Davis Strait Transport and Freshwater Fluxes

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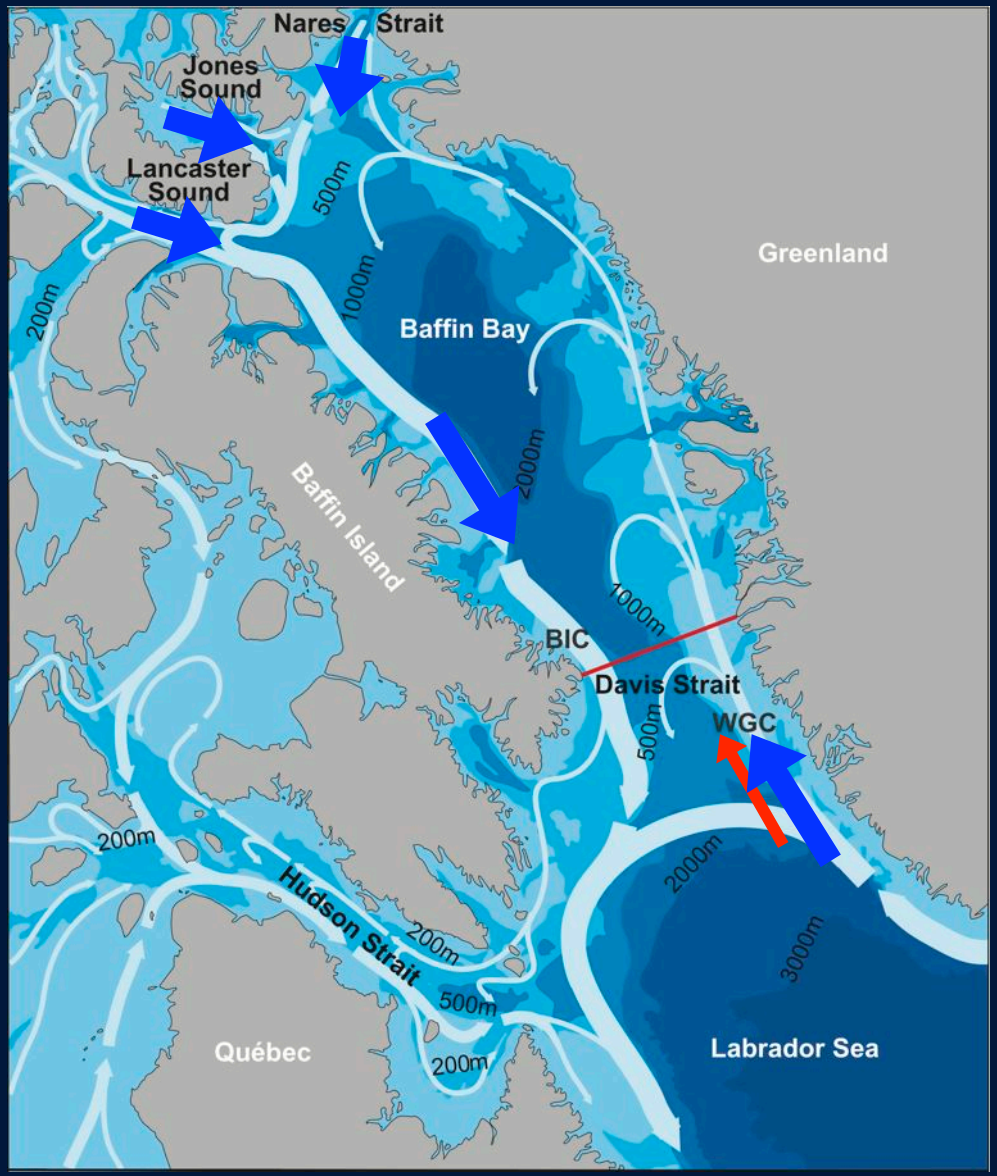
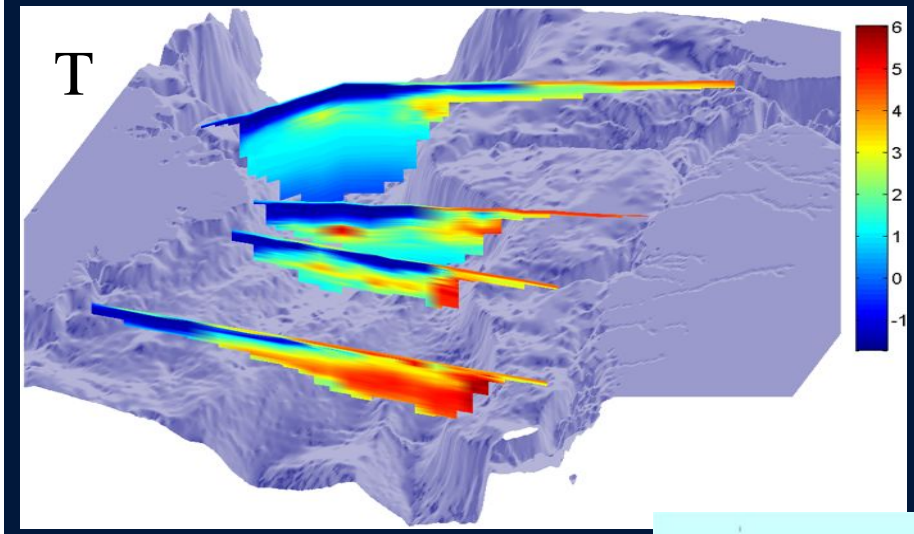


With thanks to:
Captains Colburn, Shesley & Seamans and R/V Knorr, Captain Martin and CCGS Hudson, GINR, Kunuk Lennart, Eric Boget, James Johnson, Keith Van Thiel, James Abriel, Murray Scotney, Robert Ryan and Mathieu Ouellet

