Bering Strait - Feb 2013 update

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Thanks to Jim Johnson, David Leech, Seth Danielson, Kay Runciman, Wendy Ermold, Mike Schmidt and the crews of the Alpha Helix, Laurier, Sever, Lavrentiev and Khromov

Bering Strait - Feb 2013 update

Cruises and moorings - past, present and future

Sea-ice fluxes

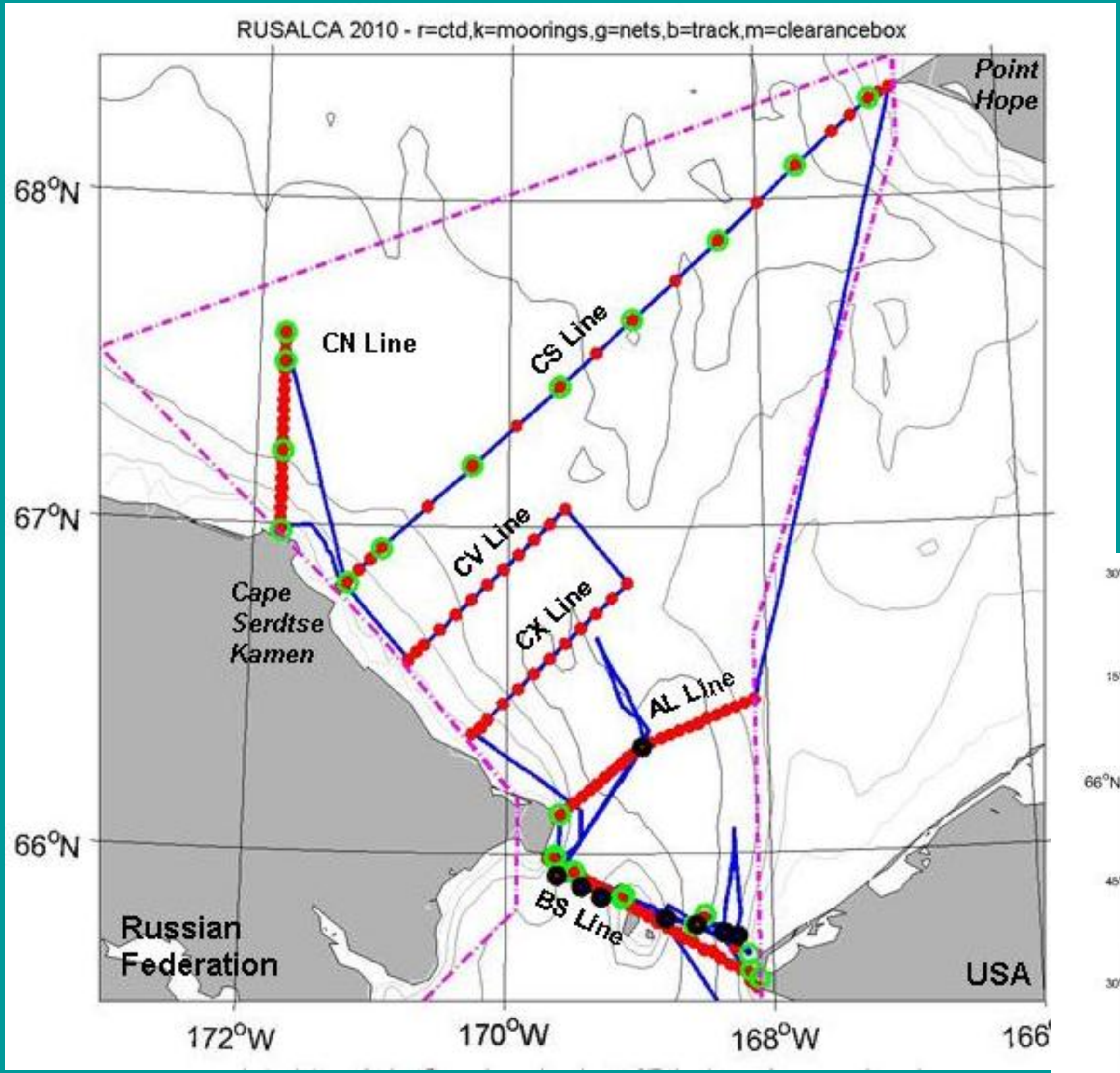
Bering Strait Observing System Design (for physics)

Interannual Change (and the curious influence of the Bering Sea on the Arctic)

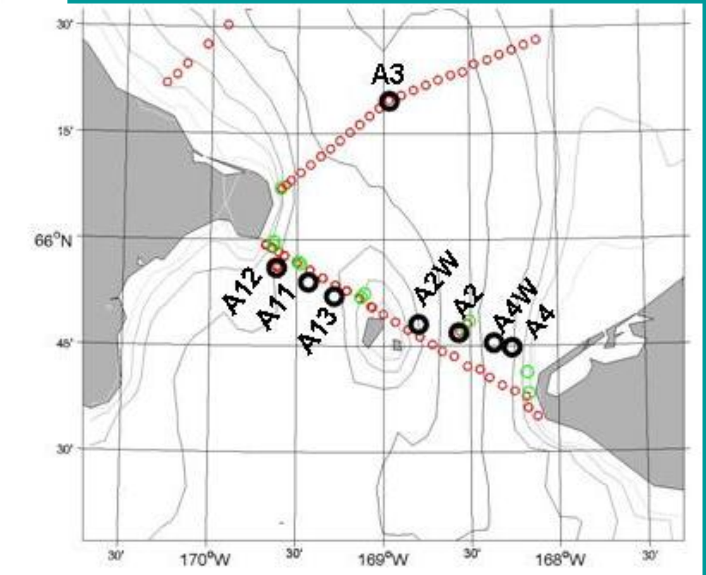
Spatial and temporal variability of the system

RUSALCA 2010 Khromov Cruise

31st July
– 11th Aug 2010
Nome to Nome

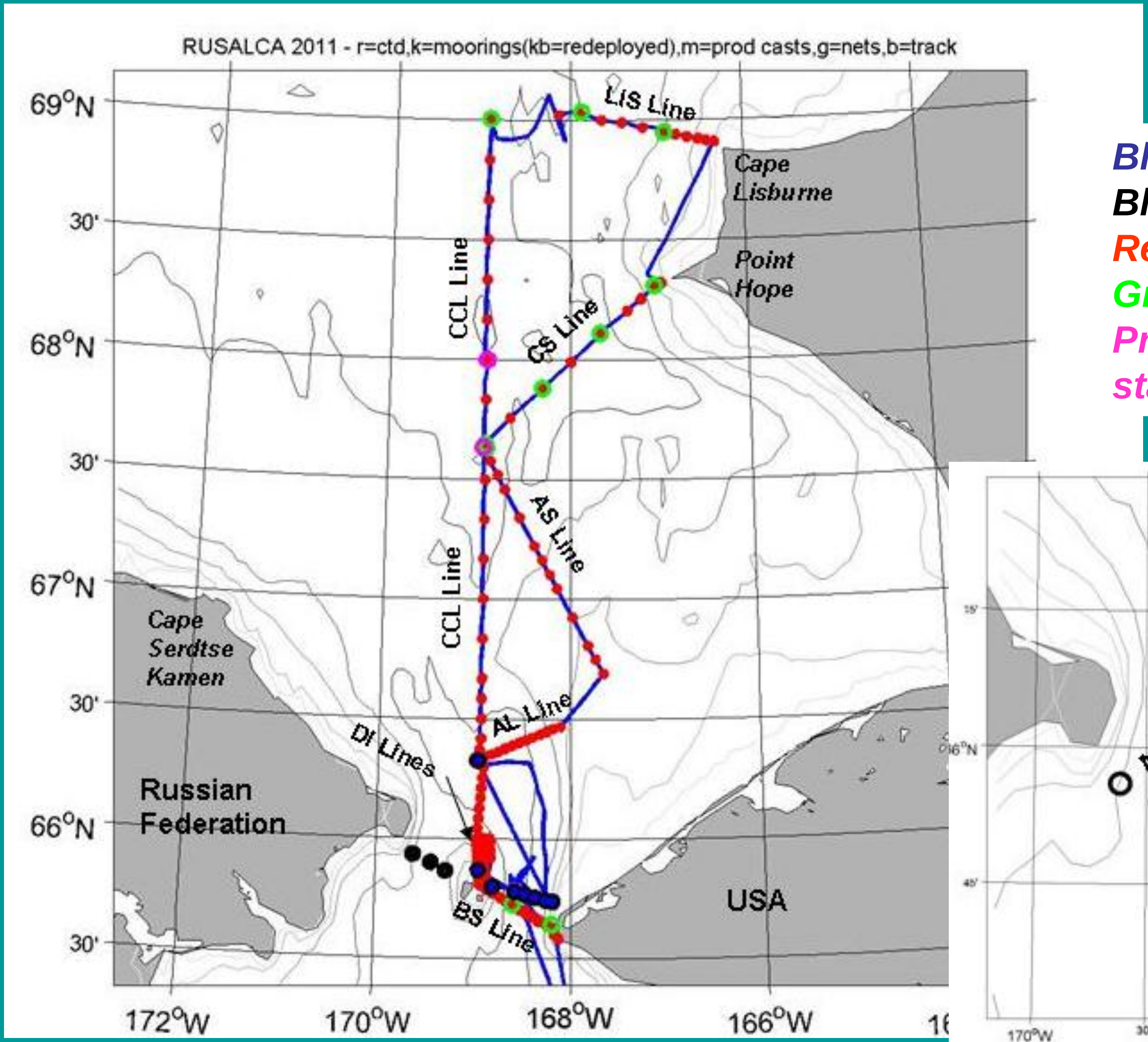


Mauve = clearance box
Blue = ship track
Black dots = moorings
Red dots = CTDS
Green dots = nets
+ 4 Primary productivity stations

