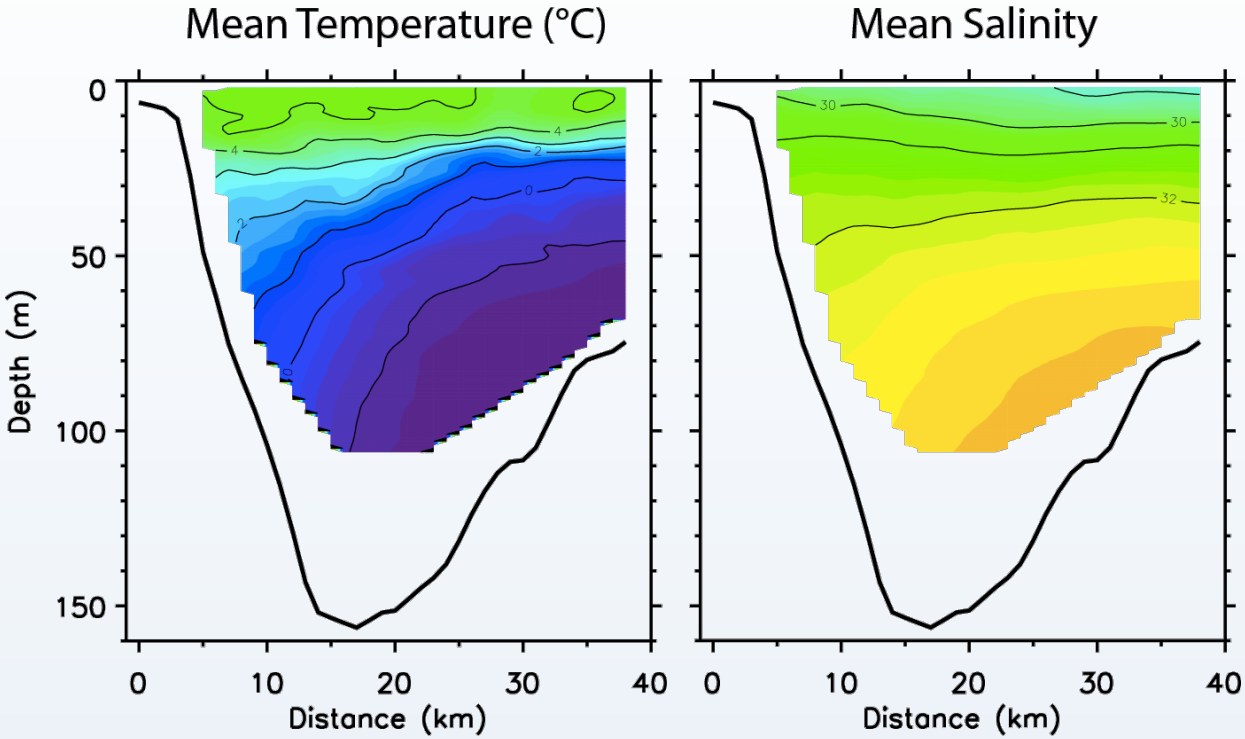
- Three water masses
- The ACW was very warm in some years (2005, 2007, 2009-2012, 2015)
- Cold ACW in other years, particularly 2006 and 2008