Davis Strait Observing System

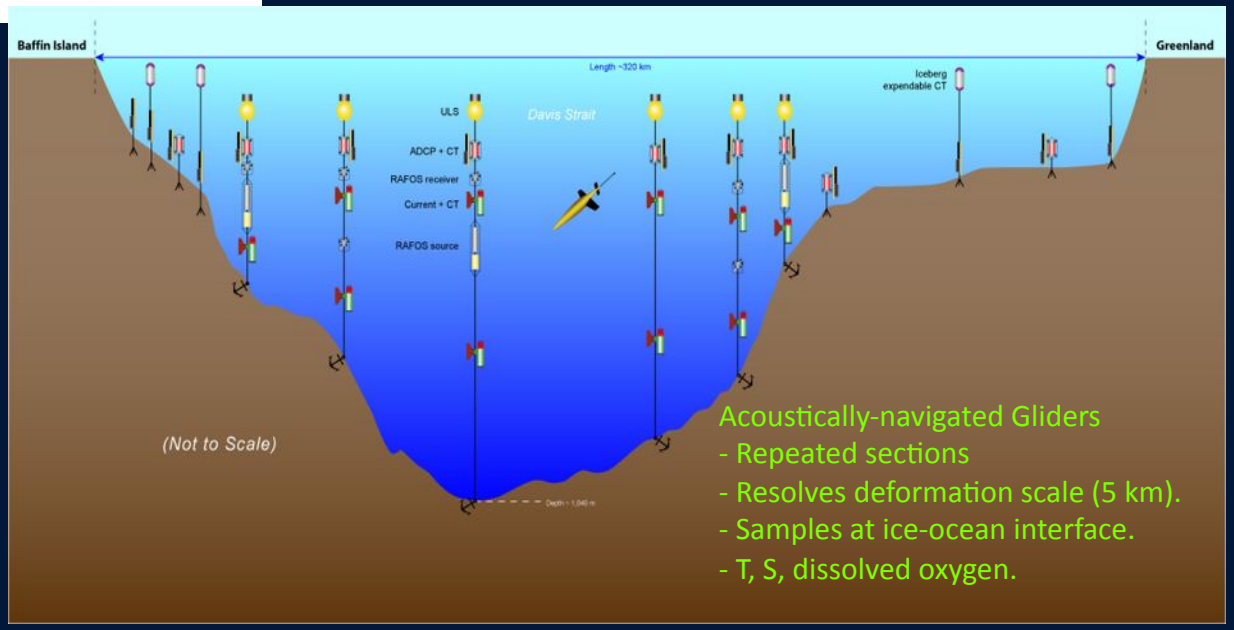


Freshwater and Arctic Gateways

- Salinity controls Arctic stratification.
- Fresh, cold layer insulates surface from warm, Atlantic layer- modulates sea ice formation.
- Arctic acts as FW source for subpolar oceans.
- FW discharge may impact deep water formation, subpolar gyre extent and strength, N. Atlantic carbon uptake, key fisheries.

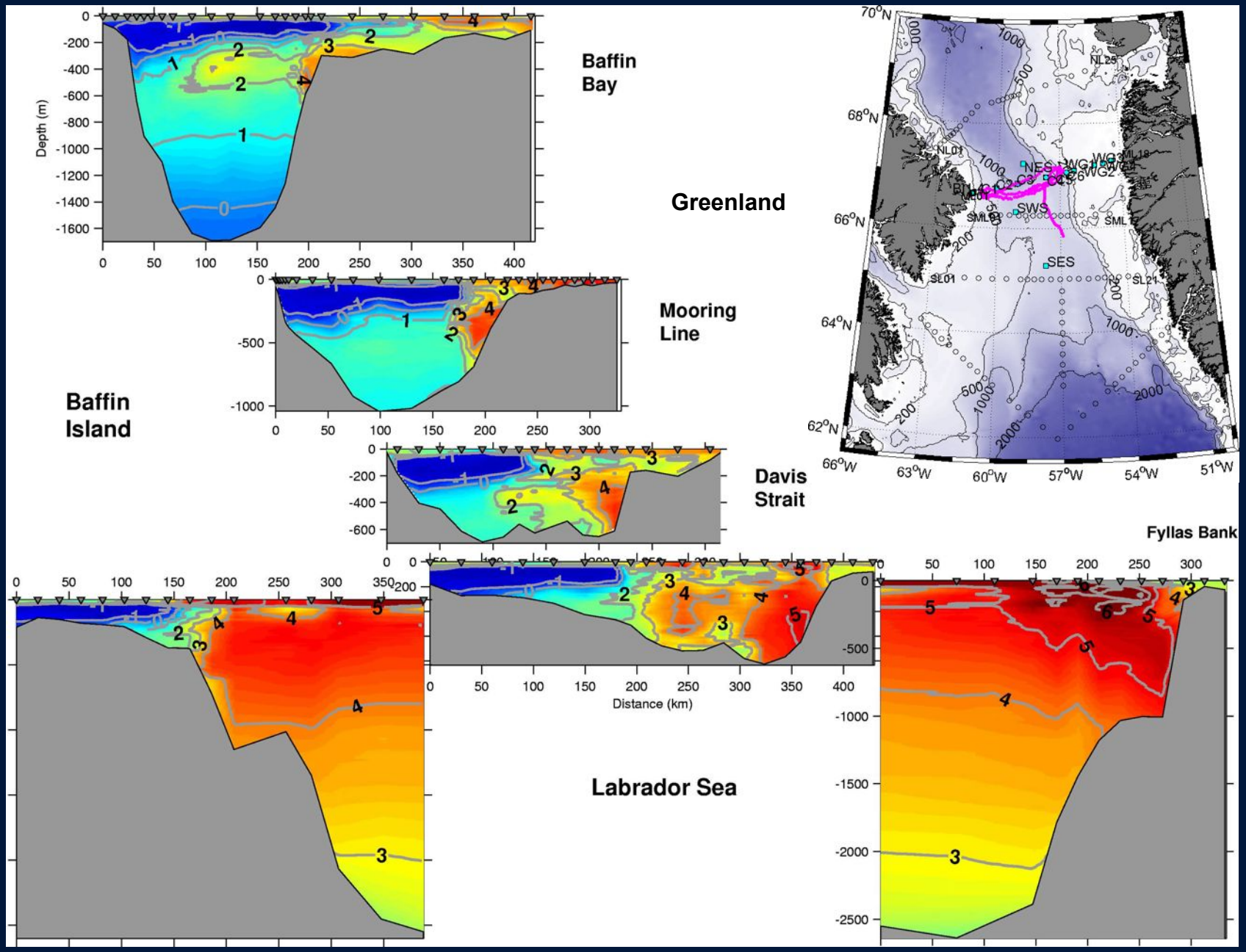
Challenges

- Small deformation scale- dynamically wide strait.
- Broad W. Greenland shelf.
- Freshwater moves in thin (~50 m) surface layer.
- Ice cover & icebergs.
- Measure at daily to weekly timescales, maintain over decade-long spans.

