
SCICEX Phase II
CALIBRATION ACTIVITIES
For Biogeochemistry
at ICEX 2011
Ray Sambrotto
Bill Smethie

Biogeochemical Calibration & Validation Activities: Strategic Objectives

1. Calibrate sub-based measurements with CTD-bottle casts at the ICEX experimental site in March 2011.

2. Develop validated sampling protocols for the newer classes of Navy submarines for use on Phase II SAMs.

3. Establish the sample and data handling procedures. Logistics of transport and raw data QA/QC process en route to the SCICEX data management center.

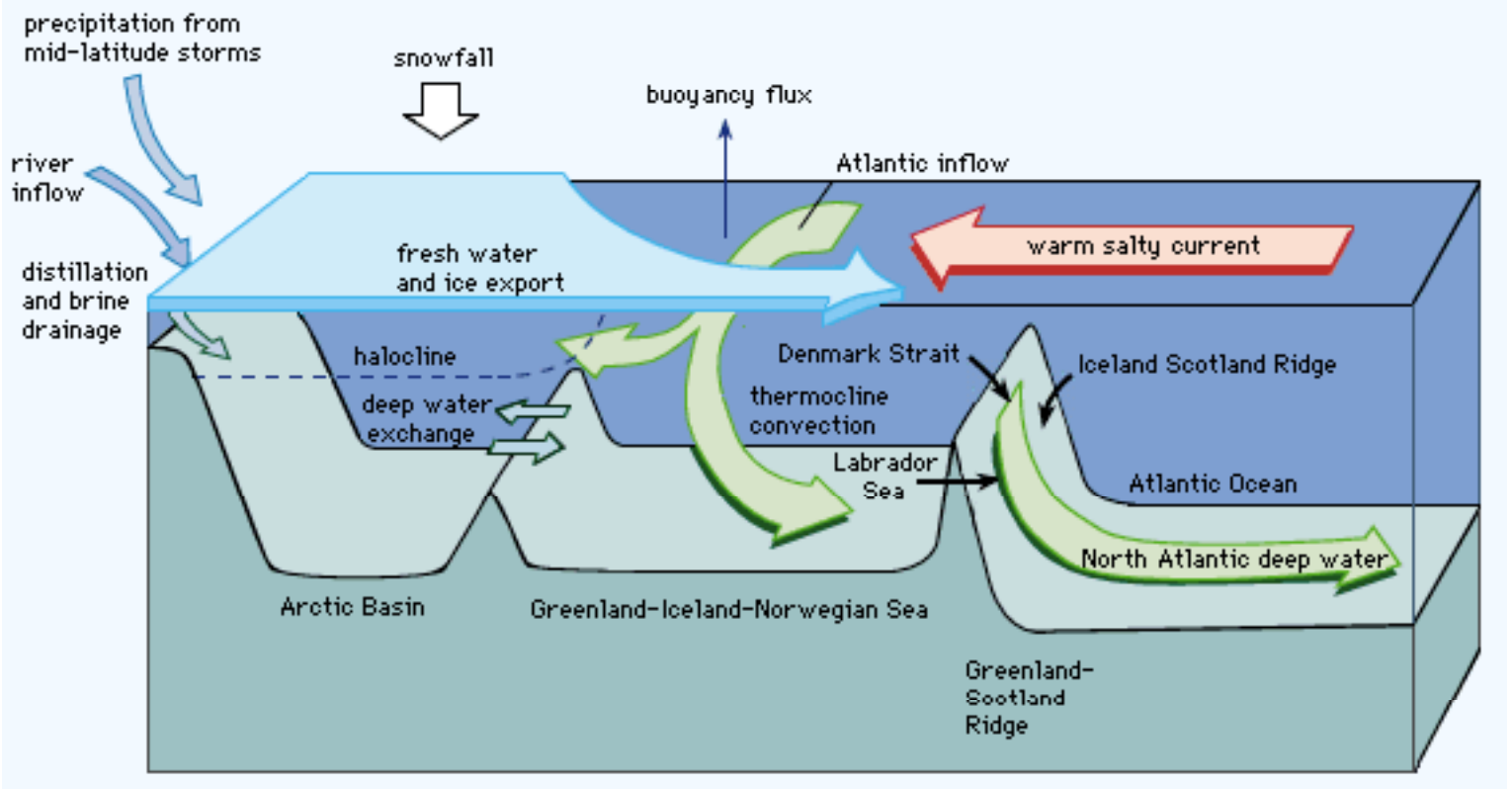
4. Sample data-poor regions of the Arctic Ocean and integrate this data flow into the expanding Arctic Observing Network

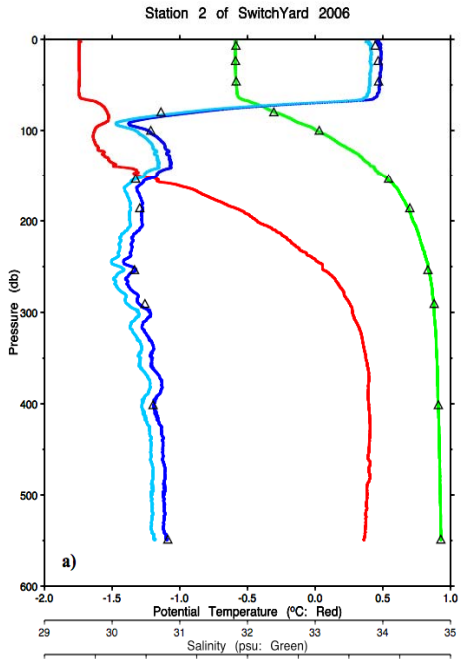
Coordination with Scientific & Navy Objectives

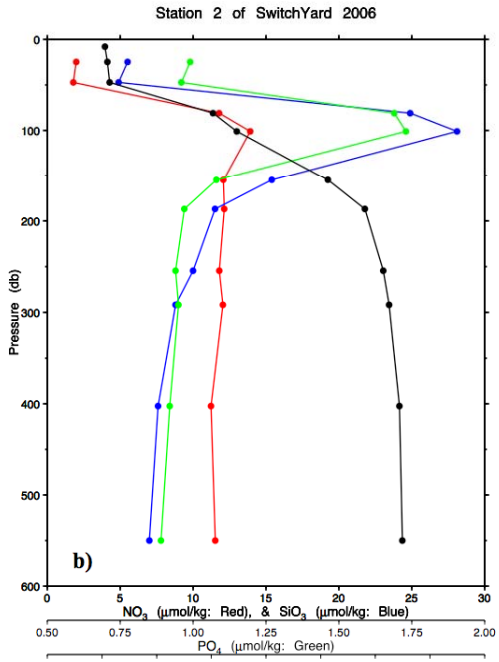
- **Scientific Coordination** with the Arctic Observing Network (AON)
- **Coordination with Navy Objectives** - Addresses Phase I activities specified by the Navy in its Arctic Roadmap (Task Force Climate Change/ Oceanographer of the Navy, 2009):
  - 1. The development of a Capabilities Based Assessment (Action Item 3.2)
  - 2. The development of a biennial Arctic Environmental Assessment and Outlook Report (Action Item 5.7).

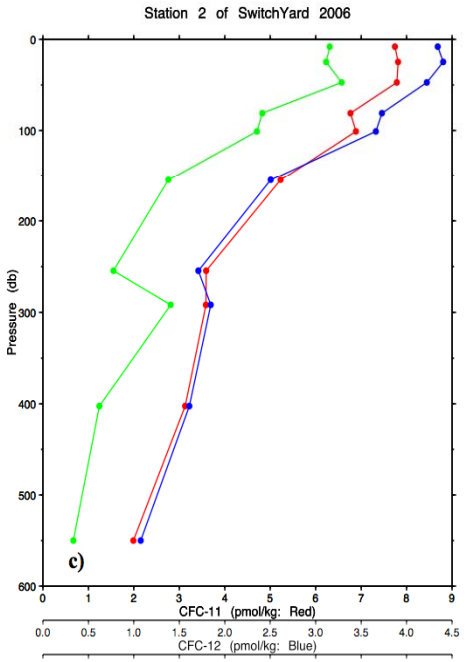
Major Sampling Objectives (Chemistry)

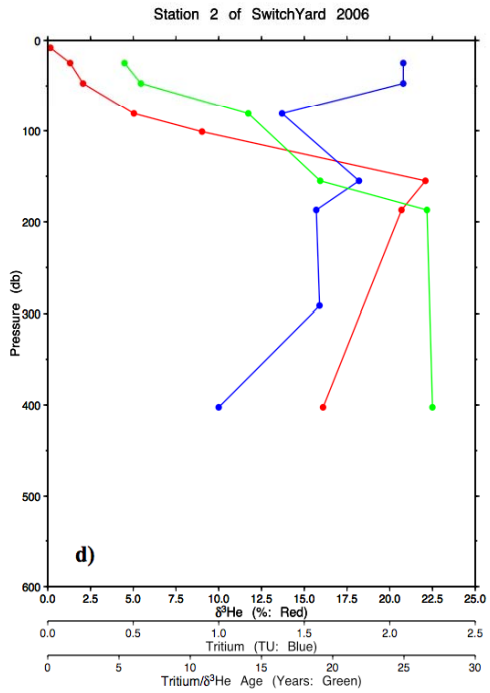
- Monitor the spatial and temporal (including seasonal) variability and longer-term trends of freshwater distribution and composition in the mixed layer and in the halocline.
- Monitor the spatial and temporal (including seasonal) variability and longer-term trends of CO_2, alkalinity, and pH in the mixed layer and in the halocline and compare these observations to variability and trends in plankton community structure.
- Monitor the spatial and temporal variability and longer term trends in the composition of the halocline and upper Atlantic layer.
- Delineate circulation pathways for Atlantic and Pacific waters within the halocline and upper Atlantic layer, and estimate flow rates within the main upper ocean currents and transit times from source water regions to the interior.

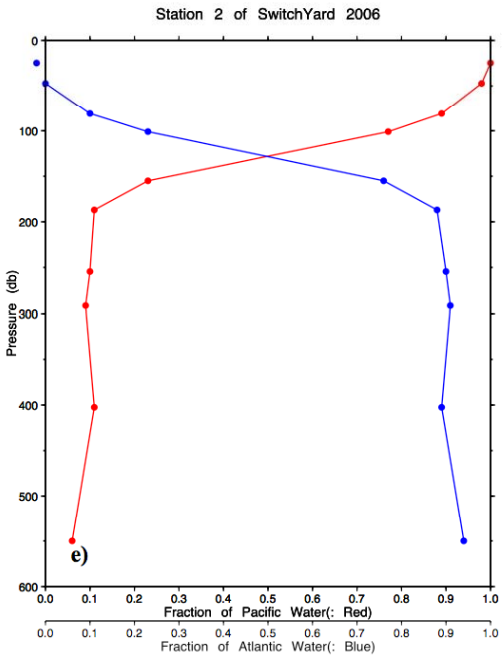

precipitation from
mid-latitude storms
snowfall
buoyancy flux
river
inflow
Atlantic inflow
warm salty current
distillation
and brine
drainage
fresh water
and ice export
halocline
Denmark Strait
Iceland Scotland Ridge
thermocline
convection
deep water
exchange
Labrador
Sea
Atlantic Ocean
North Atlantic deep water
Arctic Basin
Greenland-Iceland-Norwegian Sea
Greenland-
Scotland
Ridge

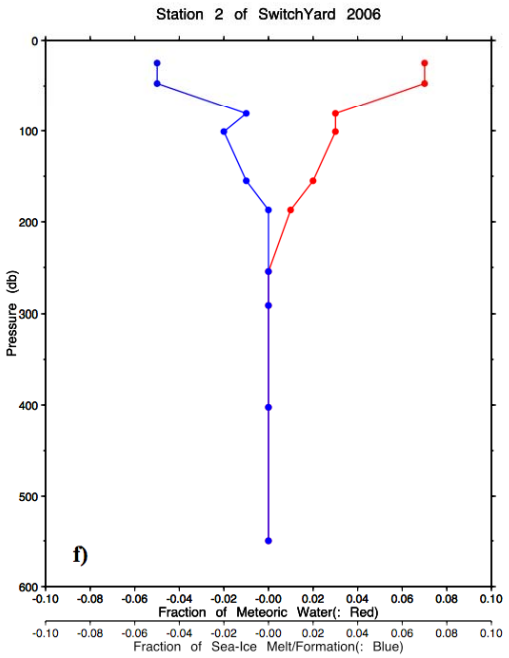

Station 2 of SwitchYard 2006
Pressure (db)
a)
Potential Temperature (°C: Red)
Salinity (psu: Green)


Station 2 of SwitchYard 2006
Pressure (db)
b)
NO3 (µmol/kg: Red), & SiO3 (µmol/kg: Blue)
PO4 (µmol/kg: Green)

