Physical, Chemical and Zooplankton Data from the Canada Basin and Canadian Arctic Archipelago, July 20 to September 14, 2006

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Canadian Data Report of Hydrography and Ocean Sciences 186

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Canadian Data Report of Hydrography and Ocean Sciences

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Rapport statistique canadien sur l'hydrographie et les sciences océaniques

Les rapports statistiques servent de véhicule pour la compilation et la diffusion des données sous une forme directement utilisable par les scientifiques et les ingénieurs. En général, les rapports contiennent des données brutes ou analysées mais ne fournissent pas d'interprétations des données. Ces compilations sont préparées le plus souvent à l'appui de travaux reliés aux programmes et intérêts des secteurs des Océans et des Sciences de Pêches et Océans Canada.

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Les établissements de l'ancien secteur des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports en décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du rapport numéro 1 en janvier 1982.

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PHYSICAL, CHEMICAL AND ZOOPLANKTON DATA FROM THE CANADA BASIN AND CANADIAN ARCTIC ARCHIPELAGO, JULY 20 TO SEPTEMBER 14, 2006

by

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Abstract

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A hydrographic survey of the Arctic Ocean's Canada Basin was conducted during a Joint Ocean Ice Study (JOIS) expedition aboard the *CCGS Louis S. St-Laurent* from 20 July – 14 September, 2006 (Institute of Ocean Sciences Mission Number 2006-18). The objective of the program was to investigate ocean circulation, Pacific and Atlantic-origin water mass distributions, storage of freshwater in the Beaufort Gyre, inter-annual variability and the distribution and concentration of bacteria and zooplankton. This report provides a summary of all science activities conducted during the cruise and includes data collected from CTD/rosette casts. The CTD consists of pressure, temperature, salinity, oxygen, transmission and fluorescence sensor data and the rosette bottle data include salinity, oxygen, nutrients including ammonium, oxygen isotope ratio, barium, dissolved inorganic carbon, alkalinity, chlorophyll-a and phaeopigment, bacteria, cesium and iodine radionuclides, halocarbons including CFCs and carbon tetrachloride, particulate organic carbon and total suspended solids. Sample collection and analytical methods are described. Other samples collected during the expedition, not reported here, are also listed.

Résumé

McLaughlin, F., Proshutinsky, A., Carmack, E.C., Shimada, K., Brown, K., Corkum, M., Dempsey, M., Drost, H., Eert, J., Green, I., Guay, C., Hutchings, J., Illasiak, J., Jackson, J., Krishfield, R., Li, W.K.W., Maclean, H., Nelson, J., Newhall, K., Nishino, S., Ostrom, W., Smith, J., Steel, M., Sutherland, N., White, L., Yamamoto-Kawai, M., Zhao, J. and Zimmermann, S. 2012. Physical, chemical and zooplankton data from the Canada Basin and Canadian Arctic Archipelago, July 20 to September 14, 2006. *Can. Data Rep. Hydrogr. Ocean Sci.* 186: x + 373 p.

Une enquête hydrographique de l'eau du bassin Canada, dans l'océan Arctique, ont été évaluées lors d'une expédition menée dans le cadre des Études conjointes sur les glaces (JOIS) à bord du NGCC *Louis S. St-Laurent*, du 20 juillet au 14 septembre 2006 (mission numéro 2006-18 de l'Institut des sciences de la mer). L'objet du programme était d'étudier les mouvements de circulation océaniques, notamment la distribution des masses d'eau d'origine atlantique et pacifique, les réserves d'eau douce de la gyre de Beaufort, les variabilités interannuelles et la distribution/concentration de bactéries et de zooplancton. Ce rapport présente un sommaire de toutes les activités scientifiques ainsi que les données des profils de conductivité-température-profondeur(CTP)/Rosette. Les données de CTP informent sur la pression, la température, la salinité et la teneur en oxygène, alors que les données captées par transmission et fluorescence et les données de bouteille (données recueillies dans des échantillons d'eau) touchent la salinité ainsi que la teneur en oxygène, en nutriments, en ammoniaque, le ratio des isotopes de l'oxygène, en baryum, en carbone inorganique dissous, l'alcalinité, en chlorophylle *a* et en phaéopigments, des bactéries, en radionucléides de l'iode et du césium, halocarbures, y compris les CFS, en carbone organique particulaire et le total a suspendu solids. Les méthodes d'échantillonnage et d'analyse sont décrites. D'autres échantillons prélevés au cours de l'expédition mais non traités dans ce rapport sont également mentionnés.

Acknowledgements

We would like to thank Captain McNeill and Captain Potts and crew of the *CCGS Louis S. St-Laurent*. Once again we have seen the accomplished and dedicated crew successfully handle problems as small as filling in a door gap to as large as fixing the ship's propulsion system. The care with which the ship is kept a comfortable and productive place to work is much appreciated. We would also like to thank the Canadian Ice Service for their assistance with ice images and weather information as well as the helicopter pilots and mechanics for their valuable help with ice observations and transport. Thanks go to the *CCGS Sir Wilfrid Laurier* for transporting much of our equipment back to Victoria after the completion of Leg 3.

This work was supported by Fisheries & Oceans Canada in collaboration with scientists from the Japan Agency for Marine-Earth Science and Technology and Woods Hole Oceanographic Institution, the latter supported by the U.S. National Science Foundation (NSF). A portion of the costs of the JWACS cruise and hydrographic station data collection and the BGFE mooring and buoy installations was provided by NSF grant number OPP-0424864 "The Beaufort Gyre System: Flywheel of the Arctic Climate?" awarded to Dr. Andrey. Proshutinsky. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the NSF.

1. INTRODUCTION

The Joint Ocean Ice Study (JOIS) is a collaboration between DFO researchers from the Institute of Ocean Sciences (IOS) and colleagues from Japan and the U.S. It combines two ongoing programs: the Joint Western Arctic Climate Study (JWACS), a collaboration with scientists from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) to conduct oceanographic surveys; and the Beaufort Gyre Exploration Project (BGEP), a collaboration with U.S. scientists from Woods Hole Oceanographic Institution (WHOI). The four primary investigators are Fiona McLaughlin (DFO), Eddy Carmack (DFO), Andrey Proshutinsky (WHOI) and Koji Shimada (JAMSTEC).

Five researchers from Natural Resources Canada (NRCan) were also onboard to test seismic equipment in preparation for survey work to provide data under the United Nations Convention of the Law of the Sea (UNCLOS). This program was directed by Ruth Jackson, NRCan Halifax.

The JOIS-2006 study area was the Arctic Ocean's southern Canada Basin, extending as far north as 80°N. The program objective was to study the effects of climate variability and the relationships between the physical environment and biota across shelf break, slope and basin domains. Specifically, the objectives were:

- To understand the impacts of global climate change on the physical environment by linking decadal scale perturbations in the Arctic atmosphere (e.g. Arctic Oscillation and Beaufort Gyre) to interannual basin-scale changes in water mass properties and circulation.
- To understand the impacts of global climate change on sea ice and other fresh water products by utilizing a suite of stable isotopes and geochemical markers to quantify freshwater into their meteoric and sea ice components.
- To investigate water mass modification due to processes such as convection and primary production with a suite of geochemical tracers.
- To understand the impacts of global climate change on the distribution of biota by investigating distributions and abundances of bacteria and zooplankton.
- To investigate physical processes such as thermohaline intrusions, ventilation and nutrient flux.

The JOIS-2006 program was conducted aboard the *CCGS Louis S. St-Laurent* from 20 July to 14 September, 2006 (Institute of Ocean Sciences Mission Number 2006-18). A science team of 27 people (**Appendix 1**) conducted Conductivity, Temperature and Depth (CTD) rosette casts, mooring recovery and deployments, expendable CTD (XCTD) casts and vertical net tow operations. A high resolution, full ocean-depth hydrographic survey of the southern Canada Basin was obtained.

This report briefly describes all science activities conducted on the *CCGS LSSL* in 2006. In particular, it provides a summary of all JOIS science activities and data collected from CTD/rosette casts: the CTD include pressure, temperature, salinity, oxygen, transmission, fluorescence sensor data; rosette bottle data include salinity, dissolved oxygen, nutrients including nitrate plus nitrite (hereafter referred to as nitrate), reactive silicate (hereafter referred to as silicate), orthophosphate (hereafter referred to as phosphate), ammonium, oxygen isotope ratio ($\delta^{18}O$), barium, dissolved inorganic carbon (DIC), alkalinity, chlorophyll-a and phaeopigment, bacteria, iodine and cesium radionuclides (^{129}I and ^{137}Cs), halocarbons including CFC-11, CFC-12, CFC-113, and carbon tetrachloride (CCl_4), particulate organic carbon (POC) and total suspended solids (TSS). Sample collection procedures and analytical methods for the CTD rosette water chemistry program, conducted primarily by the team from the IOS, are also reported. Other samples collected but not included in this report are Carbon-13 isotope (^{13}C), helium (He) and tritium (^{3}H). Samples for salinity, dissolved oxygen, nutrients, $\delta^{18}O$, barium, alkalinity (FW), bacteria and ^{13}C were collected at every station; samples for halocarbons, chlorophyll-a and phaeopigment were collected at most stations; and ammonium, DIC, radionuclides, POC and TSS were collected at select stations.

1.1 FIELD WORK SUMMARY

The main science program was conducted in the Beaufort Sea and Canada Basin. Science was also conducted opportunistically in Davis Strait, Baffin Bay and the Canadian Arctic Archipelago during transit of the ship from its home port in Dartmouth, NS to Kugluktuk, NU. Although the science program was divided into 4 legs only the activities and data from the first three legs are reported here. Details and data from the fourth leg (Mission 2006-43), a hydrographic survey of Baffin Bay conducted in collaboration with US scientists in the study of the Freshwater Cycle, are found in *Canadian Data Report of Hydrography and Ocean Sciences 188.*

Mission #2006-18 accomplishments are summarized below and data included in this report are outlined in **bold font**. Specific location and time of events are listed in **Appendix 2**.

Leg 1: Transit through Baffin Bay
20 July to 28 July, 2006, Halifax, NS to Resolute, NU

Program Objectives
As a Japan/Canada contribution to the international Arctic and Sub-arctic Ocean Fluxes (ASOF) program, continue the “Freshwater Watch” initiated in 2002 by collecting XCTD data.

- 30 XCTD Casts typically to 1100 m depth
- 1 test Rosette cast

Leg 2: Transit through the Canadian Archipelago
28 July to 5 August, 2006, Resolute, NU to Kugluktuk, NU

Program Objectives
Embark select scientific personnel to set up equipment in preparation for JOIS and UNCLOS programs.

- **10 Rosette Casts: salinity, nutrients, barium, δ^{18}O,** and **bacteria** samples were collected
- 84 Drift Bottles were deployed
- **River water samples were collected from the Kugaryuak River. Samples from Coppermine River, collected during 2006-43, are also included here.**
- Seismic package tow-handling test (NRCAN)

Leg 3: Canada Basin Survey
5 August to 14 September, 2006, Kugluktuk to Kugluktuk, NU

Program Objectives
Embark remaining science team in Kugluktuk. Achieve the combined objectives of the JOIS program as described above.

- **75 CTD/Rosette Casts** typically full ocean depth

    1. CTD: The primary CTD (a Seabird SBE911plus) was equipped with 2 **temperature** sensors, 2 conductivity sensors (for **salinity**), SBE43 **oxygen** probe, **transmissometer, fluorometer**, bottom contact warning device and an altimeter.
    2. Rosette: Water chemistry samples drawn from the 24 10 L Niskin bottles include **salinity**, **oxygen**, **nutrients** including **ammonium**, **δ^{18}O**, **barium**, **DIC**, **alkalinity (FW)**, **chlorophyll-a**, **bacteria**, **^{129}I**, **^{137}Cs**, **halocarbons**, **POC** and **TSS**. Other samples collected but not included in this report are ^{13}C, He and ^{3}H.

- 51 PRR/MCTD Casts (Profiling Reflectance and Radiometer deployed with a compact CTD), typically to 100 m depth, at selected Rosette stations (China Ocean University).
- 3 PRR/MCTD Casts performed at ice stations, through the ice to 120 m depth (China Ocean University).
- 55 XCTD Casts typically to 1100 m depth (JAMSTEC).
- 33 Vertical Net Casts, typically to 100 m depth, at selected Rosette stations using 3 mesh sizes (53 μm, 150 μm and 236 μm).
- 106 Drift Bottles were deployed.
- 4 BGEP moorings recovered and redeployed (WHOI).
- 1 Shelf-Break mooring recovery (WHOI; Bottom depth 149 m).

- 1 Canadian Arctic Basin Observing System (CABOS) mooring recovered and deployed for the International Arctic Research Center (IARC).
- 3 Ice Buoy deployments (WHOI):
  * one Ice Tethered Profiler (ITP)deployed at two sites (WHOI).
  * one ITP, Ice Mass Balance Buoy (CRREL), Ice Heat-Flux Buoy, all surrounded by a ring of 6 GPS Buoys deployed at one site (IARC).
- **Ice Observations (IARC):**
  * Hourly visual observations from bridge;
  * Opportunistic aerial observations during flights;
  * 4 on-ice surveys with limited results.
- Seismic Package Towing (NRCAN):
  * Tests conducted to observe performance and durability of equipment in ice and to assess data quality with respect to equipment performance, ship noise and ocean floor composition;
  * Data collection along cruise-track as possible;
  * Test of ship's new 12-kHz echo sounder.
- Underway data collection of ship's meteorological and depth sensors.

1.2 STUDY AREA

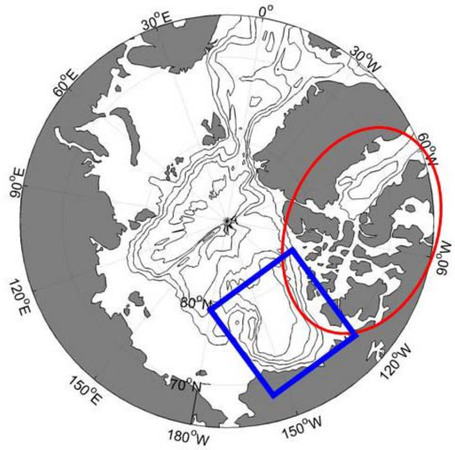


Figure 1. View of the Arctic showing the Canada Basin (blue box) and the Canadian Archipelago and Baffin Bay (red circle).

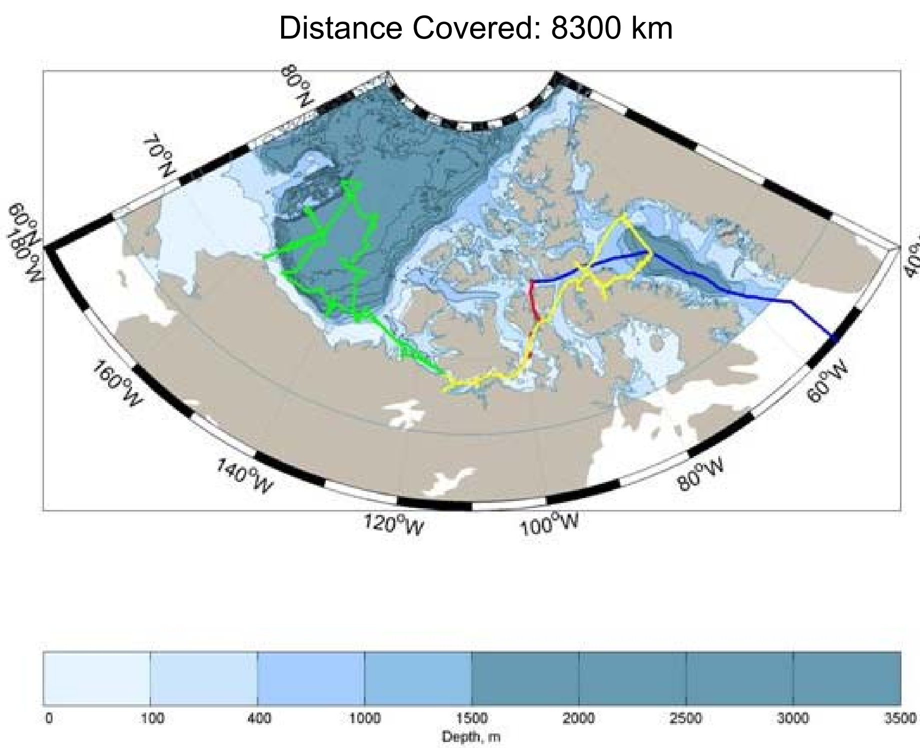


Figure 2. Map of the cruise track with Legs 1 to 3 plus Leg 4 (Cruise 2006-43), coloured blue, red, green and yellow, respectively.

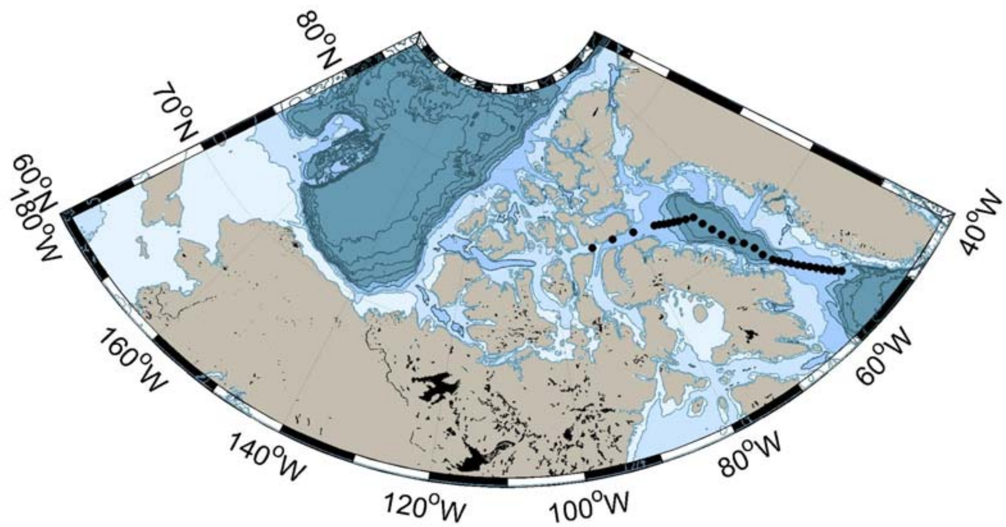


Figure 3. XCTD casts performed on Leg 1.

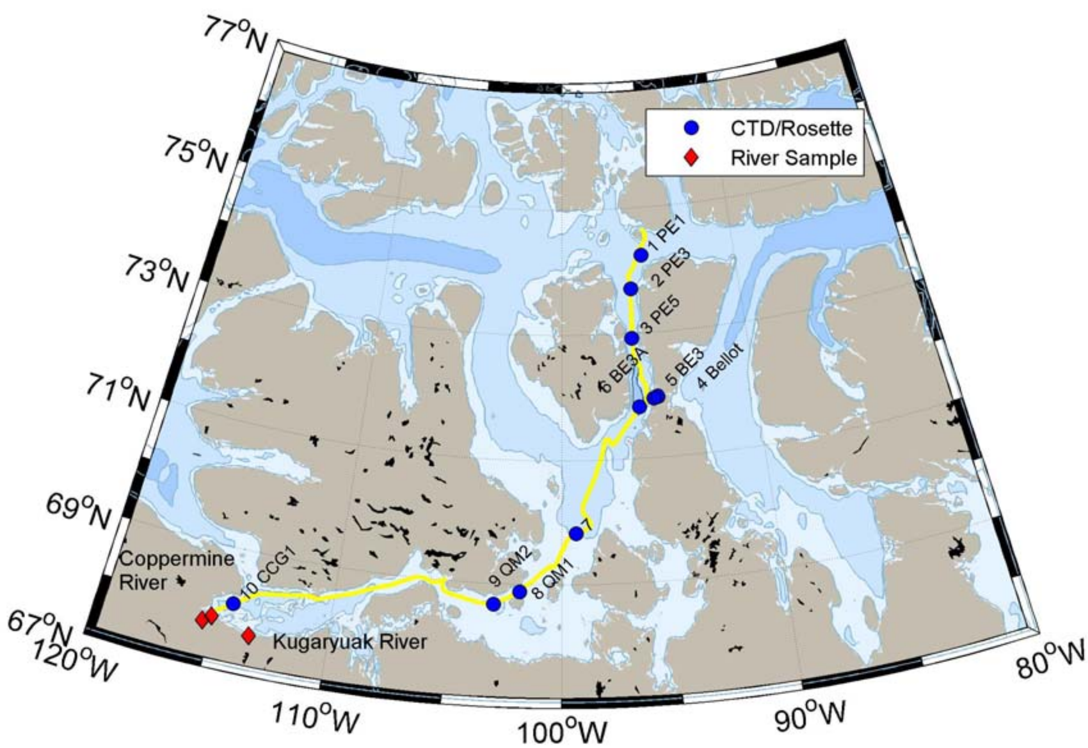


Figure 4. Rosette/CTD casts and Kugaryuak River samples on Leg 2. Samples from the Coppermine River, collected during Leg 4 (Cruise 2006-43), are also shown.

During the Canada Basin survey (Leg 3) stations were occupied in a clockwise fashion from south to north along 150°W and from north to south along 140°W, with additional stations in between. This cruise track allowed the ship to work in optimal ice conditions, i.e. start in the southern ice-free area and then move to the north and east Beaufort when the ice was near the seasonal minimum. Four sections were measured in the Canada Basin, two north-south and two approximately east-west. The four deep BGEP moorings are located at the section intersections. XCTDs were deployed between the CTD/Rosette stations.

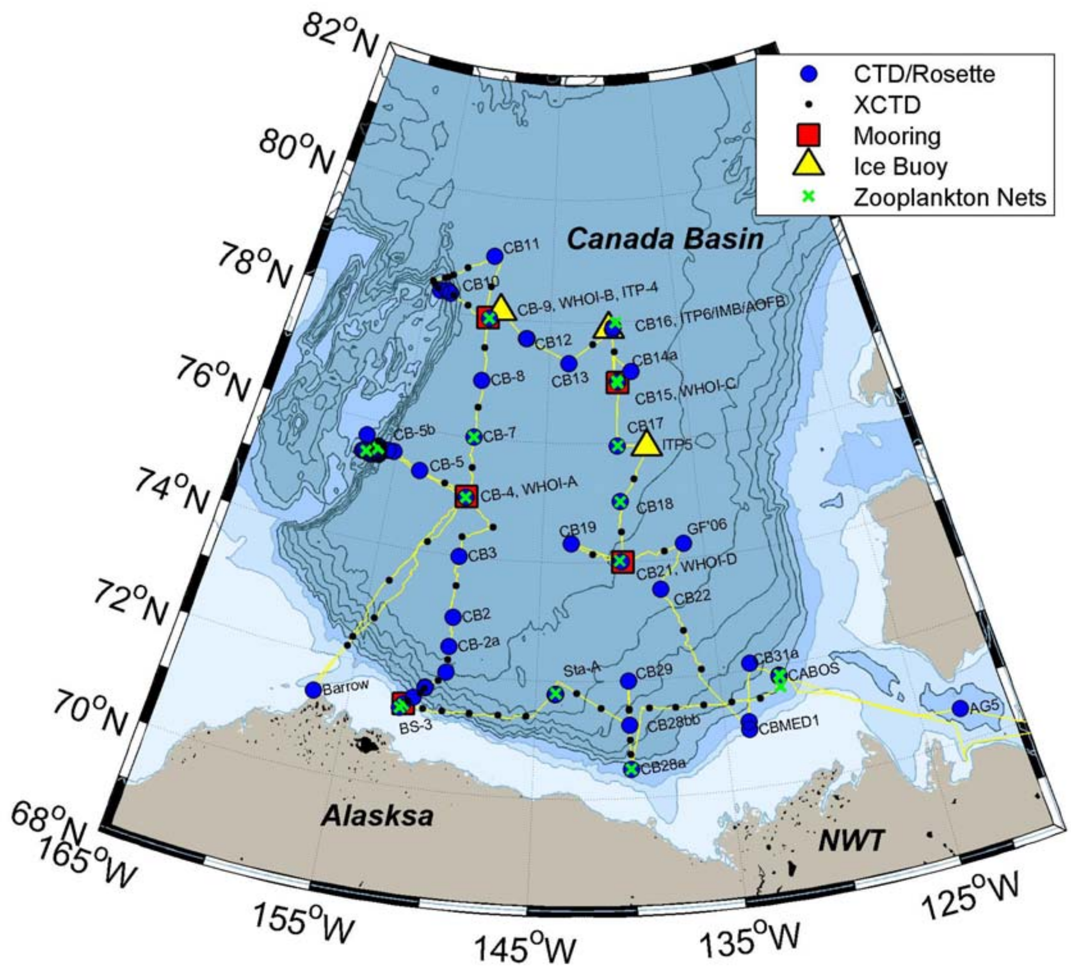


Figure 5. Rosette, XCTD, mooring and buoy locations on Leg 3.

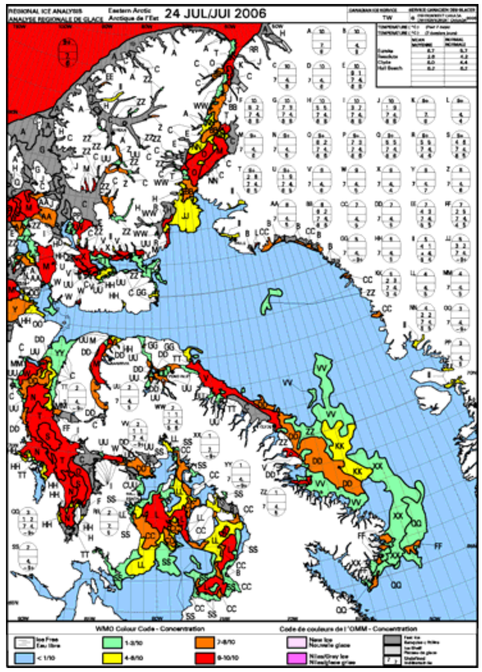


Figure 6. Regional ice concentration by the Canadian Ice Service, 24 July 2006, showing ice conditions through Baffin Bay (Leg 1).

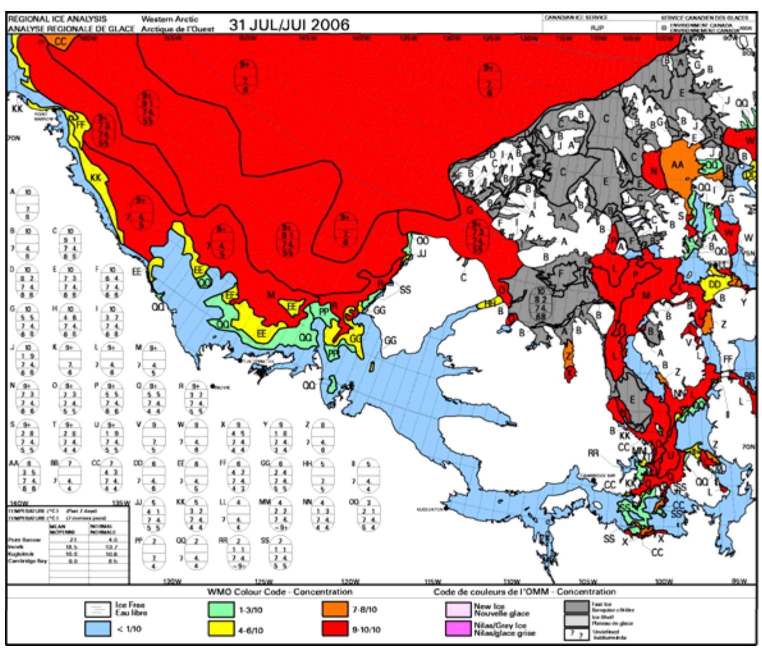


Figure 7. Regional ice concentration during the transit through the Archipelago, 31 July 2006 (Leg 2).

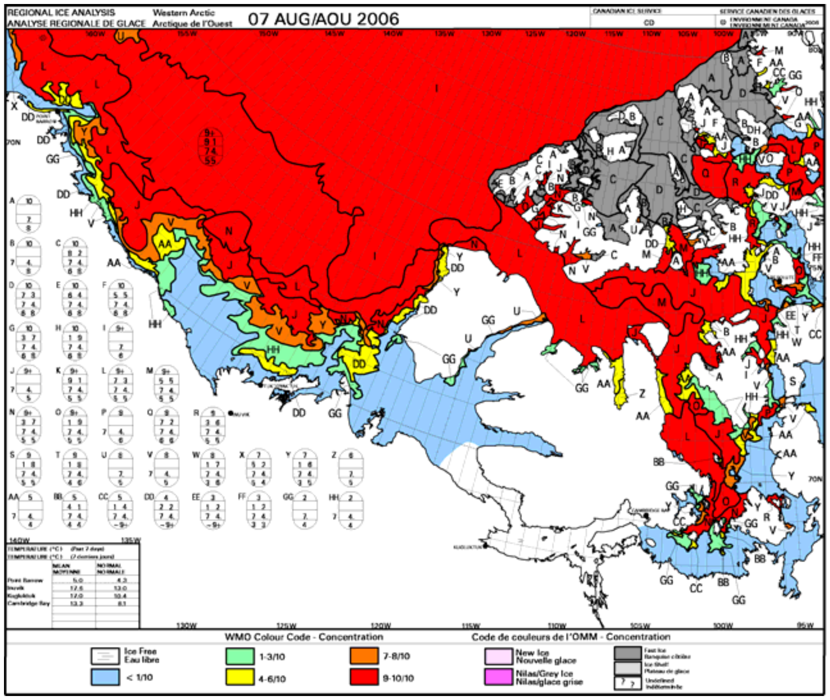


Figure 8. Regional ice concentration in the Canada Basin, 7 August 2006, at the start of the cruise (Leg 3).

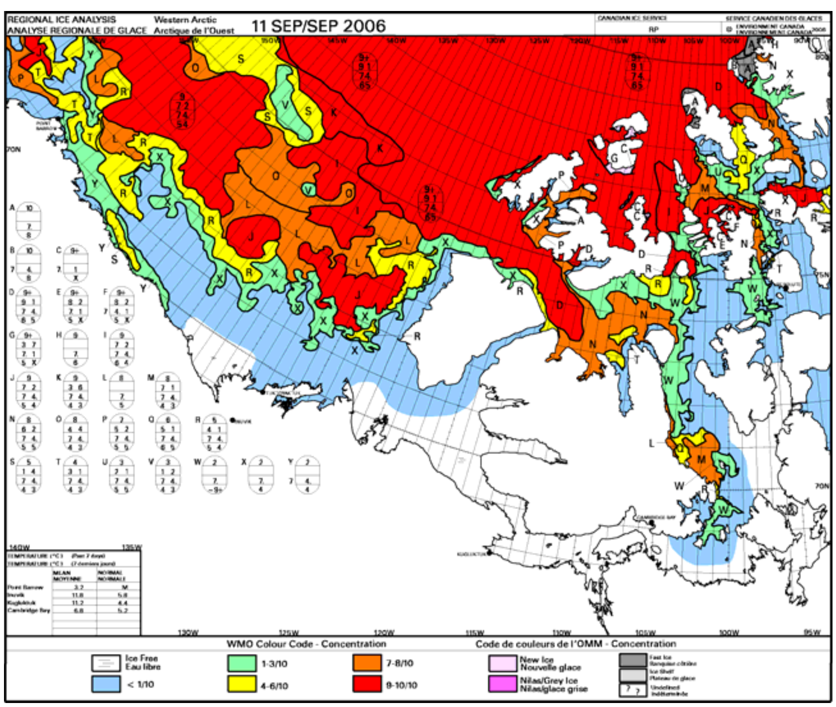


Figure 9. Regional ice concentration in the Canada Basin, 11 September 2006, at the end of the cruise (Leg 3).

2. METHODS AND ANALYSIS

2.1 SCIENCE PLATFORM: *CCGS Louis S. St-Laurent*

The *CCGS Louis S. St-Laurent* is a 26,000 HP Canadian Coast Guard icebreaker equipped with helicopter and deployable rigid hull boats. An ice specialist from the Canadian Ice Service received frequent Radarsat ice images and weather forecast information from shore, sent daily ice and weather observations back to shore, and assisted in navigation and information regarding science station locations.

The Canada Basin was ice covered from roughly 72°N to the north over August, 2006 with operations dependent on the ship making openings in the ice to allow deployments and recoveries. Mooring and vertical net tow operations were performed from the ship's foredeck using the starboard crane and A-frame. Handheld PRR casts were performed from the foredeck from whichever side had the direct sunlight. CTD/Rosette casts were performed on the boat deck, mid-ships, using a starboard A-frame. XCTDs were deployed from the aft deck by a handheld launcher. Ice buoys were deployed away from the ship, using a portable gantry set up on the ice.

The ship's forward science lab was used as a mooring instrument shop, the rosette and CTD operations were performed from newly-replaced boat deck container labs. Nutrient, oxygen, CFC, alkalinity and chlorophyll analyses were performed in the ship's main lab. Salinity analysis was performed in the more temperature stable after-lab. Zooplankton operations were split between the well-ventilated container lab on the foredeck and the after-lab.

Ships soundings were taken using a newly installed Knudsen sounder configured with a new 12 kHz transducer and an existing ship's 35 kHz transducer. Although continuous measurements were taken, the quality was typically poor while traveling through ice. The quality was good when stopped on station or moving through ice free areas.

2.2 FIELD SAMPLING: CTD/ROSETTE CASTS

Rosette casts were taken with a Seabird SBE911plus CTD system, operating at a 24Hz scan rate, equipped with dual temperature sensors, dual conductivity sensors, SBE43 oxygen probe, Wetlabs CST–DR transmissometer, Seapoint pumped fluorometer, bottom contact warning device and Datasonics altimeter. See **Appendix 3** for sensor serial numbers, calibration information and position on frame. Twenty-four 10 liter Niskin bottles with internal stainless steel springs made by OceanTest Equipment, Inc., also mounted on the frame, were used to collect water samples.

A typical full depth cast took 3.5 hours to complete. The ship stopped near the pre-determined location to find a position that would keep the wire clear of ice during the deployment. If ice approached the wire during deployment the wire was moved closer to the ship for protection or the winch spooling stopped while the ice pushed by, preventing the wire from sawing into and catching in the ice. The ship's bubbler system was also used to push ice out of the way although the bubblers' location is most suited to clear the foredeck area, forward of the CTD/rosette launch area.

At the start of the cast the CTD/rosette package was rolled out of the heated sampling container, the protective water-filled plugs removed from the temperature, conductivity and oxygen sensors, and the CTD was powered on to record in-air information while still on deck. The CTD/rosette was deployed after communication was established between the CTD, SBE 32 water sampler and computer, connected by 5500 m of single conductor CTD wire.

Using the newly-installed instrumented sheave (Brook Ocean Technology) which provides winch readouts to the CTD computer and LAN computers on the bridge and main lab, the rosette was lowered to 5 m, the sensor pumps turned on and the package soaked for 3 minutes to equilibrate the oxygen sensor. The package was then raised to just below the surface and lowered at 60 m/min to within 10 m of the ocean floor. After closing the first bottle at the bottom of the cast, the package was raised at 60m/minute then slowed to 30 m/minute for the upper 300 m. There was typically a stop at 900 m in both directions to change the winch gearing between high and low. Bottles were closed on the upcast without slowing the raising speed to capture the least disturbed water. In the upper 400 m, the sample depths were chosen to match a set of salinity values. During the downcast, the depths of the salinity values were noted and on the upcast, bottles were closed at these pre-determined depths.

CTD data acquisition was not stopped until after the CTD/rosette was brought back on deck, again to record in-air measurements. The CTD/rosette was rolled back into the heated rosette room, the water-filled sensor plugs reattached and the water sampler rinsed with fresh water. Care was taken to avoid rinsing the Niskin bottles prior to being sampled.

Water sampling took place immediately after each cast in the heated rosette room. The sampling order was determined by the susceptibility of the property to temporal change, i.e. gases were sampled first.

The SBE911plus CTD and rosette were used for all stations except during the period of ship drift (repairs to the ship's propulsion system) on the North Wind Ridge. Here an internally-recording SBE19 CTD, configured with pumped temperature, conductivity and oxygen sensors was deployed using the foredeck winch and non-conducting wire. Water samples were taken with 5 L and 1.7 L Niskin bottles attached to the wire and closed using weighted messengers.

2.2.1.1 Downcast CTD Files

The downcast CTD data are provided in 1-db averaged files with one file per cast. Standard Seabird processing steps were used. Pressure, primary temperature, primary conductivity and oxygen were calibrated. Data from spikes in temperature, conductivity and oxygen were replaced with linearly interpolated data. Derived variables (salinity, potential temperature, sigma-theta and sound velocity) were recalculated. Transmission, fluorescence and altimetry data were not calibrated.

2.2.1.2 Chemistry

All water sample (WS) data are presented in a single EXCEL spreadsheet with station location and time, CTD and water sample data are referenced to a unique sample number. The spatial lag between CTD reading and bottle water was determined by examining the CTD and bottle salinity in the high gradient near-surface water (upper 300 m) and thus CTD data entered with the water sample data are 1 second averages, lagged by -2.2 seconds to the bottle closure. The CTD oxygen data is from the downcast, matched on pressure not density.

Salinity, oxygen, nutrients, CFC and CCl_4, alkalinity, chlorophyll and ammonium were analyzed on board except for a few samples collected near the end of the cruise which were brought back for analyses in the lab.

Oxygen isotope ratio, barium, DIC and paired alkalinity, ^{129}I, ^{137}Cs, bacteria, TSS and POC samples were analyzed onshore.

2.3 CTD DATA ACQUISITION, PROCESSING AND VALIDATION

2.3.1 Overview/Highlights

The same CTD equipment was used for cruises 2006-18 in the Canada Basin and Canadian Arctic Archipelago (casts 1 to 76) and 2006-43 in Baffin Bay (casts 77 to 113). The CTD data were processed together and are discussed as a whole below, with statements of accuracy reported for each cruise.

The persistent data spikes present in the CTD data last year and the communication errors with closing Niskin bottles were not present this year, due to either the new cable installed between the deck unit and winch or the new electrical termination on the wire.

Three oxygen sensors were used on this cruise but only one performed well for the entire trip. One sensor had a problem with its SPAR assembly, the other had a leak between bulkhead connector and cable. Only the working sensor was calibrated and reported in the final data.

Two transmissometers were used on the frame, individually and at times simultaneously. A connector problem during Leg 4 (Cruise 2006-43) in Baffin Bay required one transmissometer to be removed. Due to repositioning the transmissometers on the CTD, the transmissometer data labels of ‘primary’ and ‘secondary’ are not specific to a single instrument. The configuration for each cast is given in the CTD data file headers and in section **2.3.8** CTD Transmission.

There were bottle closure problems due to the pylon latches failing to release the Niskin lanyards. Clumps of lanolin from the CTD wire had likely fallen into the top of the pylon and gotten into the latch mechanisms. In addition, the sideways angle of the lanyard from latch to bottle may have been too large for certain bottles and thus the tension on the latch was in the wrong direction to successfully release the lanyard when triggered. Of the 1769 samples, 31 Niskins failed to close, 8 Niskins had staggered closures resulting in unusable water from a mixture of depths, and 2 Niskins had delayed closures where CTD data were found to match the water samples.

The CTD had problems with leaking connectors. Mid-cruise, a pair of auxiliary sensors was moved to a different CTD bulkhead connector due to a leaking connection and presumed compromised CTD bulkhead connector. At the end of the cruise three of the four auxiliary sensor bulkhead connectors were showing corrosion when the CTD was disassembled. Corrosion was seen on connectors 1, 3 and 4 which impacts data on external channels 0, 1, 4, 5, 6, and 7. To reduce this problem in the future, the CTD’s bulkhead connectors to auxiliary sensors were replaced with the newer wet-mate types.

Two CTDs were used this cruise. Primary casts were taken with a SBE9+ CTD installed on a rosette. Ancillary casts during the ship’s drift over the Northwind Ridge were taken using a SBE19 CTD with bottles on the wire tripped with messengers. Primary cast numbers with the SBE911plus CTD are: 1 to 30; 40; 42 to 113. Ancillary cast numbers with the SBE19 CTD are: 6 (mounted on rosette frame with the SBE911plus); 31 to 35; 37 to 39; 41. See Table 1 below for details on CTD accuracy.

Table 1. CTD Accuracy for 2006-18.

Sensor	Accuracy	Lab Calibration for Initial Comparison	Correction to Lab Calibration	Comment
Pressure	1 db	29 Oct 2002	None	
Temperature, Primary	0.001 °C	Pre cruise 24 Feb 2006	None	
Temperature, Secondary	0.001 °C	Pre cruise 24 Feb 2006	None	Not checked for data spikes
Conductivity, Primary	0.003 mS/cm shallower than 1500 m; 0.002 mS/cm deeper than 1500 m	Pre cruise 10 Feb 2006	None	From water sample comparisons
Conductivity, Secondary	0.003 mS/cm shallower than 1500m; 0.002 mS/cm deeper than 1500 m	Pre cruise 10 Feb 2006	None	From water sample comparisons; Not checked for data spikes
Salinity, Primary	0.002 below 500 m	NA	NA	Recalculated with calibrated conductivity
Salinity, Secondary	0.002 below 500 m	NA	NA	Recalculated with calibrated conductivity; Not checked for data spikes
Oxygen	0.06 mL/L (2006-18) 0.08 mL/L (2006-43)	Pre cruise 6 Jun 2006	Updated terms: lag, voffset, soc	From water sample comparisons
Transmission (primary)	NA	None	None	Not calibrated
Transmission (secondary)	NA	28 Jul 2006	None	Not calibrated
Fluorescence	NA	None	None	Not calibrated
Altimeter	NA	None	None	Not calibrated

2.3.2 Acquisition and Processing Steps

CTD data were acquired and processed with Seabird software on a PC platform initially. Acquisition occurred real-time through a conducting cable from the CTD to a PC running Seasave (Seasave Win32 V 5.34). The ship's GPS position was added to each data scan via the NMEA interface. Upon completion of the station, the data were copied to a new directory and Seabird's Windows-based processing software, SBEDataProcessing, was used to produce 1db averaged downcast and upcast profiles. The standard processing steps were: sensor alignment through advancing conductivity; spike removal; a correction for the thermal mass of the temperature sensors; filtering; removal of pressure reversals; calculation of oxygen; averaging to 1 db levels; calculation of other derived properties; and the file separation between downcast and upcast profiles.

Final processing was completed using Matlab-based routines to calibrate, plot and remove spikes in the data. The primary conductivity sensor was calibrated to the salinity of deep water samples. The calibrated conductivity was then used to determine a standard bottle depth offset due to closing bottles 'on-the-fly' through comparisons with salinities from shallow water samples. Using the corrected bottle depths, the downcast oxygen sensor data were then calibrated with the bottle oxygen data. Data were plotted station by station to identify density inversions in the downcast. Inversions were replaced with interpolated primary temperature and conductivity sensor data, and the derived properties (salinity, density, theta) recalculated. The interpolations are listed in **Appendix 4**. The fluorometer, transmissometer and altimeter data are unprocessed.

2.3.3 CTD Pressure

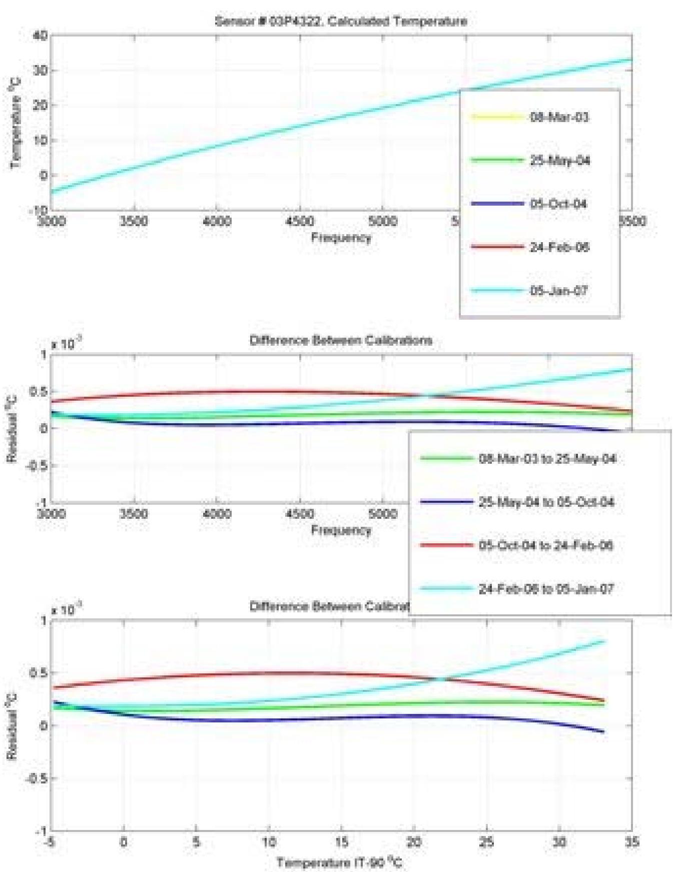
The instrument did not receive a pre- or post-cruise calibration. There is insignificant surface bias from the on-deck readings, and salinity comparisons provide no reason to suspect the deep pressure readings are inaccurate. The average surface bias at the start and end of the casts were +0.11 db and -0.09 db respectively (measured approximately every fifth cast). The standard deviation was low, 0.04 db for both. These biases are small and no correction was made. Stated SBE911plus pressure accuracy is 0.015% of full scale (1 m at 6800 m).

2.3.4 CTD Temperature

<u>Laboratory Calibration</u>

Pre-cruise and post-cruise laboratory calibrations were performed by Seabird Inc. They showed the sensors have a very stable response with minimal drift (Figure 10). Over the ten-month period between calibrations, the primary and secondary sensors changed by less than +0.0003 °C over the range of interest
(-2 - 10 °C). The pre-cruise calibrations are used for the temperature sensors.

(a)



(b)

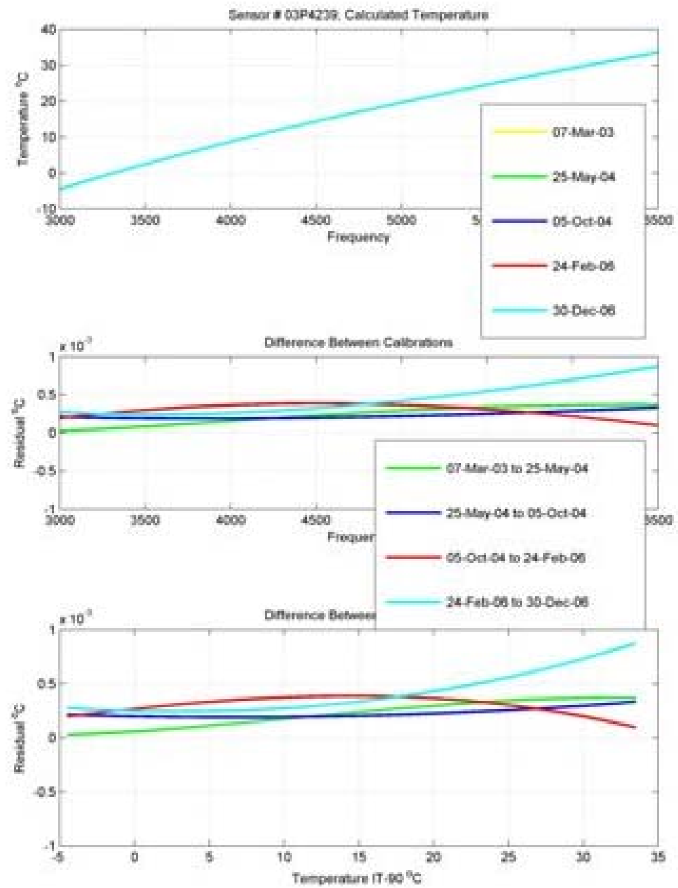


Figure 10. Lab calibration of (a) primary temperature sensor #4322 and (b) secondary temperature sensor #4239. The light blue line in both figures shows the calibration change for this cruise.

Dual Sensor Comparison

Comparisons between the primary and secondary sensors in the station data show very little difference in the deep water throughout the cruise (0.0002 °C offset below 1000 db with standard deviation of 0.0002 °C between casts). There is a larger difference, 0.0009 °C in the upper 200 m (Table 2).

Table 2. Dual Temperature Sensor Comparison with mean and STD of the difference between 1-m binned data.

Depth Range	**0 to 200 m**	**300 to 500 m**	**Over 1000 m**
Mean	0.0009 °C	-0.0000 °C	0.0002 °C
STD	0.0063 °C	0.0008 °C	0.0002 °C

No adjustments besides interpolating over spikes were performed. The data presented are calibrated with the pre-cruise laboratory calibration.

Stated SBE911plus Temperature Accuracy is 0.001 °C. Laboratory calibrations suggest this is appropriate. Dual sensor comparisons show the sensors are in agreement and have been stable throughout the cruise.

2.3.5 CTD Conductivity

Lab calibrations, dual sensor comparisons and water sample comparisons were examined. For both primary and secondary conductivity sensors, water sample calibrations support the use of the pre-cruise laboratory calibrations without any need for adjustment. Dual sensor comparisons indicate no calibration drift during the cruise until cast 80 where secondary conductivity had a small change of +0.0005 mS/cm. This change was too small to need correction.

Laboratory Results

Pre and post cruise laboratory calibrations, performed by Seabird Inc, show there has been little change over the eleven month period (Figure 11). Between pre and post-cruise calibrations, the primary sensor changed by -0.0005 mS/cm at the fresh end and 0.0005 mS/cm at the salty end of the range of interest, 20 to 31 mS/cm. The secondary sensor changed by -0.001 mS/cm at the fresh end and -0.0005 mS/cm at the salty end, over the same range.

Dual Sensor Results

Comparisons between primary and secondary sensors prior to calibration corrections show good agreement with no offset during the cruise in the deep water until casts 80 to 96, see Table 3. The average offset is 0.0000 mS/cm (-0.0003 PSU) below 1000 db with a standard deviation (STD) of 0.0003 mS/cm (0.0003 PSU). Averages of each cast were used to find the cruise average and STD.

(a) (b)

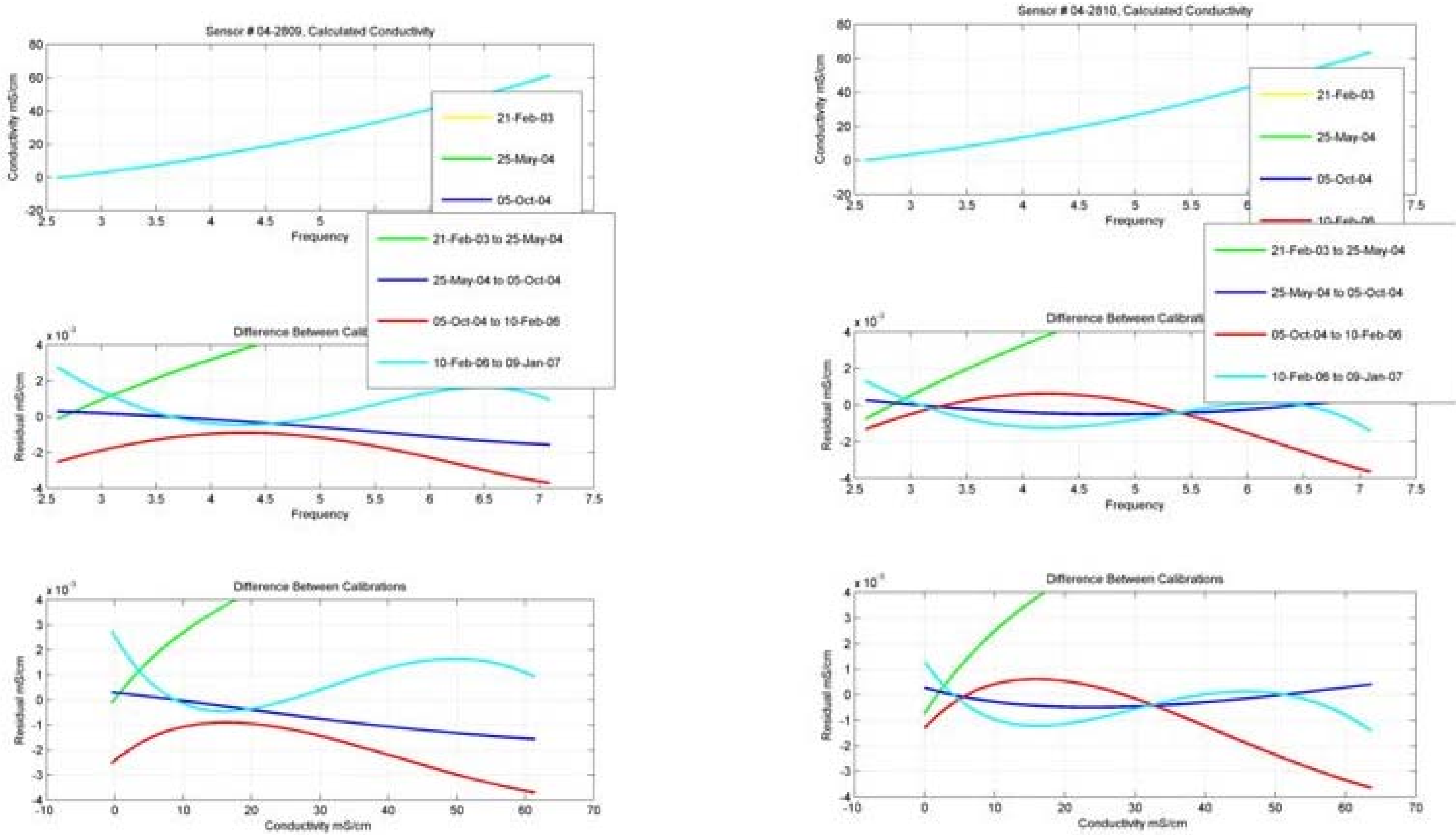


Figure 11. Lab calibration of (a) primary conductivity #2809 and (b) secondary conductivity #2810. The light blue line in both figures shows the calibration change for this cruise.

Table 3. Comparison of conductivity sensors using mean and STD of the difference between 1-m binned data.

Depth Range	0 to 200 m	300 to 500 m	Over 1000 m
Mean	-0.0001 mS/cm	0.0007 mS/cm	0.0000 mS/cm
STD	0.0036 mS/cm	0.0064 mS/cm	0.0003 mS/cm

Salinity differences in the upper 200 m and in depths greater than 1000 m are due primarily to differences between the temperature sensors. The difference between 200 and 500 m is primarily controlled by the conductivity difference, see Table 4.

Table 4. Comparison of salinity calculated from primary temperature and conductivity sensors and secondary sensors using mean and STD of the difference between 1-m binned data.

Depth Range	0 to 200 m	300 to 500 m	Over 1000 m
Mean	-0.0010	-0.0010	-0.0003
STD	0.0066	0.0082	0.0003

<u>Bottle Salt Results</u>

Bottle salts were used to calibrate the primary and secondary conductivity sensors (Figure 12). The majority of samples were taken on-the-fly during the upcast. Only the deep water below 1500 db where the vertical gradient is small (less than 0.005 over 200 m), was used for calibration to remove bottle flushing effects. An iterative fitting routine was used with a standard deviation criterion of 2.5. Casts 1 through 69 were analyzed on board. Due to time constraints and problems with maintaining stable room temperature, Casts 70 to 113 were brought back for analyses on shore. The bottle salts analyzed onshore had an offset of 0.003 psu that was not supported by the CTD lab calibrations, dual sensor comparison, historic data or duplicate bottles run both on board and onshore and has been attributed to an offset in the autosalinometer. Because of this offset error, only the bottles analyzed on board were compared with the CTD data. The on-shore offset may be due to evaporation over the three month period between sampling and analysis, however the sample bottles have tight inserts under the screw-top caps and the analyst did not find excessive accumulation of salt crystallization on the screw-top cap. These samples were corrected later and CTD salinity comparisons in the following section use the adjusted salinity data.

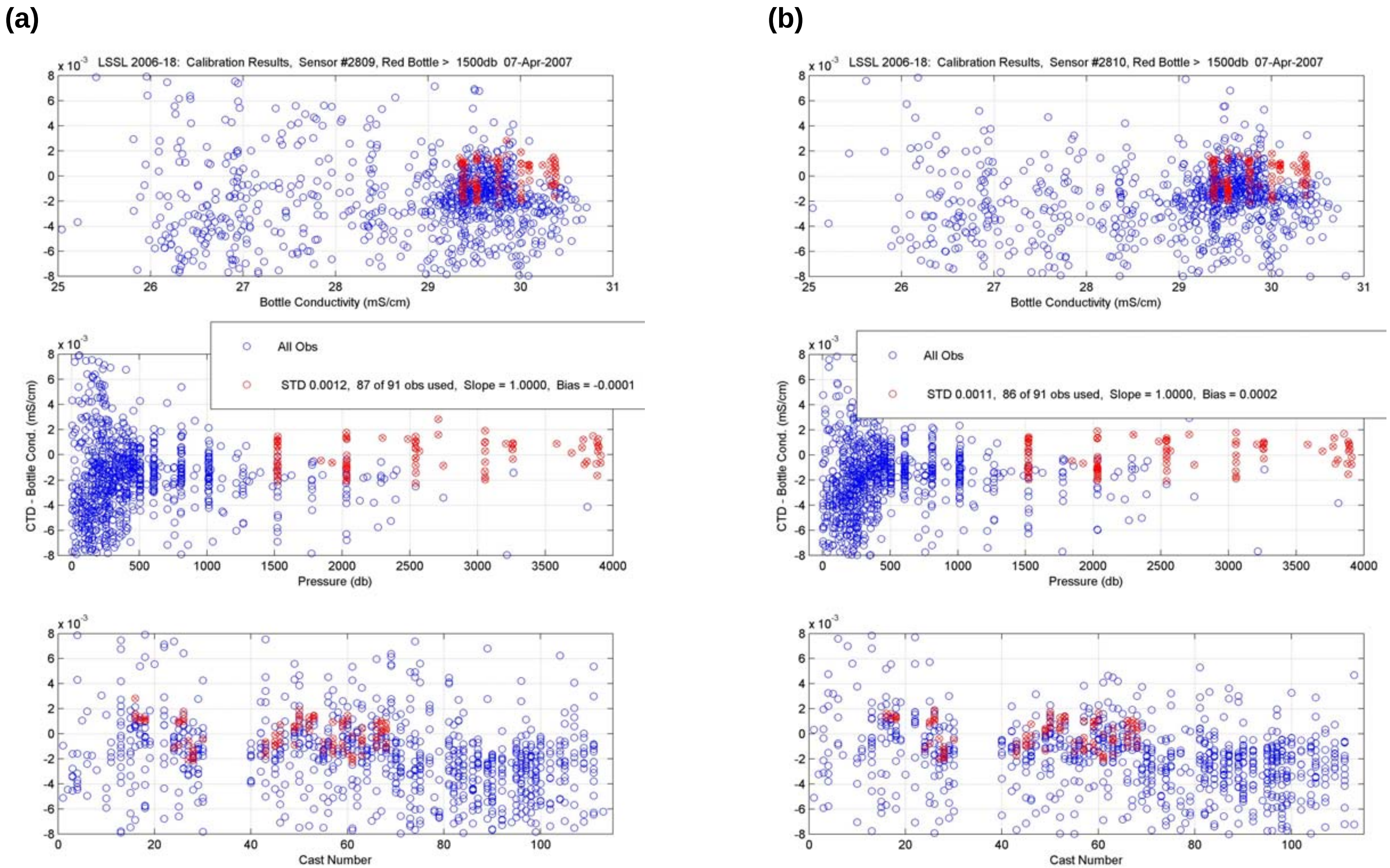


Figure 12. Calibration of (a) primary conductivity #2809; and (b) secondary conductivity #2810 to water samples.

- Primary conductivity bias: -0.0001 mS/cm; STD 0.0012 mS/cm; 87 out of 91 observations used in the calculation; observations were deeper than 1500 db; no correction applied (bias too small)

- Secondary conductivity bias: +0.0002 mS/cm; STD 0.0011 mS/cm; 86 out of 91 observations used in the calculation; observations were deeper than 1500 db; no correction applied

- Only Casts 1 to 69 were used for the calibrations due to offset calibration error in bottle salts for Casts 70 to 113.

Stated SBE911plus conductivity accuracy is 0.003 mS/cm. Laboratory calibrations suggest this is appropriate for data shallower than 1500 db. Calibration to bottle salts suggests an accuracy of 0.002 mS/cm is appropriate for deeper water.

2.3.6 CTD Salinity

CTD salinity was recalculated from the calibrated conductivity. The CTD does not agree as closely to the bottles in the shallow water (0 to 300 m) where there are large vertical gradients as in the deeper water. The best measure of CTD accuracy is provided by the deep water comparisons (500 to 4000 db) and can be considered ± 0.002.

The salinity of the deep Canada Basin is very close to the measurements made in other years. The deep salinity value is 34.9572 compared to the mean 34.9571 (using water samples from 9 cruises, over the years 2002 to 2007).

The comparisons in Table 5, Table 6 and Figure 13 below have been made using the final salinity water sample data (see section 2.4.2 Salinity).

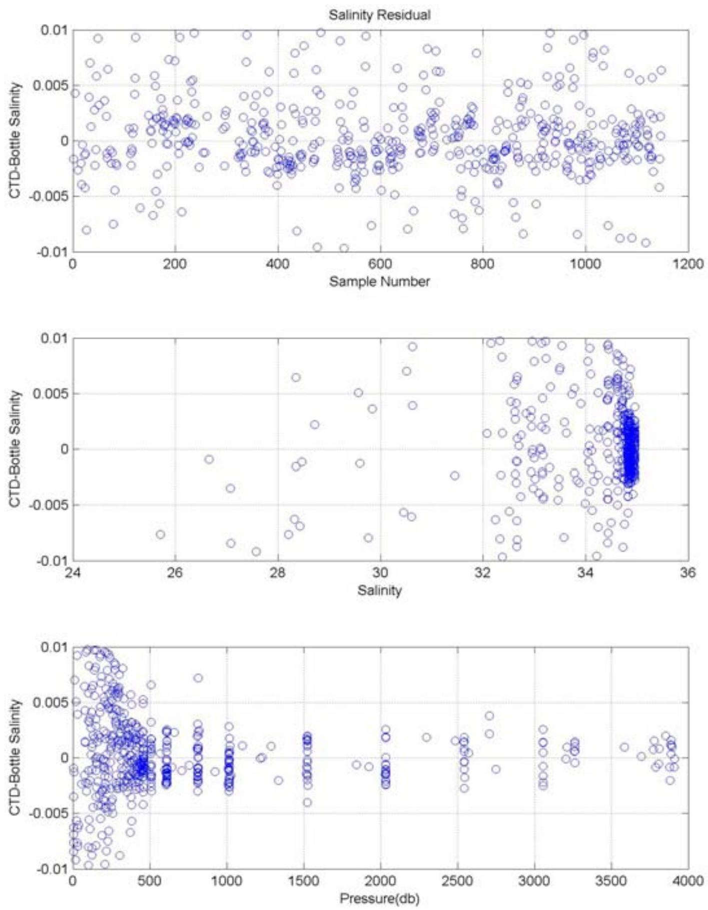
Table 5. Mean and STD of residuals (CTD-WS) for samples run on board (#1 to 1161, Casts 1 to 69), from cruise 2006-18. All flagged samples removed.

Pressure Range (db)	STD	Mean	Number of Observations
500 to 4000	0.0017	-0.0002	221
300 to 500	0.0054	0.0001	147
0 to 300	0.1355	-0.0138	496
Full	0.1028	-0.0080	864

Table 6. Mean and STD of residuals (CTD-WS) for samples run onshore at IOS (#1162 to 1805, Cast 70 to 113), primarily from cruise 2006-43. All flagged samples removed.

Pressure Range (db)	STD	Mean	Number of Observations
500 to 4000	0.0023	-0.0003	149
300 to 500	0.0051	-0.0006	80
0 to 300	0.1426	0.0009	343
Full	0.1104	0.0004	572

(a)



(b)

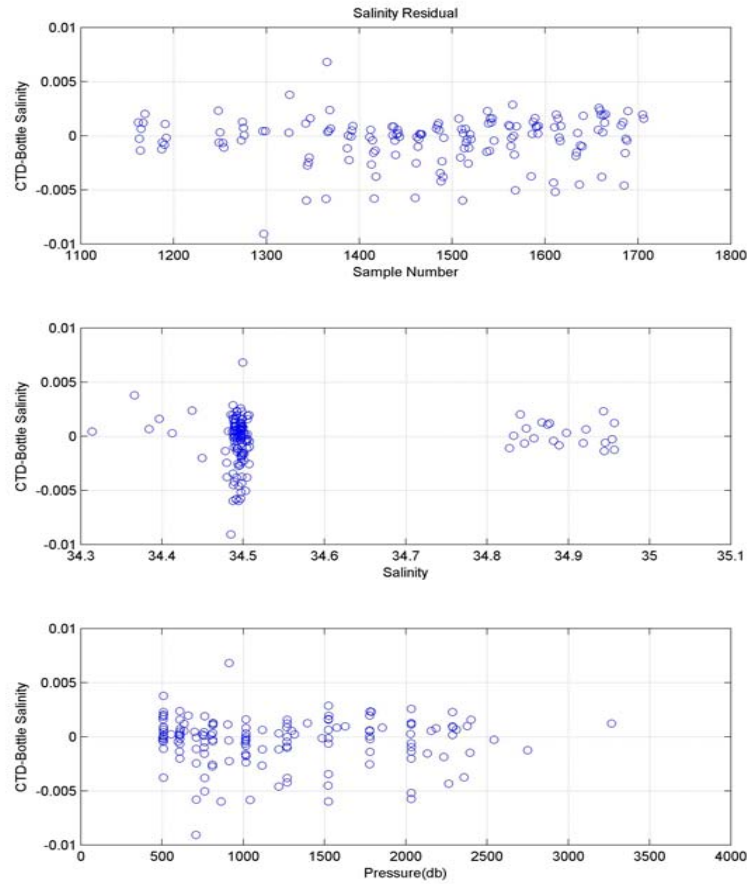


Figure 13. Mean and STD of residuals (CTD-WS) for (a) salinity samples run on board (1 to 1161, up to cast 70); and (b) salinity samples run onshore (over 1161, cast 70+).

2.3.7 CTD Oxygen

Performance

Of the three SBE43 oxygen sensors used this cruise, only s/n 435 performed well for the entire cruise and only these data are reported in the CTD files. CTD oxygen accuracy is ± 0.07 mL/L based on comparisons with bottle oxygen.

Problems addressed:

- The CTD system was originally configured with two oxygen sensors, both SBE 43s, however s/n 820 (on loan from Seabird) developed strong hysteresis, and was removed from the SBE911plus after cast 28. It was tried again for casts 43 to 48 and because data quality continued to decline it was removed permanently.
- A third SBE43 oxygen sensor, s/n 475 (a backup provided by JAMSTEC), was installed in place of s/n 820, however it experienced leaks at depth in the sensor bulkhead connection which recurred even after cleaning and servicing the connection. It was removed after its 4th cast. It was on for casts 29, 30, 40 and 42.
- Water sample data had a positive then negative drift (maximum offset of +0.10 mL/L) that required correction prior to CTD calibration.
- CTD oxygen drifted a total of -0.11 mL/L during the two cruises. This drift was corrected for using a total of 10 station groupings. There remains a bias where CTD values are larger than water samples in the high gradient 50 to 100 m region, perhaps due to effects of incomplete bottle flushing.

Calibration

The downcast oxygen data were calibrated to the upcast oxygen water samples, with consideration given to the sensor lag, hysteresis, and water sample quality. Coefficients were primarily found following the Seabird method (Application Note 64-2: http://www.seabird.com/application_notes/AN64-2.htm). However it was sometimes necessary to use a larger range of casts to find fits for a subset and sometimes new coefficients were chosen bypassing the fitting routine. New sets of coefficients were determined for two of the six coefficients (voffset and soc) and applied together with the other pre-cruise laboratory calibration coefficients and lag value (Table 7).

The lag of the oxygen voltage was determined by comparing similar oxygen voltage features in the downcast and upcast. Depending on depth and cast a lag between 6 and 12 seconds was determined. Seabird now has a new algorithm that applies a variable lag, dependant on depth and temperature but, at the time of this processing, a fixed lag of 8 seconds was chosen as this lag produced the best match for profiles of the upper 500 m. Thus the oxygen voltage was moved 8 seconds ahead of the other sensors to correct for the sensor lag.

Table 7. Coefficients for CTD oxygen equation using lag-corrected oxygen voltage.

Casts	BOC	Tau	Tcor	Pcor	Voffset	SOC
1 to 15	0	0	0.0016	0.000135	-0.50820	0.41036
16 to 27	0	0	0.0016	0.000135	-0.50400	0.41067
28 to 48	0	0	0.0016	0.000135	-0.49512	0.40917
49 to 61	0	0	0.0016	0.000135	-0.50802	0.41524
62	0	0	0.0016	0.000135	-0.49439	0.41229
63	0	0	0.0016	0.000135	-0.49289	0.41100
64	0	0	0.0016	0.000135	-0.49439	0.41229
65 to 69	0	0	0.0016	0.000135	-0.50061	0.41503
70 to 76	0	0	0.0016	0.000135	-0.50812	0.41699
77 to 113	0	0	0.0016	0.000135	-0.49846	0.41750

Due to hysteresis in the oxygen voltage, at a given depth, the upcast oxygen voltage was consistently less than the downcast voltage. The deeper and longer the sensor was at depth, the larger the hysteresis. Hysteresis occurred when casts went deeper than 1000 db with upcast showing the effect even into the shallow water (~400 m). The variable hysteresis in the upcast was too difficult to correct, so only the downcasts were calibrated. The downcast CTD data were taken at bottle trip pressures (after the bottle flushing correction was applied) and compared to water samples. There will be some error due to the real difference between down and upcast profiles.

Comparison of data from stations occupied at the start and end of the cruise, and comparisons to historical data show CTD oxygen drifted progressively lower during the cruise with a total drift of -0.11 mL/L.

As explained below in section *2.4.3 Dissolved Oxygen*, the oxygen water sample data was corrected for drift and based on the known deep water oxygen concentration in the Canada Basin:

- The deep CTD oxygen was shifted to agree with the very uniform deep water concentration below depths of 3000 m to the bottom near 3900 m.
- New oxygen standard values were determined referencing the adjusted CTD data, CTD and water sample cast-to-cast continuity, and data from repeat stations occupied at the beginning and end of the Canada Basin program (9 August and 12 September).
- These new standard values were similar to those found during the at-sea checks.
- The recalculated oxygen water samples were used to calibrate the full CTD oxygen profile.

Comparison of calibrated CTD oxygen and water sample data shows a STD of 0.06 mL/L for the Canada Basin, cruise 2006-18, based on the residuals of 905 observations, and 0.08 mL/L for Baffin Bay, cruise 2006-43, based on 471 observations (Table 8 and Table 9; Figure 14 and Figure 15).

Table 8. Pressure range, mean and STD of residuals (CTD-WS) for oxygen samples from the Canada Basin (1 to 1295 up to Cast 76). All flagged oxygen samples removed and those with residuals over |0.5| mL/L

Pressure Range (db)	STD	Mean (CTD-WS)	Number of Observations
0 to 300	0.0800	0.0182	514
300 to 4000	0.0209	-0.0005	391
Full	0.0625	0.0103	905

Table 9. Pressure range, mean and STD of residuals (CTD-WS) for oxygen samples from Baffin Bay (1296 to end, after Cast 76). All flagged oxygen samples removed and those with residuals over |0.5| mL/L.

Pressure Range (db)	STD	Mean (CTD-WS)	Number of Observations
0 to 300	0.1006	0.0055	271
300 to 4000	0.0435	-0.0005	200
Full	0.0814	0.0029	471

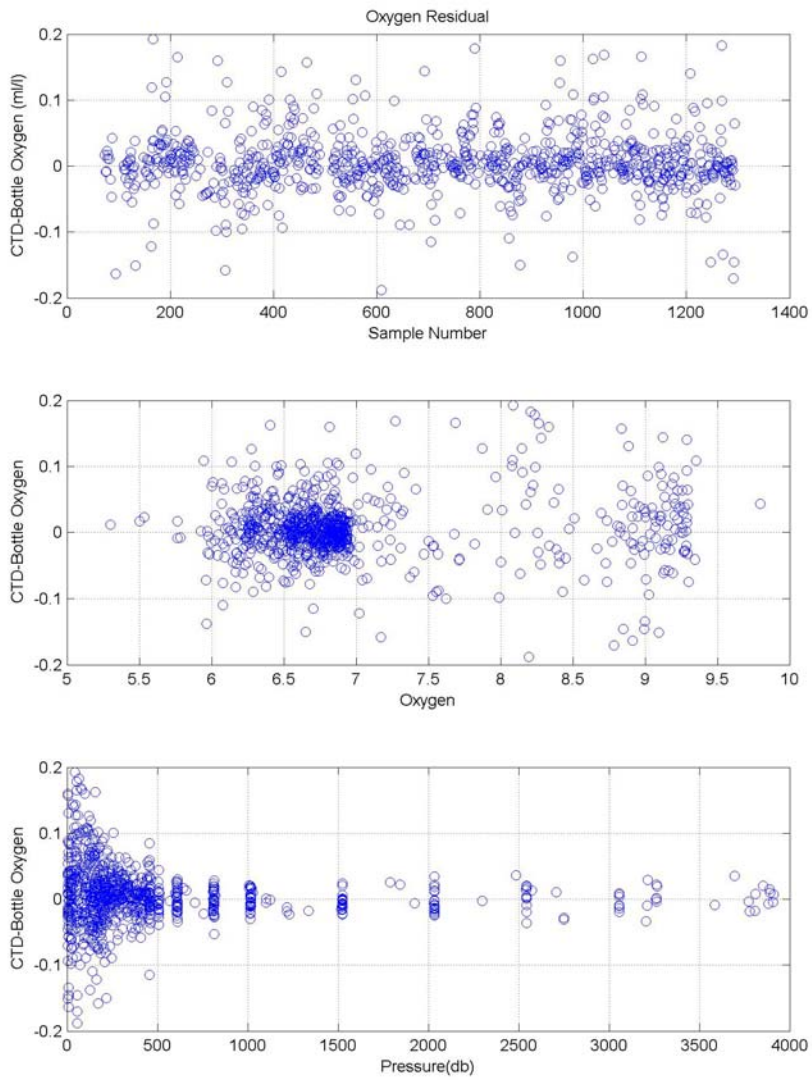


Figure 14. Mean and STD of Oxygen Residuals (CTD-WS) for Canada Basin samples (1 to 1295). All flagged oxygen samples removed and those with residuals over |0.5| mL/L.

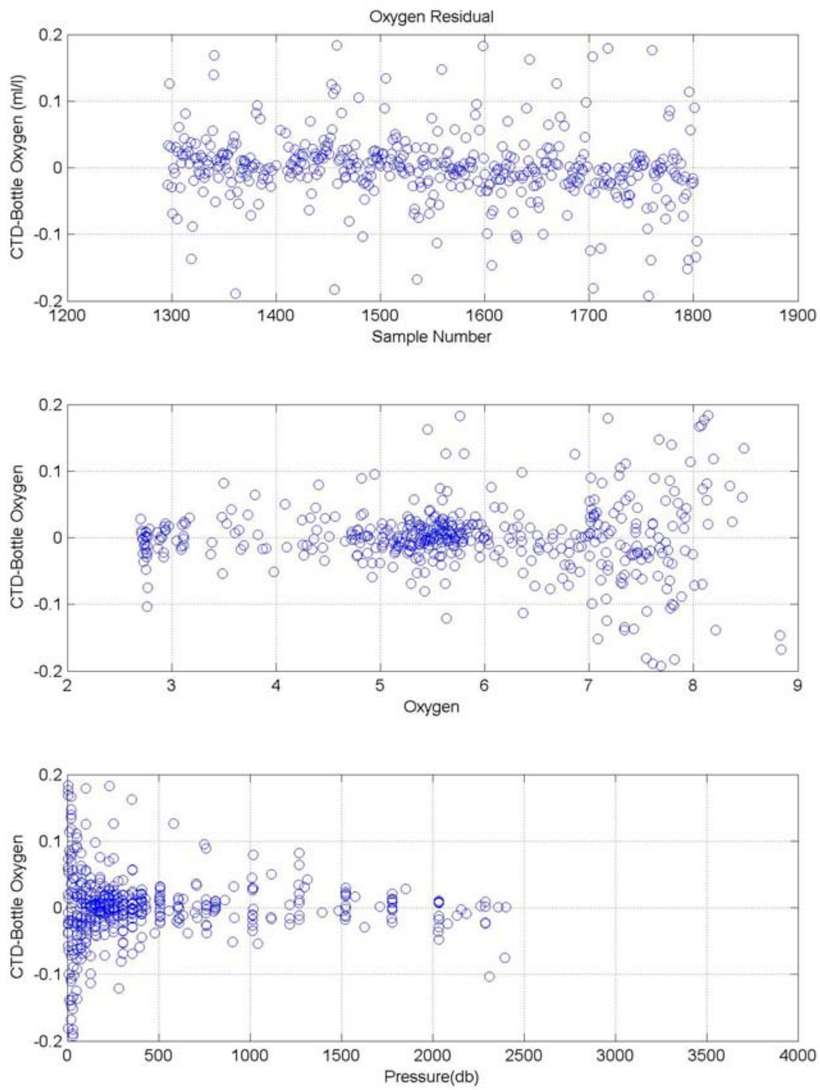


Figure 15. Mean and STD of Oxygen Residuals (CTD-WS) for Baffin Bay samples (above 1295). All flagged oxygen samples removed and those with residuals over |0.5| mL/L.

2.3.8 CTD Transmission

Two WETLabs CSTAR DR transmissometers, each with an optical path length of 0.25 m, were used, individually and at times simultaneously. A connector problem during Leg 4 in Baffin Bay (Cruise 2006-43) required one transmissometer to be removed although the data channel was left in place. Due to repositioning the transmissometers on the CTD, the transmissometer data labels of ‘primary’ and ‘secondary’ are not specific to a single instrument:

Casts 1-48 had one transmissometer installed. S/N 662 is primary.
Casts 49-63 had two transmissometers installed. S/N 993 is primary and S/N 662 is now secondary.
Casts 64-113 had two transmissometers installed. S/N 662 is primary again, s/n 993 is secondary.

The data of the transmissometers were not processed except with nominal coefficients to compute percent transmission. Units were converted to a standardized [%/m] where path length is 1 m. The change in transmission units does not affect the beam attenuation coefficient.

The windows were wiped with tissue soaked in deionized water prior to each cast as part of the CTD launching routine.

The nominal coeffiecients used for processing are:

Serial number : CST-662DR; Calibrated on : 20-Mar-2003
M* : 18.9000; B* : -1.0200; Path length : 0.250 m

Serial number : CST-993DR; Calibrated on : 20-Apr-2006
M* : 18.9800; B* : -1.0620; Path length : 0.250 m

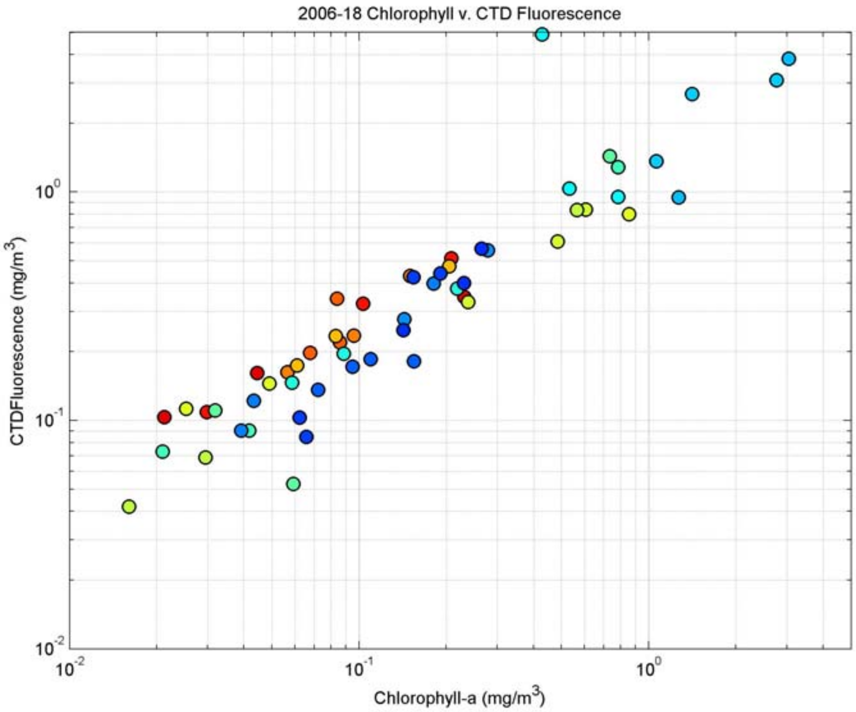
*M and B as defined in Seabird Application Note 7 (Seabird, 2008).

2.3.9 CTD Fluorescence

Water was pumped past the Seapoint fluorometer, after passing through the secondary temperature and conductivity sensors to improve the consistency of the reading. The covered housing on the fluorometer prevented accessibility for cleaning during the cruise.

The Seapoint fluorometer data were not calibrated, however chlorophyll-a data are available from this cruise for comparisons. A 30x gain cable was used with the fluorometer such that the 0-5 V fluorometer output is linearly converted to 0 - 5 mg/m^3. The Seapoint fluorometer minimum detection level is 0.02 mg/m^3. In some instances it appears the fluorometer reached full scale (~5V) and did not fully measure the chlorophyll maximum (Figure 16). Note the fluorometer measures both chlorophyll and phaeopigment.

a)



b)

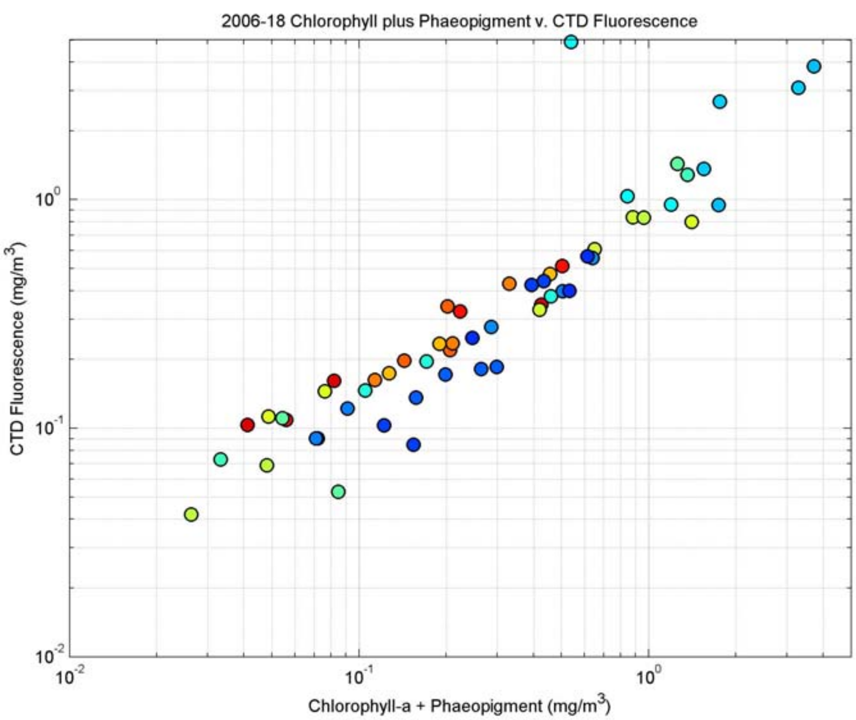


Figure 16. Plot of uncalibrated CTD fluorometer data against (a) sample chlorophyll and (b) sample chlorophyll plus phaeopigment.

2.3.10 Data Spike Removal

Data spikes were found in primary temperature and primary conductivity using the density inversion criteria listed below. Linear interpolations were performed on both primary temperature and primary conductivity if a spike was found in either property. Calculated variables including salinity were re-calculated following the interpolations. Interpolations were also performed for spikes found in oxygen data. Interpolations spanned less than 10 m except in casts 4, 51, 64, 80, 84, and 87 where inversions were typically associated with the first 15 db.

Criteria for temperature and salinity spike identification:

0 to 200 m, density inversions over 0.004 $kg/m^3/m$
200 to 600 m, density inversions over 0.001 $kg/m^3/m$
600 m and deeper, density inversions over 0.0005 $kg/m^3/m$

Cruise 2006-18: Casts 1 through 10 in the Canadian Archipelago had many density inversions due to high shear and gradients. Casts in the Canada Basin casts had fewer inversions, those most commonly found in the upper 10m, were likely due to the ship-induced mixing. The upcast was used as a reference for choosing interpolation points to avoid artificially changing the mixed layer depth or biasing the salinity values.

In cast 50, primary temperature and conductivity were replaced by the secondary sensor values for the full downcast. In cast 13 the surface values of the primary sensors were replaced with the upcast value from the primary sensors.

Cruise 2006-43: The Baffin Bay casts were conducted in the open water where ship roll caused uneven lowering rates and reversals during the descent. This effect was not fully removed from the data leaving many small inversions in profiles.

2.3.11 Determination of CTD Data at Bottle Depths

Because the Niskin bottles were closed on-the-fly, salinity comparisons between water samples and CTD in the upper 300 m were used to determine which CTD data to match with the water samples. Due to bottle flushing lags, the water in the bottles comes from slightly deeper than the depth of the CTD measurement. By applying a standard offset to the CTD data, the data were matched to the water collected in the Niskin.

The appropriate lag was found by comparing 0.2 second averaged CTD data (after applying conductivity calibration) to the bottle data. The comparisons were restricted to the upper 300 m where the vertical salinity gradient is large. Between 100 and 200 db, the vertical salinity gradient is 0.01 - 0.02 /db and wire-speeds ranging from 0.4 - 1.0 m/s created temporal salinity gradients of 0.008 - 0.012 /s. CTD salinity from 0 - 10 seconds prior to bottle closure were compared with the bottle salinities. Casts where the CTD rosette was stopped were excluded.

The casts were split into three groups: the first two in the Canada Basin where both groups were in ice-covered water though with slightly different instrument configurations; and the third in Baffin Bay with open water. Using a STD of 2.5 to remove outliers, the bottle and CTD salinities had the smallest mean difference in Group 1 at -1.8 seconds (meaning the CTD data from 1.8 seconds before bottle closure), Group 2 at -2.2 seconds and Group 3 had the smallest mean at -3.4 seconds. Plots suggest a lag of -2.2 seconds would be suitable for all three groups (Table 10; Figure 17).

Group 3's larger time offset could be explained by a bias in bottle salinities. The samples in group 3, all analyzed at IOS, were found to have a salinity bias of approximately +0.003. The shallow salinity gradient in Baffin Bay was approximately 0.003 /db so the observed bias would make the samples look like they had come from 1 db (1 to 2 seconds) deeper, thus explaining the larger time offset.

There is a skew to the data, where bottle salinities tend to be higher than the CTD salinity, indicating bottles are not uniformly flushed and outliers are biased towards water from greater depths. It should be noted that the alternative, stopping the package for a bottle sample, also results in a bias due to the lack of normal ship-rock in ice covered waters that would mechanically flush the bottles. Closing on-the-fly is thought to reduce the size of the bias and produce a more repeatable response than stopping the package for bottle closures.

Table 10. Results of select CTD time offsets. Calibrated CTD and WS salinities were compared for data within 2.5 STD and 0 to 300 db.

Group 1, with 422 observations total		
	-0.2 Seconds	Mean = 0.0070 PSU, STD = 0.0131 PSU, 194 obs
	-1.8 Seconds	Mean = -0.0001 PSU, STD = 0.0170 PSU, 231 obs
	-2.2 Seconds	Mean = -0.0019 PSU, STD = 0.0162 PSU, 230 obs
Group 2, with 212 observations total		
	-0.2 Seconds	Mean = 0.0039 PSU, STD = 0.0058 PSU, 77 obs
	-1.8 Seconds	Mean = 0.0023 PSU, STD = 0.0162 PSU, 130 obs
	-2.2 Seconds	Mean = 0.0001 PSU, STD = 0.0167 PSU, 131 obs
Group 3, with 383 observations total		
	-0.2 Seconds	Mean = 0.0034 PSU, STD = 0.0039 PSU, 199 obs
	-1.8 Seconds	Mean = 0.0020 PSU, STD = 0.0062 PSU, 243 obs
	-2.2 Seconds	Mean = 0.0014 PSU, STD = 0.0071 PSU, 254 obs
	-3.4 Seconds	Mean = 0.0002 PSU, STD = 0.0112 PSU, 279 obs

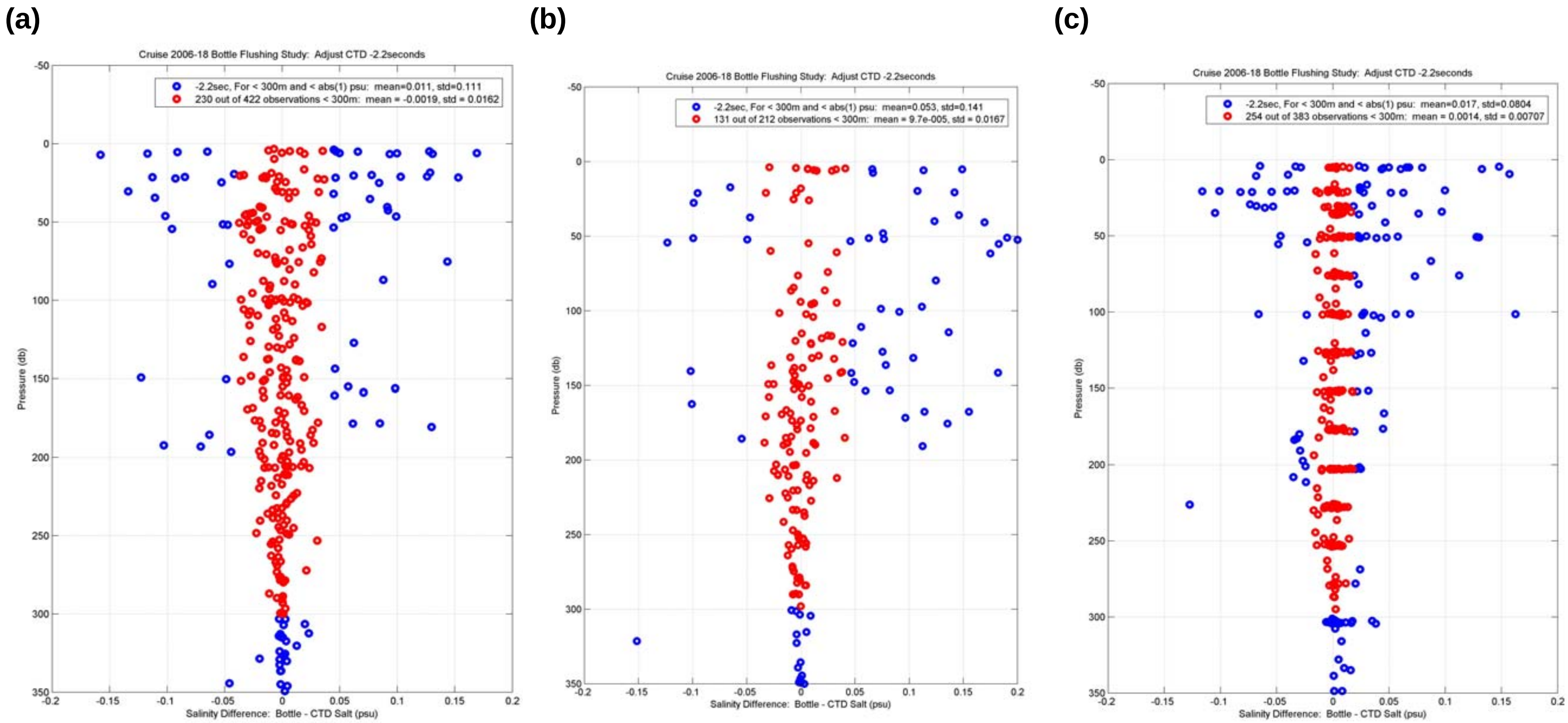


Figure 17. Salinity differences after applying a -2.2 second lag to the CTD data to (a) Group 1; (b) Group 2; (c) Group 3 (Cruise 2006-43 in Baffin Bay).

2.4 CHEMISTRY SAMPLING AND ANALYSIS

2.4.1 Overview/Highlights

Samples were collected for 26 water properties, listed below in Table 11. The precision of the reported data is summarized in Table 12. See **Appendix 5** for individual station plots, **Appendix 6** for property plots and **Appendix 7** for section plots.

Table 11. Water Sample Summary for Archipelago and Canada Basin.

Parameter	Archipelago and Canada Basin Casts (note casts 31-34,36,37,41 were with SBE19)	Depths	Analyzed	Investigator	Comment
Salinity	All	Full Depth	Ship and Shore Lab	Fiona McLaughlin (IOS)	In report
Dissolved Oxygen	All	Full Depth	Ship	Fiona McLaughlin (IOS)	In report
Nutrients (Nitrate, Silicate, Phosphate)	All	Full Depth	Ship and shore lab	Fiona McLaughlin (IOS)	In report
Ammonium	11-13, 15-22,24-30,73-75	0-300	Ship	Fiona McLaughlin (IOS)	In report
Oxygen-18 isotope (^{18}O)	All	0 to 250m and 1 deep	Shore Lab	Fiona McLaughlin (IOS)	In report
Barium	All	0 to 250 and 1 deep	Shore Lab	Chris Guay	In report
Dissolved Inorganic Carbon and Alkalinity	18,46,52,63,68	Full Depth	Shore Lab	Fiona McLaughlin (IOS)	In report
Alkalinity (Fresh Water)	All	0 to 300, 1 deep	Ship	Michiyo Kawai (IOS)	In report
Chlorophyll-a and Phaeopigment (Total using 0.7 µm filter)	A11,12,14-21,26,28,30,47-49,59,61,69	0 to 70	Shore Lab	Fiona McLaughlin (IOS)	In report
Bacteria	All	0 to 200, occasionally 1deep	Shore Lab	Bill Li (BIO)	In report
Iodine-129 isotope (^{129}I)	15,18,19,47,51,52,54,55,58, 59,63,65	Full depth	Shore Lab	John Smith (BIO)	In report
Cesium-137 isotope (^{137}Cs)	19,51,54,58,65	200-1000	Shore Lab	John Smith (BIO)	In report
CFC^{11},CFC^{12},CFC^{113} & CCl_4	All	Full range	Ship	Fiona McLaughlin (IOS)	In report
Particulate Organic Carbon (POC)	11,12,14,15,17-23,25,28-30,42,43,46-49,57,66,72,73	0-300, 1 deep	Shore Lab	Jennifer Jackson (IOS)	In report
Total Suspended Solids (TSS)	11,12,14,17,19-24,28-30,43,46-49, 72, 73	0-100, some to 4000	Shore Lab	Jennifer Jackson (IOS)	In report

Parameter	Archipelago and Canada Basin Casts (note casts 31-34,36,37,41 were with SBE19)	Depths	Analyzed	Investigator	Comment
Carbon-13 isotope (^{13}C)	All	Surface	Shore Lab	CS Wong (IOS)	Not analyzed April 2010
Helium and Tritium	11,13,15-19,24,46,51,52,54,63-65,67-70,72-74	Full Depth	Shore Lab	Bob Newton (LDEO)	Not reported here
Phytoplankton (China)	11,12,14,15,20,25,27,28,29,38,43,48,50,53,56,60,62,68,70	0-70	Shore Lab	Jinping Zhao (OUC)	Not reported here

The precision of the methods was estimated by analyzing replicates and is expressed as the pooled standard deviation, s_p, and calculated using the equation:

$$s_p = \sqrt{\frac{\sum [c(1) - c(2)]^2}{2n}}$$

where c(1) and c(2) are the concentrations of duplicate samples and n refers to the number of pairs. Outliers are removed according to Chauvenet's Criterion (Taylor 1997). Note that s_p is not the same as the standard deviation. The pooled standard deviation was used in past data reports and is continued here for consistency. In the table below the standard deviation (STDEVP), which uses the biased or "n" method, is reported for comparison.

Table 12. Water Sample Precision

Chemistry Sample	Precision (s_p)	Precision STDEVP	Units	Number of Replicates (*n*)	Outliers removed
Salinity (all)	0.015	0.021	PSU	164	1
Salinity (at Sea)	0.014	0.014	PSU	153	1
Salinity (IOS lab)	0.005	0.007	PSU	10	1
Dissolved Oxygen	0.04	0.06	mL/L	106	2
Nitrate (fresh)	0.06	0.08	mmol/m^3	131	2
Nitrate (frozen)	0.14	0.20	mmol/m^3	37	2
Silicate (fresh)	0.10	0.14	mmol/m^3	132	2
Silicate (frozen)	0.30	0.41	mmol/m^3	38	4
Phosphate (fresh)	0.03	0.04	mmol/m^3	125	7
Phosphate (frozen)	0.04	0.06	mmol/m^3	40	3
Ammonium (fresh)	0.02	0.06	mmol/m^3	196	4
Barium	1.1	1.51	µmol/m^3	28	0
DIC	1.31	1.58	µmol/kg	4	1
Alkalinity (from DIC sample)	1.45	1.72	µmol/kg	4	1
Chlorophyll a	0.02	0.03	mg/m^3	11	1
Phaeopigment	0.014	0.019	mg/m^3	11	1
CFC-12	0.05	0.06	nmol/m^3	54	4
CFC-11	0.06	0.08	nmol/m^3	54	4
CFC-113	0.01	0.02	nmol/m^3	55	3
CCl_4	0.08	0.11	nmol/m^3	54	4

Note: All samples were referenced to a unique sample number associated to each Niskin closure.

2.4.2 Salinity

Samples from cast 1 to 68 were run at sea and samples from cast 69 to 75 were transported back to IOS for analysis.

<u>Analysis at Sea</u>

Onboard, samples were analyzed on the Guildline Autosalinometer (Autosal) Model 8400A (SN: 49463) by Hugh Maclean and Mike Dempsey. Procedure followed methods as outlined in the standard IOS protocol. Water samples were collected from Niskin bottles into 200 mL glass salinity bottles immediately following a rosette cast. Salinity bottles used a two cap system, an insert cap followed by a screw on cap. Salinity bottles and insert caps were rinsed 3 times with sample water before filling. Samples were transferred to the temperature controlled room for storage and analyzed within one week of collection. Room and sample temperature was maintained consistently between 21 - 23 °C. Bottles were inverted and mixed prior to analysis.

IAPSO Standard Seawater (OSIL, batch P146, 12 May 2005, K15 = 0.99979 with salinity 34.992) was measured at the beginning and end of each run to calibrate the Autosal and identify instrumental drift. Data are reported in practical salinity units (PSU) (Lewis & Perkin 1978).

A small drift in the autosalinometer during the at-sea analysis (a change in the standard readings at end of every run) required a drift correction be applied to all measurements. This drift varied from -0.0015 to +0.0014 for batches of approximately 100 samples. This drift may have been caused by unstable lab temperatures during the analysis.

The temperature in the after-lab (Lab C "x-ray") where the Autosal was located was very difficult to regulate. At the start of the cruise, temperatures were well above the 24°C bath temperature. An in-window air conditioning unit belonging to *LSSL* was used to cool the room. However, once the outside air temperature dropped below freezing, the lab temperature fluctuated between 15 - 22.5 °C. The temperature was monitored and samples were run only when room temperatures were stable and close to the Autosal's bath temperature. The room temperature could not be kept warm enough towards the end of cruise 2006-18 and throughout 2006-43 and therefore samples (#1162 and over) were brought back for analysis at IOS.

There were two issues with the original analysis that were corrected for in the final data. Intermittently, samples between 132 and 983 were read incorrectly from the Autosalinometer display. For example, the display reading "1.9 - 0.0876" was read as "1.9 + 0.0876" and recorded as a conductivity ratio of 1.9876. Instead, the suppression knob should have been changed to get a value of "1.8 + 0.0124" (1.8124). These errors were easy to identify and correct when compared against CTD salinity profiles. The second issue was the wrong RS value for the standard water was used for samples 132 to 239. The analyst had mistakenly used a conductivity ratio of 1.99979 instead of 1.99958 for these samples. To correct these samples, the sample's conductivity ratio was multiplied by the correction coefficient where:

Correction coefficent 0.999895 = 1.99958 / 1.99979

This is an approximate adjustment of -0.004 psu for salinity range 29 – 35 psu.

Analysis onshore

Onshore at IOS samples were analyzed on the Guildline Autosalinometer 8400B, SN 68572 by Mary Steel. Procedure followed methods as outlined in the standard IOS protocol. IAPSO Standard Seawater (OSIL, batch P146, 12 May 2005, K15 = 0.99979 with salinity 34.992) was run before and after the analysis. Samples were analyzed in a 24 °C bath in a temperature-controlled lab where ambient temperature ranged between 19.8 - 22.9 °C with a 2.6 °C maximum Difference observed during a daily sampling session.

Duplicates of samples analyzed at sea and on shore, together with deep water values from the Canada Basin and comparison with historic data from Baffin Bay all showed that the salinity analysis at IOS over-reported the values by 0.003.These samples (duplicates 964-970, 1120, 1132, 1143, 1160, 1161; primary and duplicates for 1162+; and river water samples) were adjusted by -0.003 to account for an unexplained bias. Samples may have been compromised during storage or the autosalinometer may have had a problem.

See Table 13 below for statement of precision.

Table 13. Precision of salinity samples analyzed at sea and onshore.

Samples	s_p	***n***	***No. outliers removed***
At sea and onshore combined	0.015 PSU	164	1
At sea all depths	0.014 PSU	153	1
Onshore all depths	0.005 PSU	10	1

2.4.3 Dissolved Oxygen

Following the cast, once the Niskin bottle integrity was checked, samples were drawn for CFCs and then dissolved oxygen. Water was drawn through rubber tubing into a calibrated (by volume) glass flask with attached stopper. The sample was immediately pickled with 1.0 mL of manganous chloride then 1.0 mL alkaline iodide, the stopper inserted and the flask shaken to mix the contents. The flask was stored in the refrigerator until analysis.

Analysis

Dissolved oxygen samples were analyzed on board by Mary Steel within 24 hours of collection using an automated version of the Micro-Winkler Technique as described in Carpenter (1965). The methodology follows standard IOS protocol described by Minkley and Chase (1997). All chemical solutions were prepared at IOS. The titration was performed with a Metrohn Dosimat 665 and the end point was detected using a Brinkmann probe colorimeter PC910 SN910-358. Software, written at IOS (NewAutoOxy.exe), was used to calculate dissolved oxygen (mL/L).

A problem with the titration software occasionally caused the program terminate the titration prematurely. The software was restarted, the titration completed and the volume of titrate used in the two runs was summed.

The largest problem was the elevated and fluctuating lab air temperature. For several days the lab temperature ranged between 26 - 28 °C due to a lack of air circulation which caused problems when titrating. Fans and ice were brought in to help increase air circulation and decrease temperature.

Standards and Accuracy

Standards and blanks were measured whenever a new bottle of reagent and/or sodium thiosulfate or potassium iodate was opened. Subsequent analyses used these new values to calculate oxygen concentration.

Standards were also run throughout the cruise to check for drift in the system. The drift was substantial, by mid-cruise the data had shifted by +0.10 mL/L, and by the end of the cruise the data had shifted back down for a final difference of -0.02 mL/L. The cause was not known and it first was decided to correct the water sample data by determining new values for the standard and recalculating water sample data with the new values (Figure 18). These standard-check values had high variability, and an alternative method was then selected. The time-series average of oxygen in the Canada Basin's deep water, 6.57 mL/L, was used as a reference together with the CTD/O values collected between stations and data from a station repeated at the start and end of the cruise (1 month apart). These data were used to determine when shifts to the standard value occurred. For the most part the standard checks agreed with the identified shifts, however it was clear standard checks needed to be done more frequently (daily) in the future.

The pooled standard deviation was s_p = 0.04 mL/L, from 106 pairs with 2 outliers removed.

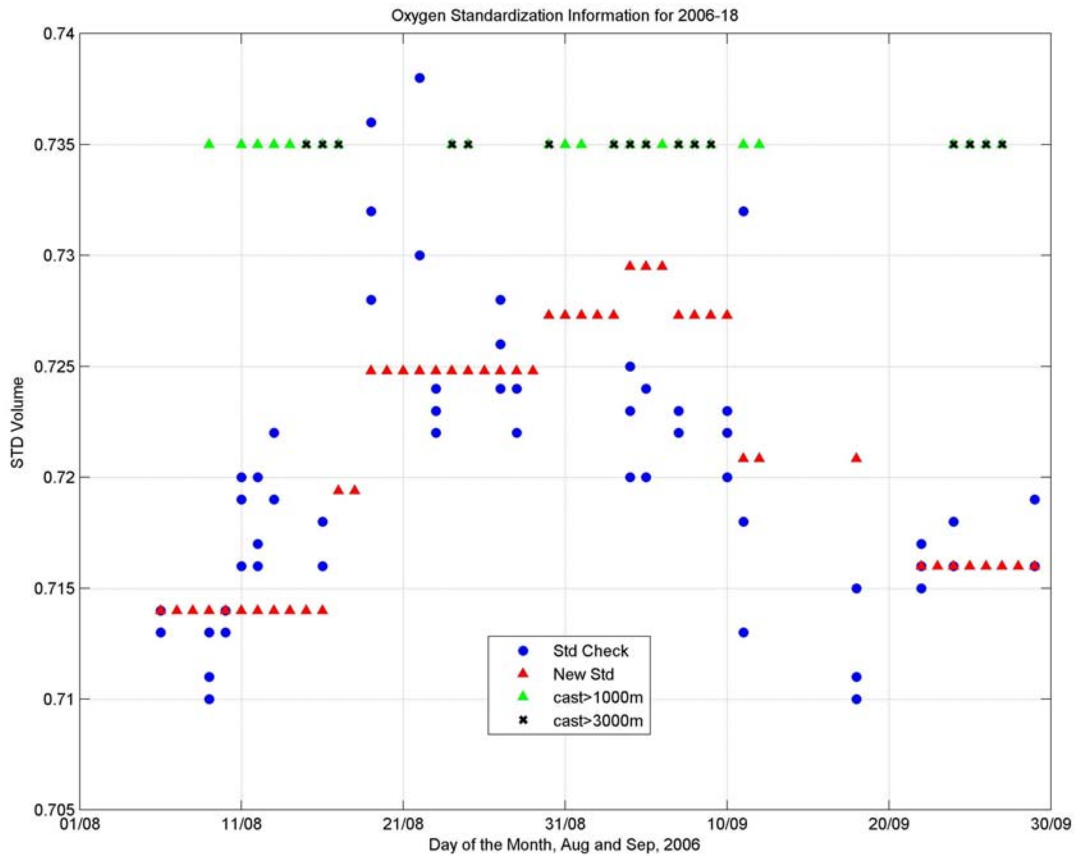


Figure 18. Comparison of the Sodium Thiosulfate standard values (blue) and new calculated standard values (red) plotted against time. The new calculated standard values were used to determine the final water sample oxygen concentration. The green and black symbols along the 0.735 STD volume line indicate which casts had deep samples to compare with the baseline value and CTD data.

Deep water samples, from depths greater than 3000db in the homogenous bottom water were found to have a mean of 6.56 mL/L with a standard deviation of 0.021 from 30 samples after outliers were removed. Note, these are not independent measurements as the oxygen samples were adjusted so that the deep water values would be close to 6.57mL/L as explained above.

Oxygen samples were compared with CTD oxygen profiles to identify outliers. At depths shallower than 500 m, differences greater than 0.1 mL/L were examined and flagged if no reason for the difference could be found. Below 500 m, the data were flagged as bad and not reported if differences were greater than 0.05 mL/L. As with the salinity samples, due to possible flushing effects through steep gradients, exceptions were made if the sample value was vertically within 5 m of the CTD profile (accepted as good values) or within 10 m (flagged as questionable values).

2.4.4 Nutrients

Sampling

Water samples for nutrient determination were collected into acid-washed glass and polystyrene test tubes after the tube and cap had been rinsed three times with the sample water. If analysis could be performed within 24 hours the samples were stored at 4 °C, if not they were frozen at -20 °C. Note that frozen nutrient samples from casts 1 to 9, except a few samples from within casts 4, 5 and 7, thawed when the freezer was accidentally turned off. The freezer had been off between 24 and 36 hours. The samples were refrozen and analyzed later during the cruise, however, samples from casts 1 and 2 were not analyzed.

Analysis and Results

Nutrients (nitrate + nitrite, silicate and orthophosphate) were analyzed by Linda White onboard ship using a three channel Technicon Auto Analyzer, following the methods described by Barwell-Clarke and Whitney (1996). Reagents were prepared onboard using water from a NANOpure system that produced 17 -18 mega ohm-cm resistance Type I reagent grade water. The system was supplied with ship's distilled water. A 3.2% weight-to-volume solution of sodium chloride (Sigma) was prepared daily and used to rinse the system between samples and to prepare working standards. Pump tubing was changed after approximately 500 samples. One cadmium column was used for all samples unless noted below. The Auto Analyzer was cleaned every other day as follows; rinsed with 3N NaOH first and then 10% HCl for approximately 5 minutes and rinsed with DMQ for over 20 minutes after all reagents and salt were disconnected at the end of the day. Data were logged both by analog (chart) and digitally using the IOS "Newget" program.

Standards and blanks

The response of NANOpure water was recorded daily before the reagents were connected and at the end of the day when the reagents were disconnected to establish the baseline and record the purity of the reagents. A set of working standards (low, medium and high) were prepared from the stock standard solution, using freshly prepared 3.2% sodium chloride solution. The stock solutions were prepared at IOS from: potassium nitrate, Fisher Scientific (FS746202), sodium silicofluoride, Anachemia (Lot #490715) and dihydrogen potassium phosphate, BDH Aristar (#135). The working standards were analyzed at the start and close of each day or, if more than 60 samples were to be analyzed in a day, standards were also run mid-day or after three hours. Concentrations of the standards were selected to bracket the expected nutrient levels in the samples. A medium standard for each nutrient was analyzed as an unknown sample followed by two zero standards after every group of samples from one station (12 - 27 samples).

Standards purchased from Wako (0 µm/L and 20 µm/L nitrate and 50 µm/L silicate) and Reference Samples (RS) purchased from KANSO (AS and

AT) were analyzed at the end of each day. Wako silicate was in short supply and ran out early on in the trip. All KANSO reference samples were 3 years old.

An onboard reference sample (collected at CABOS; 500 m depth; August 8, 2006) was stored at 4 °C in the dark and analyzed daily during the period of August 8, 2006 – September 11, 2006 to provide an operational check. The silicate concentration from this sample remained fairly stable but nitrate and phosphate concentrations decreased over the period of 4 weeks.

The order of the sample analysis was from the surface to depth and sample peaks that appeared to be out of order were re-analyzed. Duplicate samples were drawn for each station. One sample from each cast was collected in triplicate with two samples analyzed the day of sampling and the third sample analyzed the following day to verify the day-to-day calibrations. The results of the replicate and standards comparisons are listed below (Table 14; Table 15).

The turbidity of surface samples where salinity is less than 27 PSU were analyzed through the phosphate channel with no reagents being added to the sample. No phosphate samples required a turbidity correction. When the nitrate level in surface samples was the same or slightly lower than the 3.2% sodium chloride solution it was reported as zero.

The Autoanalyzer was stable throughout the analysis.

Table 14. Quality control and assurance for nutrient samples.

Nutrient	Nitrate + Nitrite (mmol/m^3)	Silicate (mmol/m^3)	Phosphate (mmol/m^3)
Sample replicates: fresh			
*s_p	0.06	0.10	0.03
No. of duplicates	131	132	125
No. of outliers removed	2	2	7
Sample replicates: frozen			
*s_p	0.14	0.30	0.04
No. of duplicates	37	38	40
No. of outliers removed	2	4	3
Medium check standard			
(analyzed as unknown)			
Calibrated value	16.0	40.0	1.60
Average and std dev	16.1 ± 0.1	39.9 ± 0.2	1.59 ± 0.02
No. of duplicates	35	32	26
Wako standard	20	50	
(analyzed as unknown)	19.9 ± 0.1	50.0 ± 0.17	
No. of duplicates	8	4	
KANSO RS: AS	0.1	1.84	0.05
(analyzed as unknown)	0.07 ± 0.04	1.84 ± 0.13	0.04 ± 0.01
No. of duplicates	12	12	9
KANSO RS: AT	7.42	18.2	0.54
(analyzed as unknown)	7.57 ± 0.06	18.4 ± 0.19	0.57 ± 0.01
No. of duplicates	12	10	9
CABOS reference sample	12.6 ± 0.36	8.1 ± 0.1	0.85 ± 0.03
Range	12.8 – 11.4	8.1 – 7.9	0.9 – 0.79

No. of duplicates	28	23	26

Note: samples were frozen for casts 3 to 10, 74 and 75.

Table 15. Precision of nutrient samples analyzed in triplicate

	Nitrate				Silicate				Phosphate			
Sample ID	same day (-1)	same day (-2)	next day (-3)	s_p	same day (-1)	same day (-2)	next day (-3)	s_p	same day (-1)	same day (-2)	next day (-3)	s_p
696	0.0	0.0	0.0	0.0	2.8	2.9	3.1	0.10	0.51	0.51	0.53	0.01
694	0.0	0.0	0.0	0.02	3.2	3.2	3.3	0.06	0.58	0.58	0.59	0.00
693	0.0	0.0	0.0	0.02	2.9	3.0	3.0	0.04	0.64	0.64	0.65	0.00
692	2.7	2.7			8.3	8.1	8.0	0.13	1.01	1.02	0.99	0.01
691	11.1	11.1	11.1	0.01	22.6	22.7	22.9	0.14	1.61	1.61		
690	13.9	13.8	13.9	0.04	29.0	28.8	29.3	0.20	1.79	1.77	1.78	0.01
689	15.6	15.5	15.6	0.04	34.2	34.1	34.3	0.11	1.86	1.85	1.85	0.00
688	15.3	15.3	15.3	0.04	30.4	30.3			1.69	1.67	1.68	0.01
687	14.1	14.2	14.2	0.03	22.6	22.6	22.8	0.09	1.37	1.36	1.37	0.01
686	14.0	14.0	14.1	0.02	19.0	19.1	19.3	0.14	1.26	1.25	1.26	0.01
685	13.7	13.8	13.8	0.04	16.2	16.3	16.5	0.11	1.16	1.17	1.17	0.01
786	15.9	15.9	15.7	0.09	36.8	36.8	37.2	0.23	1.86	1.90	1.89	0.02
856	15.9	15.6	16.0	0.17	37.2	37.3	37.2	0.06	1.91	1.96		
828	11.4	11.5	11.7	0.10	7.6	7.6	7.7	0.06	0.83	0.84	0.81	0.02
842	12.7	12.8	12.6	0.08	6.8	6.9	7.0	0.07	0.88	0.89	0.86	0.01
818	13.6	13.7	13.6	0.03	9.2	9.2	9.5	0.14	0.96	0.96	0.93	0.01
770	14.9	14.8	14.5	0.15		12.3	12.4		1.05	1.02	0.97	0.03
930	15.9	16.0	15.7	0.10	36.7	36.6	36.3	0.18	1.89	1.90	1.92	0.02
916	14.5	14.5	14.4	0.07	11.2	11.2	11.2	0.01	1.01	1.01	1.03	0.01
952	14.3		14.2	0.04	28.3	28.2	28.6	0.16	1.51	1.50	1.53	0.01
938	14.9	14.9	14.7	0.10	13.4	13.6	13.7	0.11	1.03	1.01	1.01	0.01
977	14.1	14.1	14.1	0.02	29.3	29.4	29.3	0.04	1.51	1.52	1.53	0.01
963	14.9	14.9	14.9	0.01	12.9	13.0	13.0	0.06	1.02	1.01	1.03	0.01

2.4.5 Ammonium Analysis

Methods

Ammonium concentrations in the shallow waters of the Canadian Basin were determined by Kristina Brown following the procedures outlined by Holmes et al. 1999. Samples of 40.5 (± 0.58) mL of seawater was collected in 50 mL glass test tubes with plastic screw top lids in duplicate at each station along the shelf sections from the surface to a depth where salinity = 34.6 plus a sample taken at ~ 450 m depth. Samples were then prepared by adding 10.00 mL of working reagent (prepared according to Holmes et al. 1999) and left to sit in the dark for 5 to 8 hrs at room temperature. Samples were then measured using a TD-700 fluorometer (Turner Designs), in simple mode, with sensitivity calibrated to a 0.5 μM standard, reading sensitivity level 26. 400 samples were collected and processed during this cruise along with 13 sets of standards.

