Evolution of water masses and nutrients in Barrow Canyon during summer 2010: Preliminary results from the DBO Pilot Study

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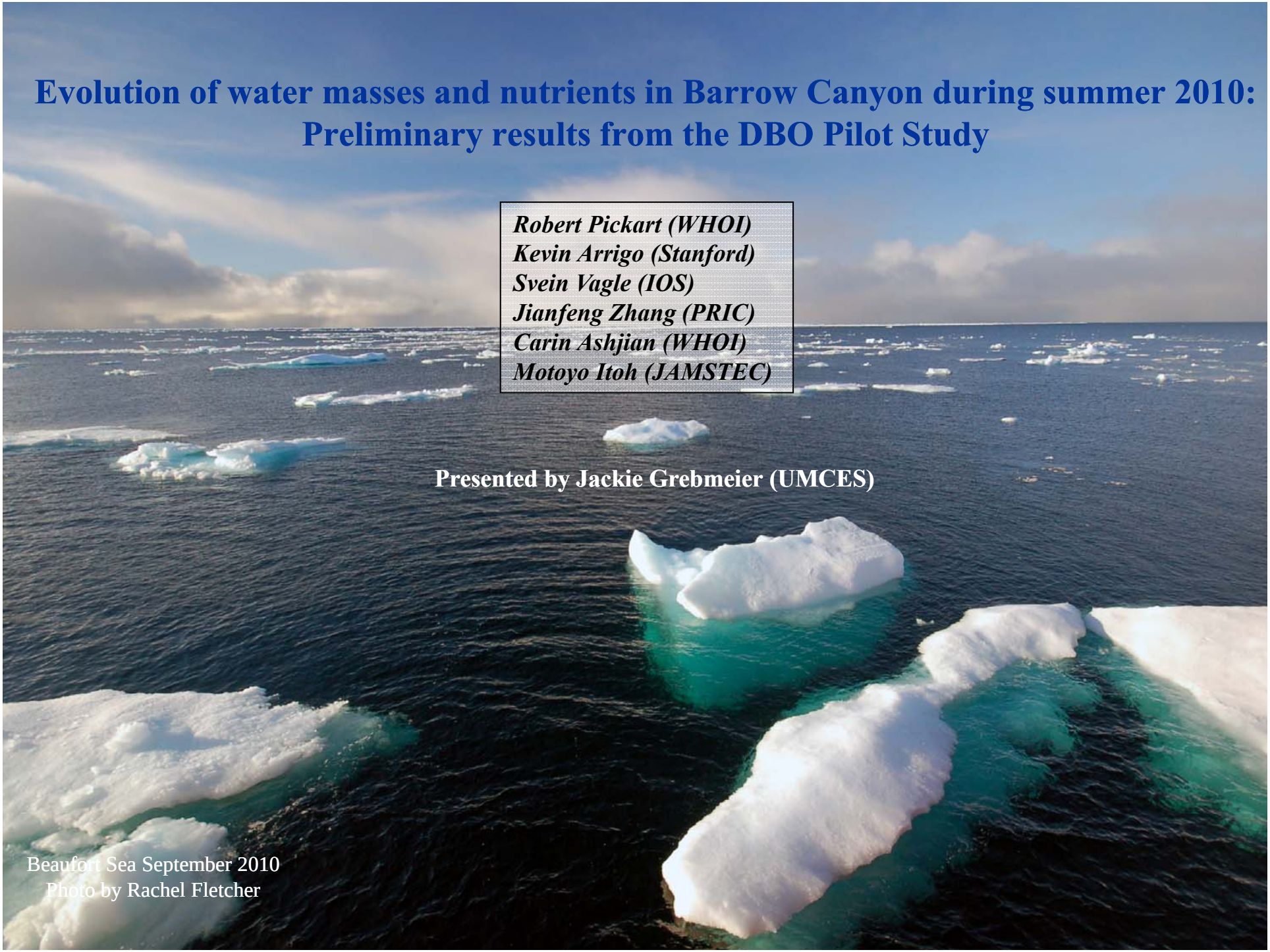
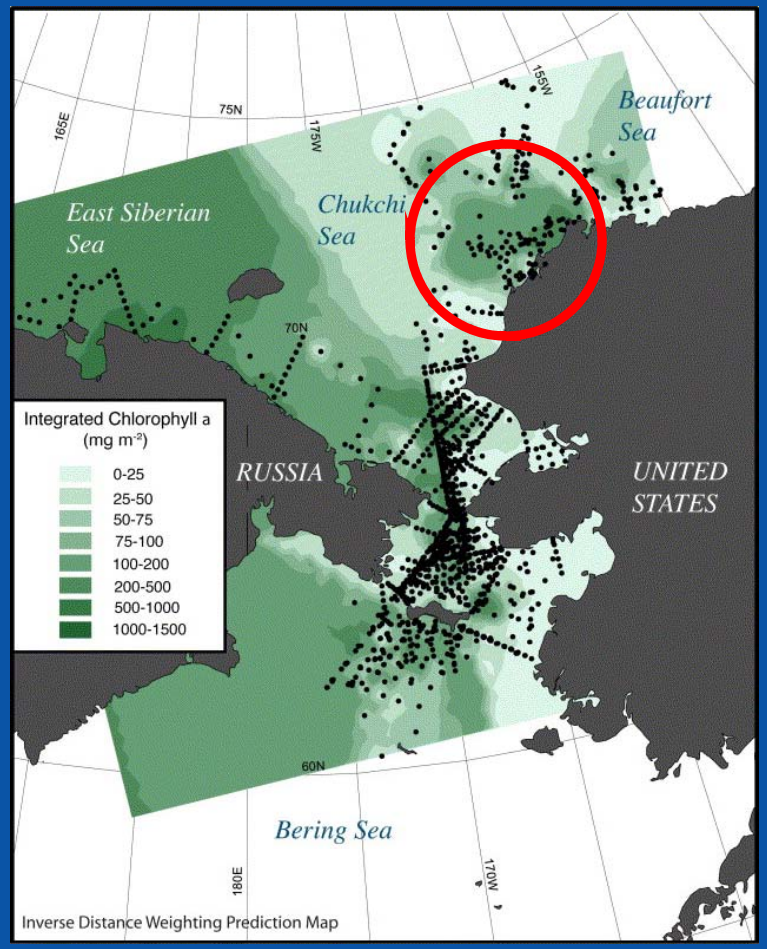


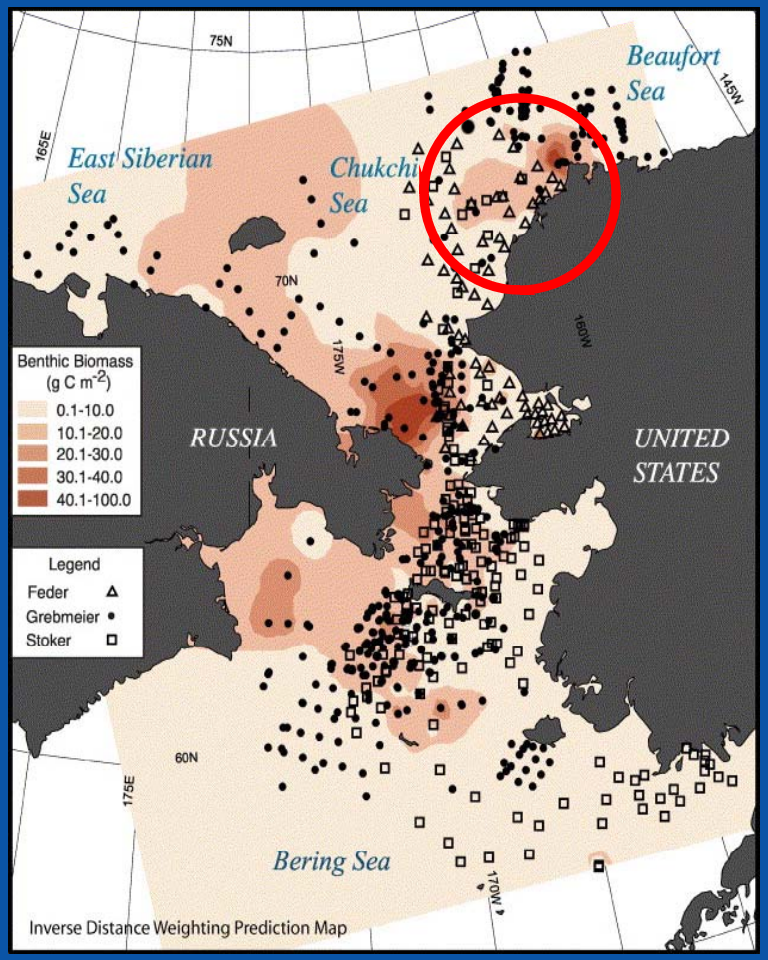
Beaufort Sea September 2010
Photo by Rachel Fletcher

Barrow Canyon: One of the highest levels of primary productivity and benthic biomass in the western Arctic