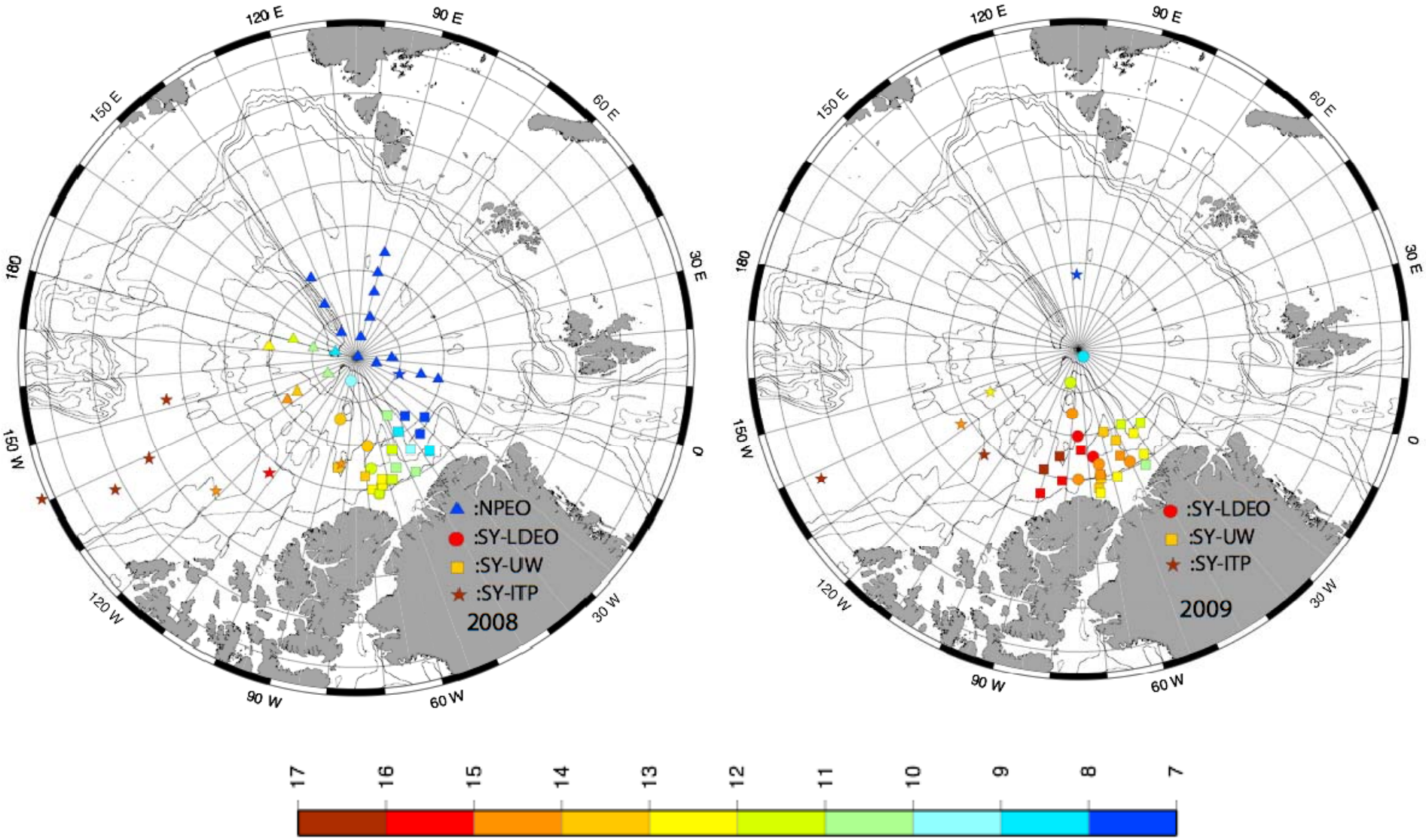

Station 2 of SwitchYard 2006
Pressure (db)
c)
CFC-11 (pmol/kg: Red)
CFC-12 (pmol/kg: Blue)


Station 2 of SwitchYard 2006
Pressure (db)
d)
δ3He (%: Red)
Tritium (TU: Blue)
Tritium/δ3He Age (Years: Green)

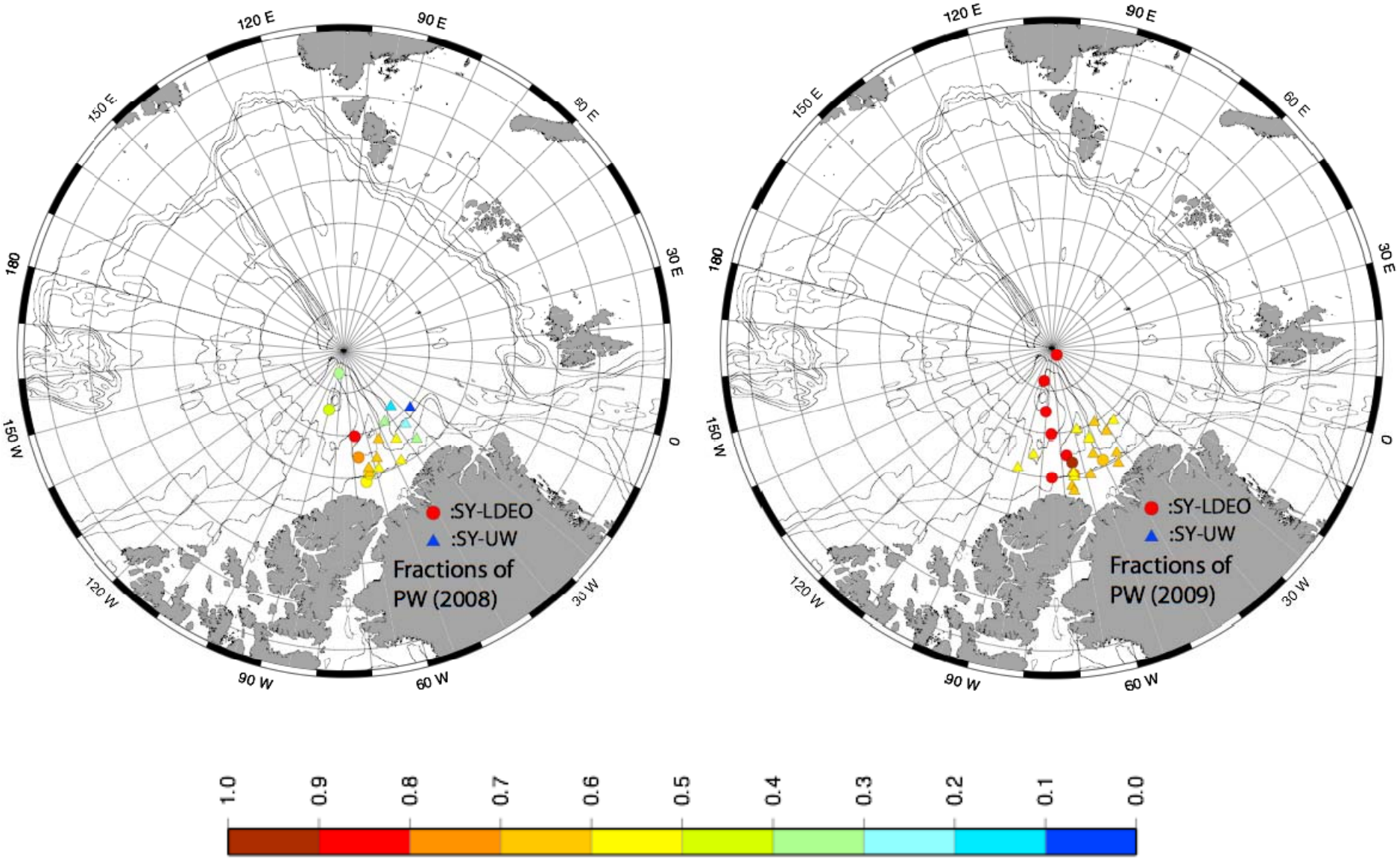

Station 2 of SwitchYard 2006
Pressure (db)
e)
Fraction of Pacific Water(: Red)
Fraction of Atlantic Water(: Blue)


Station 2 of SwitchYard 2006
Pressure (db)
f)
Fraction of Meteoric Water(: Red)
Fraction of Sea-Ice Melt/Formation(: Blue)

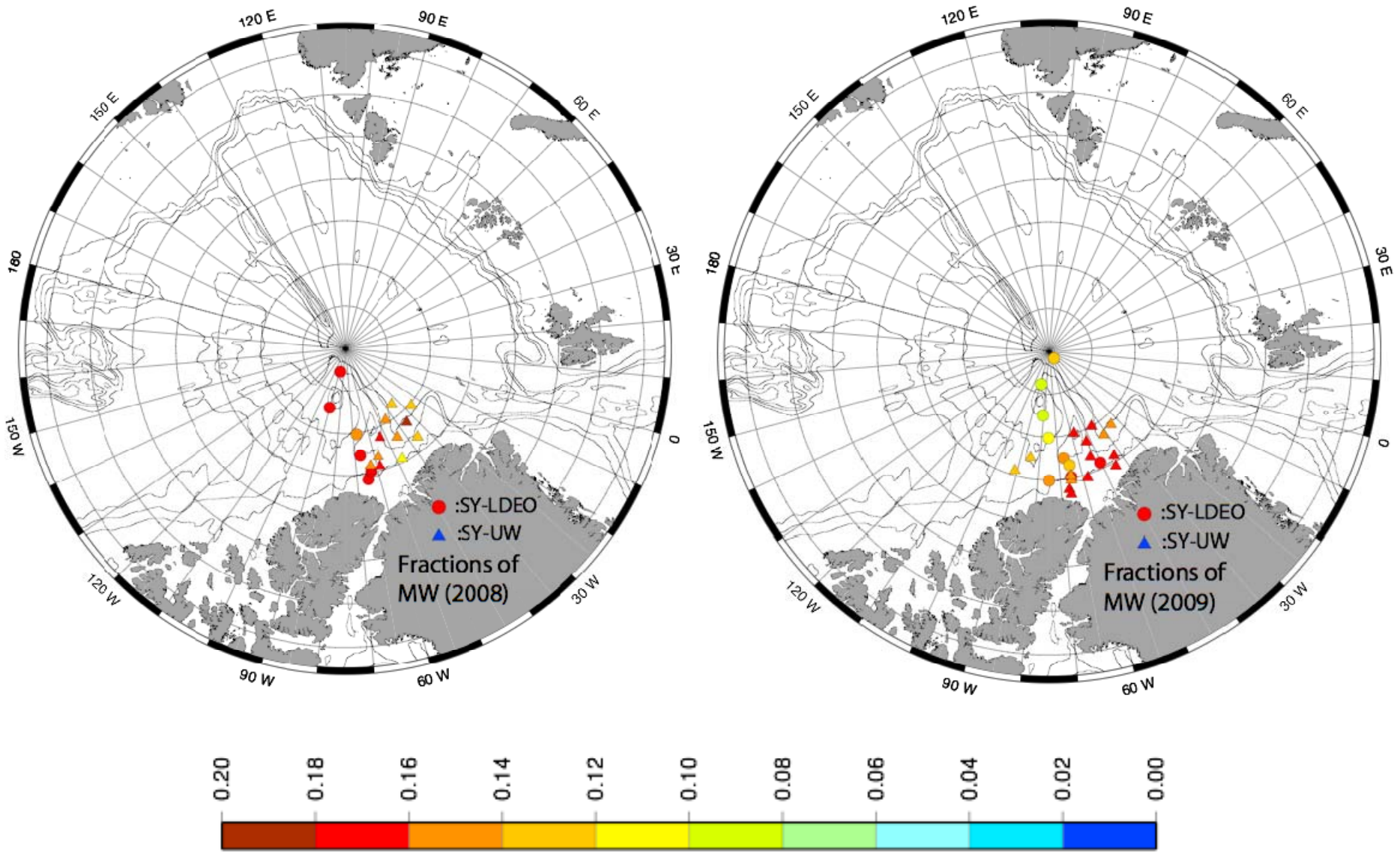
Freshwater inventory (meters)



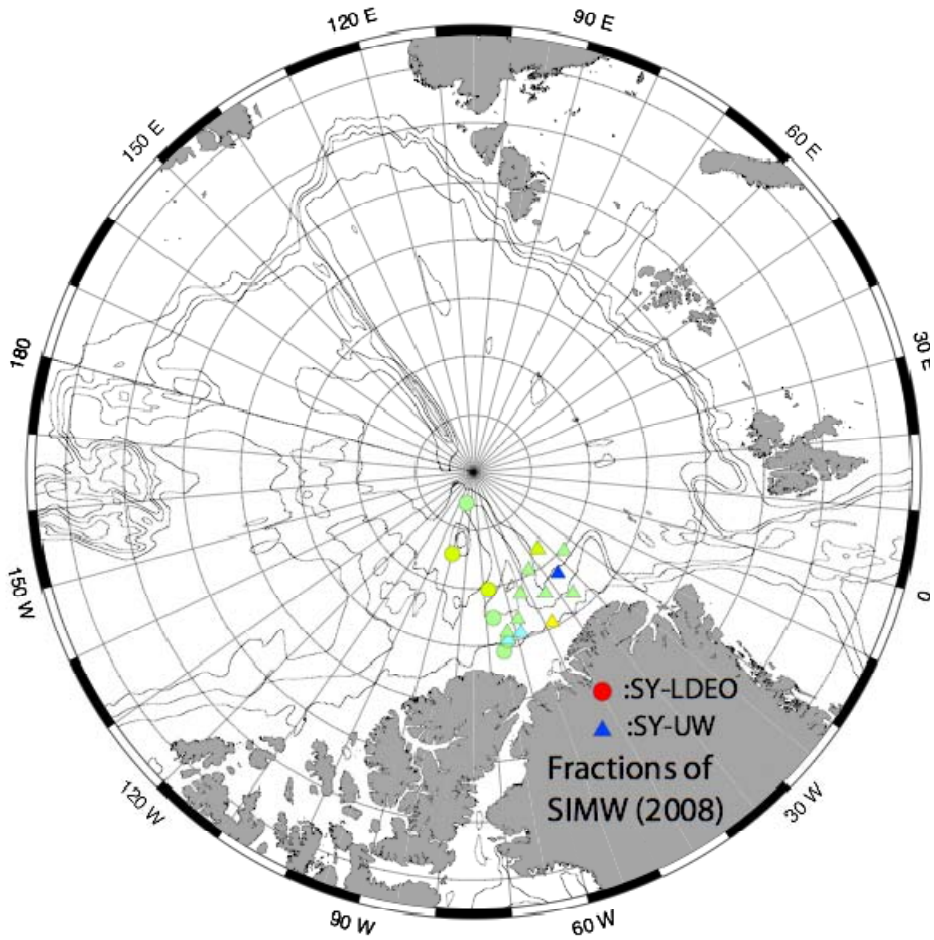
Fraction Pacific Water in Surface Mixed Layer

