Flow of dense water through Herald Canyon: Results from the 2004 RUSALCA hydrographic survey

Robert S. Pickart
Woods Hole Oceanographic Institution

Outline

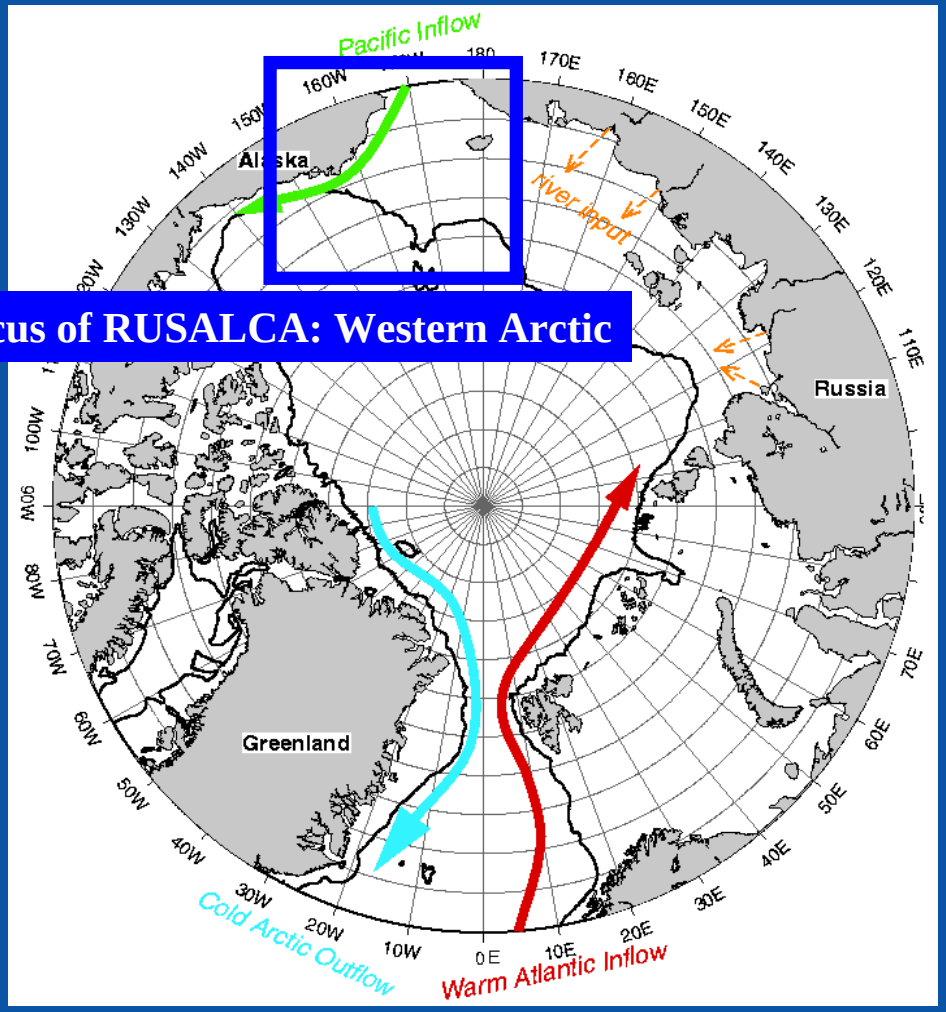
1. **Introduction and overall setting: Ventilation to hydraulics.**

2. **Evolution of water masses and flow through Herald canyon.**

3. **The far field.**

Prof. Khromov in the Chukchi Sea, Aug. 2004

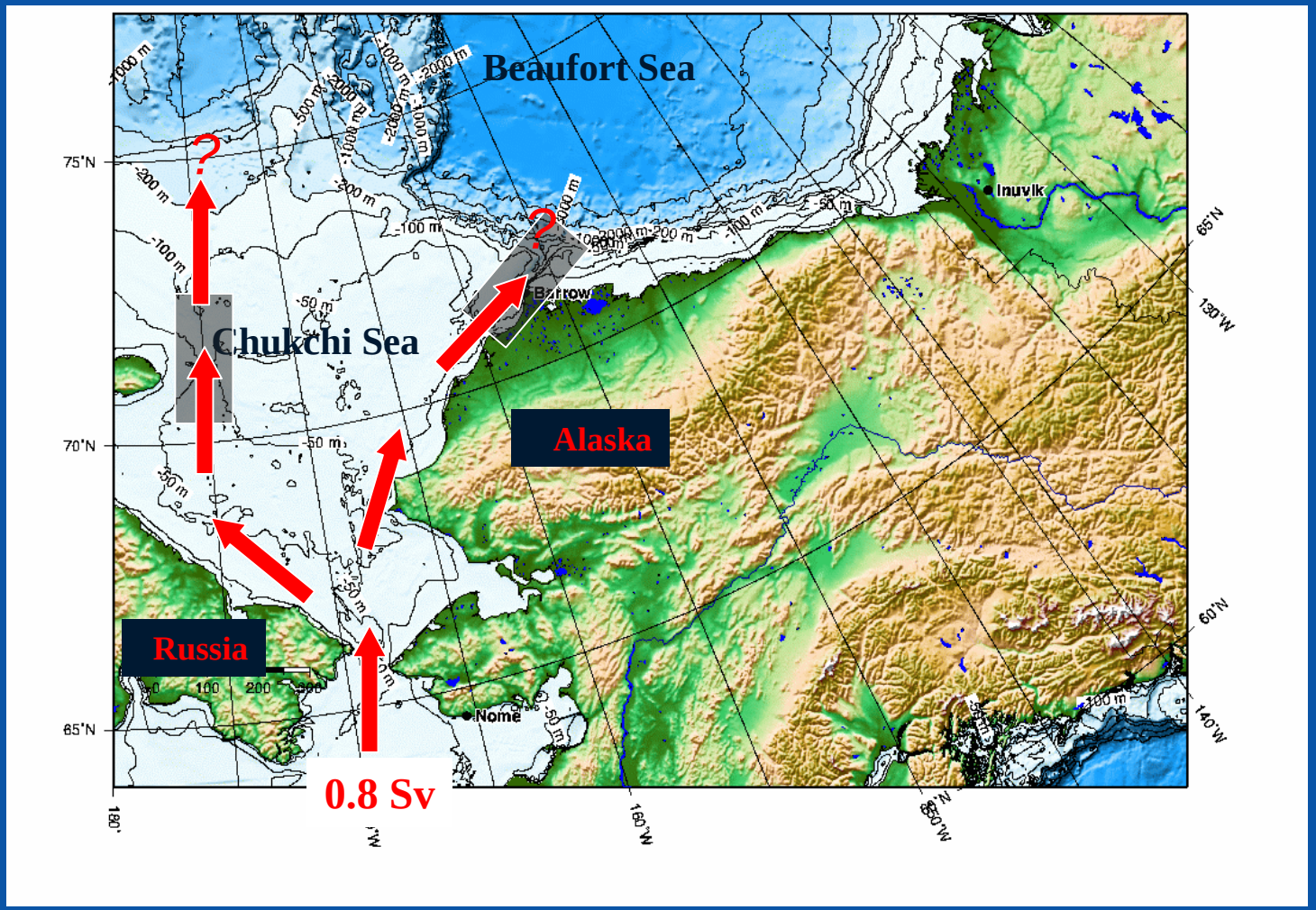
A delicate balance…



Focus of RUSALCA: Western Arctic

- Warm to cold conversion
- Deep, “warm” Atlantic layer
- The cold halocline shield
- Halocline origin: probably the shelves

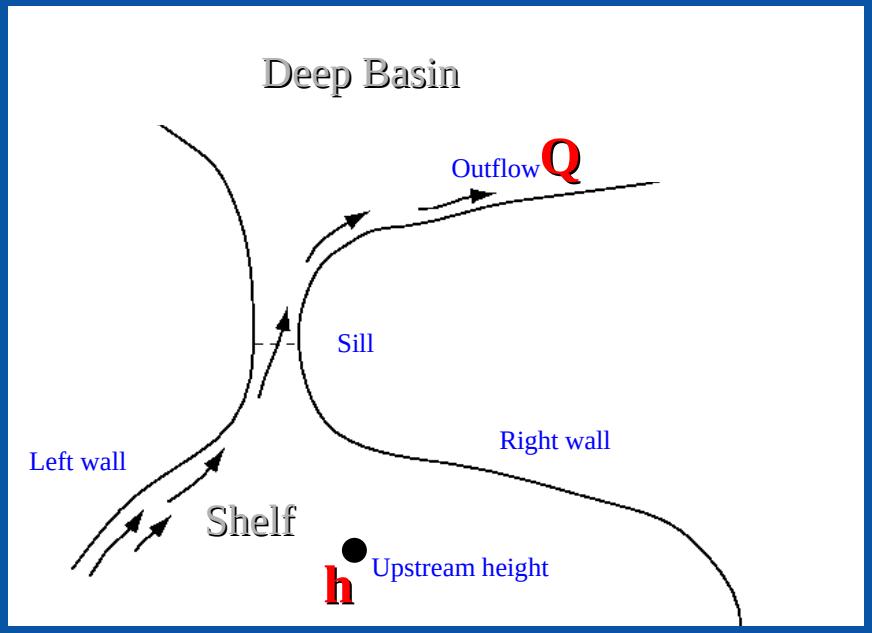
Pacific-origin inflow



Hydraulic control

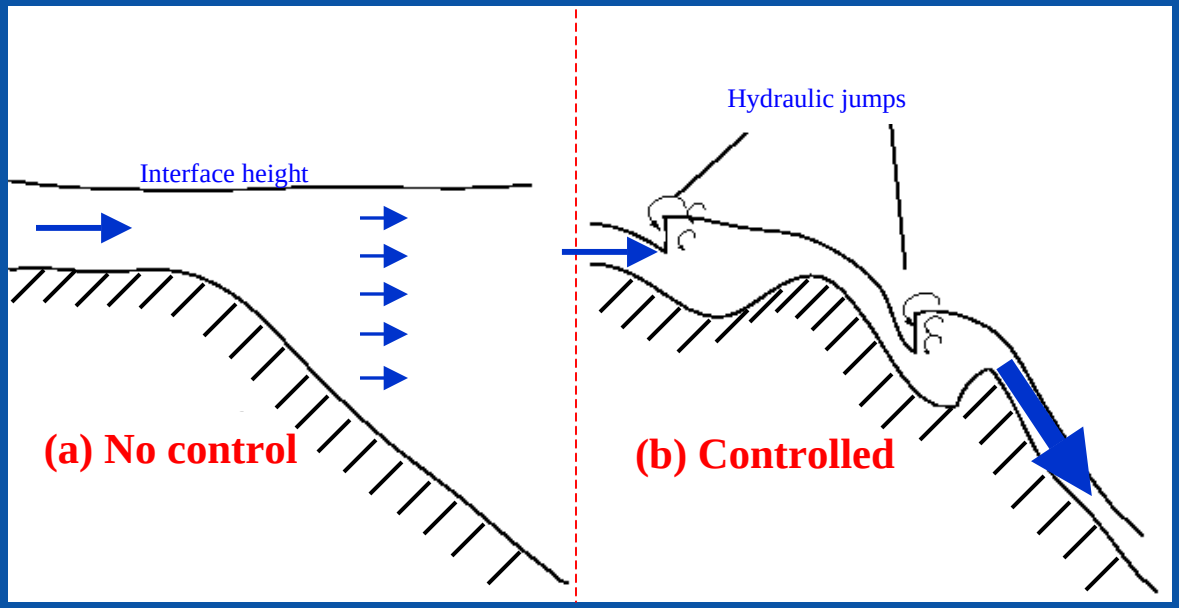
Q is functionally related to h

Plan view

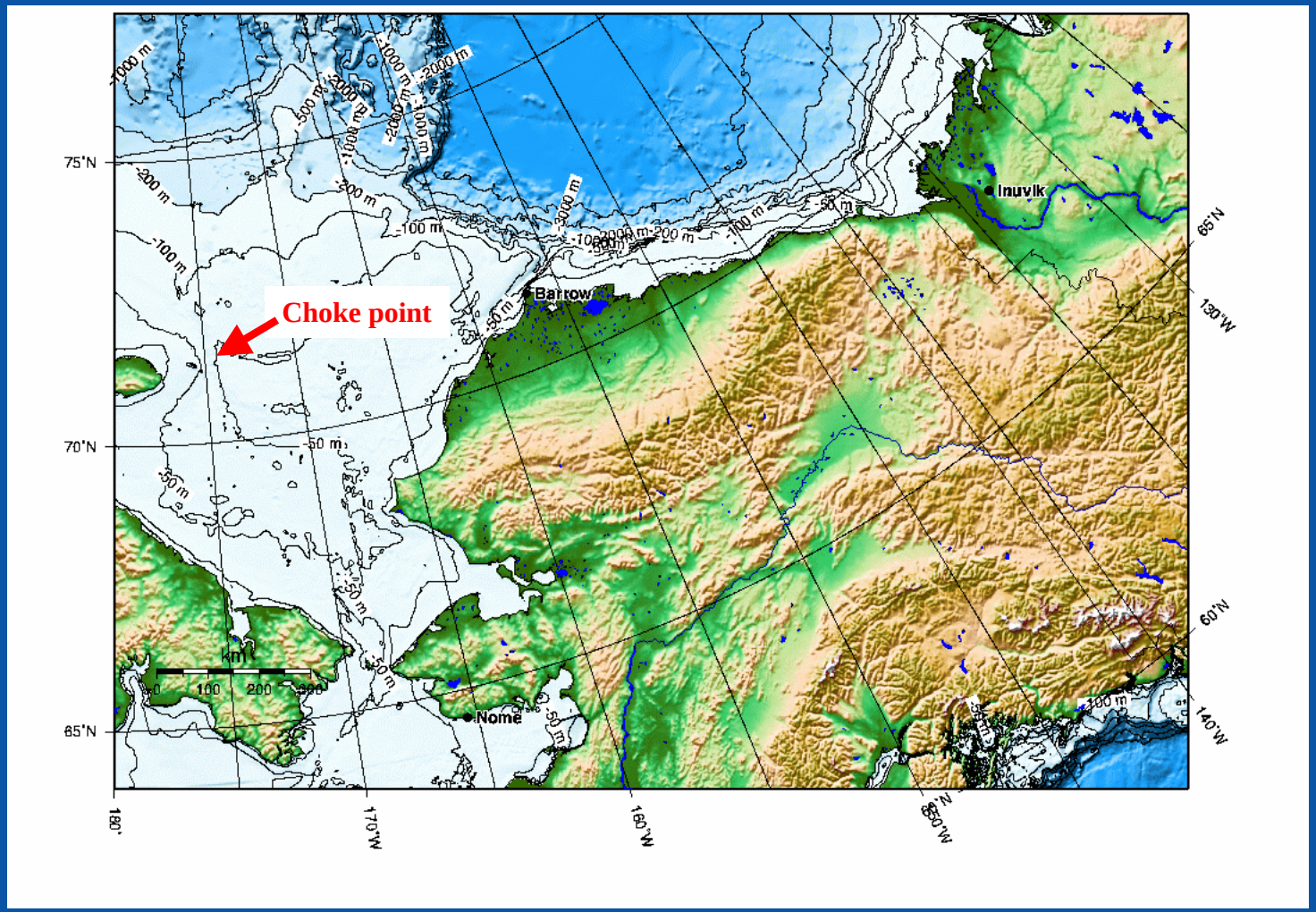


Pratt (2003)

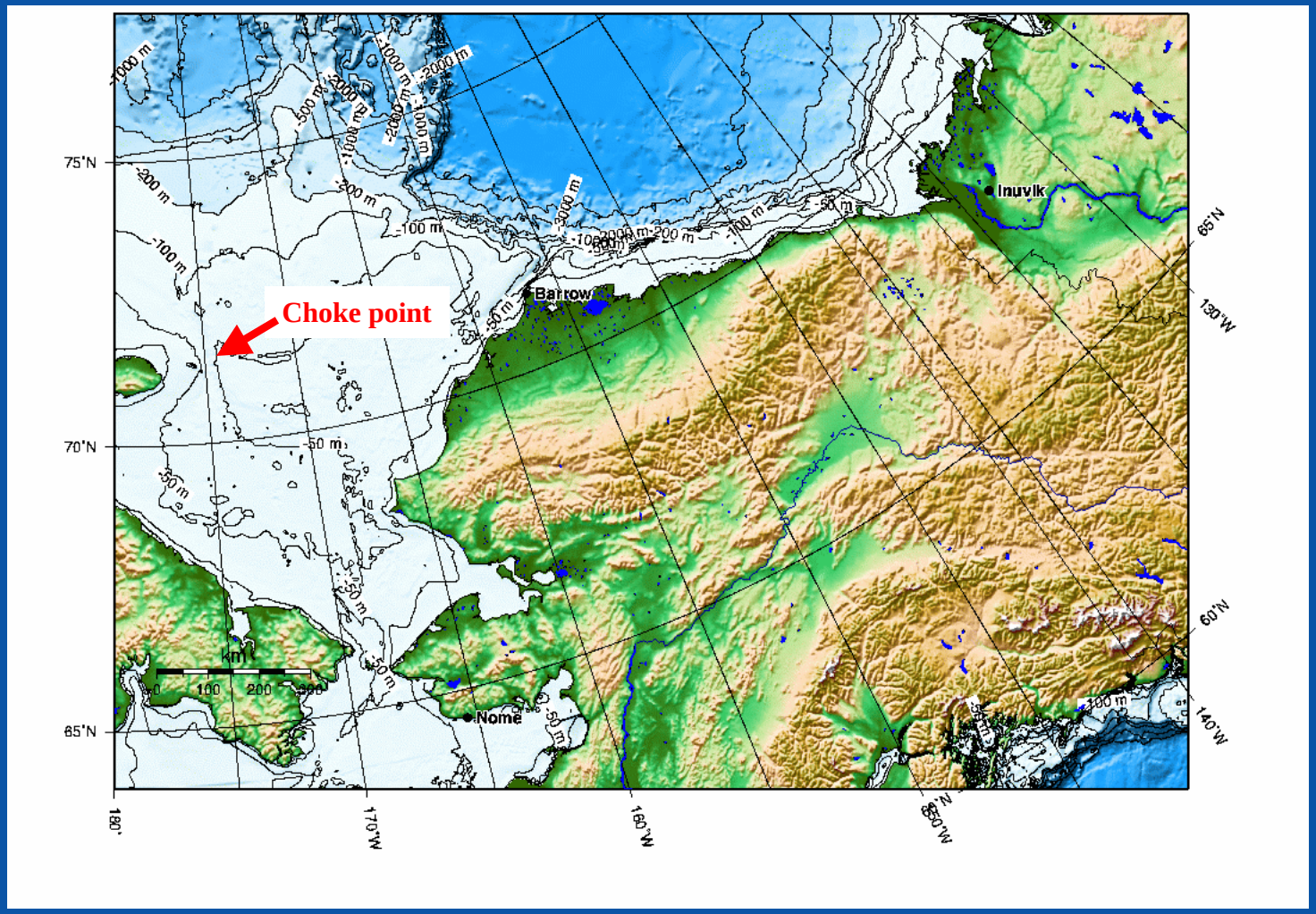
Sideways view



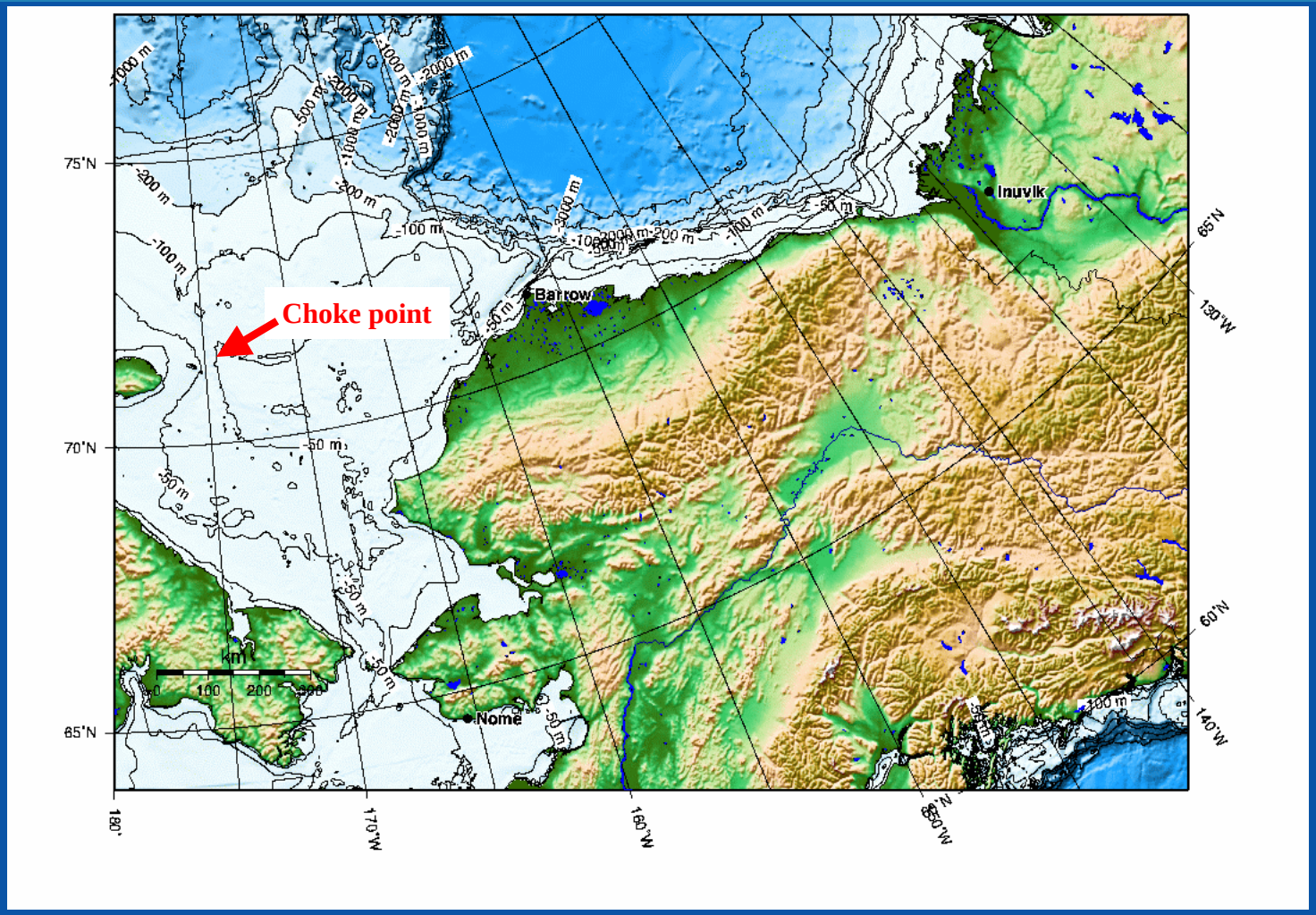
Importance and climatic implications of hydraulic control