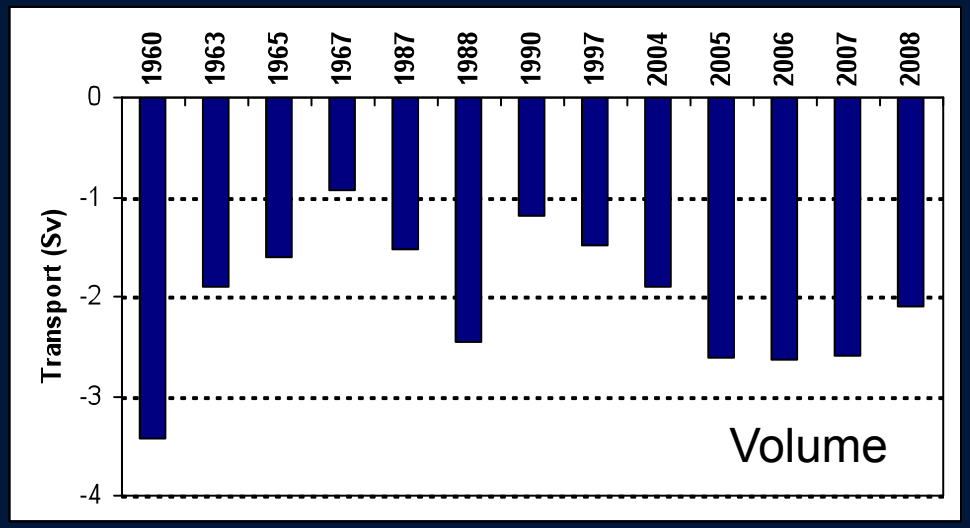


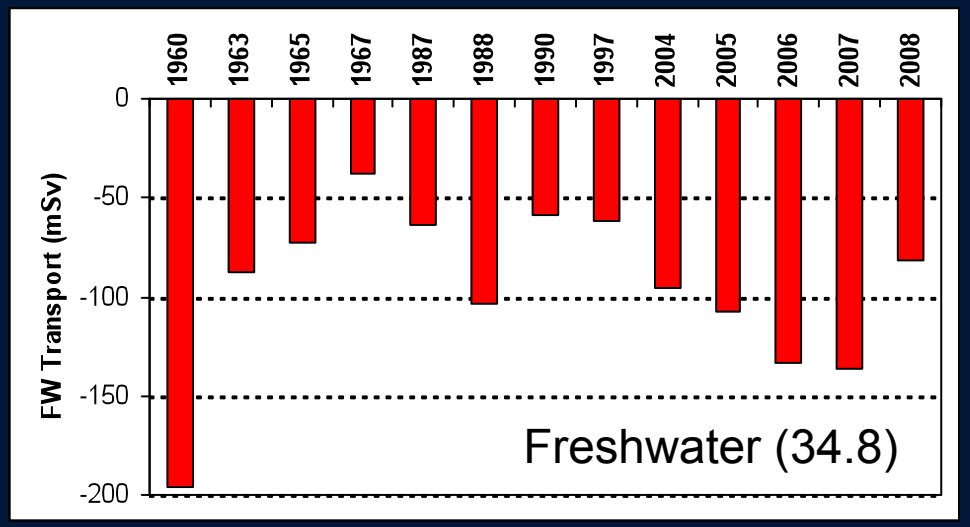
Ship-based Hydrographic Sections: Autumn. Biogeochemical tracers (nutrients, trace metals, TOC, TAlk, CFCs, oxygen isotopes. Spans broad region from S. Baffin Bay to N. Labrador Sea.

Oct 2006 Potential Temperature



Autumn Volume and FW Geostrophic Transports at Sill

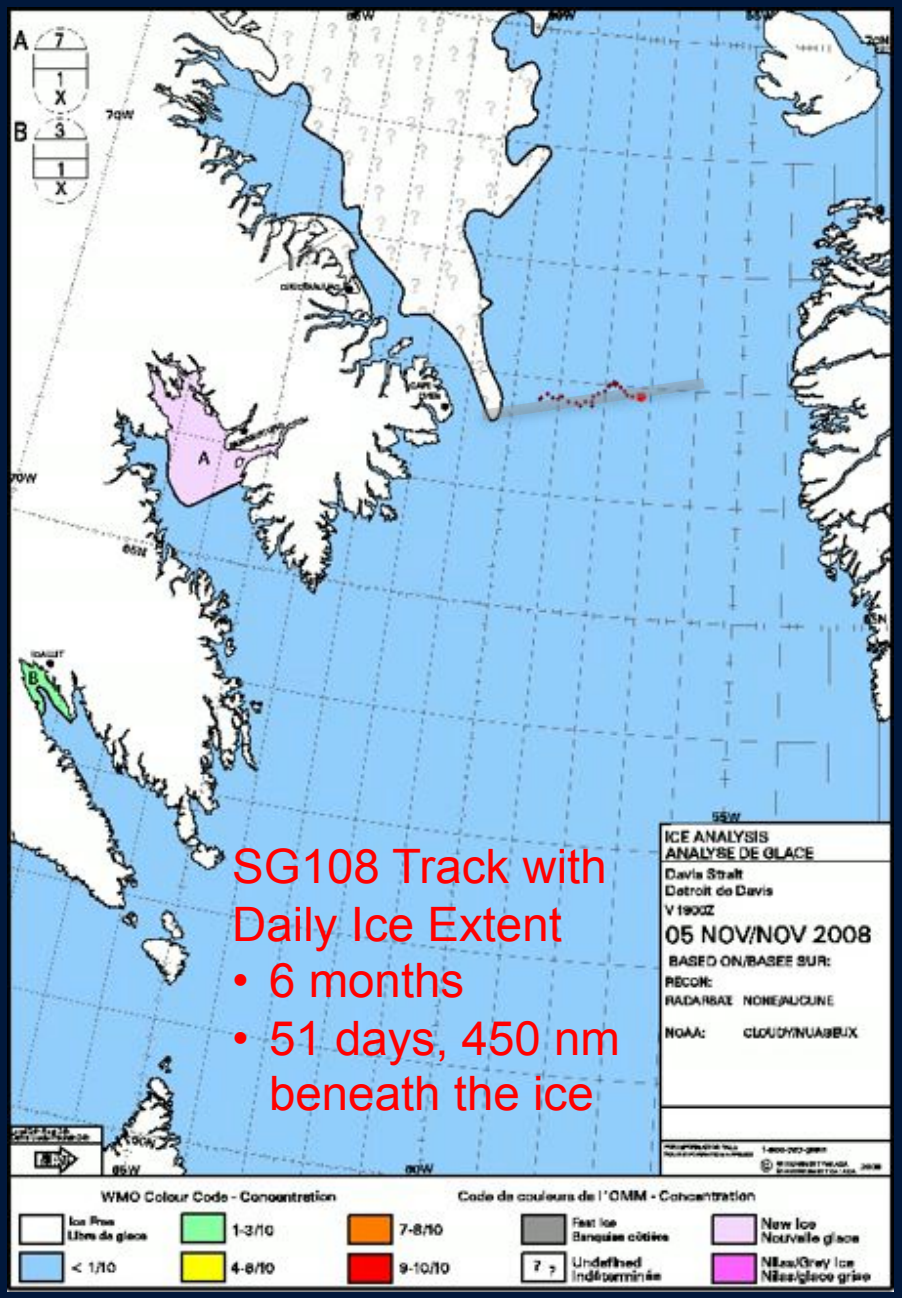




Year	Number of Stations
1960	9
1963	6
1965	8
1967	10
1987	19
1988	19
1990	18
1997	11
2004	17
2005	17
2006	17
2007	17
2008	17