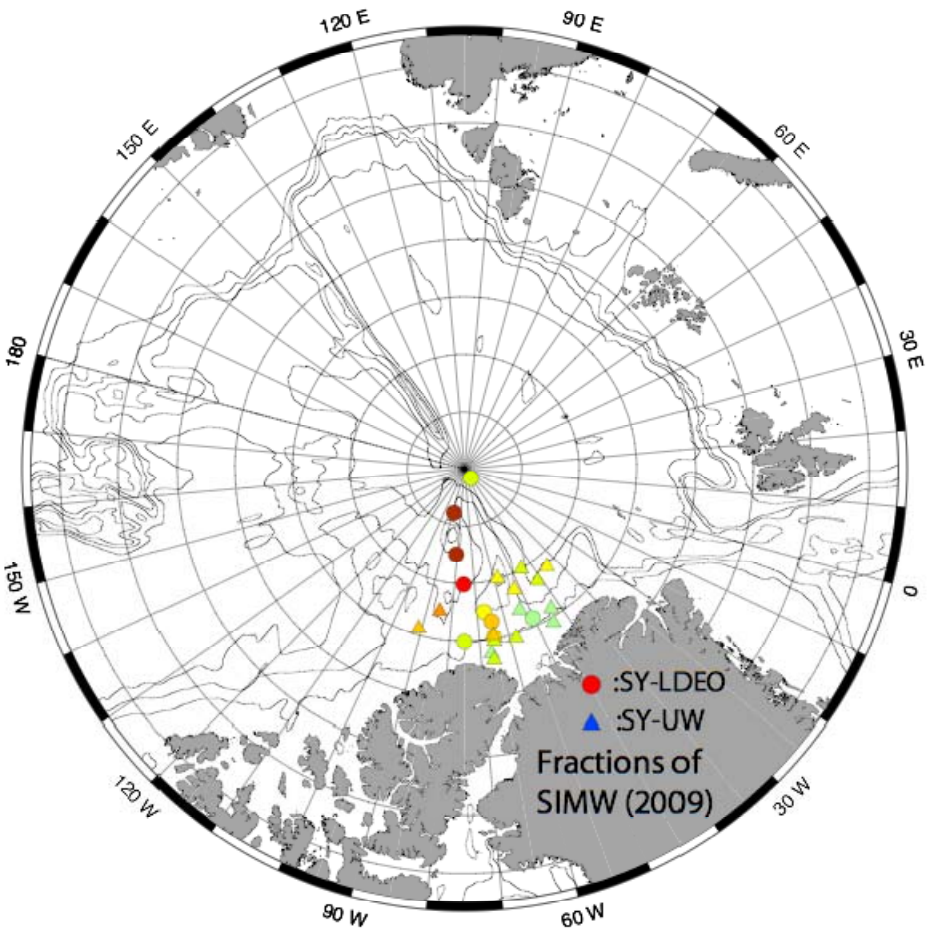


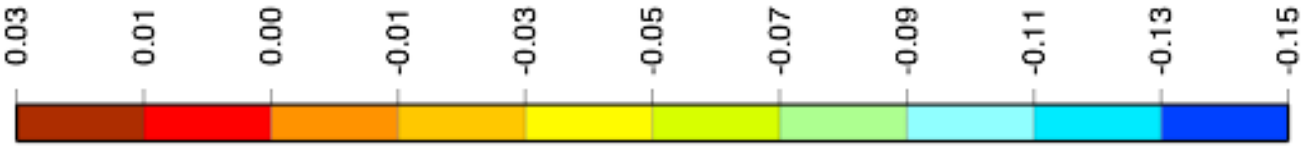
Fraction Meteoric Water in Surface Mixed Layer



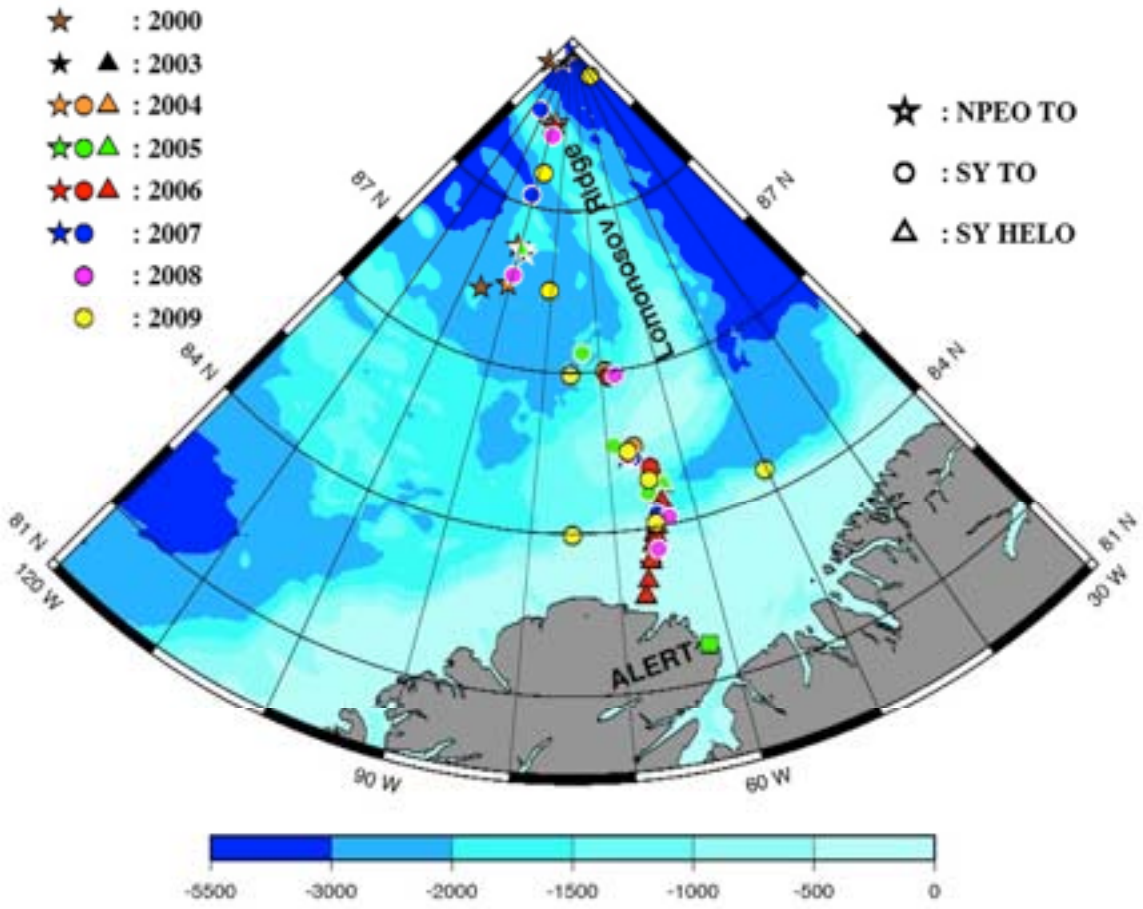
Fraction Sea Ice Melt Water in Surface Mixed Layer

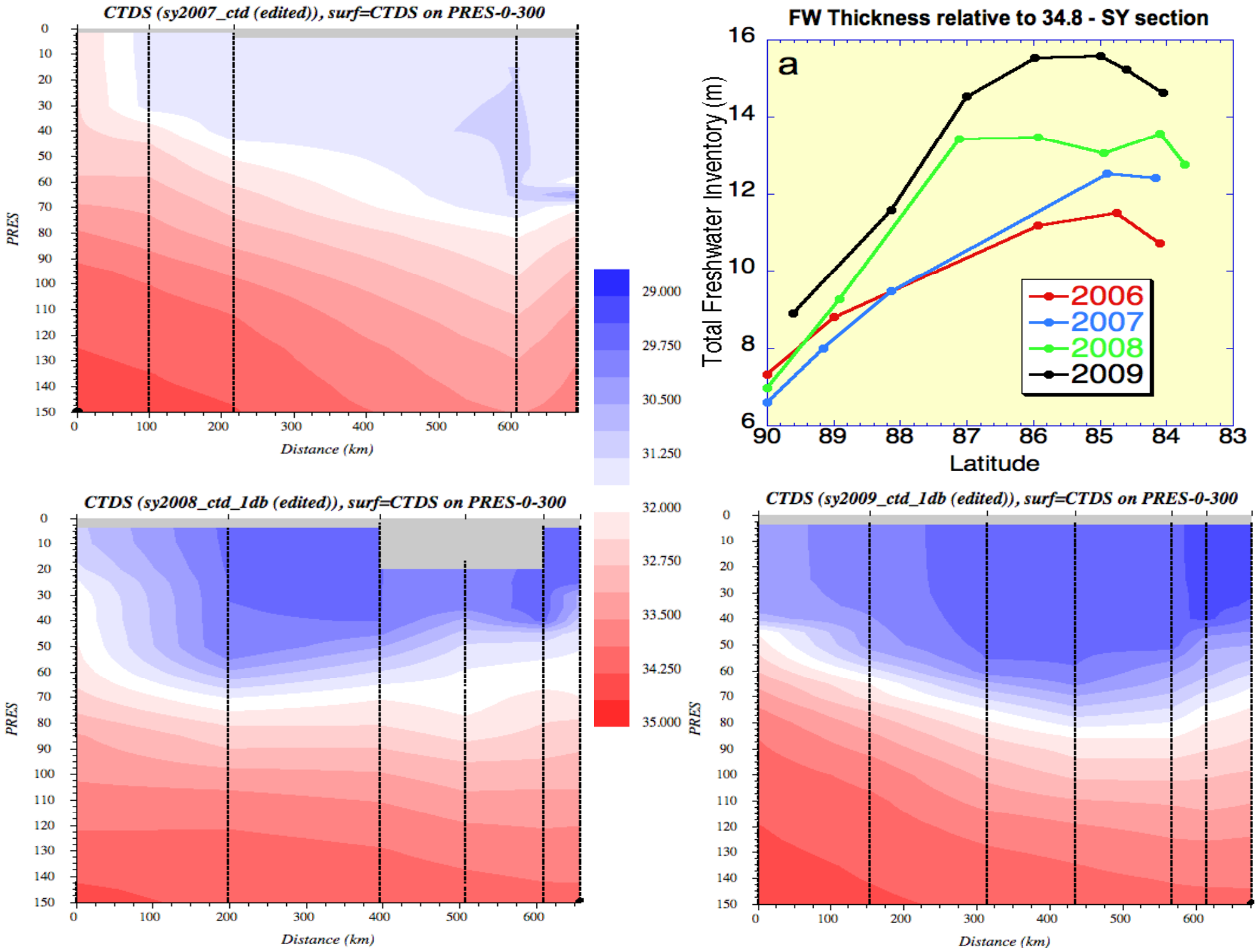


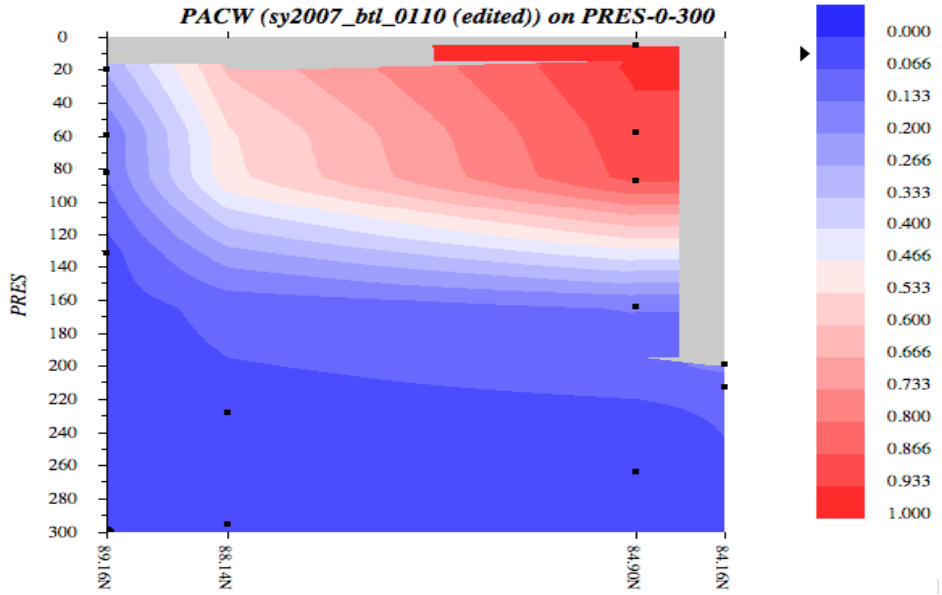


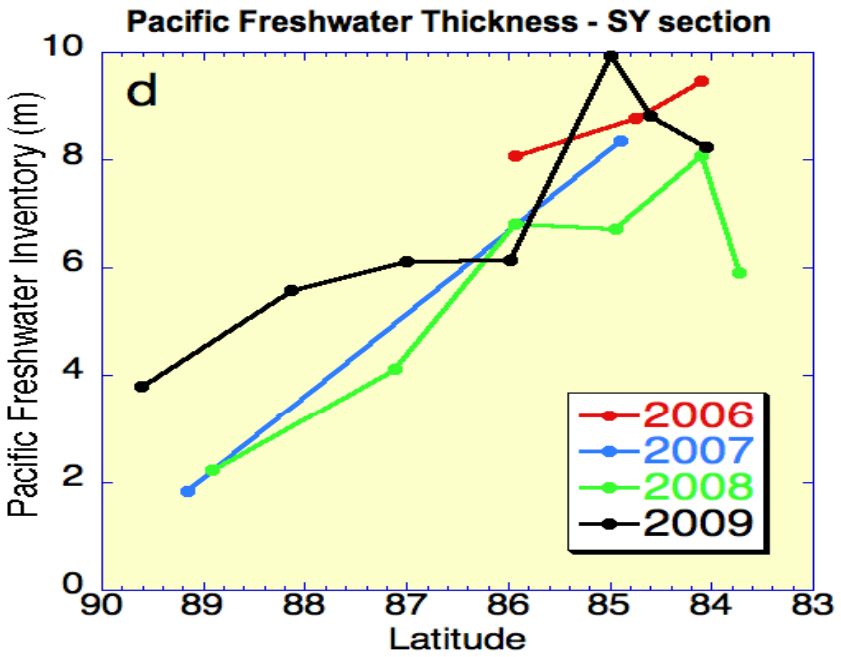


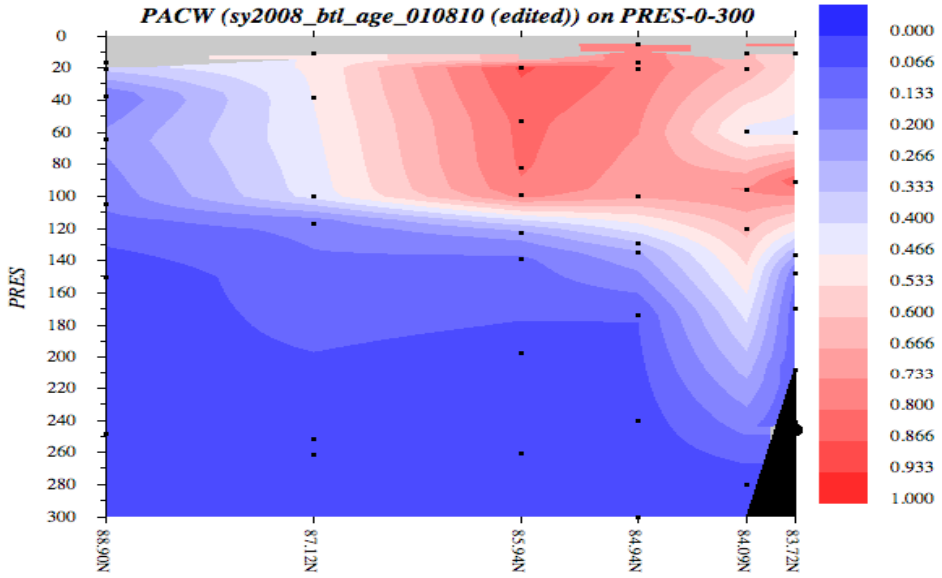
Switchyard and NPEO Stations between Alert and the NP