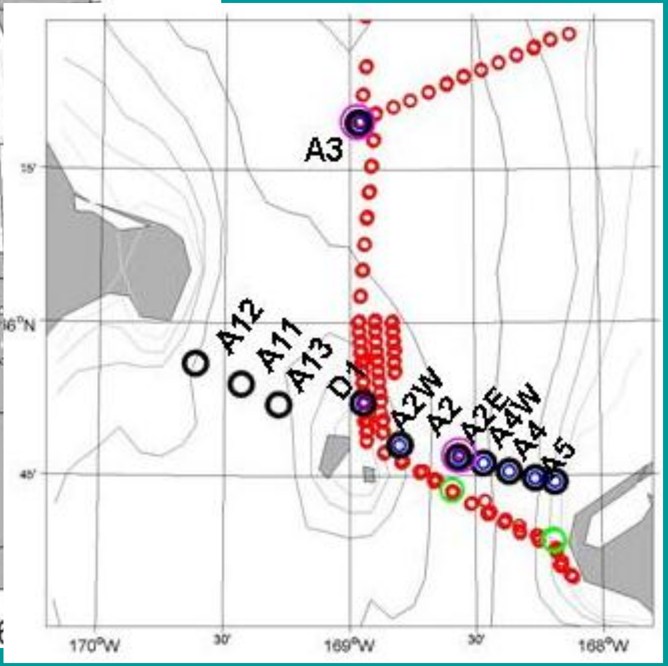


RUSALCA 2011 - Khromov

12th – 23rd July 2011
Nome to Nome

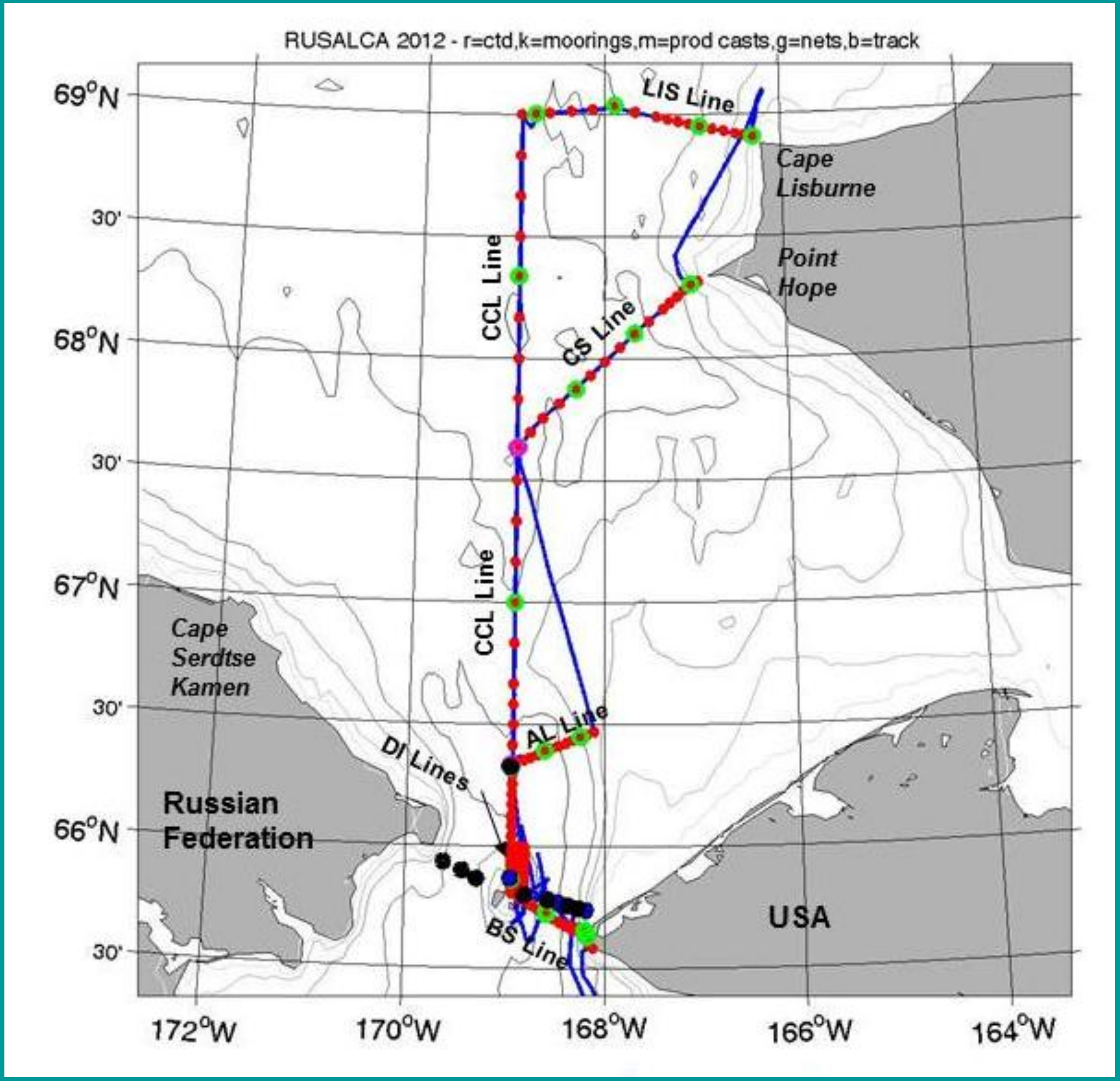


Blue = ship track
Black dots = moorings
Red dots = CTDS
Green dots = nets
Primary productivity stations



RUSALCA 2012 Leg 1 - Khromov

10th – 20th July 2012
Nome to Nome



Blue = ship track
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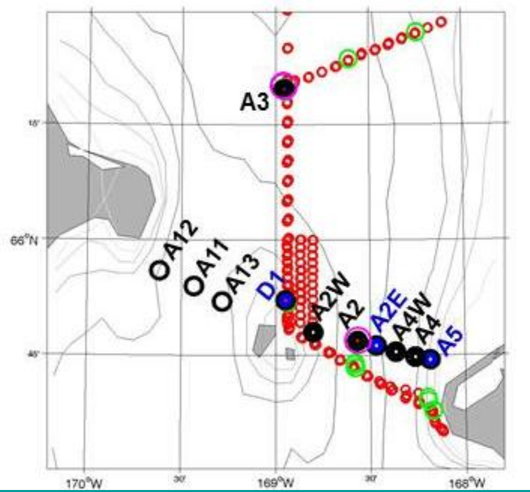
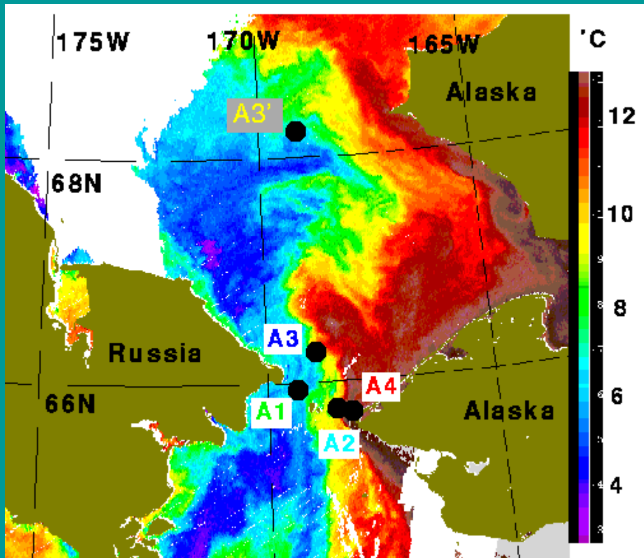
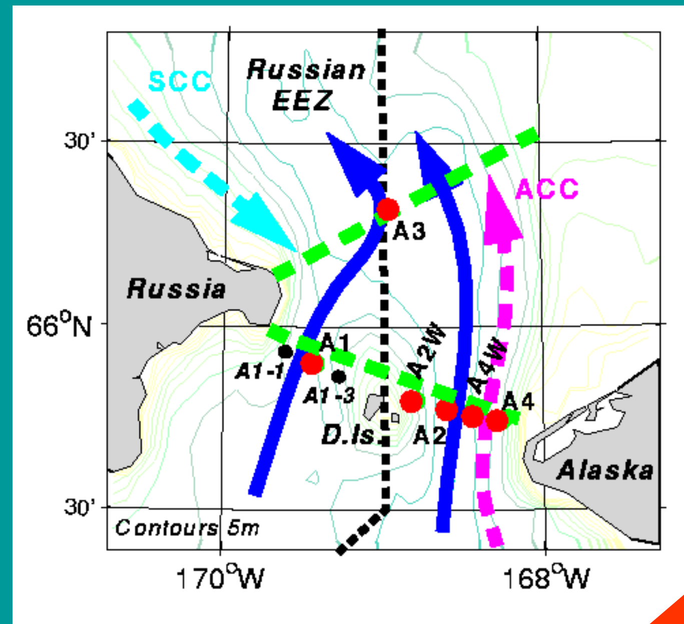
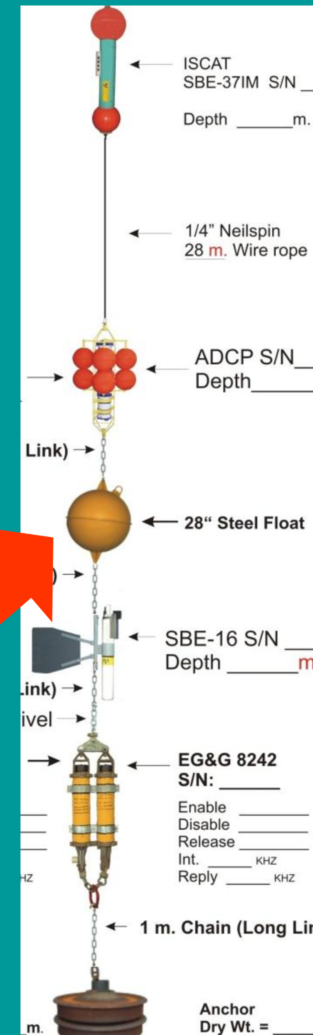
Primary productivity stations



Bering Strait Moorings







<u>Since 1990</u>
1-4 near–bottom moorings

<u>Since 2007</u>
(International Polar Year)
8 moorings with upper and lower sensors

Your instrument here!!!!