Increasing fall transport 1990-2007; peak FW flux 2007, reduced 2008

Under-ice Glider Surveys

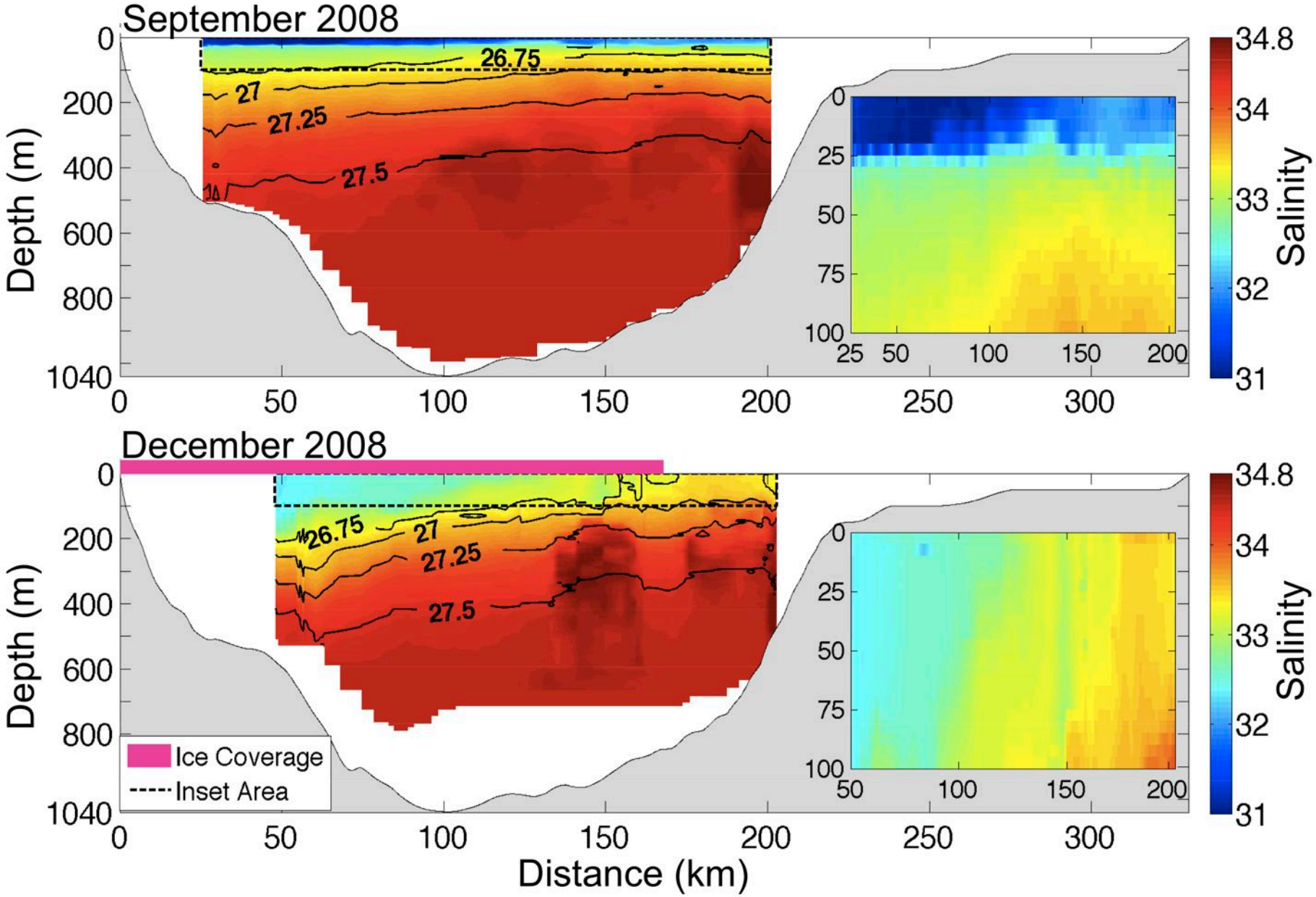


Charts Provided by Canadian Ice Service

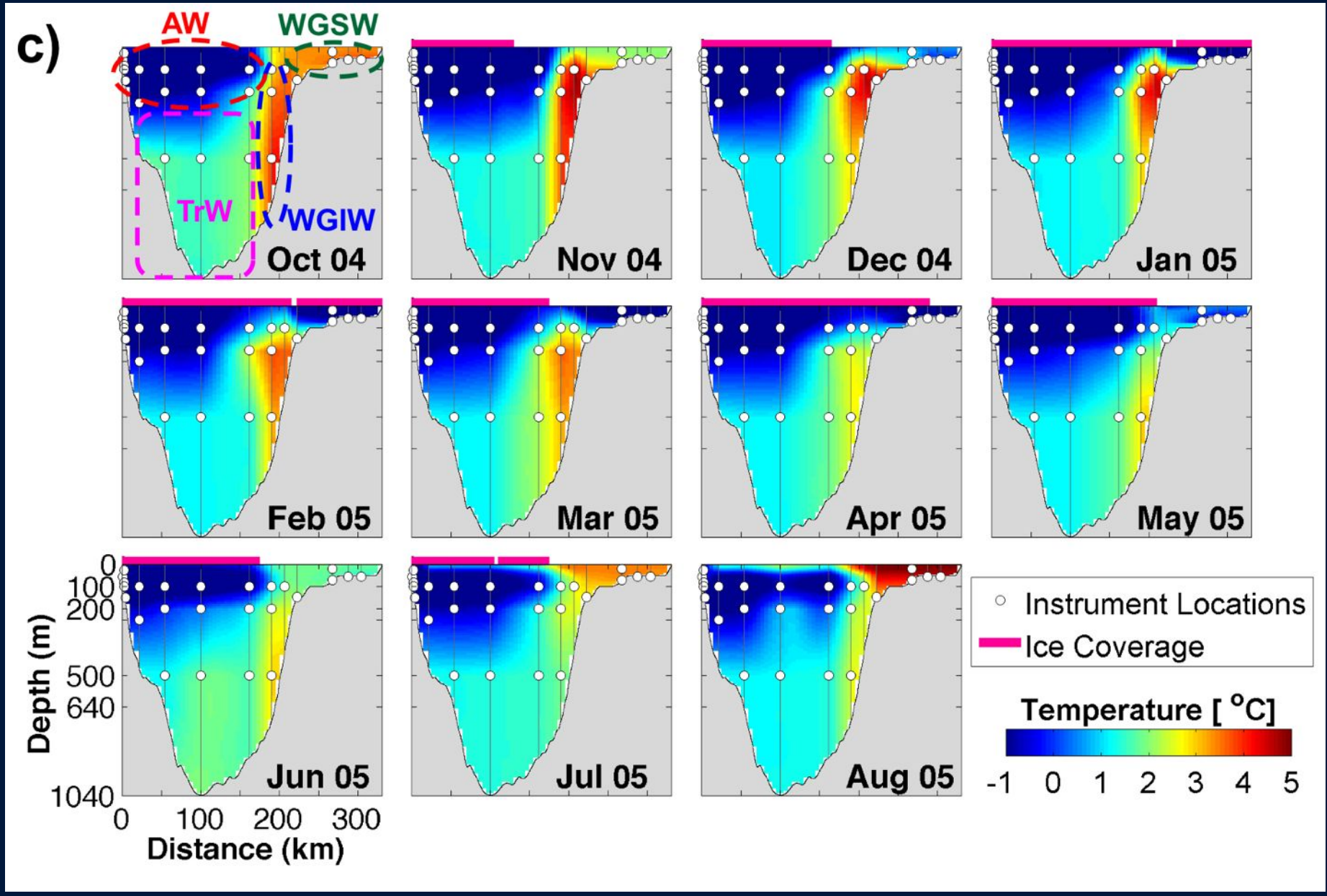
- Acoustic navigation
- Enhanced autonomy
- T, S, oxygen
- Full ice cover
- Marginal ice zone
- Scalable, flexible operations

- Arctic Missions (06, 08/09, 09/10)
  6 month max duration
  Fully-autonomous under ice ops:
  51 days, 800+ km.
  Profiles to within 5 m of ice-ocean interface.
  Utilized 8 leads (33 attempts).
- For 2010
  Extended endurance.
  More sophisticated navigation.
  Acoustic download to moored data depots.