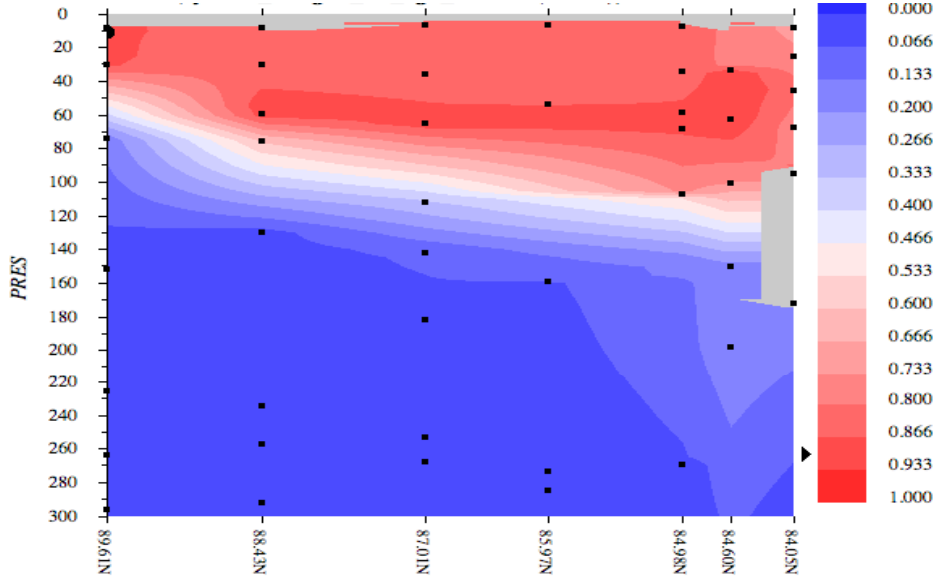



CTDS (sy2007_ctd (edited)), surf=CTDS on PRES-0-300
PRES
Distance (km)
29.000
29.750
30.500
31.250
32.000
32.750
33.500
34.250
35.000
FW Thickness relative to 34.8 - SY section
a
Total Freshwater Inventory (m)
Latitude
2006
2007
2008
2009
CTDS (sy2008_ctd_1db (edited)), surf=CTDS on PRES-0-300
CTDS (sy2009_ctd_1db (edited)), surf=CTDS on PRES-0-300

