

What's new in the Bering Strait

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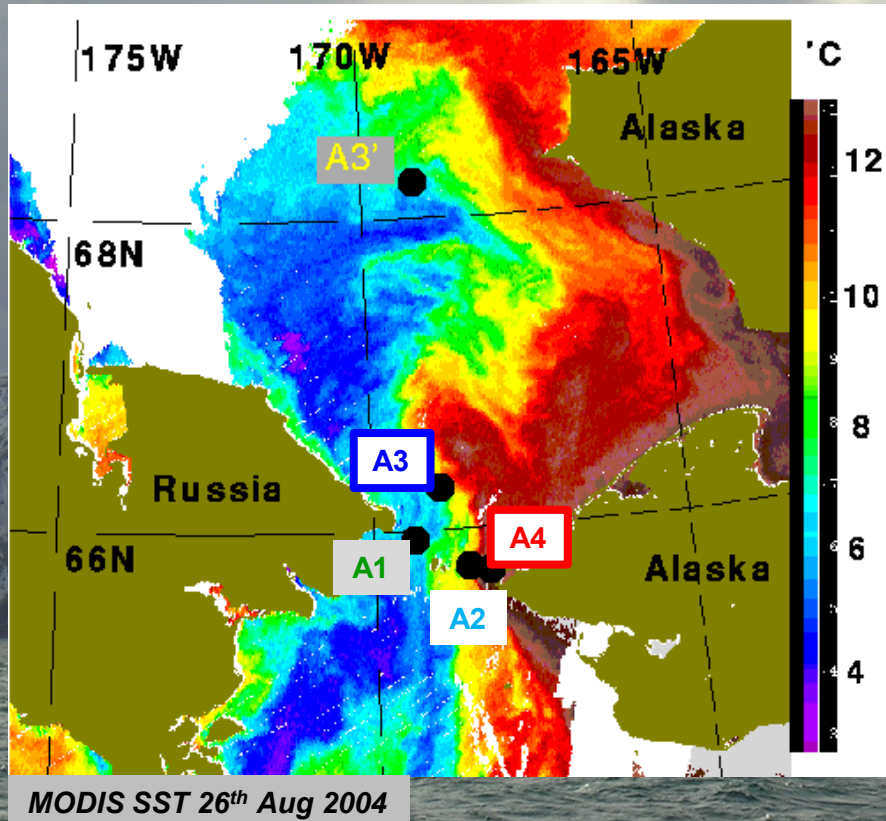
Annual trends, change, drivers, and implications

How strange were recent years

***Funded by US National Science Foundation
Office of Polar Programs, Arctic Observing Network***

*Diomedede Islands,
mid Bering Strait,
Photo: R Woodgate*

Bering Strait moorings



1990 – present (29+ years)
== year-round moorings in US mid-channel (A1, A2, A3, A3')
== mostly near bottom
== 2001 started measuring the Alaskan Coastal Current with A4

Total Flow is ~
Climate site (A3)
+
Alaskan Coastal Current (A4)

== Woodgate et al, 2015, Bering Strait Synthesis, RUSALCA special issue of *Oceanography*, doi:10.5670/oceanog.2015.57
== Woodgate, 2018, *Progress in Oceanography*, doi: 10.1016/j.pocean.2017.12.007