Now also with
- Whale Recorders – Kate Stafford and Carter Esch
- pH and pCO2 sensors – Fred Prahl, OSU

Annual CTD sections

Quantifying Sea-Ice Volume Flux using Moored Instrumentation in the Bering Strait

Cynthia S. Travers, Master's Defense

30 May 2012

Research Advisor: Dr. Rebecca Woodgate

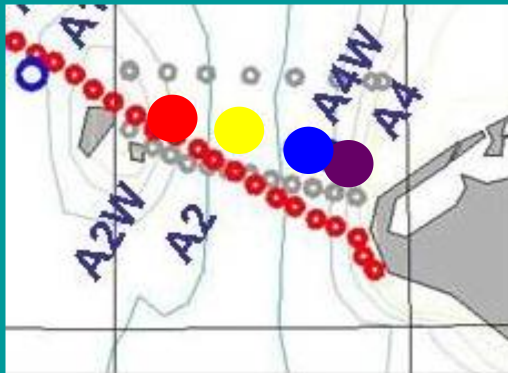
Committee Members: Dr. Ignatius Rigor,

Dr. Peter Rhines, Dr. Jody Deming

Thesis at psc.apl.washington.edu/BeringStrait.html

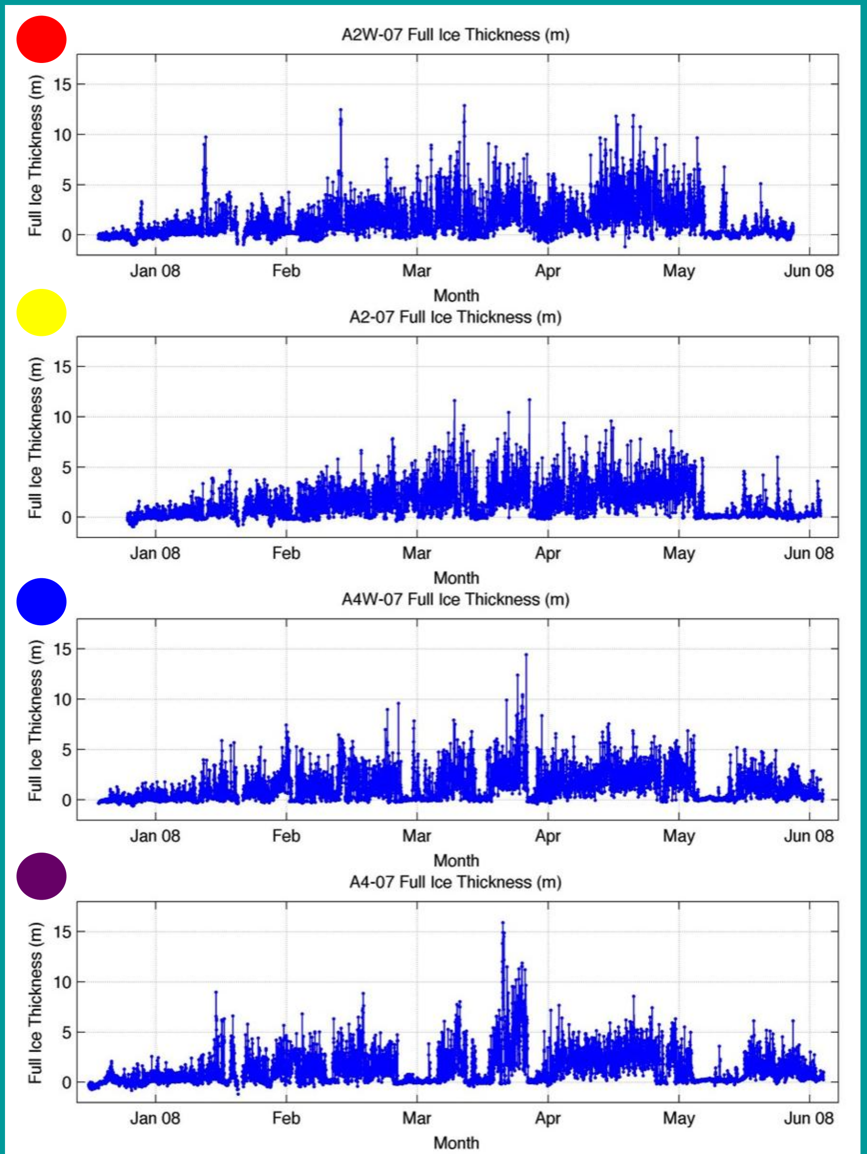
Photo: Little Diomede Island, Bering Strait

Eastern Channel Sea-Ice Thickness Time Series from ADCP

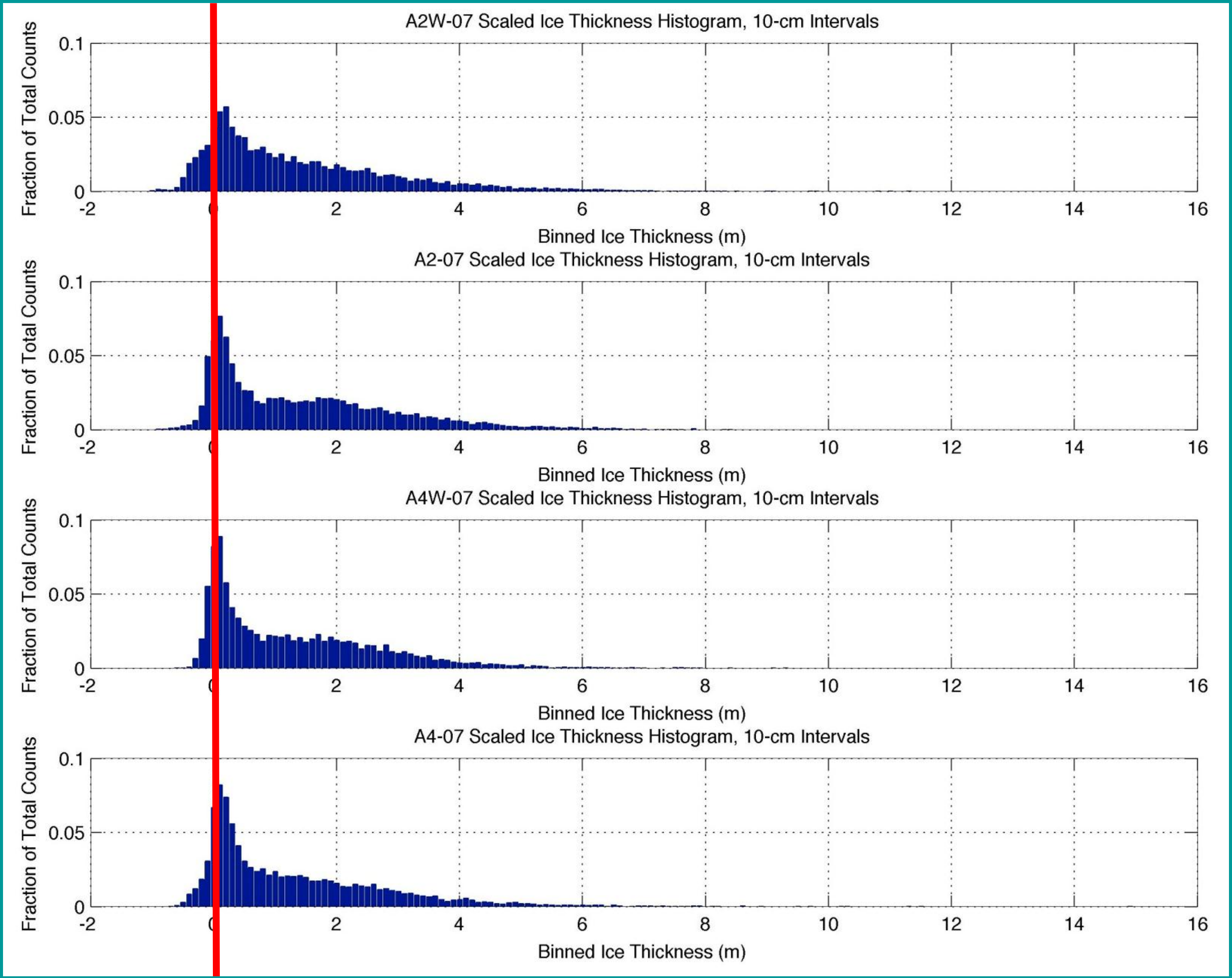


- Gradual increase up to March
- Deepest keel at A4-07 (closest to Alaskan coast)
- Mean ice thickness ~1.4 m

Mooring (E to W)	Mean Thickness (m)	Max Thickness (m)
A2W-07	1.4m	12.9 m
A2-07	1.5 m	11.7 m
A4W-07	1.3 m	14.5 m
A4-07	1.4 m	15.9 m



Eastern Channel Sea-Ice Thickness Histograms from ADCP



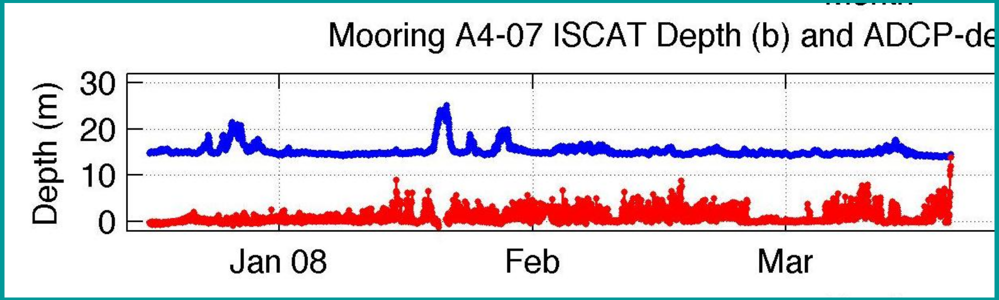
Bering Strait Ice thickness, velocity and flux

Estimated Bering Strait freshwater flux for 2007-2008:
≈ 140 ± 40 km³/yr   (0.004 ± 0.001 Sv)

Freshwater flux from Aagaard and Carmack (1989):
≈ 24 km³/yr

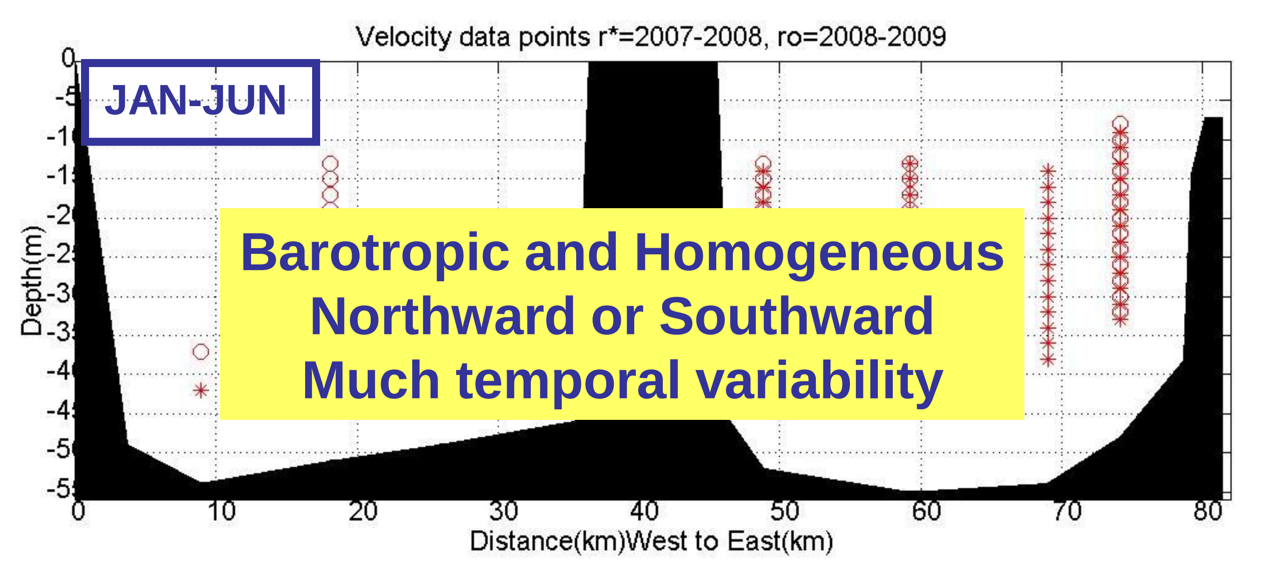
Freshwater flux from Woodgate and Aagaard (2005):
≈ 100 ± 70 km³/yr