Temperature is variable between years



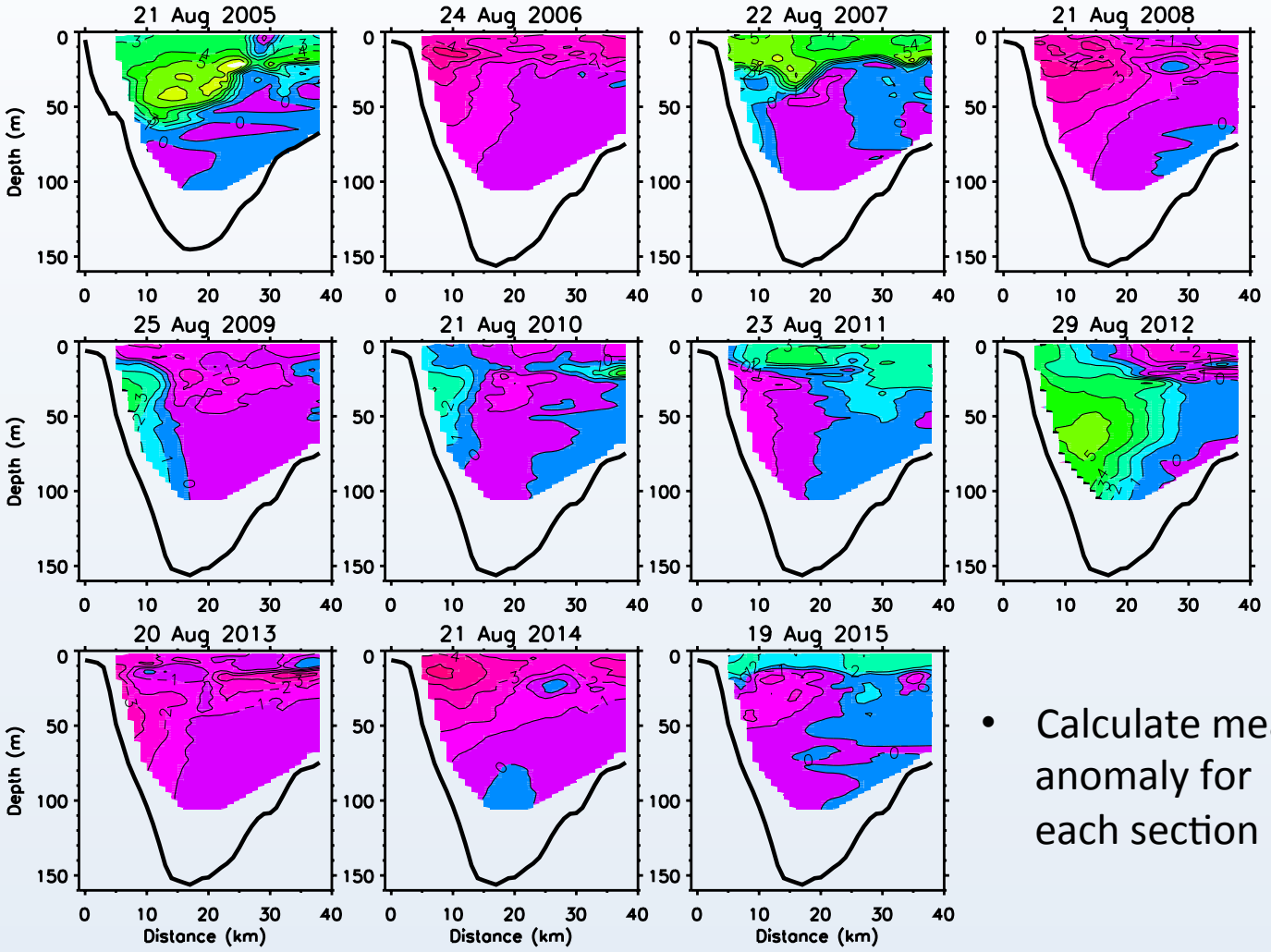
- Cold years: 2006, 2008, 2013, 2014
- Warm years: 2005, 2007, 2011, 2012, 2015 (?)

Mean Sections show Three Major Domains



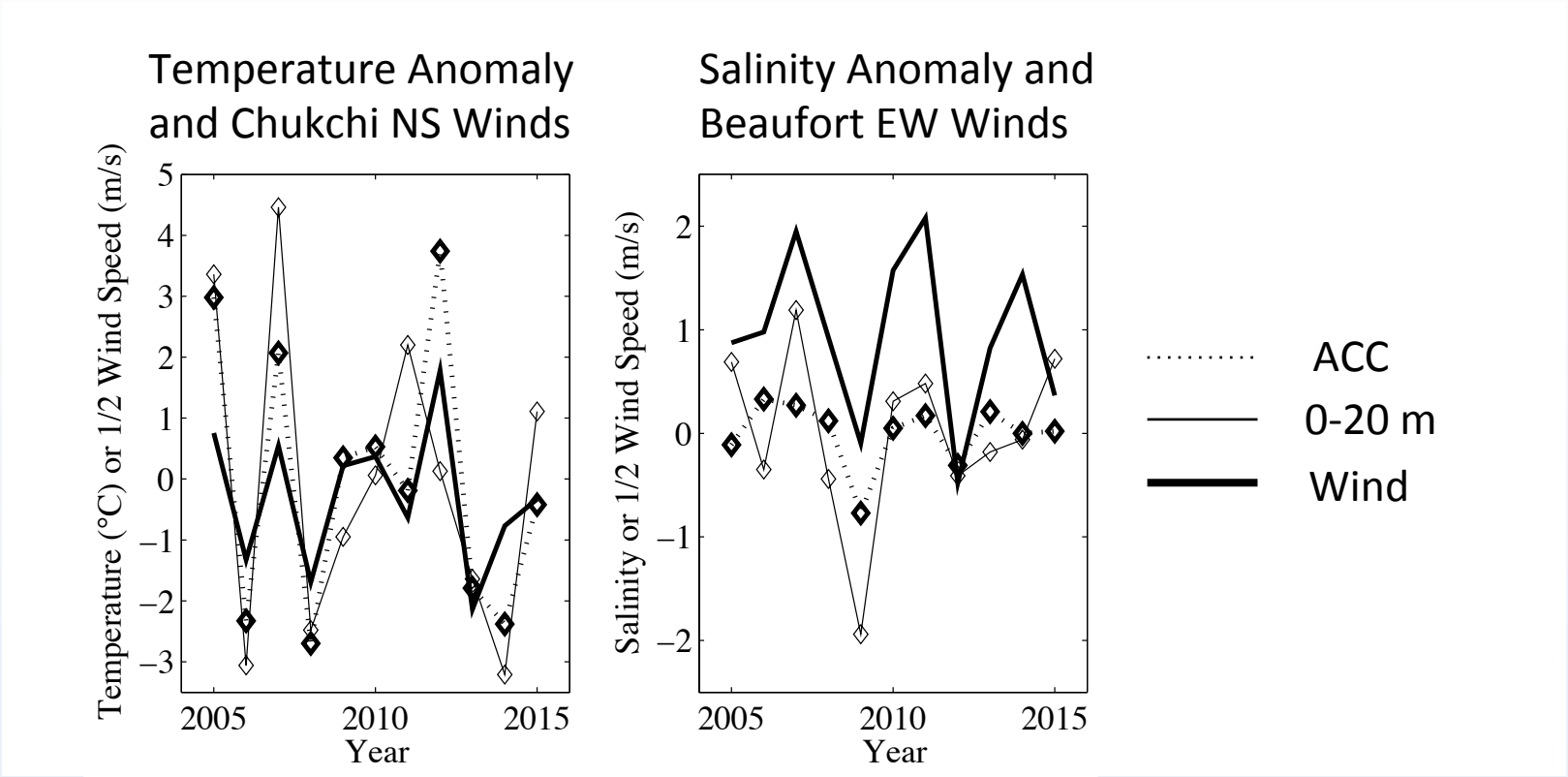
- Surface Layer (0-20 m)
  - Fresher water on western side derived from ice melt
- Alaskan Coastal Current with Alaskan Coastal Water (water column, 0-17 km)
  - Flows NE
  - Sloping isopleths
- West Barrow Canyon (20 m – bottom, 17-39 km)
  - Southward flowing cold, salty remnant Winter Water

