

# **RUSALCA 2004 versus 2009: A comparison of hydrographic conditions**

*Robert S. Pickart (WHOI) and Terrence E. Whitledge (UAF)*

**Collaborators: Marshall Swartz (WHOI)  
Daniel Torres (WHOI)  
Elena Bondareva (AARI)  
Michael Kong (UAF)**

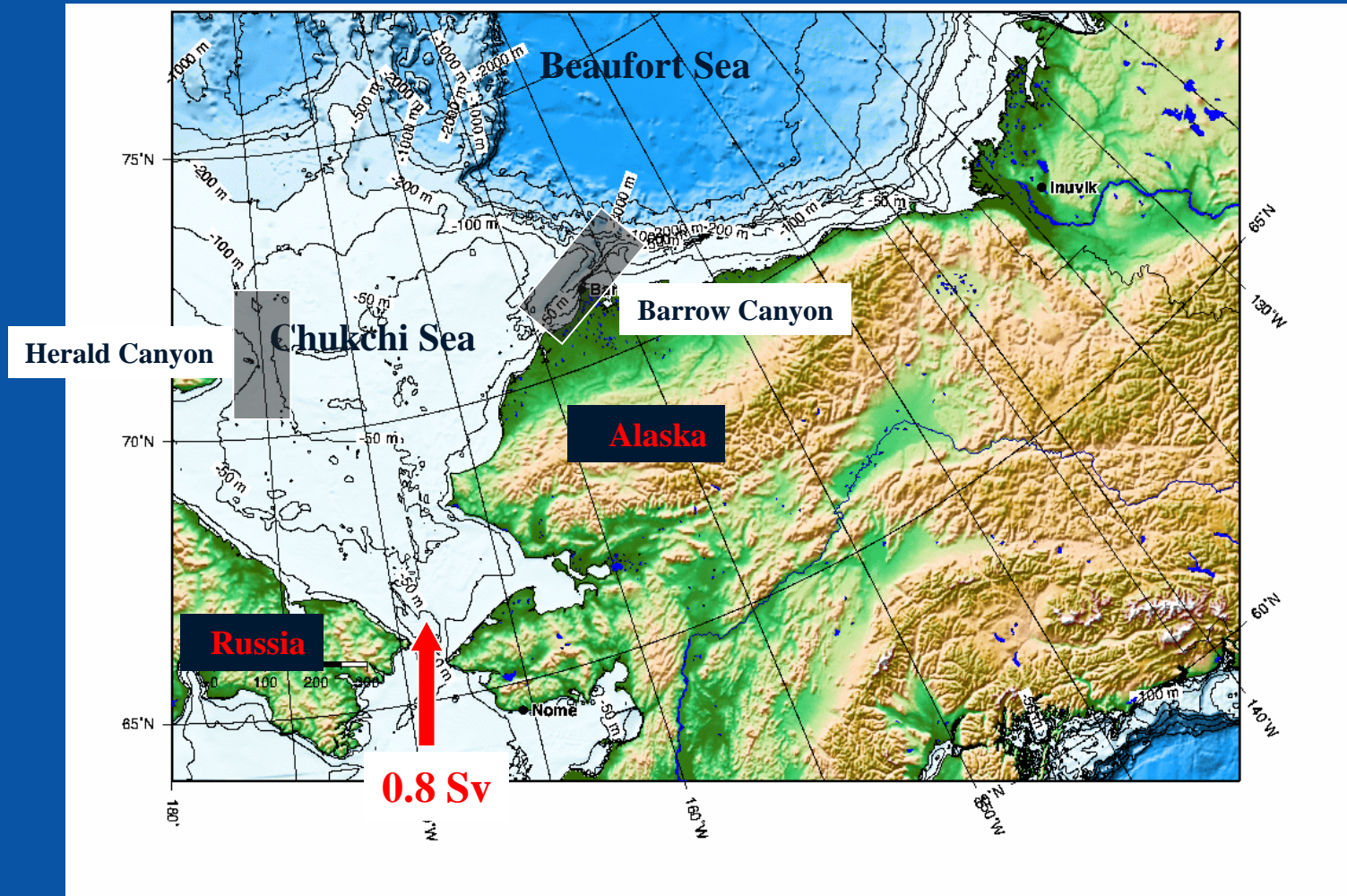
Professor Khromov  
Canada Basin, Sep 2009  
(Photo by D. Torres)

## **Outline**

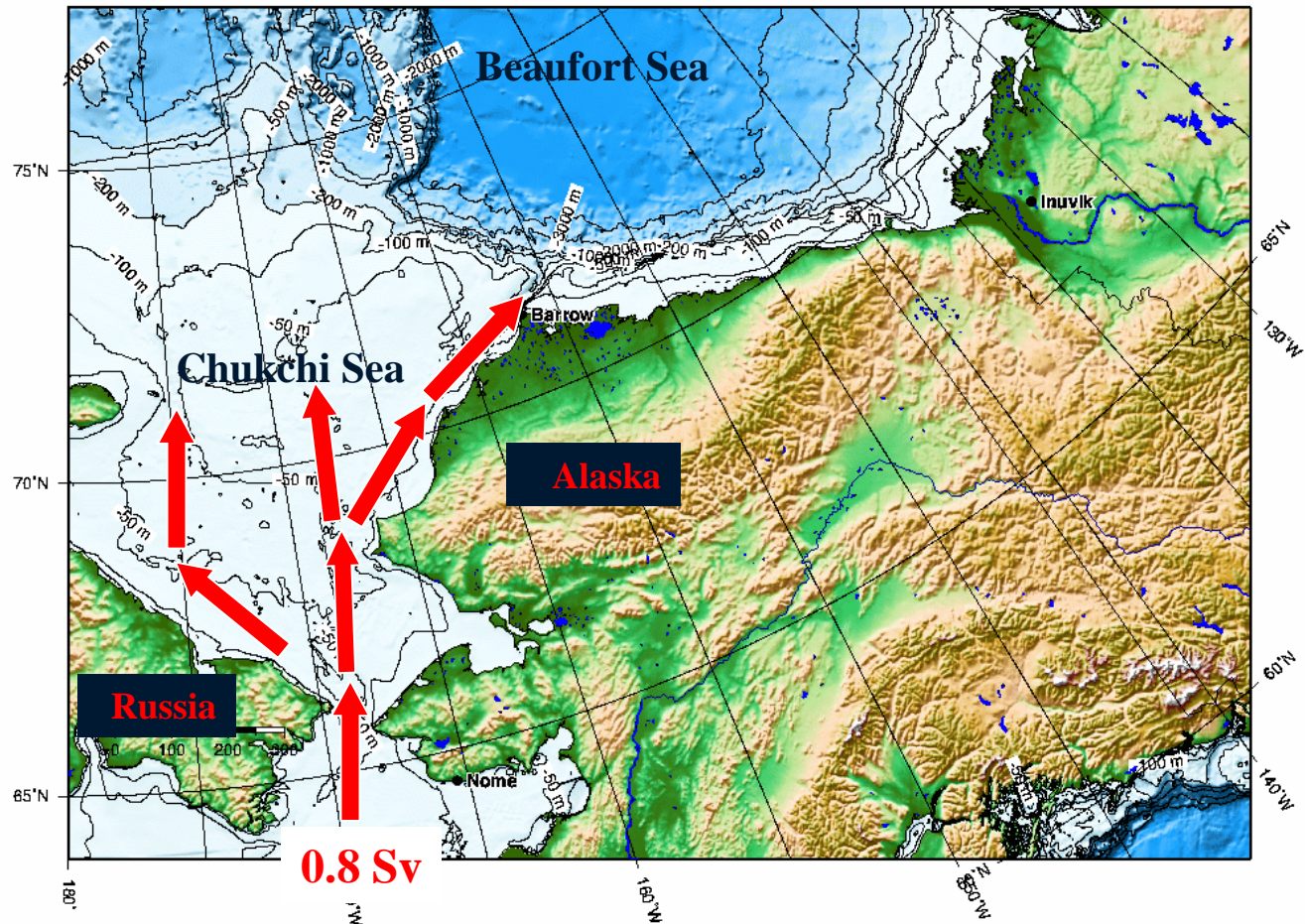
- 1. Review of Chukchi Sea circulation and RUSALCA 2004 hydrographic highlights.**
- 2. Expanded coverage in RUSALCA 2009: What did it tell us, and what was different from five years ago.**



# Pacific water inflow

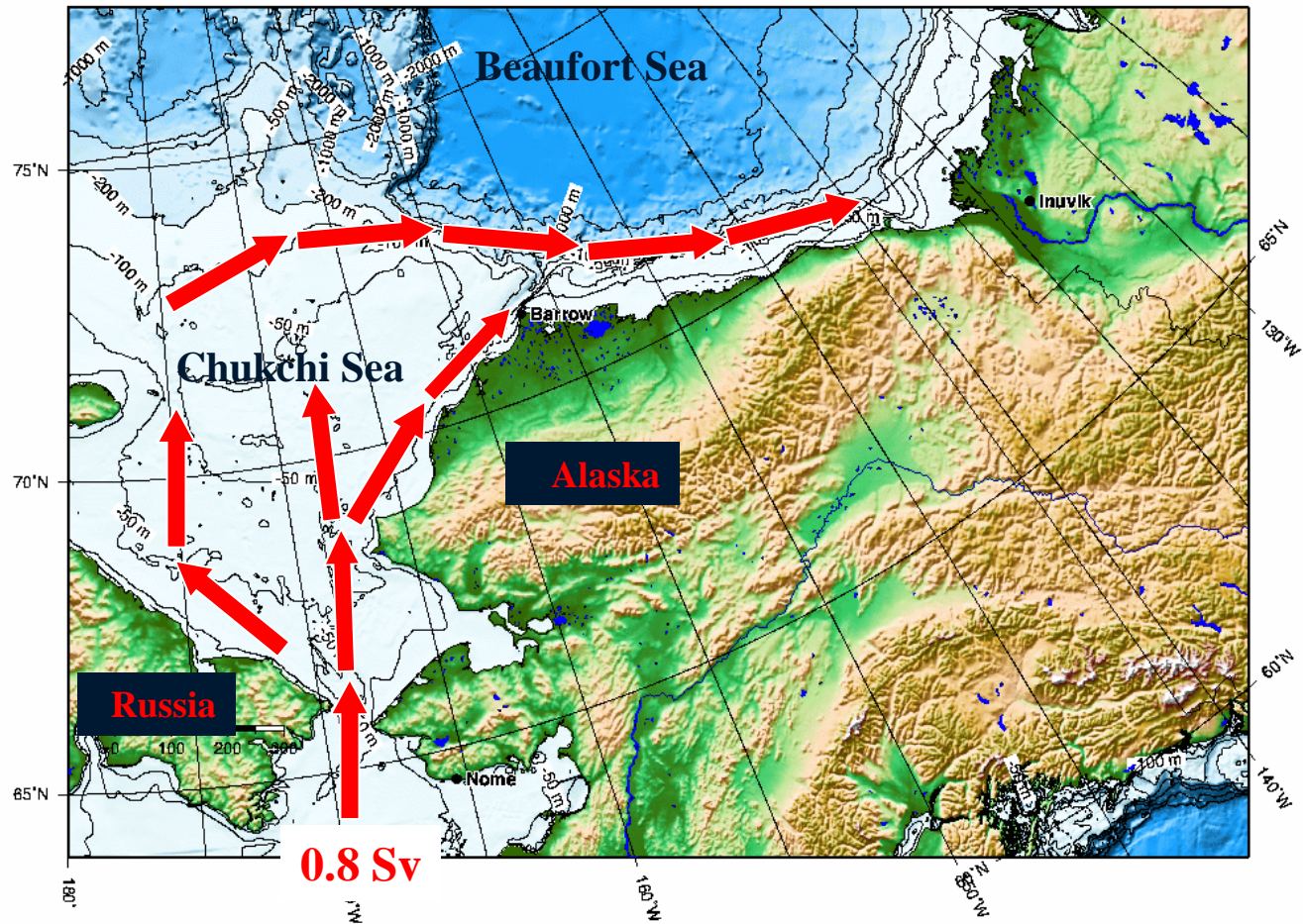


# Pacific water inflow

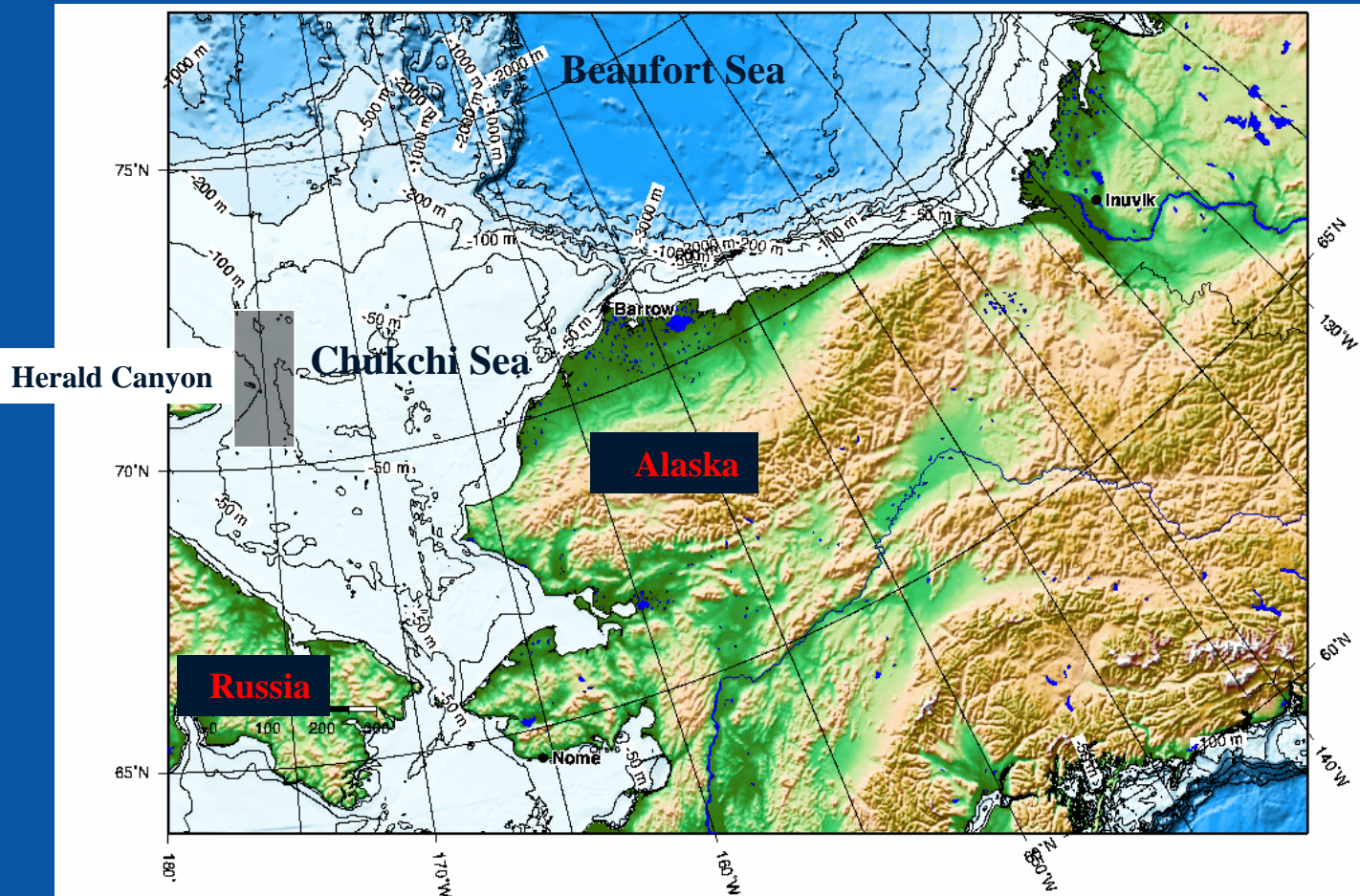




# Pacific water inflow



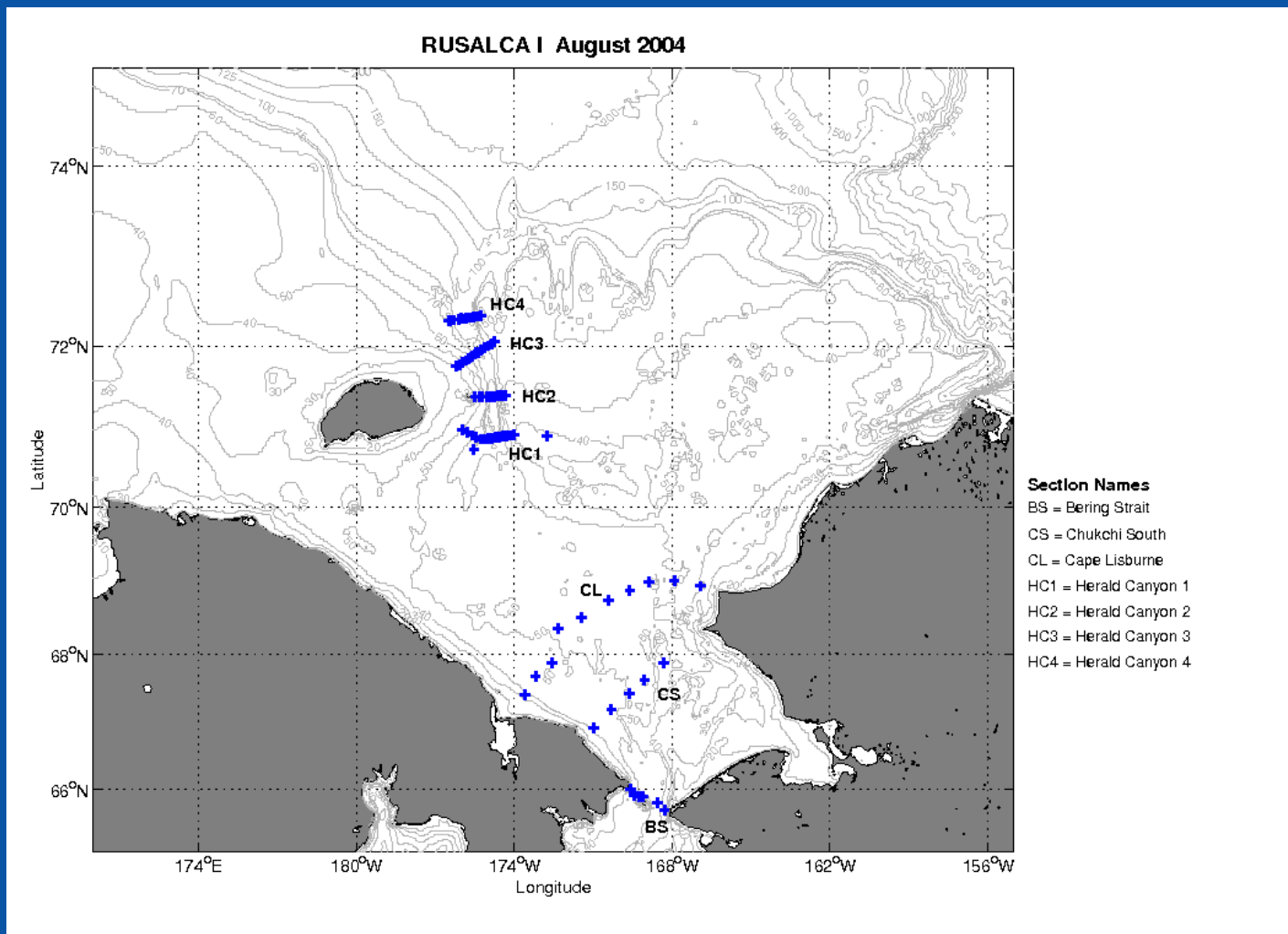
# Herald Canyon





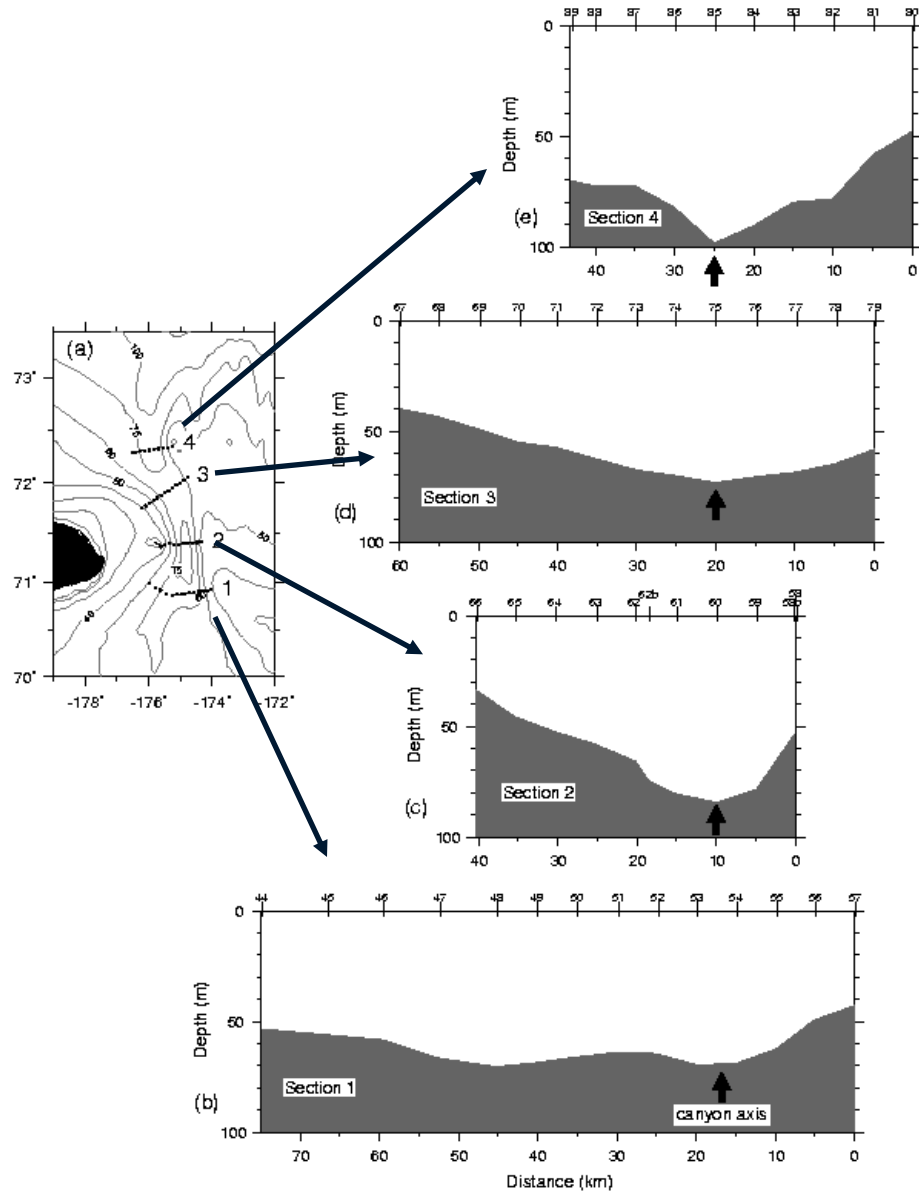


# CTD Survey 2004





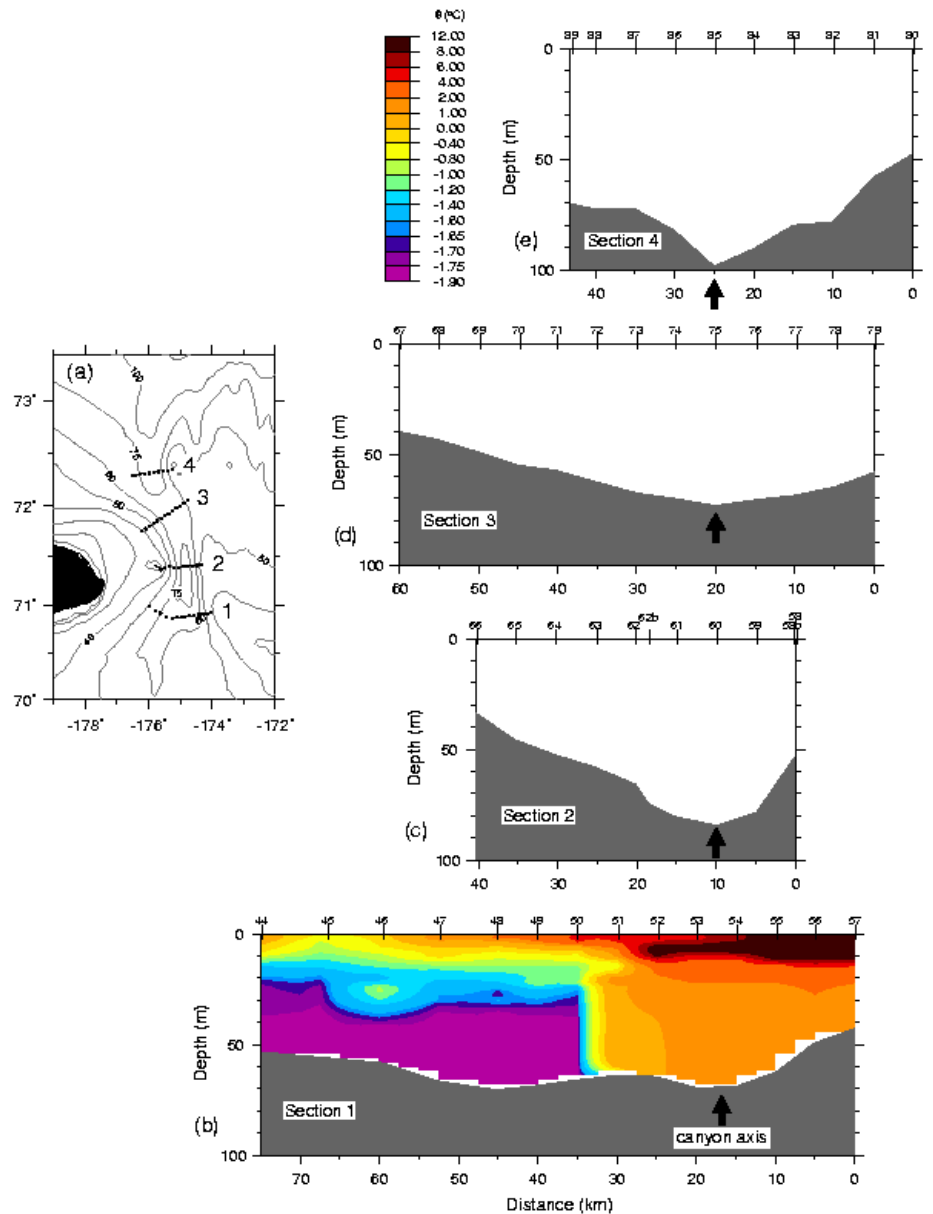
# Evolution of flow through Herald Canyon





# Evolution of flow through Herald Canyon

Potential temperature ( $^{\circ}\text{C}$ , color)

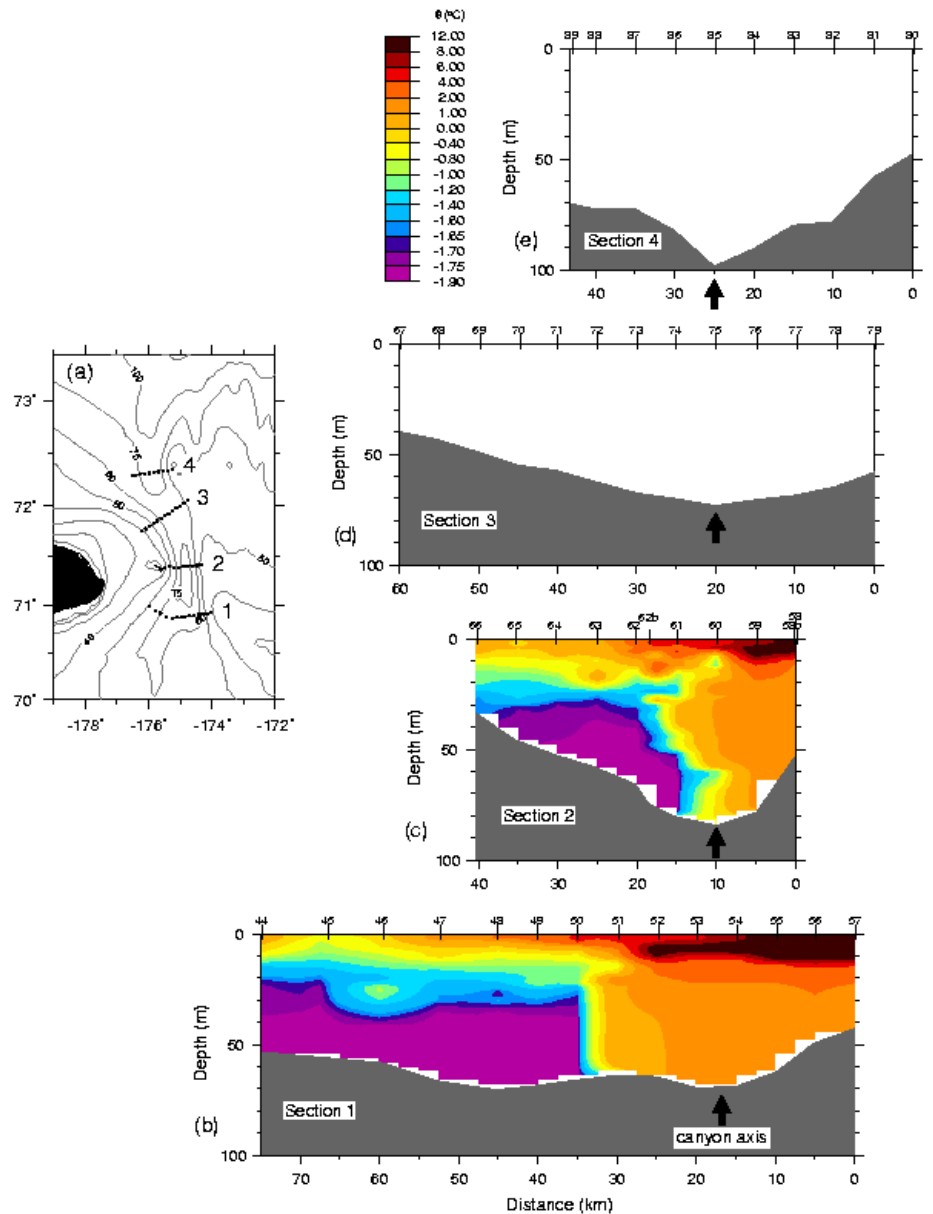






# Evolution of flow through Herald Canyon

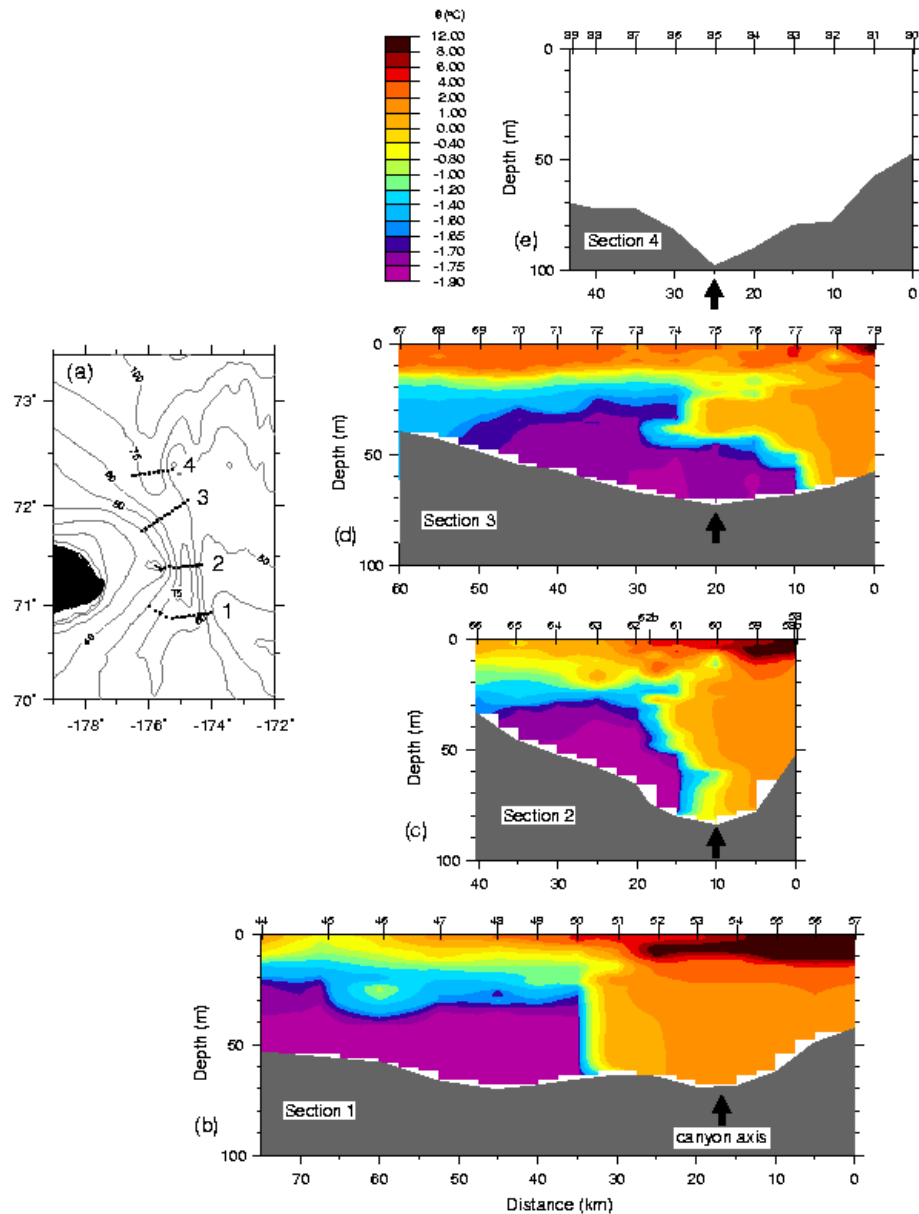
Potential temperature ( $^{\circ}\text{C}$ , color)