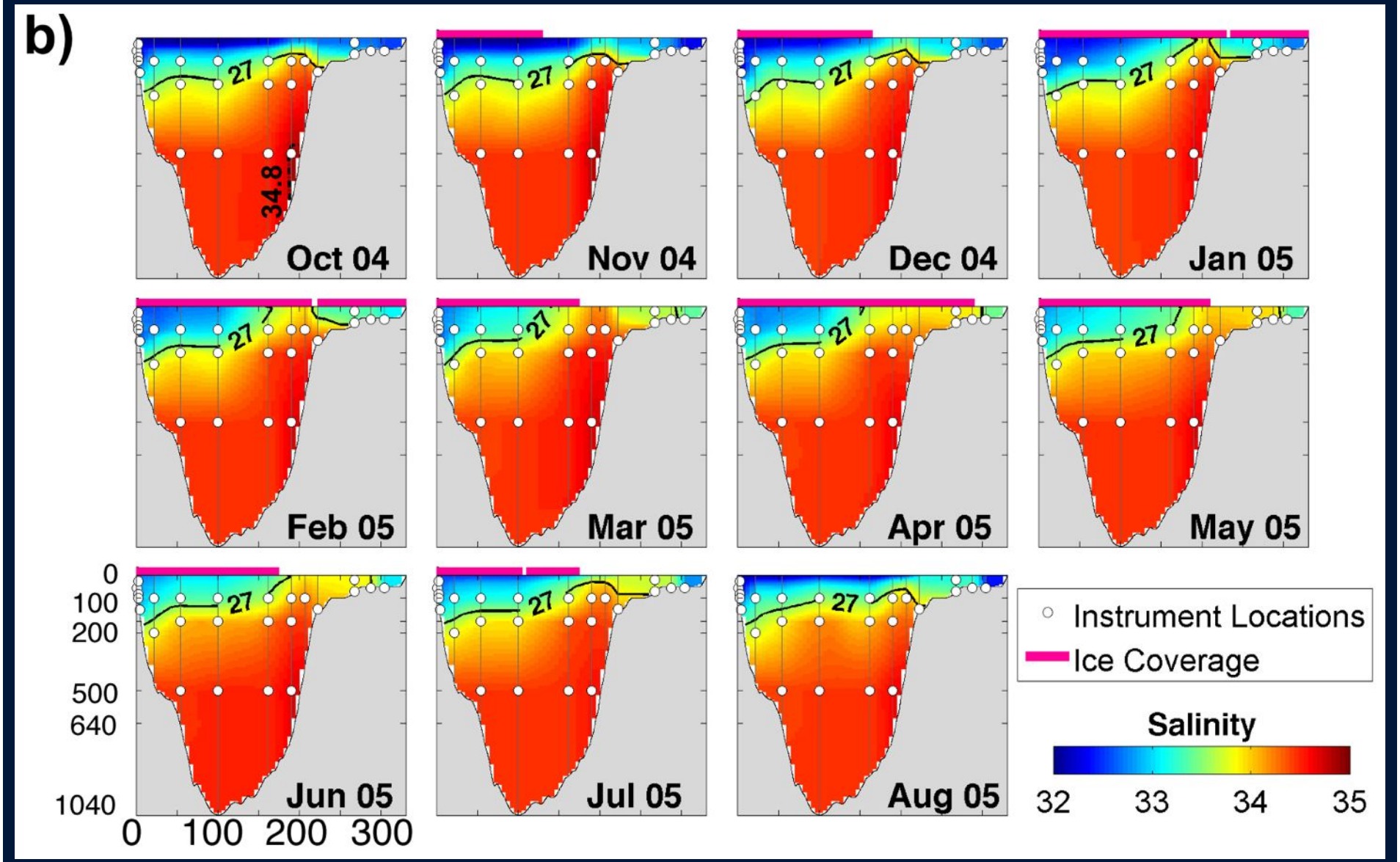
September (ice-free) and December (ice-covered) 2008



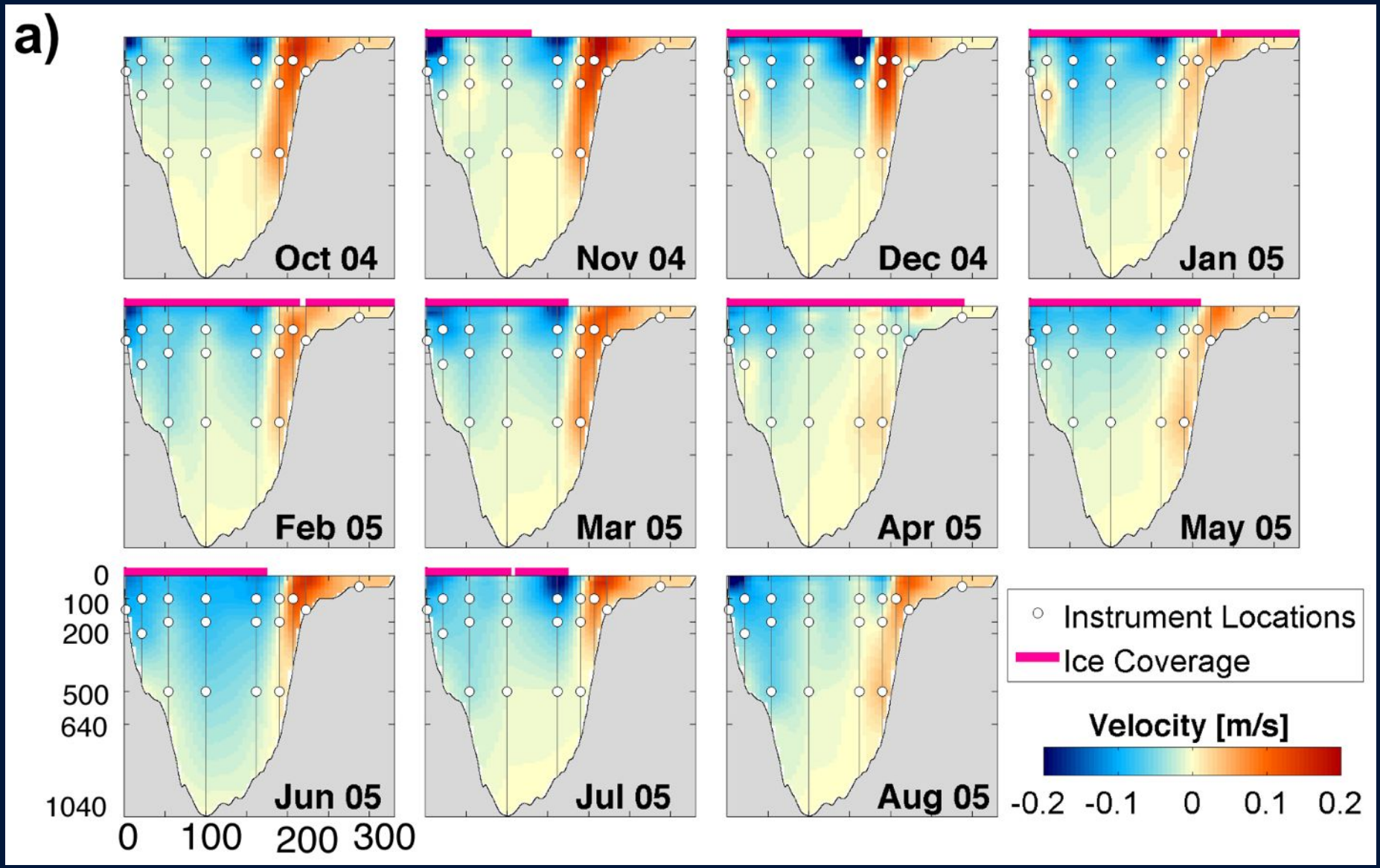
Davis Strait Monthly Mean Potential Temperature (04-05)