Integrated chlorophyll

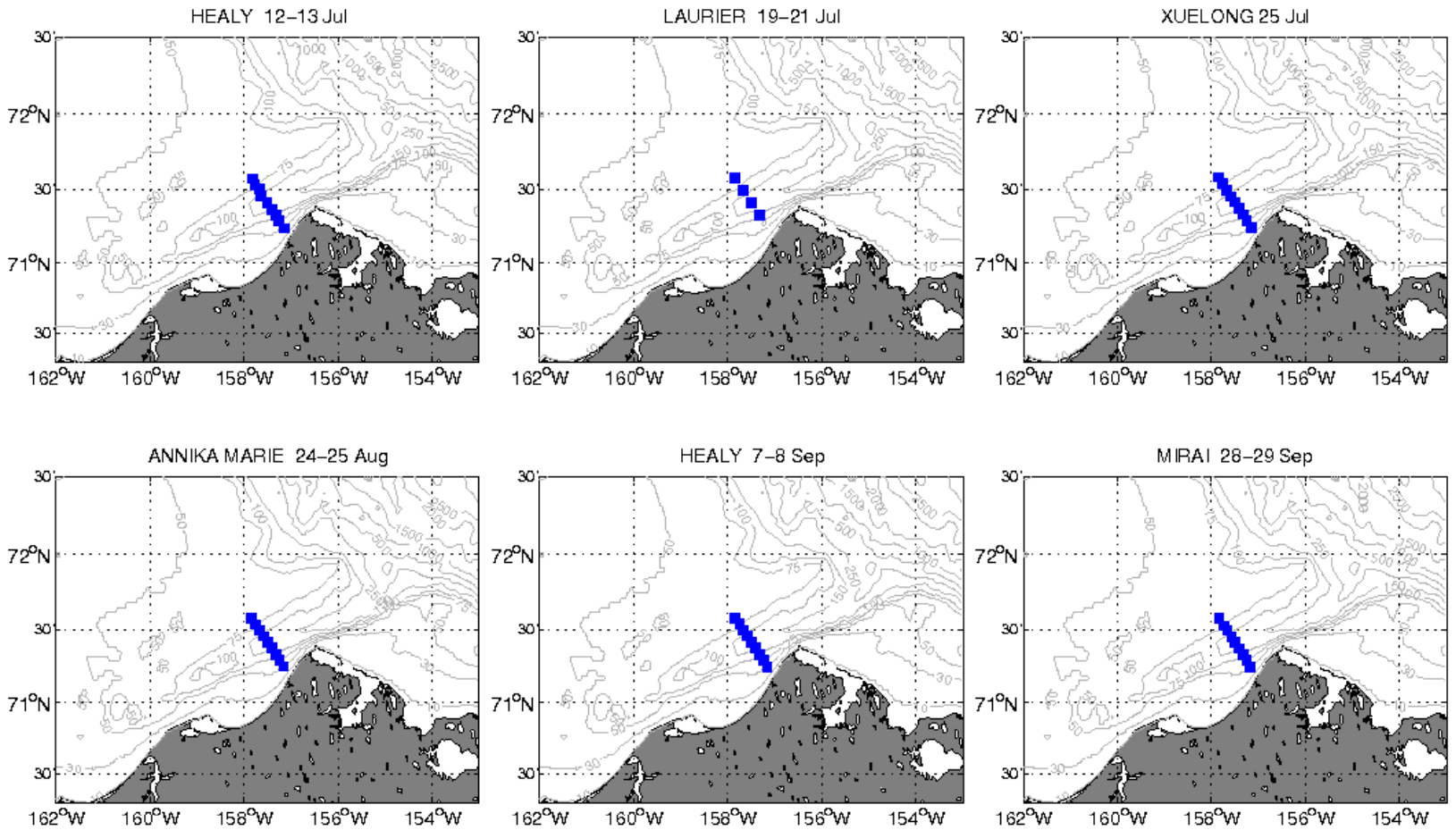


Benthic biomass



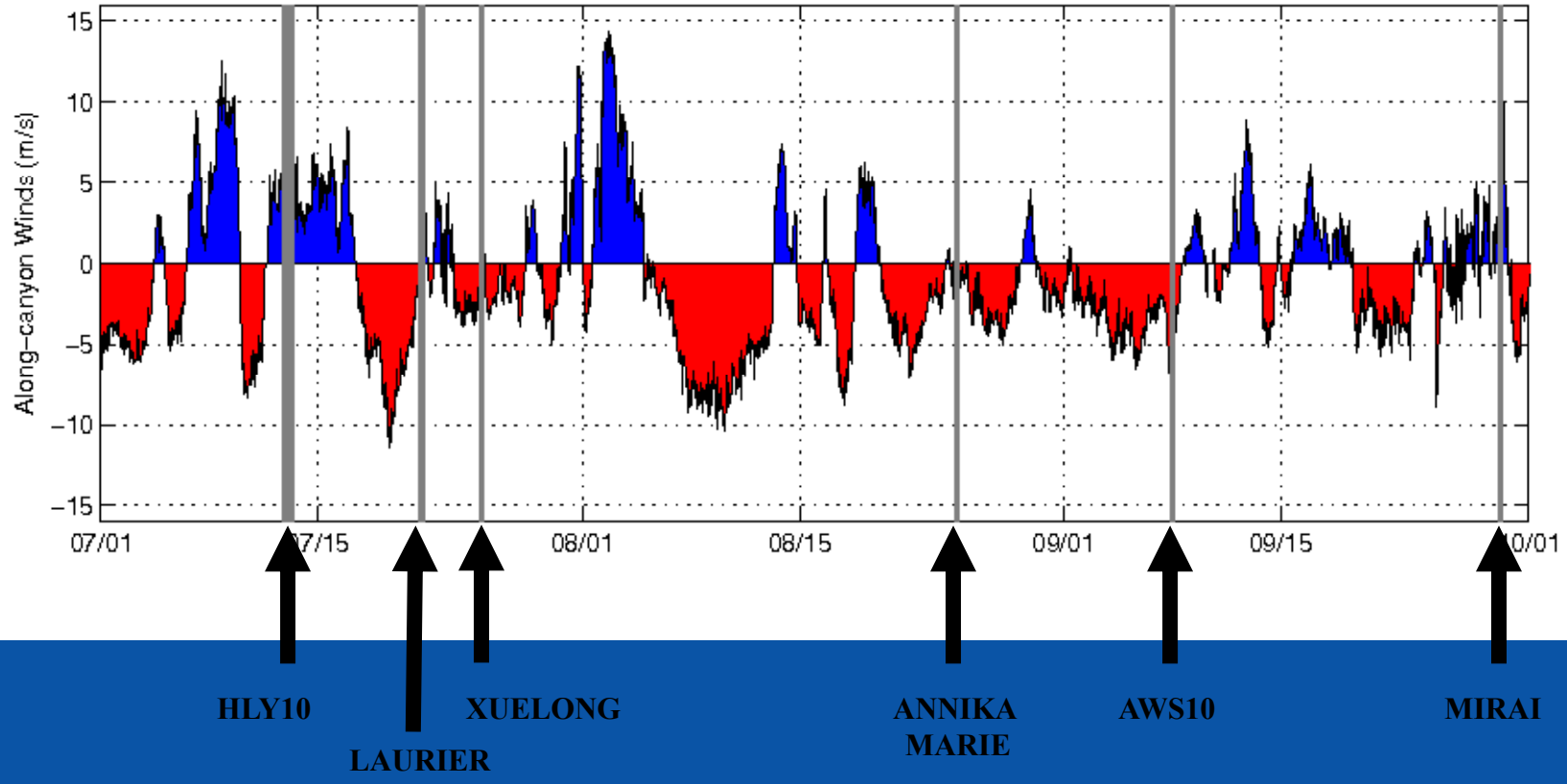
From Grebmeier et al. (2006)

6 occupations of Barrow Canyon transect in 2010



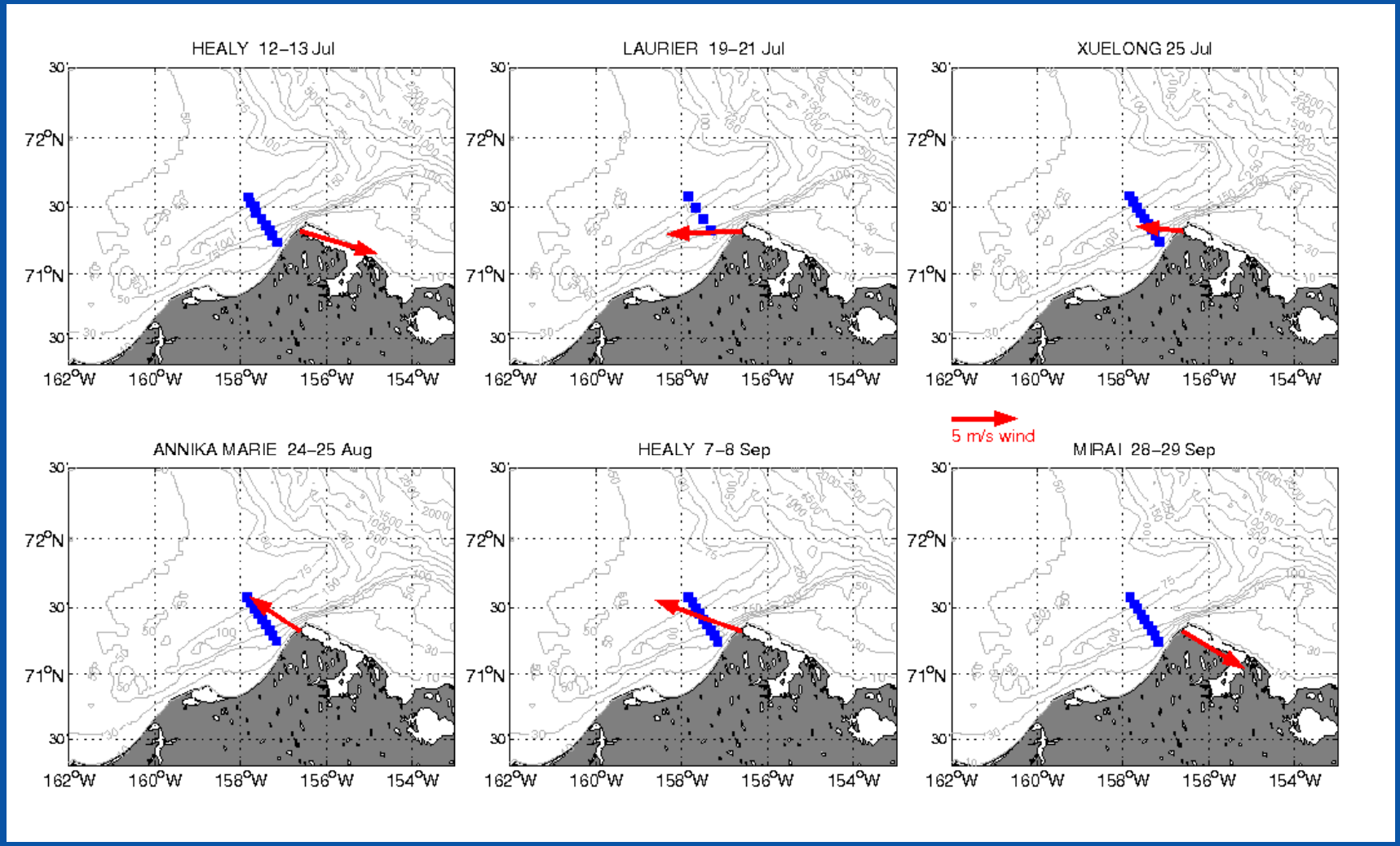
Along-canyon winds summer 2010

Blue = downwelling-favorable *Red = upwelling-favorable*

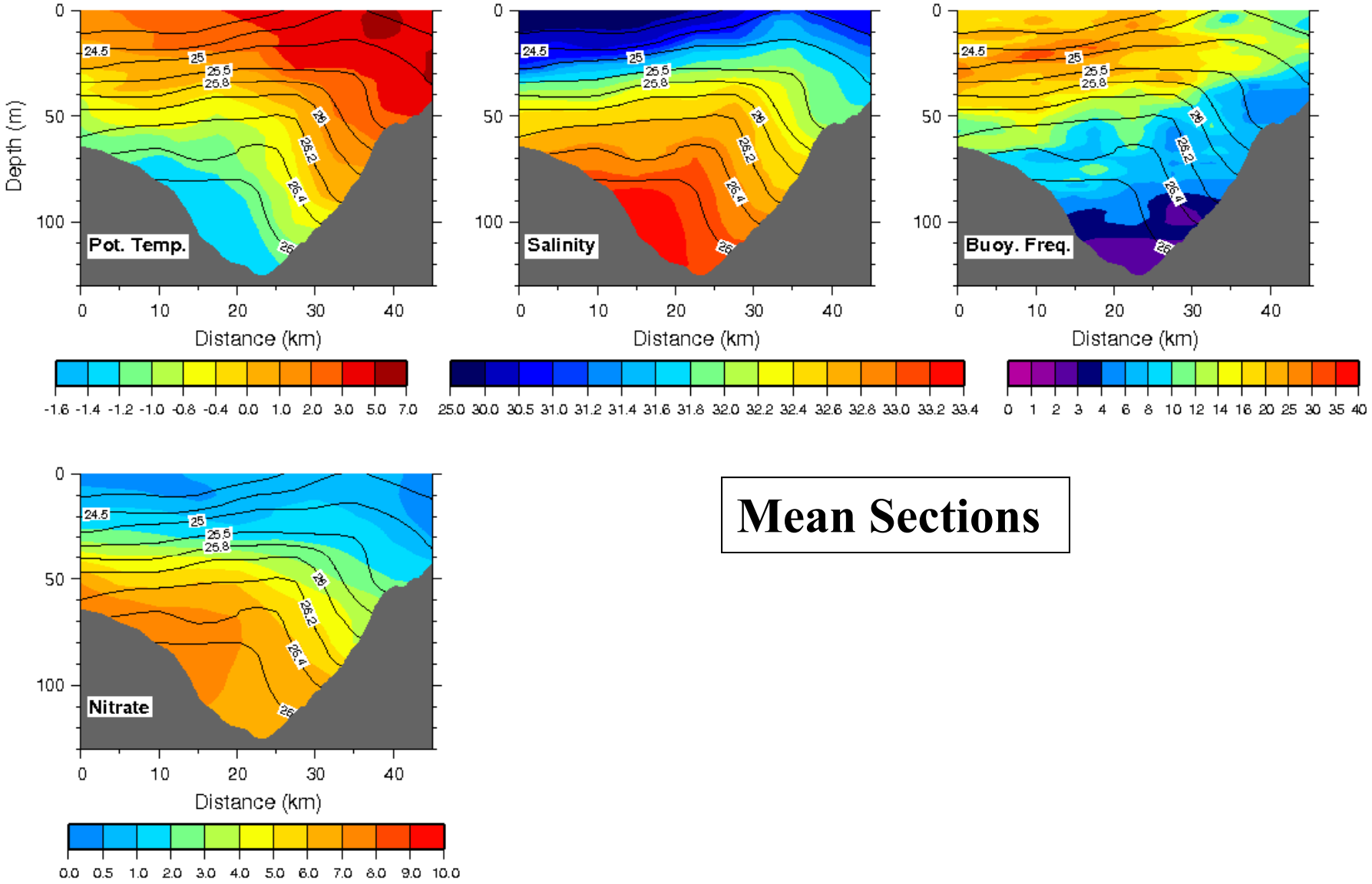


Not much influence from the wind (except perhaps Laurier section, occupied shortly after moderate upwelling event)