Temperature anomalies from mean section (Purple – negative anomaly, green – high positive anomaly)



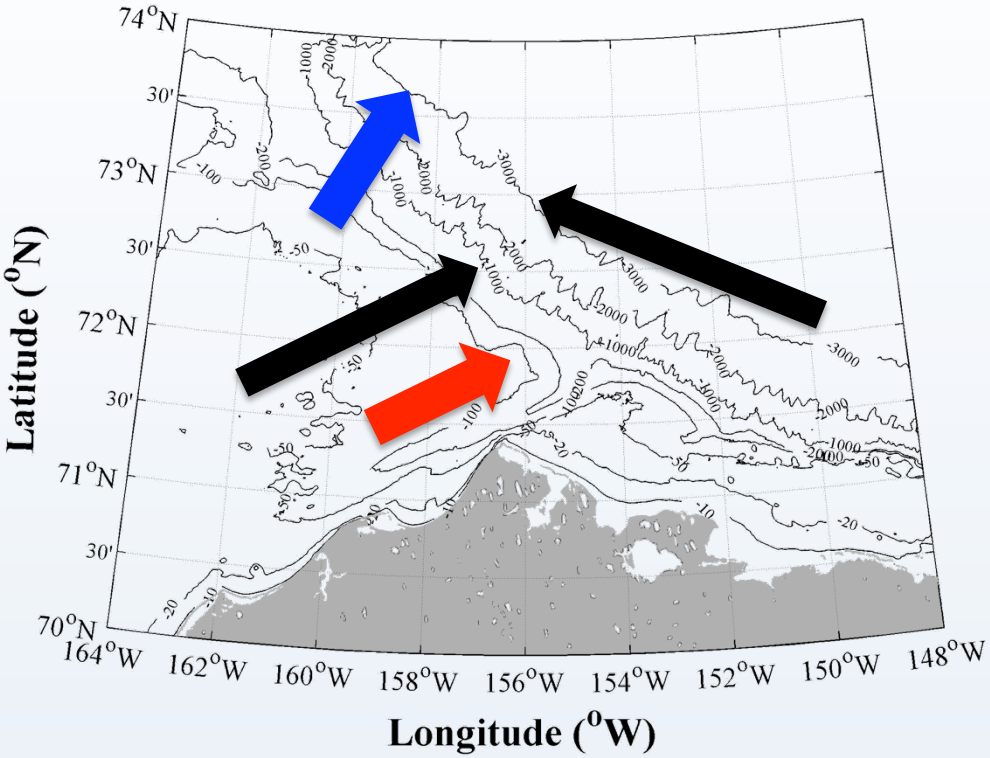
- Calculate mean anomaly for each section