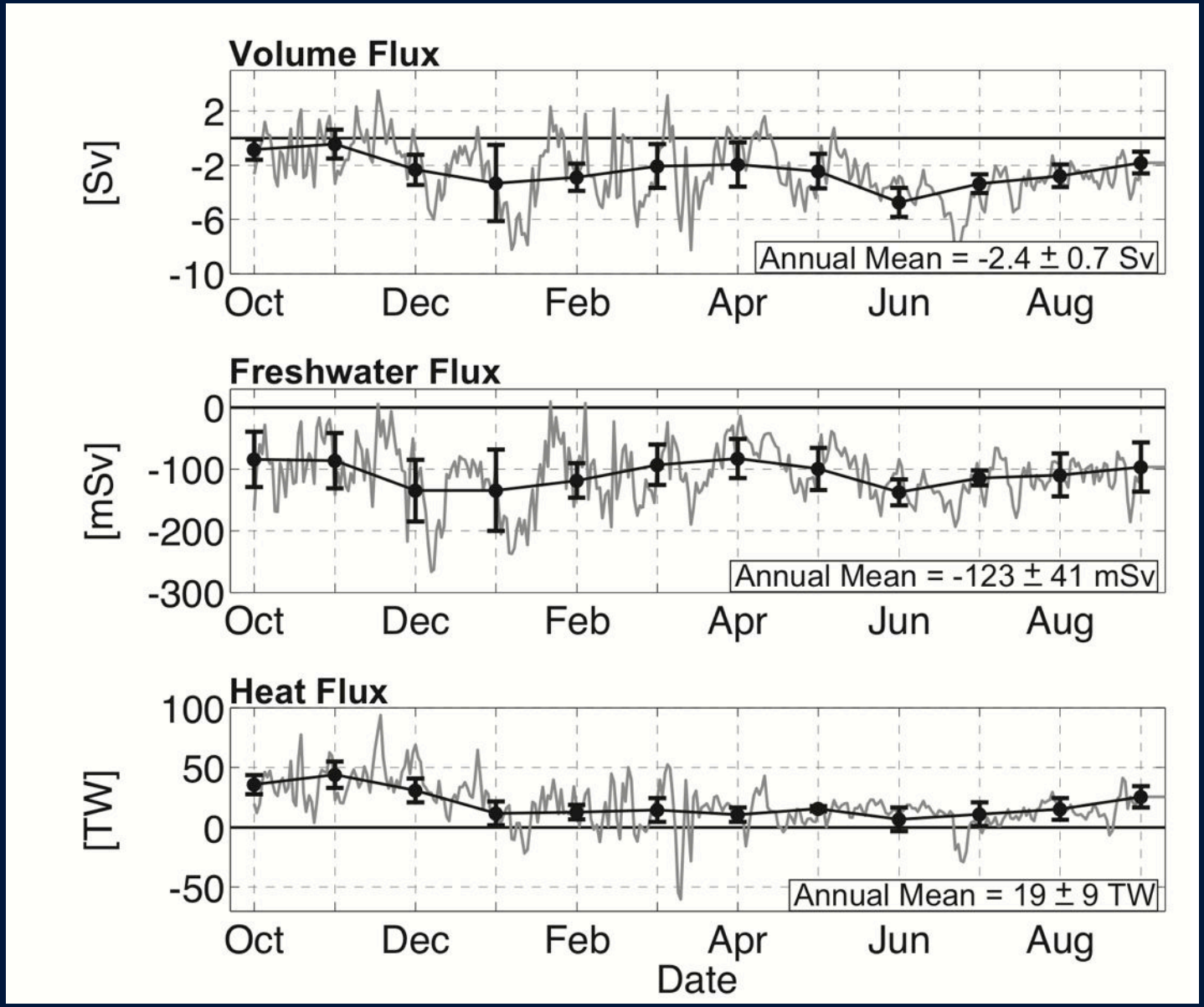
Davis Strait Monthly Mean Salinity (04-05)



Davis Strait Monthly Mean Velocity (04-05)



Davis Strait Volume, Freshwater and Heat Flux (04-05)



South Vol Flux
70% AW
30% TW
54% <150 m
0.3 Sv WG Shelf
0.1 Sv BI Shelf

South FW Flux
87% AW
13% TW
73% <150m
13 mSv WG Shelf
7 mSv BI Shelf

North Heat Flux
42% AW
38% WGIW
10% WGSW
3 TW WG Shelf
1 TW BI Shelf

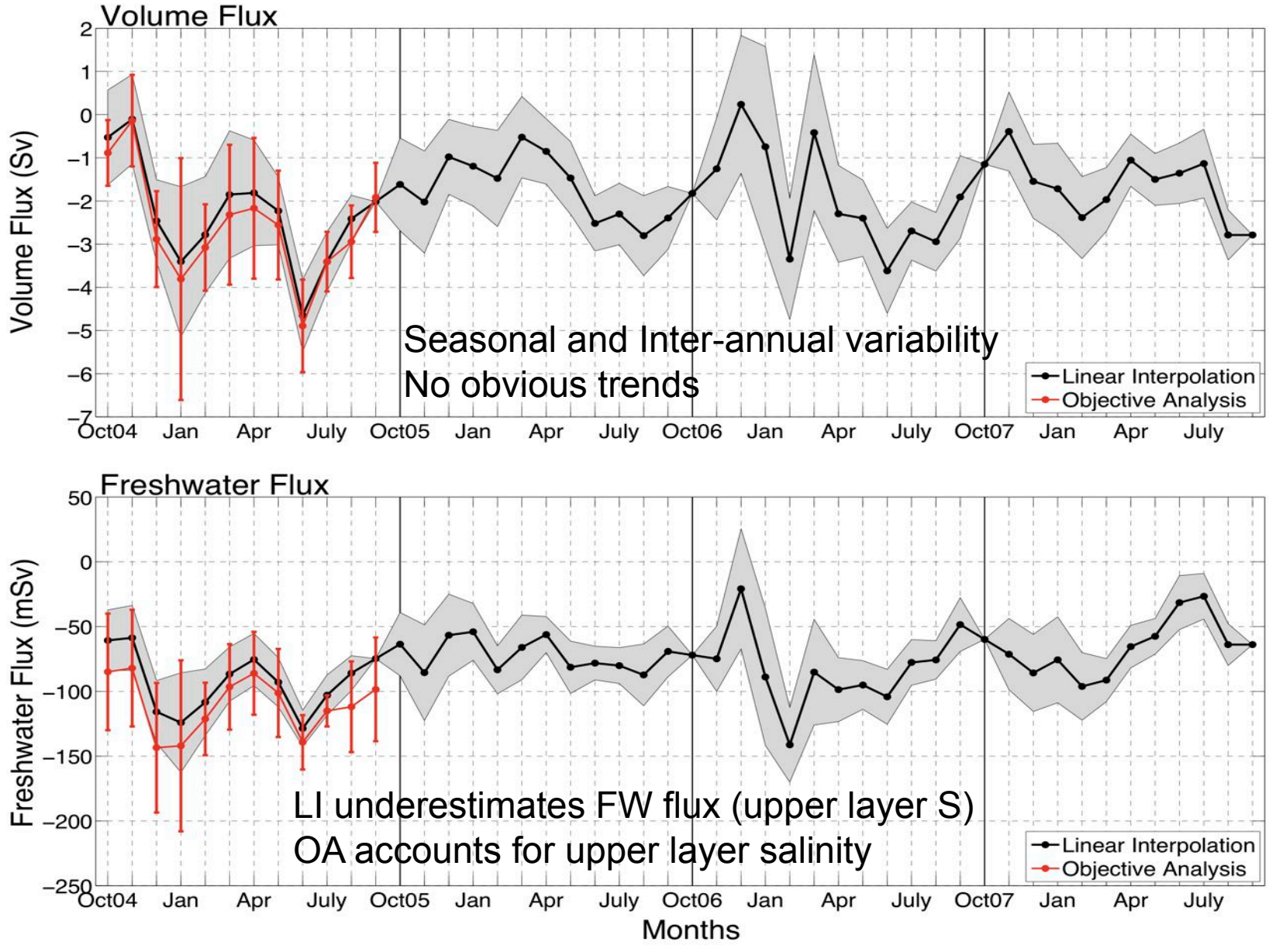
Baffin Bay Volume and FW Budgets (04-05)

Table 1: Baffin Bay volume and freshwater (referenced to 34.8) budgets.