Trends in Annual Means to 2018

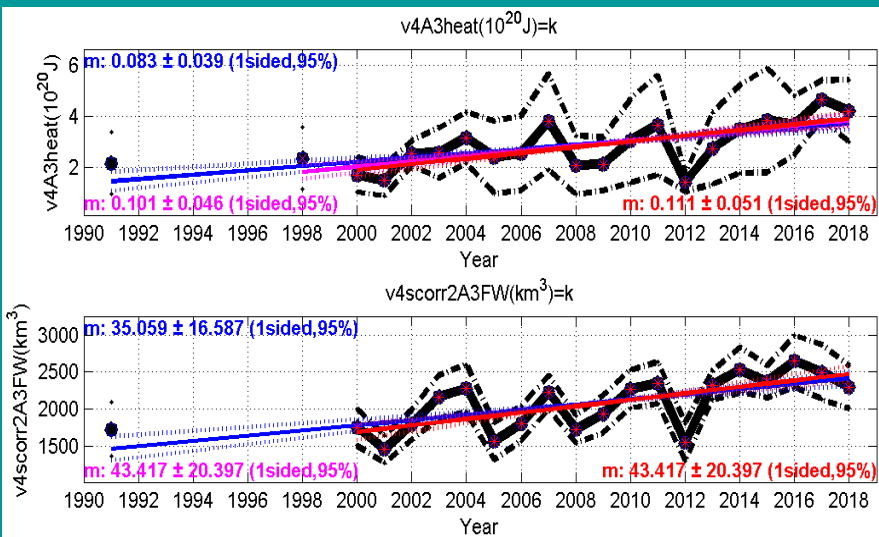
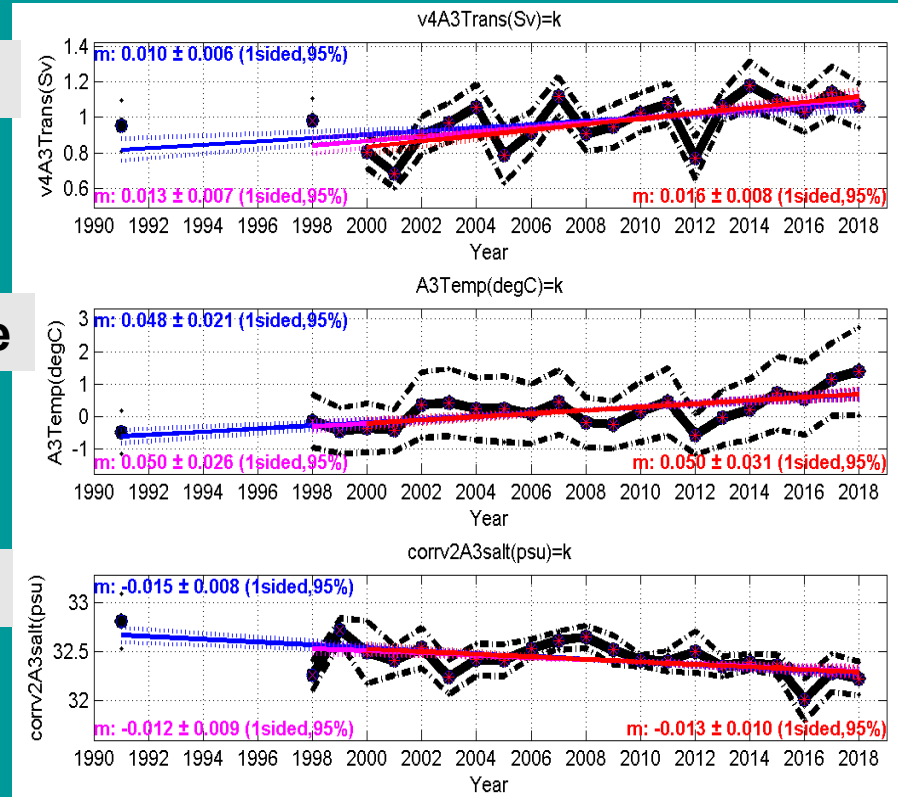
From Climate Site, A3:
Significant trends in
 - transport (*increasing*)
 - temperature (*warming*)
 - salinity (*freshening*)

Transport

Temperature

Salinity

.. and increasing heat and freshwater fluxes



Heat relative to -1.9°C
 before ACC/stratification
 contribution ($\sim 2 \times 10^{20}$ J)

.. almost doubling
 since 1990s

... mostly driven by transport

Freshwater relative to 34.8psu
 before ACC/stratification contribution ($\sim 1000 \text{ km}^3$)

Transport Variability

Fit for:

$$\text{Transport} = A + B \times \text{Northward Wind}$$

A = Pressure Head (PH)