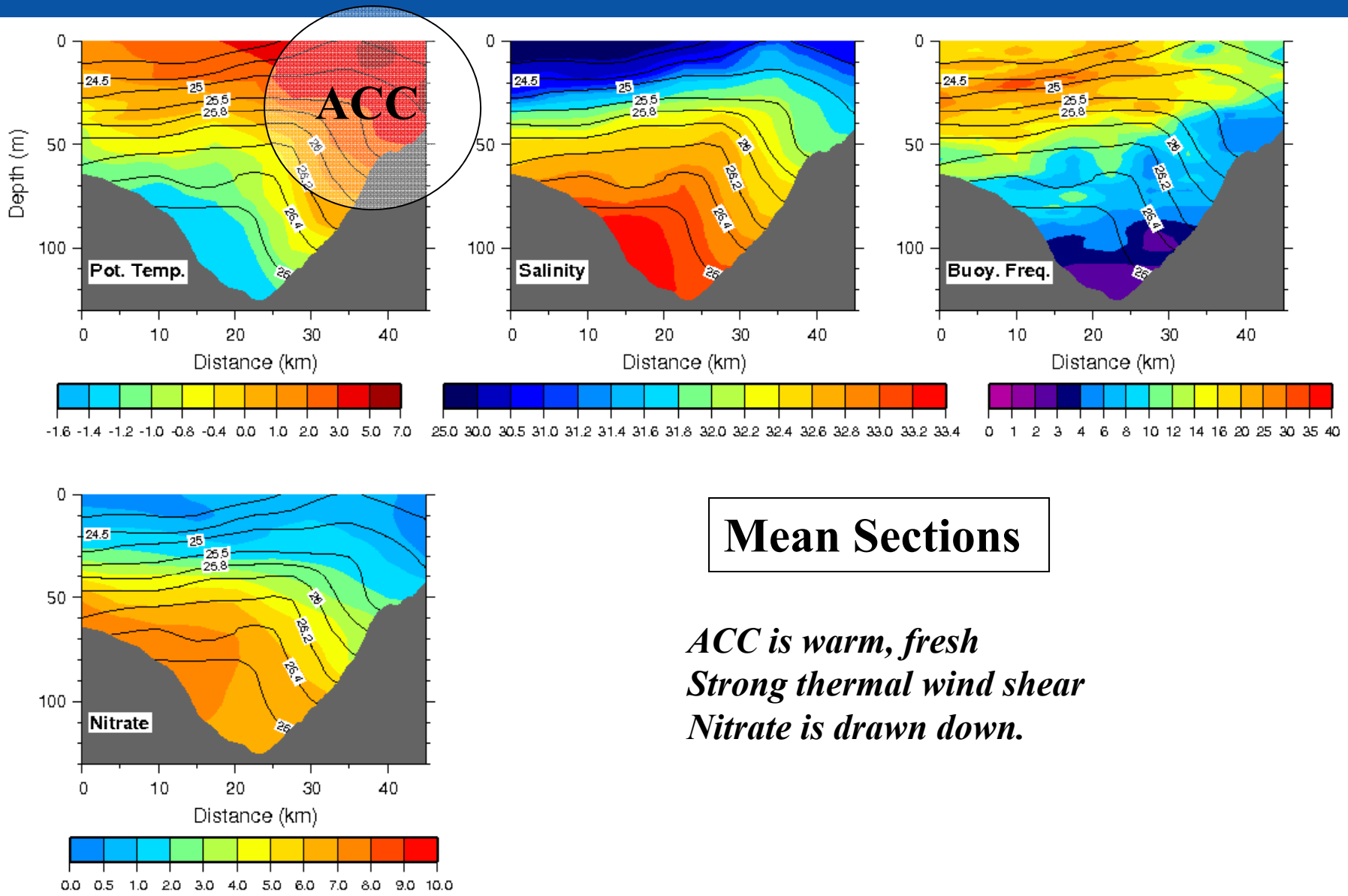
Composite winds during each occupation



Winds from Pt. Barrow weather station

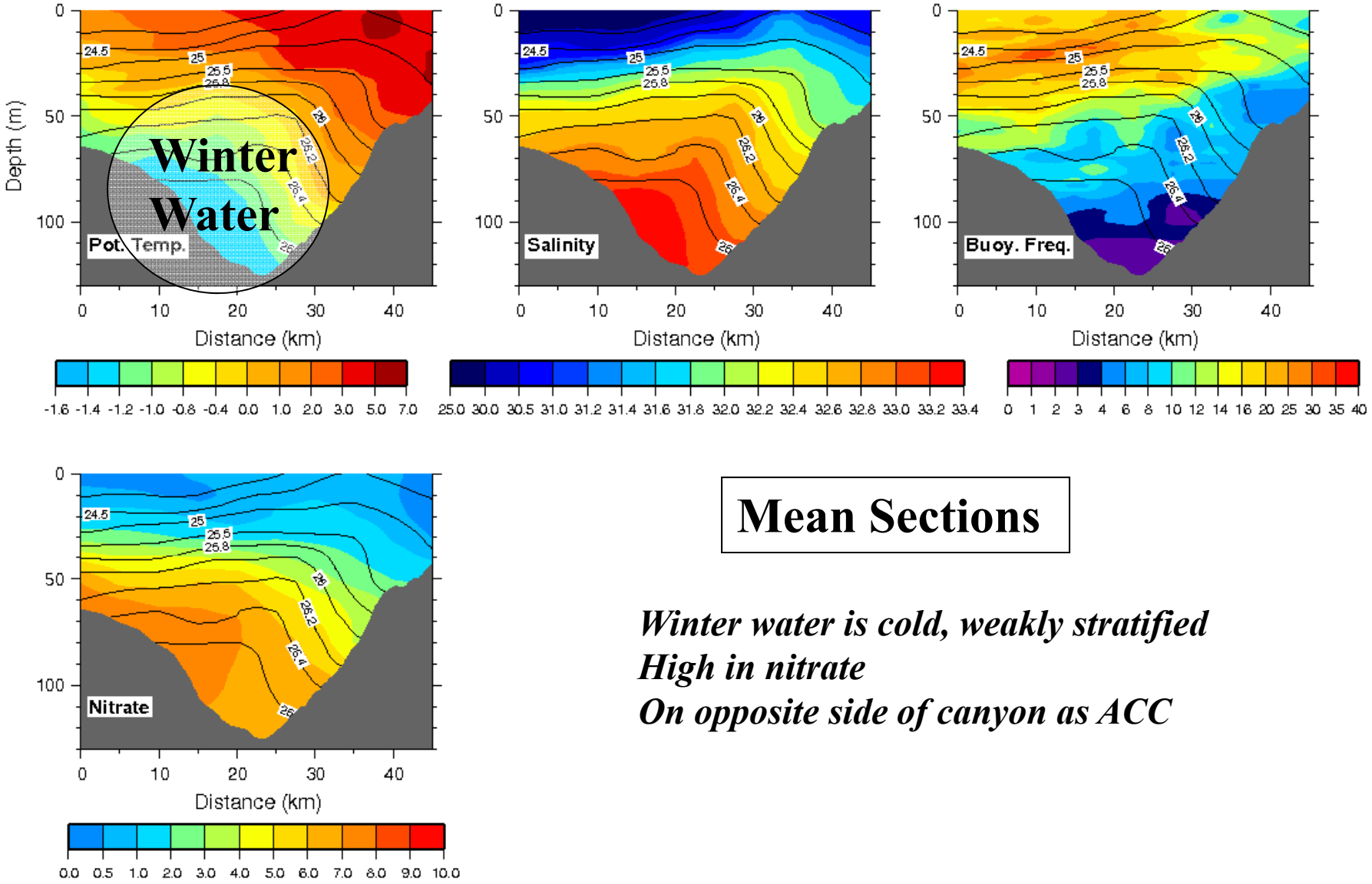


Mean Sections



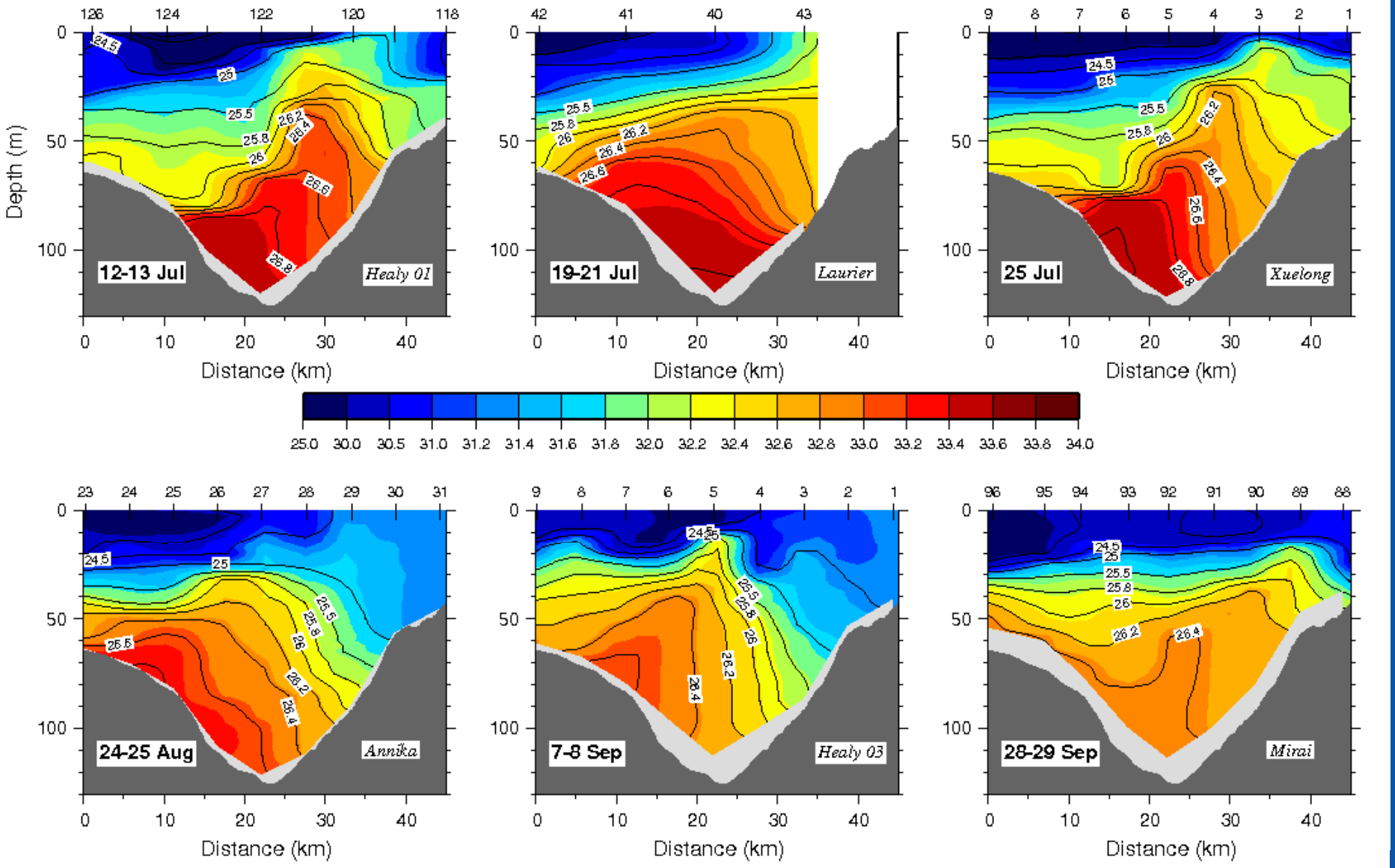
Mean Sections

ACC is warm, fresh
Strong thermal wind shear
Nitrate is drawn down.