# Evolution of flow through Herald Canyon

Potential temperature ( $^{\circ}\text{C}$ , color)

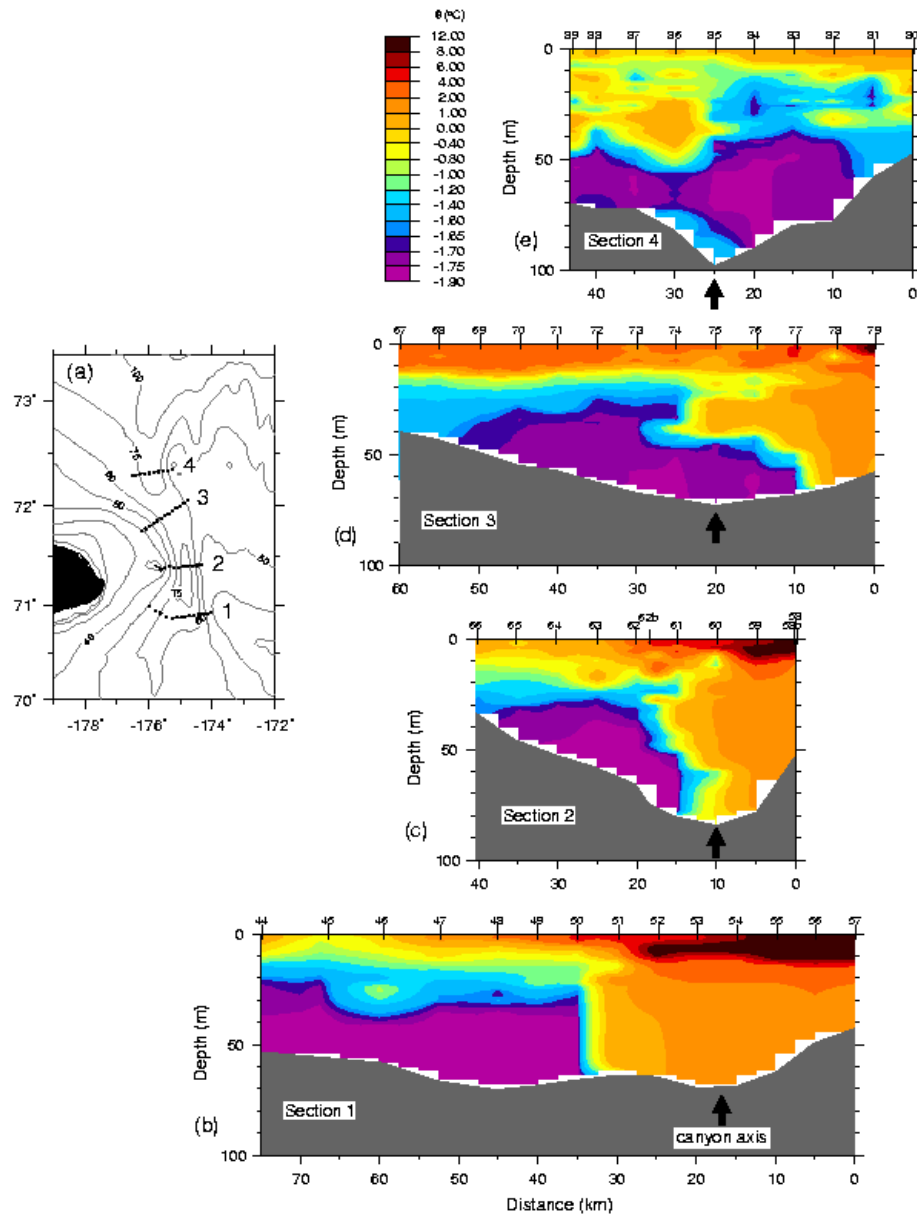






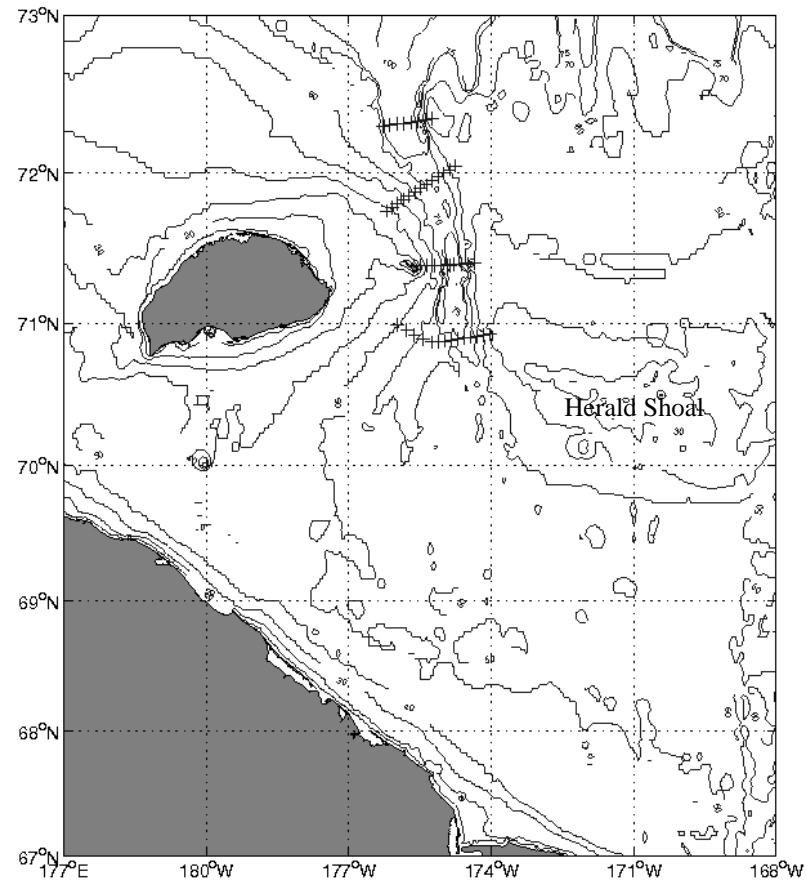
# Evolution of flow through Herald Canyon

Potential temperature ( $^{\circ}\text{C}$ , color)





# Evolution of flow through Herald Canyon



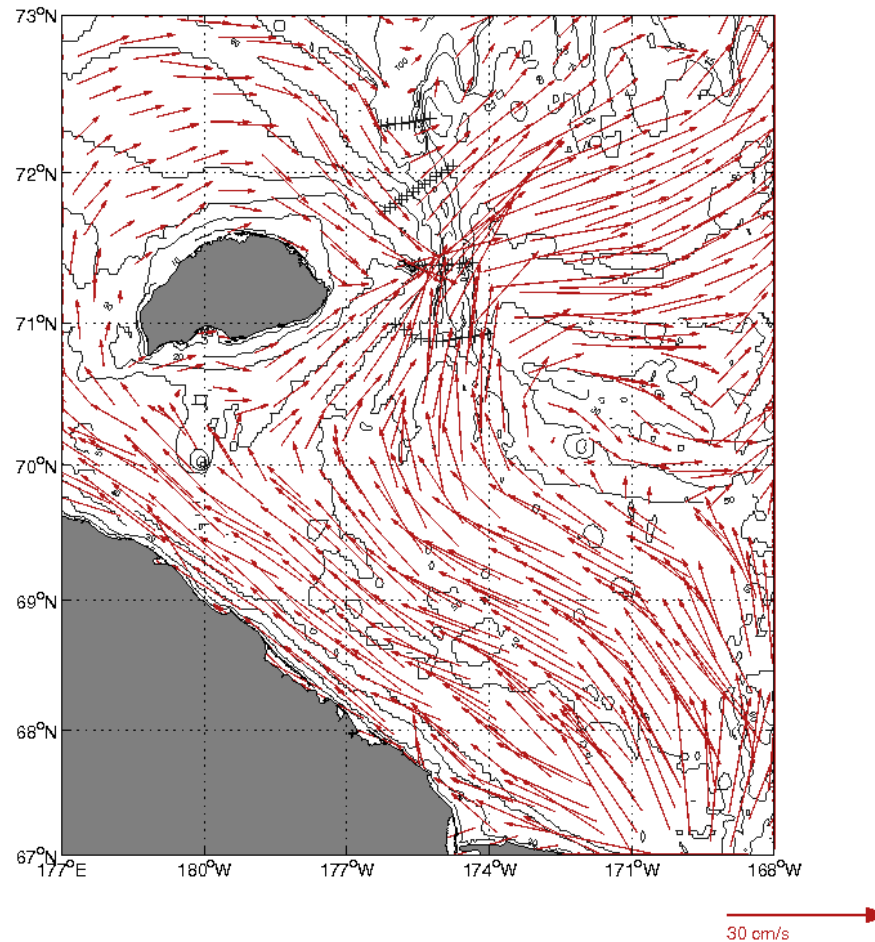




## Depth-averaged flow vectors from Proshutinsky model

# Evolution of flow through Herald Canyon

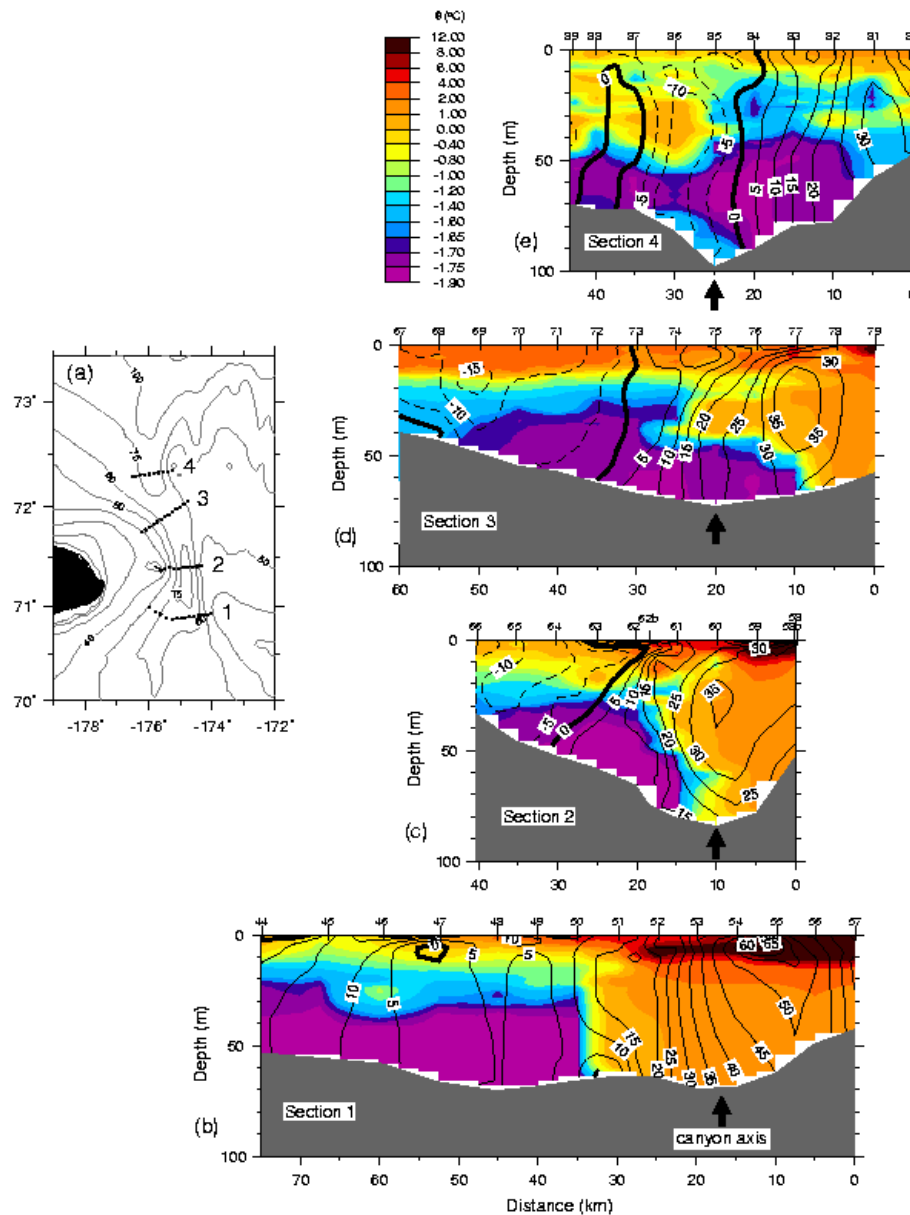
Averaged for the week-long  
period prior to the 2004  
Herald Canyon survey





# Evolution of flow through Herald Canyon

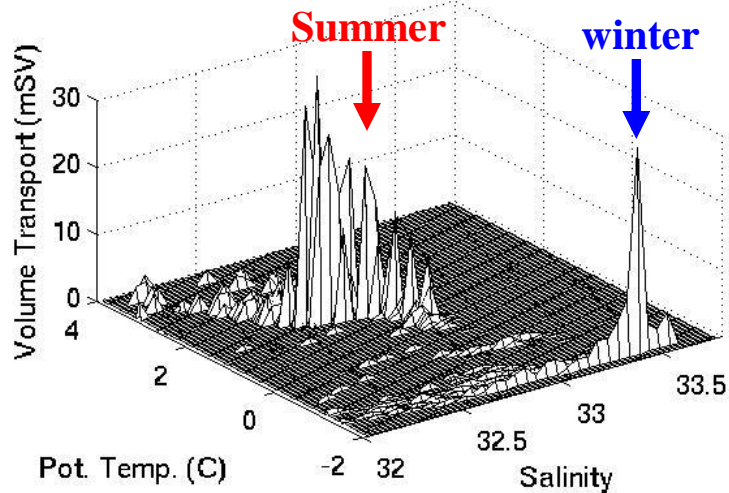
Potential temperature ( $^{\circ}\text{C}$ , color) overlain by  
Absolute Geostrophic Velocity (cm/s, contours)