1990-1991 and 2007-2008 values agree within errors

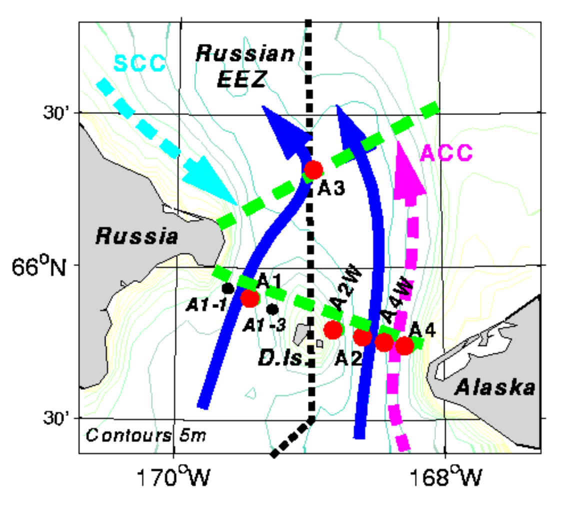


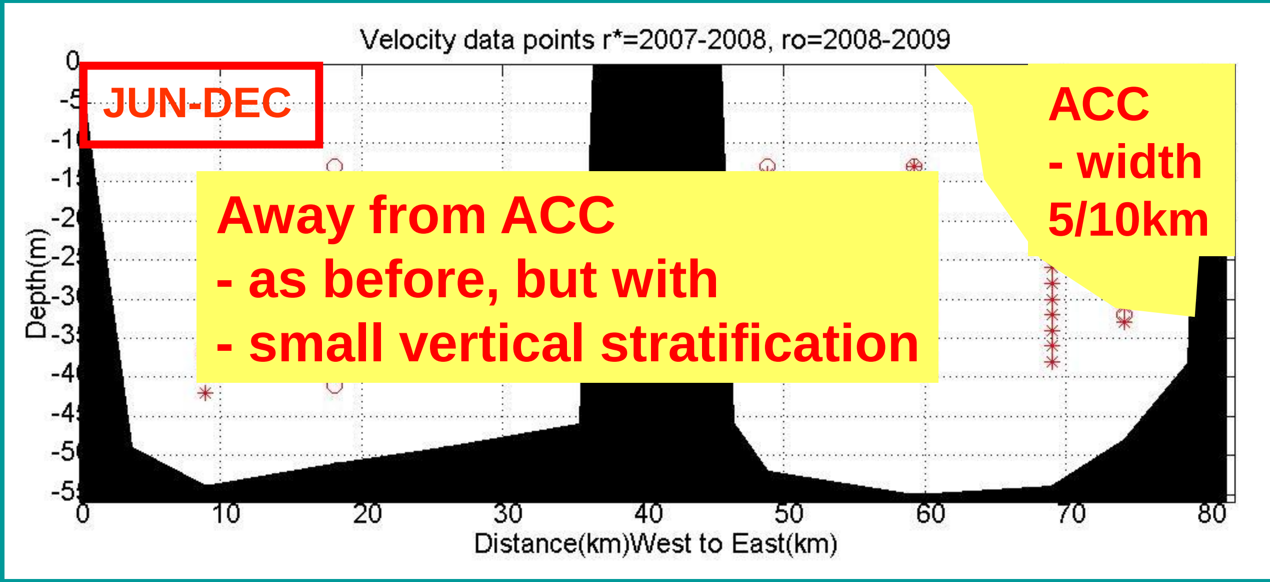
Travers, 2012

Observing System Design



Barotropic and Homogeneous
Northward or Southward
Much temporal variability



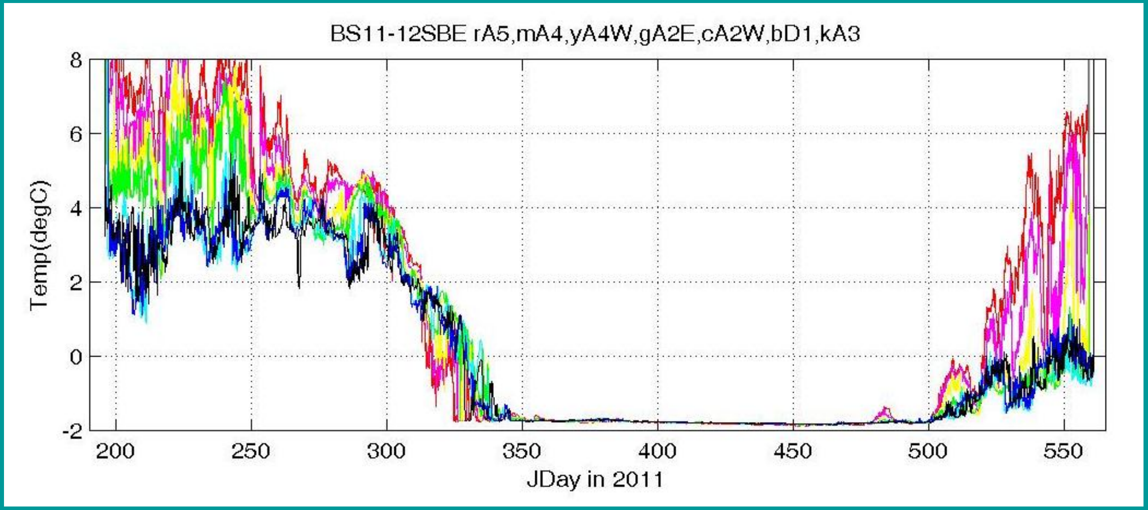


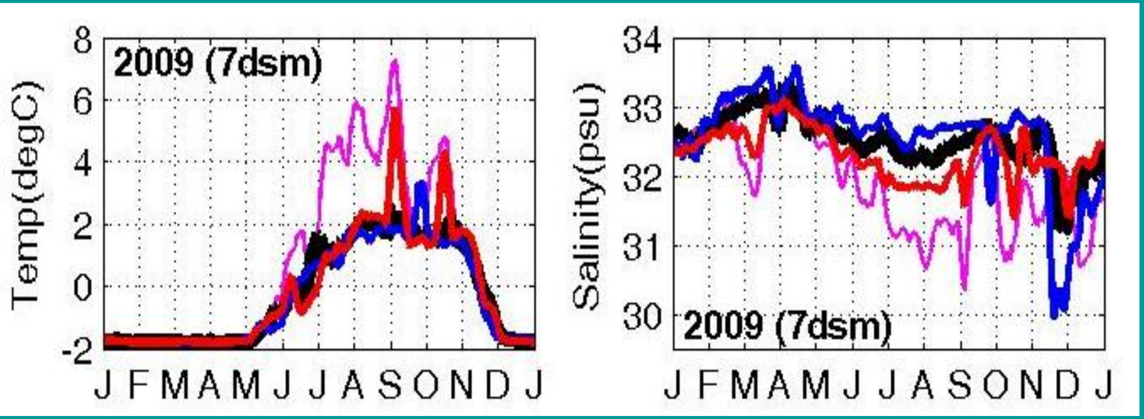
Away from ACC
- as before, but with
- small vertical stratification

ACC
- width
5/10km

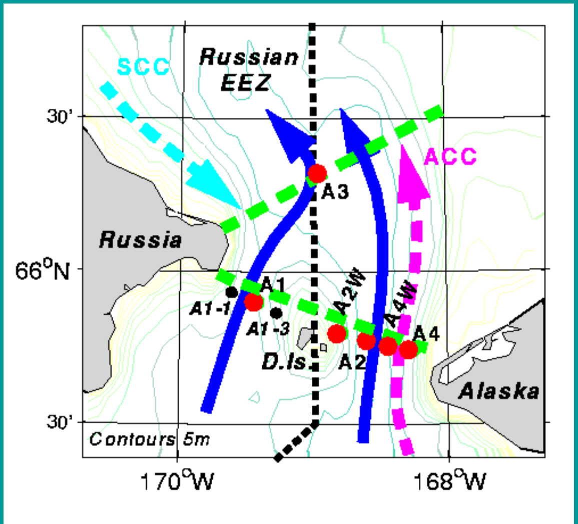
VOLUME FLUX
- estimated from
A3 + ACC (A4)

Observing System Design





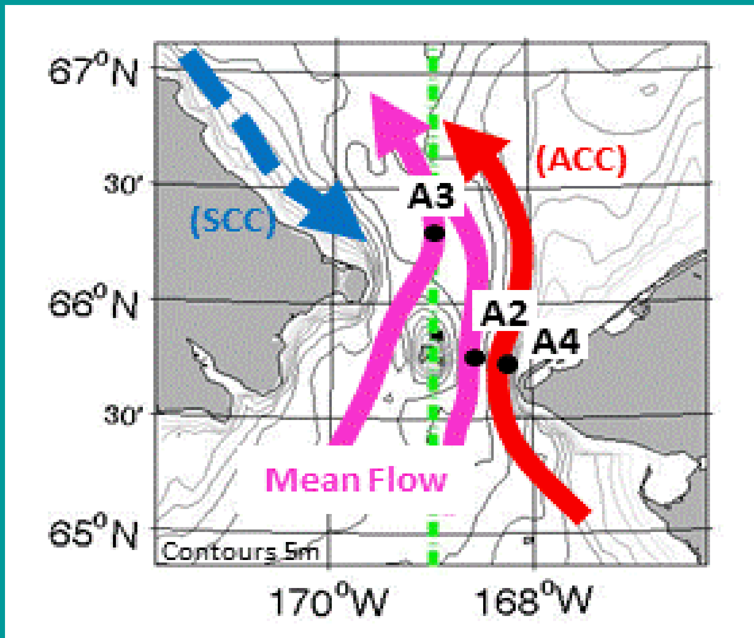
Blue=A1 Red=A2
Black=A3 Magenta=A4



<u>TEMPERATURE and SALINITY</u>
- estimated from A3 + ACC (A4)
- use A2 and A3 to infer Russian Channel