$B \times N$ Wind = Wind Contribution

Updated from Woodgate, 2018

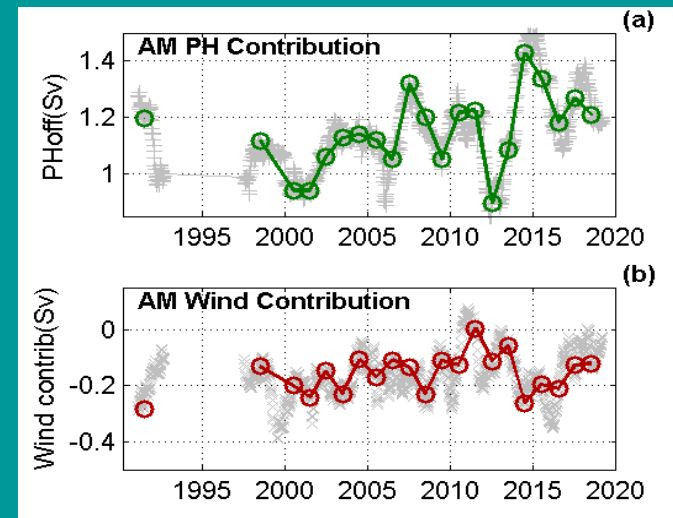
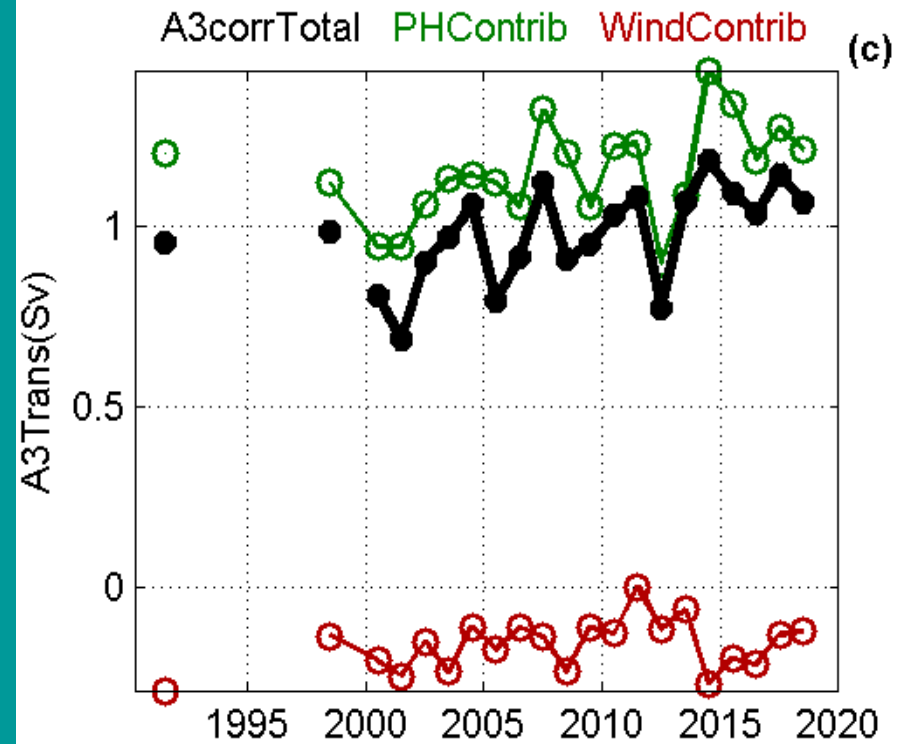
Recent change due to both
- wind change AND
- pressure head (PH) change

= Trends in PH are significant,
and are in almost all months.

= No significant trend in wind

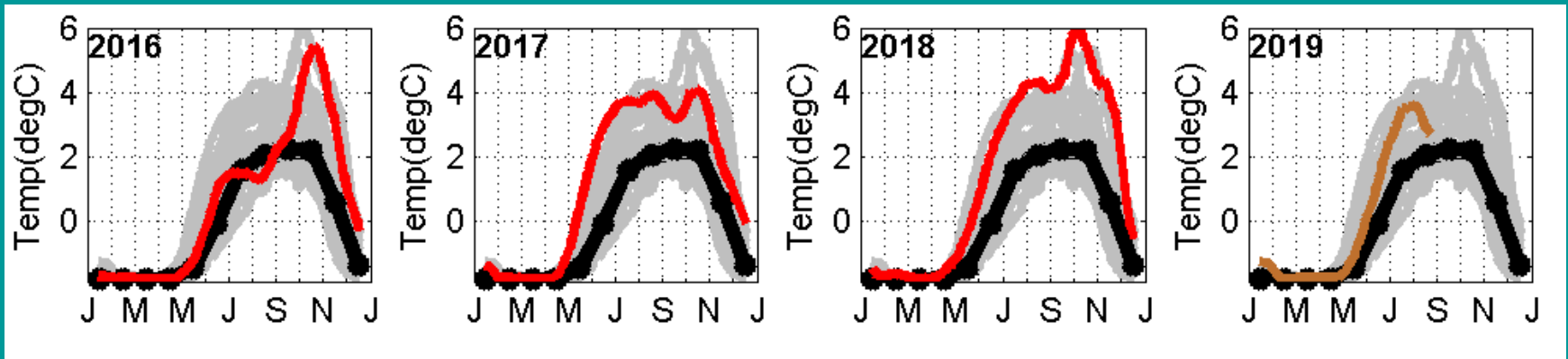
What causes trend in Pressure Head?