Standard sets were run with every station or group of stations and prepared with samples using seawater either collected from the 450 m Niskin bottle or from a cubitainer of water collected from deep bottles at CABOS at the beginning of the cruise. Stock solutions were prepared from ammonium chloride (Anachemia Lot #490526). In order to analyze stations that were close together some samples were stored in the oxygen fridge (away from any ammonium based chemicals) before adding working reagent. These samples were analyzed in batches with one set of standards and prepared for analysis within 36 hrs of sampling.

Reagents were prepared on board in the main lab fume hood and allowed to sit for at least 24 hrs prior to use. Glassware was rinsed twice in DMQ water before being soaked in a 10 % HCl bath for at least 4 hrs (usually overnight) and then rinsed again twice in DMQ and allowed to air dry. The plastic screw top test tube lids used for this voyage were found to become brittle after successive acid cleanings and it was decided that they would be cleaned by soaking them overnight in DMQ water and then allowing them to air dry. While the acid bath remained in the main lab fume hood, all other cleaning was done in LAB B to keep glassware and plastics away from ammonium reagents in the main lab.

Problems and Solutions

After the first few stations it was noticed that the zero values (reagent blank) for the standard curves were very high, at an average of 270.65 fsu. After some tests with different test tube caps and cleaning procedures it was determined that the high blank was due to the old set of hard plastic caps with plastic conical inserts, and it was decided that they would no longer be used. However, this meant that the number of test tubes available for sampling was drastically reduced, as the new plastic caps were brought as spares and only 125 of them were available.

Reagent Blank

Although the reagent blank for each new batch of working reagent gives a different value, once the new plastic caps were in use the blank value remained low, regardless of working reagent used. The average reagent blank value (all batches of working reagent) is given below. A test was also done on the second trip to the CABOS mooring station to determine the reproducibly of duplicates and the detection limit of the method.

Reagent Blank (Zero Standard): All stations and working reagents
Average: 17.0 fsu (n = 23)
Standard Deviation: 11.1 fsu

10 Blank CABOS Test (450 m bottle)
Average: 14.2 fsu (n = 10)
Standard Deviation: 4.8 fsu

From the Blank test at CABOS the detection limit for this method should be 14.5 fsu (3 x 4.8 fsu), or around 0.02 μM. However, based on the zero standard readings over the course of this cruise it is apparent that fluorometer readings below 30 fsu (~0.05 μM) are highly variable, and perhaps this value is a more accurate detection limit.

Precision

The pooled standard deviation (s_p) was 0.02 based on the analysis of 196 pairs with 4 outliers removed.

2.4.6 *Oxygen Isotope Ratio ($\delta^{18}O$)*

<u>Sampling</u>

Samples were drawn from the Niskin into 30 mL glass vials following three rinses of the vials with sample water. Once at room temperature the caps were retightened and wrapped with parafilm for storage until analysis back onshore.

<u>Analysis</u>

Samples were analyzed at JAMSTEC by Kazuma Tamura using a Finnigan MAT 252 mass spectrometer connected to a H_2O-CO_2 equilibration unit. The oxygen isotope composition is referenced to Vienna-Standard Mean Ocean Water (V-SMOW):

(V-SMOW): $\delta^{18}O = ((H_2{}^{18}O/H_2{}^{16}O)_{sample} / (H_2{}^{18}O/H_2{}^{16}O)_{VSMOW} - 1) \times 10^3$ [‰].

The obtained "raw" $\delta^{18}O$ values are normalized using internal laboratory standards, which were calibrated periodically using international standards (VSMOW, SLAP, GISP). Internal standards used were DKWJ, Dome, and JMSW.

Precision of analysis calculated based on sample replicates was $s_p = 0.01$; $n = 2$.

2.4.7 *Barium*

Barium samples were drawn from the Niskin into small (~20 mL) plastic vials following three rinses of the vials. Once at room temperature the caps were retightened for storage. Barium concentrations were determined at Oregon State University by Christopher Guay on a VG Thermo Excel inductively coupled quadrupole mass spectrometer. An isotope dilution method was used as described in Falkner et al. (1994) with minor modifications. Briefly, 250 µL aliquots of sample were spiked with an equal volume of a ^{135}Ba-enriched solution (Oak Ridge National Laboratories) and diluted with 10 mL of 1% HNO_3. The spectrometer was operated in peak jump mode, and data were accumulated over three 20 s intervals for masses 135 and 138. Based on replicate analyses of samples and standardized reference materials, the precision (2-sigma) of the analytical procedure ranges from < 5% at 10 nmol Ba L^{-1} to < 3% at 100 nmol Ba L^{-1}.

Duplicate samples were used to determine precision: $s_p = 1.1$ µmol/m^3; $n = 28$ pairs with no outliers removed.

2.4.8 Dissolved Inorganic Carbon and Alkalinity

DIC and Alkalinity Sampling

Seawater was transferred to a glass sample bottle (250 or 500 mL) as soon as possible after the rosette cast to minimize gas exchange. The sampling tube was connected to the spigot of the Niskin bottle and, by holding the tube above the spigot, was rinsed by flowing approximately one tube volume of sea water through the tube. Any trapped air bubbles were removed by tapping or squeezing the tube. The bottle was filled smoothly from the bottom (tubing touching the bottom of the bottle) and the bottle overflowed by two times its volume. The tubing was withdrawn to the neck and the spigot valve closed or the flow in the tubing squeezed off before the tubing was removed from the bottle. One percent of the stoppered sample volume was removed to leave a headspace (about 1% of the bottle volume - i.e., 5 mL for a 500 mL bottle) by inserting a nylon plug into the bottle. A volume of 100 µL of saturated mercuric chloride solution ($HgCl_2$) was added to the bottle (either 250 mL or 500 mL). A greased stopper was inserted and sealed with elastic bands or electrical tape. Samples were stored at 4 °C until analysis back onshore. Both DIC and then alkalinity were measured from the same sample.

DIC Analysis

Samples were analyzed at IOS by Marty Davelaar using a SOMMA (Single-Operator Multi-Metabolic Analyzer) - Coulometer system to determine the concentration of dissolved inorganic carbon (total carbon dioxide). The SOMMA is a sea-going, computer-controlled automated dynamic headspace analysis, constructed at IOS by Ken Johnson (University of Rhode Island) and Keith Johnson (IOS). The current design of the SOMMA system is similar to the one described by Johnson et al. (1993). The SOMMA is interfaced with an IBM compatible computer and a coulometric detector (UIC Coulometrics, model 5011). The SOMMA dispenses and acidifies a known volume of seawater, strips the resultant CO_2 from solution, dries it and delivers it to the coulometric detector.

At the start of each day, seawater was run through the system to condition the cell. Once the system appeared to be working well, standard water or a known sample was run to confirm proper operation. For each analysis (standard or sample) CO_2 in nitrogen was used to push liquid out of the sample bottle and into the water-jacketed calibrated pipette. The water from the pipette was then drained into a scrubber compartment to which approximately 0.5 mL of 8.5% ortho-phosphoric acid had been added. The CO_2 was stripped from the water by the acid and then passed into the coulometer cell where it was measured. The coulometer was operated in the µg C mode. Using the SOMMA software, this mode takes the coulometer's voltage to frequency converter output along with constants supplied by the user and calculates µmol *C* titrated. For each sample or standard, the analysis was run twice. The first analysis was considered a rinse and the second analysis the final value. The final concentrations are calibrated with the daily measured standard where:

$$\textit{corrected value} = \frac{\textit{(raw value * measured standard)}}{\textit{(standard value * correction for mercuric chloride volume)}}$$

The mercuric chloride correction was either 1.0002 or 1.0004, depending on whether the sample volume was 500 or 250 mL, respectively. DIC values are reported in units of µmol/kg.

Standards, blanks and precision

The accuracy of DIC analysis was assured by daily analysis of IOS standard sea water (batch 14, concentration 2036.68 µmol/kg) which had been calibrated using certified reference material (batch 73 with a concentration of 2057.3 µmol/kg) supplied by Andrew Dickson from Scripps Institute of Oceanography, San Diego, USA (DOE 1994; Dickson 2001; Dickson et al. 2003). The difference between the measured value and calibrated value of the IOS standard seawater was less than ±1 (0.05%).

Precision, given by the pooled standard deviation of sample replicates, is s_p = 1.31 µmol/kg, where n = 4 pairs with one outlier removed.

Alkalinity Analysis

Samples were analyzed at the Institute of Ocean Sciences (IOS) by Marty Davelaar using an automated potentiometric titration system to determine the total alkalinity. The pH was measured using a Ross combination electrode. Acid was dispensed with a Dosimat 665. A program written by the University of Hawaii was used to control the Dosimat.

At the start of each day, seawater was run through the system to condition the instruments. Once the system appeared to be working well, standard water was run to confirm proper operation. For each analysis (samples and standard), a known amount (~75 grams) of sample was weighed in an open beaker. An initial amount of 0.7N (0.6N NaCl, 0.1N HCl) acid (IOS batch 14, concentration 2268.75), was added to the seawater to take its pH to approximately 3.5. The acid volume was adjusted depending on the salinity of the sample such that the initial pH was near 3.5 to allow the full titration between 3.5 and 3.0 to be performed. After an eight minute period in which CO_2 was stripped from the seawater, 0.025 mL aliquots of acid were added to the seawater until a final pH of approximately 3.0 was obtained. The University of Hawaii program was used to calculate the alkalinity of the seawater by use of a Gran plot. The final concentrations are calibrated with the daily measured standard where:

$$\textit{corrected value} = \frac{\textit{(raw value * measured standard)}}{\textit{(standard value * correction for mercuric chloride volume)}}$$

The mercuric chloride correction was either 1.0002 or 1.0004, depending on whether the sample volume was 500 or 250 mL, respectively. Alkalinity values are reported in units of µmol/kg.

Standards and precision

The accuracy of the alkalinity analysis was assured by daily analysis of certified reference material (batch 73, concentration of 2253.5 μmol/kg) (DOE 1994; Dickson 2001; Dickson et al. 2003) supplied by Andrew Dickson (Scripps Institute of Oceanography, San Diego, USA).

Precision, given by the pooled standard deviation of sample replicates, is s_p = 1.45 μmol/kg, where n = 4 pairs with one outlier removed.

2.4.9 Alkalinity (Fresh Water)

Seawater samples were collected from Niskin bottles into 500 mL glass bottles for alkalinity measurements. In total, 540 water samples were collected from 53 stations and analyzed onboard the vessel within 48 hours after sampling by Michiyo Kawai. The total alkalinity was determined by potentiometric titration using 0.1 N HCl with a Brinkman Dosimat 665, a Ross combination pH electrode, and an Orion pH meter model 725A. The Dosimat was controlled using a program written by the University of Hawaii. An initial amount of 0.1N HCl was added to the seawater to take its pH to approximately 3.5. Then, 0.025 mL aliquots of acid were added to the seawater until a final pH of approximately 3.0 was obtained. The University of Hawaii program was used to calculate the total alkalinity of the seawater by use of a Gran plot. A plot of total alkalinity measurements vs. CTD-salinity, CTD-depth or Niskin bottle number was made simultaneously during analysis, and samples that seemed unusual in the plot were re-analyzed. In addition, a couple of samples were randomly chosen for each station and analyzed in duplicate.

Onboard analysis

Samples were stored in the cooler (~4 °C) and then pipette and sample bottles were moved into a 20 °C water bath ~1 hour prior to analysis. A constant volume of sample or standard water was collected using a water-jacketed pipette (~ 100 mL), connected to the water bath, and put into an open beaker. Room temperature was read by a digital thermometer mounted next to the alkalinity system to provide the temperature of the acid.

A nominal sample weight of 101.65 g was used as an input value into the PC program for alkalinity calculation, which was determined by a “practical method” to obtain the assigned value of 2172.00 μmol/kg of IOS standard water (IOS-STD). The IOS-STD alkalinity was determined against the certified reference material supplied by A. Dickson, Scripps Institute of Oceanography.

Obtained “raw” values of the samples were then corrected for density differences by using:

T_Alk [μmol/kg] = T_Alk [raw] * density [IOS-STD] / density [sample]

where density of the IOS-STD with S = 32 at 20 °C is 1022.48 kg/m^3.

At a station CABOS (cast #3, Aug. 8), seawater were collected into nine 500 mL bottles at two depths, preserved with $HgCl_2$ and stored at room temperature, and used as running standard waters (S13 and S14). Total alkalinity values of these running standard waters were determined against IOS-STD on board.

13 bottles of IOS-STD were measured during the cruise. 4 of the 13 IOS-STD bottles had higher alkalinity values (>8 μmol/kg) than the expected value (2172.00 μmol/kg) and evaporation is assumed. Excluding these 4 bottles, the average concentration of IOS-STD was 2172.19 ± 2.85 μmol/kg; n = 27. For S13 and S14, the average concentration was 2279.16 μmol/kg (± 12.89 μmol/kg; n = 29) and 2277.04 μmol/kg (± 2.78 μmol/kg, n = 15), respectively.

IOS-STD or running standard water, determined with respect to the IOS-STD, was measured daily before and after the sample measurements.

244 of 540 samples were analyzed in replicate. When duplicate measurements did not agree within 6.5 μmol/kg, samples were reanalyzed 1 to 3 more times or flagged as “questionable” in the data sheet.

Pooled standard deviation for replicate analysis was S_p = 2.4 (n = 296).

Note: Comparison of deep water (500 to 1050 m) values indicate that TA data from this cruise (2286.5 μmol/kg; n = 26) was lower compared to cruises of LSSL-2005, LSSL-2008 and Mirai-2008 (2293.0 μmol/kg). Thus, values from this cruise were corrected by multiplying *1.002843 (= 2293.0/2286.5).

2.4.10 Chlorophyll-a

Chlorophyll *a* and phaeopigment analysis methods follow the general procedure reported by Strickland and Parsons (1972) and Arar and Collins (1997). The analysis was performed at IOS by Jennifer Jackson and overseen by Linda White.

<u>Sampling and Filtration</u>

Prior to the cruise, brown 2 L Nalgene sample bottles were calibrated (volume) and acid cleaned with 10% hydrochloric acid, rinsed twice with de-ionized water, then rinsed with double de-ionized water, air dried and capped. To collect a seawater sample the bottle was rinsed 3 times, filled to the brim or calibration mark and capped.

Total chlorophyll *a* samples were taken at the chlorophyll *a* maximum, 20 m, and 5 m and were sub-sampled directly from the 10 L Niskin bottles. The samples were kept cool and in the dark until they were filtered onto 25 mm glass fiber filters (Whatman GF/F) that had been pre-combusted at 450 °C for 2 hours. A low vacuum pump (5 psi) was used during filtration. The filtration castles were rinsed down with DMQ water just before the filtration was complete. The time of filtration and the volume of water filtered were recorded. The filters were then placed in a clean labeled glass scintillation vial and frozen at -20 °C. The filtration was performed within 4 hours of sampling unless otherwise noted. The area around the filtration setup was maintained under very low lighting and the actual filtration apparatus was covered with dark plastic.

The samples were transported by ship back to the lab at IOS and analyzed in December, 2006.

<u>Extraction</u>

Once in the lab, 10 mL of 90% acetone/10% double de-ionized water was added to the scintillation vials, the vials were shaken vigorously and placed in a tray. The filter was submerged in the acetone solution in the dark and extracted for 24 hours in a -20 °C freezer.

<u>Measurement</u>

After 24 hours, fluorescence was measured with a Turner Designs Model 10-000R Fluorometer, Serial No. 0329R. A solid standard was measured at the beginning and end of each day of analysis to validate the instrument operation. A blank of 90% acetone was run before the samples.

Samples were removed from the freezer in small batches to equilibrate for 1 hour in the dark and in the same lab as the fluorometer. The sample extracts were transferred to clean borosilicate test tubes without disturbing the filter paper. The tube exterior was wiped clean and placed in the fluorometer sample holder making sure the sample cover was in place. Once the reading stabilized the chlorophyll a fluorescence (R_b) was recorded. The extract was then acidified by the addition of 3 drops of 1.5 N HCl and the phaeopigment fluorescence (R_a) was recorded. If the fluorescence was over range the samples were diluted with 90% acetone and re-read, with the dilution factor being recorded.

Clean borosilicate test tubes were used for each sample eliminating possible sample to sample contamination of acid. Borosilicate tubes were cleaned with 10% solution of Extran, rinsed thoroughly with hot water with a final rinse of double de-ionized water, air dried and re-used.

Chlorophyll data processing

Chlorophyll estimates and phaeopigment estimates were calculated following the procedure in JGOFS manual (1994). The basic equations used were as follows:

Chl (µg L^{-1}) = $(R_b - R_a) * W_f * (Vol_{ex}/(Vol_{filt}))$

Phaeopigment (µg L^{-1}) = $W_f * ((2.22*R_a)-R_b) * (Vol_{ex}/Vol_{filt})$

where R_b is the reading before acidification; R_a is the reading after acidification; W_f is the door factor from calibration calculations; Vol_{ex} is the extraction volume (10 mL); and Vol_{filt} is the sample volume (in liters).

Standardization

Purified Chlorophyll a (Sigma) was dissolved in 500 mL of 90% acetone/10% double de-ionized water in a volumetric flask. The flask was wrapped in foil to keep the standard in the dark and stored in a freezer.

The primary stock standard was scanned using a Cary spectrophotometer to determine the chlorophyll a concentration. A series of standards, encompassing the range of sample concentrations, were prepared by dilution with 90% acetone/ 10% double deionized water and analyzed on the fluorometer the same day at IOS. A linear regression was calculated and used to determine sample concentrations. These calculations were performed in a spreadsheet that included volume filtered, volume of extract and fluorescent values and formulae for chlorophyll a and phaeopigment calculations.

In June 2006, each sensitivity door of the Turner Designs 10-000 R fluorometer was calibrated by Janet Barwell-Clarke with a series of 3 – 4 known Chl *a* standard solutions and the signal to concentration response recorded. A spreadsheet was provided with all the door factors to calculate the varying sample concentrations of extracted chlorophyll *a* and phaeopigment pigments.

Duplicate samples were used to determine precision:

S_p = 0.02 µg/L Chla; n = 11 pairs with 1 outlier removed.
S_p = 0.014 µg/L Phaeopigment; n = 11 pairs with 1 outlier removed.

2.4.11 Bacteria

Phytoplankton and bacterioplankton samples collected for Dr. Bill Li (Bedford Institute of Oceanography - BIO) by Helen Drost (IOS) were preserved in aliquots of seawater sampled from the Niskin bottles. Following standard protocol (Marie et al. 1999), 1.8 mL seawater was dispensed into a 2 mL capacity cryogenic vial and immediately fixed with 0.2 mL of 10% paraformaldehyde by vortex mixing. Samples were maintained for at least 15 min at laboratory temperature to allow fixation, and then stored at -80 °C until analysis at BIO.

Cell concentrations of picophytoplankton, nanophytoplankton, and bacterioplankton (i.e. non-autofluorescent picoplankton) in thawed samples were analyzed at BIO by flow cytometry (Becton Dickinson FACSort) following protocols in routine use (Li & Dickie 2001). Phytoplankton were detected by native autofluorescence using blue laser excitation (488 nm) and long-pass red emission (>650 nm). Cells smaller than 2 μm equivalent spherical diameter were classified as picoplankton and those larger as nanoplankton. In turn, picophytoplankton were partitioned into two groups according to the presence (cyanobacteria) or absence (picoeukaryotes) of the pigment phycoerythrin detected in the orange waveband (585 ± 21 nm). Bacterioplankton were stained with SYBR Green 1 (Molecular Probes, Oregon), a nucleic-acid binding fluorochrome, and detected in the green waveband (530 ± 15 nm). Measurements of fluorescence and light scatter were collected using logarithmic amplification and recorded in relative units in a 4-decade range spanned by 256 channels. Fluidic flow rate was calibrated by regression of the aspirated volume versus duration of analysis. Data were extracted from listmode format using WinMDI Version 2.8 (copyright Joseph Trotter, http://facs.scripps.edu/). Method for taking duplicates was not consistent through the cruise. Sometimes a second scintillation vial would be filled from the Niskin for the duplicate, other times the same scintillation vial was used to fill two cryovials.

Note: For many of the samples, pipettes were not rinsed in between pipetting one sample into a cryovial and the next. This error was not caught until late in the cruise. The progression of samples was from deepest to shallowest so the pipette would have been used from a low to high level of bacteria.

In addition, the method for taking duplicates was not consistent throughout the cruise. Sometimes a second scintillation vial would be filled from the Niskin for the duplicate, other times the same scintillation vial was used to fill two cryovials.

See **Appendix 5** for bacteria data plots.

2.4.12 Radionuclides (Iodine 129 and Cesium 137)

<u>Sampling and Analysis</u>

Seawater samples for ^{129}I analyses were collected into 1 L PVC bottles that had been pre-rinsed with seawater to remove any foreign debris. Samples were returned to John Smith at the laboratory of the Atlantic Environmental Radioactivity Unit (AERU) at the Bedford Institute of Oceanography (BIO). In the laboratory, a NaI carrier was added to a 200 mL aliquot of the seawater sample, it was slightly acidified, purified using multiple hexane extractions and iodine was precipitated as NaI. The NaI precipitate was shipped to the IsoTrace Laboratory at the University of Toronto where ^{129}I analyses were performed by accelerator mass spectrometry (Smith et al. 1998; 1999; 2005). The sample data were normalized to the IsoTrace Reference Material #2 ($^{129}I/^{127}I$ = [1.313 ± 0.017] x 10^{-11} atom ratio) which is calibrated using the NIST 3230 I and II standard reference material. The blank (KI carrier added to distilled and deionized water) for this procedure is 0.75 ± 0.10 x 10^7 at/L and the standard deviation (one sigma) ranged from 5 to10% (Edmonds et al. 1998). ^{129}I concentrations in seawater are generally expressed in units of10^7 atoms/litre. IsoTrace has participated in a number of ^{129}I International intercomparison exercises, including the NIST SRM 4359 Seaweed, the Lawrence Livermore ^{129}I intercomparison, phases I and II and the IAEA-0375 Radionuclides in Soil intercomparison. IsoTrace ^{129}I procedures and sample handling protocol have been approved by the United States Office of Civilian Radioactive Waste Management, through on-site inspections by Bechtel SAIC Inc.

Approximately 20 to 30 L of seawater were collected into 10 L plastic carboys for ^{137}Cs analyses. The water samples were passed through a potassium ferrocyanide (KCFC) packed resin column in the laboratory which quantitatively extracts ^{137}Cs from seawater (Smith et al. 1990; Smith & Ellis 1995). A second column was occasionally aligned in series to confirm that extraction efficiencies for ^{137}Cs were close to 100%. The KCFC resin was deployed in a standard geometry and measured using a hyperpure Ge detector having an efficiency of 25%. ^{137}Cs concentrations in seawater are expressed either as Bq/m^3 or mBq/L. Numerous analytical intercomparisons (including publicly reported blind exercises) have been carried out with other laboratories by the (AERU) over the past 30 years for quality assurance purposes. Intercomparison samples have been provided by the United States Environmental Protection Agency (USEPA), the United States Environmental Measurements Laboratory (EML) and the United States Department of Energy as part of their Mixed Analyte Performance Evaluation Program, MAPEP. Marine environmental samples (eg. IAEA-315; IAEA-326; IAEA-327) provided by the International Atomic Energy Agency (IAEA) were analyzed to insure compliance with international standards in the marine radioactivity community. National Institute of Standards and Technology (NIST) ocean and river sediment reference materials are analyzed on the detectors on a regular basis as a calibration check.

2.4.13 Halocarbons: CFC-11, CFC-12, CFC-113 and CCl_4

Halocarbons were sampled at most stations. Three stations were sampled in high resolution from approximately 300 to 500 m to investigate CFC concentrations within Atlantic layer intrusions.

Sampling

Before any CFC samples were collected the Niskin O-rings were replaced with O-rings that had been baked and degassed at IOS. Halocarbon samples were the first to be drawn from the Niskin following the Niskin bottle integrity checks. The sample was collected in a Perfektum 250 mL glass syringe (Popper and Sons Inc.) Syringes were rinsed three times with sample water and filled, taking care not to allow air bubbles enter the syringe. Syringes were submerged in a bucket or sink filled with cold seawater until analysis to prevent contamination from the high CFC concentration in air.

Analysis

Analyses for CFC-12, CFC-11, CFC-113, and CCl_4 were carried out by Nes Sutherland and Kristina Brown on the IOS automated purge and trap system. Separation and detection of the components was achieved using a 60 m, 0.32 mm GasPro G fused silica column and a Hewlett Packard GC/Electron Capture Detector, respectively. Standardization was done using a gas standard (S14) prepared at Brookhaven National Laboratories and standardized at Scripps Institute of Oceanography. Concentrations are reported using the SIO1998 scale. Air samples **Error! Reference source not found.**were taken as a further check on the operation of the system.

Daily Routine

1. Changed water trap and ran a blank until peaks were normal – usually by the second run.
2. Woke-up the instrument by running two 15 mL calibration gas injections or two surface seawater samples.
3. Ran the calibration curve, highest to lowest.
4. Ran a blank.
5. Ran a 6 mL standard.
6. Ran seawater samples – included one atmosphere sample and at least two duplicates per station.
7. Changed water trap as necessary.
8. Repeated steps 4-7 as necessary.
9. When the sample run was finished:
    a) ran a blank and a 2, 6 and 12 mL standard or
    b) if the unit was in continuous use, ran a complete calibration curve.

With this routine, about 65 injections per 24 hours were made including about 40 water samples.

Trap and GC were baked out for about two hours each (at the same time) once per week or when needed.

Molecular sieve traps were baked out at the start of the cruise and only again if there were signs of contamination.

The CFC crew participated in 45 of the 75 casts, or 38 stations. A few modifications made to the CFC system prior to the start of the cruise at IOS proved most valuable. The valve extraction board gas had been changed to Helium from Nitrogen, allowing instant leak detection with the gas sniffer. The magnesium perchlorate trap as well as the tubing leading to it was increased in size, to prevent clogs and allow longer run times between repacking. These two changes helped prevent most of the problems found in previous years.

The CFC system had been set up onboard ship in Halifax. However, after warming up and cleaning out the molecular sieve traps, it was noted that there was a major temperature problem with the ECD. When the fan would come on to cool the oven, the ECD temp would drop, from 280 to 245 to 255 °C, and take a long time to recover. This was reflected in changing baseline conditions and slight changes in peak areas of samples. We changed the temp program, starting the initial run with 40 °C, rather than 30 °C. This was actually also necessary because of the high lab temp - reaching 30 °C at times. The change to the temp program helped, but did not completely solve the problem. The problem was finally traced to insufficient insulation packed around the ECD when it was installed in the GC in Halifax. Extra glass wool was used.

When changing the initial temp to 40 °C, the ramp rate was also changed to 4 °C/min from 5, and rising to 120 °C, rather than 90 °C. Peak separation improved, and a bothersome peak that came out in the vicinity of F12 to F113 disappeared.

The air injection system was modified by adding another valve, as the original one leaked helium, resulting in a larger than expected usage of gas.

After a few weeks the Valve 3 rotor started to leak – there was no effect on the standards, but a small amount of helium could be detected coming out of the stripper drain. As a precaution, the rotor was replaced, and scratches were found on the old rotor between ports 1 and 2. The new rotors appeared to be manufactured from a different material that was tougher to scratch. However, following the insertion of the new rotor, port 4 clogged up intermittently, creating a huge back pressure in the system, and crashing the channel 2 flow meter. It appeared that some sea water had oozed around the rotor to this port and dried, pushing into the very small hole of the swagelock nut assembly. This port was from then on cleaned out roughly every two days. The chief engineer provided a set of welding rod cleaners fine enough to unclog the hole and ream it out wider.

During the process of troubleshooting the first time port 4 clogged up, it was found that the base of the stripper chamber had broken. A replacement stripper was installed to prevent future leaks.

The temperature of the sea water in the syringes seemed to run a bit higher this year, resulting in faster bubble formation. Finally it was decided to store the syringes outside at roughly 5 °C, and bringing them back in when the temperature cooled to 4 °C. A purge efficiency check test using 5, 6 and 7 minutes was conducted on the 5 °C syringes to ensure sufficient time for the stripper gas to warm the sample and carry off the CFCs. Five minutes appeared to be enough, and so the program was left at 6 minutes. A test of replicate syringes collected from two depths (near bottom and near surface) and stored at the two temperatures, 5 and 13 °C (loop water), did not indicate significant loss of CFC to the outgassed bubbles in the higher temp water bath.

See Table 16 below for statement of precision.

Table 16. Precision of water samples.

Property	s_p (nmol/m^3)	No. of pairs (n)	No. of outliers removed
CFC-12	0.05	54	4
CFC-11	0.06	54	4
CFC-113	0.01	55	3
CCl_4	0.08	54	4

2.4.14 Particulate Organic Carbon/Total Suspended Solids

<u>Particulate organic carbon</u>

Particulate organic carbon samples were collected by Jen Jackson at the bottom, at select salinities (34.4, 33.1, 32.9, 32.6 and 32.3 PSU), at the fluorometer maximum, at 20 m, at 5 m and at any interesting transmissometer features. Water was subsampled directly from the 10 L Niskin bottles into two pre-calibrated acid cleaned 2 L Nalgene bottles. Onboard ship, 4 L samples were filtered onto 47 mm GF75 filters that had been pre-combusted at 500 °C for 4 hours. A low vacuum pump (5 psi) was used during filtration. The filtration castles were rinsed down with DMQ water just before the filtration was complete. The time of filtration and the volume of water filtered were recorded. The filters were then placed in a labeled 50 mm glass petrie dish and frozen at -20 °C. The filtration was performed within 4 hours of sampling unless otherwise noted.

Samples were analyzed at UBC by Maureen Soon. The filters were first dried for 24 hours at 50 °C, then fumed with HCl for 48 hours, dried again at 50 °C for 24 hours, and then wrapped in aluminum foil and pressed into pellets. The pellets were run through the CN analyzer where the POC was determined. Sulfanilamide and blank cups were used as standards.

<u>Total suspended solids</u>

Total suspended solids samples were collected by Jen Jackson at the bottom, at the fluorometer maximum, at the transmissometer minimum, at 20 m, at 5m and at any interesting transmissometer features. Water was subsampled directly from the 10 L Niskin bottles into two to three pre-calibrated acid cleaned 2 L Nalgene bottles. Onboard ship, 4 to 6 L were filtered onto 47 mm 0.4 μm polycarbonate nucleopore filters that had been rinsed acid cleaned, rinsed with DMQ water, dried at 50 °C and pre-weighed to 0.001 mg. A low vacuum pump (5 psi) was used during filtration. The filtration castles were rinsed down with DMQ water just before the filtration was complete. The filters were rinsed with 3% Ammonium carbonate solution after filtration was complete. The time of filtration and the volume of water filtered were recorded. The filters were then placed in a labeled 50 mm plastic petrie dish and frozen at -20 °C. The filtration was performed within 4 hours of sampling unless otherwise noted.

Samples were analyzed at UBC by Maureen Soon. The TSS samples were dried at 50 °C for 24 hours and then weighed. The TSS concentration was equal to the final weight minus the initial weight divided by the volume of water filtered. A Mettler Toledo XP205 scale was compared to the original scale by measuring pre-weighed petrie dishes. It was found that the petrie dishes weighed on average (with standard deviation) 0.00057 g (± 0.00009 g) less on the new scale so 0.00057 g was added to the final weight of the filters.

2.5 OTHER FIELD SAMPLING

Short summaries of additional data collected but not included in this report are given below.

2.5.1 XCTD Casts (Legs 1, 2 and 3)

XCTD (e**X**pendable **C**onductivity **T**emperature **D**epth) probes provided water profile data between more time intensive CTD casts. The probes were provided by JAMSTEC (Type XCTD-1 made by Tsurumi Seiki) and WHOI (Type XCTD-3). The probes were deployed from the stern of the ship by Shigeto Nishino, and measured temperature and conductivity every 0.15 m from the surface to 1100 m. Data were transmitted to the ship during the freefall descent by a thin conducting wire extending from the XCTD to an onboard computer. To prevent sea ice from cutting the wire of the XCTD, the ship slowed to 12 knots for the deployment in open water areas and completely stopped in heavy ice areas. It took 5 minutes for the XCTD to descend from the surface to 1100 m.

According to the manufacturer's nominal specifications, the range and accuracy of parameters measured by the XCTD are as follows:

Table 17. XCTD range and accuracy.

Parameter	**Range**	**Accuracy**
Conductivity	0 ~ 60 mS/cm	± 0.03 mS/cm
Temperature	-2 ~ 35 °C	± 0.02 °C
Depth	0 ~ 1000 m	5 m or 2 %

In this cruise, 30 XCTDs were launched during Leg 1 and 56 in the Canada Basin. Only 1 XCTD (Cast No. 38) failed. Locations are listed in **Appendix 2**.

For more information and data see the JAMSTEC website: http://www.jamstec.go.jp/e/.

2.5.2 Optical measurements (PRR)

Data was collected by Jiuxin Shi and Yutian Jiao from the Ocean University of China for Dr. Jinping Zhao.

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2.5.2.1 Light measurements

A high resolution **P**rofiling **R**eflectance and **R**adiometer system, which included a profiler PRR800 (downwelling irradiance and upwelling radiance sensors) and a surface sensor PRR810 (downwelling irradiance sensors), was used to collect optical observations during Leg 3 in the Canada Basin. Specifications are listed in Table 18. A Compact-CTD (MCTD) with chlorophyll and turbidity sensors was used to collected reference data for these studies; see Table 19 for specifications.

Table 18. Instrument specifications.

	PRR-800	**PRR-810**
Optical features	Wavelenths:313,380,412,443,490,510, 520,532,555,565,589,625,665,683,710, 765,780 and 875 nm Bandwidth: 10 nm FWHM	Wavelenths:313,380,412,443,490, 510,520,532,555,565,589,625,665 , 683,710,765,780 and 875 nm Bandwidth: 10 nm FWHM
Sensors	Upwelling radiance, downwelling irradiance, dual axis instrument inclinometer, detector array temperature, PRT water temperature, and pressure/depth	Upwelling radiance and detector array temperature
Irradiance array	Typical Saturation: 10^5 μWcm^{-2} nm^{-1} Noise Equivalent Irradiance: 10^{-5} μWcm^{-2}nm^{-1}	
Radiance array	Typical Saturation: 10^{-3} Wcm^{-2}nm^{-1} sr^{-1} Noise Equivalent Irradiance: 10^{-12} Wcm^{-2}nm^{-1} sr^{-1}	

Table 19. MCTD specifications.

Sensor	**Range**	**Resolution**	**Accuracy**
Depth	0 to 600 m	0.01 m	0.3% FS
Temperature	-5 to 40 °C	0.001 °C	±0.01 °C
Conductivity	0 to 60 mS/cm	0.001 mS/cm	±0.02 mS/cm
Chlorophyll	0 to 400 ppb	0.01 ppb	±1% or ±0.1 ppb
Turbidity	0 to 1000 FTU	0.03 FTU	±2% or ±0.3 FTU

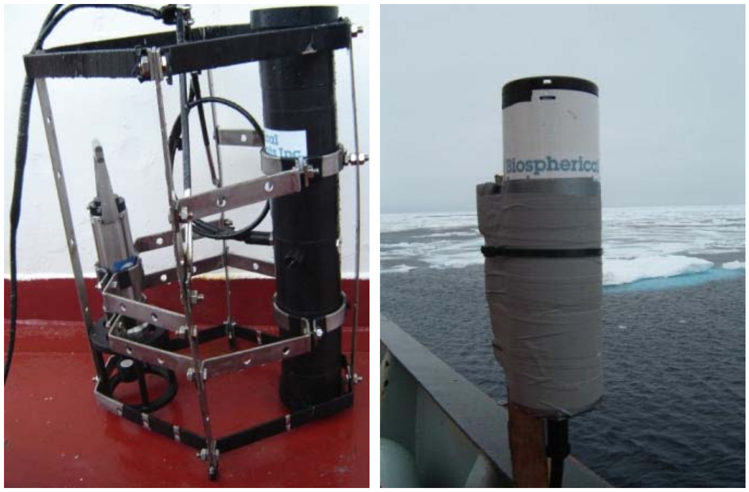

Figure 19. (a) MCTD (left) and PRR-800 (right) on the frame; (b) PRR-810 mounted on port side of foredeck.

The PRR800 and MCTD were mounted on a frame and lowered to a depth of approximately 100 m on the side of the ship facing the sun (or at any side when the sun was invisible). The PRR810 was set up near the deployment location to observe the downwelling irradiance at surface for reference. PRR/MCTD profiling casts were conducted at most CTD/Rosette stations when light, open water and time permitted. The sampling frequency of the PRR800/810 was 5 Hz and for the MCTD was 10 Hz. The deployment usually took 20 minutes and was conducted simultaneously with the CTD/Rosette cast. In total, 51 PRR/MCTD profiling casts were completed during this cruise. See **Appendix 2** for PRR cast locations.

The surface sensor PRR810 was mounted on the port side of the foredeck to observe downwelling irradiance between August 14 and 26. In total, 178 hours of data were recorded. The sampling interval was set at 60 seconds.

On three ice floes, the MCTD and PRR800 were lowered to a depth of approximately 120 m through an ice hole. The RR800 was lowered into the ice hole on a frame to measure the irradiance and radiance under ice. Surface sensor PRR810 was mounted at the ice surface to observe downwelling irradiance during PRR800 deployment. In total, 3 MCTD profiling casts, 1 PRR profiling cast and 3 PRR under-ice observations were completed at the 3 ice stations. See in **Appendix 2** for ice floe station locations.

2.5.2.2 Water samples

Water samples were also collected from CTD/Rosette casts as part of the optical program at depths of 5 m, 20 m and at the chlorophyll maximum (referred to as "Phyto" in the rosette sampling log). Water samples were filtered to provide the following samples:

- one filter for detritus/particulates (47 mm diameter, pore size 0.7 μm);
- two filters for phytoplankton (25 mm diameter, pore size 0.7 μm; one in tinfoil, one in a plastic box);
- one filter for gelbstoff (yellow matter); (100 mL filtered through a 0.2 μm filter).

In total, 82 filter samples for detritus (particulate), 85 x 2 filter samples for phytoplankton and 85 filter samples for gelbstoff (yellow matter) were collected at 29 CTD/Rosette stations. All samples were stored in an icebox in the -20 °C freezer onboard ship.

Figure 20. PRR preparation (left) and deployment (right).

2.5.3 Moorings and Buoys

(Richard Krishfield, William Ostrom, Kris Newhall – WHOI; Mike Dempsey – IOS for UAF)

<u>Moorings</u>

Mooring operations completed during Leg 3 were performed from the ship's foredeck using the starboard A-frame and WHOI provided LEBUS winch. Typical recovery procedure was to confirm the mooring's location at the mooring site, determine the ship's drift, open an ice free area and recover the mooring. New this year was the ability to attach the acoustic release deck unit into the ship's transducer. This meant the surveys and release commands could all be performed from inside the forward lab. A rosette cast was performed at the site to help with calibration of the mooring's CTD. The set up for the mooring operation typically began in the morning with the actual release/deployment starting late morning. Three or more survey positions were obtained to pinpoint the mooring's location. The ship then broke ice for 1 to 2 hours over the mooring region, taking into account the predicted ice drift. After creating an ice free area over the given location the bridge would signal the deck team to release the mooring. The top float, only 50 m below the surface, would appear within 30 seconds of being released. The float was hooked using the foredeck crane, brought on board and the line brought through the A-frame for recovery.

Figure 21. Mooring recovery.

WHOI moorings A, B, C , D and BS-3, and the University of Alaska Fairbanks' CABOS mooring deployed in August 2005 were recovered, and except for the BS-3 mooring, were serviced and redeployed. Each mooring carried a profiling CTD and current meter (McLane Moored Profiler, MMP) except for BS-3 which only had a CTD. Mooring locations are listed in **Appendix 2**.

The mooring operations were completed successfully. The difficulty of working in ice covered waters means there is the chance the mooring will come up under the ice. Two of the six moorings did come up under the ice, however with patience they were found and recovered. In the first case the mooring was recovered by bringing in the bottom set of floats first and retrieving the top float imbedded under multi-year ice last. The latter mooring's top float just took a little while to work its way to the surface and then was caught the standard way. Resulting design modifications for next year will have a transponder below the top float to will allow easy ranging before and after release. New this year was the option to connect the release's acoustic deck unit to the ship's sounder allowing communication to the releases from the ship's forward lab. The only difficulty is that bubbles under the hull from the bubbler and thrusters interfere with the communication. Thus, timing the mooring release with ship position and ice cover takes more care. The moored profilers had all climbed their scheduled distances for the year except the for the CABOS profiler which unfortunately was incorrectly ballasted and meant the profiler did not have the ability to profile below the pycnocline.

Buoys

Buoys were set up at three sites this year along the northern range of our study area. Sites were chosen for ice thickness (over 3 m), protective ridging and location. The northwest buoy is likely to stay fairly stationary in the centre of the sea-ice gyre while the northeast set will likely drift southwest through the Canada Basin. There is an ice-tethered profiler (ITP) at each of the buoy sites. The northeast buoy site has additional buoys installed: ice mass balance buoy (IMBB), an Arctic Ocean Heat Flux (AOHF) buoy, and 6 GPS buoys in a 20 nm radius ring around the other three.

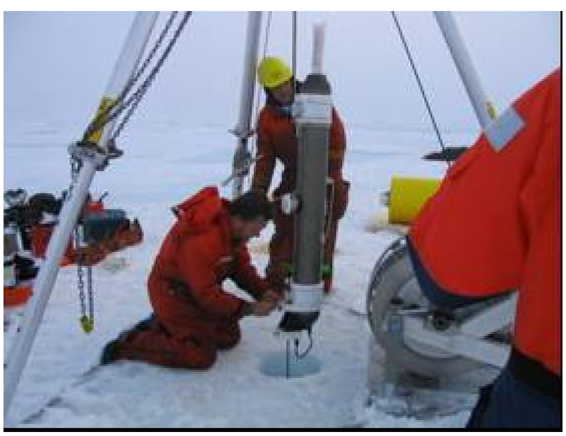

Figure 22. Profiler being deployed.

The buoys were all deployed using helicopter assistance to and from the ice. To install the ITPs, a hole was drilled; a gantry system set over the hole to assist in the lowering of the underwater portion of the buoy and positioning of the surface part; and then the gantry was removed. One of the two ITP/IMBBs deployed in 2005 was not far off the cruise track and a recovery was attempted. The attempt showed that different gear would be needed to successfully recover the buoy, in particular a gantry system that could be set up in a melt pond which may typically form around the buoy. Refer to Newhall (2007) for deployment operation procedures for the WHOI Ice-Tethered Profiler.

Complications

The first buoy deployment was into a floe that contained a void which unfortunately trapped the anchor before it could be pulled back out. The anchor was cut off and the line brought in. A new termination and anchor were needed before it could be redeployed. The second try at this northwest corner was worse. The installation went well, but only after we left the site was it determined the profiler was not communicating with the buoy. There is a chance the profiler is working and saving data to memory although it is slim. The AOHF buoy also had a problem. It had the wrong startup information for the ADCP. An attempt was made to return to the site and correct the information however, due to the drifting ice, we were not able to find the buoy with the limited amount of time available.

WHOI buoy deployment locations are listed in **Appendix 2**.

<u>CABOS</u>

The Canadian Basin Observation System (CABOS) mooring has been deployed on Institute of Ocean Sciences (IOS) Arctic cruises on behalf of the University of Alaska Fairbanks International Arctic Research Center since 2003. The location of the mooring has varied due to ice conditions but has been continuously placed to monitor the flow of Atlantic water around the south east slope of the Canada Basin. The mooring is part of a string of moorings deployed by IARC to observe the movement of Atlantic water through the Arctic and measure the heat flux to upper waters. The CABOS mooring provides complementary data for the Nansen/Amundsen Basin Observation System (NABOS), which consists of a series of McLane Moored Profiler and conventional moorings located around the self break of the Laptev Sea.

2.5.4 Vertical Net Tows

Zooplankton sampling during Leg 3 was conducted by Helen Drost and Hugh Maclean with help from the CTD watch using a modified Bongo net system consisting of four nets (Figure 23). One bongo frame was fitted with a 236 µm mesh net and a 150 µm mesh net. A second smaller frame was fitted with two 53 µm mesh nets and was attached perpendicular to the first bongo frame. Each net contained a unidirectional flowmeter to measure the amount of water flowing through the nets. The vertical net tows (two per station) were primarily to 100 m depth, with two casts to 500 m. Between casts the nets were stored on the foredeck in a box custom built by the ship to accommodate the bongo net.

There were 33 casts performed at 14 stations; locations are listed in **Appendix 2** and shown in Figure 24 below. Samples from the first tow were preserved in formalin, individually from the 150 and 236 µm mesh nets, whereas the samples from the 53 µm nets were combined into one sample. From the second tow, the 236 µm net sample and the combined 53 µm net sample were preserved in 100% ethanol, and the 150 µm net sample was washed with 4% ammonium formate and dried at 50 °C for 24 hours. The formalin samples will be examined for species identification and the ethanol samples for DNA sequence analysis. The dried sample provided a measurement of biomass.

The samples from the 236 µm mesh were collected for John Nelson (DFO/UVic) and samples from the 150 µm and 53 µm mesh for Russ Hopcroft (UAF). The 53 µm ethanol sample was collected for the Census of Marine Life's DNA barcoding study, an affiliated program of the International Council of Science, Scientific Committee on Oceanic Research.

Figure 23. Zooplankton bongo net set-up.

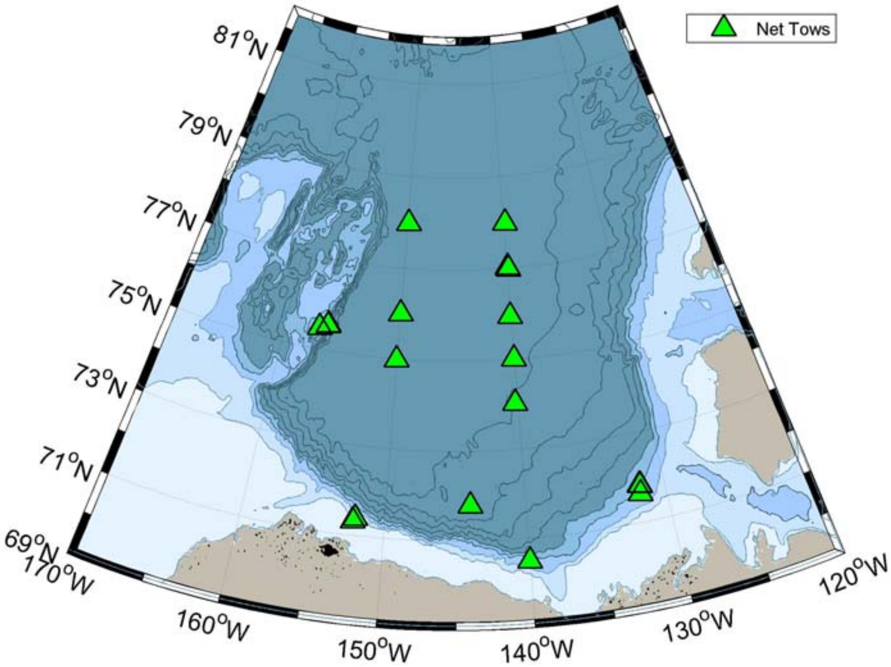

Figure 24. Cruise track: zooplankton net casts marked with green triangles.

Table 20. Zooplankton biomass data.

Tray ID	Station	Cast no.	Weight (g)
2a	BS-3	20	0.7322
2b	CB-5a/b	30	1.1979
2c	CB-5b9	38	1.2340
2d	CABOS	12	0.8530
2e	CB-28a	14	0.7294
2f	Sta A	18	1.4843
4a	CB-4	46	0.6869
4b	CB-7	49	0.8626
4c	CB-9	52	1.0275
4d	CB-15	65	0.5772
4e	CB-15	65	0.5424
4f	CB-17	66	0.6325
5a	CB-18	67	0.4750
5b	CB-21	68	0.4112
5c	CABOS	75	0.5342

*Dried biomass samples at 60 °C for 20 minutes
Note: not all samples were weighed.

2.5.5 Wildlife Observations

Two wildlife observers, Joseph Illasiak and Ian Green (NRCan), stood watches daily above the bridge to record bird and mammal sightings. Their observations will be used for ecological studies and were used to adjust the ship's scientific activity as needed to prevent disturbing marine mammals. No activity adjustments were needed. The observers stood three two-hour watches daily unless seismic operations were being conducted. During seismic operations, the observers were on constant watch.

Sightings were recorded and mapped (see **Appendix 8**). "Casual observations" were also made by others within the science group - people working on the deck or taking a break - following no set observation schedule and with varied skill at identifying birds and mammals.

2.5.6 Drift-Bottle deployments

Numbered bottles with messages inside were tossed over the side during Legs 2 and 3, typically with each CTD cast. In two years we expect to from people who find these bottles washed up onshore. From the returned information, the starting and ending positions, probable route and a maximum transit time can be determined.

2.5.7 Samples collected from Kugaryuak and Coppermine Rivers

Fresh river water flowing into the archipelago has a geo-chemical signature and in 2006 we had the opportunity to collect samples from both the Kugaryuak and Coppermine rivers. See **Appendix 9** for summary of river sampling and **Figure 4** for a map of sampling locations.

2.5.8 Ice Observations

Ice observations were recorded during the cruise by Jennifer Hutchings (IARC). See **Appendix 10** for a detailed report.

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APPENDIX

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1. SCIENCE PARTICIPANTS

Table 1. Onboard Science Team.

Name	Affiliation	Position	Leg
Sarah Zimmermann	DFO-IOS	Chief Scientist	2, 3, 4
Eddy Carmack	DFO-IOS	Program Lead for Leg 2	2
Mary Steel	DFO-IOS	Oxygen Analysis	3, 4
Linda White	DFO-IOS	Nutrient Analysis	3
Nes Sutherland	DFO-IOS	CFC Analysis	3, 4
Michiyo Kawai	DFO-IOS	Alkalinity Analysis	3, 4
Kristina Brown	DFO-IOS	Ammonium, CFC Analysis	3, 4
Jane Eert	DFO-IOS	CTD Watchstander, Data manager	1, 2, 3
Michael Dempsey	DFO-IOS	Chief Technician	3
Jennifer Jackson	UBC	CTD Watchstander, Chlorophyll-a	3
Hugh Maclean	DFO-IOS	CTD Watchstander, Salinity	3
Helen Drost	DFO-IOS	CTD Watchstander, Zooplankton	3, 4
Shigeto Nishino	JAMSTEC	CTD Watchstander, XCTD Technician	3
Richard Krishfield	WHOI	WHOI Mooring Operations	3
William Ostrom	WHOI	WHOI Mooring Operations	3
Kris Newhall	WHOI	WHOI Mooring Operations	3
Jennifer Hutchings	IARC	Ice Observations	3
Abigail Spieler	LDEO	CTD Watchstander, Helium/Tritium	3
Juxin Shi	OUC	PRR	3
Yutian Jiao	OUC	PRR	3
Borden Chapman	NRCan	UNCLOS program, Chief Technician	1, 2, 3
Thomas Funk	Denmark	UNCLOS program, Lead	3
Ryan Pike	NRCan Student	UNCLOS program	1, 2, 3
Joe Manning	DFO/Maritime	UNCLOS program, NRCan Sounder	3
Joe Illasiak	NRCan	UNCLOS program, Wildlife Observation	3
Ian Green	NRCan	UNCLOS program, Wildlife Observation	3
Marty Bergmann	DFO-FWI	Program Co-coordinator for Leg 2	2

Table 2. Principal Investigators Onshore.

	Name	Affiliation	Program
Leg 1-4	Fiona McLaughlin	IOS	CTD and chemistry
Leg 1-4	Eddy Carmack	IOS	CTD and chemistry
Leg 3	Andrey Proshutinsky	WHOI	WHOI moorings
Leg 1-3	Koji Shimada	JAMSTEC	XCTD
Leg 2-4	Chris Guay	OSU	Barium samples
Leg 2-4	Bill Li	BIO	Bacteria samples
Leg 3	John Smith	BIO	Cs-137 and I-129 samples
Leg 3	Bob Newton	LDEO	Helium and Tritium samples
Leg 3	Jinping Zhao	OUC	Light absorption in seawater
Leg 3	Russ Hopcroft	UAF	Zooplankton net tows
Leg 3	John Nelson	UVic/DFO	Zooplankton net tows
Leg 3	Igor Polyakov/Rob Chadwell	IARC	CABOS mooring
Leg 3	Robert Pickart	WHOI	BS-3 mooring
Leg 3	Ruth Jackson	NRCan	Seismic Program

Table 3. Affiliation Abbreviations.

BIO	DFO - Bedford Institute of Oceanography, NS
DFO	Department of Fisheries and Oceans, Canada
IARC	International Arctic Research Center, Alaska
IOS	DFO - Institute of Ocean Sciences, BC
FWI	DFO - Freshwater Institute, MB
JAMSTEC	Japan Agency for Marine-Earth Science Technology, Japan
LDEO	Lamont Doherty Earth Observatory, NY
OSU	Oregon State University
OUC	Ocean University China
NRCan	Natural Resources Canada
UAF	University of Alaska Fairbanks, Alaska
UBC	University of British Columbia, BC
UVic	University of Victoria, BC
WHOI	Woods Hole Oceanographic Institution, Massachusetts

2. LOCATION OF SCIENCE STATIONS

Locations of CTD/Rosette, XCTD, zooplankton vertical net and over-the-side bucket casts, as well as the mooring and buoy recovery and deployments are listed in the tables below.

2.1 CTD/Rosette

Table 4. CTD/Rosette Casts (Legs 2 and 3).

Leg	Cast	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (m/d/y; UTC)	Water Depth (m)	Max CTD Depth (m)	Sample Numbers
2	1	PE1	74	14.6	95	23.03	7/29/2006 12:41	211	200	1-8
2	2	PE3	73	42.8	96	5.08	7/29/2006 17:18	249	235	9-15
2	3	PE5	72	55.6	96	12.43	7/29/2006 23:04	351	345	16-23
2	4	Bellot	71	58.5	95	1.27	7/30/2006 12:52	229	181	24-34
2	5	BE3	71	57.4	95	15.39	7/30/2006 17:15	132	125	35-41
2	6	BE3A	71	49.9	96	0.83	7/30/2006 19:03	426	422	42-50
2	7	7	69	49.3	99	19.73	7/31/2006 12:46	111	106	51-55
2	8	QM1	68	52.6	101	52.01	8/2/2006 4:51	56	51	56-60
2	9	QM2	68	40.0	103	0.4	8/2/2006 7:47	120	111	61-64
2	10	CCG1	68	6.04	114	15.71	8/4/2006 14:50	219	214	65-70
3	11	AG5	70	32.9	122	54.86	8/7/2006 17:58	645	635	73-94
3	12	CABOS	71	49.0	131	46.47	8/8/2006 19:12	1109	231	95-109
3	13	CABOS	71	48.5	131	46.61	8/8/2006 20:55	1102	1089	110-133
3	14	CB28a	70	29.9	139	59.95	8/10/2006 7:05	652	272	134-146
3	15	CB28a	70	30.1	140	0.01	8/10/2006 9:01	657	655	147-170
3	16	CB29	71	59.9	139	58.63	8/11/2006 1:25	2674	2665	171-194
3	17	CB28bb	71	14.9	140	0.28	8/11/2006 13:10	2285	2260	195-218
3	18	Sta-A	71	47.3	143	56.33	8/12/2006 7:32	3160	3146	219-242
3	19	Sta-A	71	46.7	143	58.12	8/12/2006 13:34	3167	1000	243-266
3	20	BS-3	71	23.9	152	3.11	8/13/2006 20:44	153	147	267-282
3	21	BS-3a	71	19.8	152	12.64	8/13/2006 23:41	60	54	283-292
3	22	BS-3b	71	32.0	151	35.55	8/14/2006 3:32	1283	1273	293-315
3	23	BS-3c	71	43.4	151	0.01	8/14/2006 9:45	2263	205	316-321
3	24	BS-3c	71	43.7	151	0.36	8/14/2006 10:46	2263	2250	322-345
3	25	BS-3d	72	1.37	150	0.08	8/14/2006 21:47	3162	3153	346-369
3	26	CB-2a	72	27.9	150	0.47	8/15/2006 7:56	3717	3708	370-393
3	27	CB2	72	57.8	149	56.25	8/15/2006 19:21	3744	3734	394-417
3	28	CB3	73	59.7	150	1.47	8/16/2006 12:52	3823	3809	418-441
3	29	CB-5d	75	44.1	157	12.49	8/18/2006 20:50	920	912	442-465
3	30	CB-5b	75	35.3	156	17.05	8/19/2006 0:09	1824	1814	466-489
3	31	CB5b1	75	32.6	156	15.83	8/19/2006 15:40	1887	800	ctd only
3	32	CB5b2	75	31.4	156	11.15	8/19/2006 21:27	2025	996	ctd only
3	33	CB5b3	75	29.9	156	11.94	8/20/2006 3:00	2000	1000	ctd only
3	34	CB5b4	75	28.6	156	12.16	8/20/2006 9:18	2118	999	ctd only
3	35	CB5b5	75	27.7	156	16.92	8/20/2006 17:22	1894	784	490-496
3	36	aborted rosette cast								
3	37	CB5b7	75	26.4	156	30.94	8/21/2006 11:35	1330	995	ctd only

Leg	Cast	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (m/d/y; UTC)	Water Depth (m)	Max CTD Depth (m)	Sample Numbers
3	38	CB5b8	75	26.4	156	41.9	8/21/2006 19:20	1398	1013	497-505
3	39	CB5b9	75	27.8	156	58.25	8/22/2006 8:35	1409	996	506-513
3	40	CB5b10	75	28.6	157	10.07	8/22/2006 19:51	1386	500	514-534
3	41	CB5b11	75	27.8	157	16.04	8/23/2006 7:00	1306	999	ctd only
3	42	CB5b12	75	27.4	157	15.57	8/23/2006 12:08	1326	1319	536-559
3	43	CB5a	75	33.6	155	34.53	8/23/2006 20:55	3842	3832	560-583
3	44	CB5a	75	33.5	155	37.3	8/23/2006 23:15	3842	50	584-588
3	45	CB-5	75	19.2	153	16.2	8/24/2006 4:24	3840	3835	589-612
3	46	CB-4	74	59.2	150	1.95	8/24/2006 14:15	3825	3815	613-636
3	47	CB-4	74	59.1	150	3.77	8/25/2006 0:36	3825	500	637-658
3	48	Barrow	71	20.8	156	51.37	8/26/2006 16:50	53	49	659-672
3	49	CB-7	76	0.22	149	59.36	8/29/2006 8:19	3829	3820	673-696
3	50	CB-8	76	57.5	149	52.96	8/29/2006 19:19	3825	3814	697-720
3	51	CB-9	77	59.0	149	52.26	8/30/2006 8:01	3822	1000	721-744
3	52	CB-9	77	59.0	149	52.22	8/30/2006 10:46	3822	3813	745-768
3	53	CB10	78	18.1	153	12.57	8/31/2006 5:04	2455	2444	769-792
3	54	CB10a2	78	20.6	153	29.08	8/31/2006 9:12	1907	1000	793-816
3	55	CB10a2	78	20.6	153	28.98	8/31/2006 11:09	1907	1847	817-840
3	56	CB10a	78	19.4	154	4.1	8/31/2006 16:11	1005	994	841-864
3	57	CB11	79	0.44	149	59.64	9/1/2006 14:08	3817	3808	865-888
3	58	CB12	77	42.4	146	48.67	9/3/2006 6:38	3811	1000	889-912
3	59	CB12	77	42.6	146	46.1	9/3/2006 8:43	3811	3803	913-936
3	60	CB13	77	19.4	143	30.51	9/3/2006 18:20	3786	3777	937-960
3	61	CB16	77	55.1	140	5.15	9/4/2006 6:39	3748	3739	961-984
3	62	CB16	77	52.5	140	7.81	9/4/2006 11:47	3743	455	985-1001
3	63	CB15	77	0.64	139	52.66	9/5/2006 10:45	3727	3717	1002-1025
3	64	CB14a	77	10.8	138	52.32	9/6/2006 5:37	3717	1000	1026-1045
3	65	CB15	77	1.03	139	56.27	9/6/2006 9:41	3732	1000	1047-1070
3	66	CB17	75	57.2	140	5.57	9/7/2006 13:23	3708	3698	1071-1094
3	67	CB18	75	1.24	140	1.84	9/8/2006 4:01	3630	3628	1095-1118
3	68	CB21	74	0.75	140	7.97	9/8/2006 19:56	3528	3518	1119-1142
3	69	CB19	74	19.2	143	10.79	9/9/2006 14:50	3693	451	1143-1161
3	70	GF'06	74	15.1	136	14.22	9/10/2006 21:44	3215	3206	1162-1185
3	71	CB22	73	30.5	137	50.68	9/11/2006 5:49	3167	3158	1186-1209
3	72	CBMED1	70	59.9	133	45.93	9/12/2006 0:11	136	130	1210-1223
3	73	CBMED2	71	7.98	133	44.07	9/12/2006 1:55	480	474	1224-1247
3	74	CB31a	72	6.18	133	15.32	9/12/2006 8:16	1772	1763	1248-1271
3	75	CABOS	71	49.7	131	45.96	9/12/2006 16:36	1115	1108	1272-1295

2.2 XCTD

Table 5. XCTD Cast Locations in Baffin Bay (Leg 1) and the Canada Basin (Leg 3).

Leg	Cast	Month	Day	Time (UTC)	Latitude (N)		Longitude (W)		Water Depth (m)
1	XCTD-001	Jul	25	3:46:26	64	0.06	55	0.06	1100
1	XCTD-002	Jul	25	5:38:56	64	19.92	55	32.72	1052
1	XCTD-003	Jul	25	7:29:31	64	39.97	56	4.78	895
1	XCTD-004	Jul	25	9:21:15	64	59.95	56	38.01	656
1	XCTD-005	Jul	25	11:08:27	65	19.94	57	11.06	609
1	XCTD-006	Jul	25	12:45:37	65	40.11	57	43.78	579
1	XCTD-007	Jul	25	14:20:04	66	0.64	58	15.21	563
1	XCTD-008	Jul	25	16:19:40	66	19.23	58	49.63	628
1	XCTD-009	Jul	25	18:19:41	66	39.97	59	21.19	894
1	XCTD-010	Jul	25	20:15:52	66	59.90	59	53.86	937
1	XCTD-011	Jul	25	21:59:09	67	19.98	60	26.99	1065
1	XCTD-012	Jul	25	23:39:15	67	39.90	60	59.63	1517
1	XCTD-013	Jul	26	3:16:00	68	20.54	61	41.29	1730
1	XCTD-014	Jul	26	6:51:31	69	0.03	61	55.34	1851
1	XCTD-015	Jul	26	11:01:51	69	40.07	62	44.86	1970
1	XCTD-016	Jul	26	15:24:18	70	19.99	64	1.62	2077
1	XCTD-017	Jul	26	18:35:21	71	0.45	64	45.63	2158
1	XCTD-018	Jul	26	21:37:52	71	40.01	65	29.85	2266
1	XCTD-019	Jul	27	0:38:27	72	20.14	66	17.43	2330
1	XCTD-020	Jul	27	3:34:38	72	59.90	66	58.59	2346
1	XCTD-021	Jul	27	5:34:02	73	11.39	68	29.35	2329
1	XCTD-022	Jul	27	7:30:46	73	22.45	69	59.41	1686
1	XCTD-023	Jul	27	8:50:36	73	29.96	70	59.45	1217
1	XCTD-024	Jul	27	10:09:15	73	37.35	71	59.42	1089
1	XCTD-025	Jul	27	11:31:18	73	45.13	73	0.01	872
1	XCTD-026	Jul	27	12:48:07	73	52.29	74	0.67	836
1	XCTD-027	Jul	27	14:02:59	73	59.94	74	59.44	813
1	XCTD-028	Jul	27	19:47:26	74	15.20	79	59.43	805
1	XCTD-029	Jul	28	1:35:40	74	22.85	84	59.07	540
1	XCTD-030	Jul	28	8:24:01	74	19.99	90	0.65	296
3	XCTD-031	Aug	9	4:39:56	71	29.55	132	57.88	814
3	XCTD-032	Aug	9	9:04:33	71	30.11	134	29.85	1456
3	XCTD-033	Aug	9	13:11:53	71	30.32	135	59.96	1803
3	XCTD-034	Aug	9	17:59:06	71	30.41	137	30.03	2028

Leg	Cast	Month	Day	Time (UTC)	Latitude (N)		Longitude (W)		Water Depth (m)
3	XCTD-035	Aug	9	21:37:45	71	31.62	138	54.90	2227
3	XCTD-036	Aug	10	11:24:32	70	44.98	139	59.96	1464
3	XCTD-037	Aug	10	13:16:05	70	59.62	139	59.70	2069
3	XCTD-038	Aug	10	16:12:44	71	30.24	139	59.46	2375
3	XCTD-039	Aug	10	16:29:59	71	31.18	139	59.46	2390
3	XCTD-040	Aug	11	19:30:52	71	32.52	141	30.00	2644
3	XCTD-041	Aug	11	22:26:57	71	48.20	142	47.77	2930
3	XCTD-042	Aug	12	20:22:19	71	23.52	145	30.14	3137
3	XCTD-043	Aug	13	0:44:10	71	22.78	146	59.80	2595
3	XCTD-044	Aug	13	5:18:14	71	22.61	148	29.86	3033
3	XCTD-045	Aug	13	10:40:06	71	21.95	149	57.94	1535
3	XCTD-046	Aug	13	14:08:48	71	21.85	151	0.02	228
3	XCTD-047	Aug	14	1:48:40	71	27.48	151	49.14	437
3	XCTD-048	Aug	14	7:01:00	71	37.42	151	13.88	1758
3	XCTD-049	Aug	14	8:28:56	71	42.60	151	2.03	2192
3	XCTD-050	Aug	14	15:48:57	71	51.93	150	21.24	2723
3	XCTD-051	Aug	15	3:30:06	72	14.46	149	58.66	3524
3	XCTD-052	Aug	16	4:57:30	73	29.99	150	0.65	3762
3	XCTD-053	Aug	16	20:58:30	74	19.58	149	58.94	3775
3	XCTD-054	Aug	17	8:09:05	74	32.54	148	6.23	3747
3	XCTD-055	Aug	18	6:16:53	75	10.59	151	30.27	3792
3	XCTD-056	Aug	18	16:15:13	75	37.51	155	59.06	2395
3	XCTD-057	Aug	18	17:10:48	75	40.10	156	21.29	1342
3	XCTD-058	Aug	26	1:21:27	72	44.85	154	25.08	3258
3	XCTD-059	Aug	26	5:32:03	72	22.27	155	22.43	1673
3	XCTD-060	Aug	26	6:57:28	72	12.70	155	34.48	504
3	XCTD-061	Aug	28	1:19:43	73	25.17	153	58.05	3802
3	XCTD-062	Aug	28	10:09:12	74	10.32	152	4.02	3791
3	XCTD-063	Aug	29	4:03:13	75	29.63	149	50.16	3779
3	XCTD-064	Aug	29	15:20:11	76	29.95	149	56.35	3777
3	XCTD-065	Aug	30	2:30:36	77	29.82	149	56.46	3821
3	XCTD-066	Aug	31	0:13:28	78	9.26	151	41.88	3817
3	XCTD-067	Aug	31	3:04:17	78	17.07	152	58.62	3177
3	XCTD-068	Aug	31	18:13:44	78	21.63	154	16.86	948
3	XCTD-069	Aug	31	19:25:06	78	25.11	154	40.53	1541
3	XCTD-070	Sep	1	1:59:12	78	27.62	154	48.81	1800
3	XCTD-071	Sep	1	3:23:31	78	32.37	153	51.38	2011
3	XCTD-072	Sep	1	4:03:55	78	33.60	153	38.36	2516

Leg	Cast	Month	Day	Time (UTC)	Latitude (N)		Longitude (W)		Water Depth (m)
3	XCTD-073	Sep	1	5:14:22	78	37.02	153	13.26	3734
3	XCTD-074	Sep	1	5:18:16	78	37.03	153	12.65	3734
3	XCTD-075	Sep	1	7:53:51	78	46.03	152	8.93	3814
3	XCTD-076	Sep	1	7:59:27	78	46.05	152	8.71	3814
3	XCTD-077	Sep	2	5:20:32	78	30.18	150	2.07	3815
3	XCTD-078	Sep	4	1:43:13	77	38.68	141	40.82	3764
3	XCTD-079	Sep	5	4:15:27	77	30.75	140	2.86	3732
3	XCTD-080	Sep	8	1:31:17	75	23.68	139	5.09	3656
3	XCTD-081	Sep	8	9:45:08	74	30.56	140	3.51	3642
3	XCTD-082	Sep	9	18:07:25	74	8.50	141	51.08	3642
3	XCTD-083	Sep	10	15:22:06	74	9.20	137	26.18	3343
3	XCTD-084	Sep	10	15:25:51	74	9.20	137	26.06	3343
3	XCTD-085	Sep	11	13:42:08	72	47.57	136	42.73	2721
3	XCTD-086	Sep	11	19:12:07	72	6.69	135	56.87	2213

2.3 Moorings and Buoys

Table 6. WHOI Mooring Operations.

Investigator: Andrey Proshutinsky (BGOS-A to D); Robert Pickart (BS-3)

	BS-3	BGOS-A	BGOS-B	BGOS-C	BGOS-D
Recovery date (m/d/y)	8/13/06	8/17/06	8/30/06	9/5/06	9/8/06
Recovery time (UTC)	17:53	17:55	17:50	18:05	16:14
Surveyed latitude (°N)	71 23.729	75 0.3262	77 59.626	76 58.2515	74 0.1500
Surveyed longitude (°W)	152 2.154	149 53.3997	149 57.958	139 59.5852	139 58.9264
Depth (m)	149	3825	3821	3722	3510
Duration (days)	372	370	378	375	376
Redeployment date (m/d/y)		8/24/06	9/2/06	9/6/06	9/10/06
Redeployment time (UTC)		23:10	18:23	18:01	2:26
Drop latitude (°N)		74 59.945	77 59.662	76 59.757	74 0.018
Drop longitude (°W)		149 59.936	149 58.167	139 54.321	139 59.794

Table 7. UAF CABOS Mooring.

Investigator	Recovery Depth (m)	Recovery Location	Recovery Time (m/d/y; UTC)	Deploy Depth (m)	Deploy Location	Deploy Time (m/d/y; UTC)
UAF/IARC I. Polyakov	1112	71° 49.676'N 131° 45.663'W	9/12/06 15:22	1111	71° 49.688'N 131° 45.691'W	9/12/06 21:56

Table 8. WHOI Buoy Operations.

Investigators: Andrey Proshutinsky and John Toole

	ITP4	ITP6/IMB/AOFB	ITP5
Deployment date (m/d/y)	9/3/06	9/4/06	9/7/06
Deployment time	0:00	20:00	20:00
Latitude (°N)	78 7.80	77 53.61	75 54.69
Longitude (°W)	148 57.53	140 25.00	138 4.19

Table 9. IARC GPS Buoys.

Investigator: Jennifer Hutchings

Description	6 ice drifting GPS buoys were deployed in a 10 mile radius ring about a central site with Ice Tethered Profiler, Ice Mass Balance Buoy and Heat Flux Buoy
Deployment date (m/d/y)	9/4/06
Buoys at center of array	ITP6/IMB/AOFB
Latitude, center of array (°N)	77 53.61
Longitude, center of array (°W)	140 25.2

2.4 PRR

Table 10. PRR Light Transmission Casts (Leg 3).

PRR Profile No.	Station	Date (m/d/y)	Start time	Position		Deployment		Water sample (CTD cast #)
			UTC	Lat (°N)	Lon (°W)	depth (m)	location	
1	AG5	8/7/06	18:56	70 32.96	122 54.86	100	6	11
2	CABOS	8/8/06	23:31	71 48.45	131 46.62	120	2	12
3	CB28A	8/10/06	8:27	70 29.88	139 59.92	100	2	13
4	CB29	8/11/06	3:03	71 59.90	139 58.63	100	3	
5	CB28BB	8/11/06	13:21	71 14.88	140 00.29	110	2	
6	STAA	8/12/06	11:34	71 47.25	143 57.41	120	2	18
7	STAAA	8/12/06	16:13	71 46.02	144 00.84	80	2	
8	BS3	8/13/06	21:21	71 23.52	152 02.90	100	2	20
9	BS3C	8/14/06	12:09	71 44.07	151 00.65	50	1	24
10	BS3D	8/14/06	21:59	72 01.58	150 00.02	100	4	25
11	BS3DR	8/14/06	23:22	72 01.66	150 00.08	120	4	
12	CB2A	8/15/06	8:15	72 27.77	150 04.65	70	4	26
13	CB2	8/15/06	19:30	72 57.84	149 56.26	130	4	27
14	CB3	8/16/06	13:18	73 59.35	150 01.77	120	4	28
15	CB3R	8/16/06	15:02	73 58.79	150 02.94	120	4	0
16	CB5D	8/18/06	21:24	75 44.12	157 12.55	120	4	29
17	CB5B	8/19/06	0:33	75 35.26	156 17.05	120	4	
18	CB5BR	8/19/06	5:47	75 35.10	156 15.93	80	4	
19	CB5BR1	8/19/06	14:28	75 32.64	156 15.76	120	3	
20	CB5BR2	8/19/06	19:13	75 31.98	156 12.46	120	3	
21	CB5BR3	8/20/06	0:59	75 30.09	156 11.04	120	3	
22	CB5BR4	8/20/06	15:01	75 27.93	156 15.90	80	3	
23	CB5BR5	8/20/06	17:24	75 27.66	156 17.11	125	4	
24	CB5BR6	8/20/06	22:11	75 27.99	156 19.14	120	4	
25	CB5BR7	8/21/06	3:51	75 27.82	156 23.28	60	3	
26	CB5BR8	8/21/06	17:11	75 26.12	156 38.93	100	3	
27	CB5BR9	8/21/06	22:20	75 27.07	156 44.83	130	3	38
28	CB5BRA	8/22/06	16:52	75 28.42	157 07.10	120	4	
29	CB5BRB	8/23/06	0:15	75 28.30	157 13.86	4	3	
30	CB6BRC	8/23/06	2:01	75 28.30	157 13.86	50	3	

PRR Profile No.	Station	Date (m/d/y)	Start time	Position		Deployment		Water sample (CTD cast #)
			UTC	Lat (°N)	Lon (°W)	depth (m)	location	
31	CB6BRD	8/23/06	2:09	75 28.30	157 13.86	37	4	
32	CB7BRE	8/23/06	15:44	75 26.94	157 56.17	105	3	42
33	CB5A	8/23/06	21:50	75 33.65	155 35.52	80	3	43
34	CB5	8/24/06	5:01	75 19.45	153 15.90	110	3	45
35	CB4	8/24/06	16:00	74 59.21	150 02.87	100	4	46
36	BARROW	8/26/06	17:32	71 20.73	156 51.61	50	3	48
37	CB8	8/29/06	19:40	76 57.47	149 52.68	110	3	50
38	CB9	8/30/06	12:39	77 59.02	149 51.81	100	4	52
39	CB10	8/31/06	5:37	78 18.82	153 12.28	50	3	53
40	CB10A	8/31/06	15:47	78 19.37	154 03.72	100	3	56
41	CB11	9/1/06	17:07	79 00.45	149 59.61	90	4	foredeck
42	CB12	9/3/06	6:54	77 42.42	146 47.46	100	3	59
43	CB13	9/3/06	18:57	77 20.42	143 29.51	45	4	60
44	CB16	9/4/06	14:25	77 52.78	140 07.74	100	4	62
45	CB15	9/6/06	18:07	76 59.70	139 53.64	100	4	
46	CB17	9/7/06	15:00	75 56.98	140 03.22	100	4	
47	CB18	9/8/06	4:49	75 00.76	140 01.67	100	3	67
48	CB21	9/8/06	20:20	74 01.00	140 09.62	90	3	68
49	CB19	9/9/06	15:25	74 19.07	143 10.46	15	3	
50	GF06	9/10/06	22:09	74 14.90	136 15.28	100	3	70
51	CABOSR	9/12/06	17:40	71 49.44	131 46.46	110	4	75

Table 11. PRR On-Ice Casts.

Station	Date	Latitude (N)	Longitude (W)	Time
ICE1	8/31/06	78 27.41	154 47.80	21:06-23:45
ICE2	9/1/06	78 57.77	149 28.42	
ICE3	9/4/06	77 54.77	140 22.10	

2.5 Zooplankton

Table 12. Zooplankton Casts (Leg 3).

Net event	Station Information	Lat (°N)	Long (°W)	Date (m/d/y) UTC)	Time (UTC)	Cast Depth (m)	Water Depth (m)	Notes
1	CTD cast #8, CABOS Mooring	71.63	131.79	8/8/06	23:00	100	1100	flow meter #4 (50µm) not working; spilt some of sample 236a Labels dated 09/08/06 should be 08/08/06
2	CTD cast #8, CABOS Mooring	71.63	131.79	8/8/06	23:20	100	1100	flow meter #4 (50µm) not working
3	CTD cast #14, CB-28a	70.50	140.00	8/10/06	7:45	100	655	no ice present; net went under boat on downcast so waited at 100m for ~15mins
4	CTD cast #14, CB-28a	70.50	140.00	8/10/06	8:14	100	655	
5	CTD cast #18, Station A	71.79	143.94	8/12/06	10:38	100	3300	start of flow meter changed - estimated at the number listed
6	CTD cast #18, Station A	71.79	143.95	8/12/06	10:52	100	3300	
7	CTD cast #18, Station A	71.79	143.95	8/12/06	11:09	500	3300	large *Mysid* in 500m haul (150µm)
8	CTD cast #20, BS-3	71.39	152.05	8/13/06	21:46	100	150	1st haul not vertical
9	CTD cast #20, BS-3	71.33	152.21	8/13/06	22:03	100	150	both hauls: abundance of chaetognaths and jelly fish clogged up mesh
10	CTD cast #30, CB-5b1	75.56	156.25	8/19/06	10:57	100	2026	ship offline to fix shafts; used bubbler to make hole low arrow worms high copepods
11	CTD cast #30, CB-5b1	75.55	156.27	8/19/06	11:12	100	2026	236µm put in 40% ethanol - changed to 97% 22 August, 2006
12	CTD cast #39, CB-5b9	75.47	157.00	8/22/06	11:44	500	1409	
13	CTD cast #39, CB-5b9	75.47	157.00	8/22/06	12:14	100	1409	
14	CTD cast #39, CB-5b9	75.47	157.00	8/22/06	12:27	100	1409	
15	CTD cast #46, CB-4	74.98	150.04	8/24/06	15:18	100	3778	
16	CTD cast #46, CB-4	74.99	150.04	8/24/06	15:27	100	3778	
17	CTD cast #49, CB-7	76.00	149.99	8/29/06	8:47	30	3780	
18	CTD cast #49, CB-7	76.00	149.98	8/29/06	9:07	30	3780	
19	CTD cast #49, CB-7	76.00	149.97	8/29/06	9:44	100	3780	
20	CTD cast #49, CB-7	76.00	149.97	8/29/06	9:55	100	3780	
21	CTD cast #52, CB-9	77.98	149.87	8/30/06	11:11	100	3819	
22	CTD cast #52, CB-9	77.98	149.87	8/30/06	11:23	100	3819	biomass left in oven 34 hours

Net event	Station Information	Lat (°N)	Long (°W)	Date (m/d/y) UTC)	Time (UTC)	Cast Depth (m)	Water Depth (m)	Notes
23	CTD cast #65, CB-15	77.026 8333	139.966 1667	9/6/06	11:15	100	3726	contaminated
24	CTD cast #65, CB-15	77.029 3333	139.969 3333	9/6/06	11:26	100	3726	contaminated
25	CTD cast #65, CB-15	76.99	139.874 6667	9/6/06	19:46	100	3726	redo 23
26	CTD cast #65, CB-15	77.989 6667	139.874 5	9/6/06	19:55	100	3726	redo 24
27	CTD cast #66, CB-17	75.950 5	140.067 8333	9/7/06	15:11	100	3705	
28	CTD cast #66, CB-17	75.950 1667	140.066 6667	9/7/06	15:24	106	3705	high wind - used bubbler when nets were on the way back up
29	CTD cast #67, CB-18	75.011 6667	140.041 1667	9/8/06	5:49	100	3629	
30	CTD cast #67, CB-18	75.010 6667	140.044	9/8/06	6:00	100	3629	
31	CTD cast #68, CB-21	74.025 1667	140.209 5	9/8/06	21:52	100	3525	ice algae in 53µm net? scraped ice on upcast; 2nd tow cancelled due to wind
32	CTD cast #75, CABOS	71.818 8333	131.712	9/12/06	17:15	100	1125	flow meter #3 did not work?
33	CTD cast #75, CABOS	71.828	131.772 8333	9/12/06	17:37	100	1125	

3. CTD SETUP SPECIFICATIONS

Sensors

Primary: Seabird SBE 9+ CTD s/n 0724
Pressure s/n 90559, Calibration: 29Oct02
Primary Temperature s/n 4322, Calibration: 24Feb06, 5Jan07
Secondary Temperature s/n 4239, Calibration: 24Feb06, 30Dec06
Primary Conductivity s/n 2809, Calibration: 10Feb06, 9Jan07
Secondary Conductivity s/n 2810, Calibration: 10Feb06, 9Jan07
Oxygen (pumped, configured with primary and secondary)
  s/n 0435 IOS sensor, Calibration: 06Jun06 25Jan07
  s/n 0575 JAMSTEC Loaner
  s/n 0820 Seabird Loaner, Calibration: 10May06
Transmissometer
  Wetlabs s/n CST-662DR, IOS sensor, Calibration: 20Mar03
  Wetlabs s/n CST-993DR, Jen Jackson/UBC, Calibration: 28Jul06
Fluorometer Seapoint (pumped, configured with secondary sensors) s/n 2569 gain set at 30x
Altimeter Datasonics PSA-916D #1161
Primary Pump s/n 053610
Secondary Pump s/n 053615

Ancillary: Seabird SBE 19 CTD s/n 747
Pressure Strain Gauge s/n 143930, Calibration: 13Feb2001
Temperature s/n 747, Calibration: 07Feb2001
Conductivity s/n 747, Calibration: 07Feb2001
Oxygen s/n 820, Calibration: 10May2006

4. LIST OF INTERPOLATIONS

Table 13. List of Interpolations.

Cast	Start (db)	End (db)	Interval (db)	Property
1	206	208	2	Temperature and Conductivity. 206db set to 207db's value.
2	12	17	5	Temperature and Conductivity
2	17	21	4	Temperature and Conductivity
3	7	9	2	Temperature and Conductivity
3	10	12	2	Temperature and Conductivity
3	13	15	2	Temperature and Conductivity
4	3	14	11	Temperature and Conductivity
4	69	71	2	Temperature and Conductivity
4	77	80	3	Temperature and Conductivity
4	86	88	2	Temperature and Conductivity
4	124	128	4	Temperature and Conductivity
4	142	150	8	Temperature and Conductivity
5	50	52	2	Temperature and Conductivity
6	11	13	2	Temperature and Conductivity
7	0	3	3	Temperature and Conductivity. 2db set to 3db's value.
7	6	8	2	Temperature and Conductivity
7	19	21	2	Temperature and Conductivity
8	3	10	7	Temperature and Conductivity
9	0	2	2	Temperature and Conductivity. 1db set to 2db's value.
10	0	3	3	Temperature and Conductivity. 2db set to 3db's value.
13	1	1	0	Use upcast value for emperature and conductivity.
14	5	7	2	Temperature and Conductivity
16	915	919	4	Temperature and Conductivity
17	1690	1695	5	Temperature and Conductivity
18	8	10	2	Temperature and Conductivity
19	0	2	2	Temperature and Conductivity. 1db set to 2db's value.
19	6	8	2	Temperature and Conductivity
24	5	7	2	Temperature and Conductivity
24	303	305	2	Temperature and Conductivity
27	412	414	2	Temperature and Conductivity
28	1	3	2	Temperature and Conductivity
29	0	5	5	Temperature and Conductivity. 2 to 4db set to 5db's value.
29	5	11	6	Temperature and Conductivity
30	8	10	2	Temperature and Conductivity
30	334	337	3	Temperature and Conductivity
40	7	10	3	Temperature and Conductivity
47	4	7	3	Temperature and Conductivity
47	7	9	2	Temperature and Conductivity
49	6	8	2	Temperature and Conductivity
49	14	16	2	Temperature and Conductivity
49	1866	1868	2	Temperature and Conductivity

Cast	Start (db)	End (db)	Interval (db)	Property
50	2	3891	3889	Primary temperature and conductivity replaced with secondary temperature and conductivity (no interpolation) for the full profile due to high signal variability in primary sensors.
51	0	13	13	Temperature and Conductivity. 2 to 12 db set to 13db's value.
52	1	9	8	Temperature and Conductivity
52	9	12	3	Temperature and Conductivity
52	17	22	5	Temperature and Conductivity
53	0	6	6	Temperature and Conductivity. 1 to 5db set to 6db's value.
53	7	11	4	Temperature and Conductivity
53	311	314	3	Temperature and Conductivity
55	0	2	2	Temperature and Conductivity. 1db set to 2db's value.
56	0	8	8	Temperature and Conductivity. 1 to 7db set to 8db's value.
56	11	15	4	Temperature and Conductivity
57	0	3	3	Temperature and Conductivity. 1 and 2db set to 3db's value.
57	5	12	7	Temperature and Conductivity
58	0	2	2	Temperature and Conductivity. 1db set to 2db's value.
58	14	19	5	Temperature and Conductivity
60	0	3	3	Temperature and Conductivity. 1 and 2db set to 3db's value.
60	10	14	4	Temperature and Conductivity
60	19	21	2	Temperature and Conductivity
62	609	614	5	Oxygen
62	1013	1017	4	Oxygen
63	0	6	6	Temperature and Conductivity. 3 to 5db set to 6db's value.
63	12	16	4	Temperature and Conductivity
63	22	25	3	Temperature and Conductivity
64	0	12	12	Temperature and Conductivity. 1 to 11db set to 12db's value.
64	819	823	4	Temperature and Conductivity
65	0	9	9	Temperature and Conductivity. 1 to 8db set to 9db's value.
65	16	19	3	Temperature and Conductivity
66	609	611	2	Temperature and Conductivity
67	1	6	5	Temperature and Conductivity
67	8	10	2	Temperature and Conductivity
68	0	8	8	Temperature and Conductivity. 1 to 7db set to 8db's value.
68	8	10	2	Temperature and Conductivity
68	12	14	2	Temperature and Conductivity
69	0	6	6	Temperature and Conductivity. 1 to 5db set to 6db's value
70	0	7	7	Temperature and Conductivity. 1 to 6db set to 7db's value.
71	0	4	4	Temperature and Conductivity. 1 to 3db set to 4db's value.
71	14	16	2	Temperature and Conductivity
74	0	2	2	Temperature and Conductivity. 1db set to 2db's value.

5. INDIVIDUAL STATION PLOTS

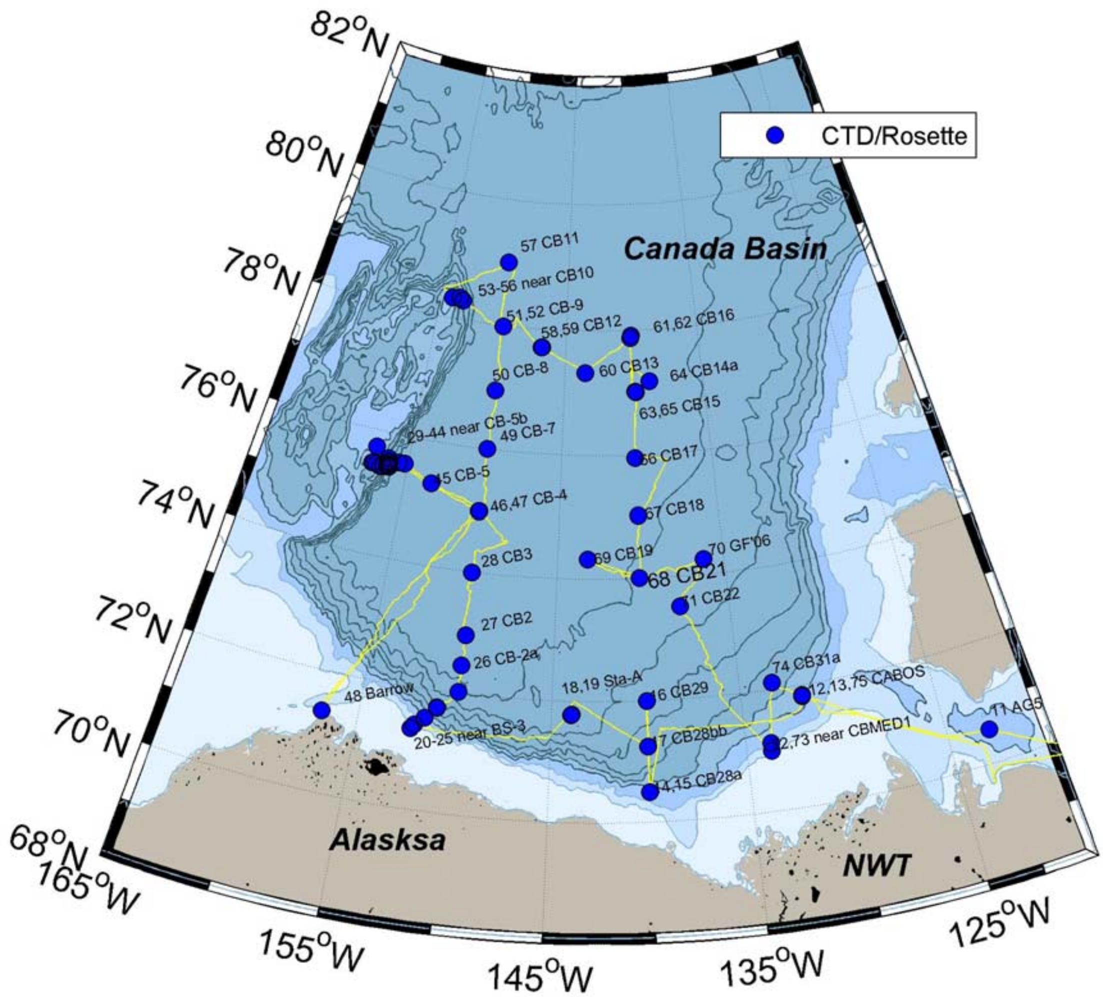
The following section contains data plots for each CTD cast taken on the 2006-18 cruise. CTD and chemistry data are plotted in eight figures per cast with primarily CTD properties on the even pages and chemistry properties on the odd pages.

Table 14. Property Legend for Individual Station Plots.

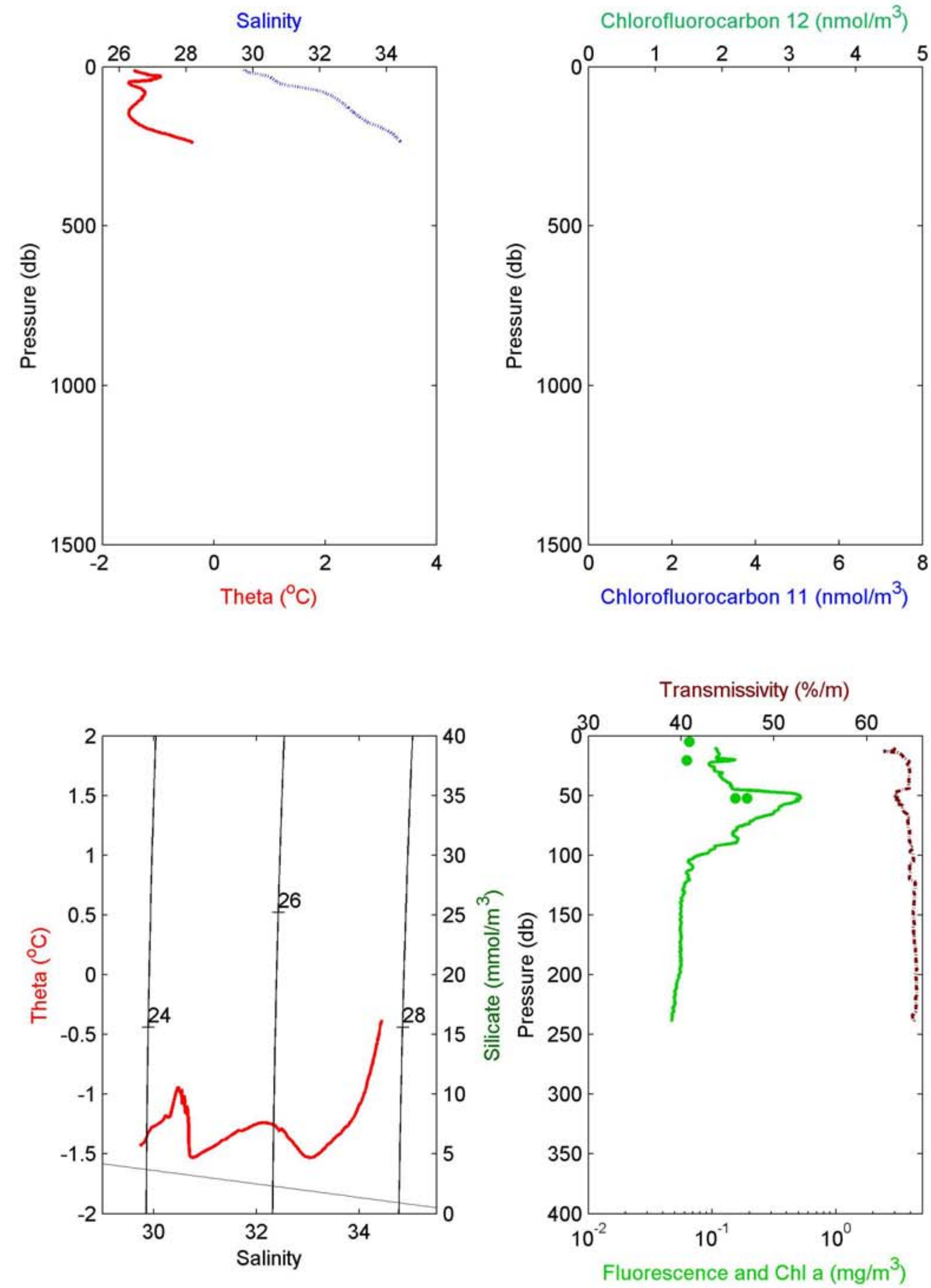
	Salinity (PSU), CTD
	Salinity (PSU), Bottle
	Theta (°C)
	CFC 12 (nmol/m^3)
	CFC 11 (nmol/m^3)
	Silicate (mmol/m^3)
	Transmissometer (%/m)
	Fluorescence (mg/m^3)
	Chlorophyll-a (mg/m^3)
	Phosphate (mmol/m^3)
	Nitrate (mmol/m^3)
	Silicate (mmol/m^3)
	Oxygen (mmol/m^3), Sensor
	Oxygen (mmol/m^3), Bottle
	Ammonium (µmol/m^3)
	O^{18} (‰)
	Alkalinity FW (µmol/kg)
	DIC (µmol/kg)
	Alkalinity (µmol/kg) (from DIC bottle)
	Cesium (Bq/m^3)
	Iodine-129 (10^7 atom/L)
	TSS (mg/m^3)
	POC (mg/m^3)

5.1 Canada Basin

5.1.1 Standard



2006-18: Cast 12 Station CABOS (Canada Basin)



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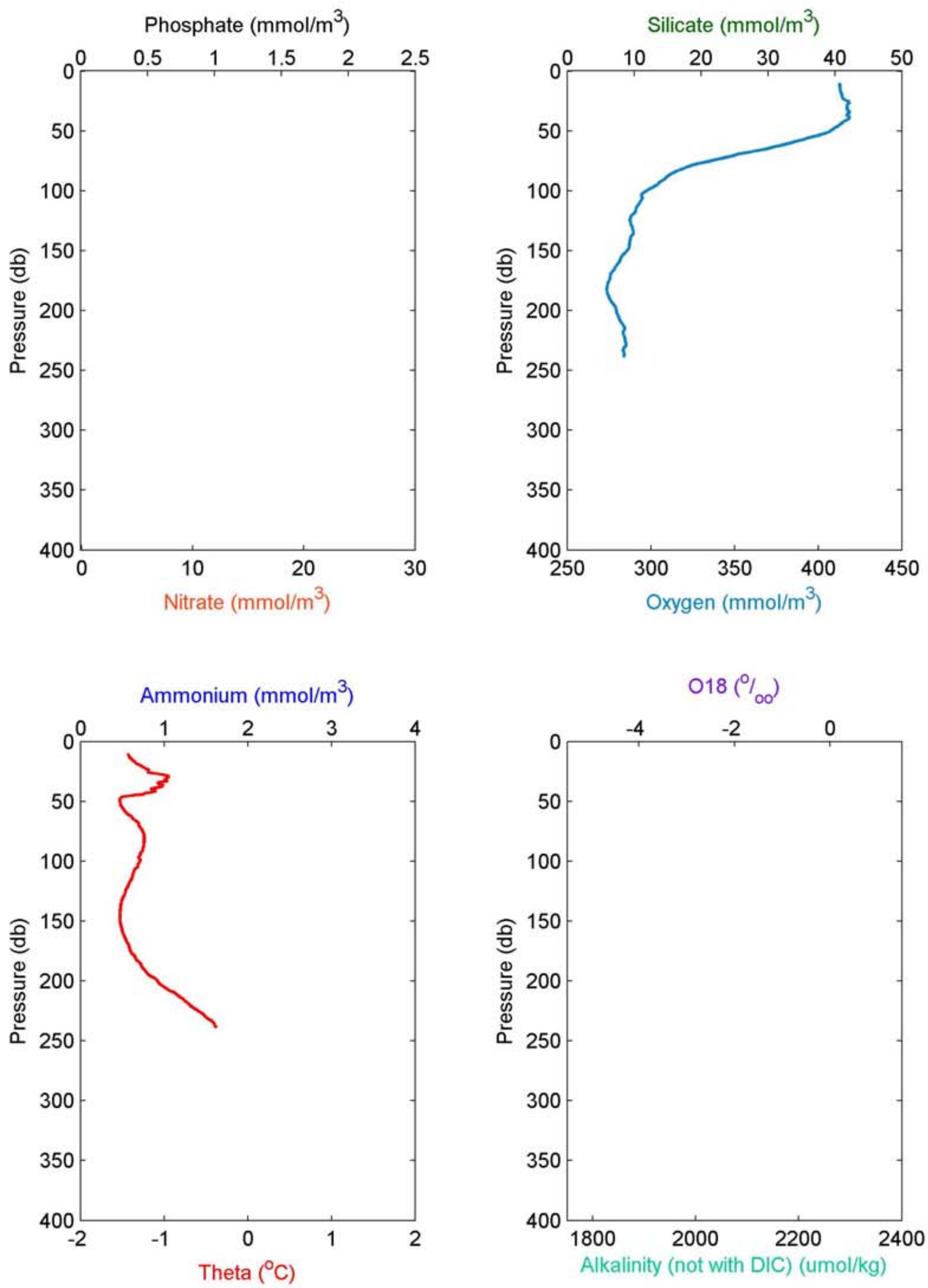

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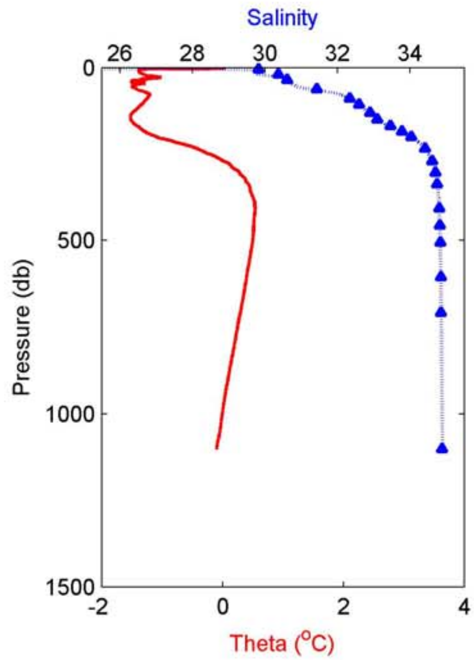

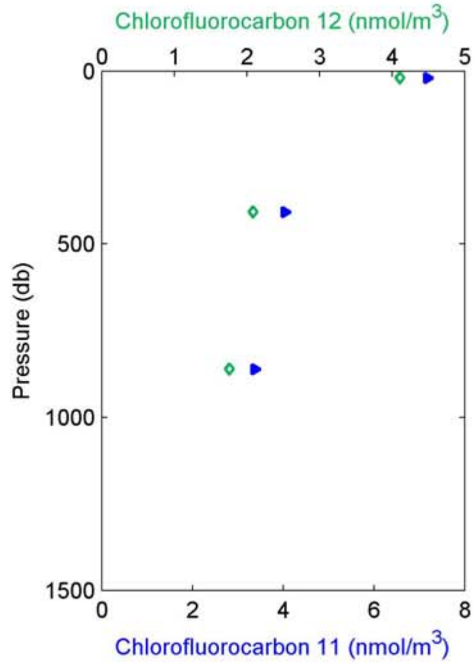

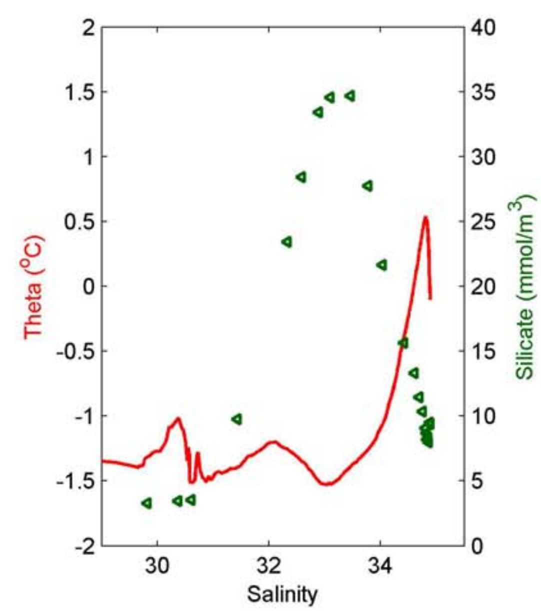

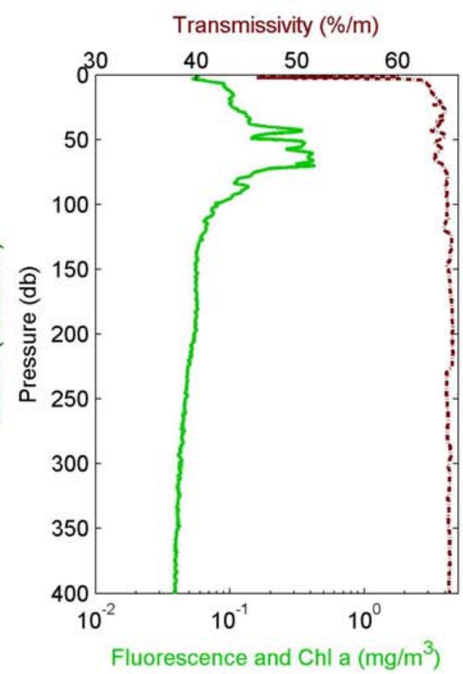

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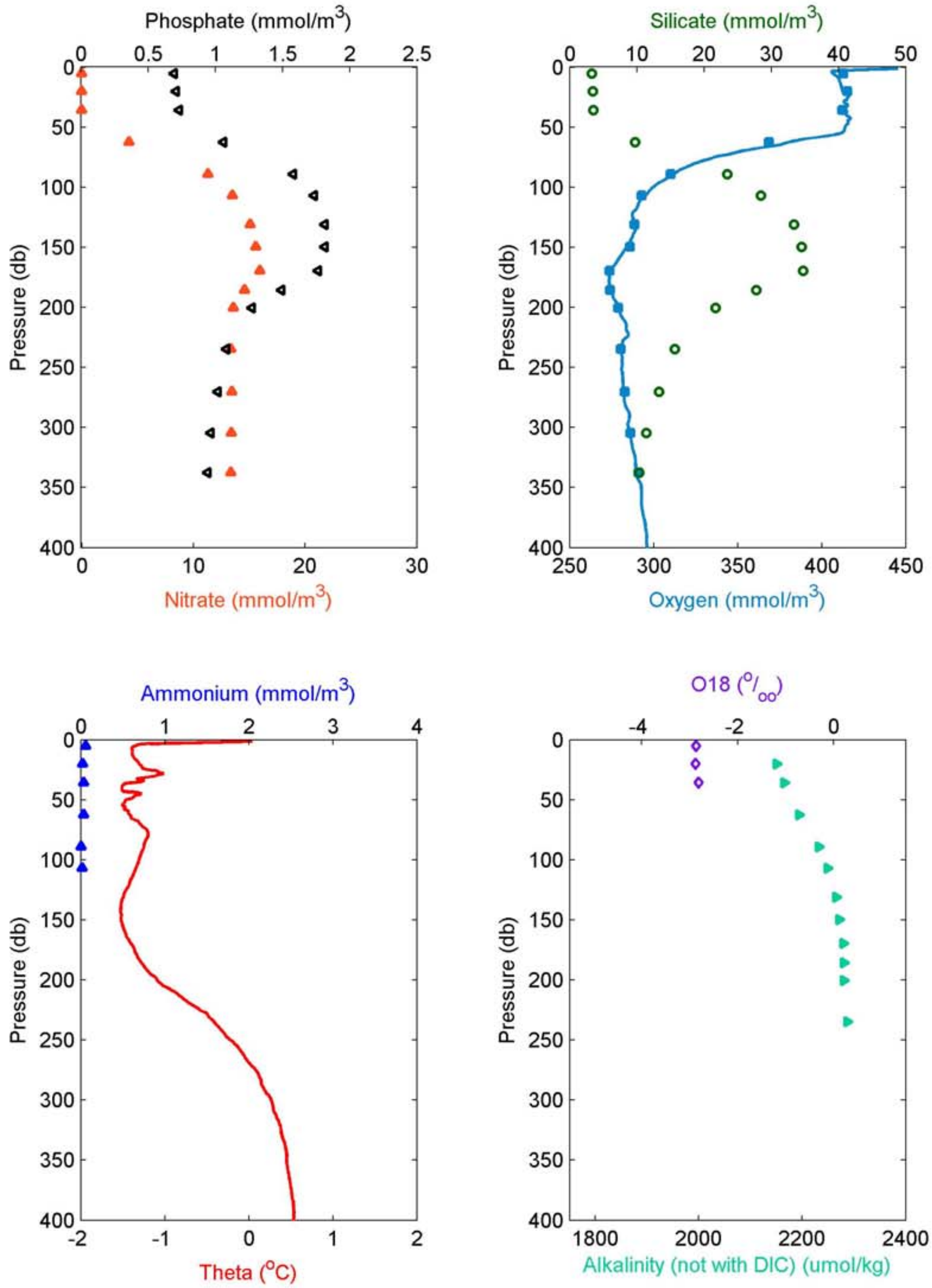
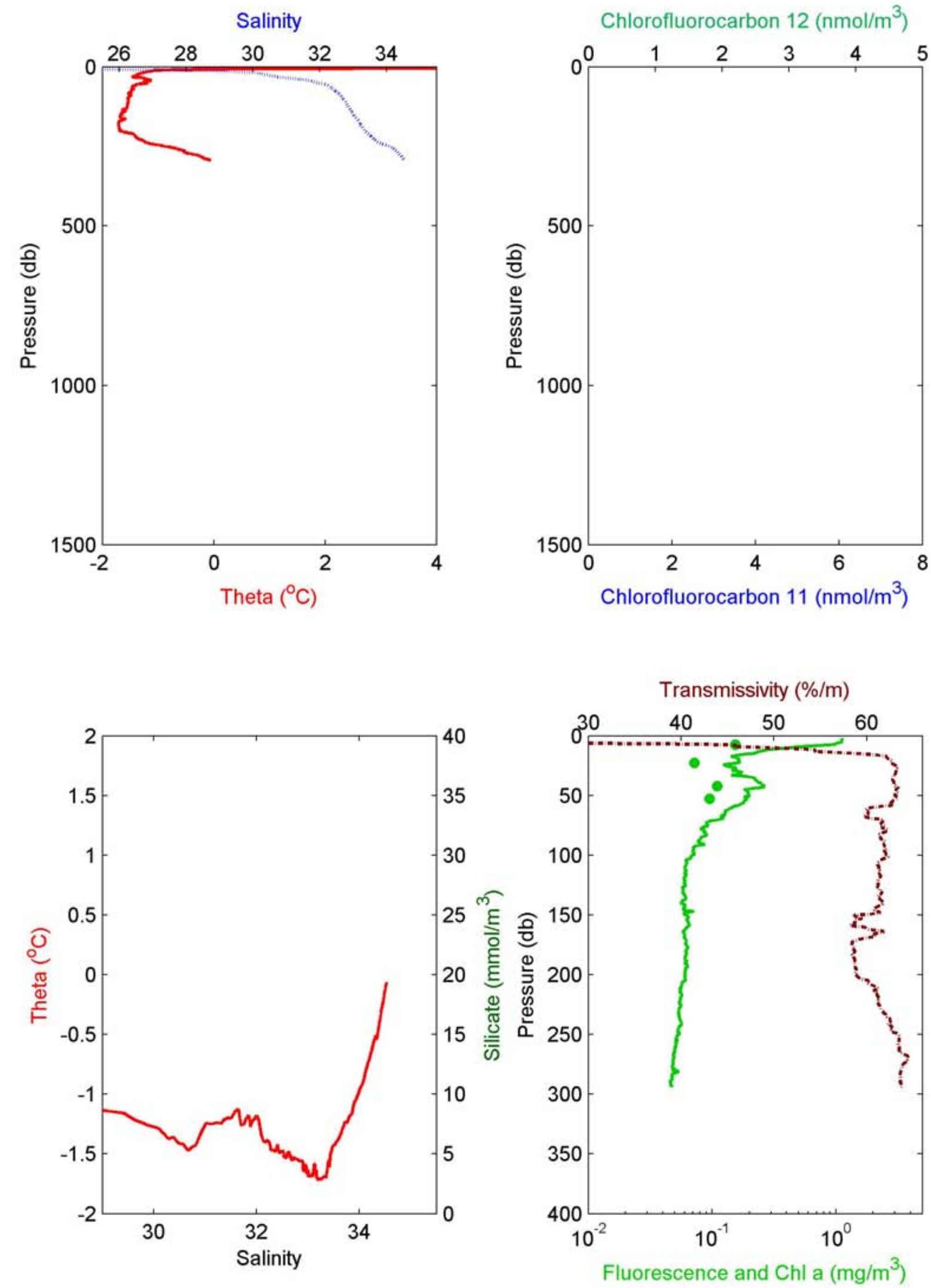
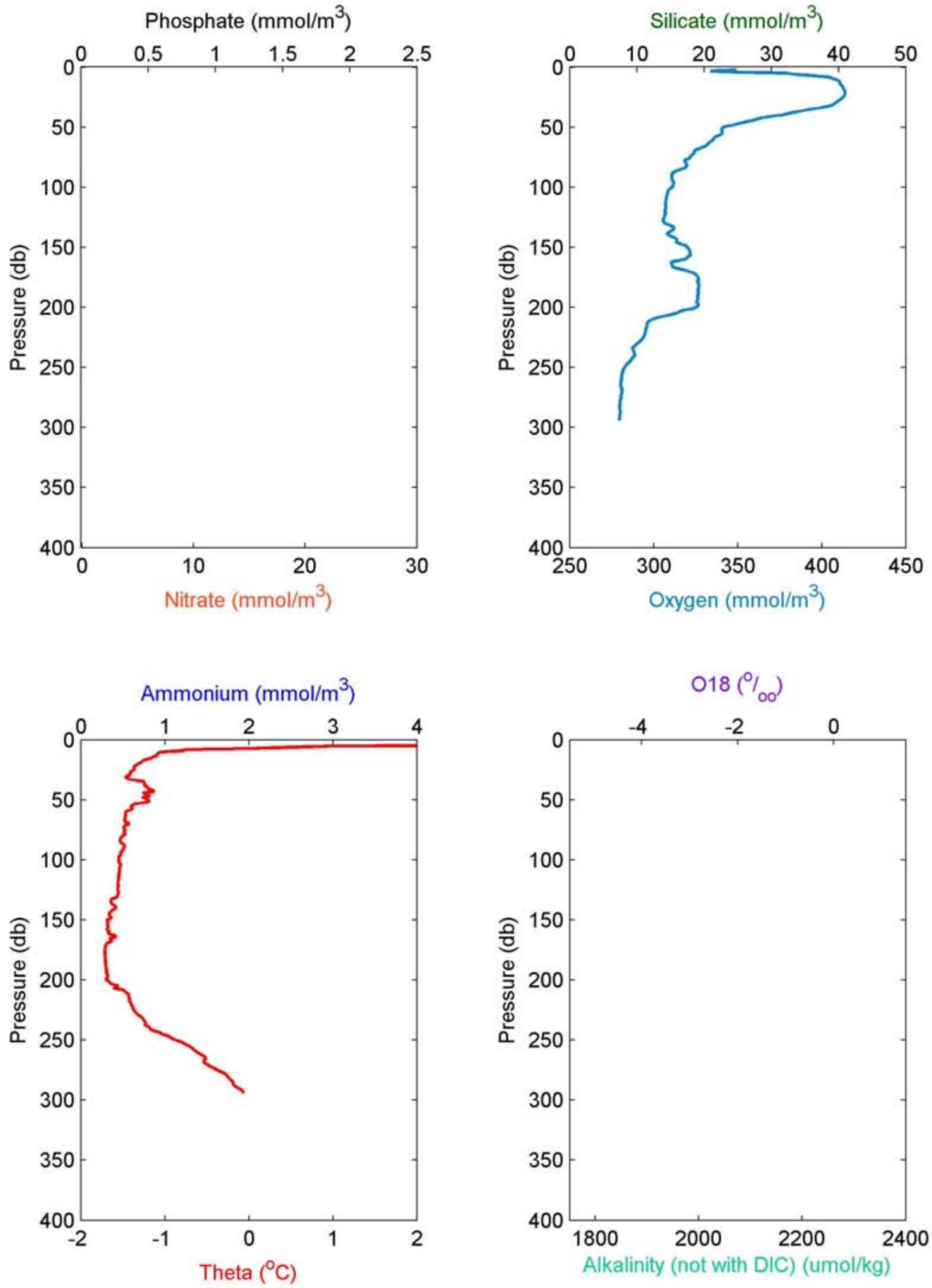