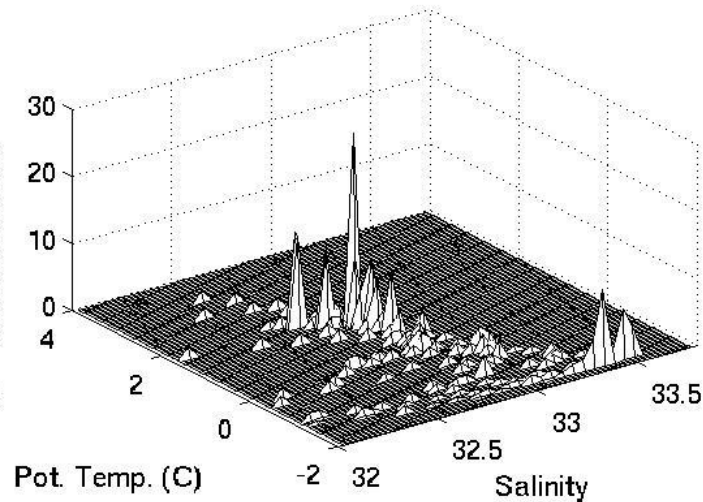


# Evolution in Northward Transport

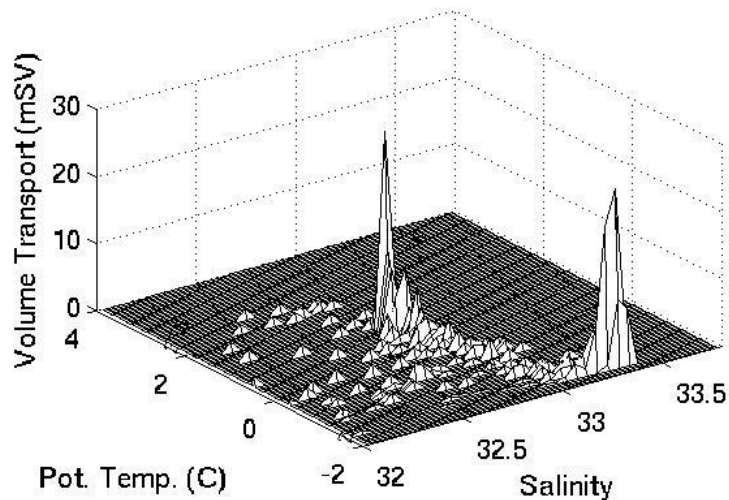
(a) Section 1



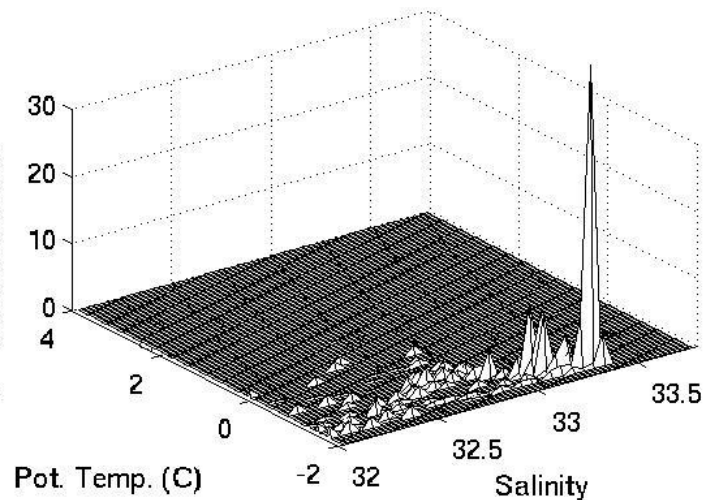
(b) Section 2



(c) Section 3

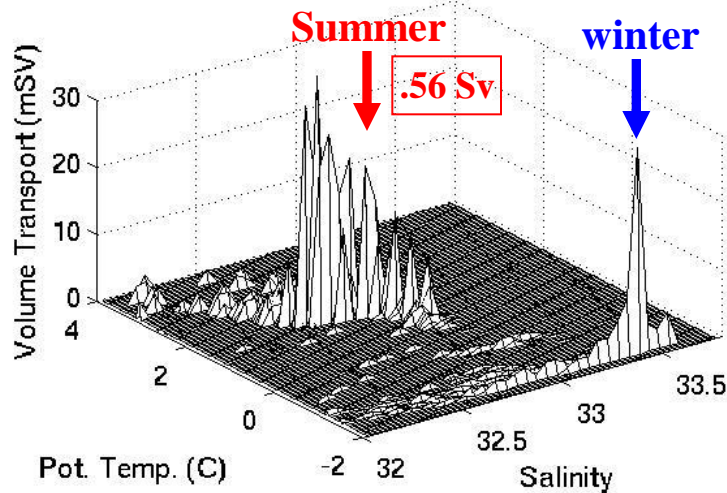


(d) Section 4

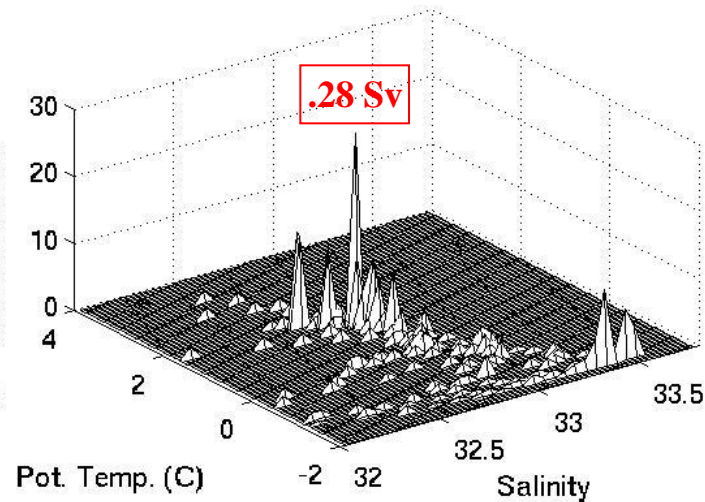


# Evolution in Northward Transport

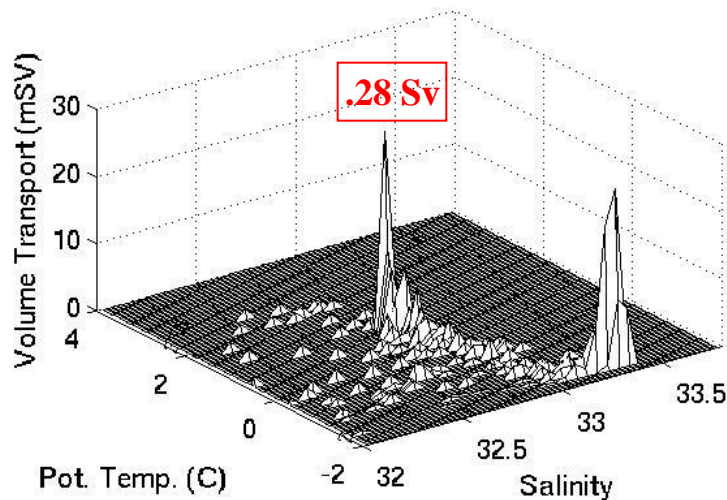
(a) Section 1



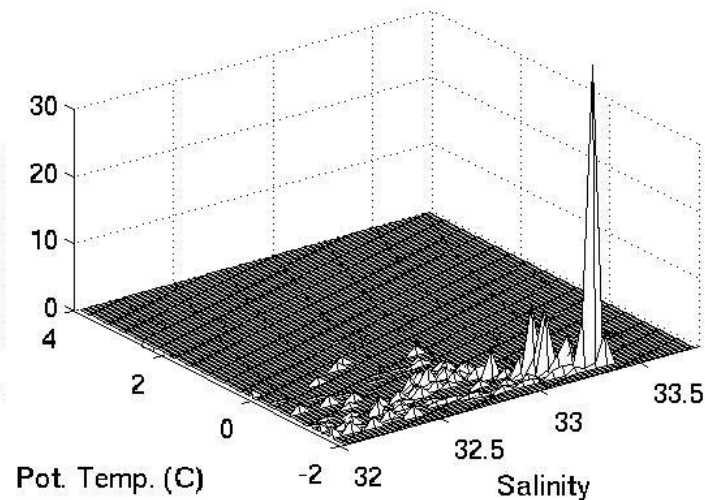
(b) Section 2



(c) Section 3



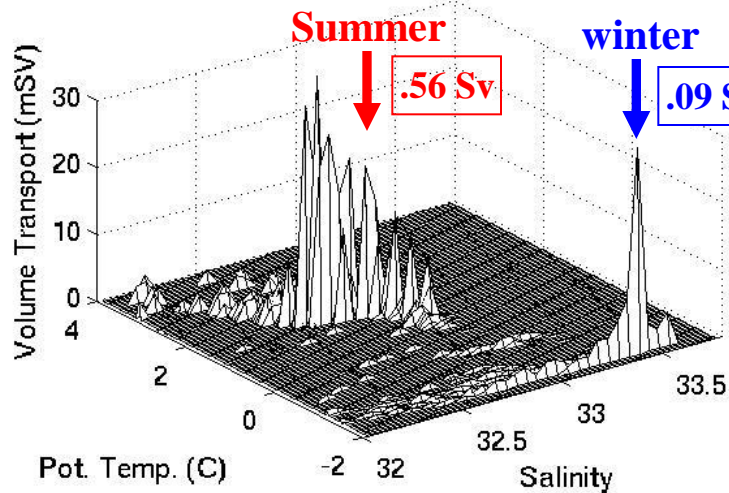
(d) Section 4



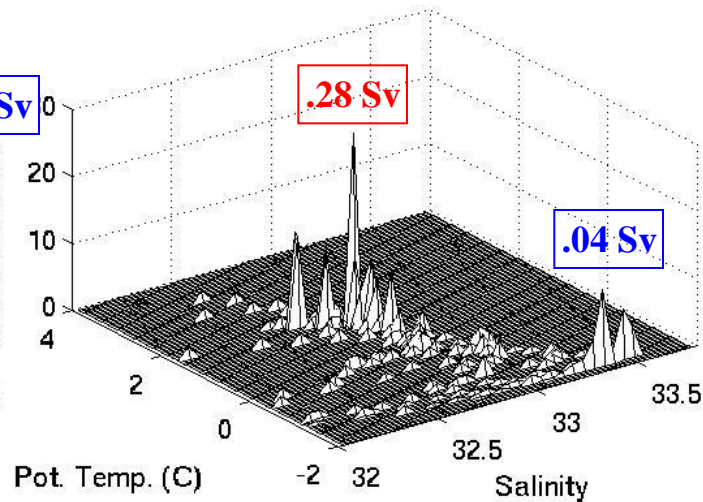


# Evolution in Northward Transport

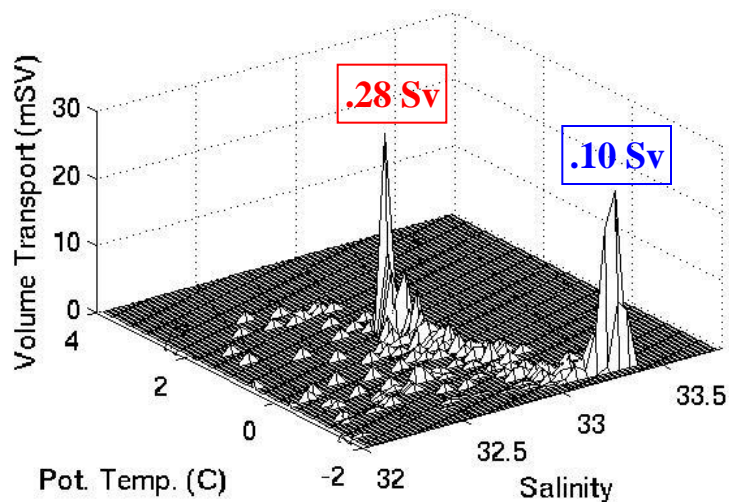
(a) Section 1



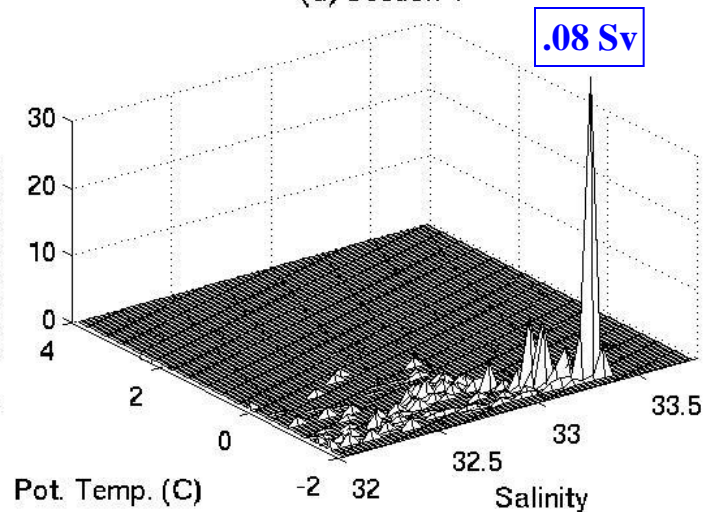
(b) Section 2



(c) Section 3



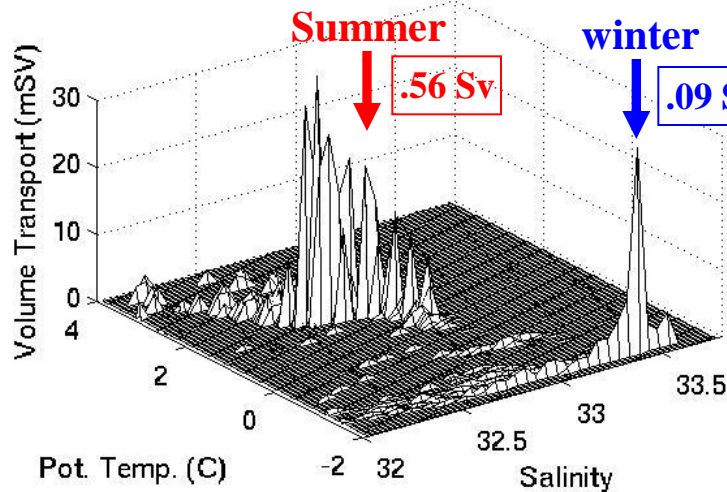
(d) Section 4



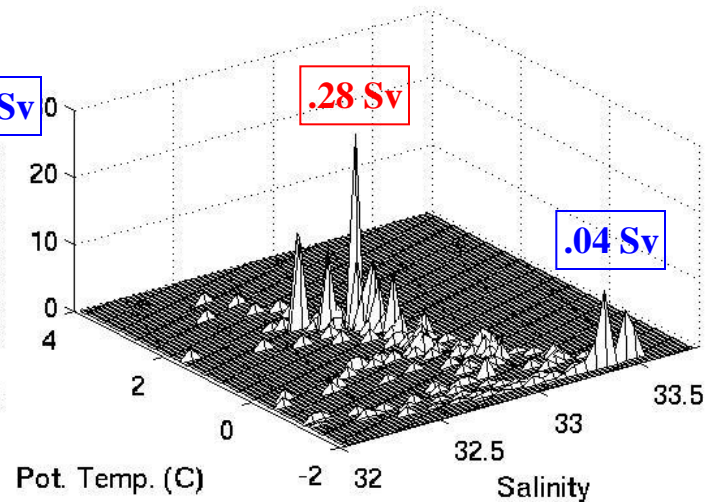


# Evolution in Northward Transport

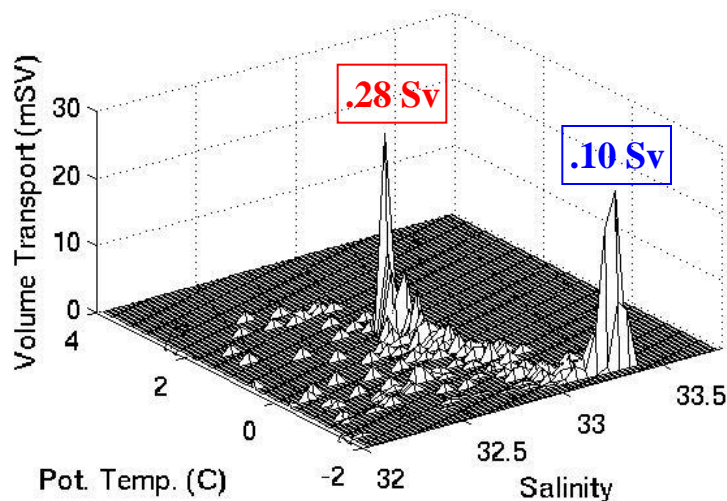
(a) Section 1



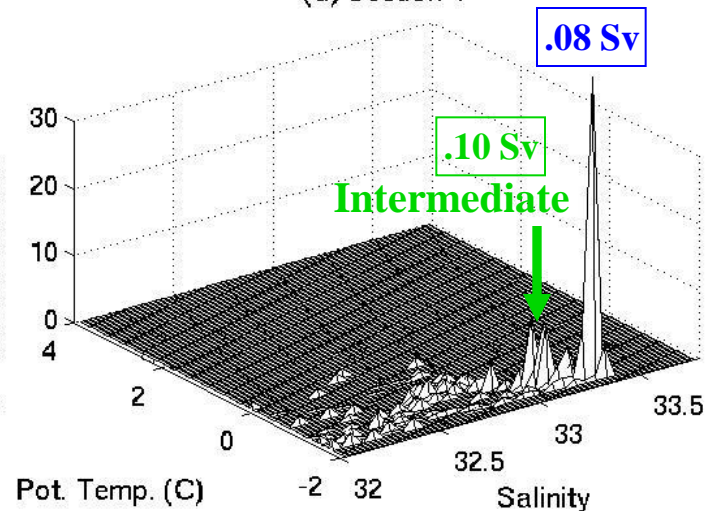
(b) Section 2



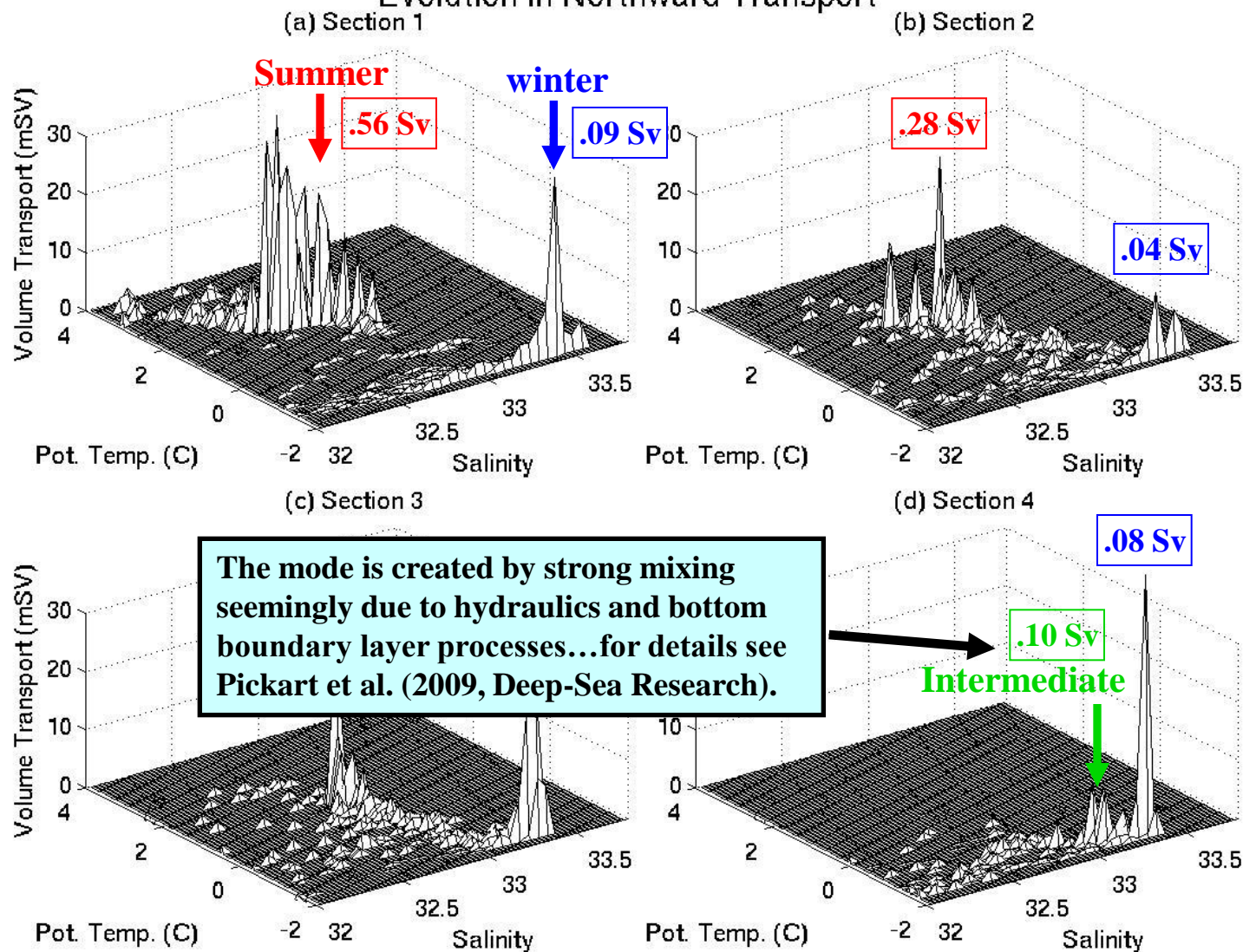
(c) Section 3



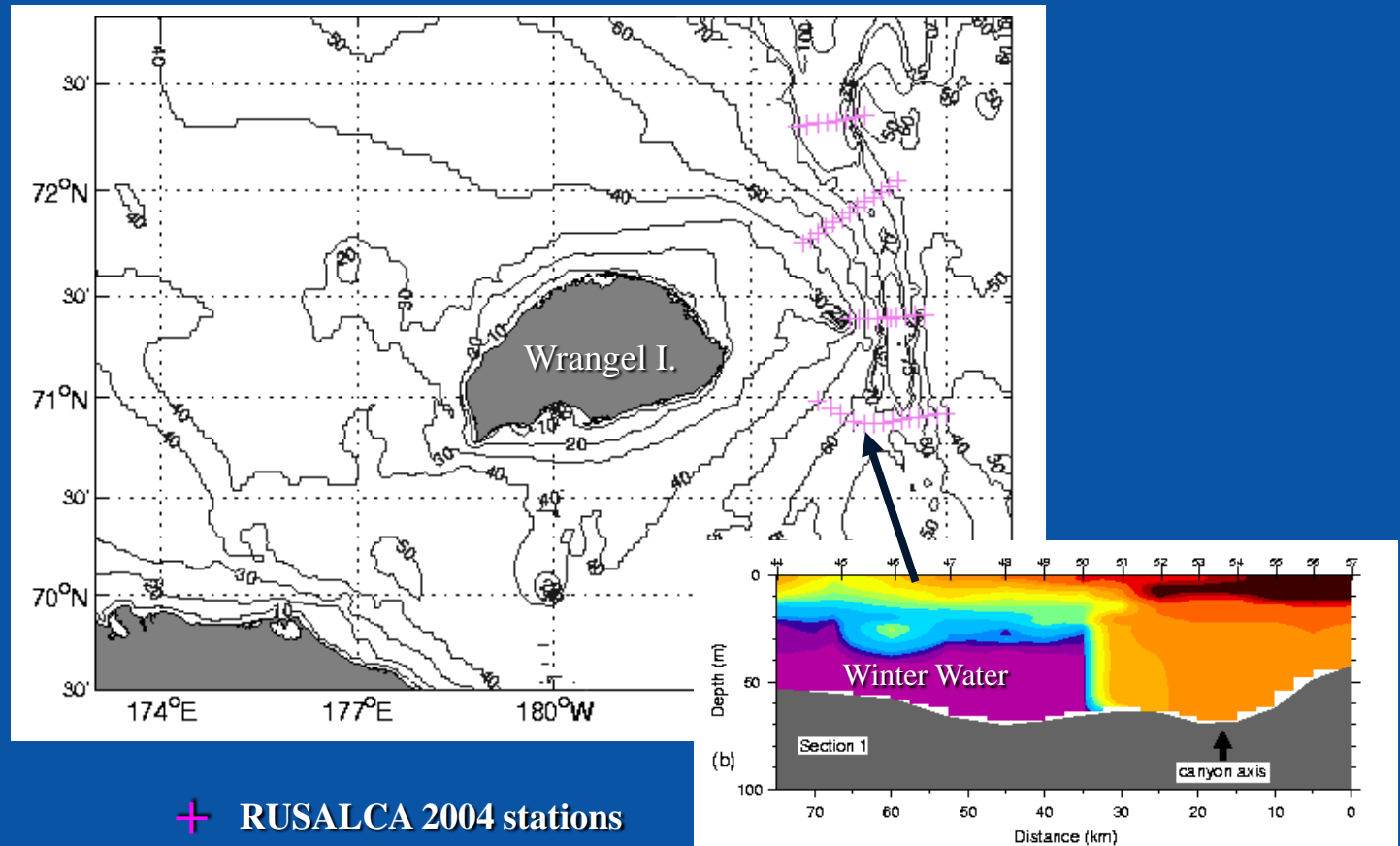
(d) Section 4



## Evolution in Northward Transport

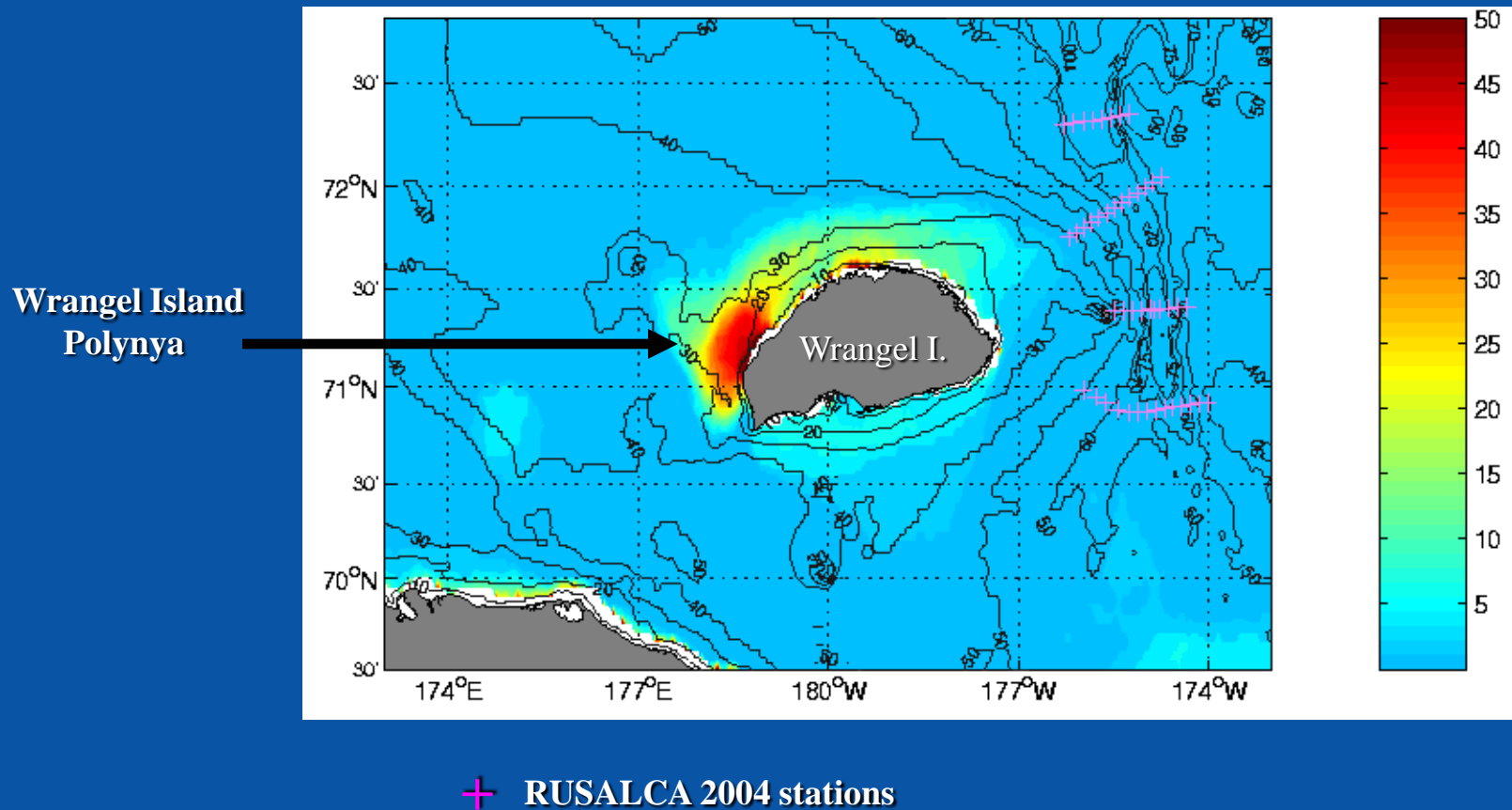


# Origin of the winter water



# Wrangel Island Polynya

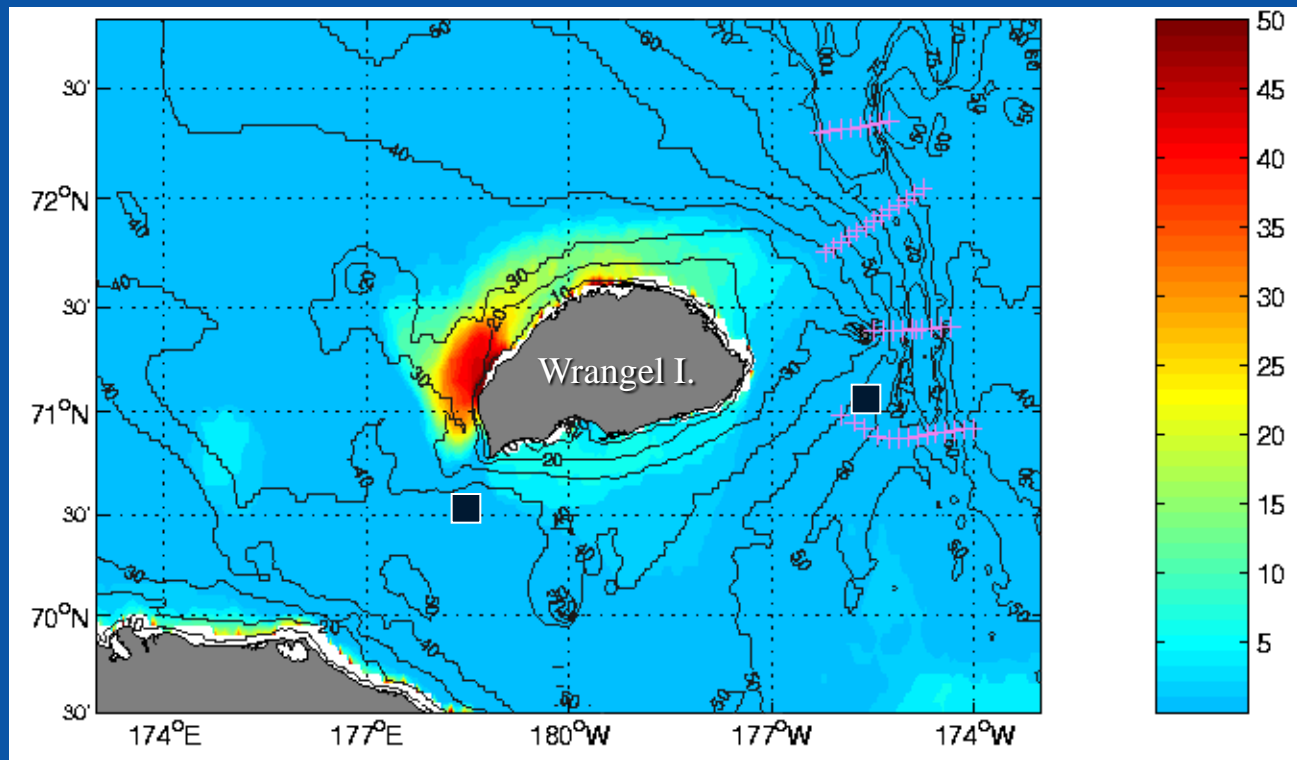
Number of days that polynya was present, winter 2003-4 (from AMSR-E)





# How does the winter water feed the canyon?

Number of days that polynya was present, winter 2003-4 (from AMSR-E)

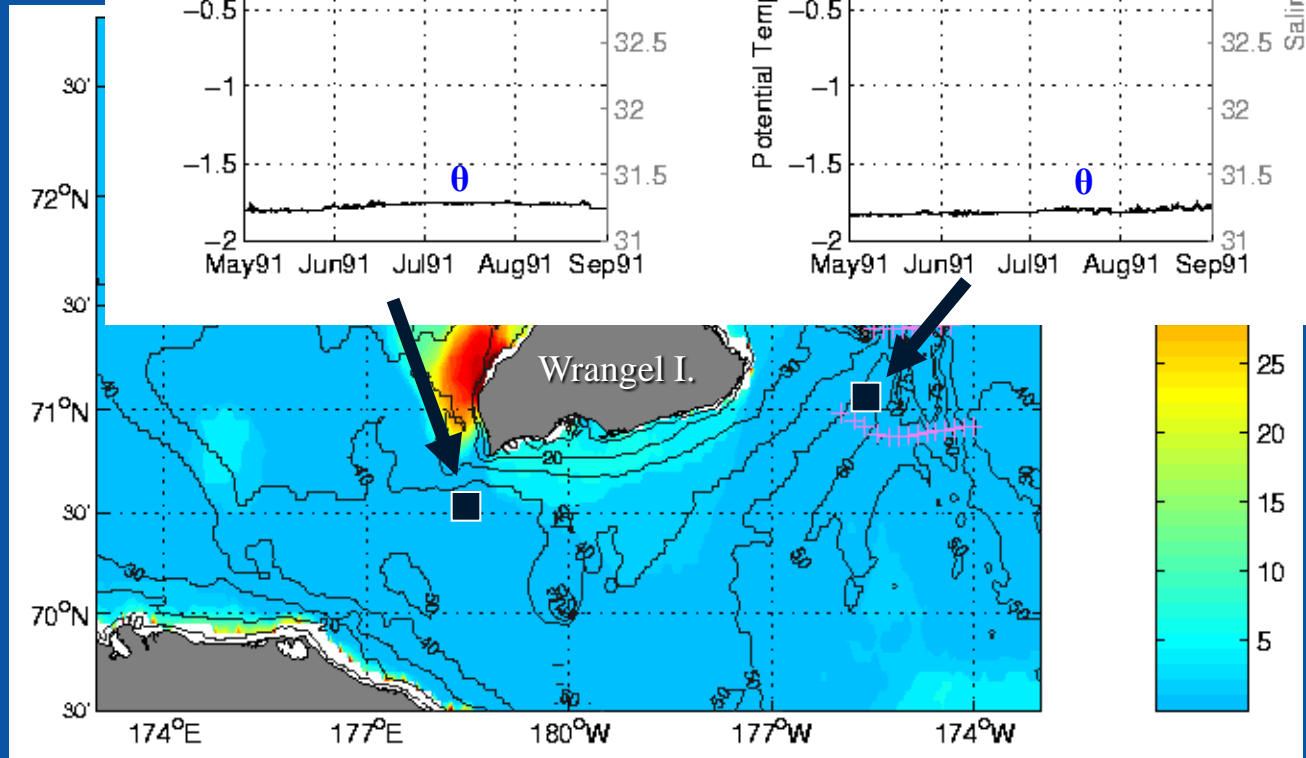


+ RUSALCA 2004 stations

■ Moorings 1990-1

# How do

Number

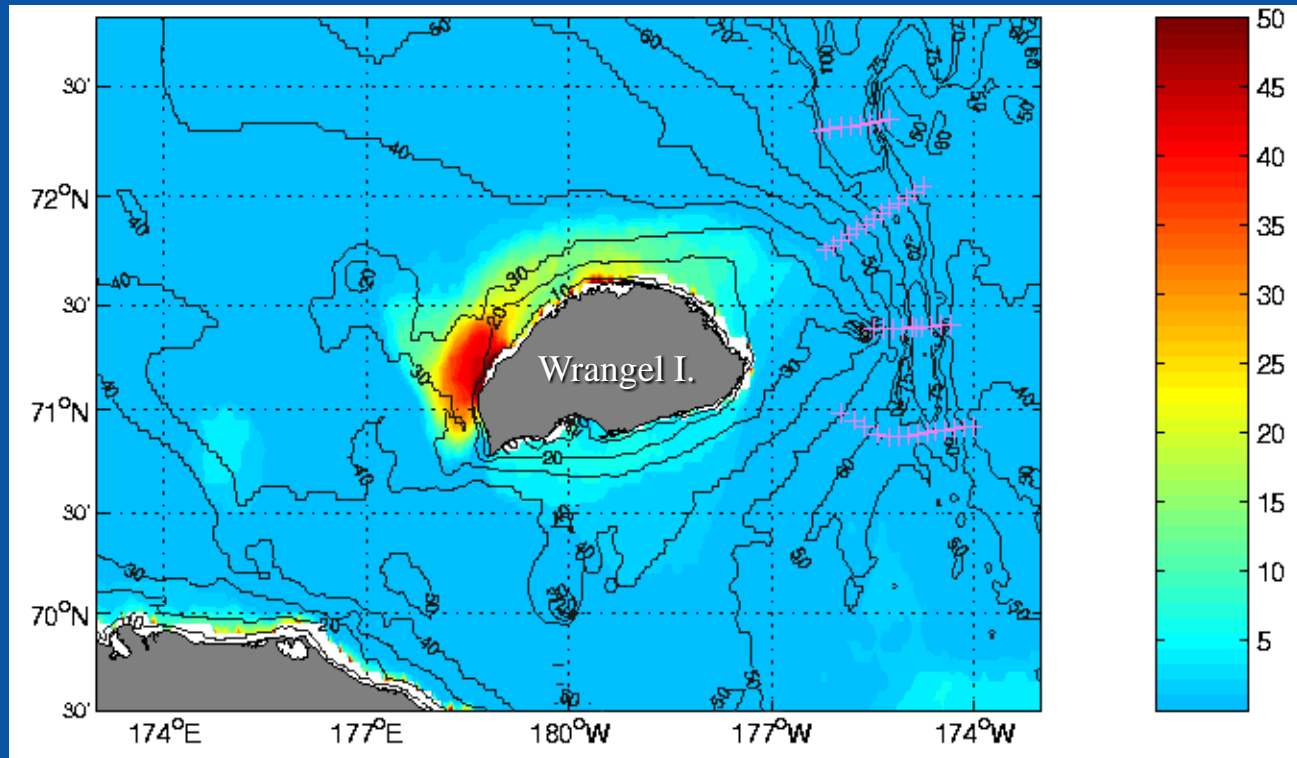


+ RUSALCA 2004 stations

■ Moorings 1990-1

# How does the winter water feed the canyon?

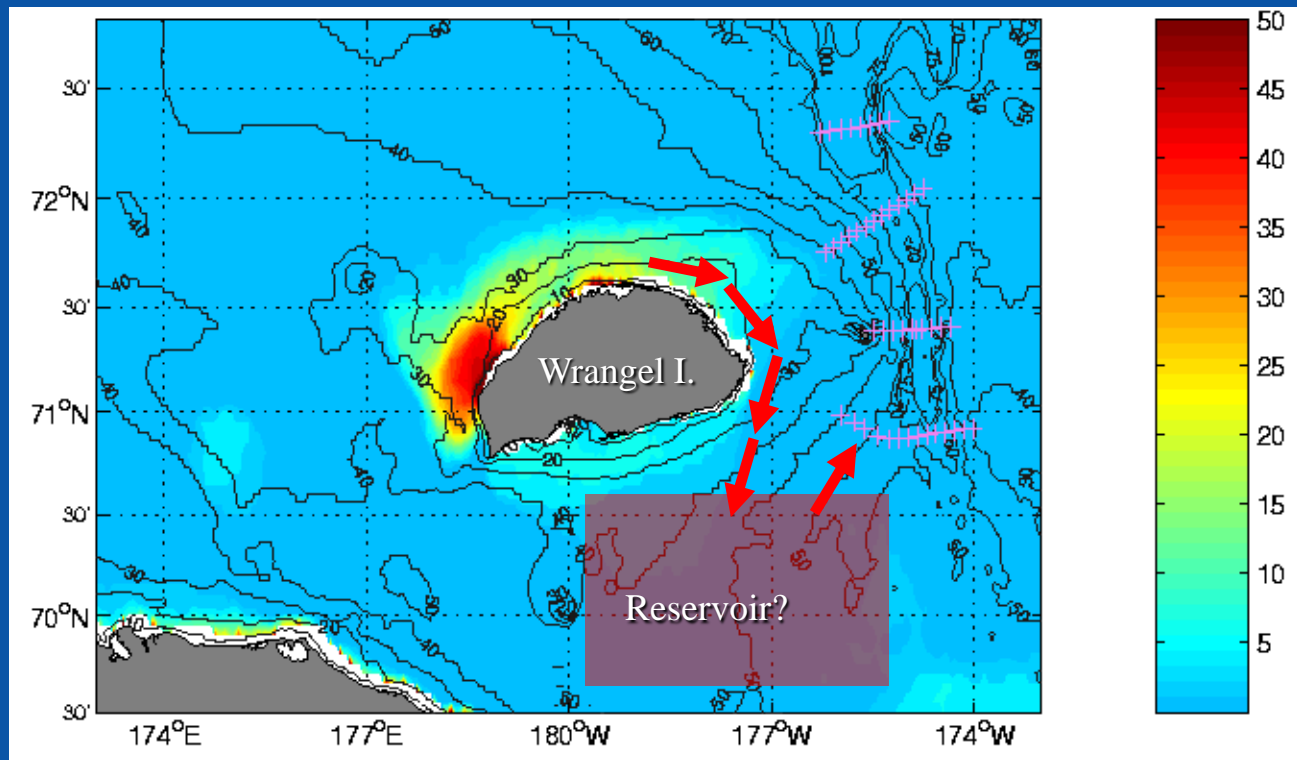
Number of days that polynya was present, winter 2003-4 (from AMSR-E)



+ RUSALCA 2004 stations

# How does the winter water feed the canyon?

Number of days that polynya was present, winter 2003-4 (from AMSR-E)

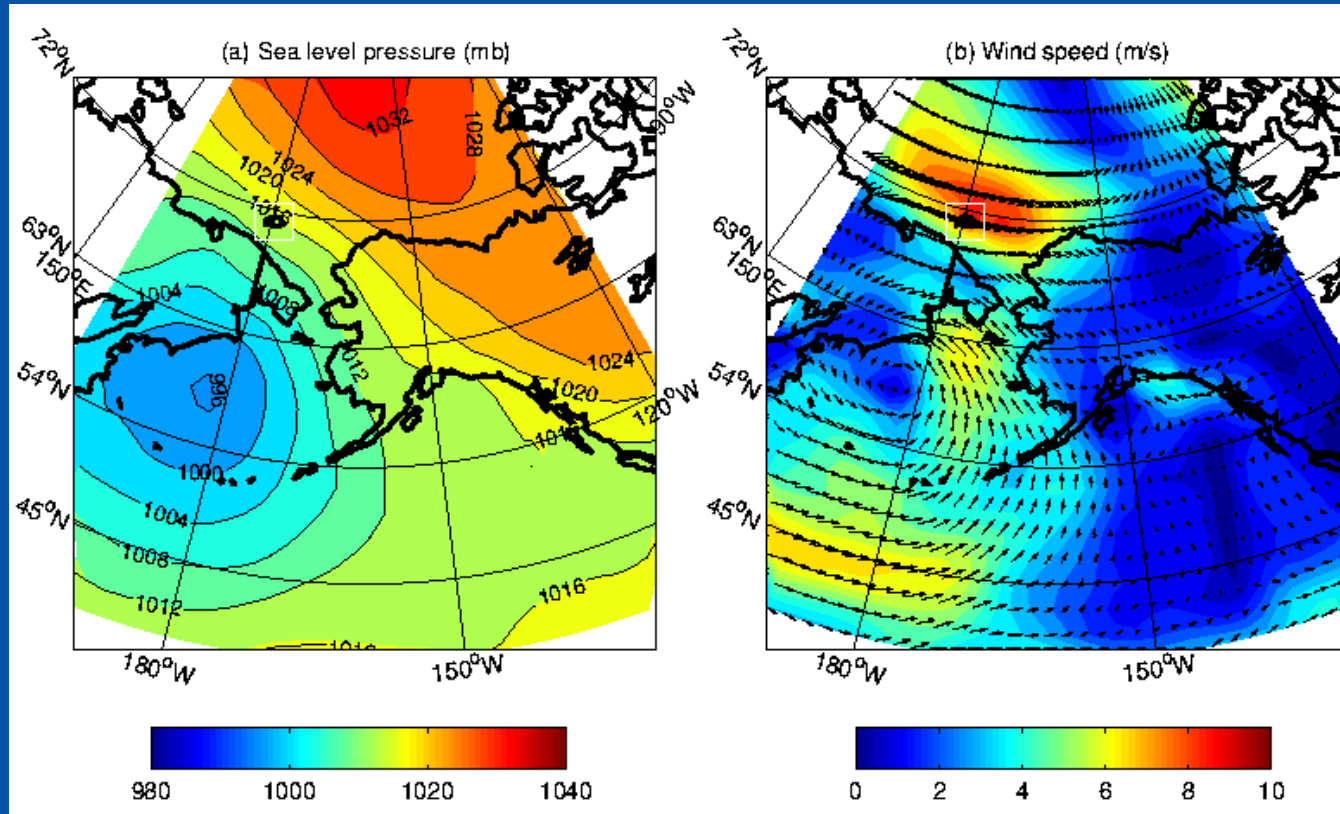


+ RUSALCA 2004 stations



# Meteorological conditions causing the polynya

Composite average from NCEP for the major Wrangel Island polynya events





## **Summary of 2004 RUSALCA Herald Canyon survey**

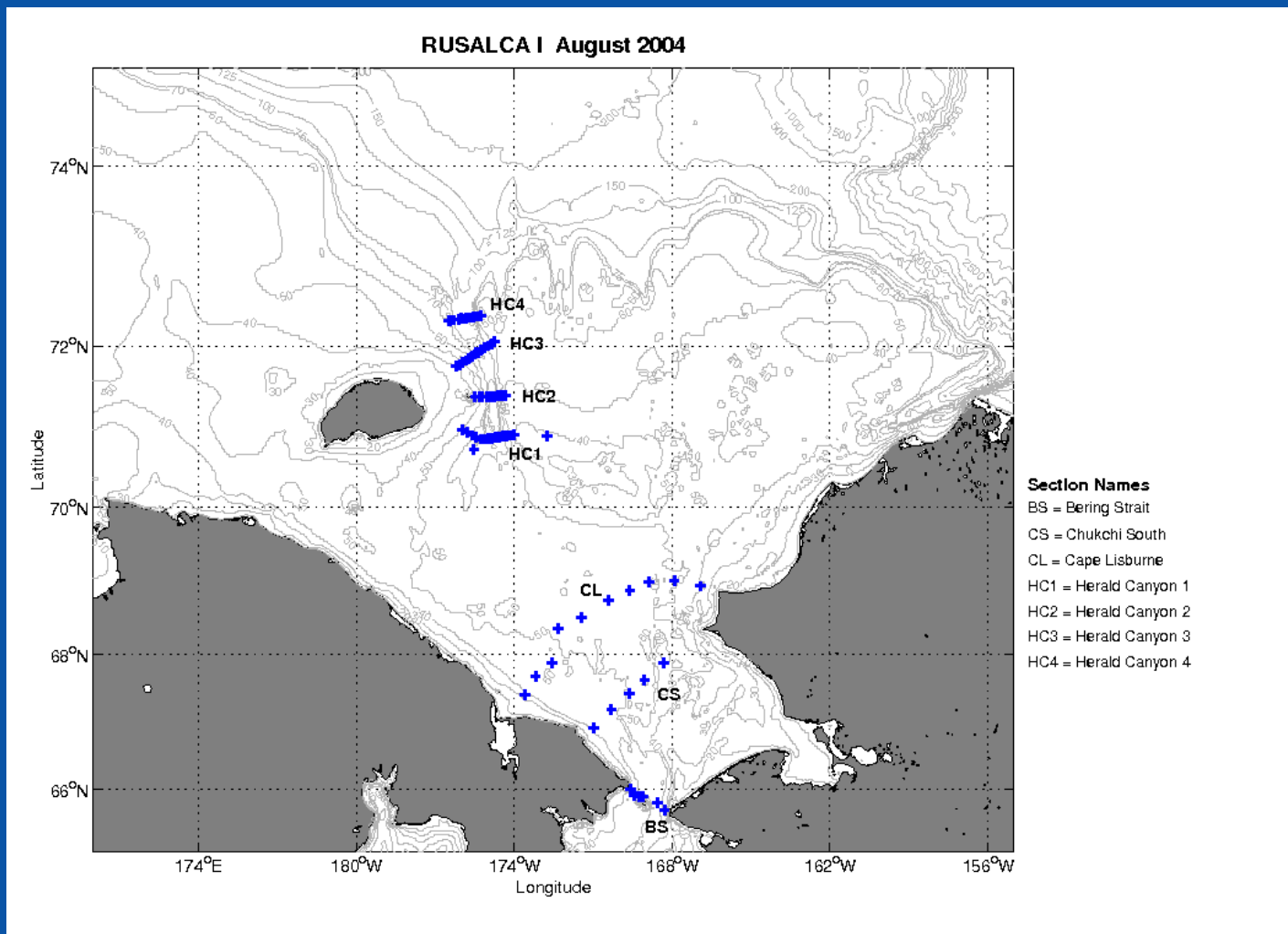
- 1. Winter water was likely formed locally near Wrangel Island, feeding into Herald Canyon adjacent to the summer water from Bering Strait.**
- 2. The winter water switched sides of the canyon and mixed with the summer water to form a new transport mode entering the basin. Hydraulics likely played a role.**
- 3. A portion of the summer water appears to have been shunted to the east into the central Chukchi shelf.**