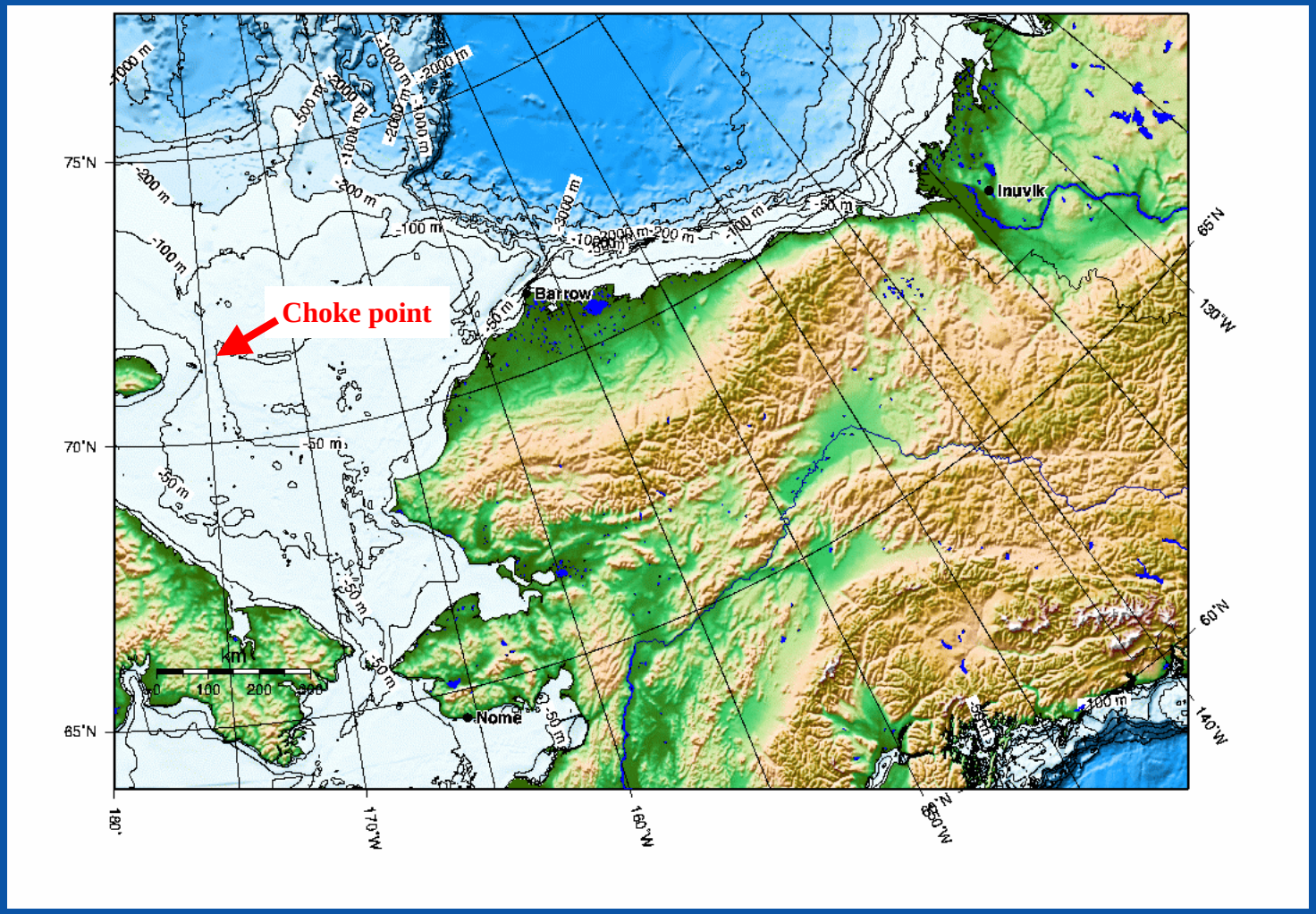
1. Pathways of circulation within the Chukchi Sea are influenced by the Herald Canyon choke point.



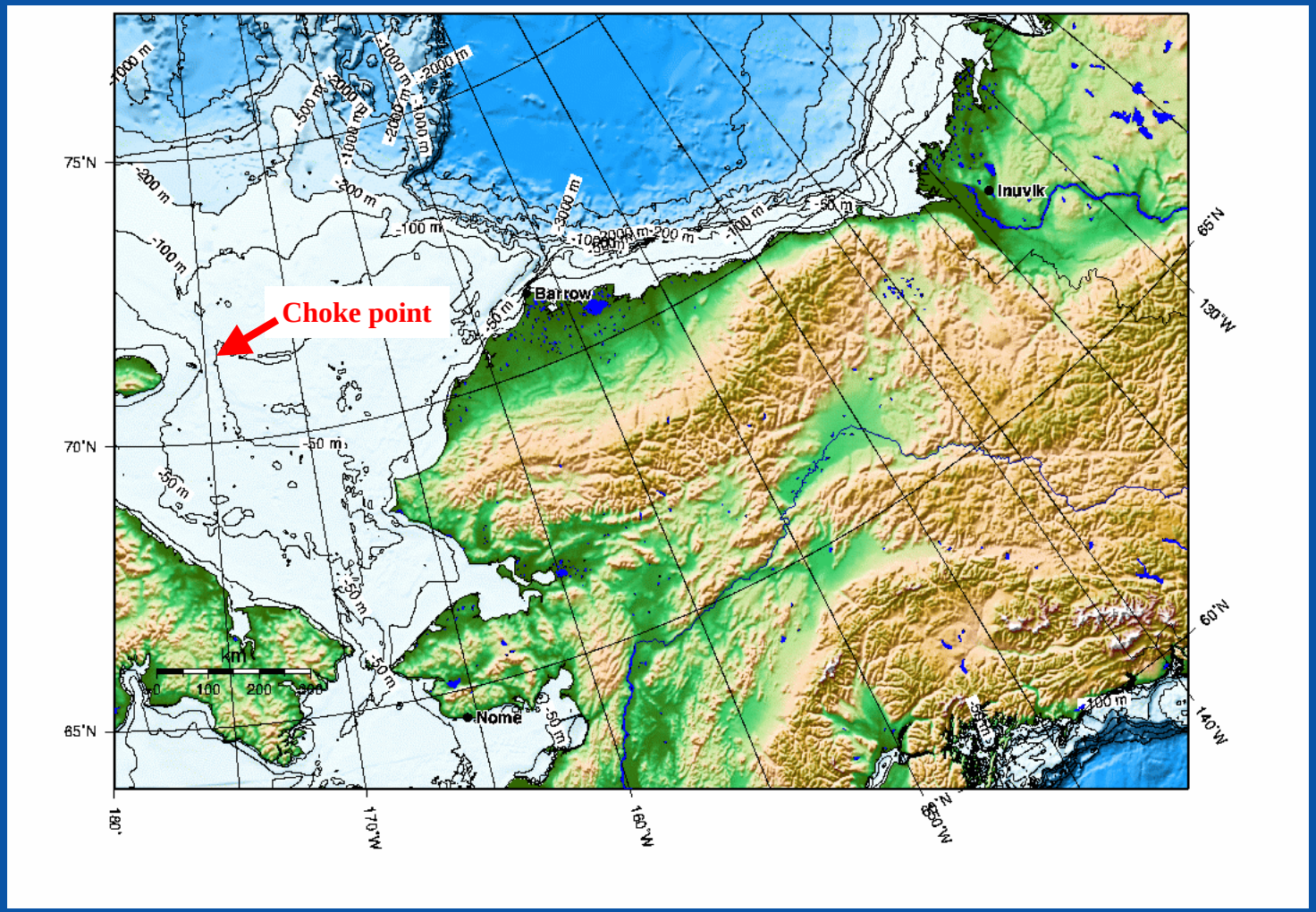
2. Hydraulic control can cause significant changes in the upstream basin (Chukchi Sea) based on perturbations of external climate parameters.