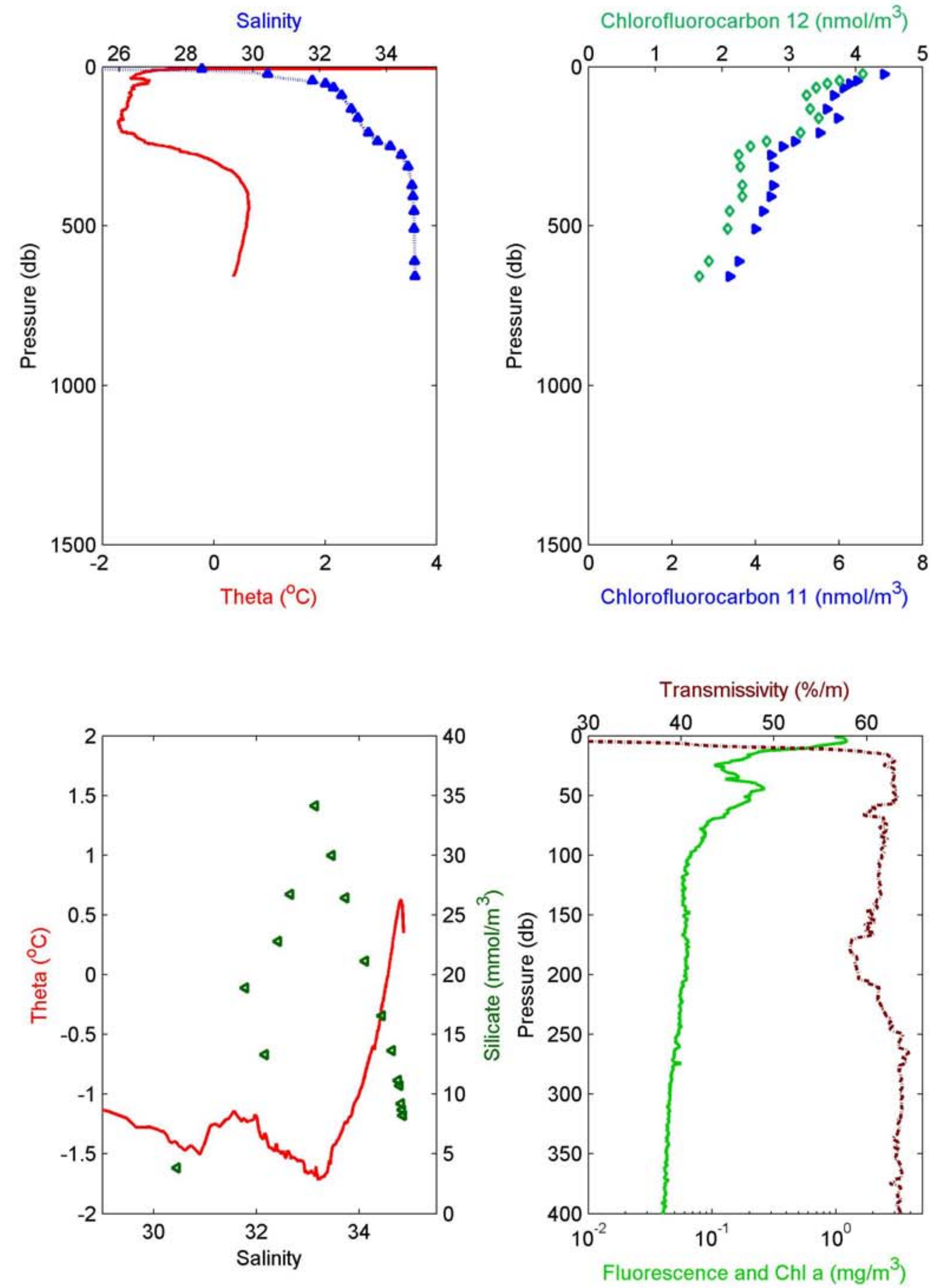
2006-18: Cast 14 Station CB28a (Canada Basin)



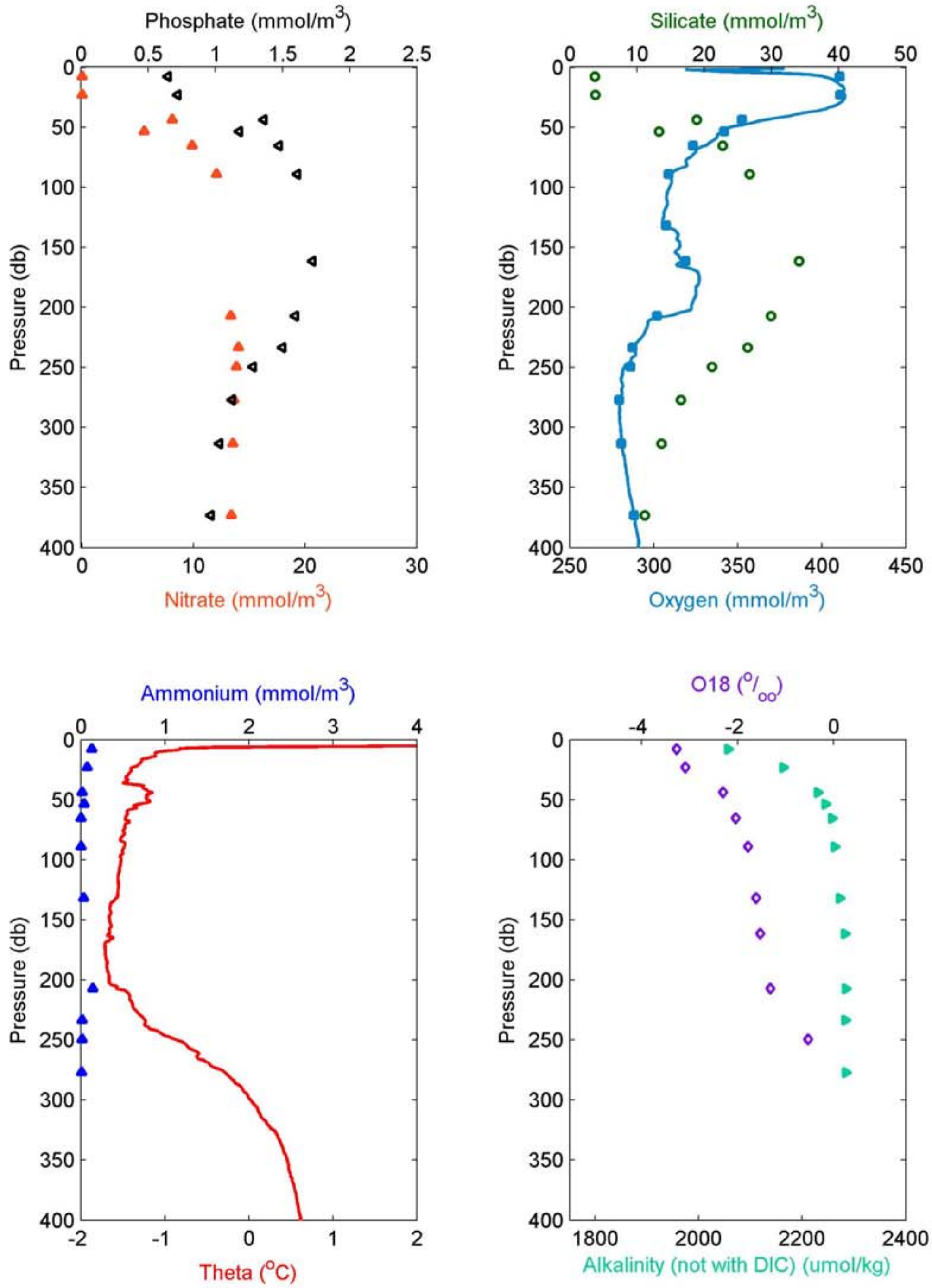
2006-18: Cast 14 Station CB28a (Canada Basin)



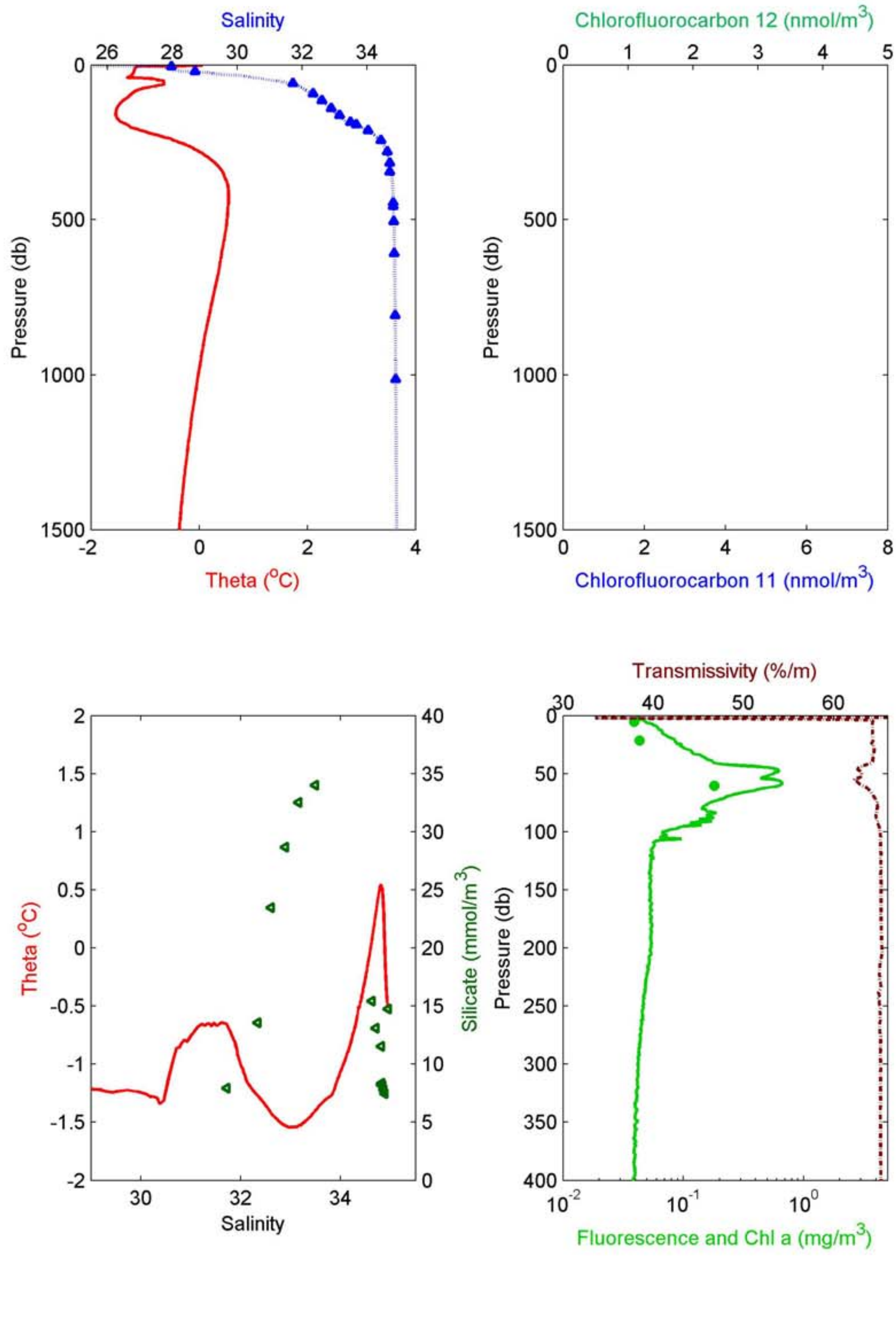
2006-18: Cast 15 Station CB28a (Canada Basin)



2006-18: Cast 15 Station CB28a (Canada Basin)



2006-18: Cast 16 Station CB29 (Canada Basin)



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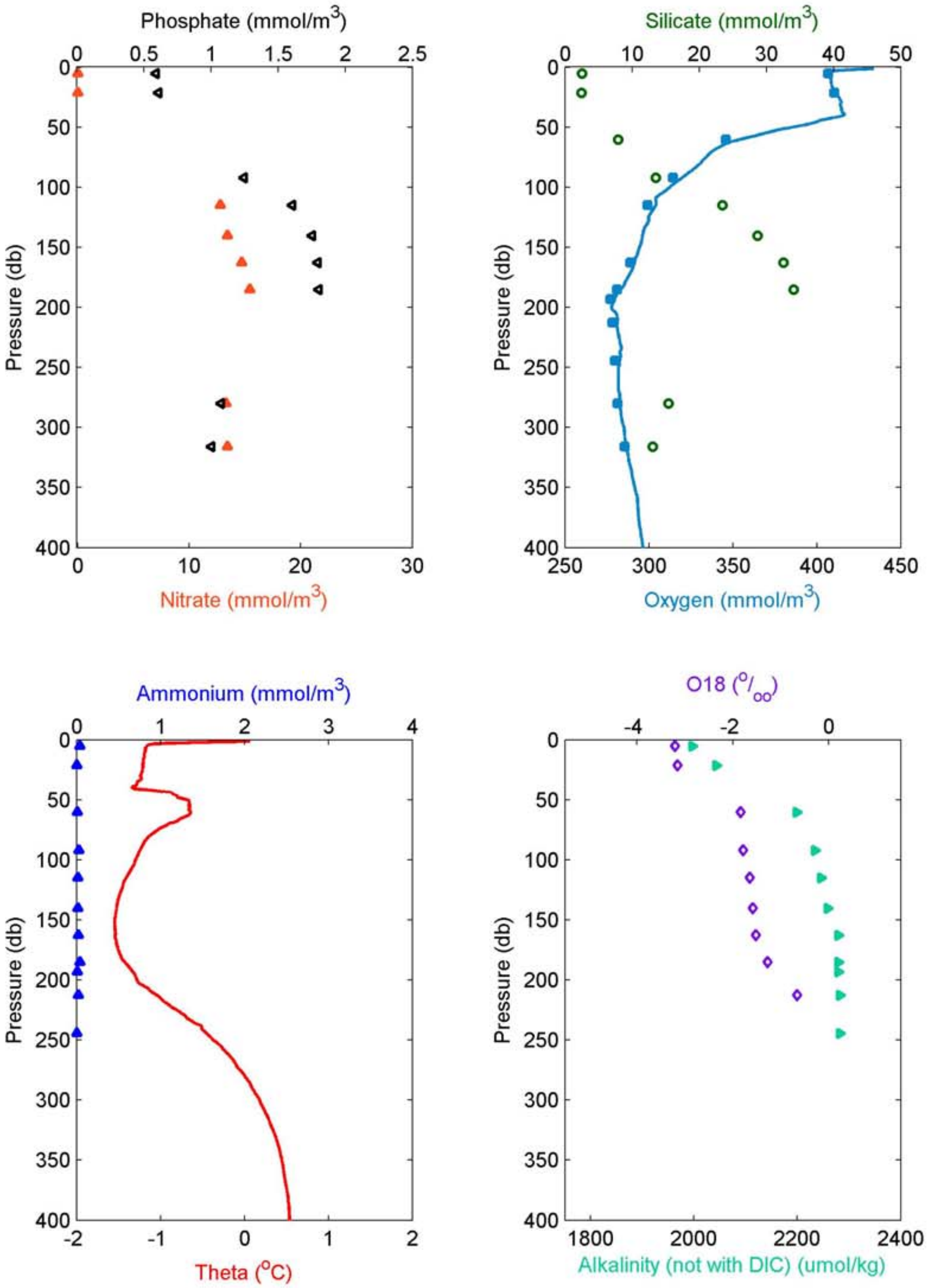
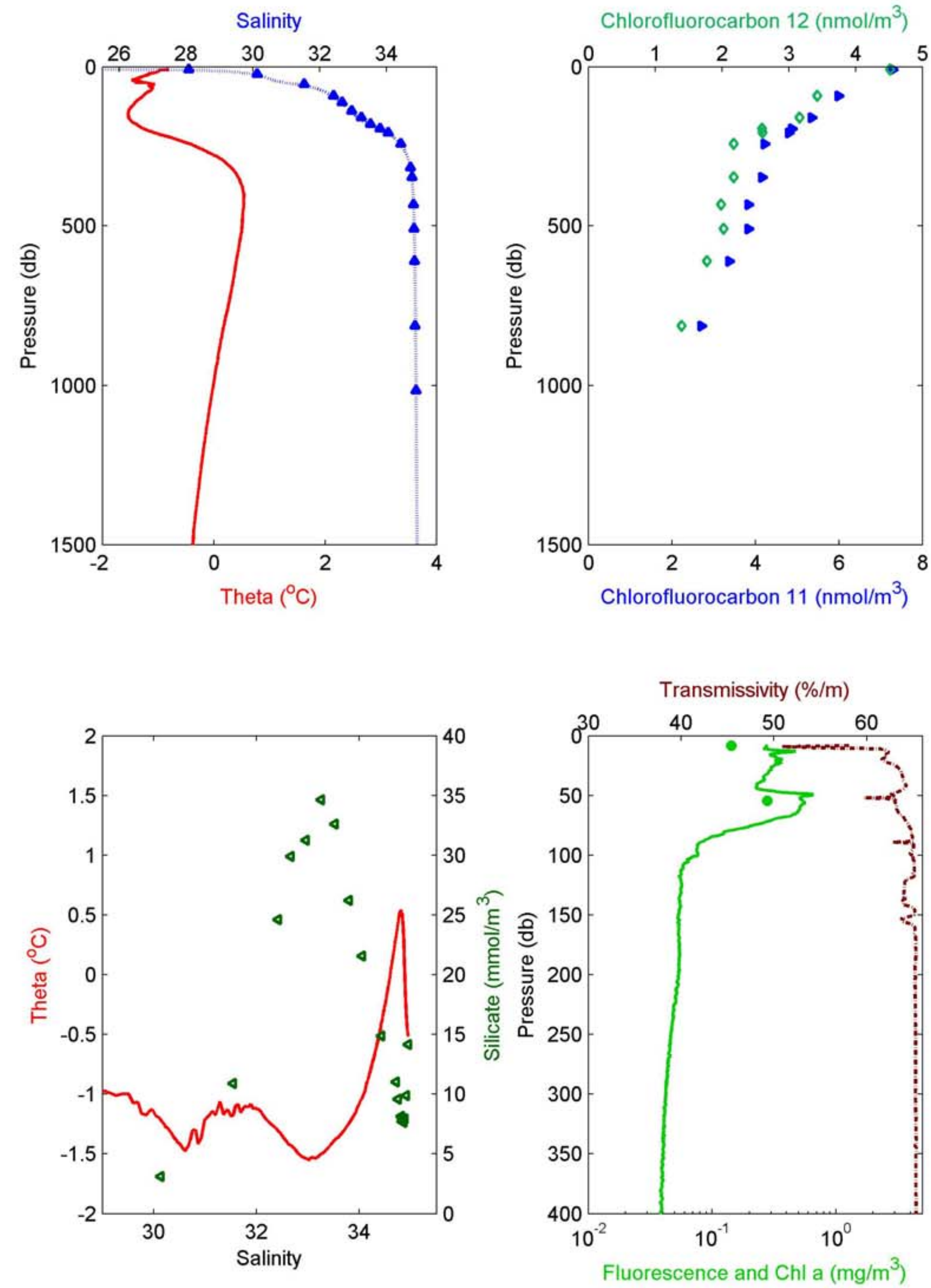


2006-18: Cast 17 Station CB28bb (Canada Basin)



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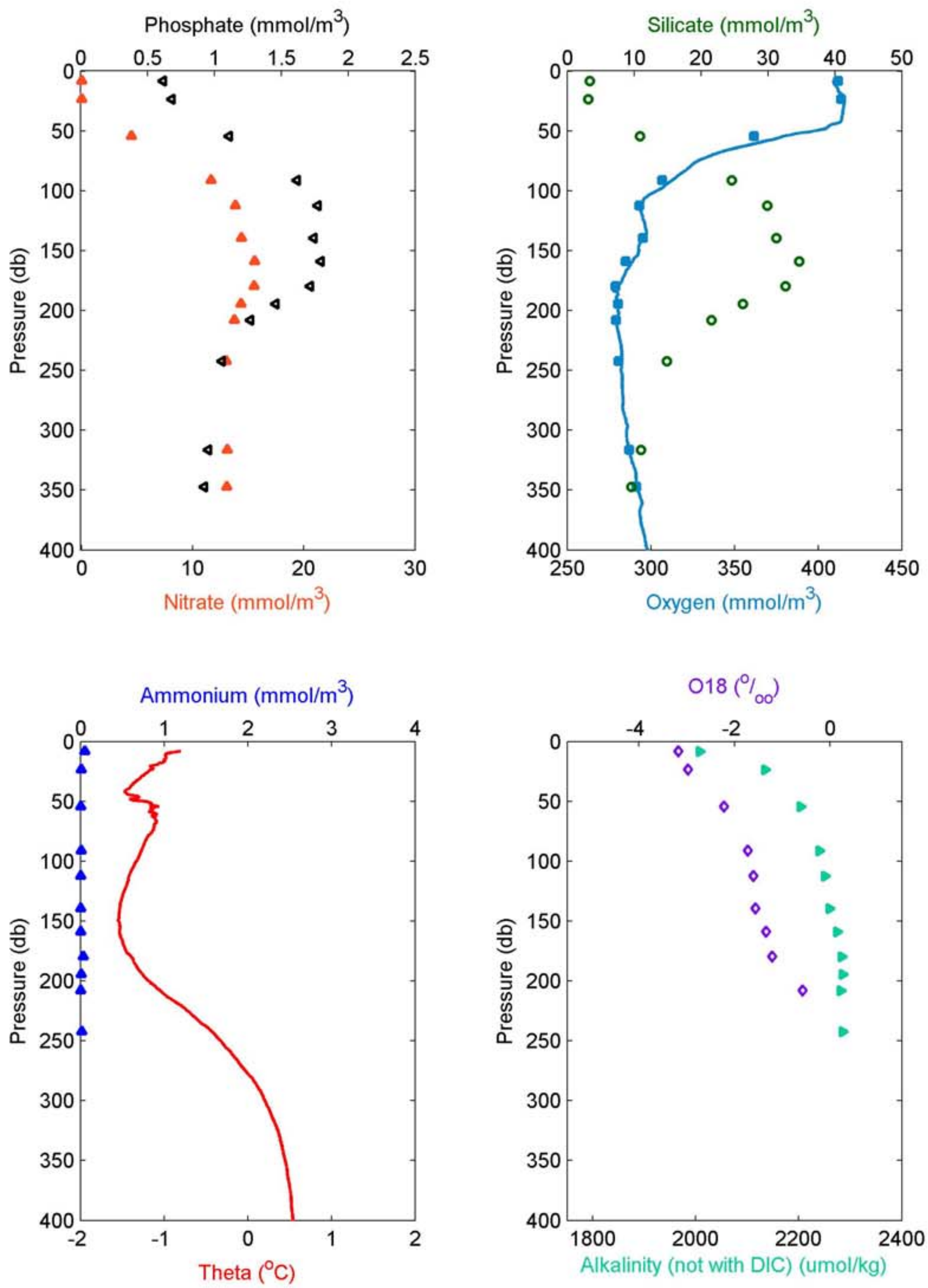
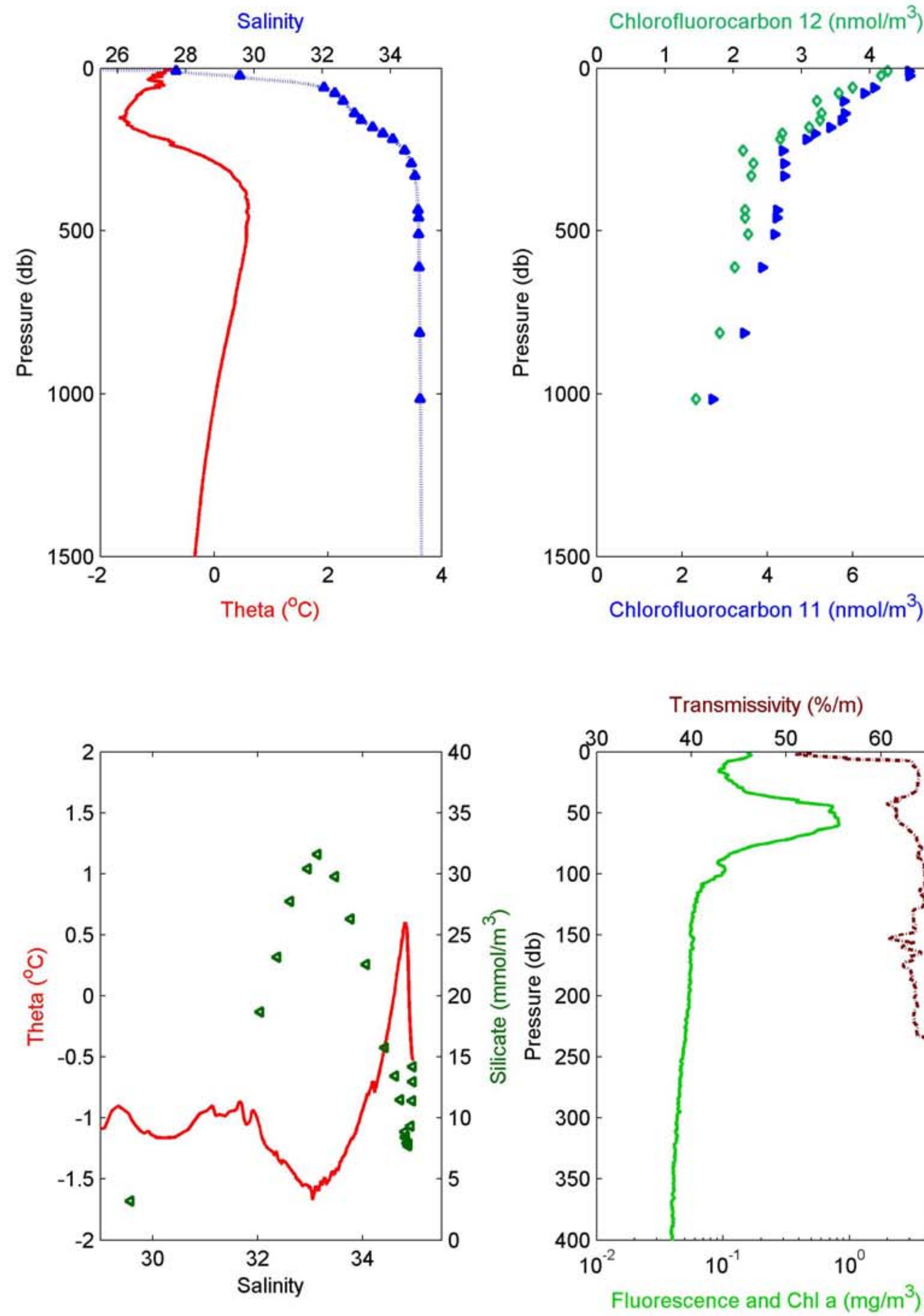
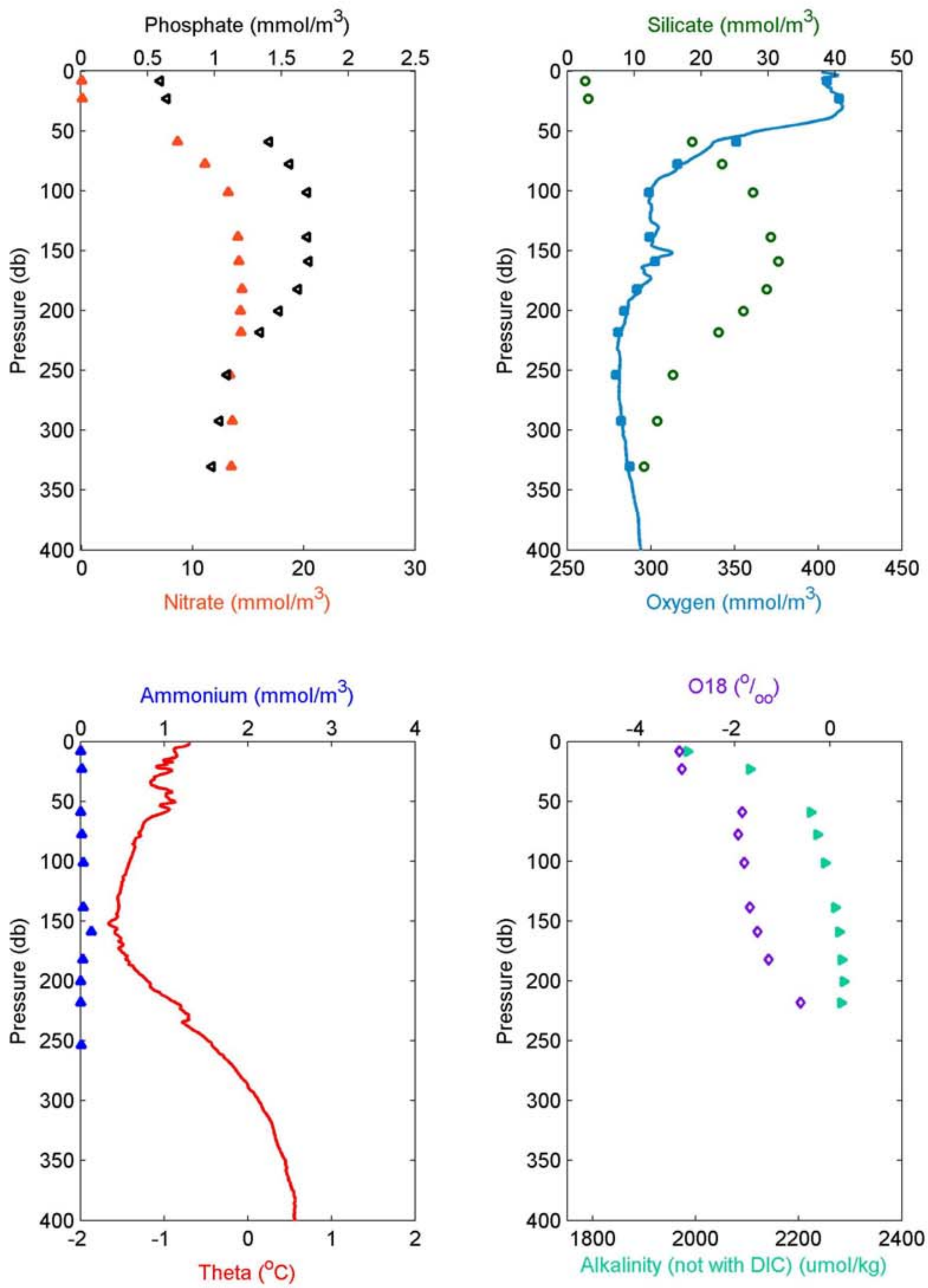


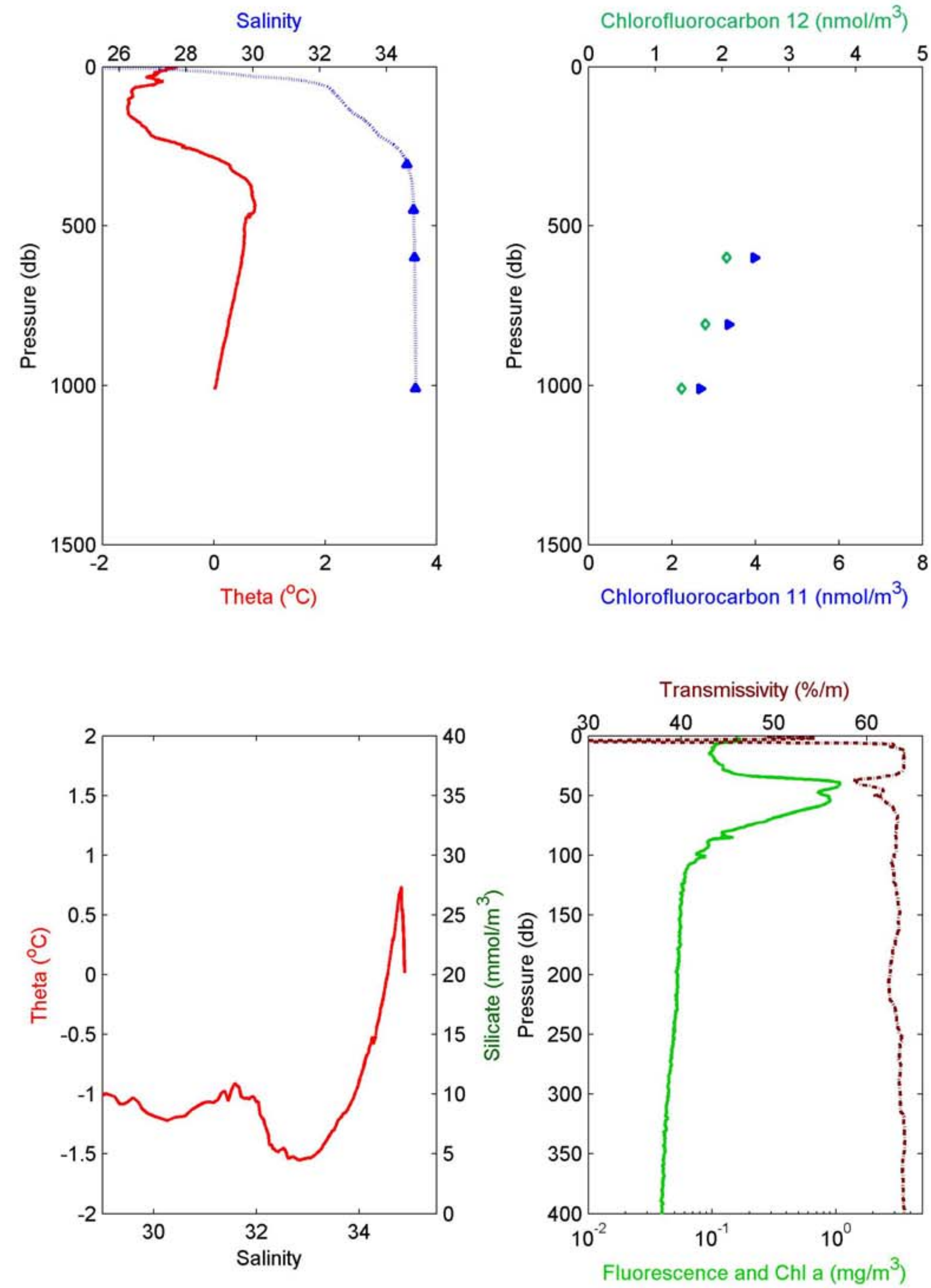
2006-18: Cast 18 Station Sta-A (Canada Basin)



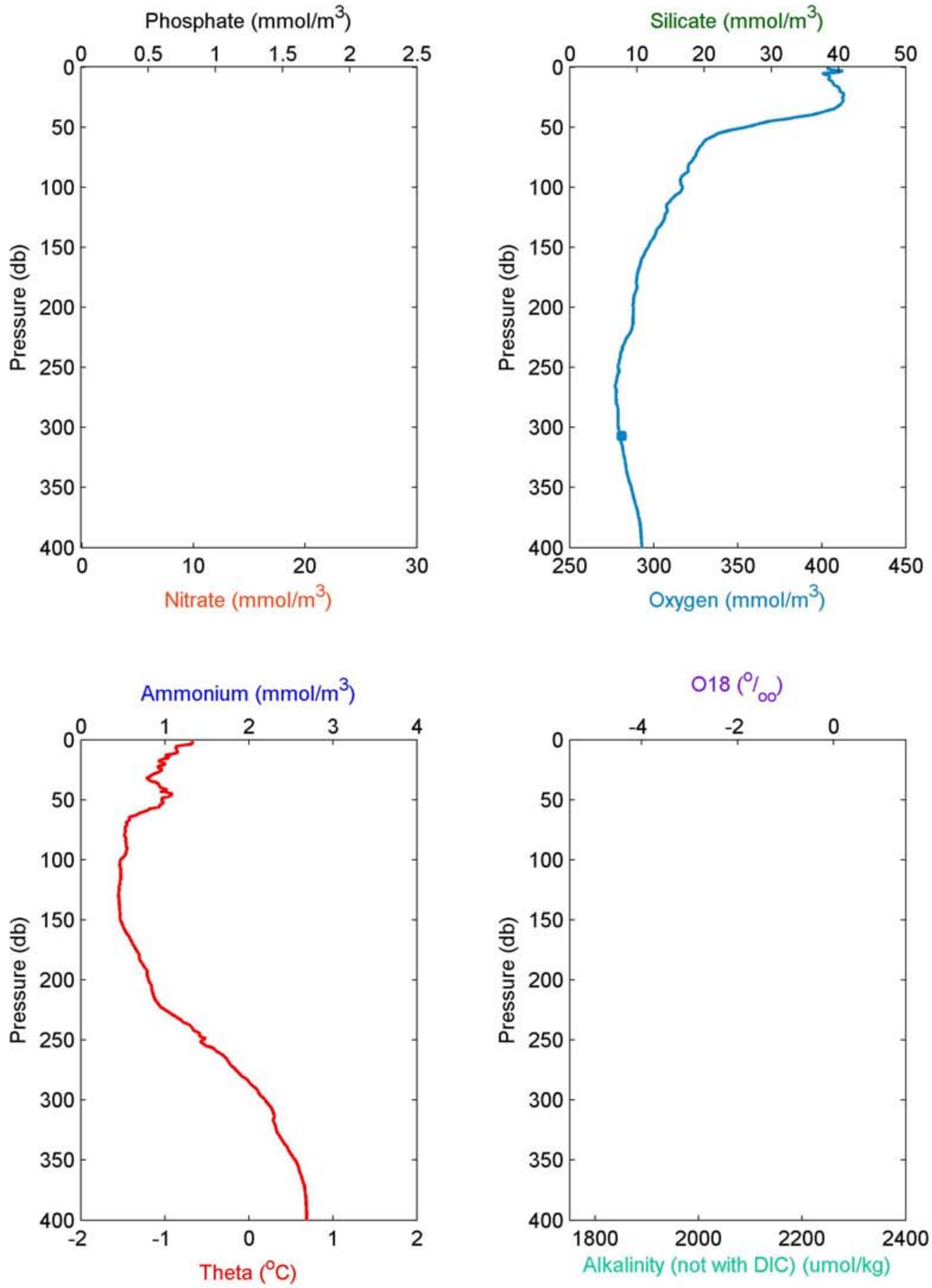
2006-18: Cast 18 Station Sta-A (Canada Basin)



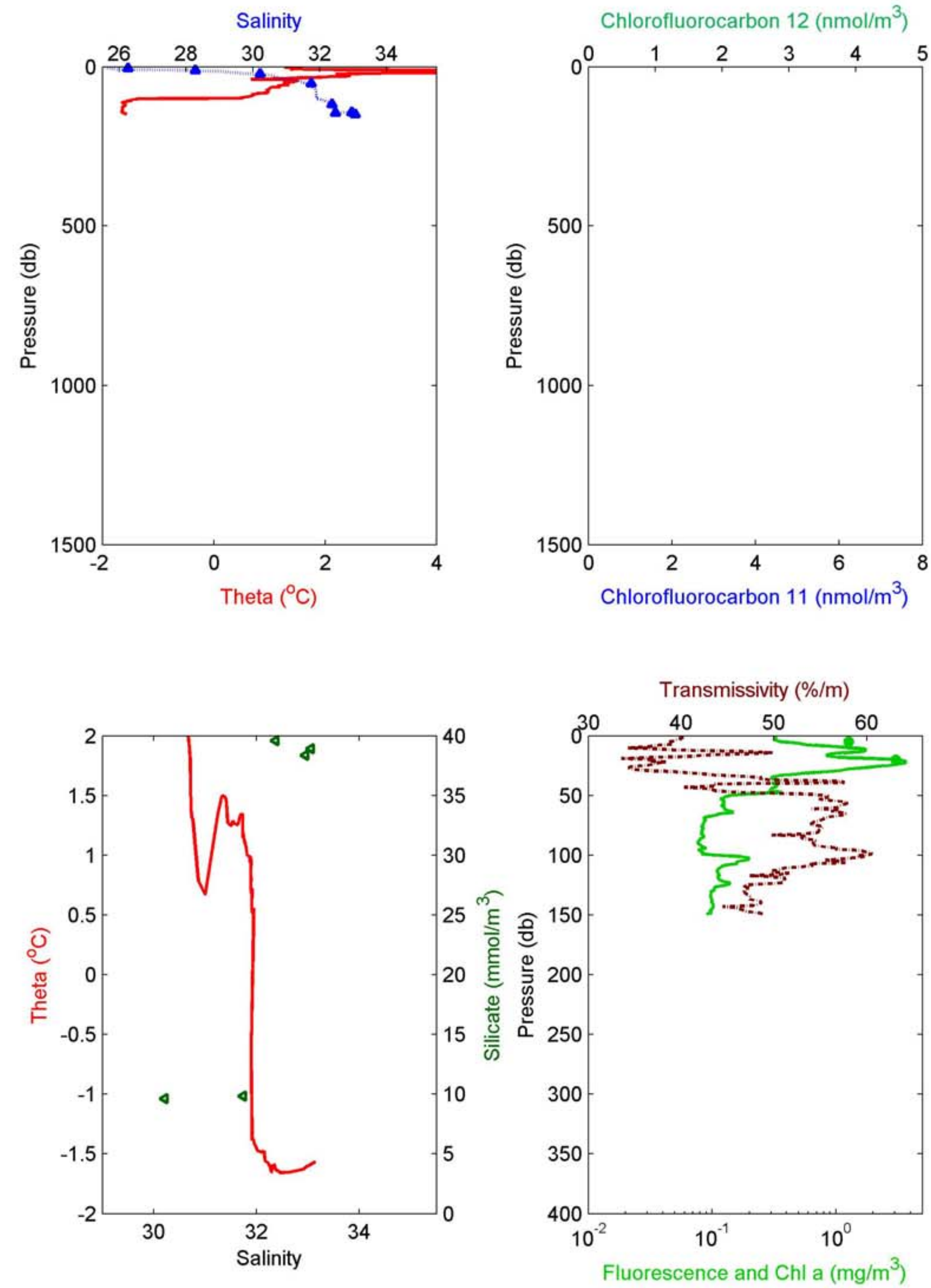
2006-18: Cast 19 Station Sta-A (Canada Basin)



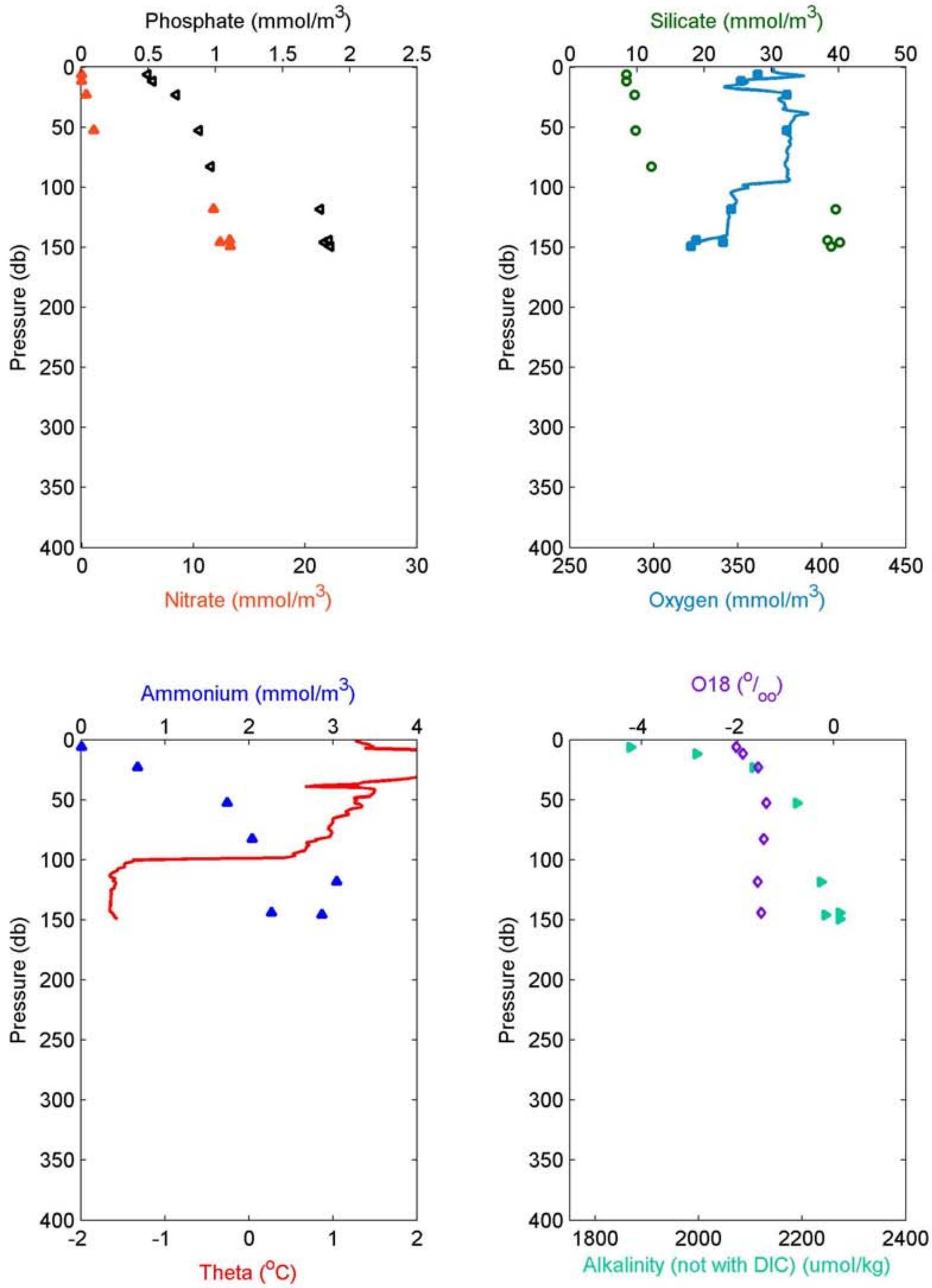
2006-18: Cast 19 Station Sta-A (Canada Basin)



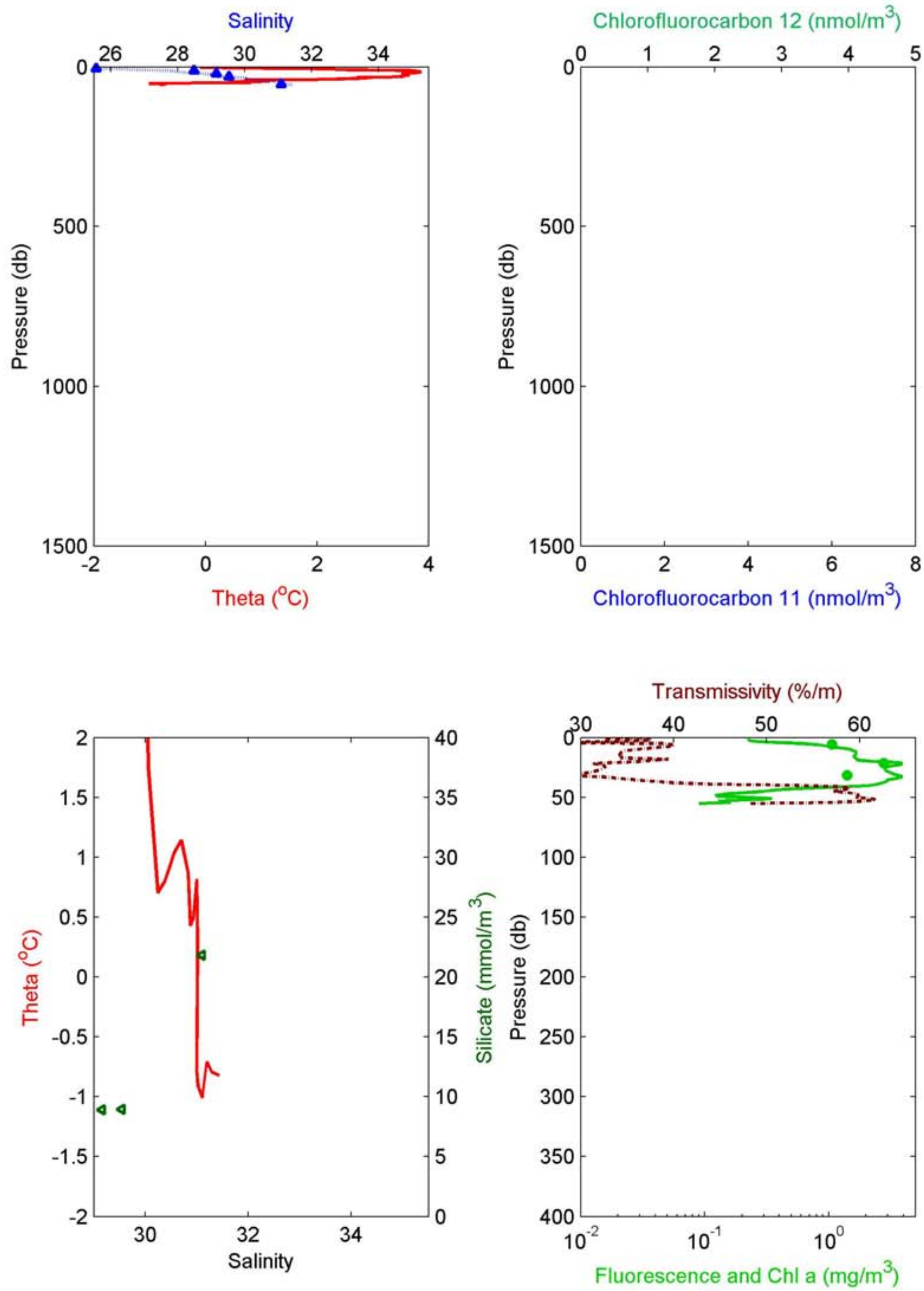
2006-18: Cast 20 Station BS-3 (Canada Basin)



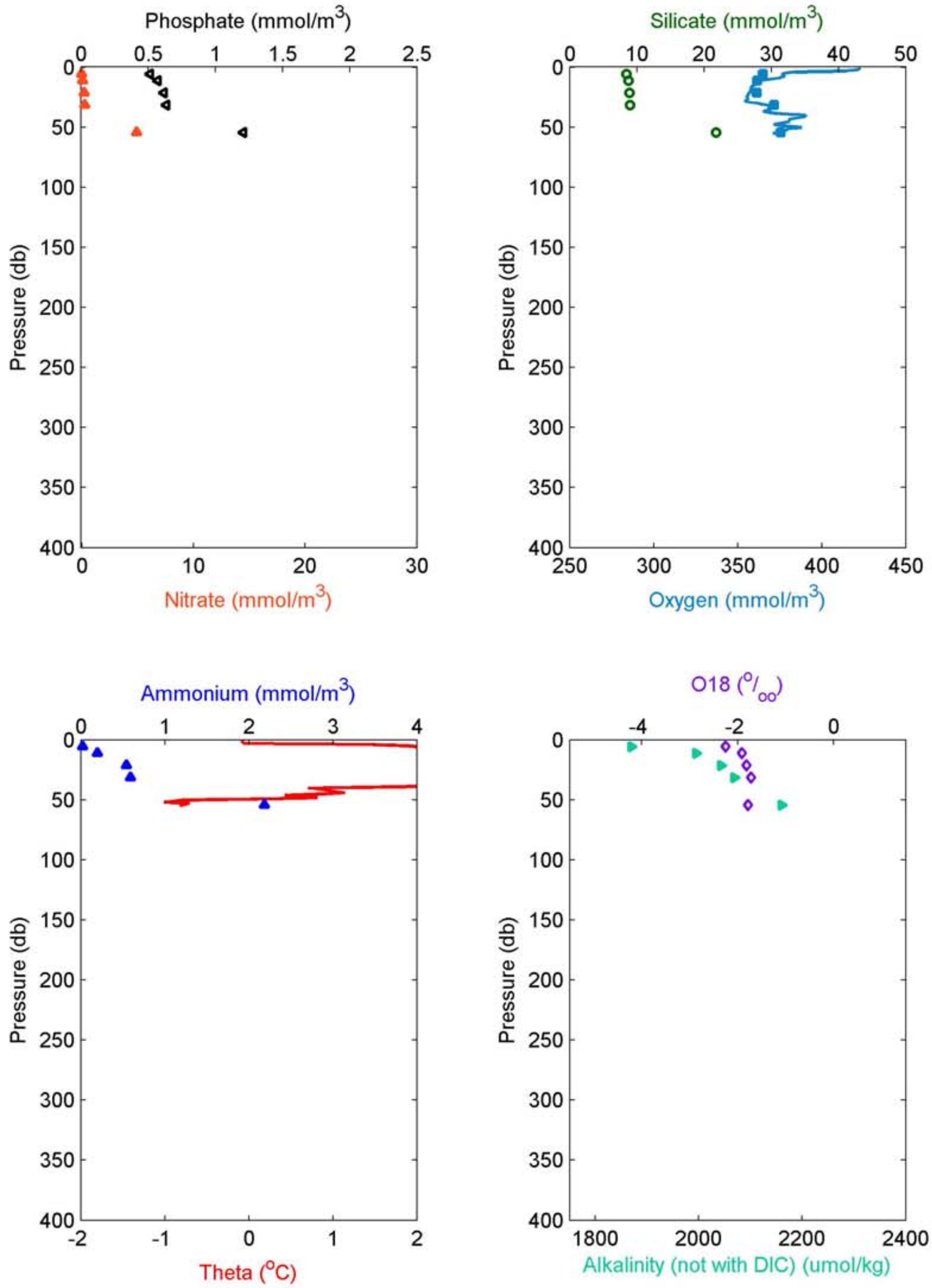
2006-18: Cast 20 Station BS-3 (Canada Basin)



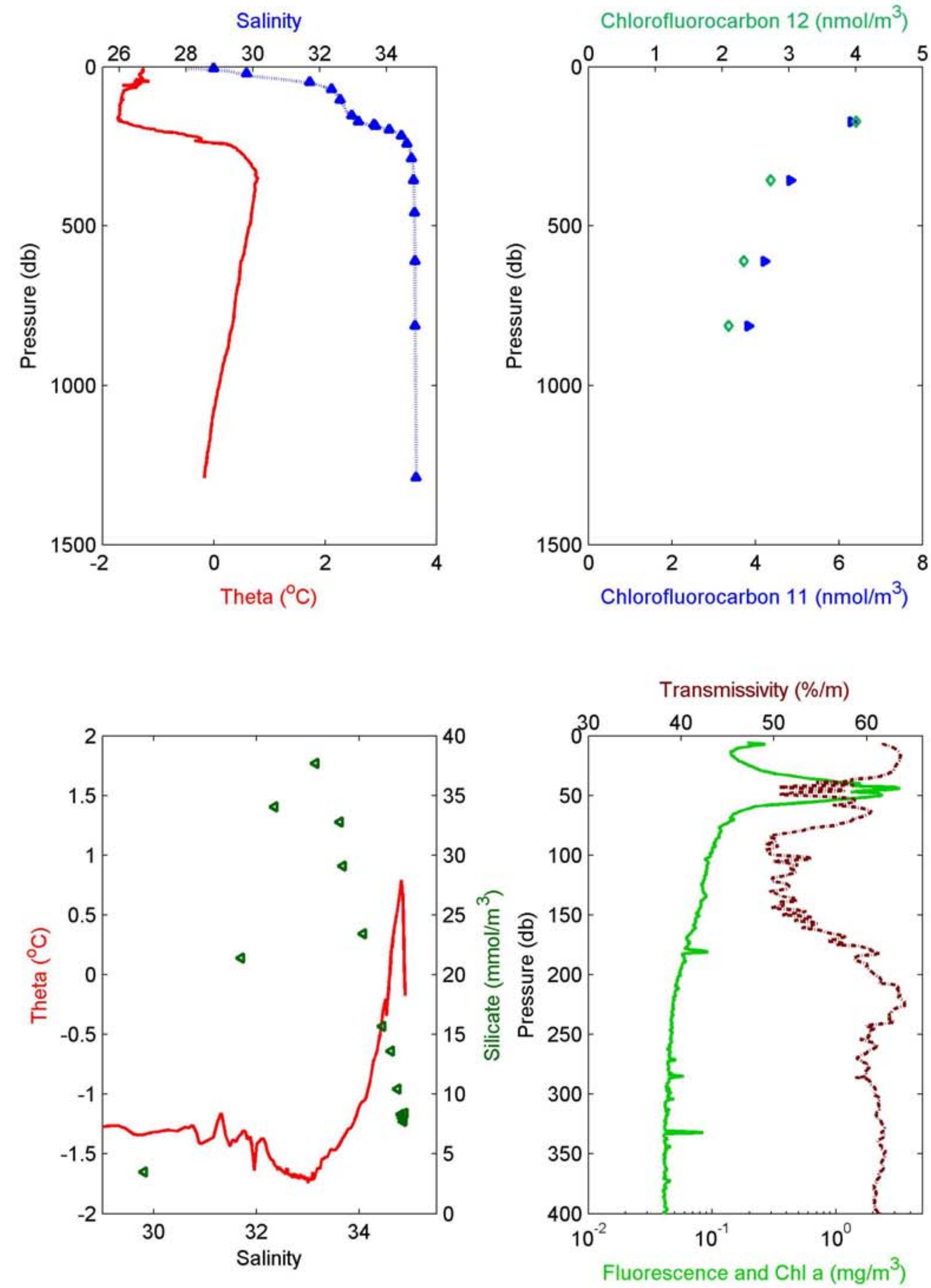
2006-18: Cast 21 Station BS-3a (Canada Basin)



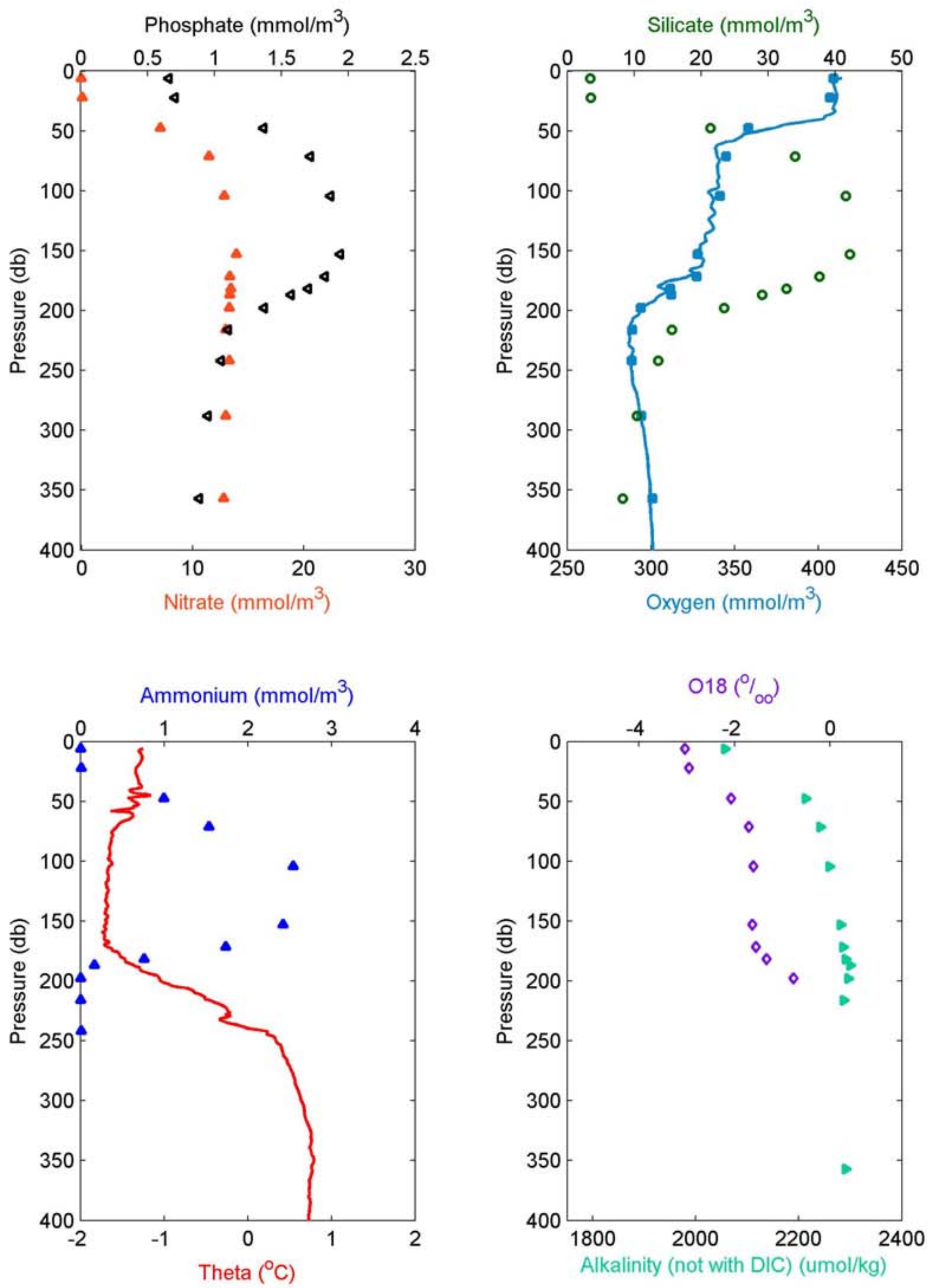
2006-18: Cast 21 Station BS-3a (Canada Basin)



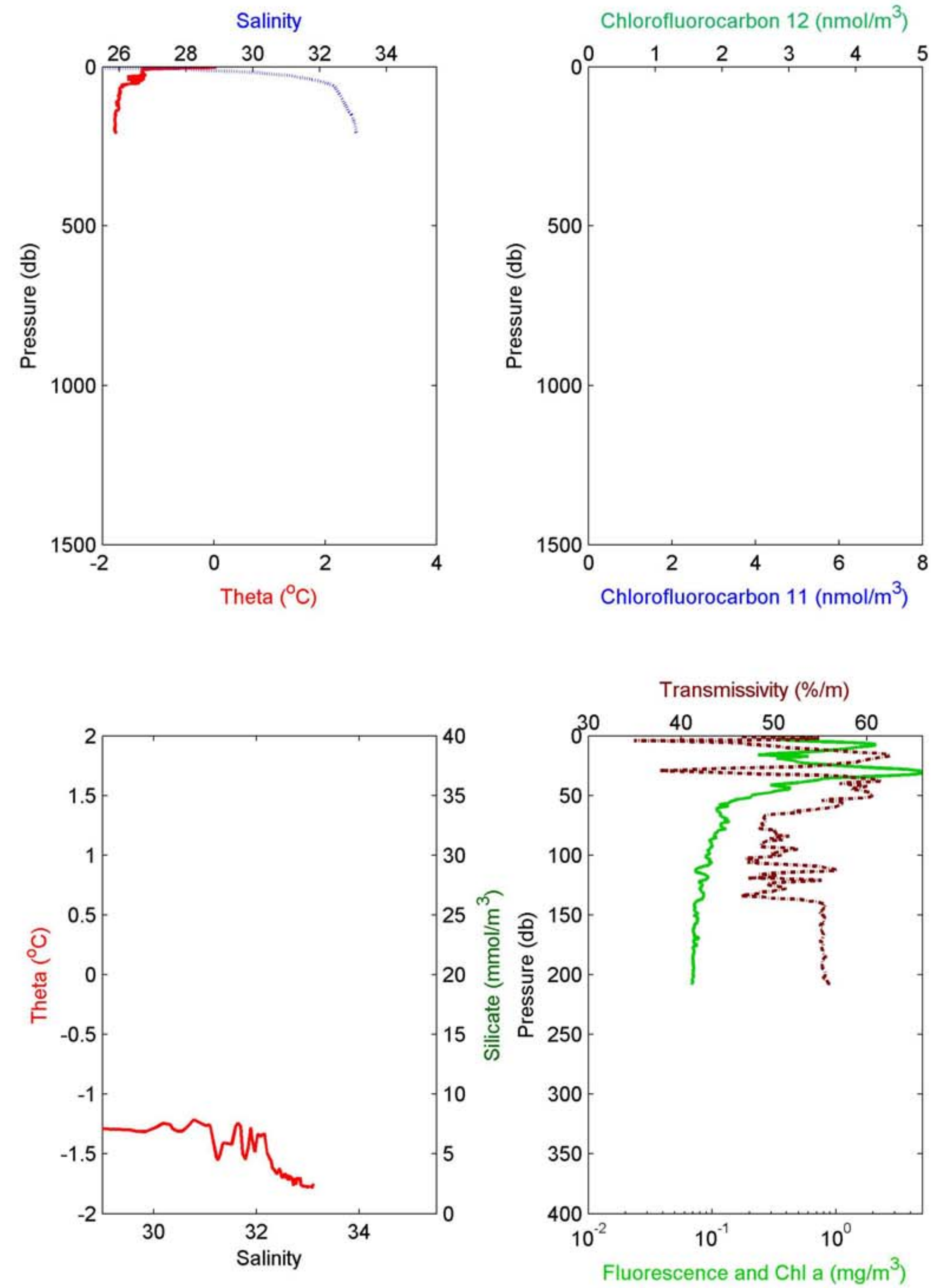
2006-18: Cast 22 Station BS-3b (Canada Basin)



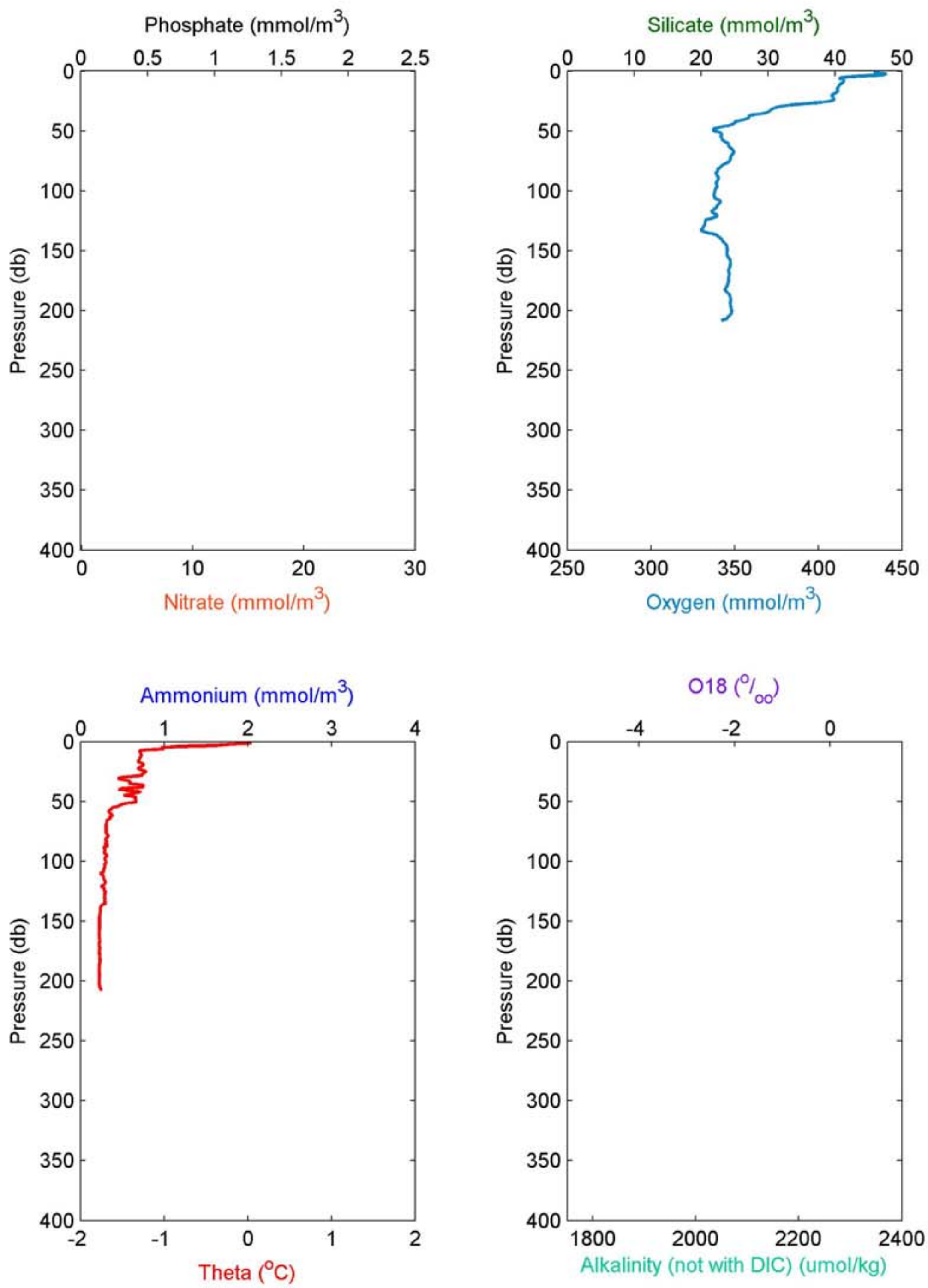
2006-18: Cast 22 Station BS-3b (Canada Basin)



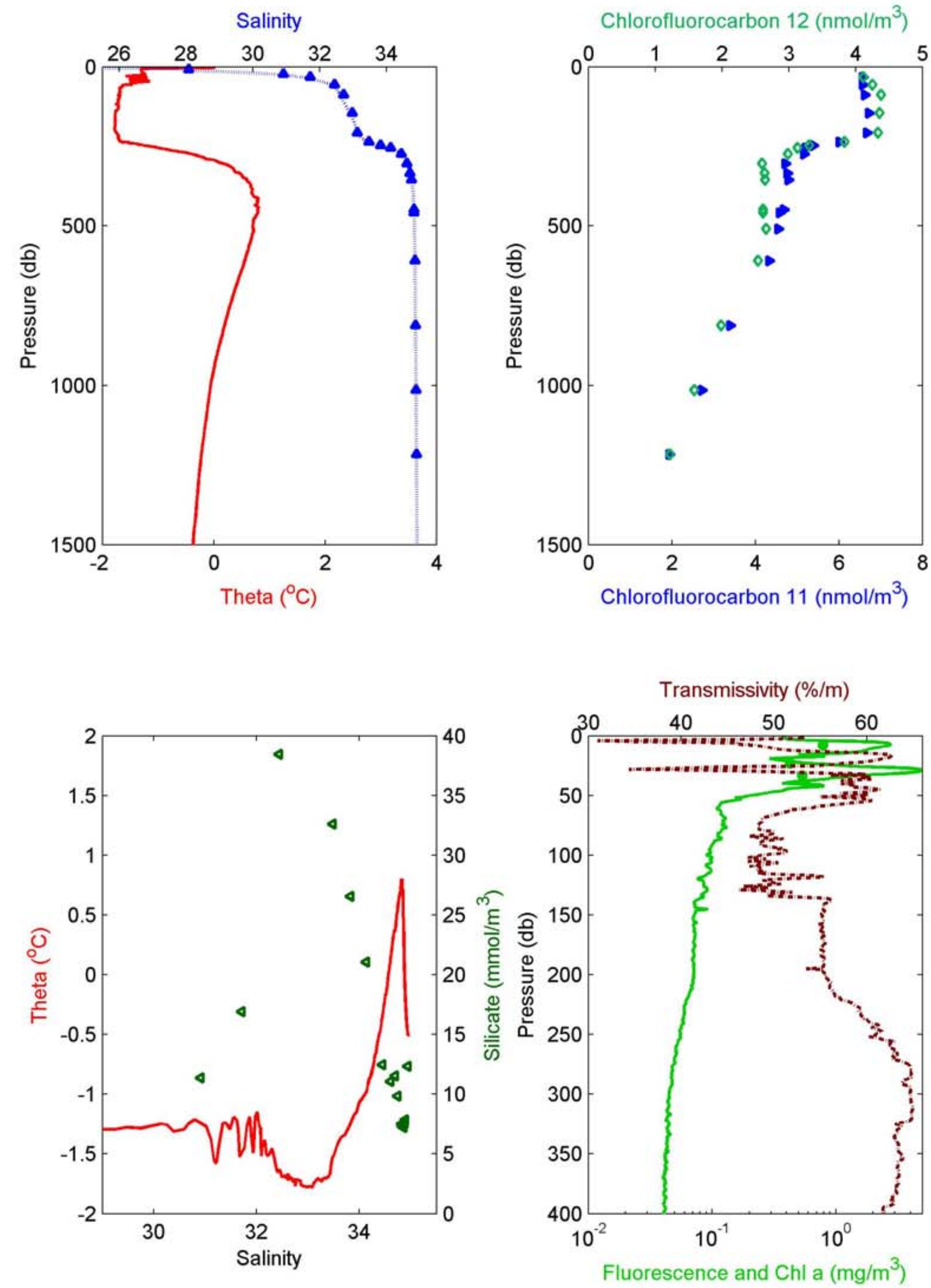
2006-18: Cast 23 Station BS-3c (Canada Basin)



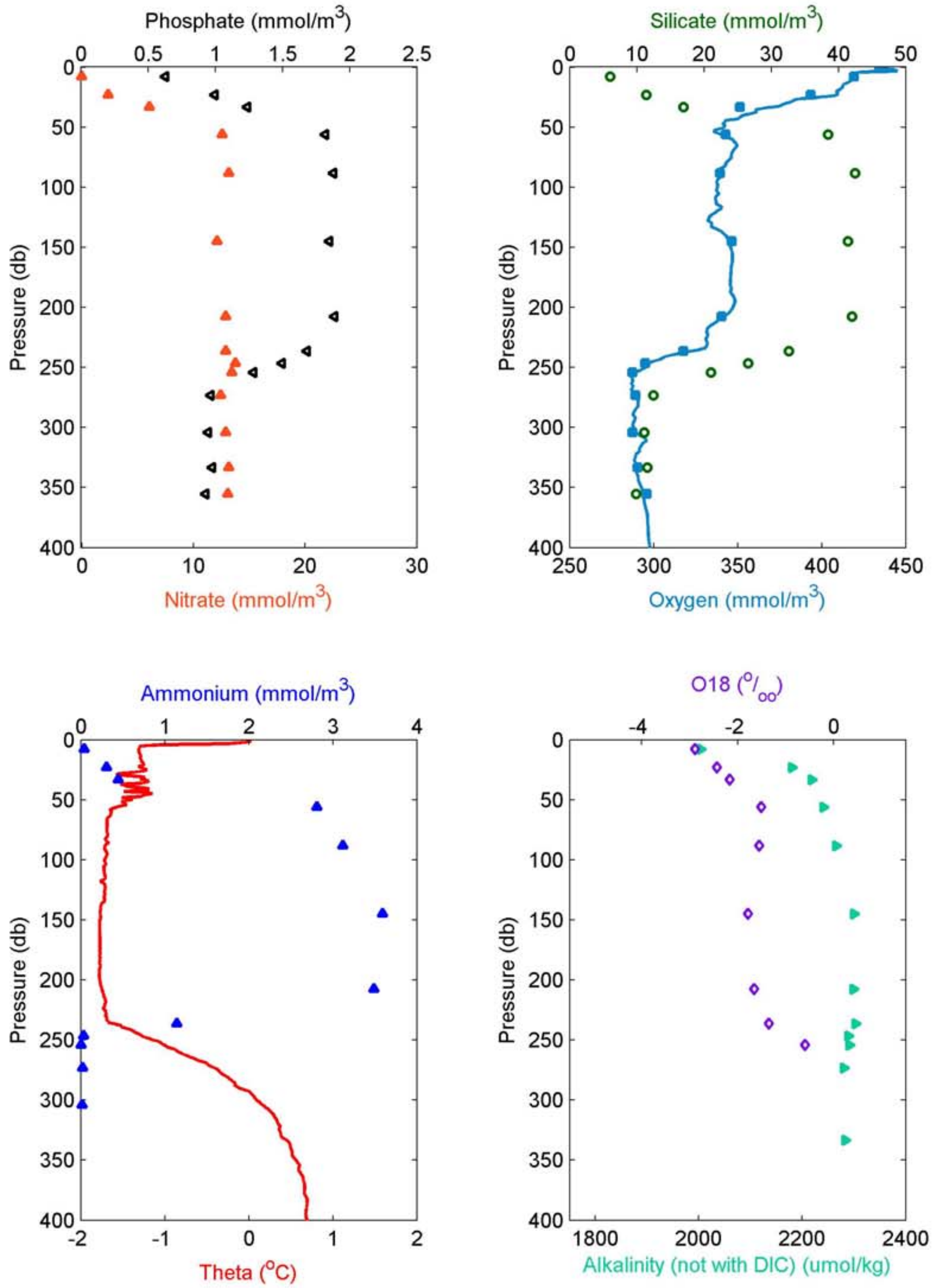
2006-18: Cast 23 Station BS-3c (Canada Basin)



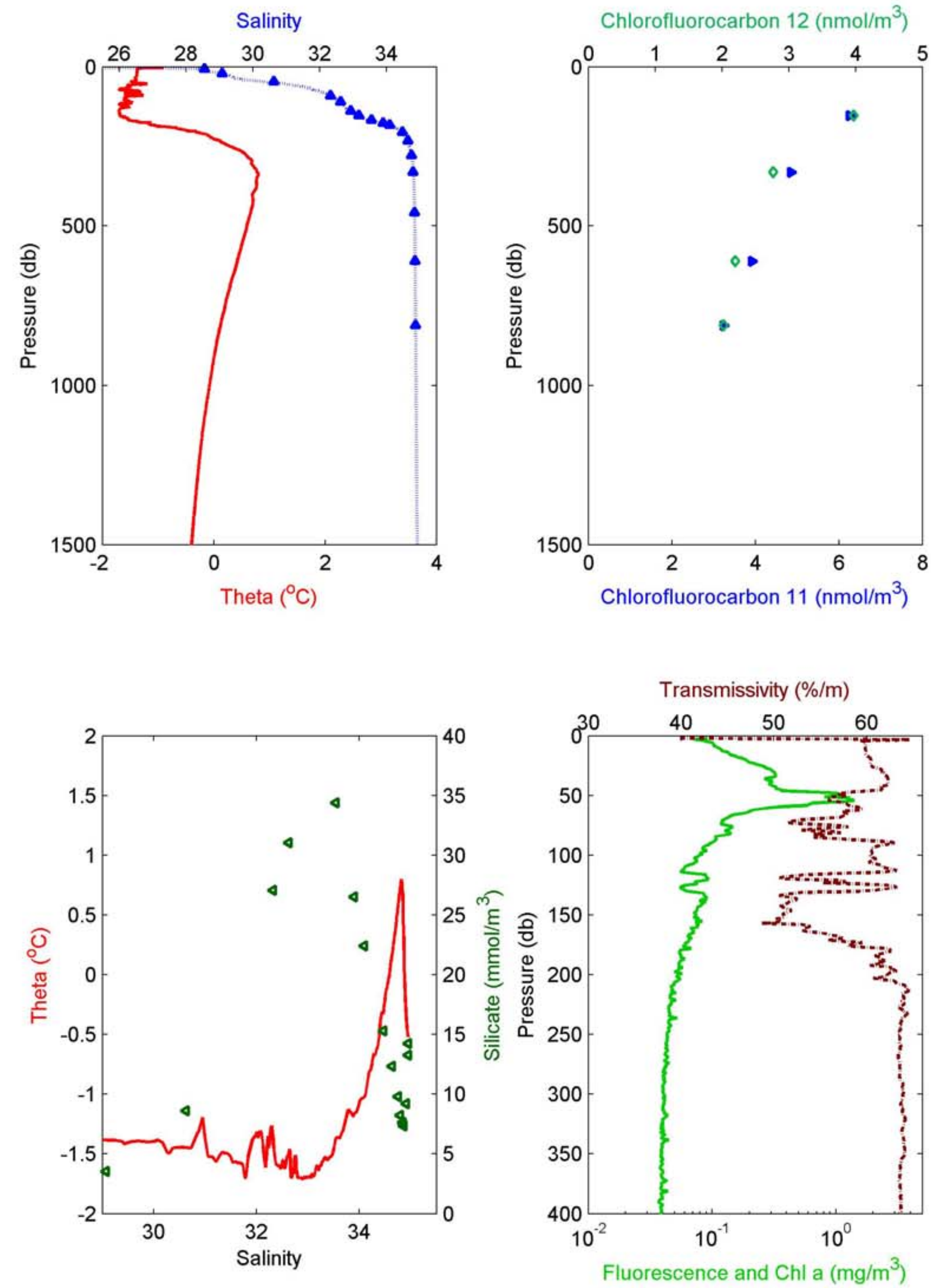
2006-18: Cast 24 Station BS-3c (Canada Basin)



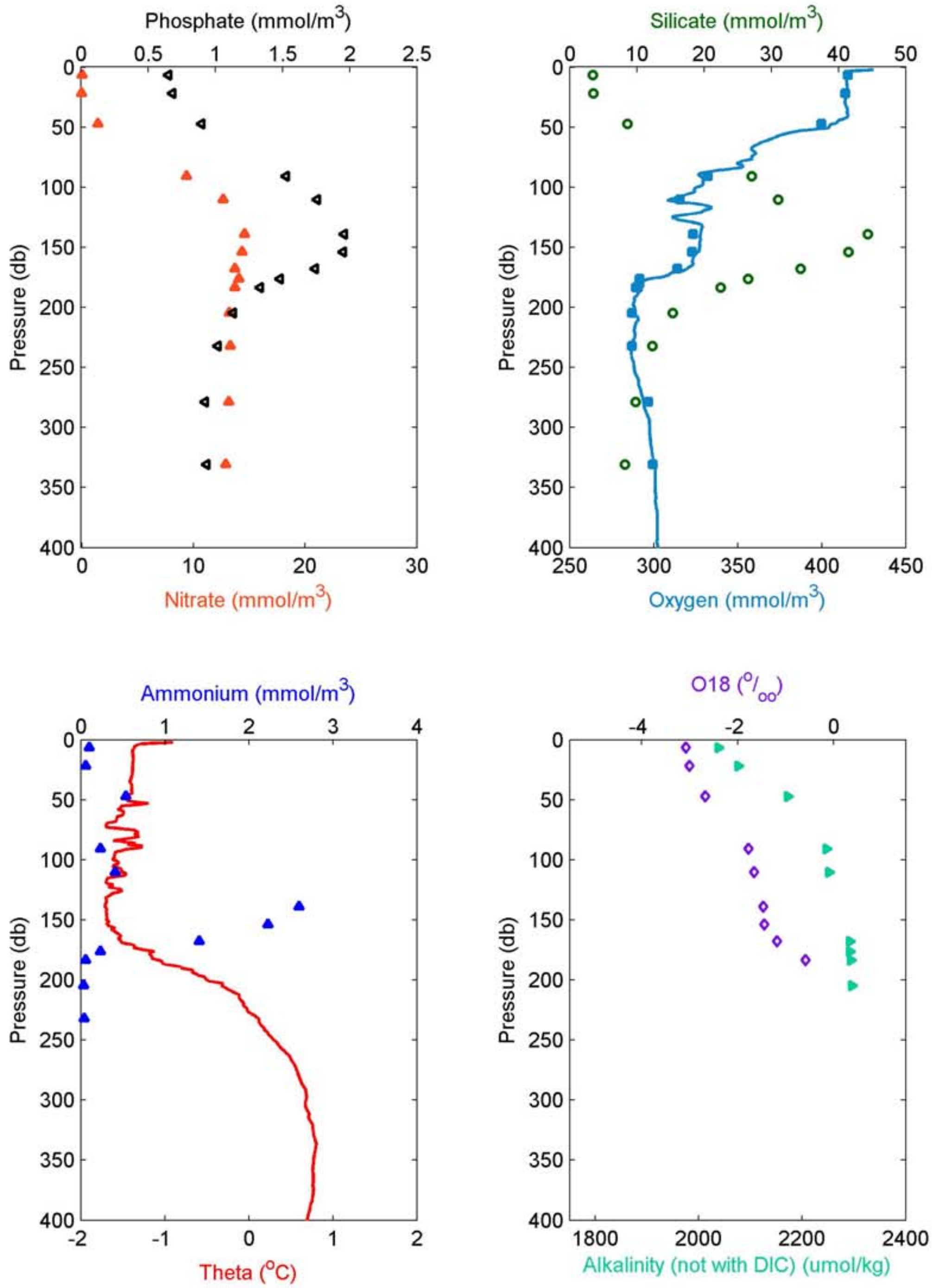
2006-18: Cast 24 Station BS-3c (Canada Basin)



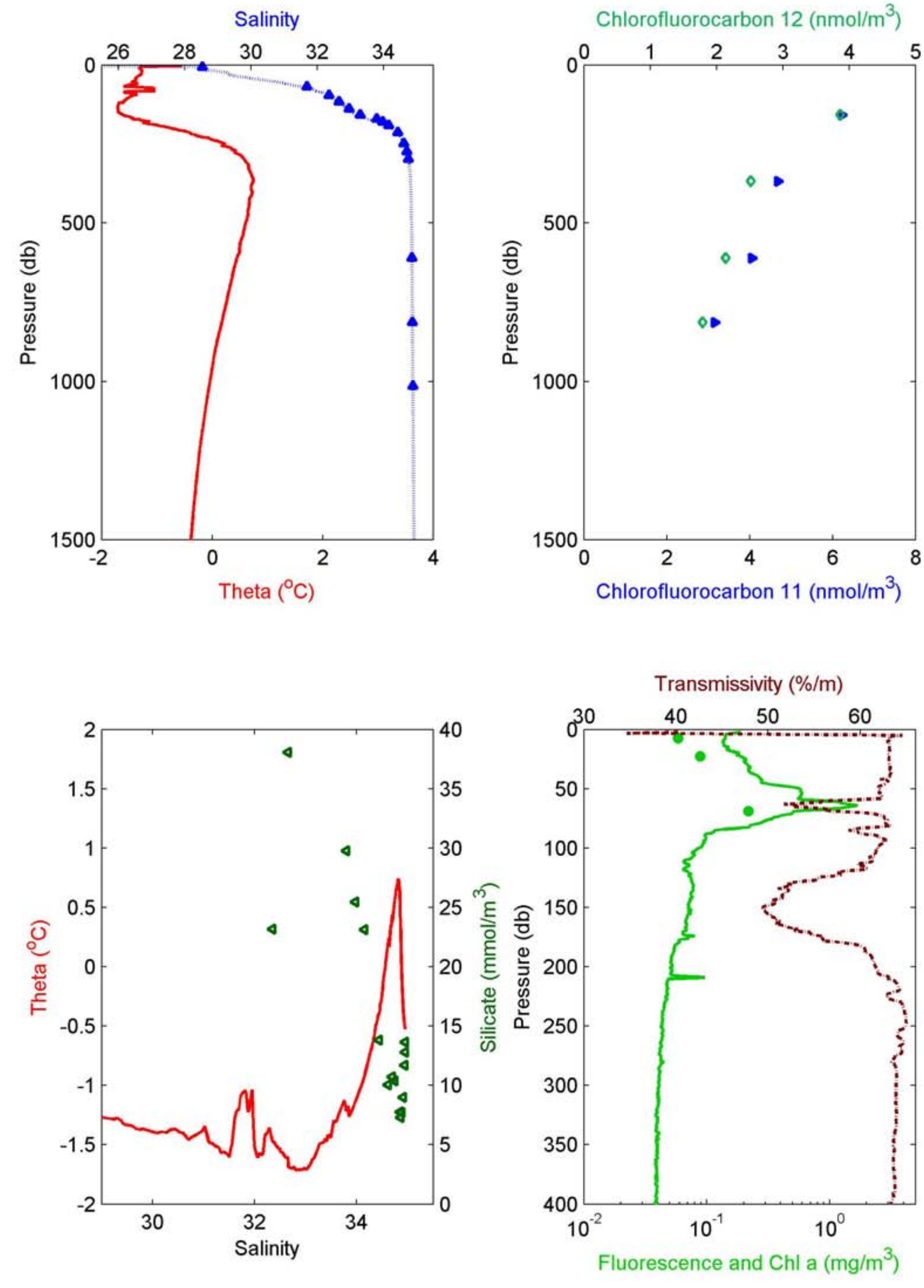
2006-18: Cast 25 Station BS-3d (Canada Basin)



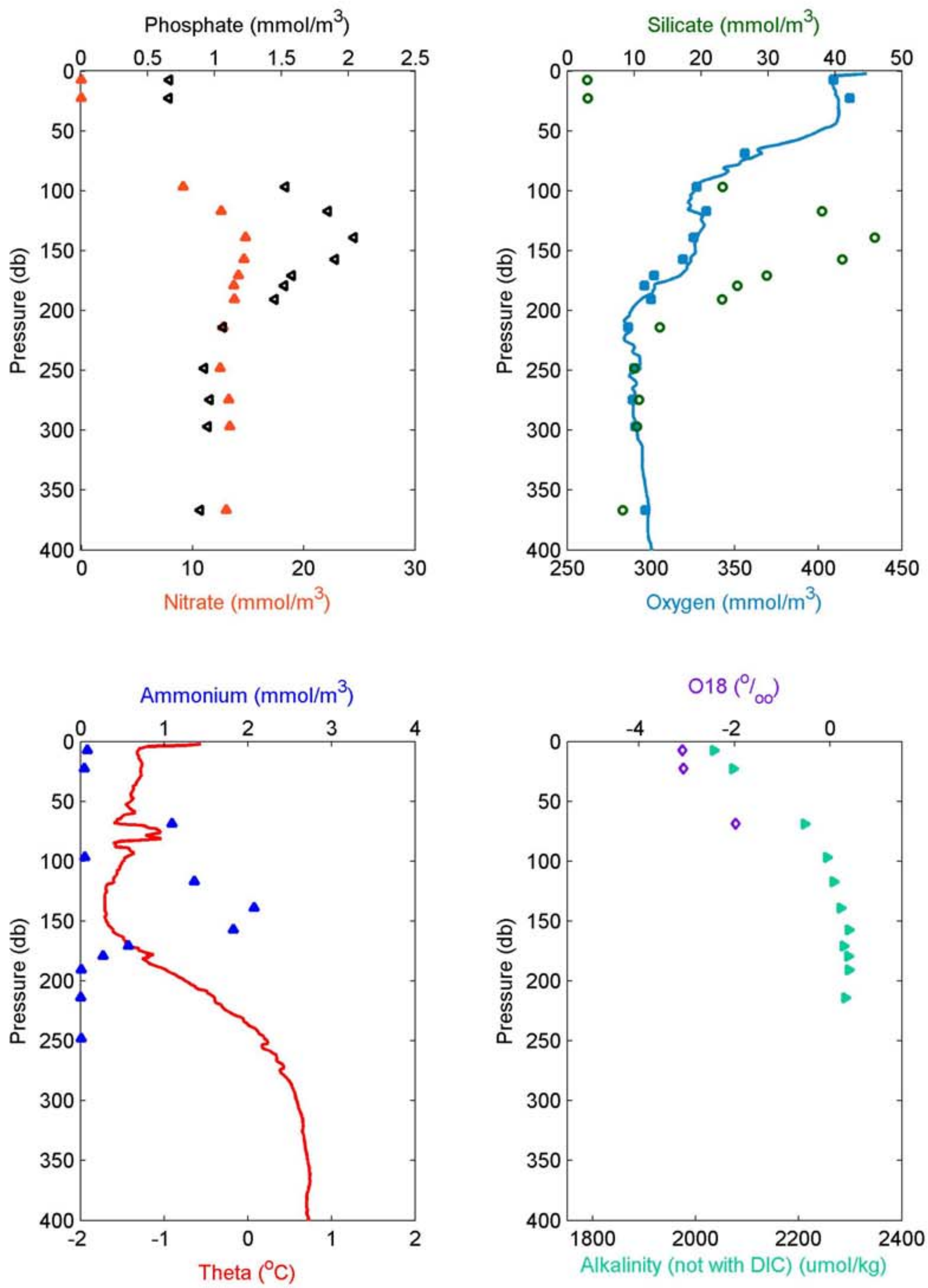
2006-18: Cast 25 Station BS-3d (Canada Basin)



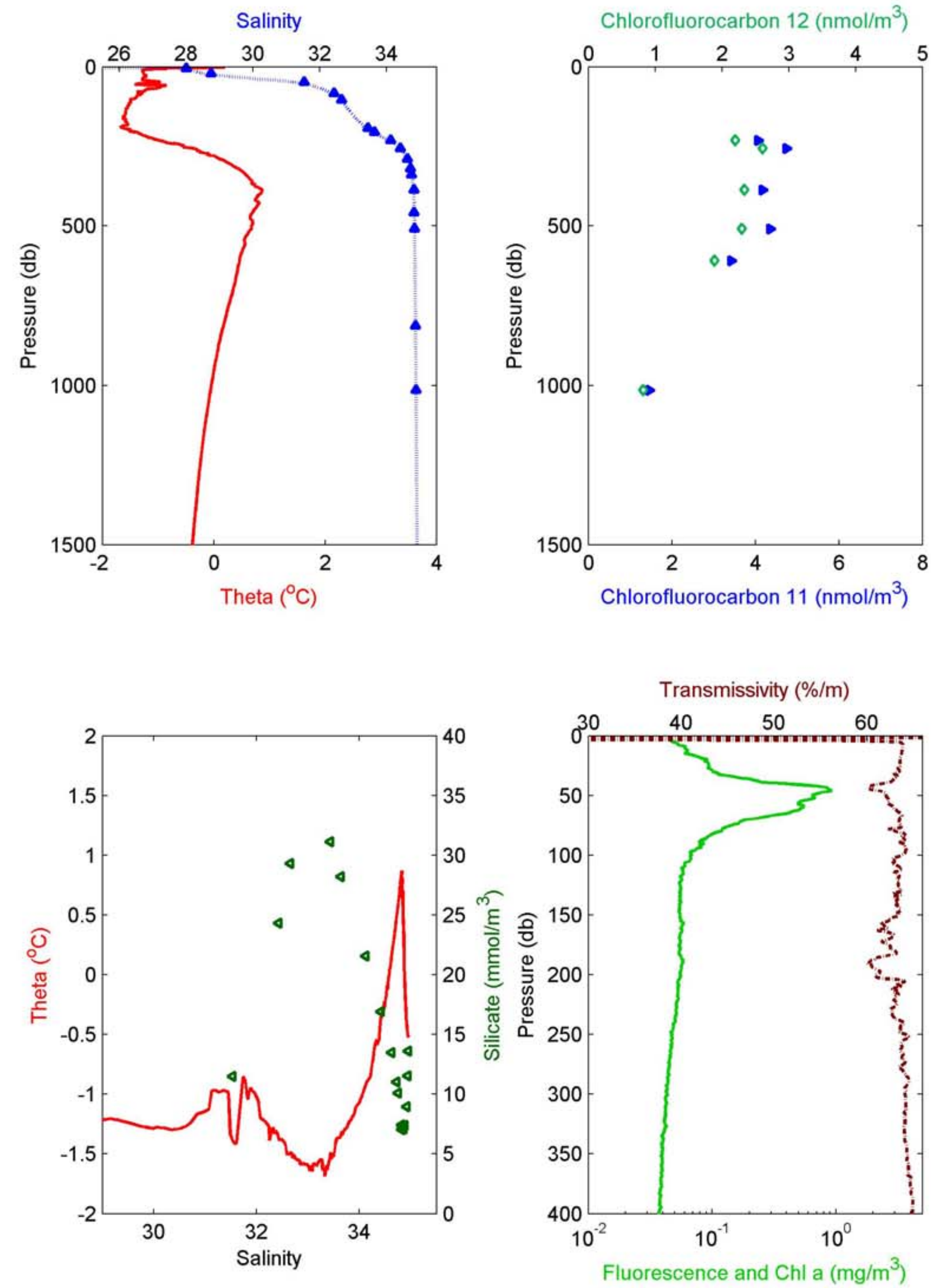
2006-18: Cast 26 Station CB-2a (Canada Basin)



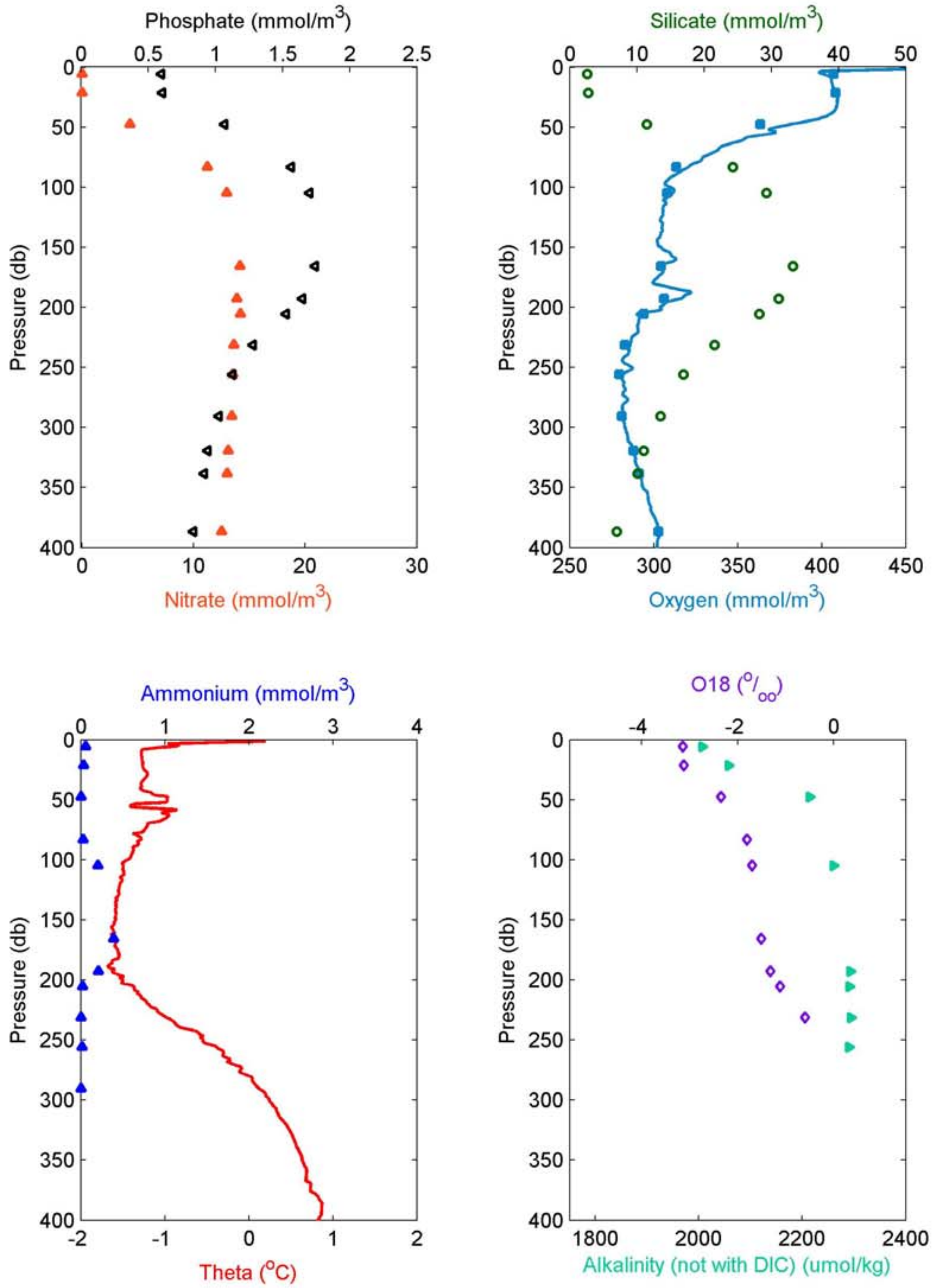
2006-18: Cast 26 Station CB-2a (Canada Basin)



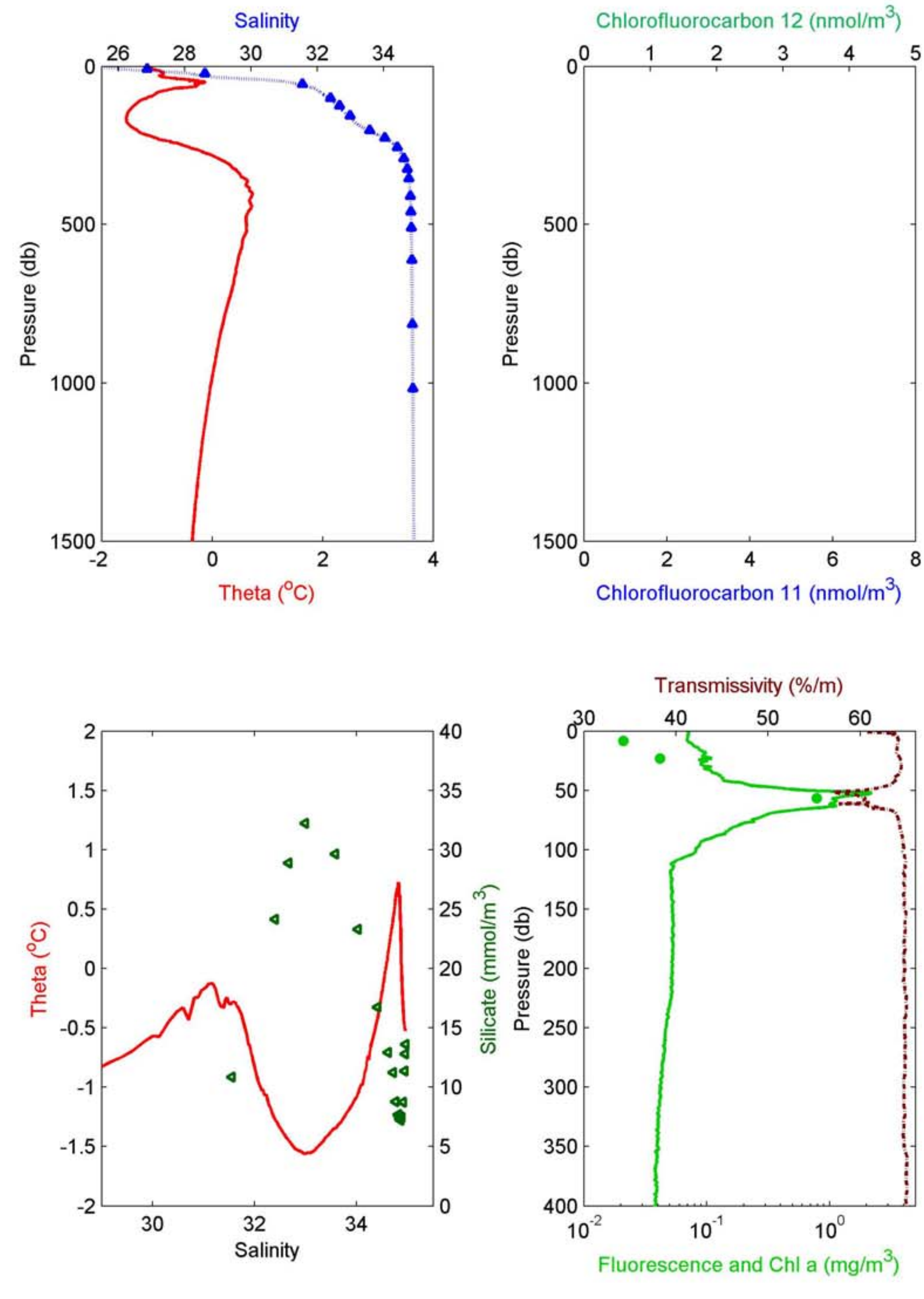
2006-18: Cast 27 Station CB2 (Canada Basin)



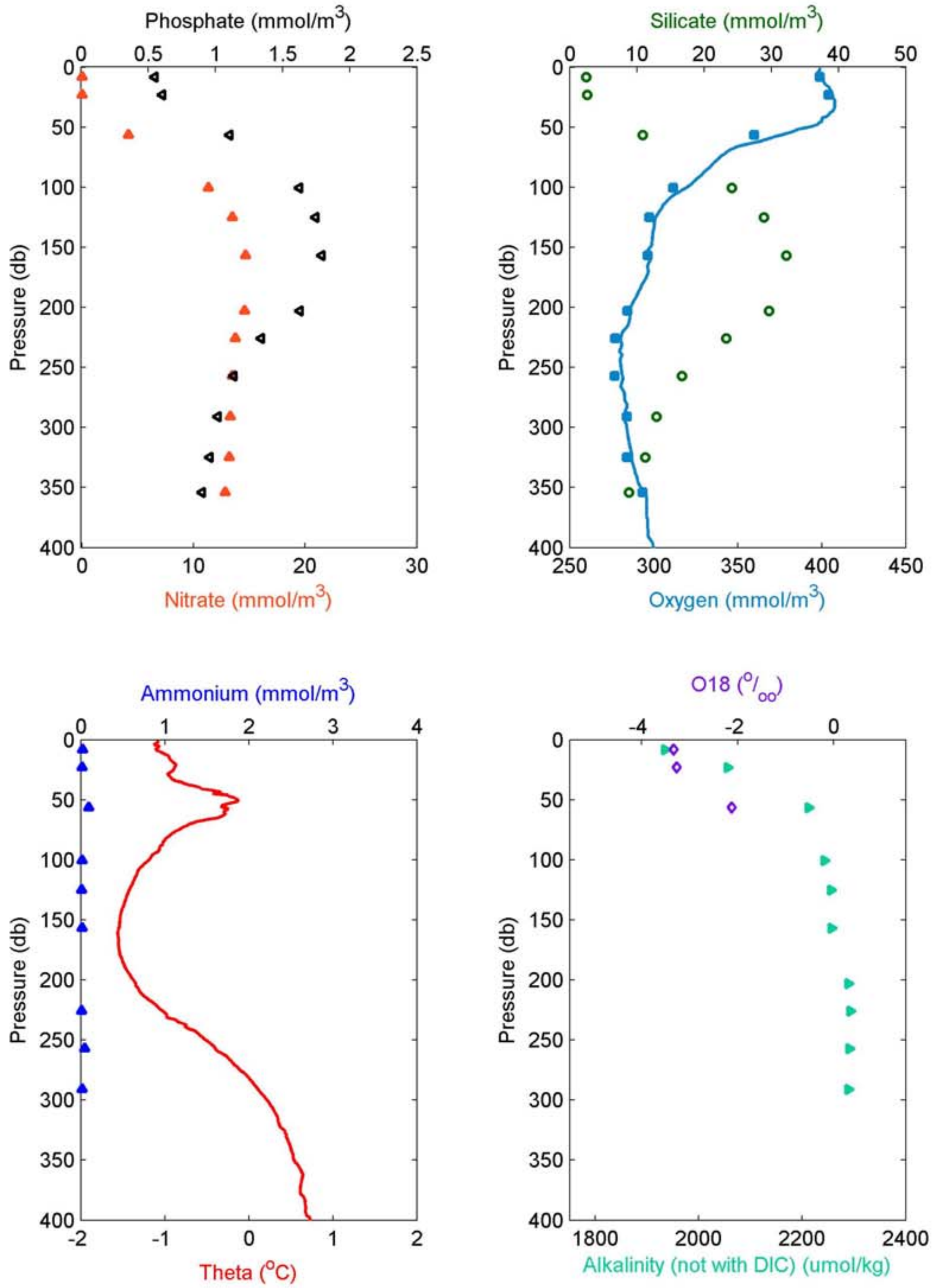
2006-18: Cast 27 Station CB2 (Canada Basin)



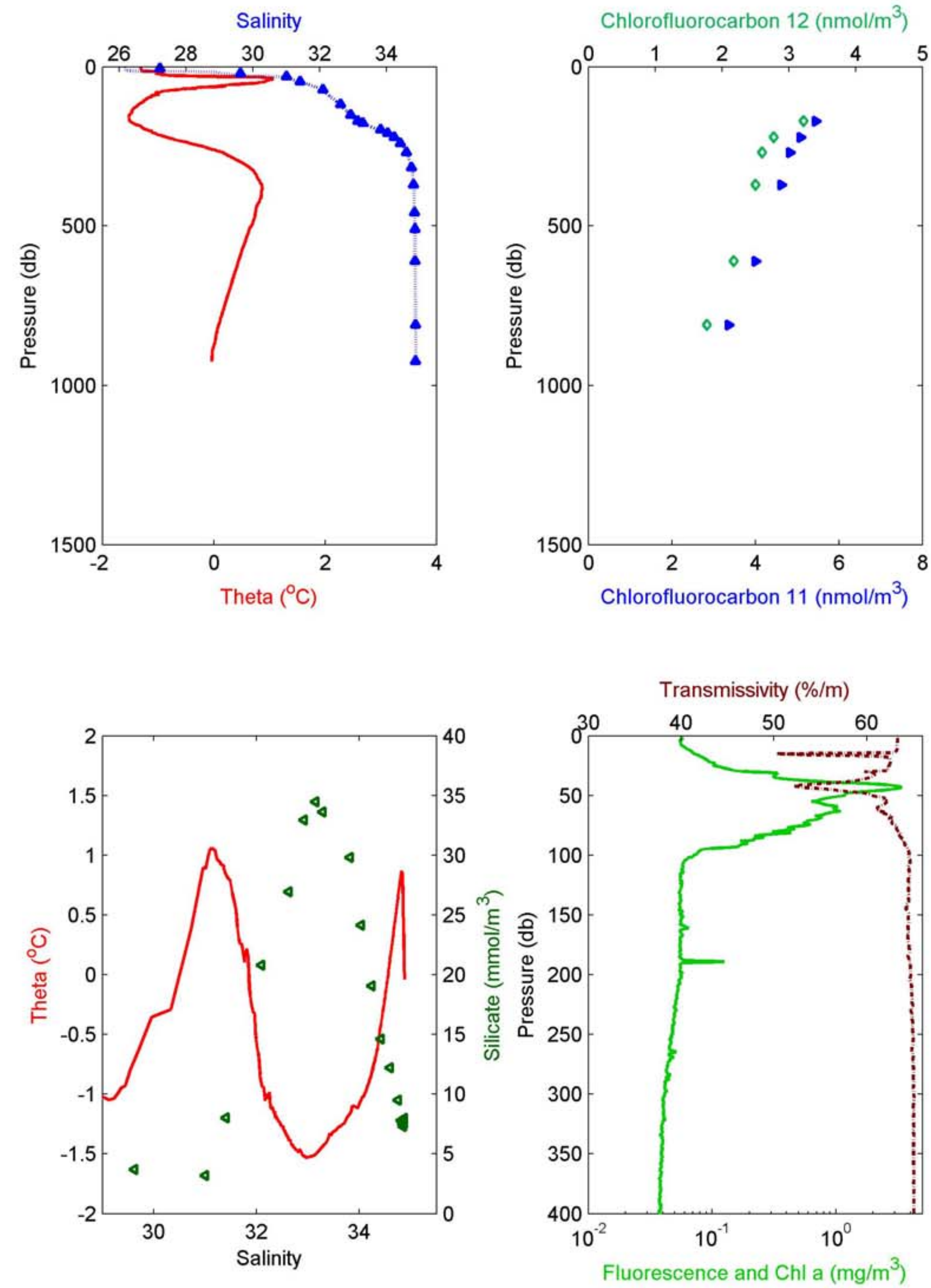
2006-18: Cast 28 Station CB3 (Canada Basin)



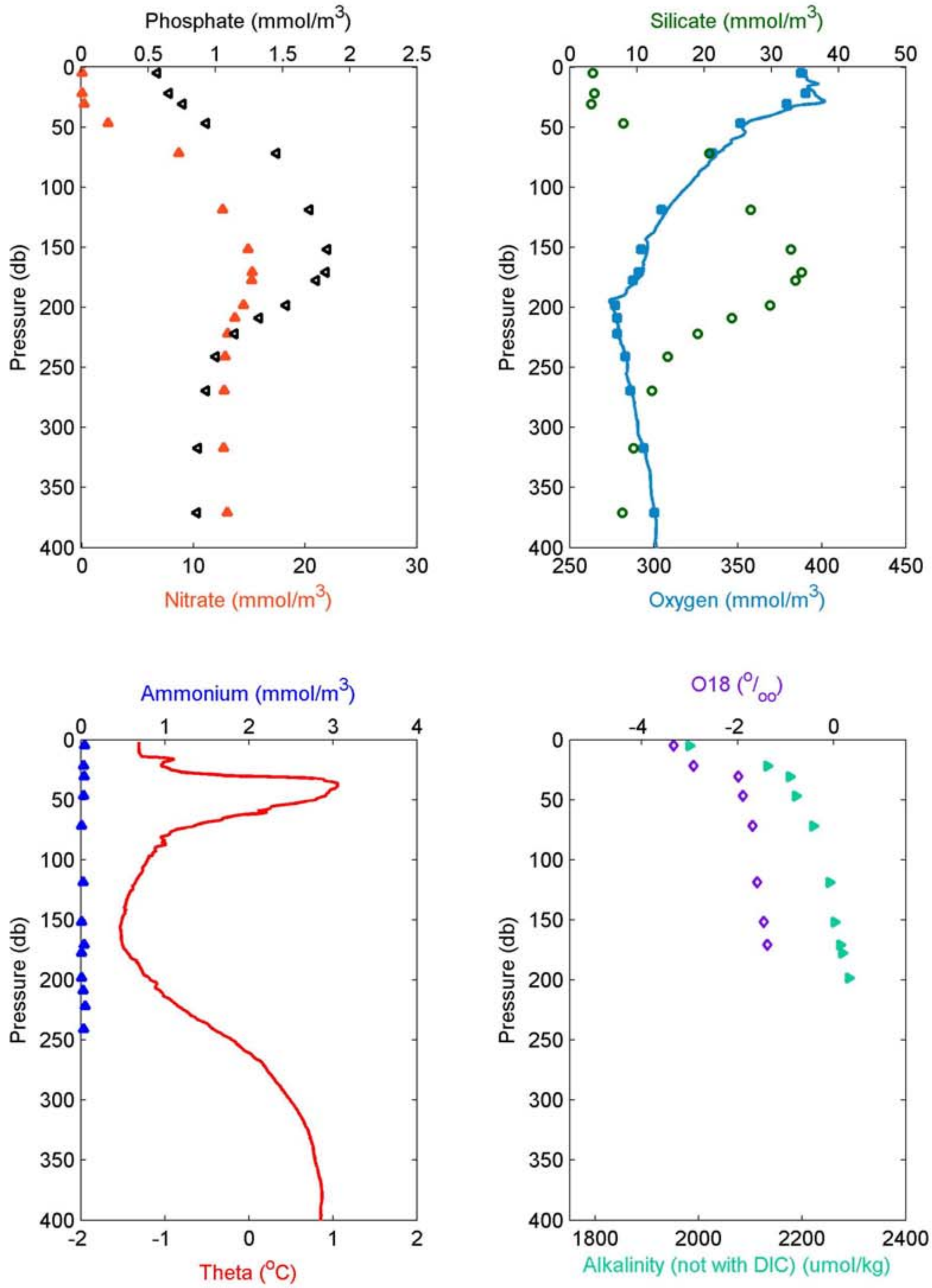
2006-18: Cast 28 Station CB3 (Canada Basin)



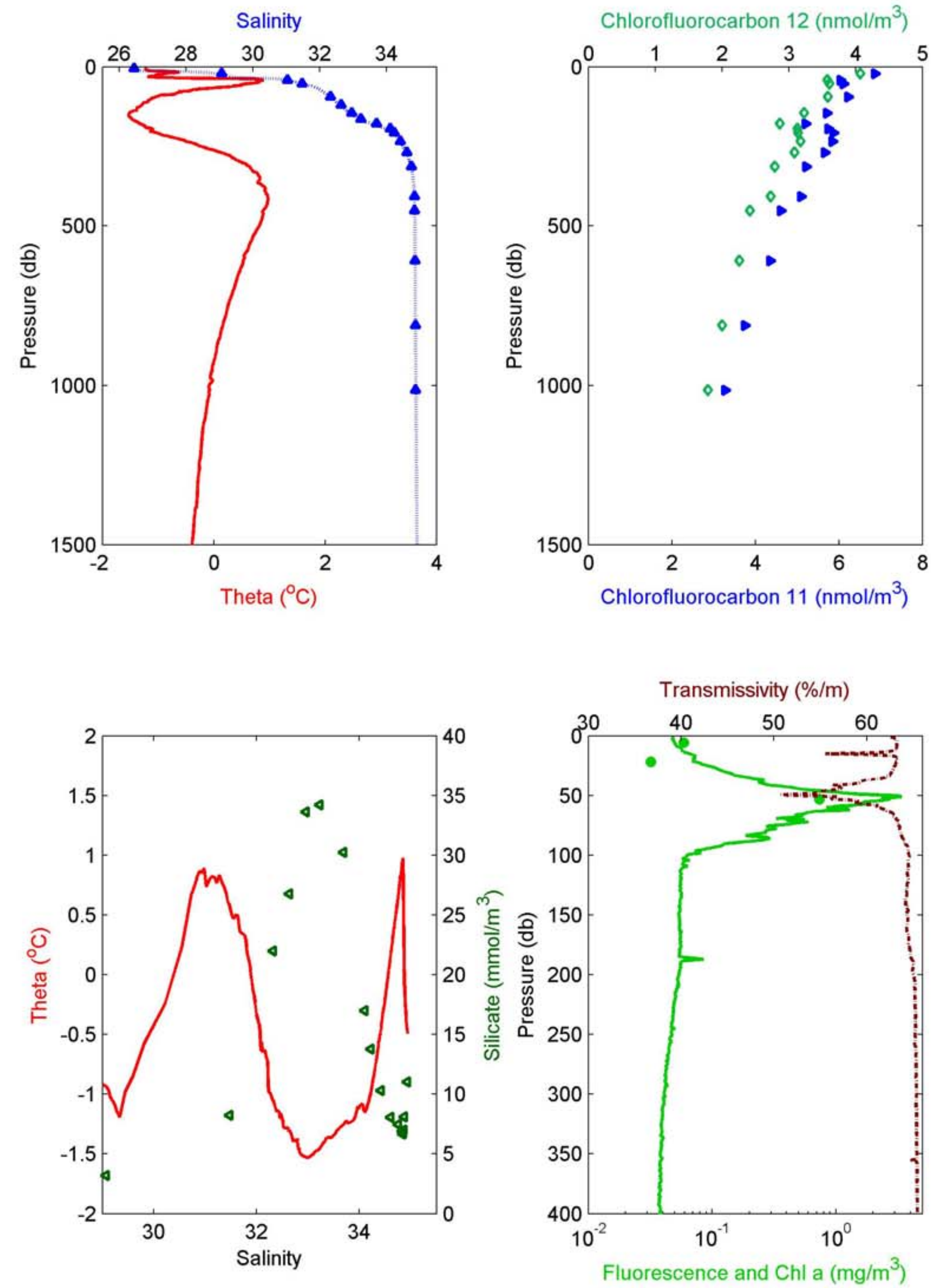
2006-18: Cast 29 Station CB-5d (Canada Basin)