# ***RUSALCA 2009***

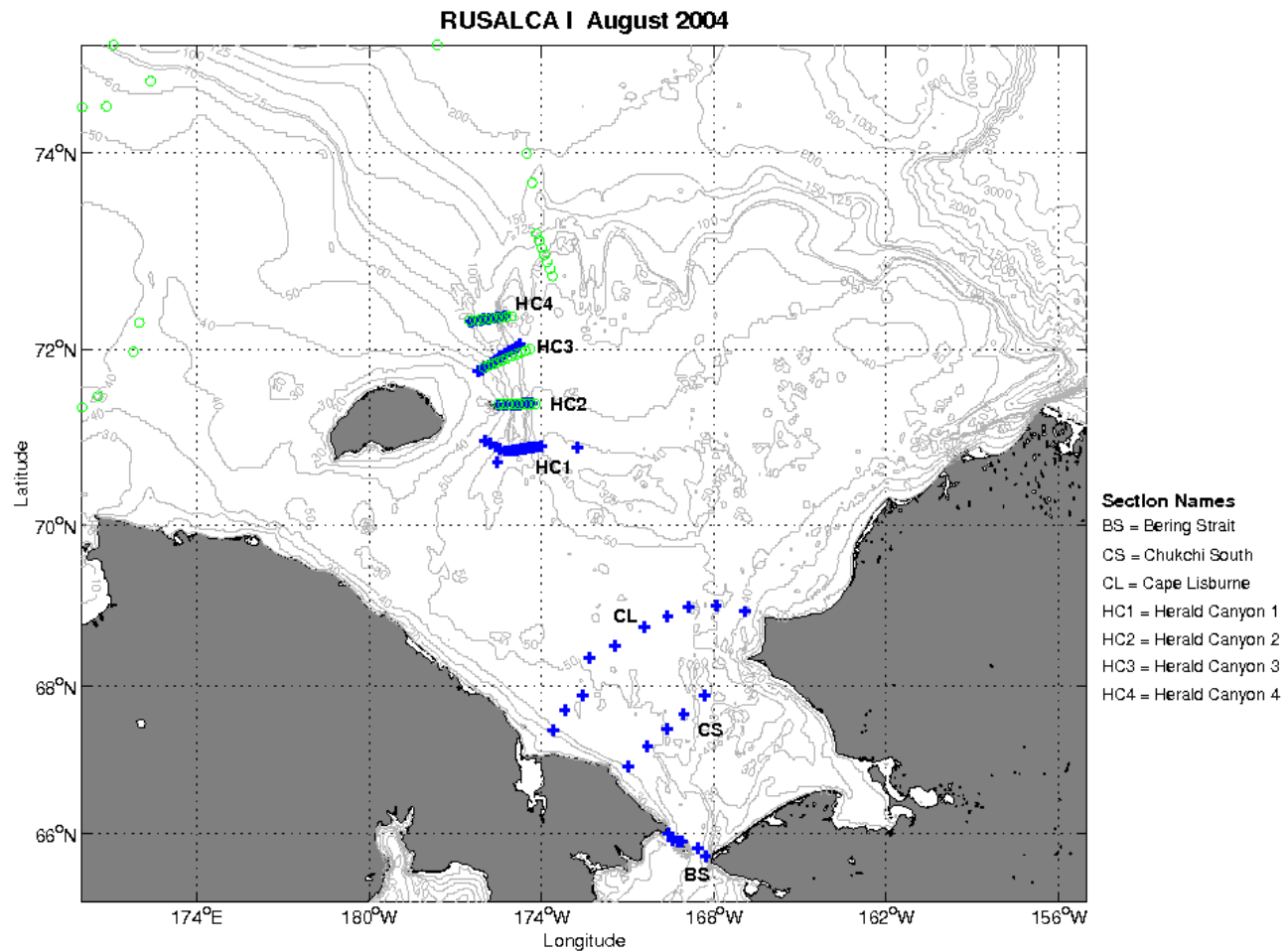


# CTD Survey 2004



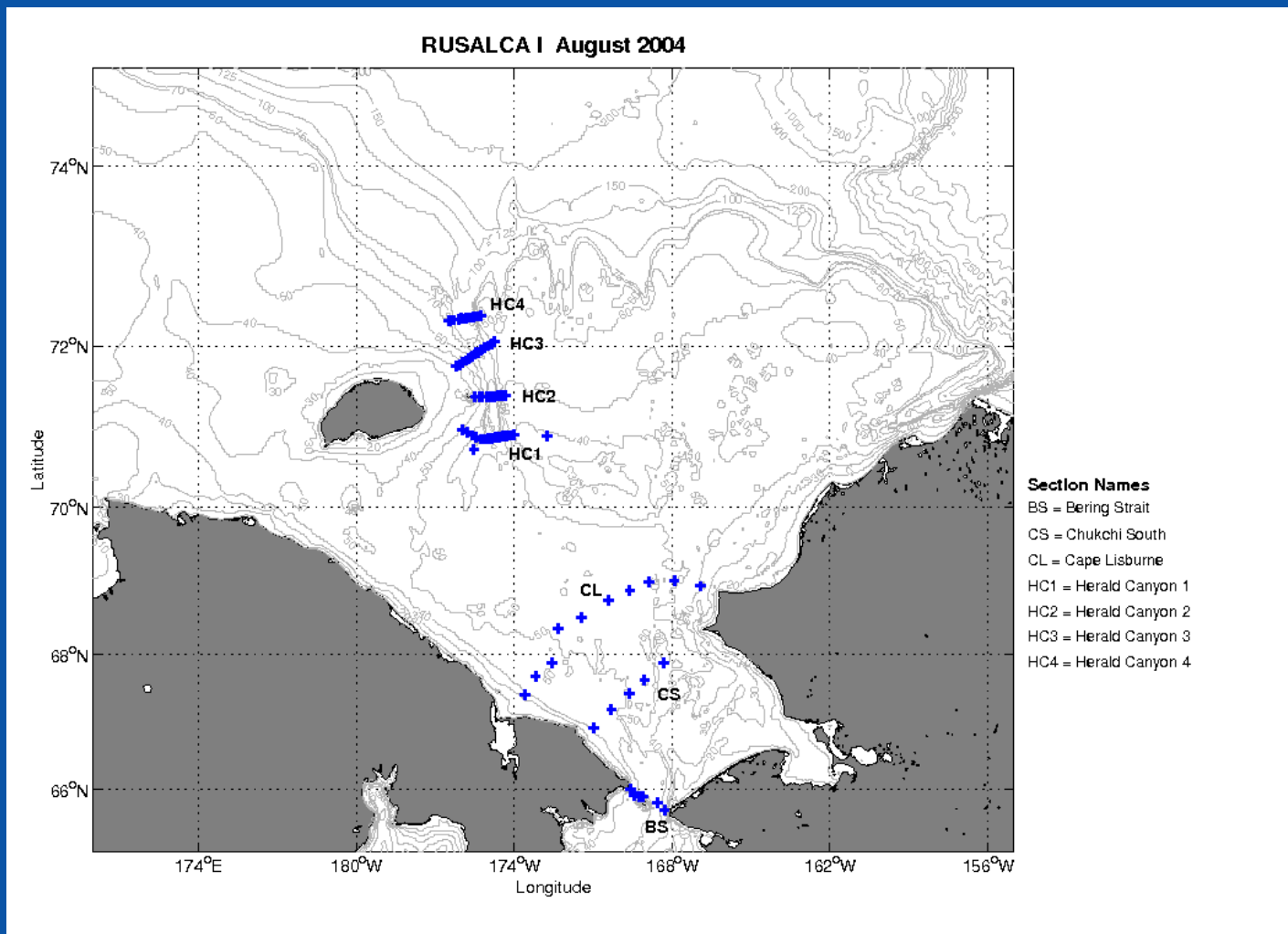


○ 2008 Swedish Survey of Herald Canyon

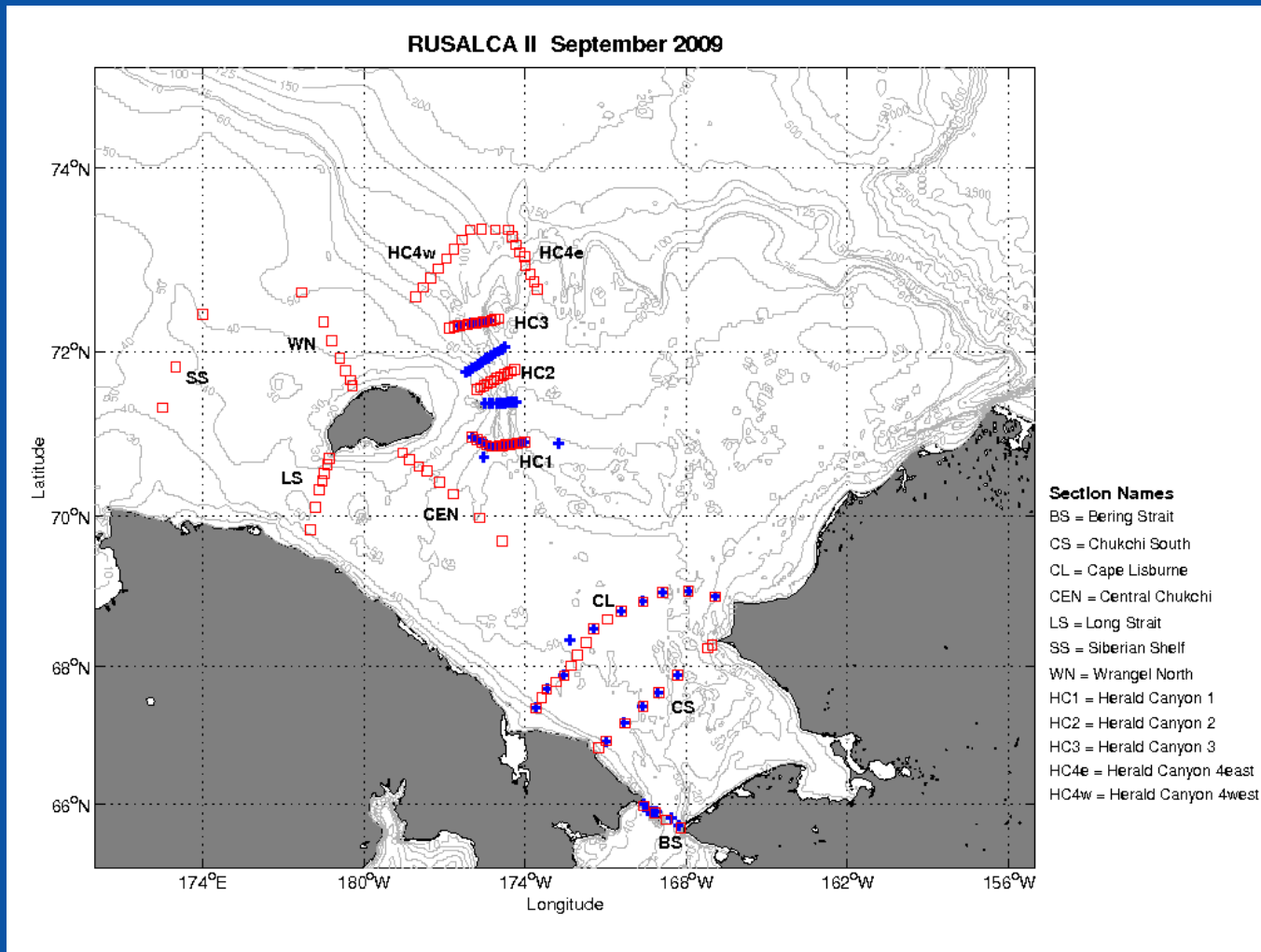




# CTD Survey 2004



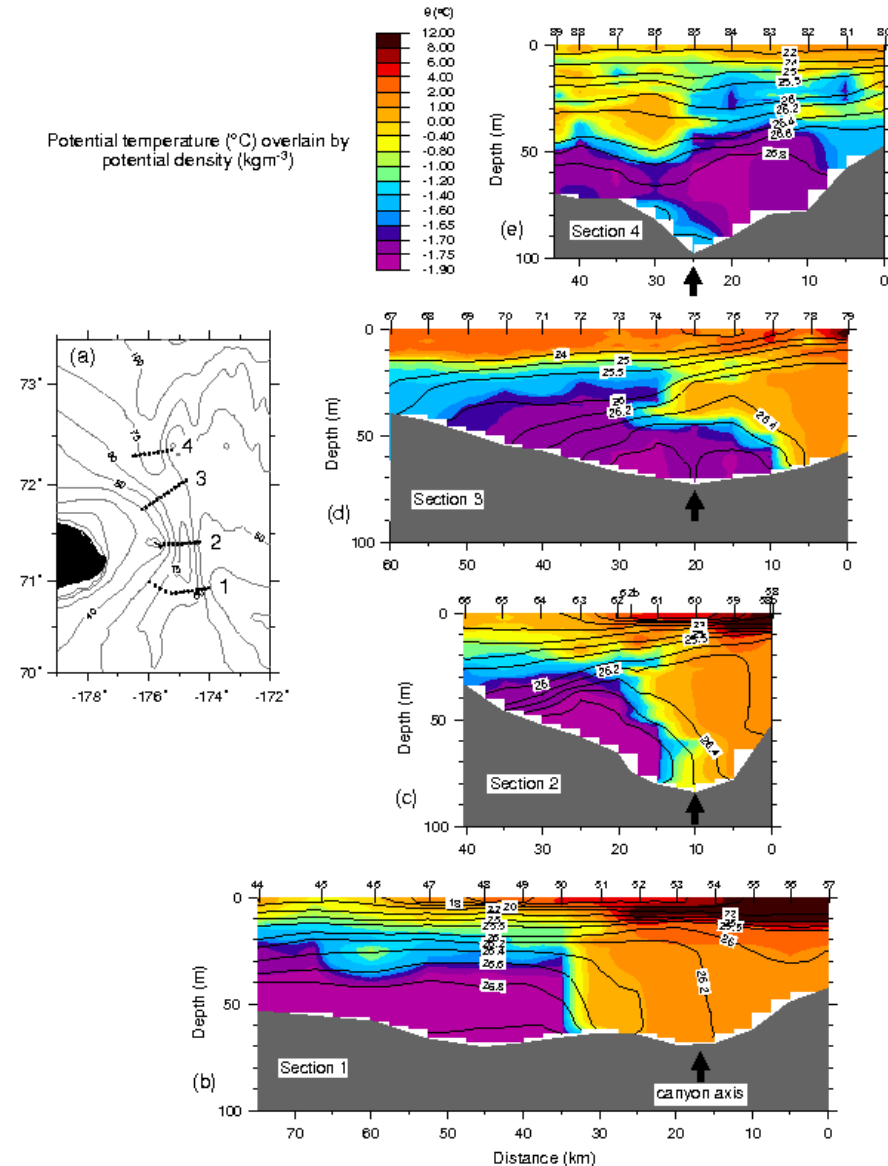
# CTD survey 2004 (blue) and 2009 (red)





# Evolution of flow through Herald Canyon

August 2004

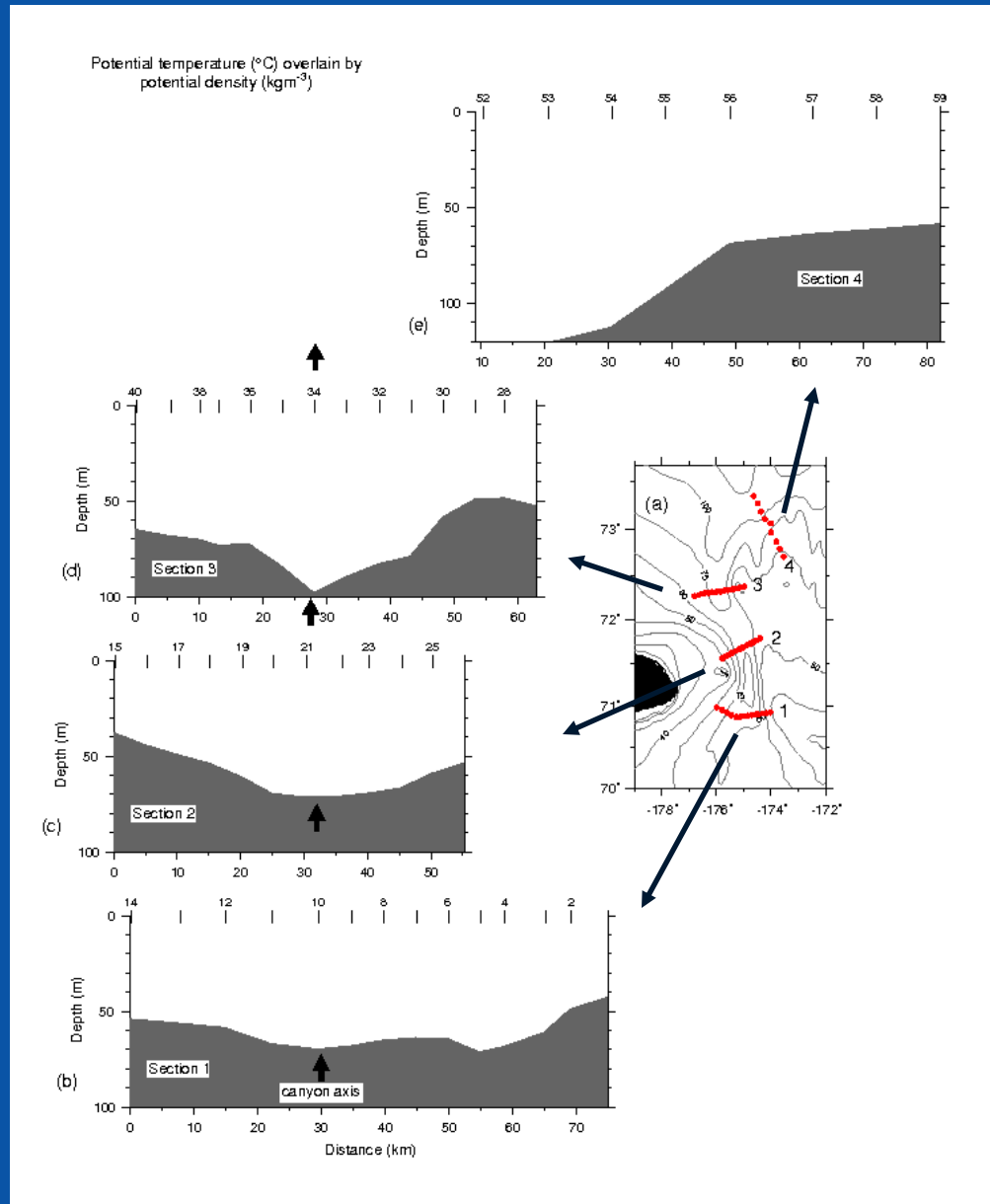


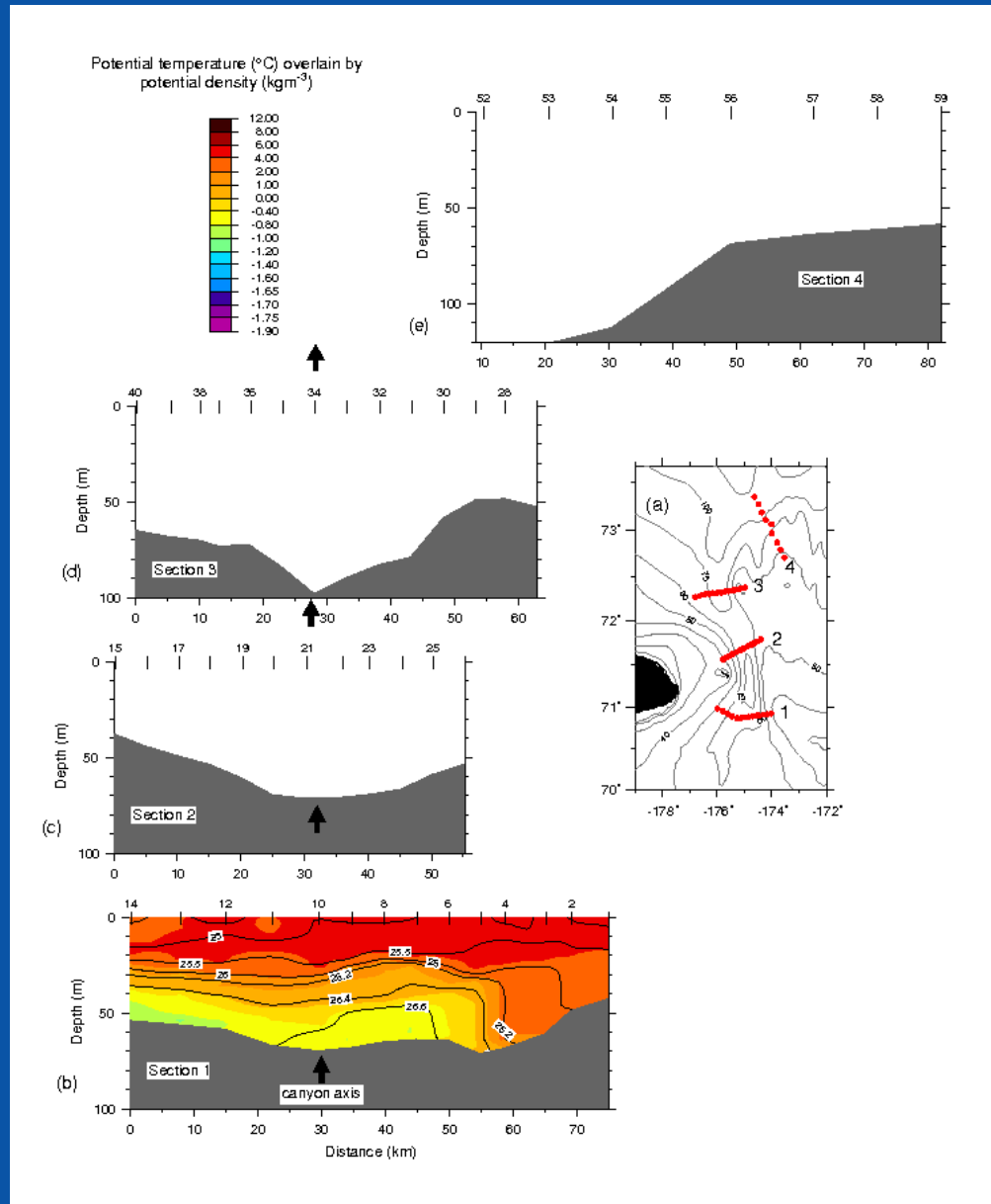




# Evolution of flow through Herald Canyon

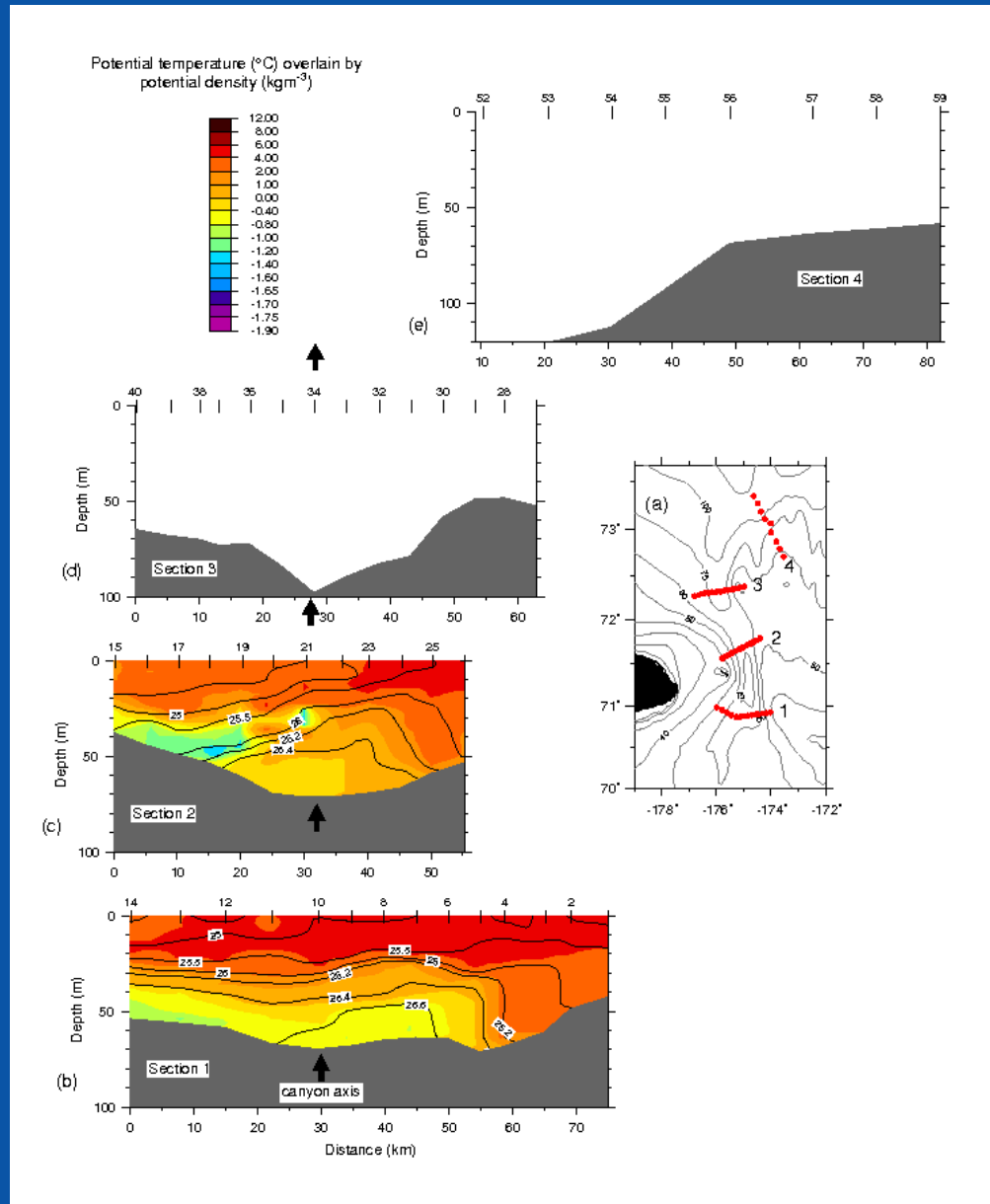
September 2009





# Evolution of flow through Herald Canyon

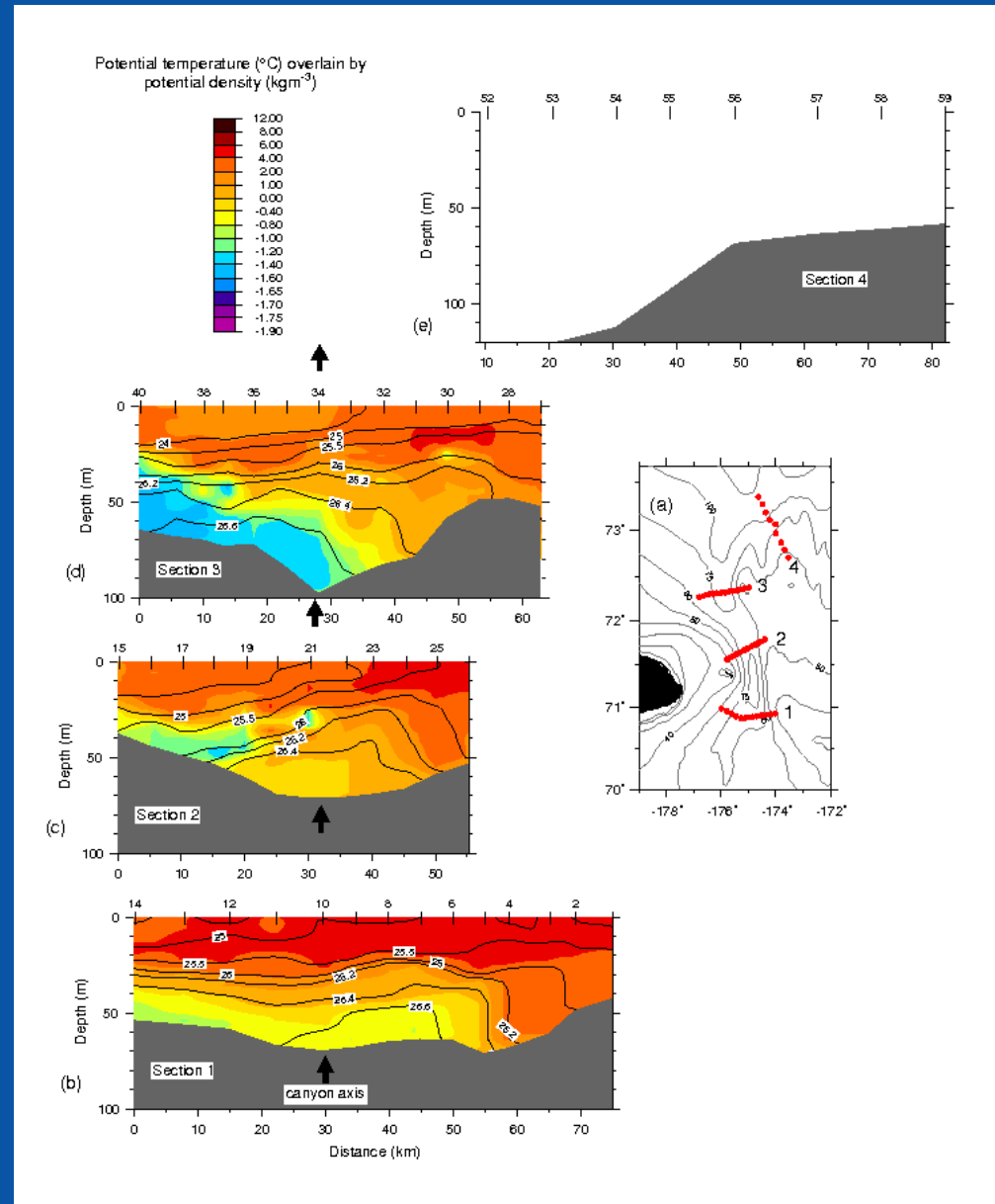
September 2009





# Evolution of flow through Herald Canyon

September 2009

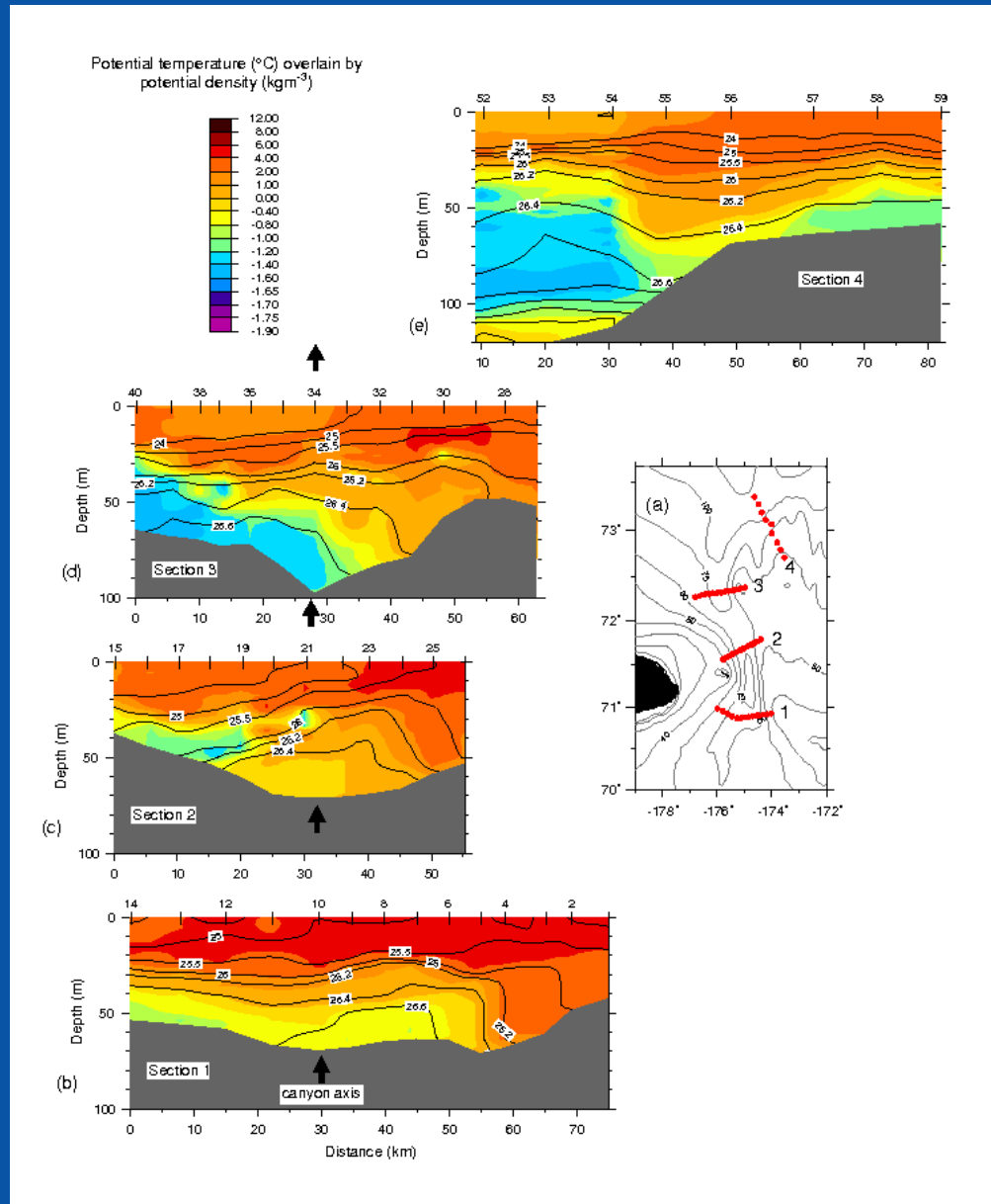






# Evolution of flow through Herald Canyon

September 2009





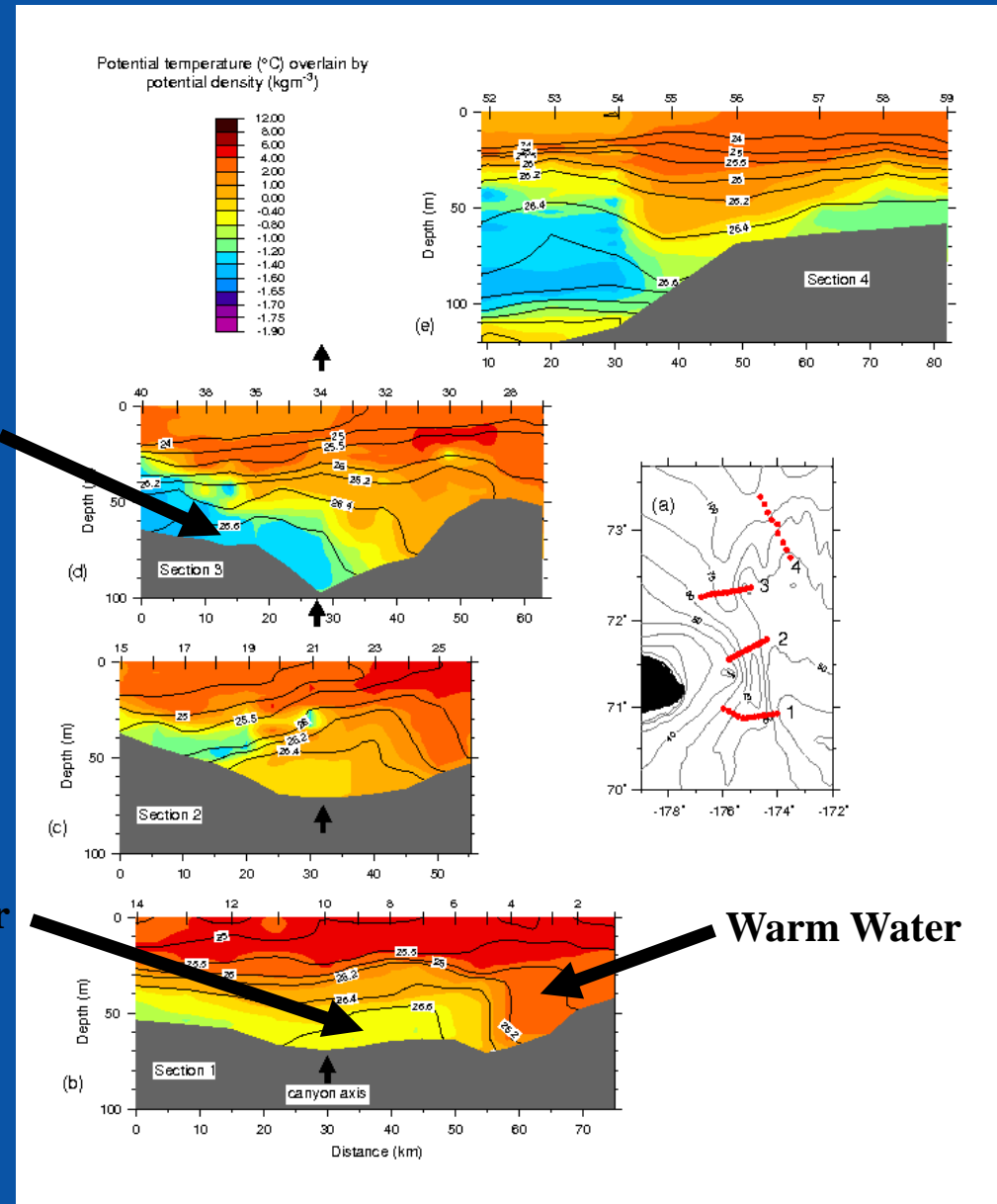
# Evolution of flow through Herald Canyon