3. Outflow entrainment/mixing is strongly enhanced by hydraulic control in Herald Canyon.

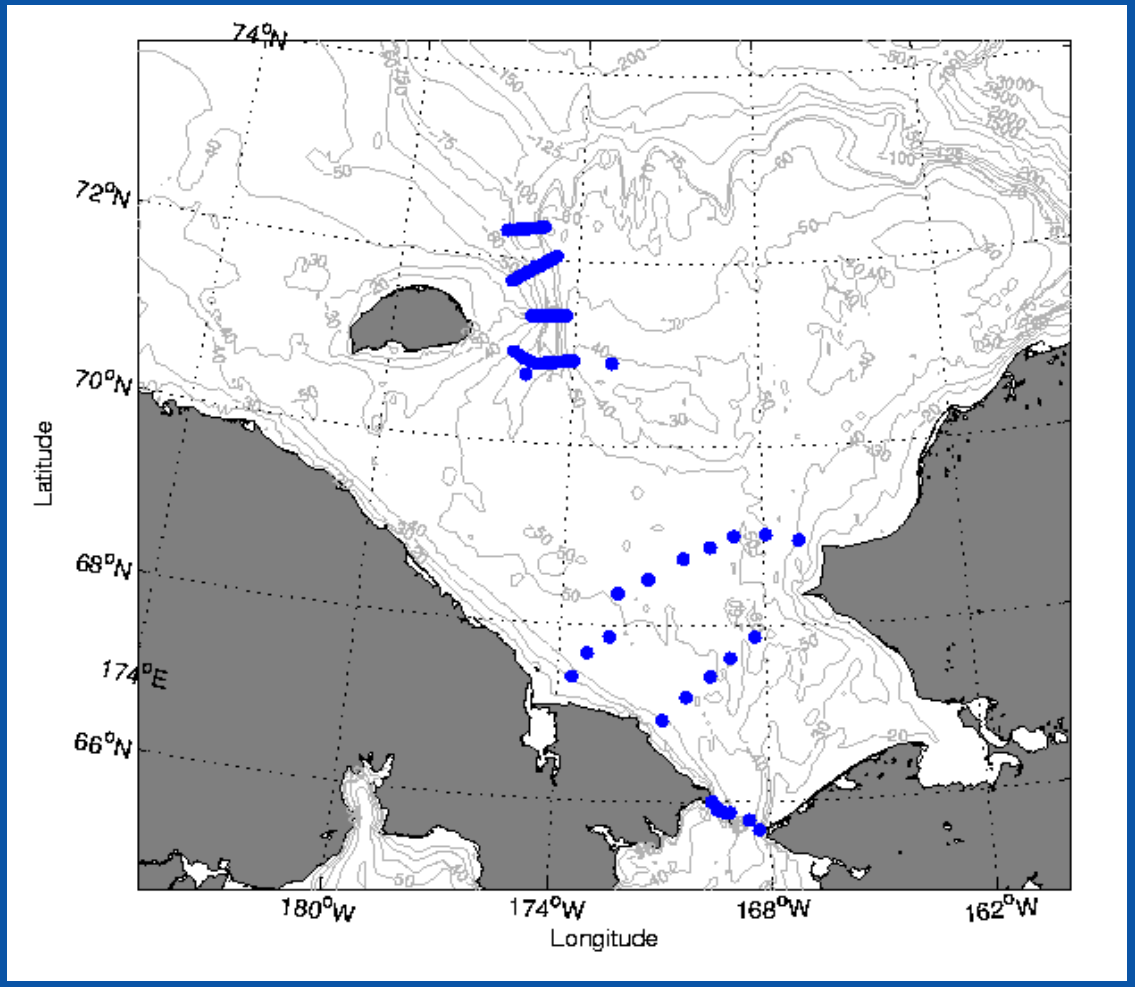


4. Dynamical structure of outflow is altered by hydraulic control in Herald Canyon.



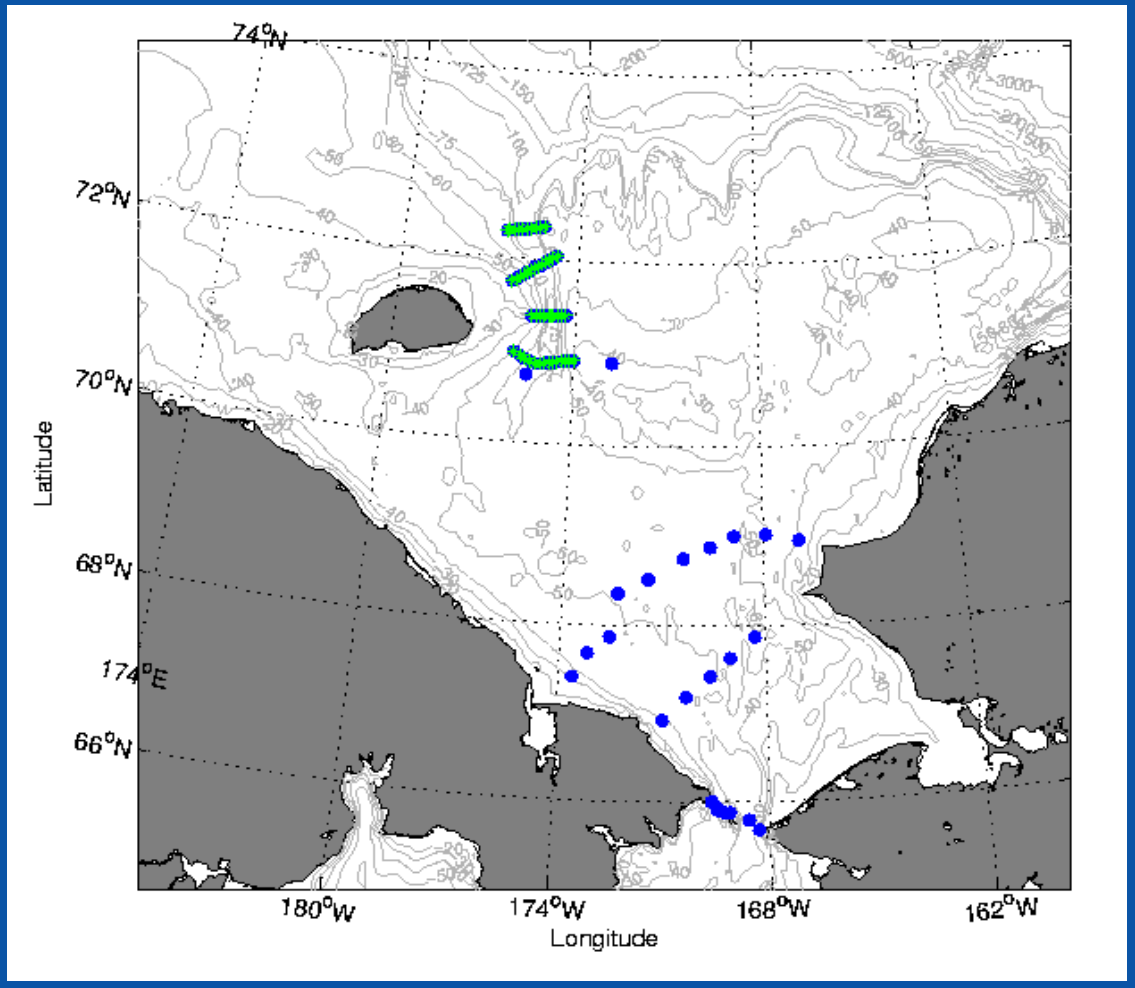
RUSALCA 2004 CTD survey

9-24 August

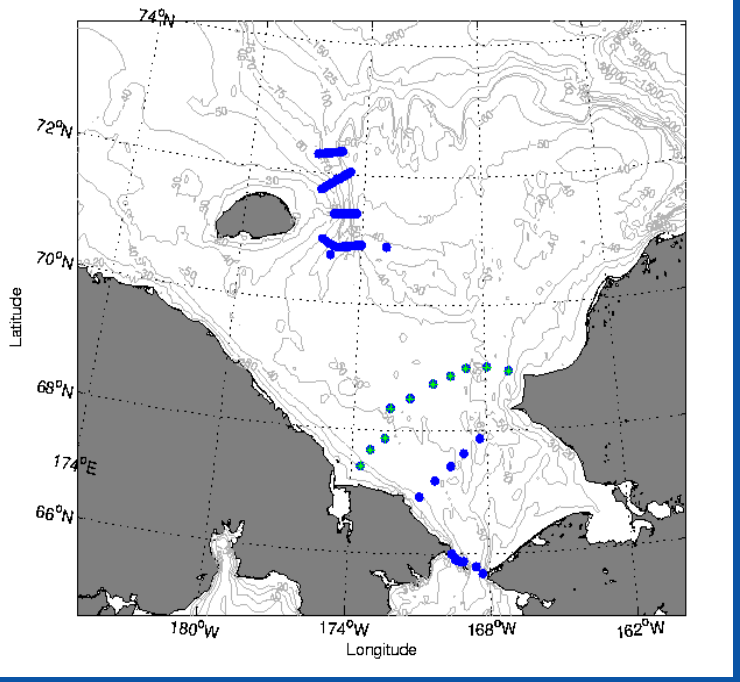


RUSALCA 2004 CTD survey

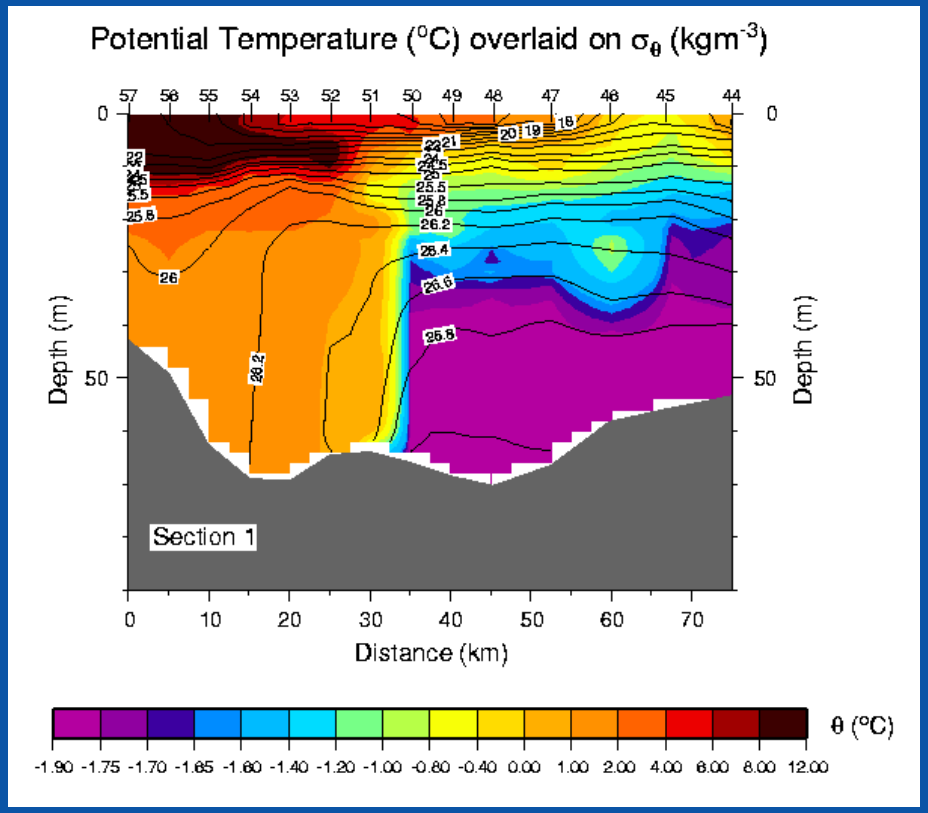
9-24 August



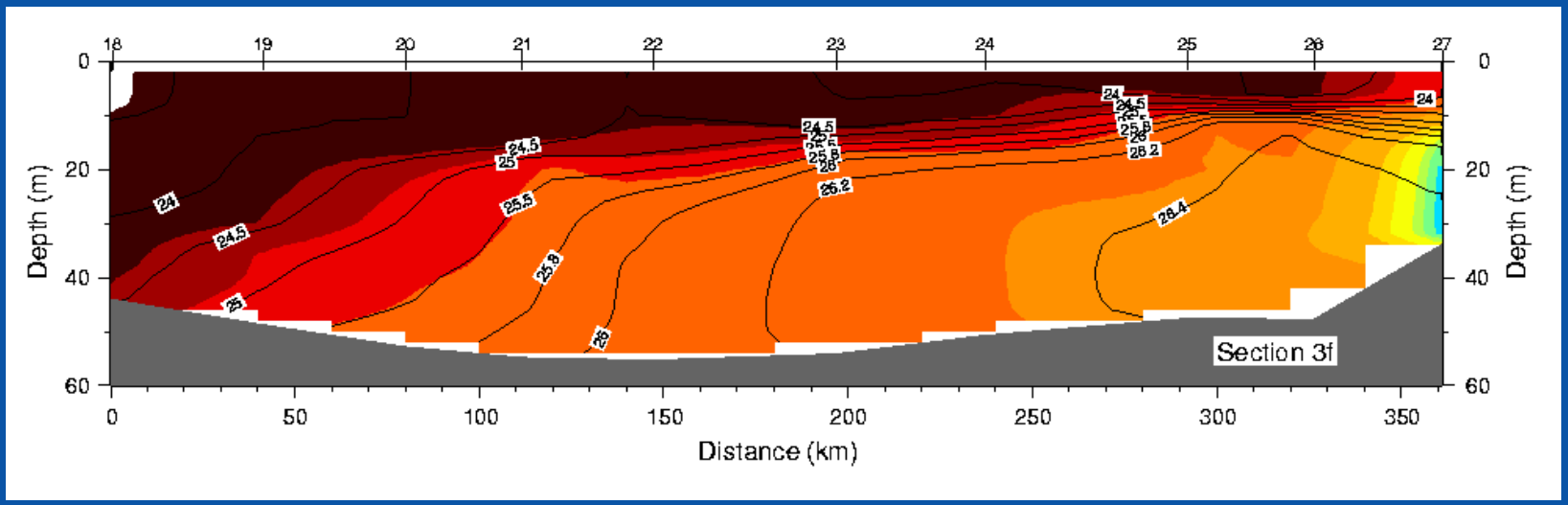
Source water



Head of Herald Canyon (looking upstream)

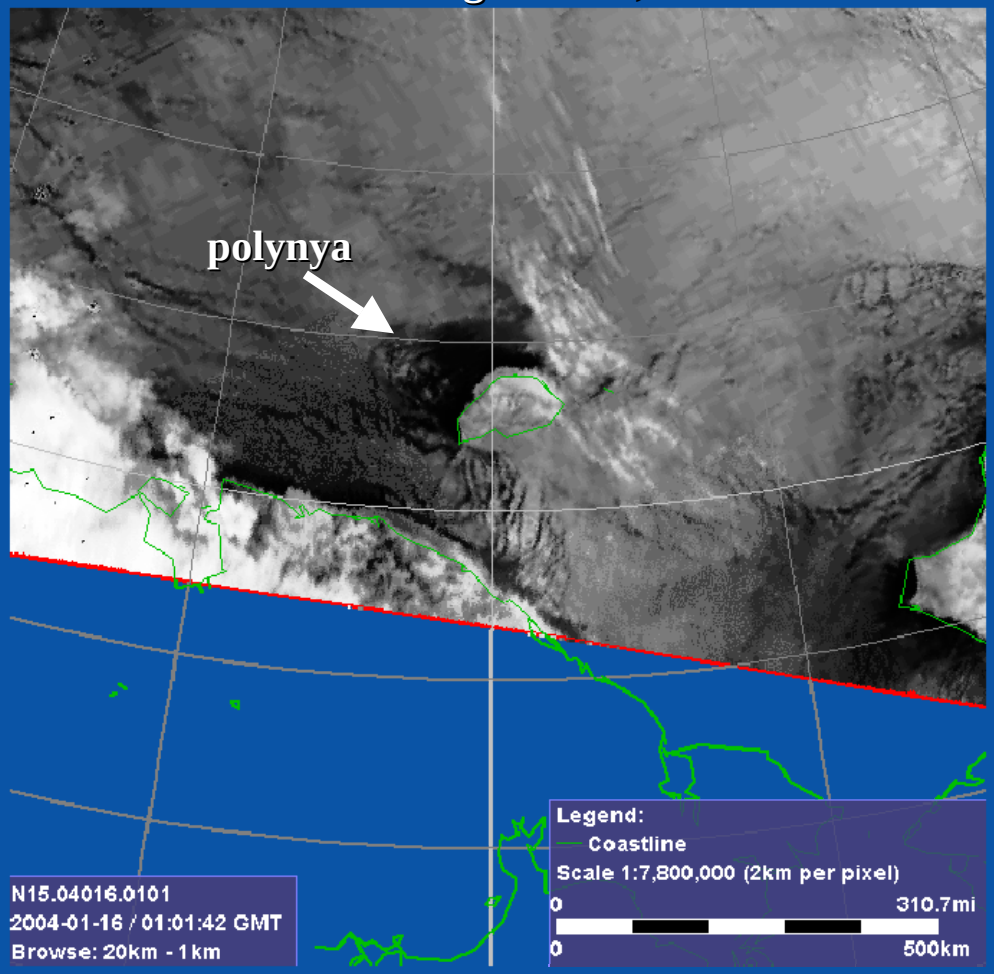


Southern Chukchi section

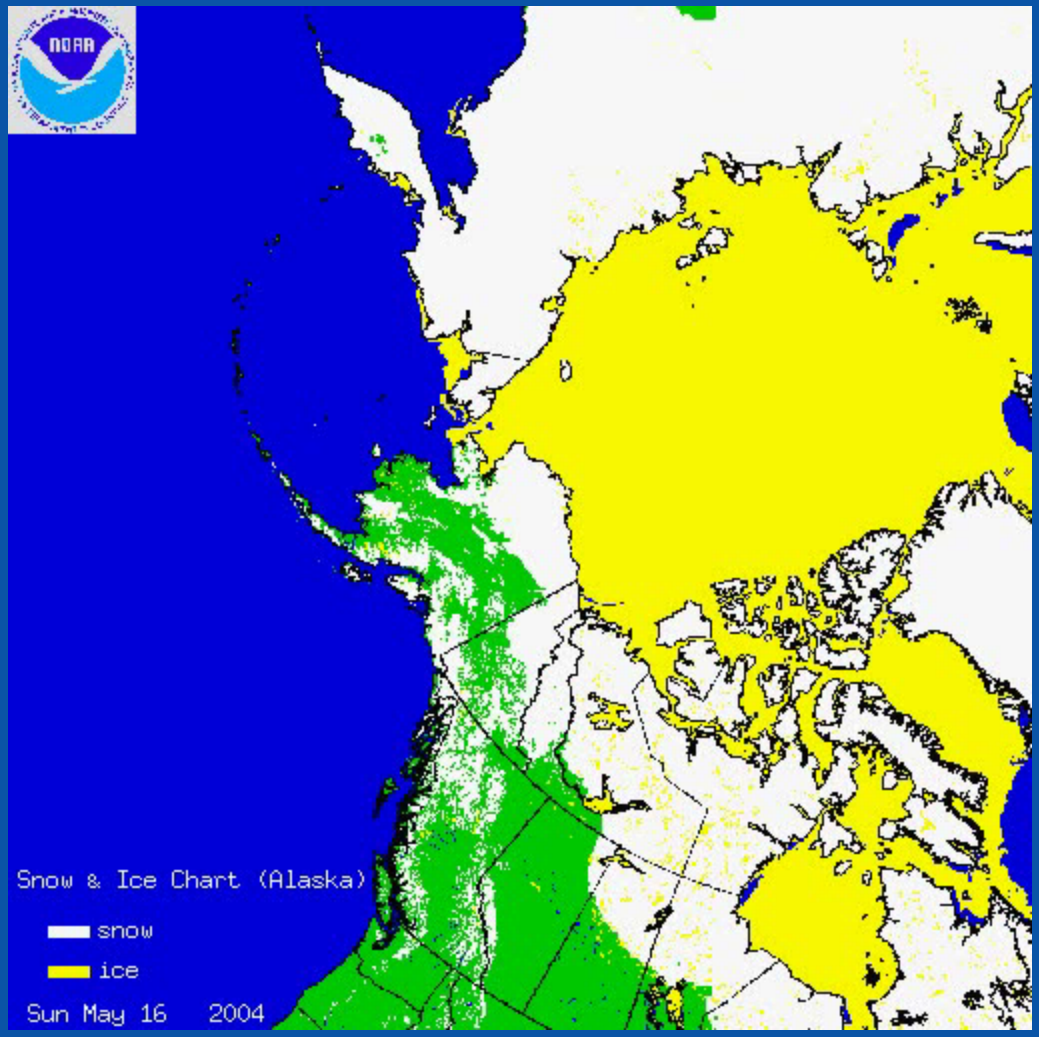


Source water

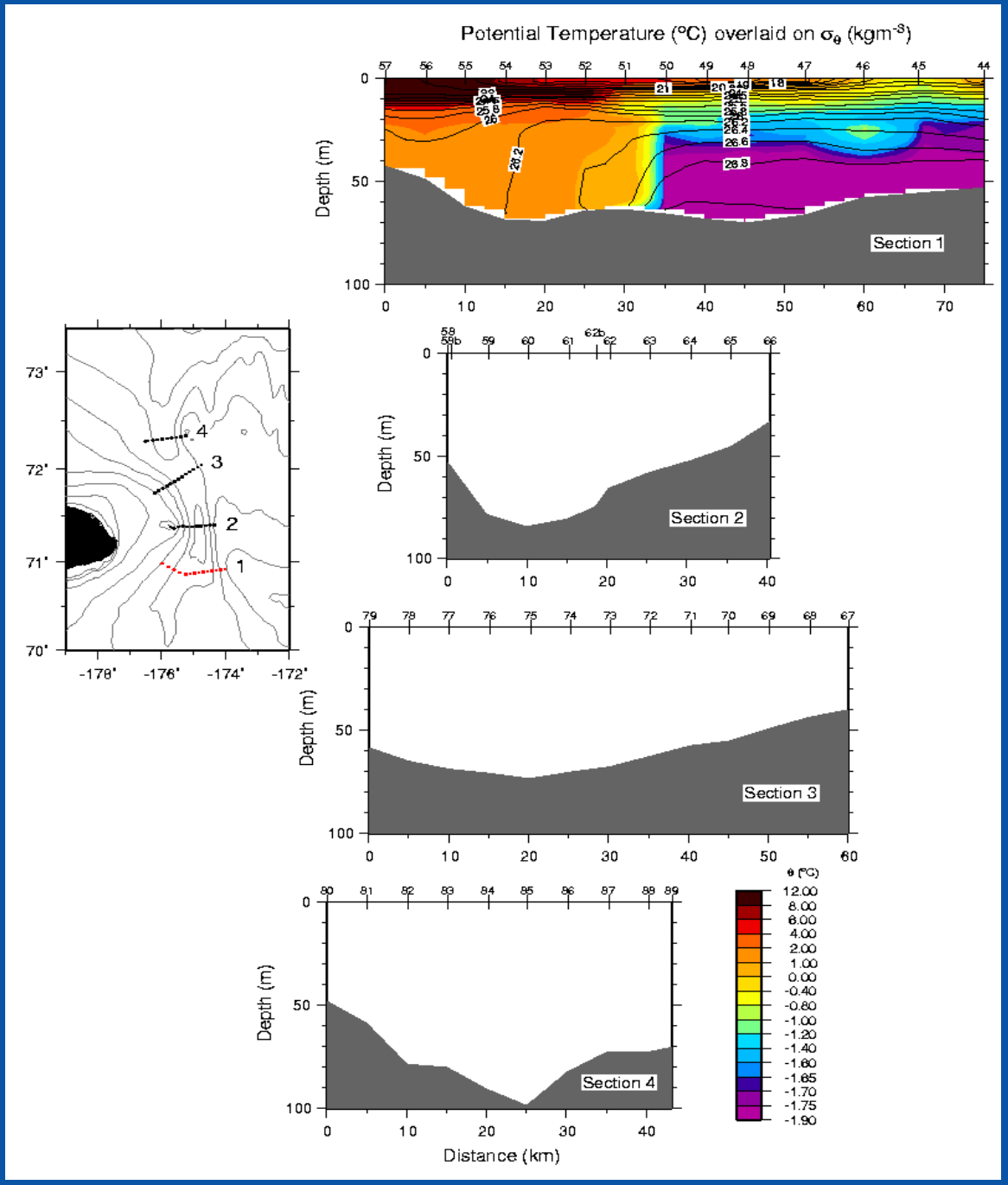
MODIS image Jan 16, 2004



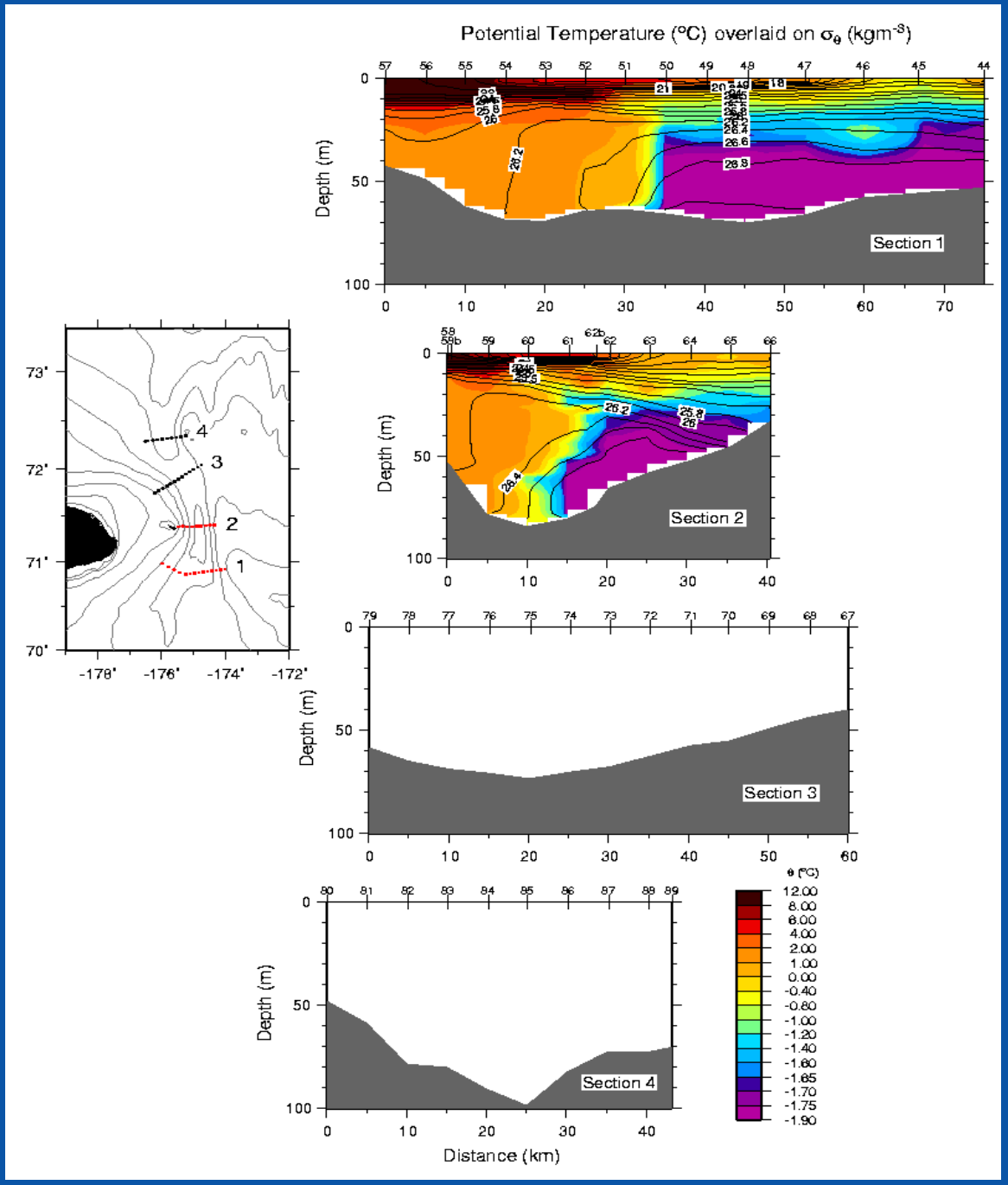
Ice melt-back in 2004



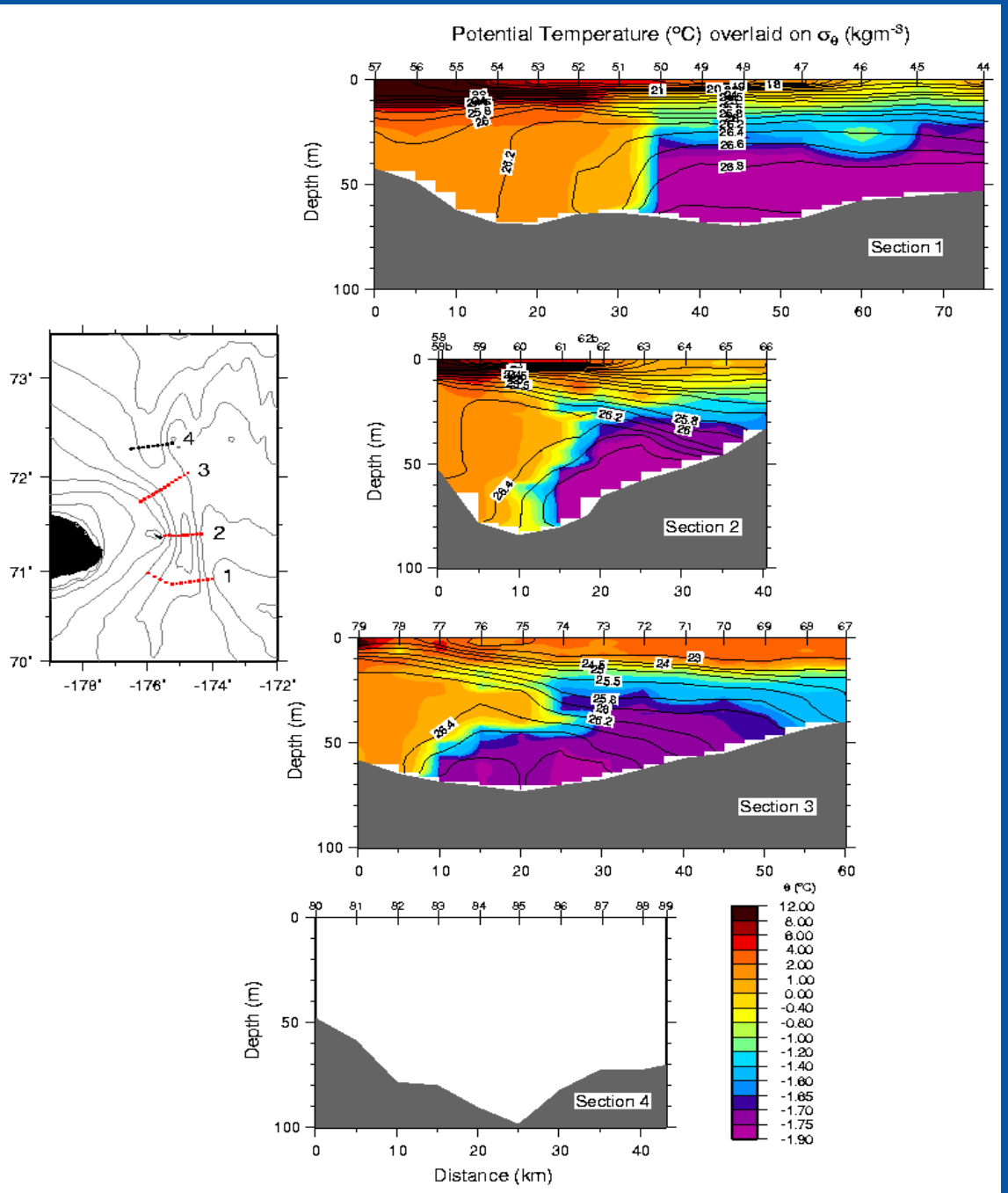
Evolution of dense water through the canyon