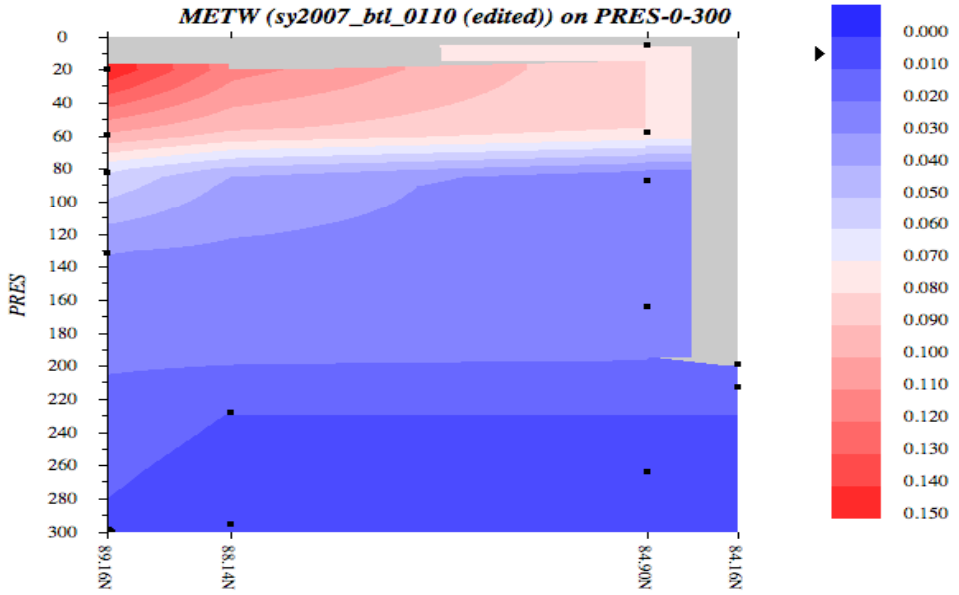


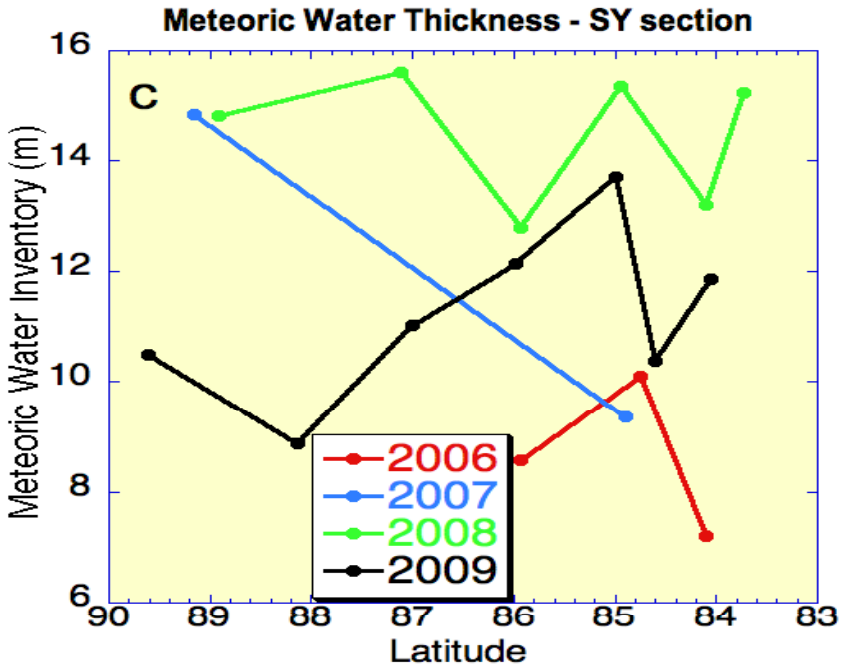


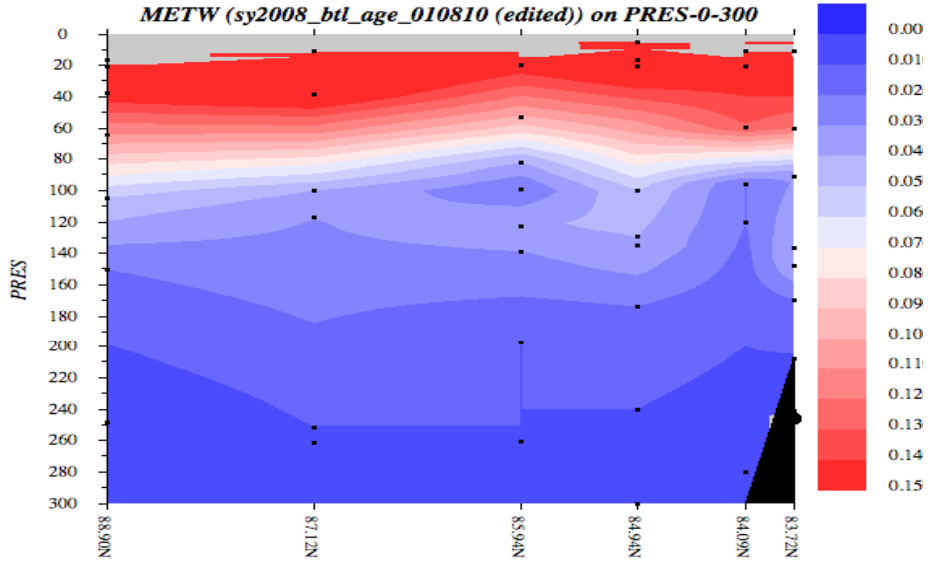


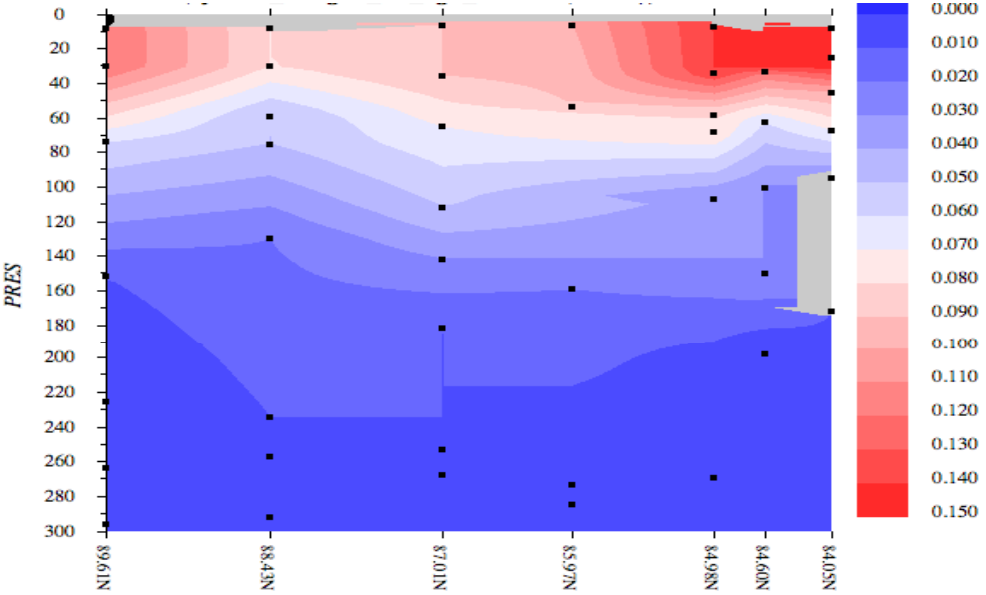


Pacific Water

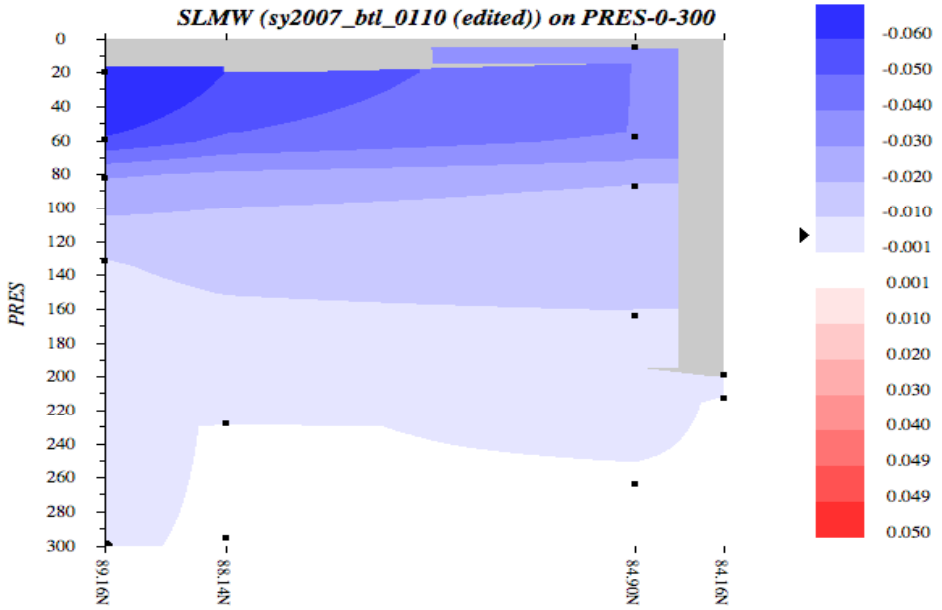


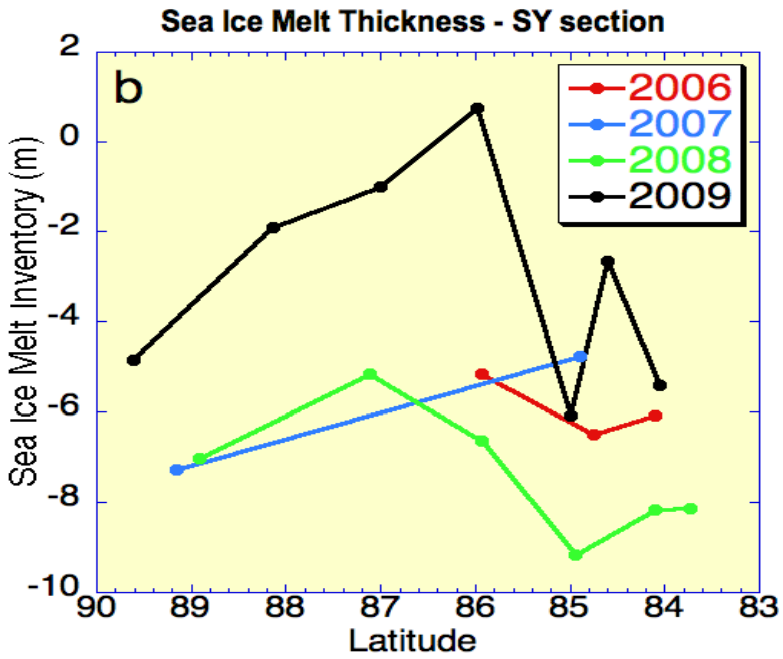


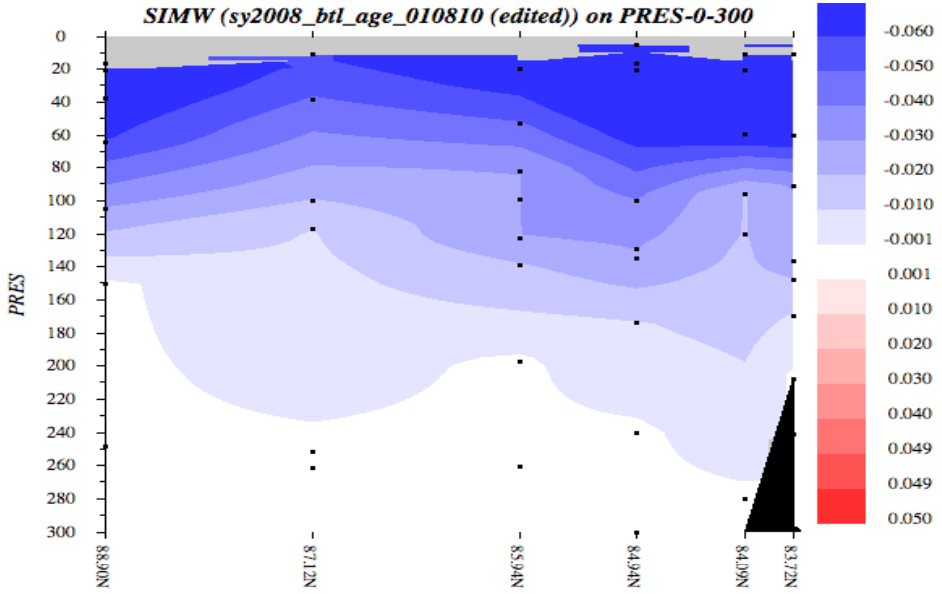


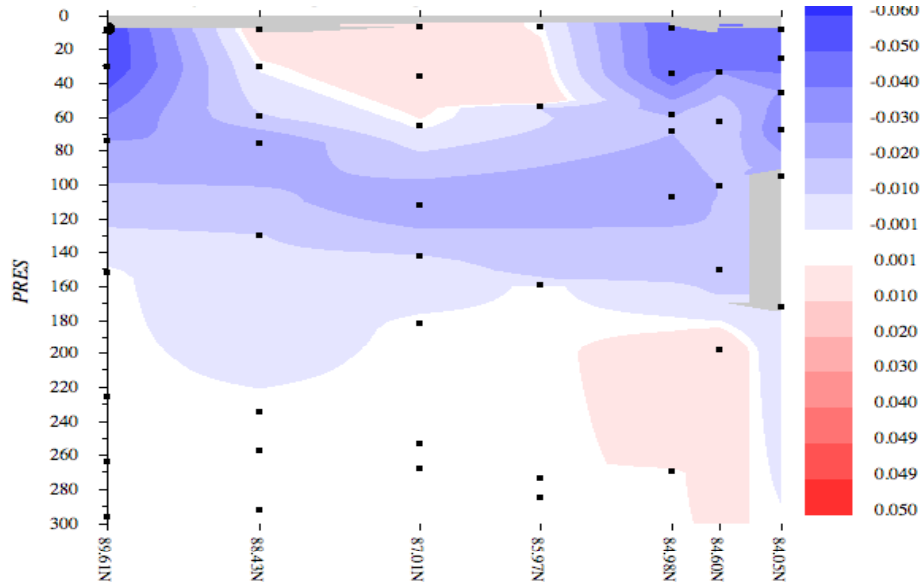


Meteoric Water



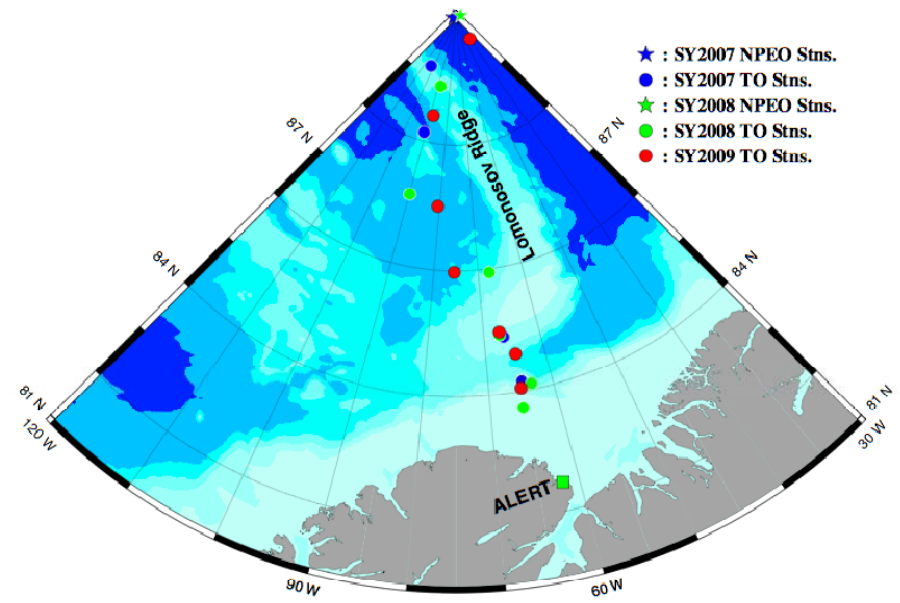


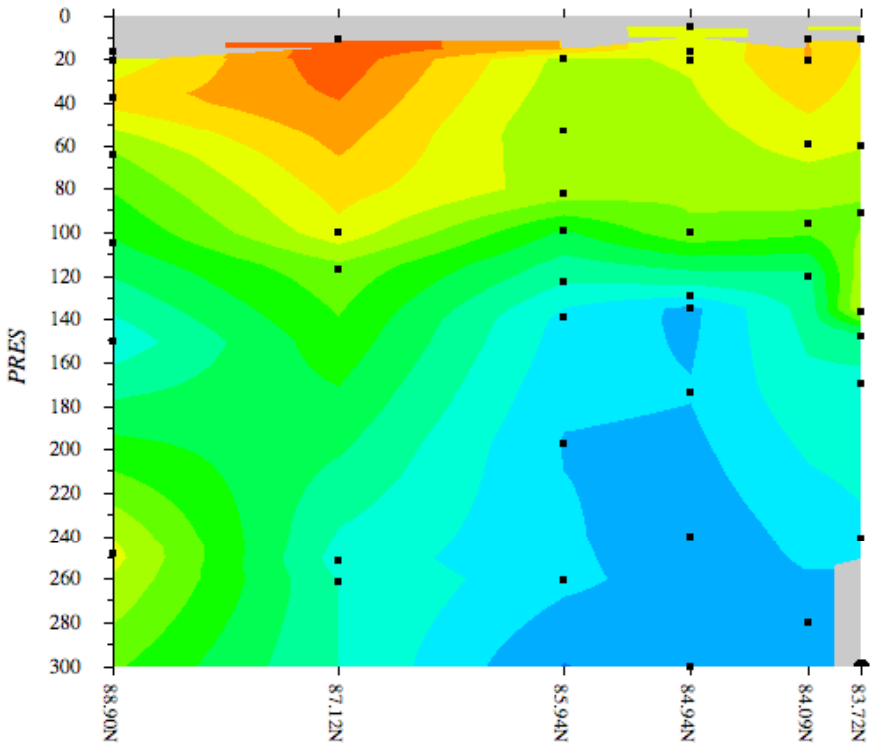


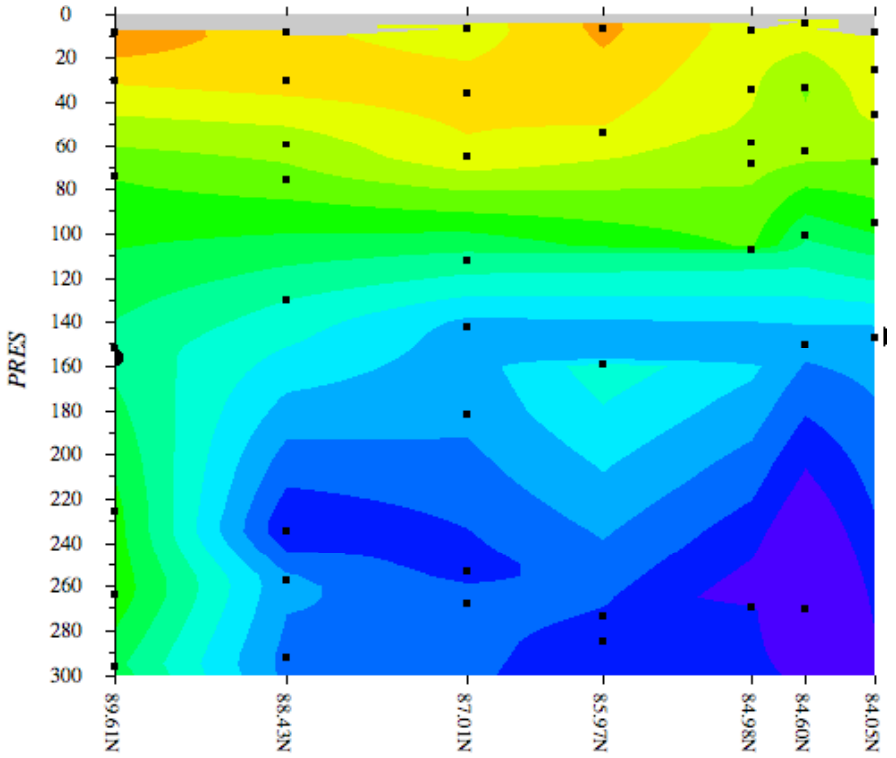


Sea Ice Melt Water

SF6:CFC-12 Ratio Age (years)