September 2009

Cold Water

Cool Water

Warm Water

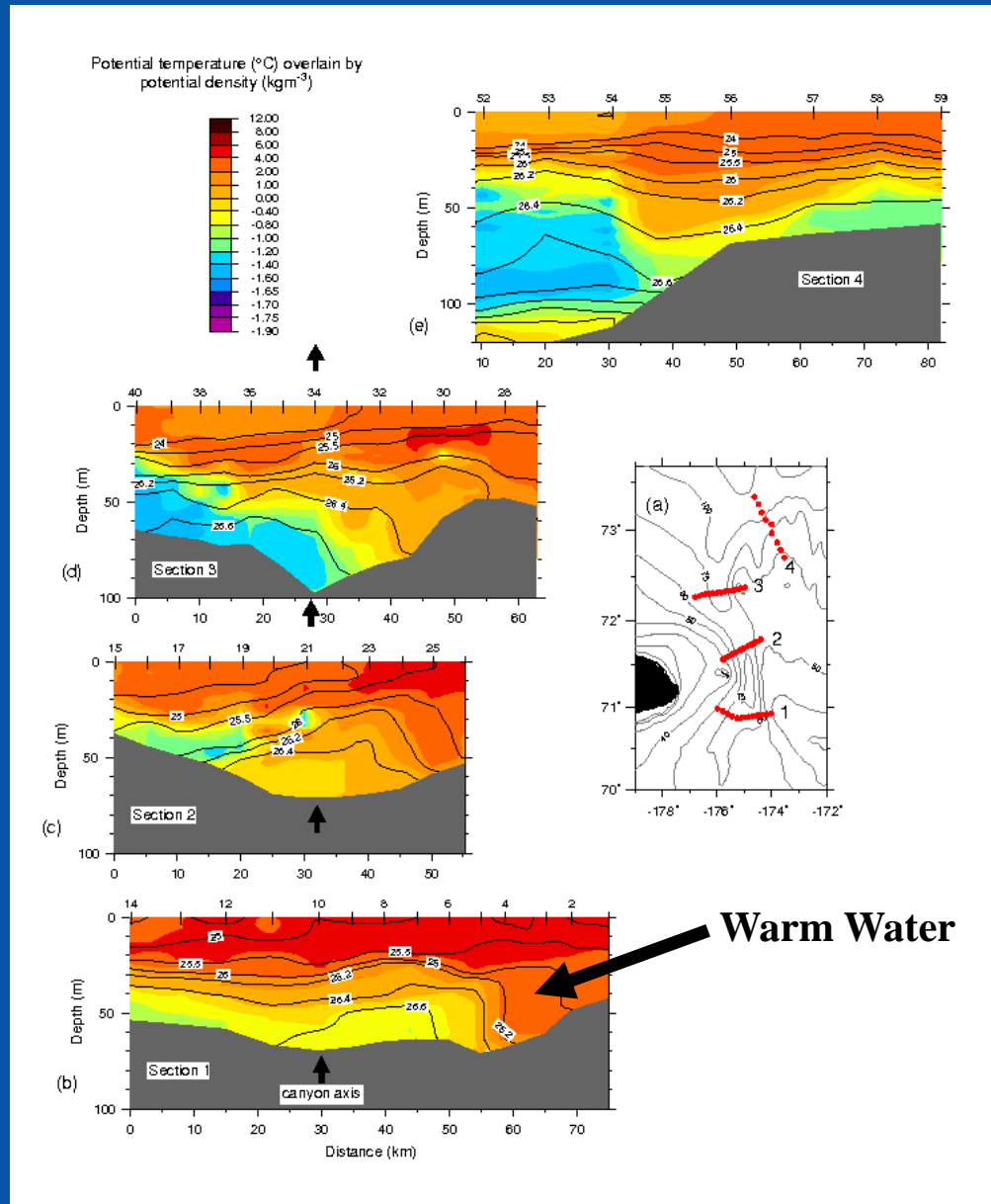




# Evolution of flow through Herald Canyon

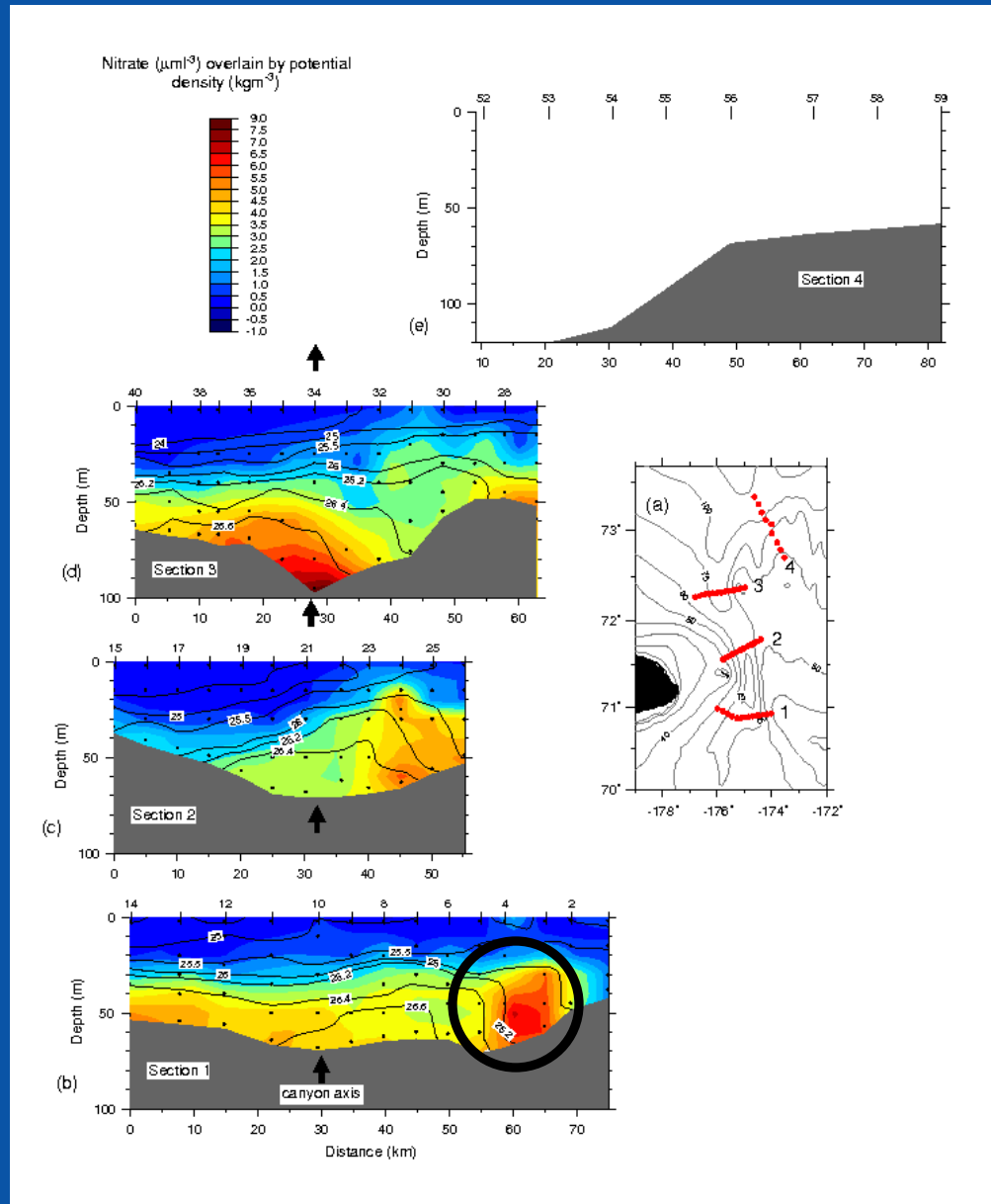
September 2009

## 1. Warm Water



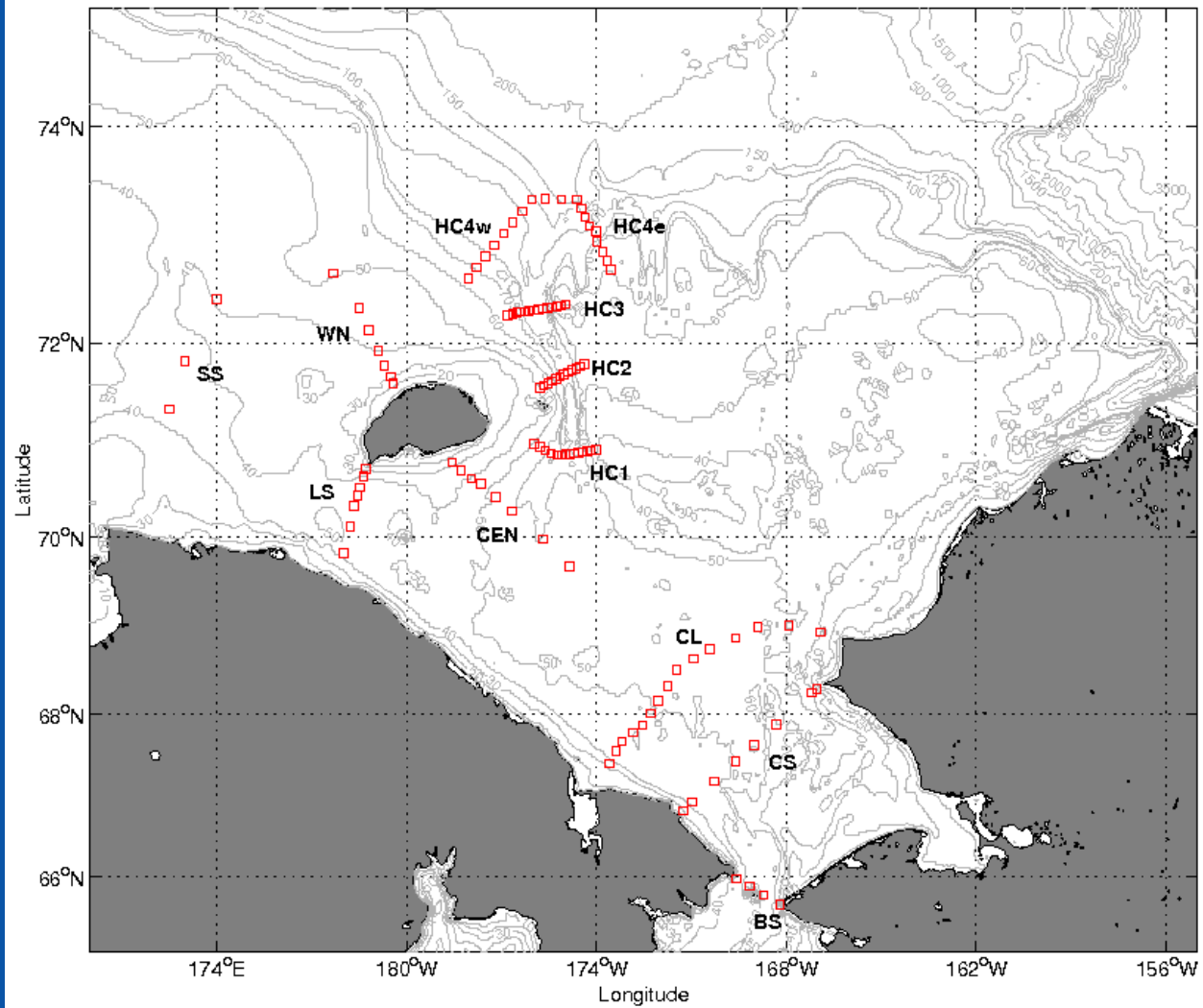
# Warm Water

Signal in Nitrate ( $\mu\text{mol}^{-3}$ )

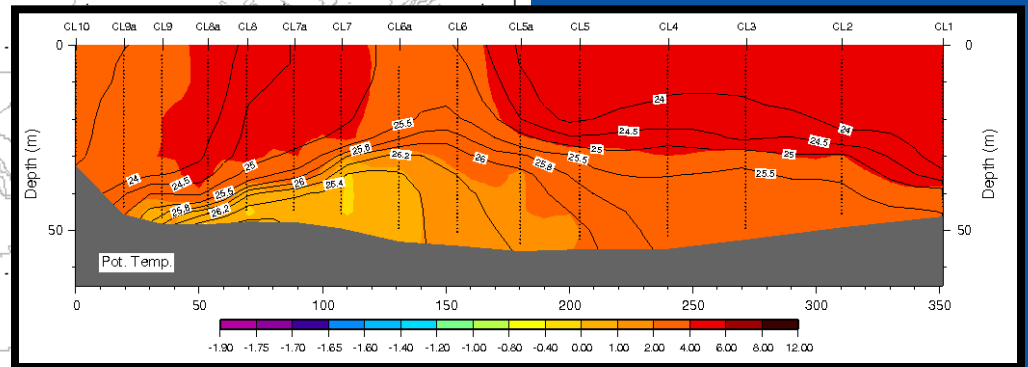
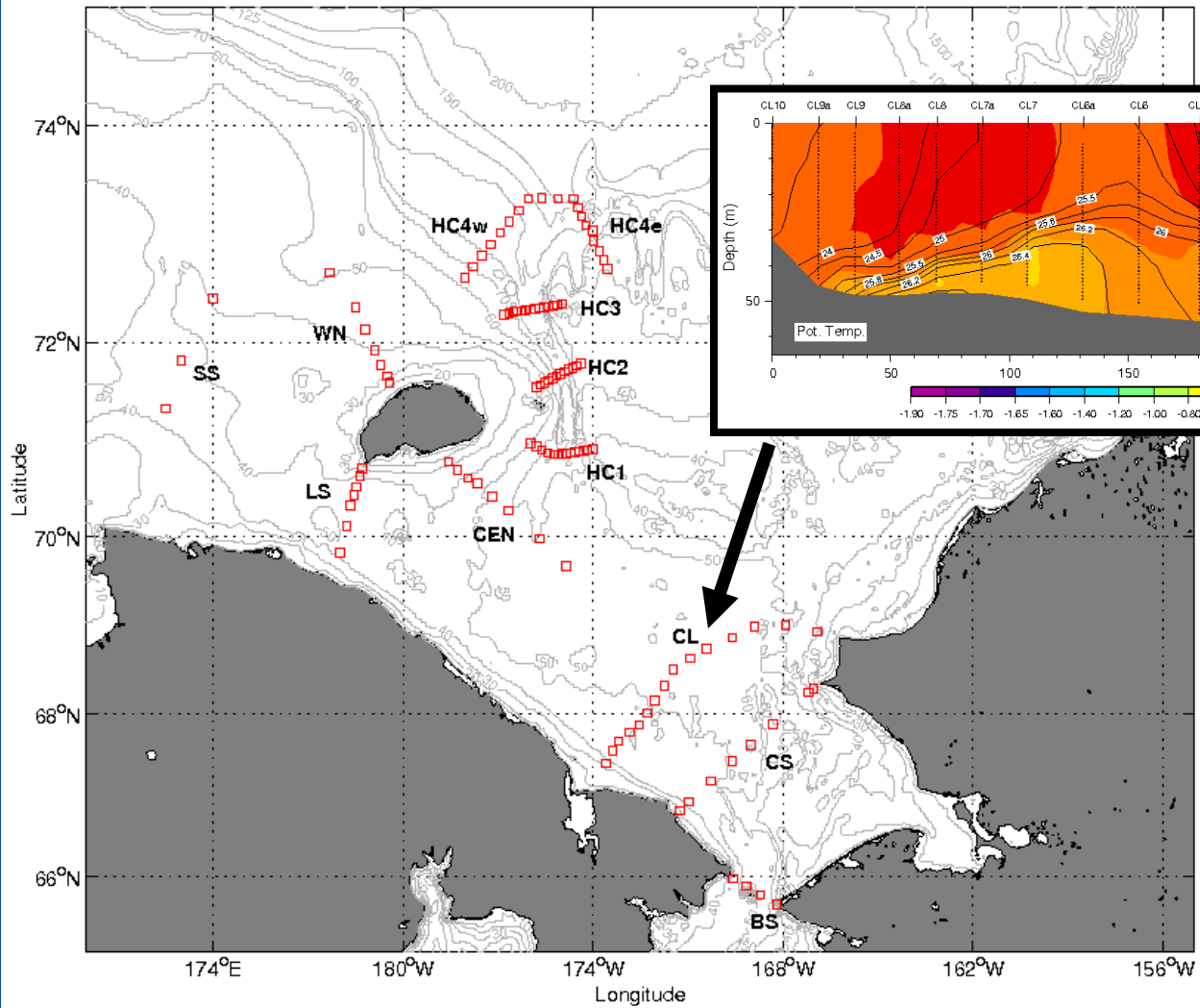




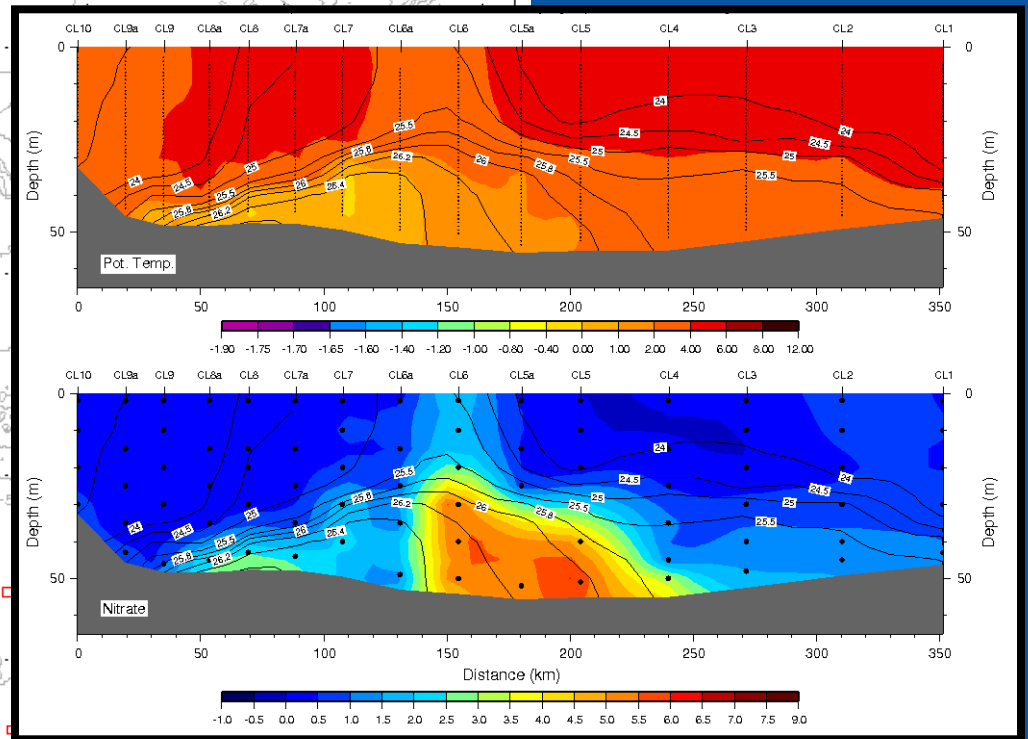
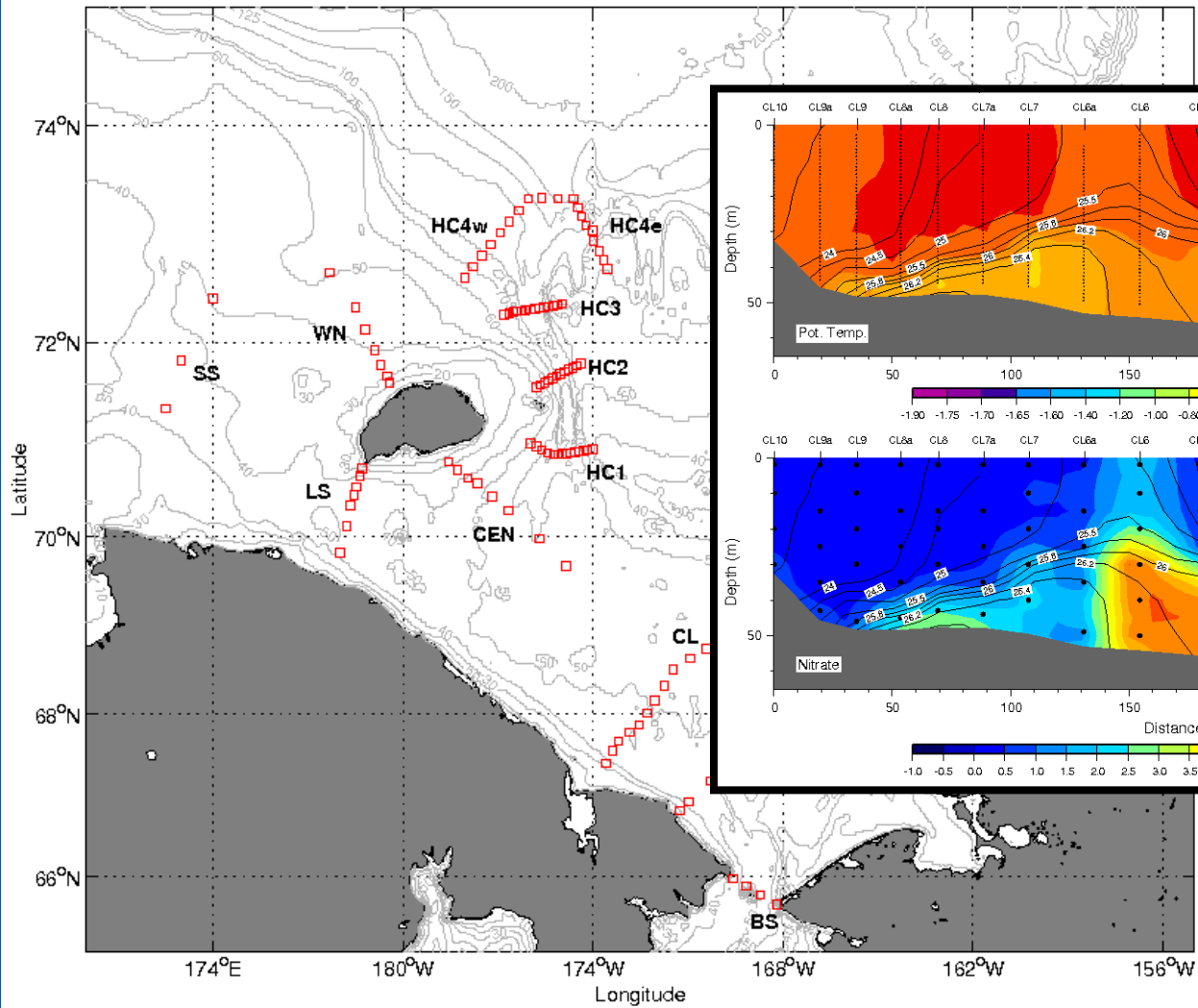
# RUSALCA II September 2009