- Peralta-Ferriz & Woodgate, 2017, find relationships to ARCTIC (East Siberian Sea) ocean mass change,
.. but trends still being investigated



How strange were recent years?

30day smoothed
TEMPERATURE
(°C)



Grey = all prior years

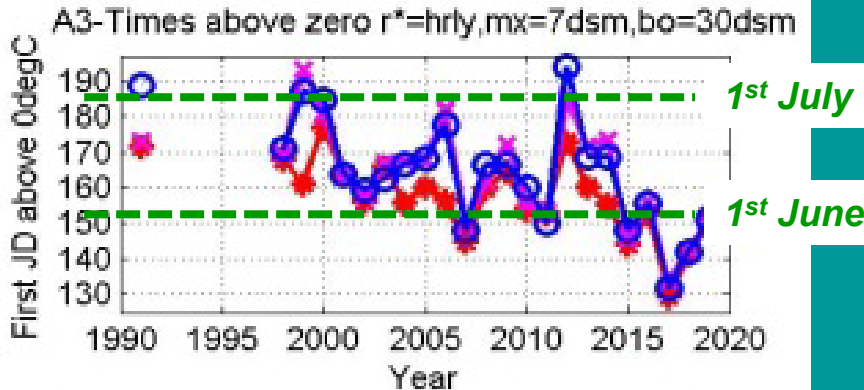
Color = year in question (red="above average")

Black = Woodgate, 2005, climatology

Early warming
Warm later in year
Several degrees above "normal"

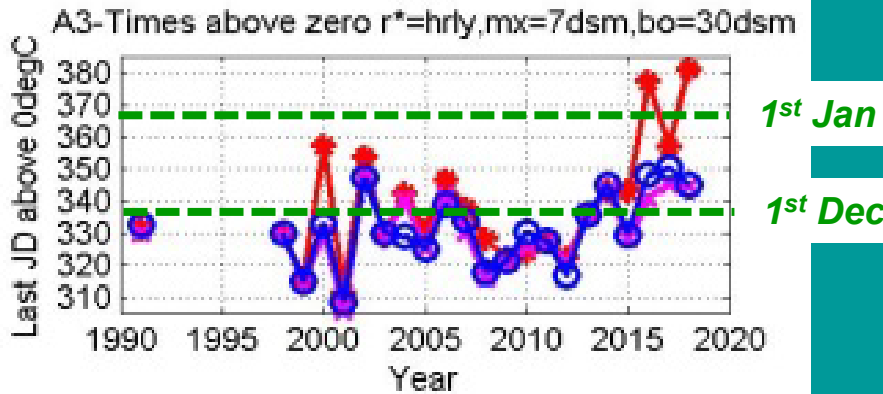
Warming, Cooling, Open Water times

MELT
First
above 0°C



Warming earlier
(1.3 days/yr)
Freezing later
(0.6 days/yr)
Longer open water
(2 days/yr)