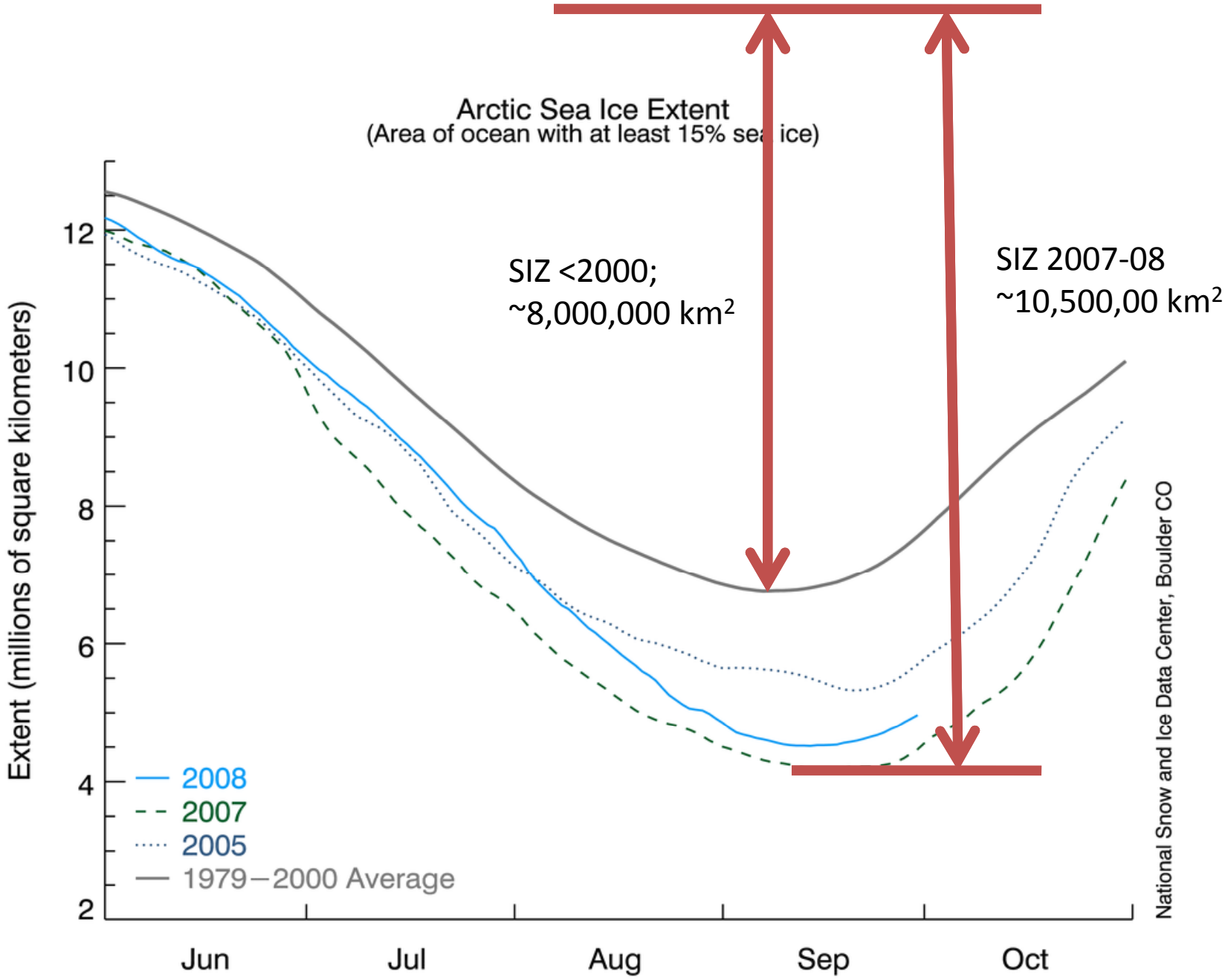




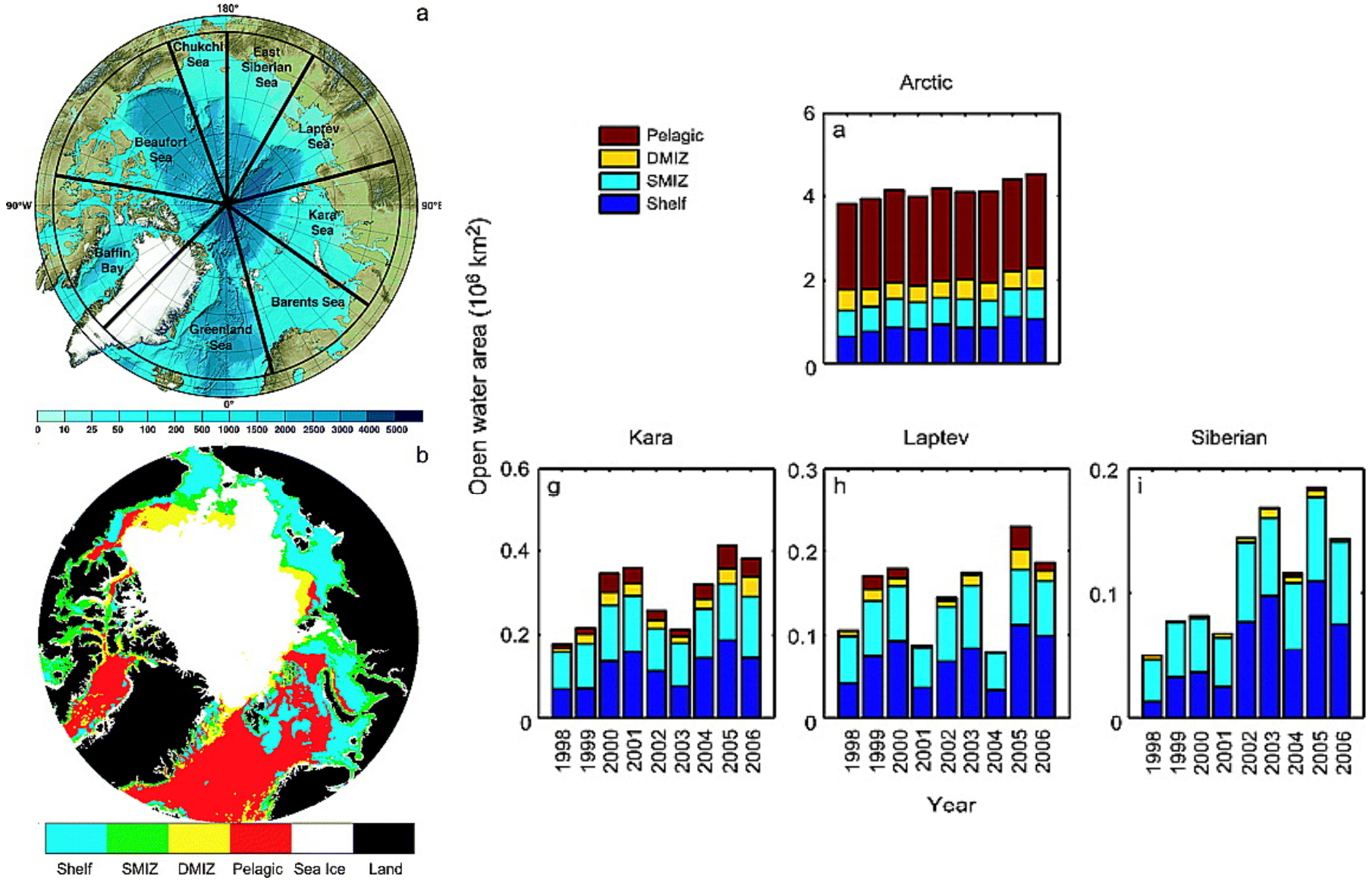


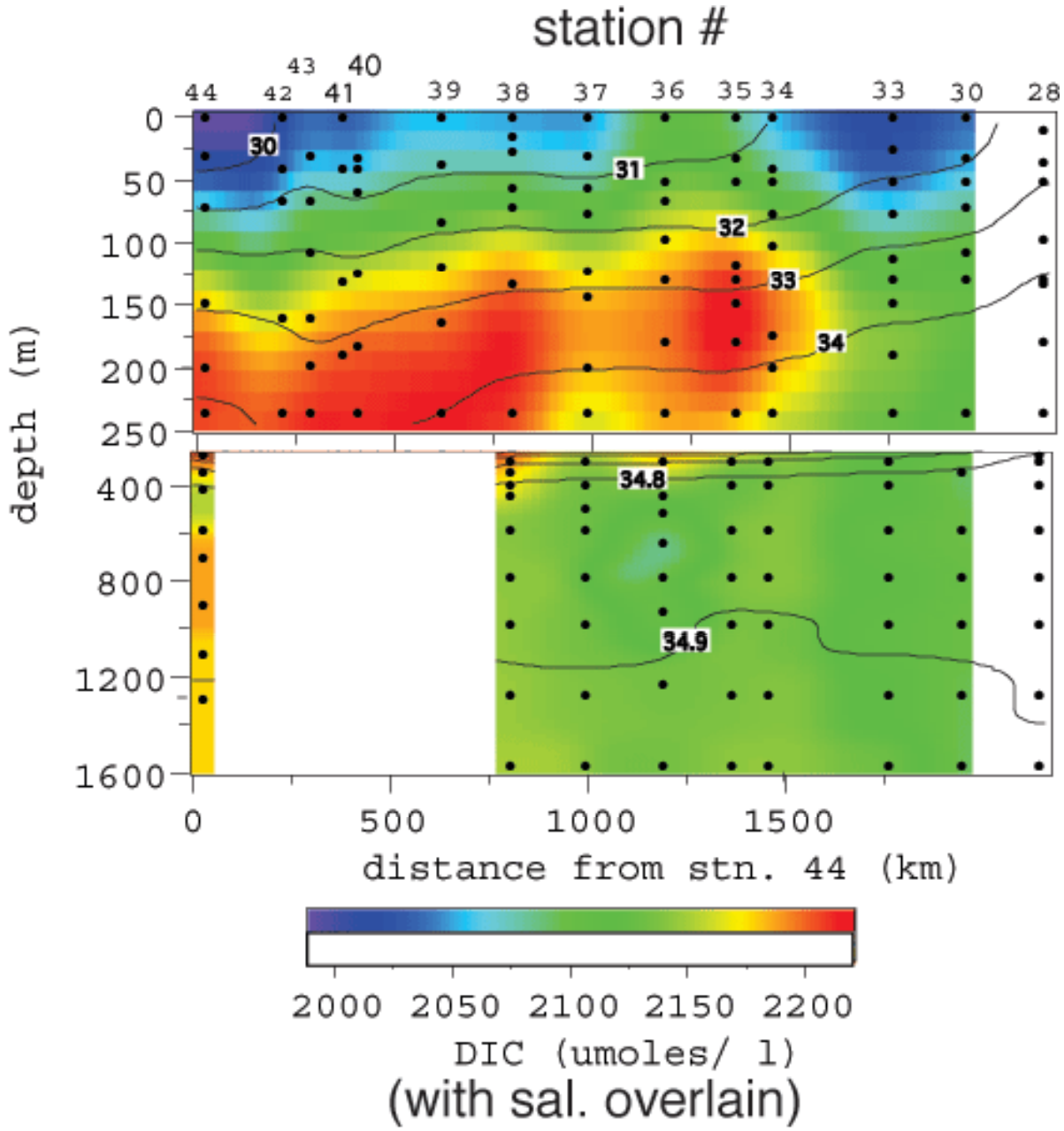
Major Sampling Objectives (Biology)

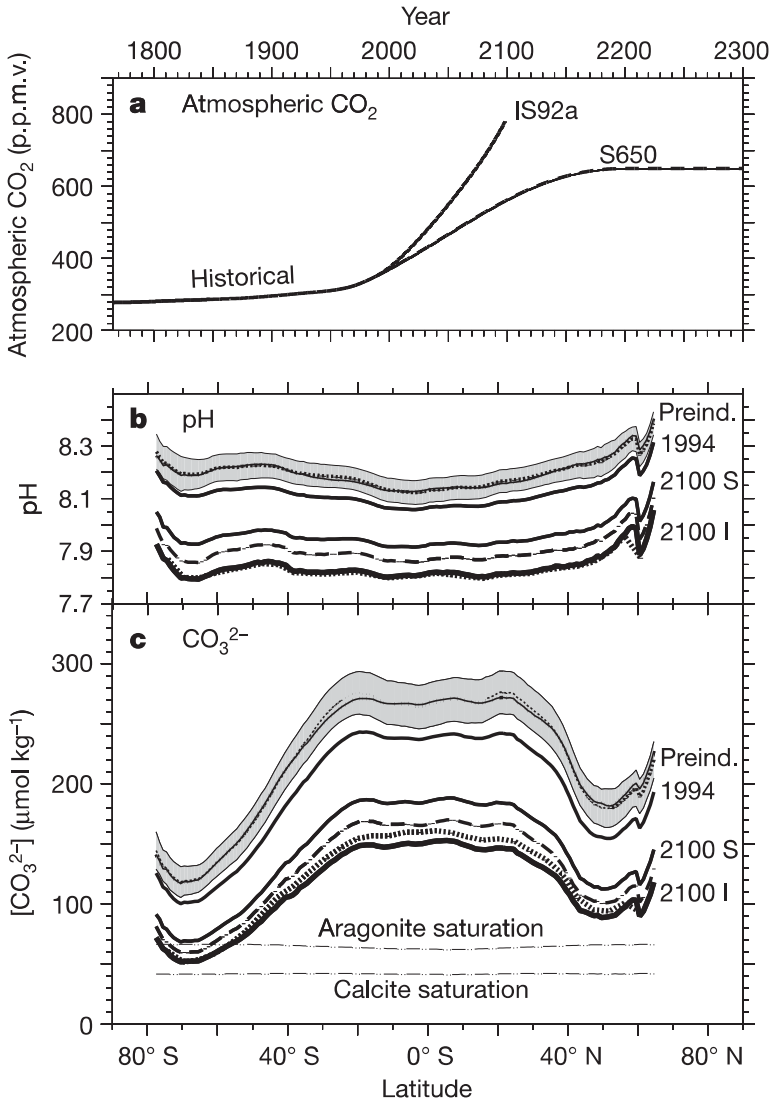
- Document the response of Arctic Ocean productivity to reduced sea ice cover.
- Quantify the interaction between biological processes and changes in the nutrient and carbon systems, including the impact of ocean acidification.
- Characterize the microbial populations across the Arctic Ocean.
- Record the time-space variation in megafauna distributions.


Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
SIZ <2000;
~8,000,000 km²
SIZ 2007-08
~10,500,00 km²
Extent (millions of square kilometers)
12
10
8
6
4
2
2008
2007
2005
1979–2000 Average
Jun
Jul
Aug
Sep
Oct
National Snow and Ice Data Center, Boulder CO

Pabi et al., 2008

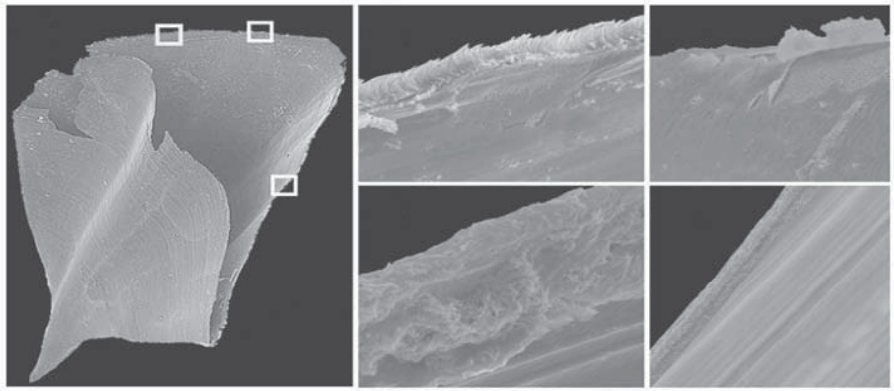


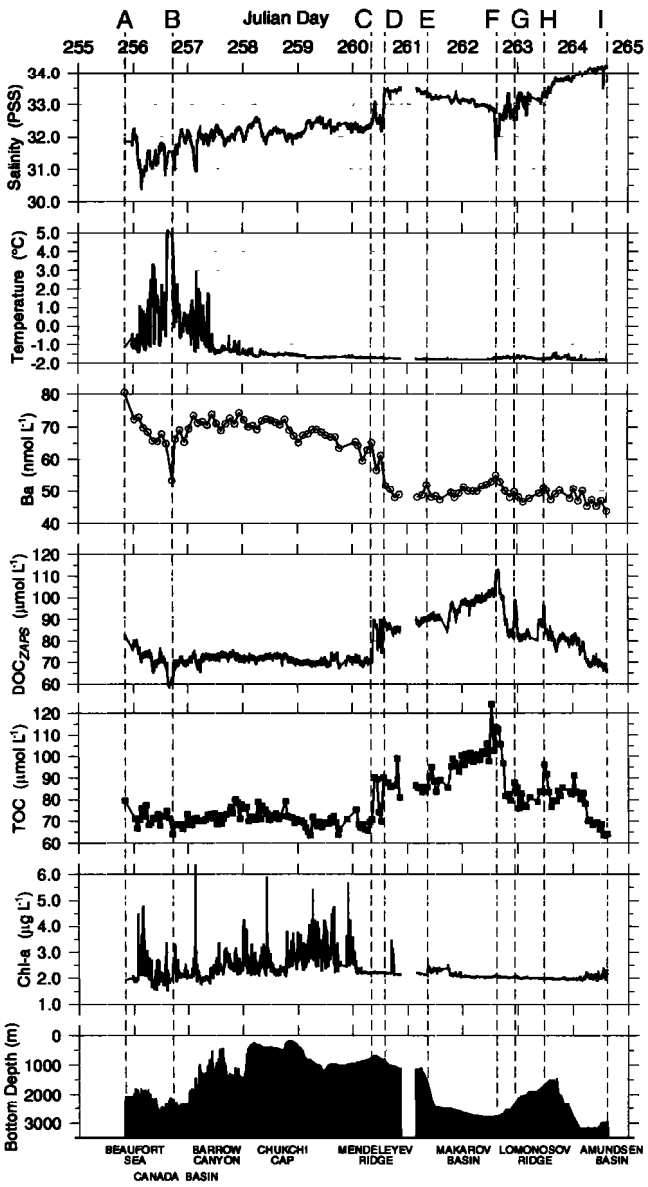

station #
44 42 43 41 40 39 38 37 36 35 34 33 30 28
depth (m)
0 50 100 150 200 250 400 800 1200 1600
30
31
32
33
34
34.8
34.9
0 500 1000 1500
distance from stn. 44 (km)
2000 2050 2100 2150 2200
DIC (umoles/ l)
(with sal. overlain)



Acidification from ocean adsorption of anthropogenic CO2 a particular concern In the Polar Oceans.

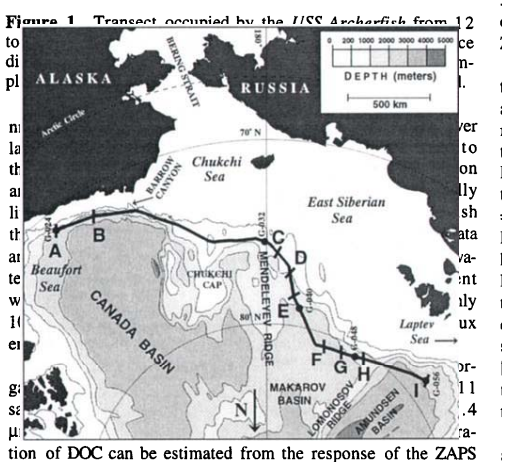
Orr et al., 2005. Nature. 437.





Data from hull-mounted sensors successful at mapping biogeochemical distributions

Guay, et al., 1999. Geophys. Res. Letters. 26:1007-1010.