Observing System Design

.. for T, S, Volume, Heat, freshwater, Ice fluxes



3 MOORING ARRAY
- A2, A4, A3
- upper & lower TS
- ADCP (velocity, shear, ice thickness and motion)

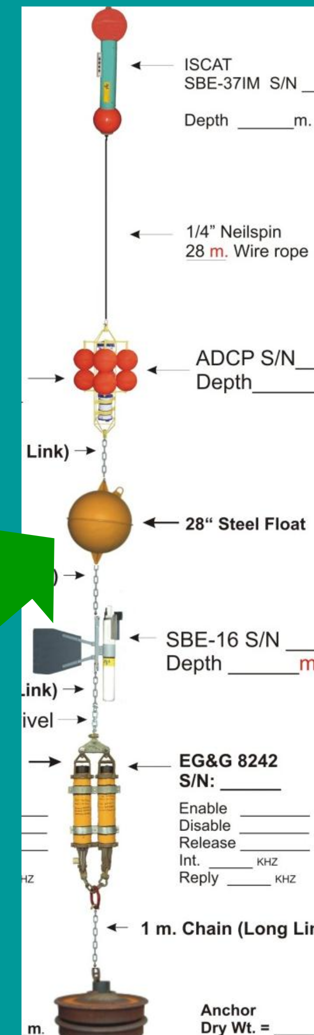
ONR Funding for 2013-2014 deployment (1 year in water)

NSF AON Proposal for 2014-2018 deployment (4 years in water)

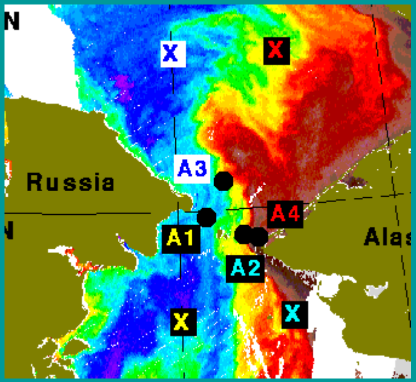
(Upcoming cruises)

Biology??

Your instrument here!!!!

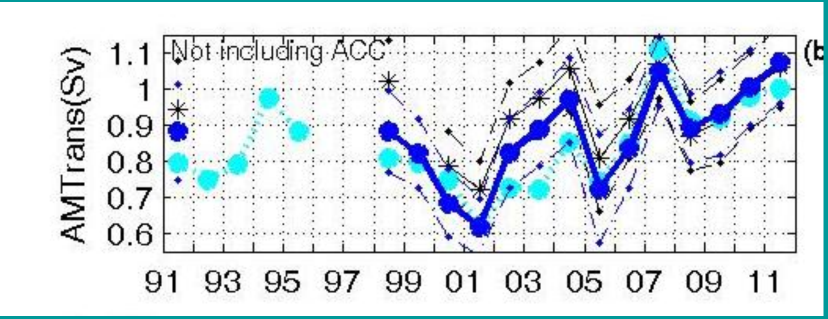


Annual Mean Transport



<u>A3 as a climate site?</u>

- yes, but must add ACC (A4,A2), stratification



<u>Significant (~50%) increase in transport</u>

2001 ~ 0.7 Sv (~ 8months flushing)

2011 ~ 1.1 Sv (~ 5months flushing)

<u>What drives the change?</u>

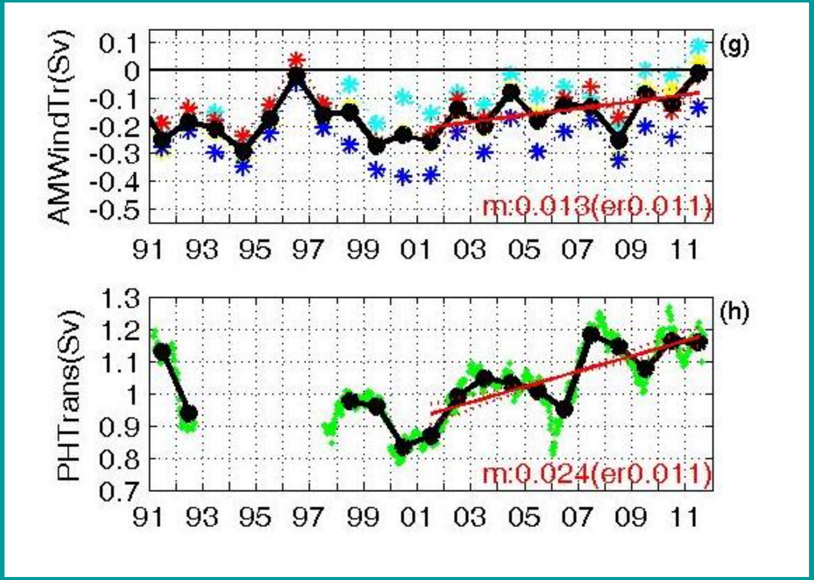
Annual fit of data to:

Transport = constant x WIND

+ Pressure Head

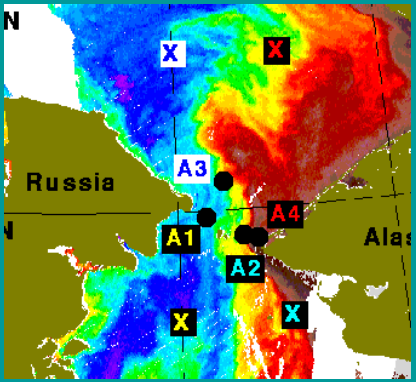
2/3rds due to Pressure Head

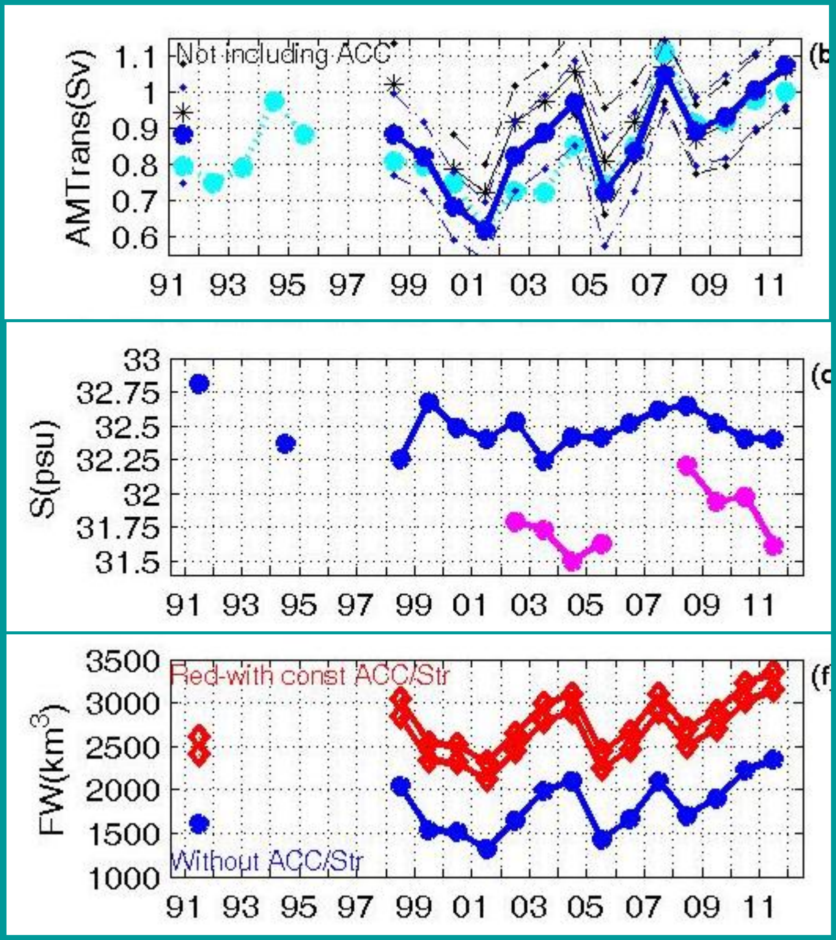
(i.e. can't infer from the wind)



Woodgate et al., GRL 2012

Annual Mean Freshwater





Blue=A3, Magenta=A4, Cyan=A2

<u>Freshwater flux relative to 34.8psu</u>

2001 ~ 2000-2500km^3

2011 ~ 3000-3500km^3

(assuming constant ACC and stratification)

= Driven by transport change

= Decadal change (~ 1000km^3),

- about twice decadal variability in

Net precipitation

(~ 500km^3, Serreze et al, 2006)

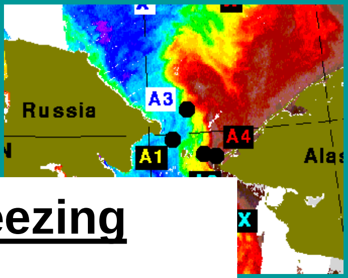
Russian Rivers

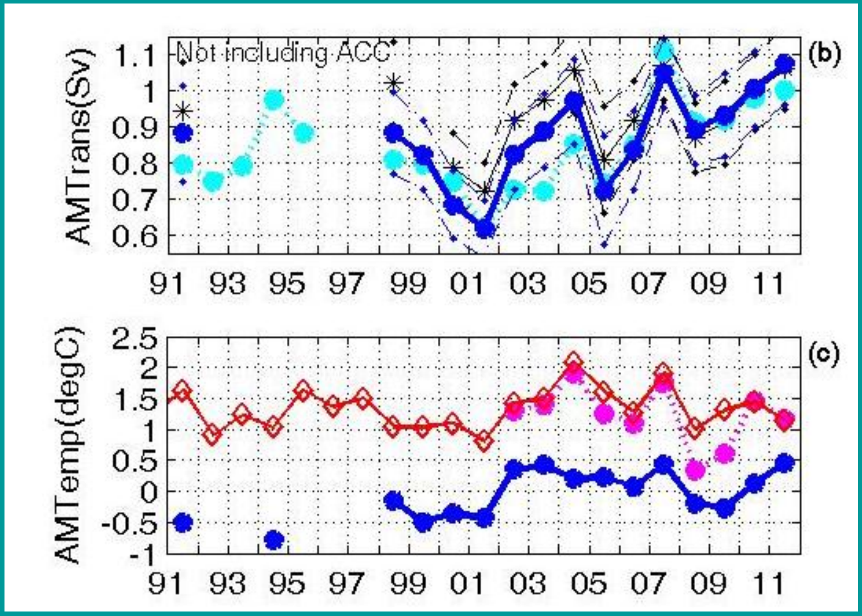
(~400km^3, Shikl

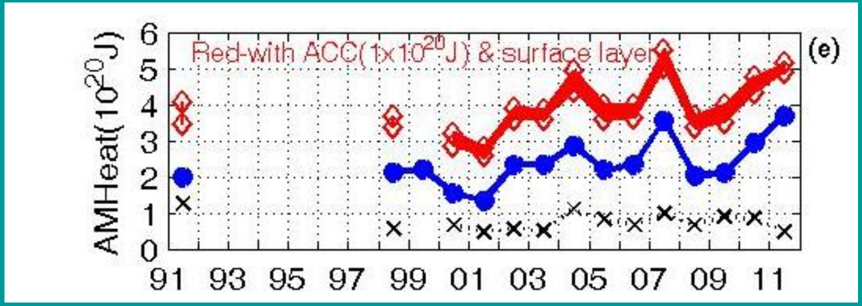
Arctic Freshwater Storage - changes in both Inflows and Outflows

Woodgate et al., GRL 2012

Annual Mean Heat flux







Blue=A3, Magenta=A4, Cyan=A2
Red Diamonds=SST

Woodgate et al., GRL 2012

Heat flux relative to Tfreezing

2001 ~ 3×10^{20}J

2011 ~ 5×10^{20}J (close to 2007)

(assuming SST surface layer and constant ACC)

≡ melting 1-2x10^{6}km^{2} of 1m ice

≡ 2-4W/m^{2} over half Arctic

(Arctic surface fluxes ~ -2 to 10 W/m^{2}, Serreze et al, 2007)

~ 1/3rd Fram Strait oceanic heat

(Schauer et al, 2008)

= ~ half due to transport change, rest LOWER layer temperature change

SST change does not match lower layer T change.