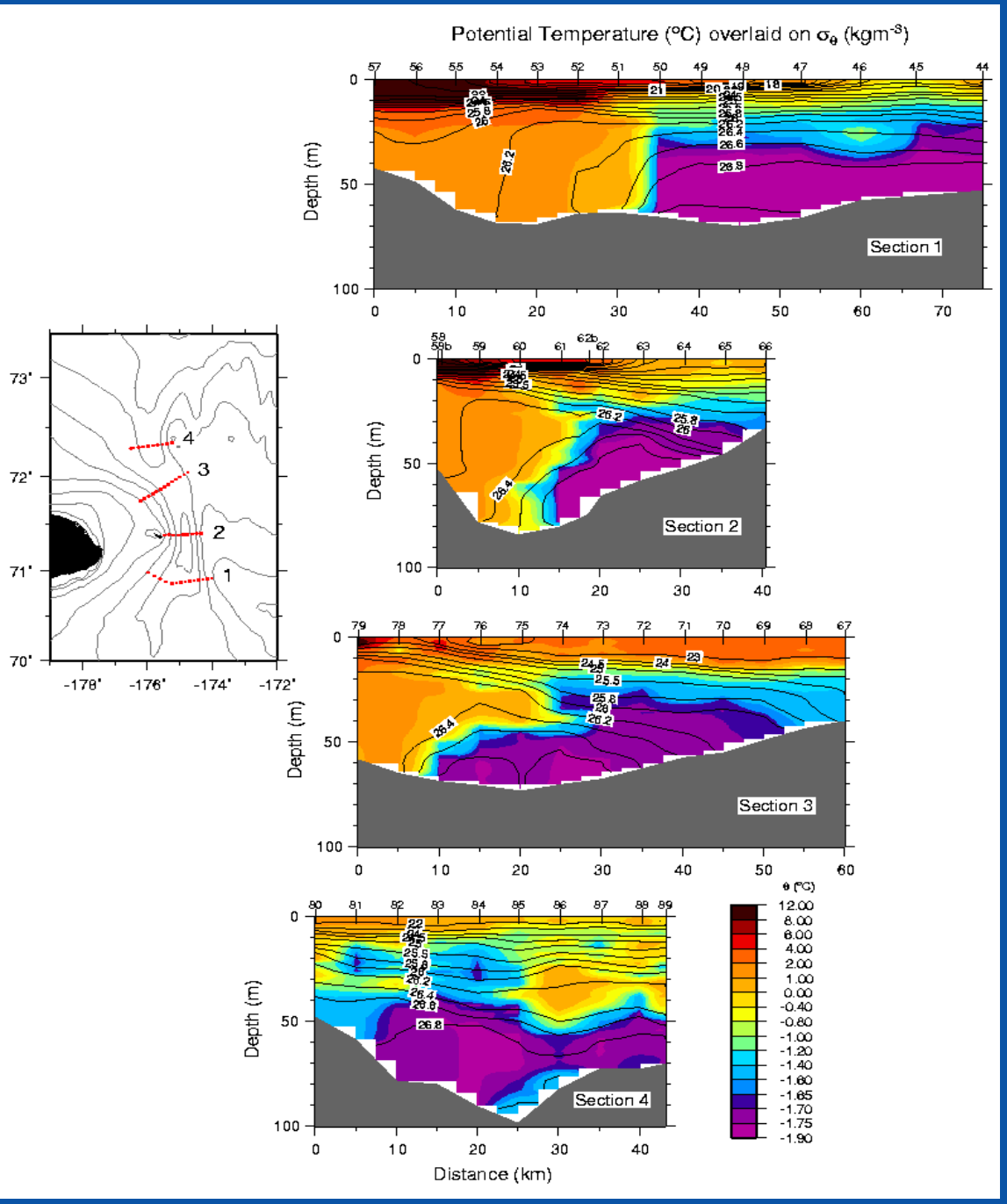
Evolution of dense water through the canyon



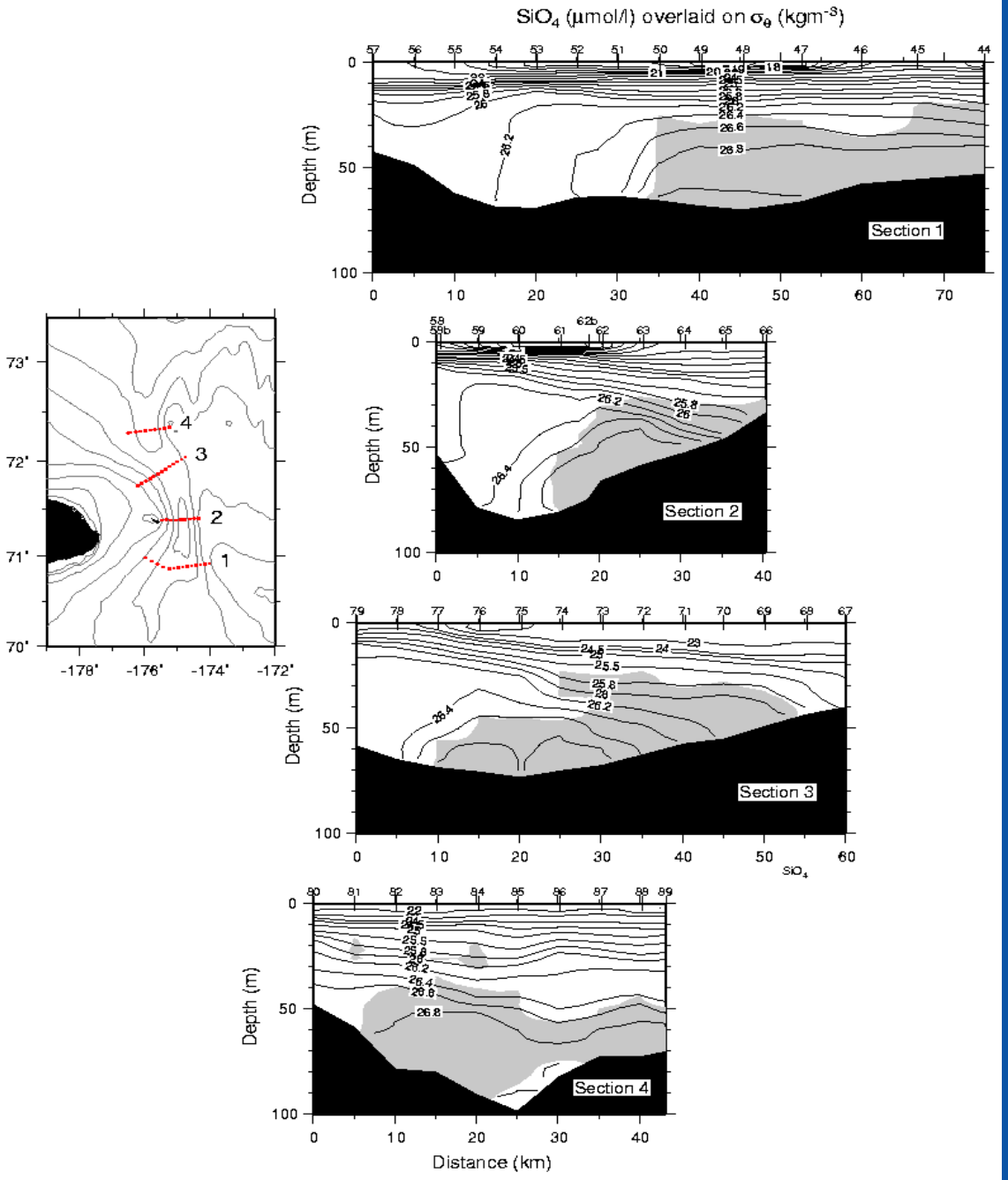
Evolution of dense water through the canyon



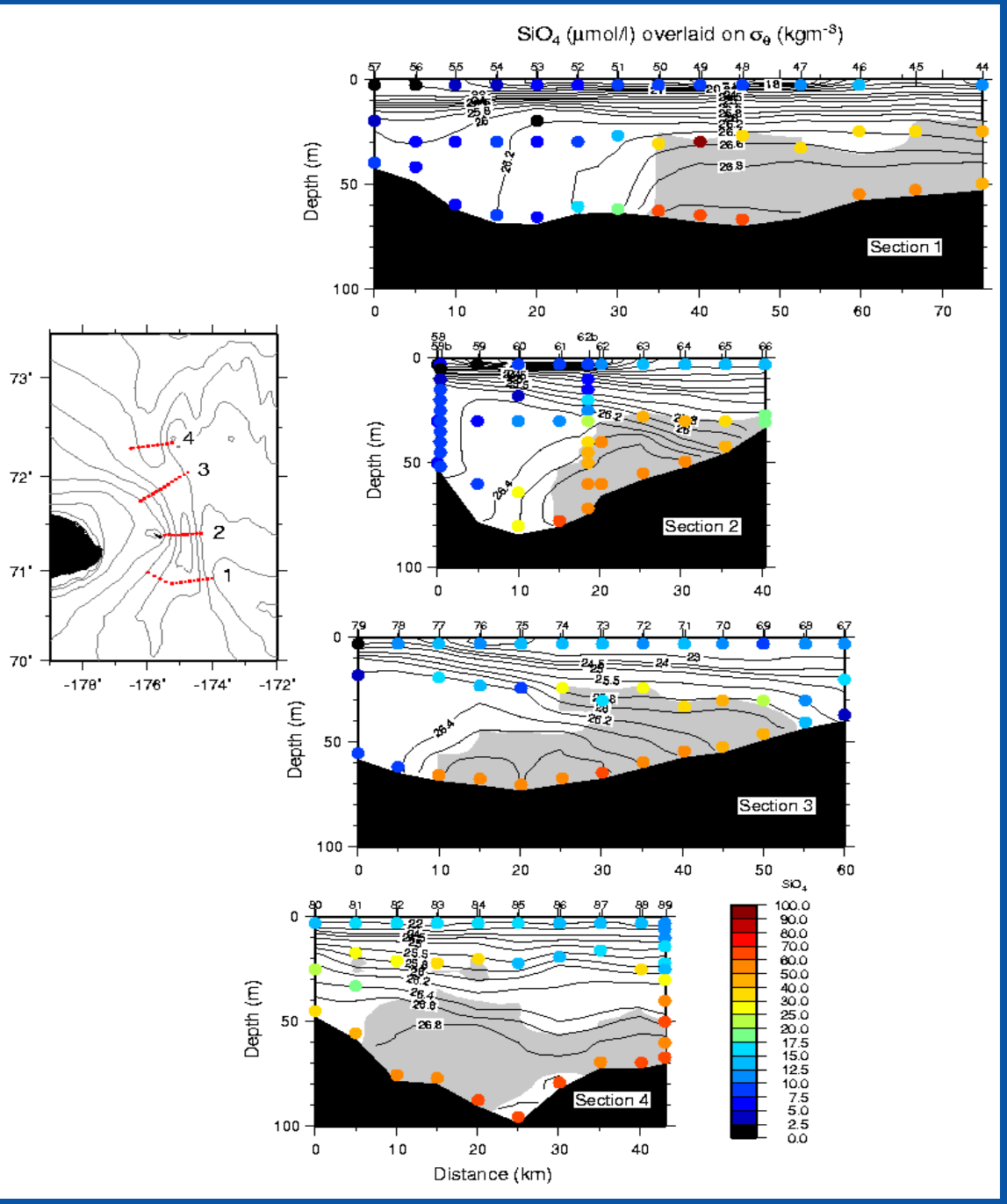
Evolution of dense water through the canyon



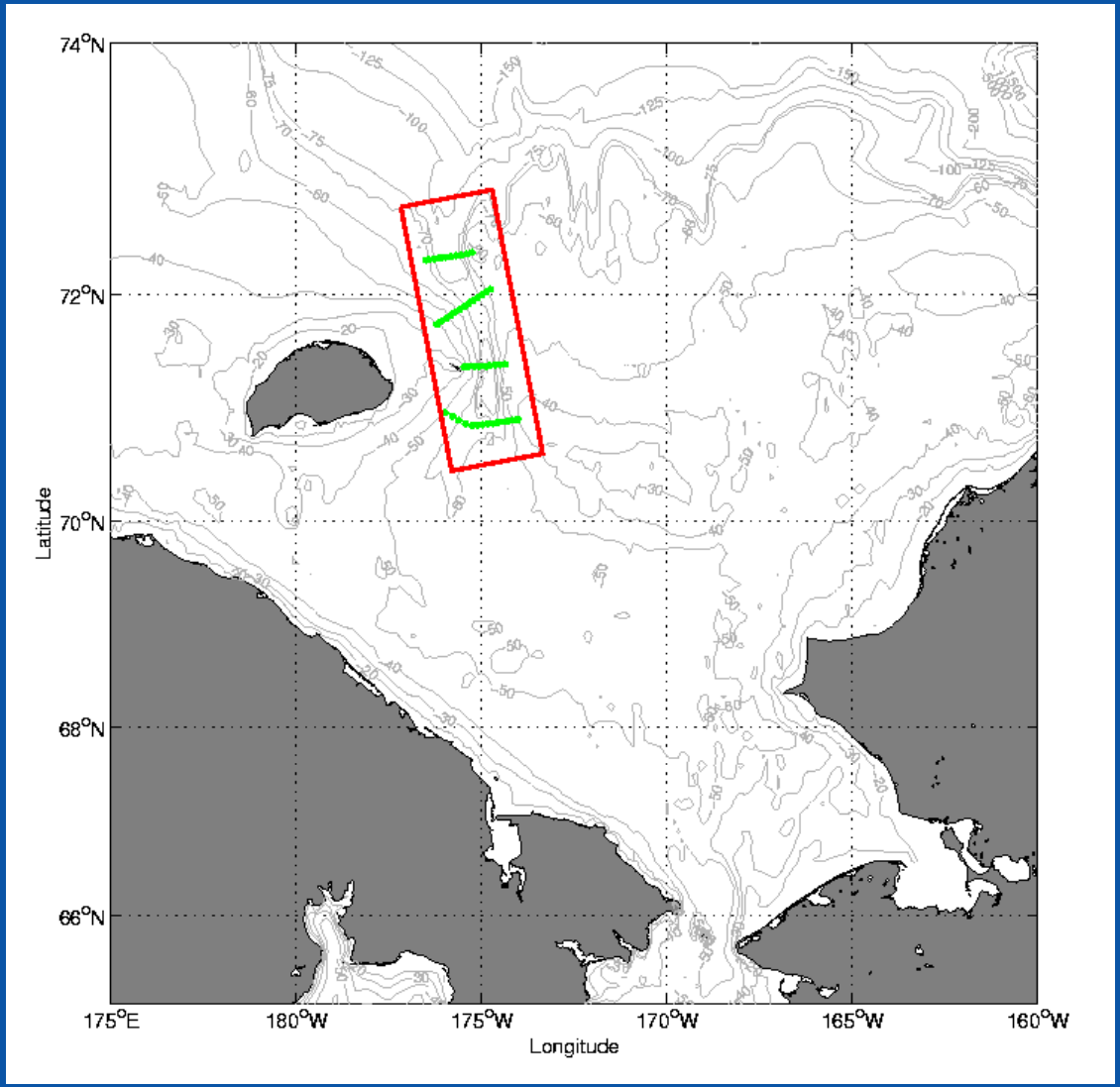
Evolution of dense water through the canyon



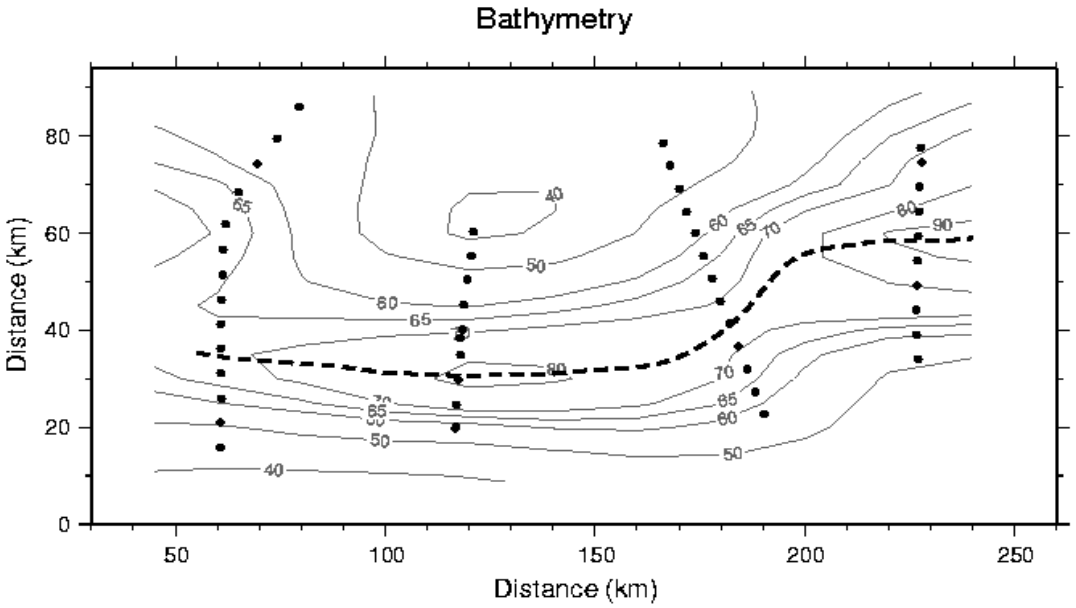
Evolution of dense water through the canyon