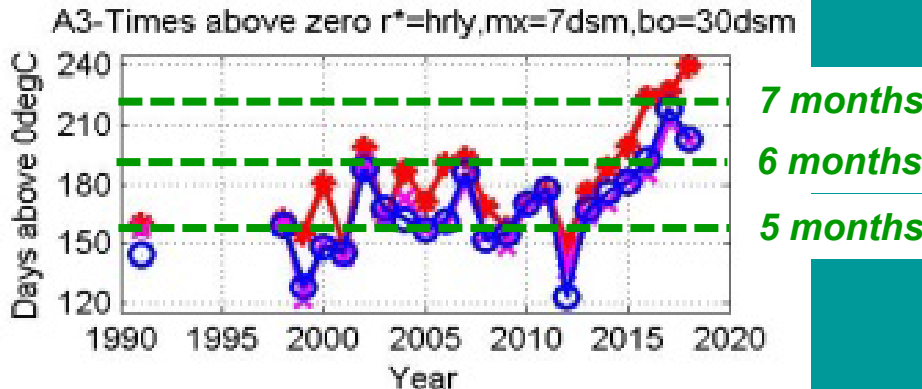
FREEZE
Last
above 0°C



*Melt was mid June,
now May*

*Waters above 0°C
was mid Nov, now Dec+*

**OPEN
WATER
TIME**
Days
above 0°C



*Now more than
6 months above 0°C*

BUT *(not shown)*
**no significant
trends in Alaskan
Coastal Current**

BUT (not shown)
no significant
trends in Alaskan
Coastal Current

**Seasonality and forcing factors of the Alaskan Coastal
Current in the Bering Strait from July 2011 to July 2012,**

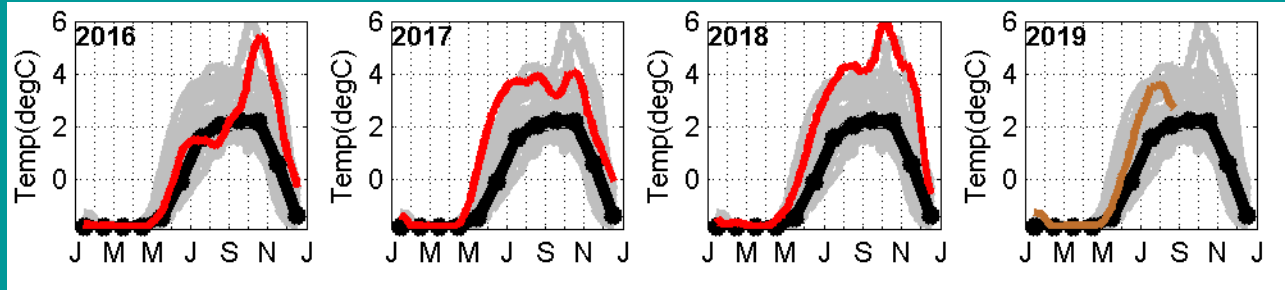
Brett Morris,

MS Thesis, University of Washington, June 2019

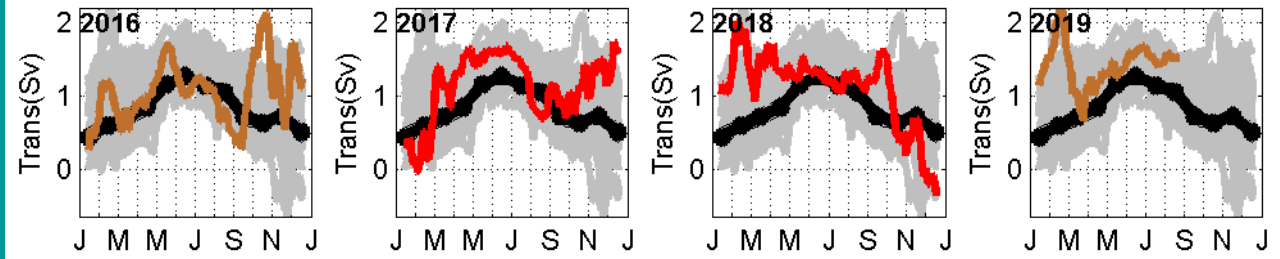
- dynamics of surface trapped buoyant coastal current
- response to wind forcing, including **separation from the coast**
- theoretical estimates for vital parameters (width, depth, nose speed)
- **strongly forced by Yukon outflow (time off set ~ 2 weeks),** but also needs freshwater from other rivers and Aleutian Chain

How strange were recent years? – heat ...

30day smoothed
TEMPERATURE
(°C)



30day smoothed
TRANSPORT
(Sv)