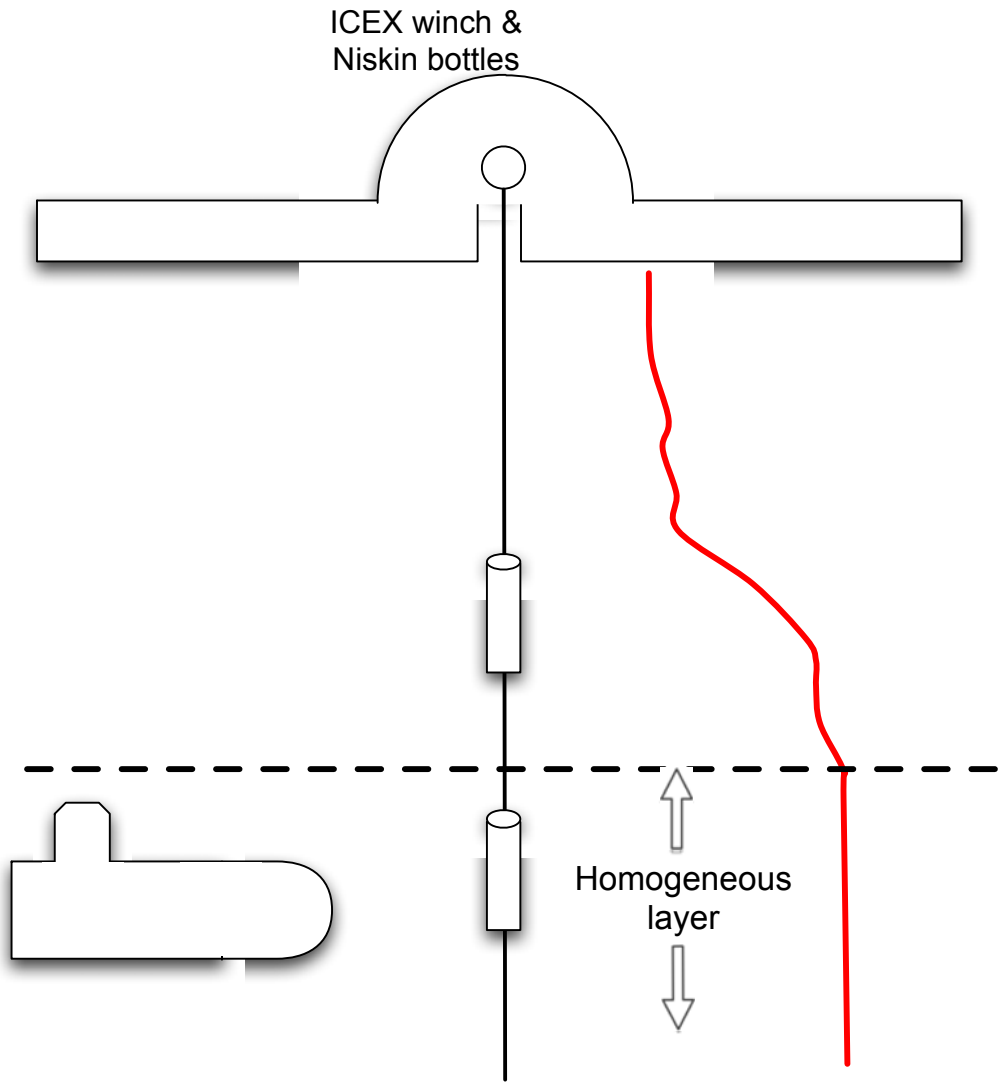


tion of DOC can be estimated from the response of the ZAPS

Preparations for ICEX calibrations – Jan. 18, 2011 at ASL

- Met with 4 people who will be on the submarines and 2 people who will be at the Ice Camp.
- Went over design of calibrations well as specific sampling procedures.
- Will provide subs & ice camp with sampling equipment and detailed protocols.

Plan for calibration samples



Sample Category	Measurement(s)
Autonomous	▪Salinity, temperature, and depth ▪Oxygen ▪Chl a fluorescence ▪pH ▪Position and time
Whole Water	▪Helium ▪Tritium ▪SF6 ▪d18O
Whole Water w/Preservatives	▪Dissolved inorganic C and alkalinity ▪Phytoplankton and microzooplankton ID ▪Bacteria by flow cytometry
Particulate	▪Chl a and other pigments ▪Bacterial genomics and proteomics ▪Particulate C and N
Filtrate	▪Nutrients

SF6/CFCs

- SF6/CFC samples are collected in ground glass stopper bottles, which are stored immersed in water in a plastic jar.

- Place the glass stopper bottle upright in the plastic jar. Allow water to flow gently from the sample port to the bottom of the glass stopper bottle through a length of clear plastic tubing. Pinch or tap the plastic tubing to clear any air bubbles.

- Allow the water to fill the glass stopper bottle, overflow into the plastic jar filling the jar and covering the glass stopper bottle and overflow from the plastic jar for the length of time required to fill the jar.

- Gently remove the plastic tubing from the glass stopper bottle with the water still flowing and quickly insert the glass stopper while the glass bottle is immersed in the jar.

- Remove the glass stopper bottle from the jar, place a plastic spacer on the top of the glass stopper and place the glass bottle back in the jar upside down. Do not remove the water from the jar, but top it off with water from the sample port.

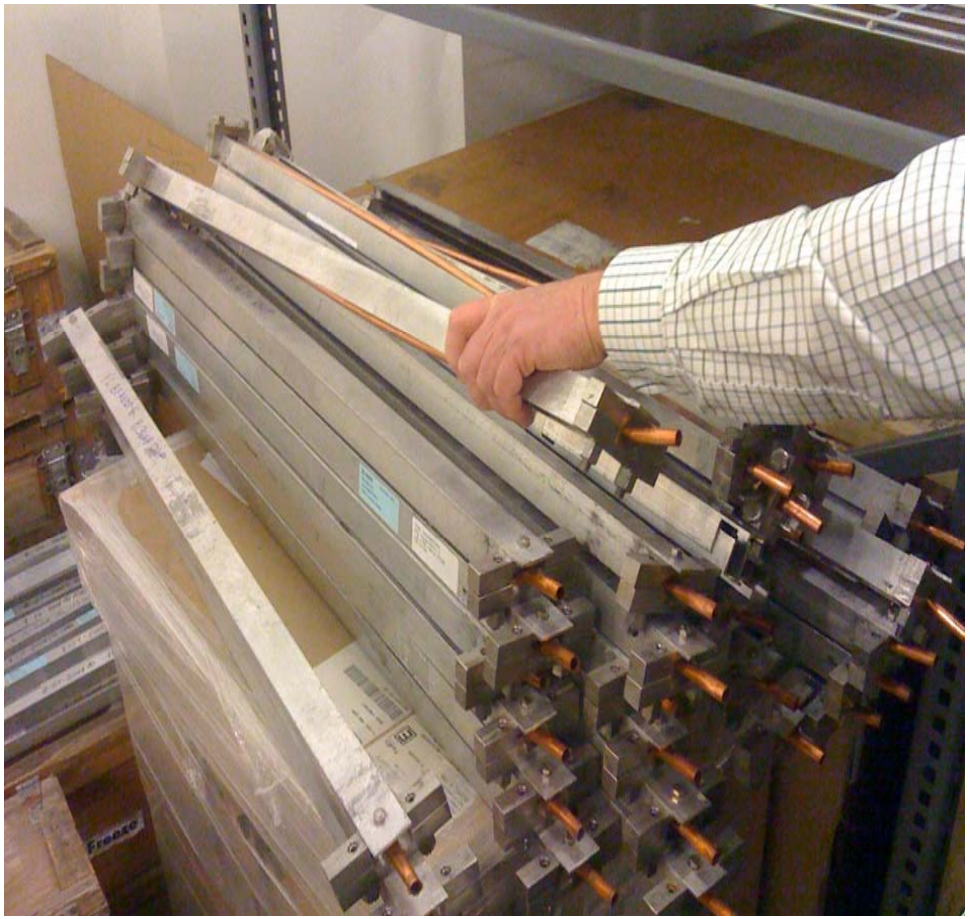
- Screw the lid on the plastic jar, dry and tape with electrical tape.

SF6/CFCs

- Store the sample in a refrigerator at a temperature between 1 and 4 °C (34 – 40 °F). The colder temperature is preferred if available. It is critical to keep the samples cold to prevent degassing.

- Ship the samples is insulated boxes, with frozen ice packs dispersed among the sample jars.

Helium Isotopes



Whole Water Samples

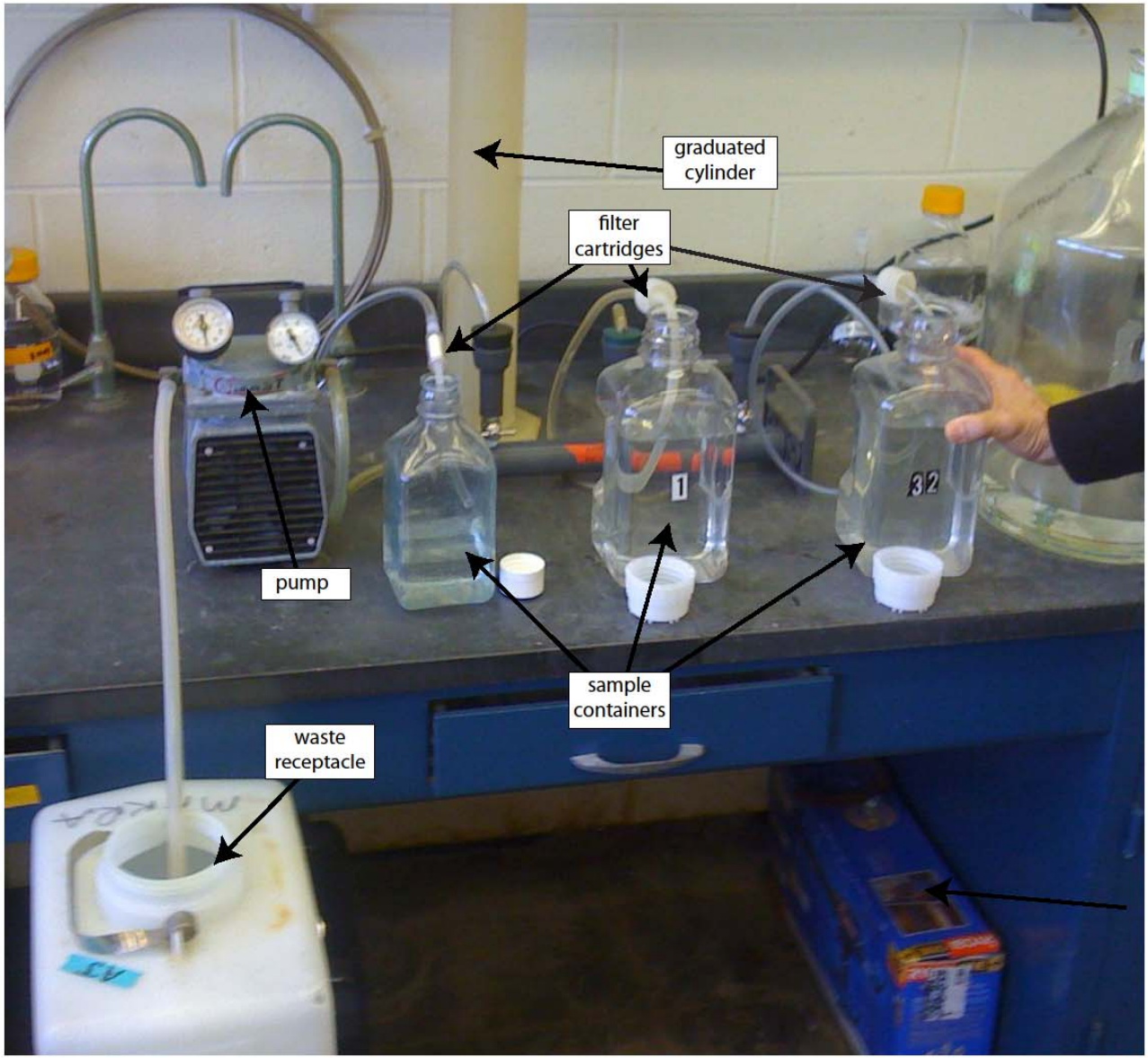
Measurement	Bottle Type	Preservative	Storage
Dissolved Inorganic C & Alkalinity	250 mL PET	$HgCl_2$	4°C
Phyotoplankton and Microzooplankton ID	250 mL Amber	Lugol's	4°C
Bacteria by flow cytometry	15 mL Centrifuge	Formaldehyde	-20°C