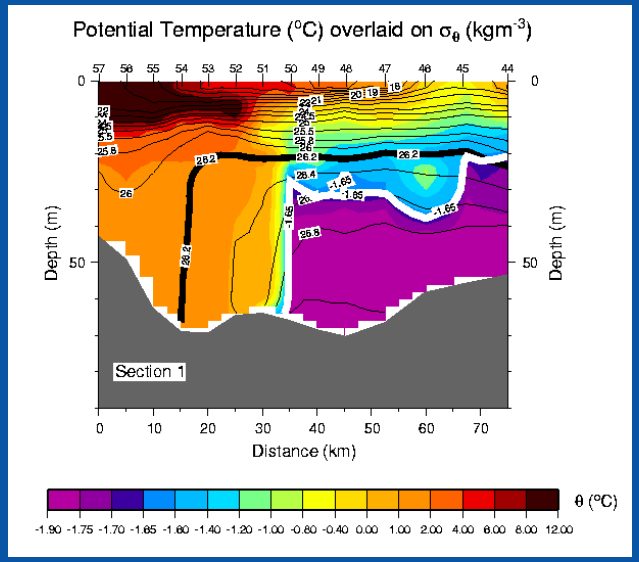


Rotated coordinate system

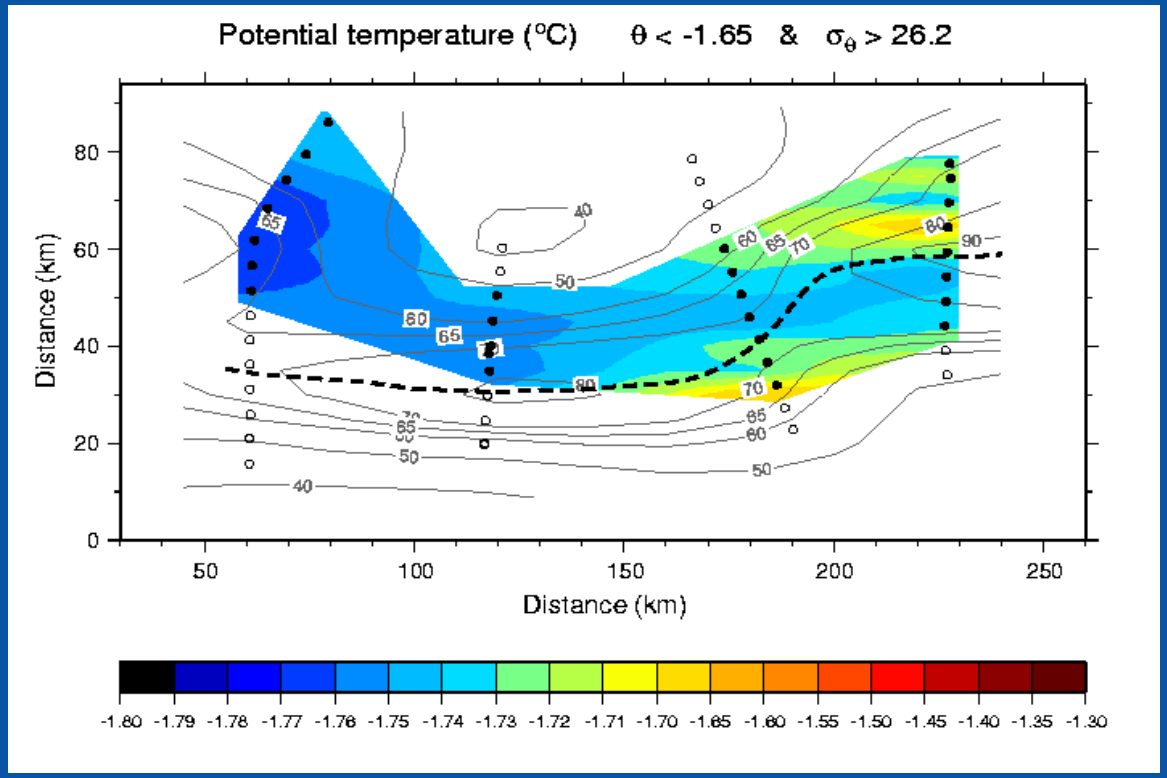


Lateral plots

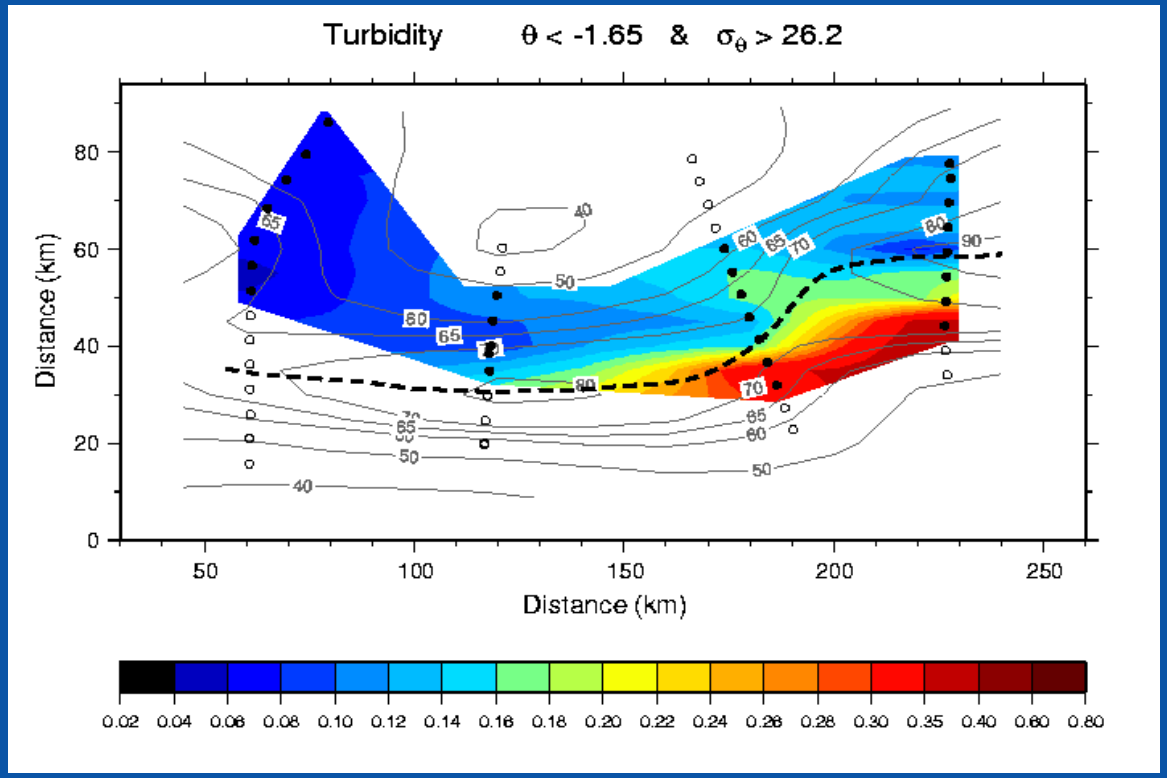




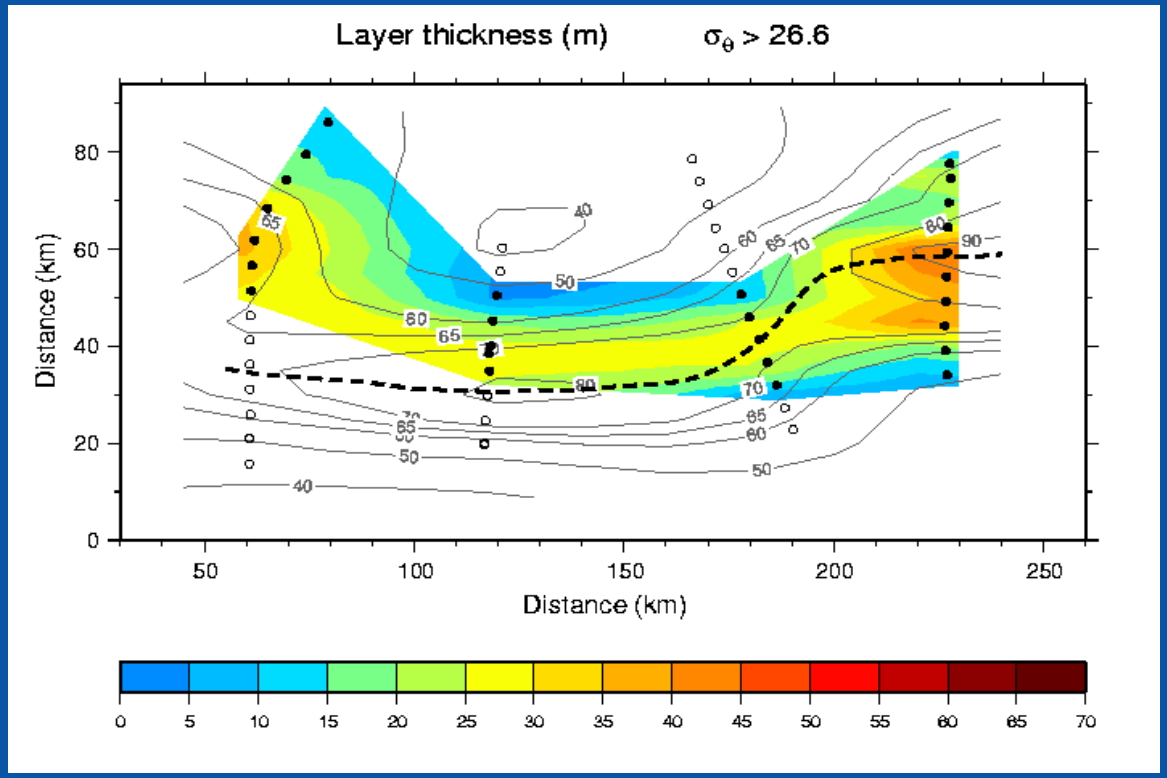
Lateral plots



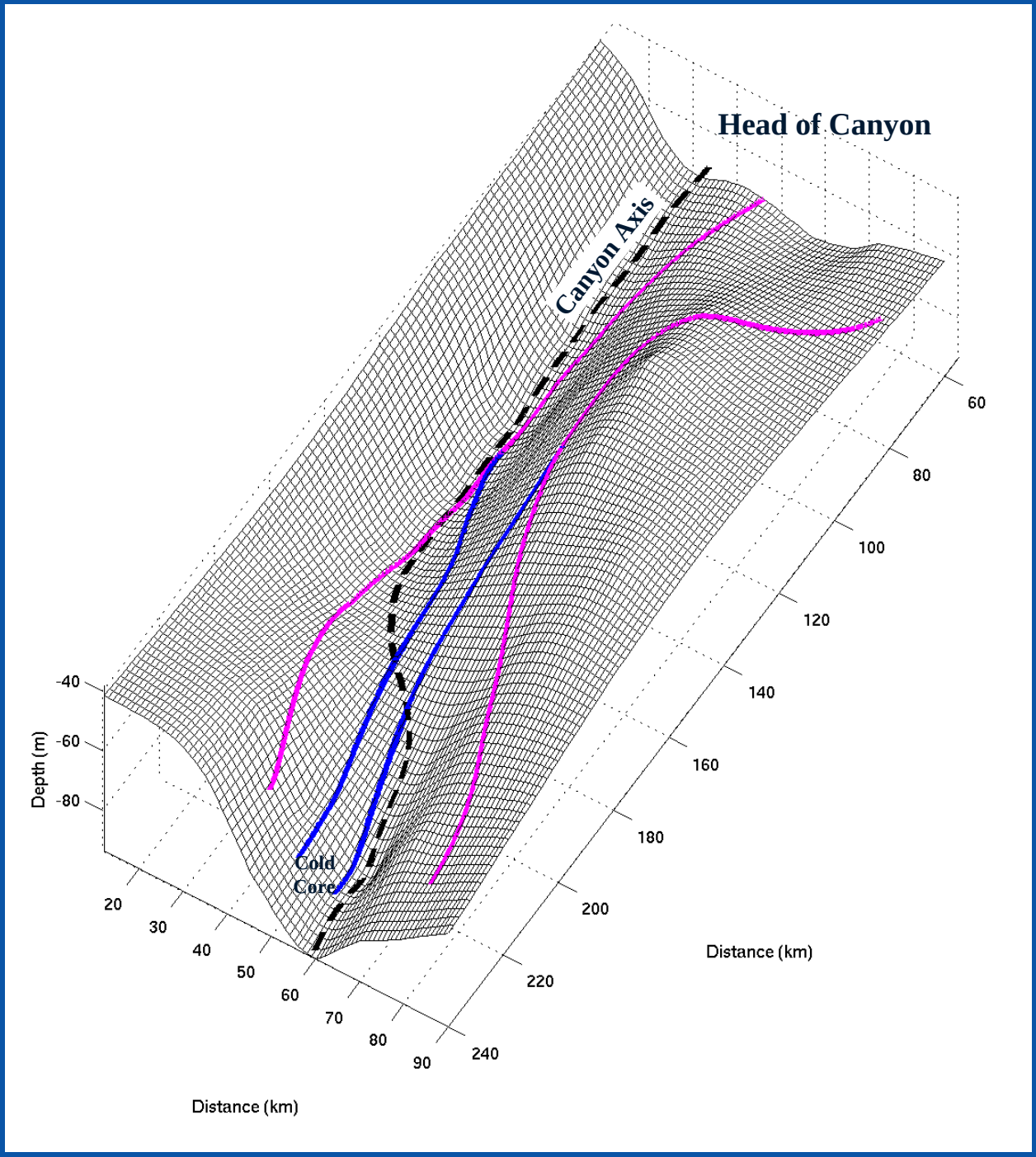
Lateral plots



Lateral plots

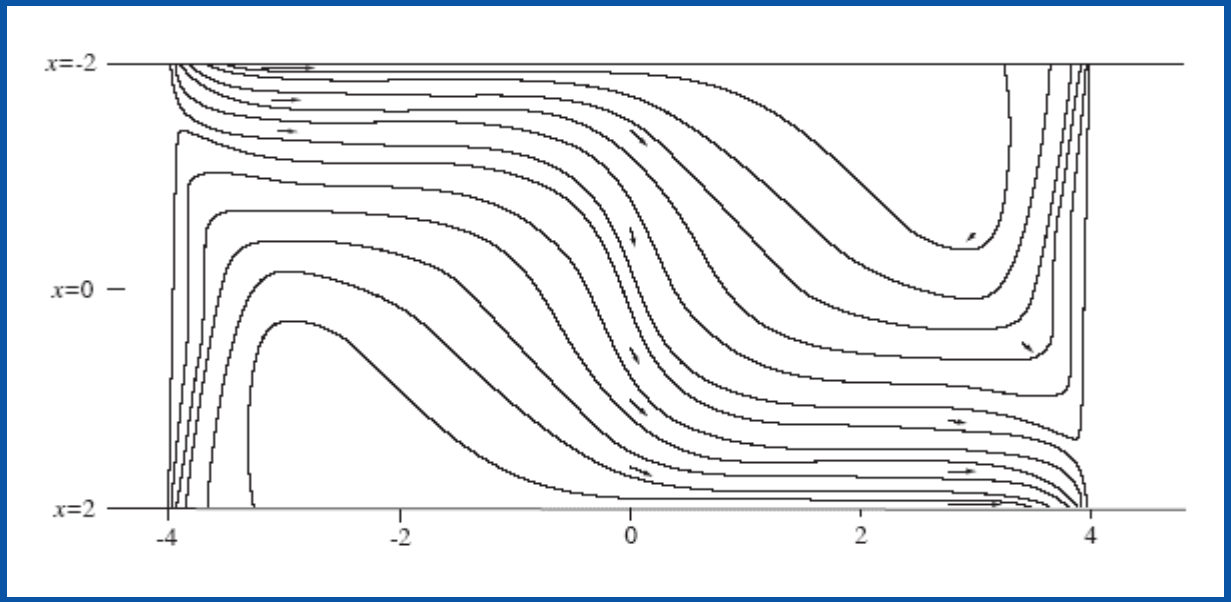


3-D view of dense water overflow



Hydraulics vs. Geostrophic Control

Initial SSH

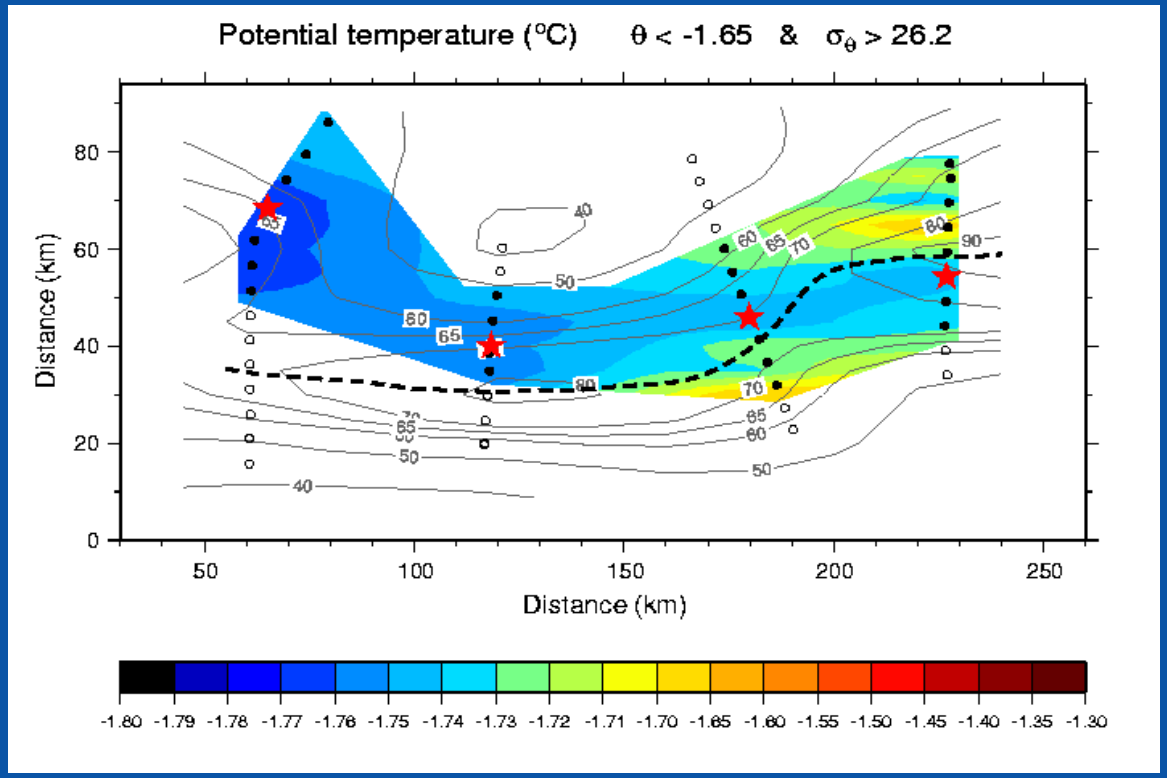


Upstream **Downstream**

Lateral view of geostrophic control

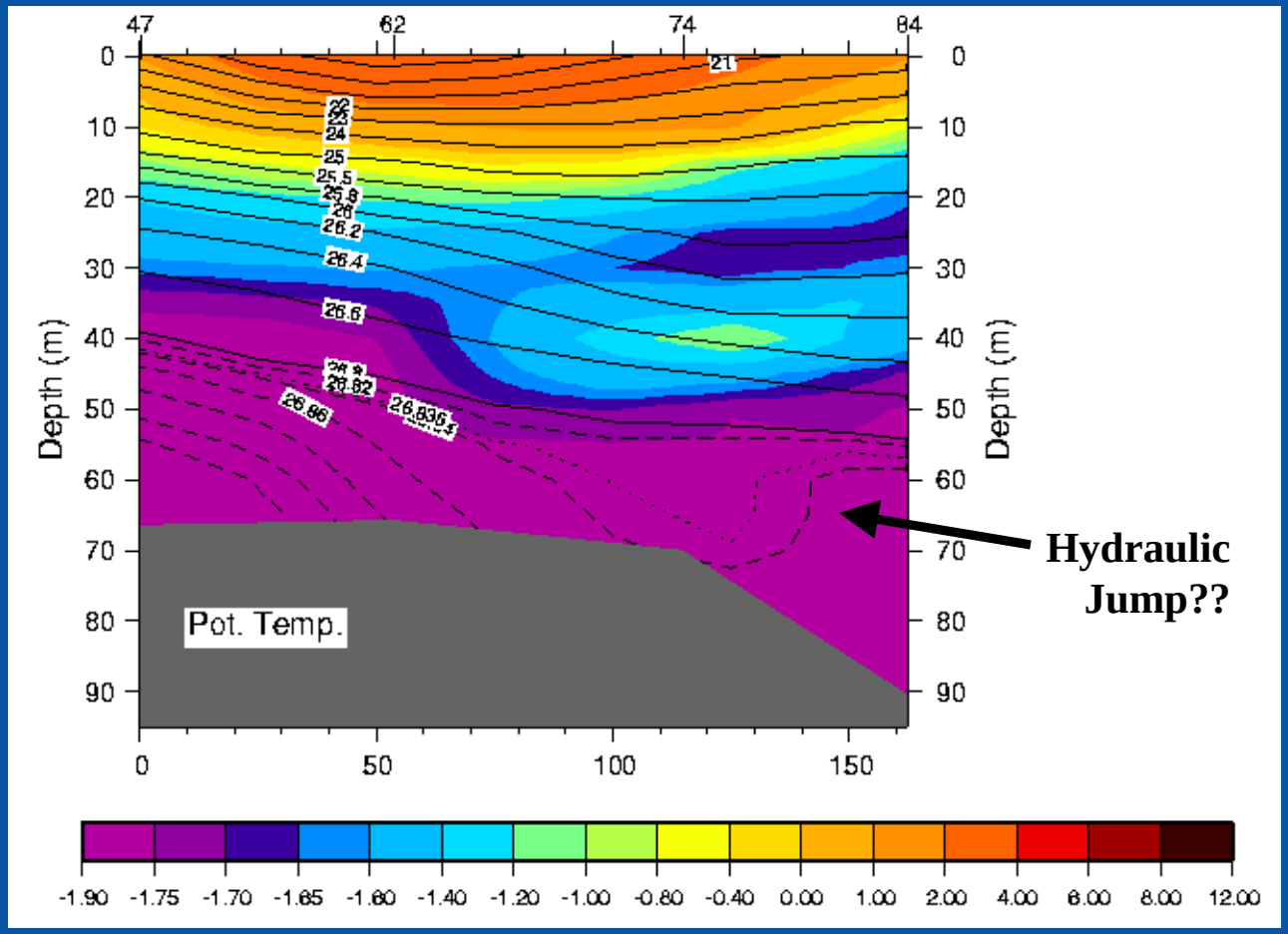
Pratt and Whitehead (2005)