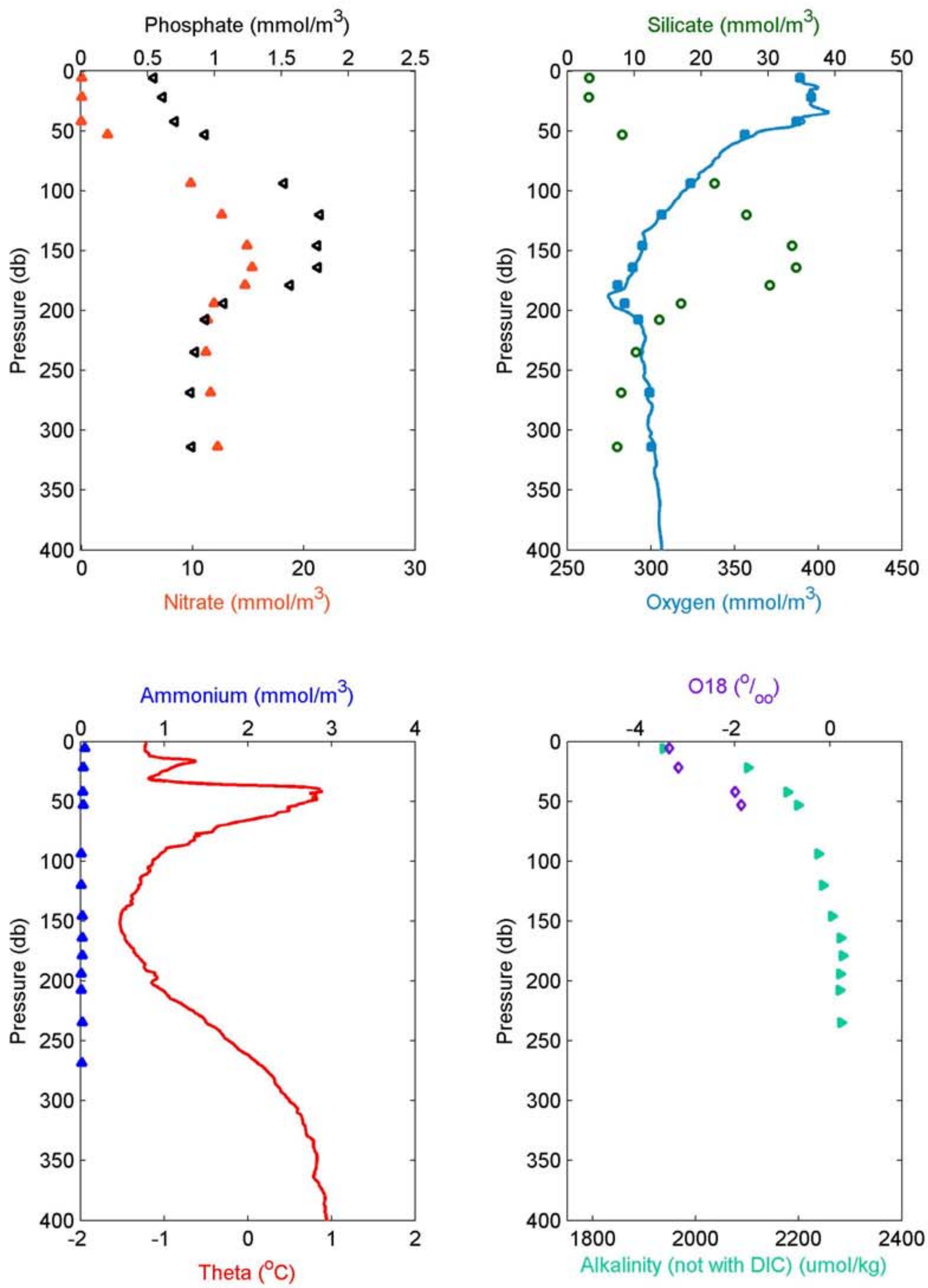
2006-18: Cast 29 Station CB-5d (Canada Basin)



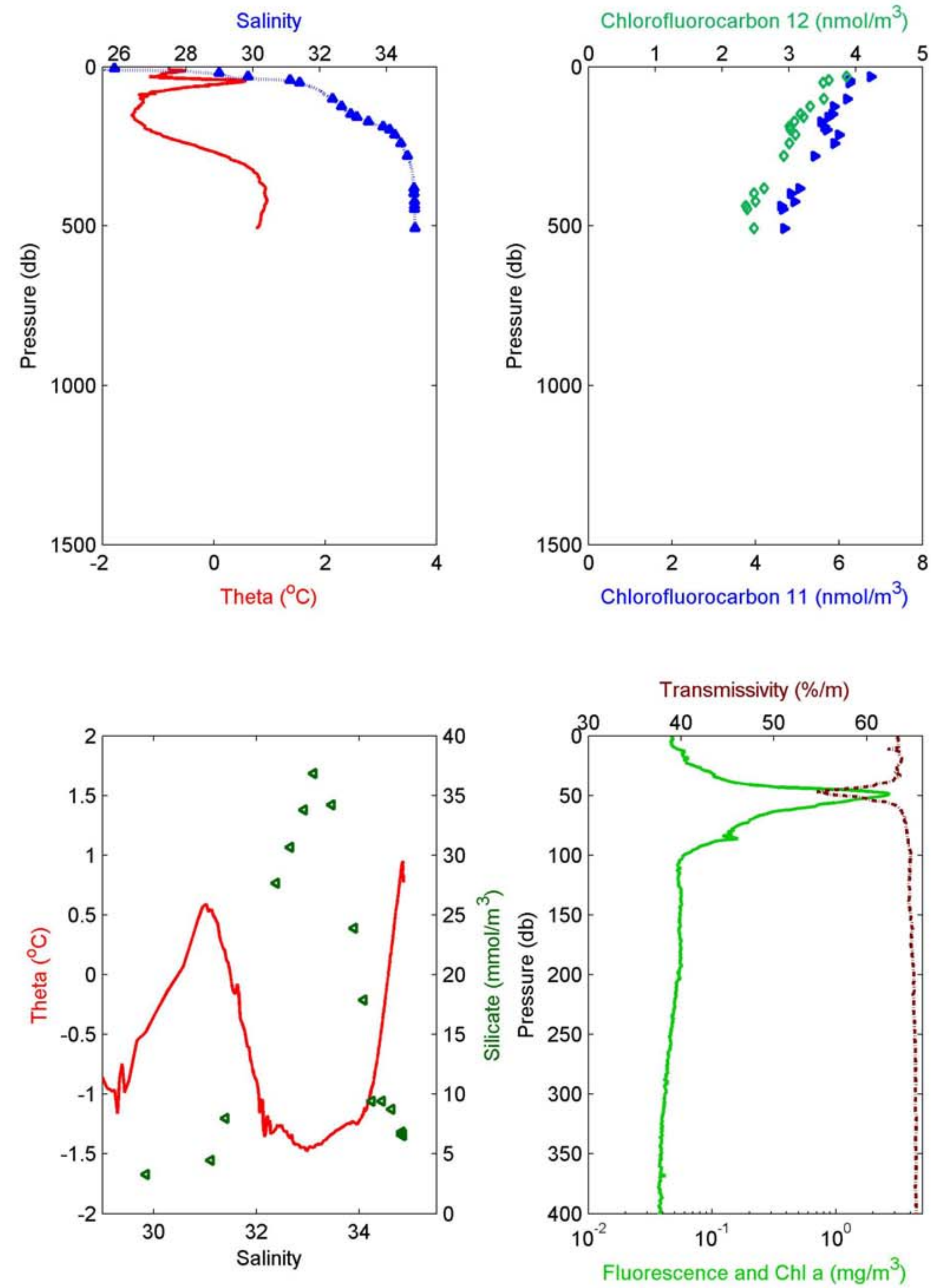
2006-18: Cast 30 Station CB-5b (Canada Basin)



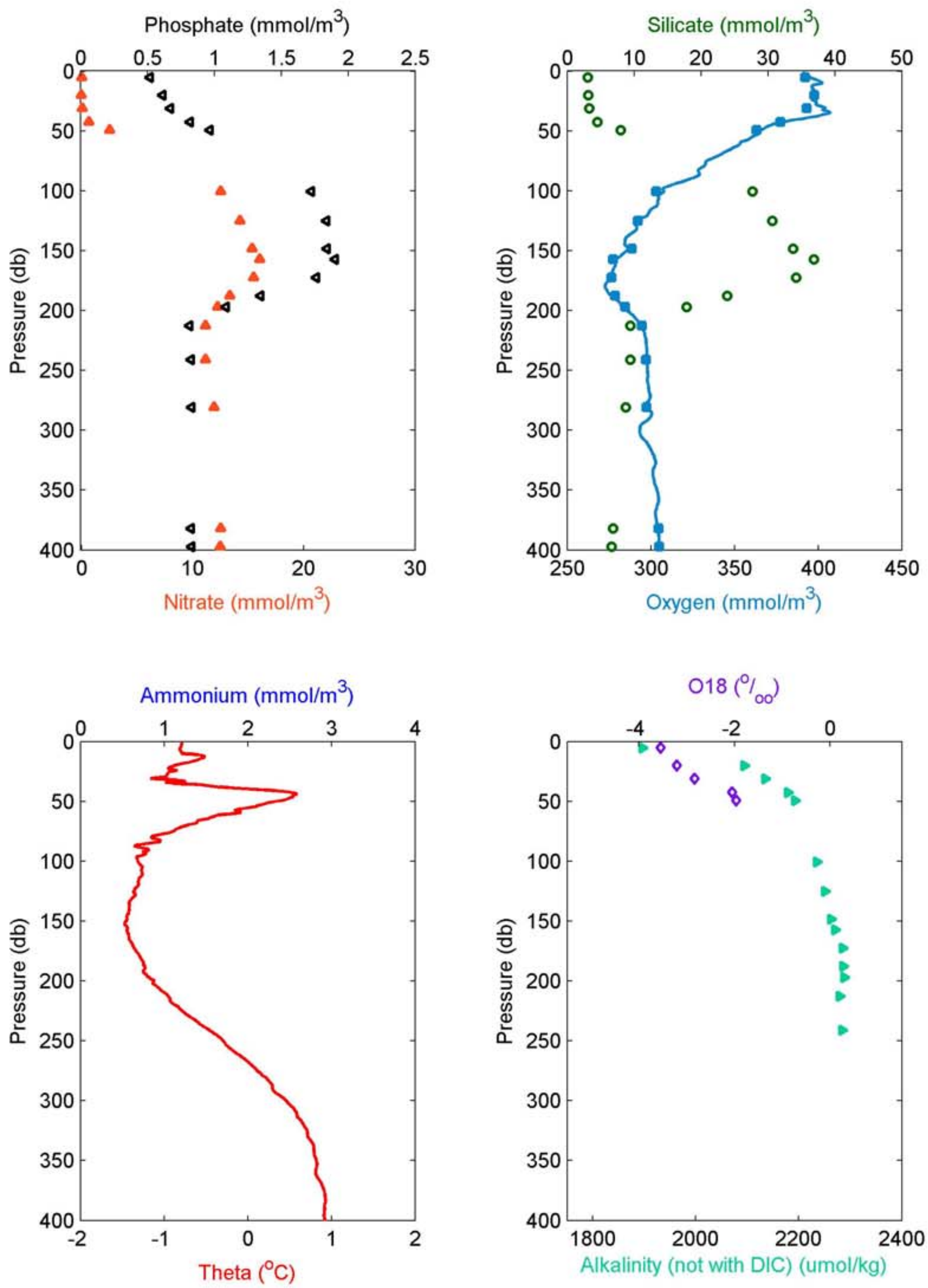
2006-18: Cast 30 Station CB-5b (Canada Basin)



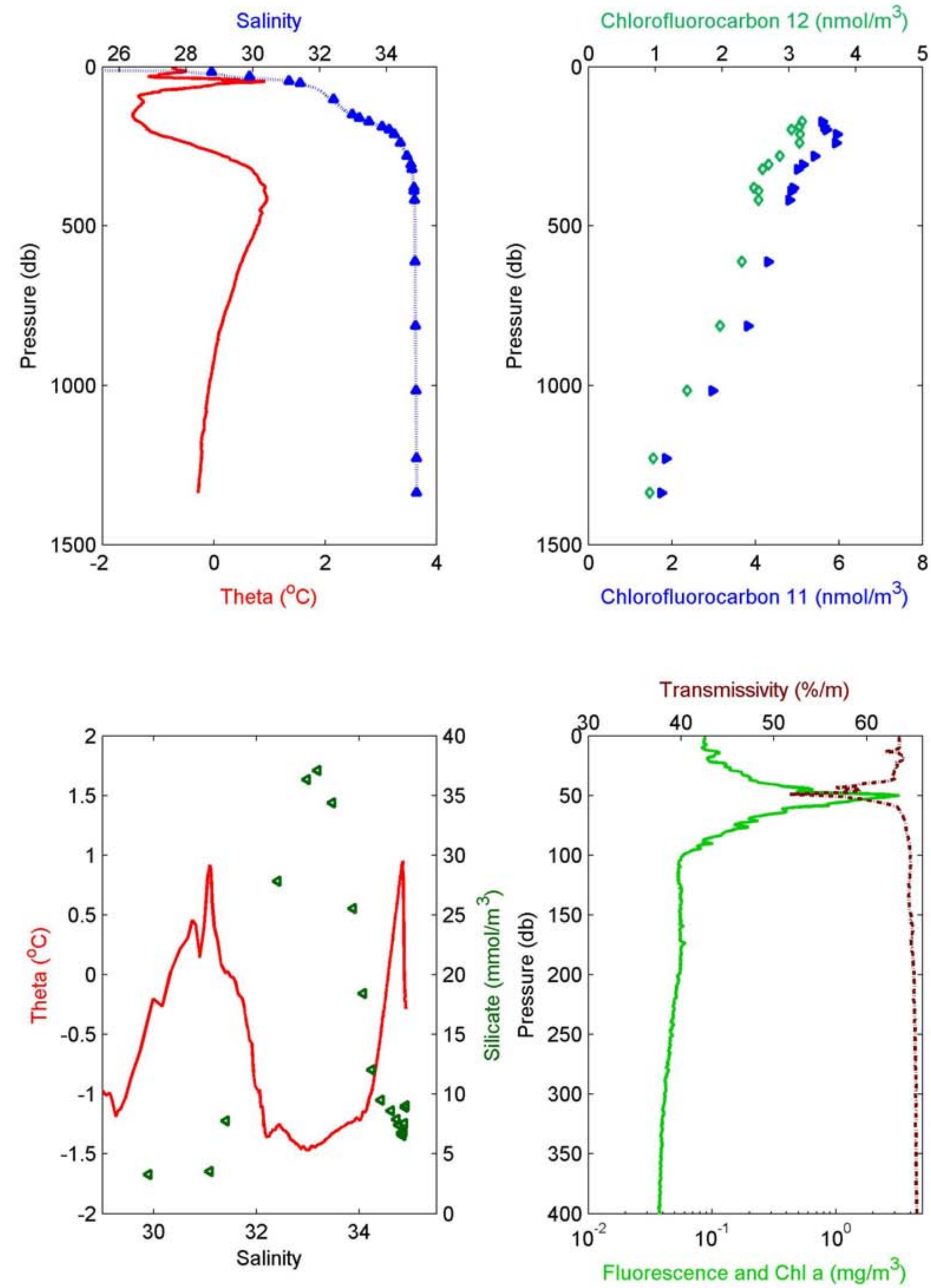
2006-18: Cast 40 Station CB5b10 (Canada Basin)



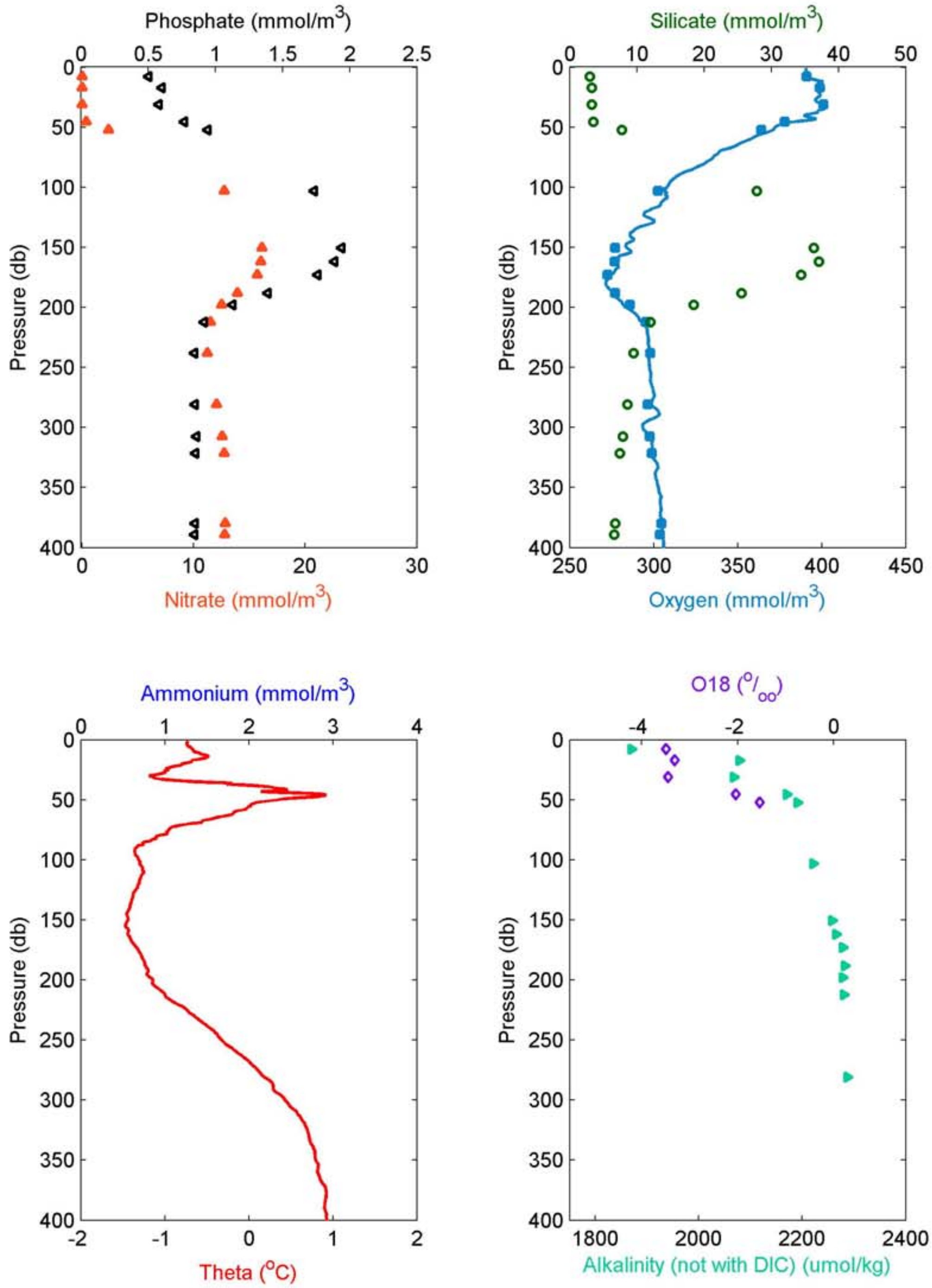
2006-18: Cast 40 Station CB5b10 (Canada Basin)



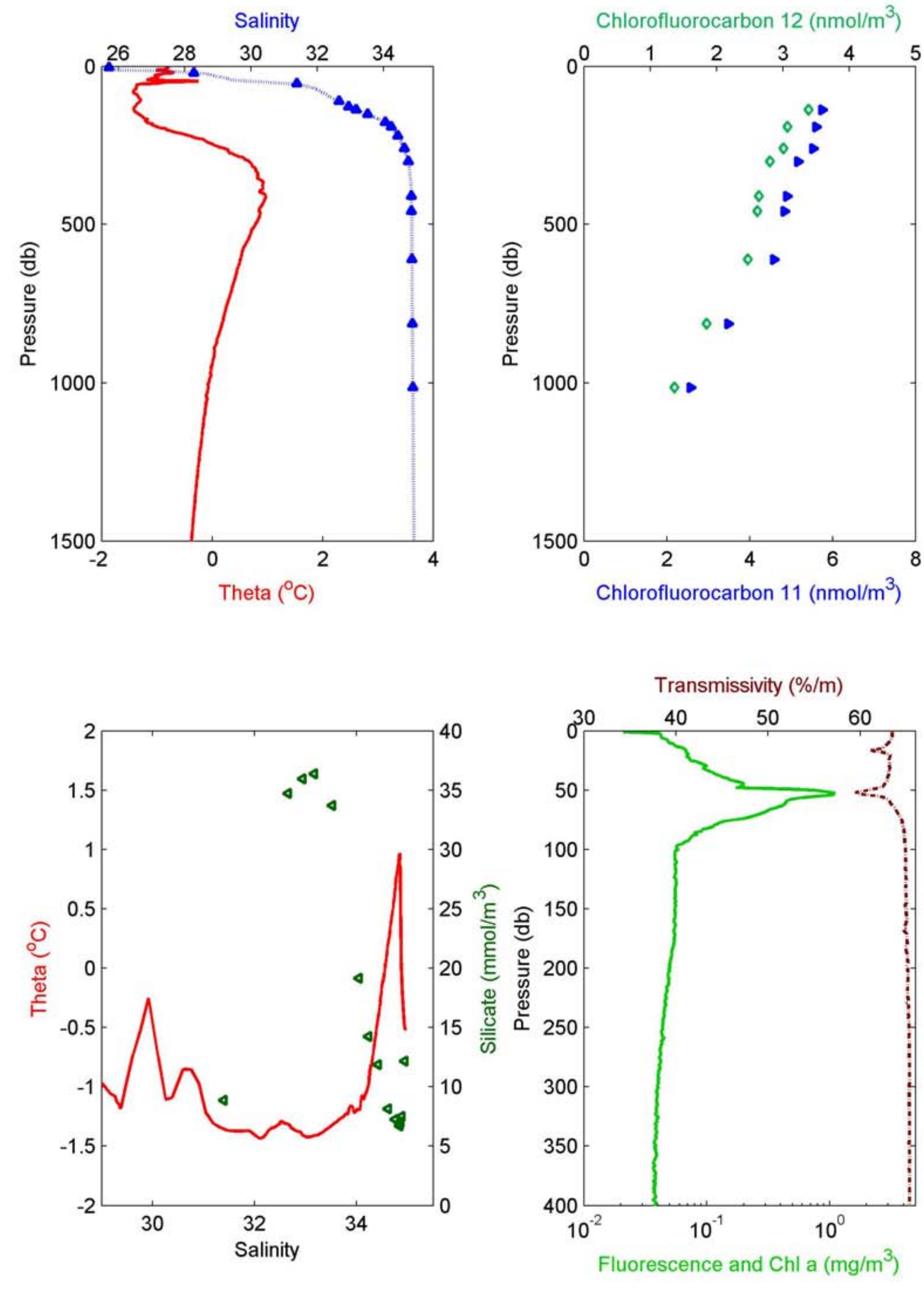
2006-18: Cast 42 Station CB5b12 (Canada Basin)



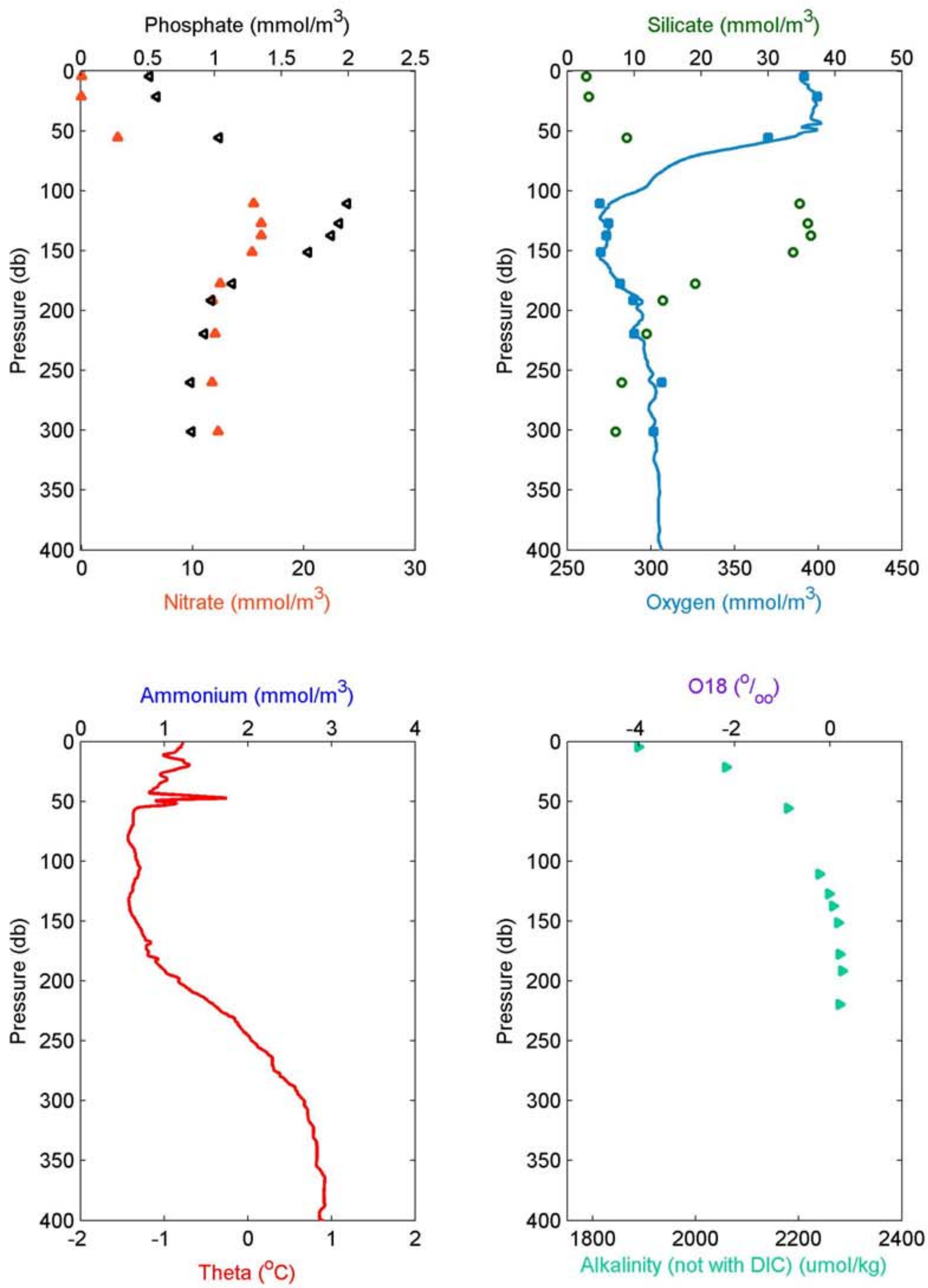
2006-18: Cast 42 Station CB5b12 (Canada Basin)



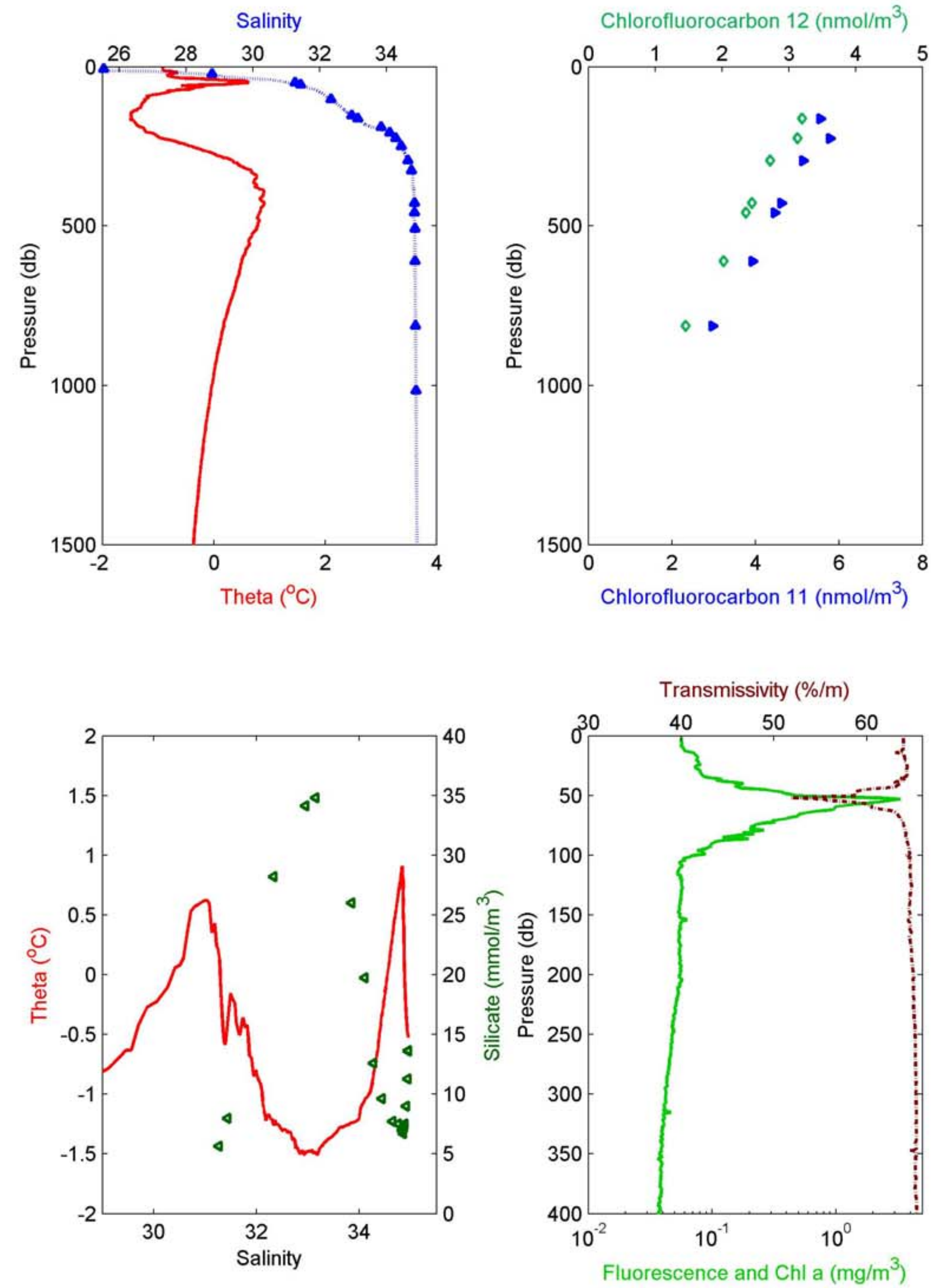
2006-18: Cast 43 Station CB5a (Canada Basin)



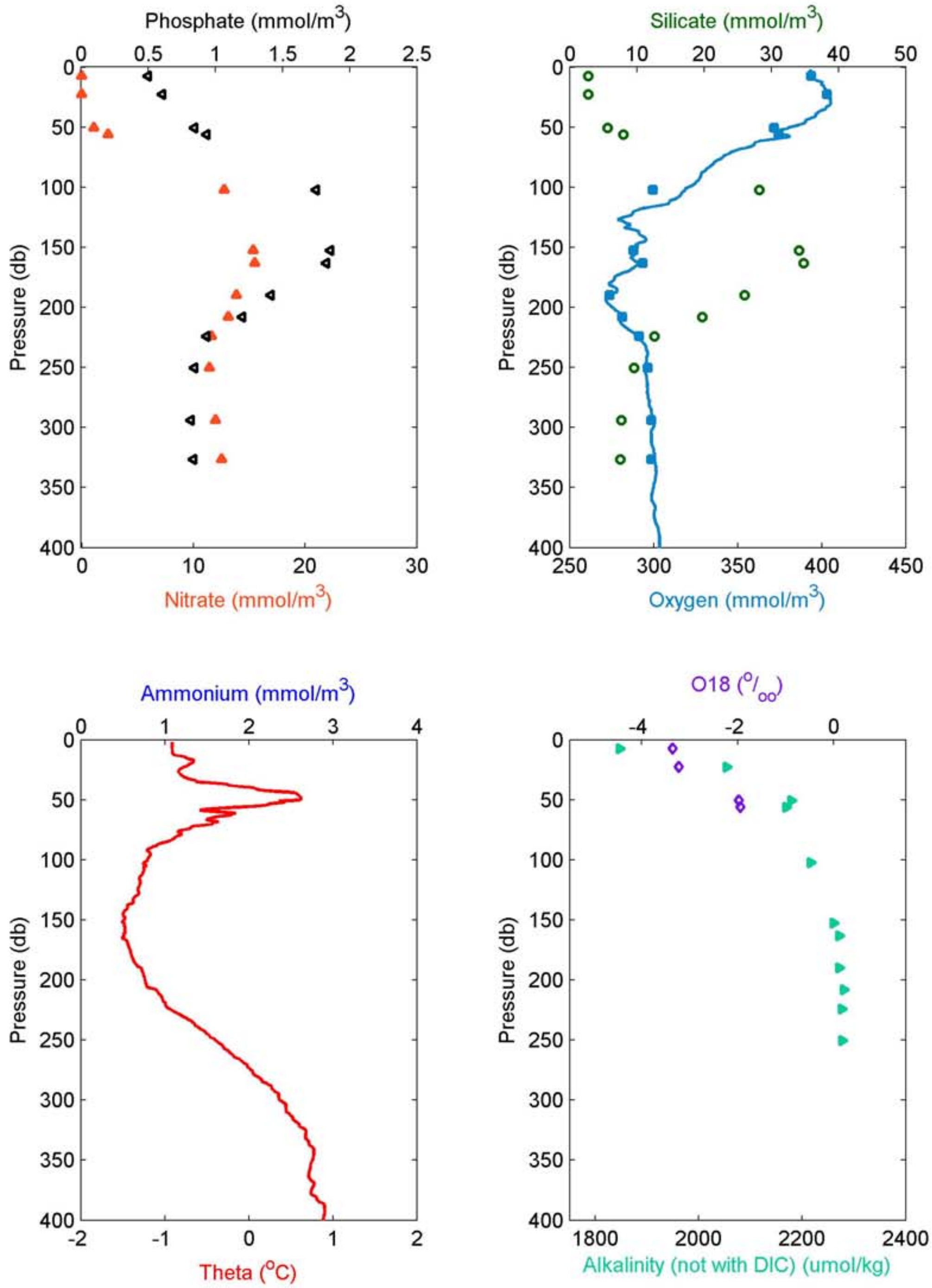
2006-18: Cast 43 Station CB5a (Canada Basin)



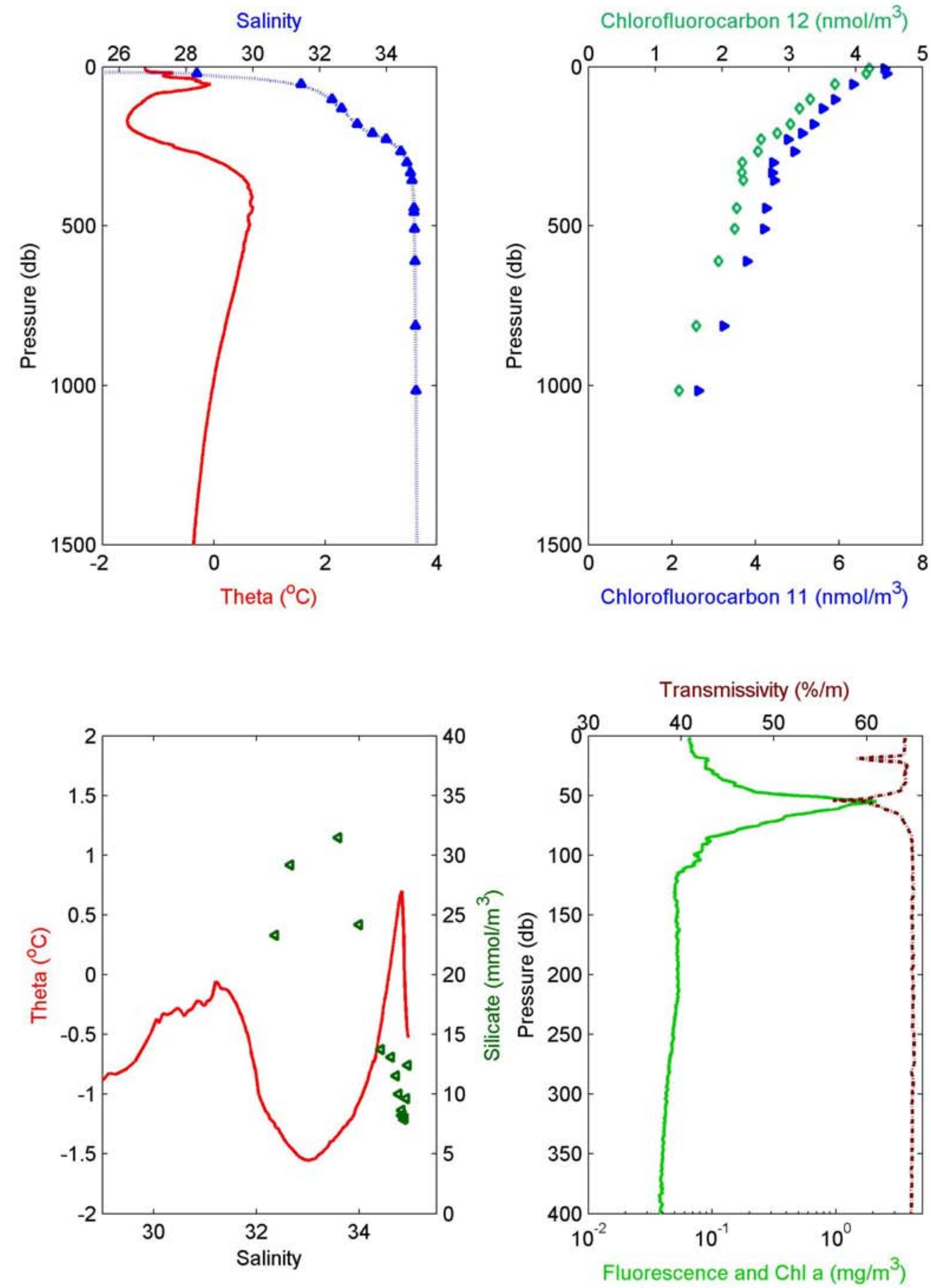
2006-18: Cast 45 Station CB-5 (Canada Basin)



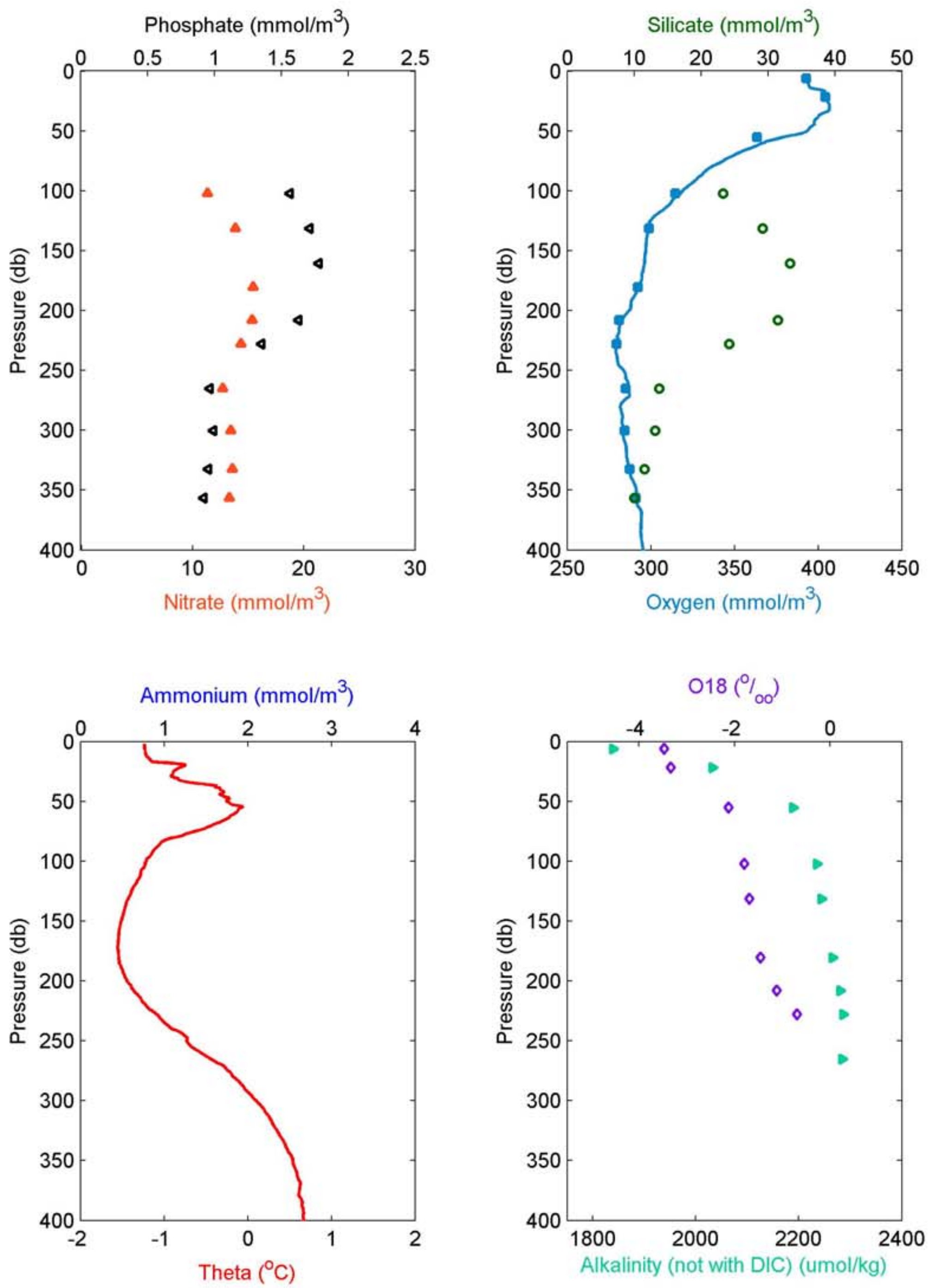
2006-18: Cast 45 Station CB-5 (Canada Basin)



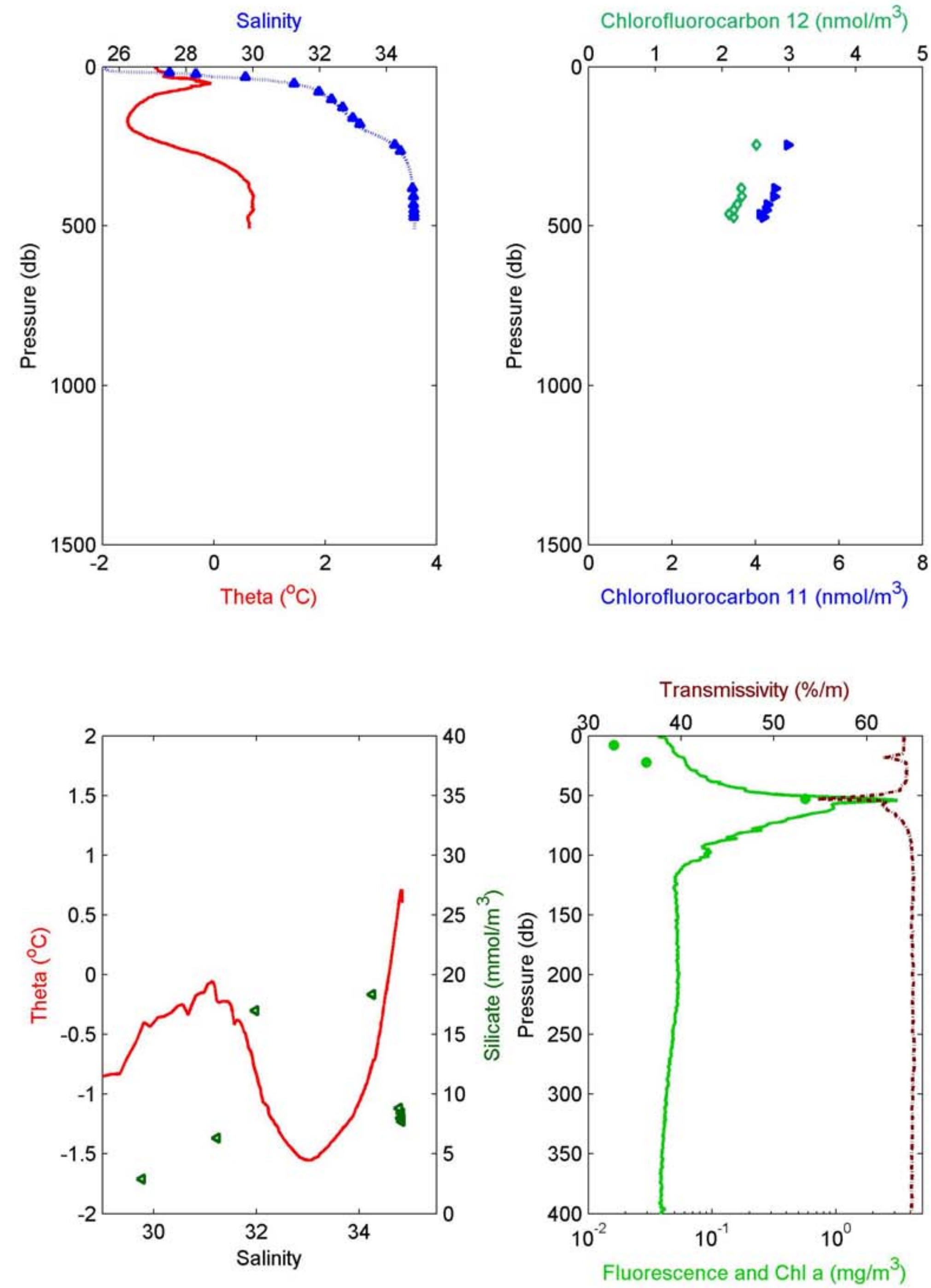
2006-18: Cast 46 Station CB-4 (Canada Basin)



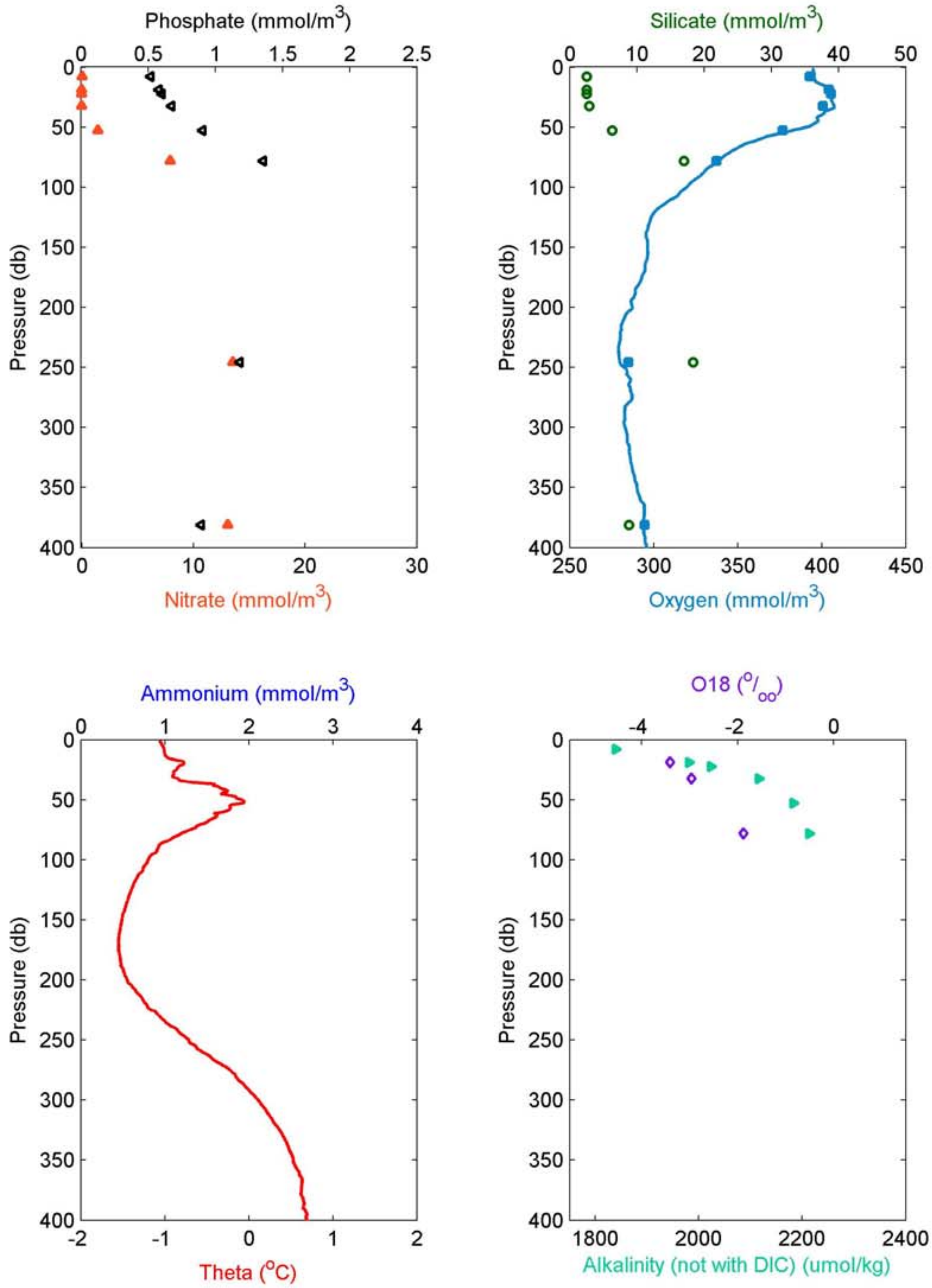
2006-18: Cast 46 Station CB-4 (Canada Basin)



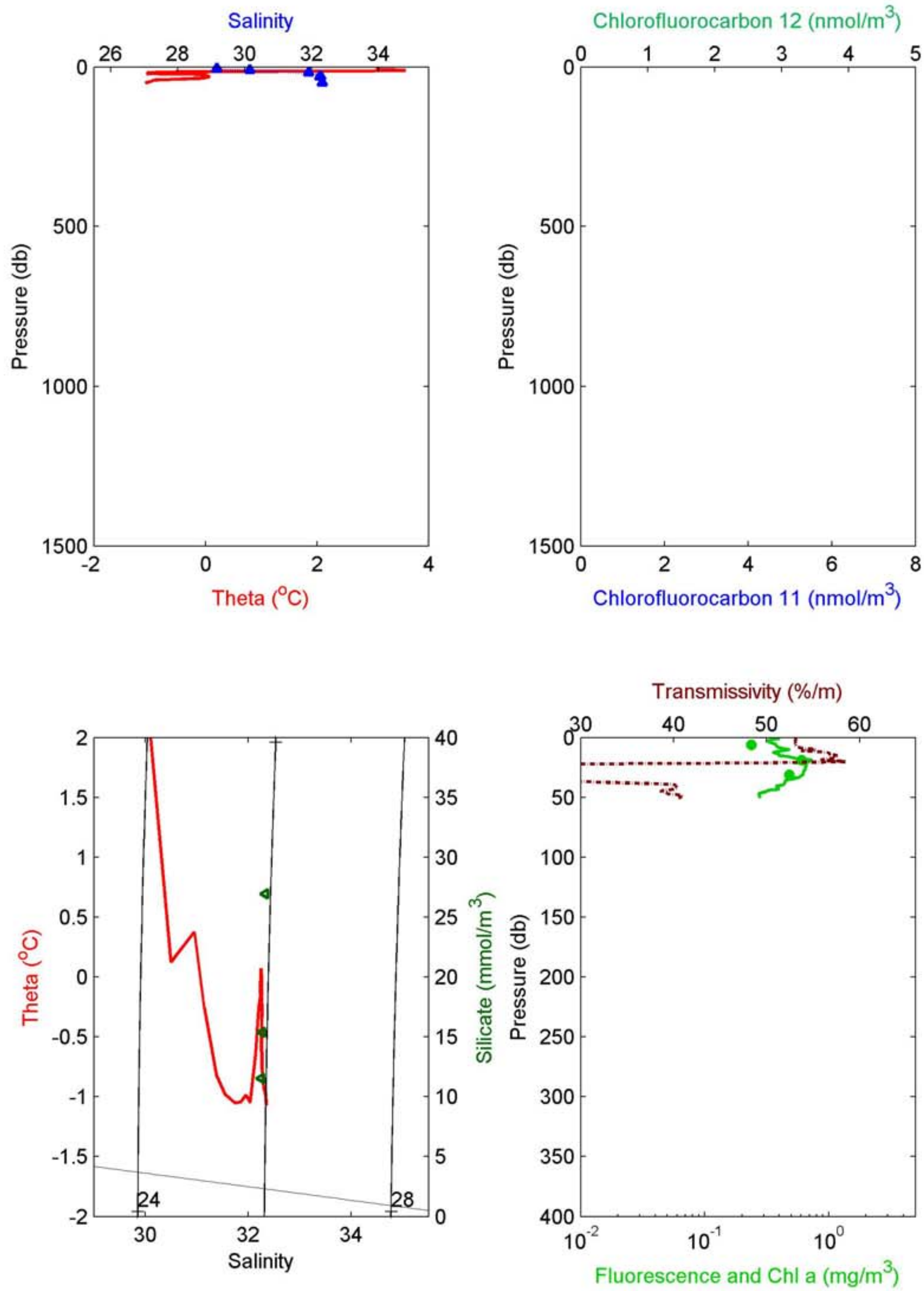
2006-18: Cast 47 Station CB-4 (Canada Basin)



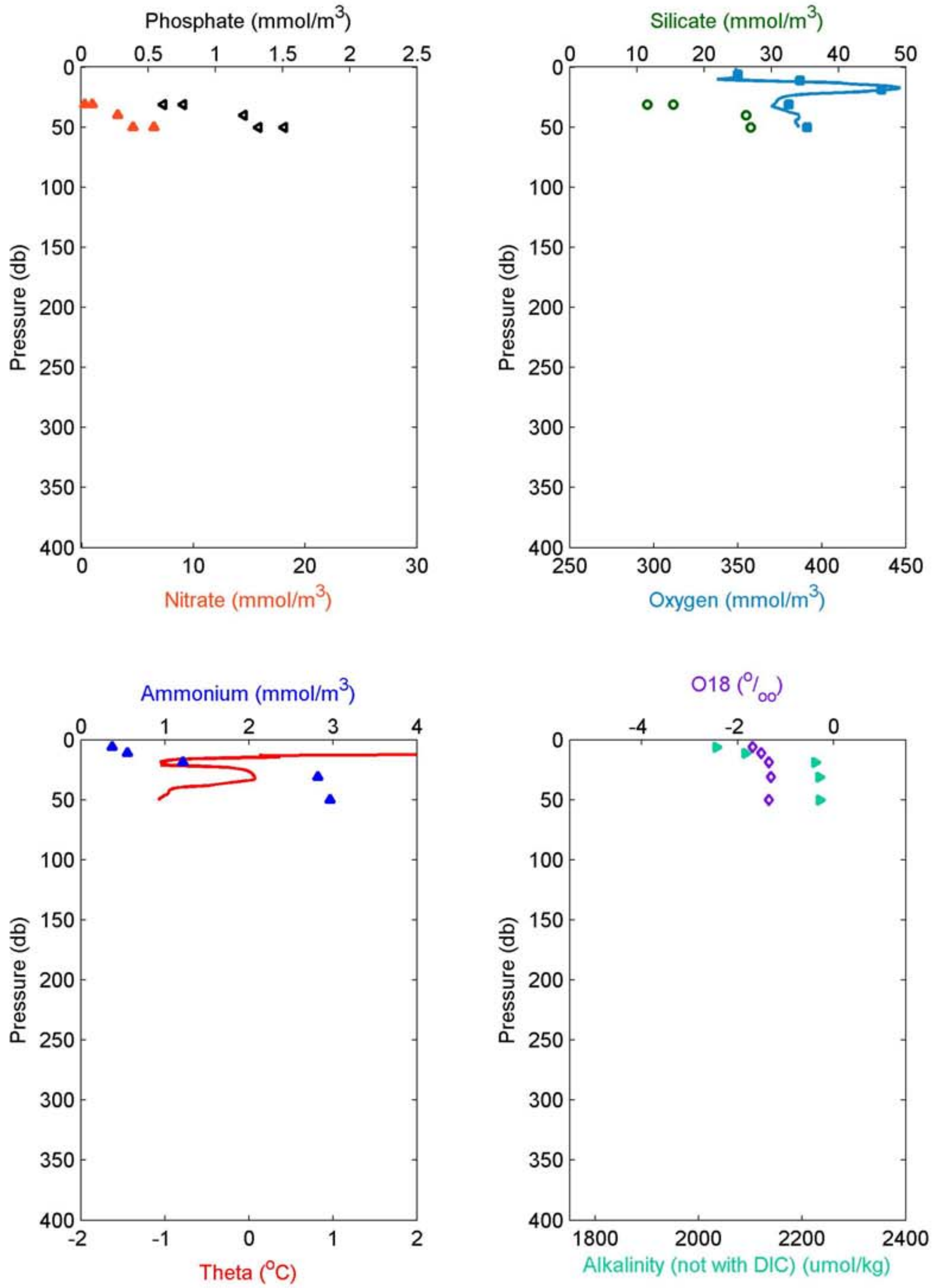
2006-18: Cast 47 Station CB-4 (Canada Basin)



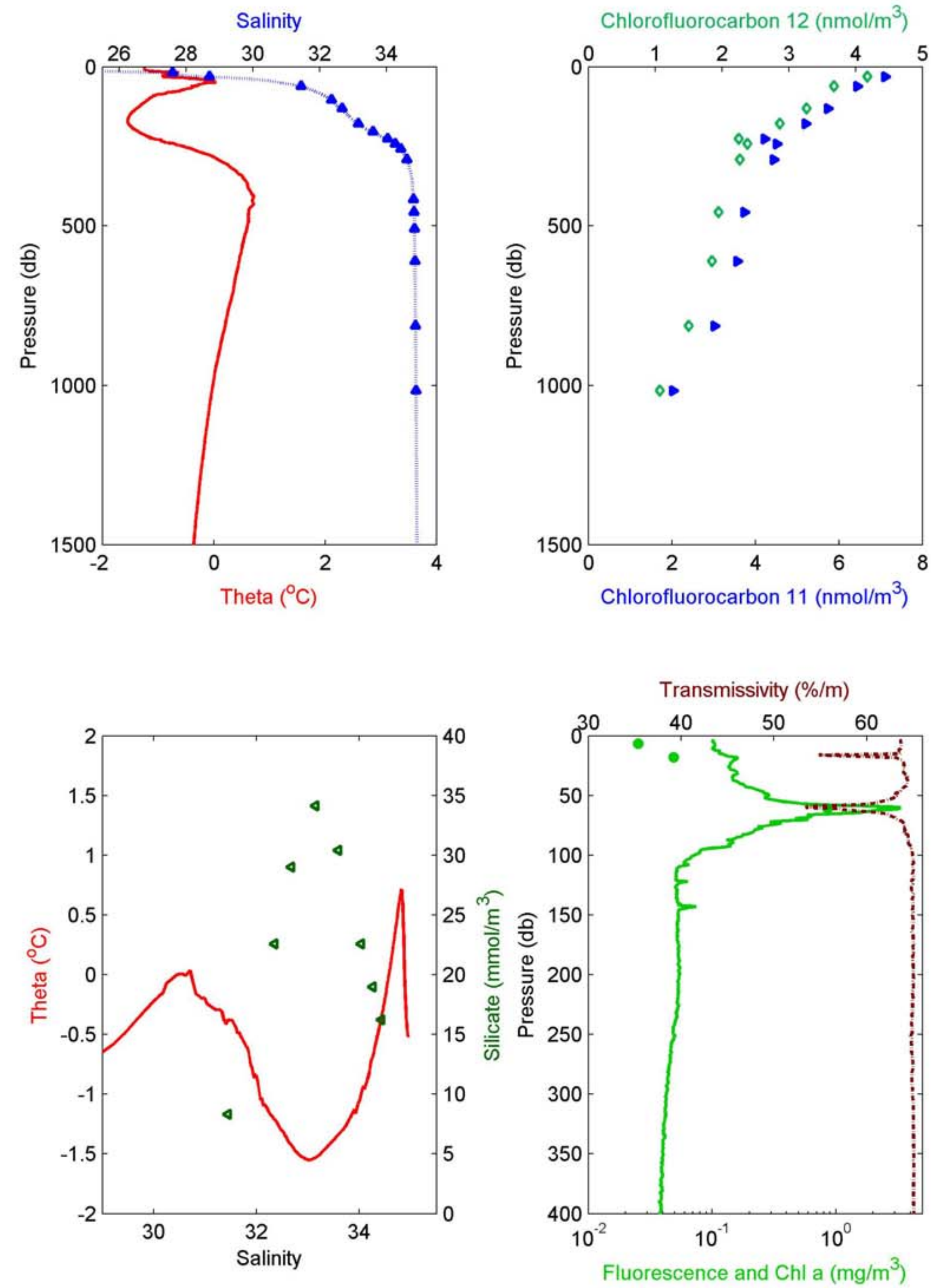
2006-18: Cast 48 Station Barrow (Canada Basin)



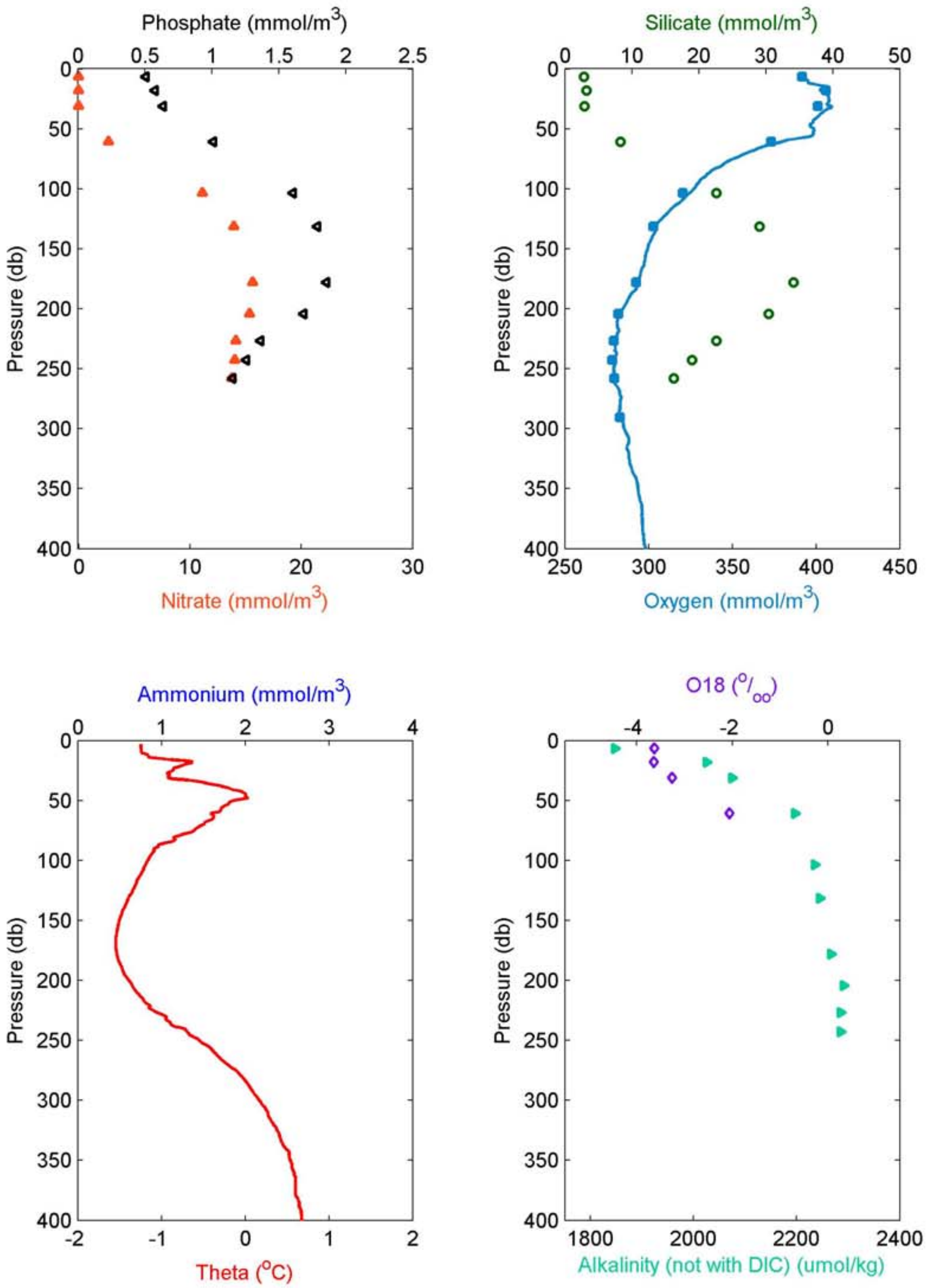
2006-18: Cast 48 Station Barrow (Canada Basin)



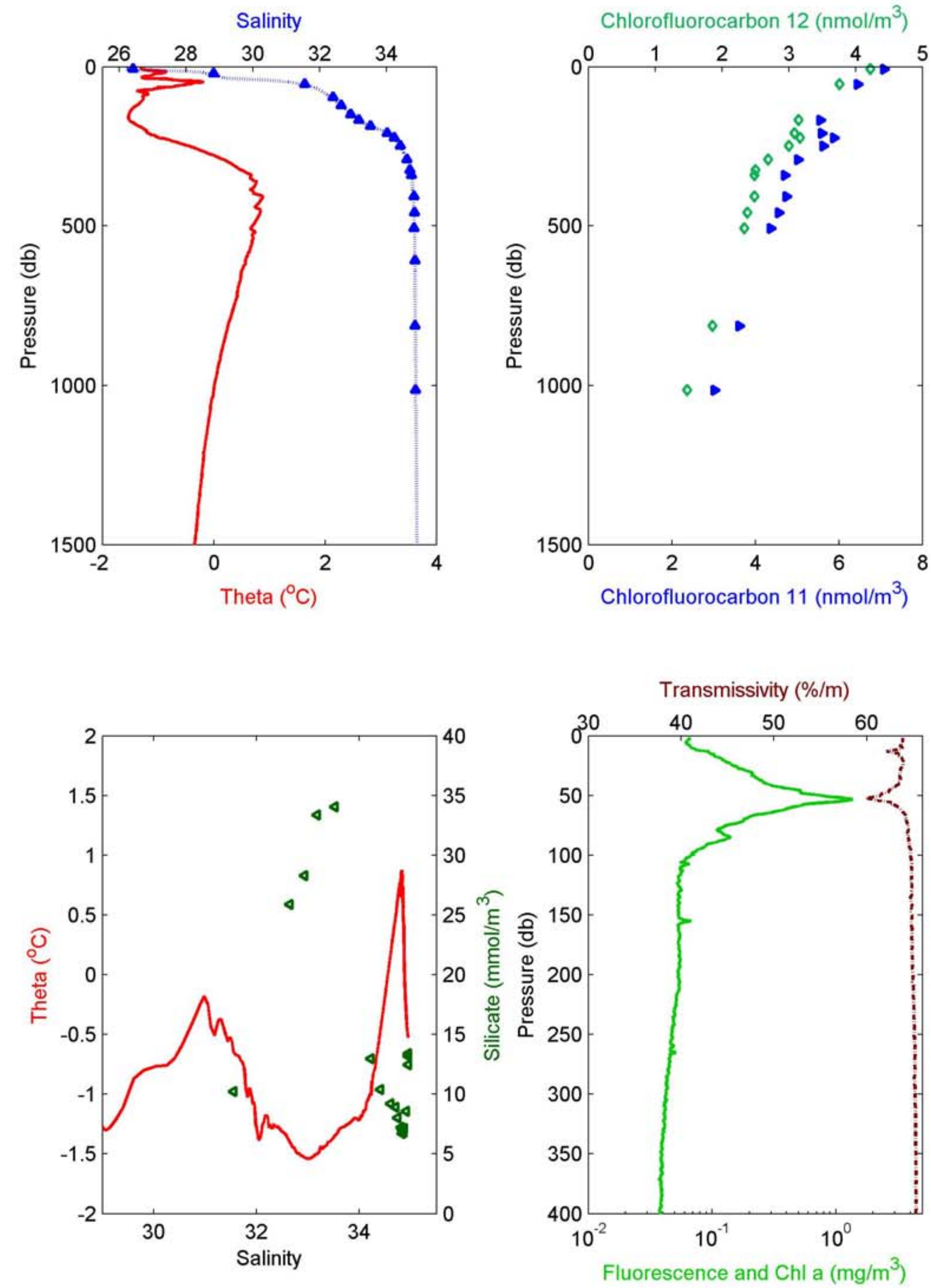
2006-18: Cast 49 Station CB-7 (Canada Basin)



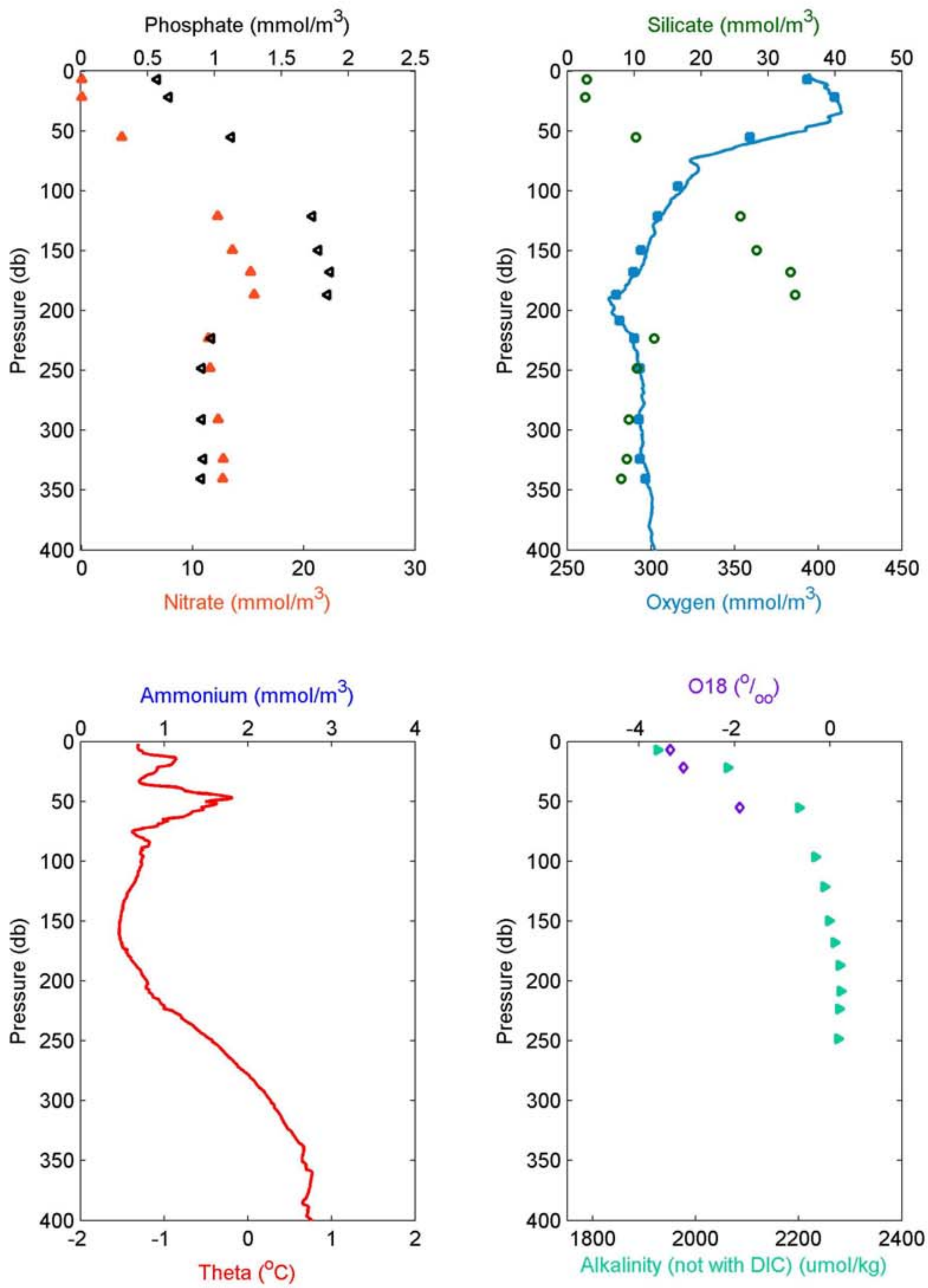
2006-18: Cast 49 Station CB-7 (Canada Basin)



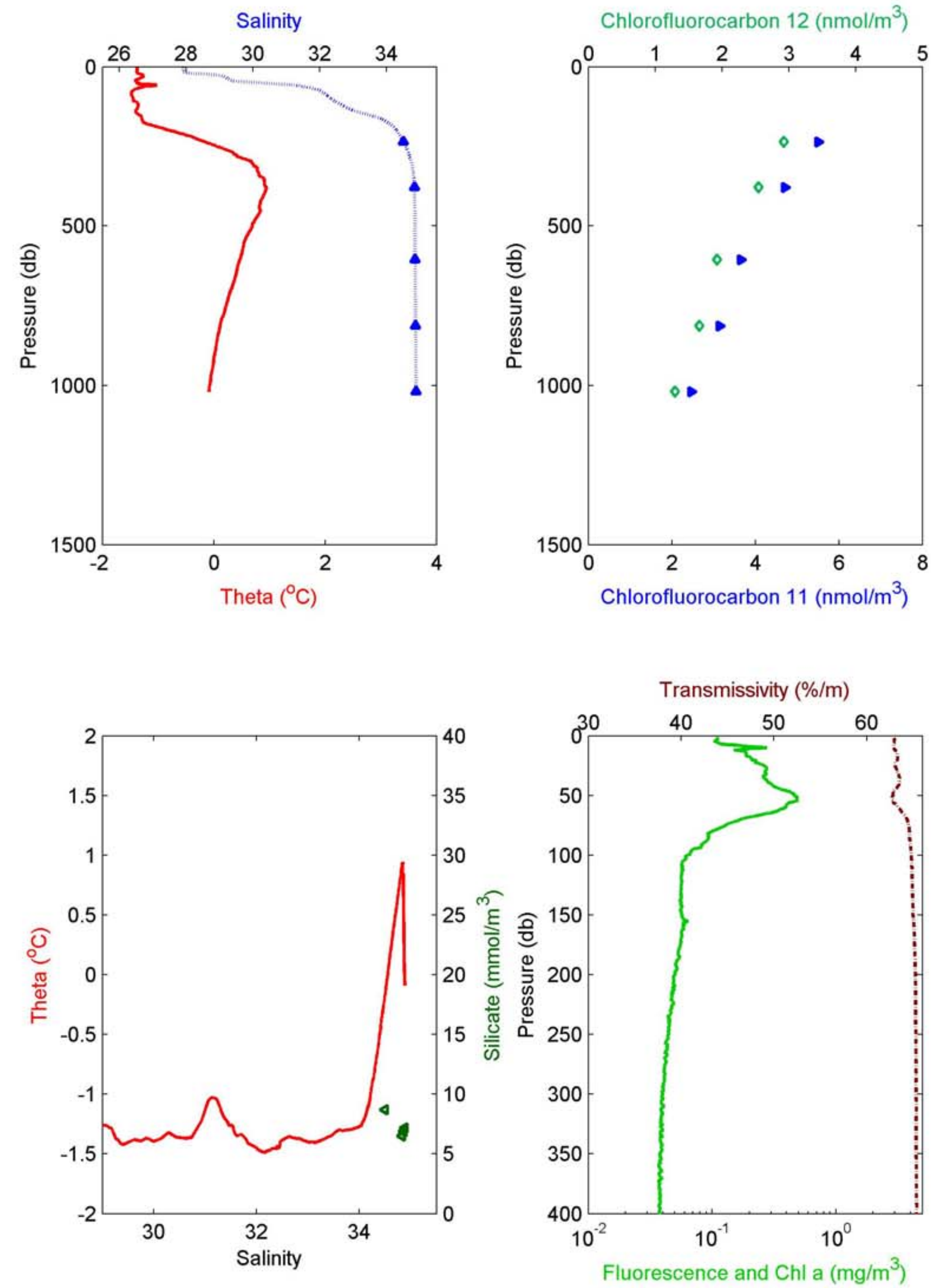
2006-18: Cast 50 Station CB-8 (Canada Basin)



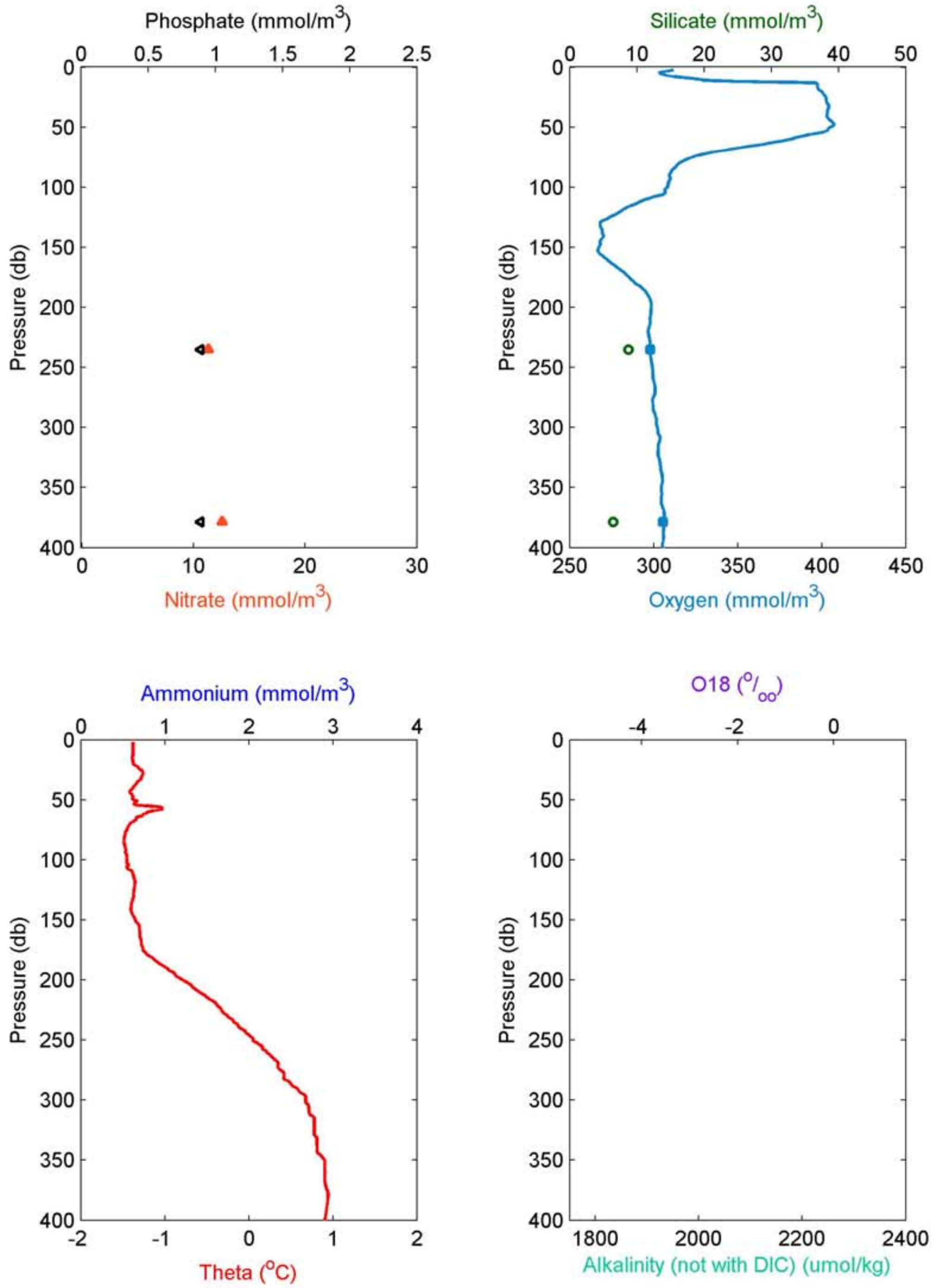
2006-18: Cast 50 Station CB-8 (Canada Basin)



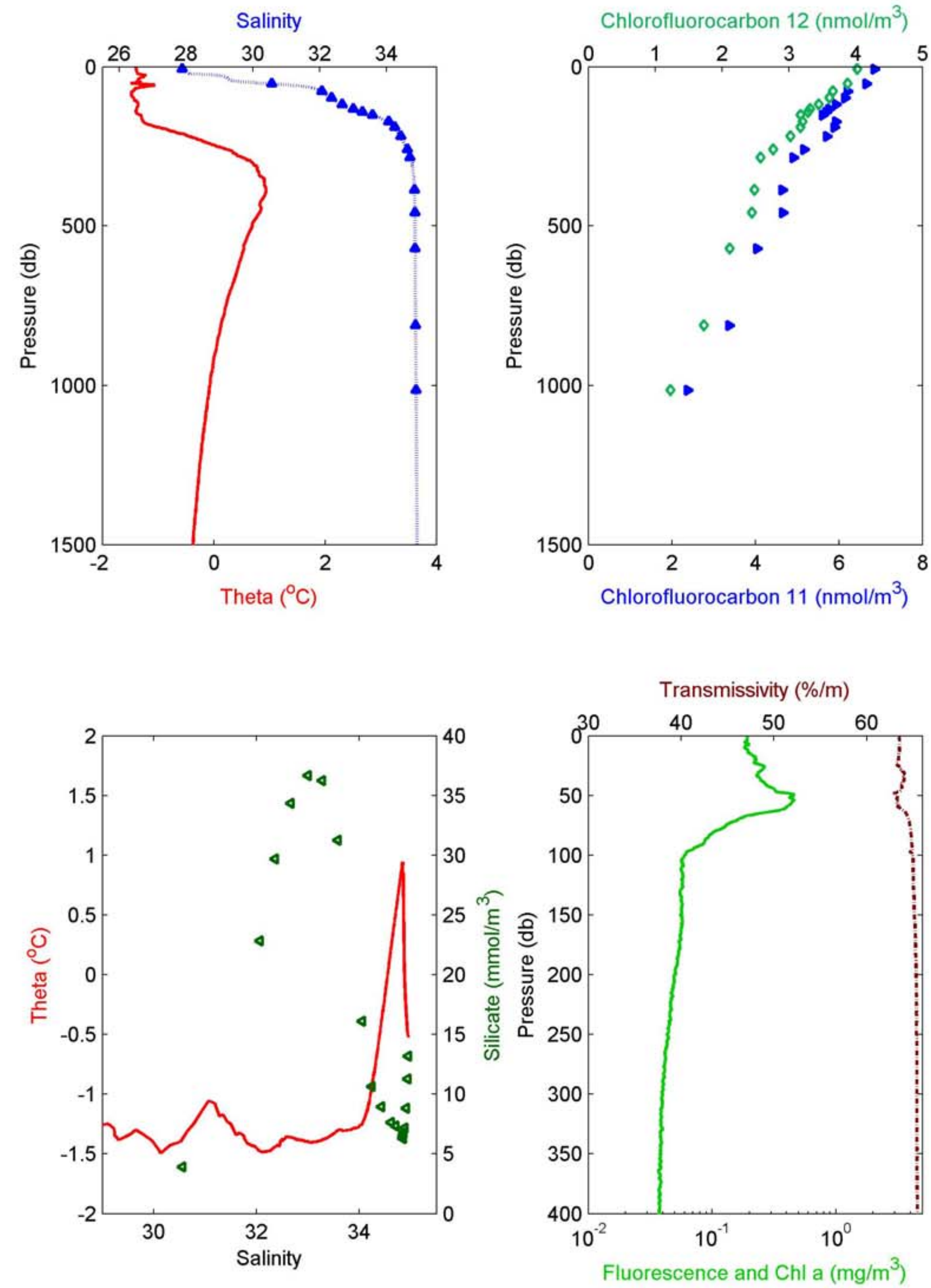
2006-18: Cast 51 Station CB-9 (Canada Basin)



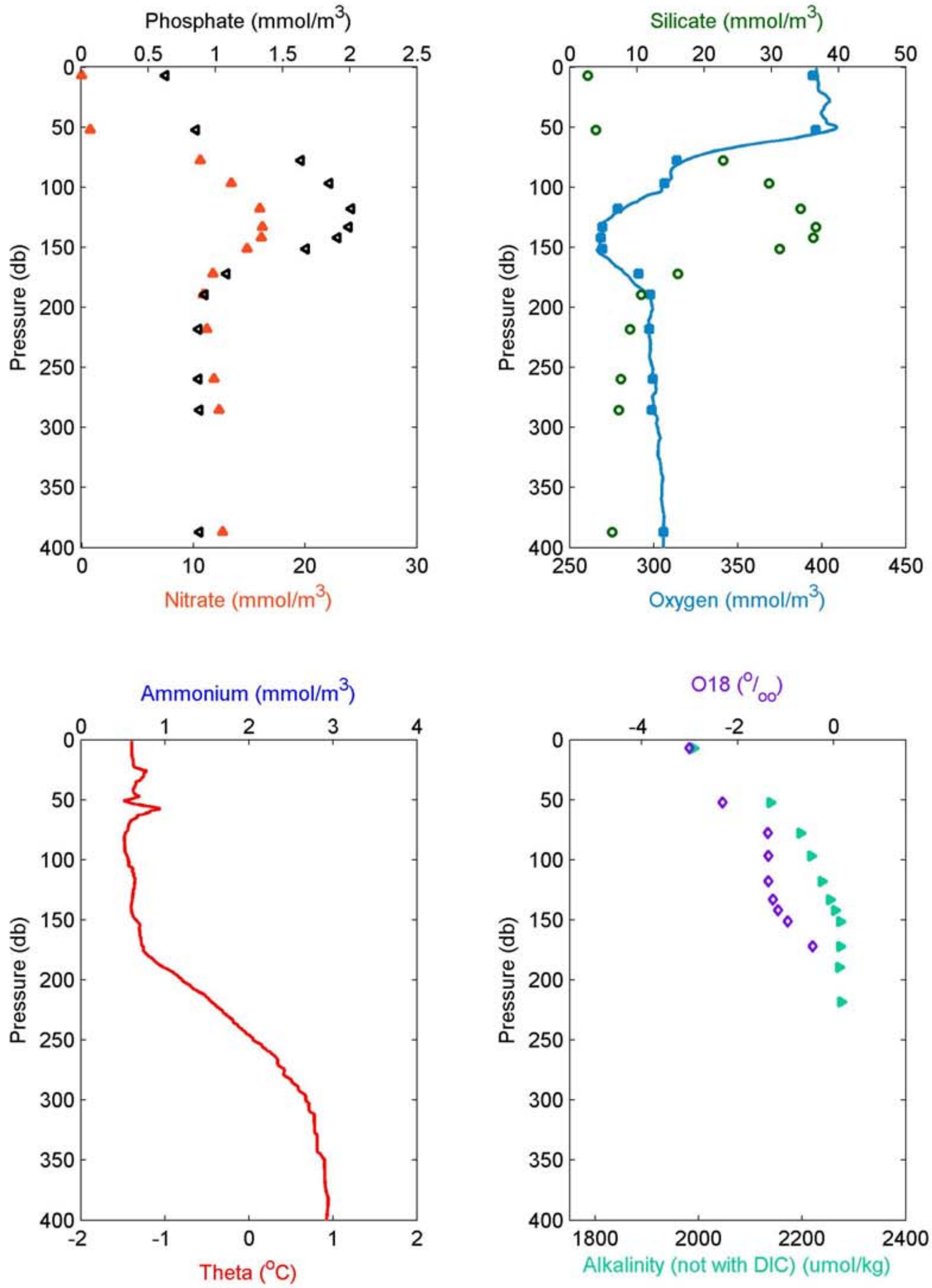
2006-18: Cast 51 Station CB-9 (Canada Basin)



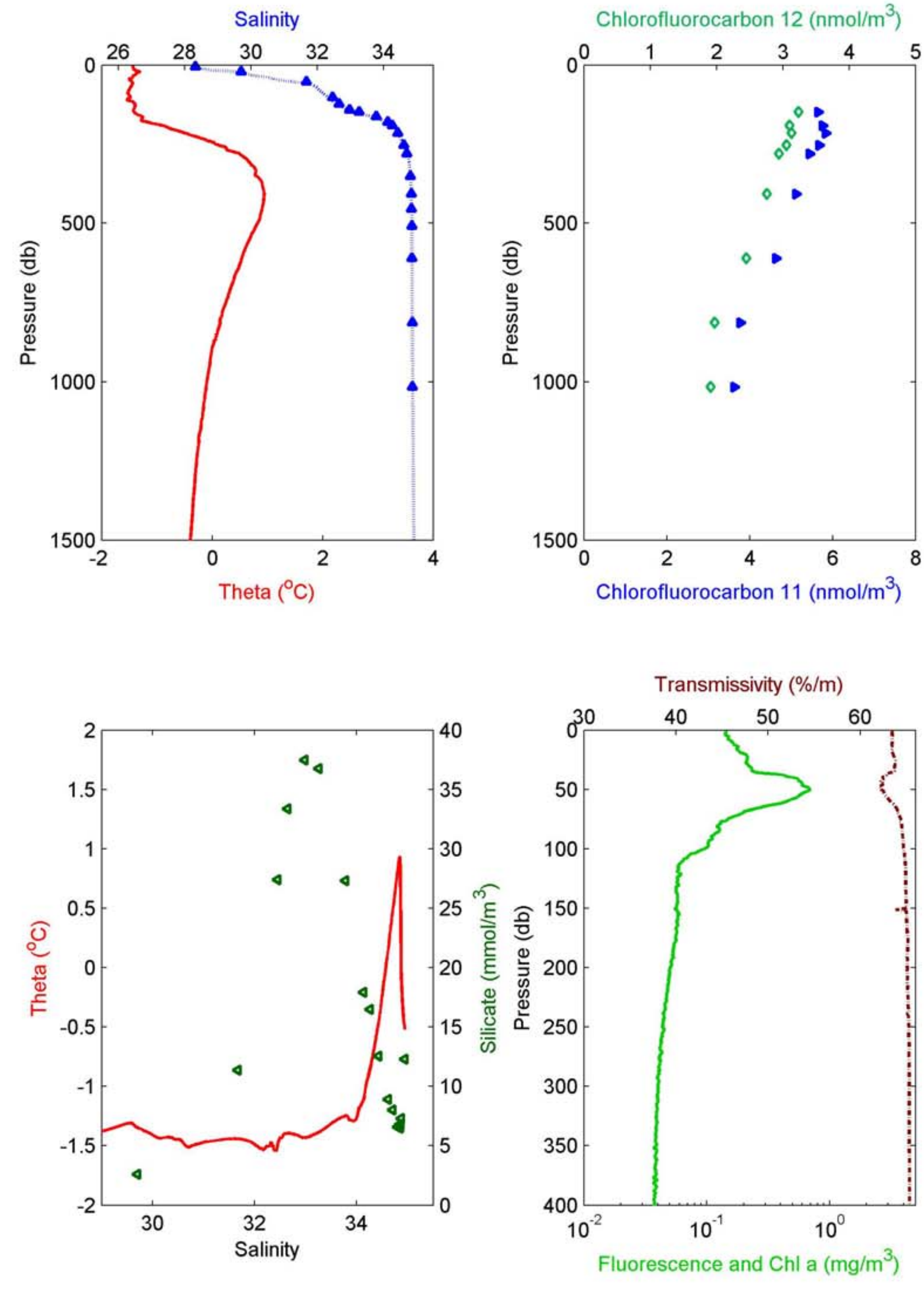
2006-18: Cast 52 Station CB-9 (Canada Basin)



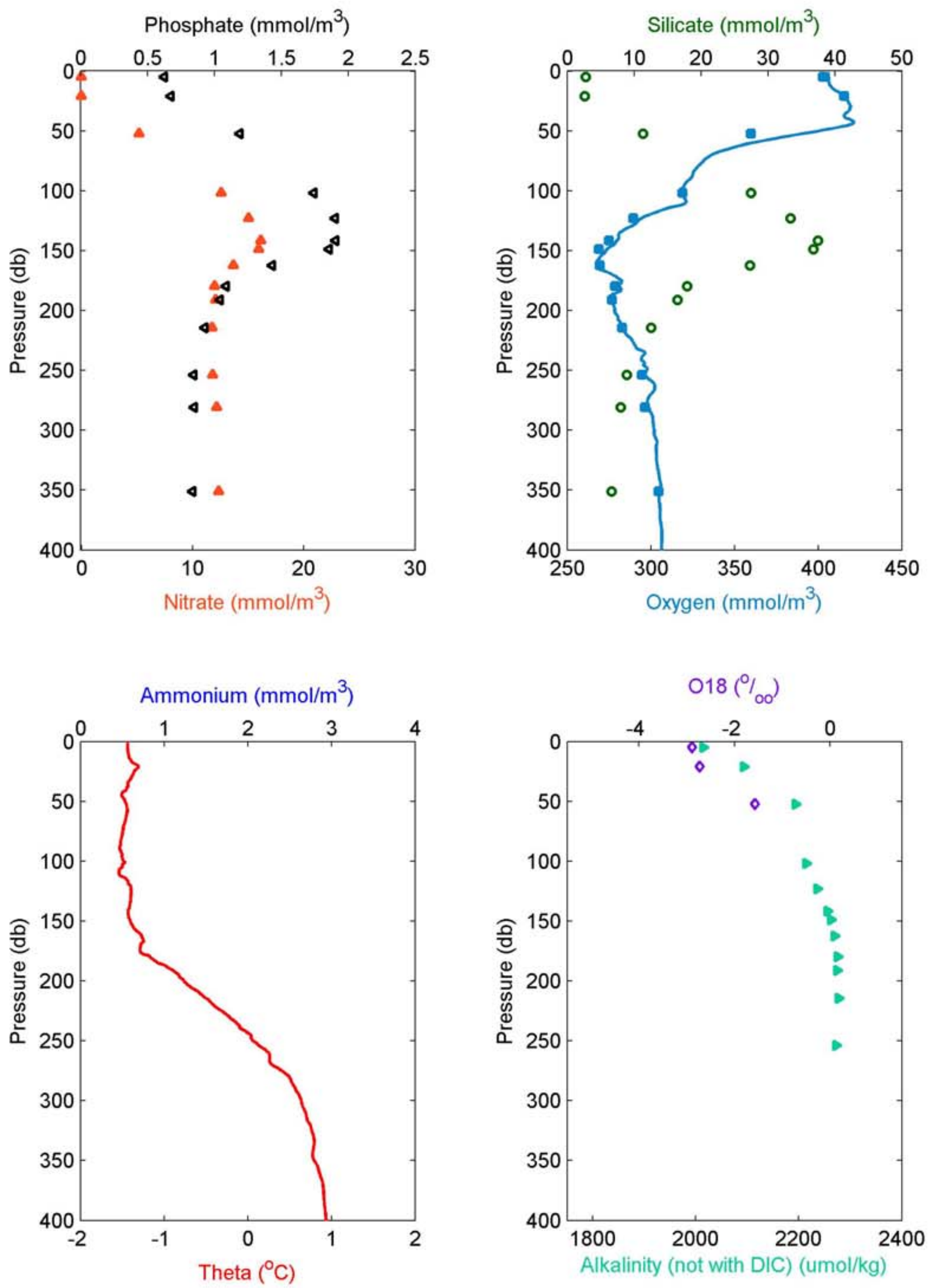
2006-18: Cast 52 Station CB-9 (Canada Basin)



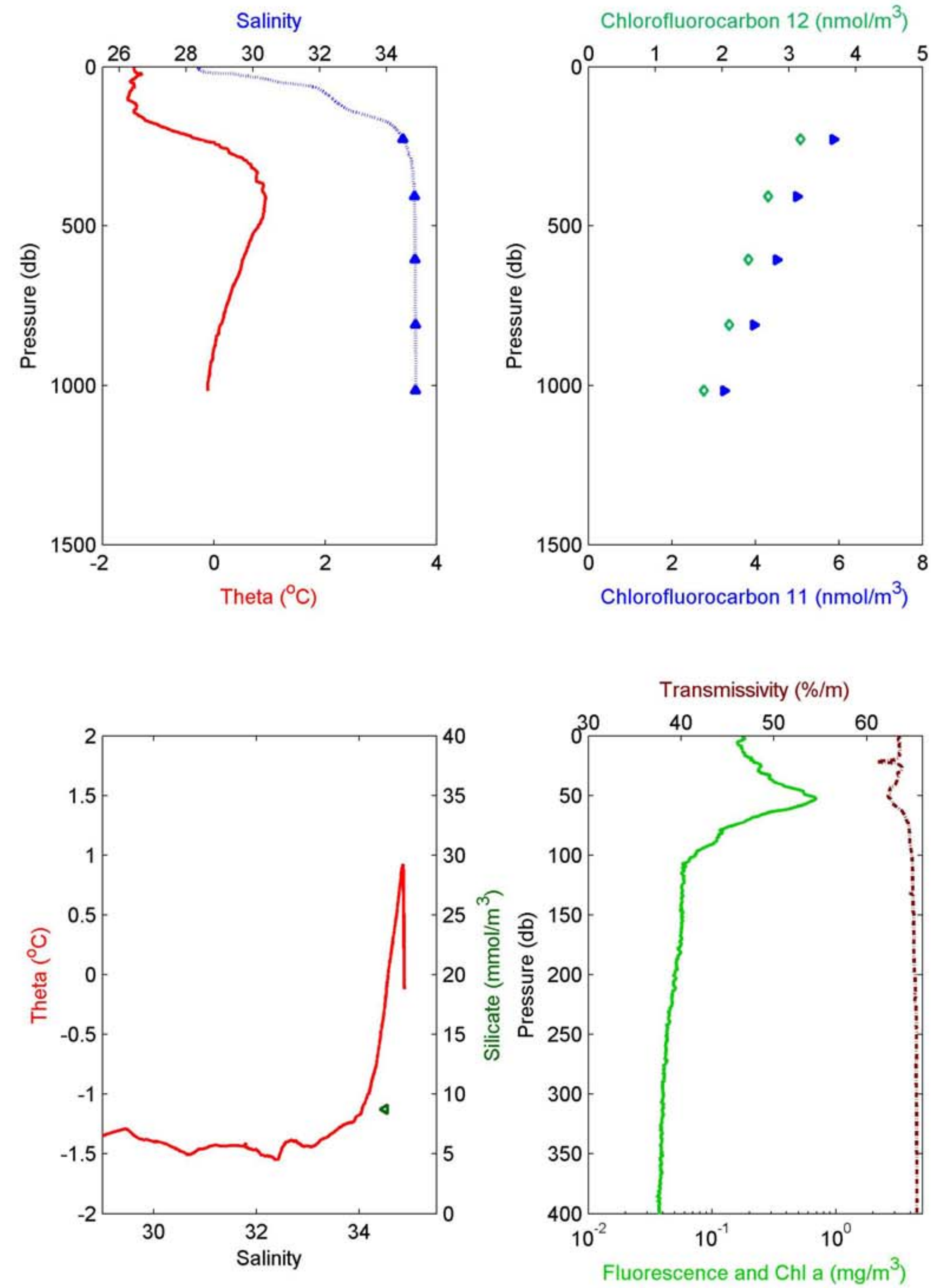
2006-18: Cast 53 Station CB10 (Canada Basin)



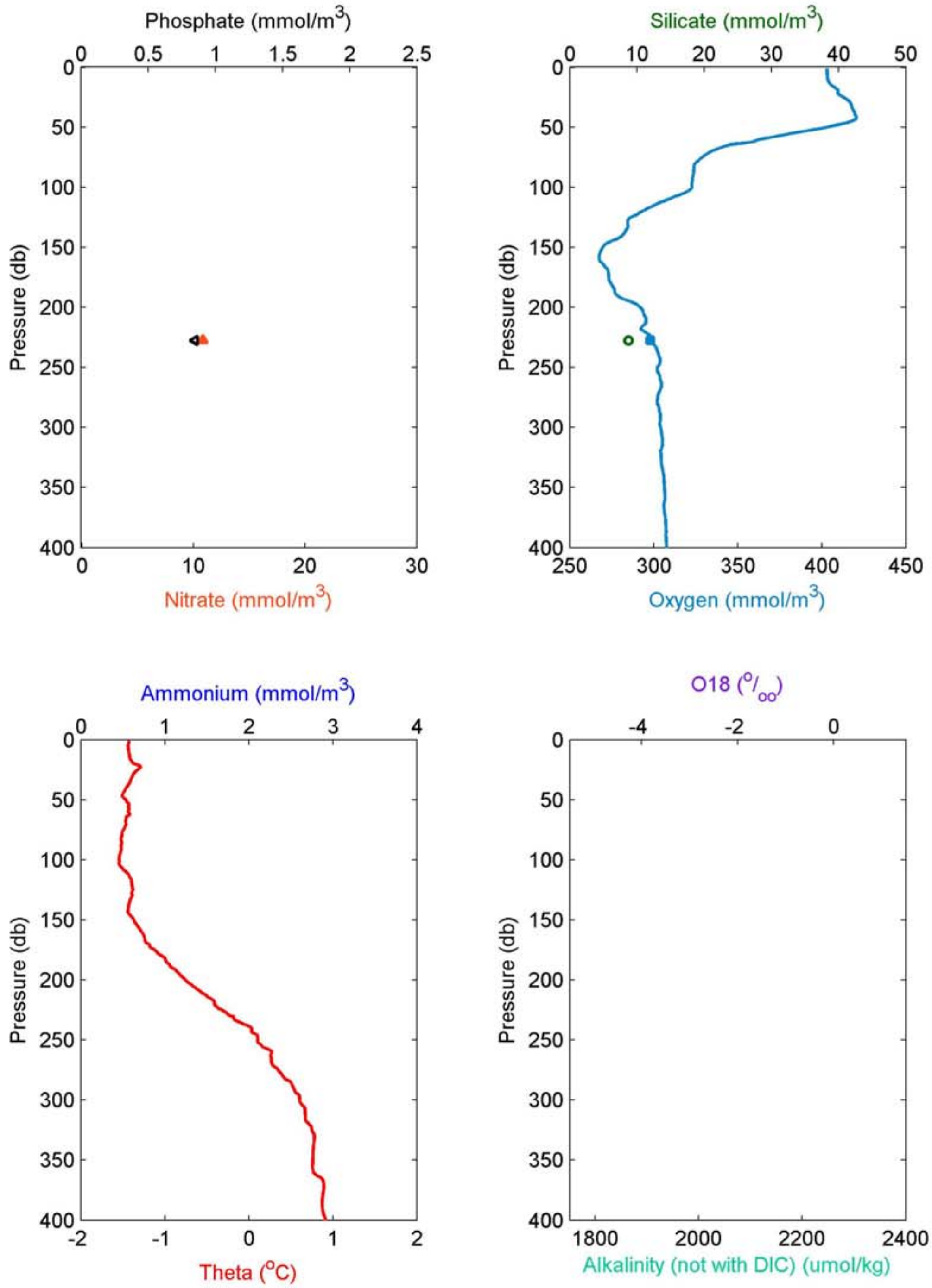
2006-18: Cast 53 Station CB10 (Canada Basin)



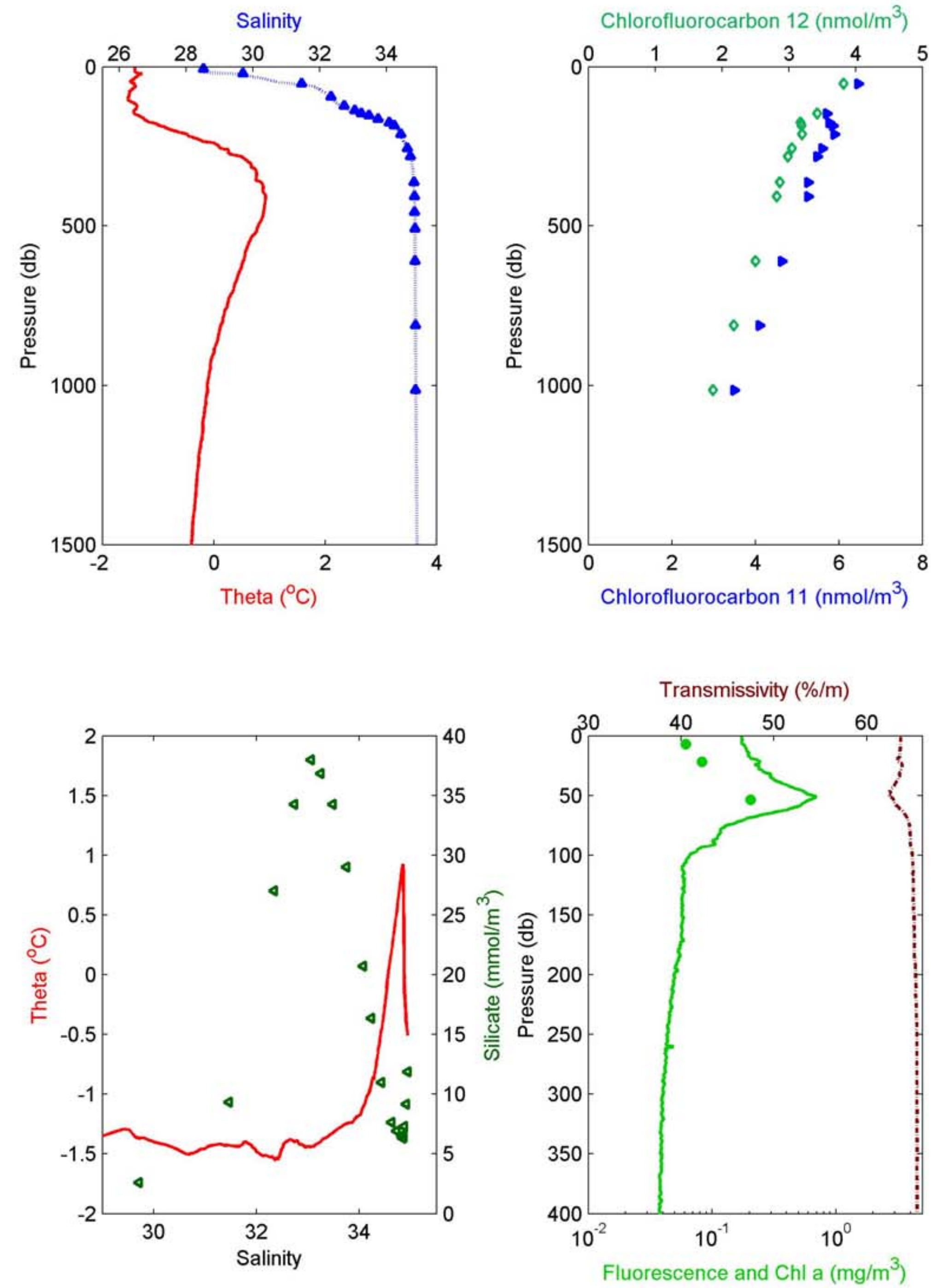
2006-18: Cast 54 Station CB10a2 (Canada Basin)



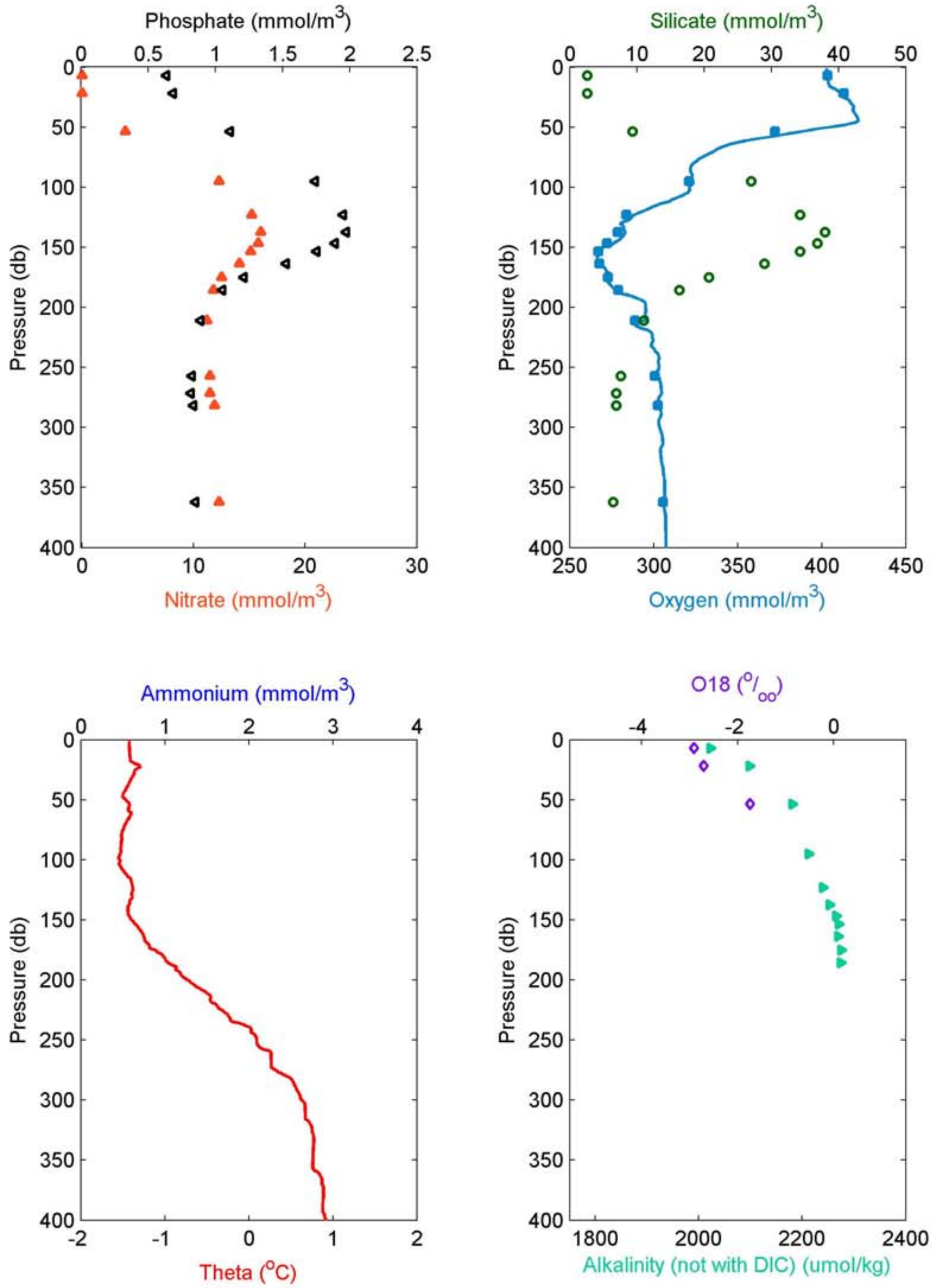
2006-18: Cast 54 Station CB10a2 (Canada Basin)



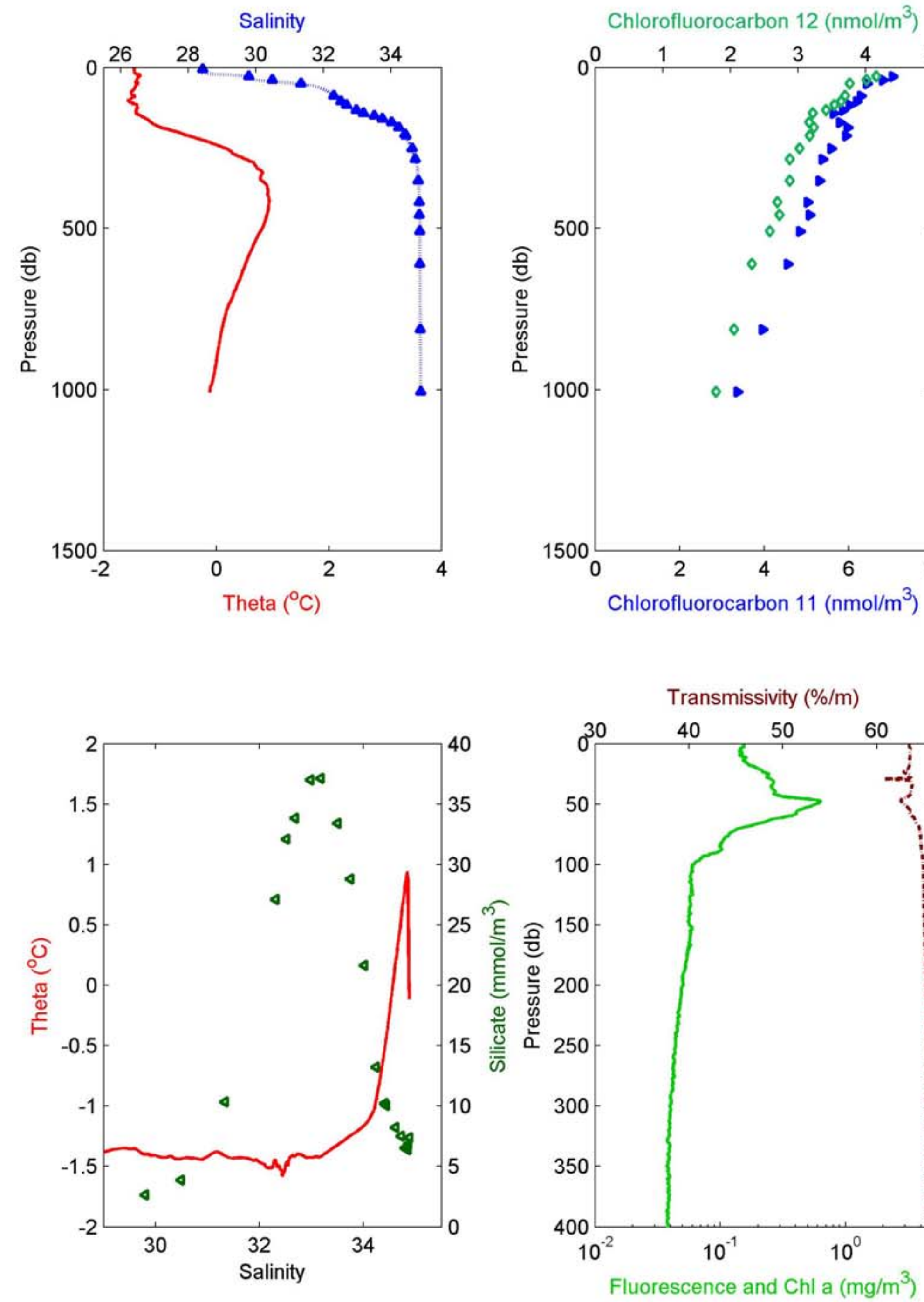
2006-18: Cast 55 Station CB10a2 (Canada Basin)