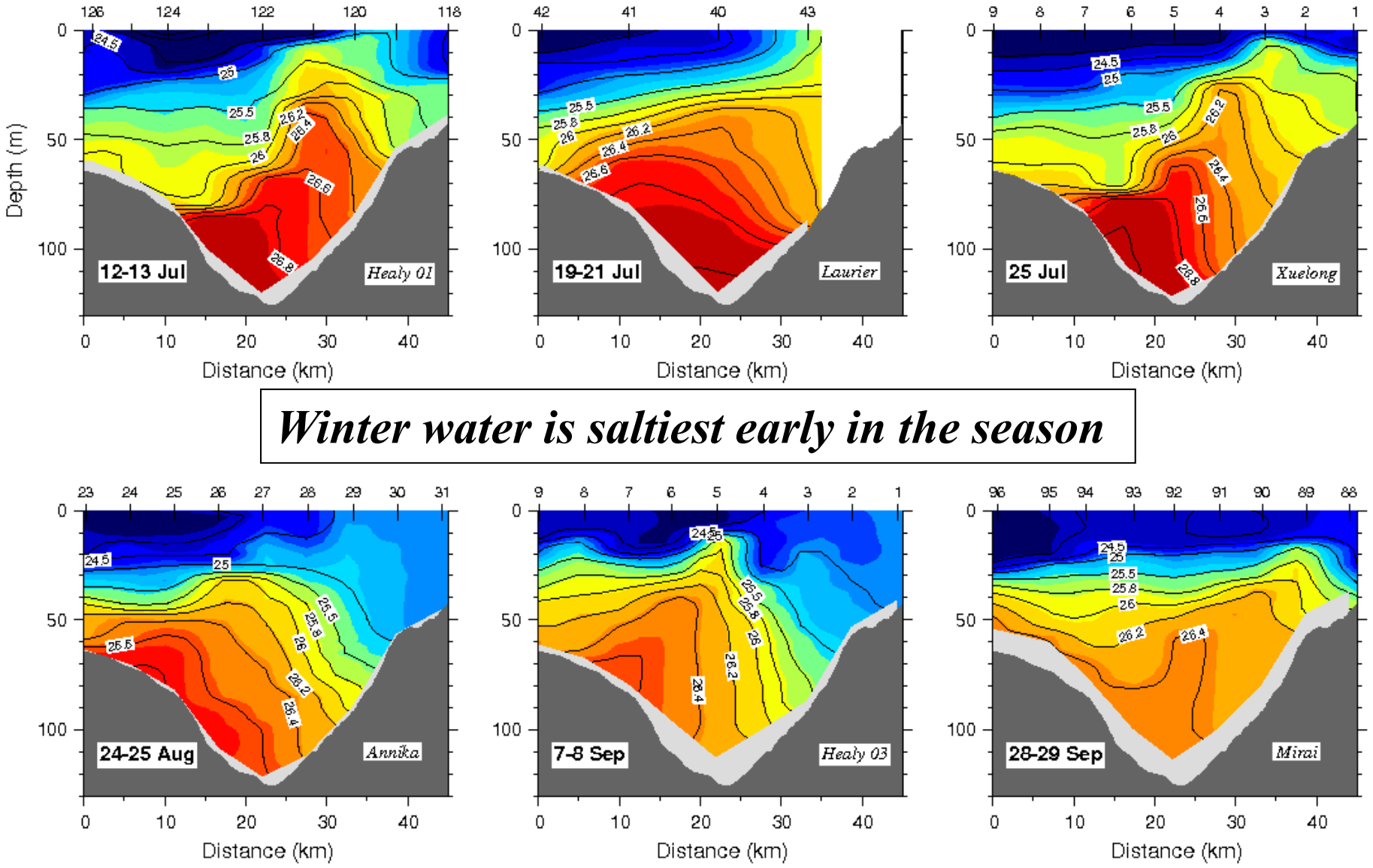


Mean Sections

Winter water is cold, weakly stratified
High in nitrate
On opposite side of canyon as ACC