Core of overflow



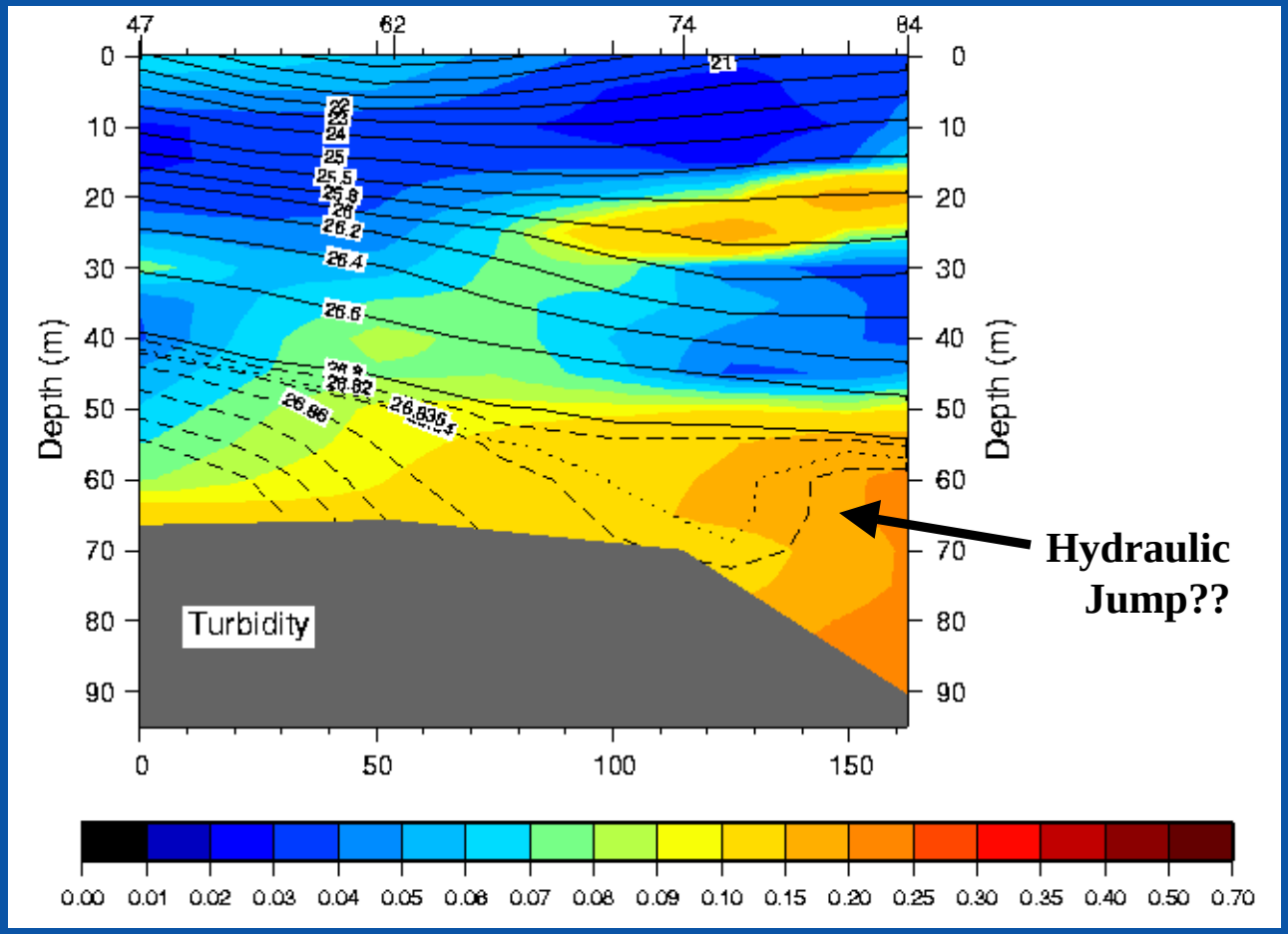
Along-canyon section

Potential Temperature (color) overlaid on potential density (contours)



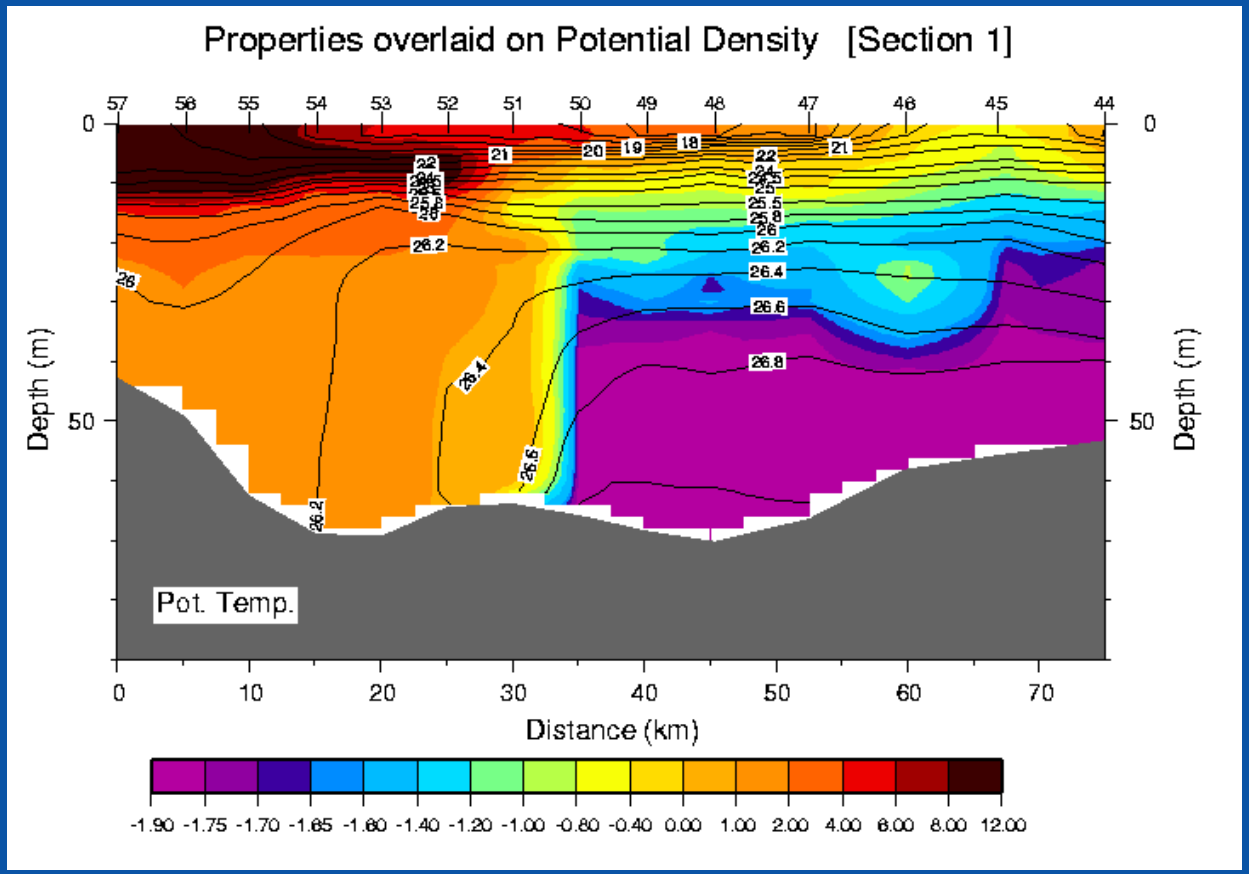
Along-canyon section

Turbidity (color) overlaid on potential density (contours)



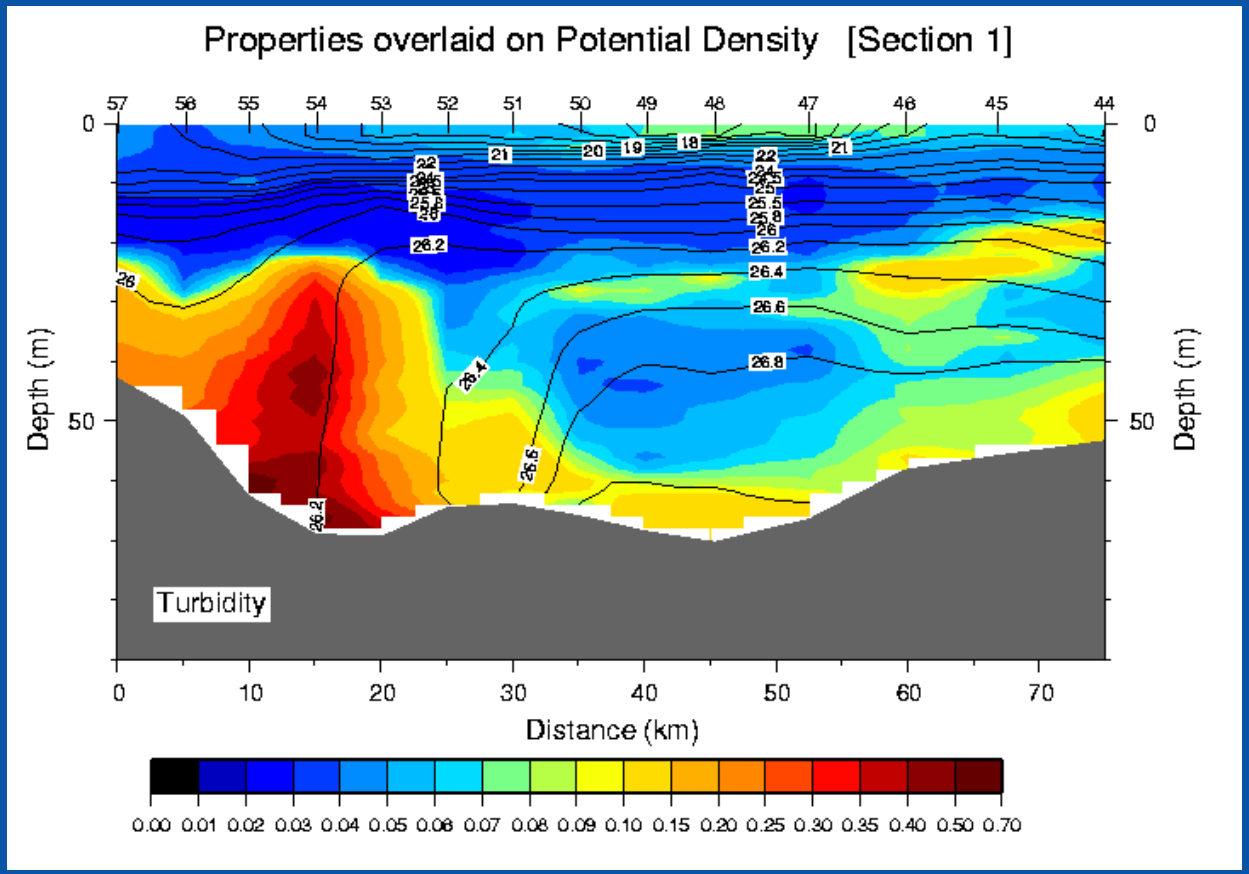
Pumping off the bottom

Head of Herald Canyon



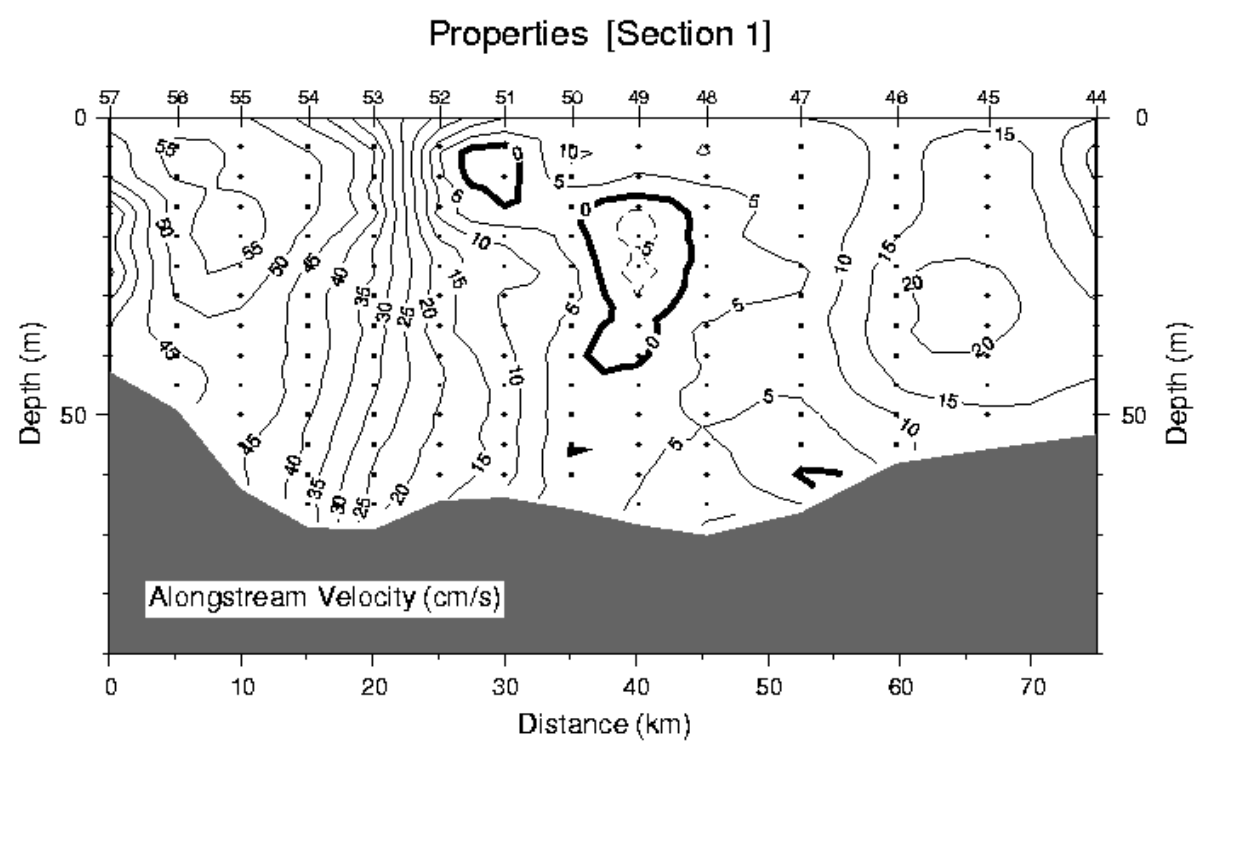
Pumping off the bottom

Head of Herald Canyon

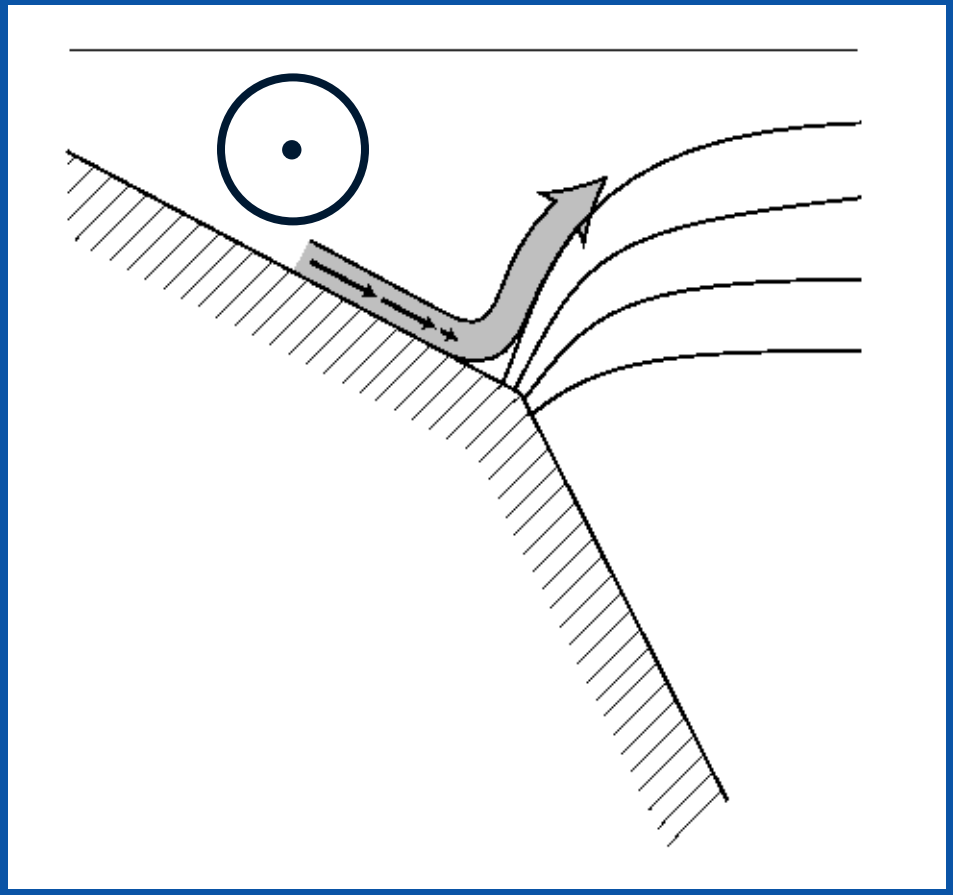


Pumping off the bottom

Head of Herald Canyon



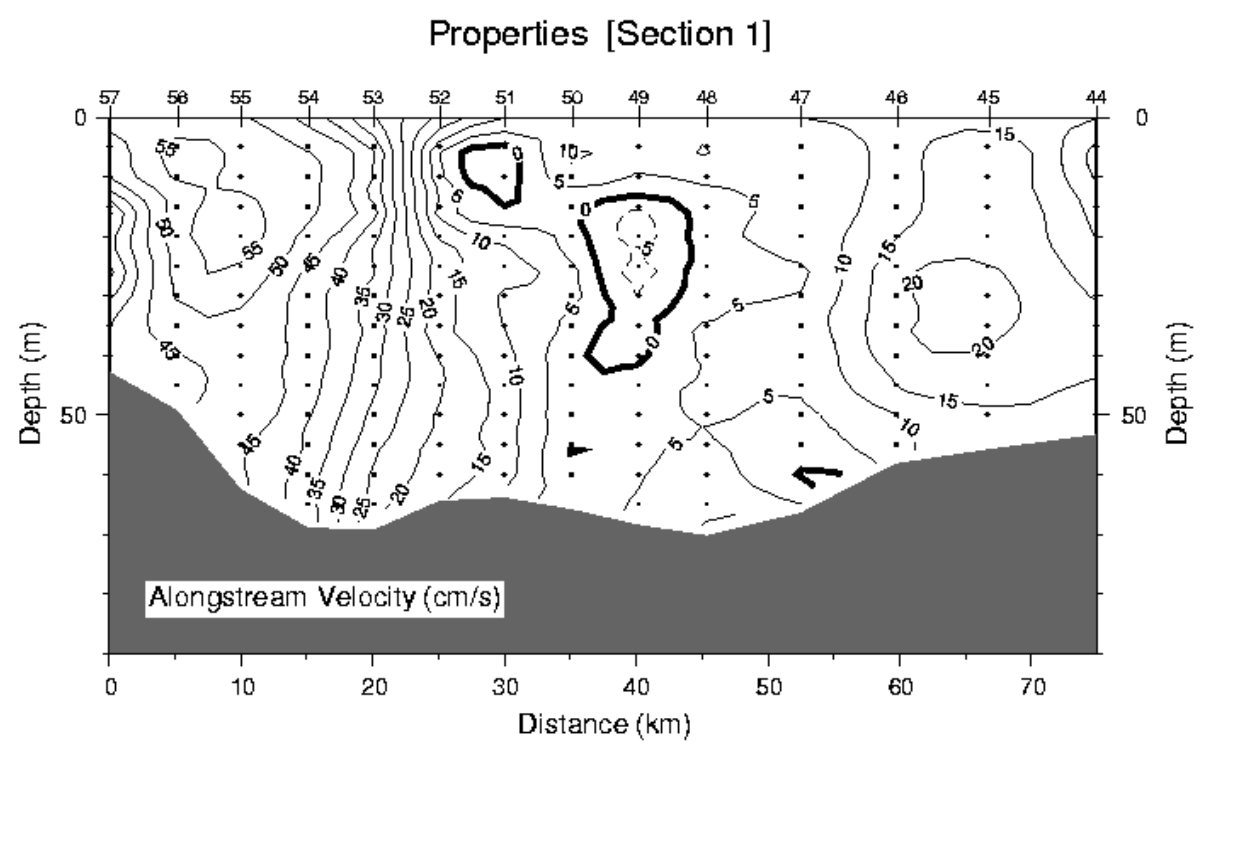
Schematic of detached bottom boundary layer