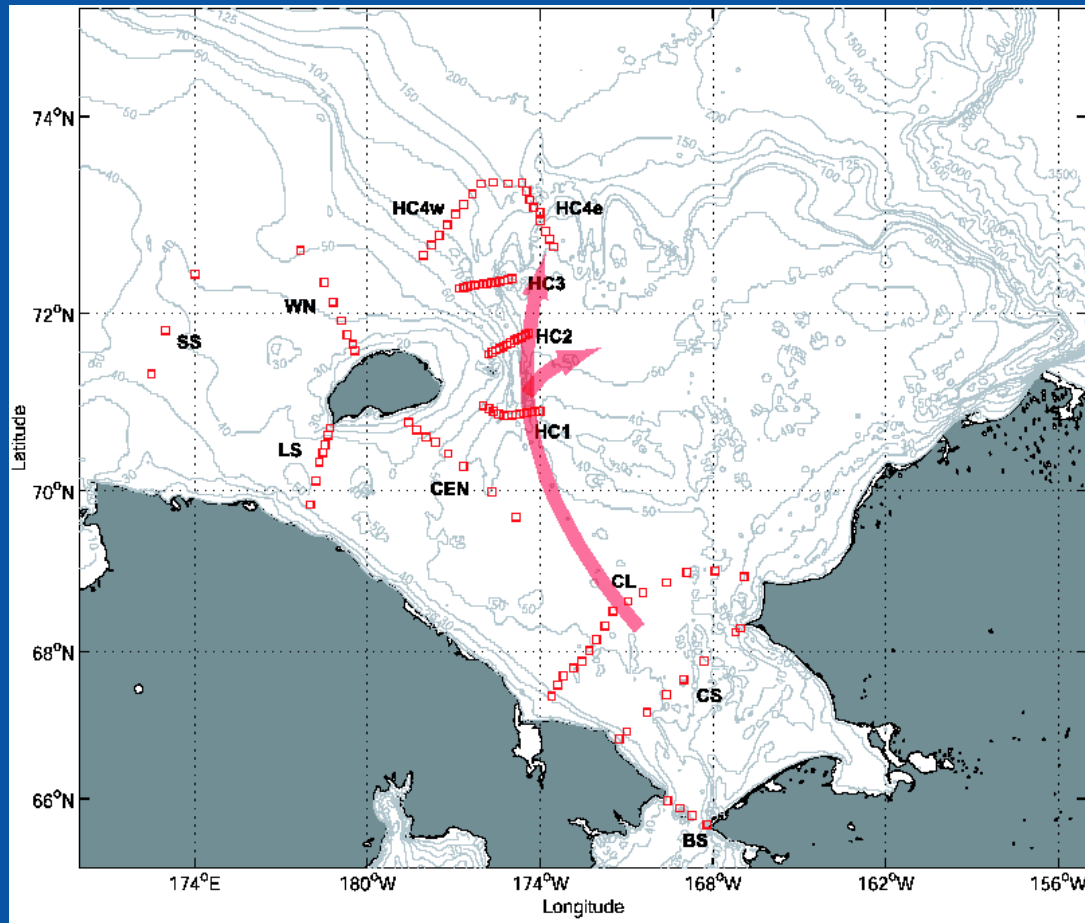
# RUSALCA II September 2009



# RUSALCA II September 2009



## Schematic circulation



→ Warm Water



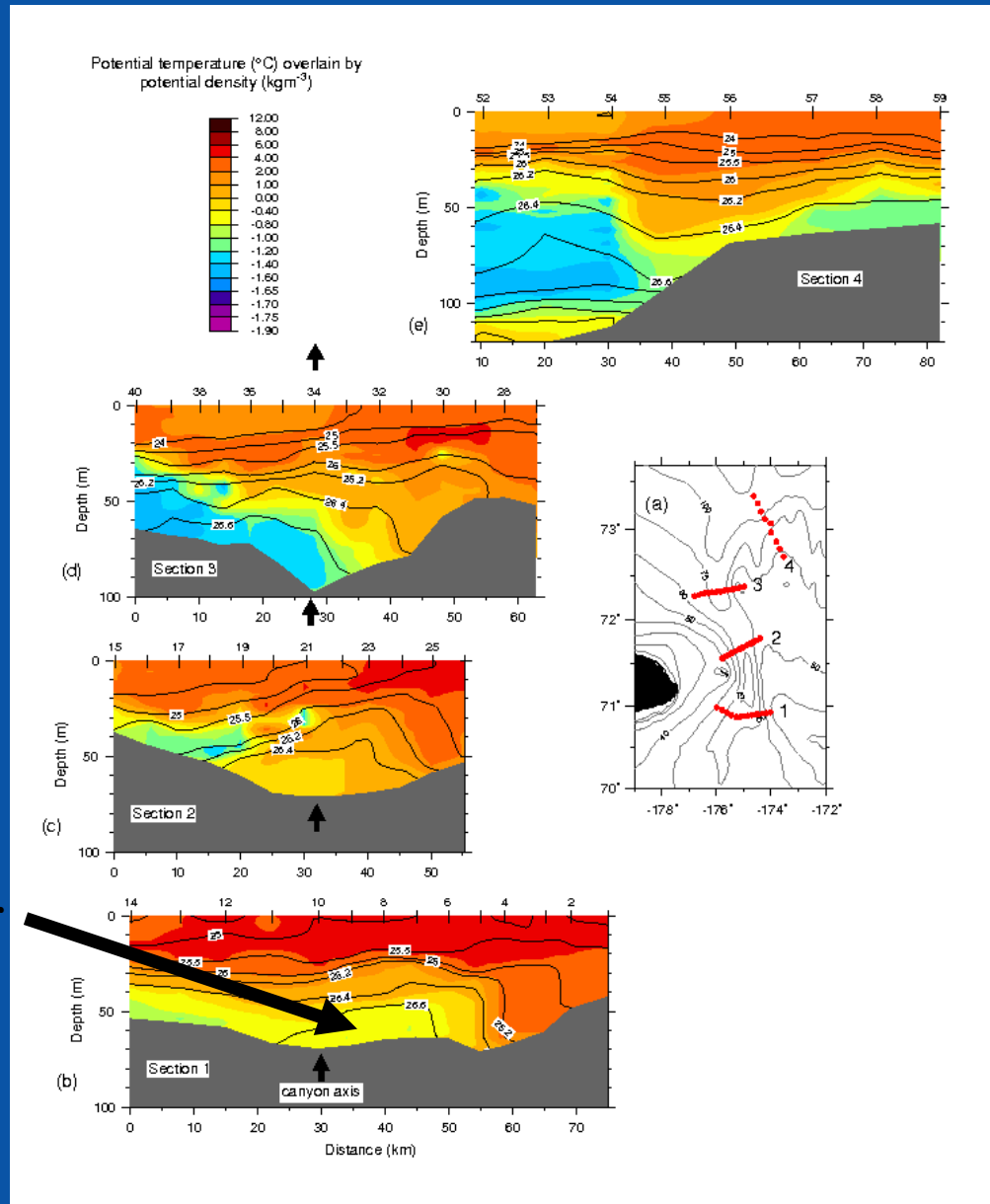


# Evolution of flow through Herald Canyon

September 2009

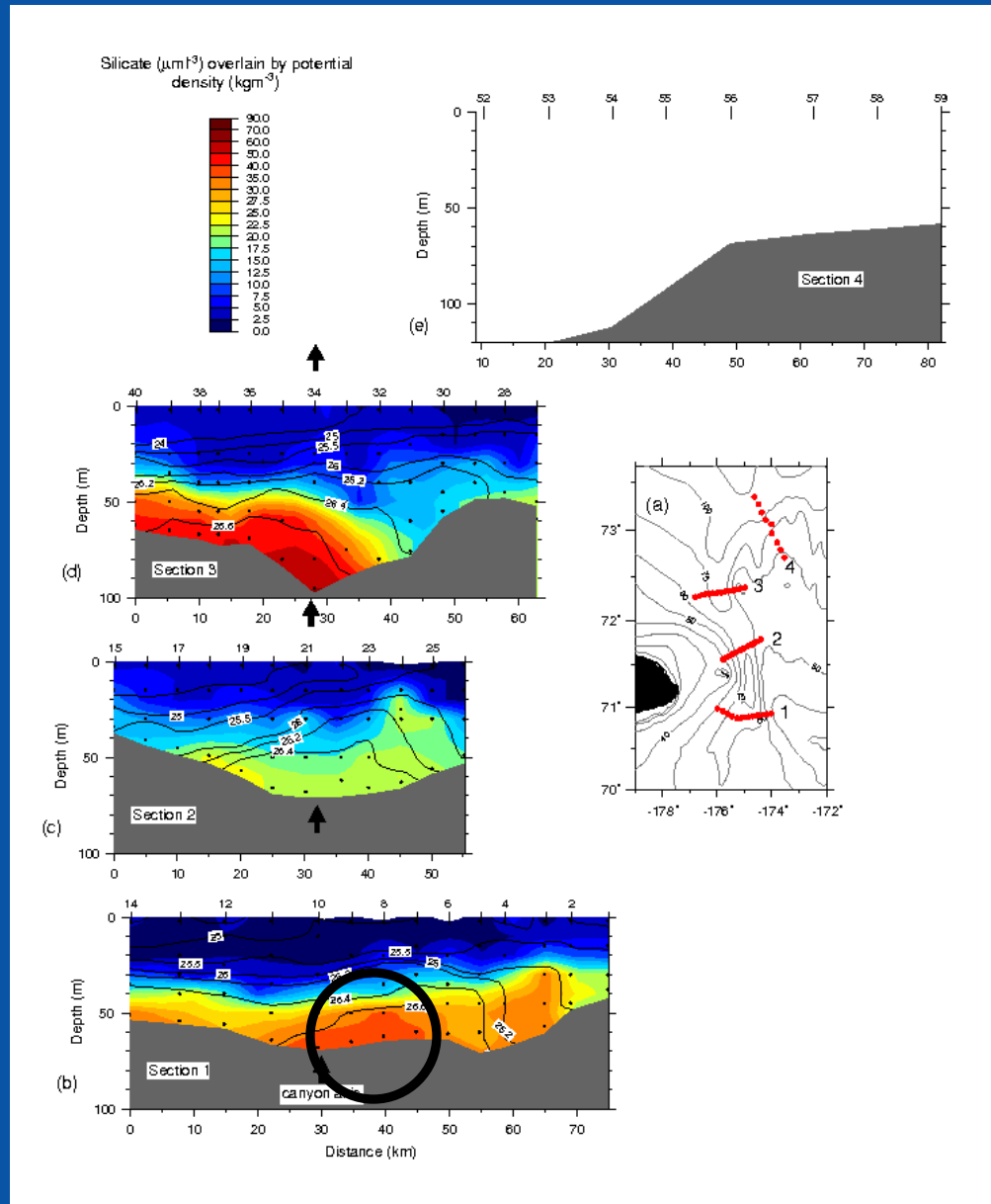
## 2. Cool Water

Cool Water



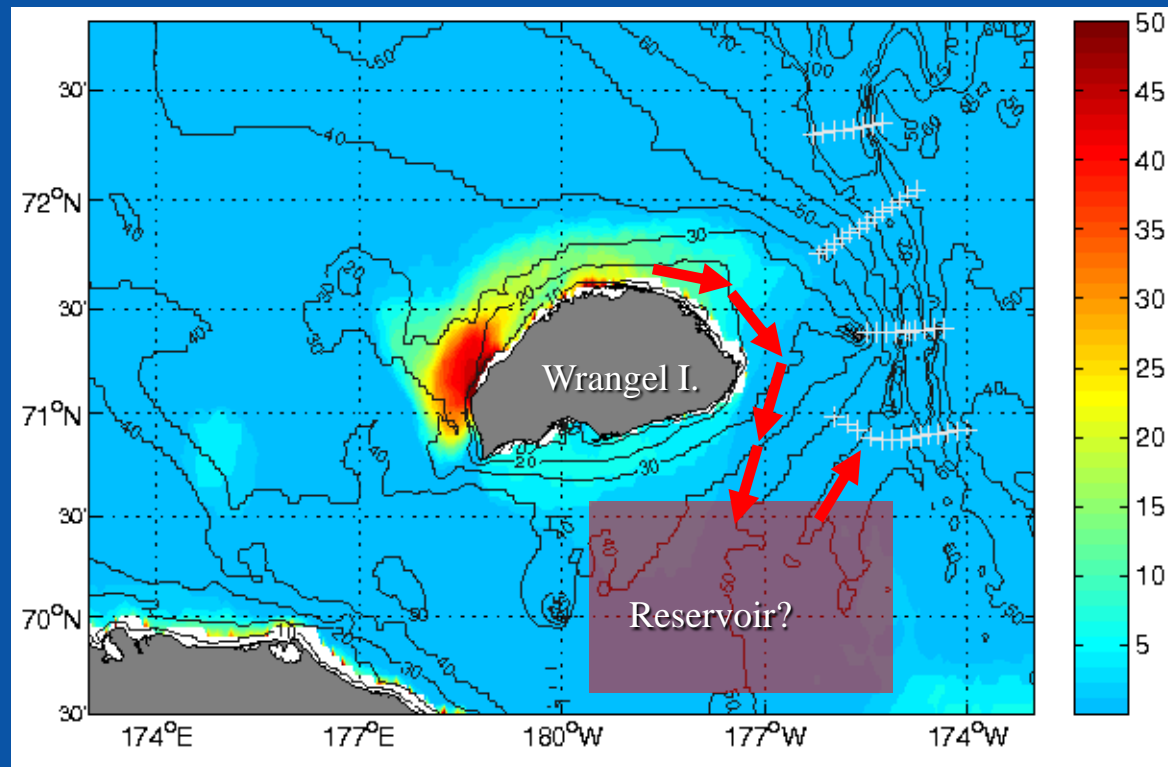
# Cool Water

Signal in Silicate ( $\mu\text{ml}^{-3}$ )



# How does the winter water feed the canyon?

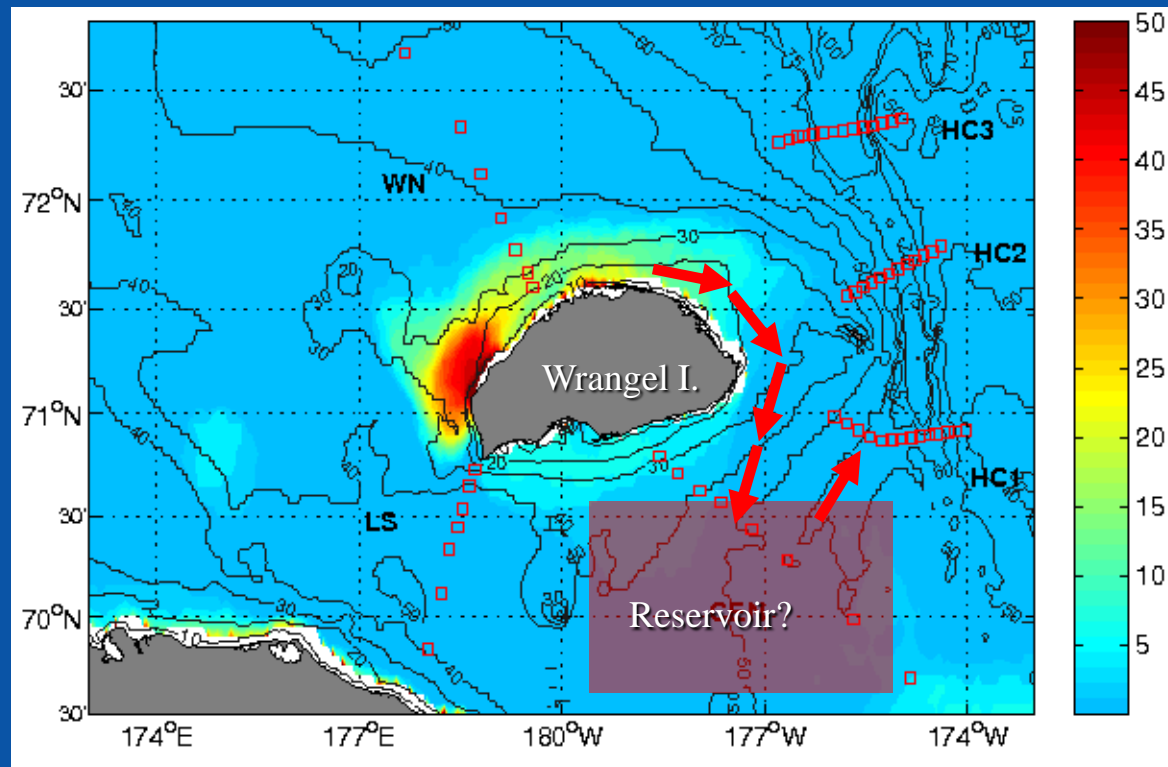
Number of days that polynya was present, winter 2003-4 (from AMSR-E)



+ RUSALCA 2004 stations

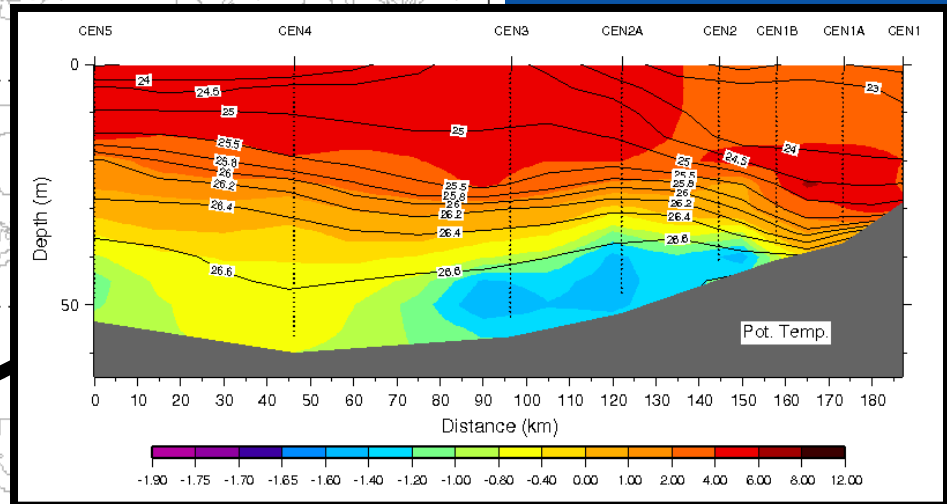
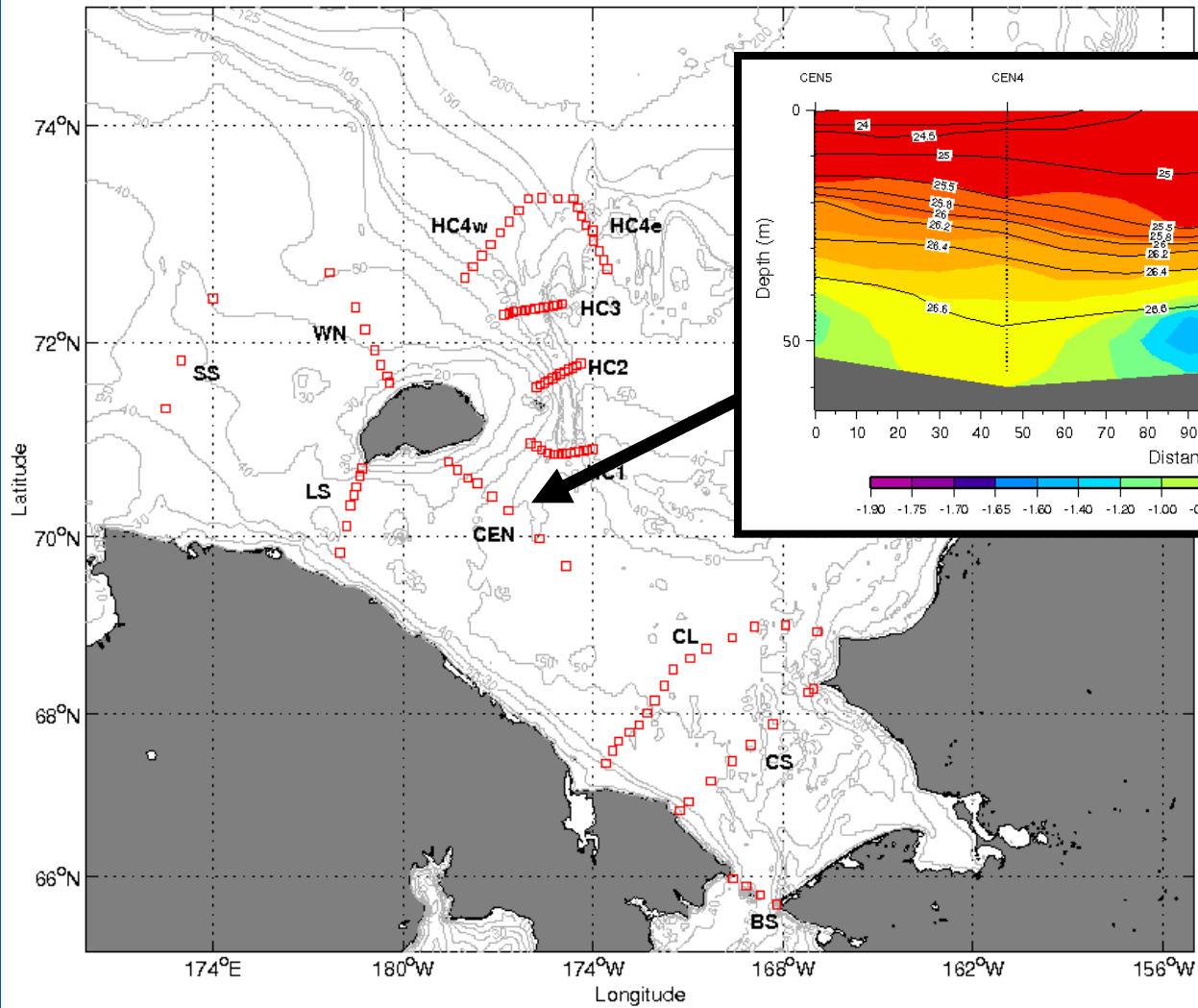
# How does the winter water feed the canyon?

Number of days that polynya was present, winter 2003-4 (from AMSR-E)



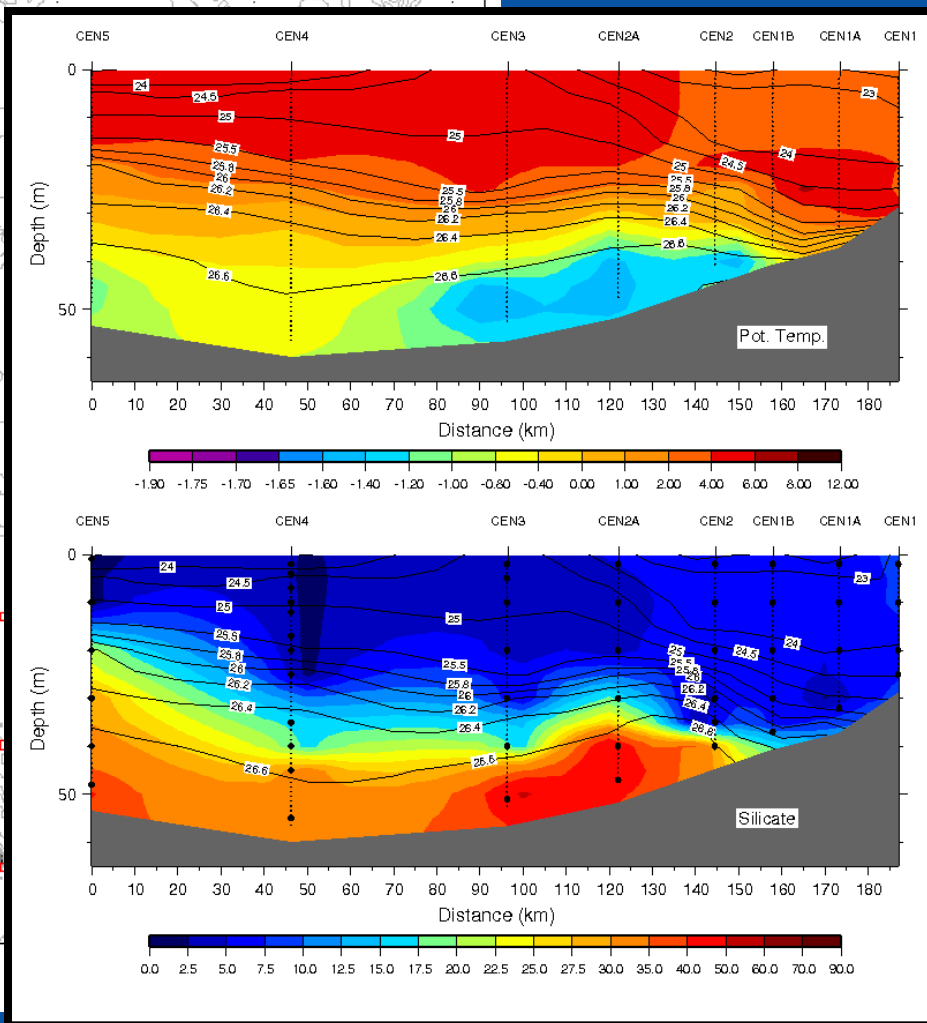
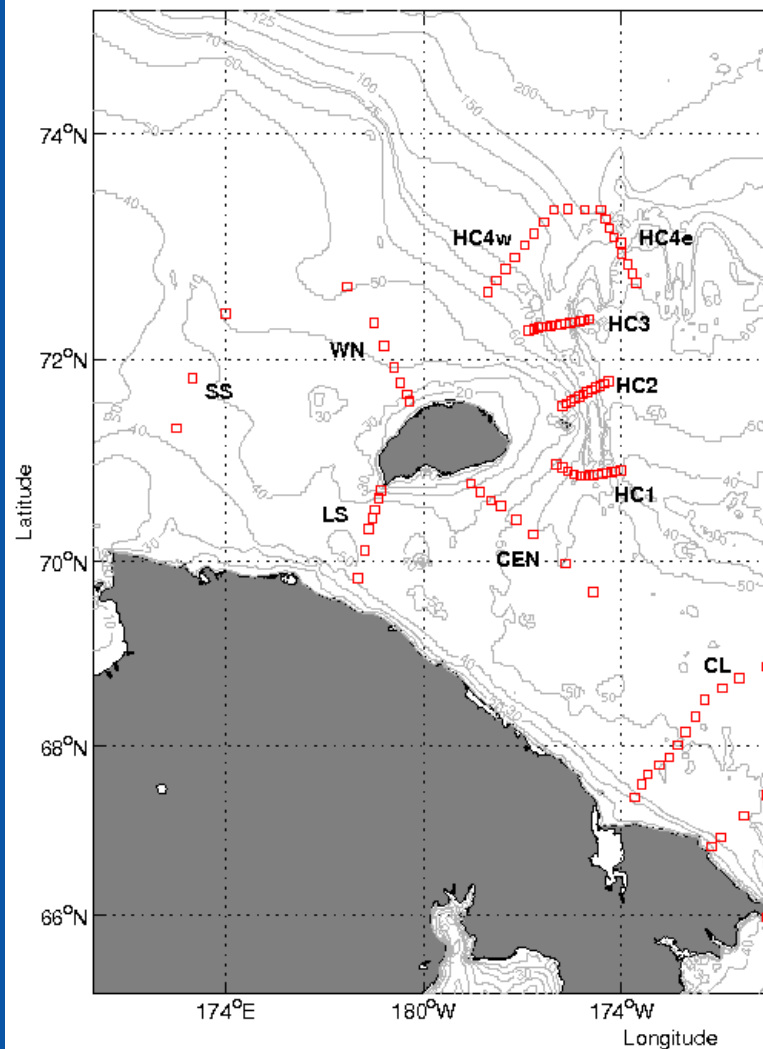
□ RUSALCA 2009 stations

# RUSALCA II September 2009

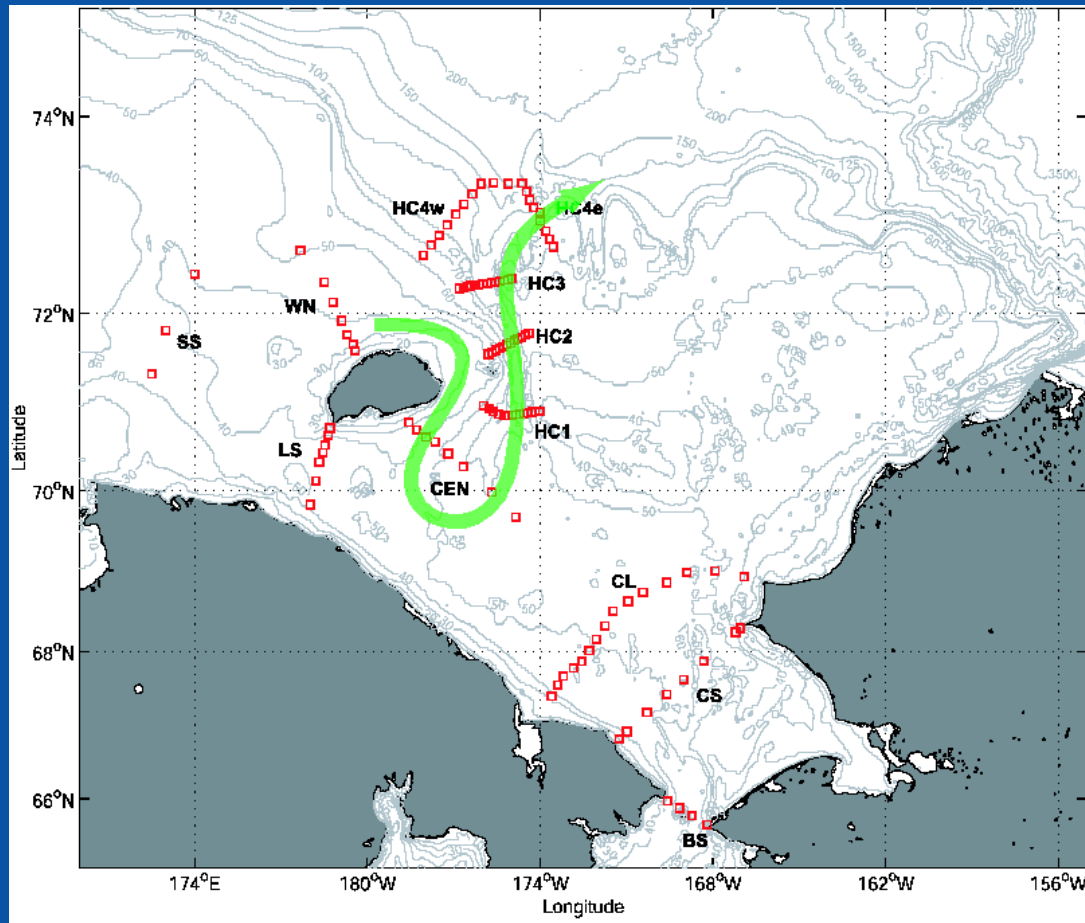




# RUSALCA II September 2009



## Schematic circulation

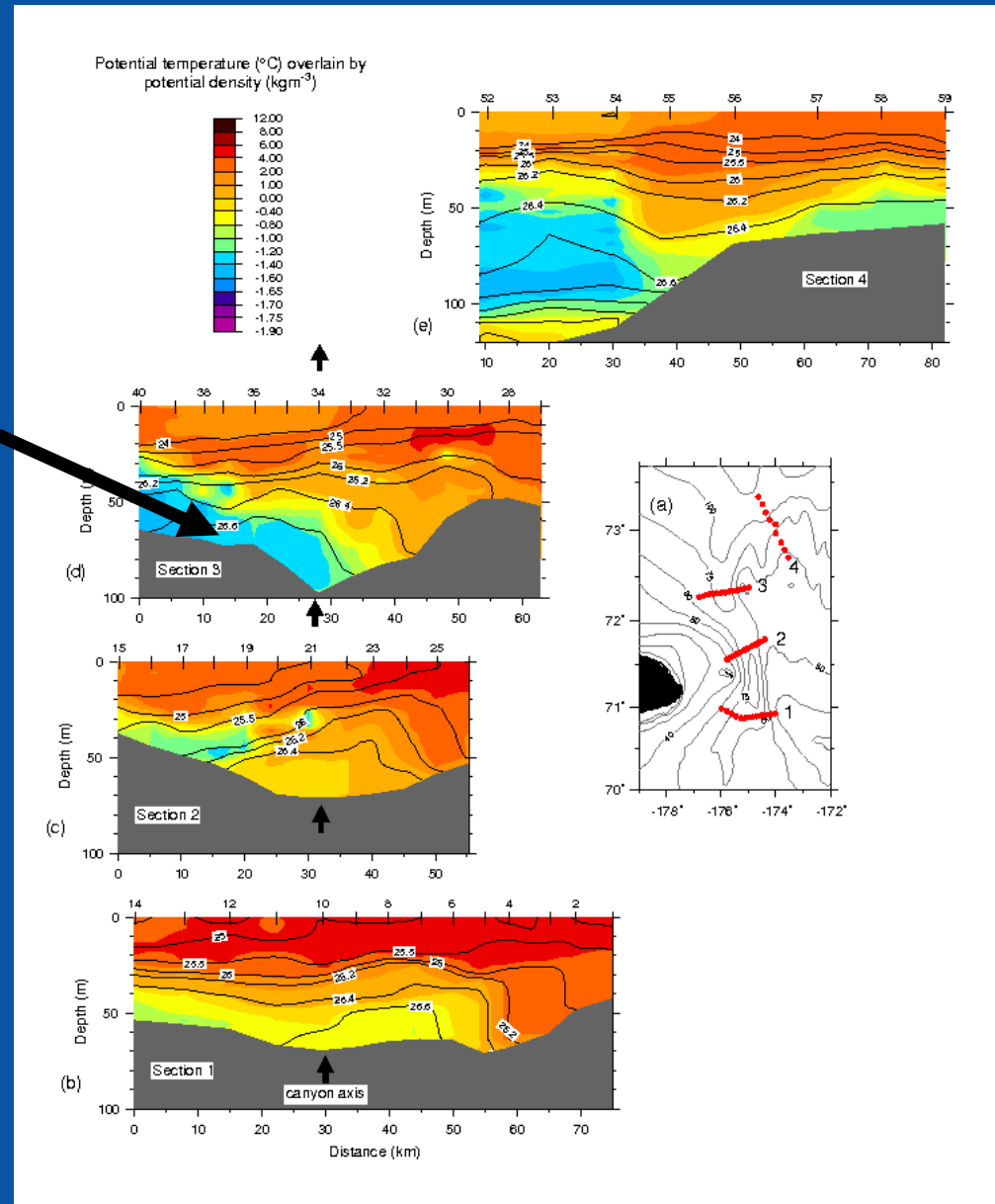


# Evolution of flow through Herald Canyon

Cold Water

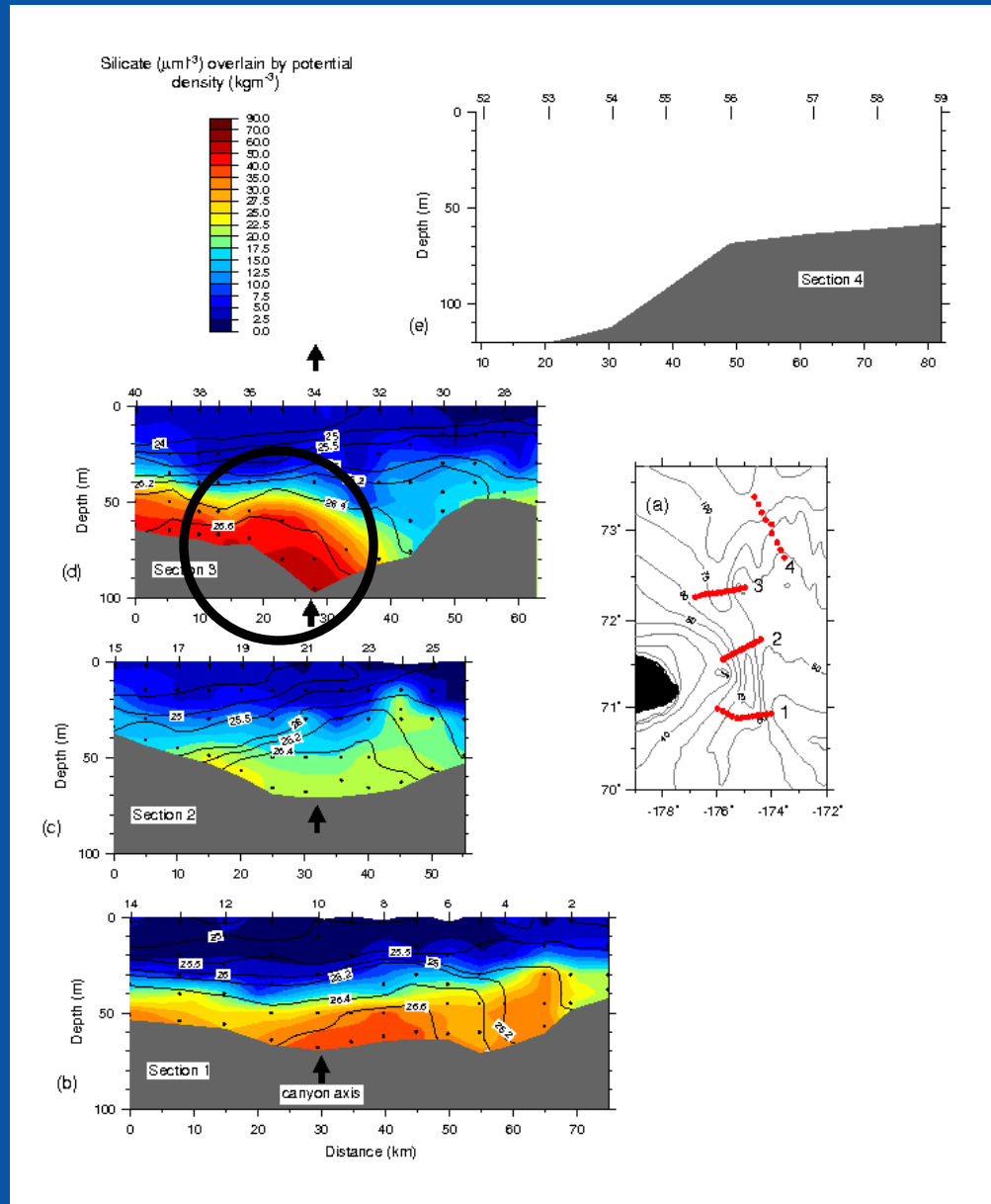
September 2009

## 3. Cold Water



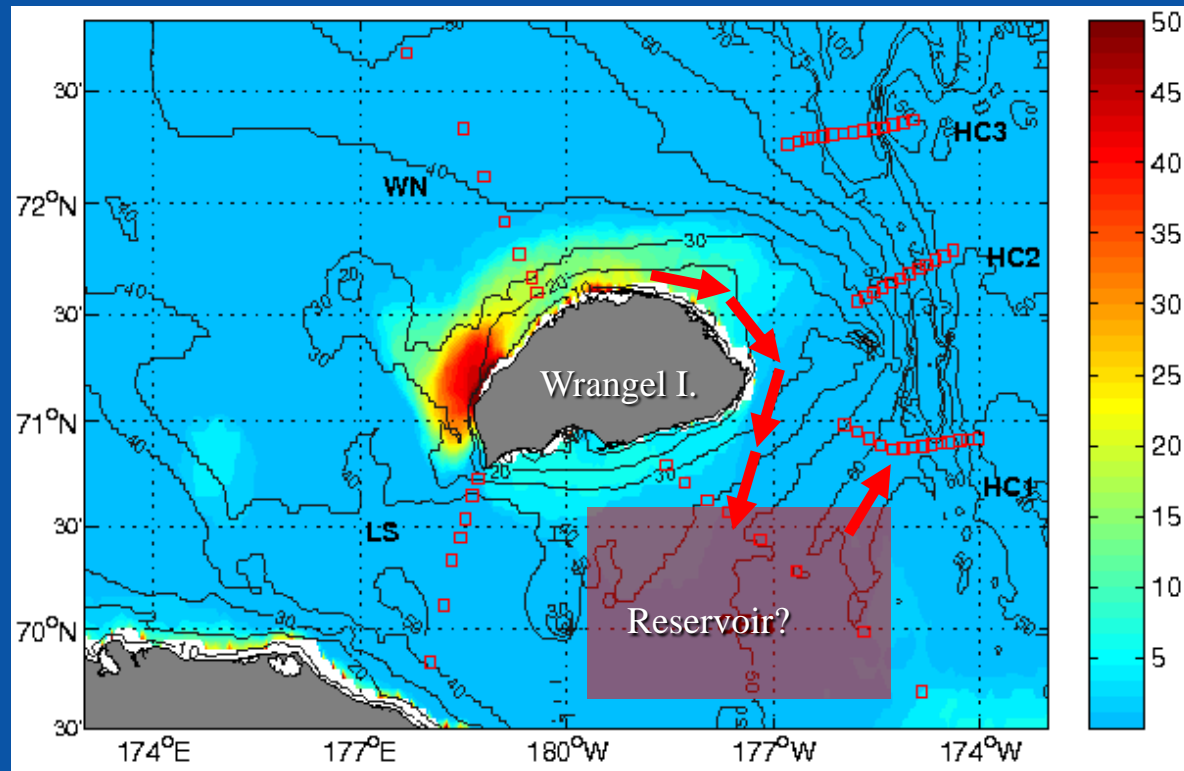
# Cold Water

Signal in Silicate ( $\mu\text{ml}^{-3}$ )



# Cold Water

Number of days that polynya was present, winter 2003-4 (from AMSR-E)

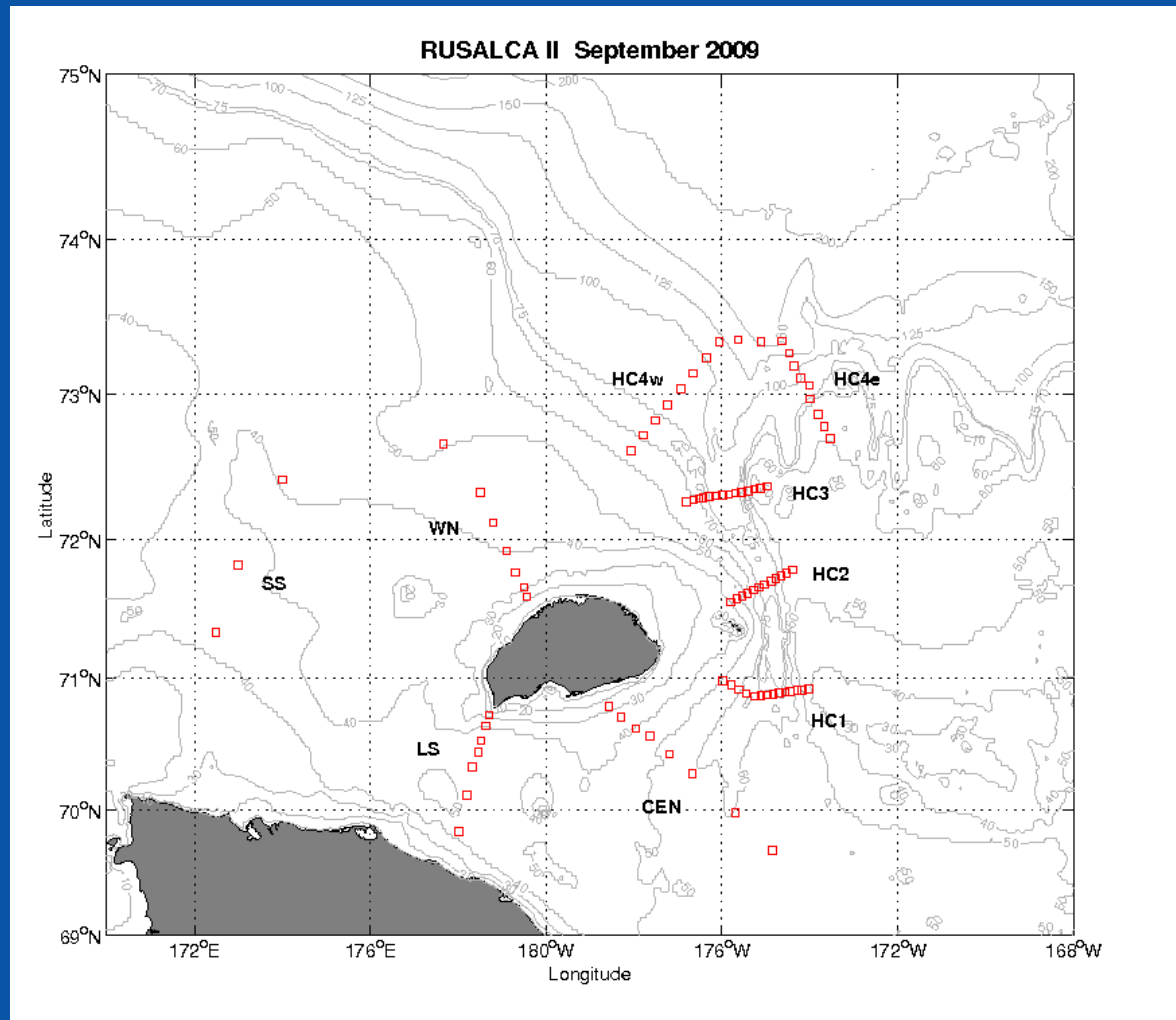


+ RUSALCA 2004 stations



## Cold Water

Uncharted canyon?