Temperature and salinity anomalies from mean section correlated with winds



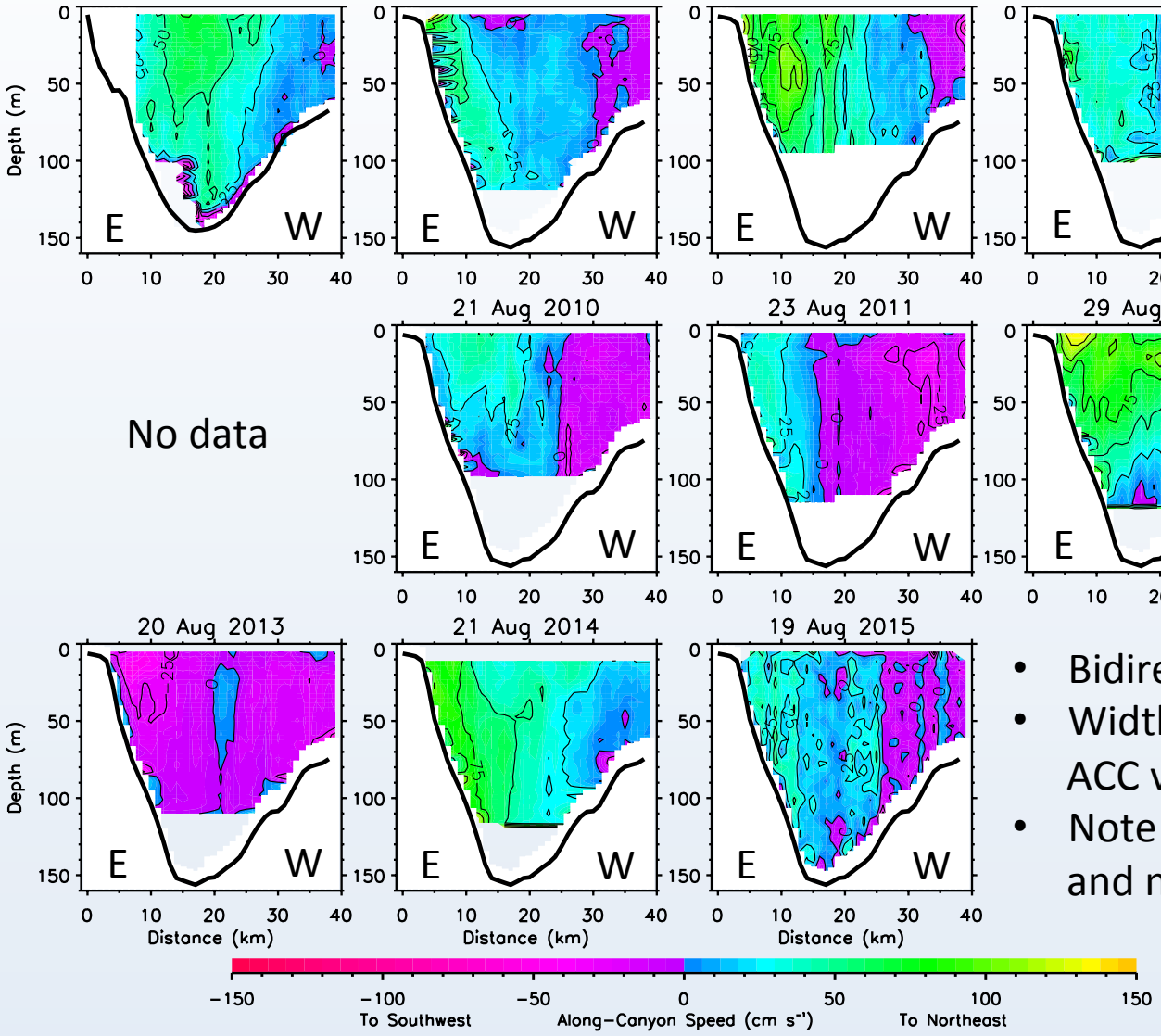
- Temperature anomalies positively correlated (ACC: r=0.92, surface: r=0.58) with Chukchi Winds to the north
- Salinity anomalies positively correlated (ACC: r=0.68, surface r=0.60) with August Beaufort winds to the west