Baffin Bay Passages	**Volume Transport (Sv)** Inflow	Outflow	**Freshwater Transport (mSv)** Inflow	Outflow
Nares Strait[1,2] 2003-2006	0.72 ± 0.11		25 ± 4	
Lancaster Sound[3] 1998-2006	0.7 ± 0.2		48 ± 15	
Jones Sound[4] 1998-2002	0.3 ± 0.1		12 ± 4	
CAA Ice[5,6] 1996-2007	< 0.1		5 ± 1	
Greenland Ice Sheet[7] 1995-2007	< 0.1		7 ± 1	
P-E[8,9,10] 1961-2001	< 0.1		7 ± 1	
Baffin Island Runoff [8,11] 1971-2000	< 0.1		3 ± 1	
Davis Strait 2004-2005		-2.4 ± 0.7		-123 ± 41
Total	**1.7 ± 0.2**	**-2.4 ± 0.7**	**107 ± 16**	**-123 ± 41**
Difference	**-0.7**		**-16**	

[1]Munchow and Melling, 2008; [2]Rabe et al.(manuscript submitted to *J. Phys. Oceanogr.*, 2009); [3]Prinsenberg et al., 2009; [4]Melling et al., 2008; [5]Agnew et al., 2008; [6]Kwok, 2005; [7]Mernild et al., 2009; [8]Canadian Climate and Data Information Archive (www.climate.weatheroffice.ec.gc.ca); [9]Jensen and Rasch, 2008; [10]National Climate Data Center (www.ncdc.noaa.gov/oa/ncdc.html); [11]Water Survey of Canada (geogratis.cgdi.gc.ca/geogratis/en/index.html)

Volume & FW Flux (Oct 2004-Sep 2008)



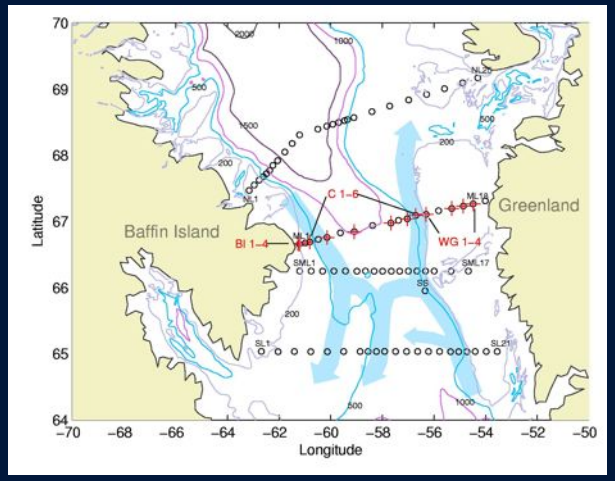
Summary

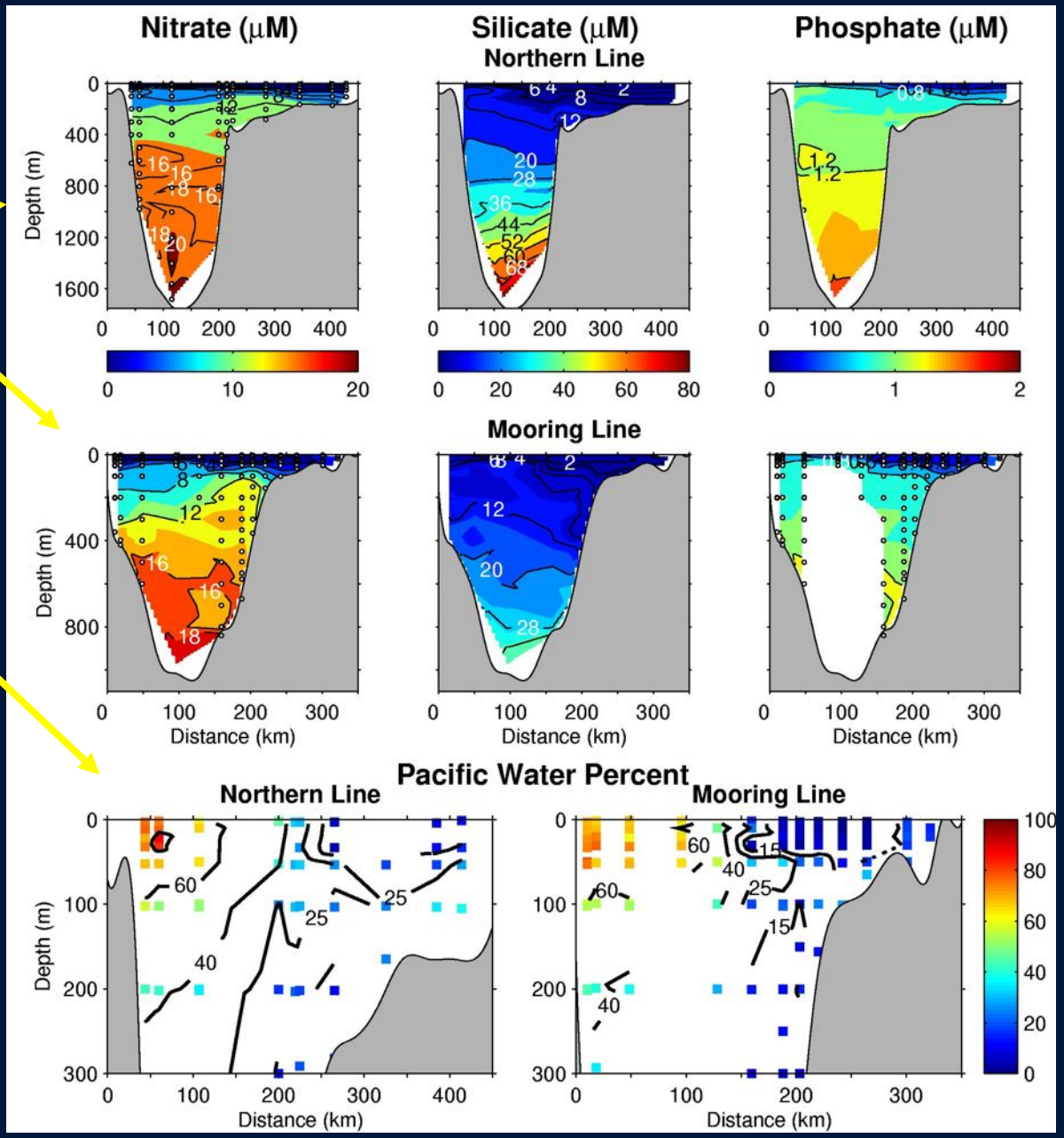
- No statistically significant change between 87-90 and 04-05 annual-average Davis Strait volume and FW fluxes (need to reanalyze 87-90 data for consistency).
- Preliminary volume and FW flux estimates 2004-2008 hint at seasonal cycle with significant inter-annual variability.
- No apparent trends in 2004-2008 volume and FW fluxes.
- Exploring proxies for large-scale forcing. No clear relationship between 2004-2008 Davis Strait fluxes and Arctic Oscillation or Arctic Dipole indices.
- Comparison of CTD-based flux ‘snapshots’ and annual means from moored array provides basic lesson in aliasing.
- Suggests caution when interpreting fluxes calculated from annually-occupied sections. Integrating properties OK.