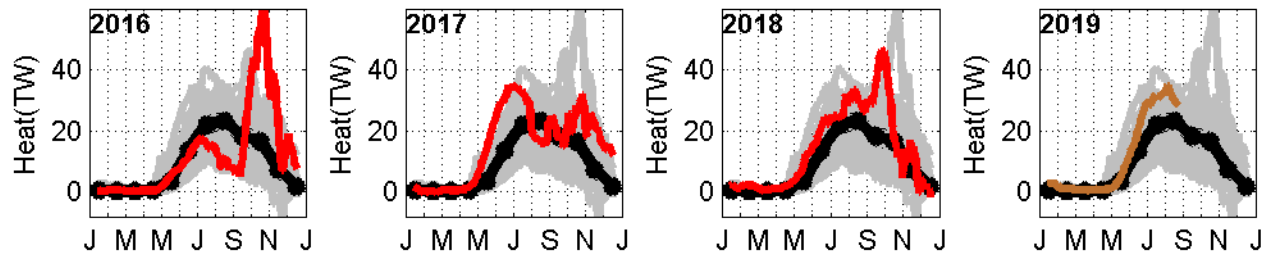


~ 1.0Sv

~ 1.1Sv

~ 1.1Sv

30day smoothed
HEAT TRANSPORT
(TW)
relative to -1.9°C



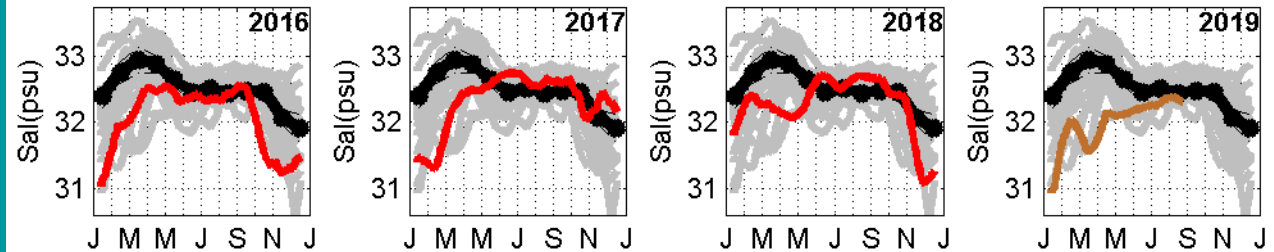
~ 3.6
 $\times 10^{20} \text{J}$

~ 4.6
 $\times 10^{20} \text{J}$

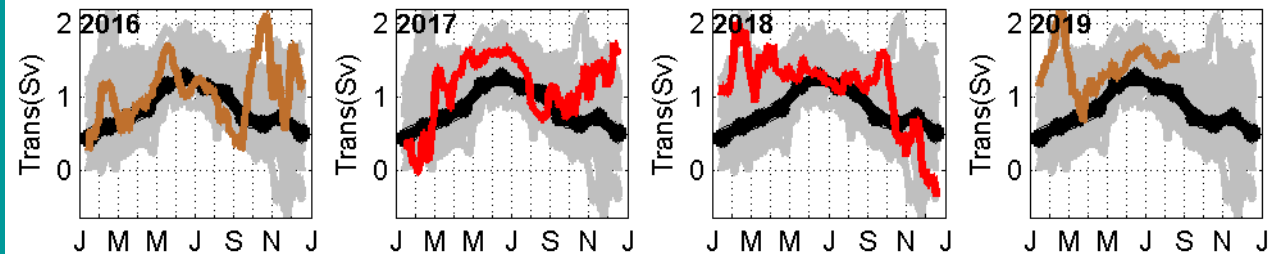
~ 4.2
 $\times 10^{20} \text{J}$

How strange were recent years? - salinity

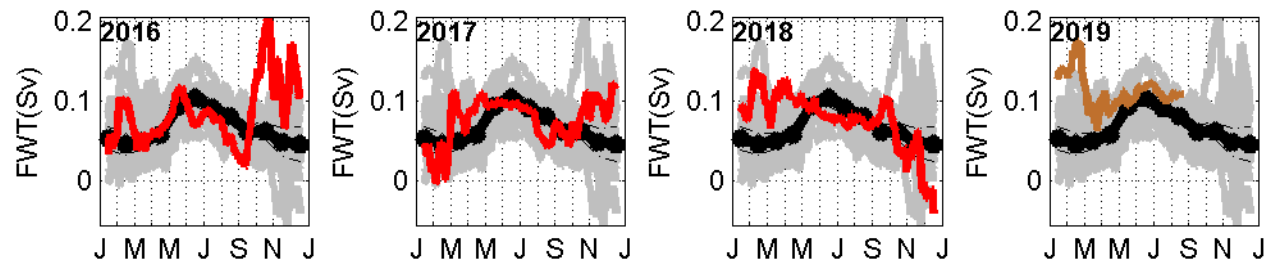
30day smoothed
SALINITY
(psu)



30day smoothed
TRANSPORT
(Sv)