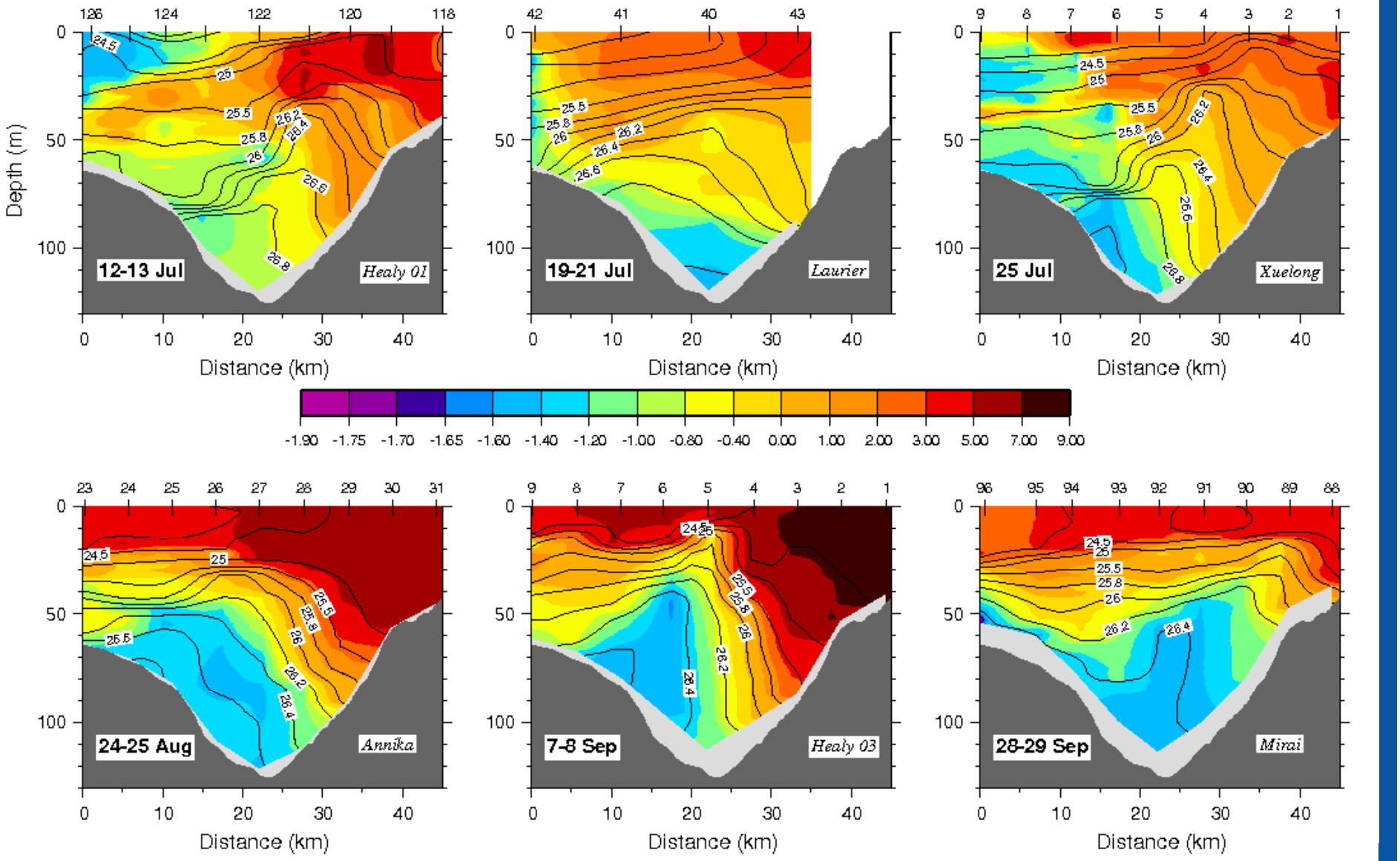


Individual Sections: *Salinity*

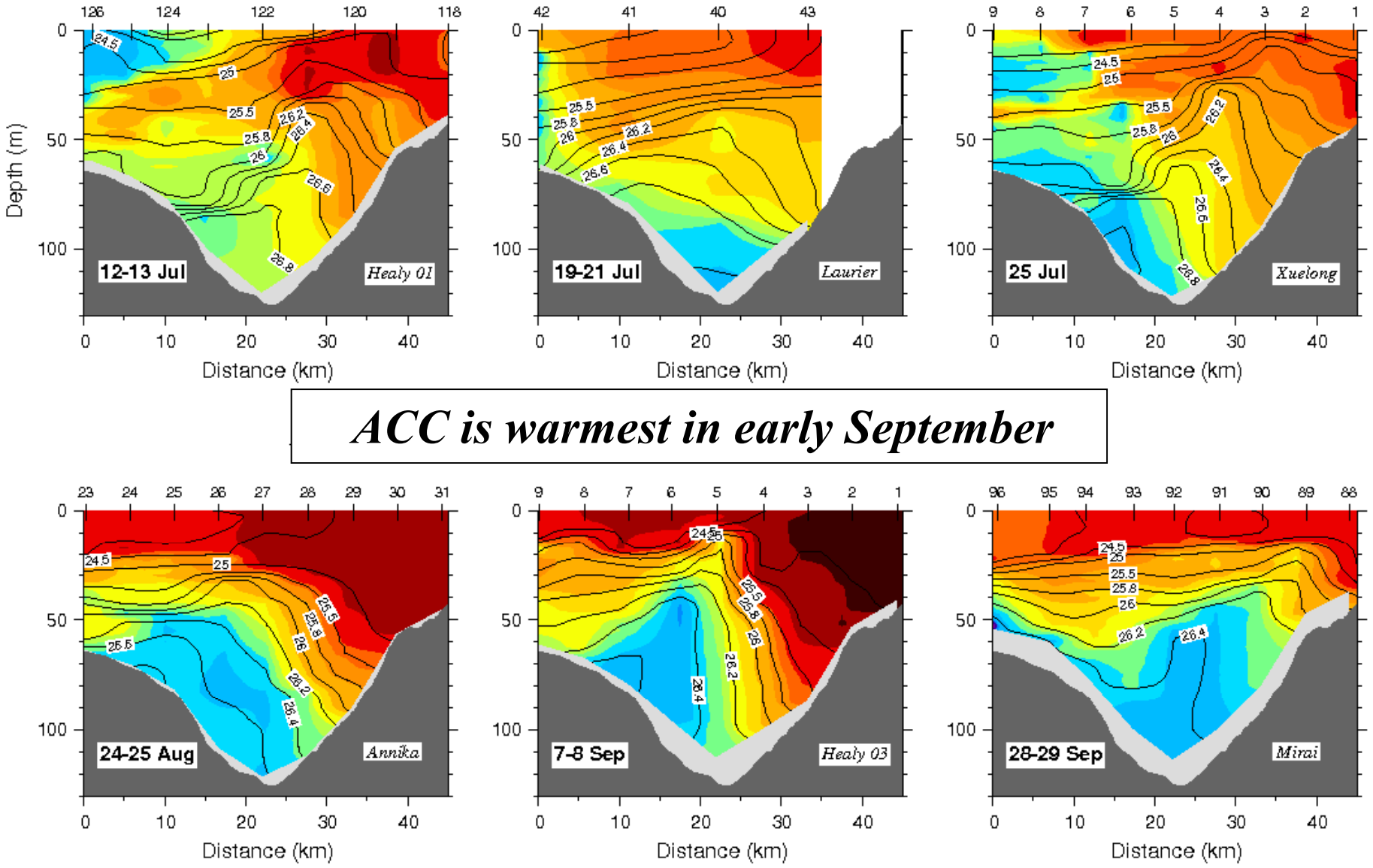


Winter water is saltiest early in the season

Individual Sections: *Salinity*

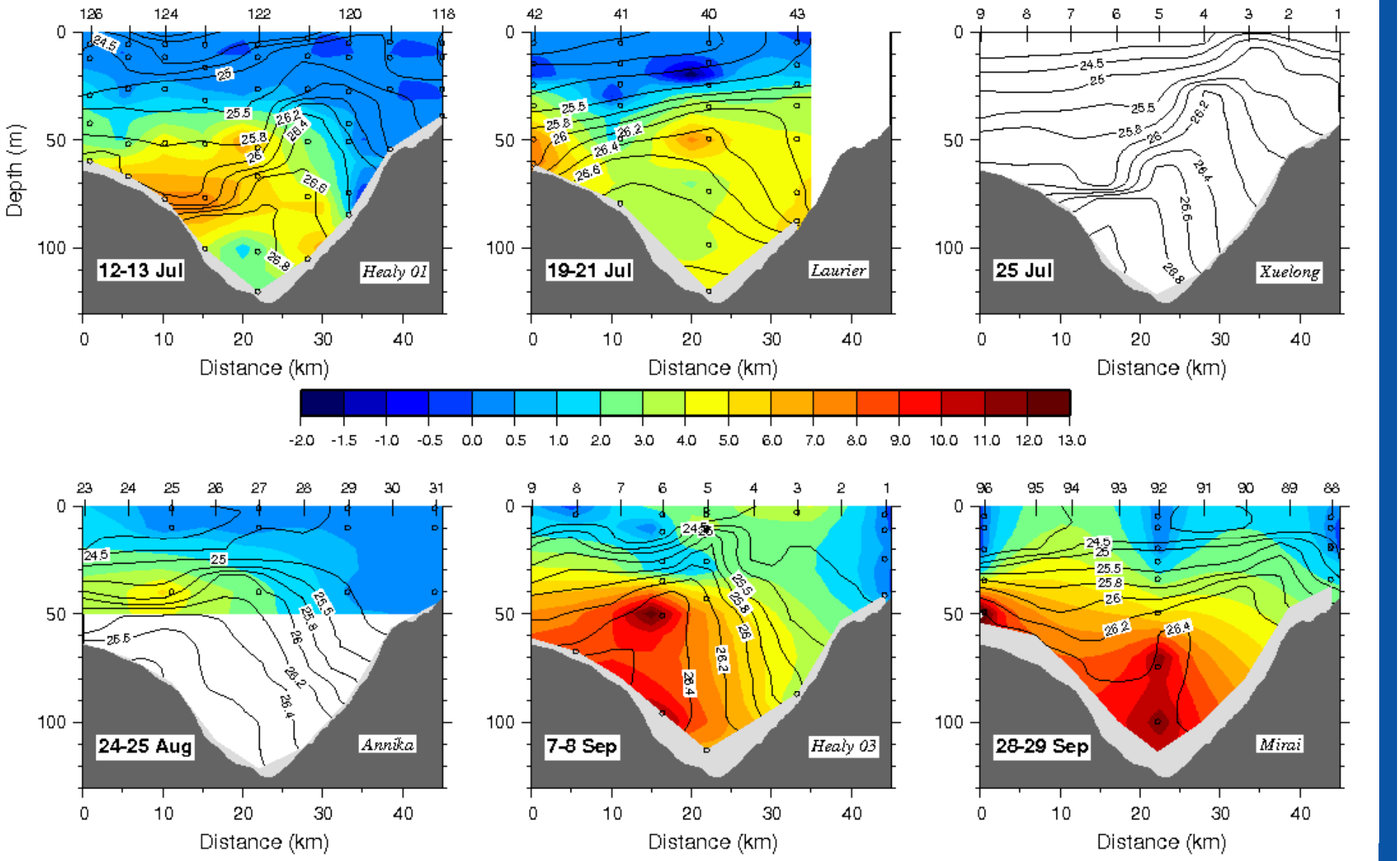


Individual Sections: *Potential Temperature (°C)*

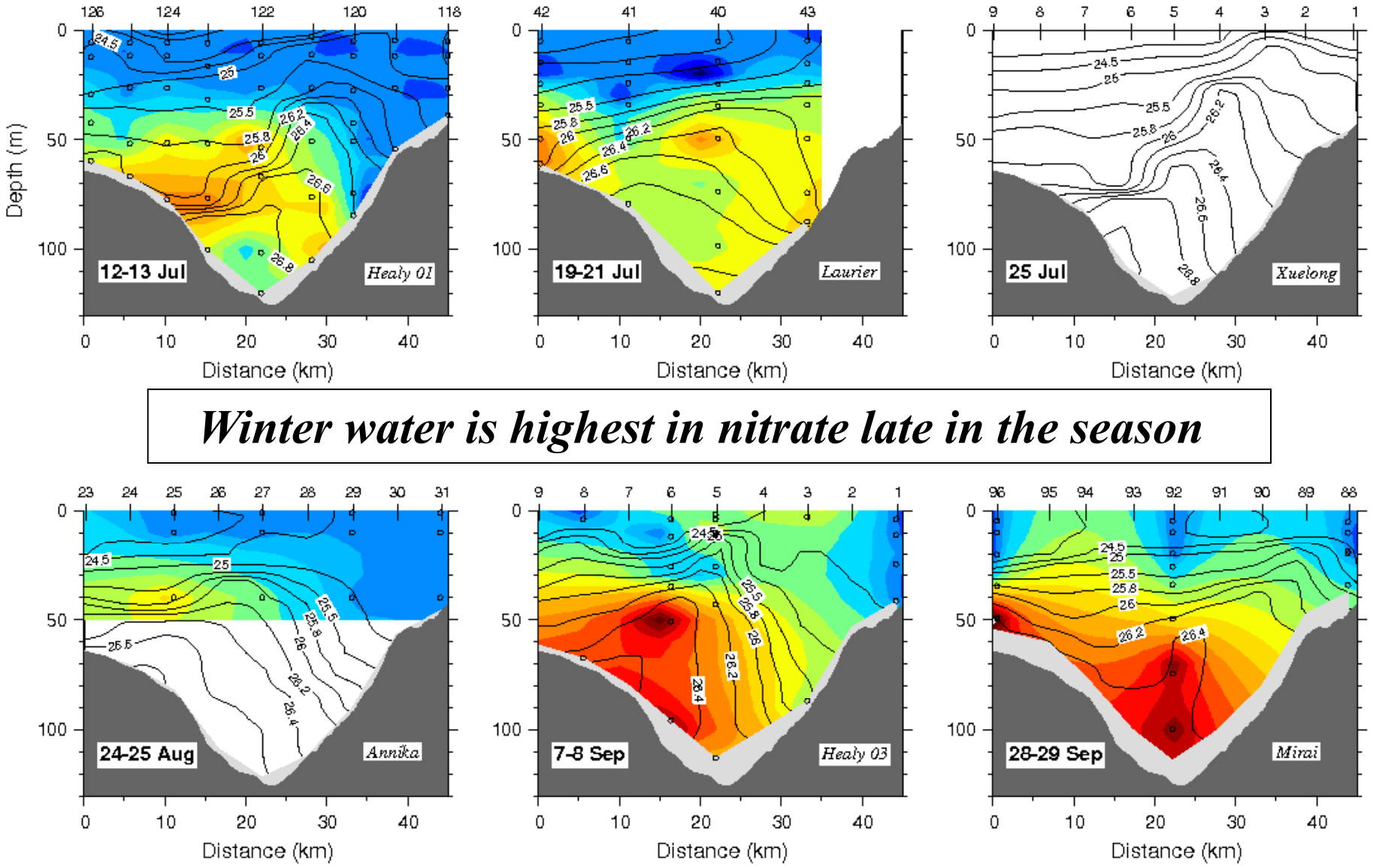


ACC is warmest in early September

Individual Sections: *Potential Temperature (°C)*



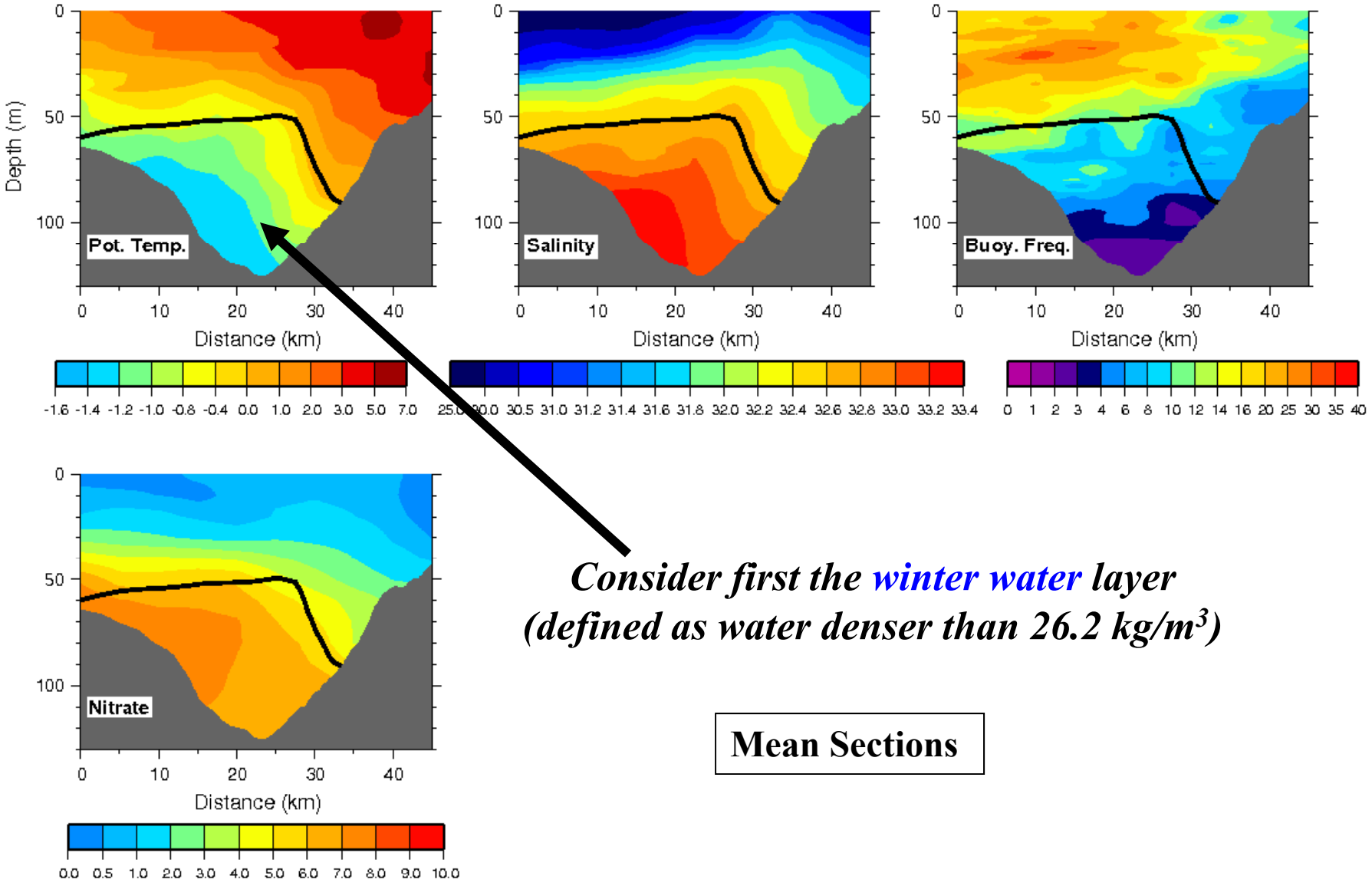
Individual Sections: *Nitrate (µm/kg)*



Winter water is highest in nitrate late in the season

Individual Sections: *Nitrate (µm/kg)*

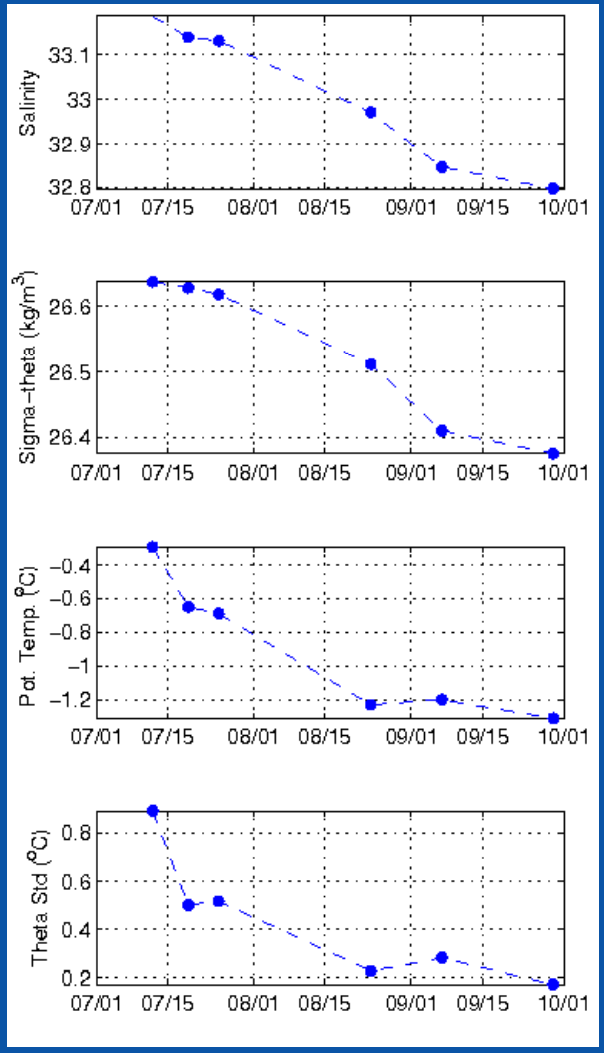
Now let's quantify the changes in the water properties.