(SST cannot predict change)

= Lower layer warm waters reach strait earlier (~1.6±1.1 days/year)

(possibly due to increased flux)

Interannual Temperature Changes

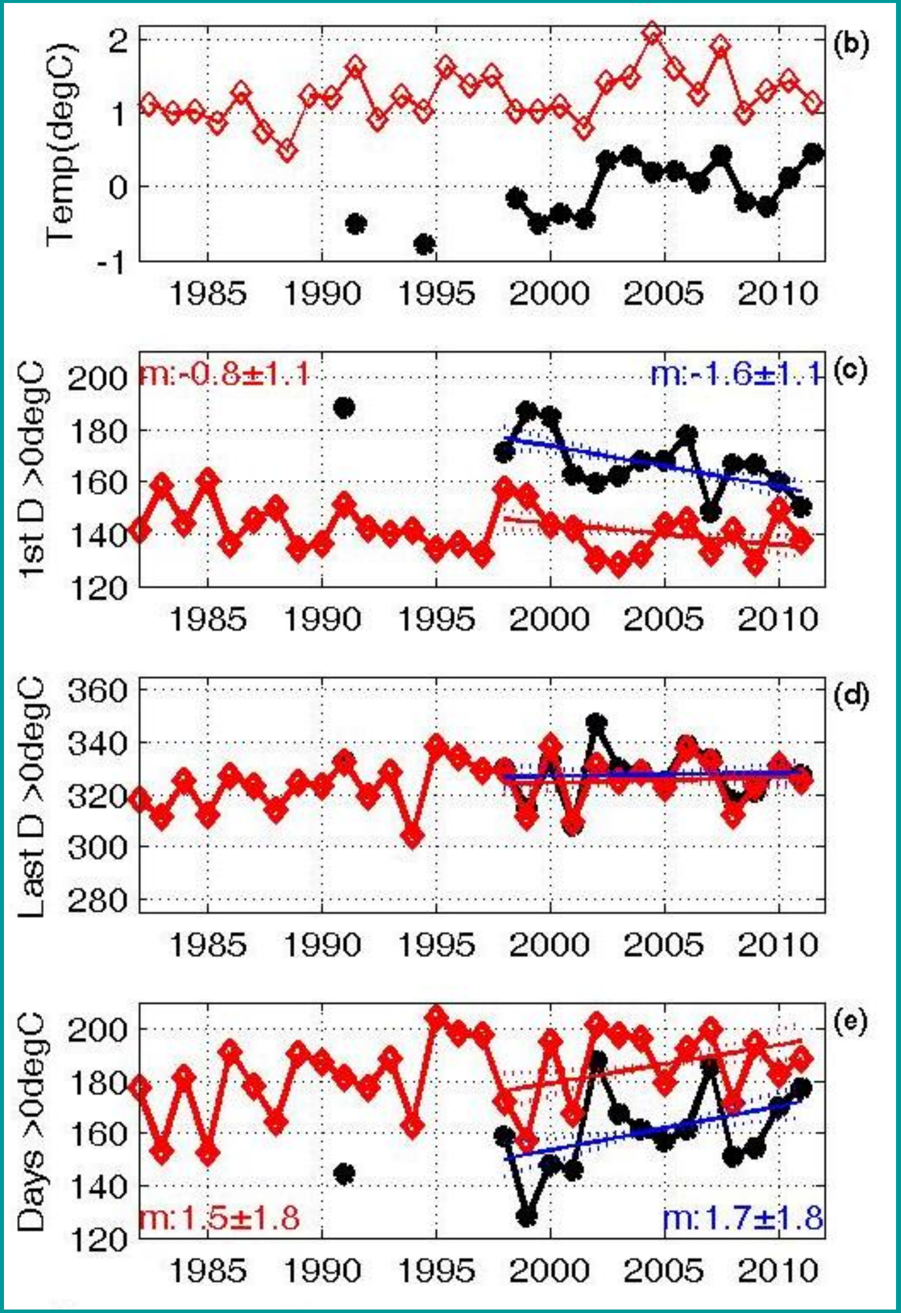
Red=SST
Black=A3

Annual Mean

First day above 0degC

Last day above 0 degC

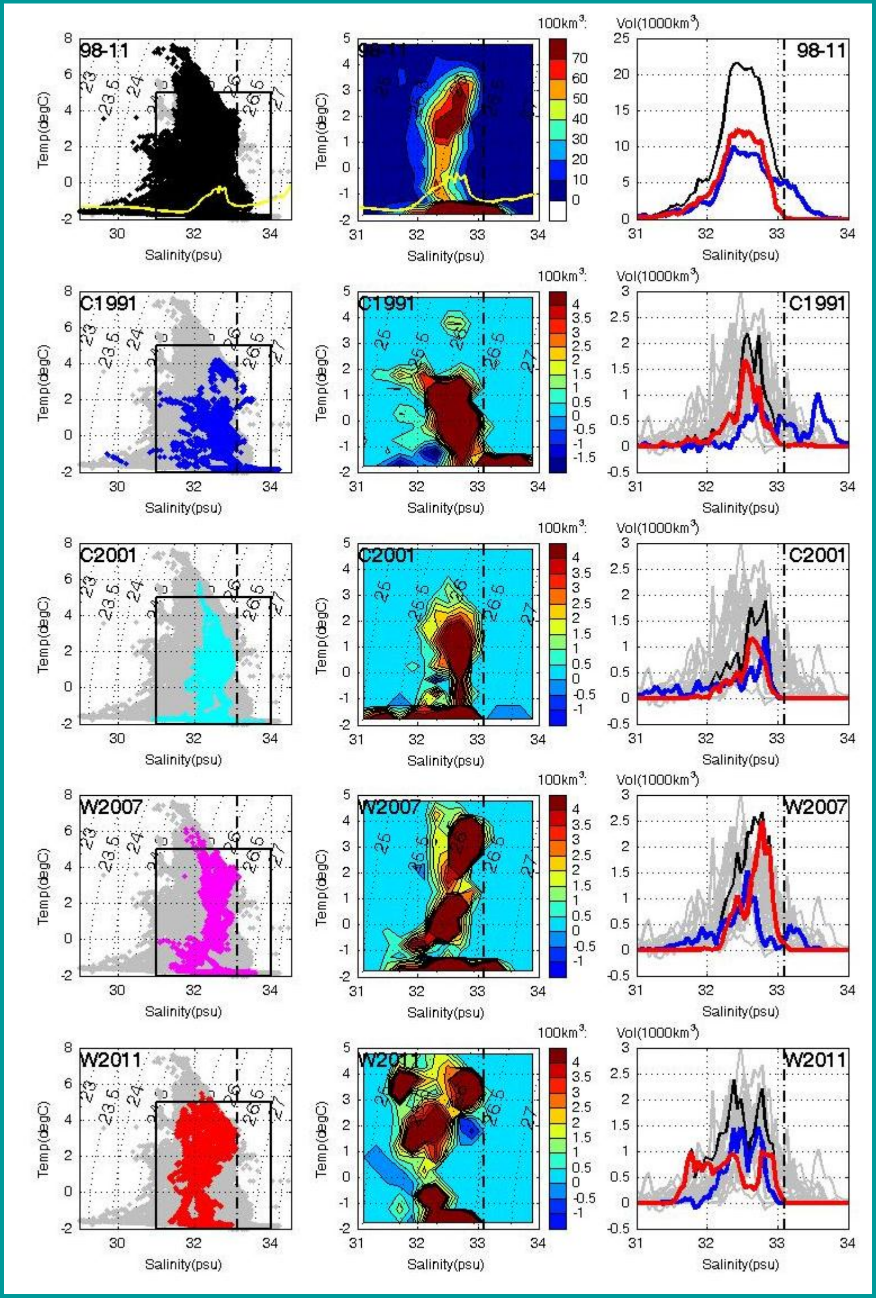
Days above 0 deg C



Significant trend in warming onset at depth (not in SST)

Longer warm season due to earlier warming

Woodgate et al., GRL 2012



Woodgate et al., GRL 2012

.. relates to salinity of Arctic Cold Halocline??