Different mechanisms drive temperature vs. salinity anomalies



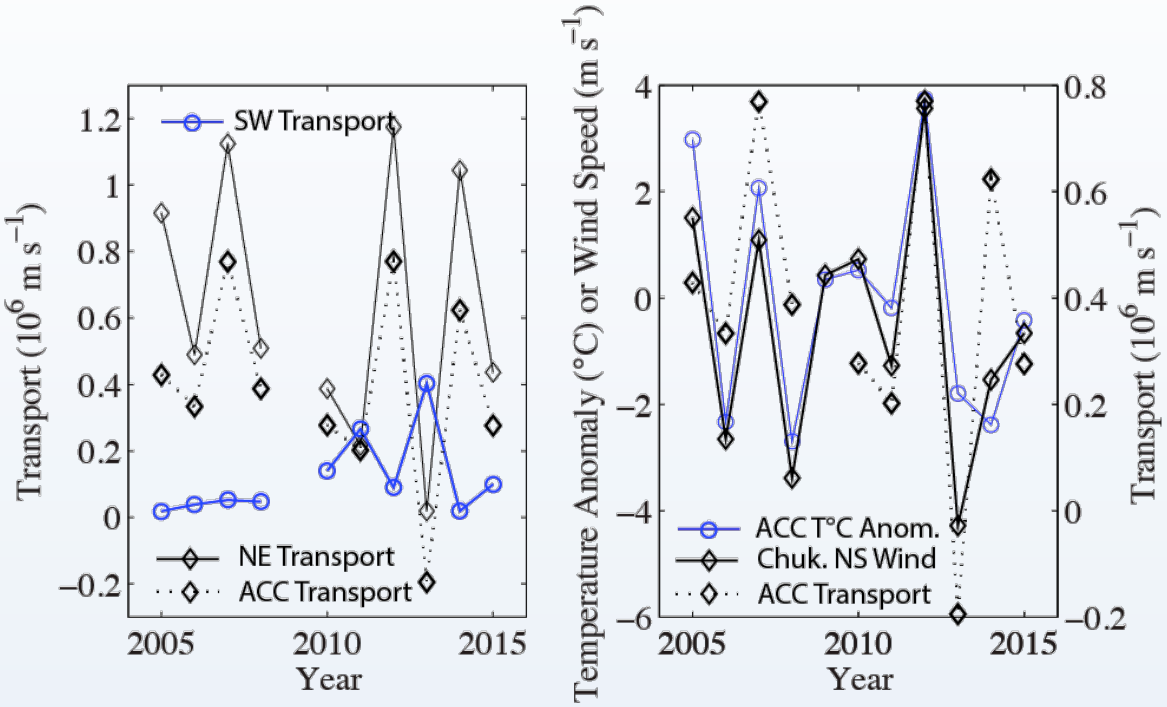
- Winds from the south in the Chukchi drive high transport of warm water to the north in the ACC
- Winds to the west in the Beaufort drives melt water from Hanna Shoal to the north via Ekman transport so the low salinity water does not reach Barrow Canyon

Towed acoustic Doppler current profiler velocities show bi-directional flow



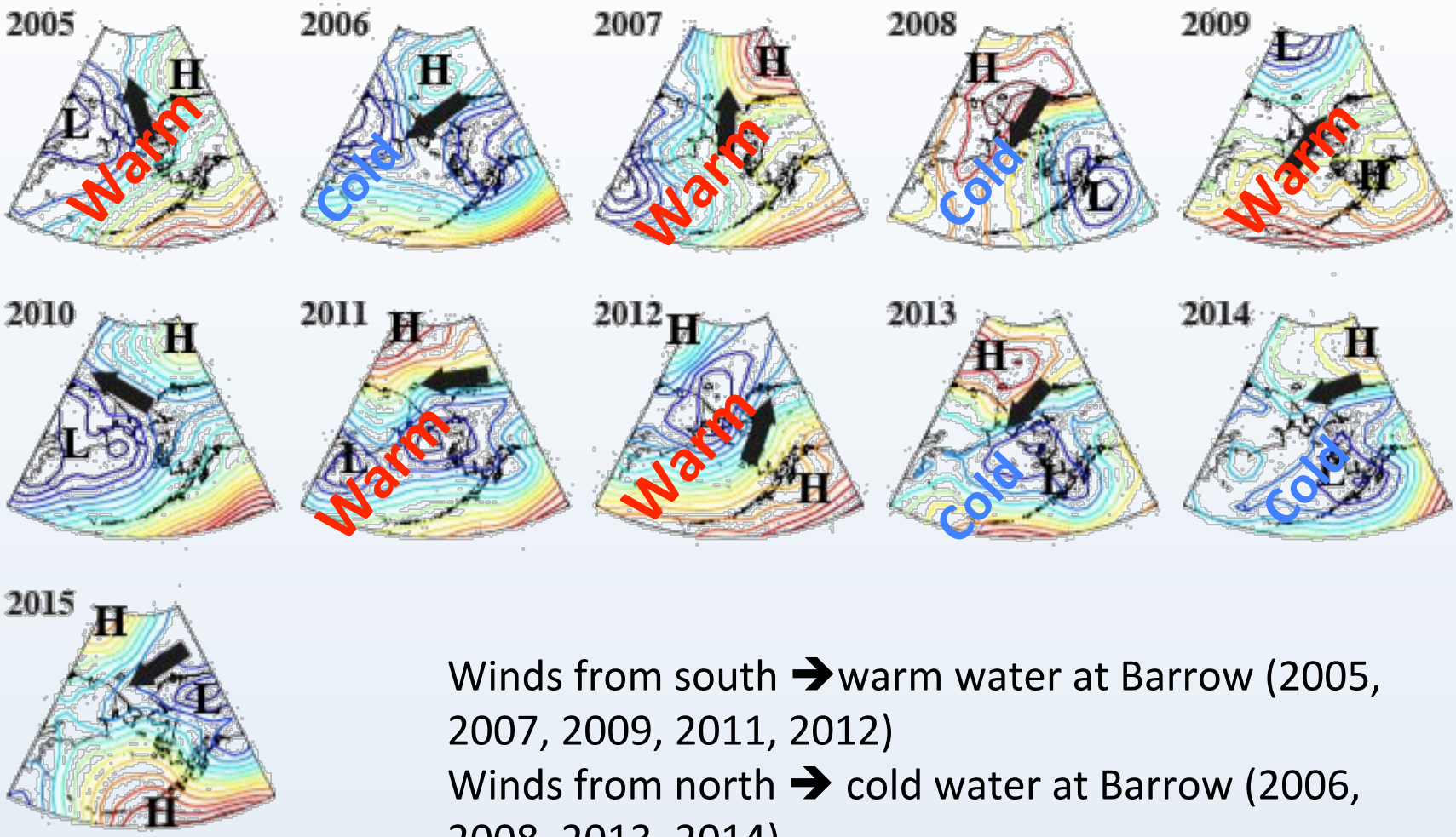
- Bidirectional flow
- Width of northward flowing ACC very variable
- Note southward flow in 2013 and northward flow in 2014