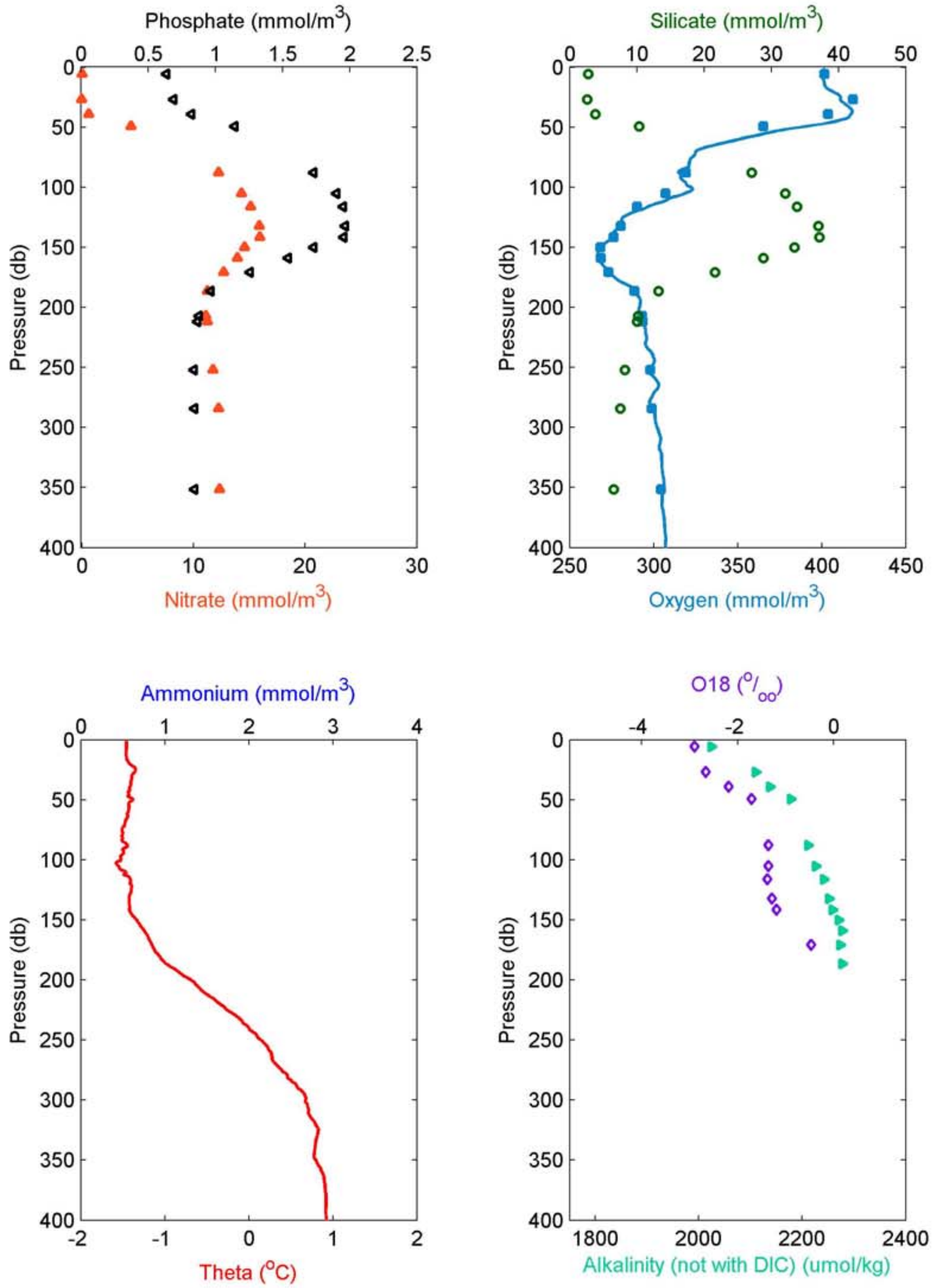
2006-18: Cast 55 Station CB10a2 (Canada Basin)



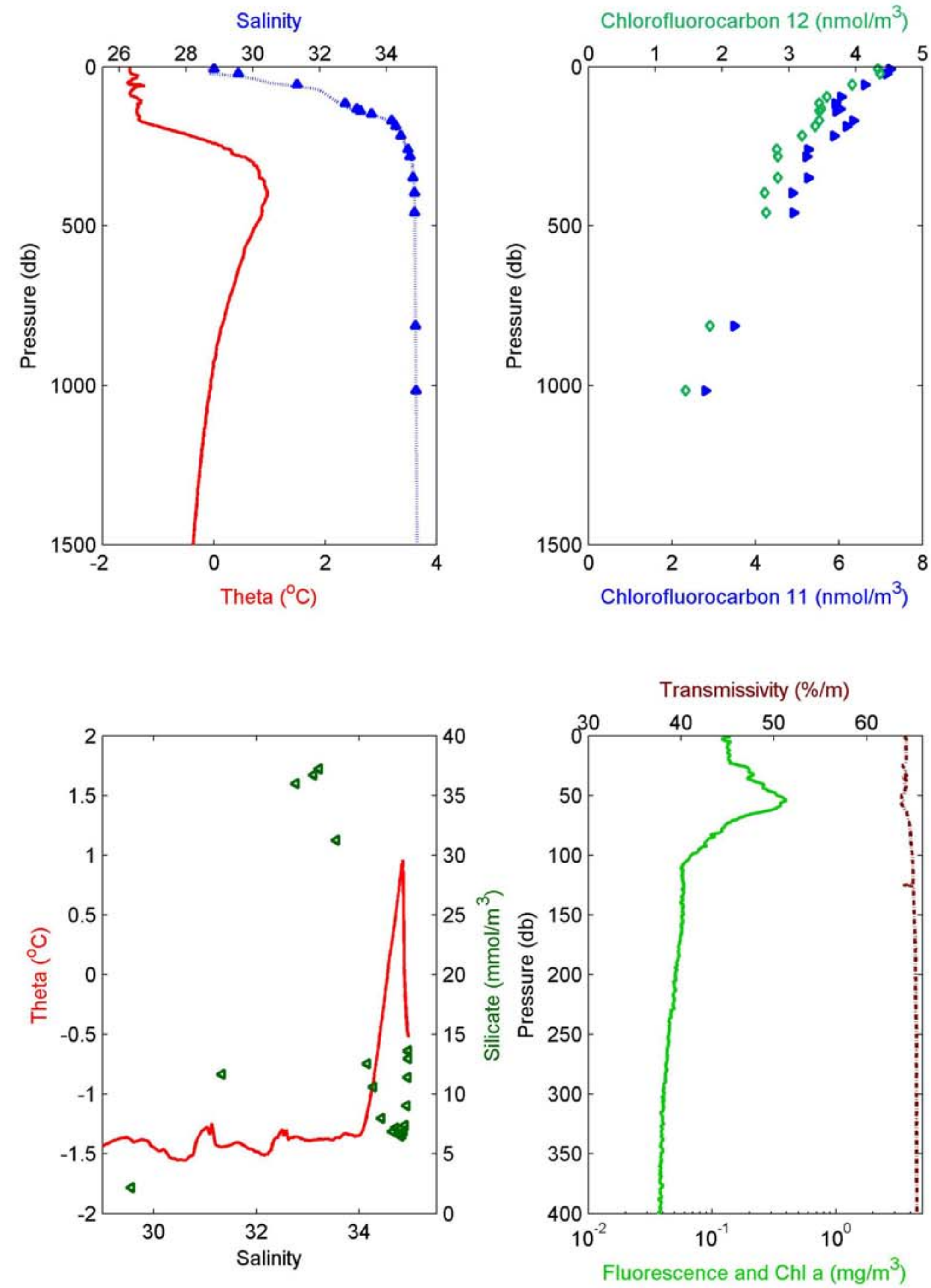
2006-18: Cast 56 Station CB10a (Canada Basin)



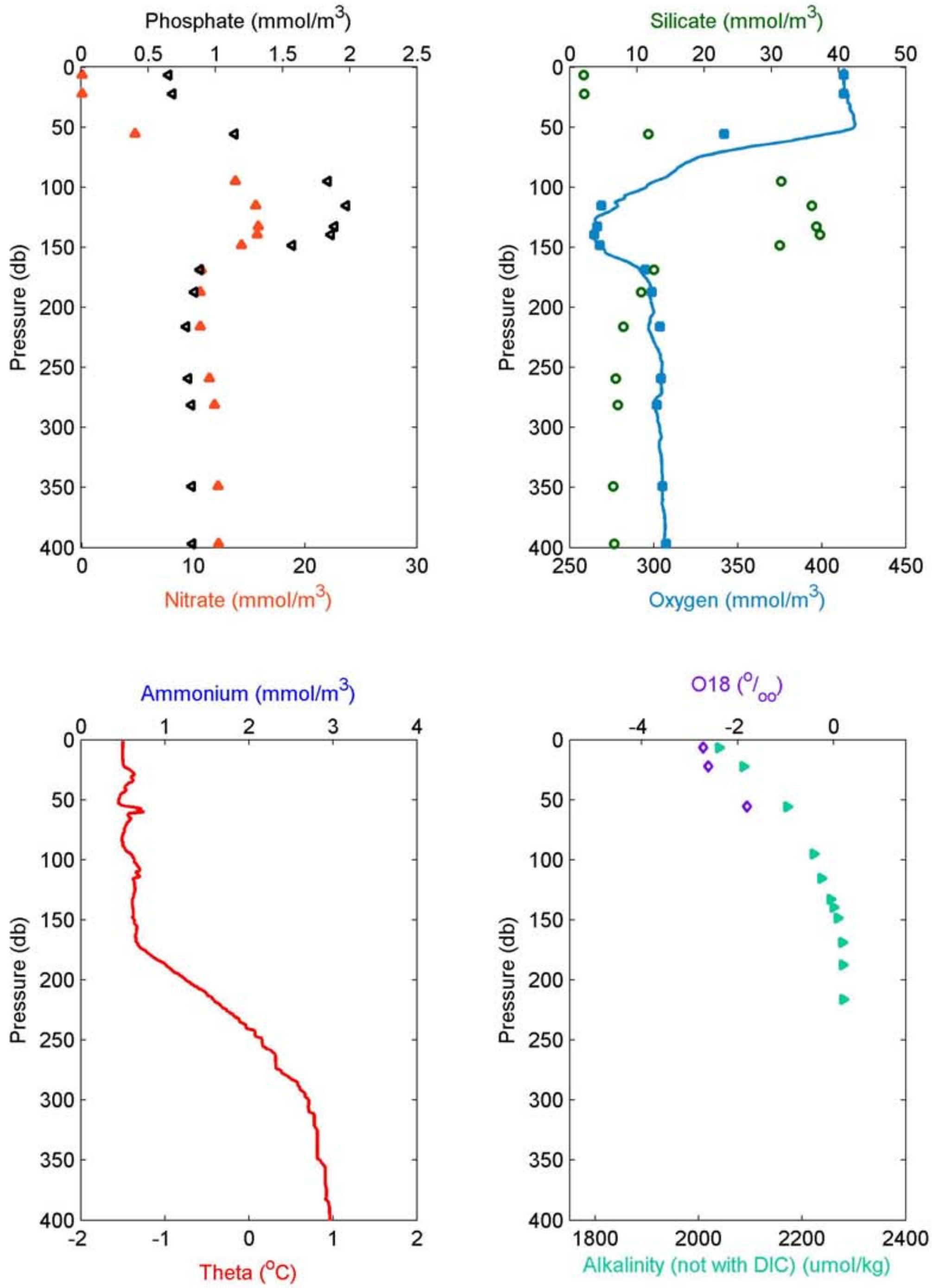
2006-18: Cast 56 Station CB10a (Canada Basin)



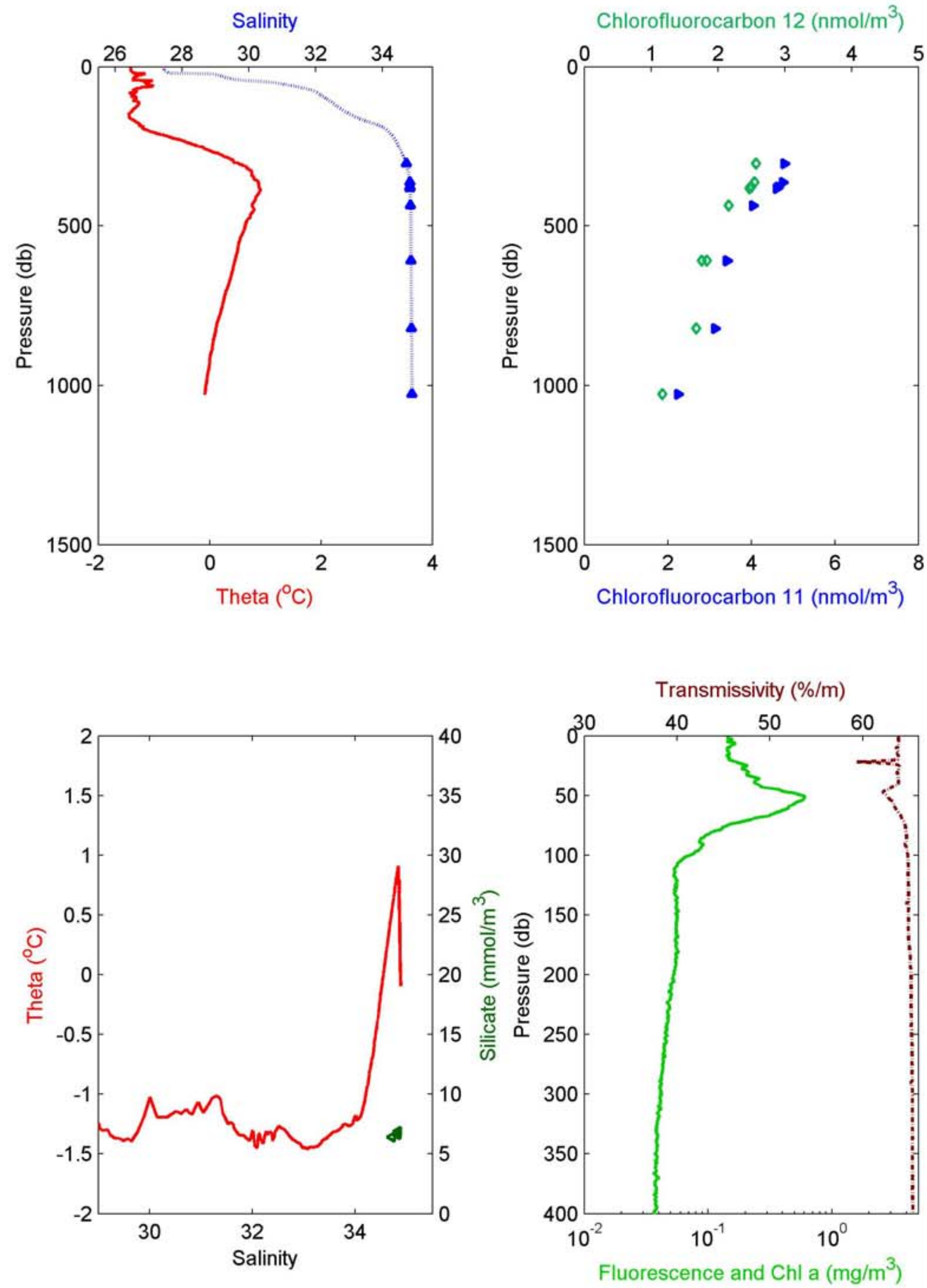
2006-18: Cast 57 Station CB11 (Canada Basin)



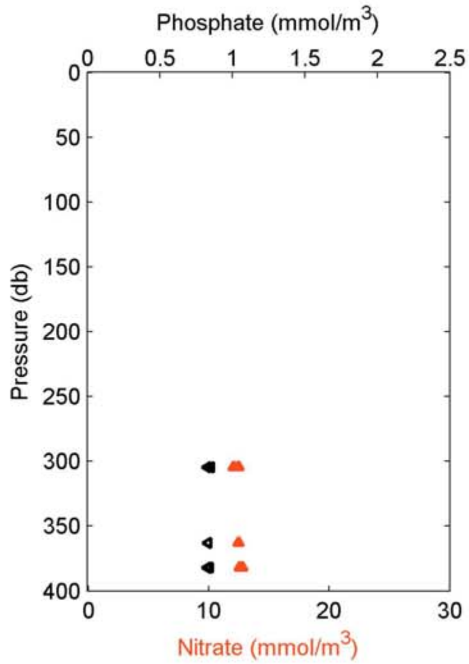
2006-18: Cast 57 Station CB11 (Canada Basin)

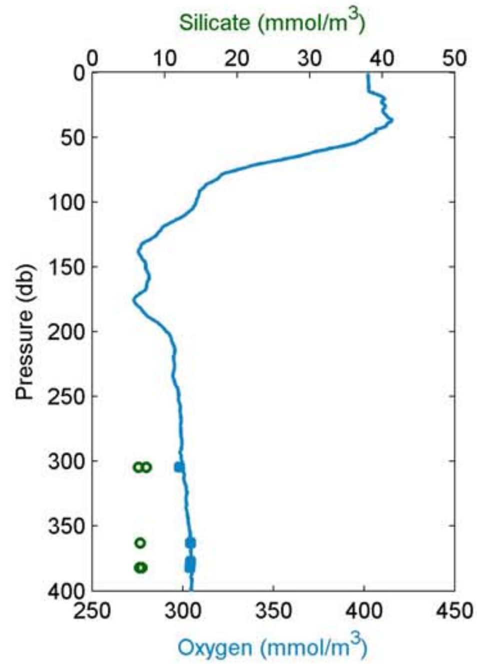


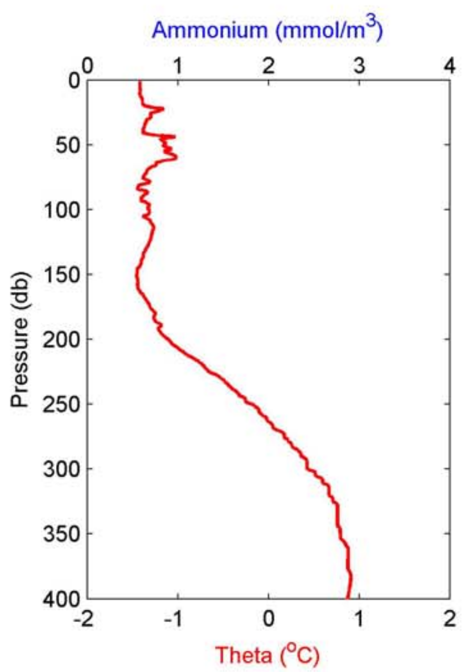
2006-18: Cast 58 Station CB12 (Canada Basin)

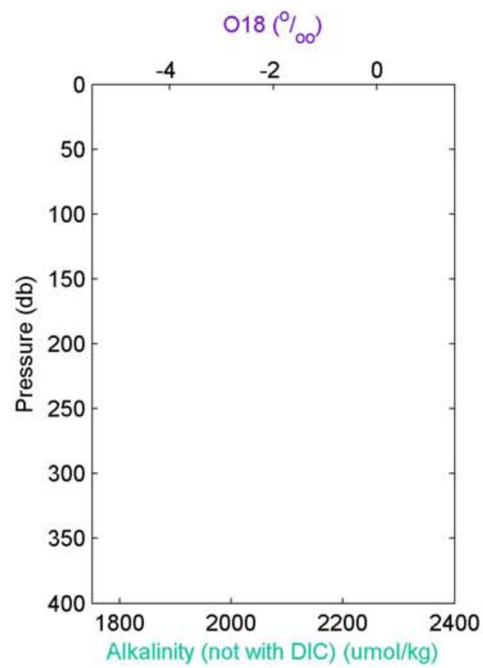


2006-18: Cast 58 Station CB12 (Canada Basin)

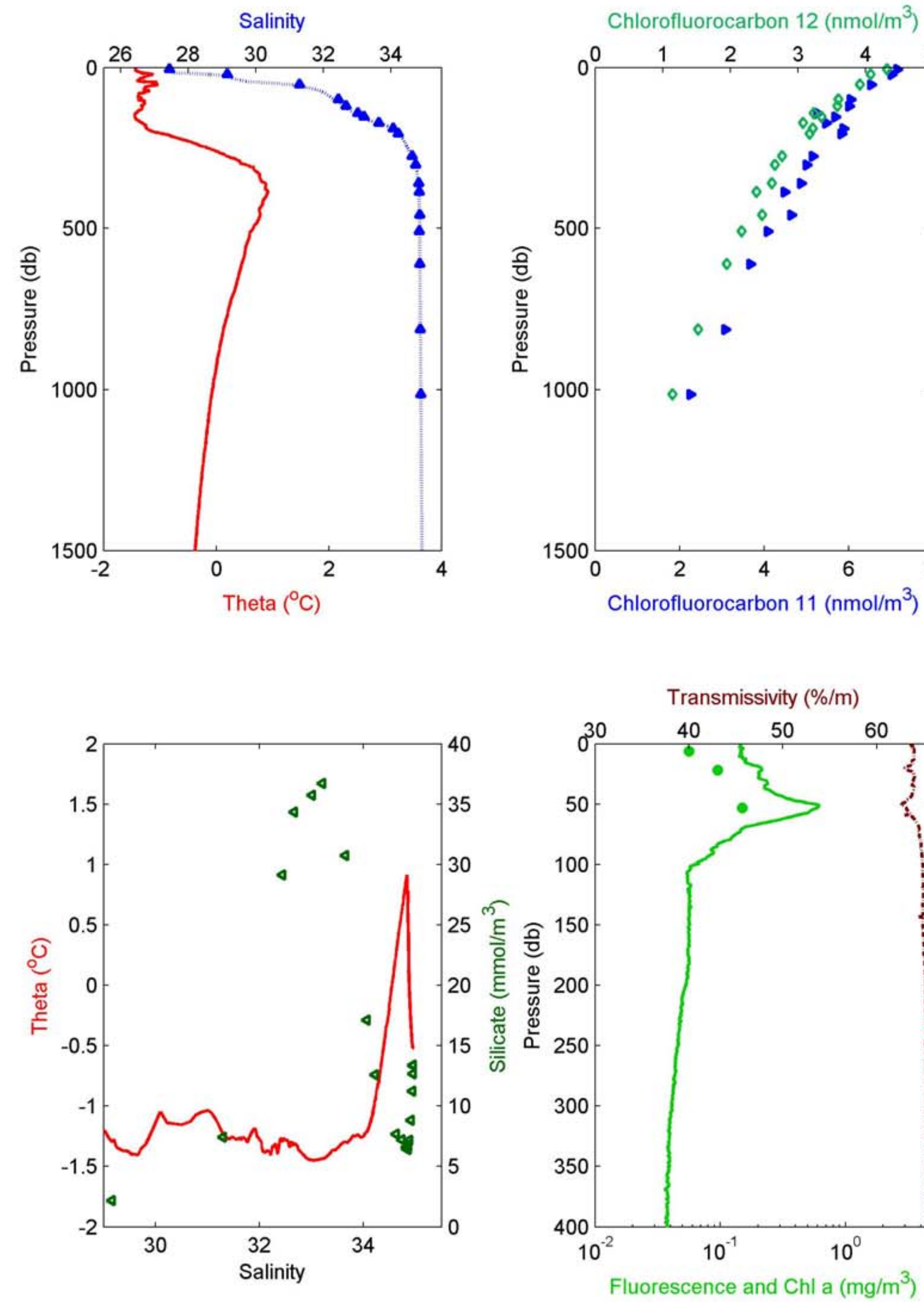




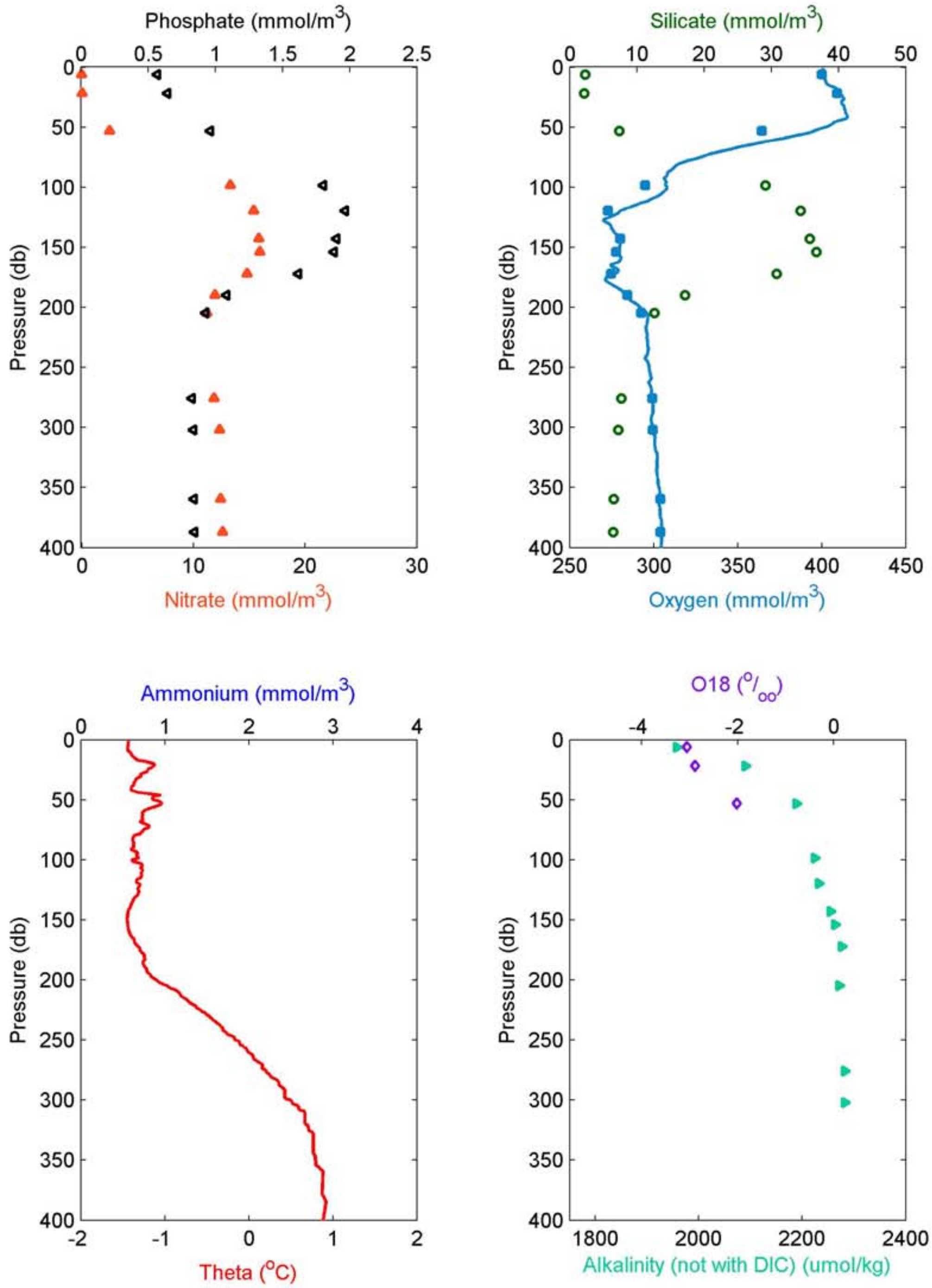




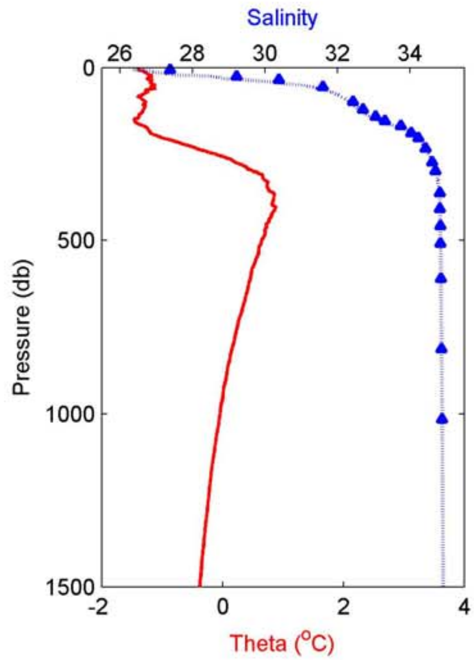
2006-18: Cast 59 Station CB12 (Canada Basin)

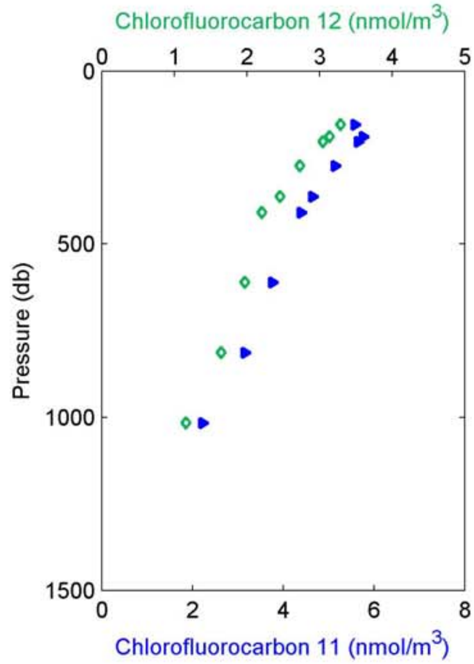


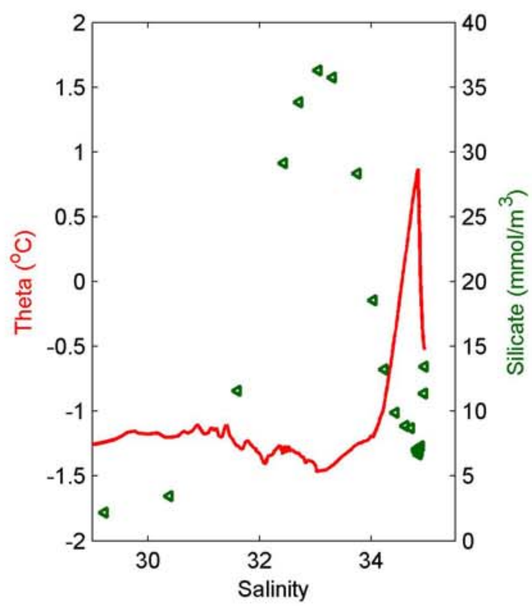
2006-18: Cast 59 Station CB12 (Canada Basin)

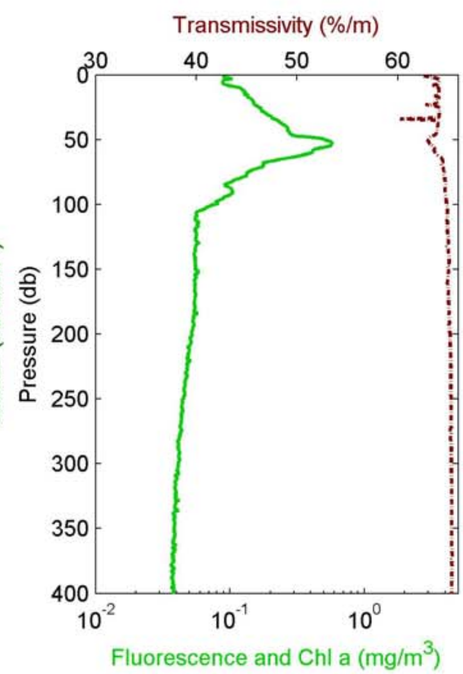


2006-18: Cast 60 Station CB-13 (Canada Basin)

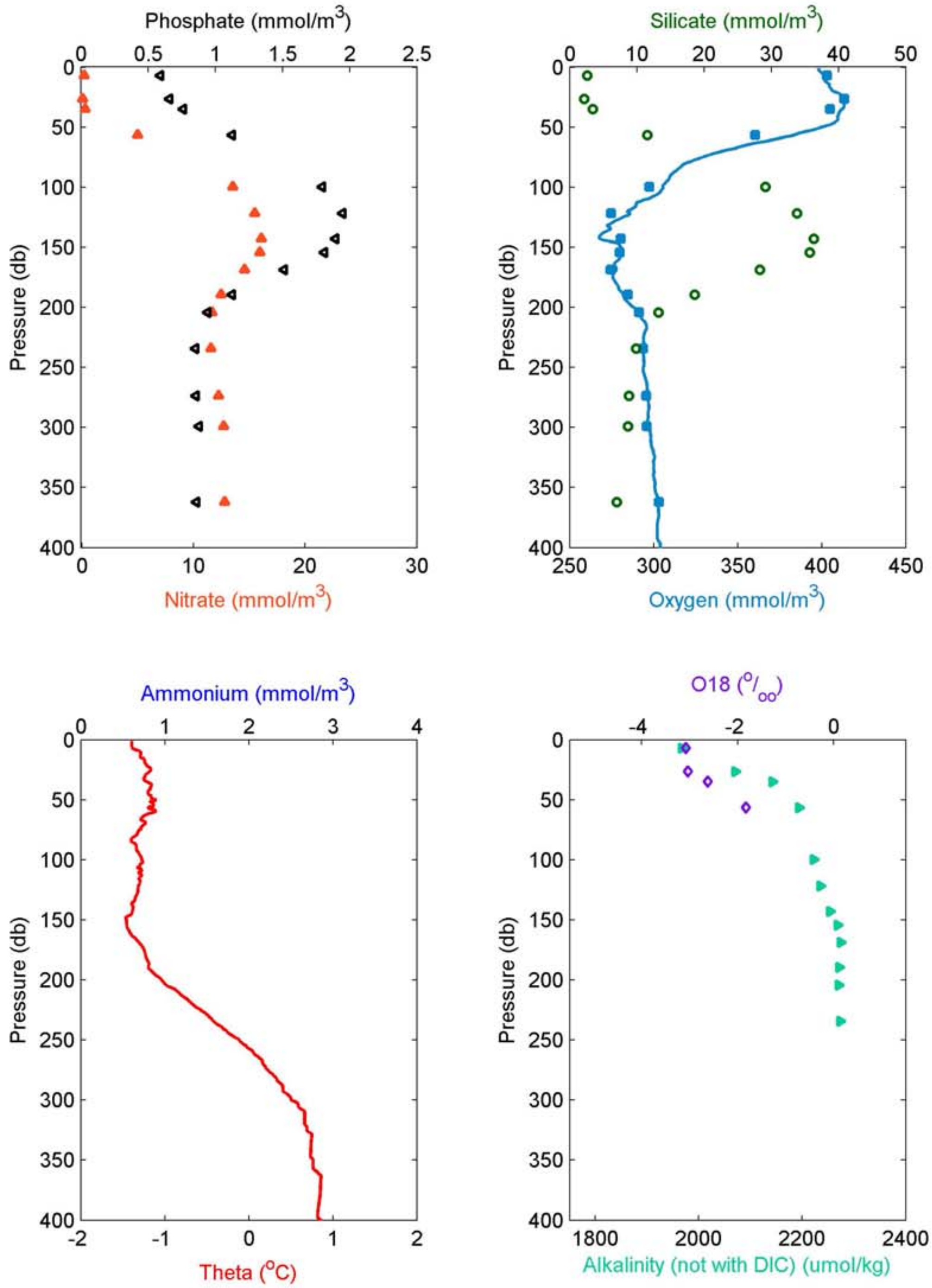




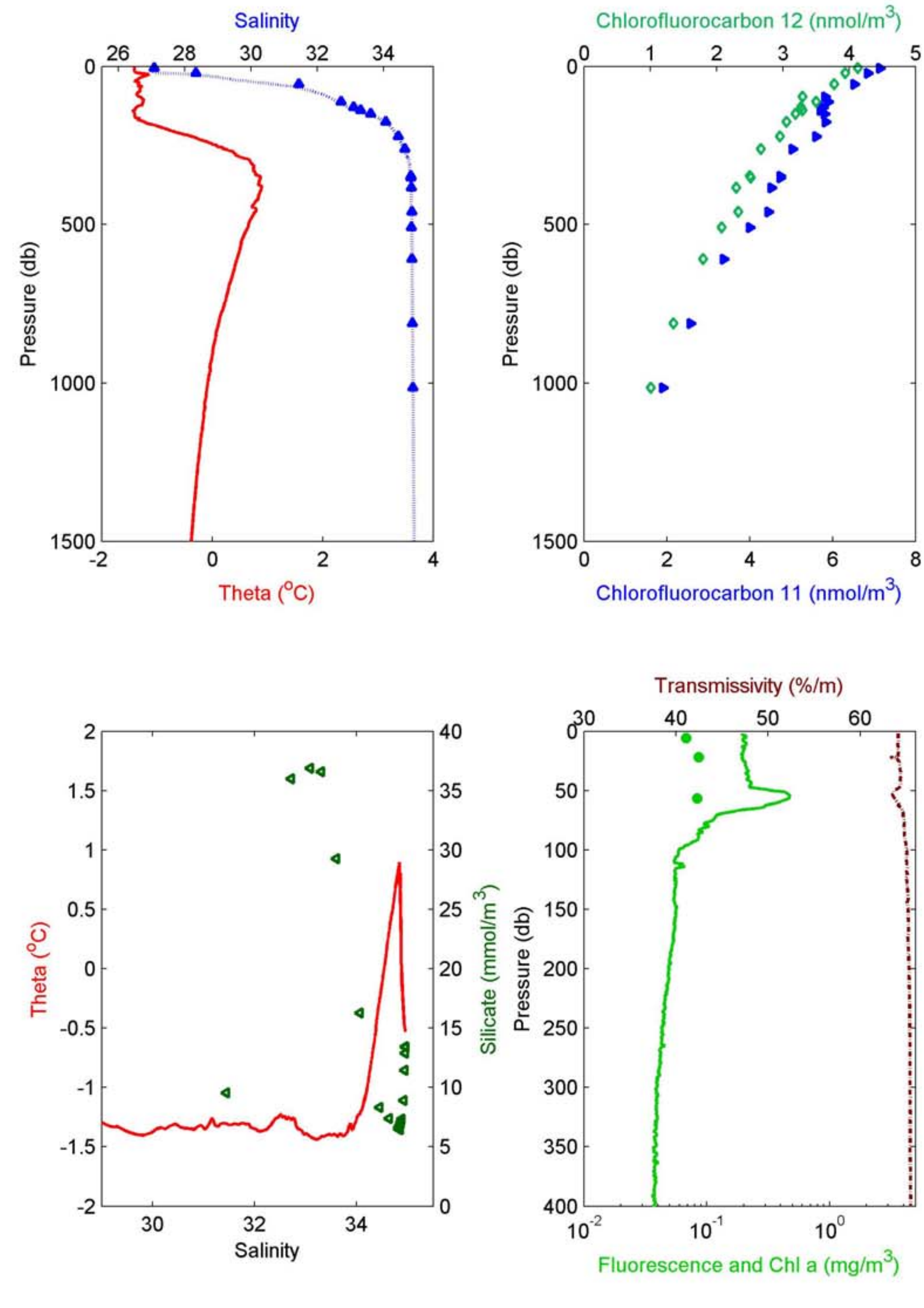




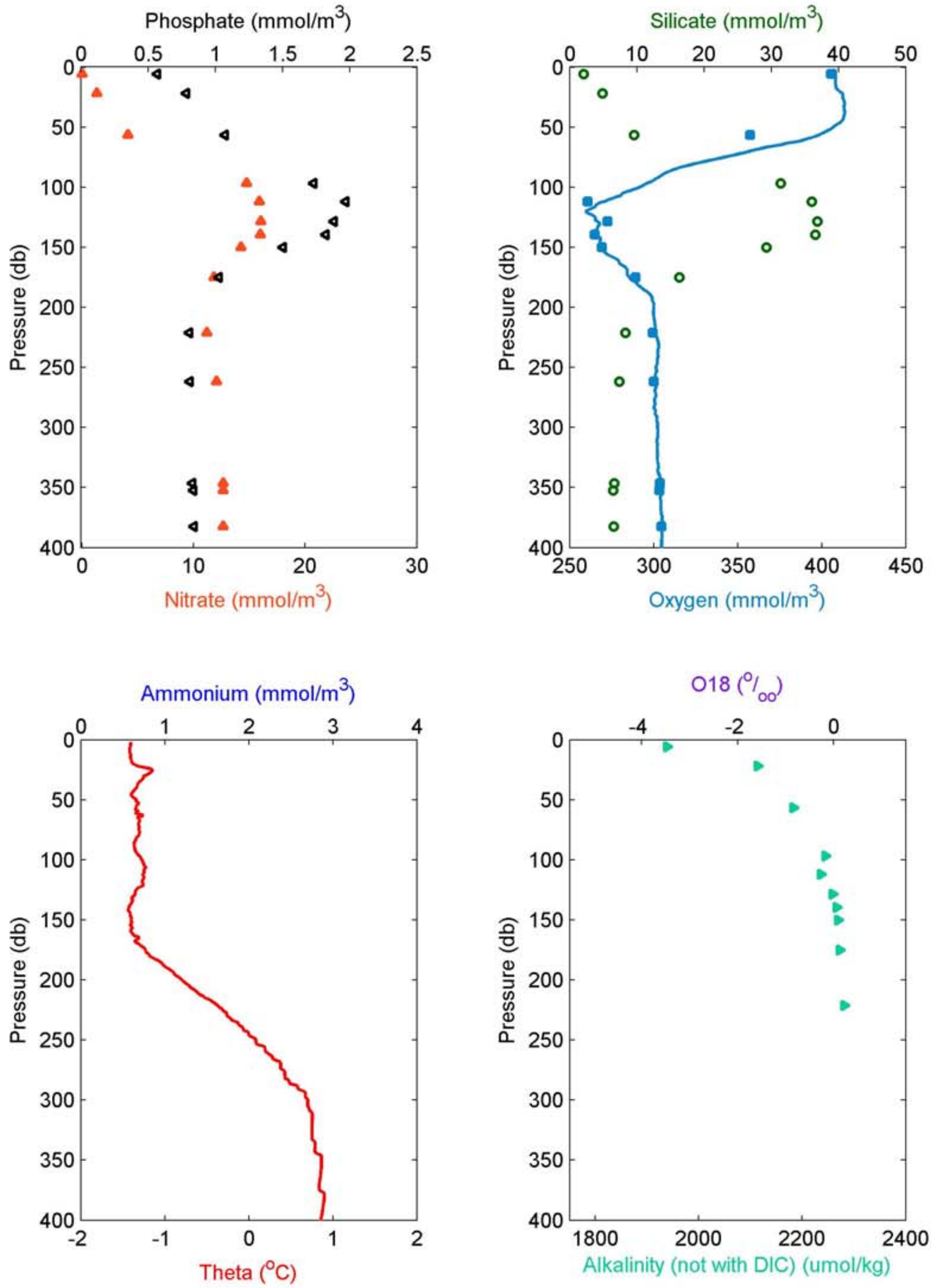
2006-18: Cast 60 Station CB-13 (Canada Basin)



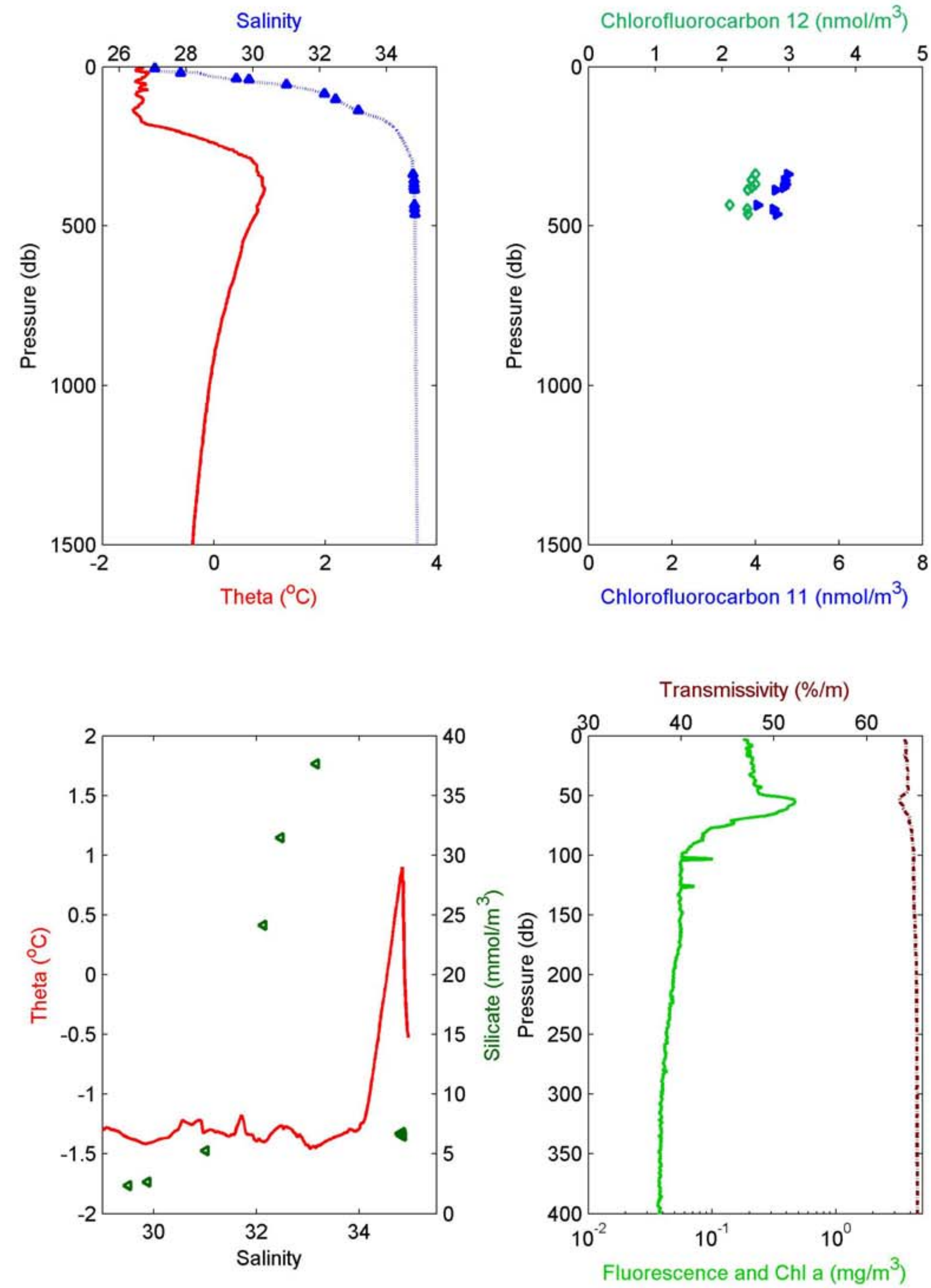
2006-18: Cast 61 Station CB-16 (Canada Basin)



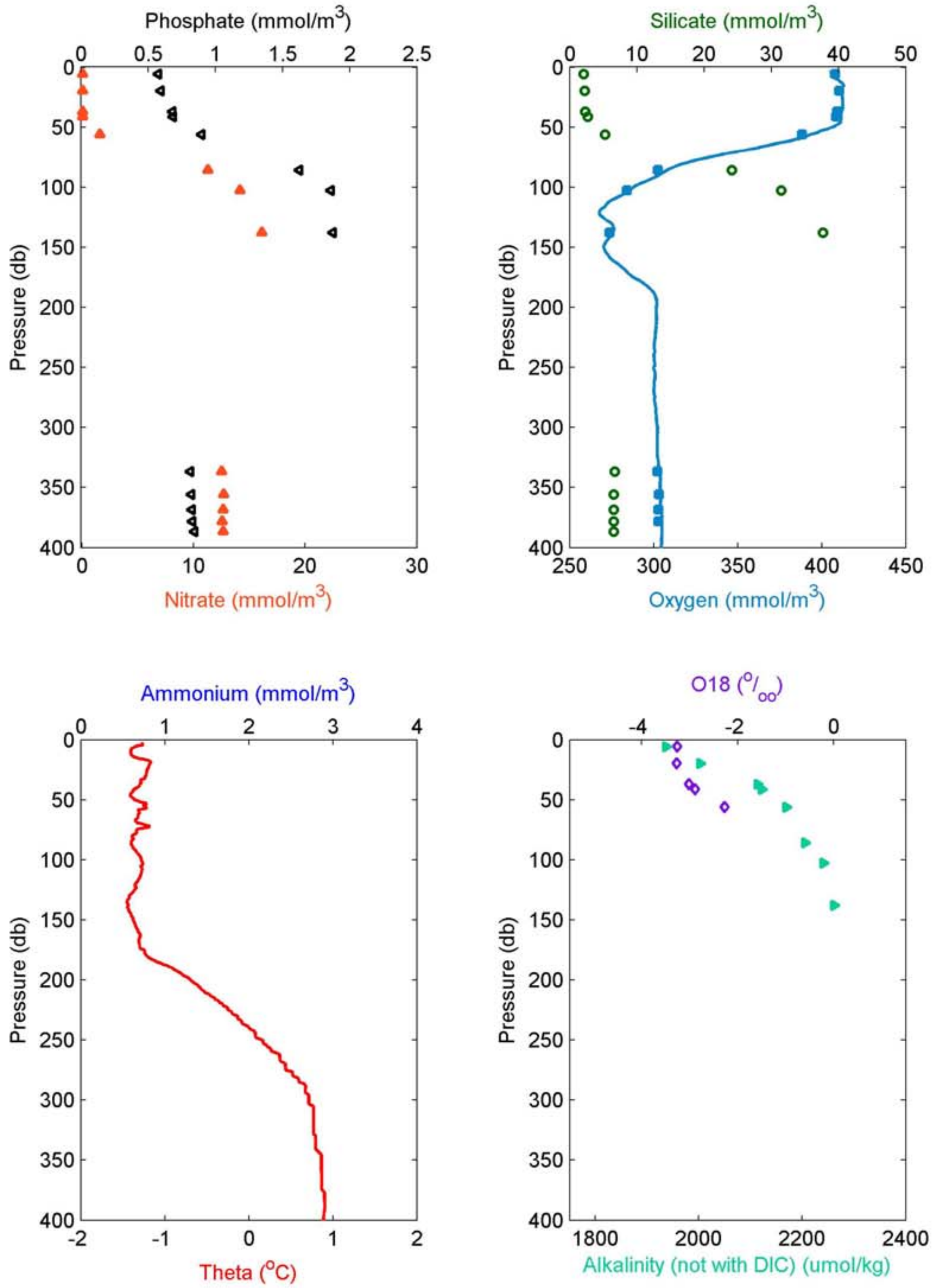
2006-18: Cast 61 Station CB-16 (Canada Basin)



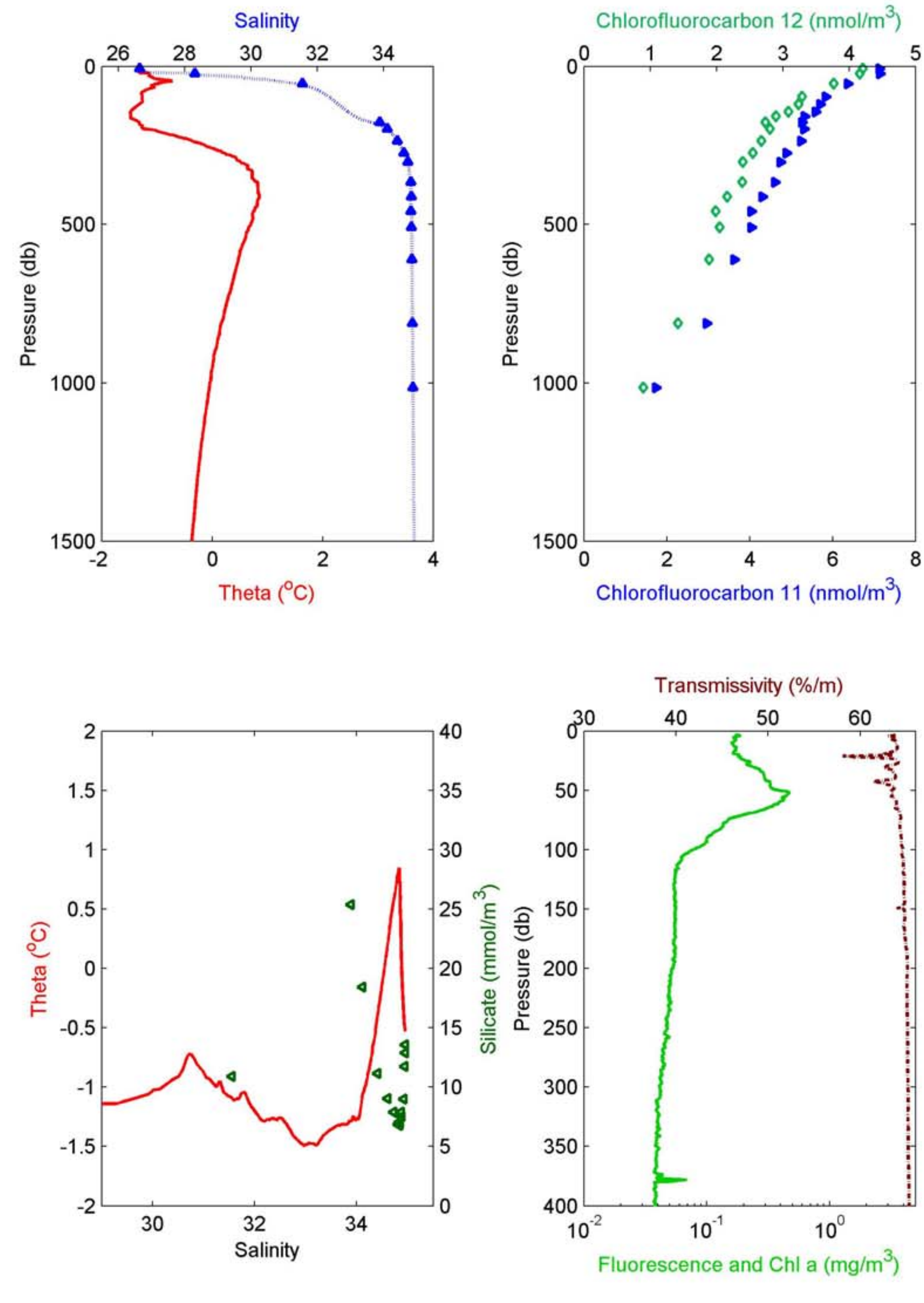
2006-18: Cast 62 Station CB-16 (Canada Basin)



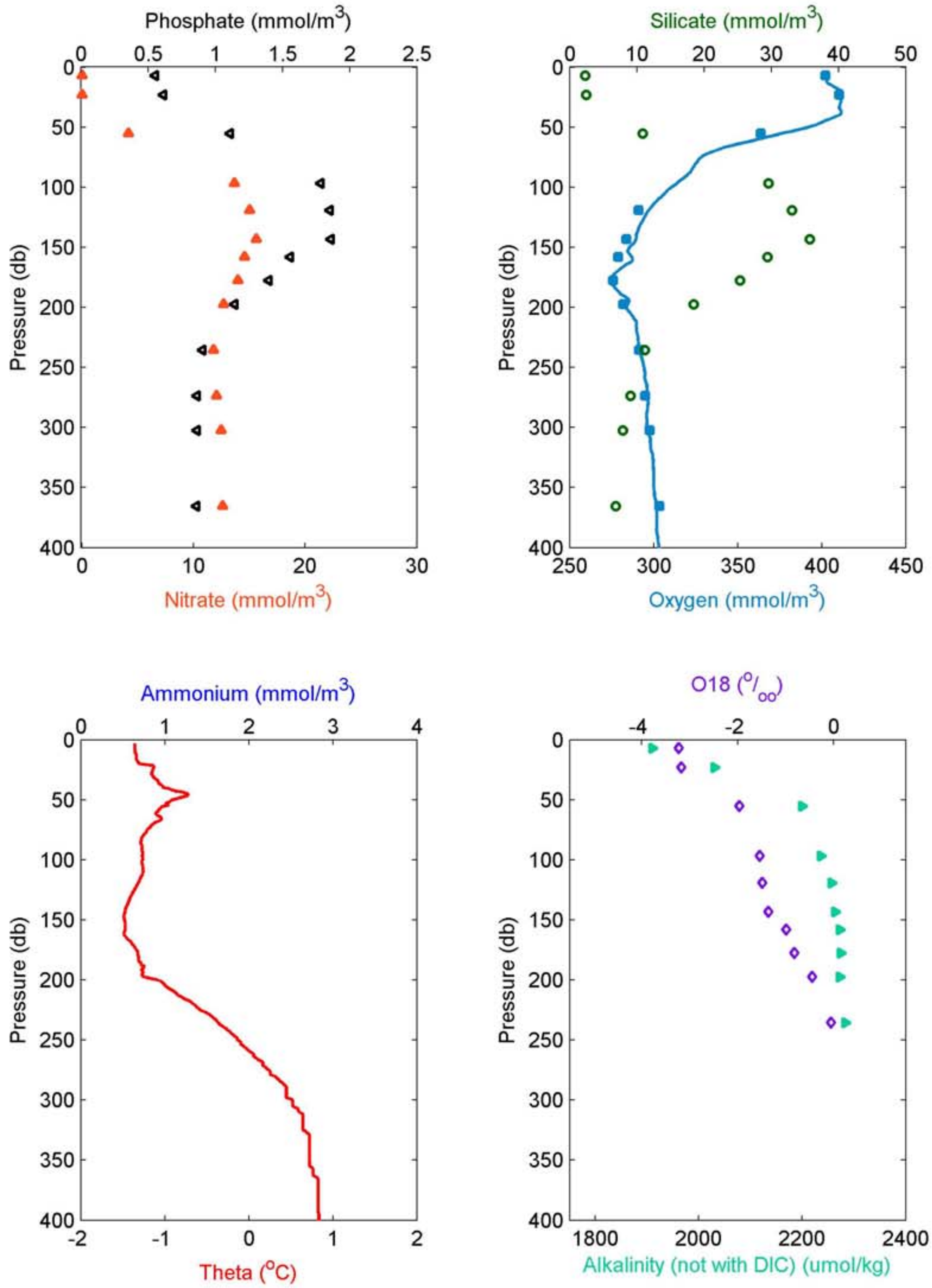
2006-18: Cast 62 Station CB-16 (Canada Basin)



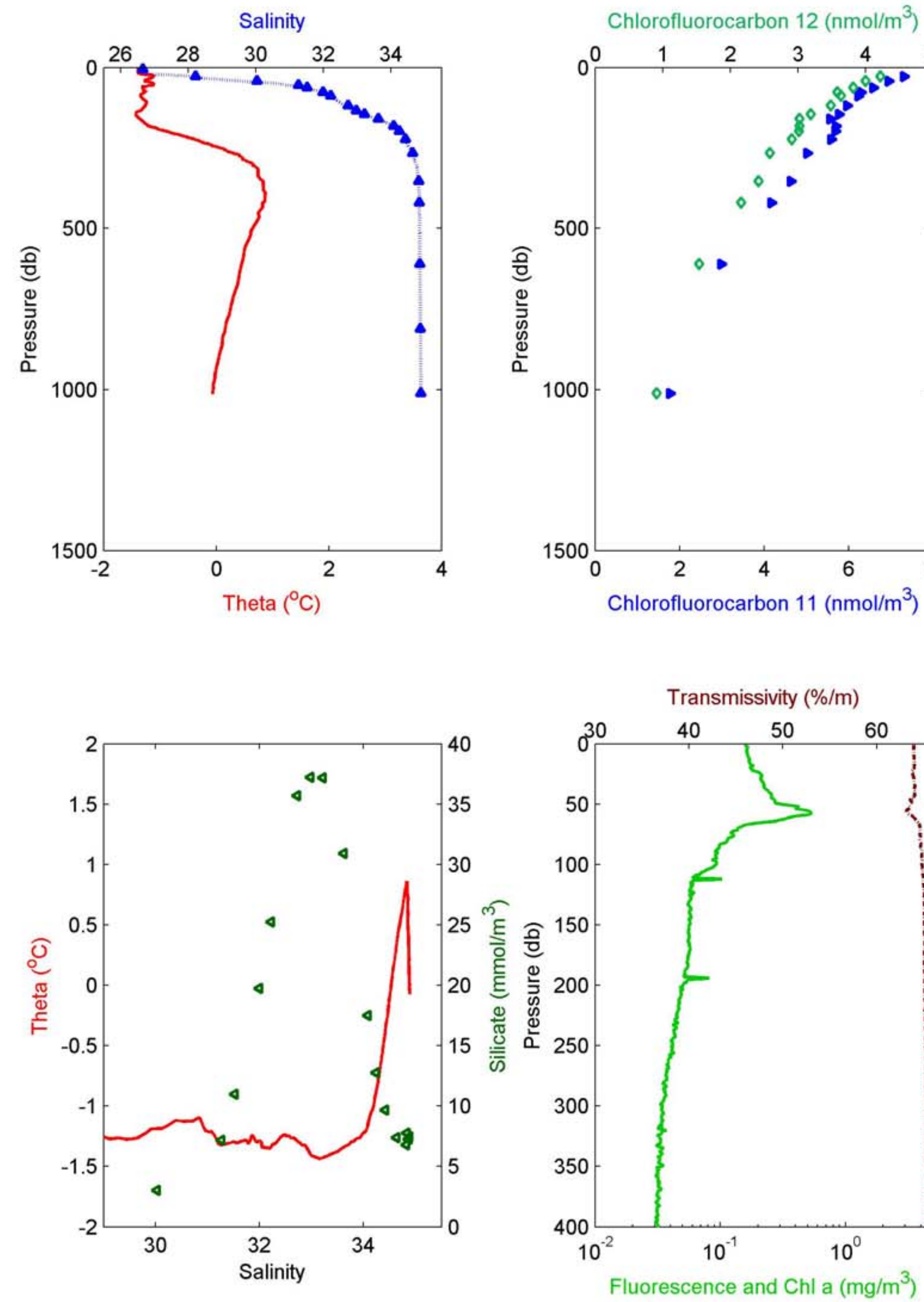
2006-18: Cast 63 Station CB-15 (Canada Basin)



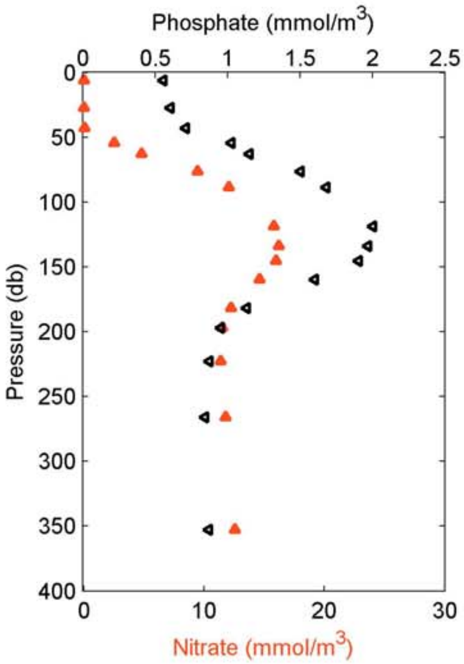
2006-18: Cast 63 Station CB-15 (Canada Basin)

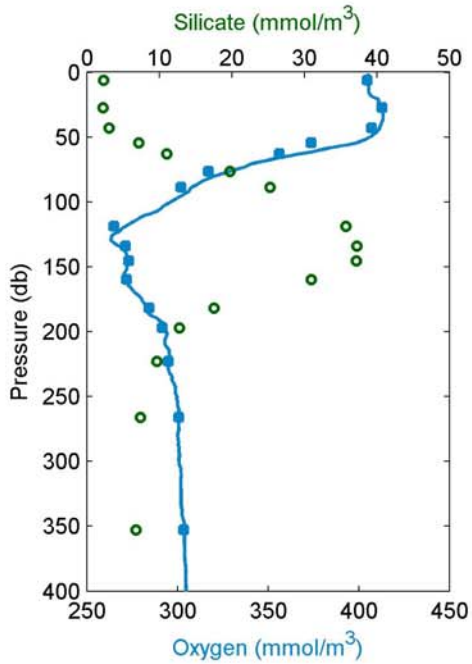


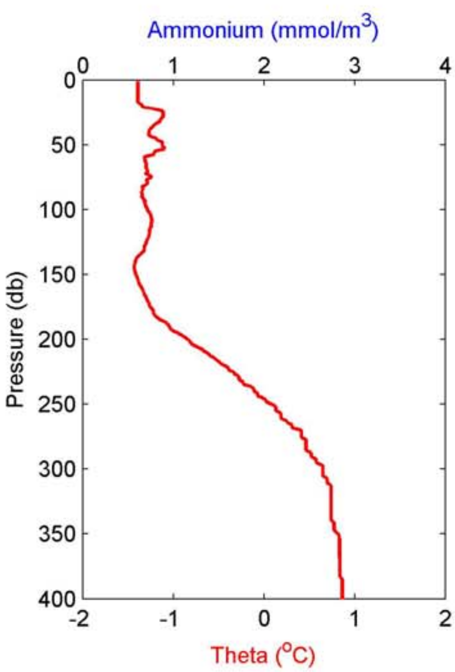
2006-18: Cast 64 Station CB14a (Canada Basin)

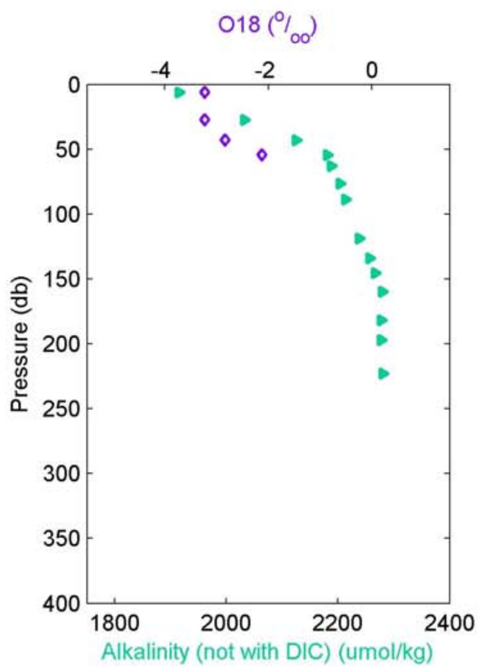


2006-18: Cast 64 Station CB14a (Canada Basin)

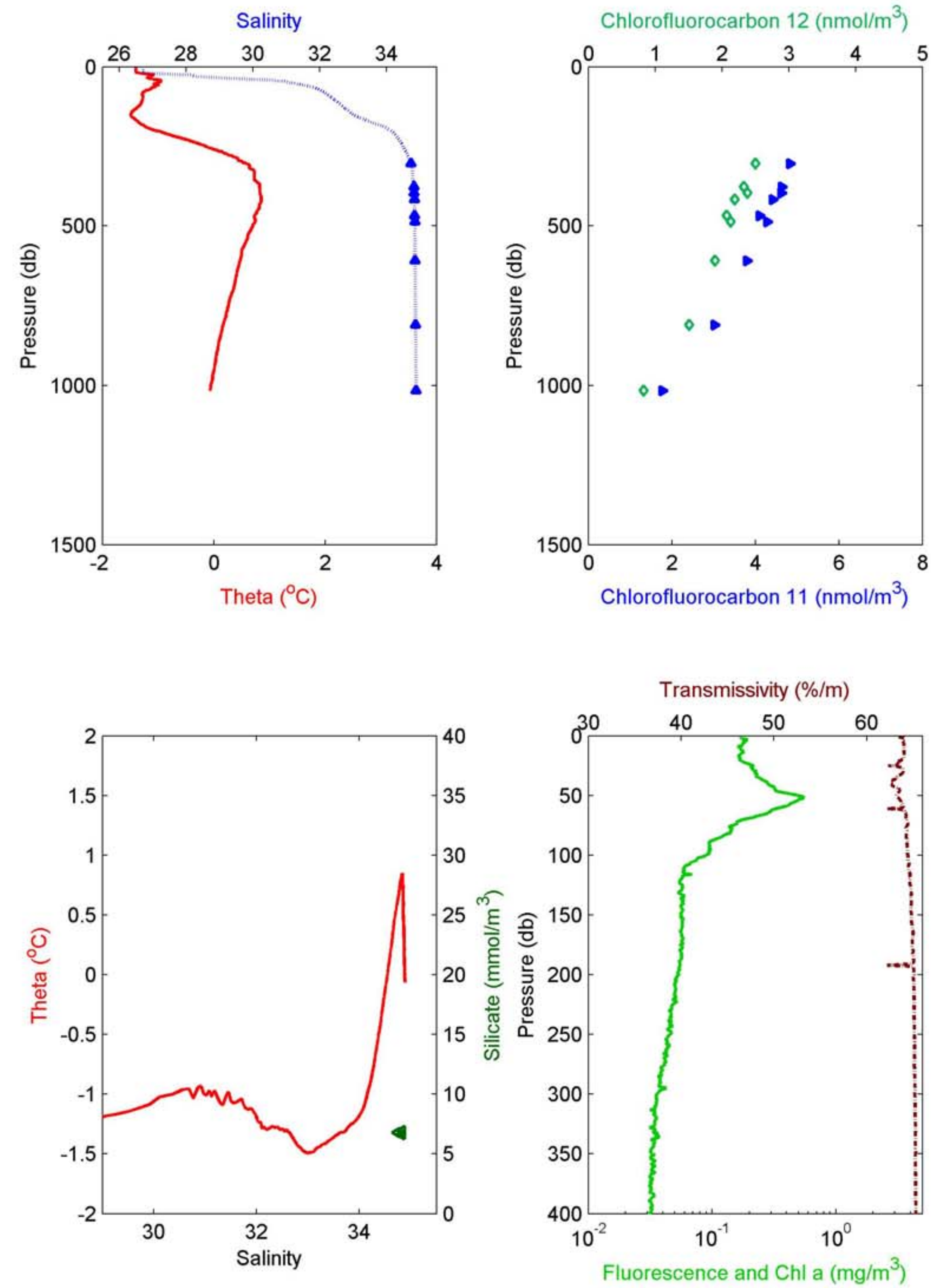




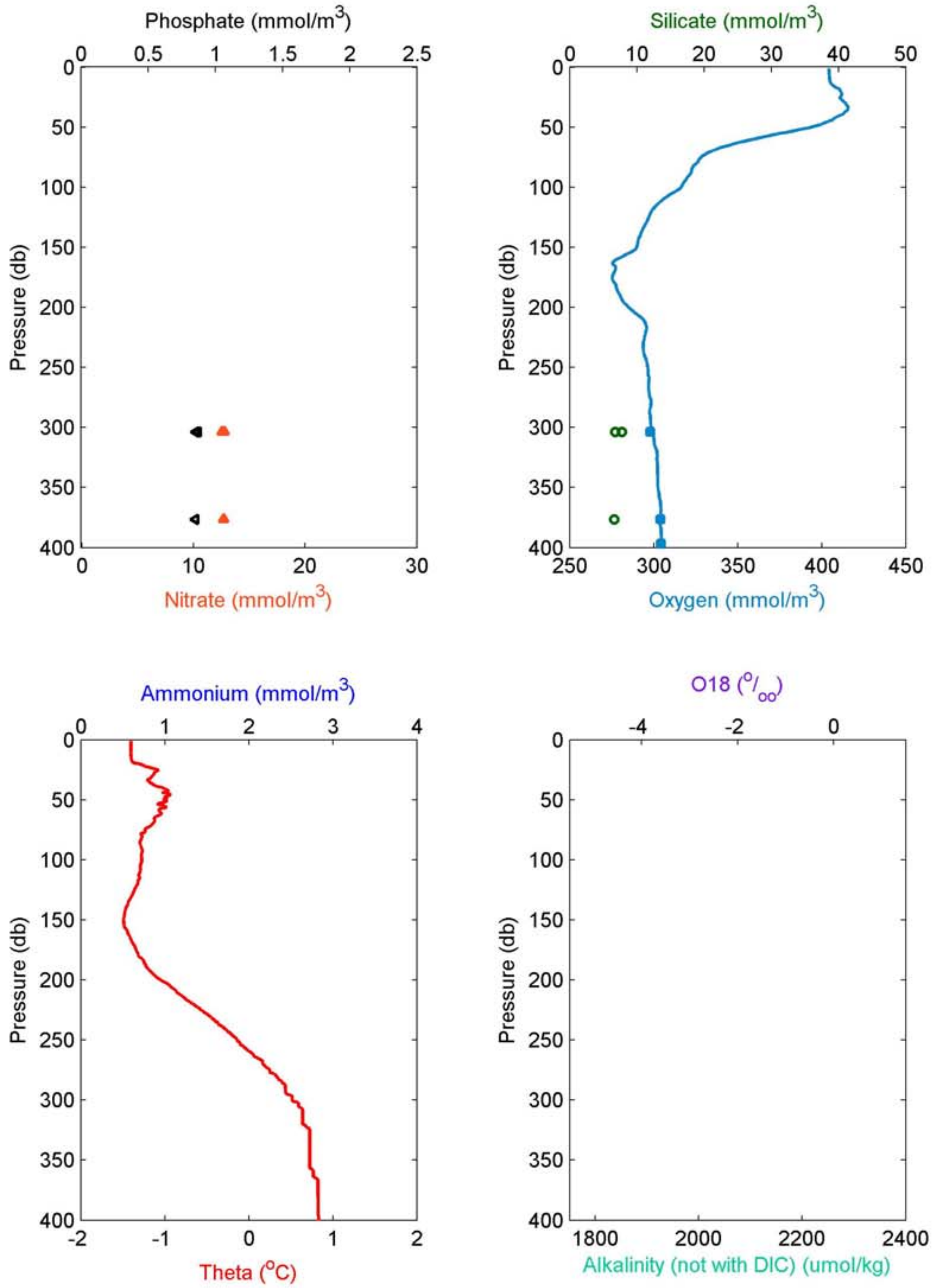




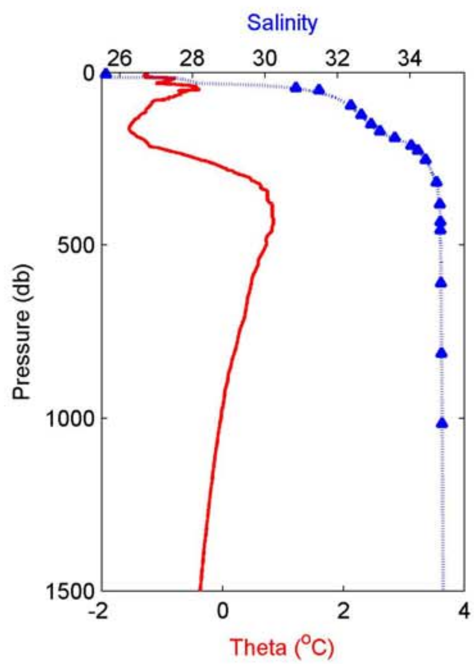
2006-18: Cast 65 Station CB15 (Canada Basin)

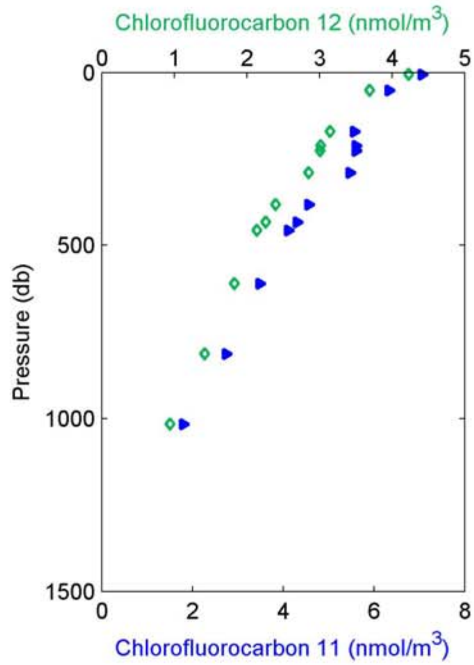


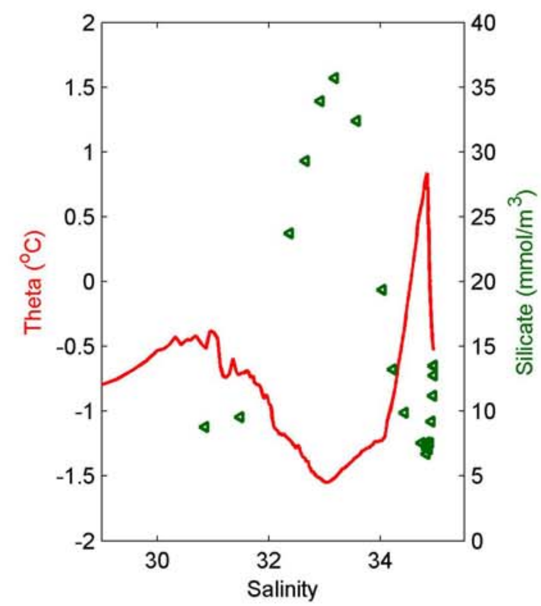
2006-18: Cast 65 Station CB15 (Canada Basin)

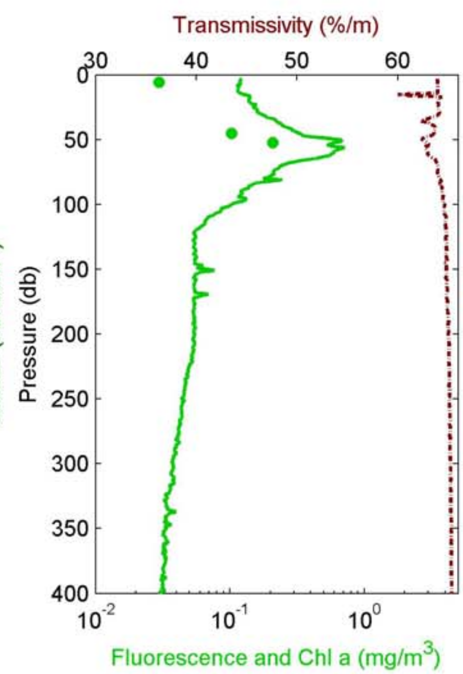


2006-18: Cast 66 Station CB17 (Canada Basin)

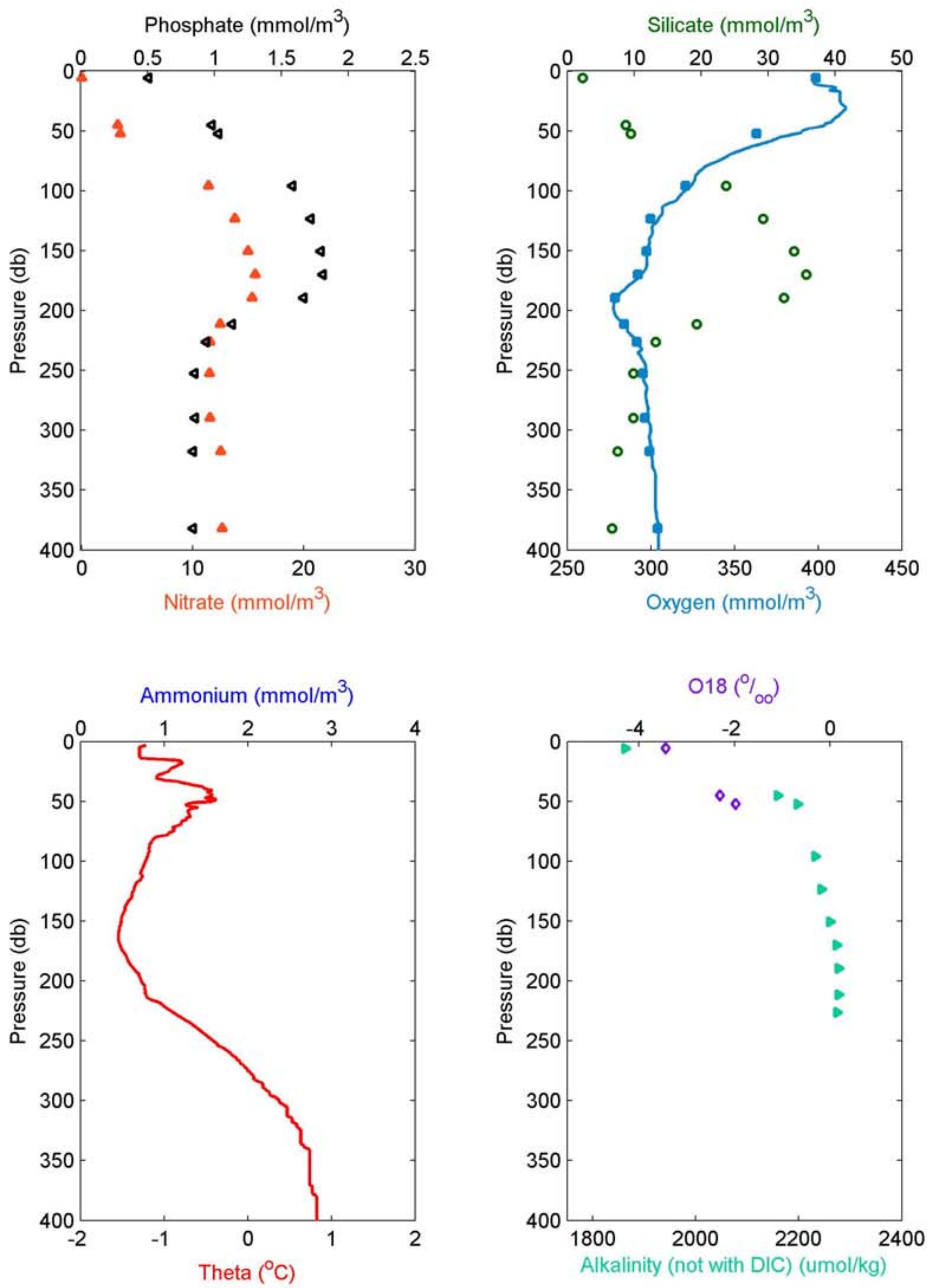




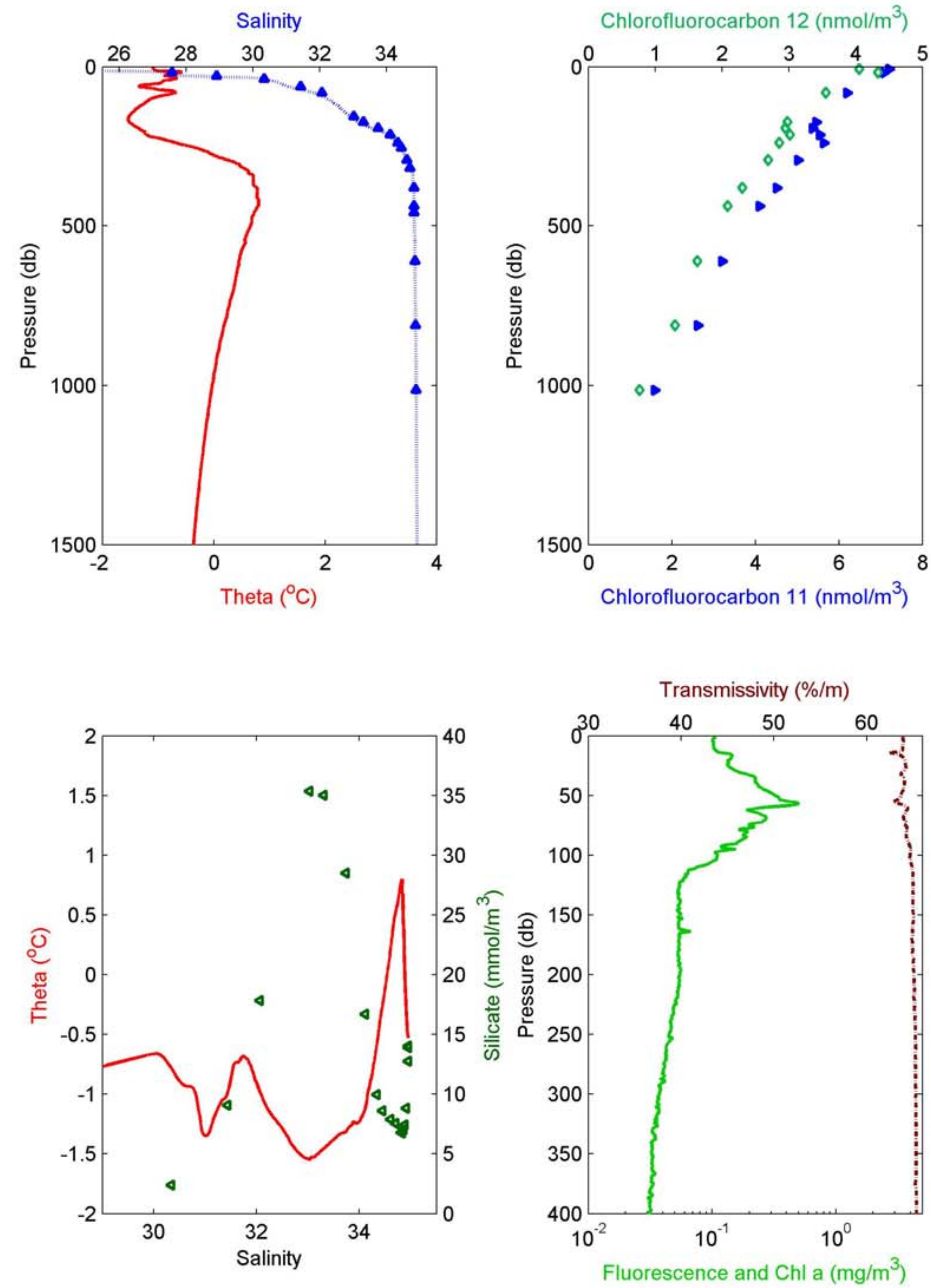




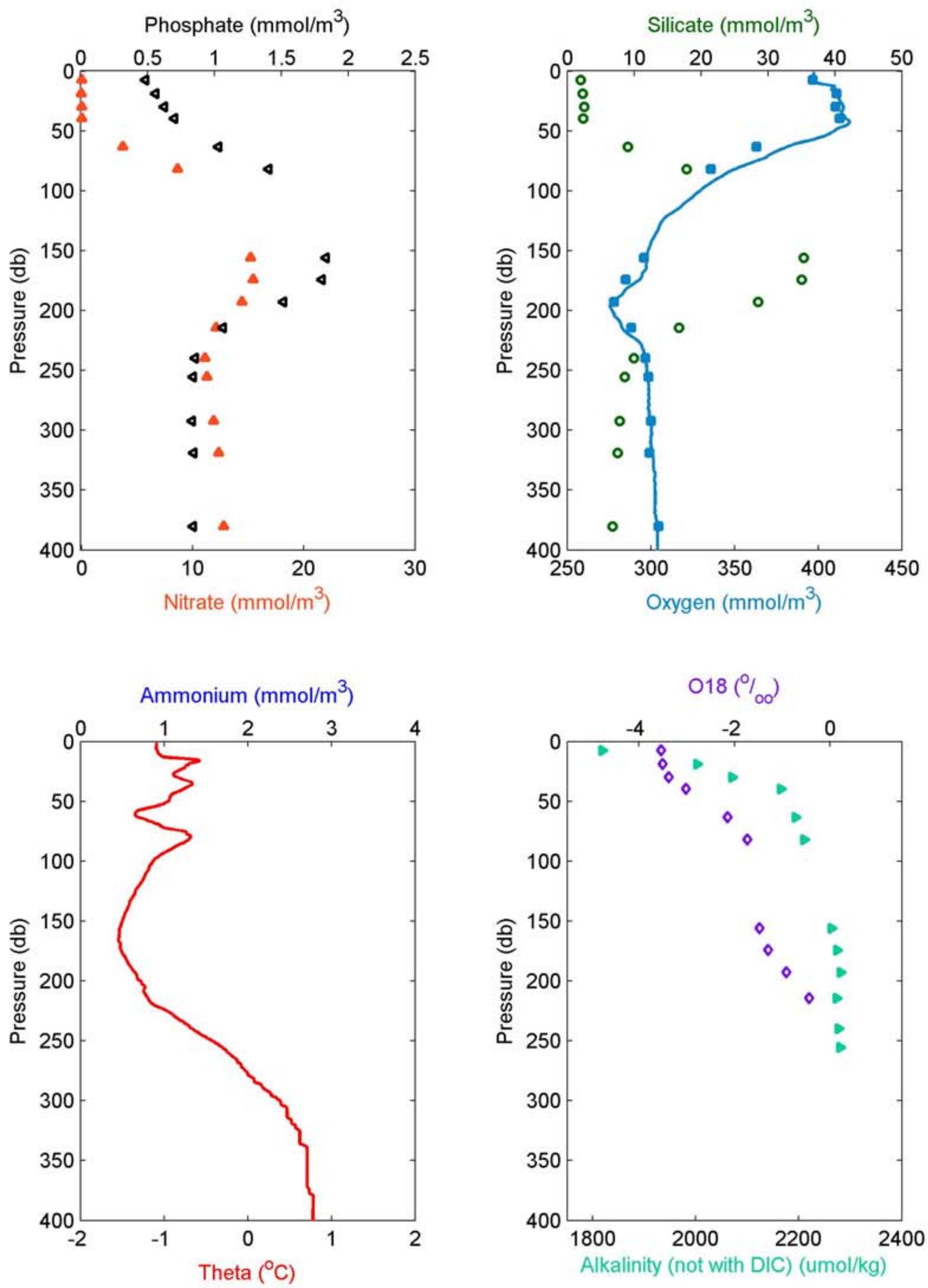
2006-18: Cast 66 Station CB17 (Canada Basin)



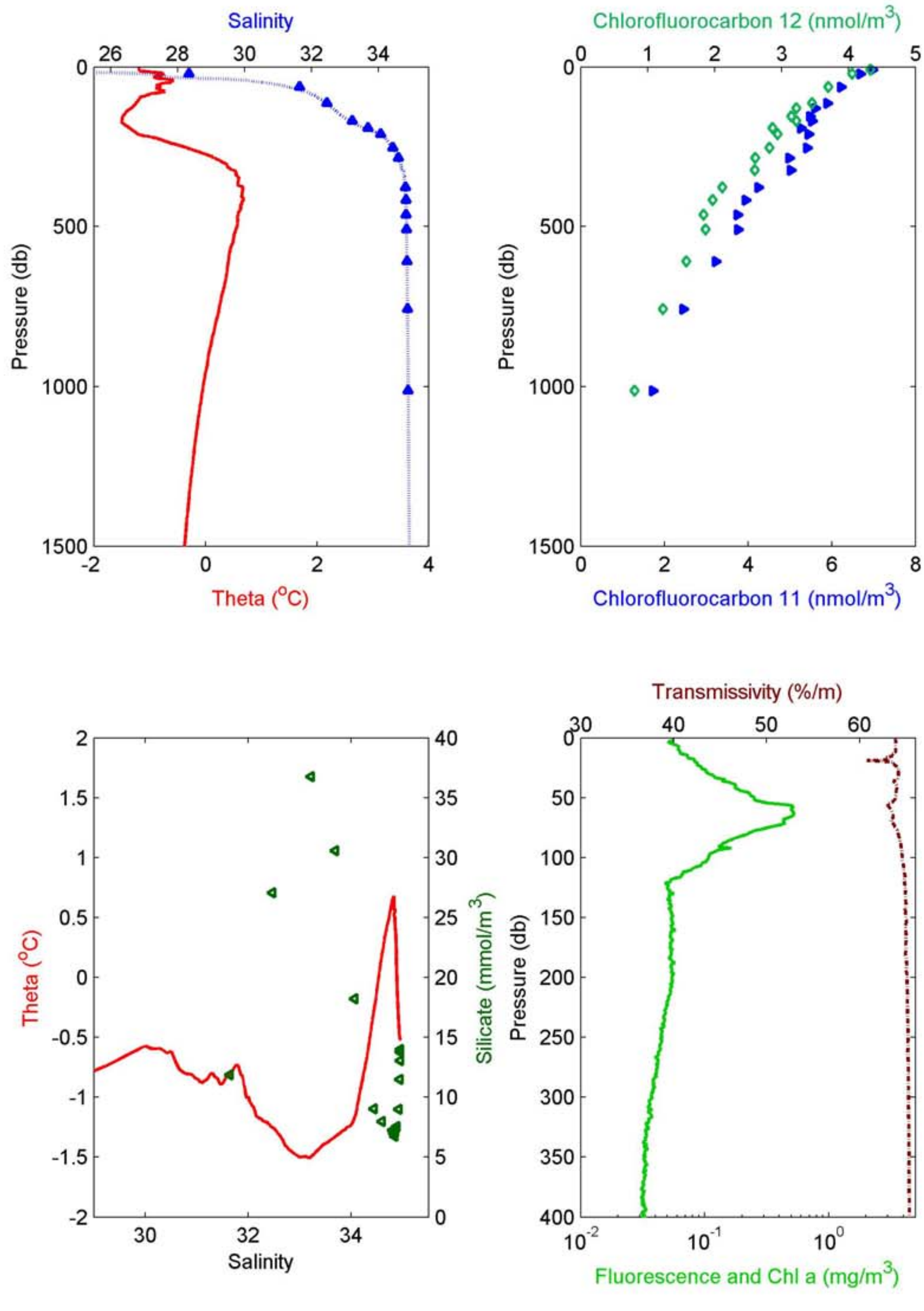
2006-18: Cast 67 Station CB18 (Canada Basin)

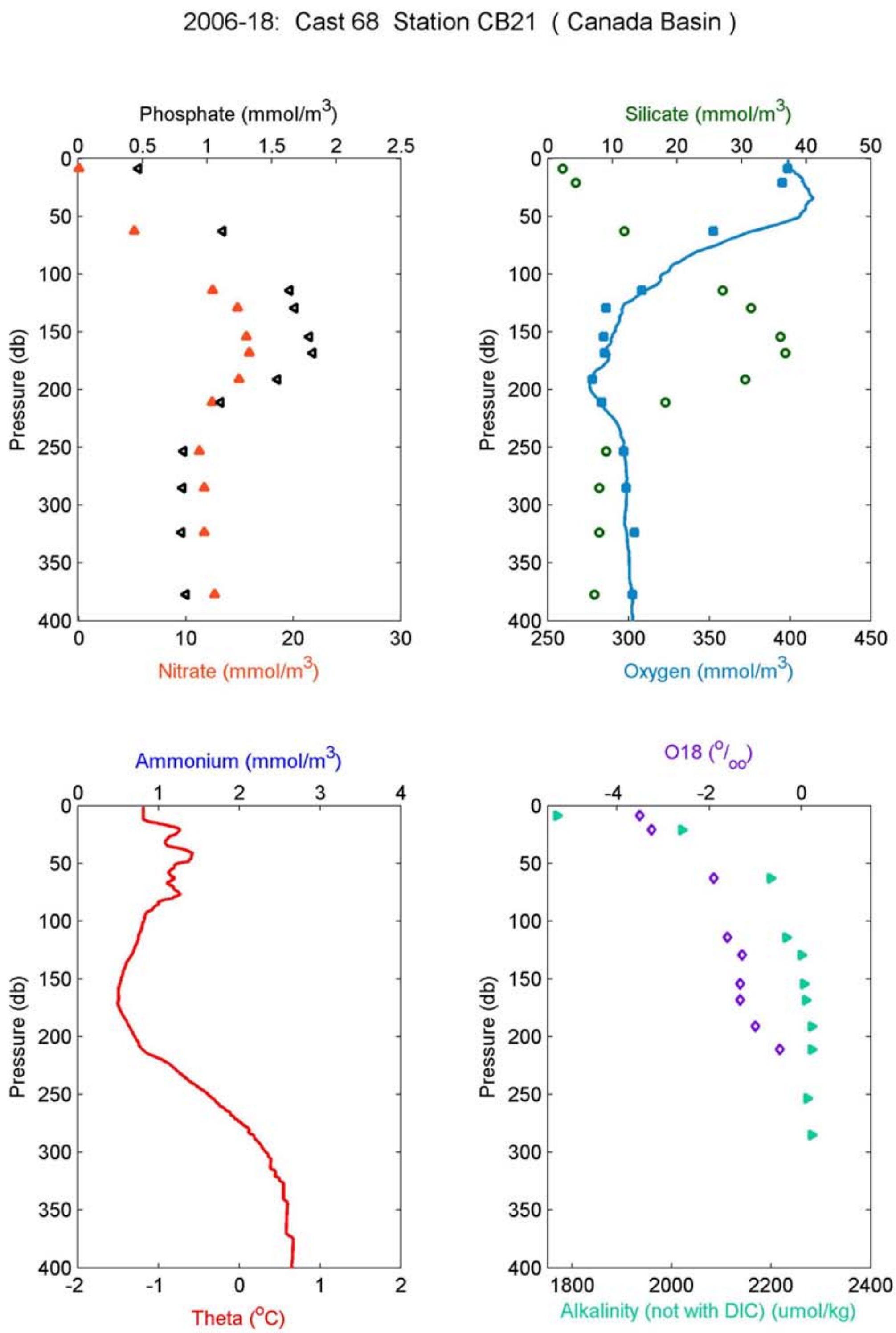


2006-18: Cast 67 Station CB18 (Canada Basin)

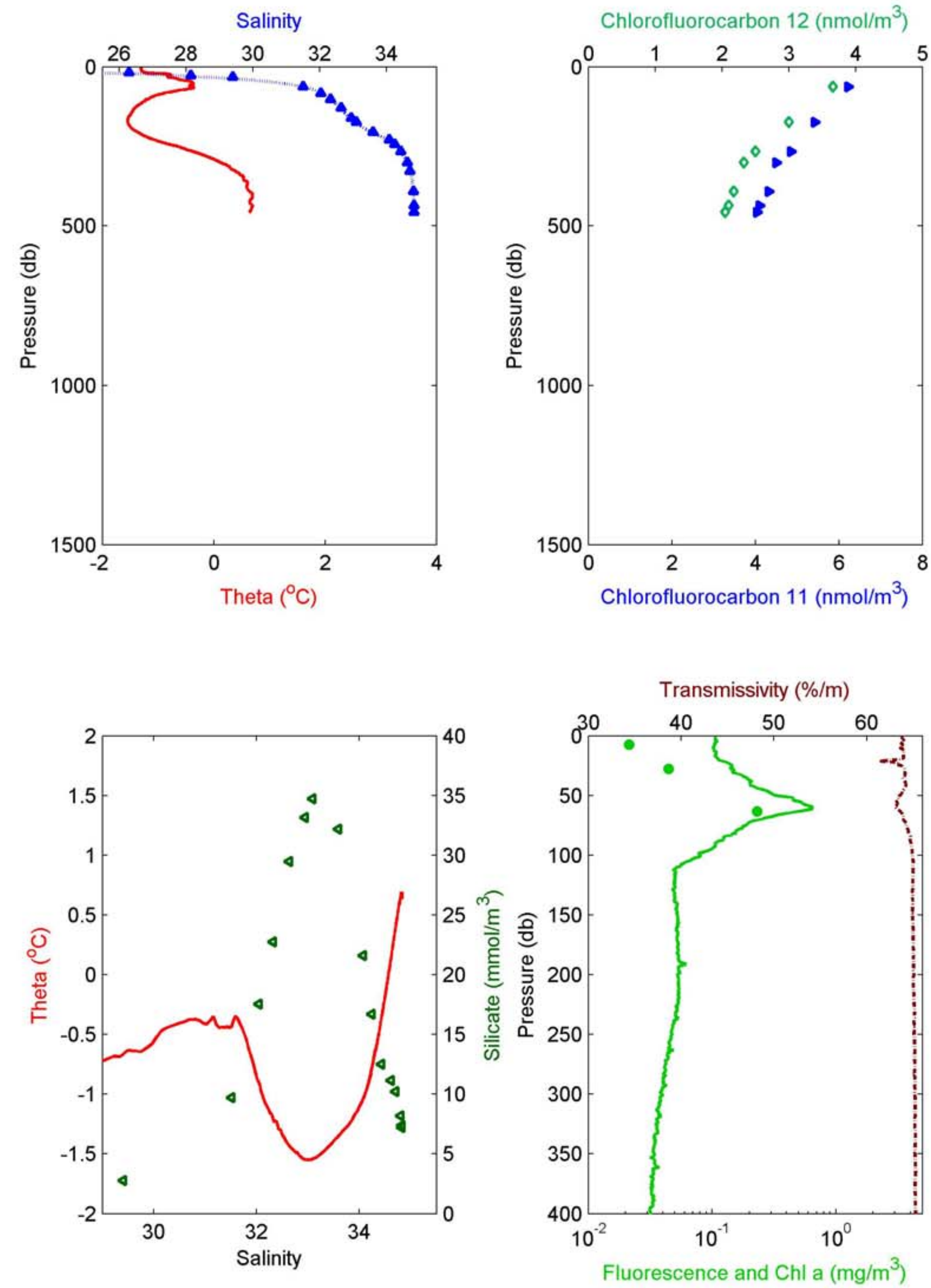


2006-18: Cast 68 Station CB21 (Canada Basin)

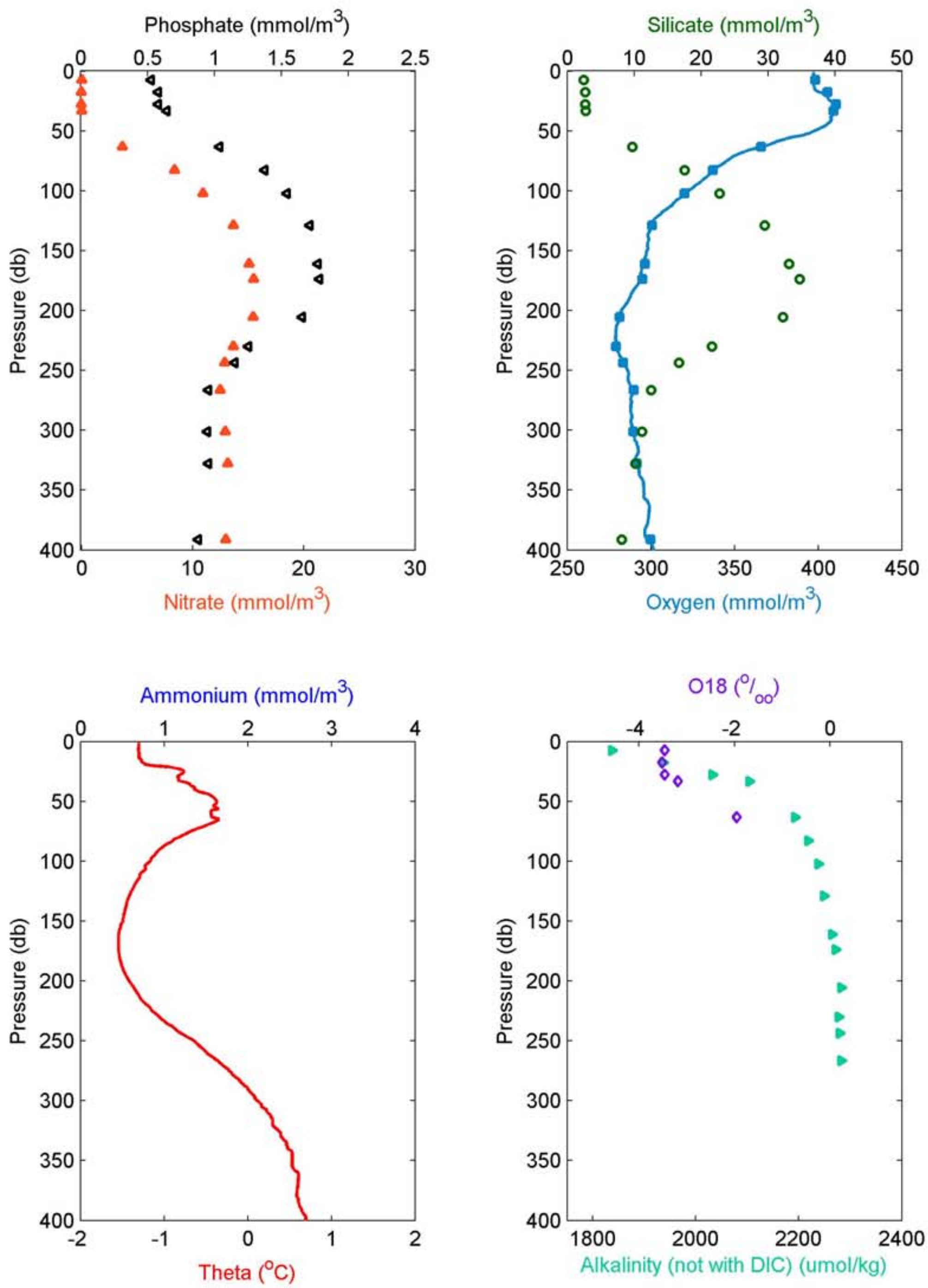



2006-18: Cast 68 Station CB21 (Canada Basin)
Phosphate (mmol/m^3)
Nitrate (mmol/m^3)
Pressure (db)
Silicate (mmol/m^3)
Oxygen (mmol/m^3)
Ammonium (mmol/m^3)
Theta (^{o}C)
O18 ($^o/_{oo}$)
Alkalinity (not with DIC) (umol/kg)

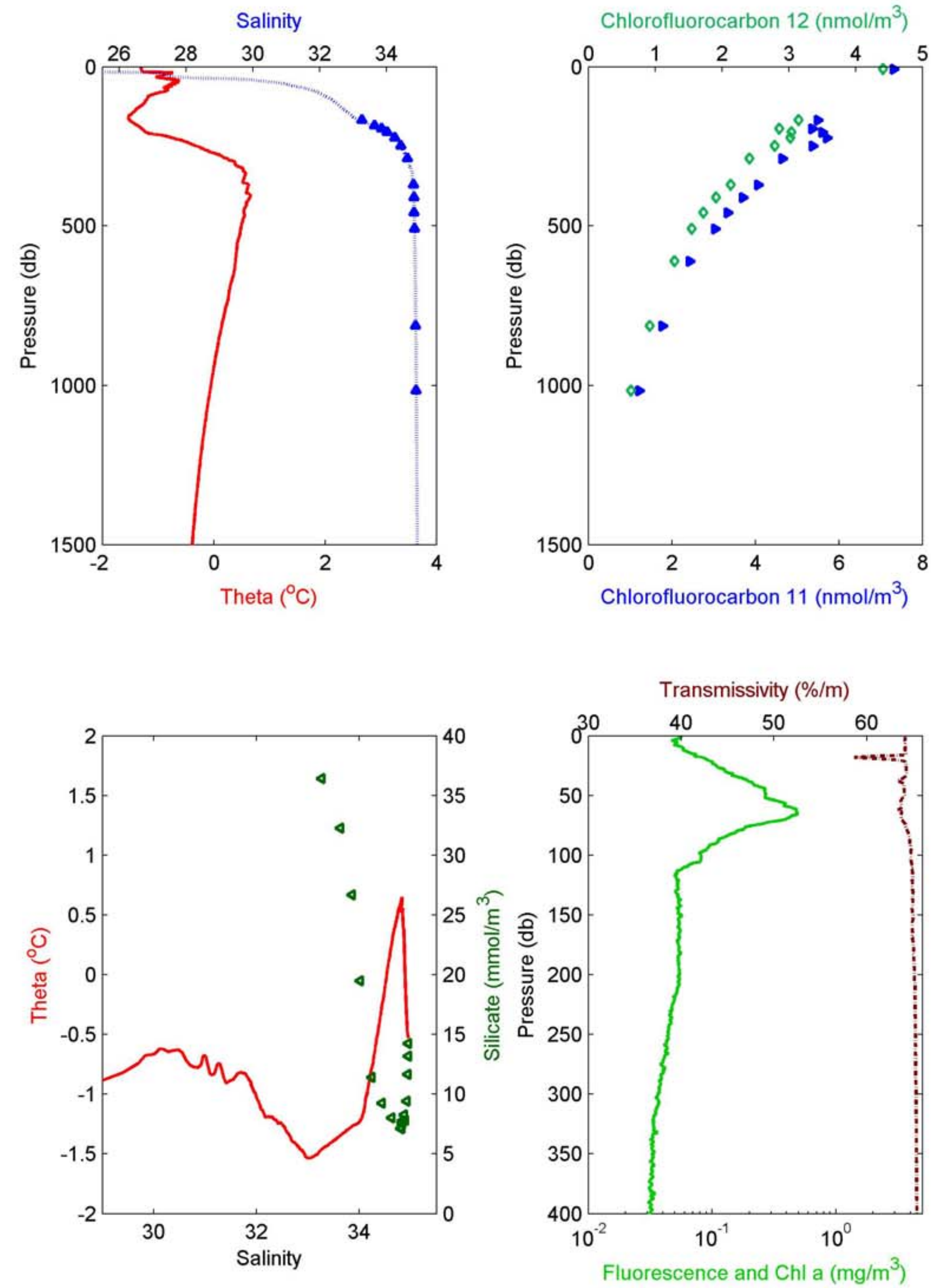
2006-18: Cast 69 Station CB-19 (Canada Basin)



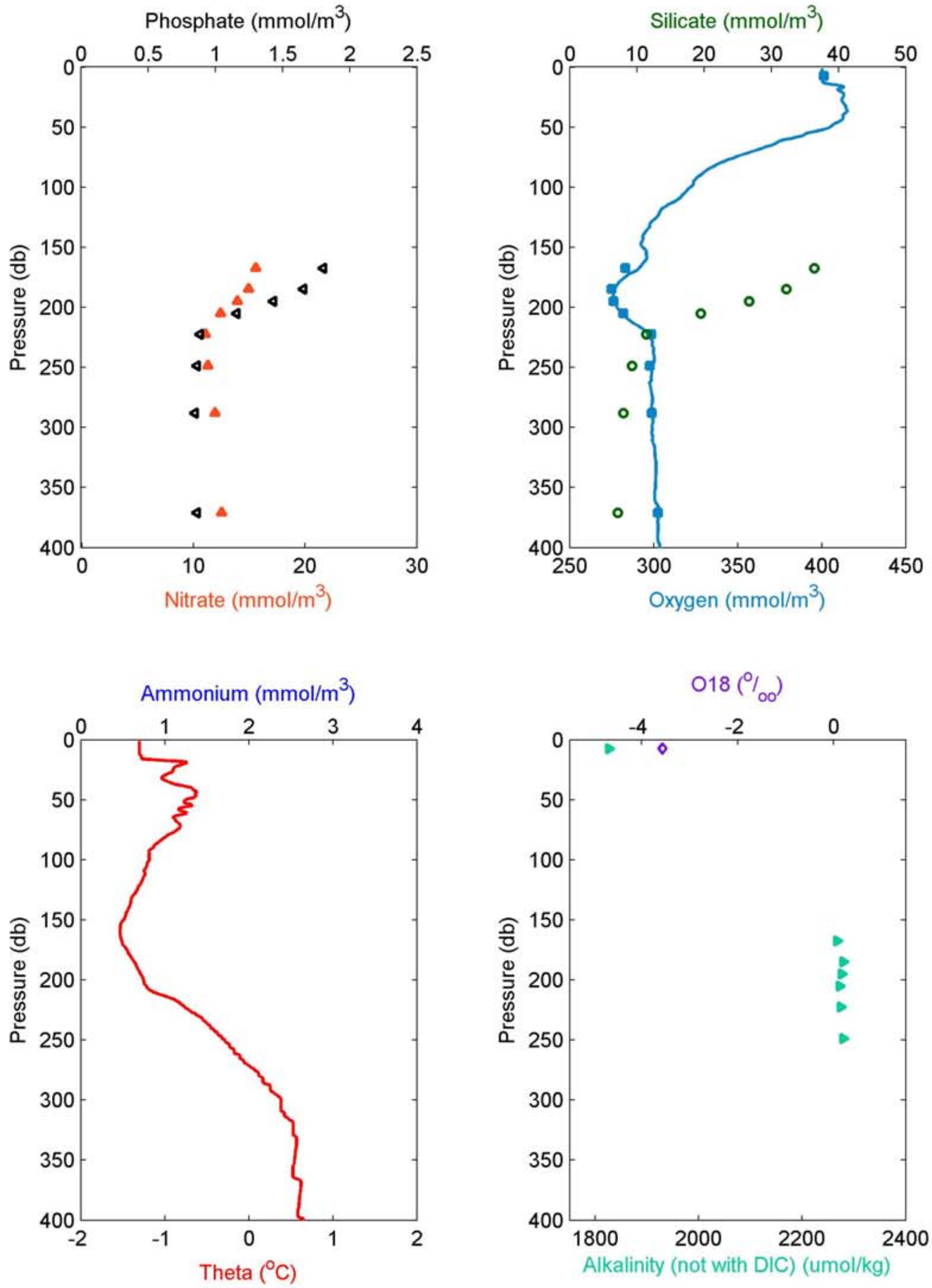
2006-18: Cast 69 Station CB-19 (Canada Basin)



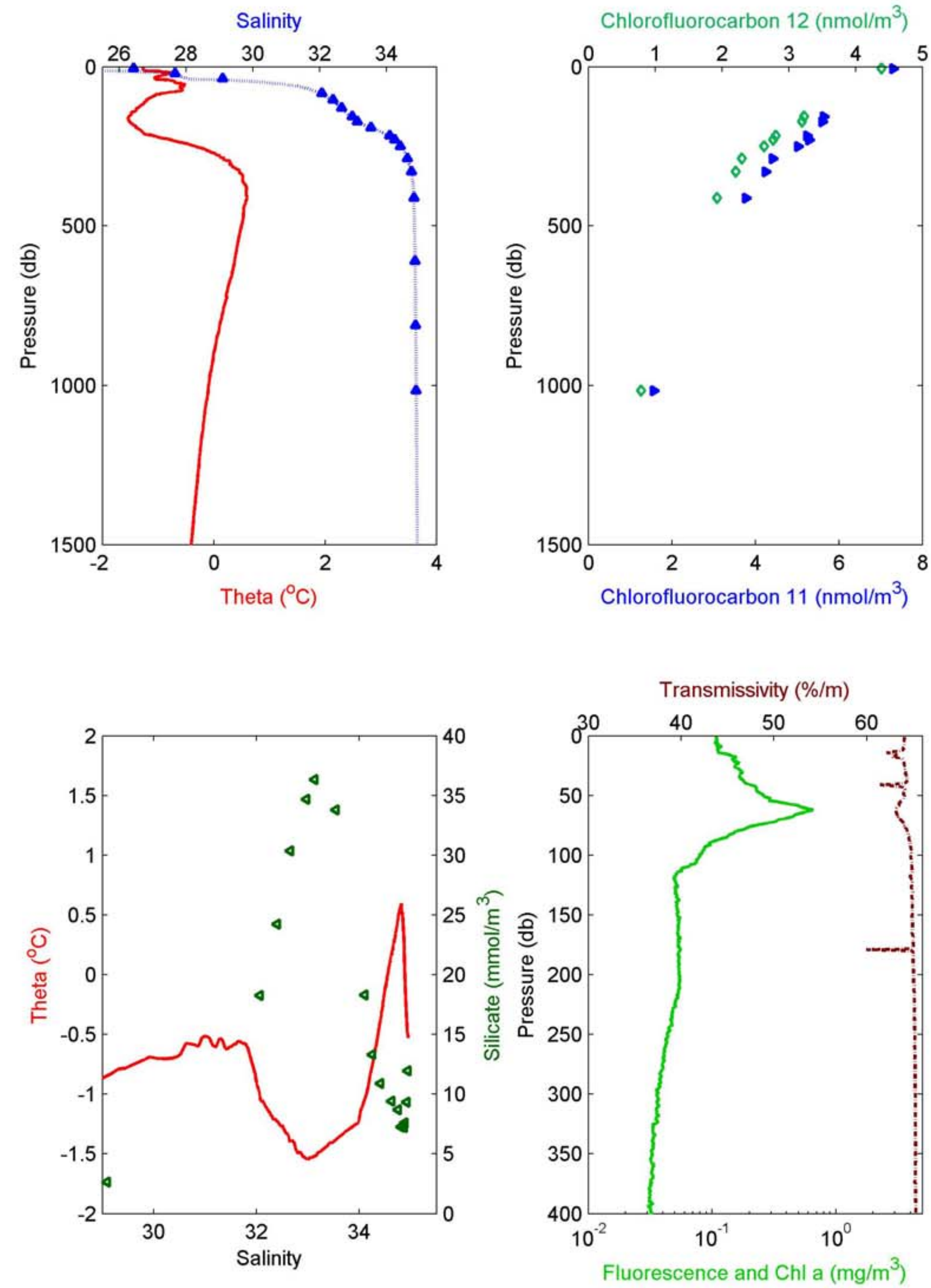
2006-18: Cast 70 Station GF'06 (Canada Basin)