30day smoothed
**FRESHWATER
TRANSPORT**
(Sv)
relative to 34.8psu



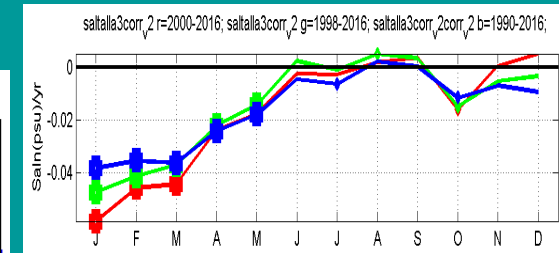
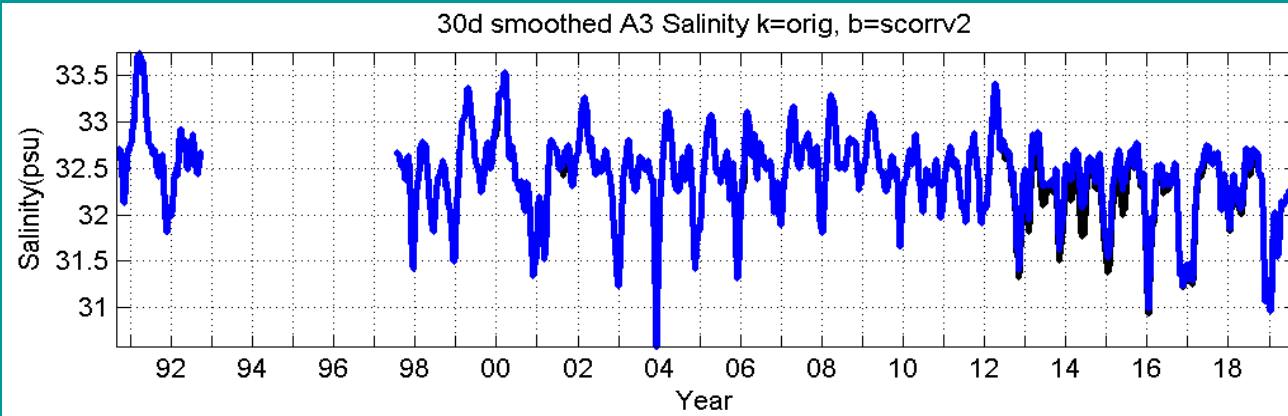
~ 2600km³

~ 2500km³

~ 2300km³

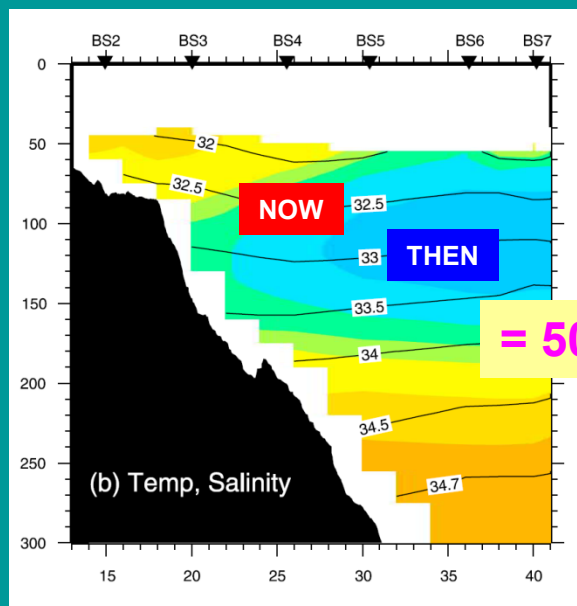
Again, winters showing large change

Freshening ... esp in winter



Salinity Trend by Month
 - colors different time periods
 - dots if significant at 95%

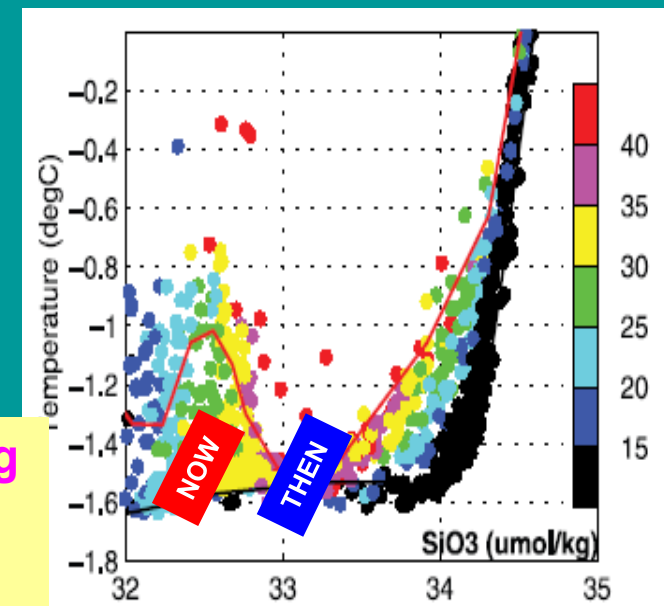
Large fresh events in winter, traditional seasonal cycle missing
Maximum salinities: from ~ 33psu in 1990s (winter), 32.5psu now (summer)