Mooring Line Nutrients 2004

Raw input data

% Pacific strongly resembles Jones et al. 1997 distribution;





Pacific Water Percentage

Red 80-100% Yellow 60-80%

Green 40-60% Blue 20-40%

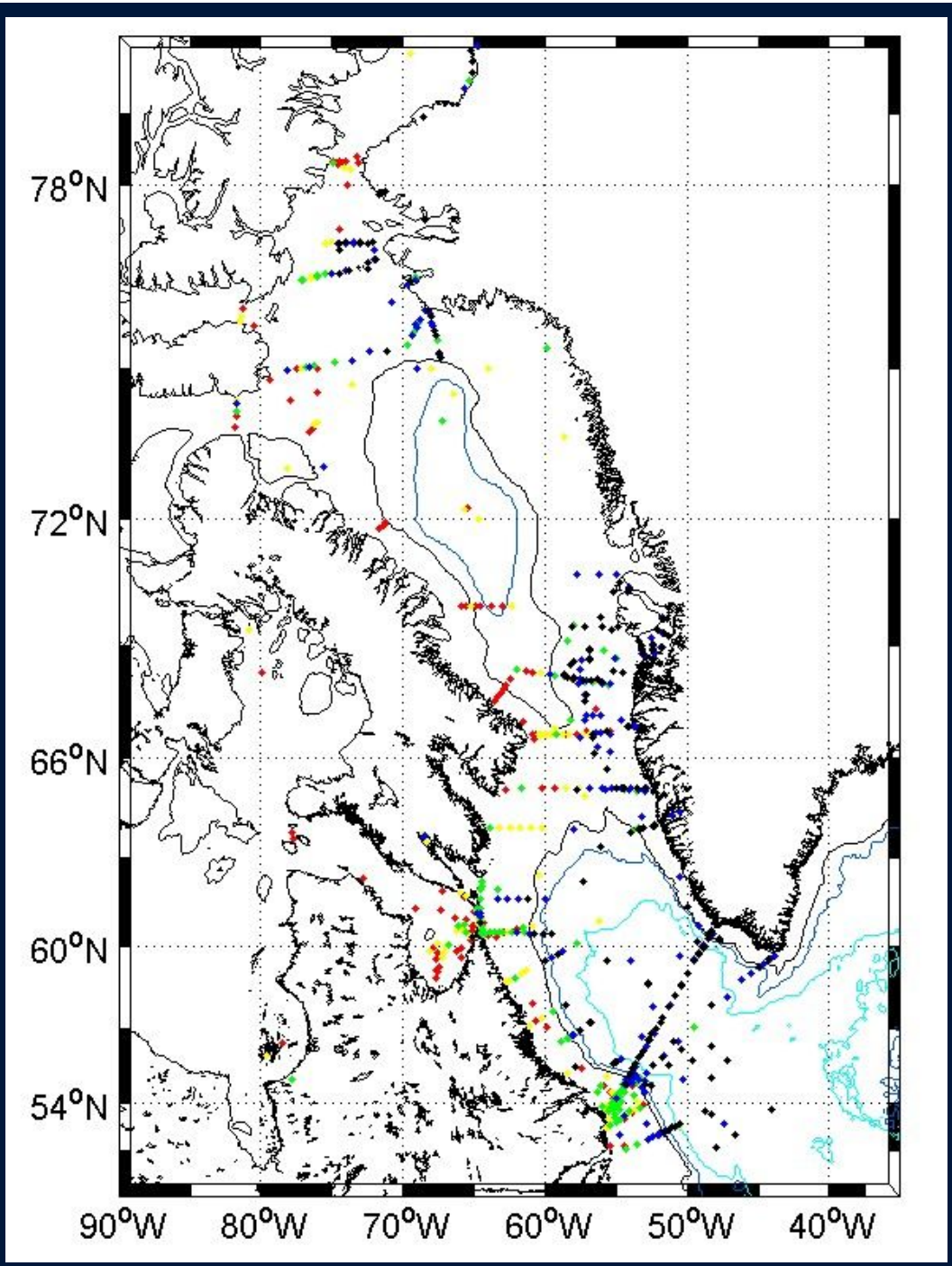
Black 0-20%

Stronger downstream decrease of Pacific water percentage, weak offshore exchange agreeing with Jones et al.

T-S analysis supports low probability of finding Arctic Water seaward of 1000 m isobath.

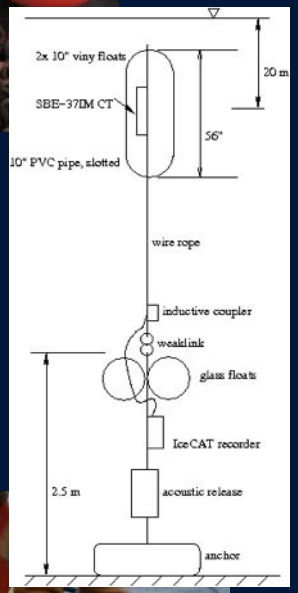
Suggests Limited role of Davis outflow in Lab Sea Convection.

Fate of CAA/Davis Strait outflow? Fratantoni & MacCartney…

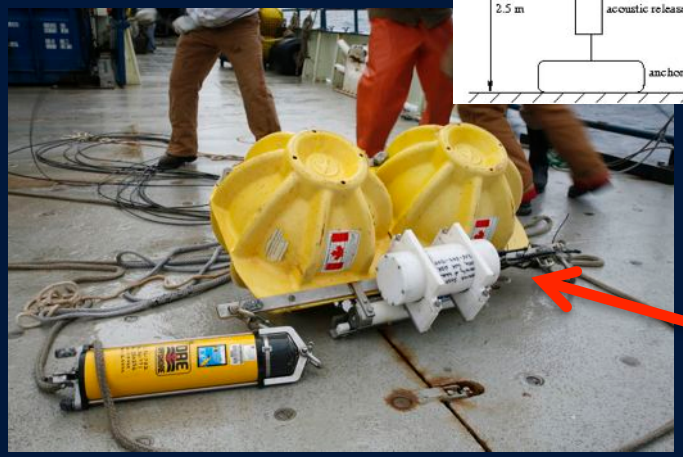


Ice-Sacrificial Mooring (ICECAT)

Expendable shallow element samples ice-threatened near-surface layer.



- Access
  - Sample ice-ocean interface, marginal ice zone
- Risk
  - Sensor(s) exposed but data protected.
  - Acoustic data upload possible.
  - Low-cost (expendable)- deploy many.
- Persistence
  - Multi-year endurance possible- would want acoustic upload.
- Adaptability
  - Originally designed for sampling shelf/slope environments.
  - Seasonal or permanent ice-cover, marginal ice zone.
  - Lightweight logistics (for a mooring).
- Extensive use in Davis Strait and Bering Strait.



Data logged below, protected by weak link.

Long-Range Under-Ice Gliders

- Arctic Missions (2006, 2008/09, 2009/10)
  6 month max duration
  Fully-autonomous under ice ops: 51 days, 800+ km.
  Profiles to within 5 m of ice-ocean interface.
  Utilized 8 leads (33 attempts) during under-ice ops.
- For 2010
  Extended endurance.
  More sophisticated navigation (robust to source loss).
  Acoustic download to moored data depots.

- Acoustic navigation (RAFOS, 2 km)
- Enhanced autonomy
- T, S, oxygen
- Samples ice-ocean interface
- Resolves deformation scale
- Full ice cover & marginal ice zone
- Telemetry in open water, leads
- Long endurance
- Scalable, flexible operations