Pickart (2000)

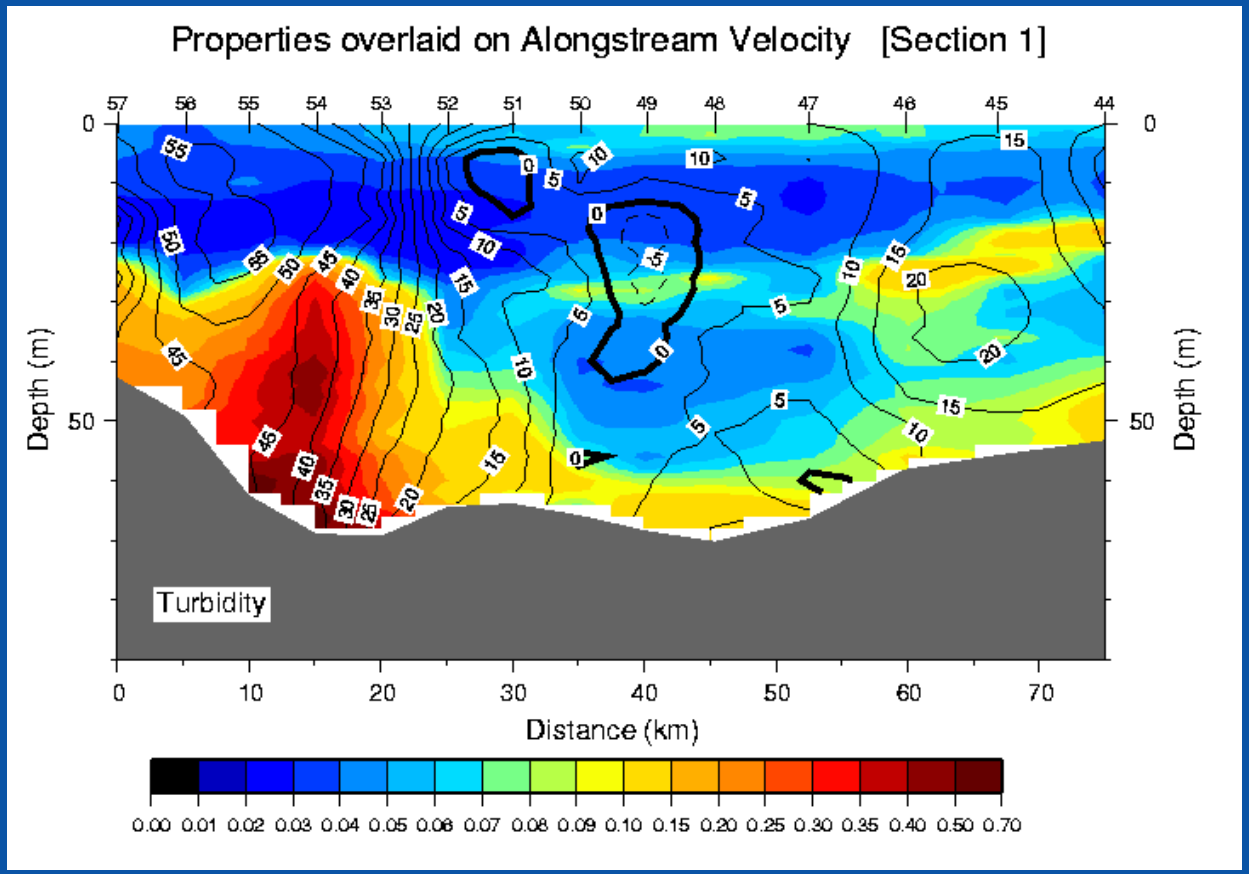
Pumping off the bottom

Head of Herald Canyon

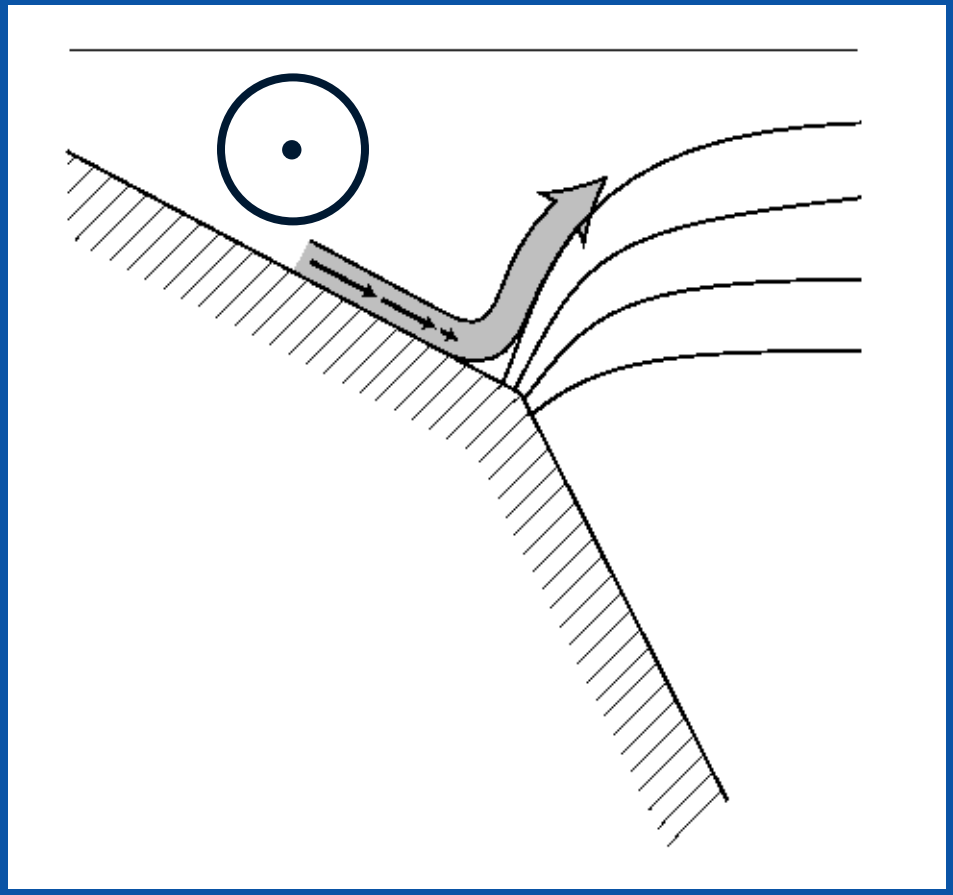


Pumping off the bottom

Head of Herald Canyon



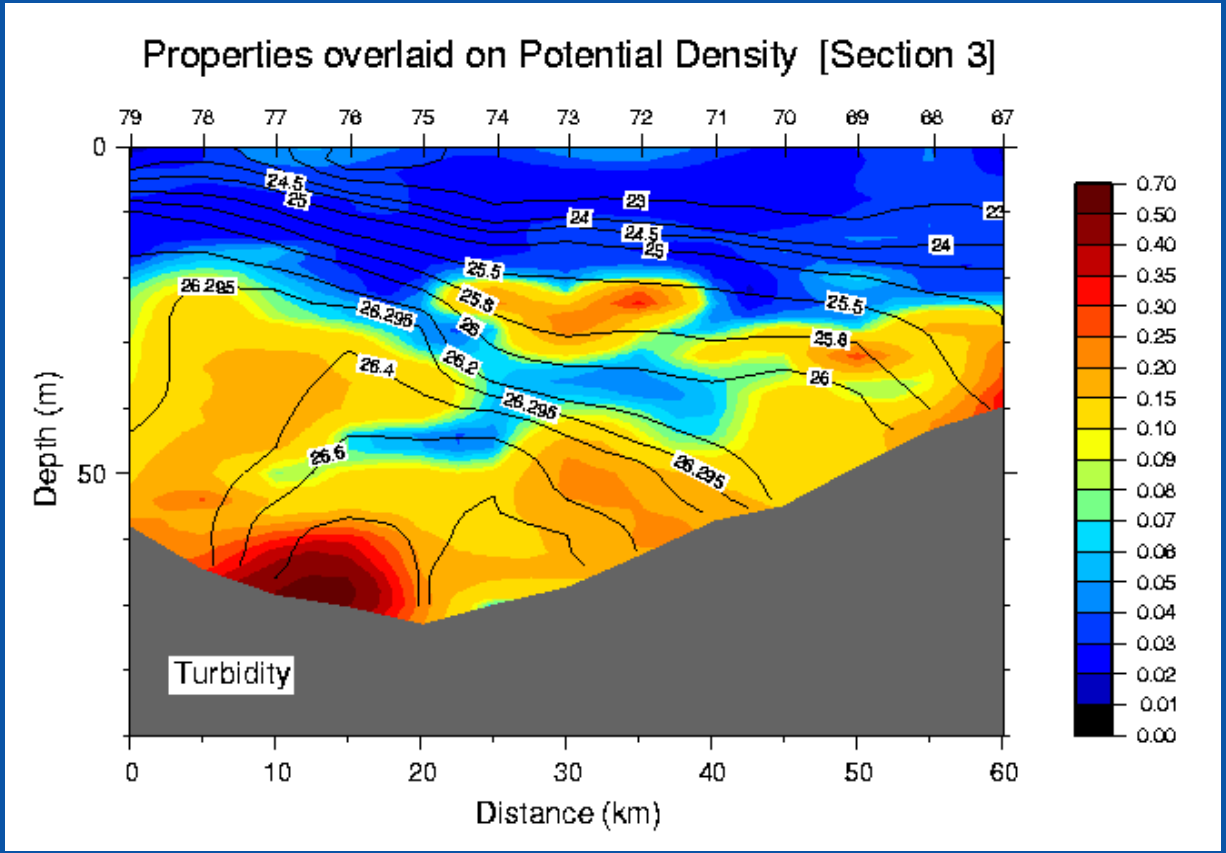
Schematic of detached bottom boundary layer



Pickart (2000)