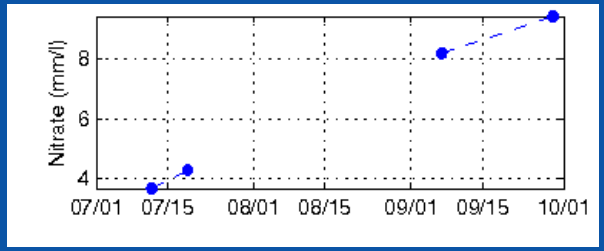


Consider first the winter water layer (defined as water denser than 26.2 kg/m^3)

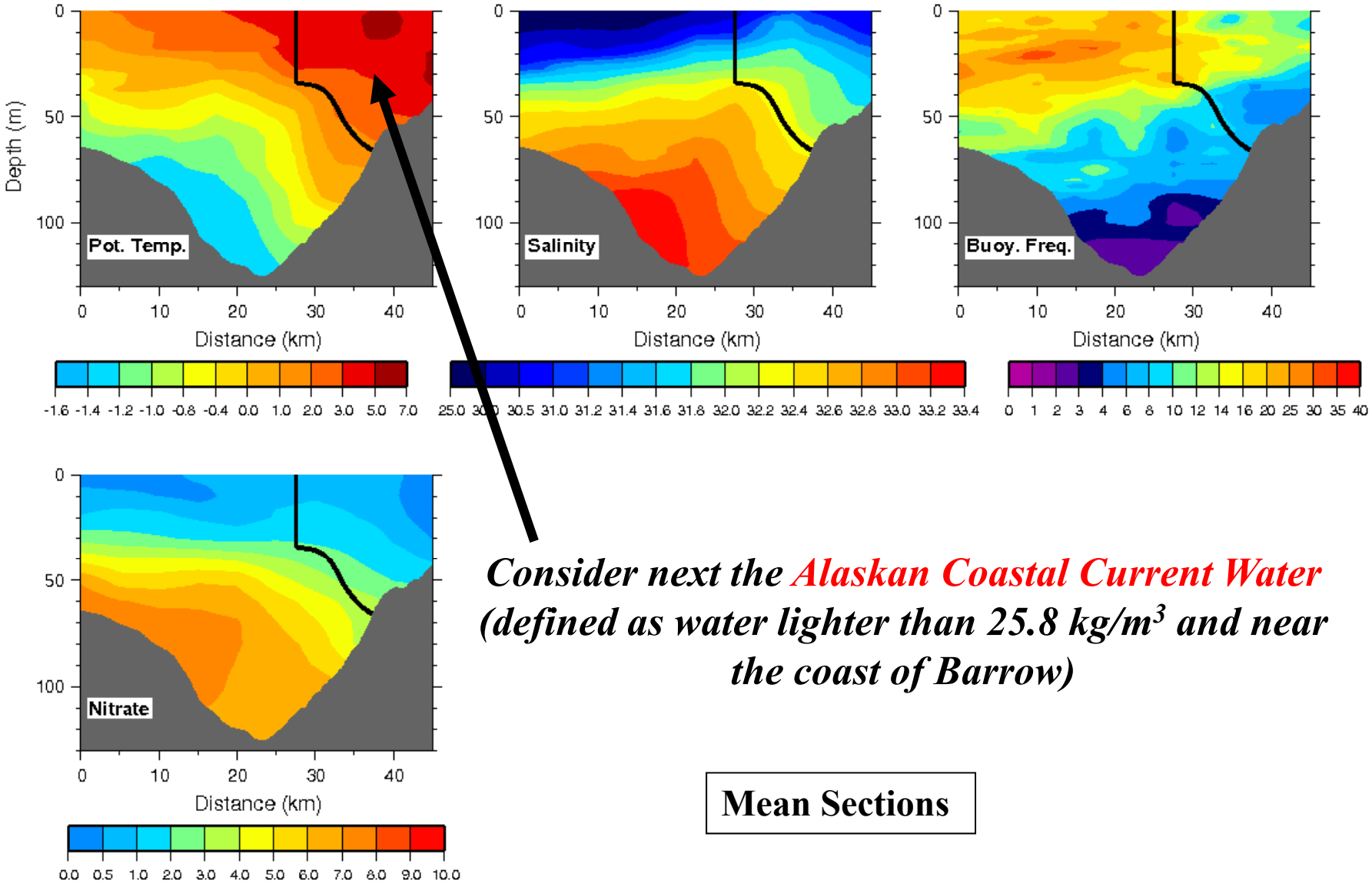
Mean Sections

Timeseries of winter water properties





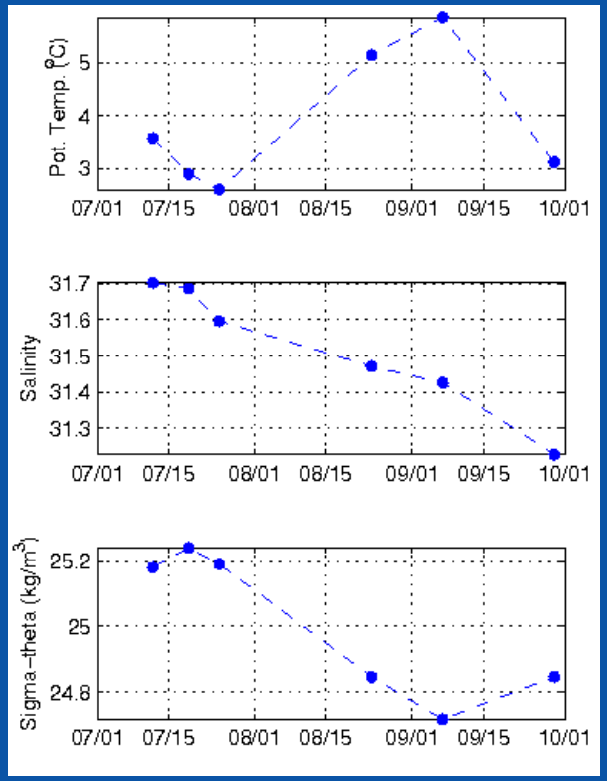
As the season progresses, the winter water gets fresher, lighter, colder, more isothermal, and higher in nitrate.



Consider next the Alaskan Coastal Current Water (defined as water lighter than 25.8 kg/m^3 and near the coast of Barrow)

Mean Sections

Timeseries of Alaska Coastal Current water



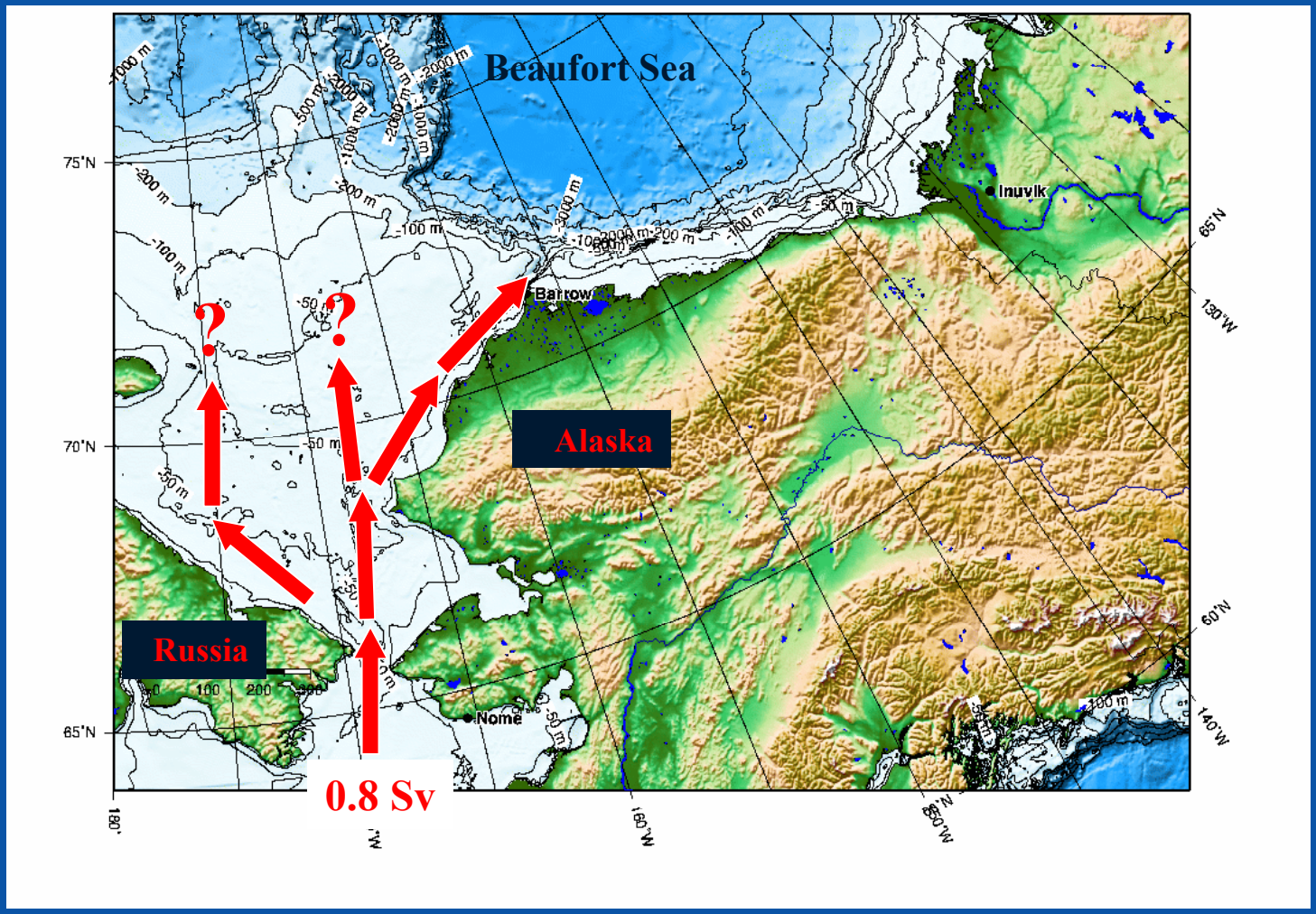
Note: Not enough spatial coverage to quantify the nitrate in the ACC

The temperature of the ACC peaks in September, but the current gets progressively fresher throughout the summer.

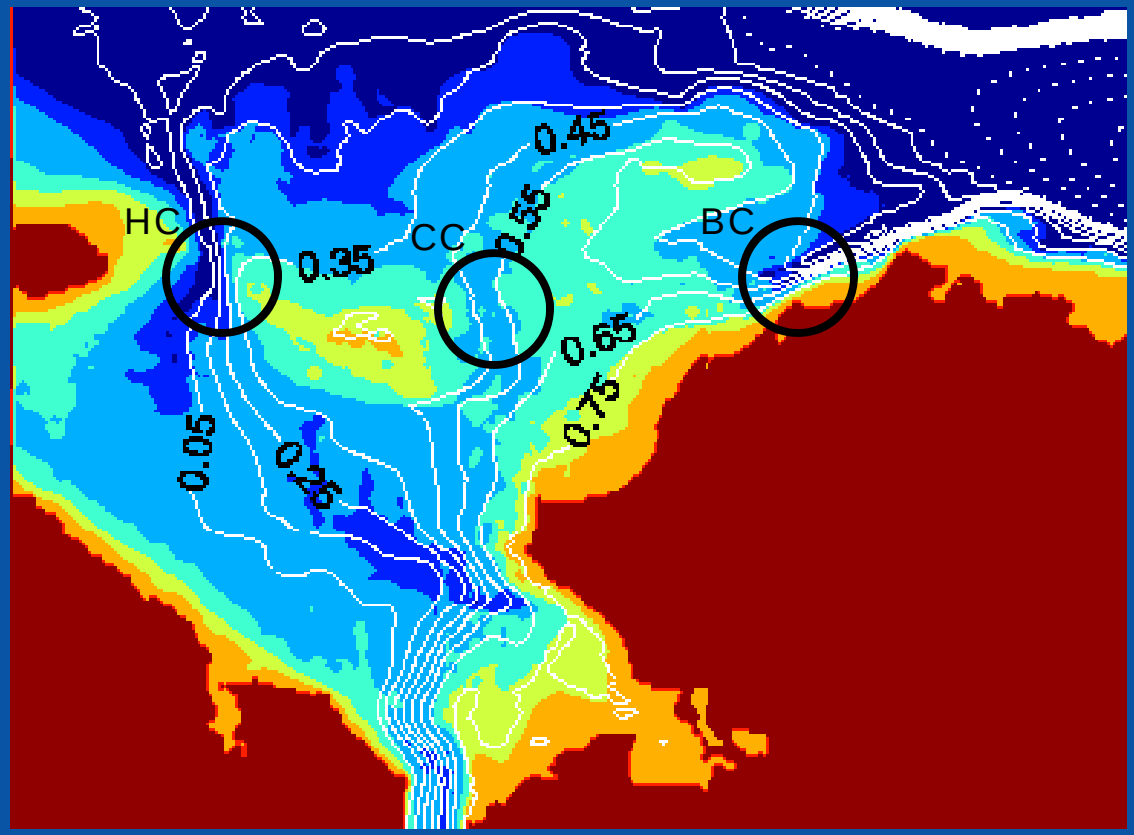
Question:

Why does the winter water get *colder* as the summer progresses (and become higher in nitrate)?