Winter water less dense (~ 0.5 kg/m³)

= 50-100m shallower?

= No longer supplying cold halocline in winter?

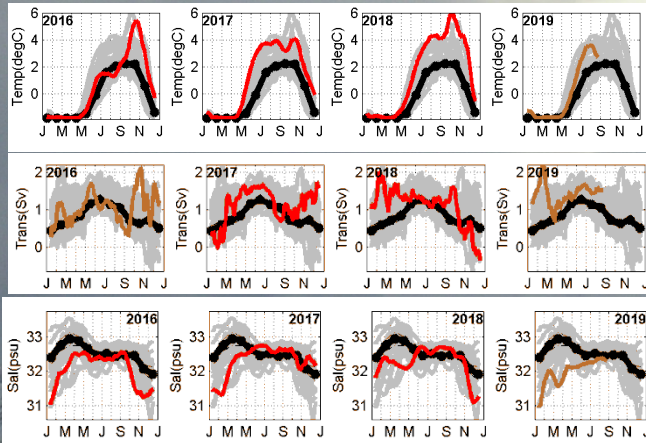


2002-2003 data, Pickart et al., 2009

2002 data, Woodgate et al., 2005

What's new in the Bering Strait

Change in recent years



Earlier warming, later cooling,
longer open water season.

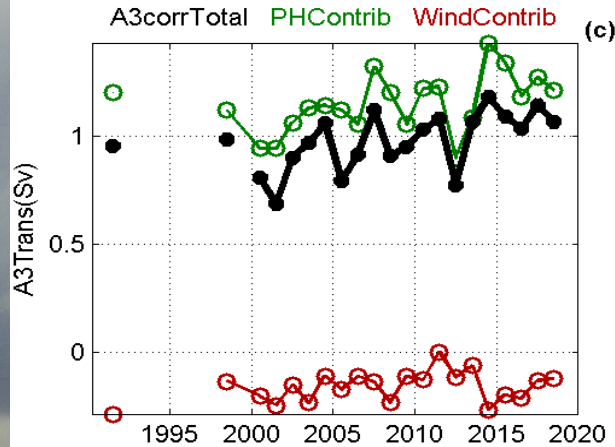
Significant trends in

- temperature (warming)
- transport (increasing)
- salinity (freshening)

*Almost doubling heat and
freshwater fluxes*

No Trend in the Alaskan
Coastal Current

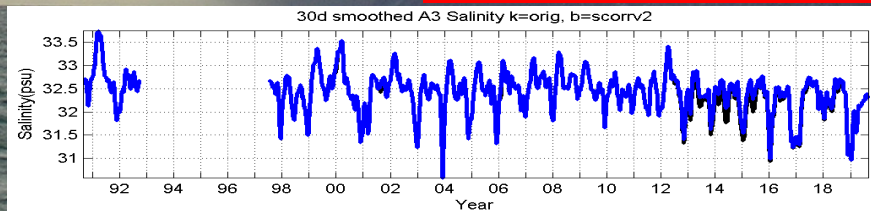
Transport increase



Both wind and pressure
head changes important.

Long term trend only in
pressure head, not wind

Winter freshening



Pacific Winter Waters less dense than in
1990s

~ 50-100m shallower?

- not ventilating cold halocline?

Annual Cruises

Cruise reports:

[psc.apl.washington.edu/
BeringStrait.html](http://psc.apl.washington.edu/BeringStrait.html)

Preliminary plots of:

- CTD sections
- underway data
- mooring results



Norseman Maritime

2020 Planning for
Sept, also Norseman2,
now with SVA, Alaska

BERING STRAIT MOORINGS 2019 Cruise Norseman II

5th - 15th September 2019, Nome to Nome,
Chief Scientist: Rebecca Woodgate (University of Washington, USA)