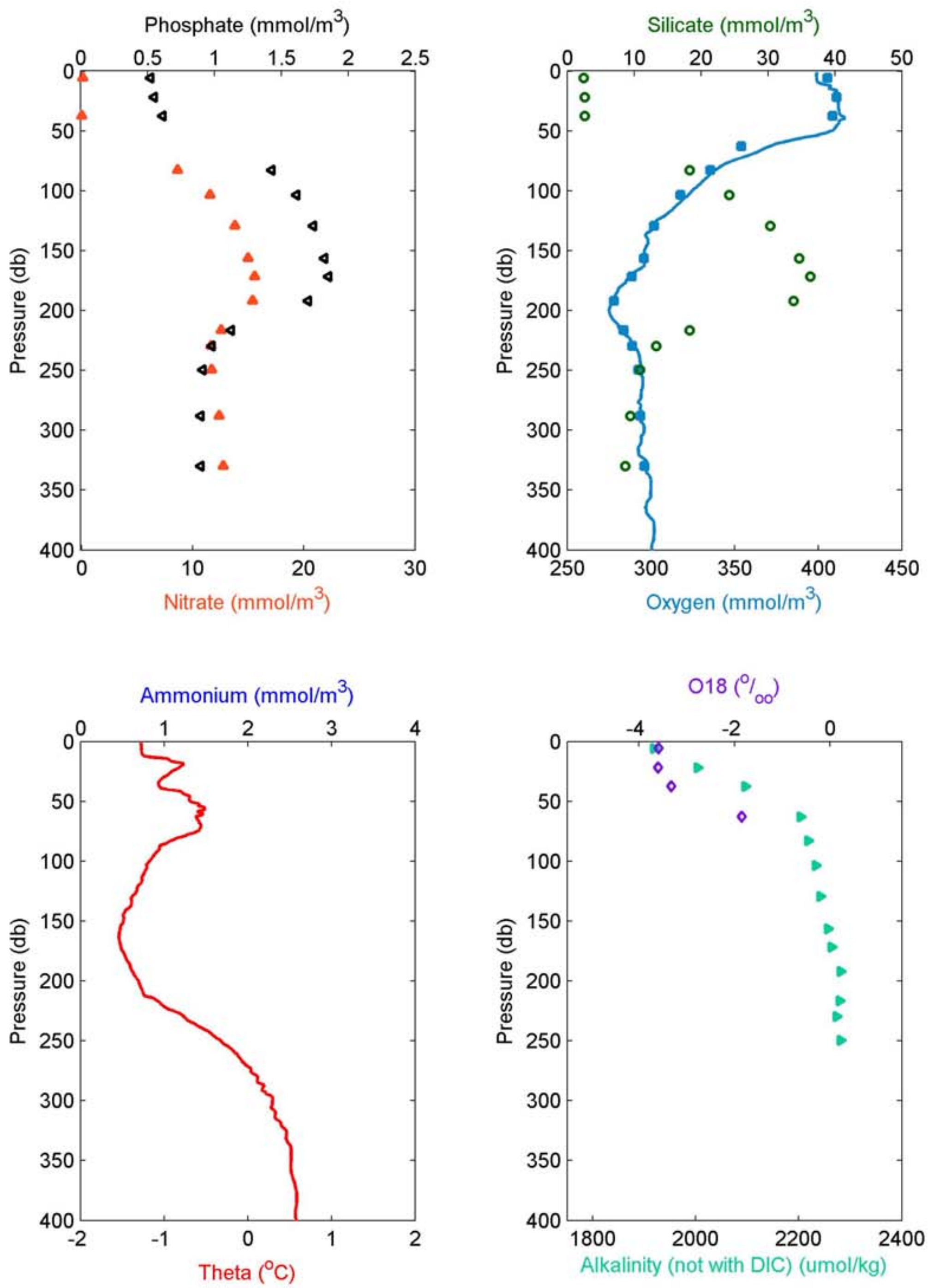
2006-18: Cast 70 Station GF'06 (Canada Basin)



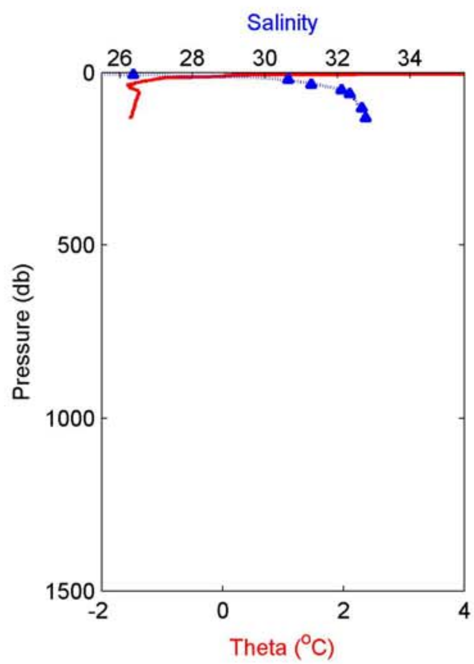
2006-18: Cast 71 Station CB-22 (Canada Basin)

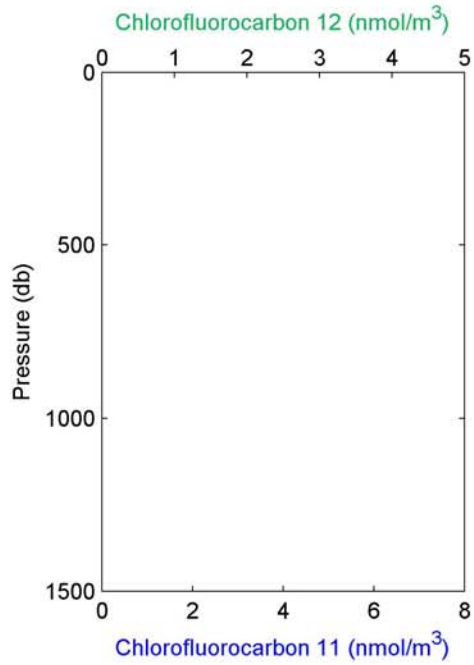


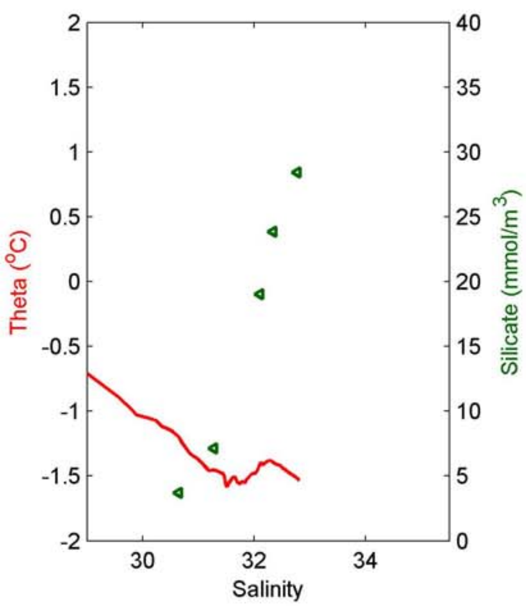
2006-18: Cast 71 Station CB-22 (Canada Basin)

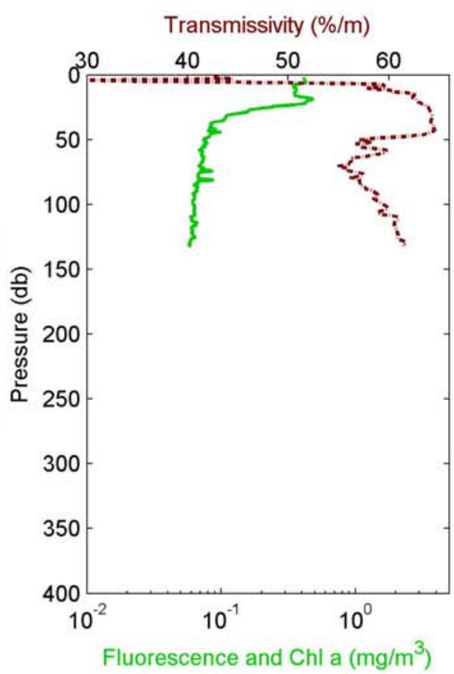


2006-18: Cast 72 Station CB-MED1 (Canada Basin)

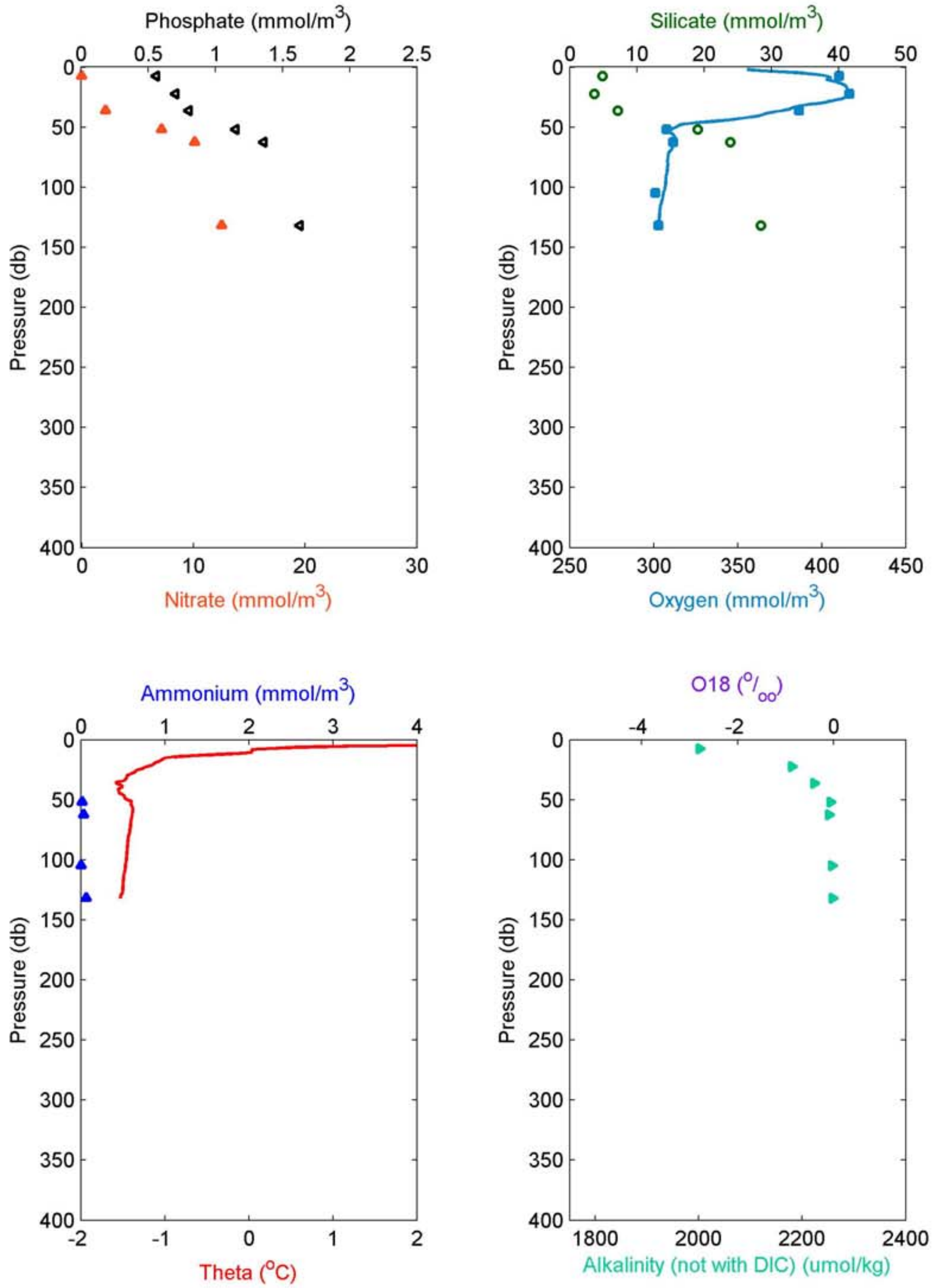




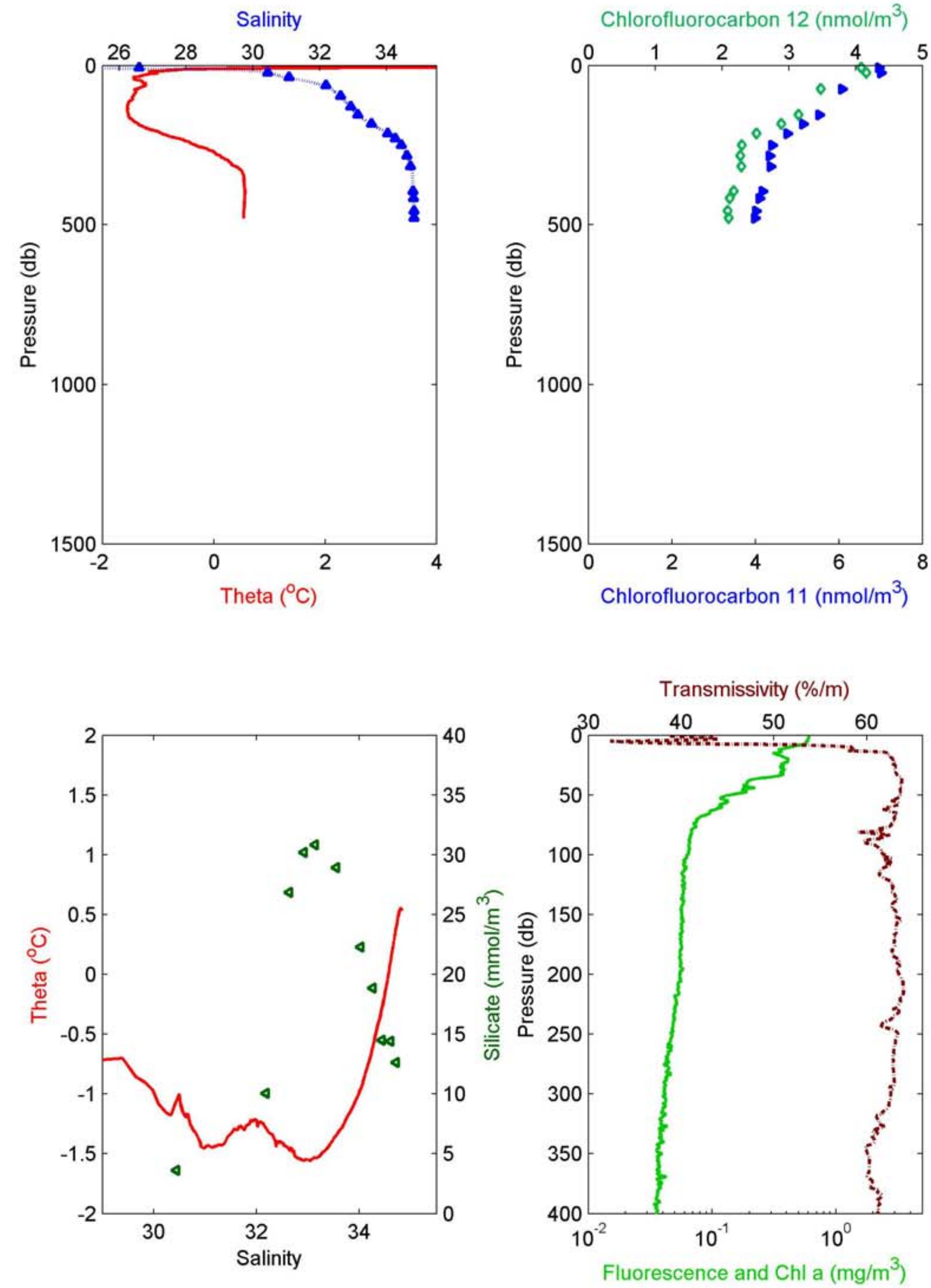




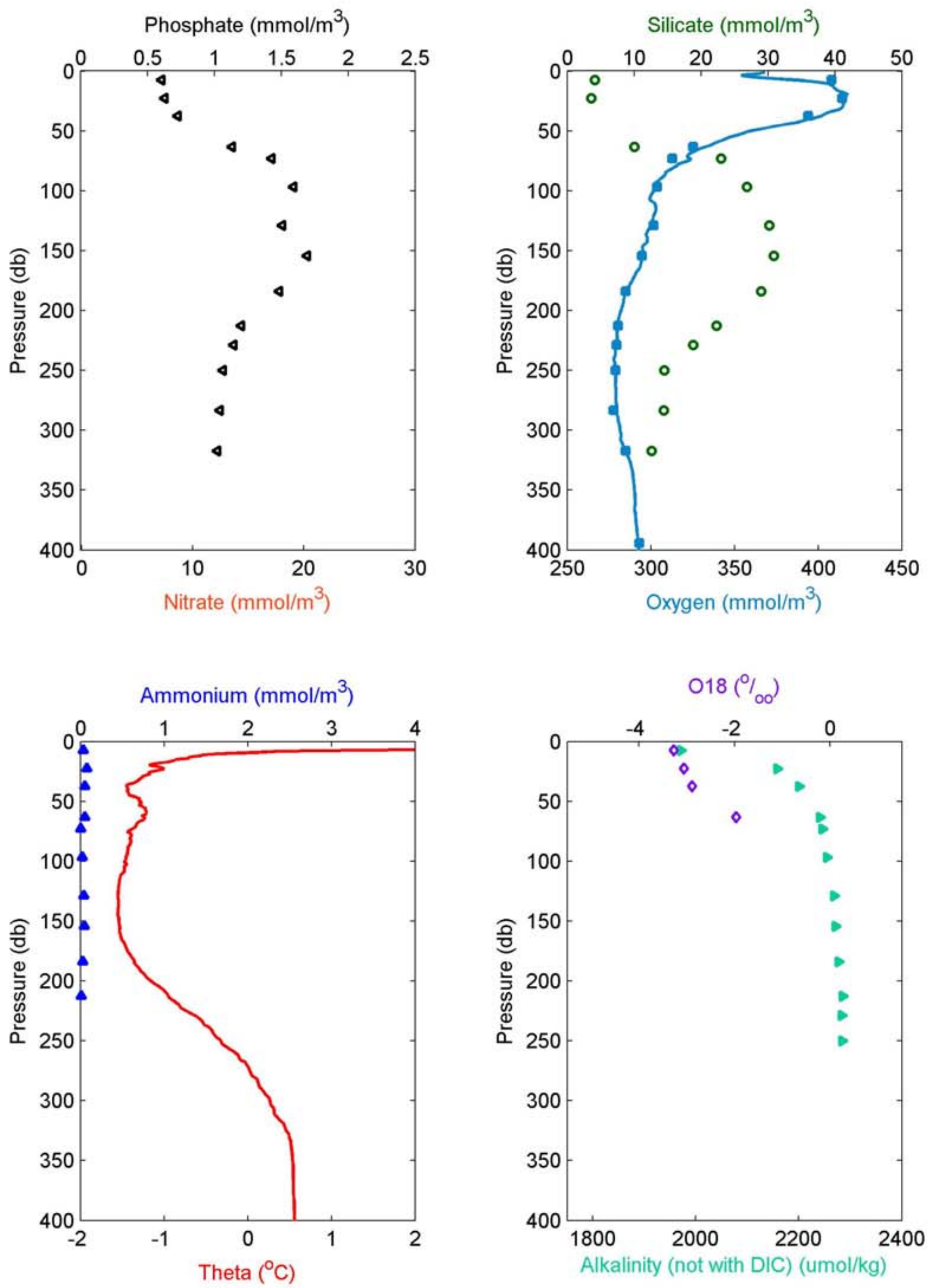
2006-18: Cast 72 Station CB-MED1 (Canada Basin)



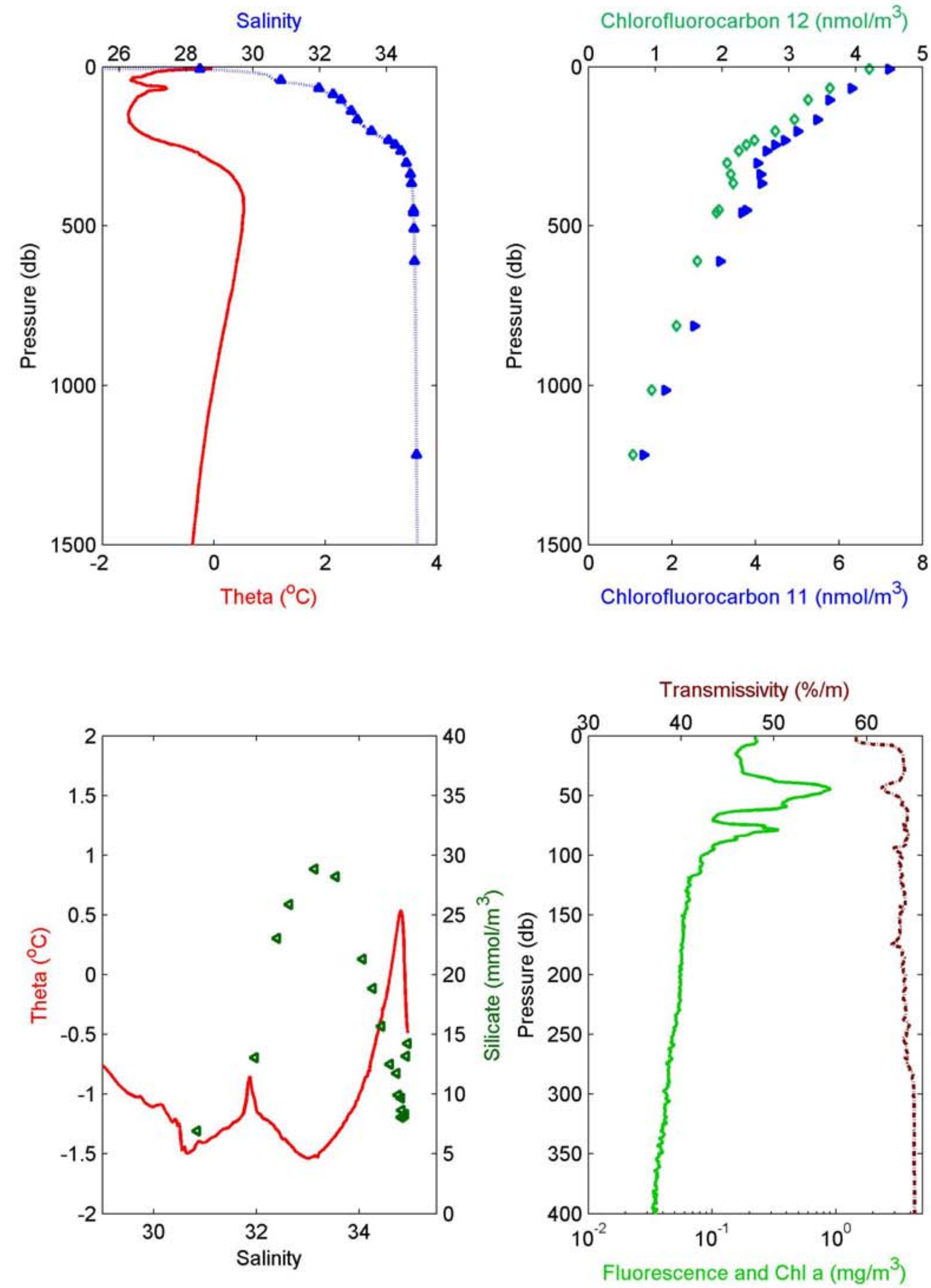
2006-18: Cast 73 Station CB-MED2 (Canada Basin)



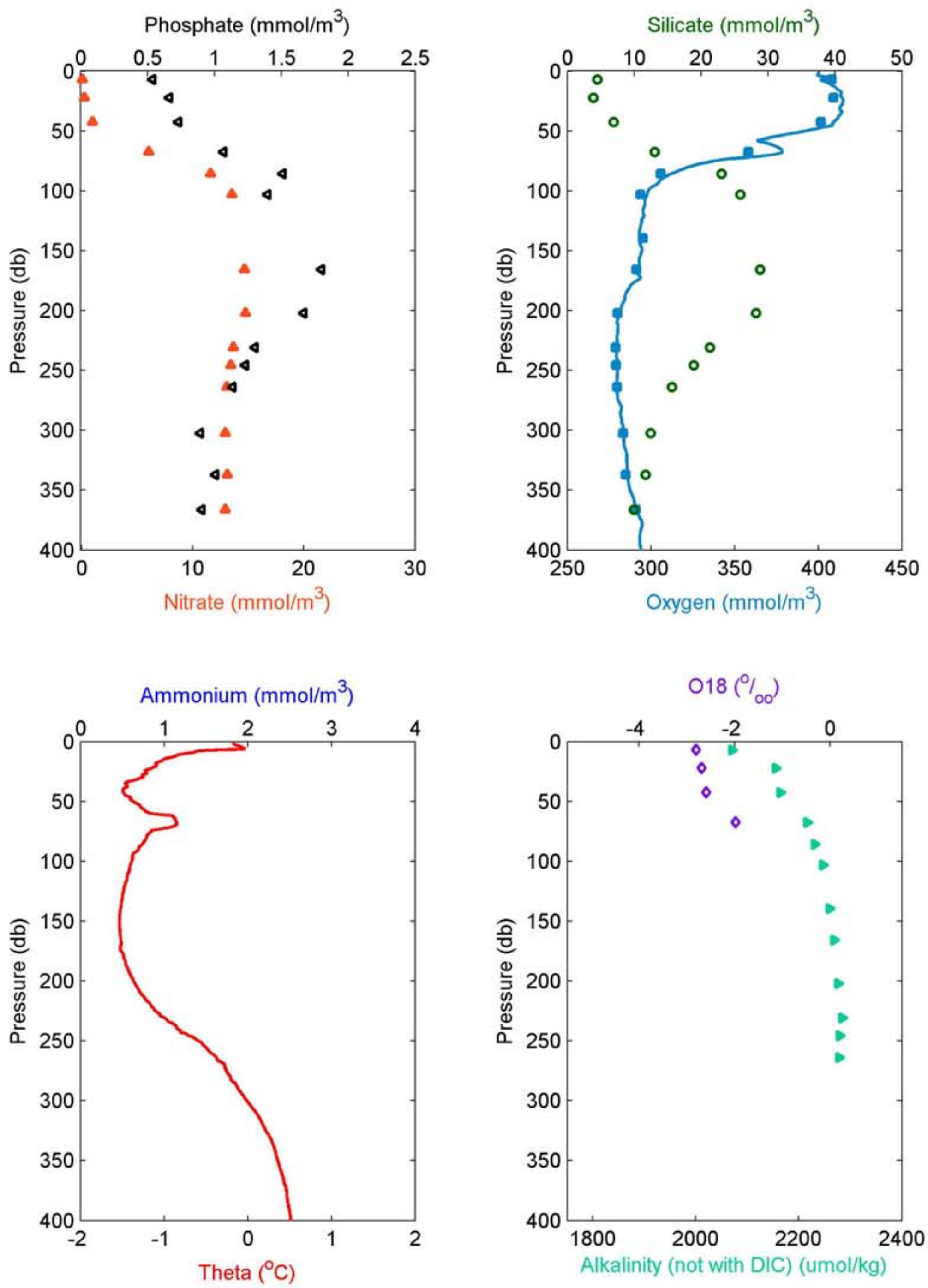
2006-18: Cast 73 Station CB-MED2 (Canada Basin)



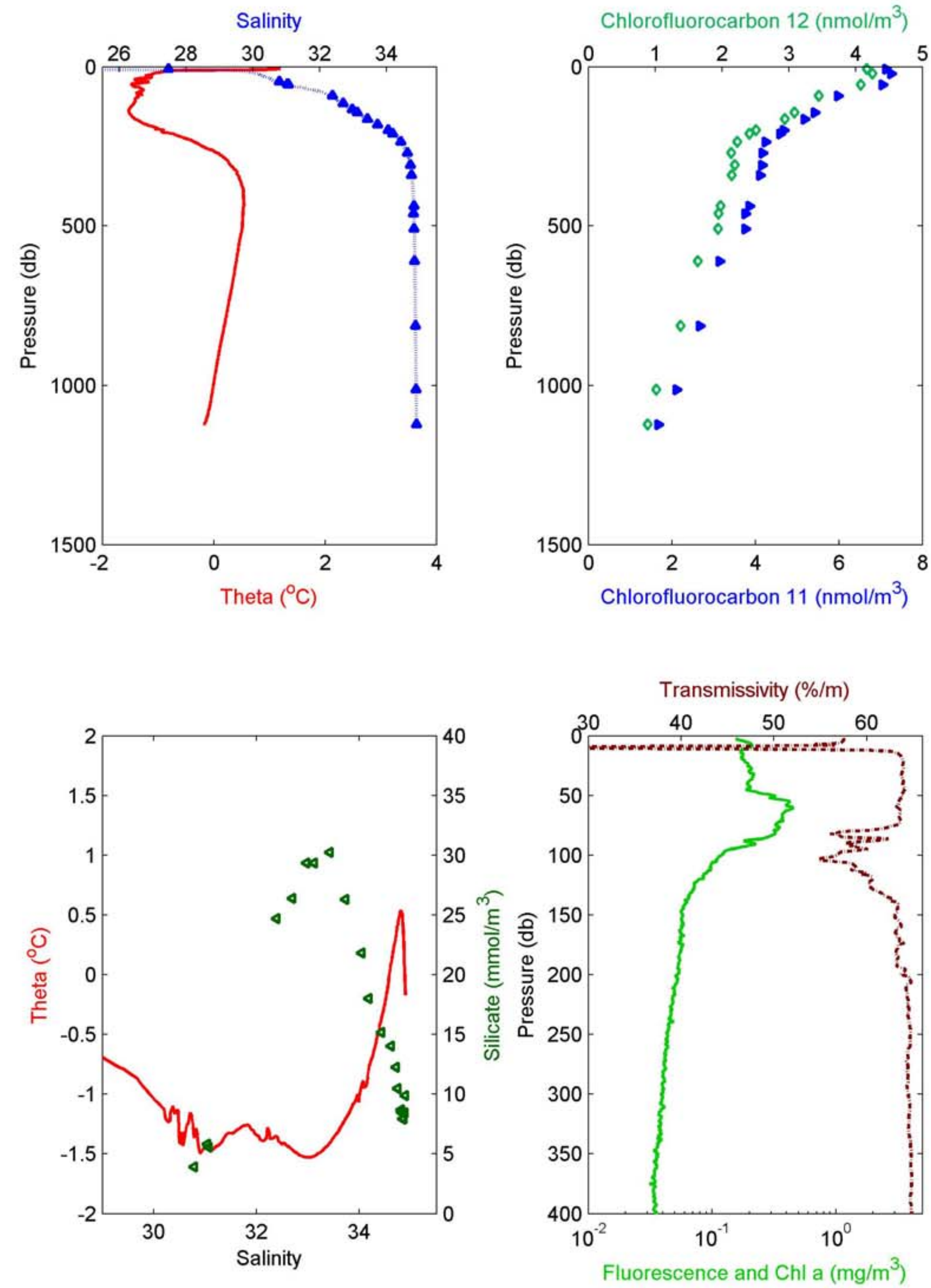
2006-18: Cast 74 Station CB-31a (Canada Basin)



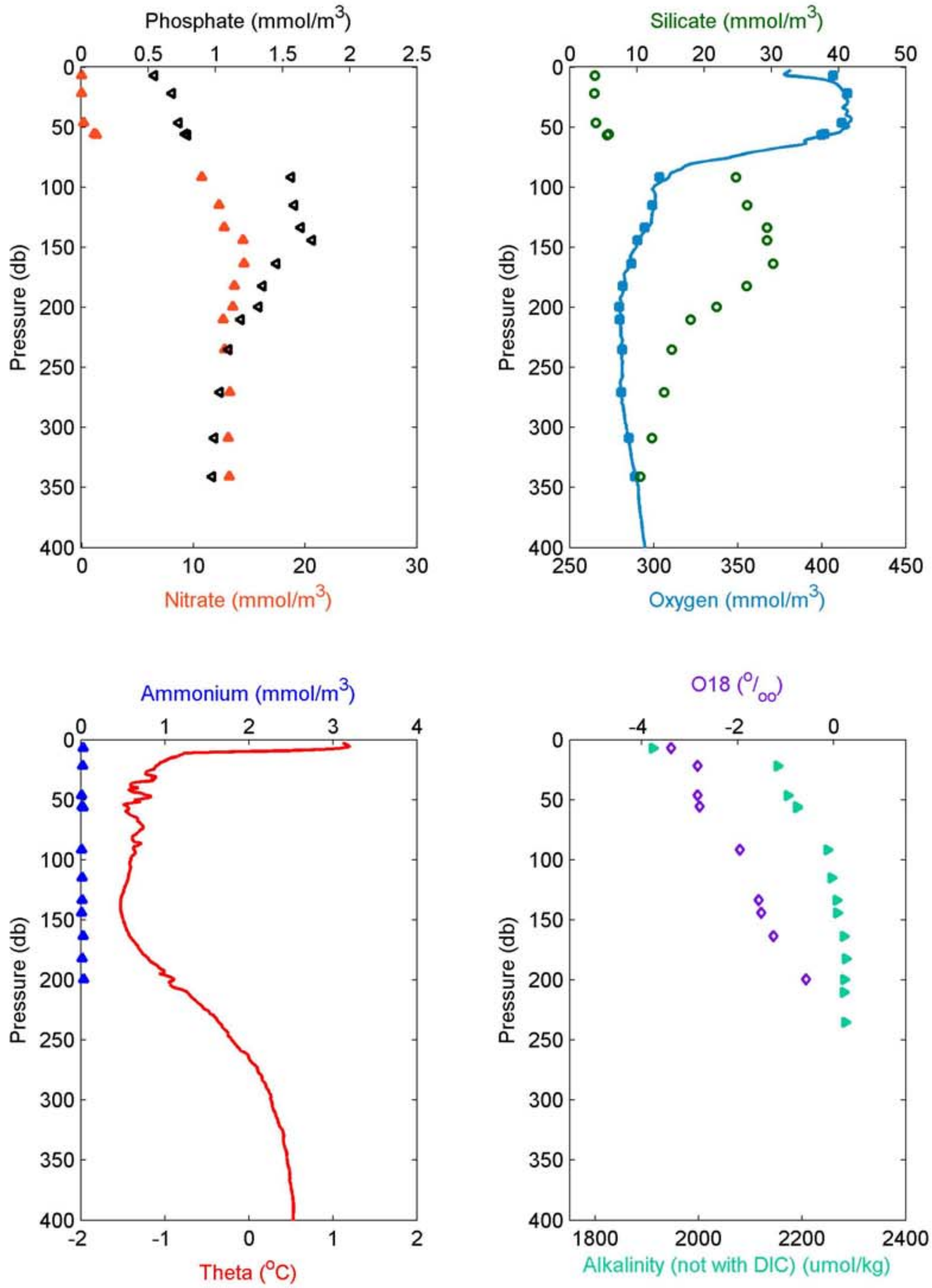
2006-18: Cast 74 Station CB-31a (Canada Basin)



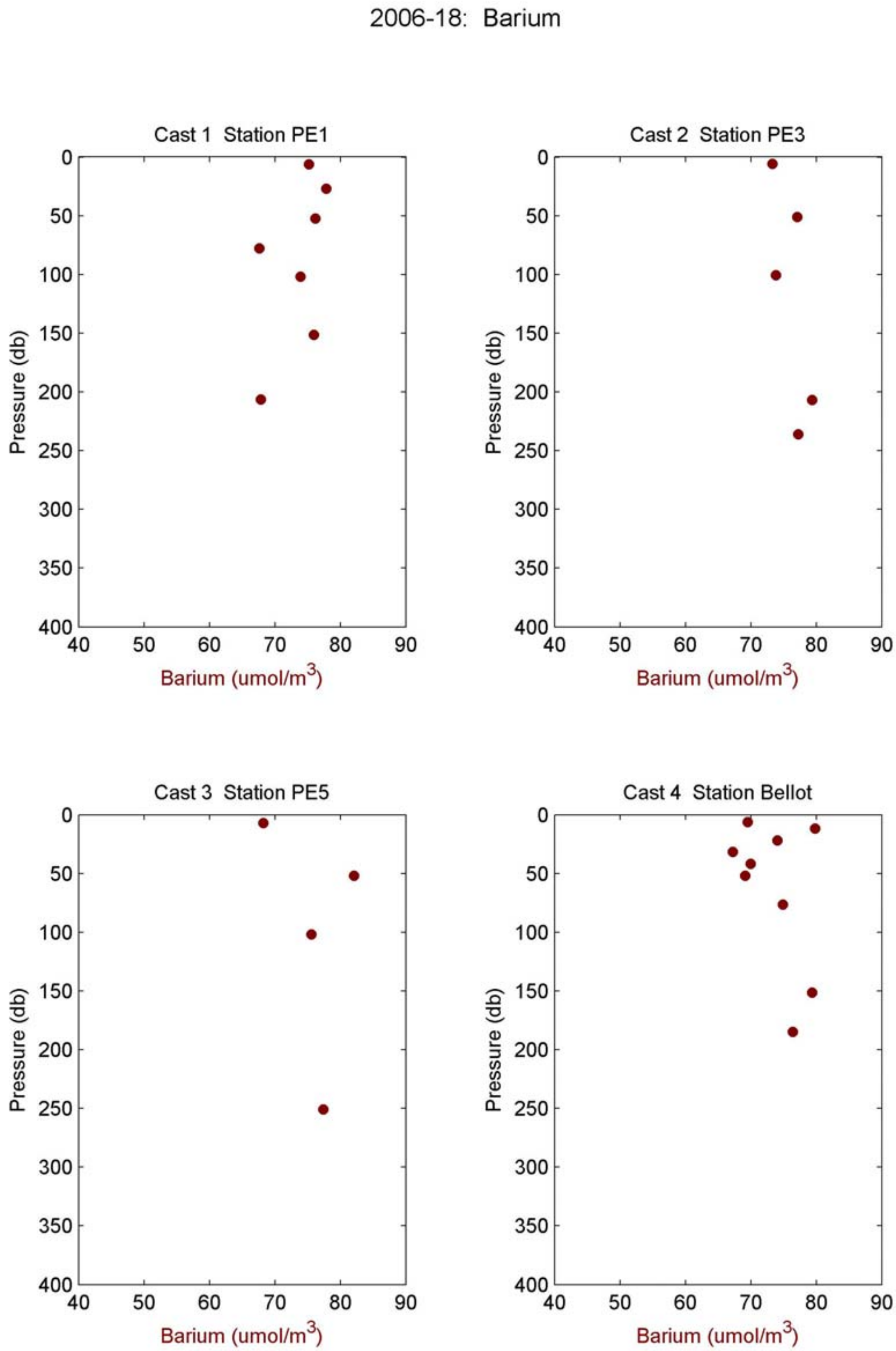
2006-18: Cast 75 Station CABOS (Canada Basin)



2006-18: Cast 75 Station CABOS (Canada Basin)

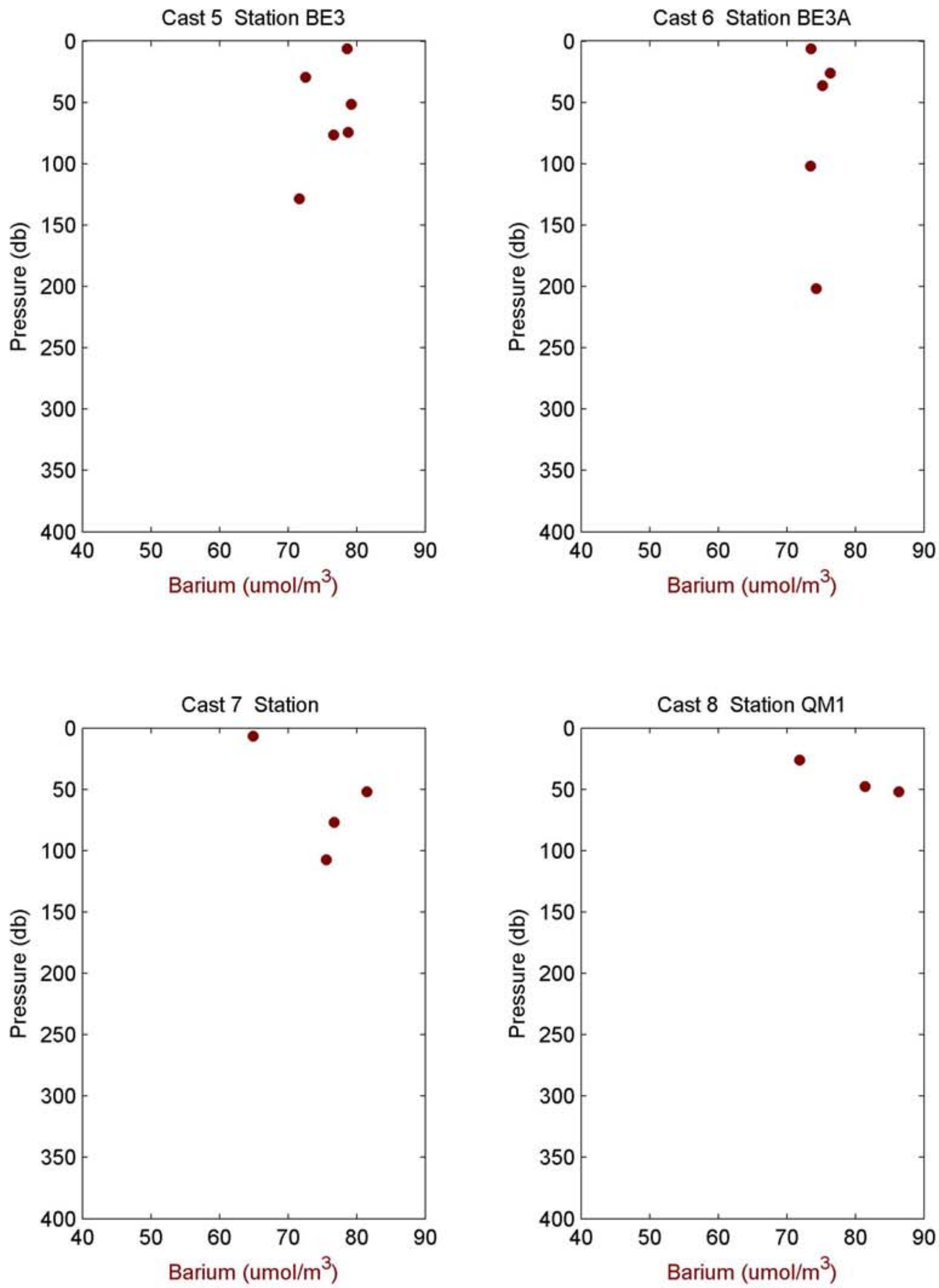


5.1.2 Barium

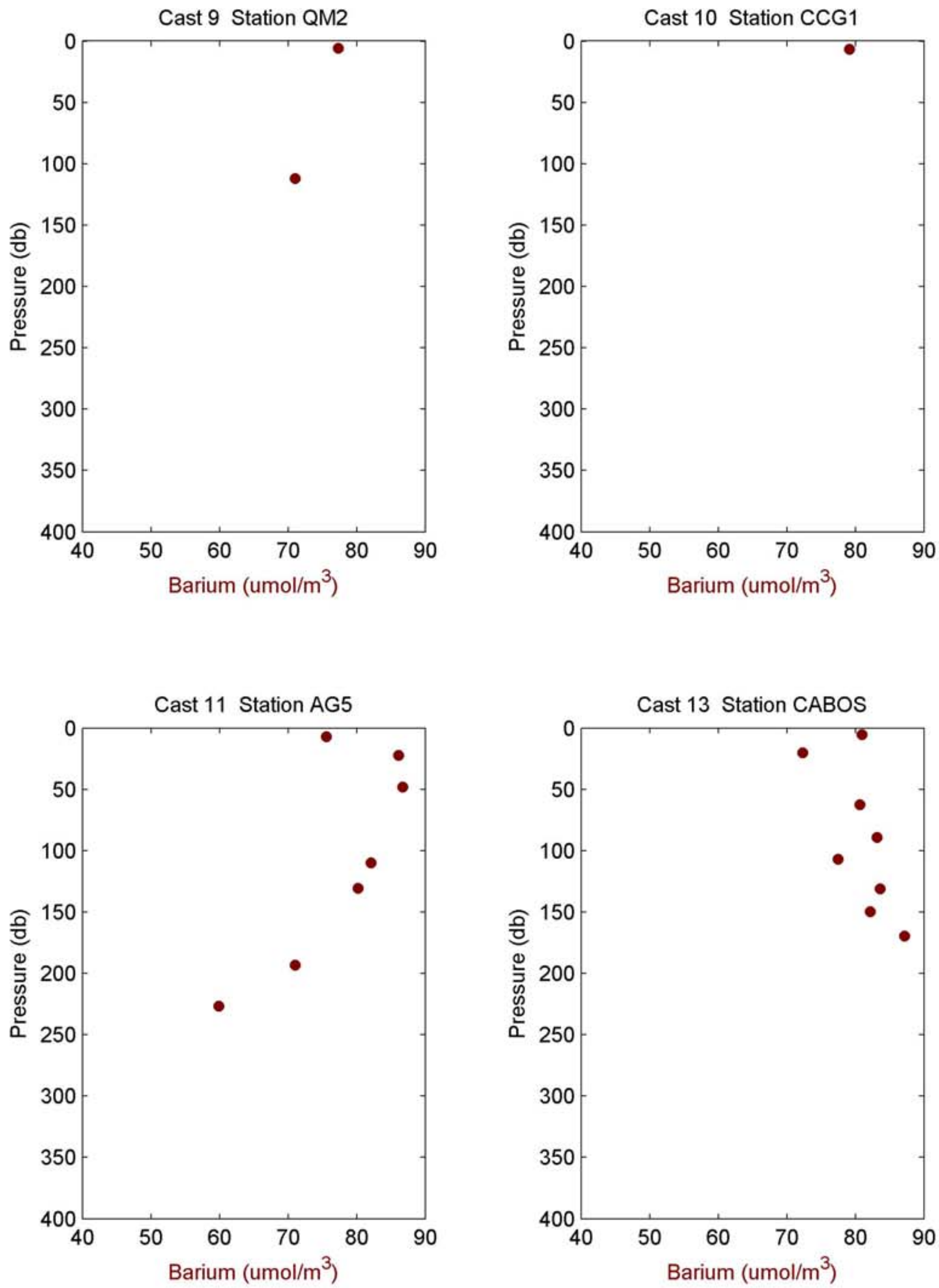


2006-18: Barium
Cast 1 Station PE1
Cast 2 Station PE3
Cast 3 Station PE5
Cast 4 Station Bellot
Pressure (db)
Barium (umol/m3)
0
50
100
150
200
250
300
350
400
40
50
60
70
80
90

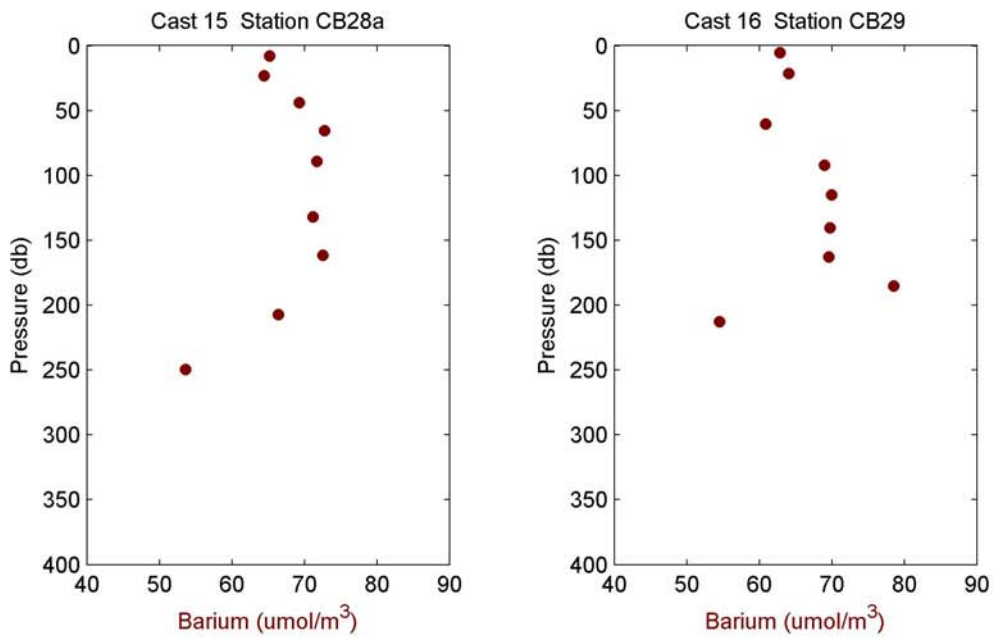
2006-18: Barium



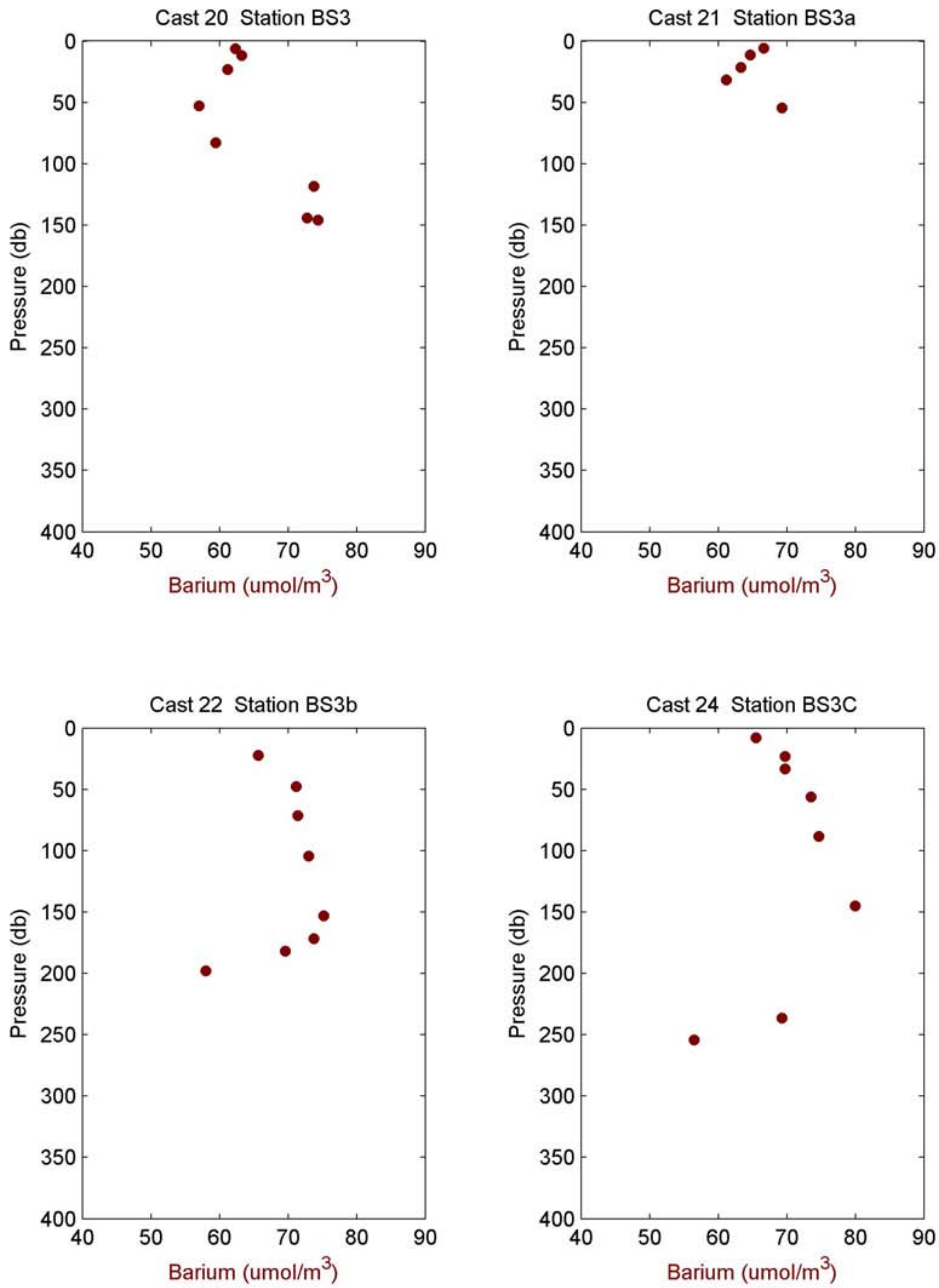
2006-18: Barium



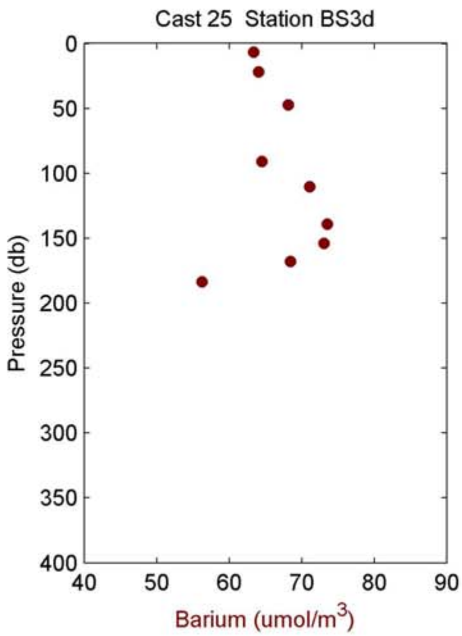
2006-18: Barium

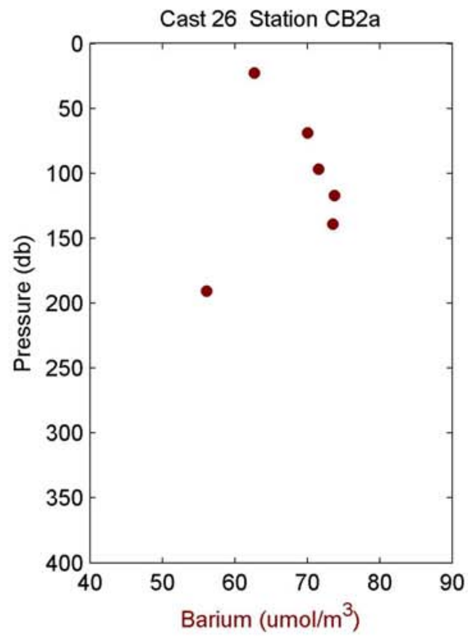


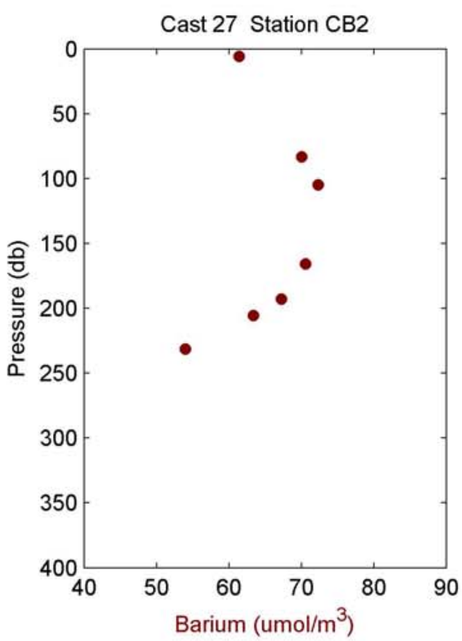
2006-18: Barium

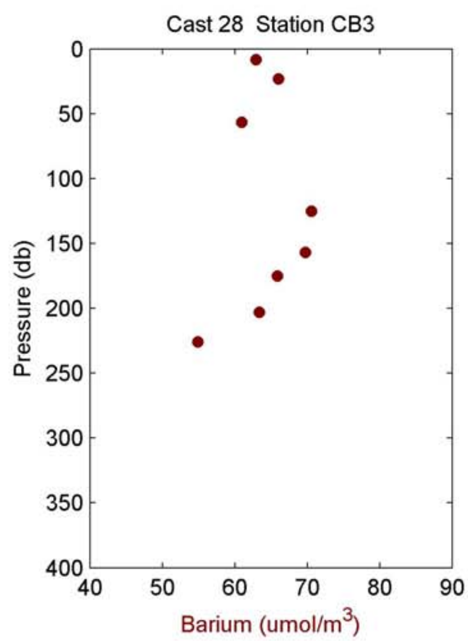


2006-18: Barium

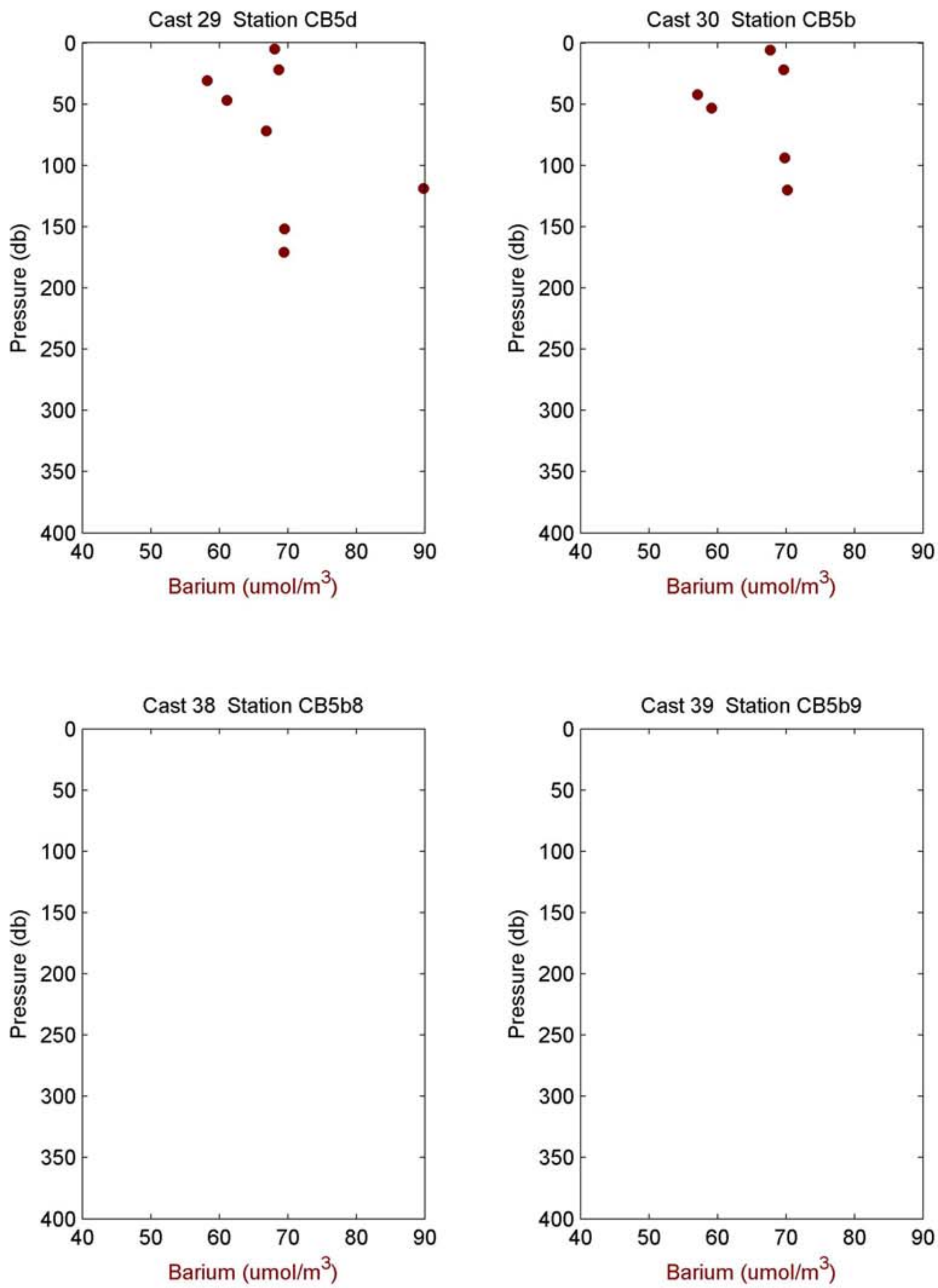




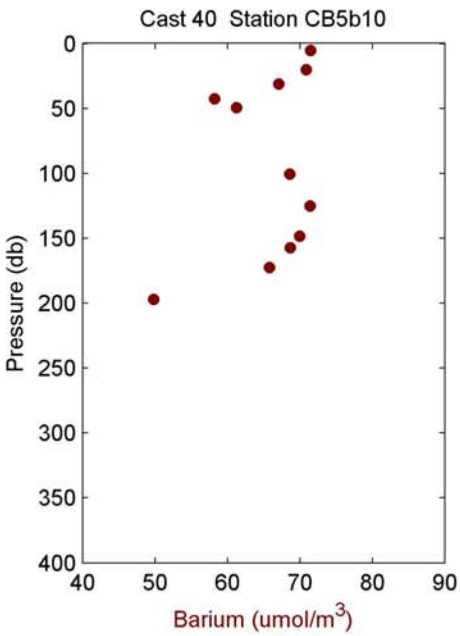


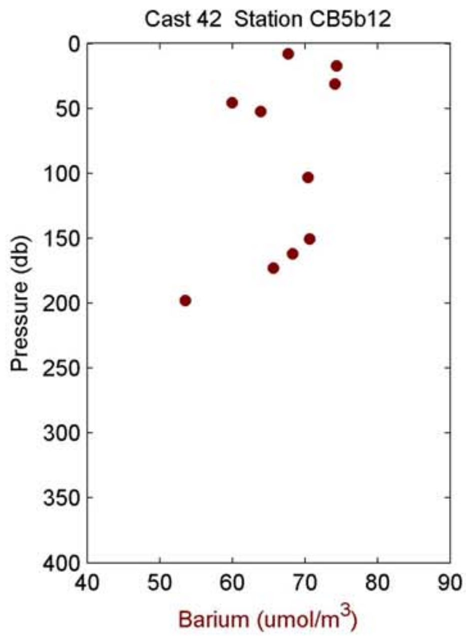


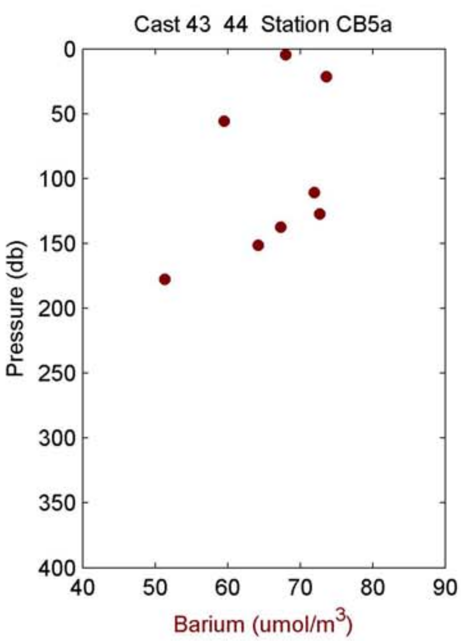
2006-18: Barium

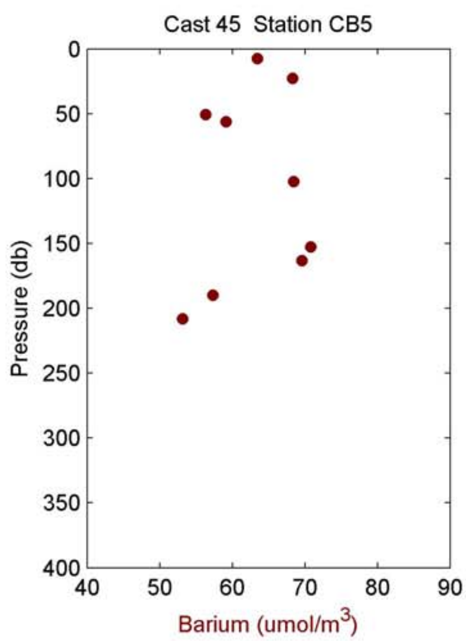


2006-18: Barium

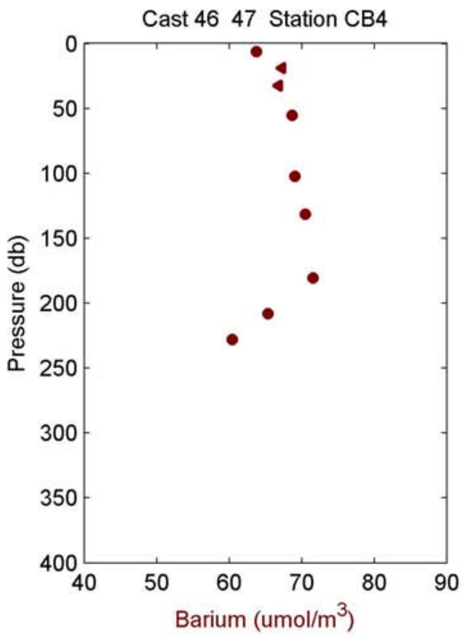


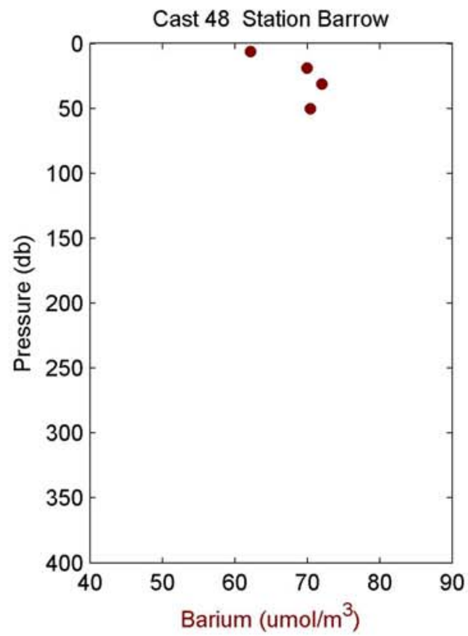


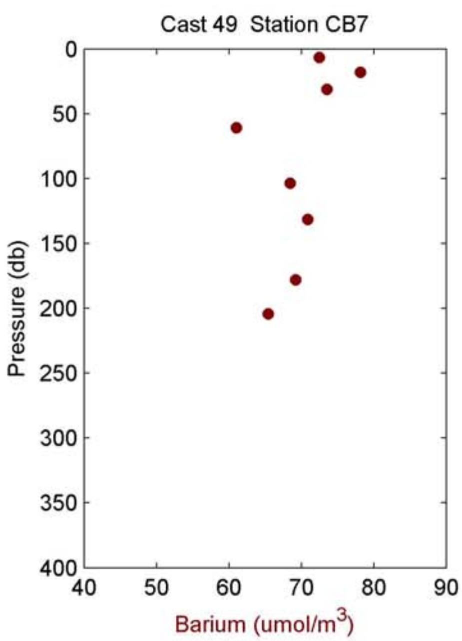


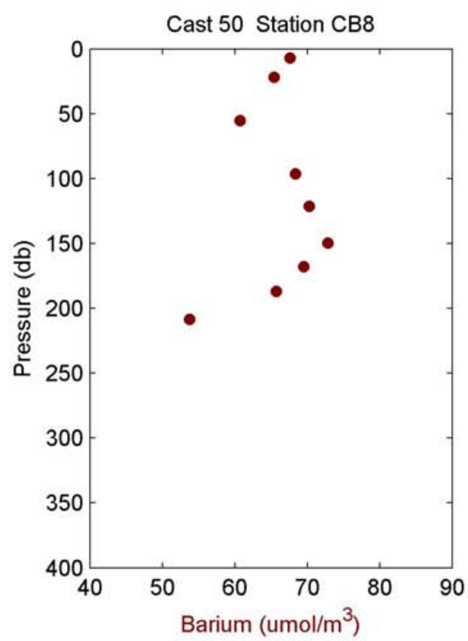


2006-18: Barium

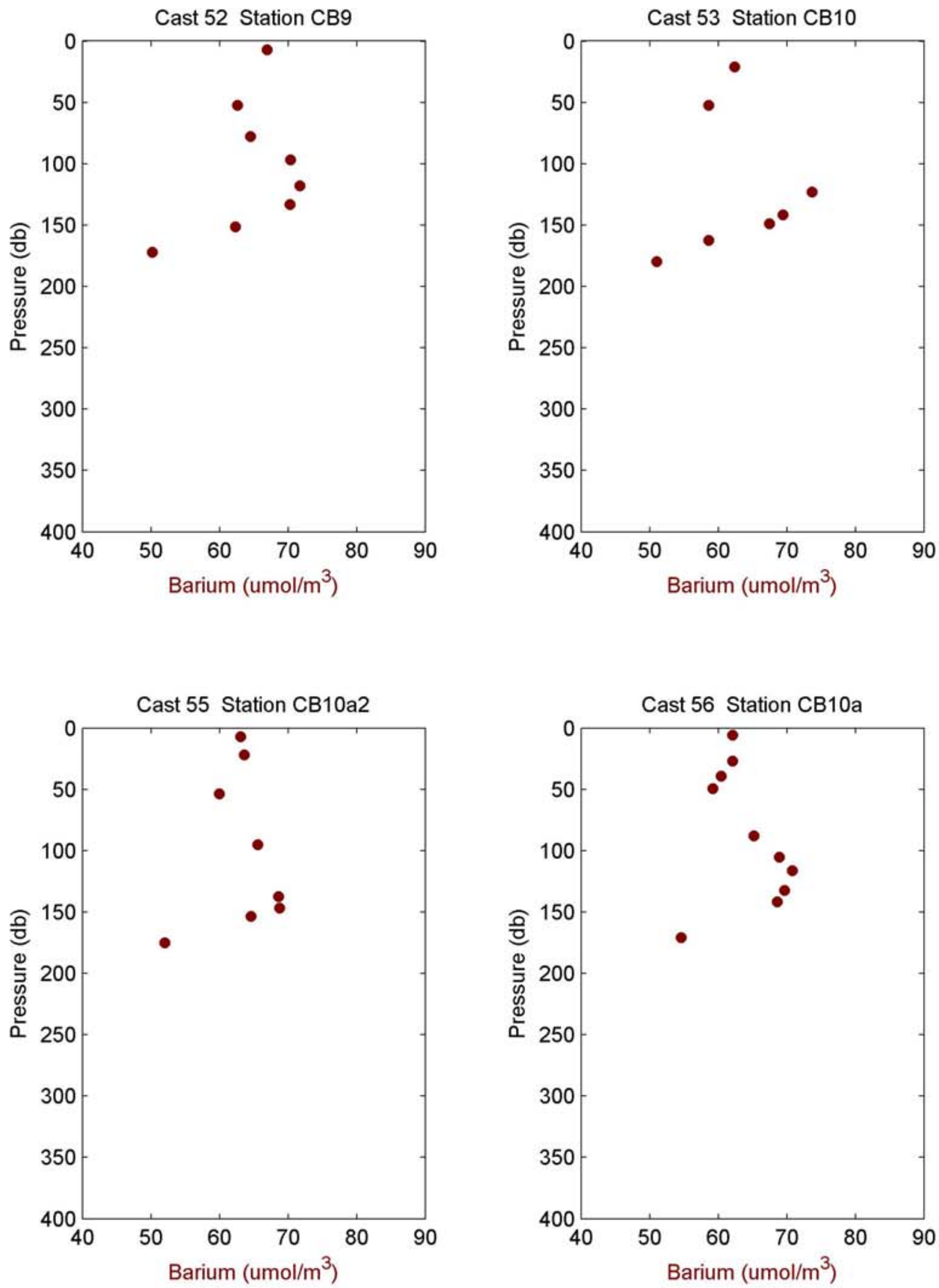




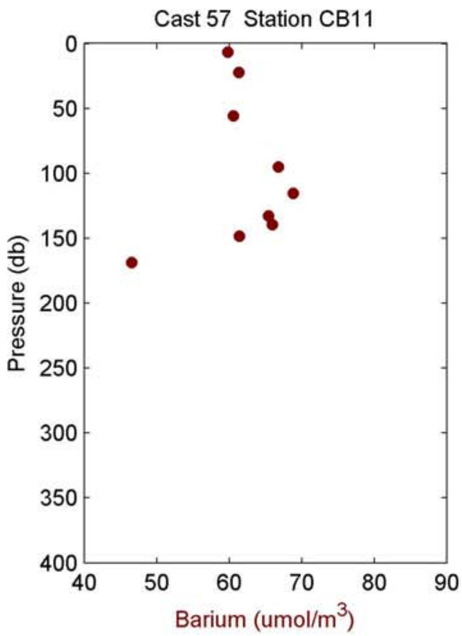


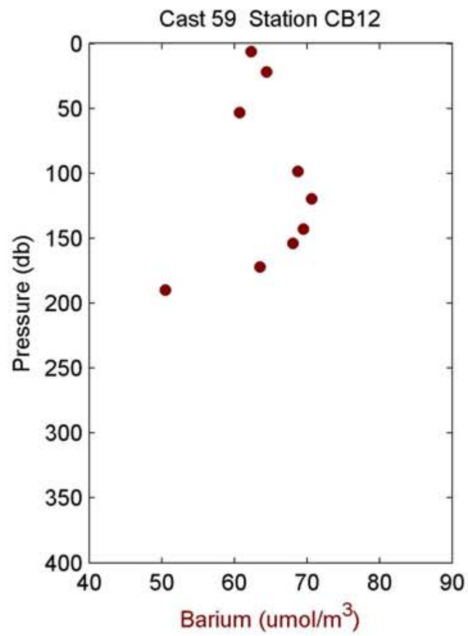


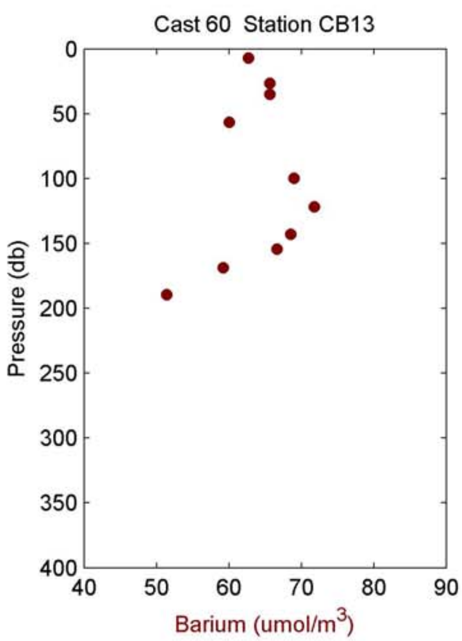
2006-18: Barium

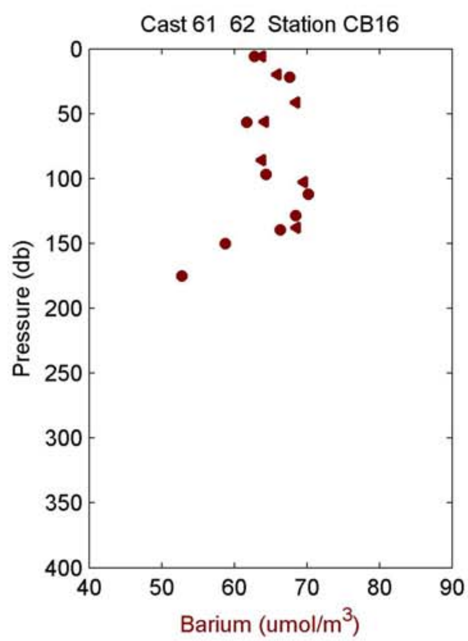


2006-18: Barium

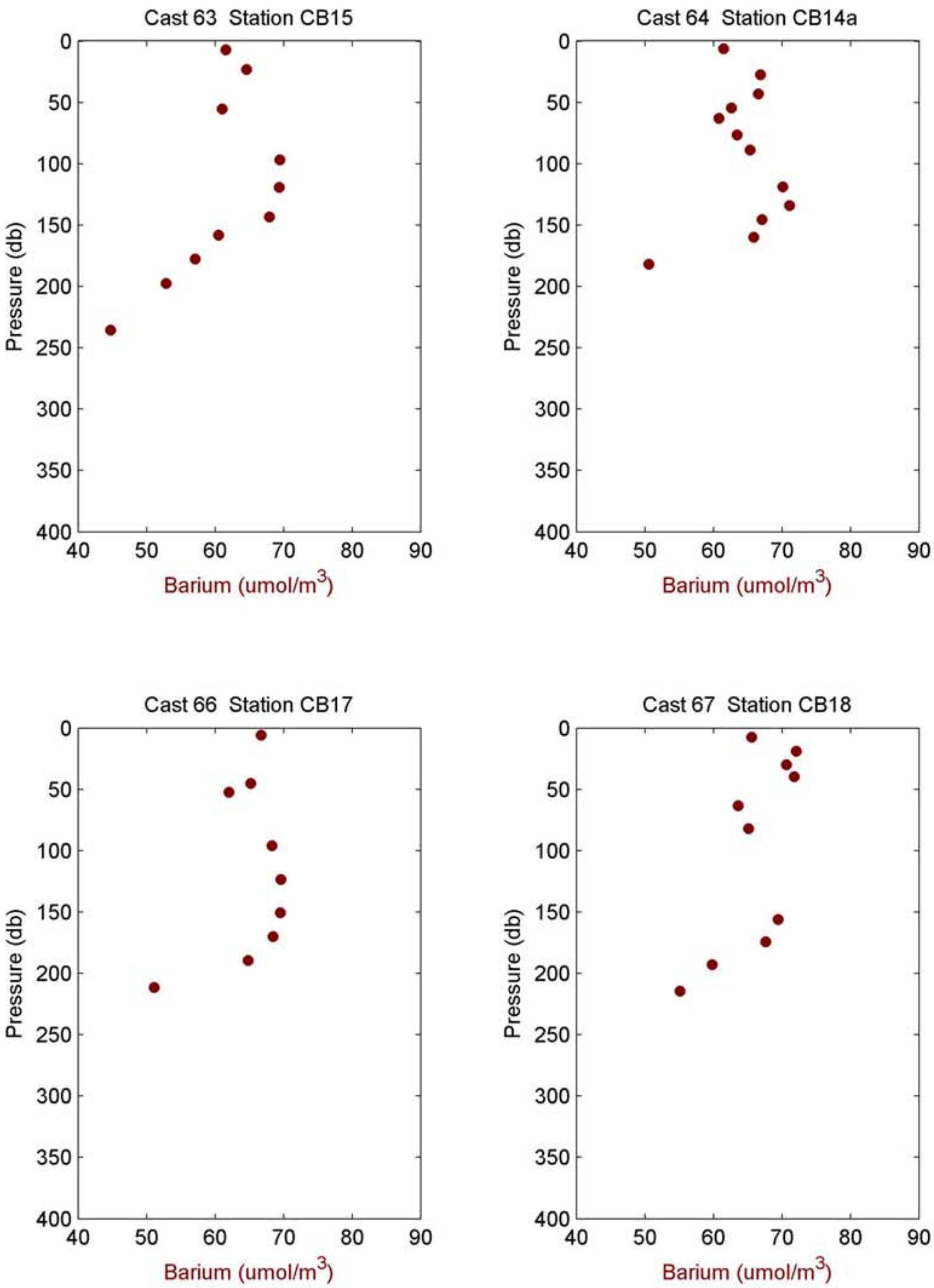




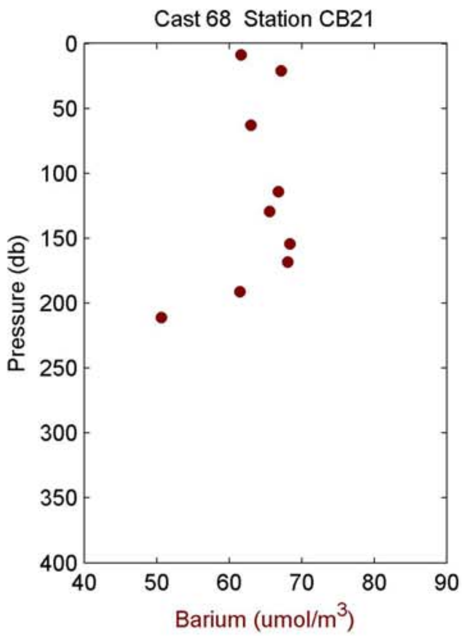


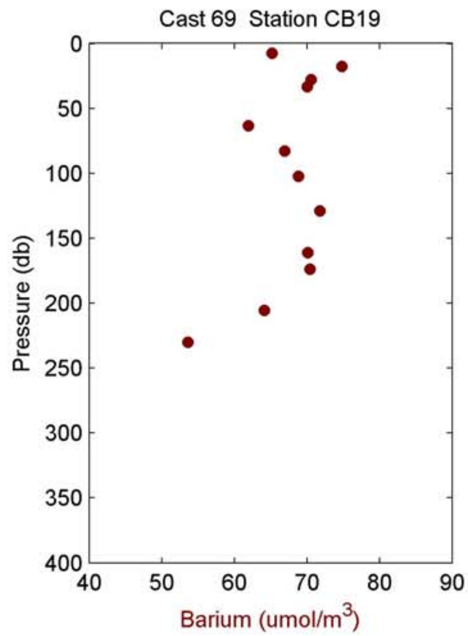


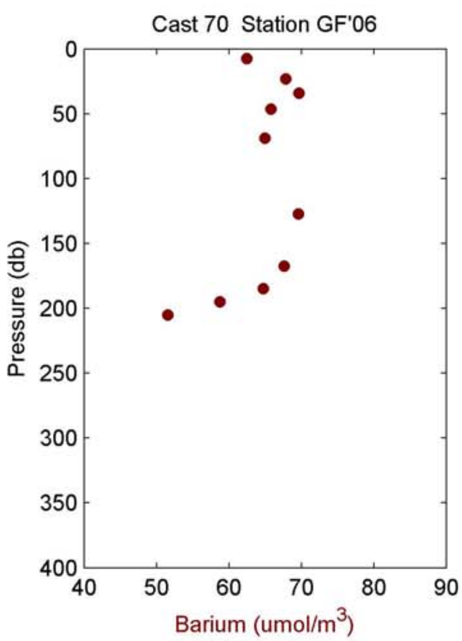
2006-18: Barium

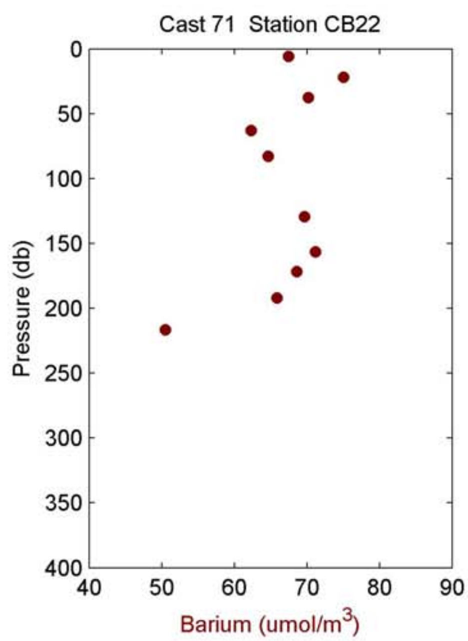


2006-18: Barium

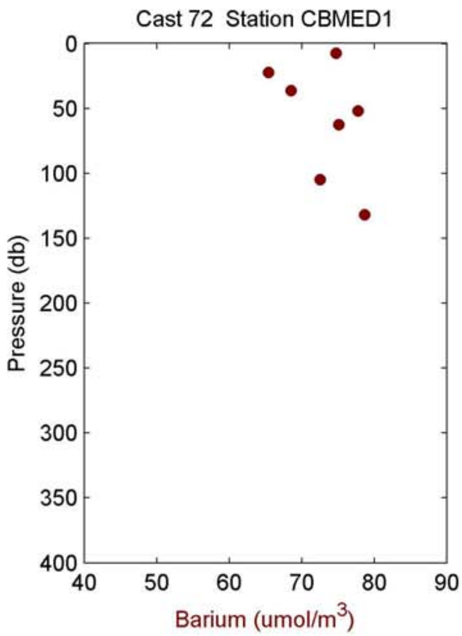


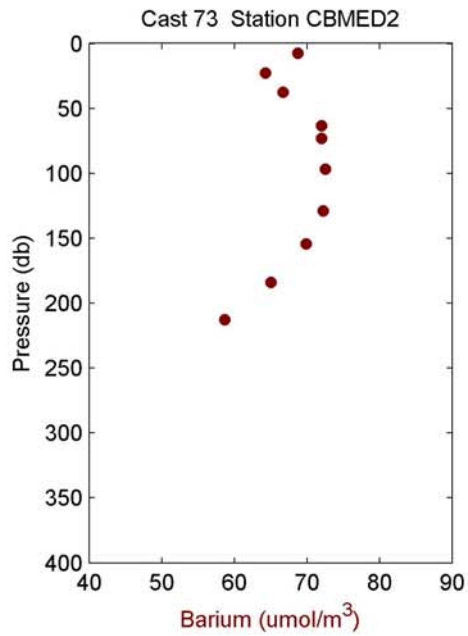


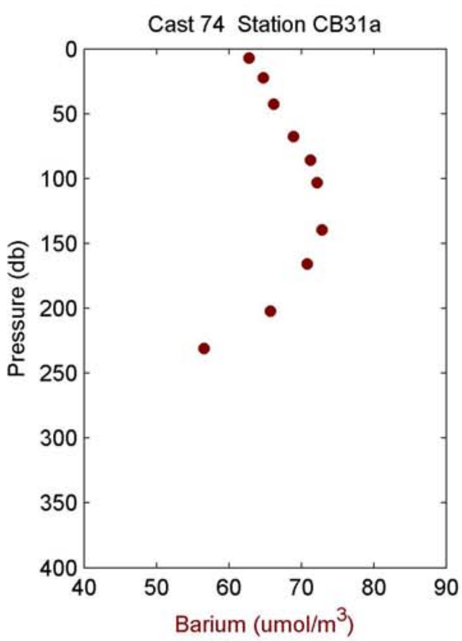


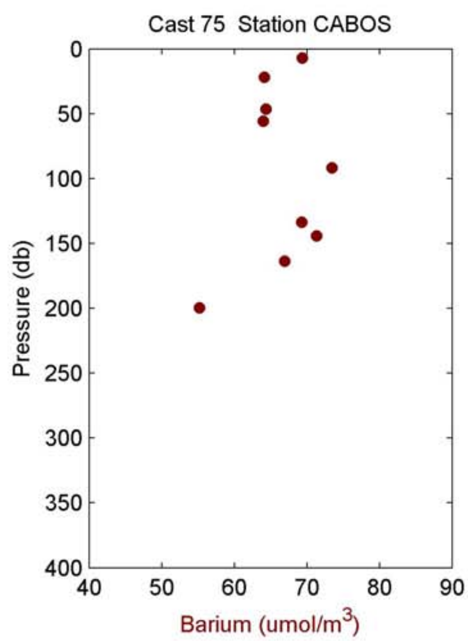


2006-18: Barium

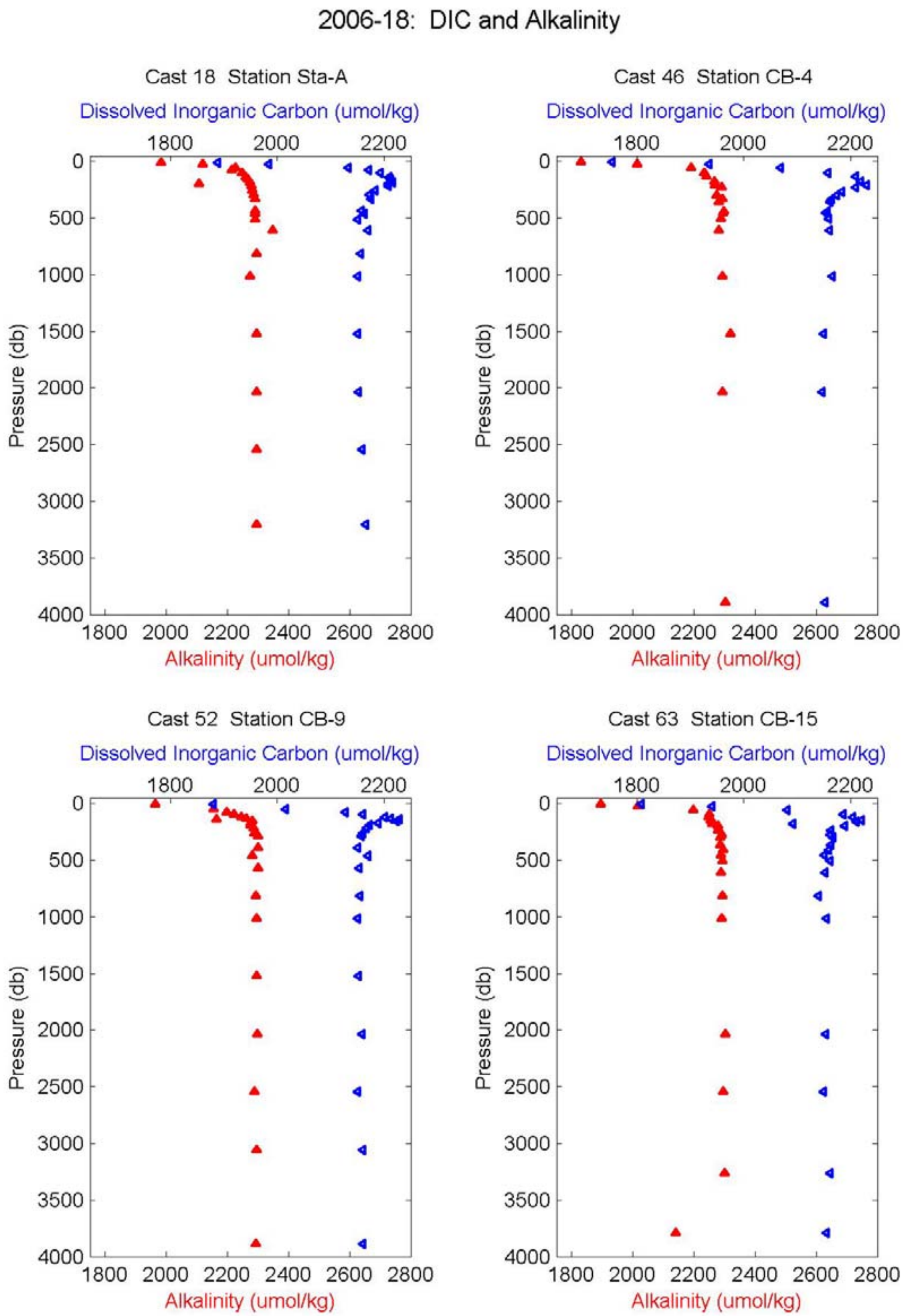




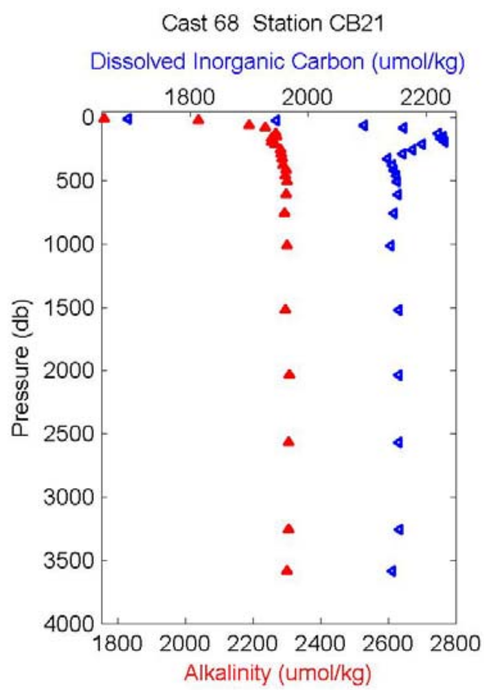




5.1.3 DIC and Alkalinity

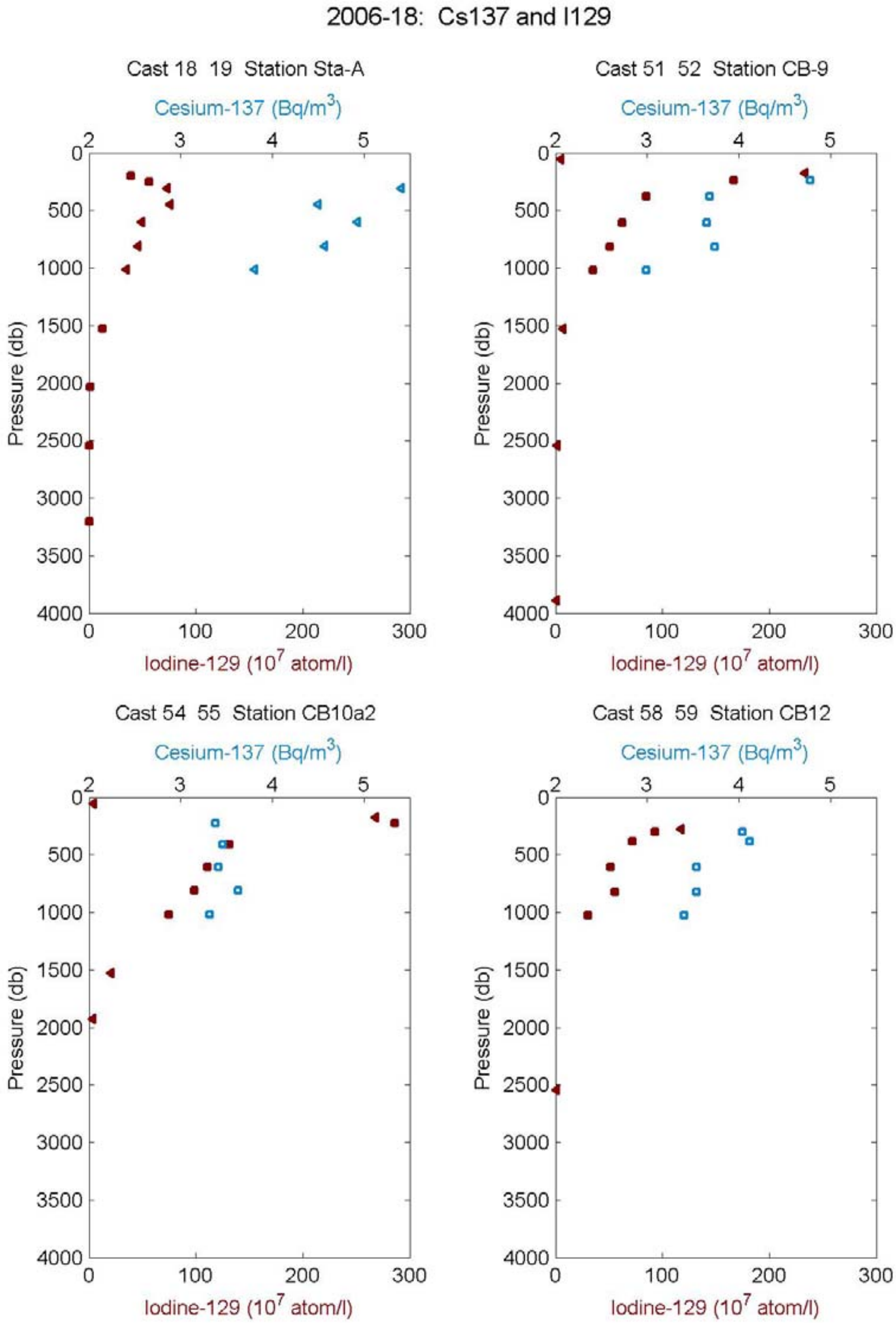


2006-18: DIC and Alkalinity

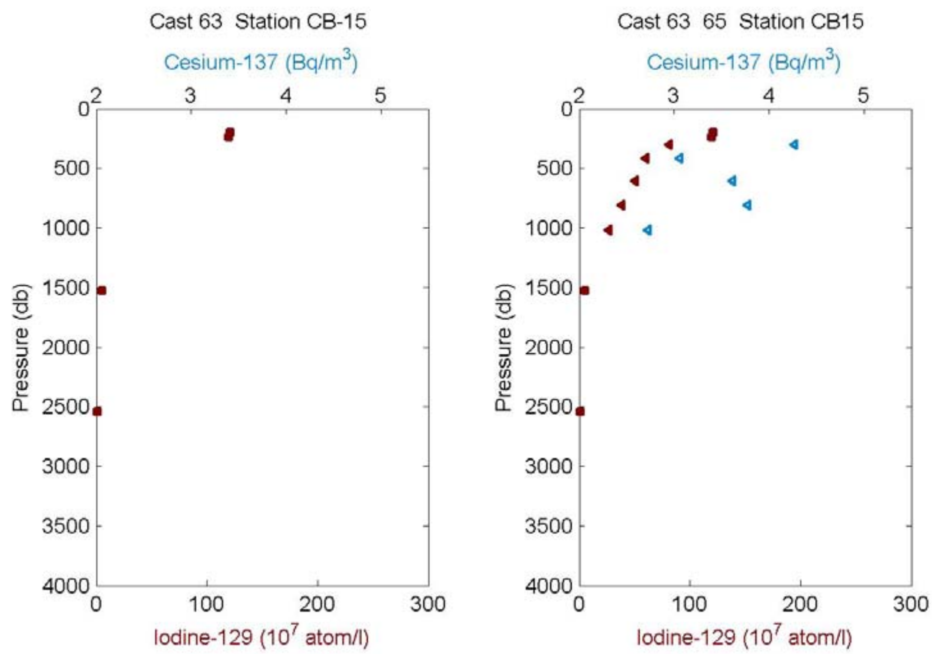


5.1.4 ^{129}I and ^{137}Cs

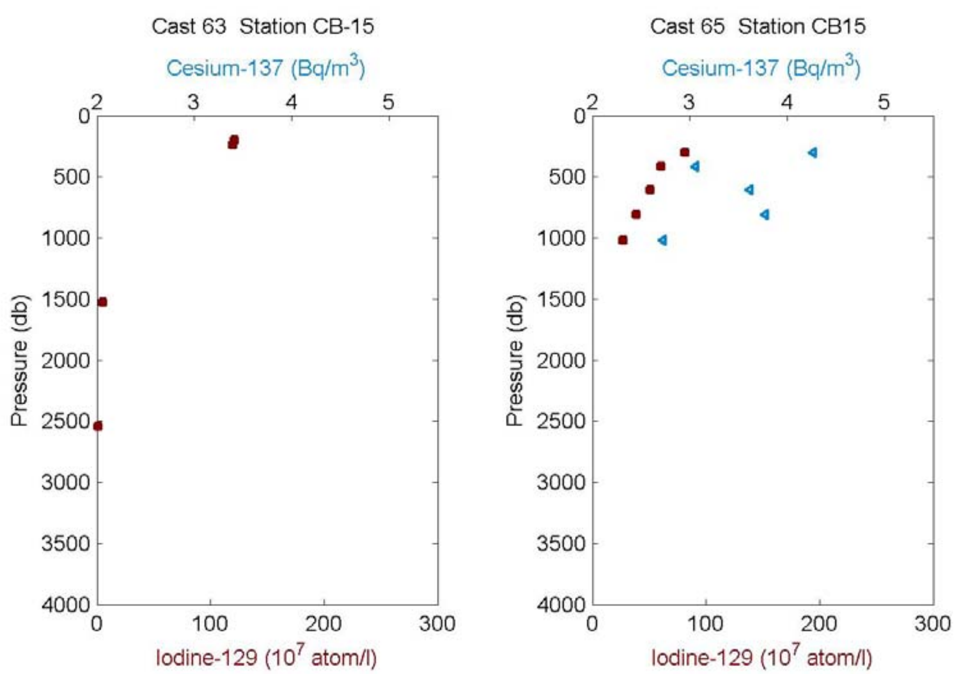
Note: For select stations, multiple casts were taken and are plotted together. Samples for each cast are distinguished by symbol type.



2006-18: Cs137 and I129

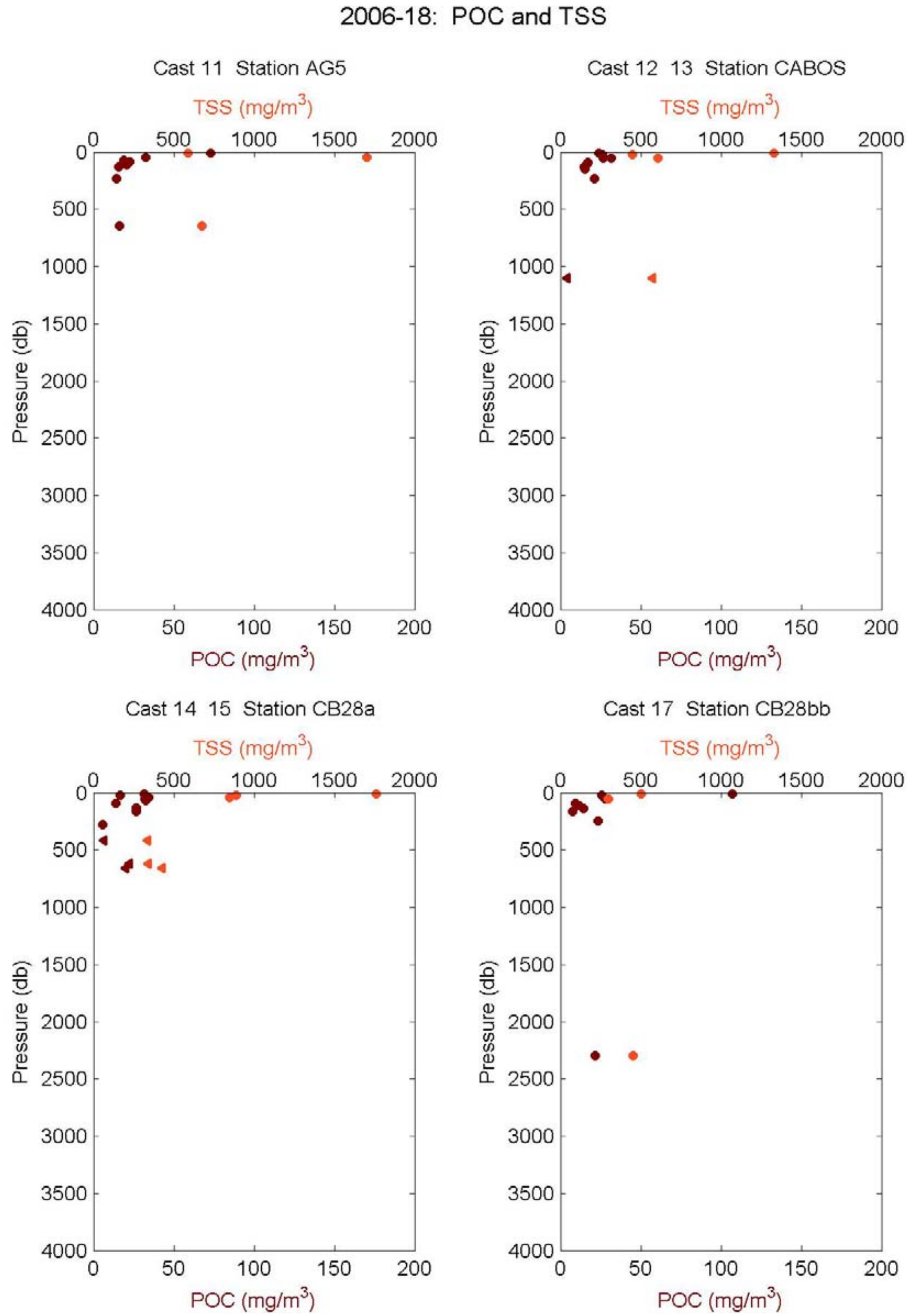


2006-18: Cs137 and I129

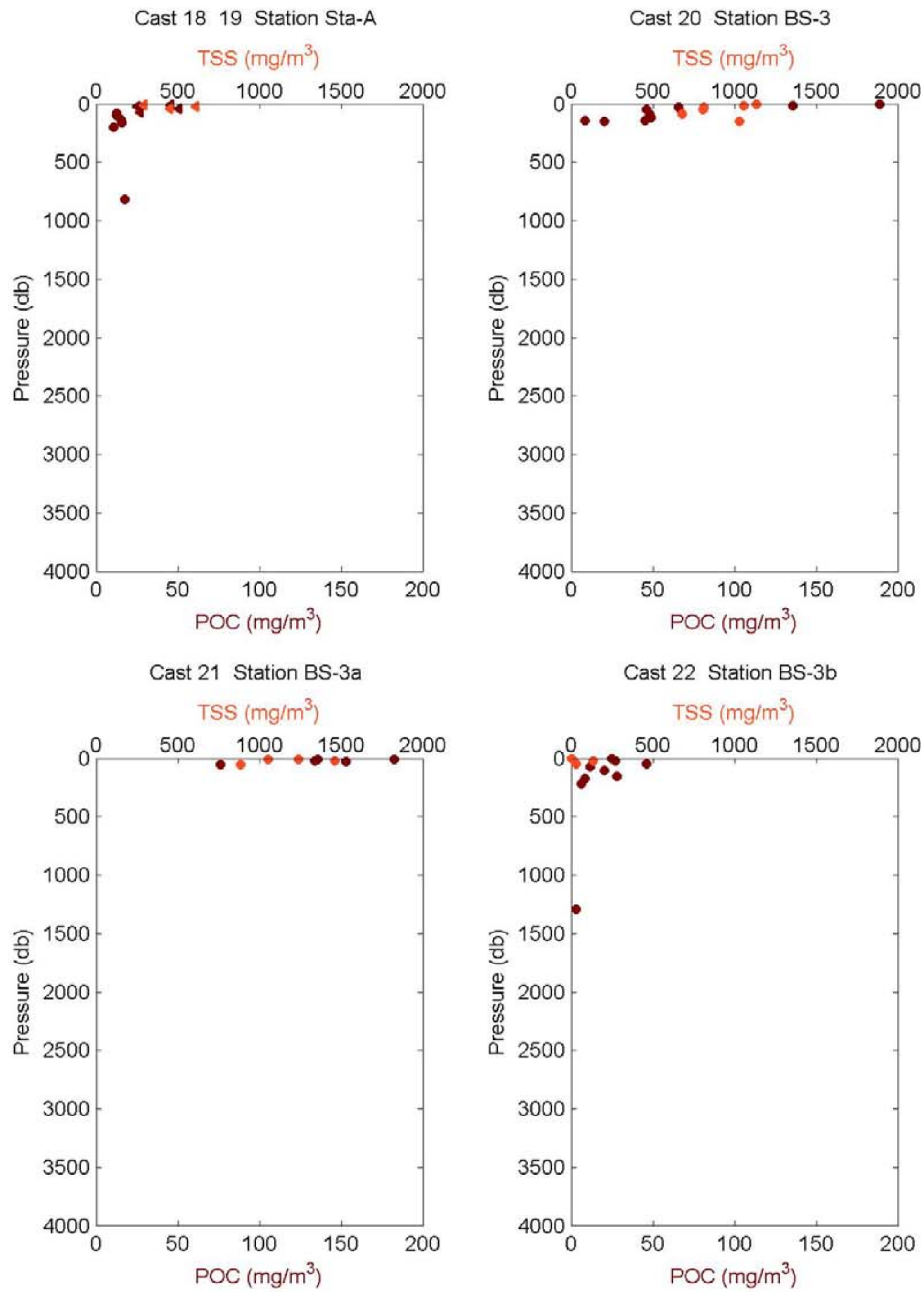


5.1.5 POC/TSS

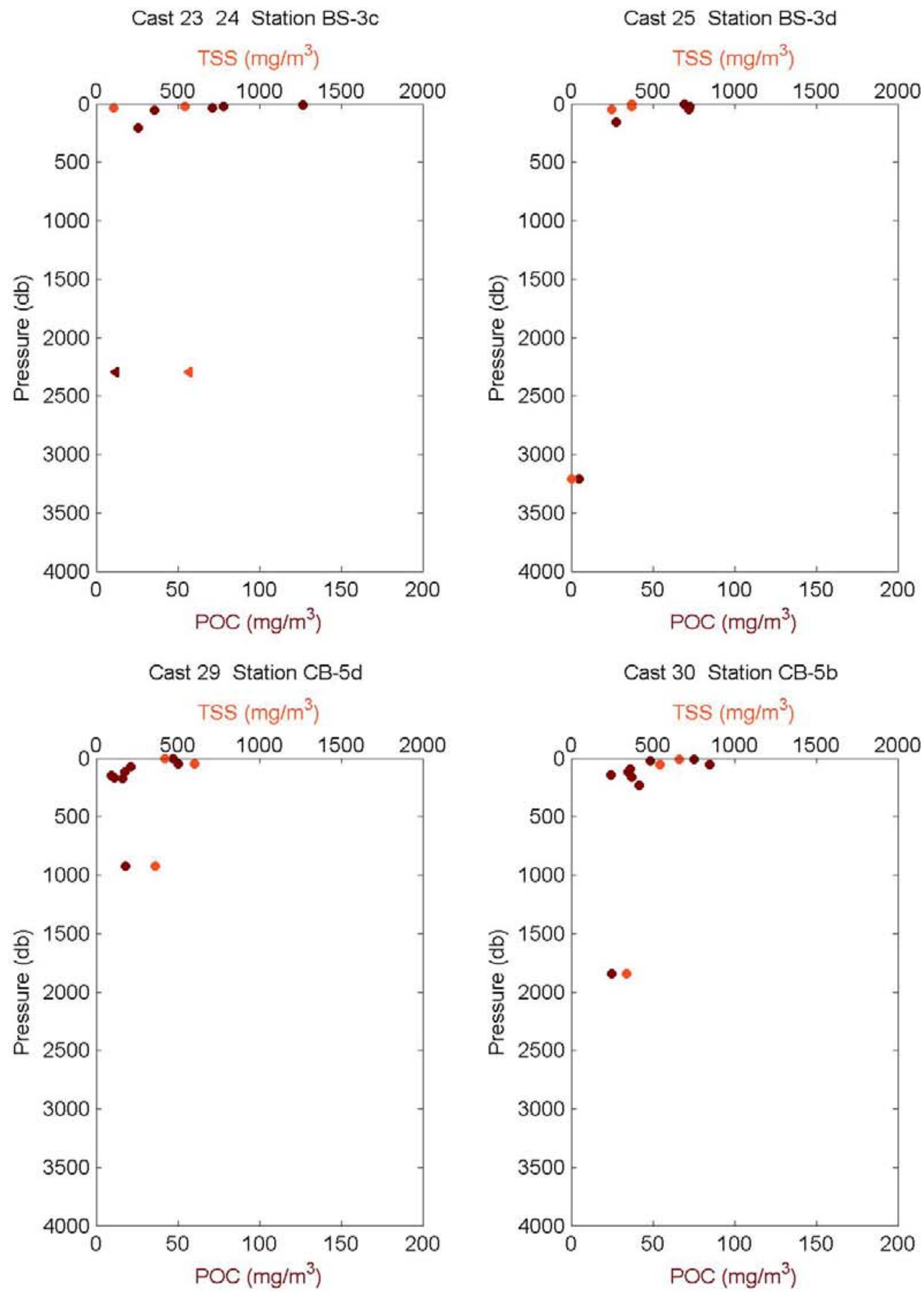
Note: For select stations, multiple casts were taken and are plotted together. Samples for each cast are distinguished by symbol type.