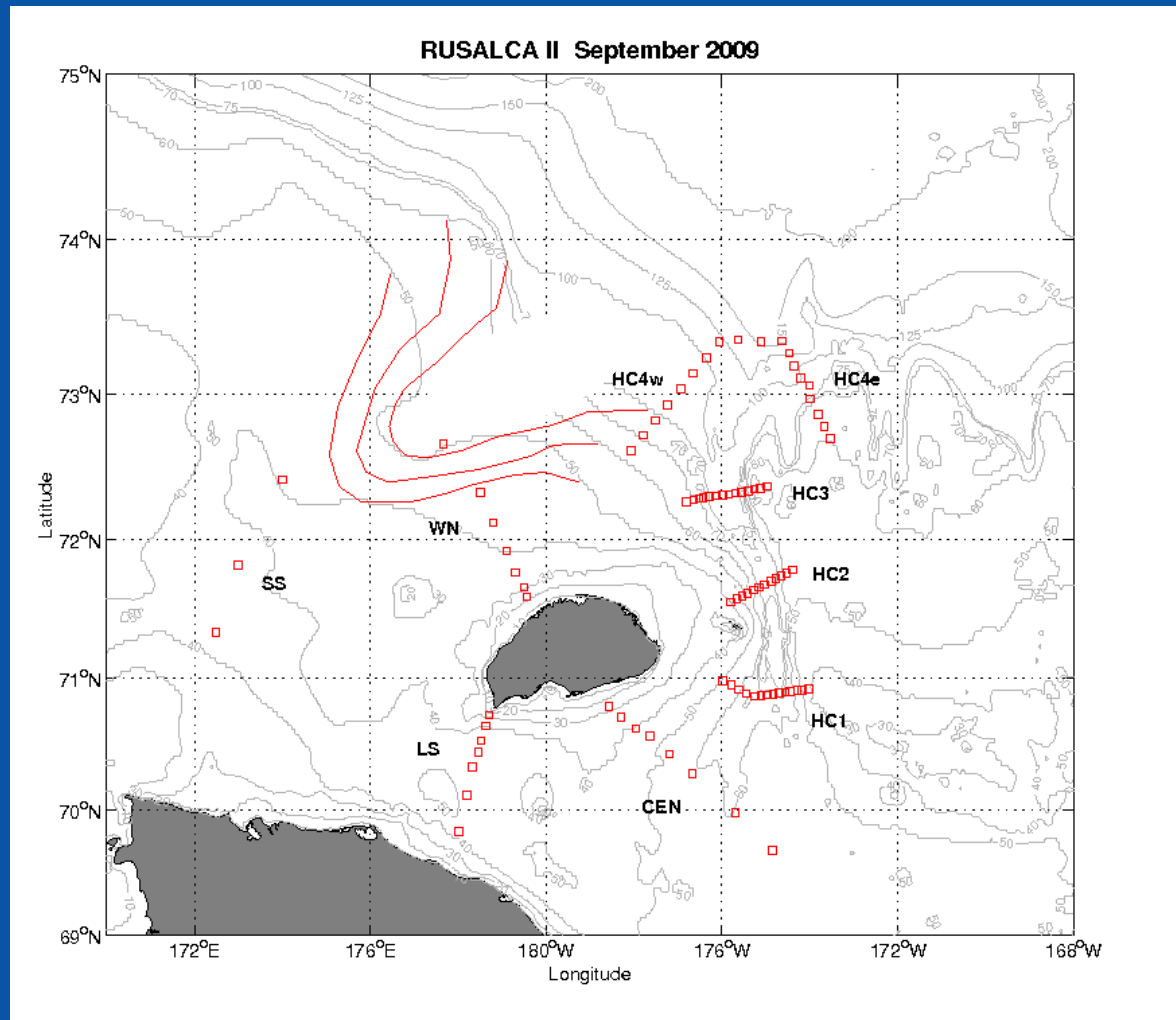






## Cold Water

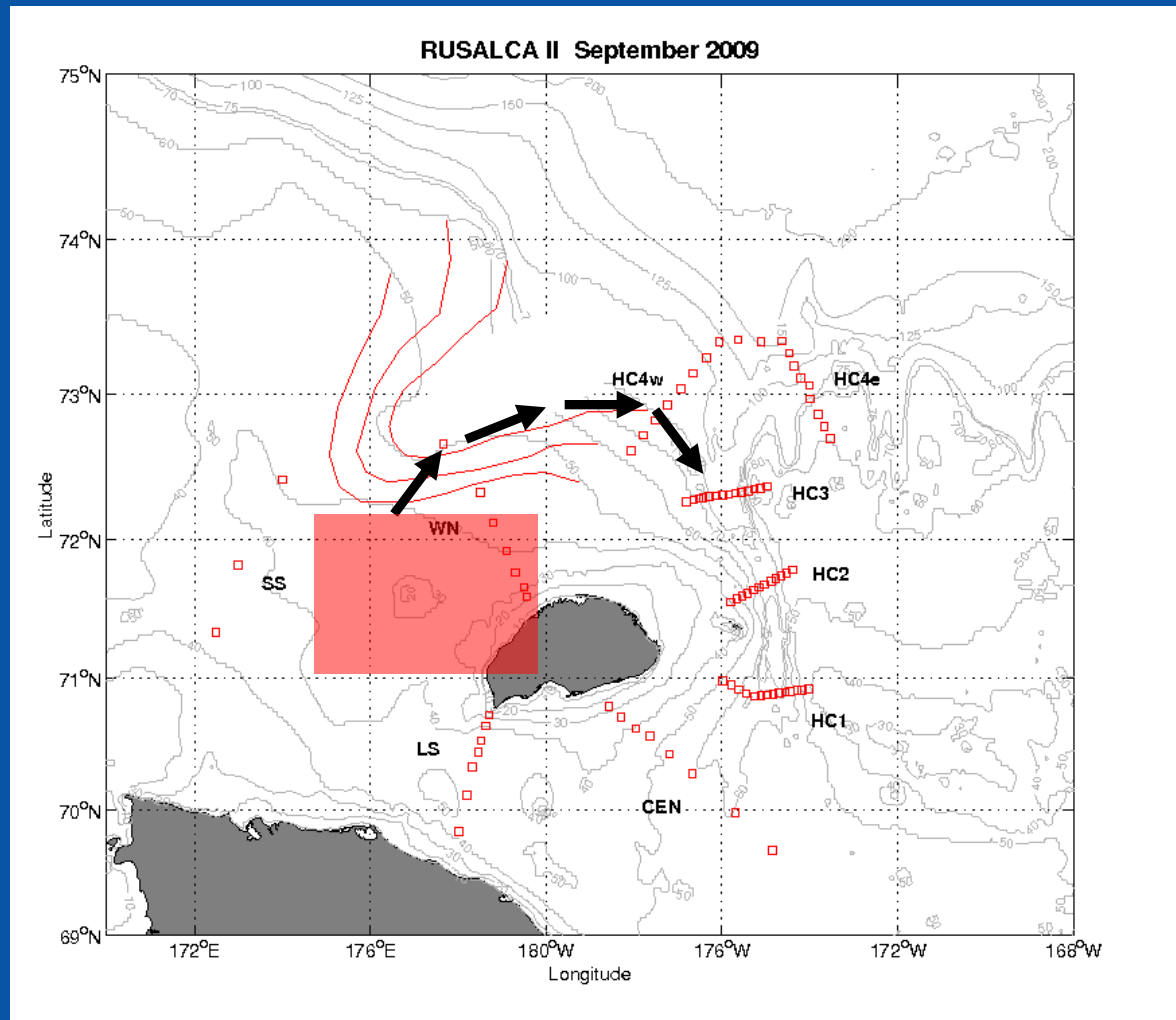
Uncharted canyon?



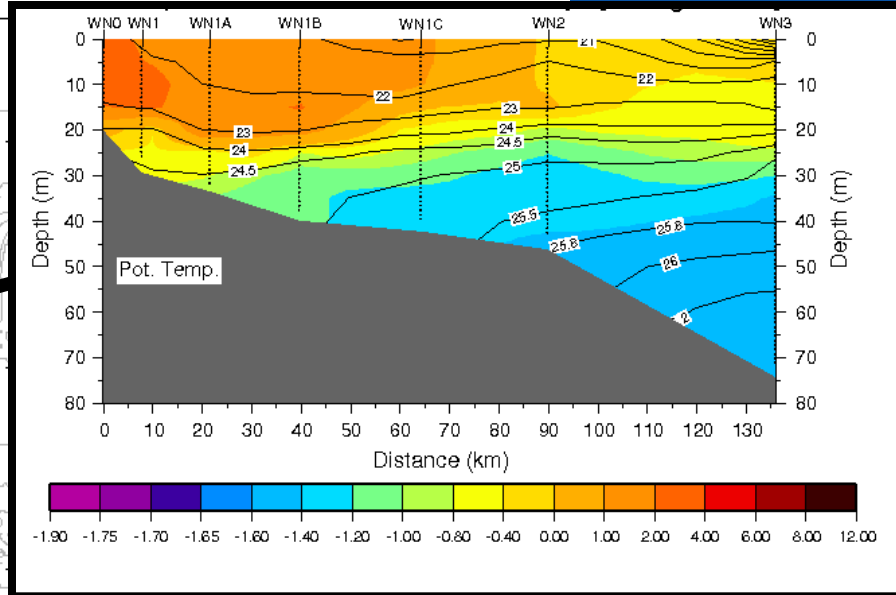
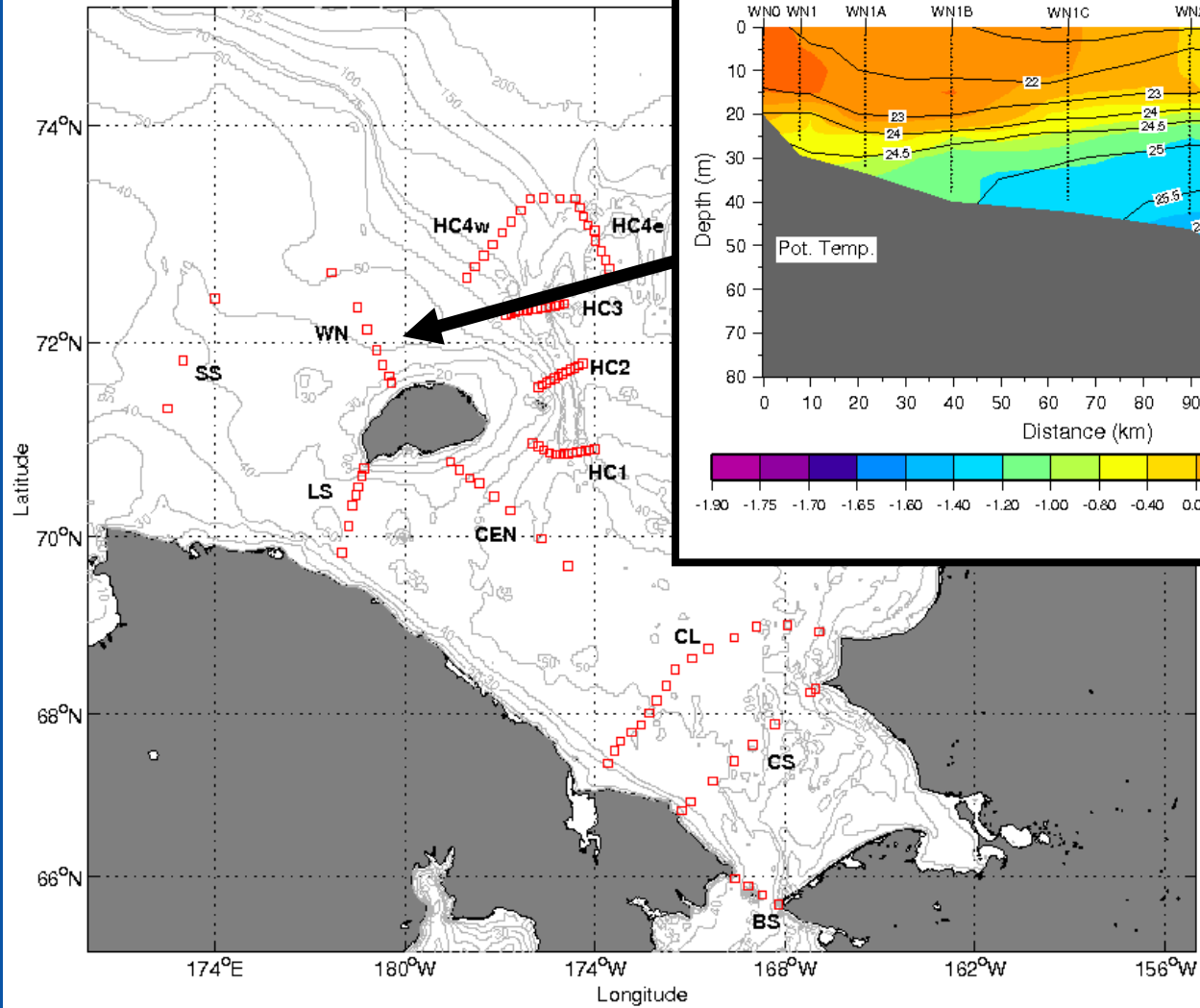


## Cold Water

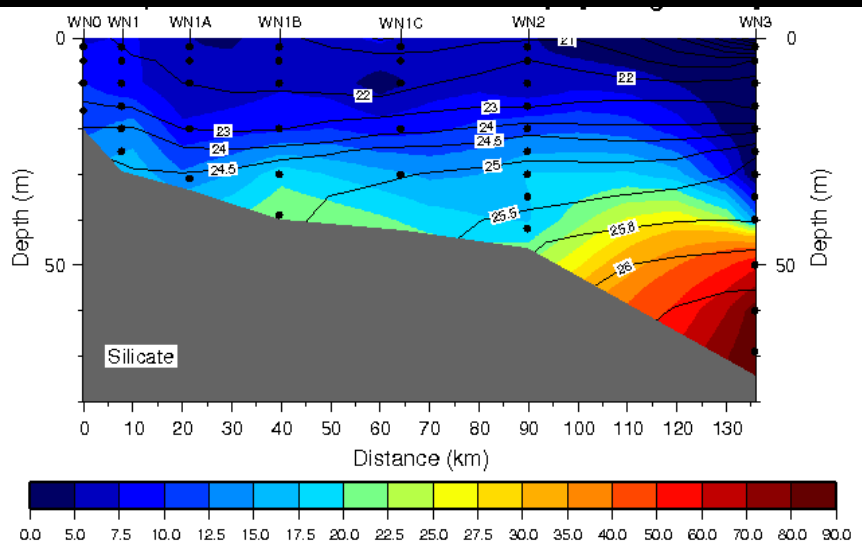
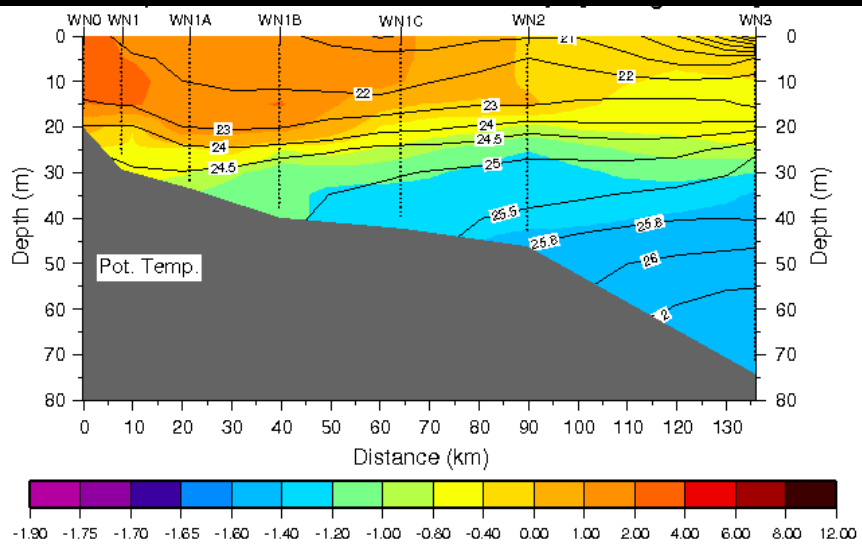
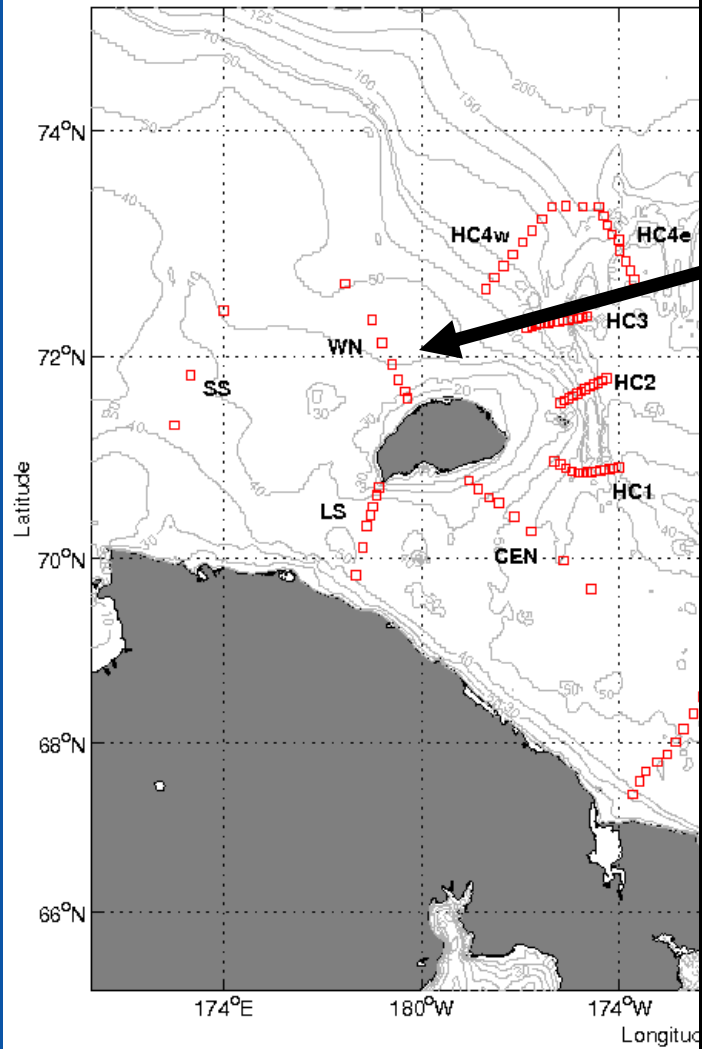
Uncharted canyon?



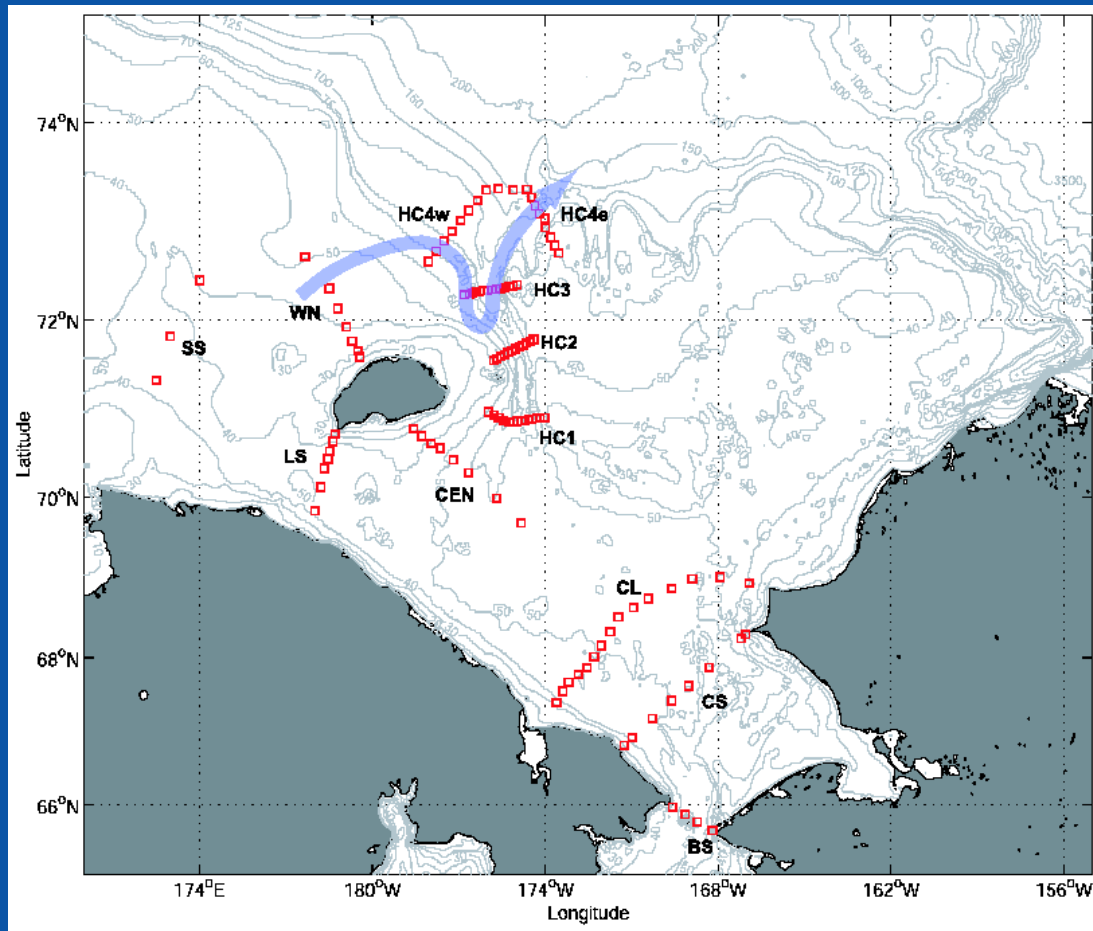
# RUSALCA II September 2009



# RUSALCA II September 2009

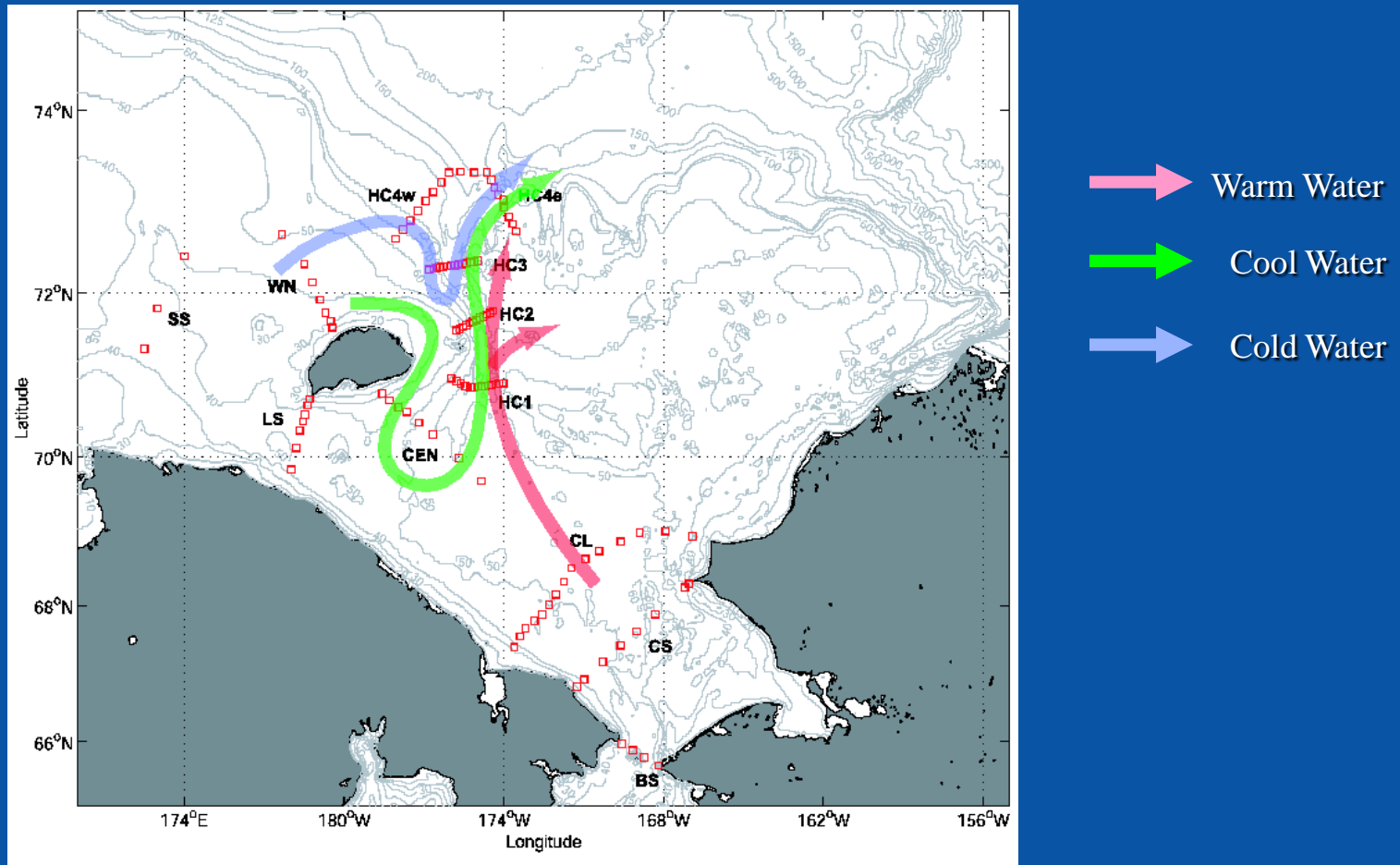


## Schematic circulation



→ Cold Water

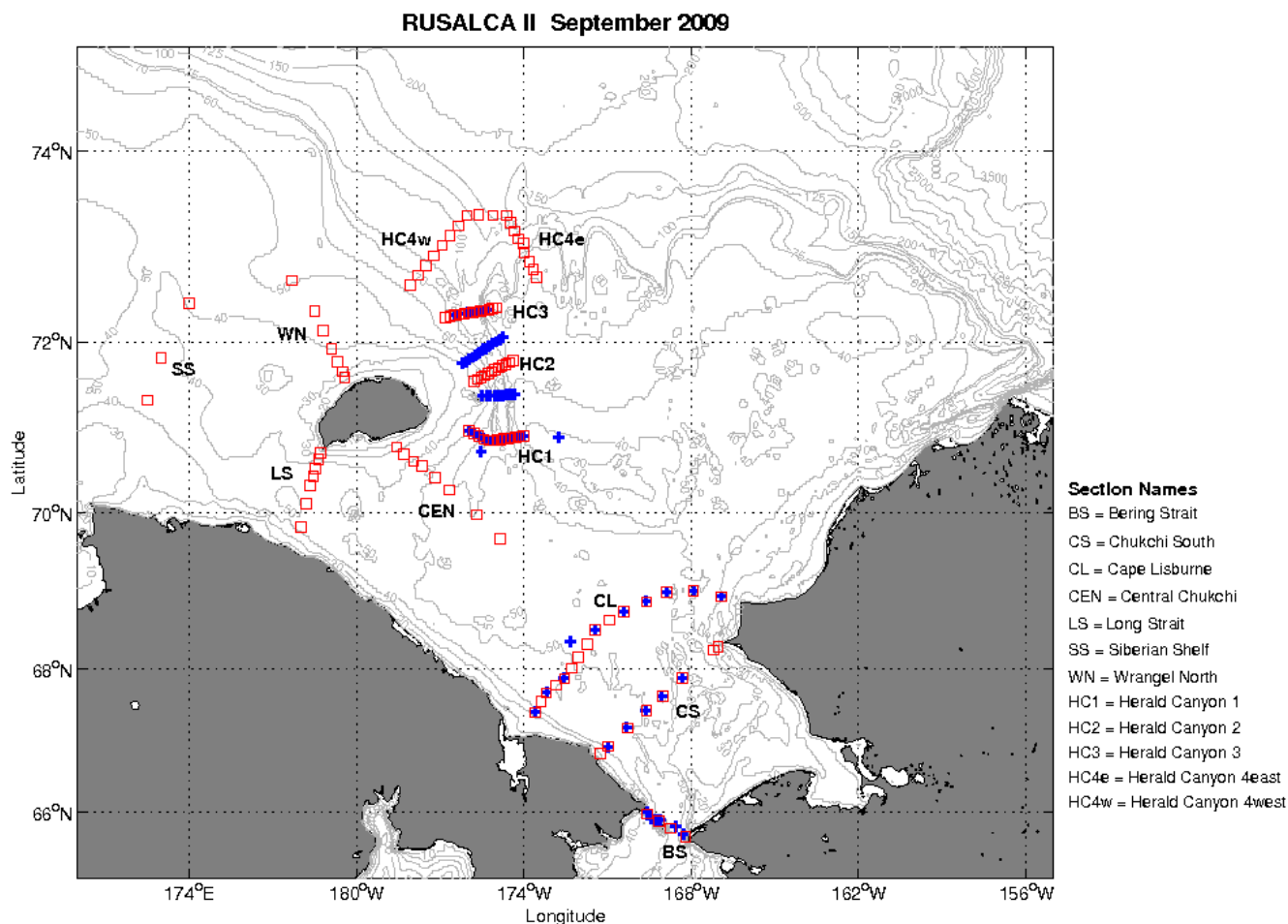
# Schematic circulation

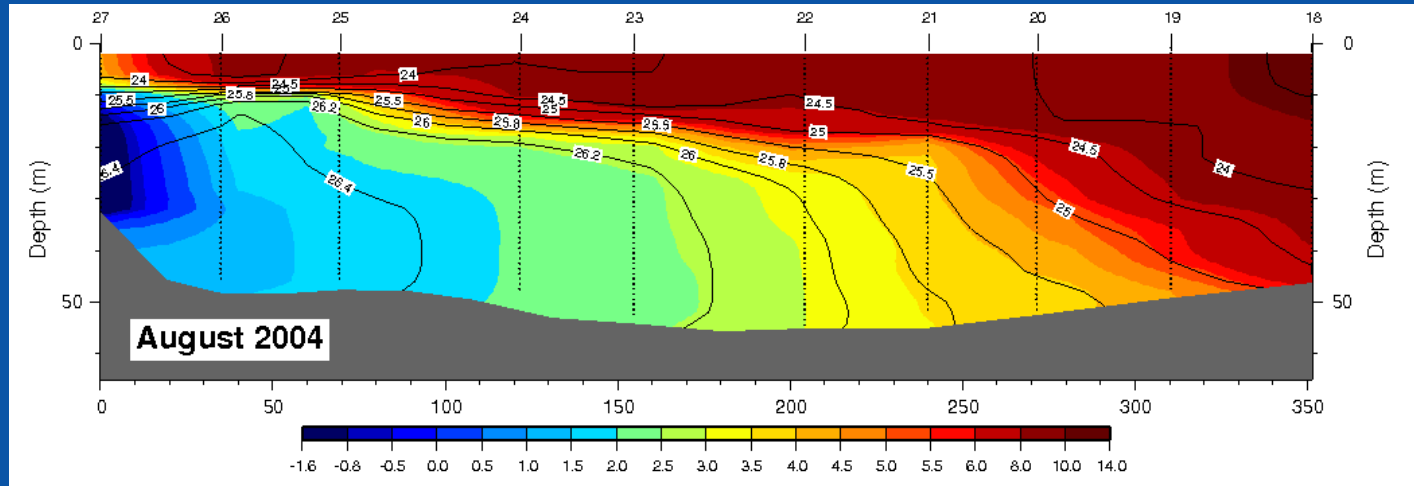




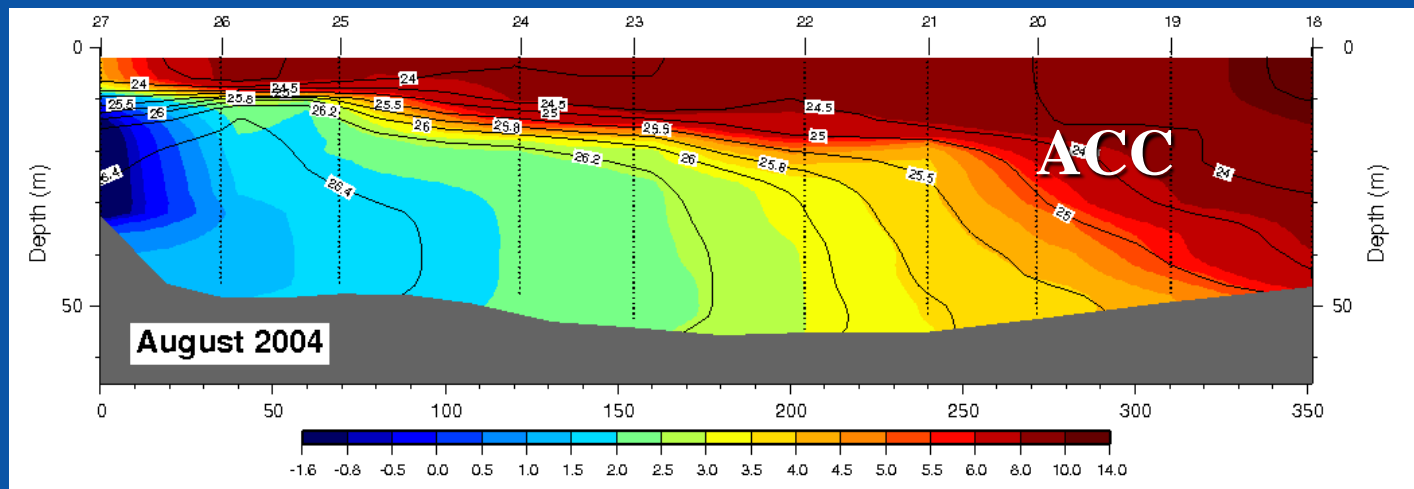
# RUSALCA 2004 vs. 2009: Interannual variability?