Three branches of Pacific Water in the Chukchi Sea



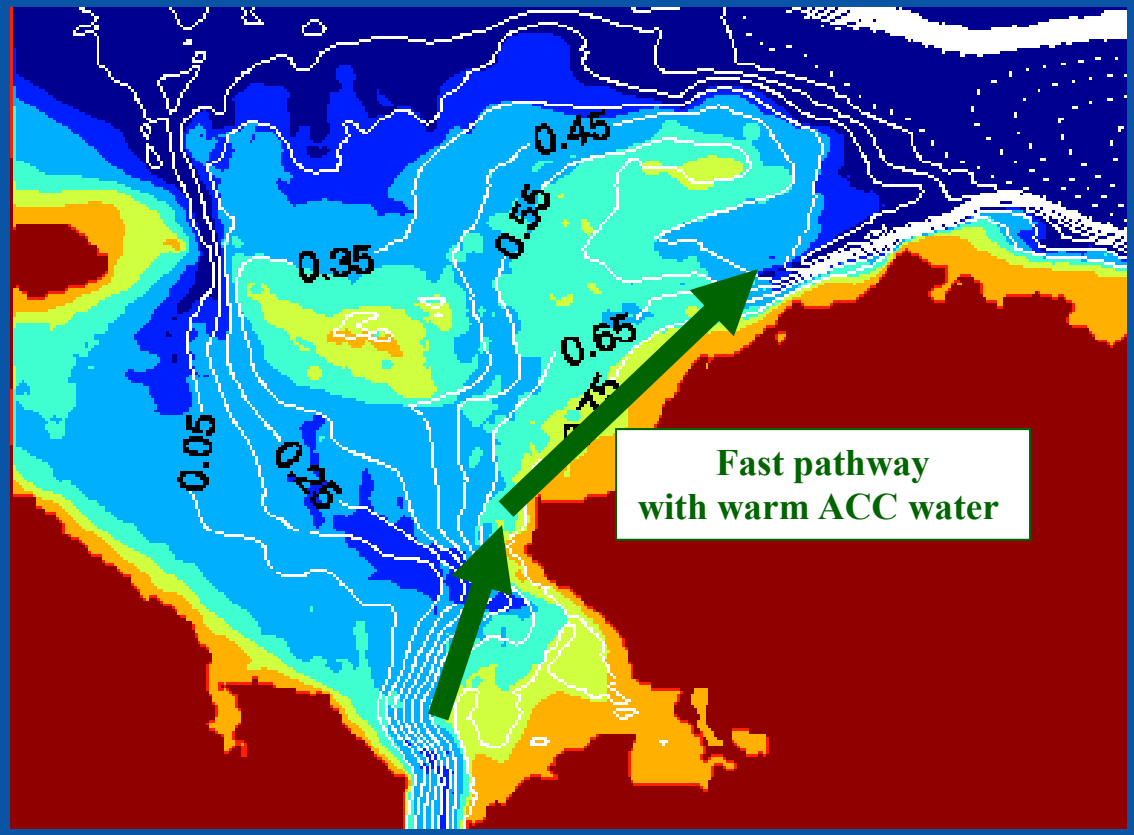
Mean flow streamlines from a general circulation model



Spall (2007)

All roads lead to Barrow Canyon!
(but the speed limit is not the same)

Mean flow streamlines from a general circulation model



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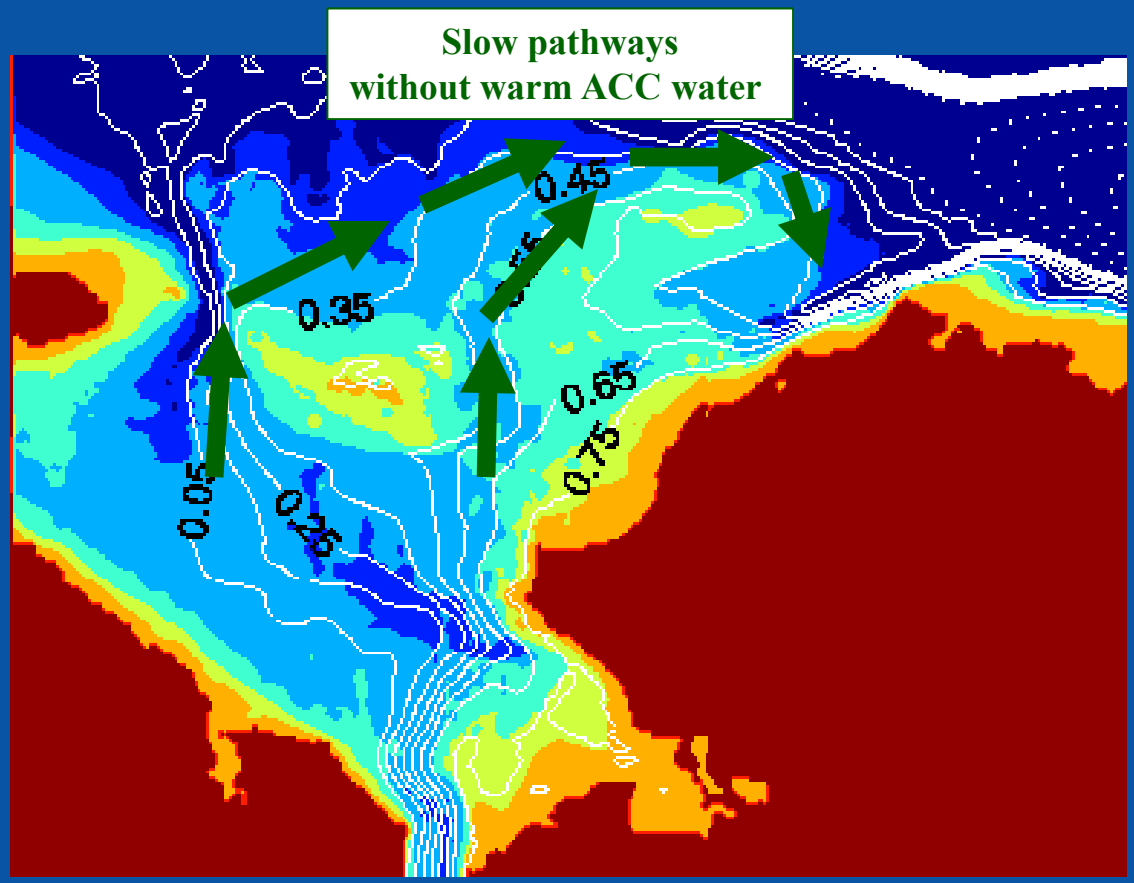

Spall (2007)

All roads lead to Barrow Canyon!
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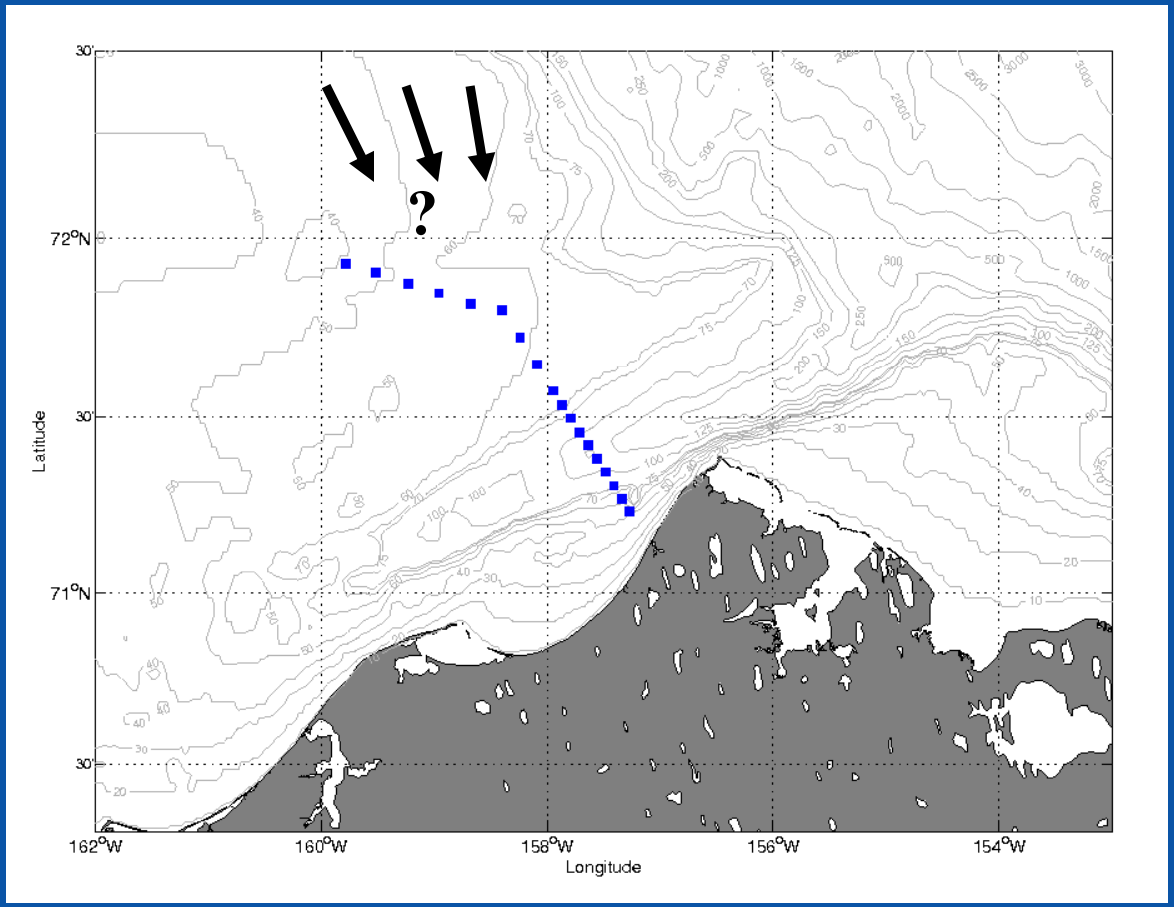
Evidence of slow pathway advecting winter water