Transports correlated with winds and temperature anomalies



- Transport to the NE exceeded transport to the SW in all years except 2011 and 2013
- Transport in the ACC was highly correlated with total transport to the NE
- ACC transport was correlated with both with mean August Chukchi NS Winds (r=0.69) and with ACC temperature anomalies (r=0.49)

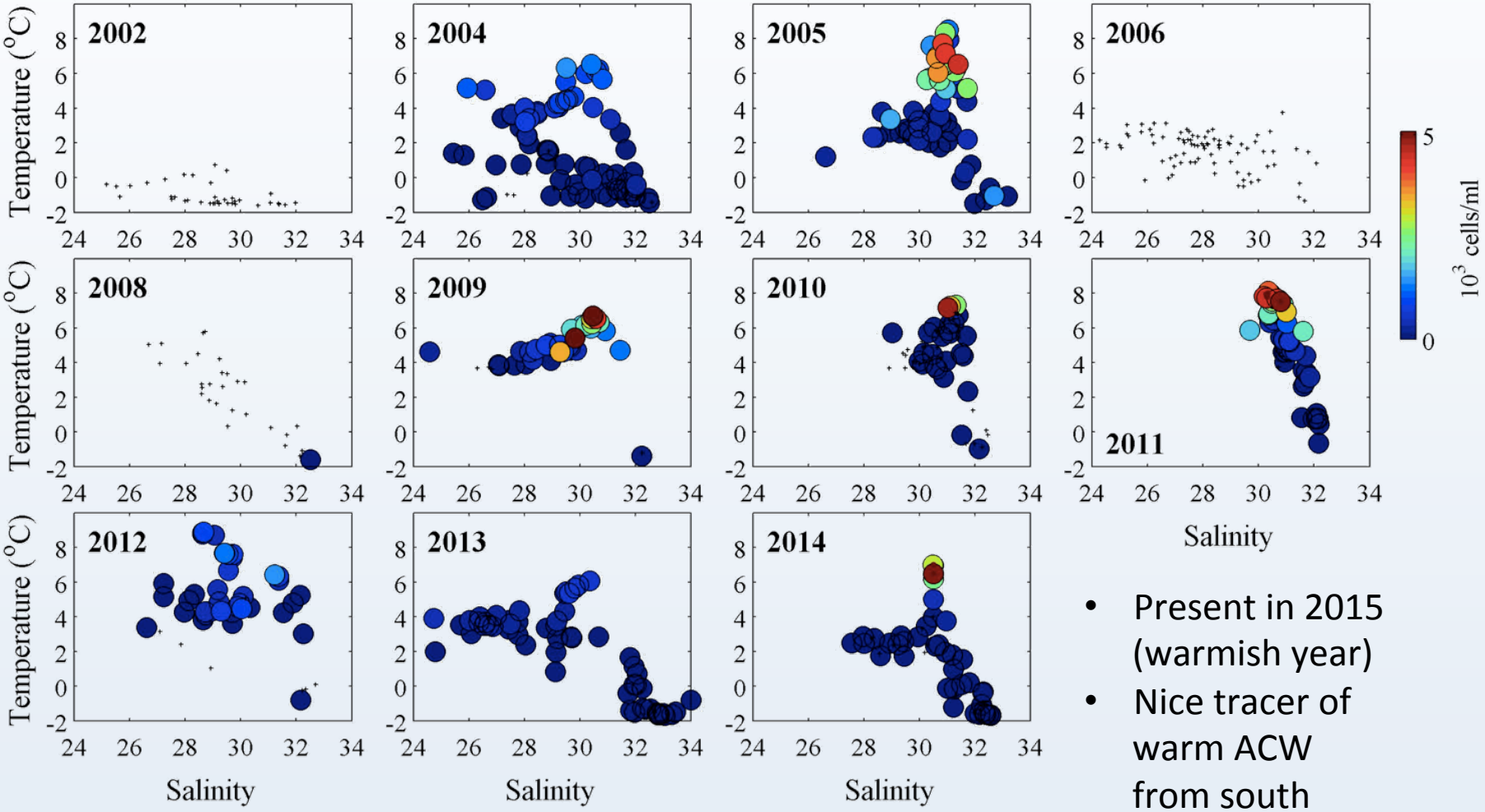
Broad-scale atmospheric forcing drives dominant winds through Chukchi Sea