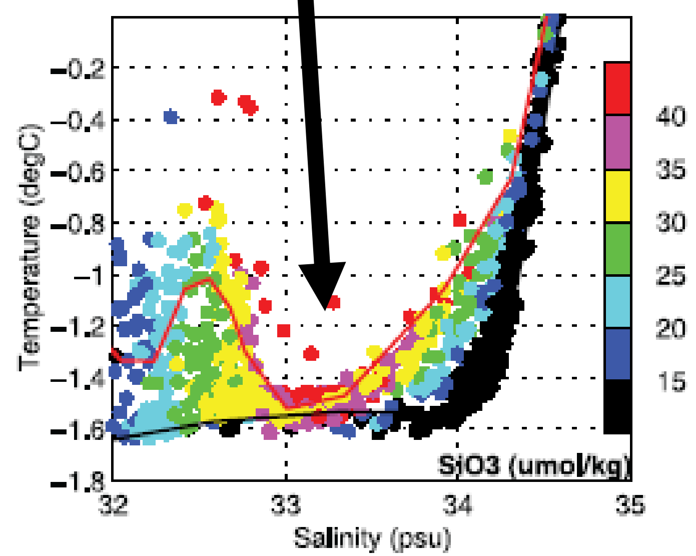
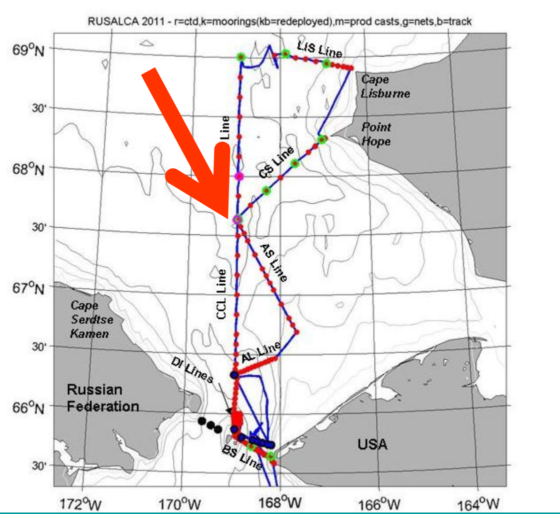


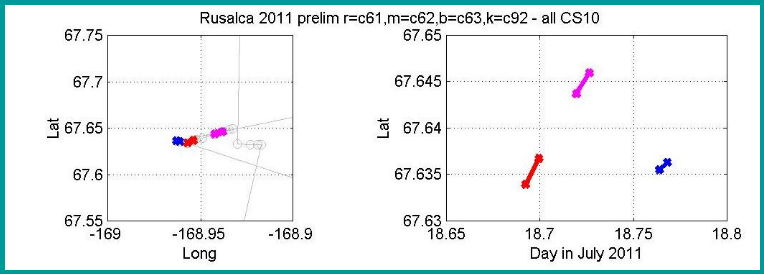
Figure 2. T-S scatter-plot of CBL2002 data, dot color indicating silicate value as per color scale. Solid lines show typical Atlantic (black) and Pacific (red) halocline profiles, as in Figure 3.

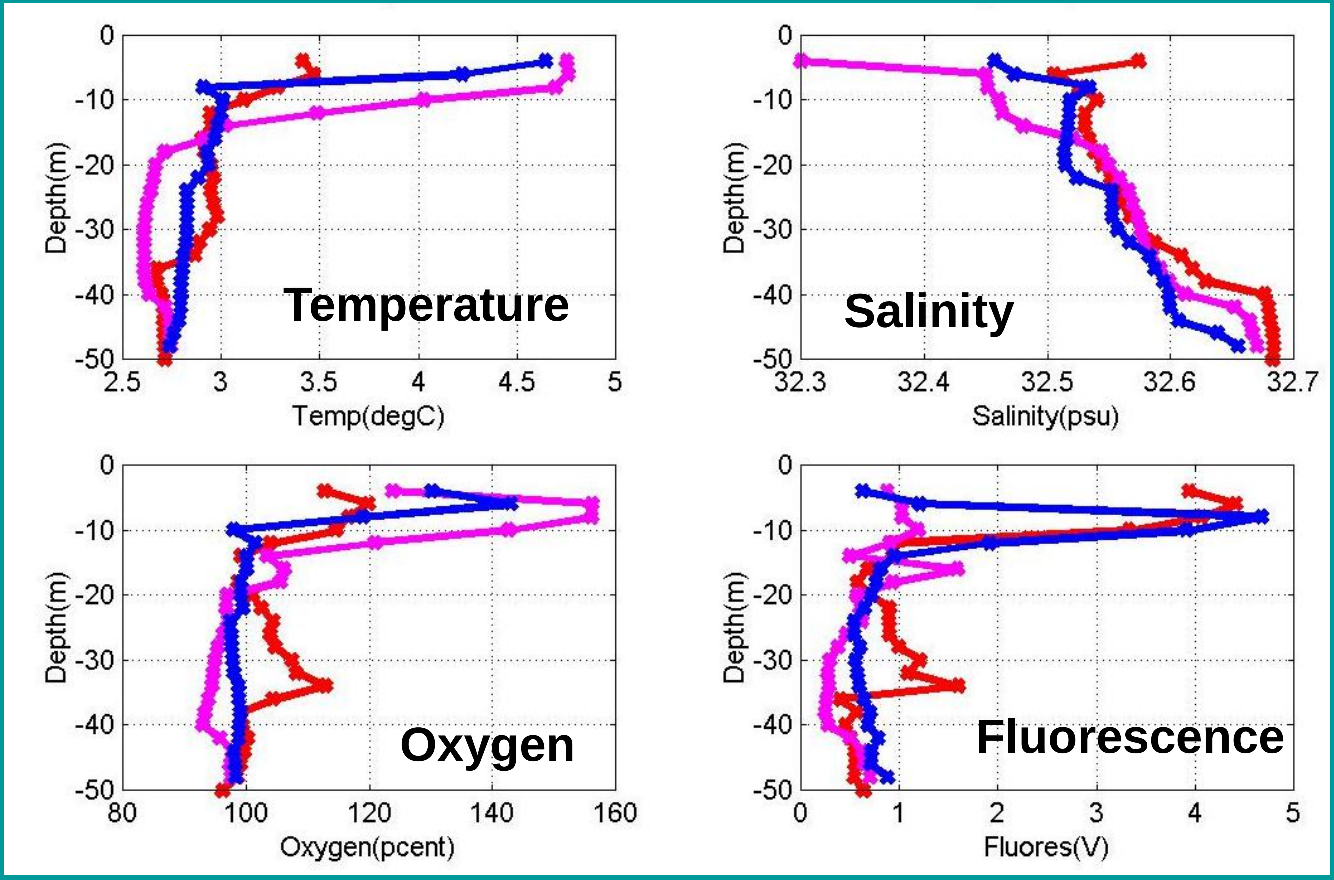
(Woodgate et al., 2005)

(no source of warm waters at this salinity)