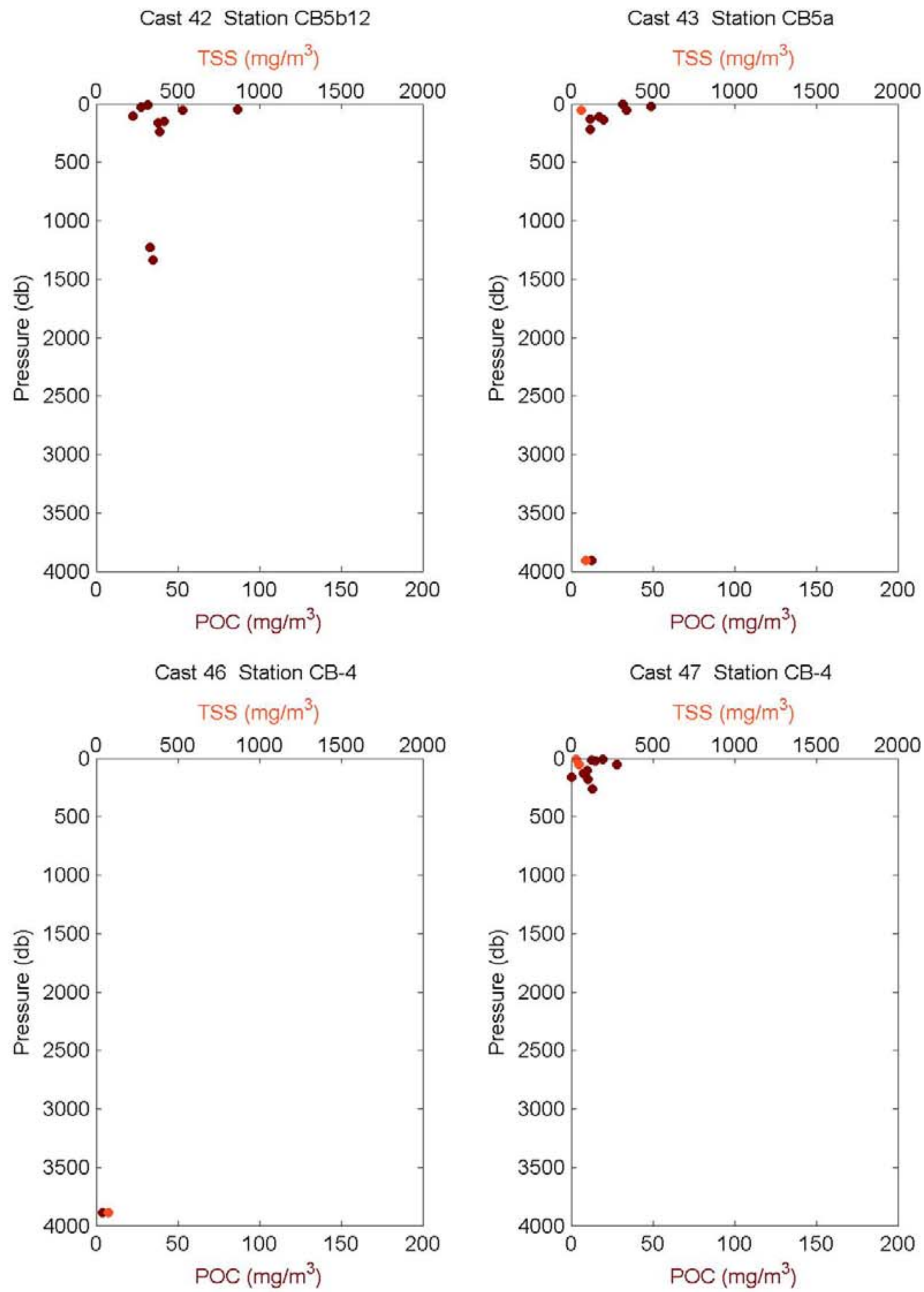
2006-18: POC and TSS



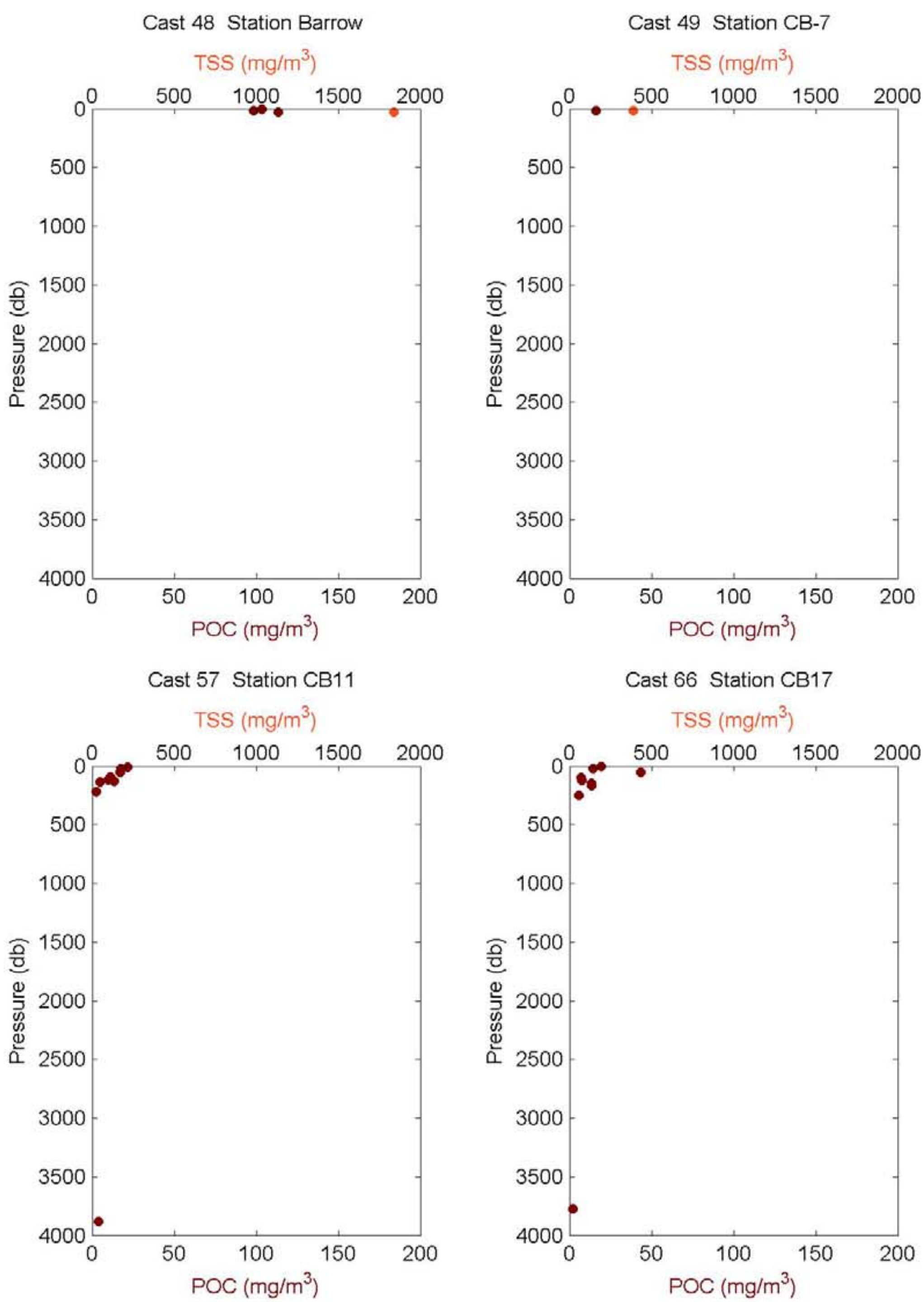
2006-18: POC and TSS



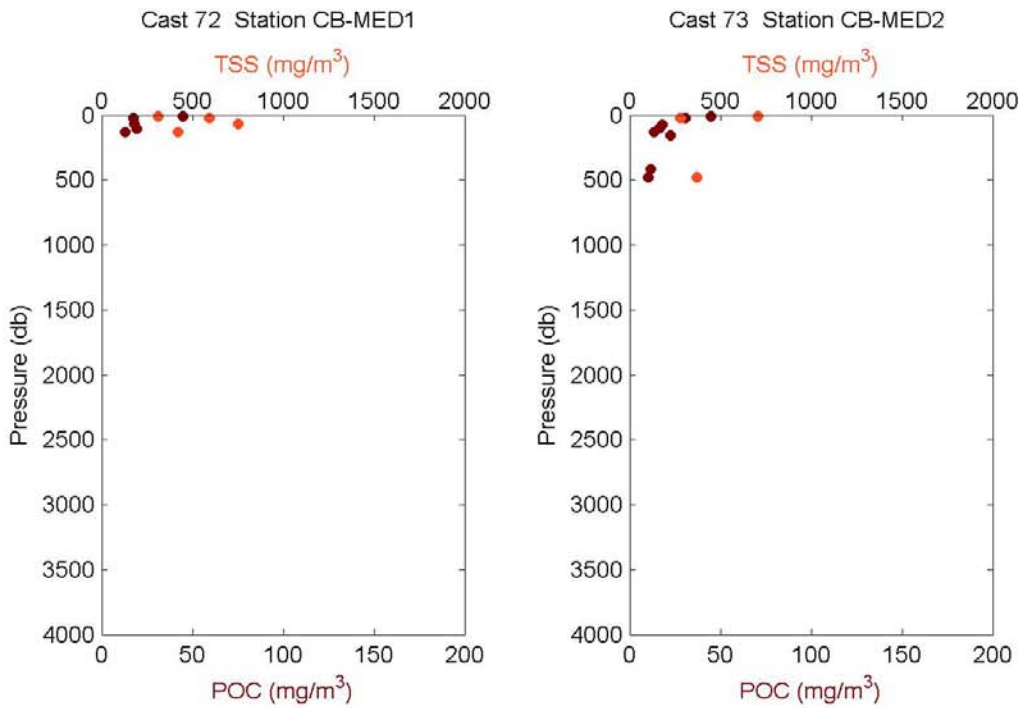
2006-18: POC and TSS



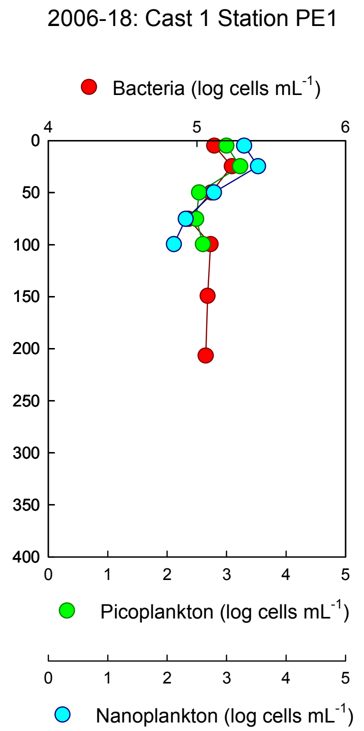
2006-18: POC and TSS

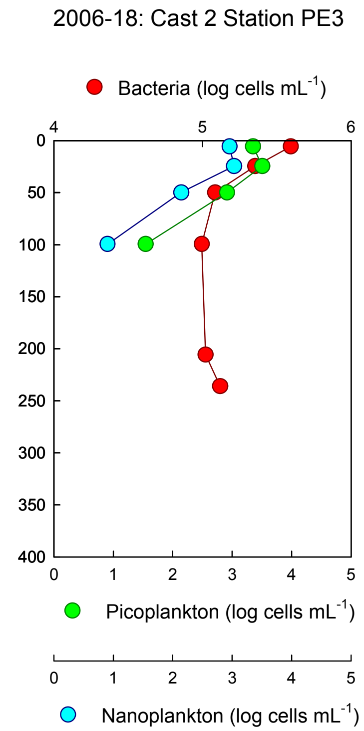


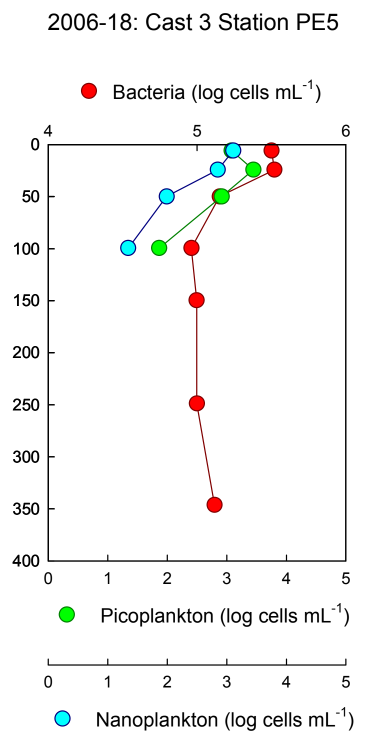
2006-18: POC and TSS

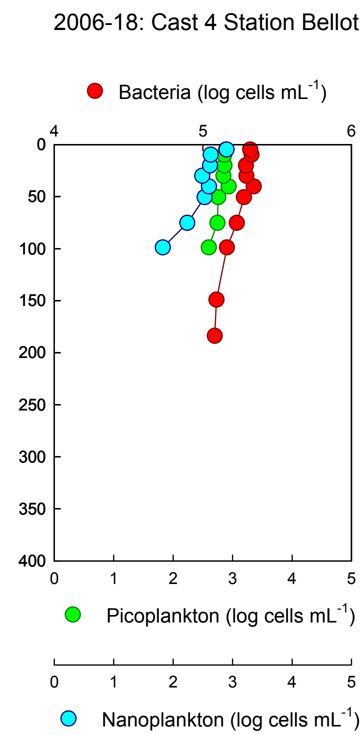


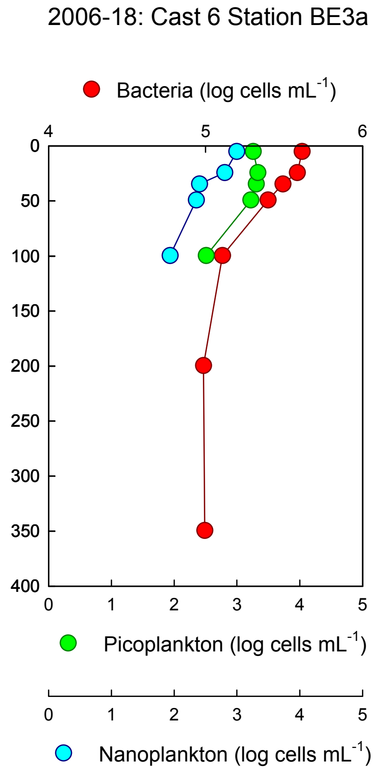
5.1.6 Bacteria

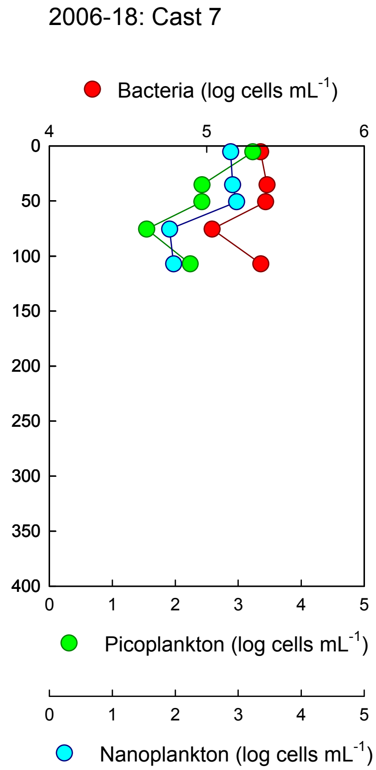


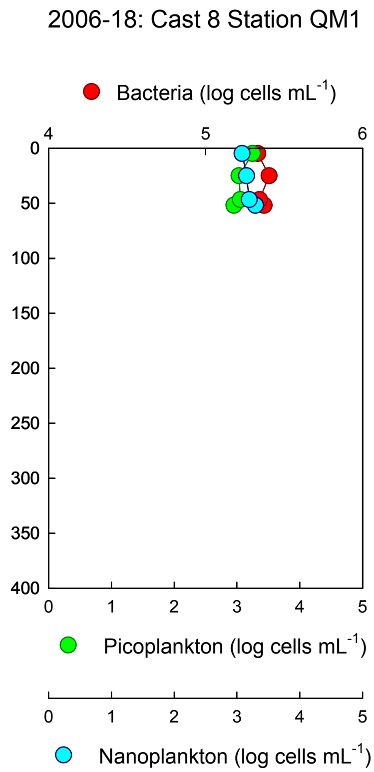


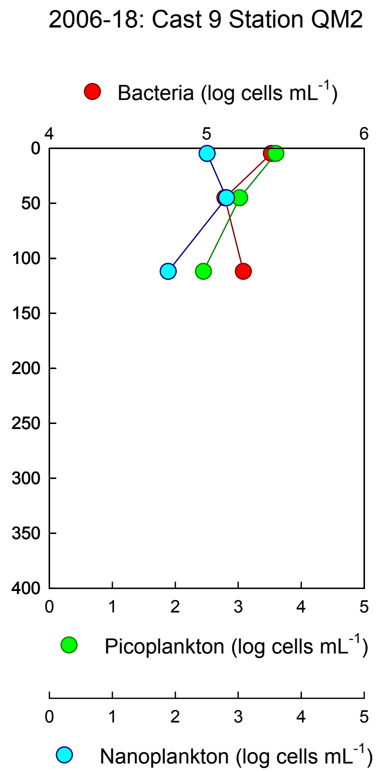


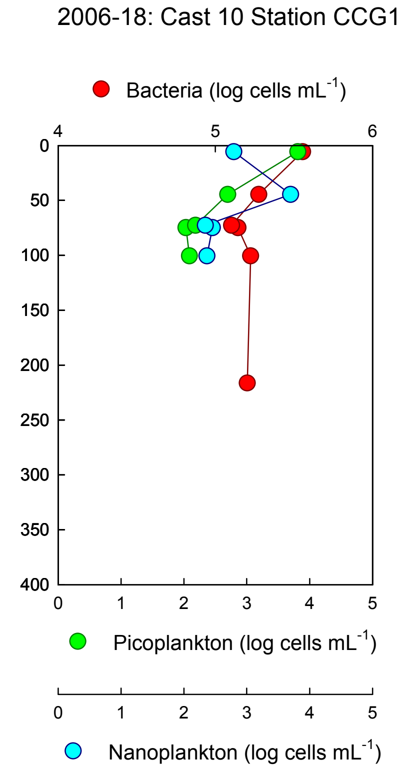


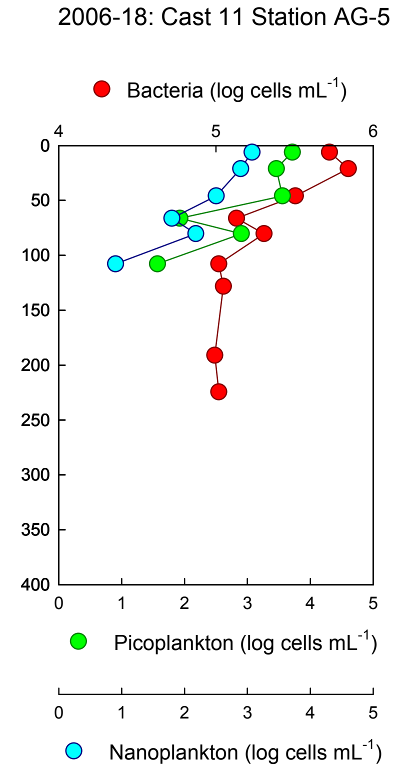

2006-18: Cast 6 Station BE3a
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

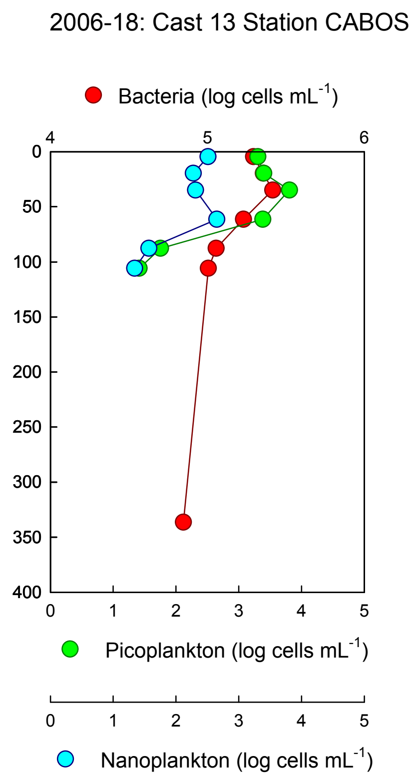

2006-18: Cast 7
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

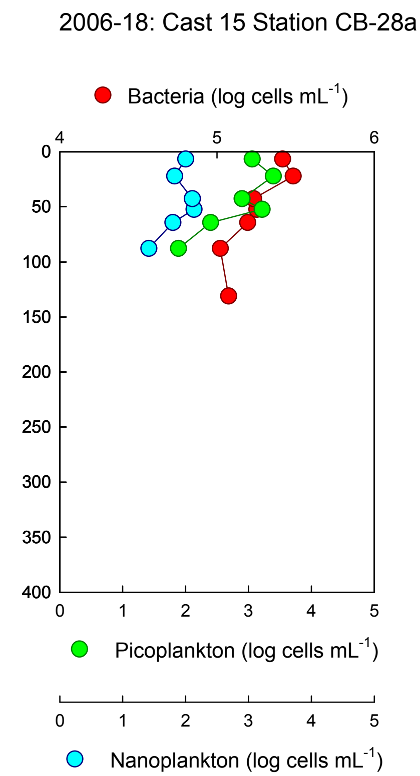

2006-18: Cast 8 Station QM1
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)


2006-18: Cast 9 Station QM2
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

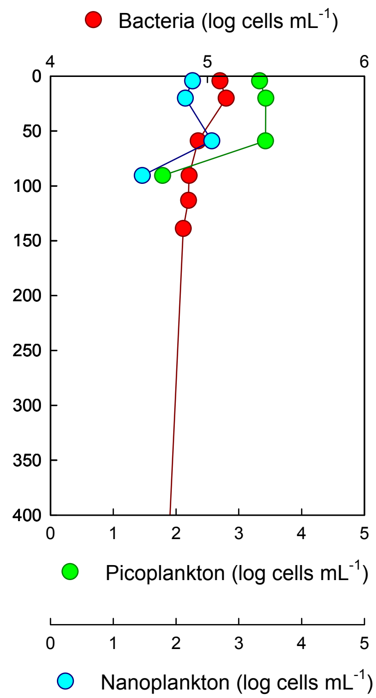

2006-18: Cast 10 Station CCG1
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)


2006-18: Cast 11 Station AG-5
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

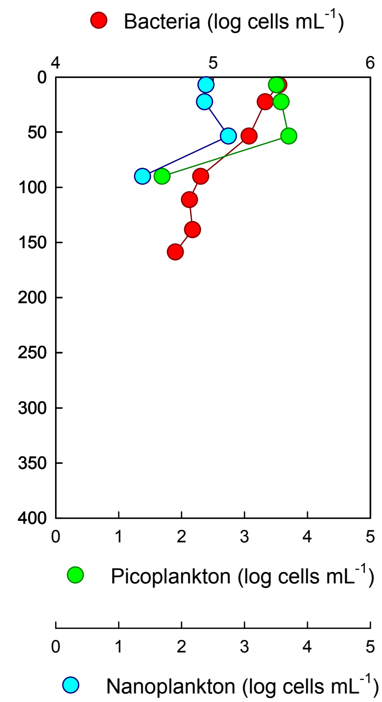

2006-18: Cast 13 Station CABOS
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)


2006-18: Cast 15 Station CB-28a
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

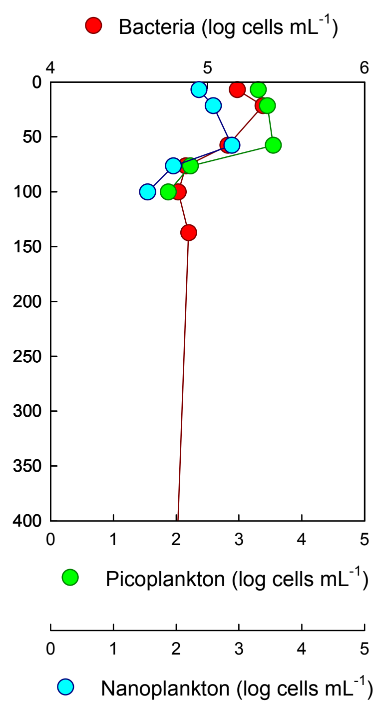
2006-18: Cast 16 Station CB-29



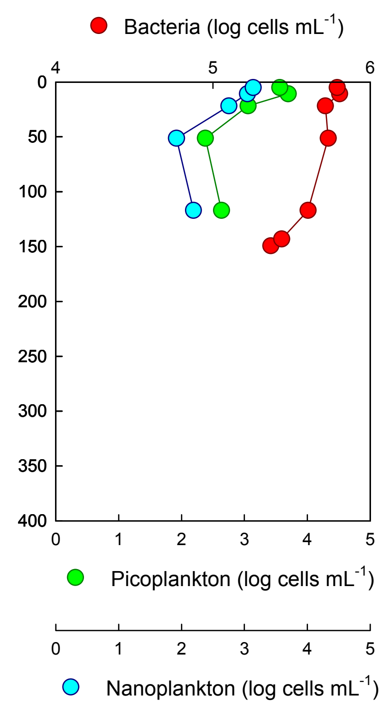
2006-18: Cast 17 Station CB-28bb



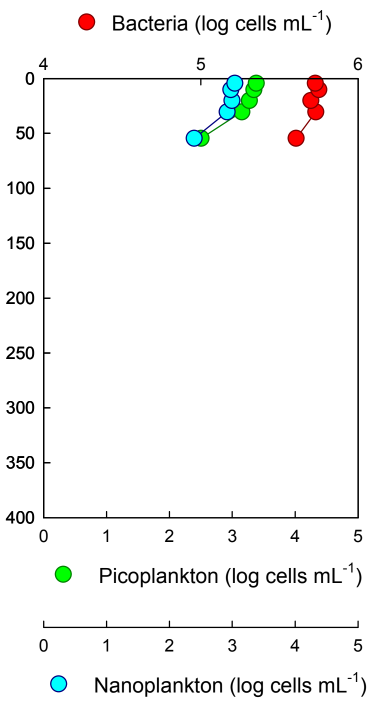
2006-18: Cast 18 Station a



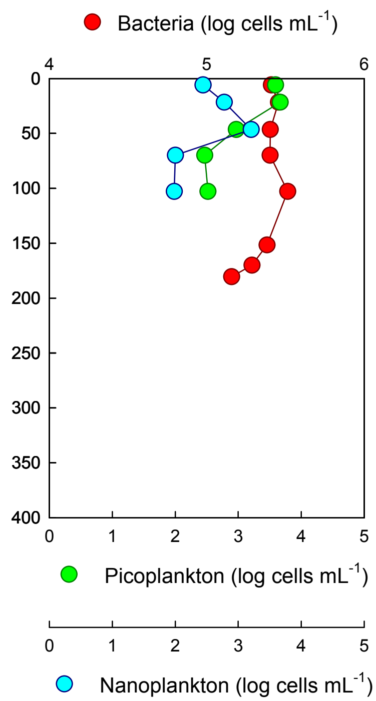
2006-18: Cast 20 Station BS-3



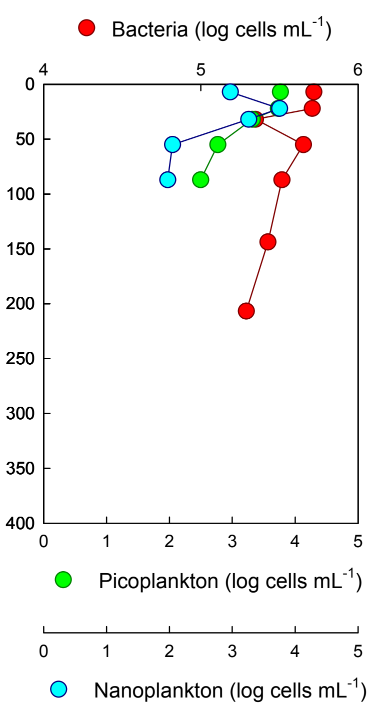
2006-18: Cast 21 Station BS-3a



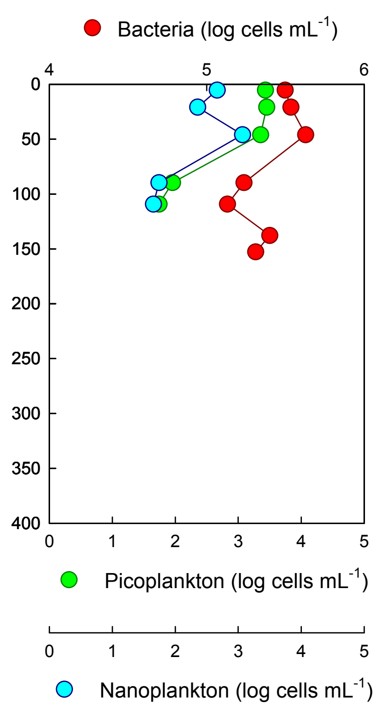
2006-18: Cast 22 Station BS-3b



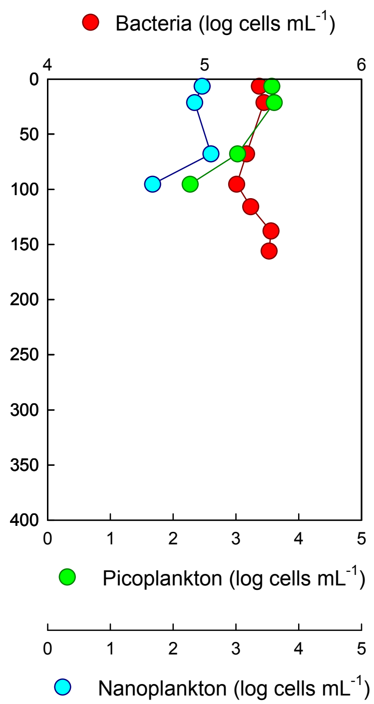
2006-18: Cast 24 Station BS-3c



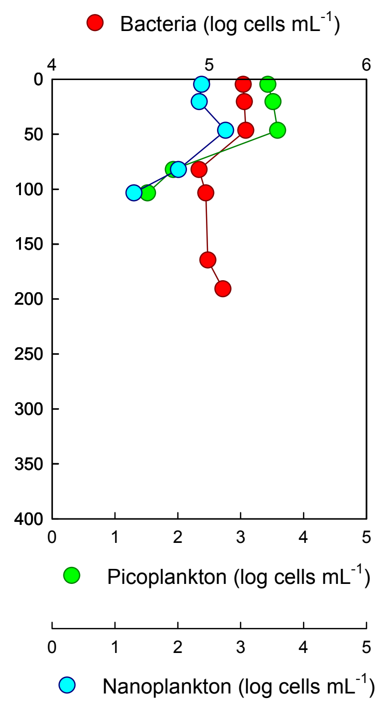
2006-18: Cast 25 Station BS-3d



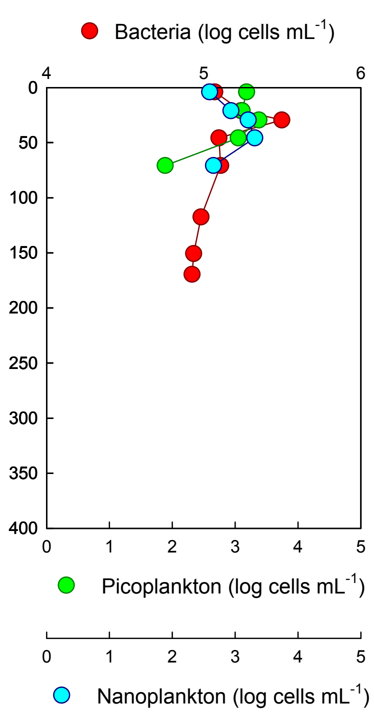
2006-18: Cast 26 Station CB-02a



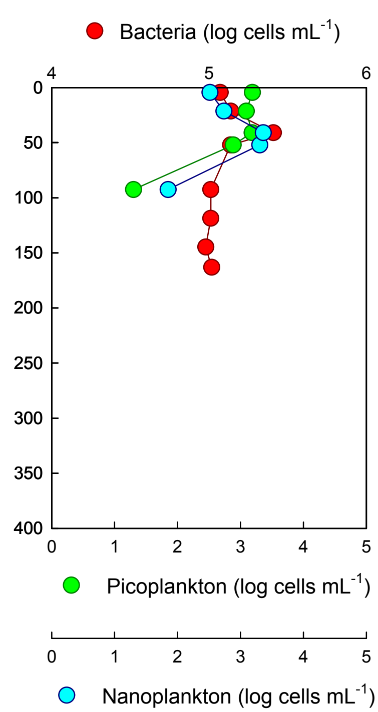
2006-18: Cast 27 Station CB-02



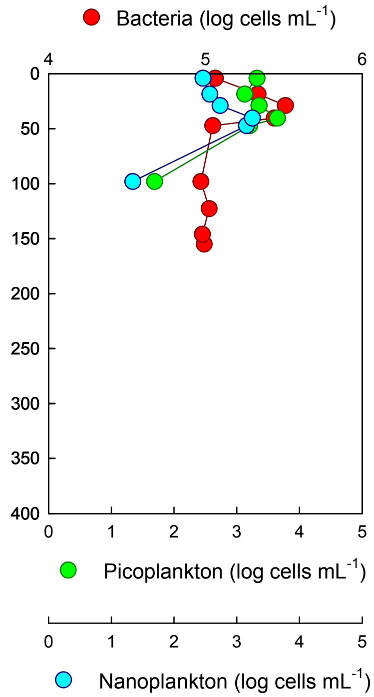
2006-18: Cast 29 Station CB-05d



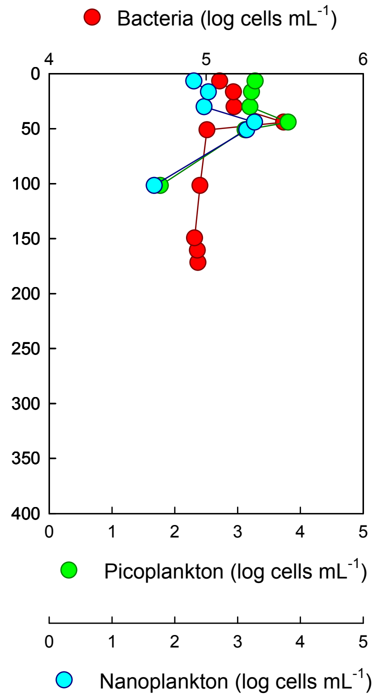
2006-18: Cast 30 Station CB-05d



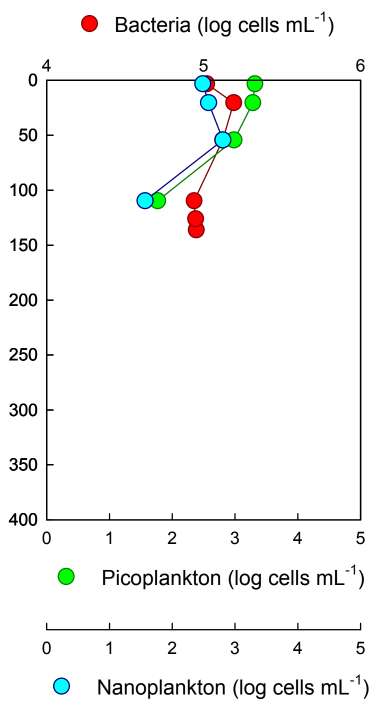
2006-18: Cast 40 Station CB-05b10



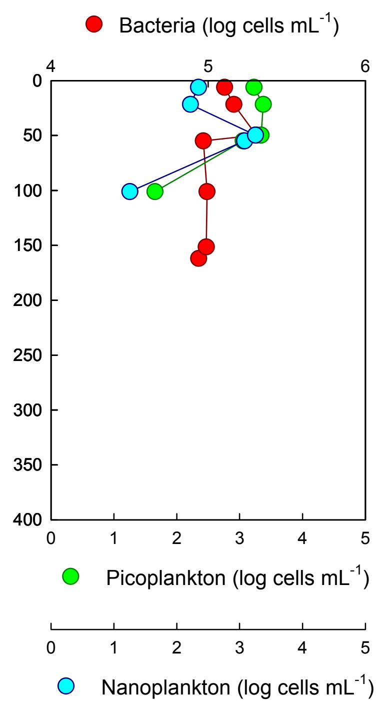
2006-18: Cast 42 Station CB-05b12

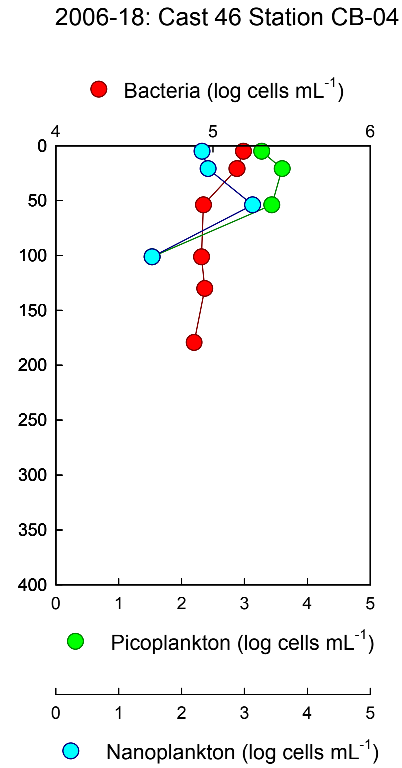


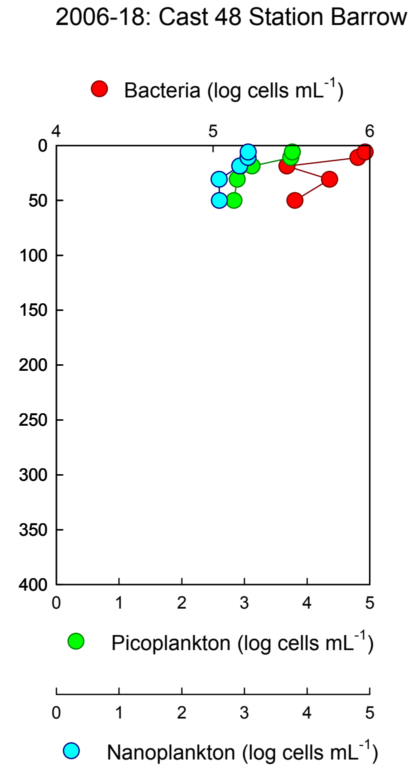
2006-18: Cast 43 Station CB-05A

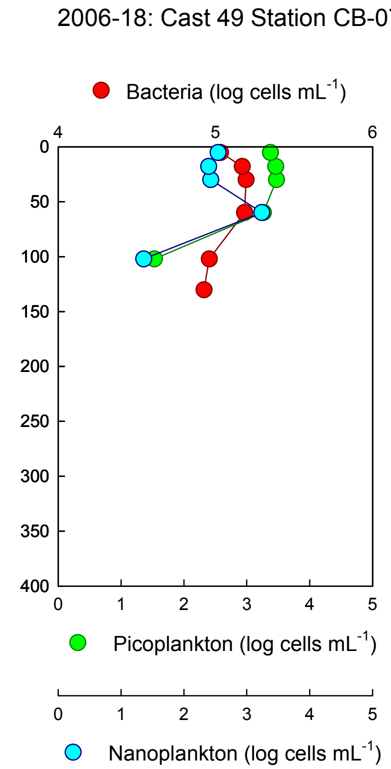


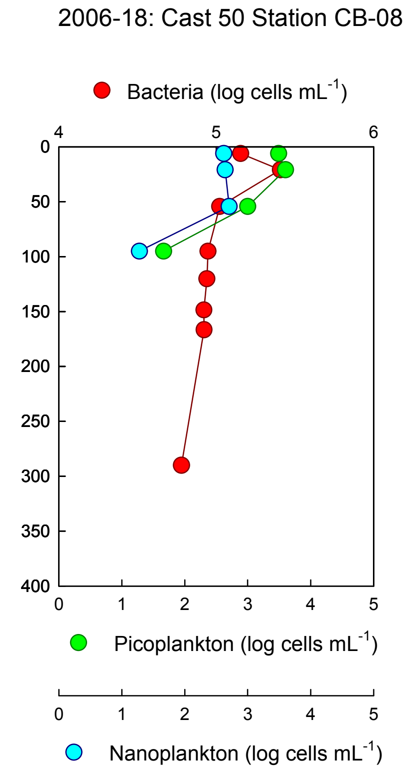
2006-18: Cast 45 Station CB-05



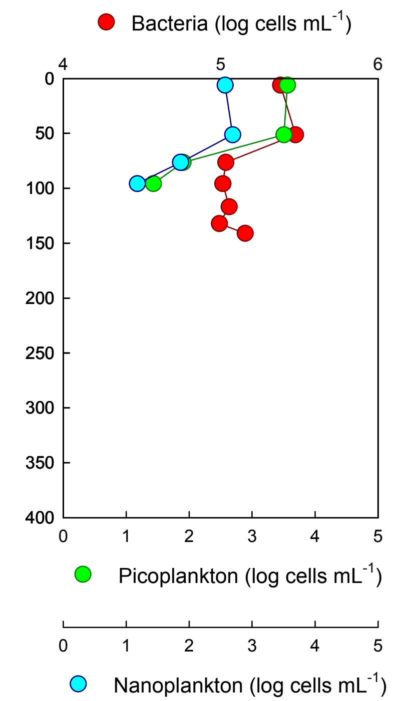

2006-18: Cast 46 Station CB-04
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)


2006-18: Cast 48 Station Barrow
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

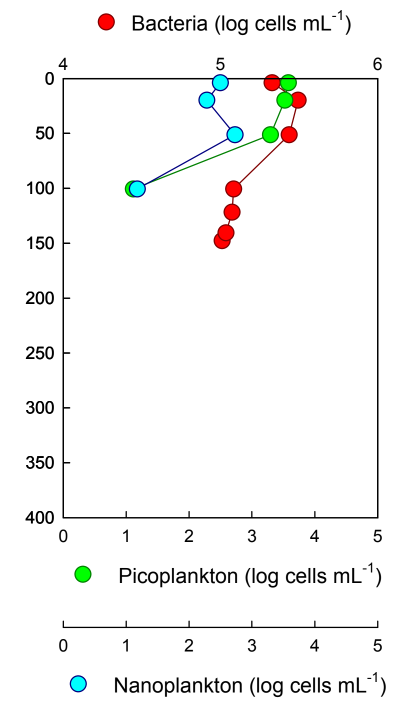

2006-18: Cast 49 Station CB-07
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)


2006-18: Cast 50 Station CB-08
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

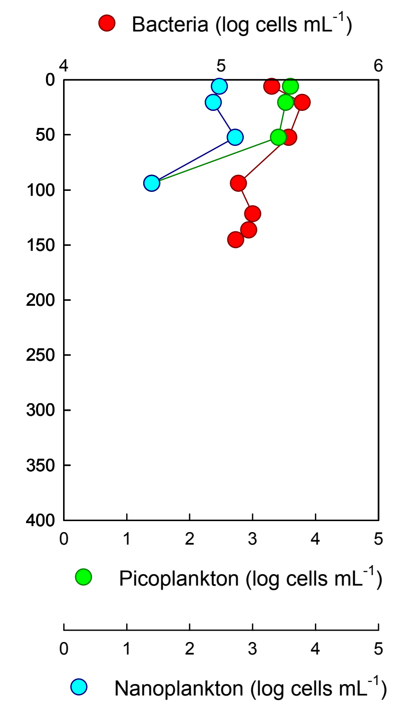
2006-18: Cast 52 Station CB-09



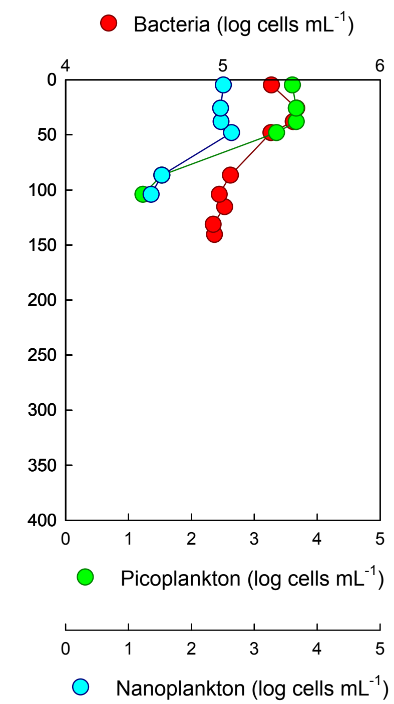
2006-18: Cast 53 Station CB-10



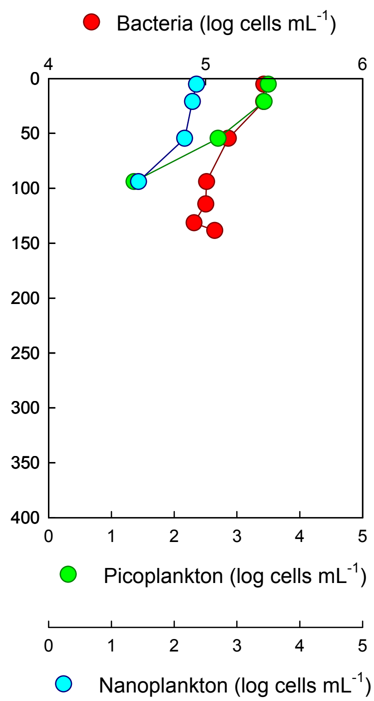
2006-18: Cast 55 Station CB-10a2



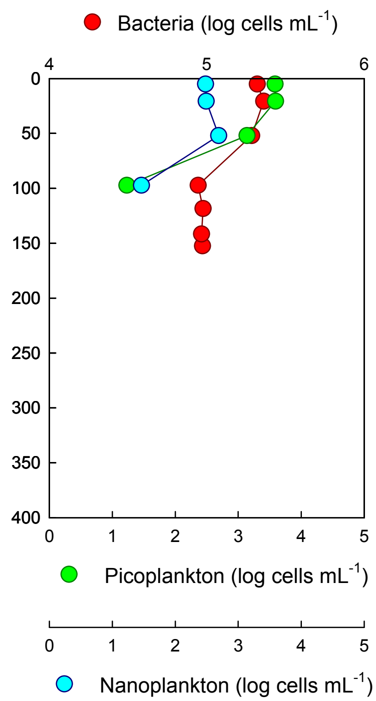
2006-18: Cast 56 Station CB-10a



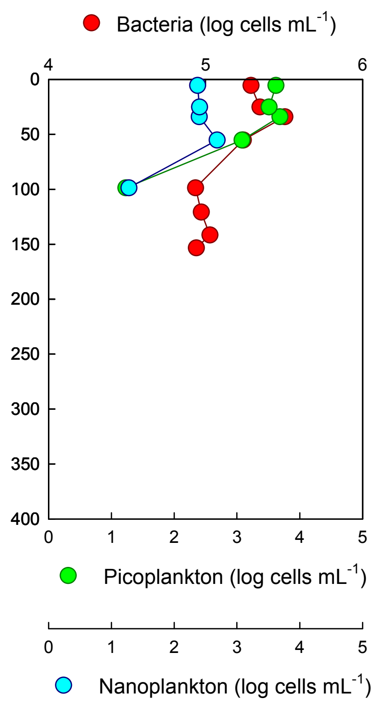
2006-18: Cast 57 Station CB-11



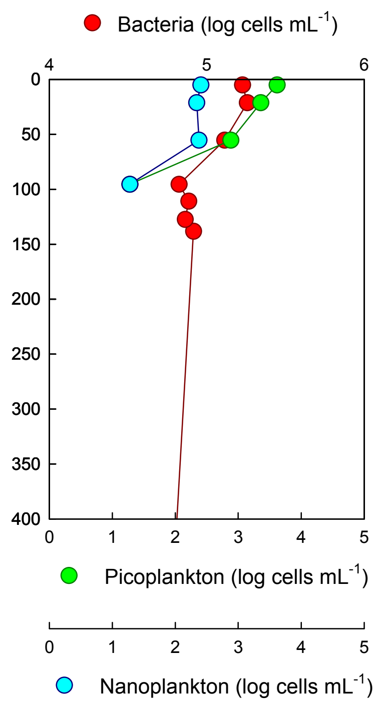
2006-18: Cast 59 Station CB-12

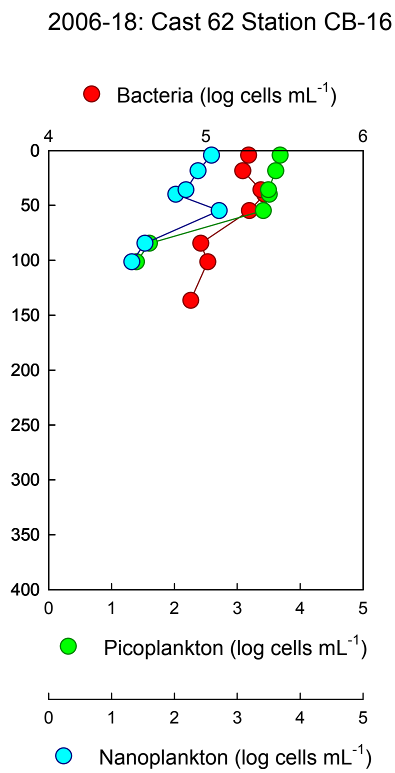


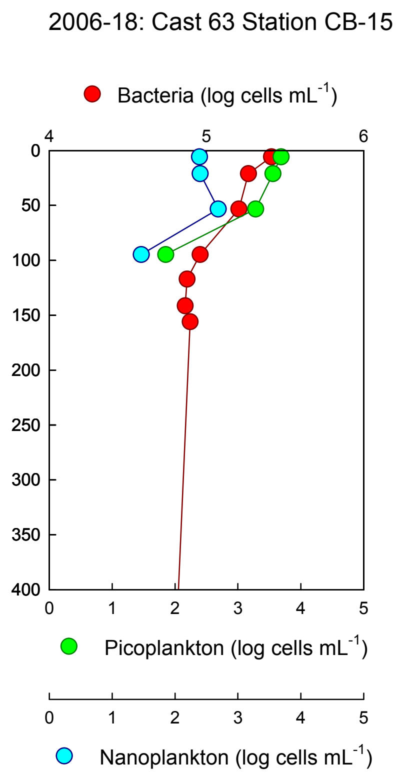
2006-18: Cast 60 Station CB-13

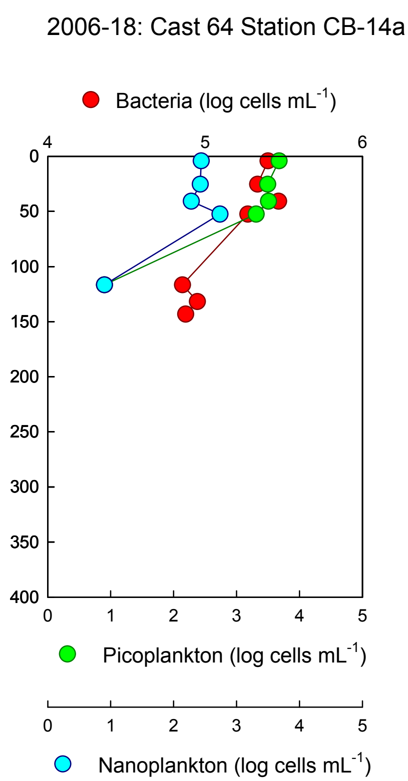


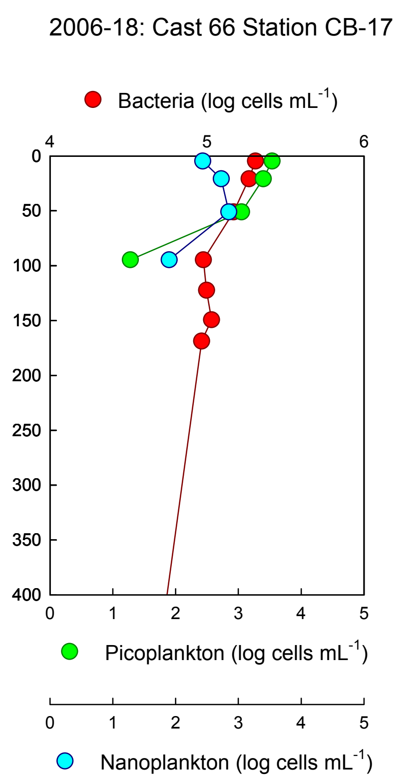
2006-18: Cast 61 Station CB-16



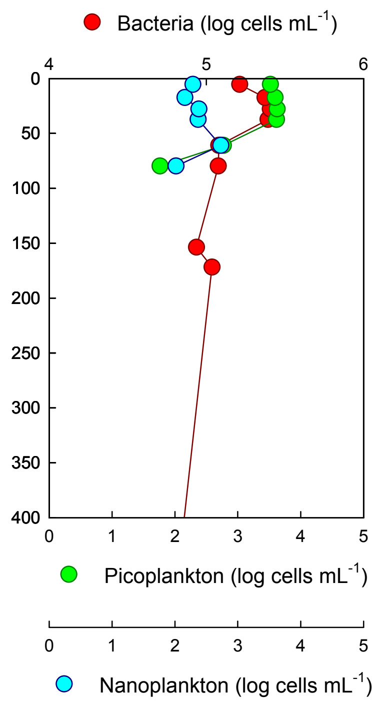

2006-18: Cast 62 Station CB-16
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)


2006-18: Cast 63 Station CB-15
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

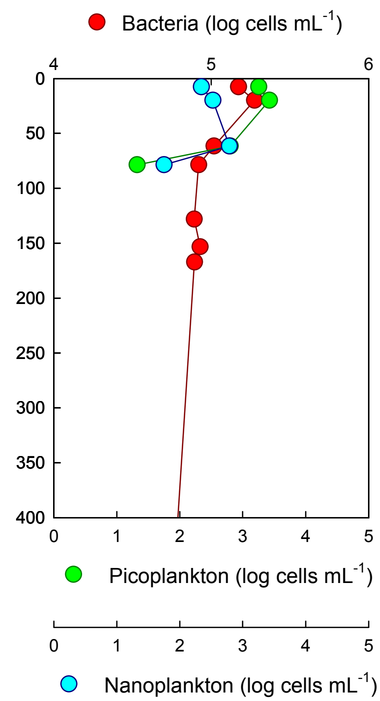

2006-18: Cast 64 Station CB-14a
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)


2006-18: Cast 66 Station CB-17
Bacteria (log cells mL-1)
Picoplankton (log cells mL-1)
Nanoplankton (log cells mL-1)

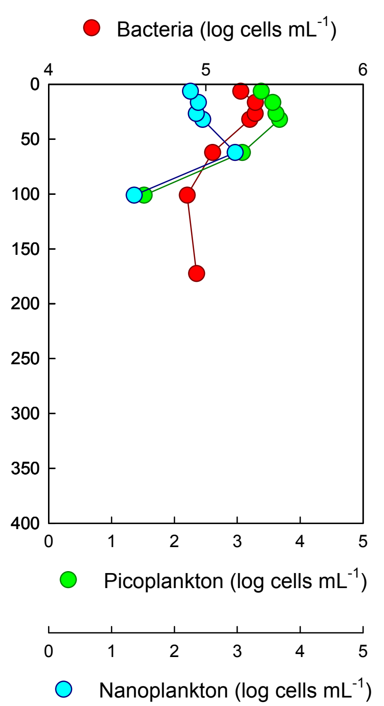
2006-18: Cast 67 Station CB-18



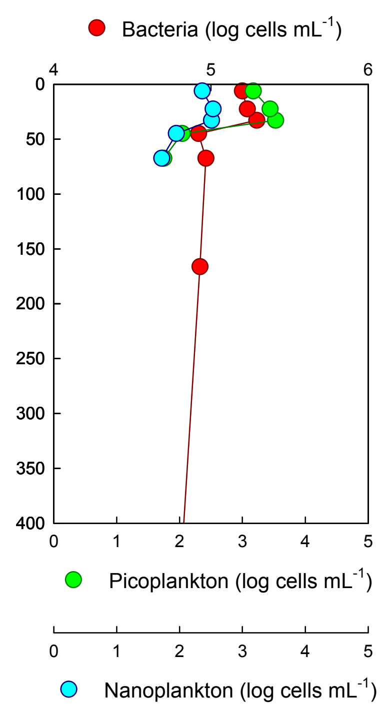
2006-18: Cast 68 Station CB-21

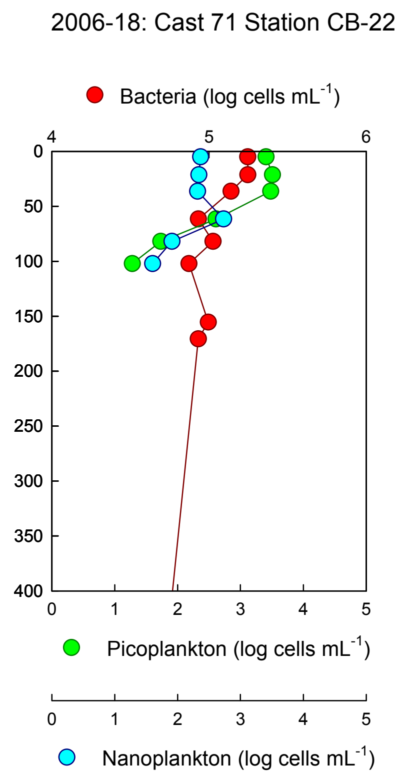


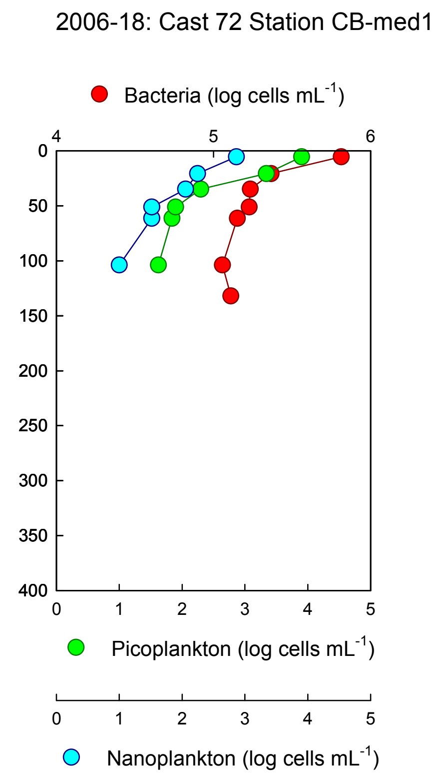
2006-18: Cast 69 Station CB-19

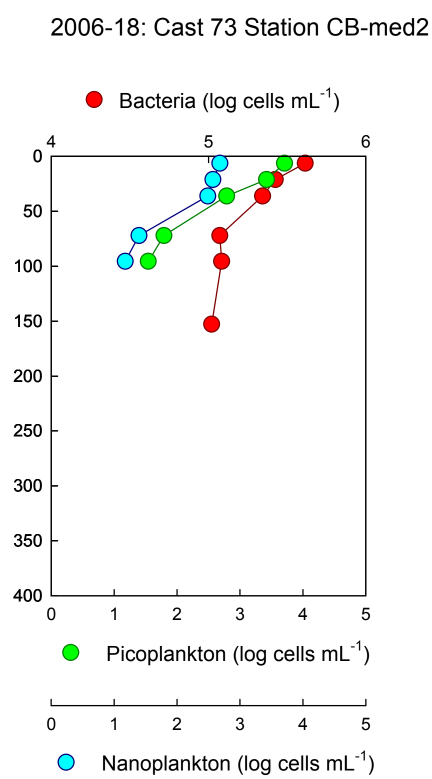


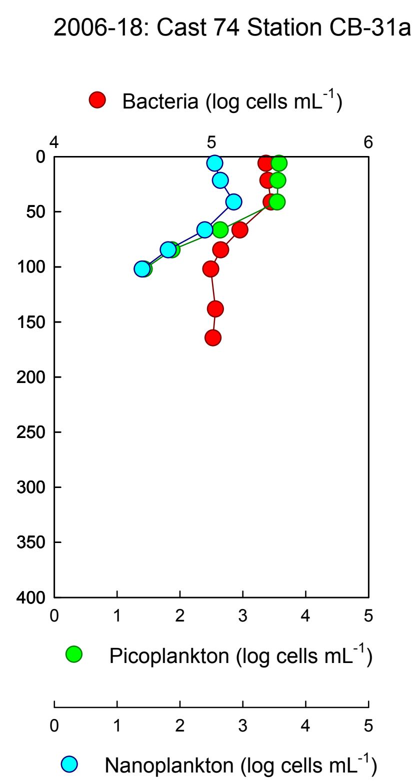
2006-18: Cast 70 Station GF-06



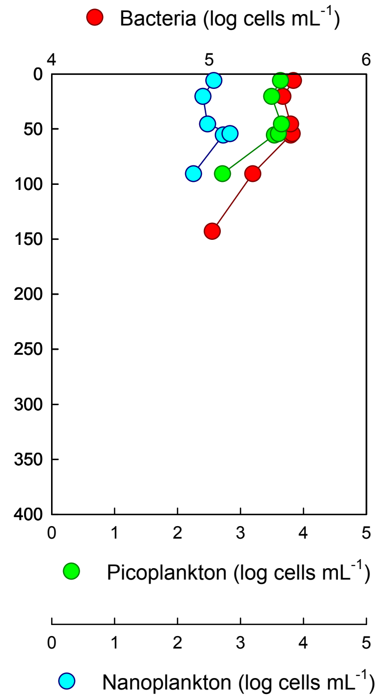

2006-18: Cast 71 Station CB-22
Bacteria (log cells mL-1)
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
Picoplankton (log cells mL-1)
0
1
2
3
4
5
Nanoplankton (log cells mL-1)


2006-18: Cast 72 Station CB-med1
Bacteria (log cells mL-1)
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
Picoplankton (log cells mL-1)
0
1
2
3
4
5
Nanoplankton (log cells mL-1)

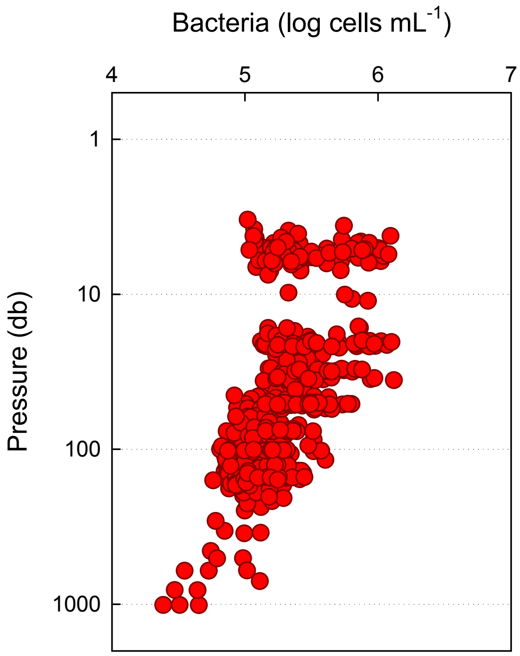

2006-18: Cast 73 Station CB-med2
Bacteria (log cells mL-1)
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
Picoplankton (log cells mL-1)
0
1
2
3
4
5
Nanoplankton (log cells mL-1)

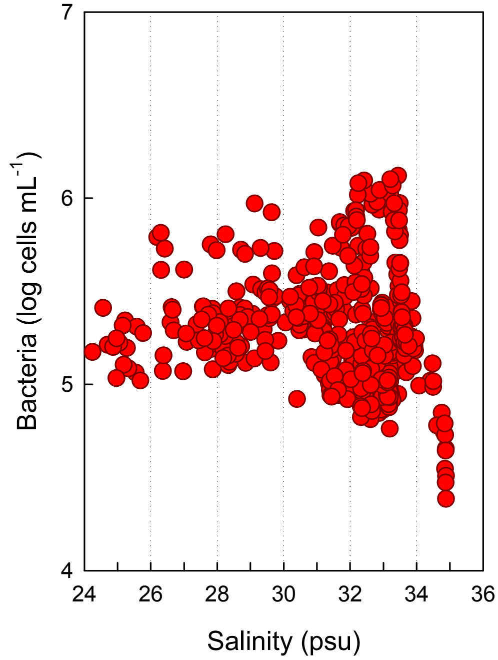

2006-18: Cast 74 Station CB-31a
Bacteria (log cells mL-1)
4
5
6
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
Picoplankton (log cells mL-1)
0
1
2
3
4
5
Nanoplankton (log cells mL-1)

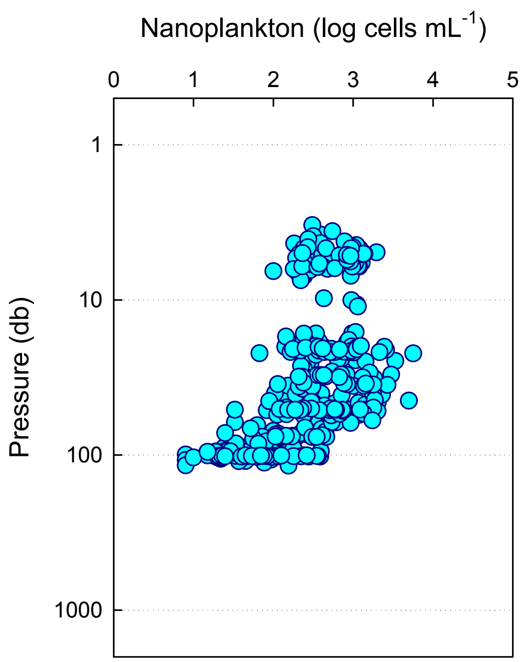
2006-18: Cast 75 Station CABOS

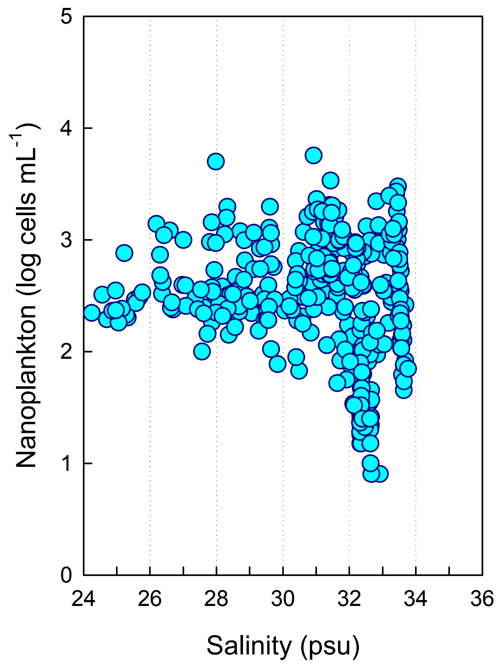


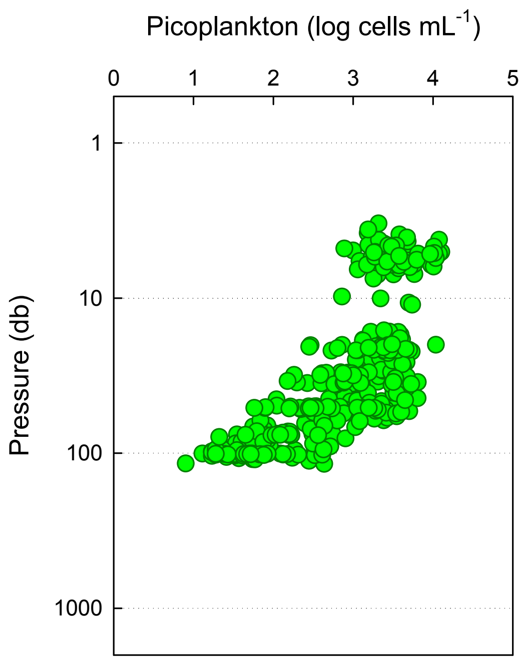
Note: The following figures provide a summary of all bacteria, nanoplankton and picoplankton data collected in the Canada Basin, Canadian Arctic Archipelago and Baffin Bay during 2006 (Missions 2006-18 and 2006-43 combined).



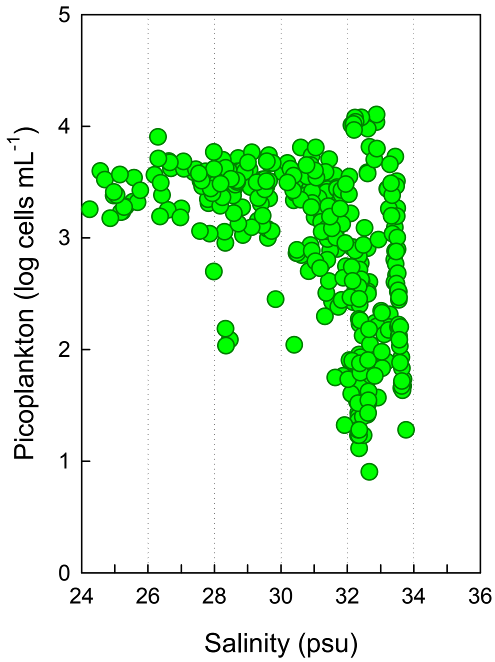






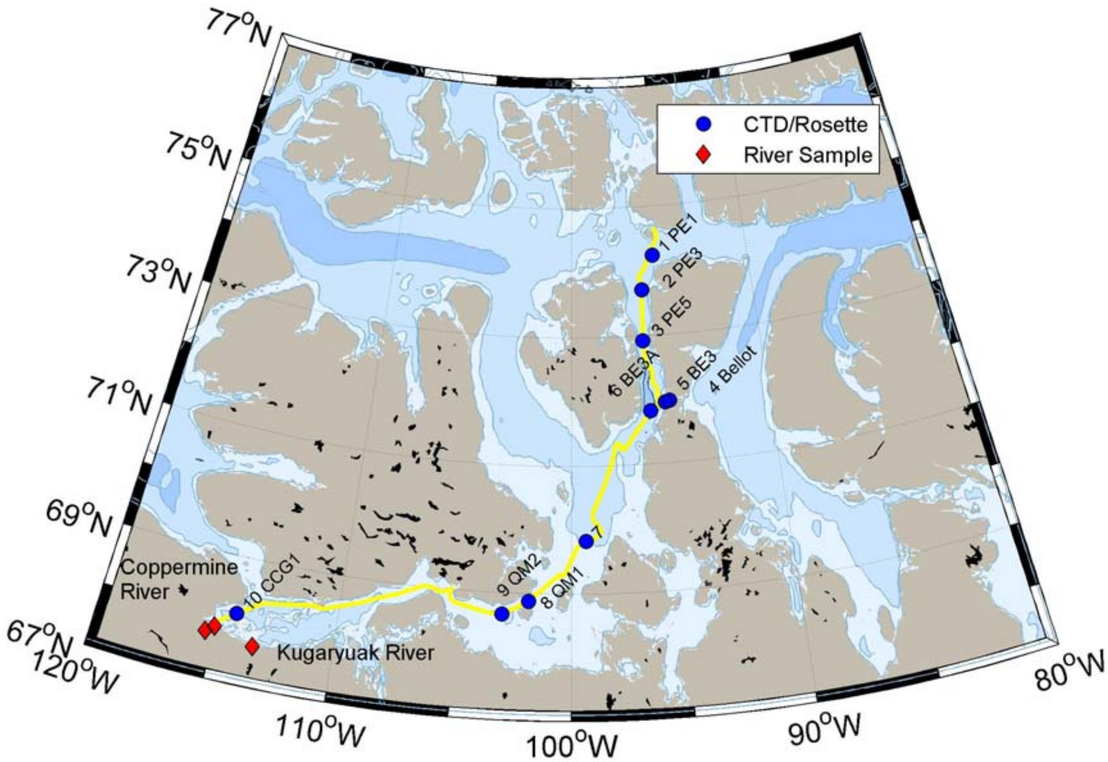


Picoplankton (log cells mL^{-1})
0
1
2
3
4
5
Pressure (db)
1
10
100
1000



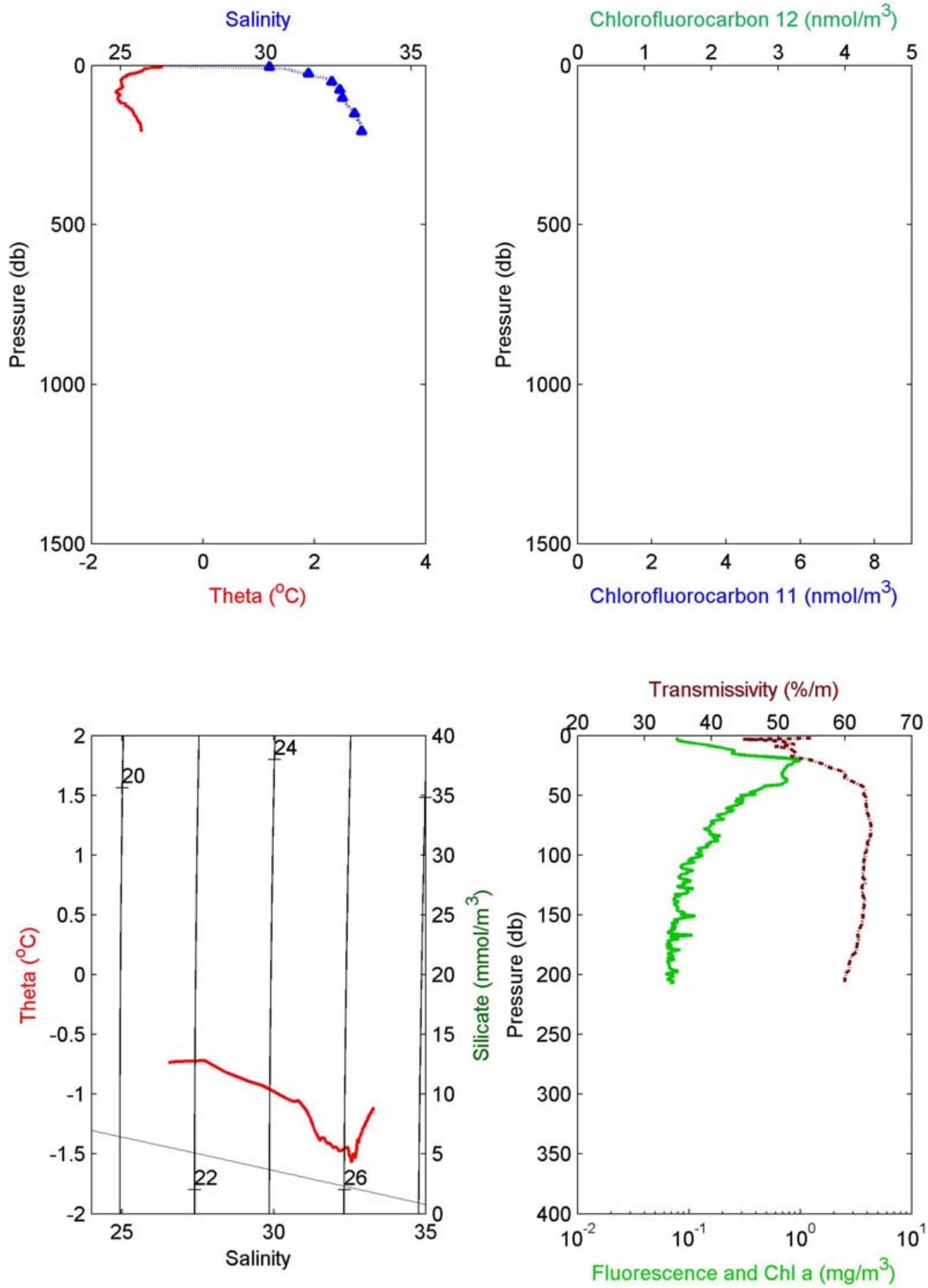
Picoplankton (log cells mL^{-1})
0
1
2
3
4
5
24
26
28
30
32
34
36
Salinity (psu)

5.2 Archipelago

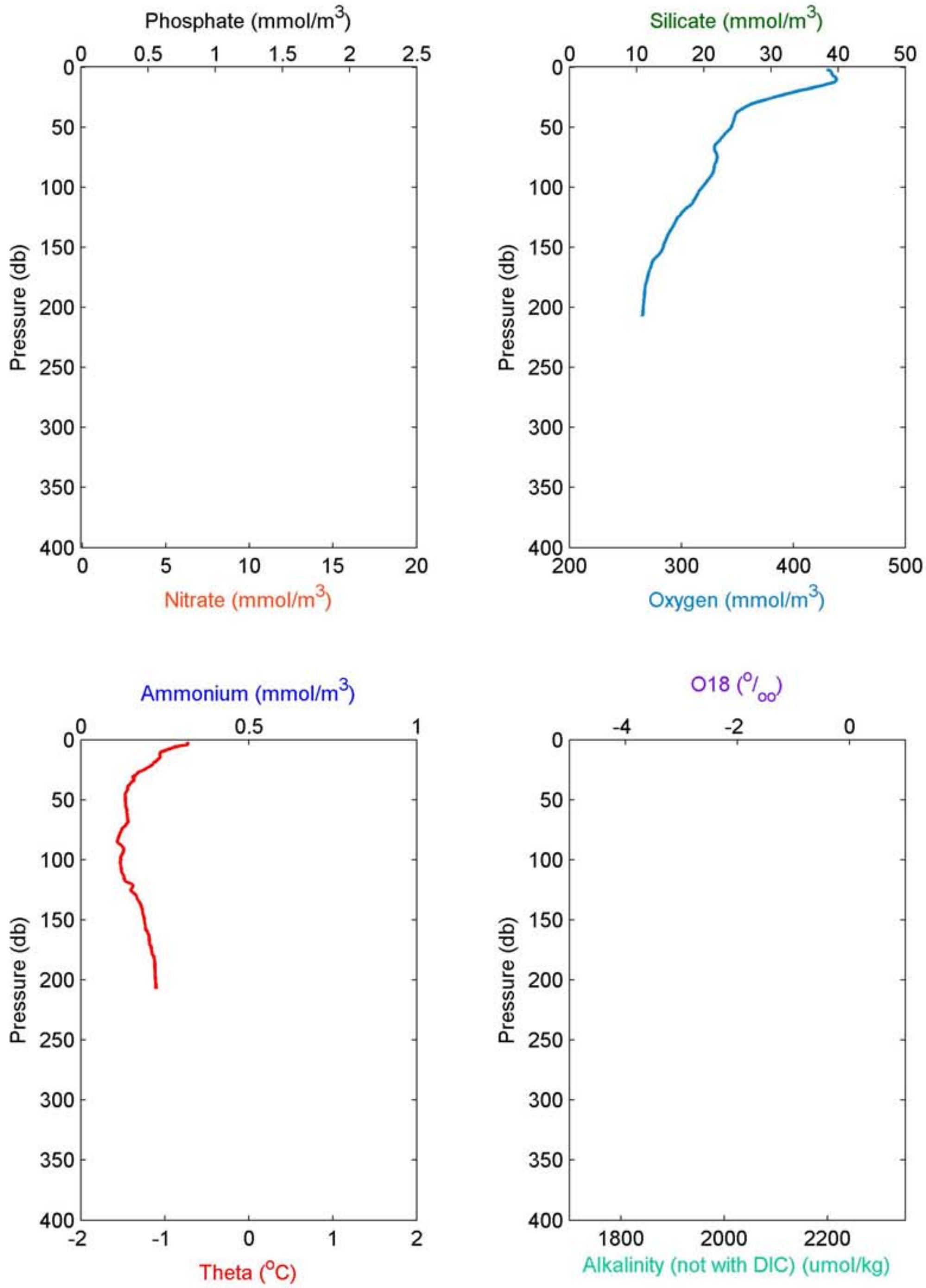


*This page has been left blank so the following plots
for each station will fall on facing pages*

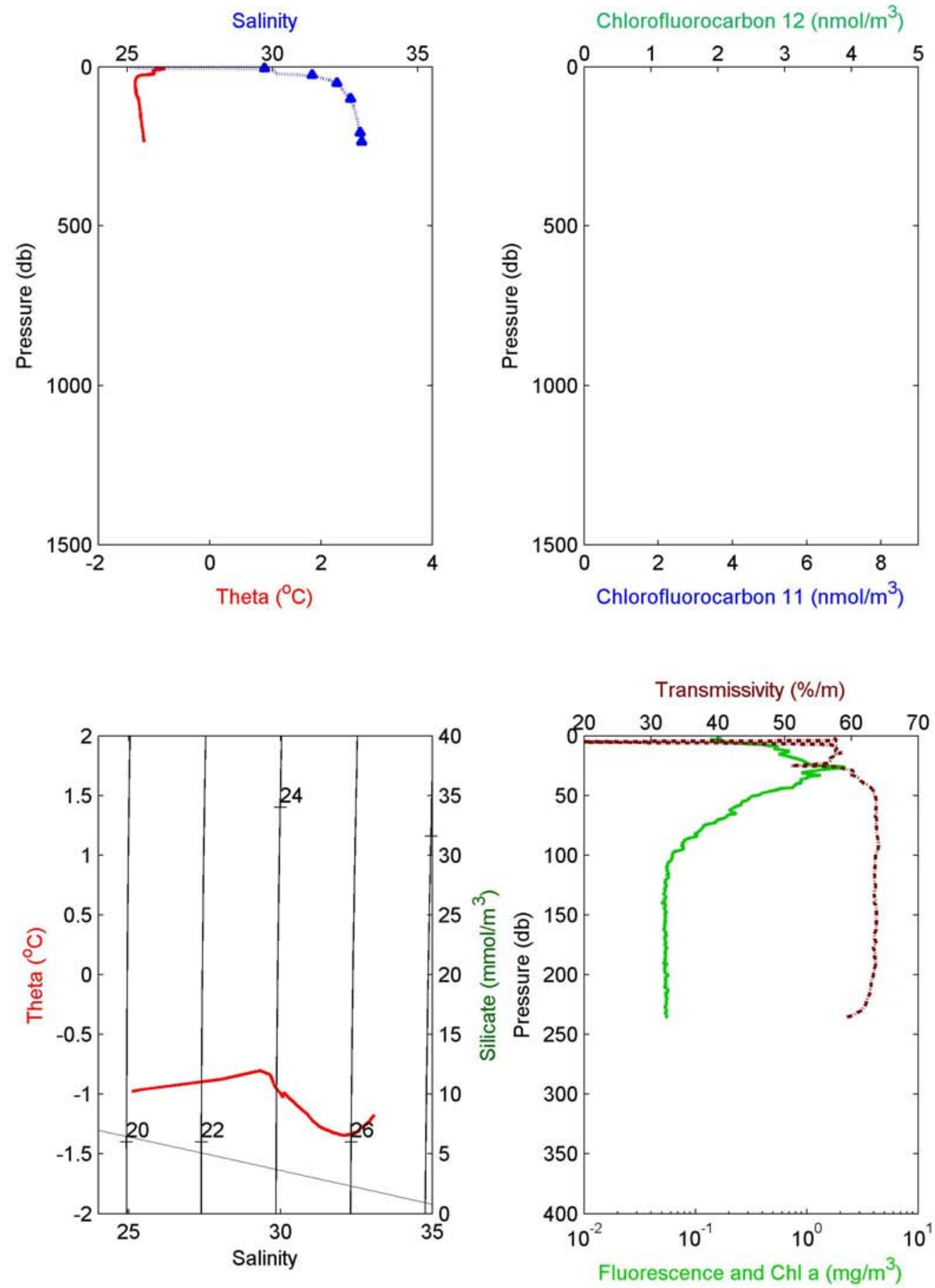
2006-18: Cast 1 Station PE1 (Canadian Archipelago)



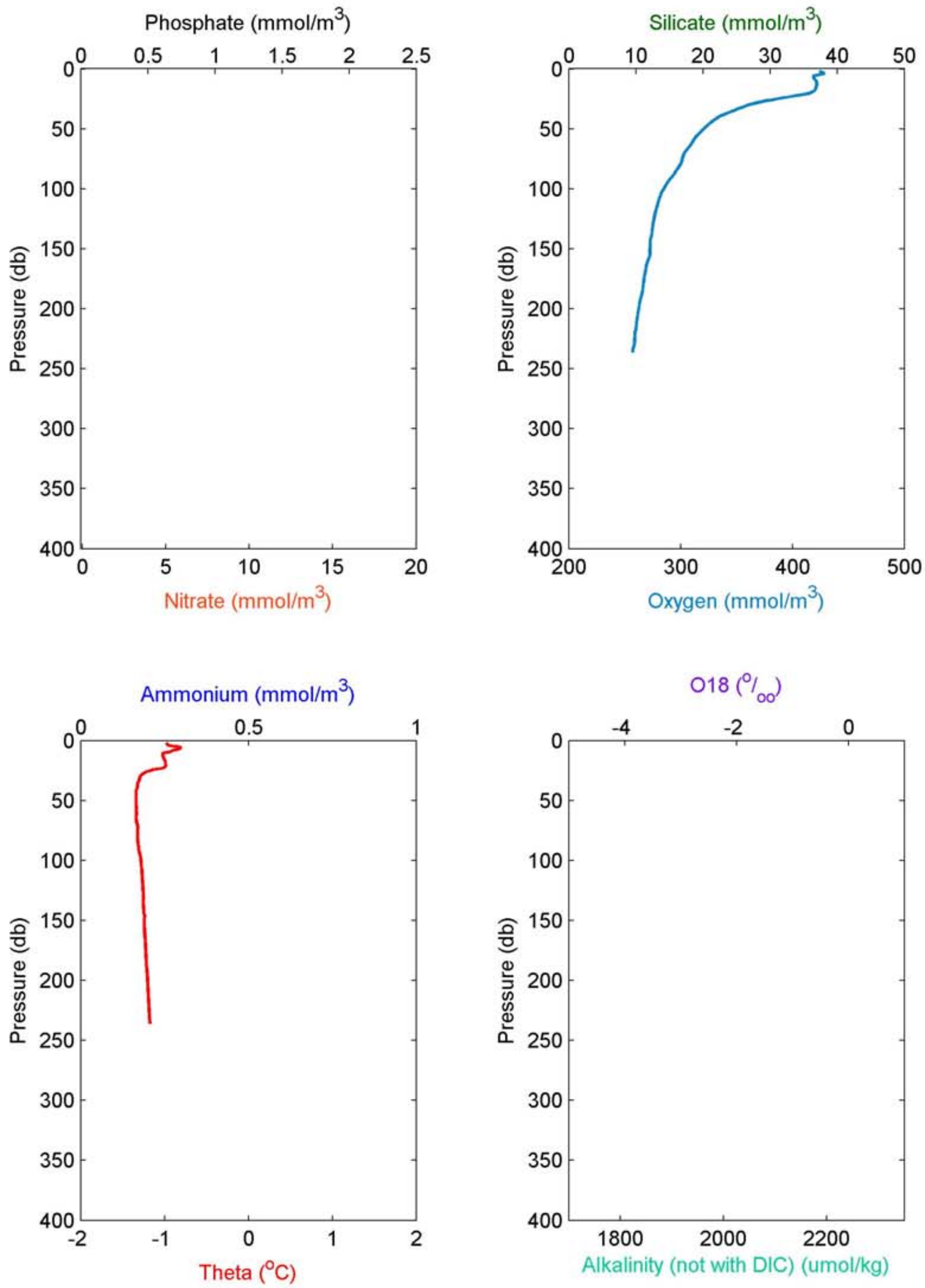
2006-18: Cast 1 Station PE1 (Canadian Archipelago)



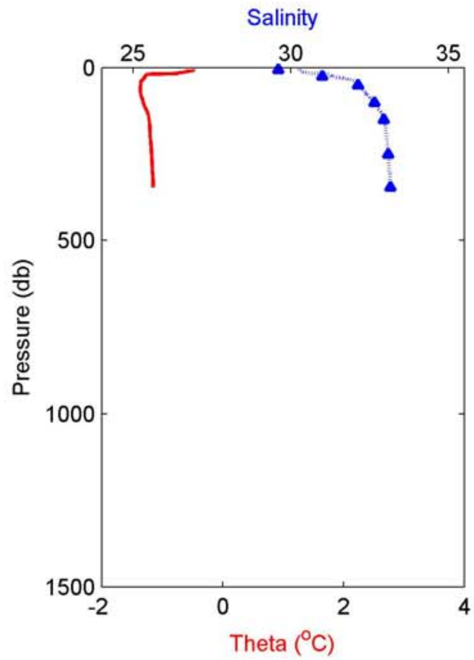
2006-18: Cast 2 Station PE3 (Canadian Archipelago)

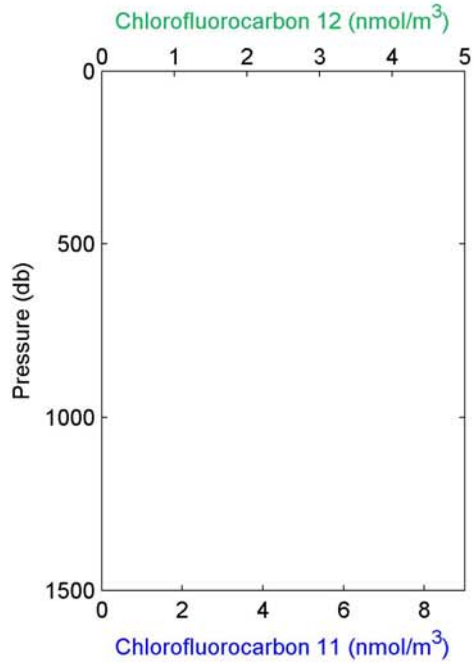


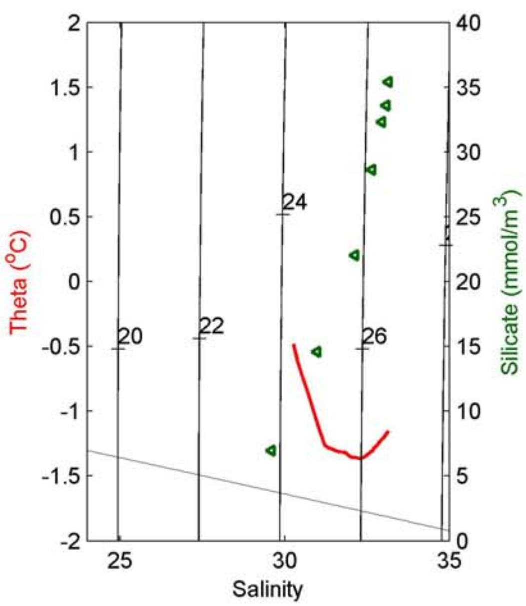
2006-18: Cast 2 Station PE3 (Canadian Archipelago)

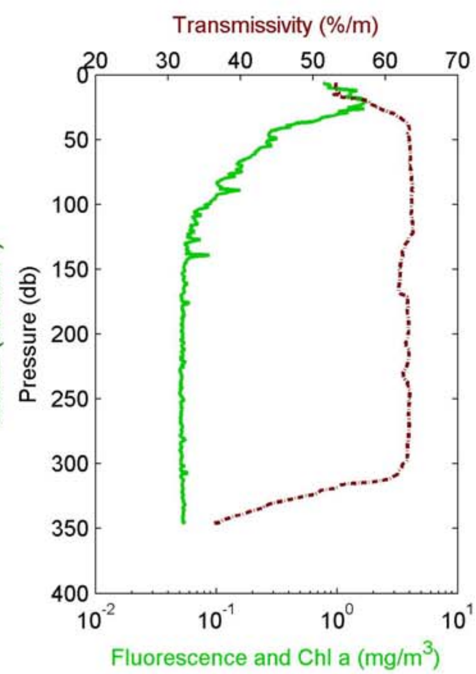


2006-18: Cast 3 Station PE5 (Canadian Archipelago)

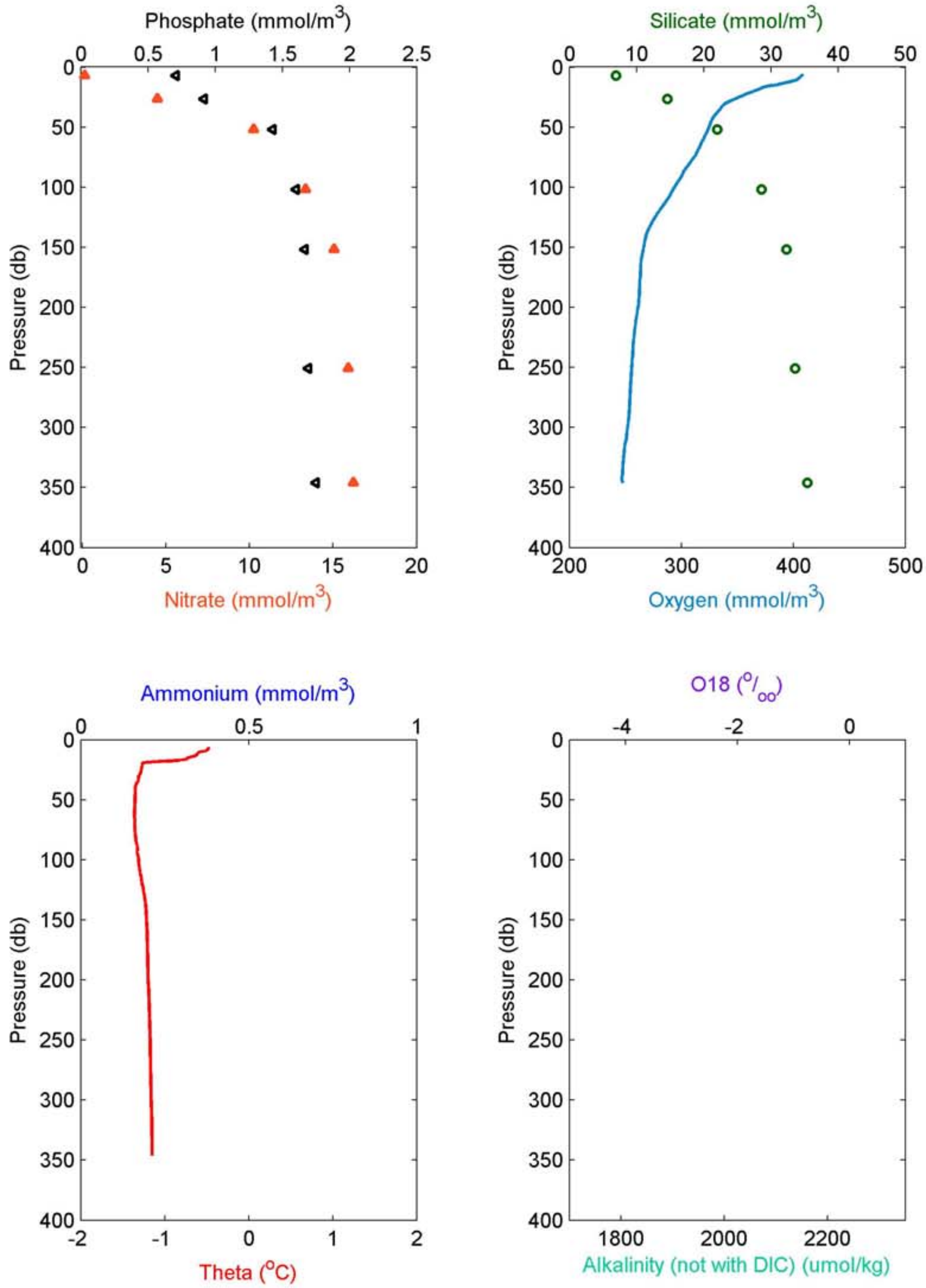




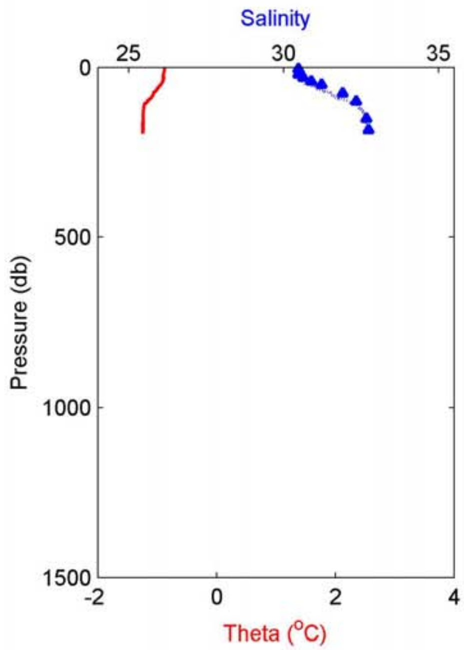


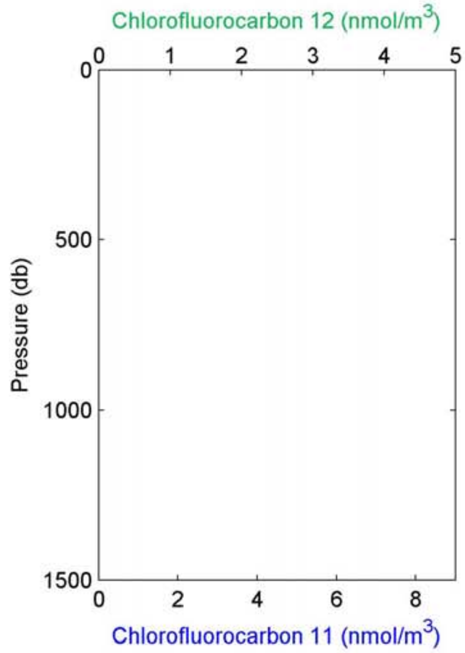


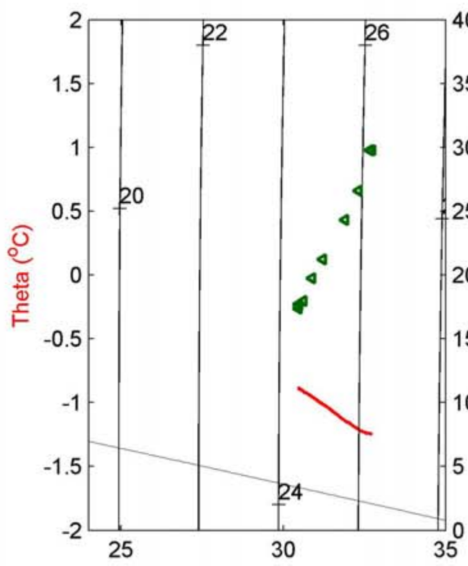
2006-18: Cast 3 Station PE5 (Canadian Archipelago)

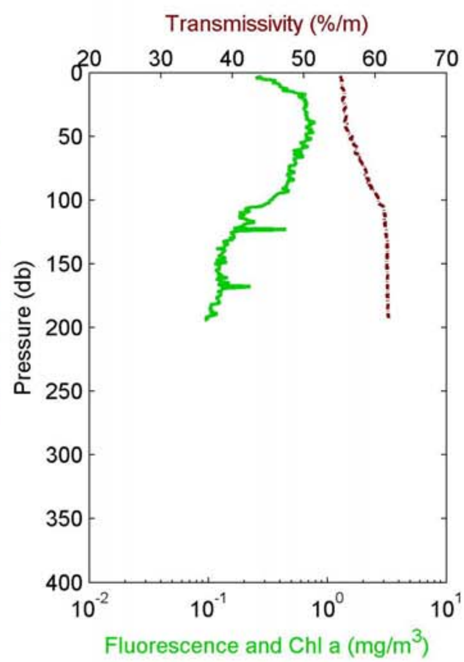


2006-18: Cast 4 Station Bellot (Canadian Archipelago)

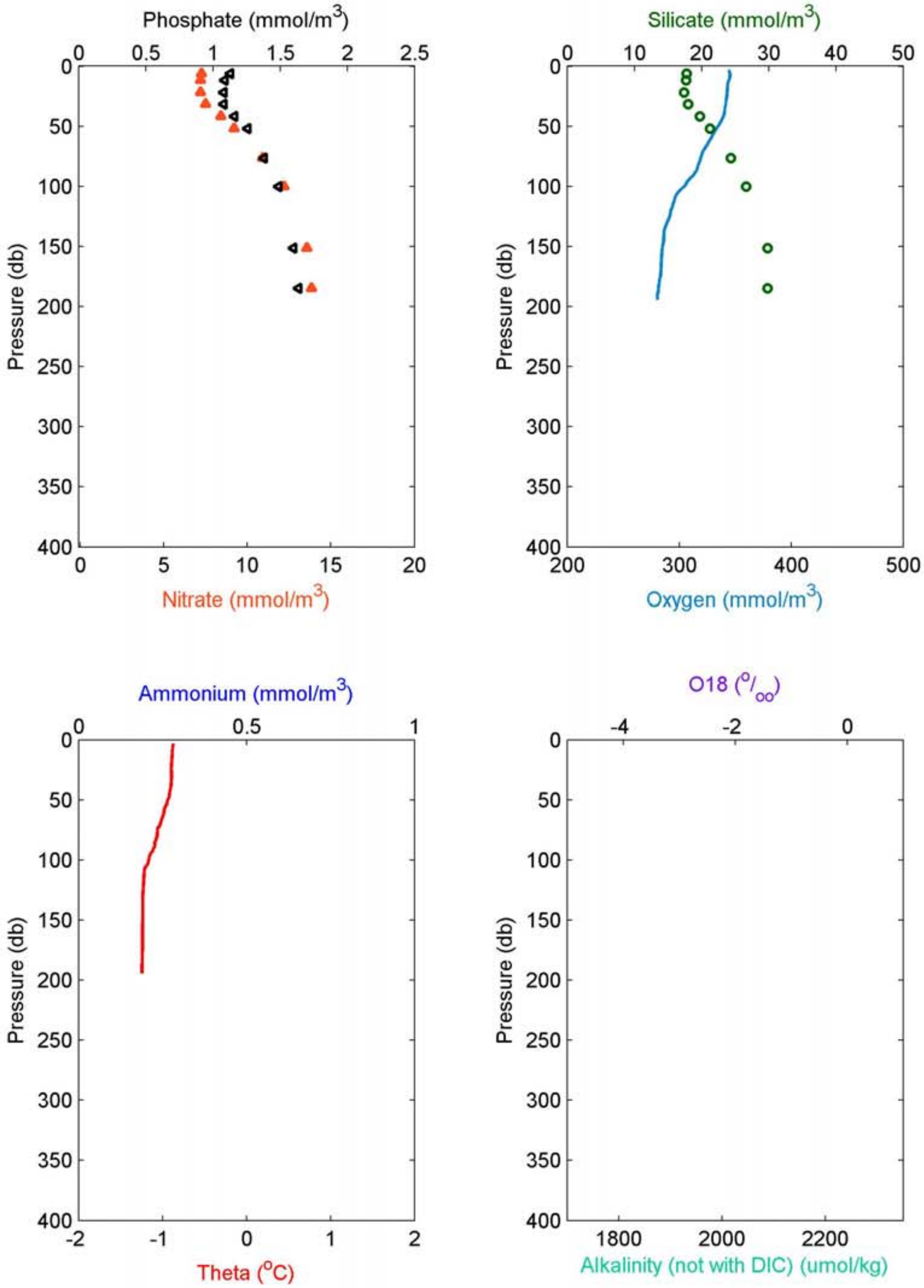




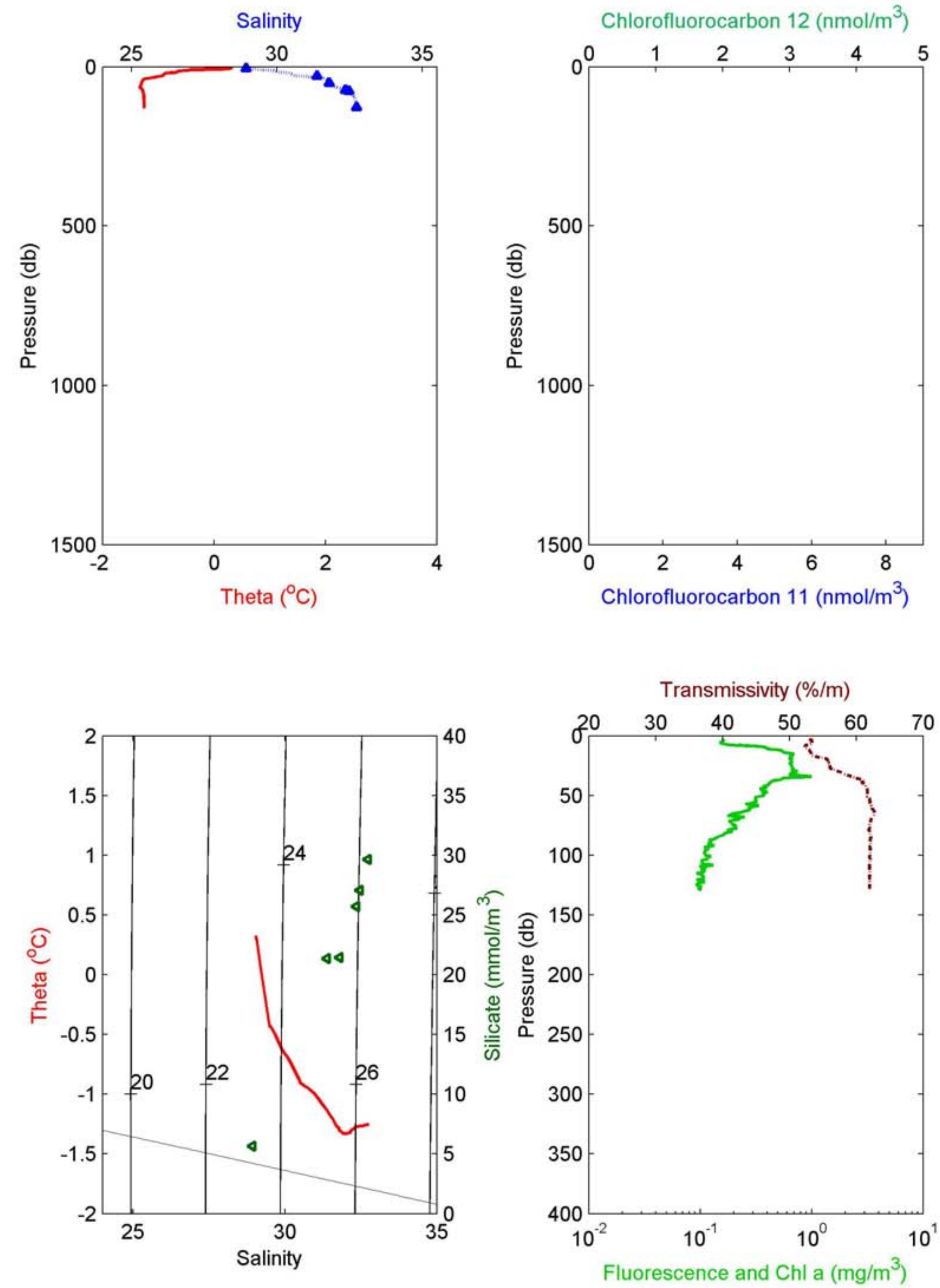




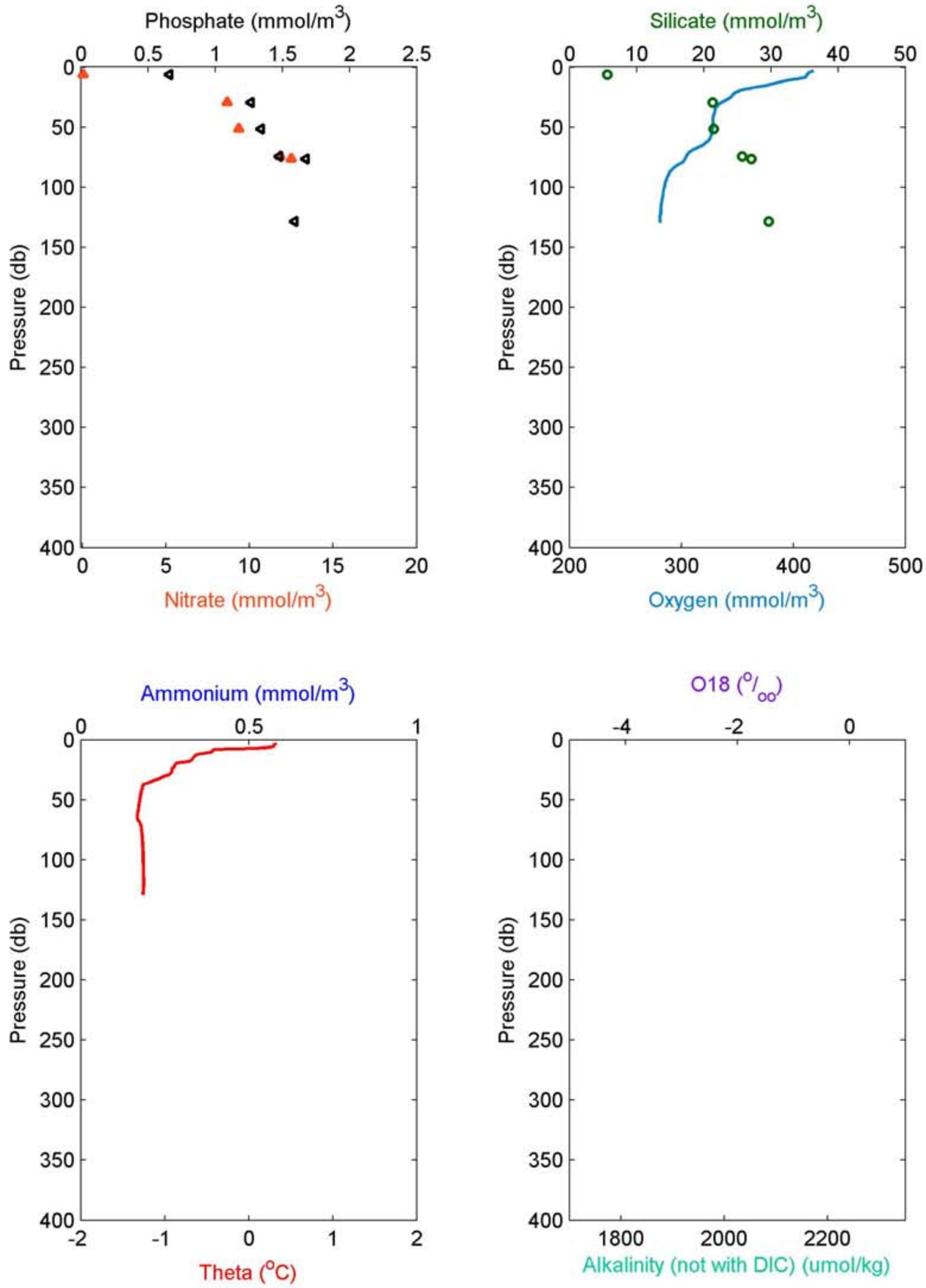
2006-18: Cast 4 Station Bellot (Canadian Archipelago)



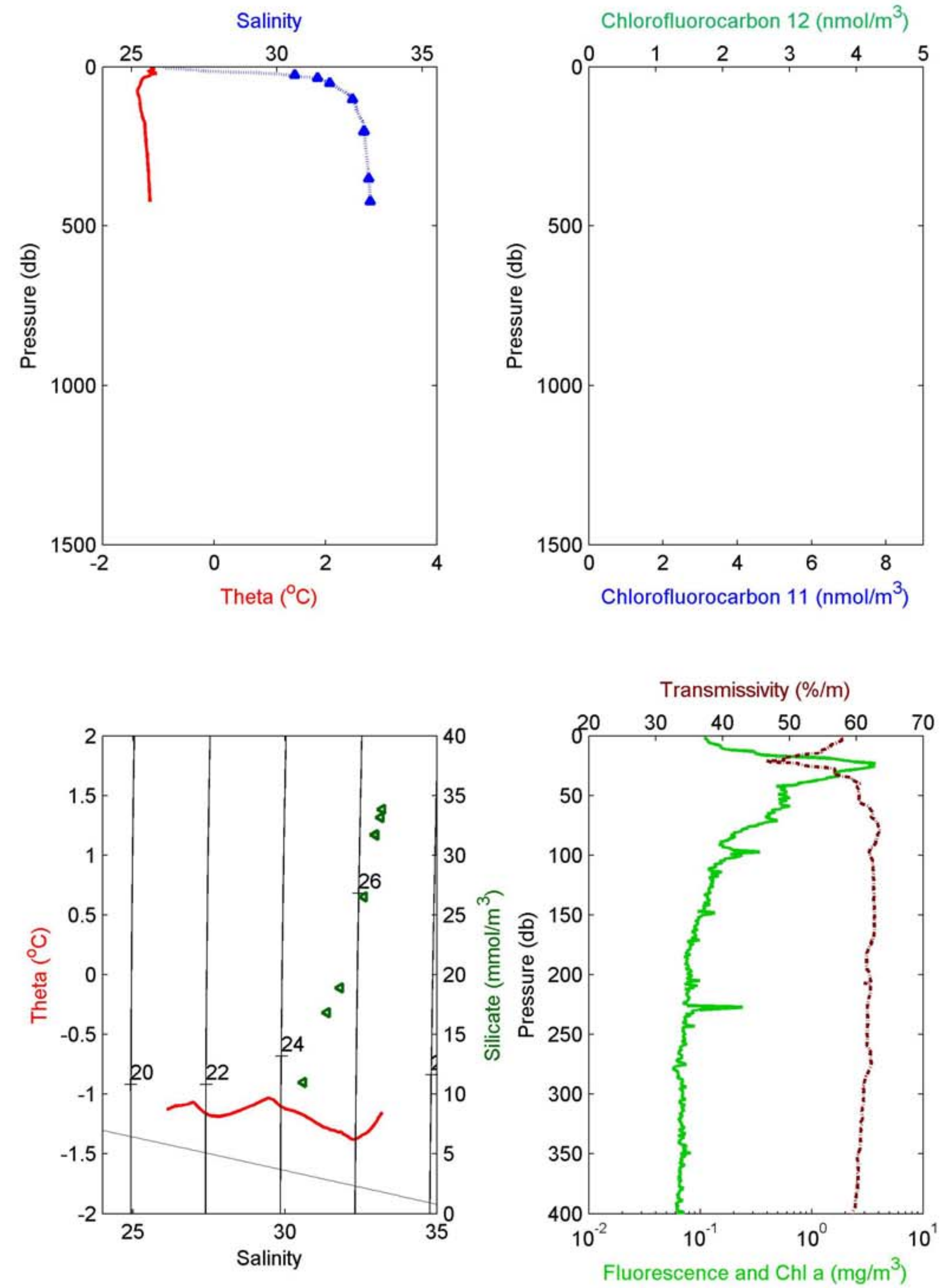
2006-18: Cast 5 Station BE3 (Canadian Archipelago)



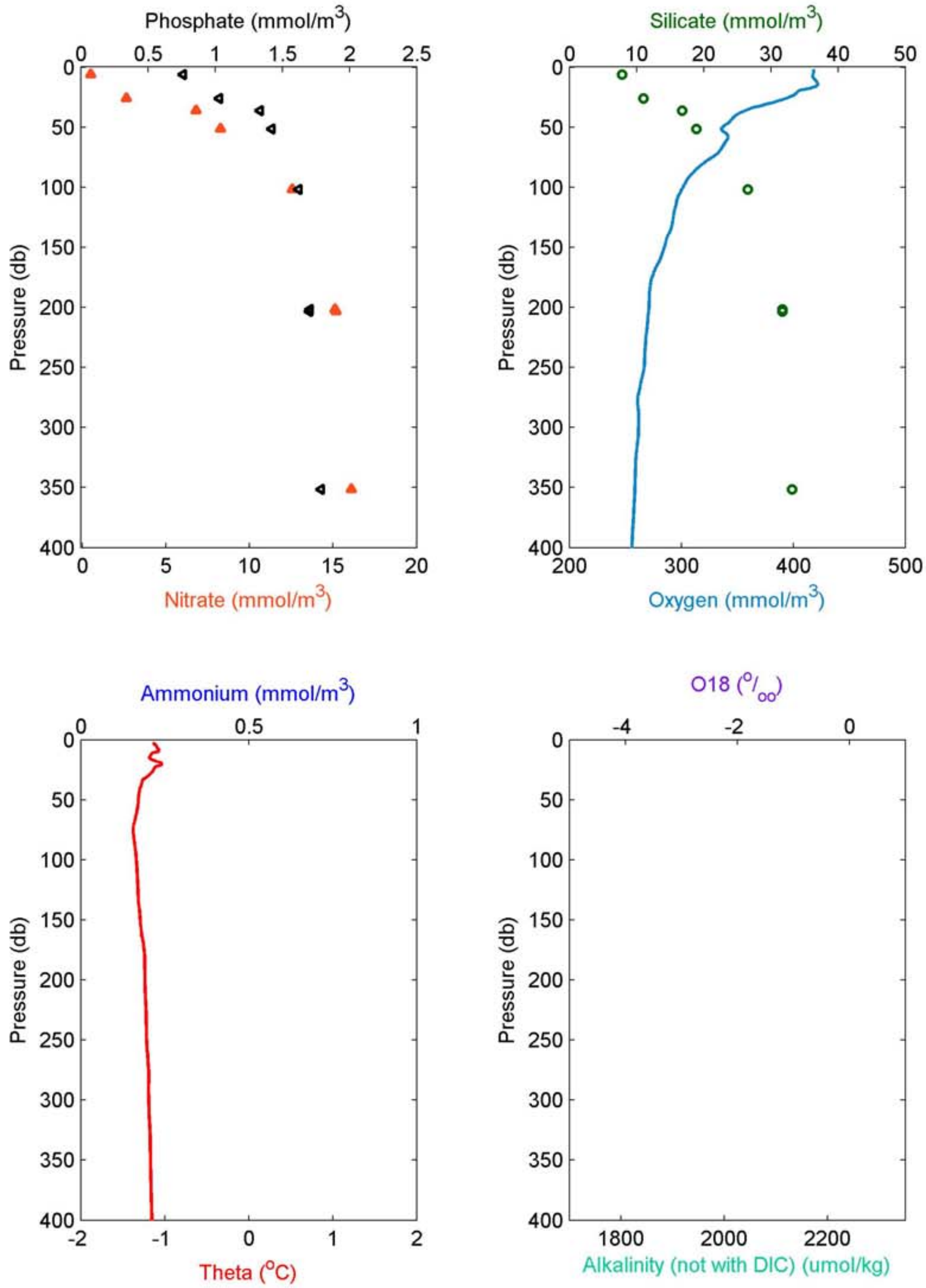
2006-18: Cast 5 Station BE3 (Canadian Archipelago)



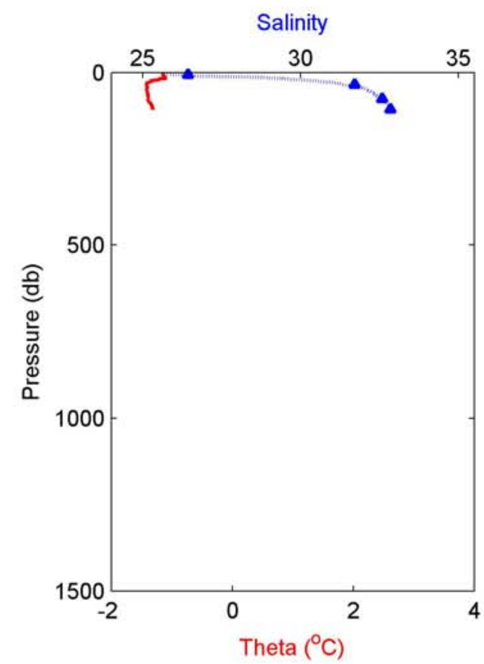
2006-18: Cast 6 Station BE3A (Canadian Archipelago)

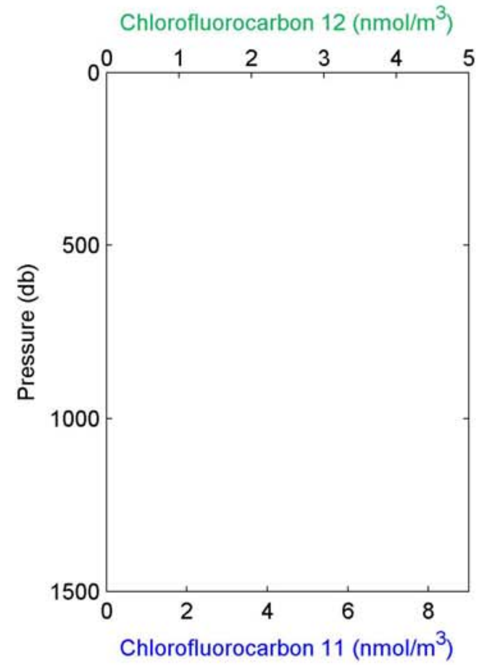


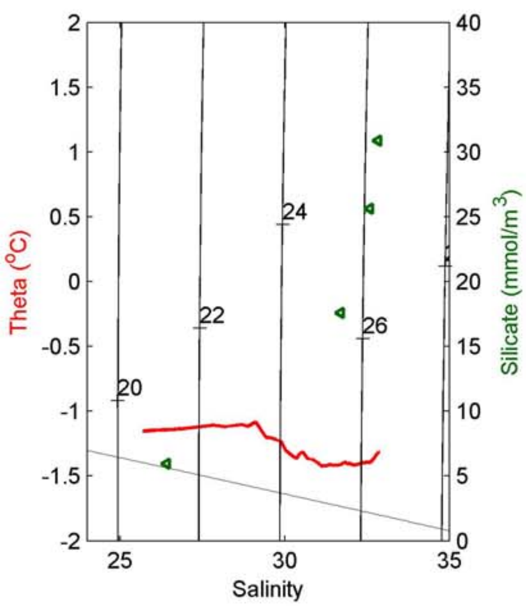
2006-18: Cast 6 Station BE3A (Canadian Archipelago)

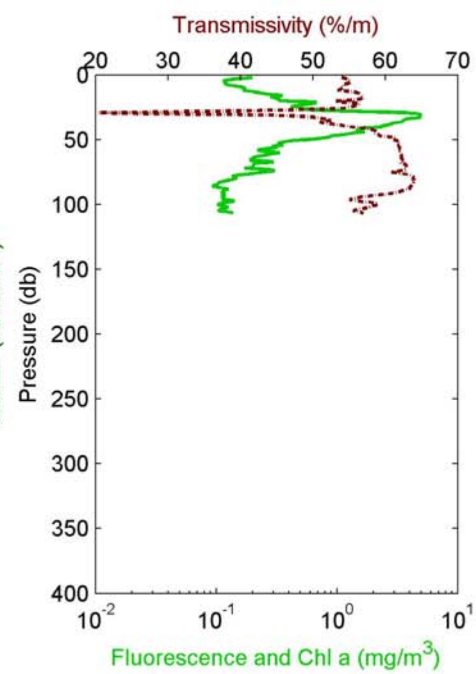


2006-18: Cast 7 Station 7 (Canadian Archipelago)