Winds from south ➔warm water at Barrow (2005, 2007, 2009, 2011, 2012)

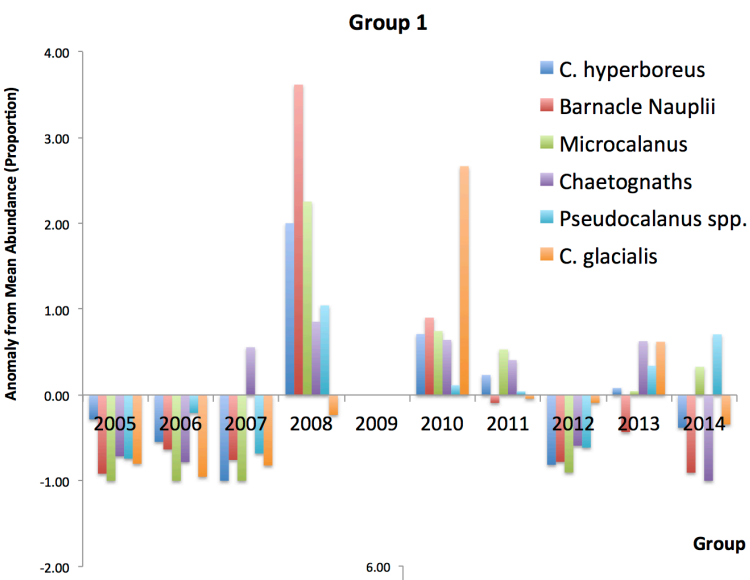
Winds from north ➔ cold water at Barrow (2006, 2008, 2013, 2014)

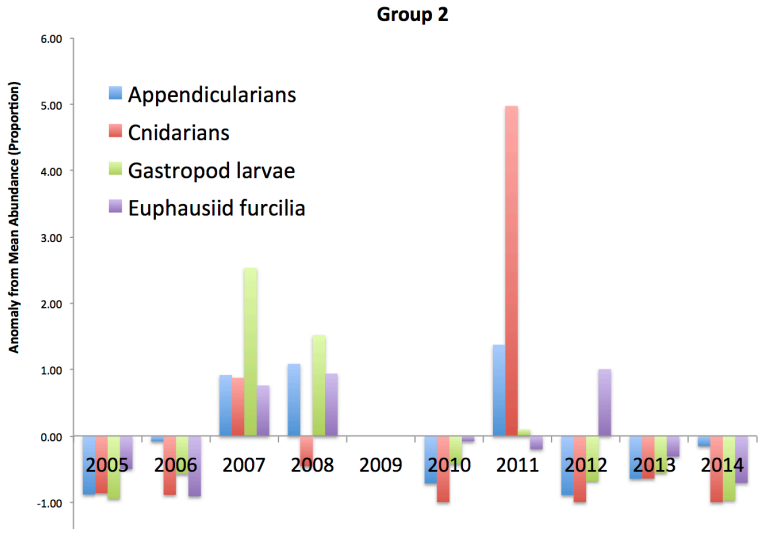
Synechococcus only highly abundant in warm ACW

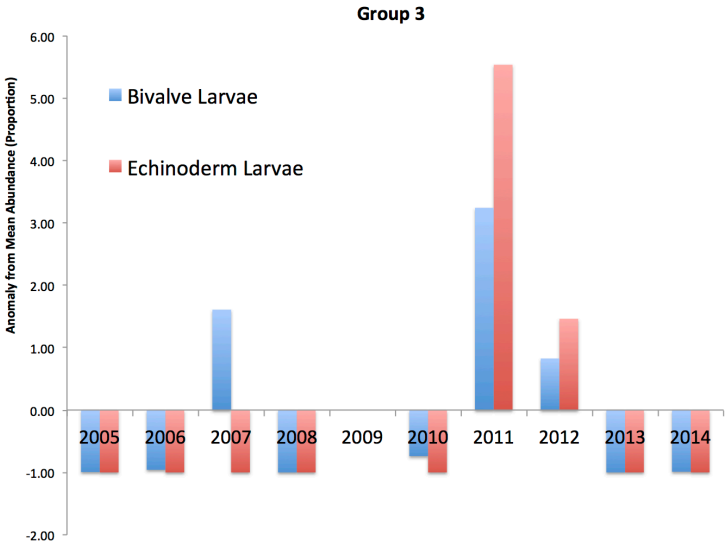


- Present in 2015 (warmish year)
- Nice tracer of warm ACW from south

Mesozooplankton variability – Anomaly from mean







- Patterns not related to inter-annual variability in transport or ACC temperature