Filtration

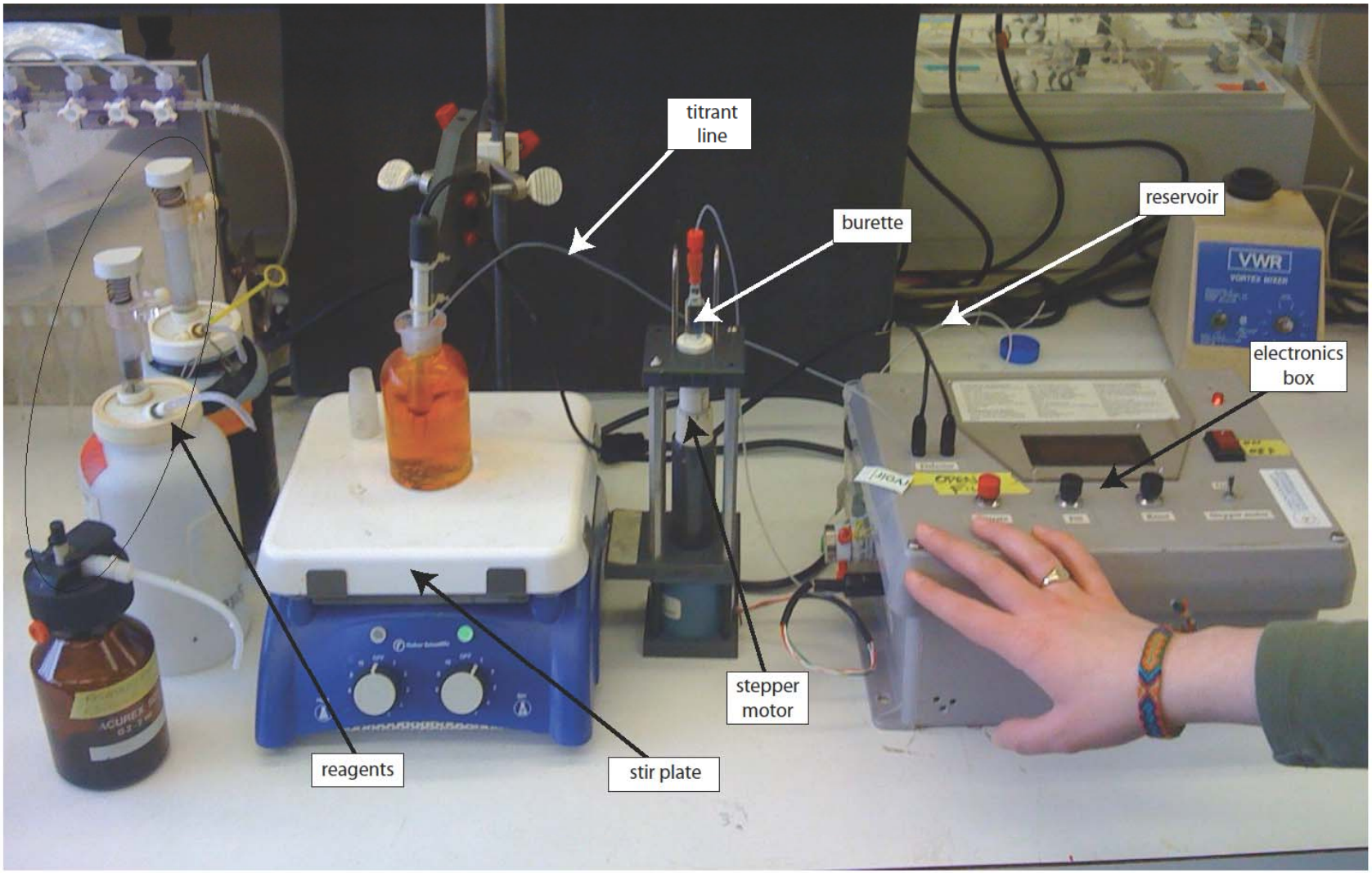
- Collect water from Niskin bottles into a 20 L carboy. Use a graduated cylinder to distribute the water into three appropriately-sized bottles.
- Attach the appropriate filter cartridges to three lengths of tubing attached to the filtration rig.
- Turn on the pump and filter the necessary volumes of water for each measurement. Allow the filtrate to flow into a waste receptacle.
- Using forceps, place the GFF filters into appropriately-sized holders or wrap in aluminum foil and plug up the sterivex filters with clay provided. Store all samples at -20°C.

Measurement	Filter Cartridge	Volume Filtered (L)	Storage
Chl a and other pigments	Sterivex	2 L	-20°C
Bacterial genomics and proteomics	25 mm GFF	4-8	-20°C
Particulate C and N	47 mm GFF	4-8	-20°C

Filtration


graduated cylinder
filter cartridges
pump
sample containers
waste receptacle

Oxygen Titration



Oxygen Titration

- Select an oxygen sample flask and insert the glass end of the sample tube into the flask and allow it to fill slowly in order to prevent bubble formation.
- When there are no bubbles adhering to the side, allow the sample flask to overflow 2 to 3 times its volume. Rinse the stopper with the overflow. The end of the sampling tube should be close to the bottom of the flask.
- Dispense 1 ml of $MnCl_2$ into the sample using the repipet. Dispense the reagent close to the bottom of the flask.
- Dispense 1 ml of the NaOH-NaI solution in the same manner.
- Stopper the flask carefully without trapping bubbles. Shake the sample very well; a milky yellow brown precipitate should be evenly dispersed throughout the sample.
- Add 1ml of H_2SO4. Swirl the flask until the precipitate is dissolved and rinse well.
- Samples should be titrated within 1 to 2 days for optimal results. It is recommended to store the flasks away from light.
- When ready to run the sample(s), place the flask on the stirrer and position the electrodes for titration. Reset the burette, so that it does not exceed its capacity.
- Push *Titrate*. The titration sequence is *TITRATE TITRATE* for standards and samples, and *TITRATE FILL* for blanks.
- The titrator will beep when the titration is complete. Record the titration value on the log sheet with the sample flask number.

Helium Isotopes

- Helium samples are collected in copper tubes, which are crimped shut to provide a gas tight seal.

- Connect the copper tube to the sample port with a length of tygon tubing. Connect a length of tygon tubing to the exit end of the copper tube to drain the water to the appropriate receptacle.

- Start the flow of water through the tubing and copper tube. Pinch or tap the tygon tubing to clear any bubbles that may be present.

- As water is flowing through the copper tube, tap the channel with a mallet or wrench to clear any bubbles that may be attached to the inside surface, allowing at least 500 cc of water to flush through the tube.

- With the water flowing, tighten the exit clamp to stop the flow of water. Then tighten the entrance clamp. Check the four bolts to insure they are all tight.

- Shut off the sample port and remove the tygon tubing from the copper tube. Rinse the interior of each end of the copper tube with fresh water from a squeeze bottle.

- Store at room temperature.

Tritium and Oxygen Isotopes

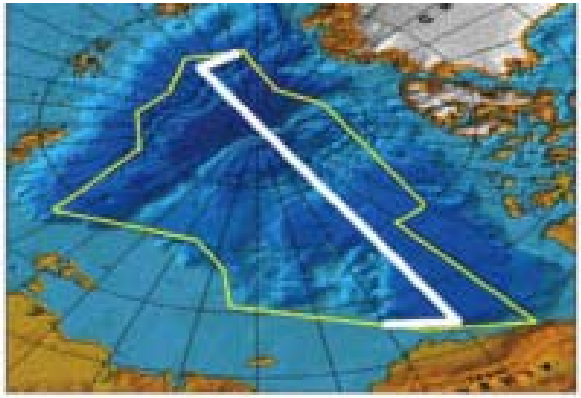
- Both tritium and oxygen isotope samples are collected in glass bottles with screw caps.

- For tritium samples, fill the bottle to the mid point of the shoulder using a length of tygon tubing connected to the sample port. Do not rinse. Allow the water to flow gently into the bottle.

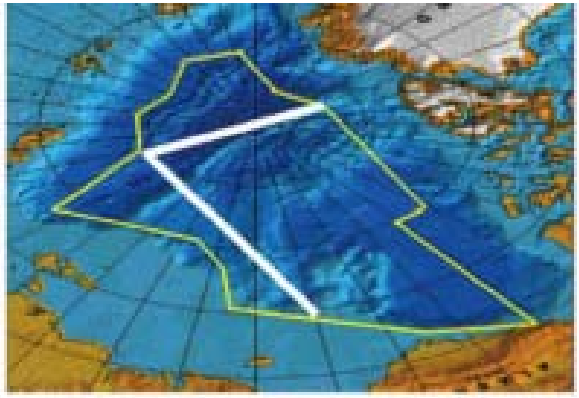
- For oxygen isotope samples, fill the bottle to the neck using a length of tygon tubing. Rinse the bottle twice before filling.

- Place the screw cap on the bottle, tighten and tape using electrical tape.

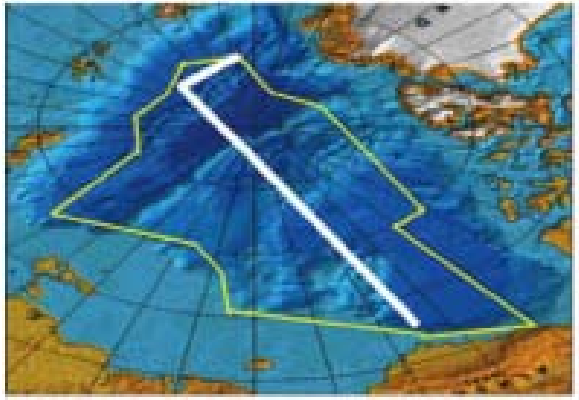
- Store at room temperature.



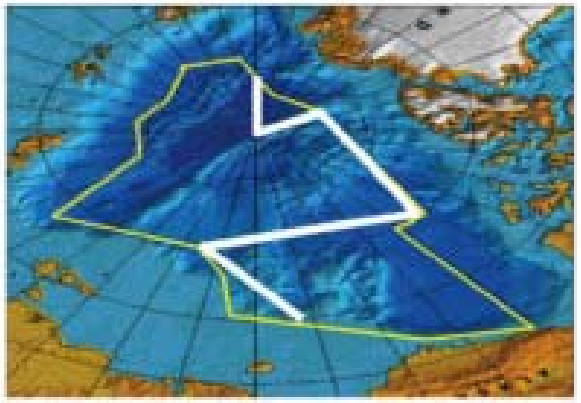
(a) North Pole Track (Corridor 1)



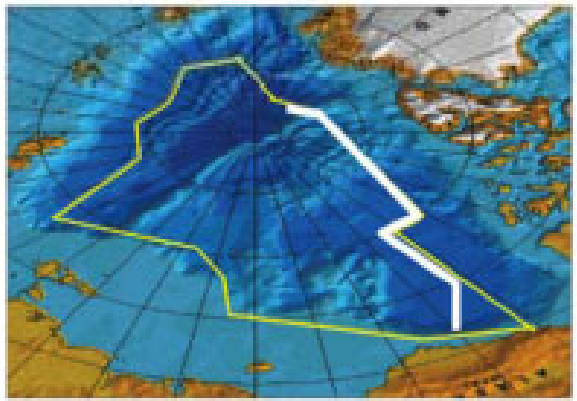
(c) Eastern Offset Track (Corridors 2 and 4)



(b) Recent SCICEX Track (Corridor 1)



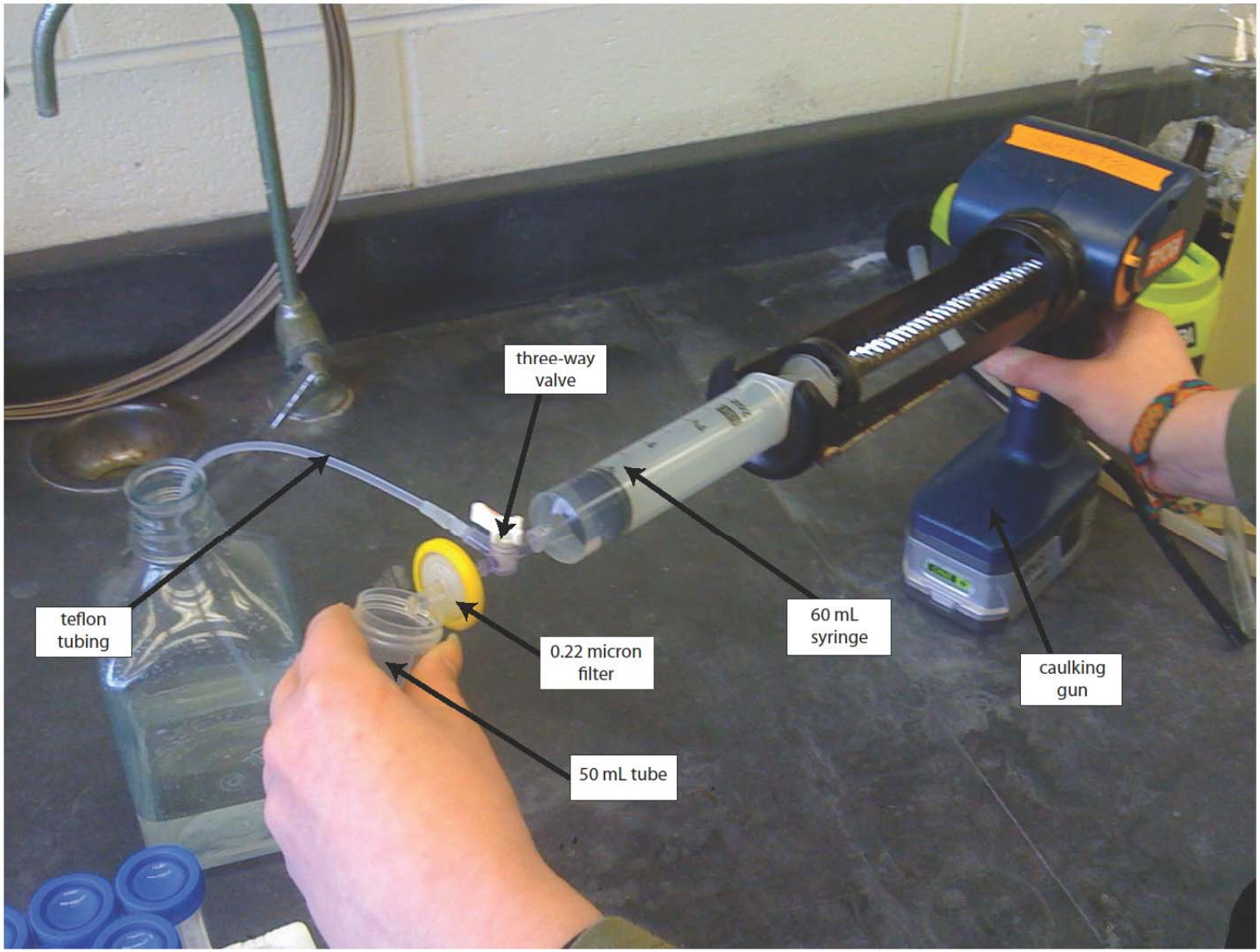
(d) Cross Canada Basin Track (Corridors 2, 3, and 5)



(e) Canadian Margin Track (Corridor 3)

Fig. 1. Maps of possible SCICEX SAM transit corridors across the Arctic Ocean as suggested by the Phase II sample plan. The yellow outline on the map denotes the extent of the data release region.

Nutrients


three-way valve
teflon tubing
0.22 micron filter
60 mL syringe
caulking gun
50 mL tube

Nutrients

- Collect water from Niskin bottles.
- Attach a luer-lok three-way valve to a 60 ml syringe with a 0.22 micron filter attached to it, with a length of teflon tubing attached as well.
- Dip the teflon tubing end into the sample, and filter 45 ml of sample into a 50 ml centrifuge tube using a caulking gun to aid in the process.
- Tape around the cap of the tube to further seal it, and put samples in the -20^{o}C freezer.

Scientific Objectives

- 1. Delineate Pacific from Atlantic water masses in the central Arctic Ocean using multiple water mass tracers.
- 2. Estimate renewal times for surface and halocline waters in the southern Canada Basin.
- 3. Estimate of end-of-winter nutrient levels, particularly in regions of the Arctic Ocean that have recently become ice-free in summer.
- 4. Assess productivity in newly ice-free regions of the Arctic Ocean.