2004: blue  
2009: red

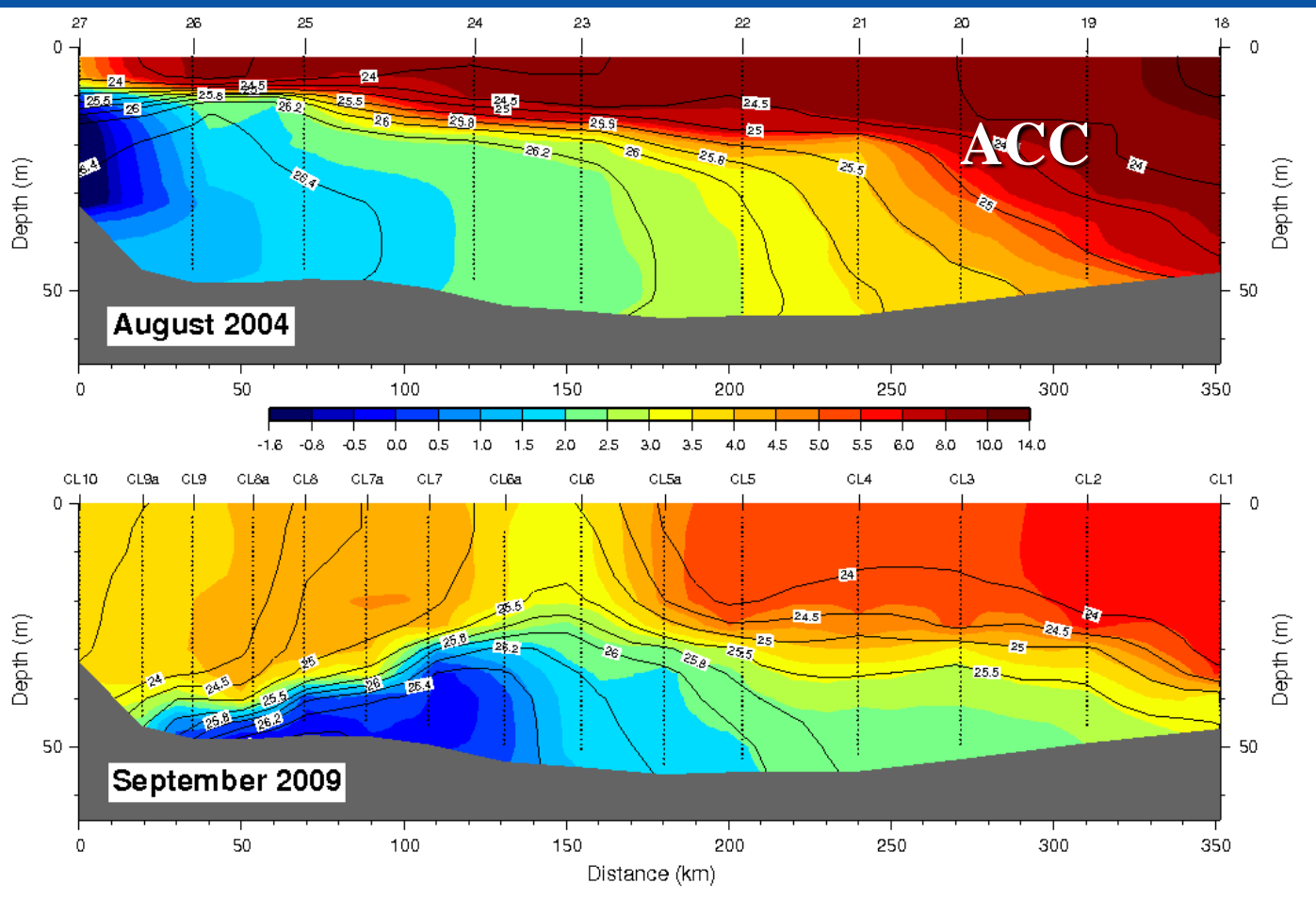




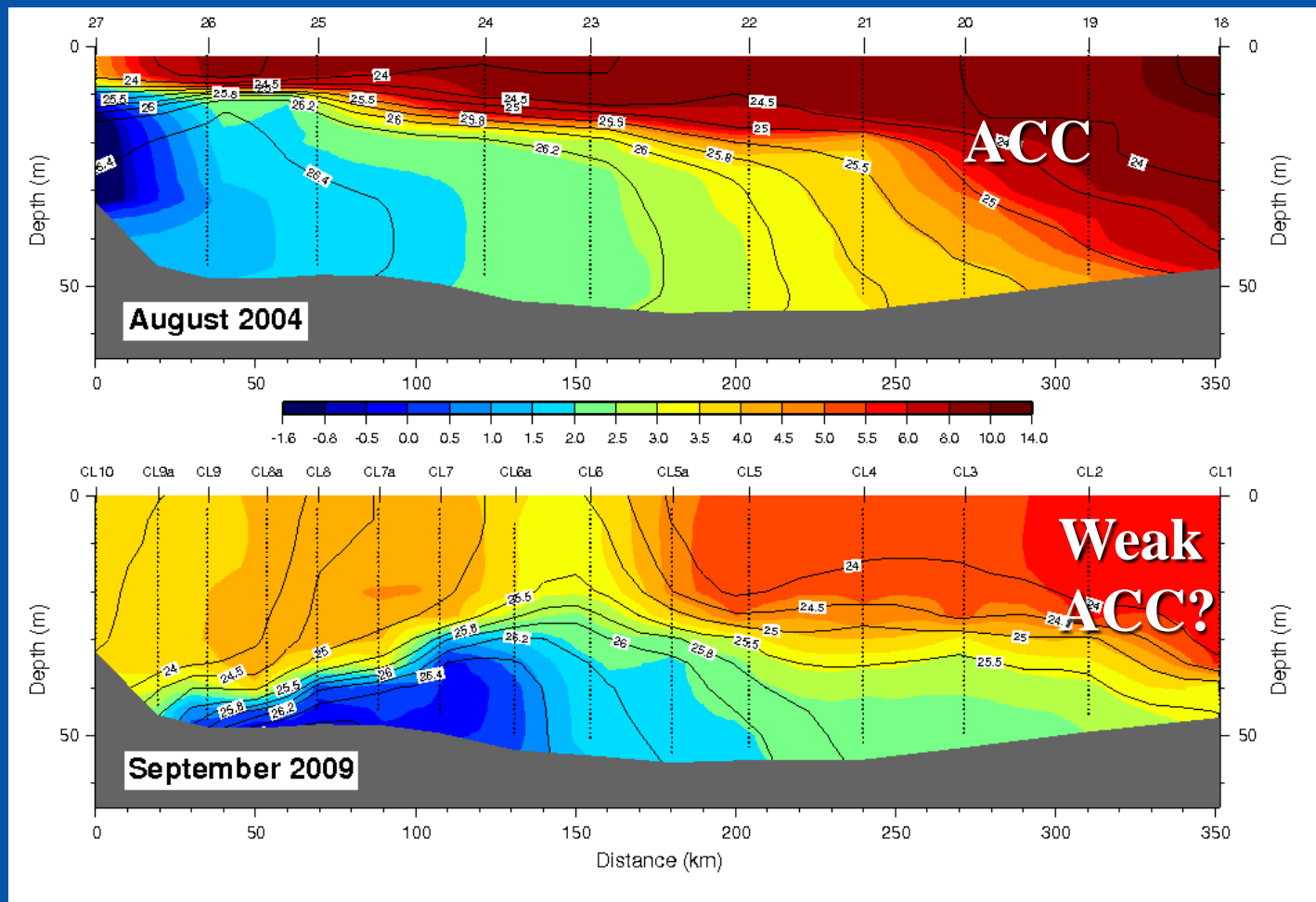
## Cape Lisburne section...temperature



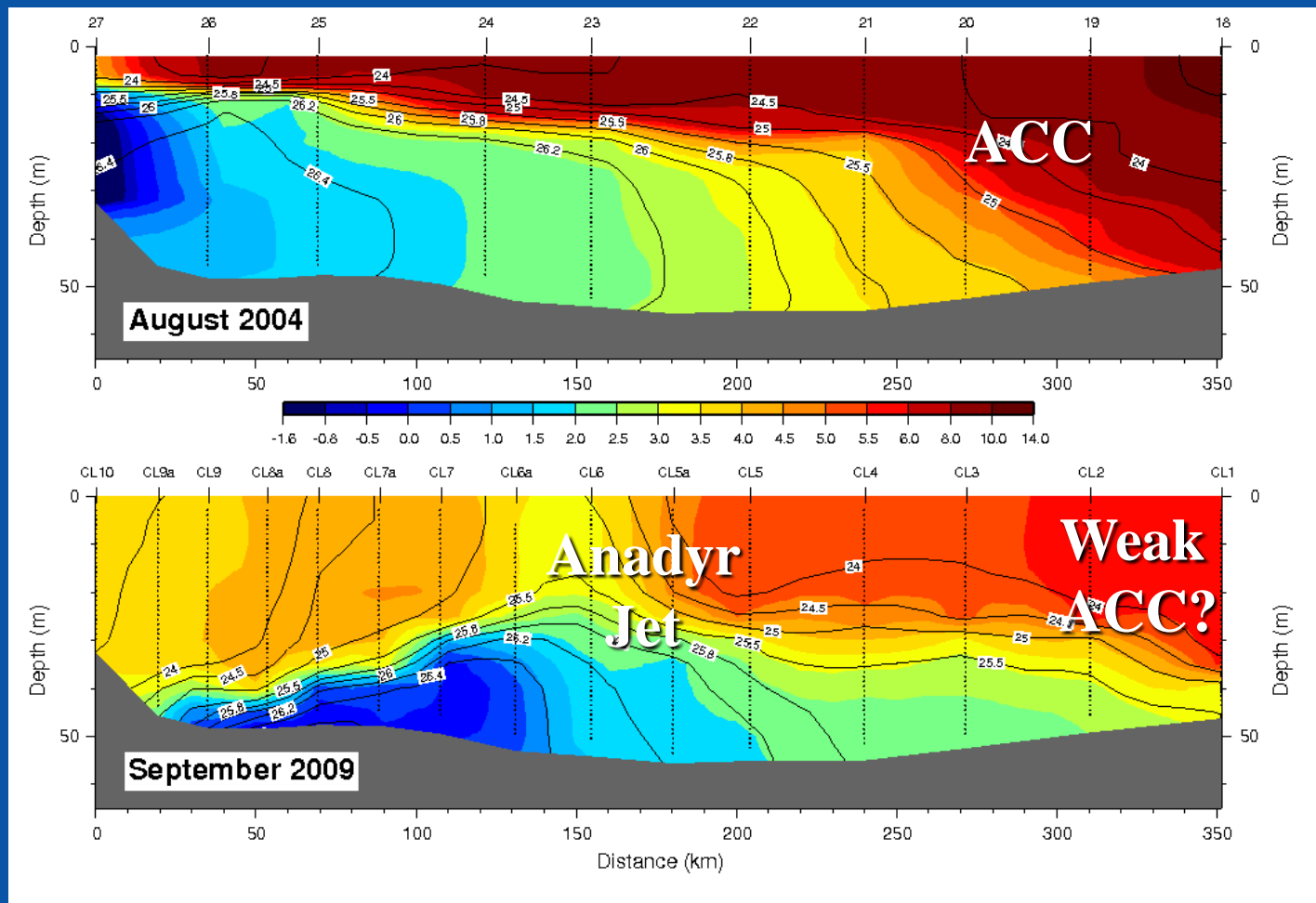
# Cape Lisburne section...temperature



# Cape Lisburne section...temperature

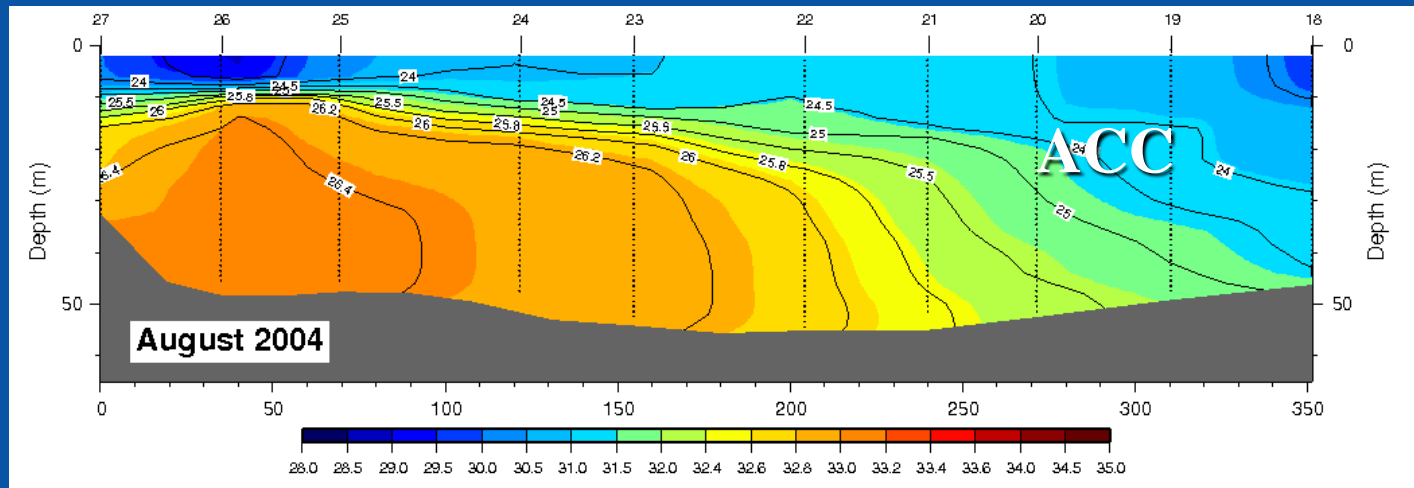


# Cape Lisburne section...temperature

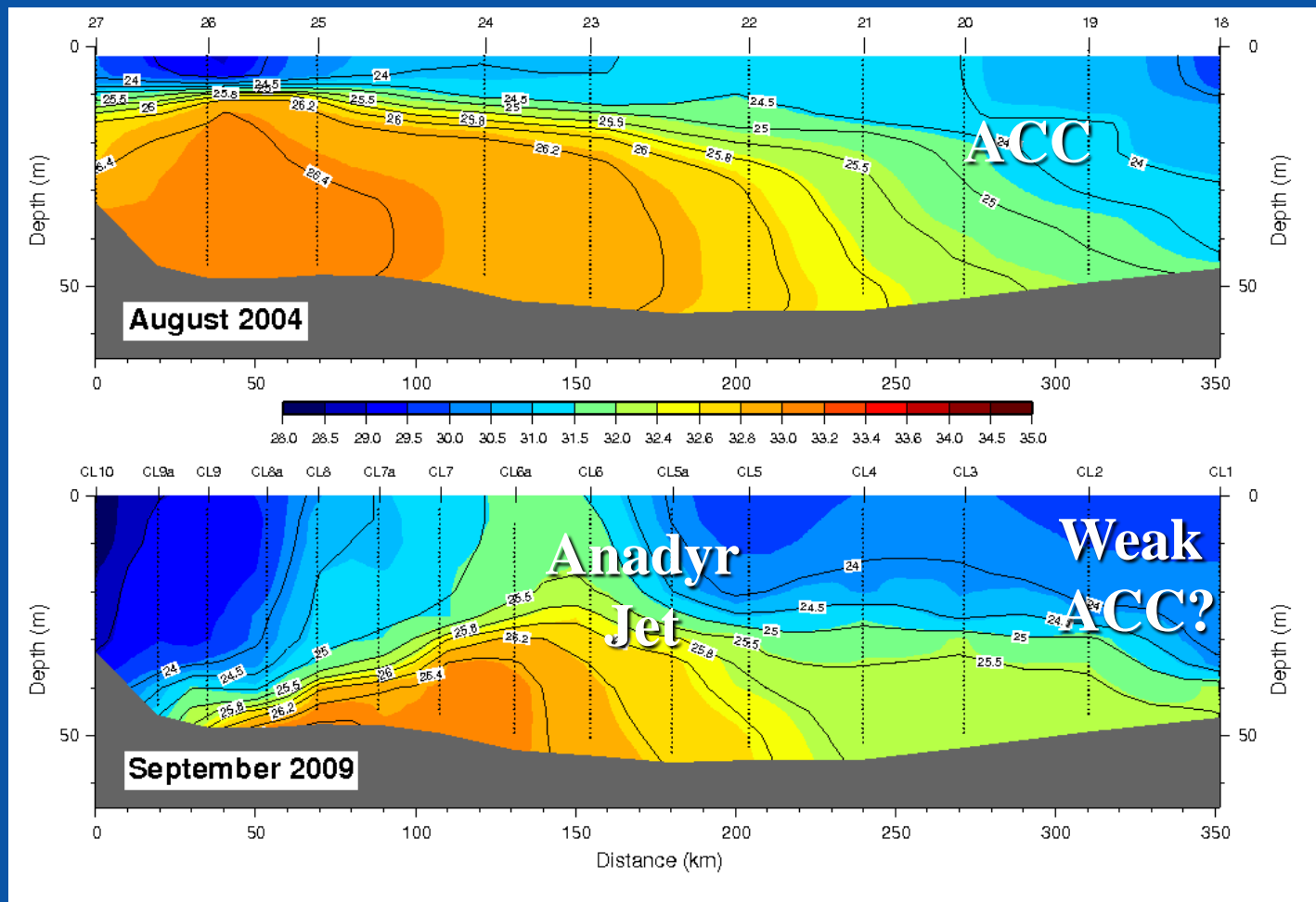




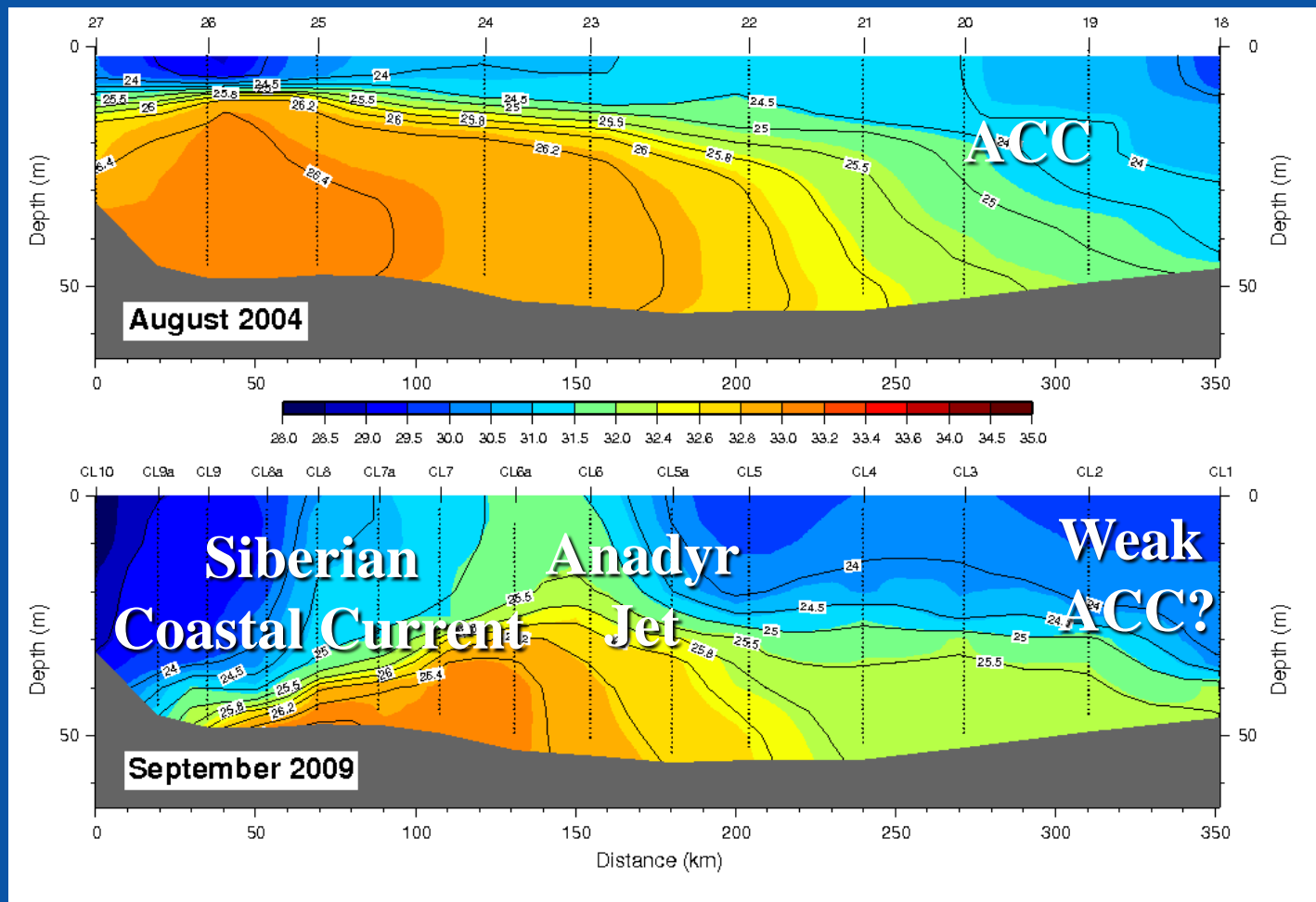
## Cape Lisburne section...salinity



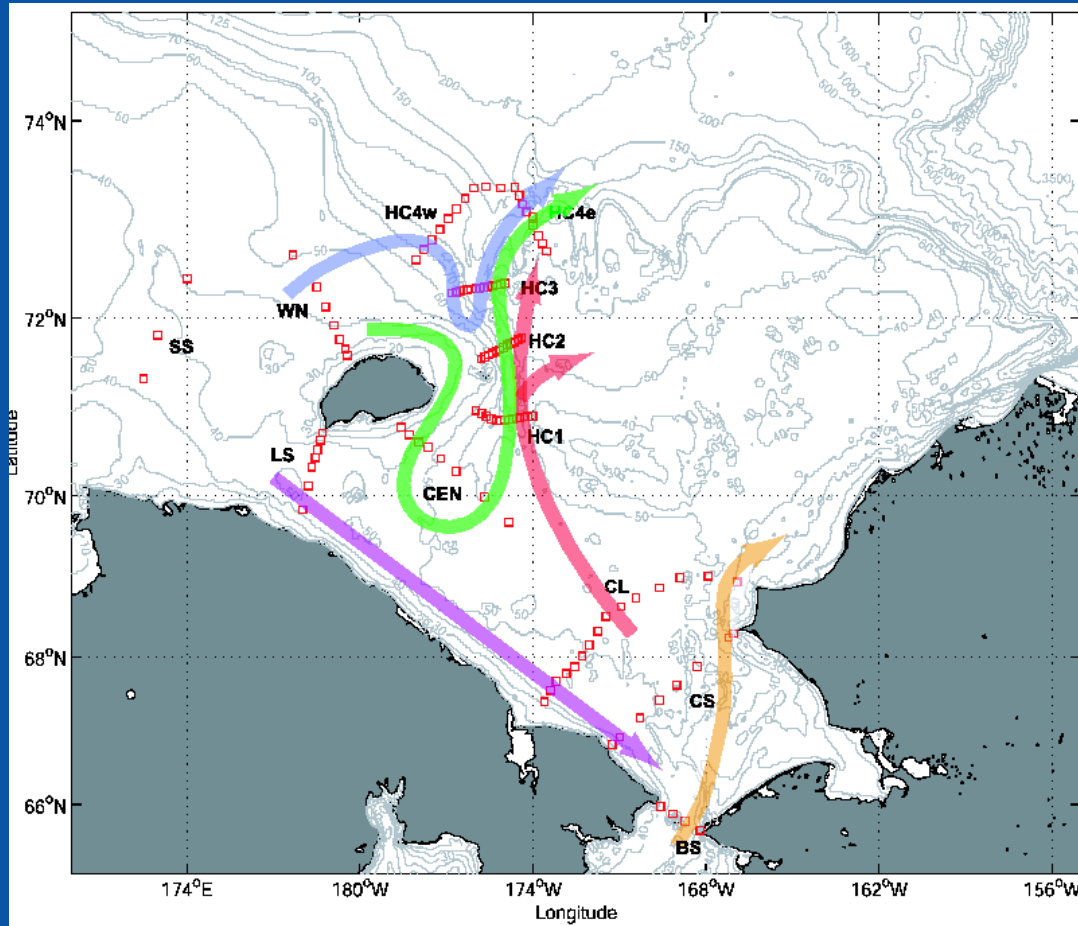
# Cape Lisburne section...salinity








# Cape Lisburne section...salinity



# Schematic circulation



-  Warm Water
-  Cool Water
-  Cold Water
-  SCC
-  ACC



## **Summary of 2004 RUSALCA Herald Canyon survey**

- 1. Winter water was likely formed locally near Wrangel Island, feeding into Herald Canyon adjacent to the summer water from Bering Strait.**
- 2. The winter water switched sides of the canyon and mixed with the summer water to form a new transport mode entering the basin.**
- 3. A portion of the summer water appears to have been shunted to the east into the central Chukchi shelf.**



## Summary of 2009 RUSALCA Herald Canyon survey

1. Winter water was likely formed locally near Wrangel Island, feeding into Herald Canyon adjacent to the summer water from Bering Strait. **Same in 2009, except that it was winter remnant water (later in season).**
2. The winter water switched sides of the canyon and mixed with the summer water to form a new transport mode entering the basin.
3. A portion of the summer water appears to have been shunted to the east into the central Chukchi shelf.





## Summary of 2009 RUSALCA Herald Canyon survey

1. Winter water was likely formed locally near Wrangel Island, feeding into Herald Canyon adjacent to the summer water from Bering Strait. **Same in 2009, except that it was winter remnant water (later in season).**
2. The winter water switched sides of the canyon and mixed with the summer water to form a new transport mode entering the basin. **Switched sides again in 2009, don't know yet if a new mode was formed.**
3. A portion of the summer water appears to have been shunted to the east into the central Chukchi shelf.



## Summary of 2009 RUSALCA Herald Canyon survey

1. Winter water was likely formed locally near Wrangel Island, feeding into Herald Canyon adjacent to the summer water from Bering Strait. **Same in 2009, except that it was winter remnant water (later in season).**
2. The winter water switched sides of the canyon and mixed with the summer water to form a new transport mode entering the basin. **Switched sides again in 2009, don't know yet if a new mode was formed.**
3. A portion of the summer water appears to have been shunted to the east into the central Chukchi shelf. **Same in 2009.**



## Summary of 2009 RUSALCA Herald Canyon survey

1. Winter water was likely formed locally near Wrangel Island, feeding into Herald Canyon adjacent to the summer water from Bering Strait. **Same in 2009, except that it was winter remnant water (later in season).**
2. The winter water switched sides of the canyon and mixed with the summer water to form a new transport mode entering the basin. **Switched sides again in 2009, don't know yet if a new mode was formed.**
3. A portion of the summer water appears to have been shunted to the east into the central Chukchi shelf. **Same in 2009.**
4. **Discovered a new area/mechanism for winter water to drain from the Wrangel Island region into the mouth of Herald Canyon from the west.**



## Summary of 2009 RUSALCA Herald Canyon survey

1. Winter water was likely formed locally near Wrangel Island, feeding into Herald Canyon adjacent to the summer water from Bering Strait. **Same in 2009, except that it was winter remnant water (later in season).**
2. The winter water switched sides of the canyon and mixed with the summer water to form a new transport mode entering the basin. **Switched sides again in 2009, don't know yet if a new mode was formed.**
3. A portion of the summer water appears to have been shunted to the east into the central Chukchi shelf. **Same in 2009.**
4. **Discovered a new area/mechanism for winter water to drain from the Wrangel Island region into the mouth of Herald Canyon from the west.**
5. **Differences in 2009: Marked seasonal change, plus presence of strong Anadyr jet and Siberian Coastal Current.**



## Final thoughts

1. **Velocity data need to be analyzed (processing is almost done).**
2. **What specific hydrographic analyses can help the other RUSALCA components?**
3. **Need to do some thinking about the timing of the 2012 cruise. (e.g. seasonal consistency?)**

A high-resolution photograph of a vast expanse of pancake ice in the Chukchi Sea. The ice consists of numerous flat, irregular floes of varying sizes, some showing concentric growth rings. The floes are closely packed, creating a textured surface. The water between the floes is a deep, dark blue, contrasting with the lighter, translucent blue of the ice. The overall scene is captured from an elevated perspective, showing the repetitive pattern of the ice floes stretching towards the horizon.

# Thank You

**Pancake ice as seen from the Professor Khromov  
Chukchi Sea, September 2009 (Photo by D. Torres)**