Conclusion

- This 11-year record near Barrow AK provided an understanding of the impact of atmospheric forcing and variability on physical and biological ocean characteristics during a period of ongoing climate change

- Observations shared with local residents and entities throughout the eleven years of the project
  -E.g., near annually at Barrow Whaling Captains' Fall Meeting

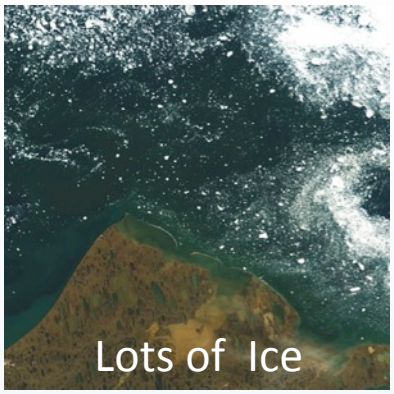
- At present, 2015 is the last year of this time series

Acknowledgments

- Funded by the National Science Foundation, the University of Alaska Coastal Marine Institute, the Woods Hole Oceanographic Institution Arctic Initiative, the NOAA National Marine Mammal Laboratory and Bureau of Ocean Energy Management, and the National Oceanographic Partnership Program
- The Barrow Whaling Captains Association, the Alaska Eskimo Whaling Commission, the North Slope Borough, and the community of Barrow
- Aaron Hartz (OSU), Heather McEachen (UAF), and Joel Llopiz (WHOI) for assistance in field sampling and data analysis
- Craig George, Robert Suydam, Cyd Hanns, Harry Brower, Taqulik Hepa, Billy Adams, and the everyone else at the NSB Dept. of Wildlife Management
- Bill Kopplin, Ned Manning, Mike Johnson, Randy Pollock, Mike Fleming, Lars Isaac, and John Bjorgaard, the captains of the *R/V Annika Marie*
- Barrow Arctic Science Consortium, Umiaq LLC, and UIC Science for logistic support in Barrow
- VECO/CH2MHill Polar Services for logistic support in Prudhoe Bay
- Bill Streever, Wilson Cullers, and Tatyana Venegas at British Petroleum for assistance in accessing West Dock in Prudhoe Bay to load the boats
- The ARMADA Program at the University of Rhode Island and the PolarTREC Program at ARCUS in Fairbanks for the participation of teachers

August 14, 2005

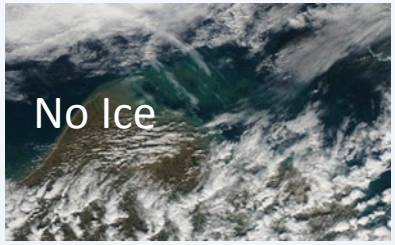
August 23, 2006



August 23, 2007

August 23, 2008

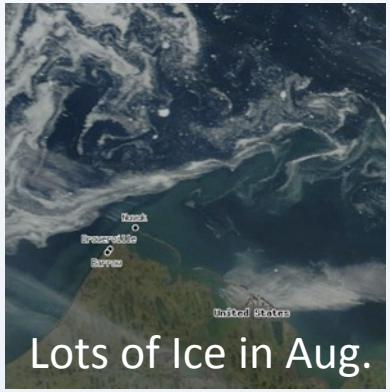
August 19, 2009



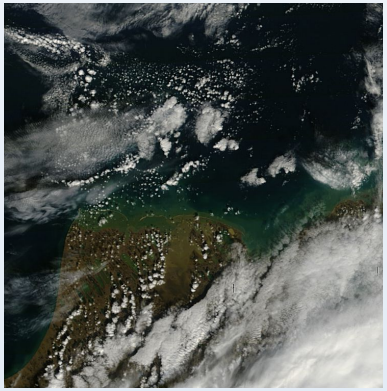
August 24, 2010

August 6, 2011

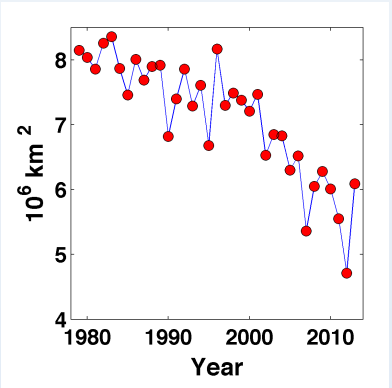
August 12, 2012



August 30, 2013



2014 – No Ice



Interannual Differences in Ice Cover

-Lowest in 2012, 2nd lowest in 2007