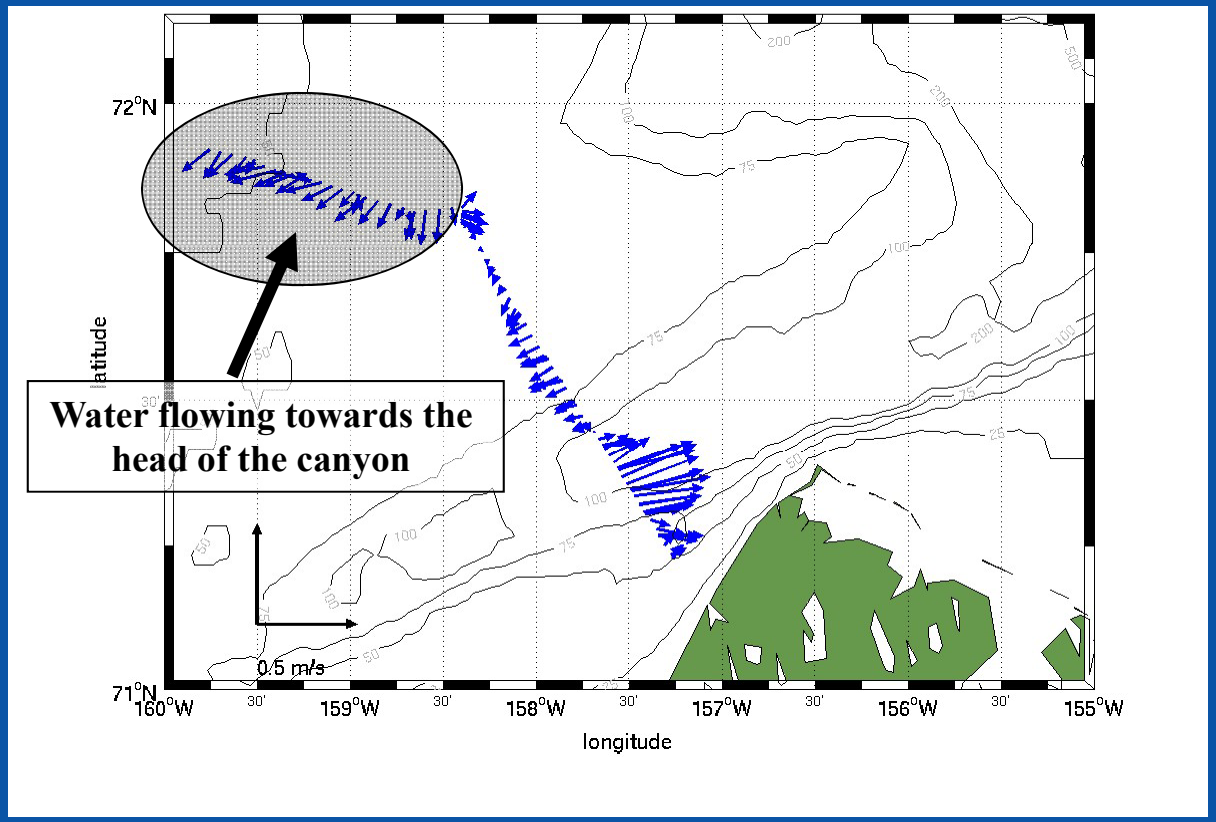


Aug 2009 occupation of DBO line

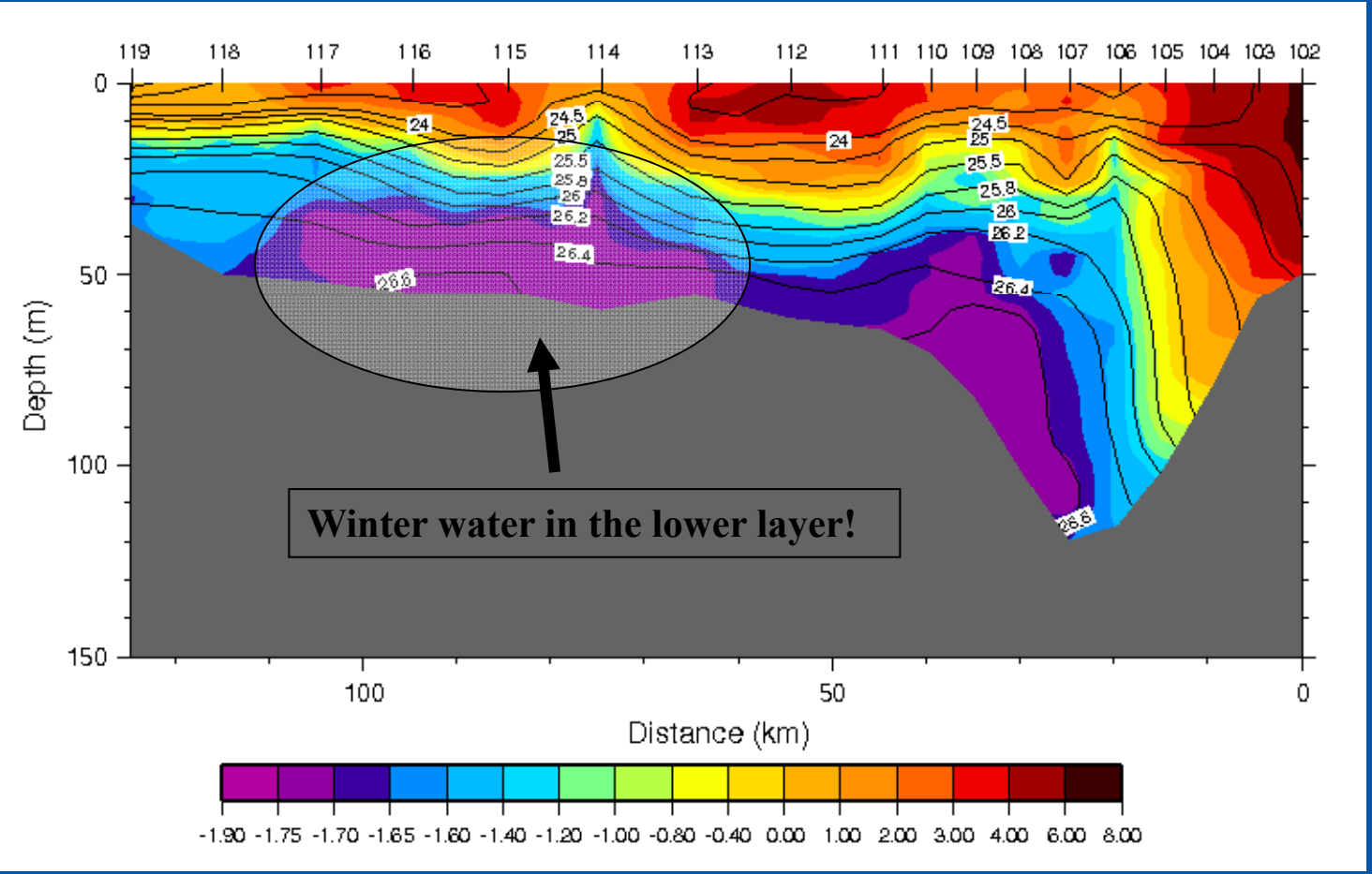
The line was extended toward Hanna Shoal crossing the slow pathway

Evidence of slow pathway advecting winter water

Depth-averaged ADCP flow vectors



Evidence of slow pathway advecting winter water



Potential temperature (°C) overlain by potential density (kg/m^3)

Returning to the question:

Why does the winter water get *colder* as the summer progresses (and become higher in nitrate)?

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Possible answer:

Early in the season, the winter water mixes with warm ACC water along the fast pathway (the warm water also melts the ice and allows the nitrate to be drawn down via PP).

Later in the season, the winter water shows up in the canyon but no heat via the western slow pathway (the nitrate was not drawn down fully because much of the time it was under ice).

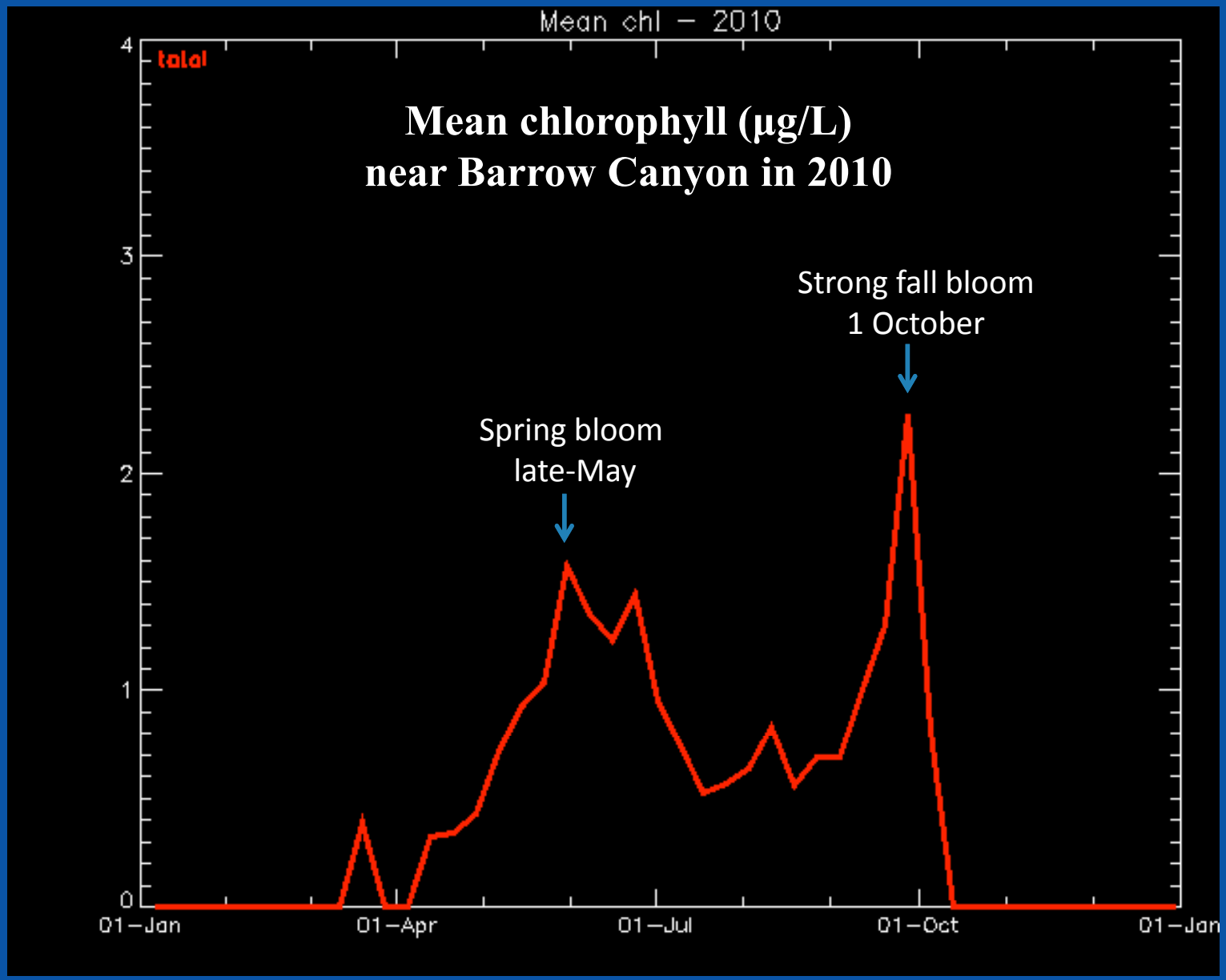
Why does the winter water get *colder* as the summer progresses (and become higher in nitrate)?

Possible answer:

Early in the season, the winter water mixes with warm ACC water along the fast pathway (the warm water also melts the ice and allows the nitrate to be drawn down via PP).

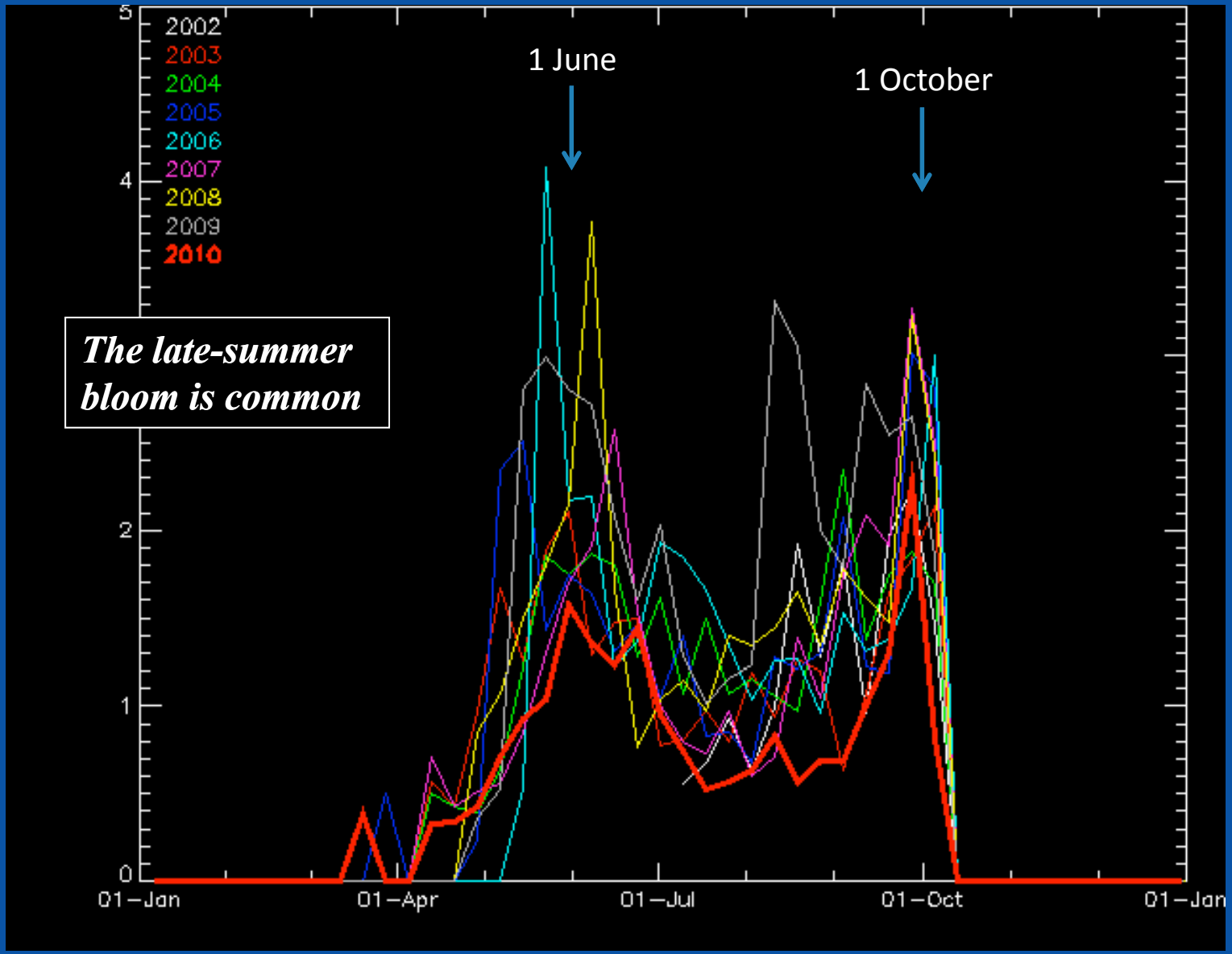
Later in the season, the winter water shows up in the canyon via the slow pathway (the nitrate was not drawn down fully because much of the time it was under ice).

This might help explain the late-summer bloom in Barrow Canyon, contributing to its status as a "hotspot".



Courtesy of G. van Dijken

Mean chlorophyll (µg/L) near Barrow Canyon from 2002-2010



Courtesy of
G. van Dijken

What have we learned from the DBO Pilot Study?

Positives

The concept can work! (6 cruises by 4 nations in 2010).

Immediate data sharing is advantageous.

The more occupations the better to help sort out seasonal versus interannual variability.

The information can help with the interpretation of individual studies by providing temporal context.

What have we learned from the DBO Pilot Study?

Challenges

Requires coordination and commitment (e.g. might have had 8 occupations in 2010) .

Need for spatial resolution of water sample variables (e.g. nitrate).

Data quality and processing.

Dedicated funding for incremental shiptime, data processing, analysis.


Thank you
Chukchi Sea September 2010
Photo by Rachel Fletcher