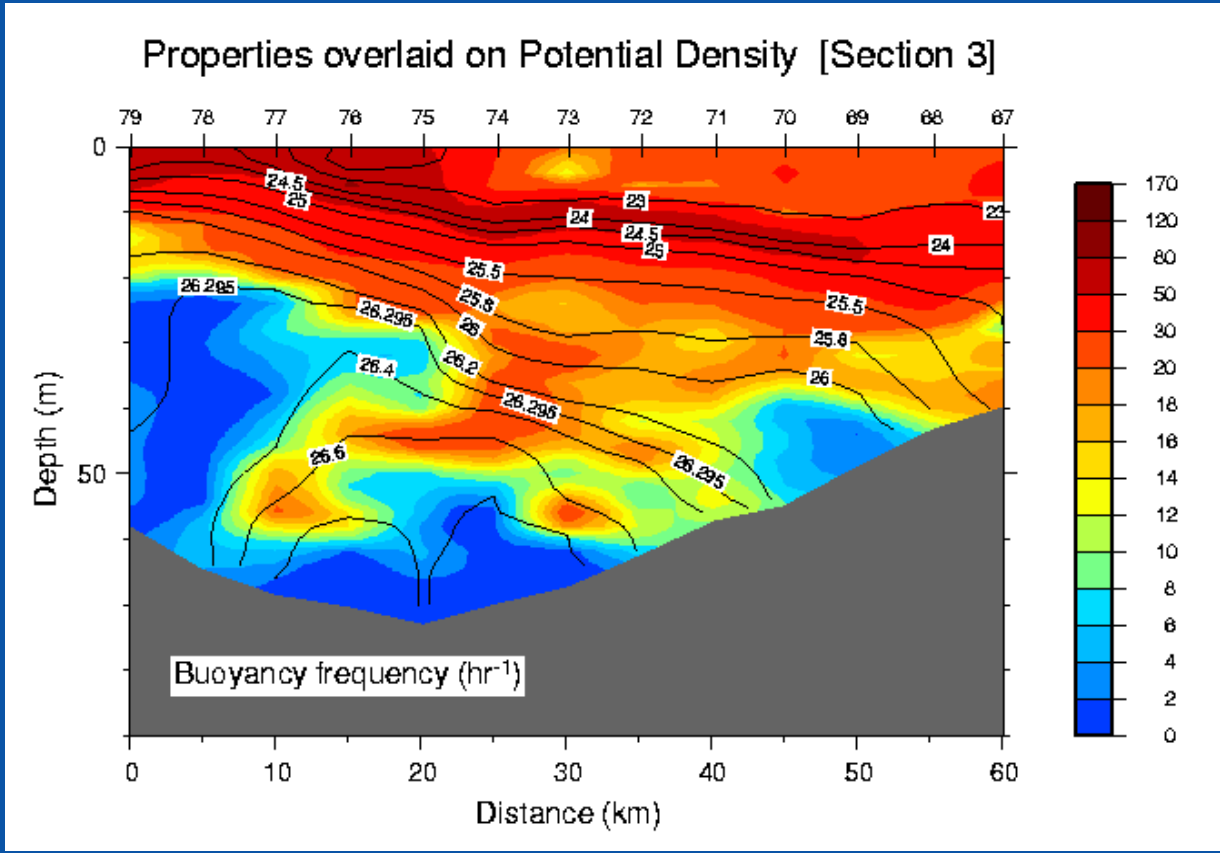
Pumping off the bottom

Central Herald Canyon



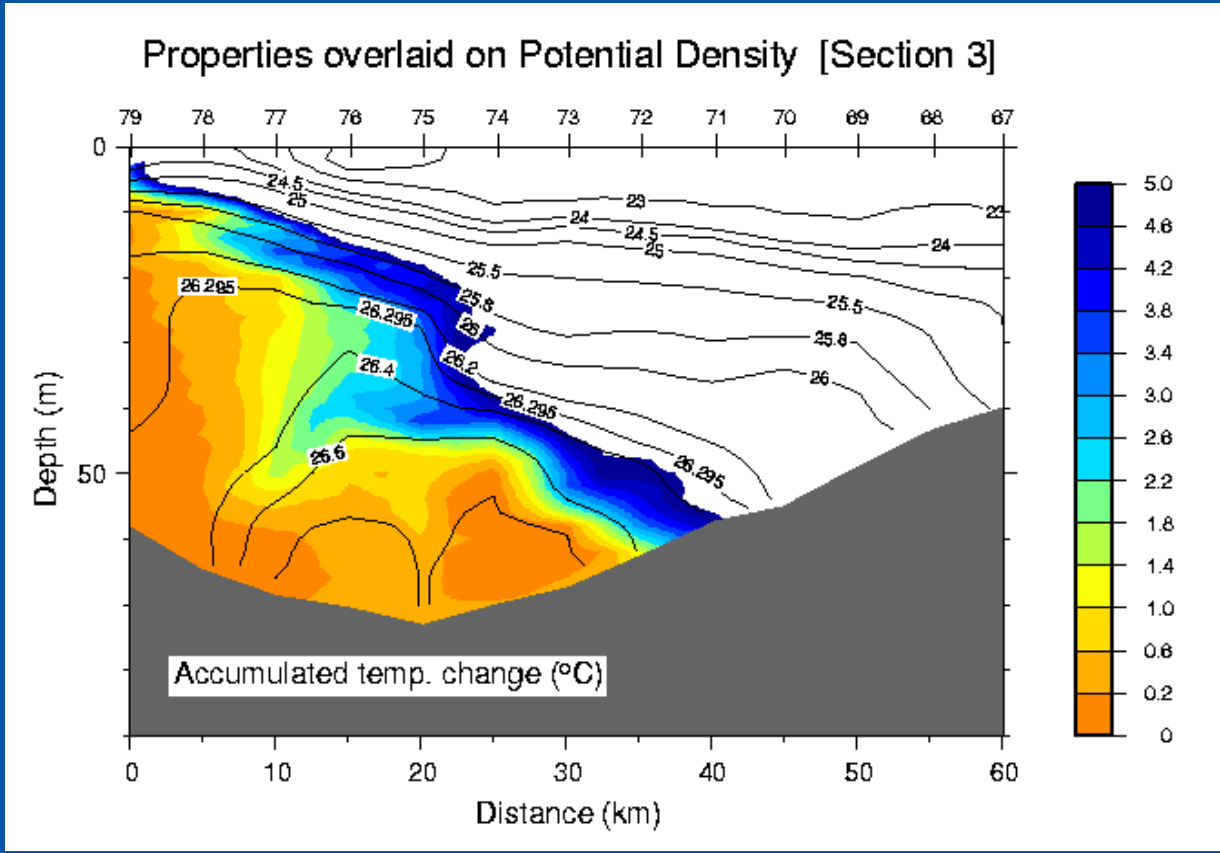
Pumping off the bottom

Central Herald Canyon

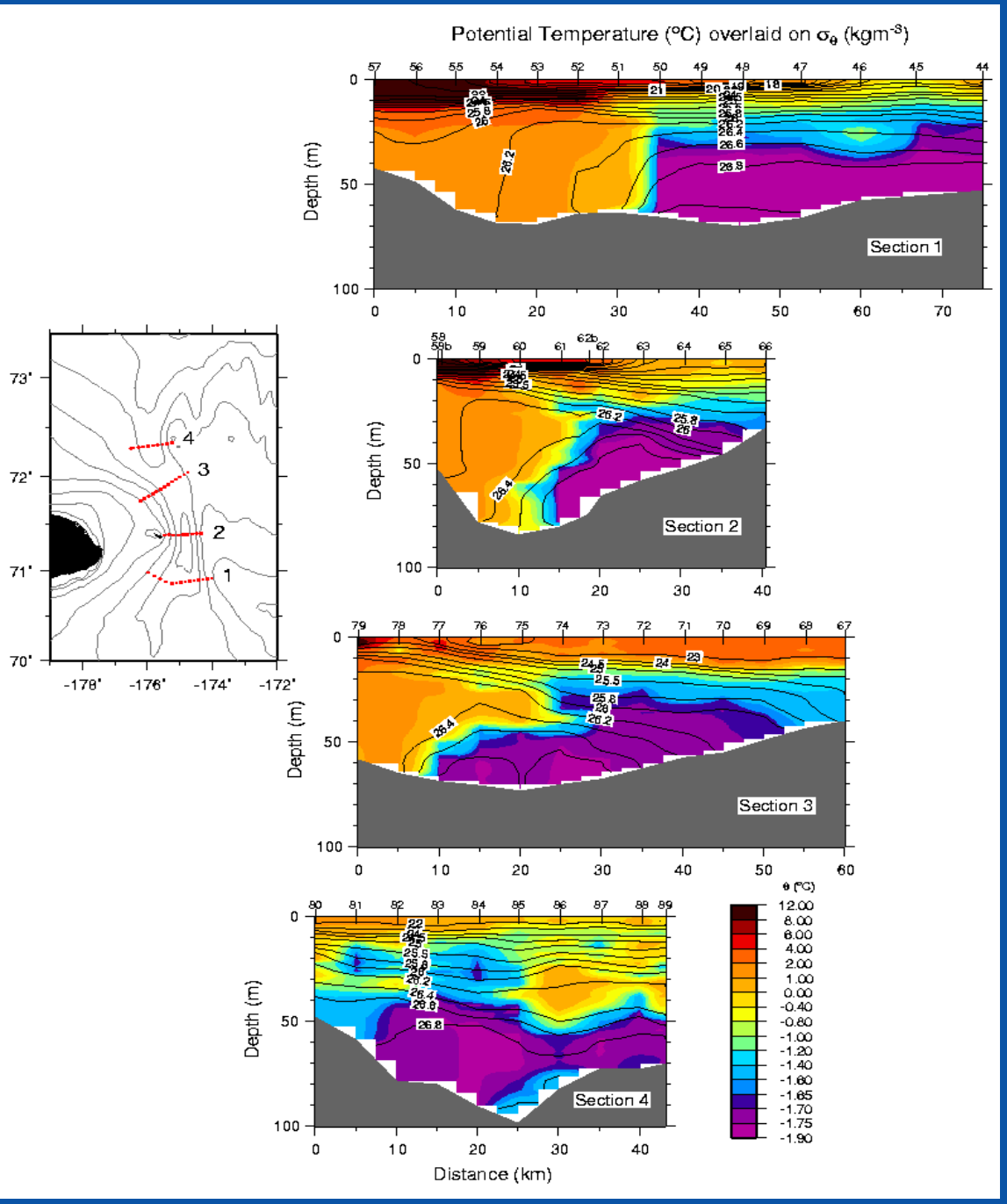


Pumping off the bottom

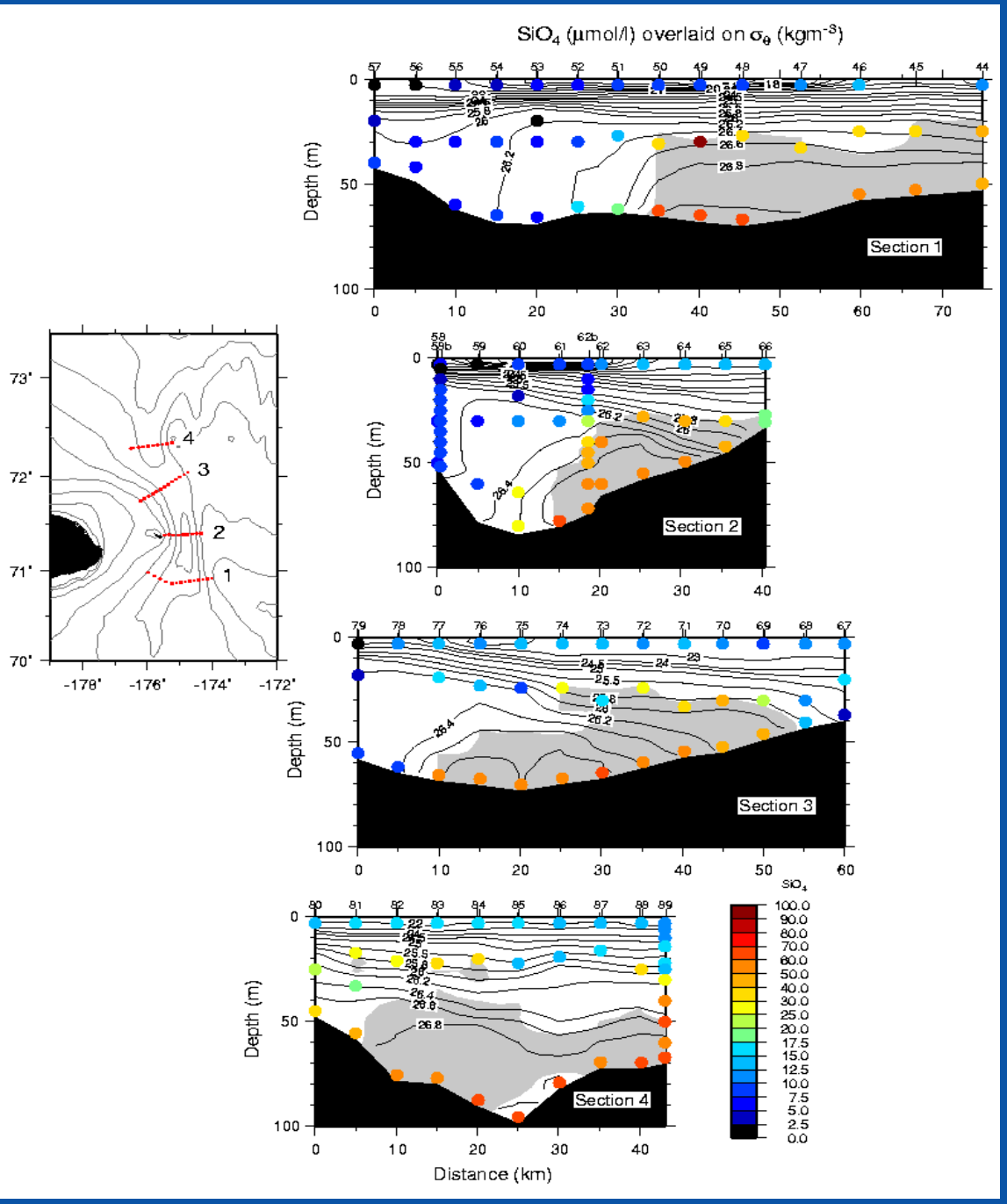
Central Herald Canyon



Evolution of dense water through the canyon

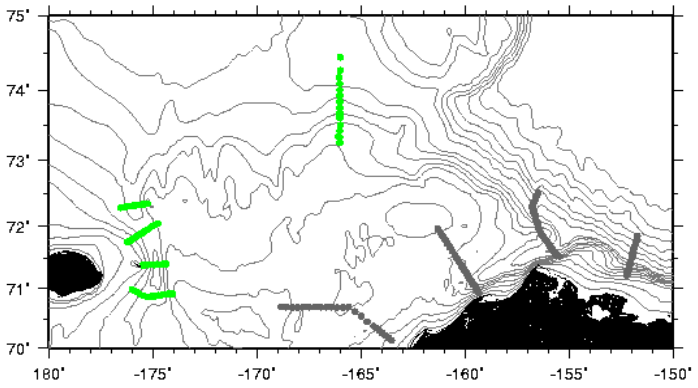


Evolution of dense water through the canyon



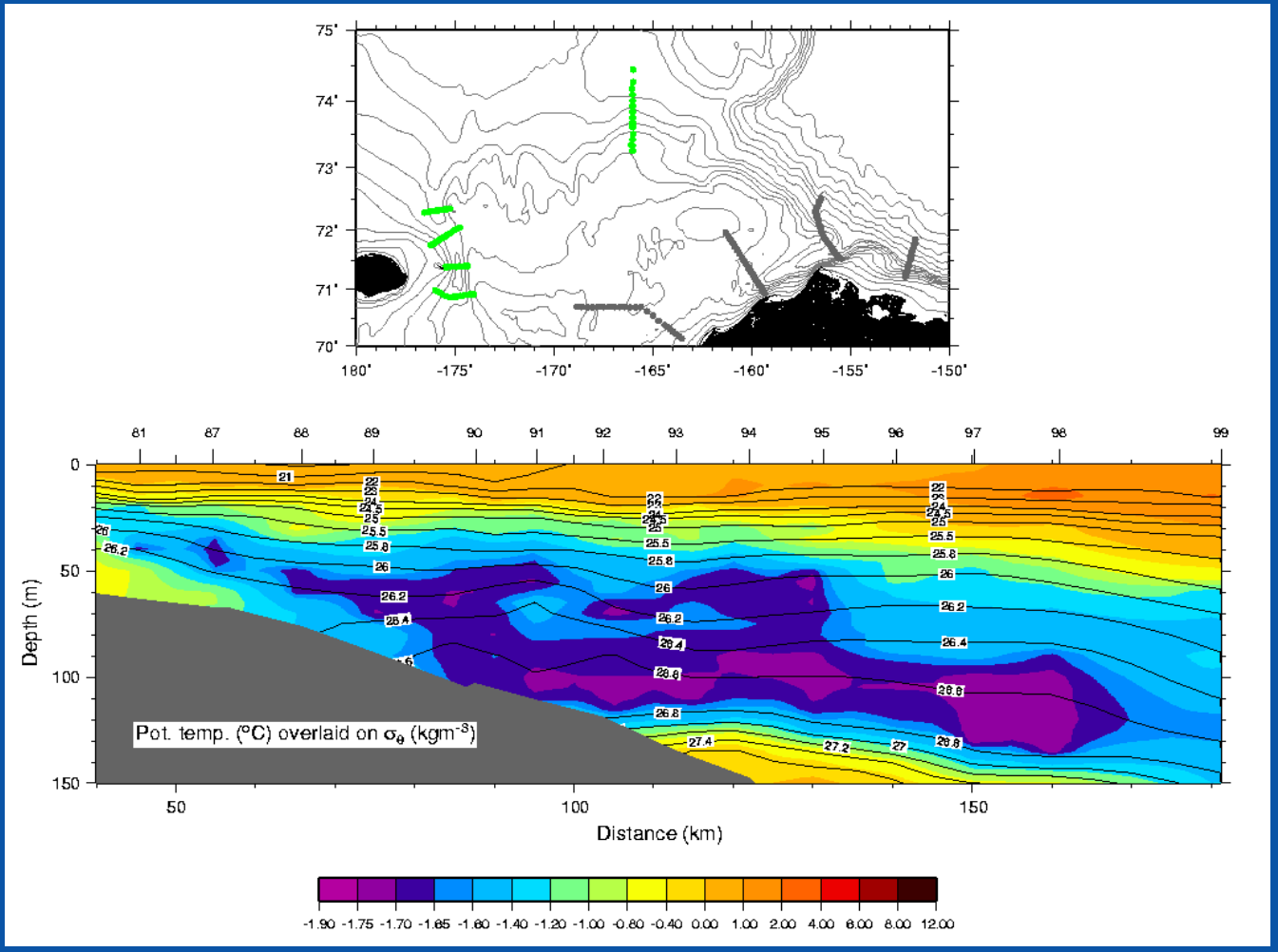
Far field

RUSALCA + SBI September 2004 survey



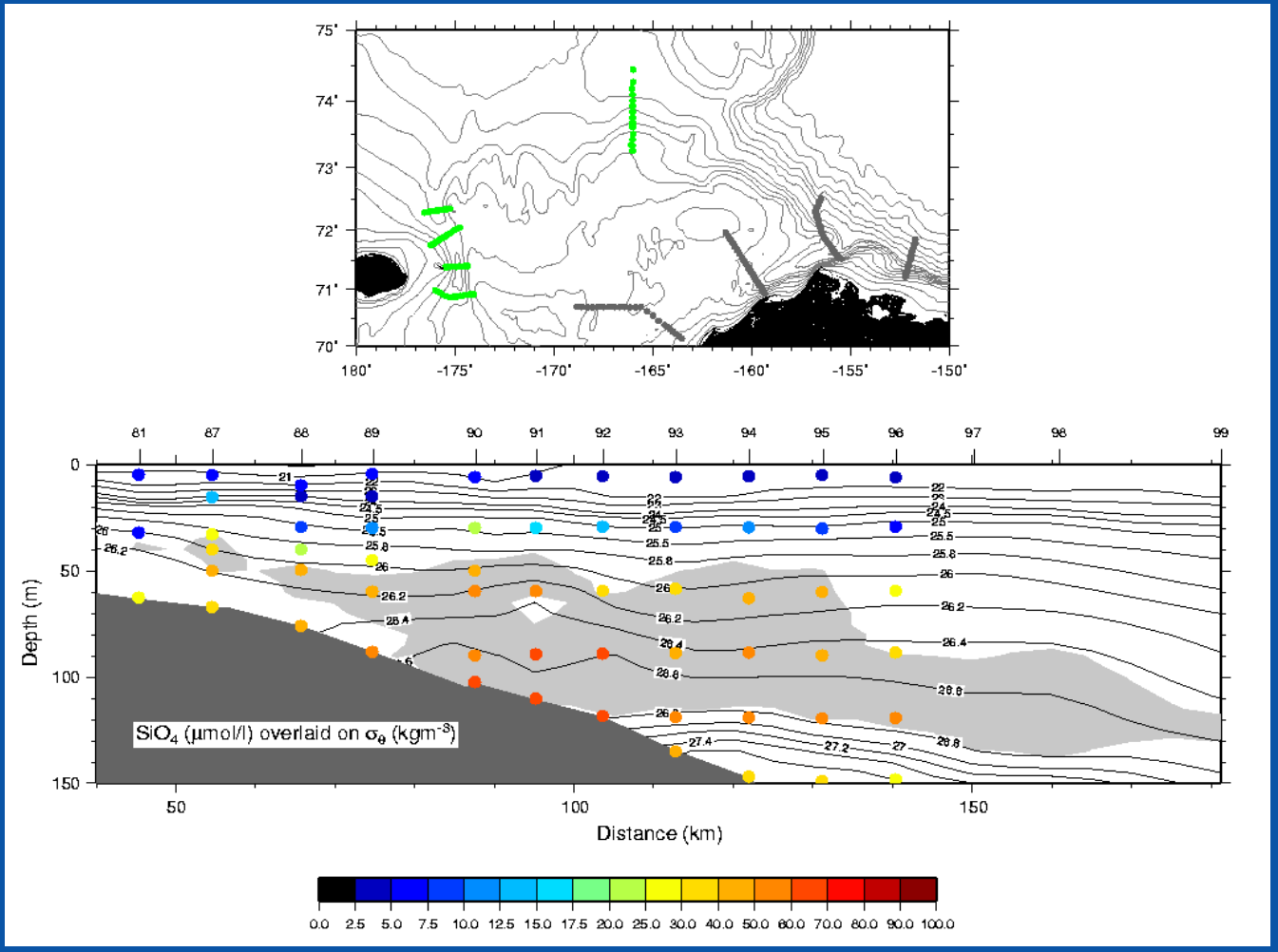
Far field

RUSALCA + SBI September 2004 survey

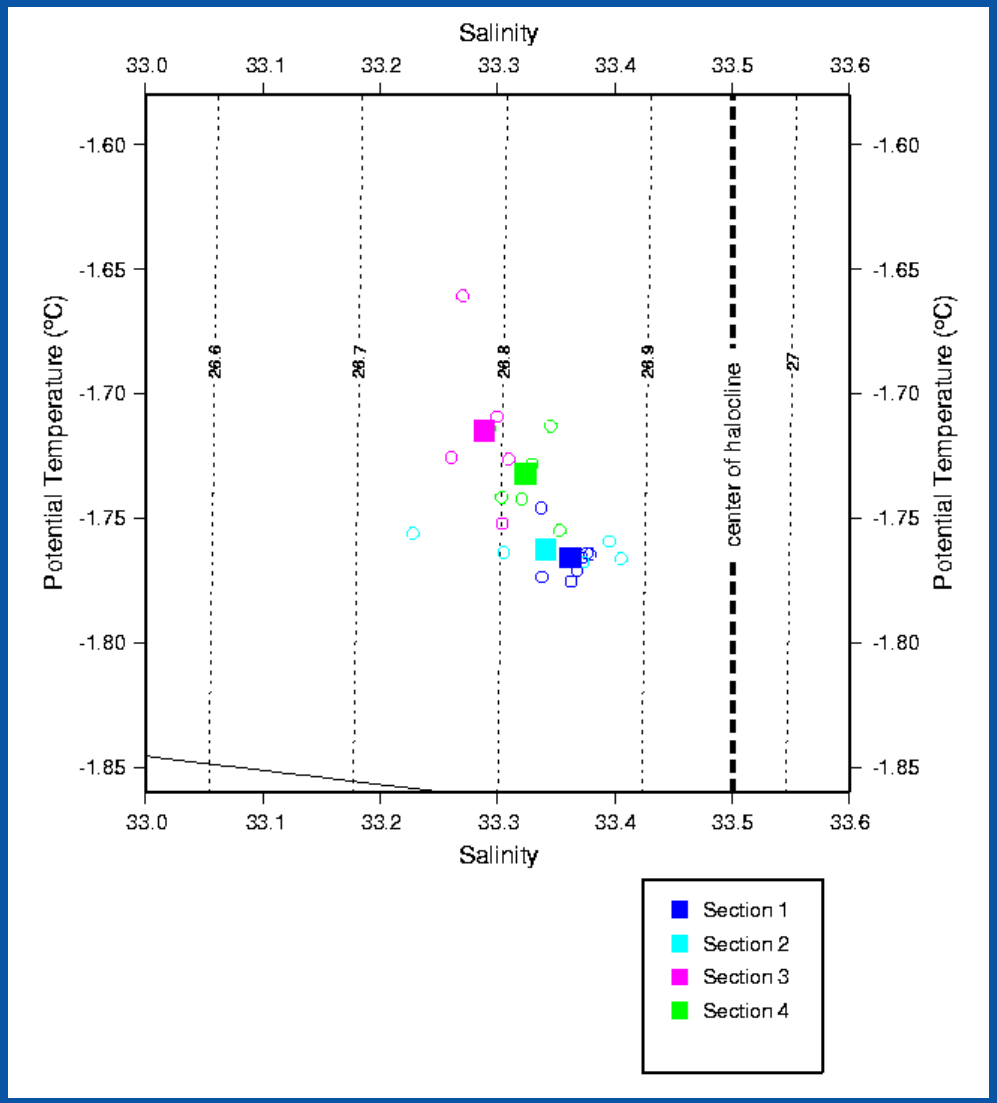


Far field

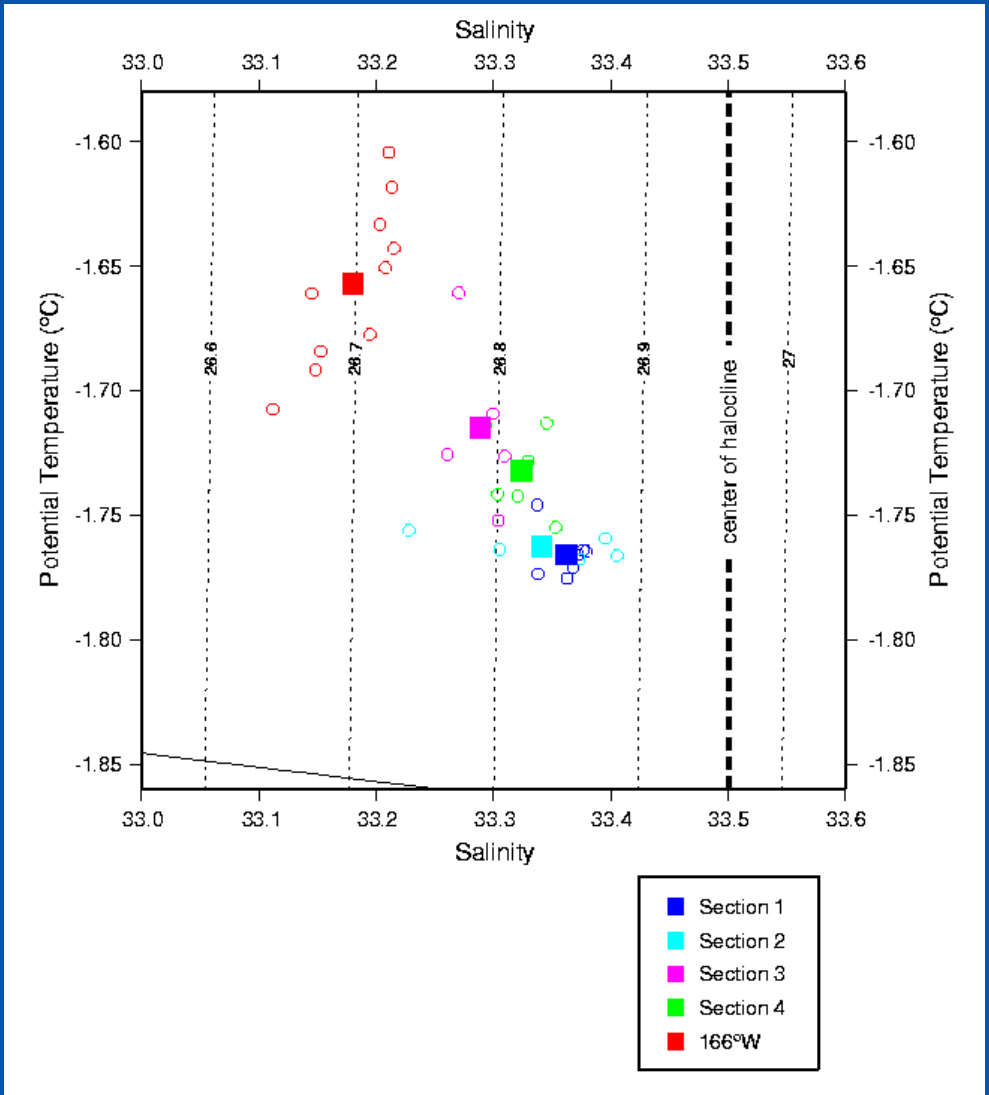
RUSALCA + SBI September 2004 survey



Evolution of dense overflow in T-S space



Evolution of dense overflow in T-S space



Conclusions

The 2004 RUSALCA survey of Herald Canyon showed that:

- **Strong jet of Bering summer water on east side, weaker flow of dense winter water on west side. [ESS source? Typical?]**
- **Dense water crossed to the other side before exiting to the shelfbreak. [Important because the water will heat east not west.]**
- **Hydraulic control looks to be active in the canyon [Lots of ramifications.]**
- **Far field evolution shows clearly that Herald Canyon is the source of Chukchi shelfbreak current. [Need to sort juxtaposition of summer and winter water in the jet.]**

Next Steps

- **Use velocity data to determine if there is a constraint on the outflow (hydraulics or geostrophic control).**
- **Relate such a constraint to historical hydrographic data to look for climate variability.**
- **Investigate polynya activity in the ESS and formation of dense water reservoir.**
- **Useful future measurements: Mooring timeseries of the Herald Canyon outflow as part of a Pacific-water network.**