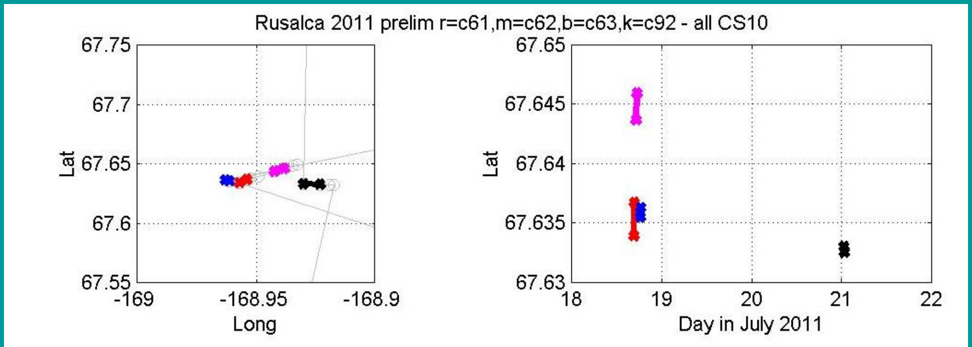
2 hrs at CS10

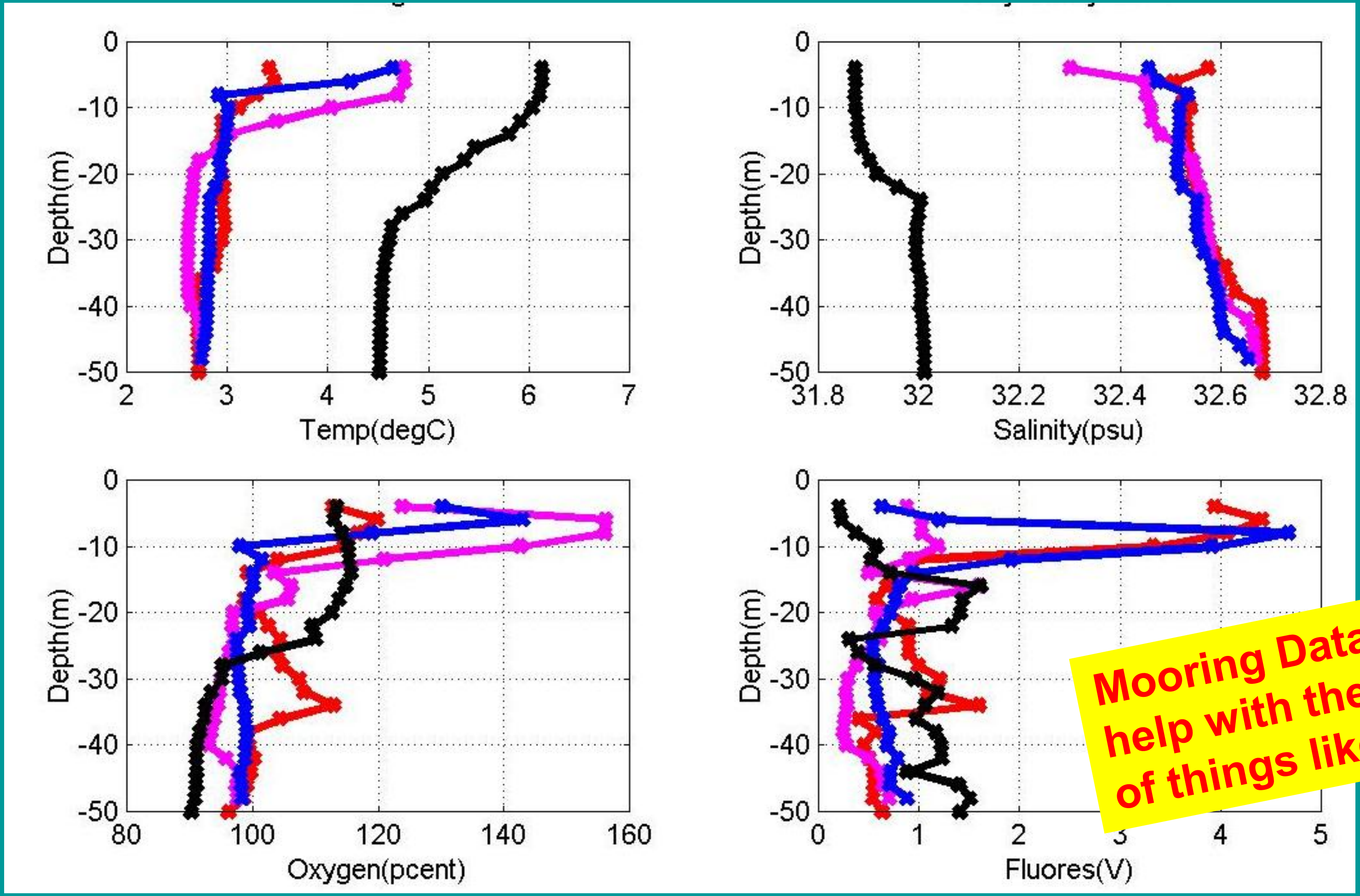




Stations few 100m apart apart, taken within 2 hrs

2 hrs and 2 days at CS10

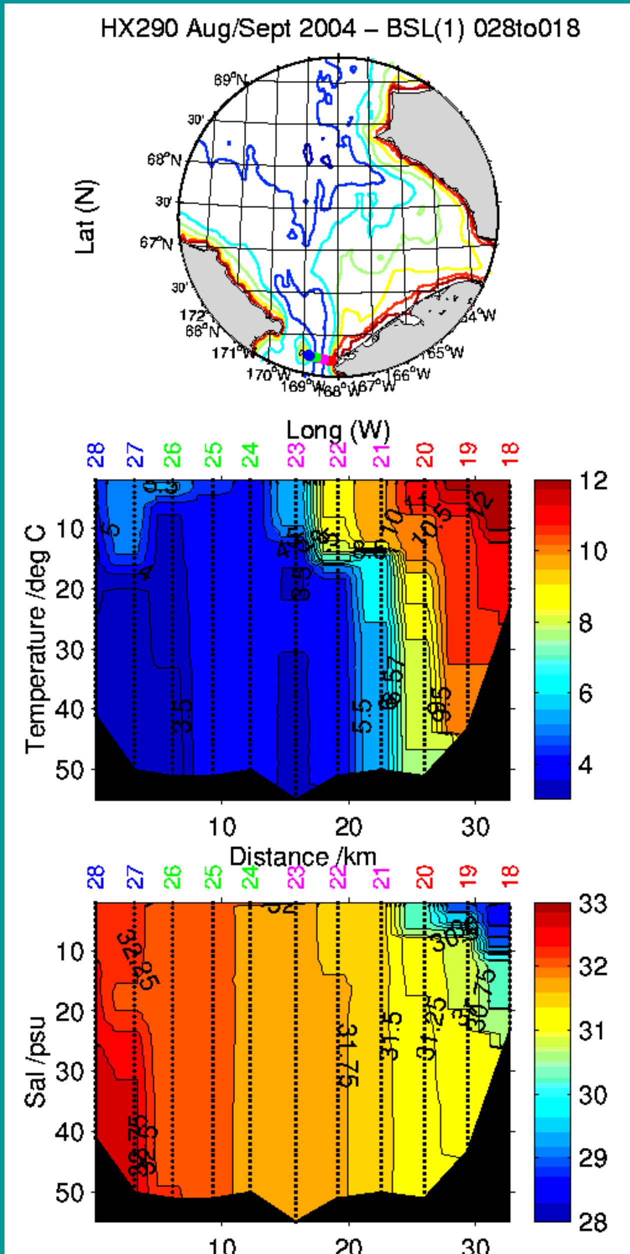




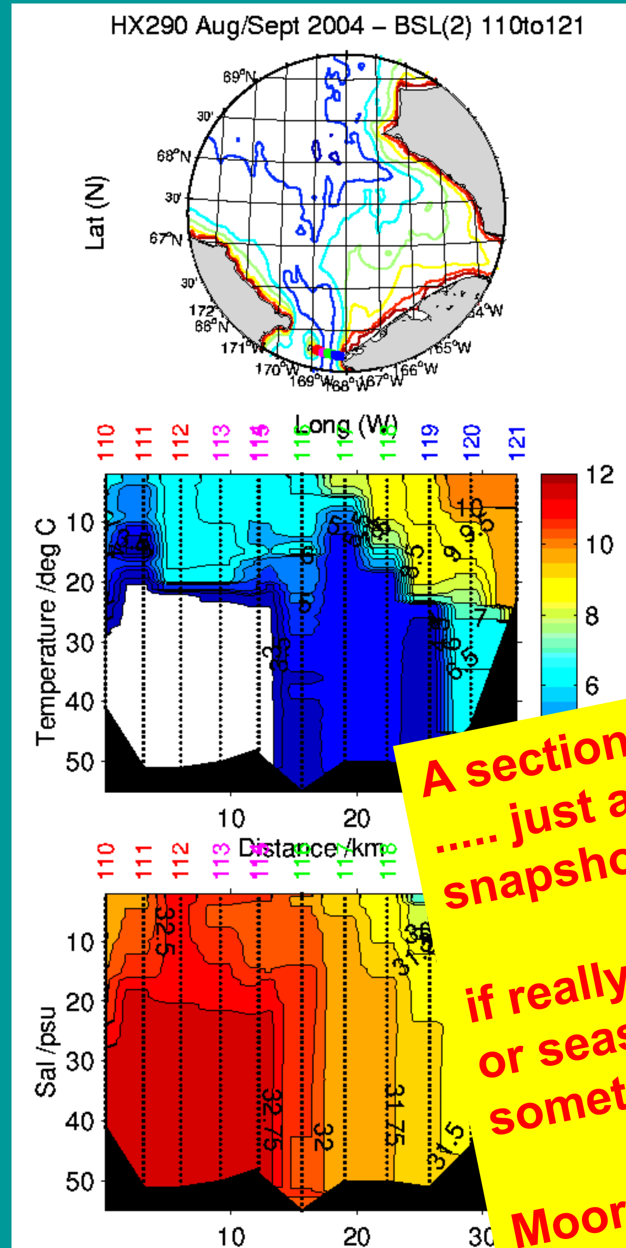
Mooring Data can help with the interpretation of things like this.

Bering Strait 2004

Temperature, salinity and velocity change rapidly and on small space scales.



1st Sept 2004

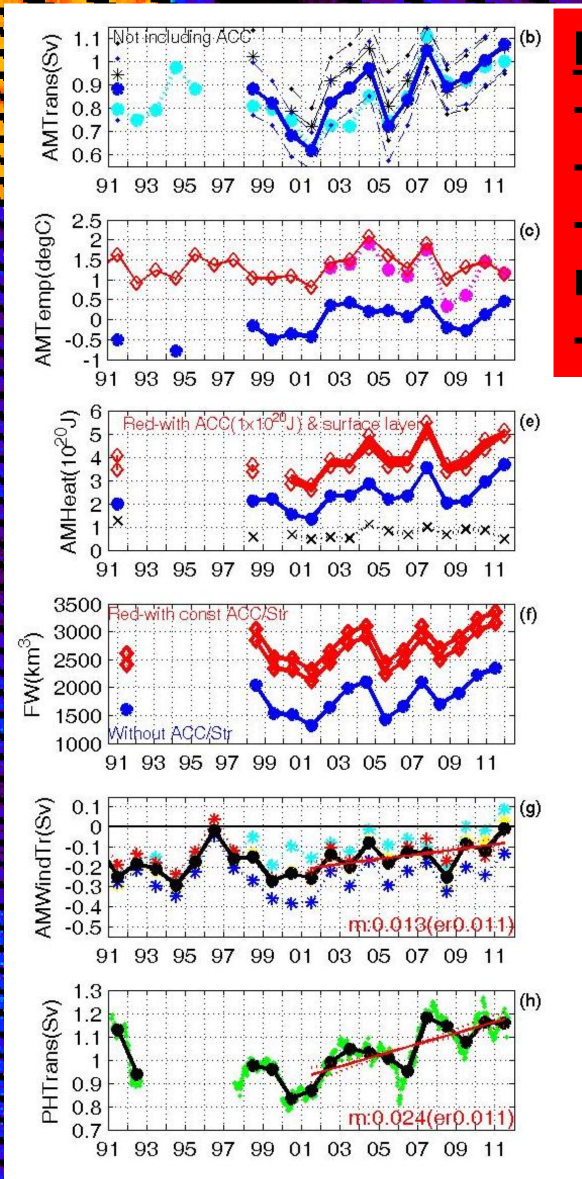


5th Sept 2004

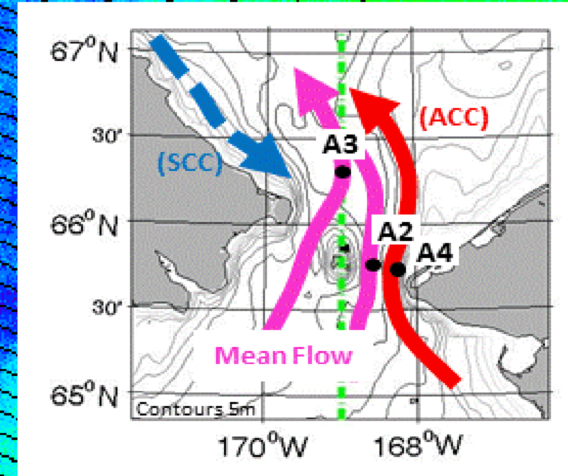
A section is . .... just a (non-synpotic) snapshot ..

if really you want a monthly or seasonal average, need something else

Mooring data can help interpret what is going on



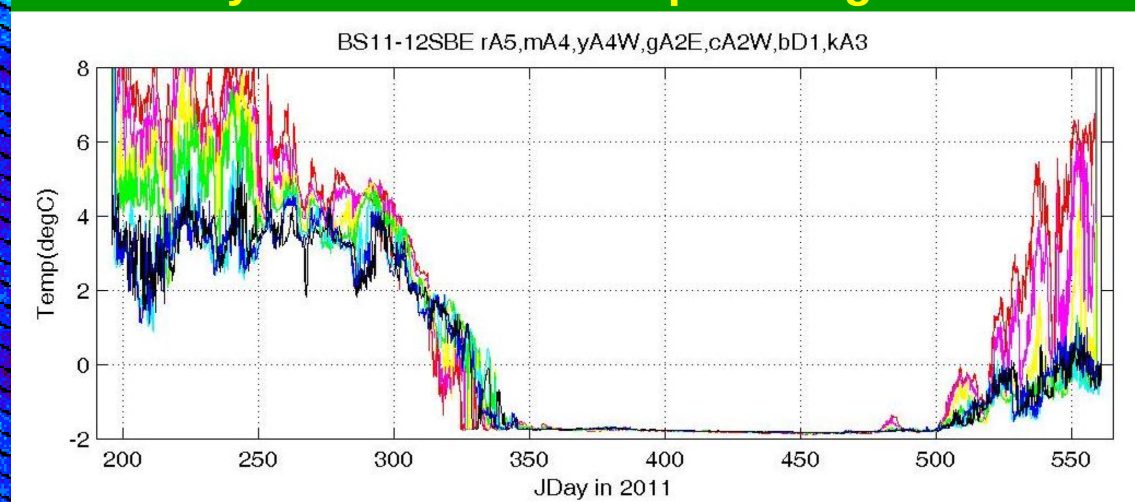
<u>Interannual change</u>
- **large**
- **2/3rd due to far field**
- **heating in Lower layer, not SST**
- **still need moorings**



psc.apl.washington.edu/BeringStrait.html

Observing System Design for T,S,Vel, Ice Vel and thickness

Quantification of short time/space scale variability essential for interpretating station data



Land Sat – CH6H – Jul18th 2003