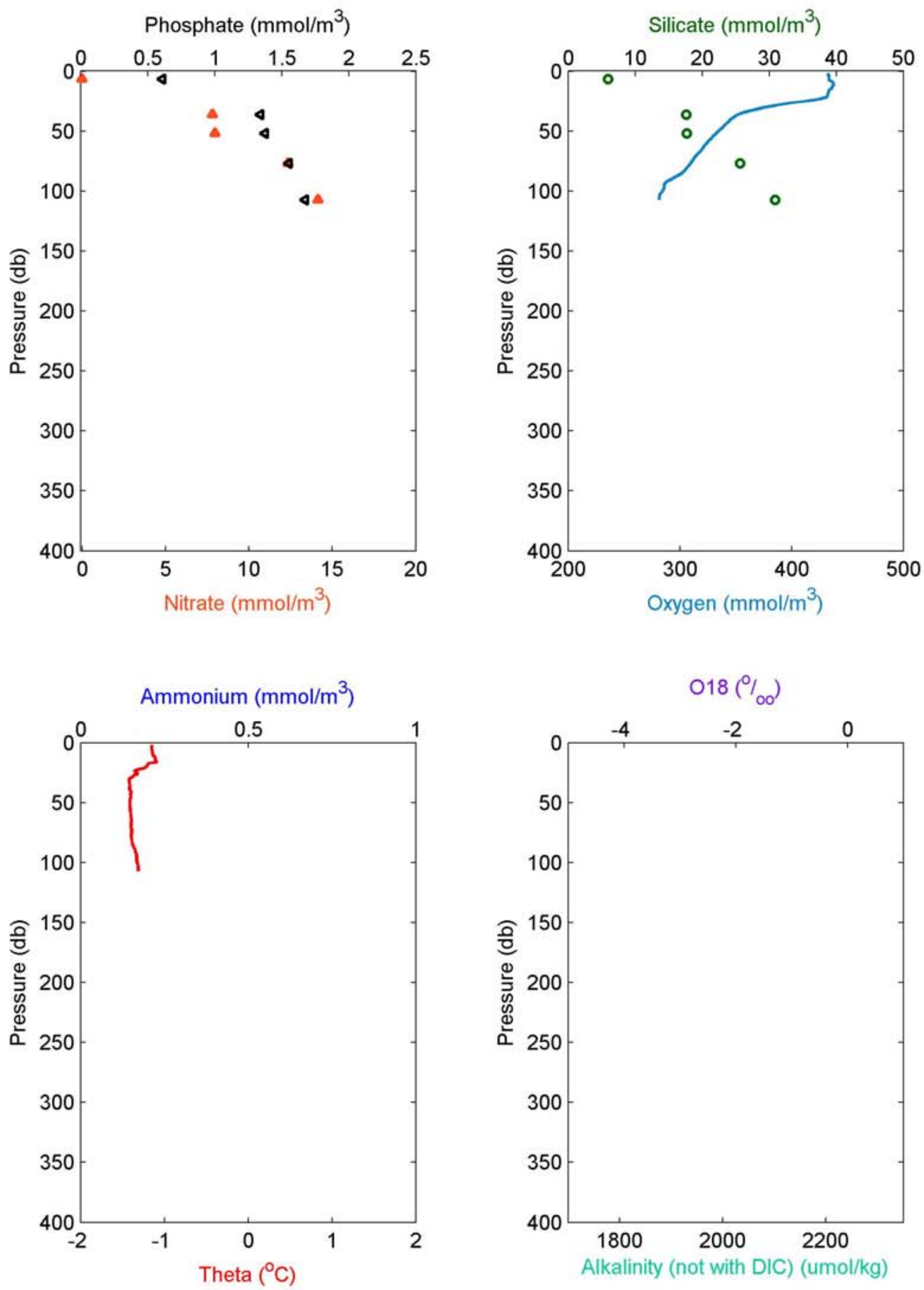




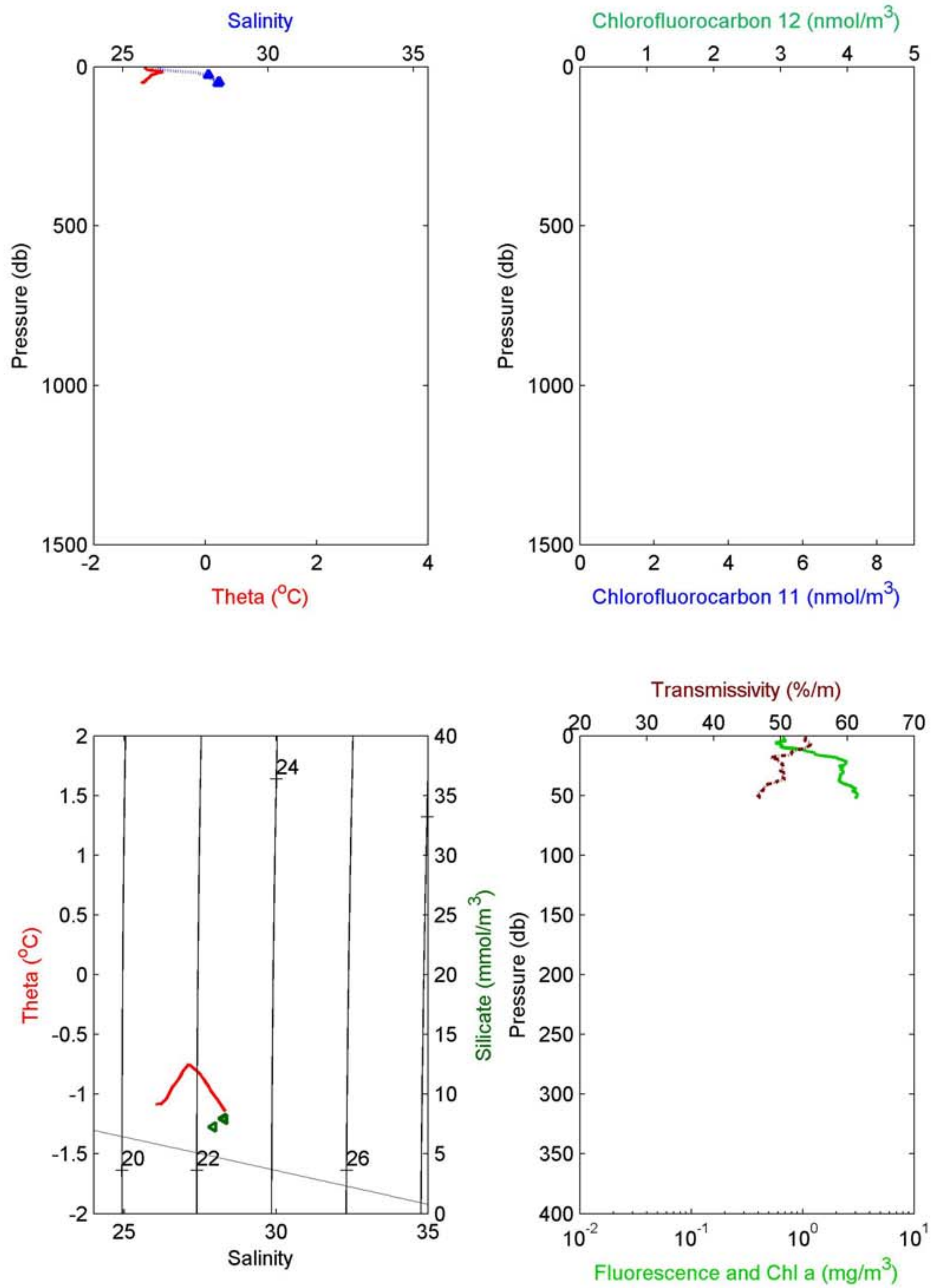




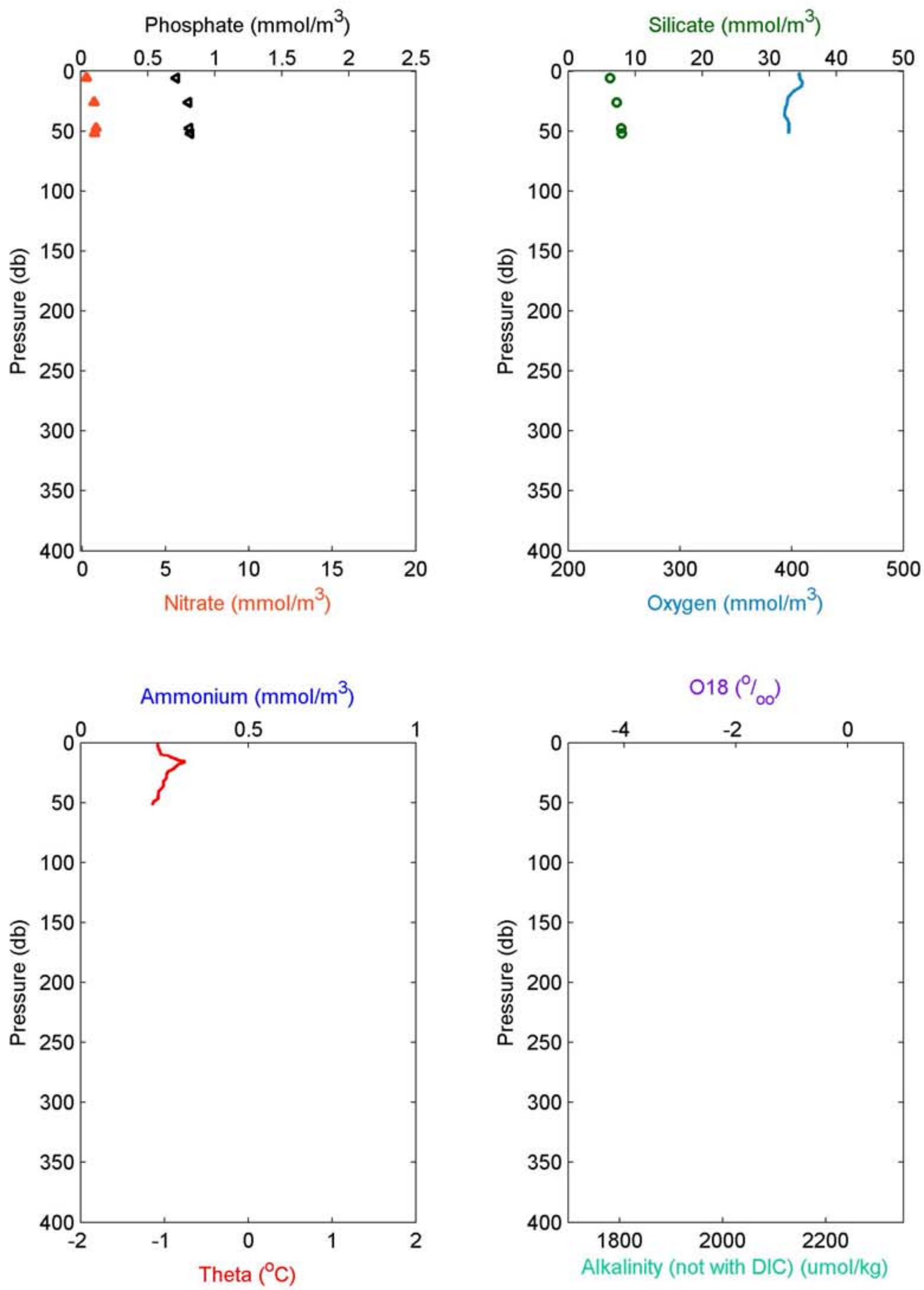
2006-18: Cast 7 Station 7 (Canadian Archipelago)



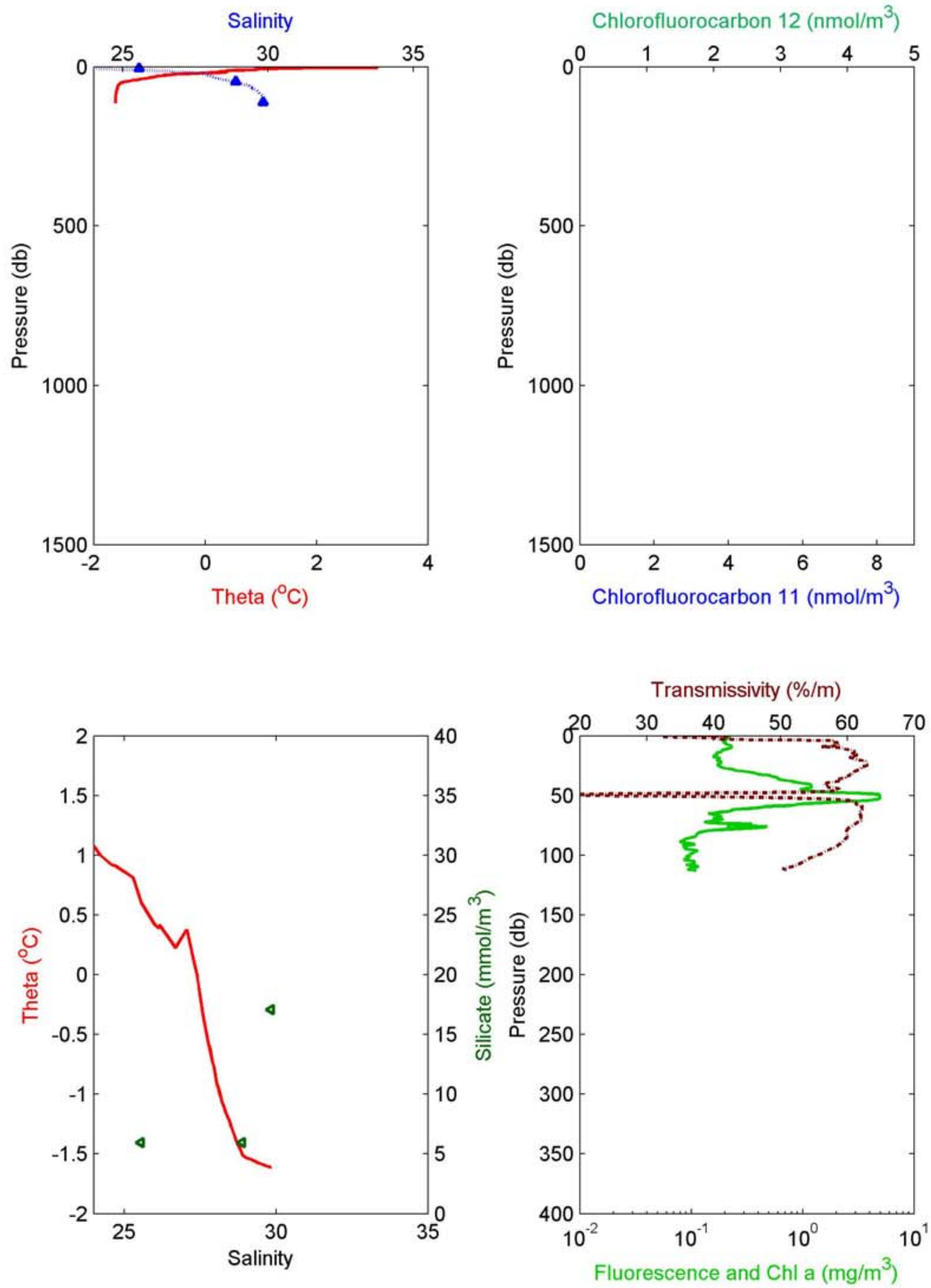
2006-18: Cast 8 Station QM1 (Canadian Archipelago)



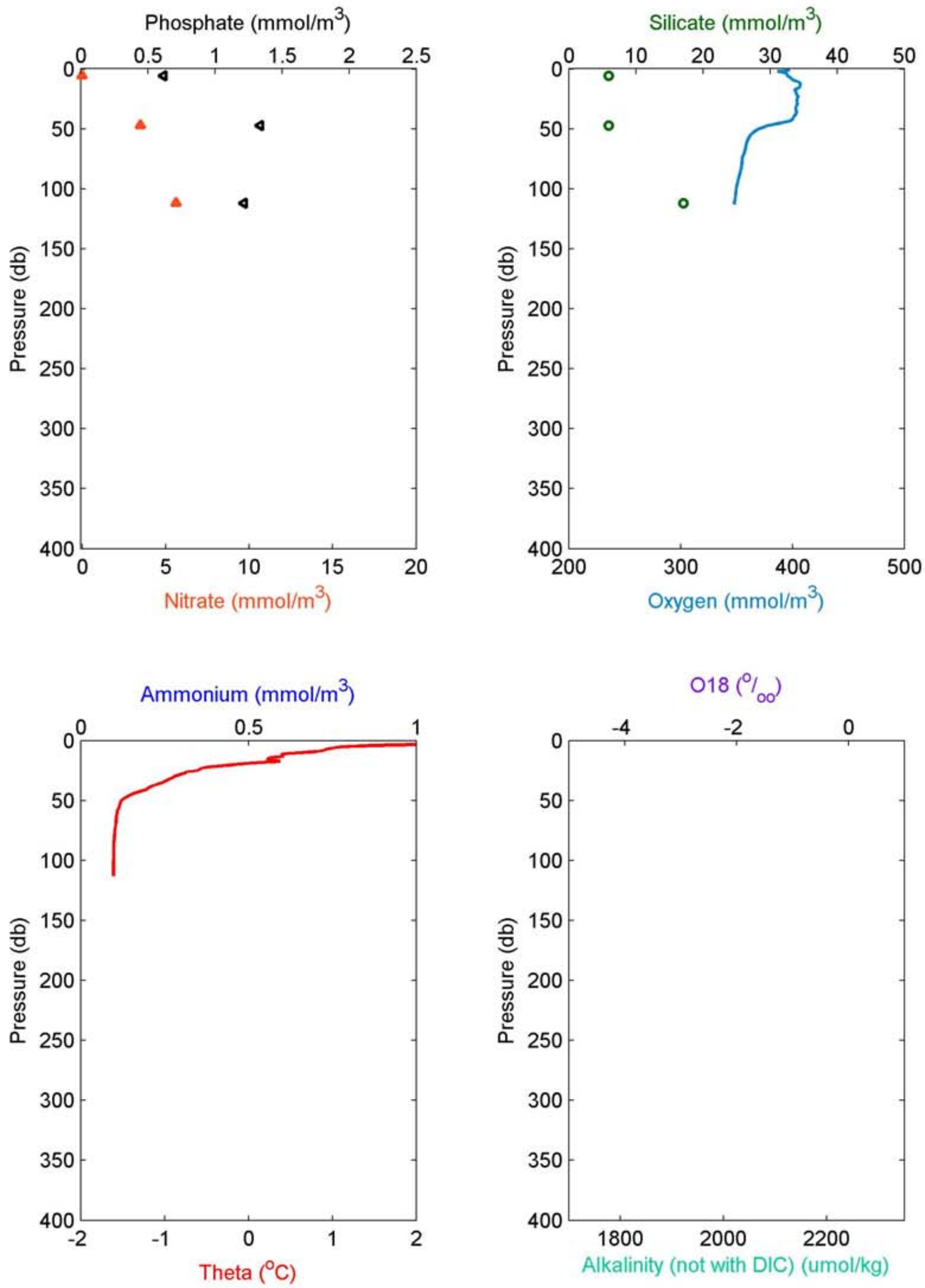
2006-18: Cast 8 Station QM1 (Canadian Archipelago)



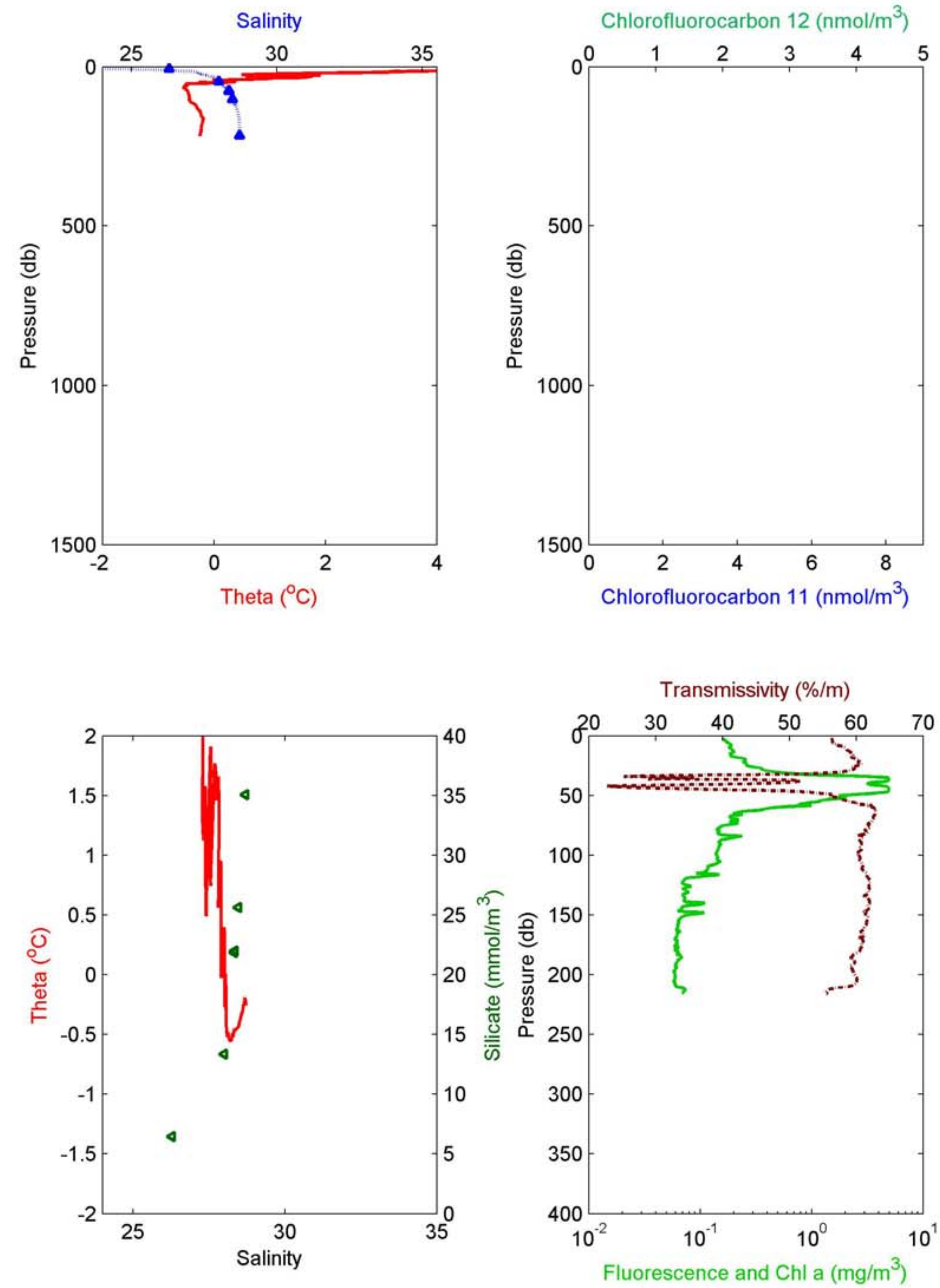
2006-18: Cast 9 Station QM2 (Canadian Archipelago)



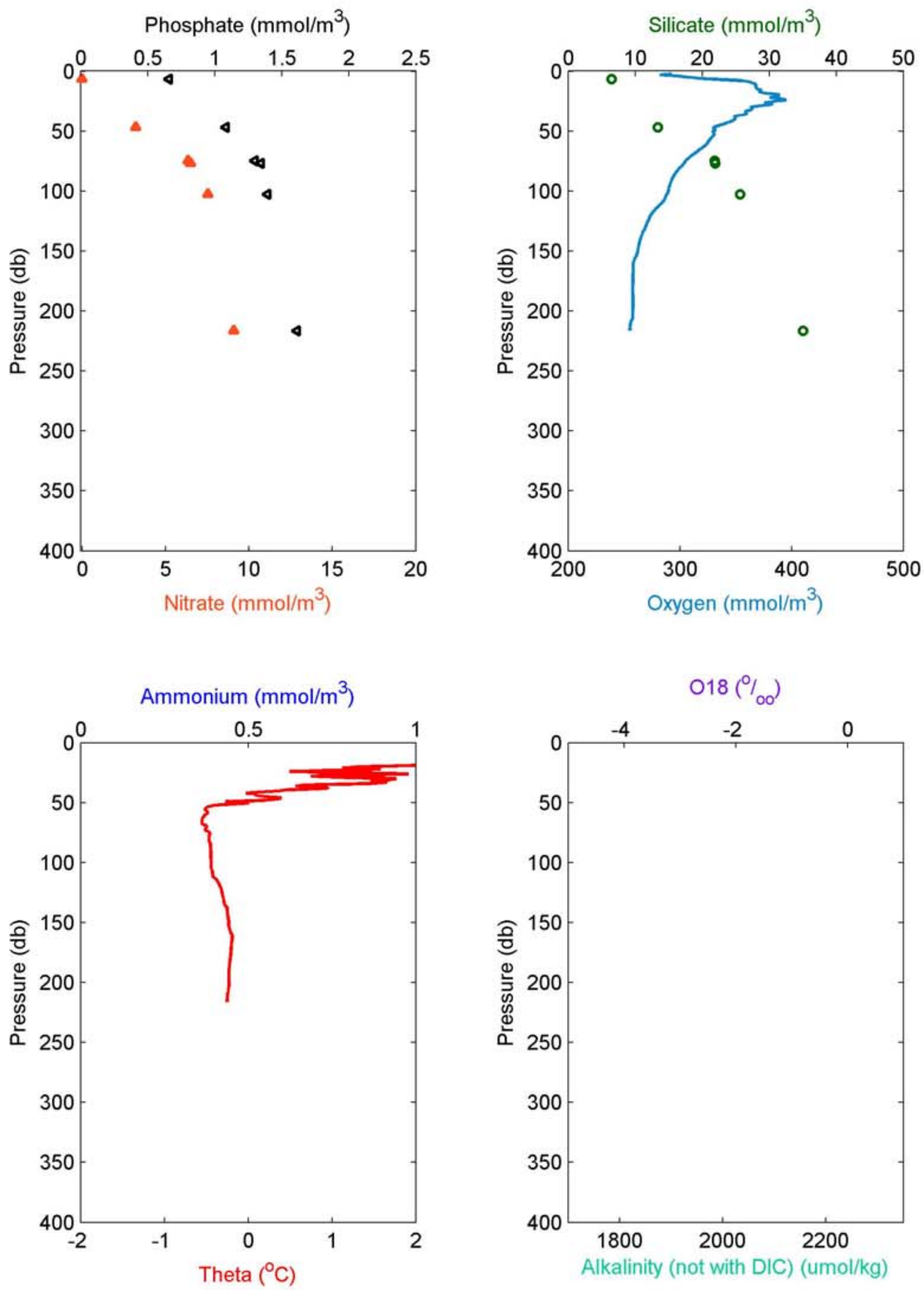
2006-18: Cast 9 Station QM2 (Canadian Archipelago)



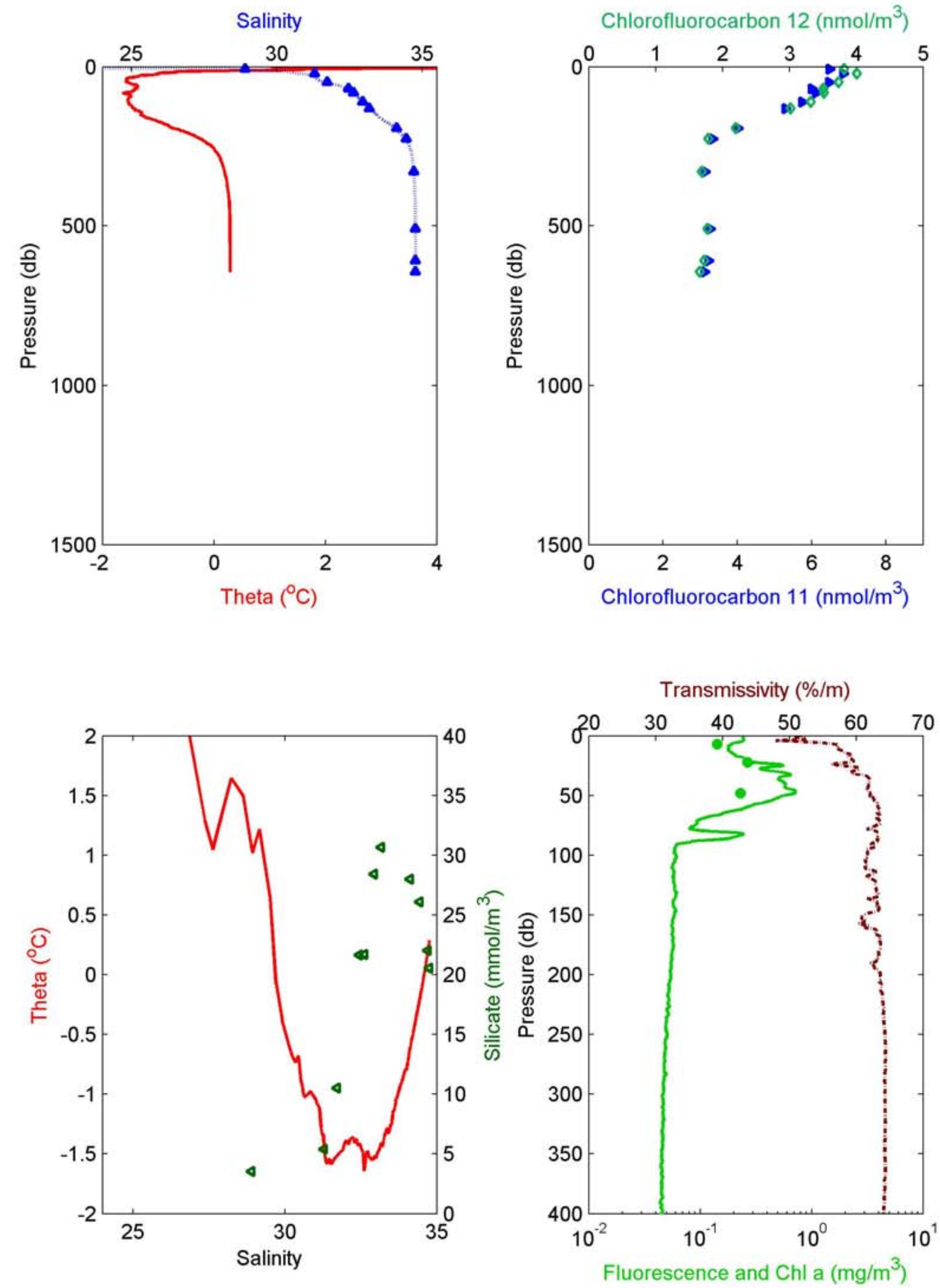
2006-18: Cast 10 Station CCG1 (Canadian Archipelago)



2006-18: Cast 10 Station CCG1 (Canadian Archipelago)



2006-18: Cast 11 Station AG5 (Canadian Archipelago)



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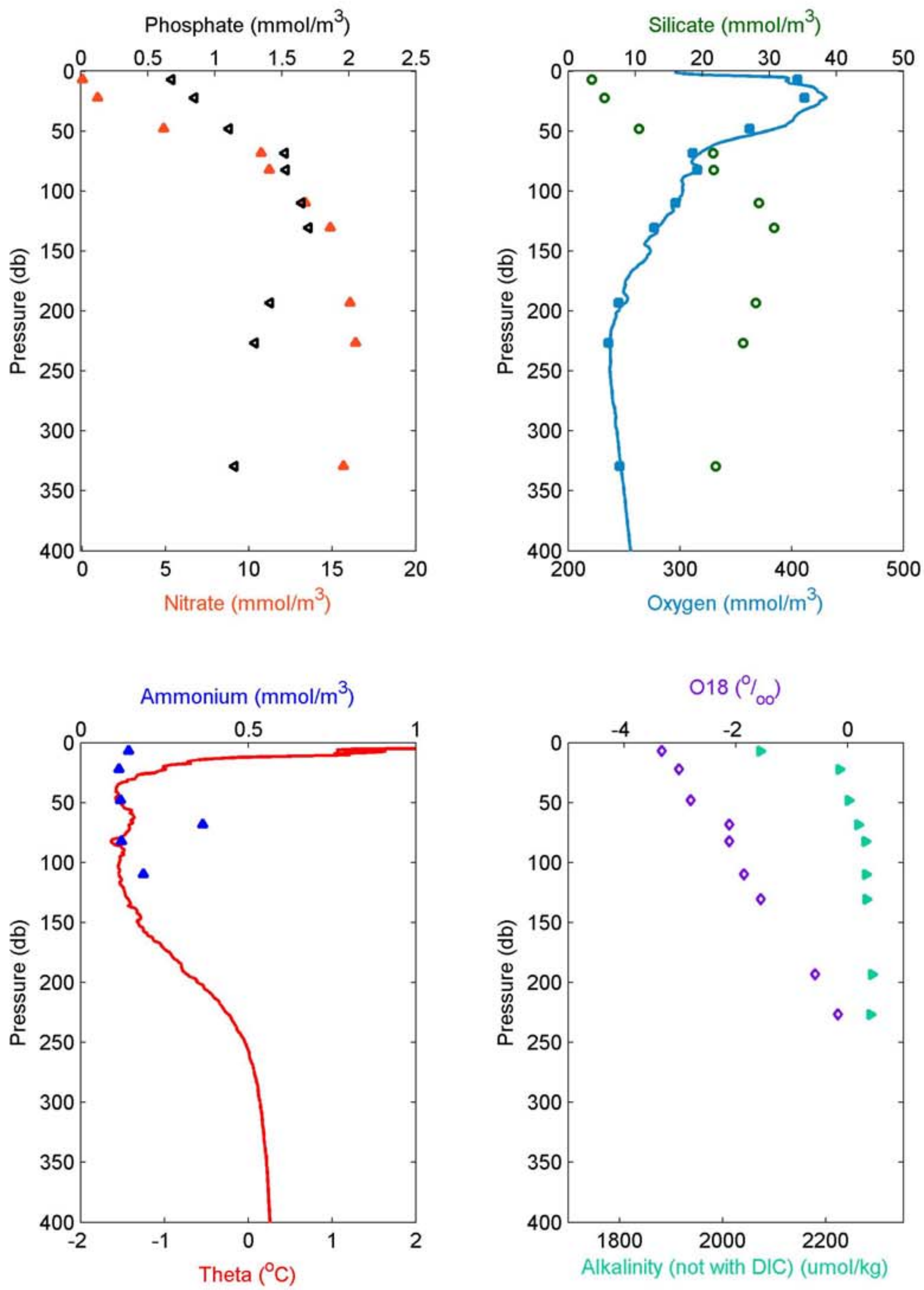
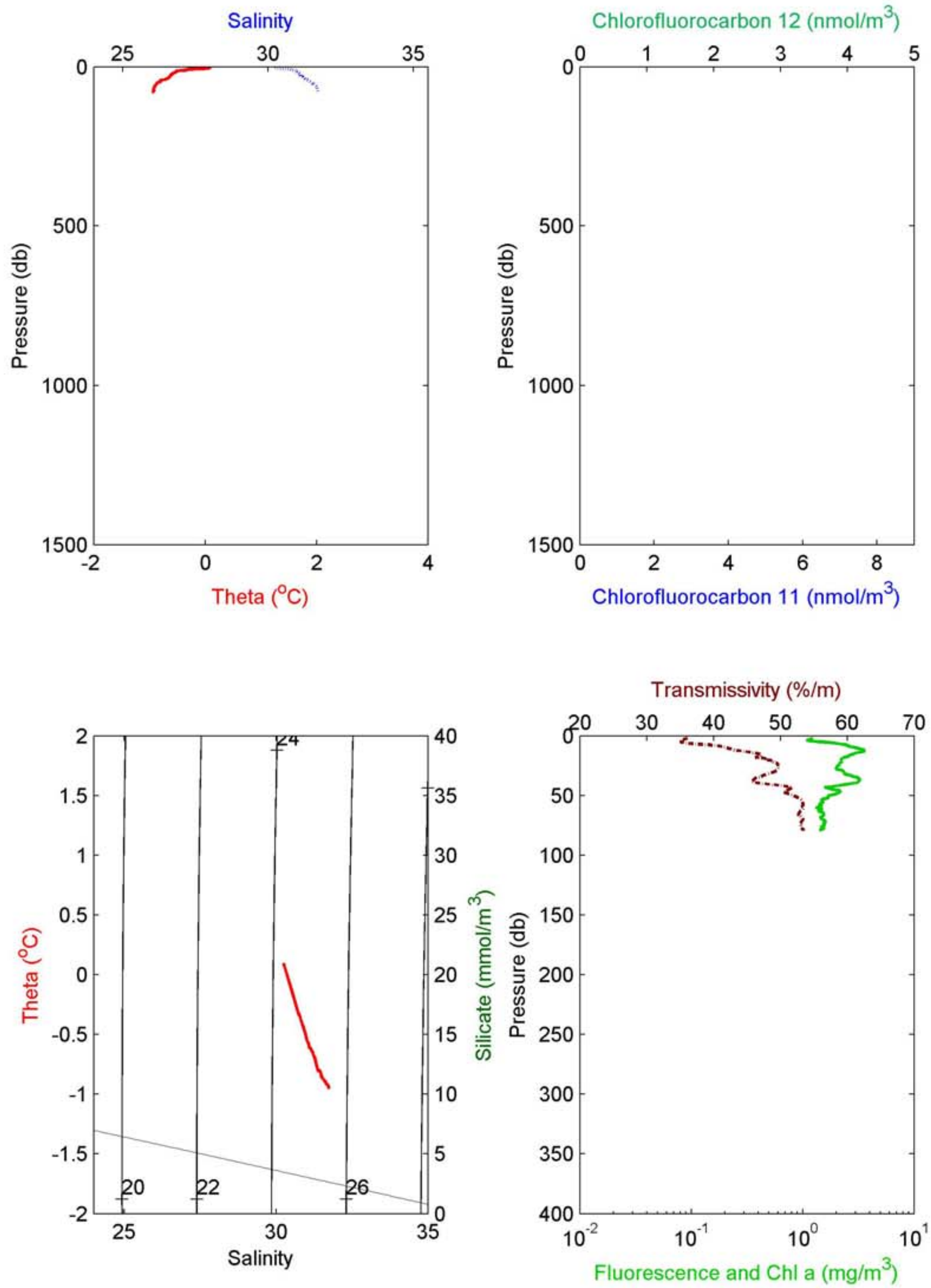


2006-18: Cast 76 Station Bellot (Canadian Archipelago)



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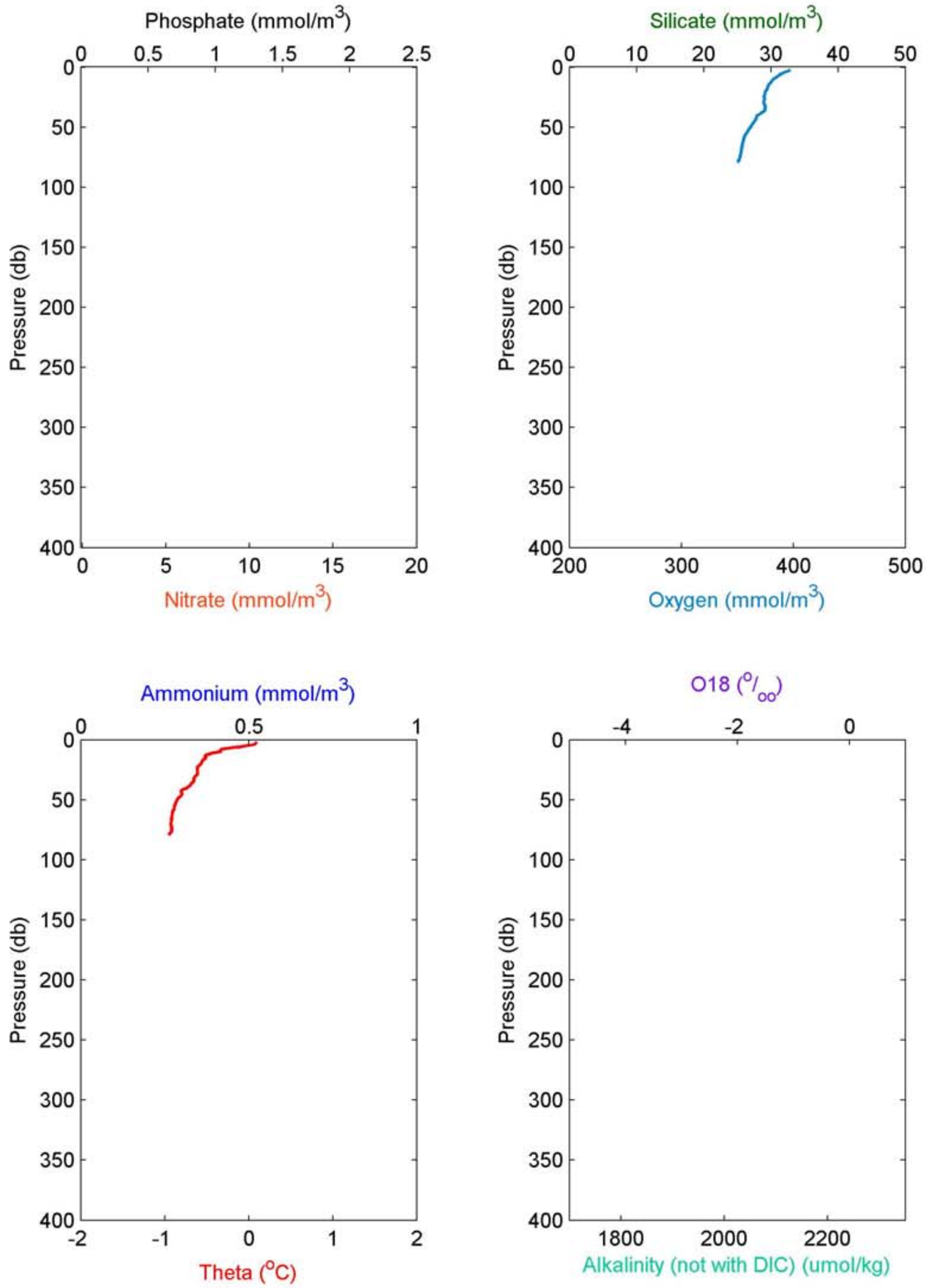
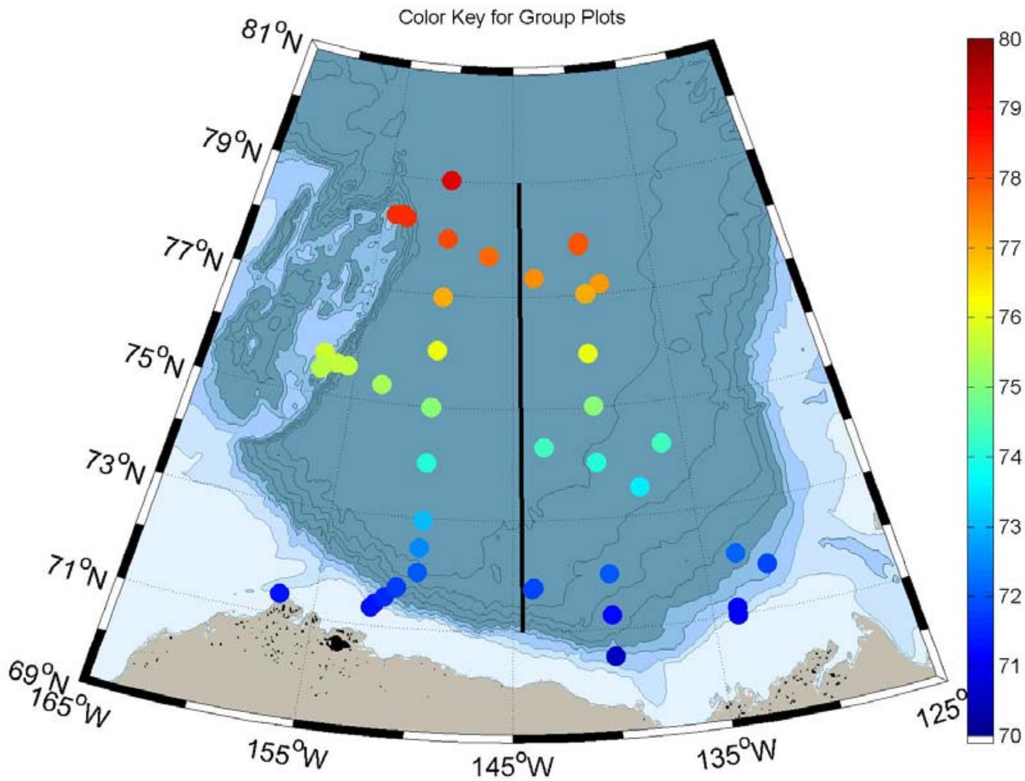


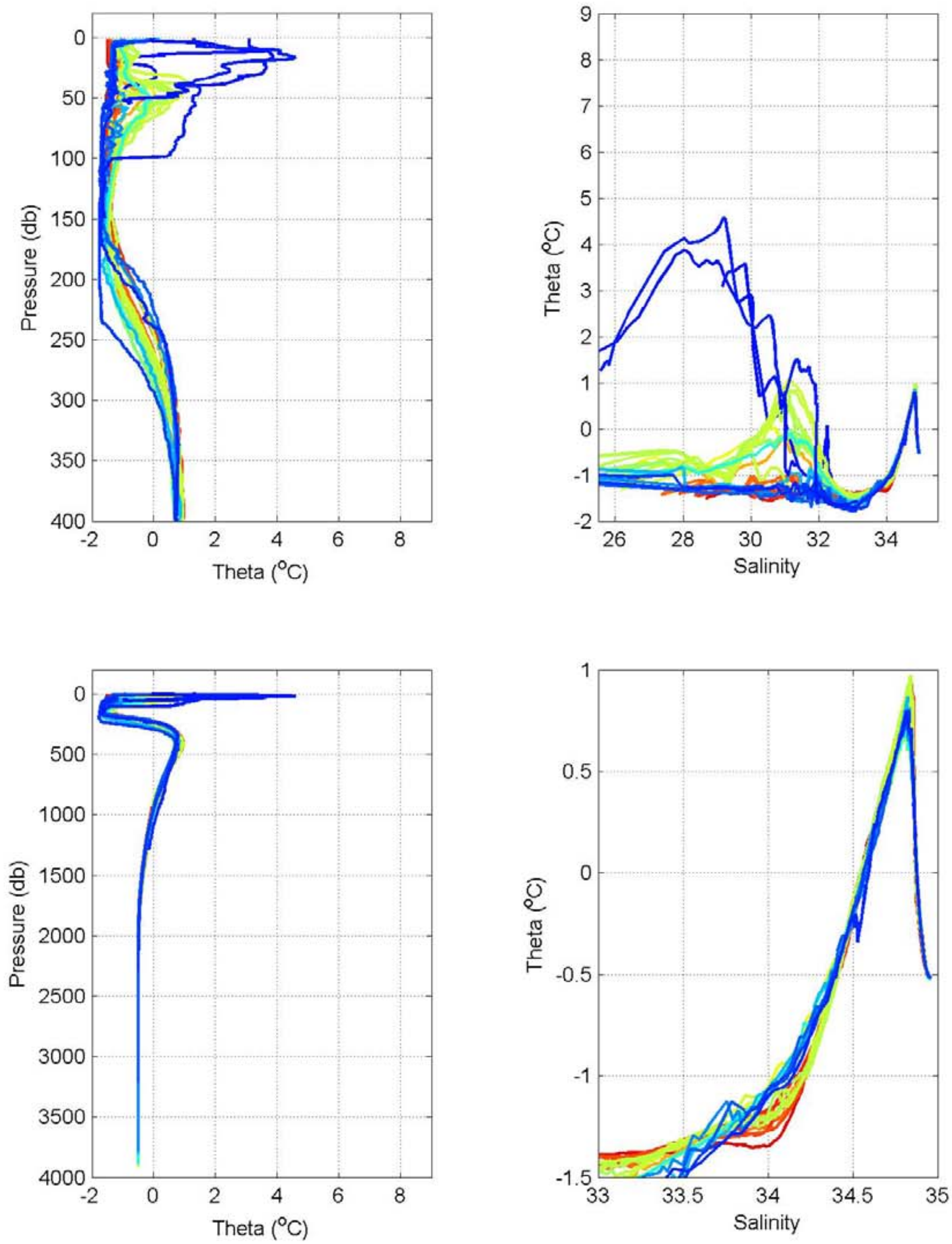
6. PROPERTY PLOTS

The data have been divided into three groups, geographically. The first two groups: casts from the Canada Basin west of 145°W and casts east of 145°W have been colored by latitude with the blue indicating south and red to the north. The figures are ordered by property and are presented with the west group shown on the left facing page and the east group on the right facing page. The third group, casts from the Canadian Arctic Archipelago, has been colored by longitude with blue indicating east and red indicating west.

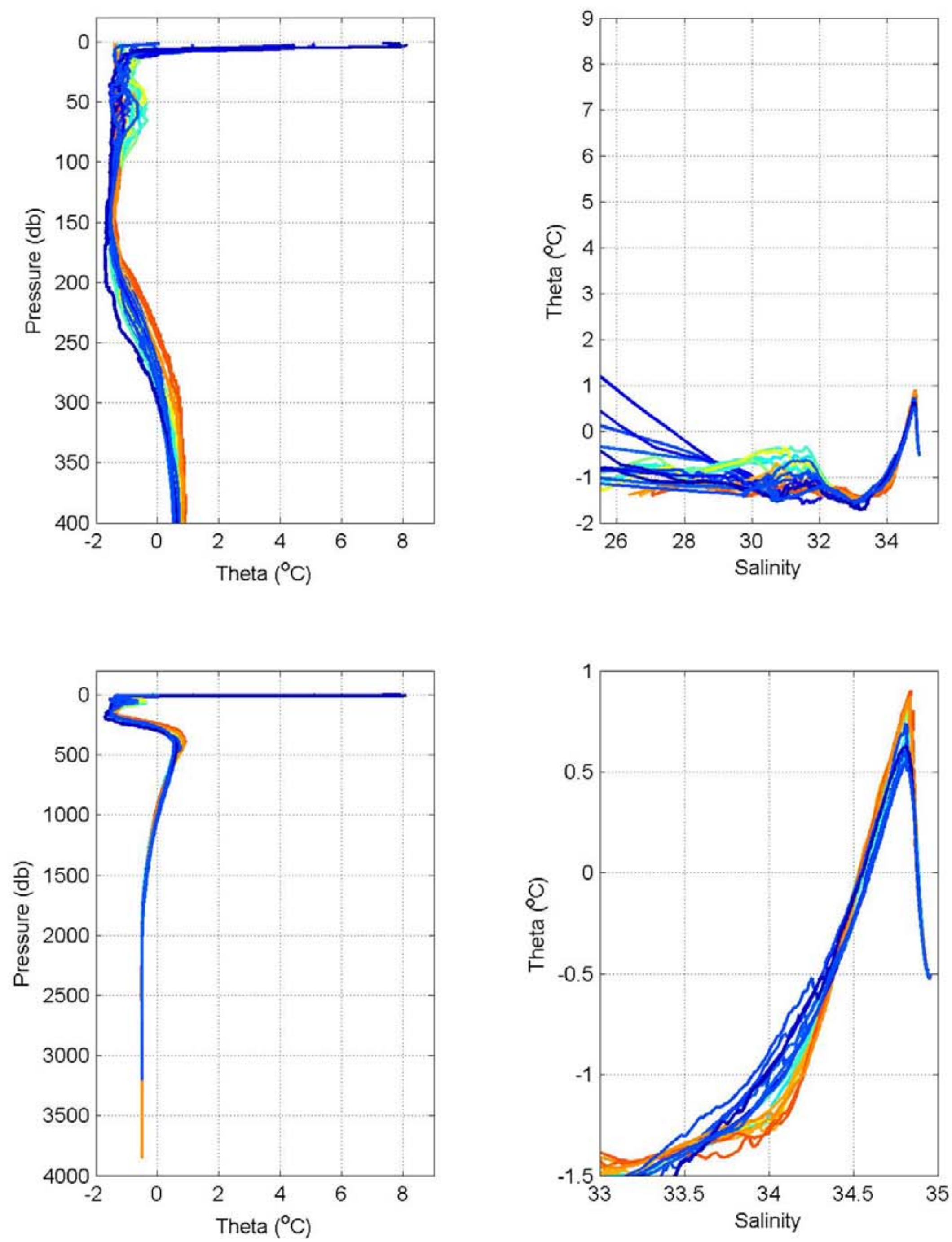
6.1 Canada Basin



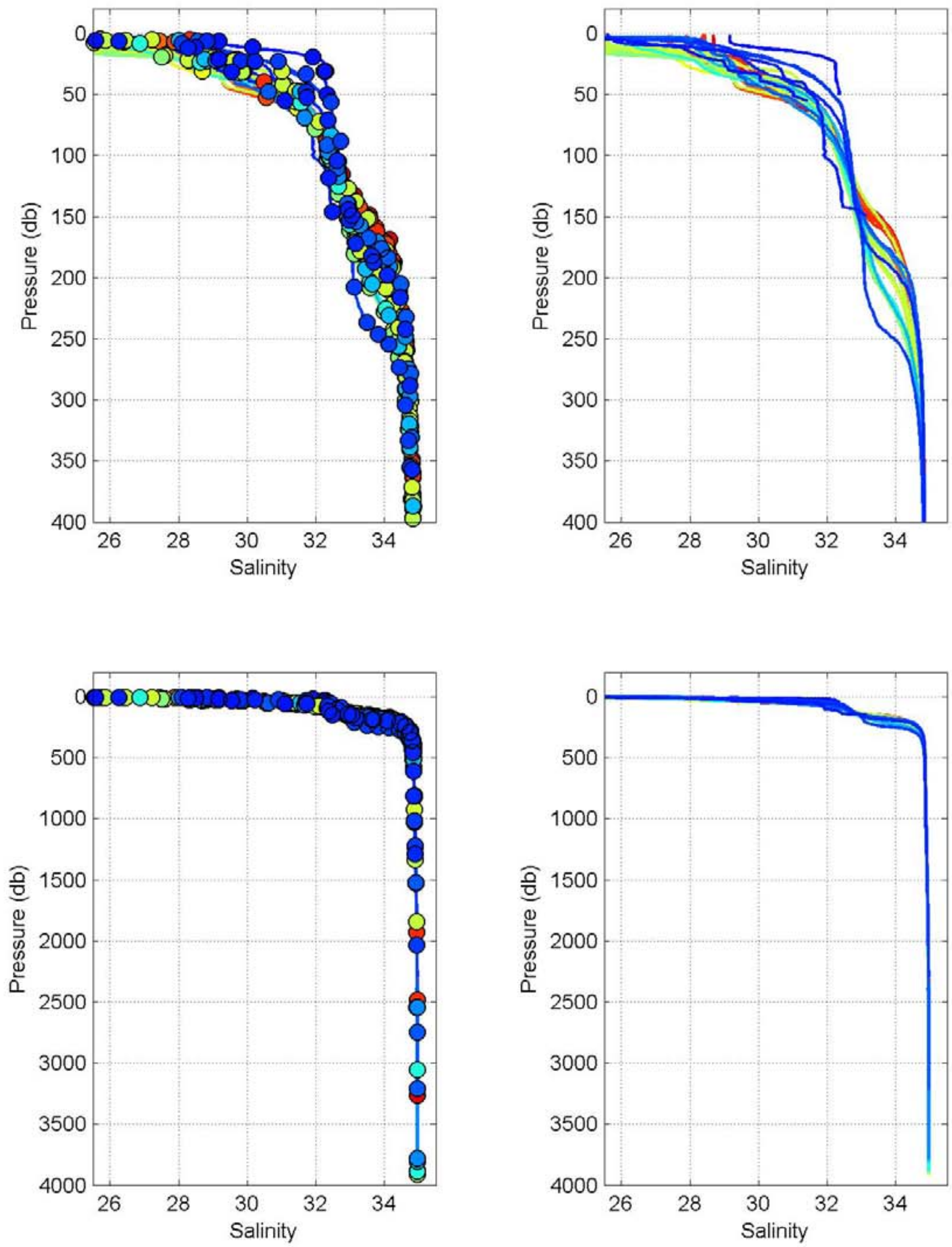
2006-18 Group: Canada Basin, West of 145°W, Property: Theta



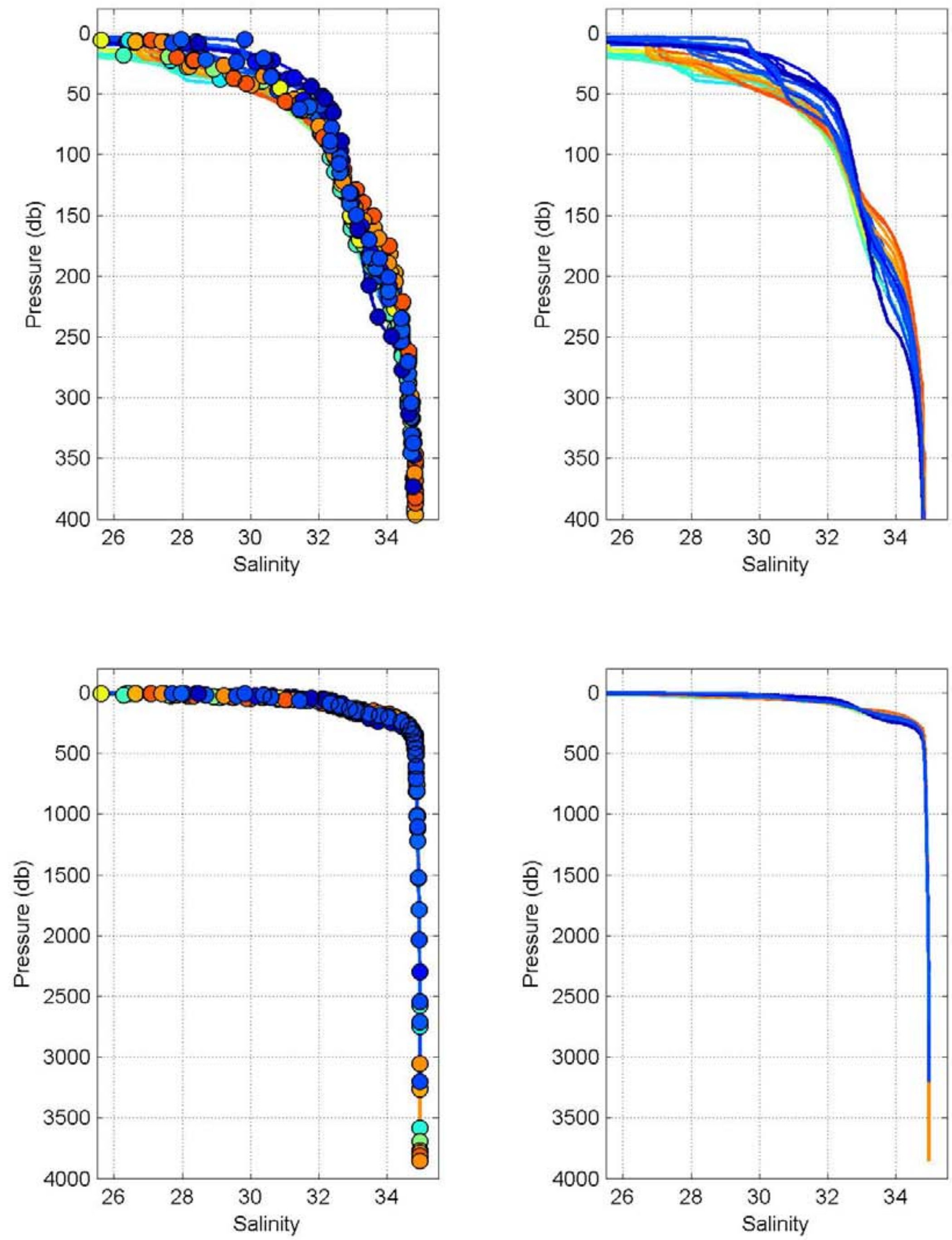
2006-18 Group: Canada Basin, East of 145°W, Property: Theta



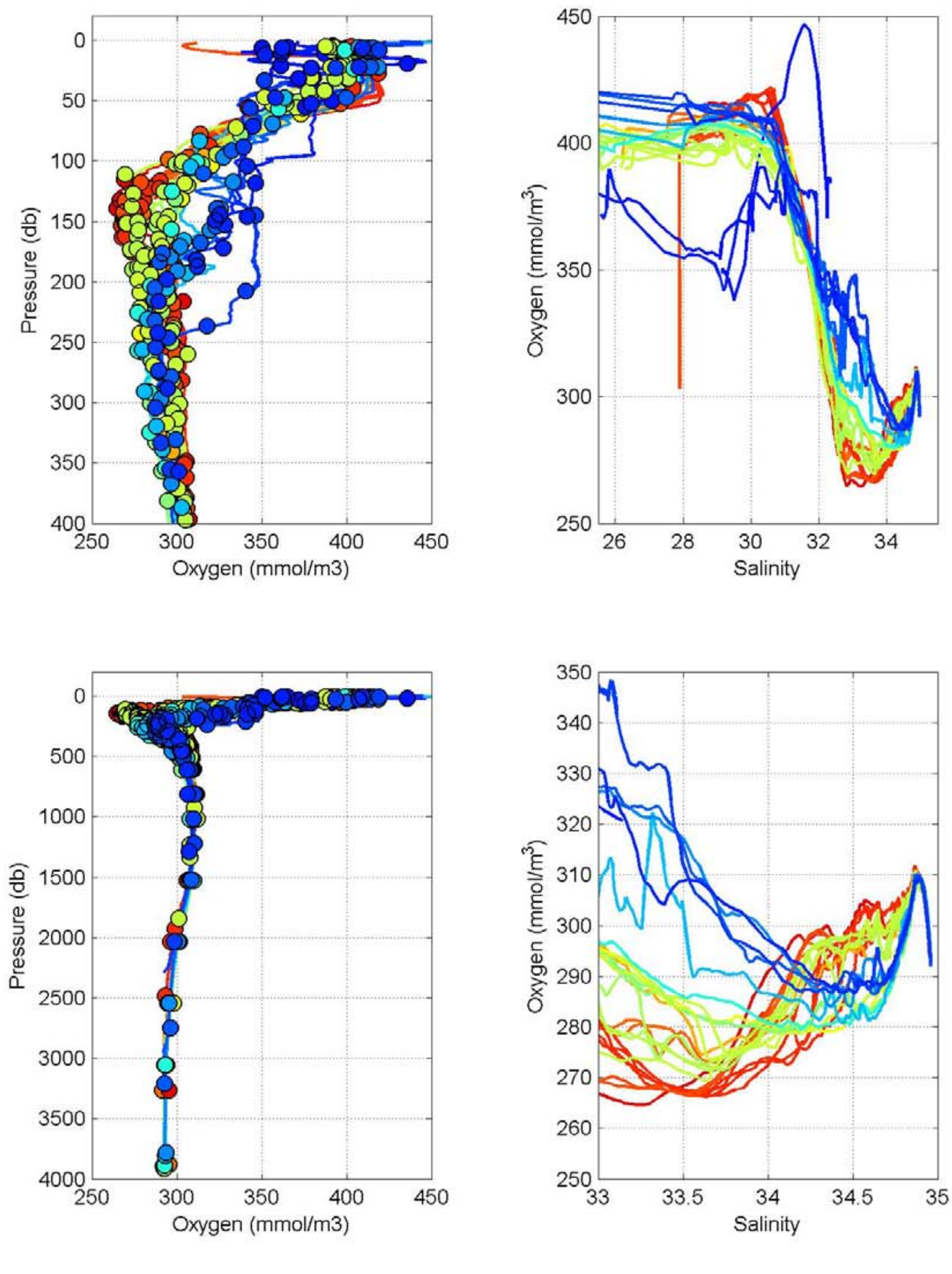
2006-18 Group: Canada Basin, West of 145°W, Property: Salinity



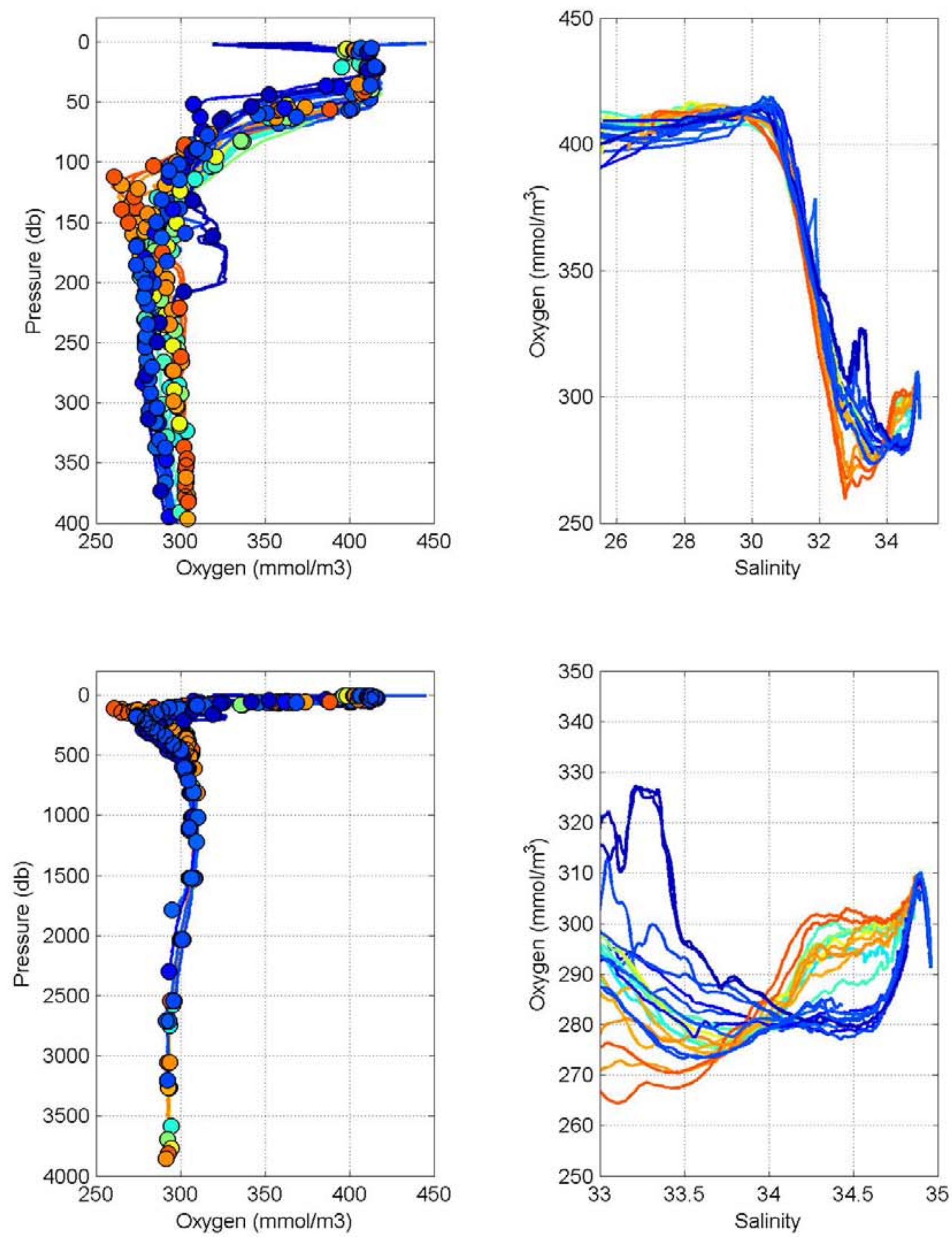
2006-18 Group: Canada Basin, East of 145°W, Property: Salinity



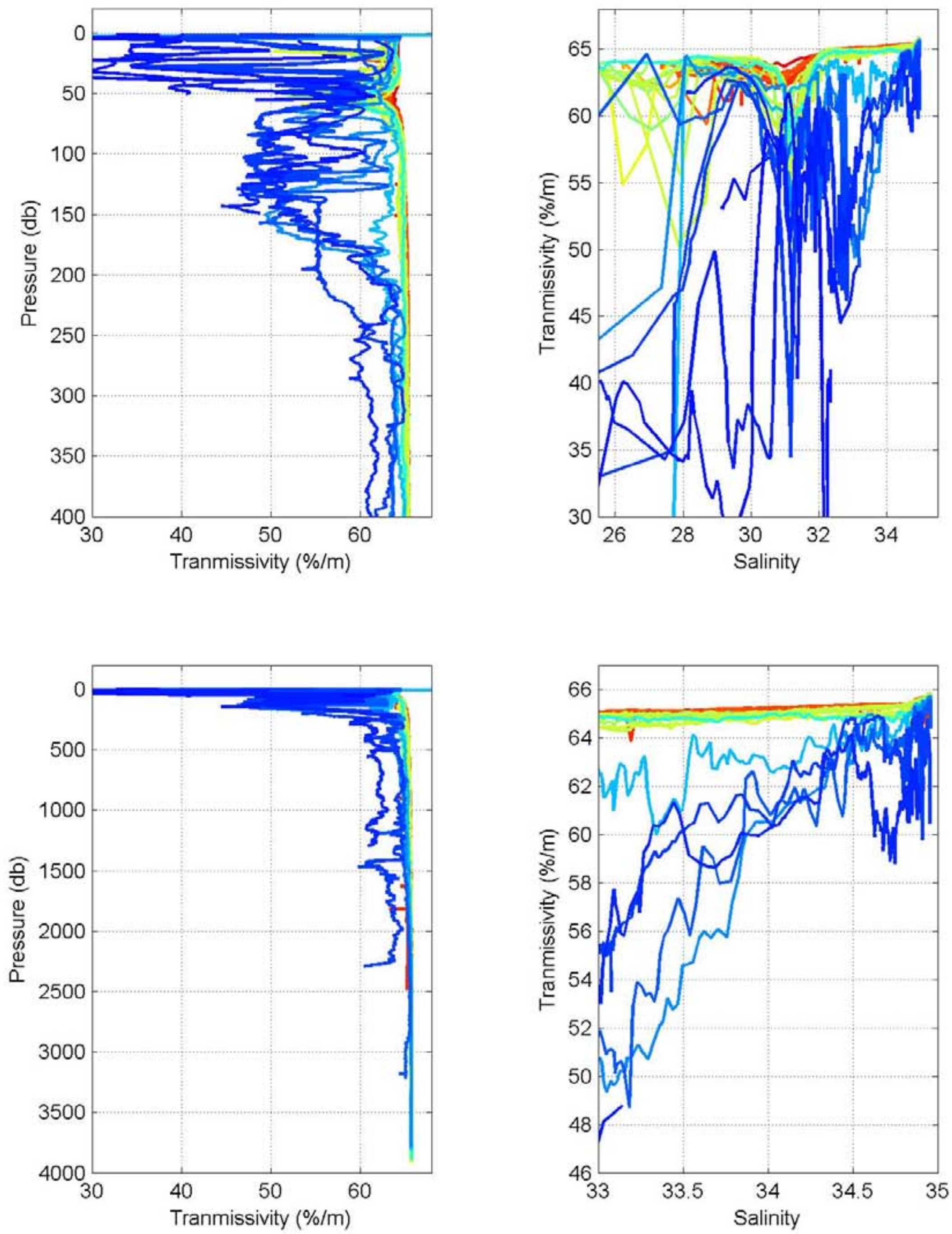
2006-18 Group: Canada Basin, West of 145°W, Property: Oxygen



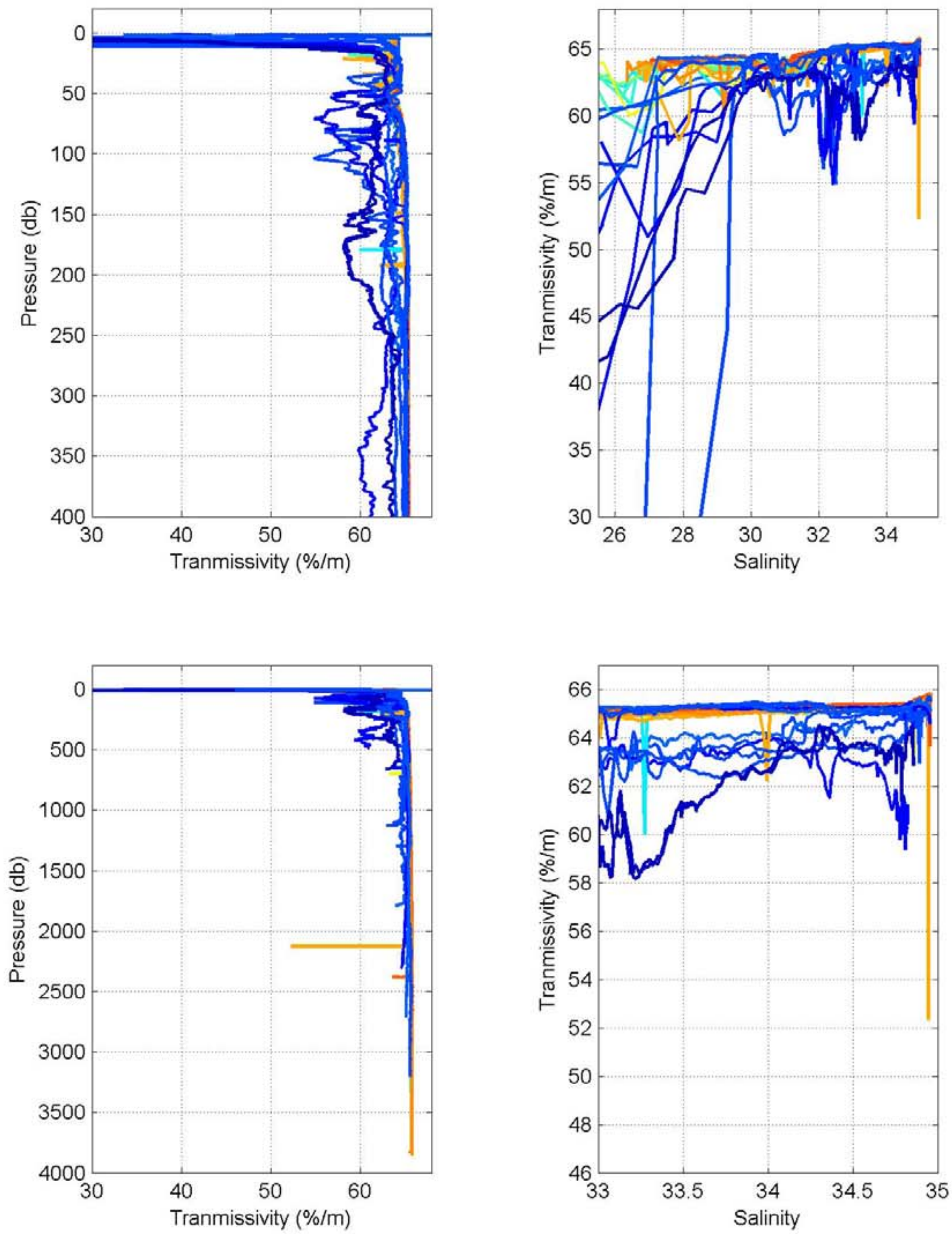
2006-18 Group: Canada Basin, East of 145°W, Property: Oxygen



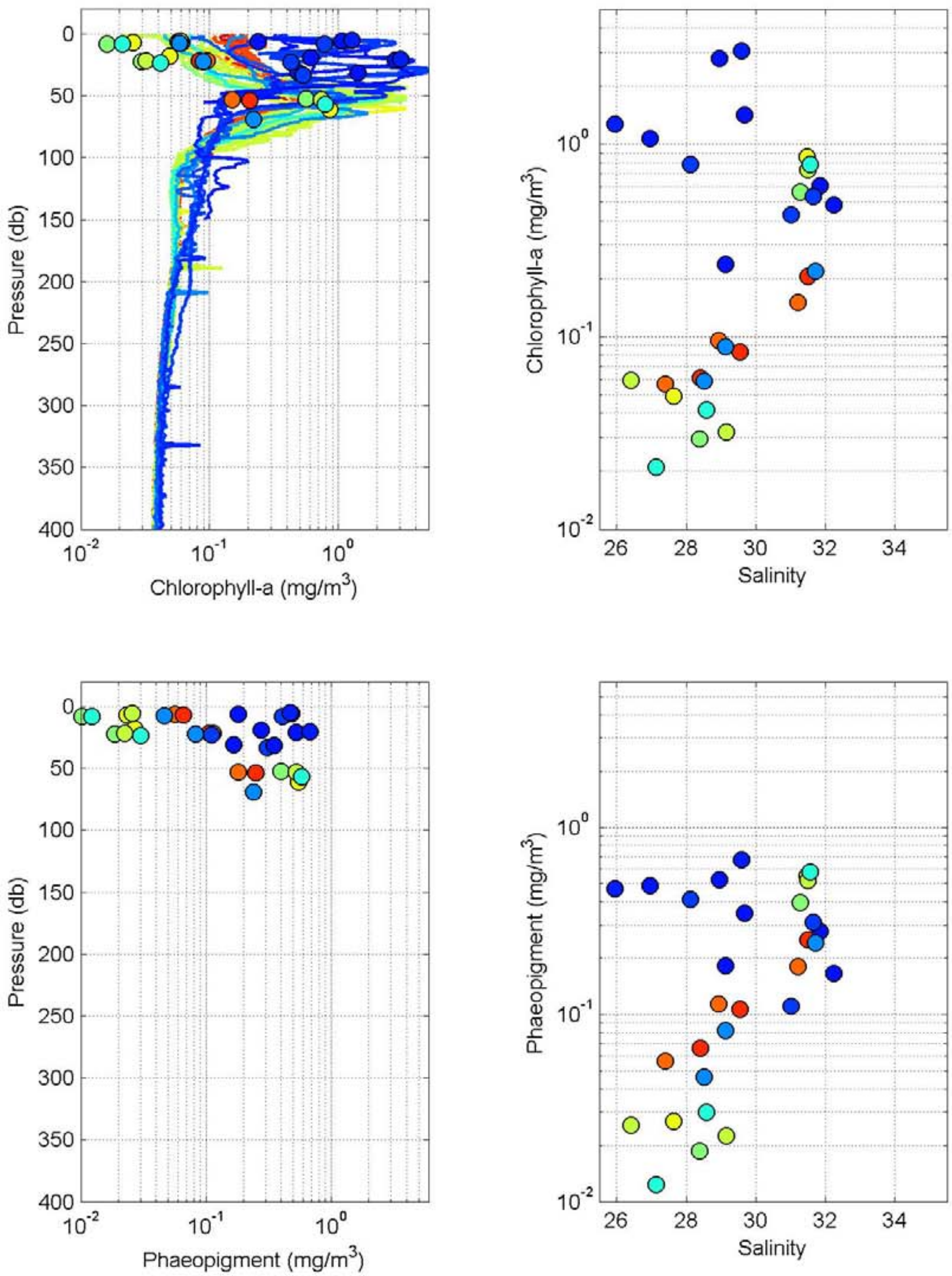
2006-18 Group: Canada Basin, West of 145°W, Property: Transmission



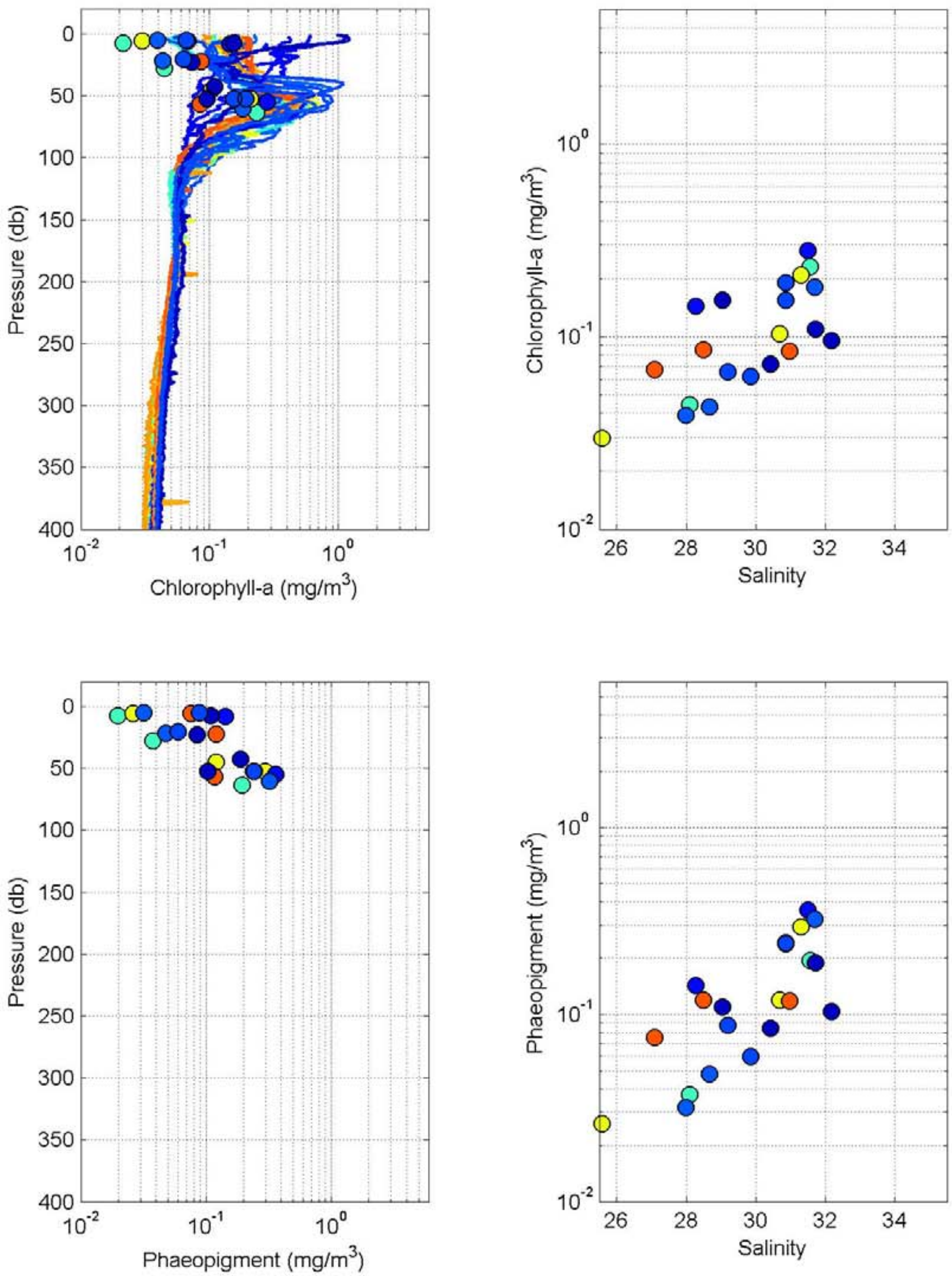
2006-18 Group: Canada Basin, East of 145°W, Property: Transmission



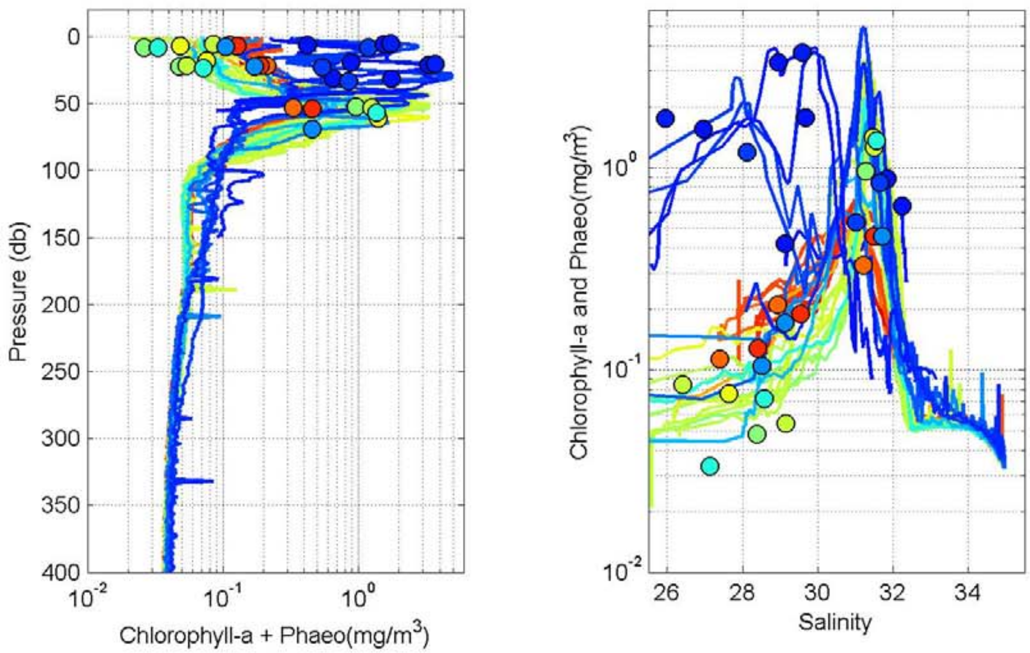
2006-18 Group: Canada Basin, West of 145°W, Property: Combined Chlorophyll-a and Phaeopigment



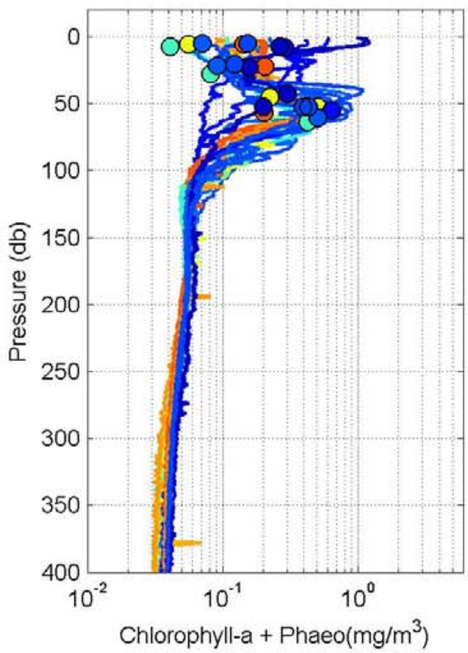
2006-18 Group: Canada Basin, East of 145°W, Property: Combined Chlorophyll-a and Phaeopigment

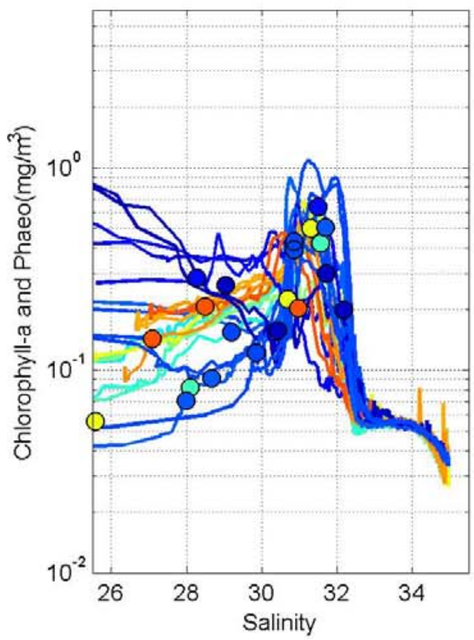


2006-18 Group: Canada Basin, West of 145°W, Property: Chlorophyll-a, Phaeopigment

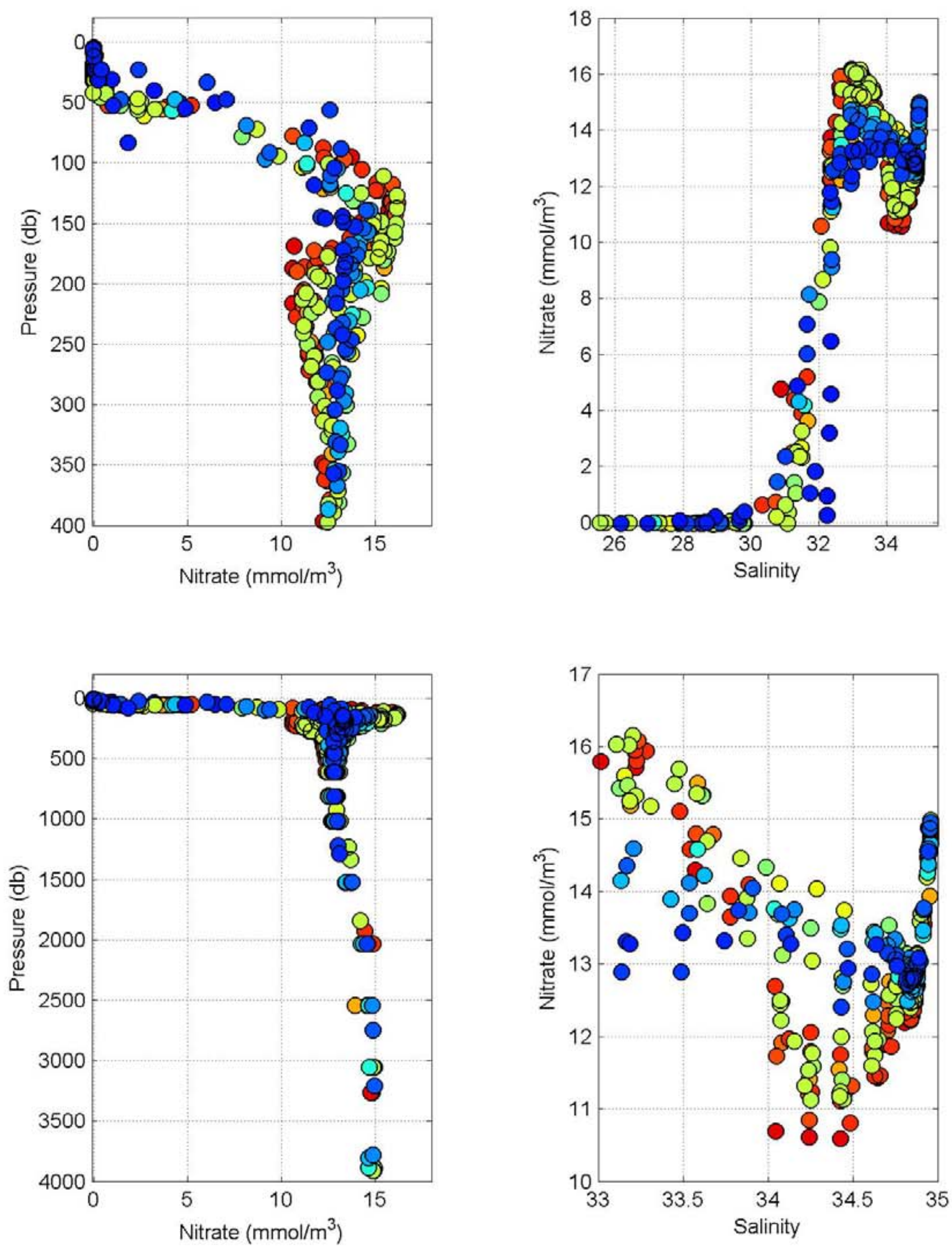


2006-18 Group: Canada Basin, East of 145°W, Property: Chlorophyll-a, Phaeopigment

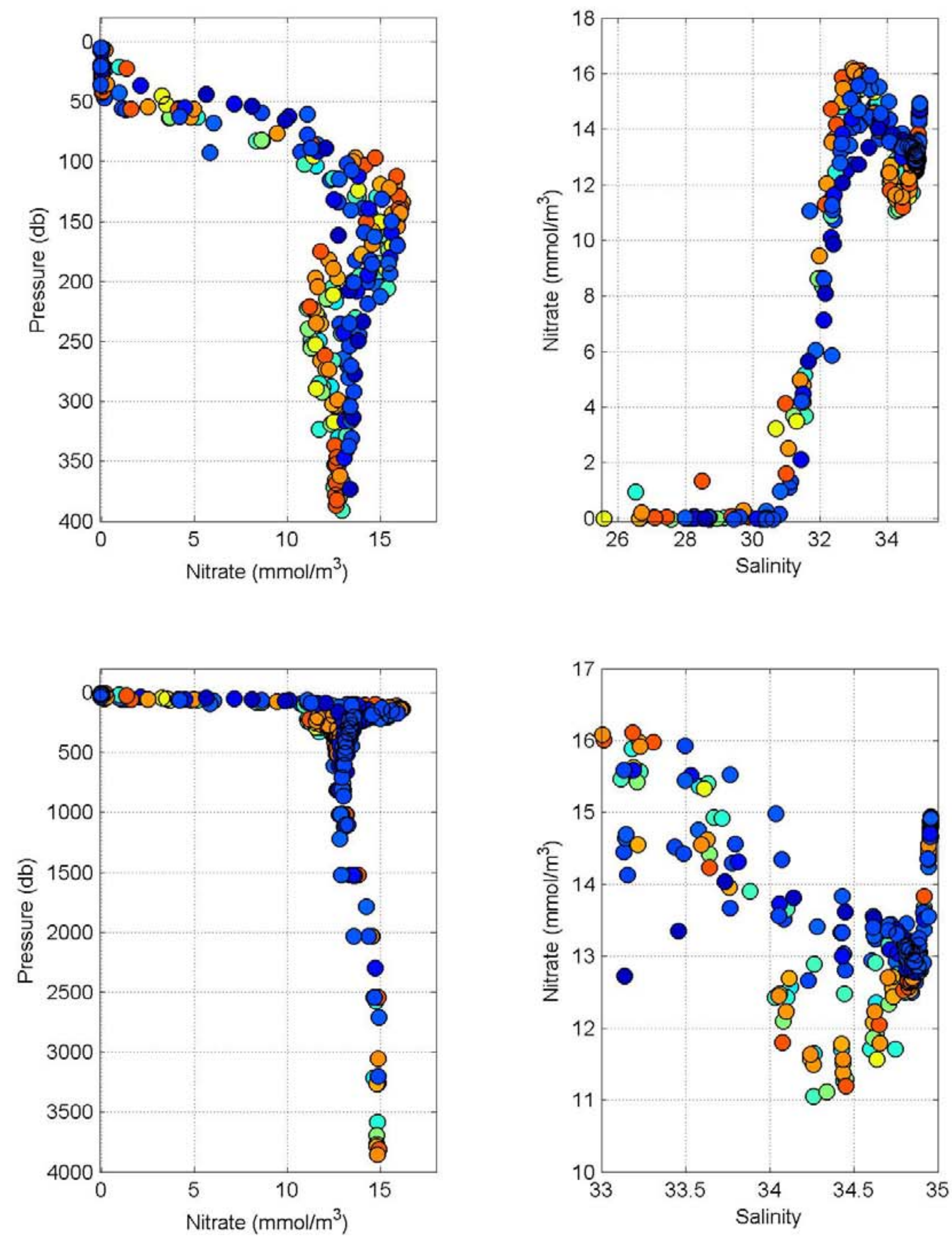




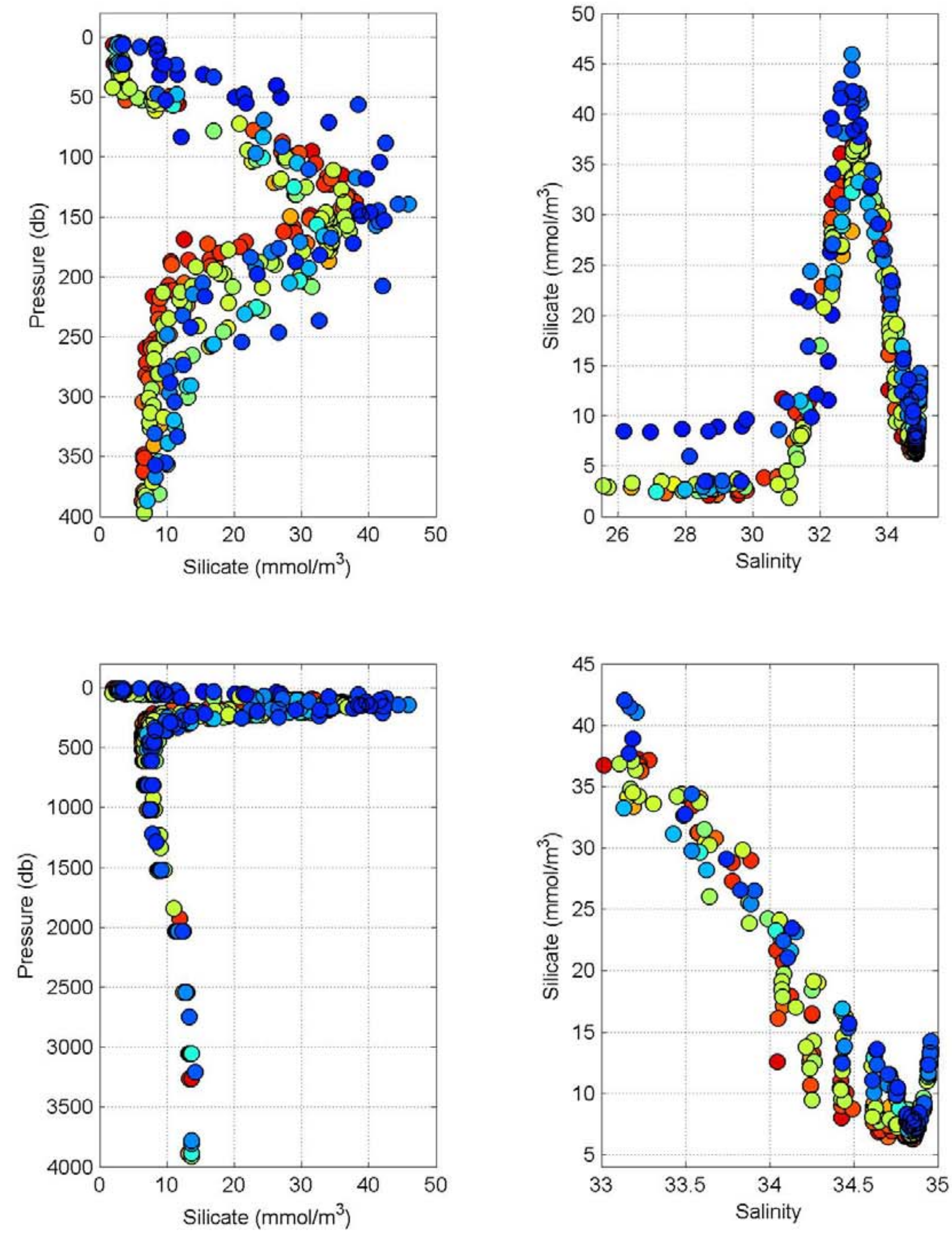
2006-18 Group: Canada Basin, West of 145°W, Property: Nitrate plus Nitrite



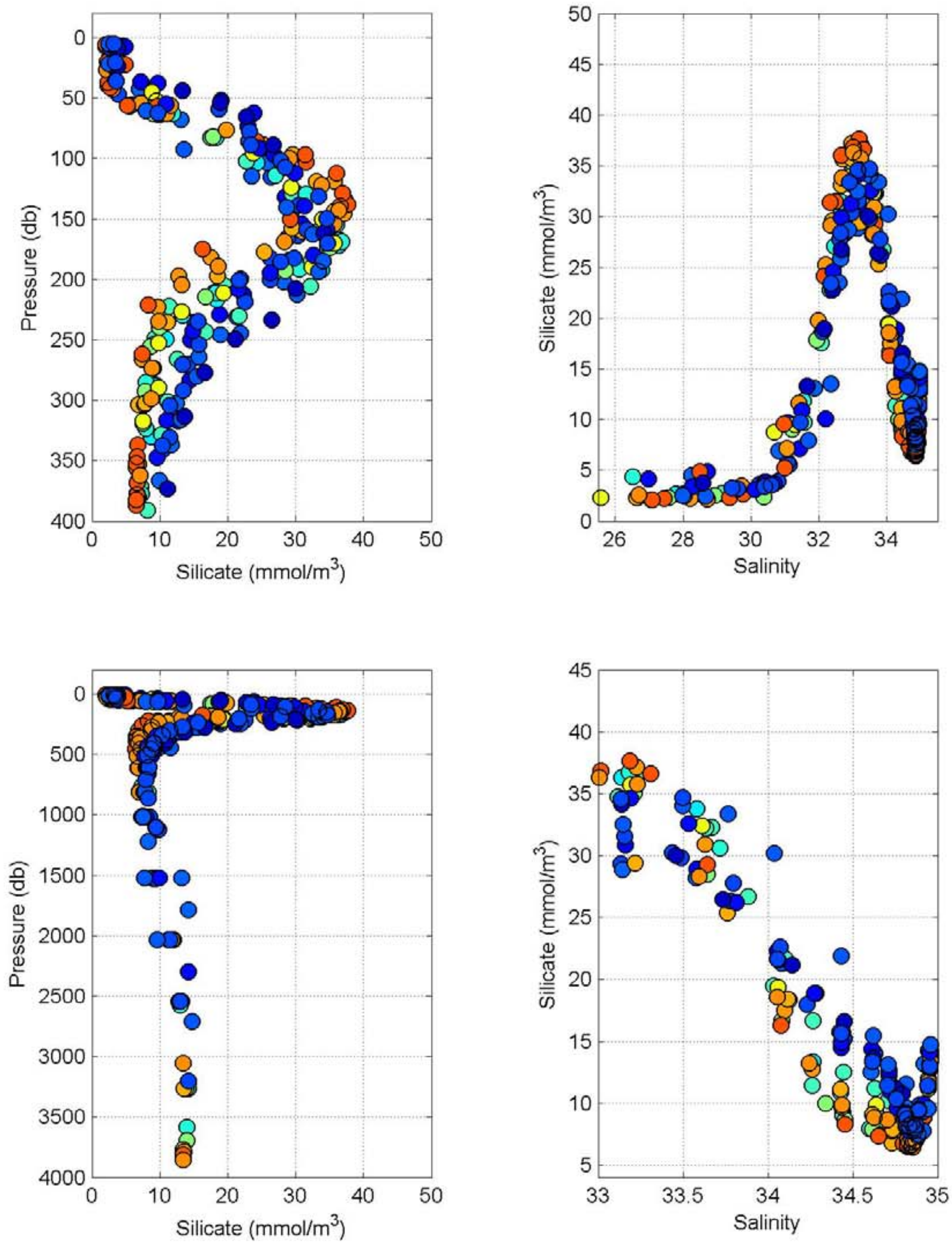
2006-18 Group: Canada Basin, East of 145°W, Property: Nitrate plus Nitrite



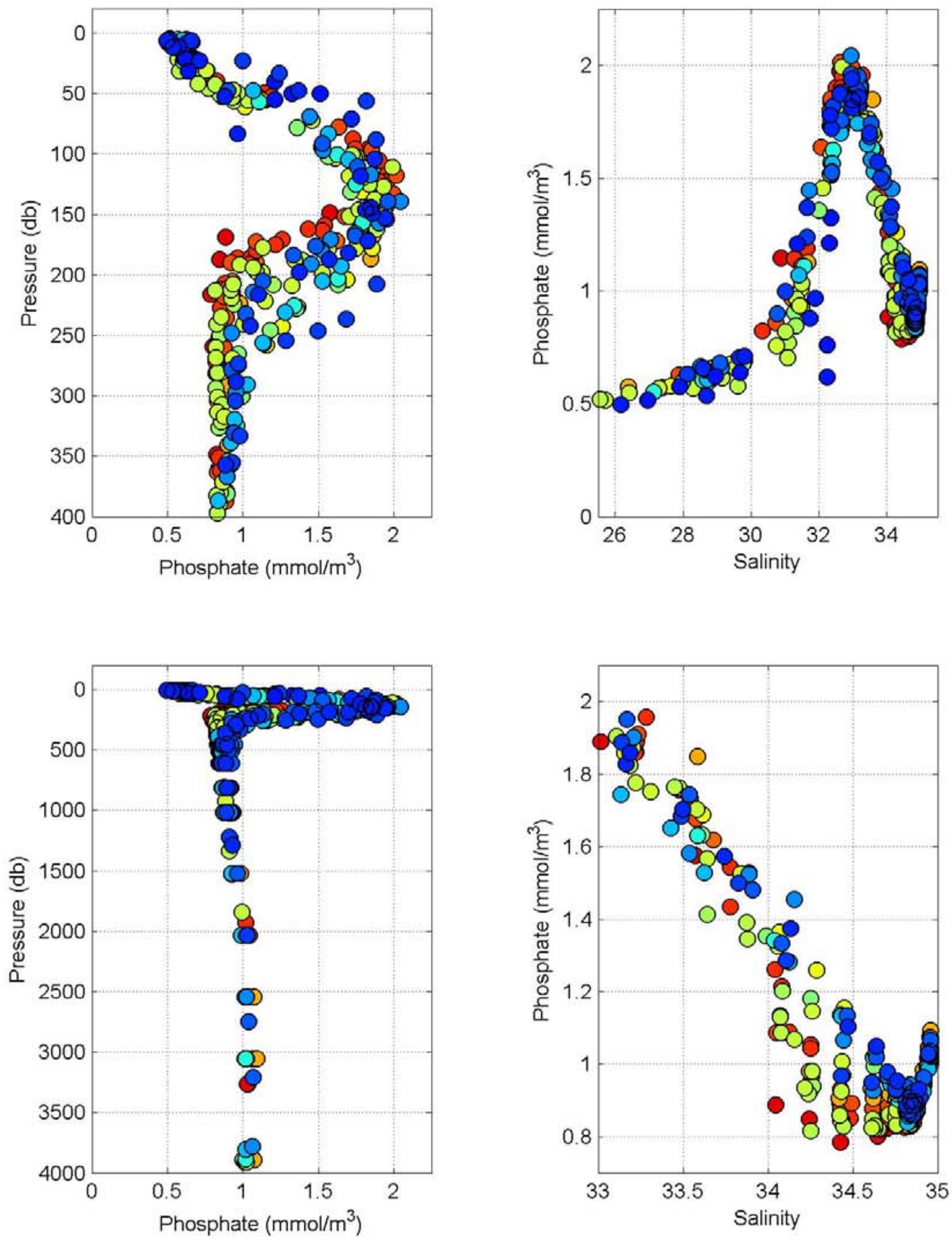
2006-18 Group: Canada Basin, West of 145°W, Property: Silicate



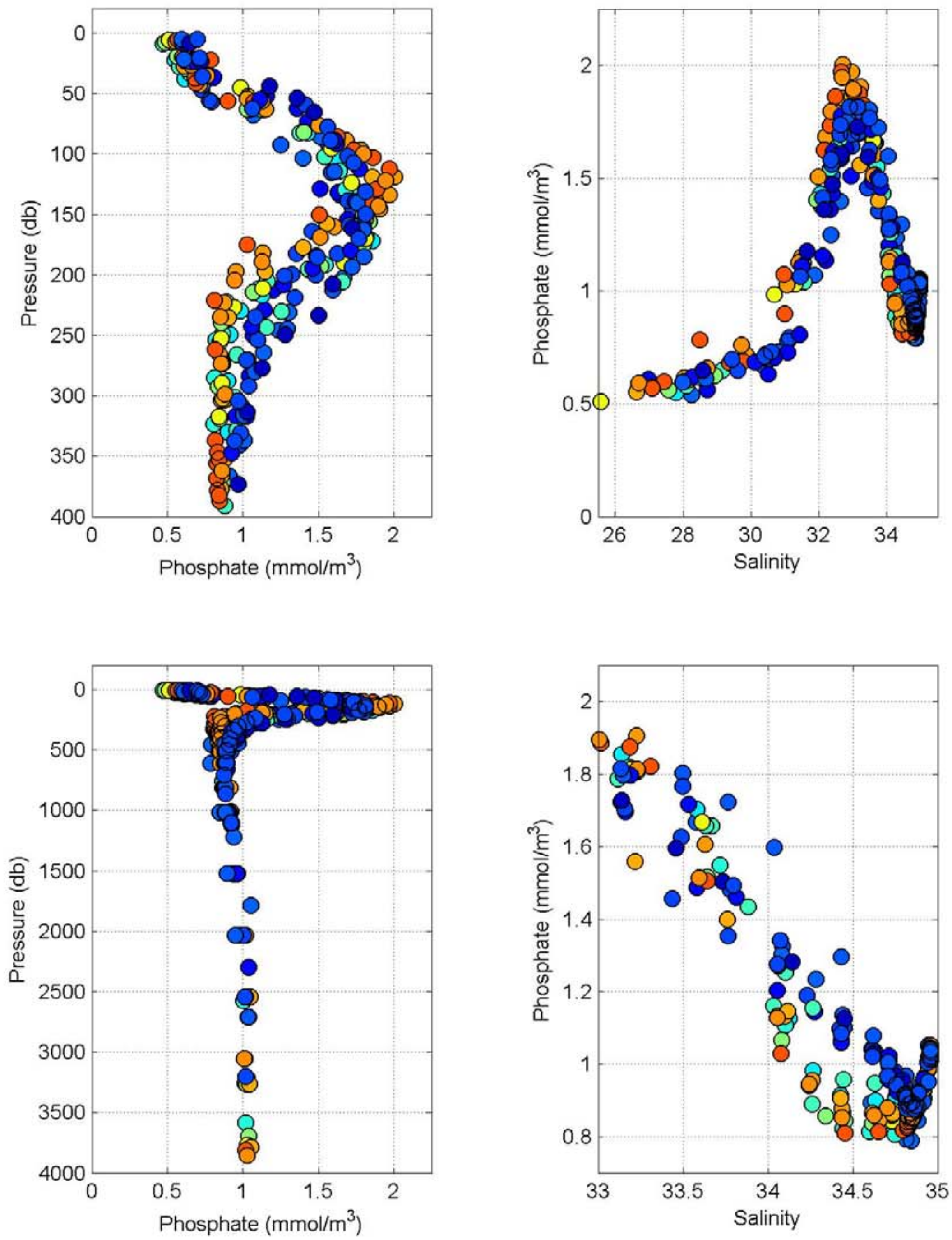
2006-18 Group: Canada Basin, East of 145°W, Property: Silicate



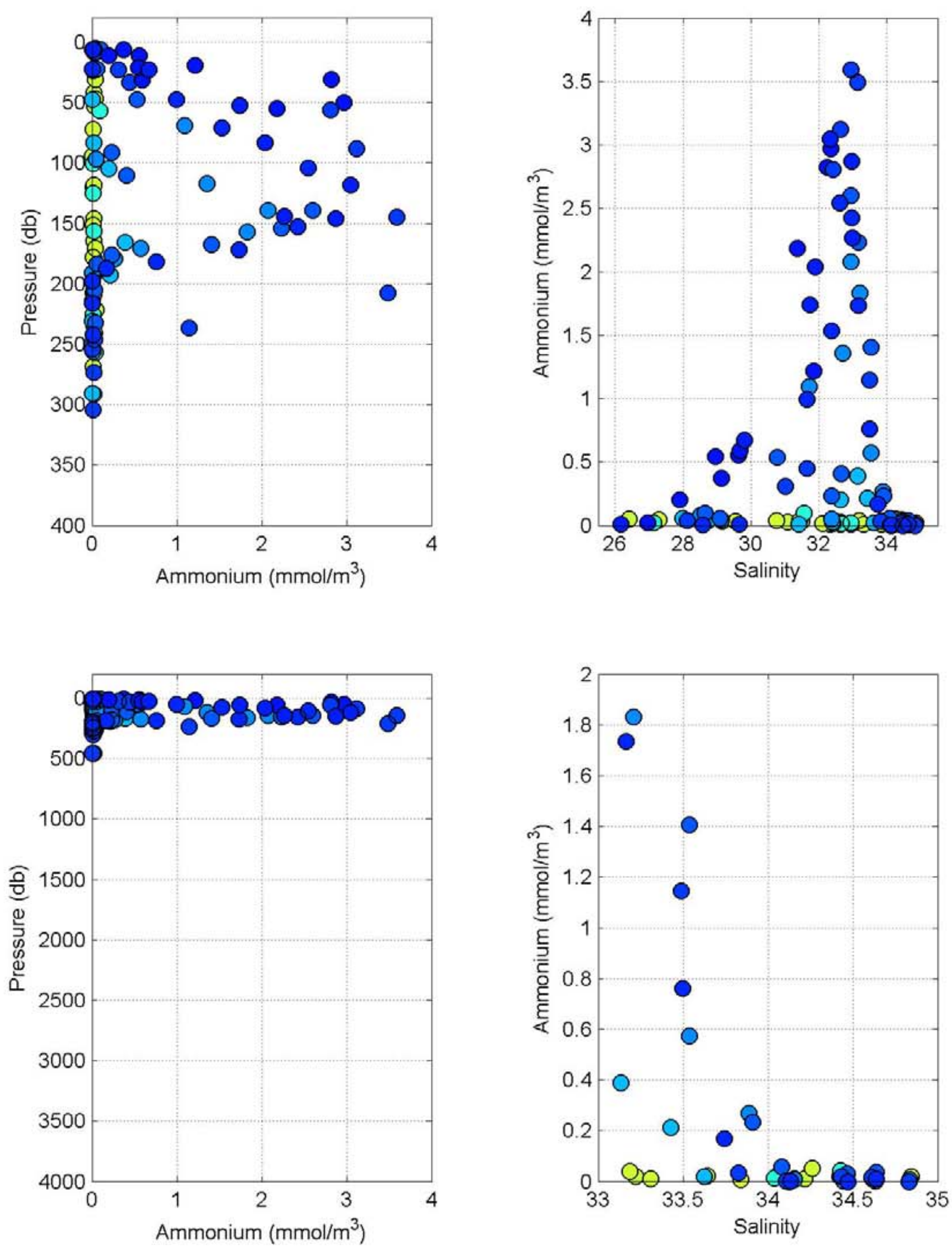
2006-18 Group: Canada Basin, West of 145°W, Property: Orthophosphate



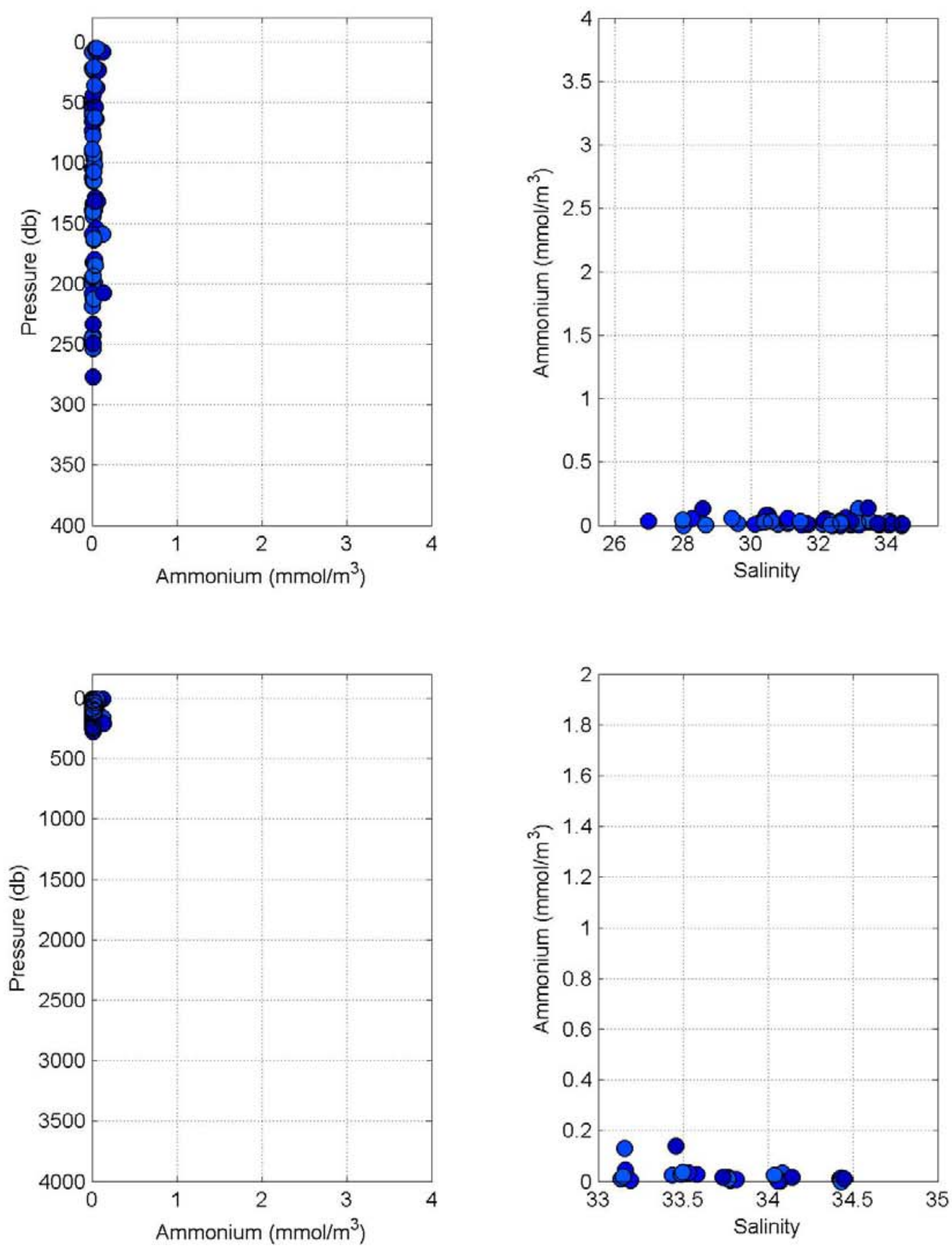
2006-18 Group: Canada Basin, East of 145°W, Property: Orthophosphate



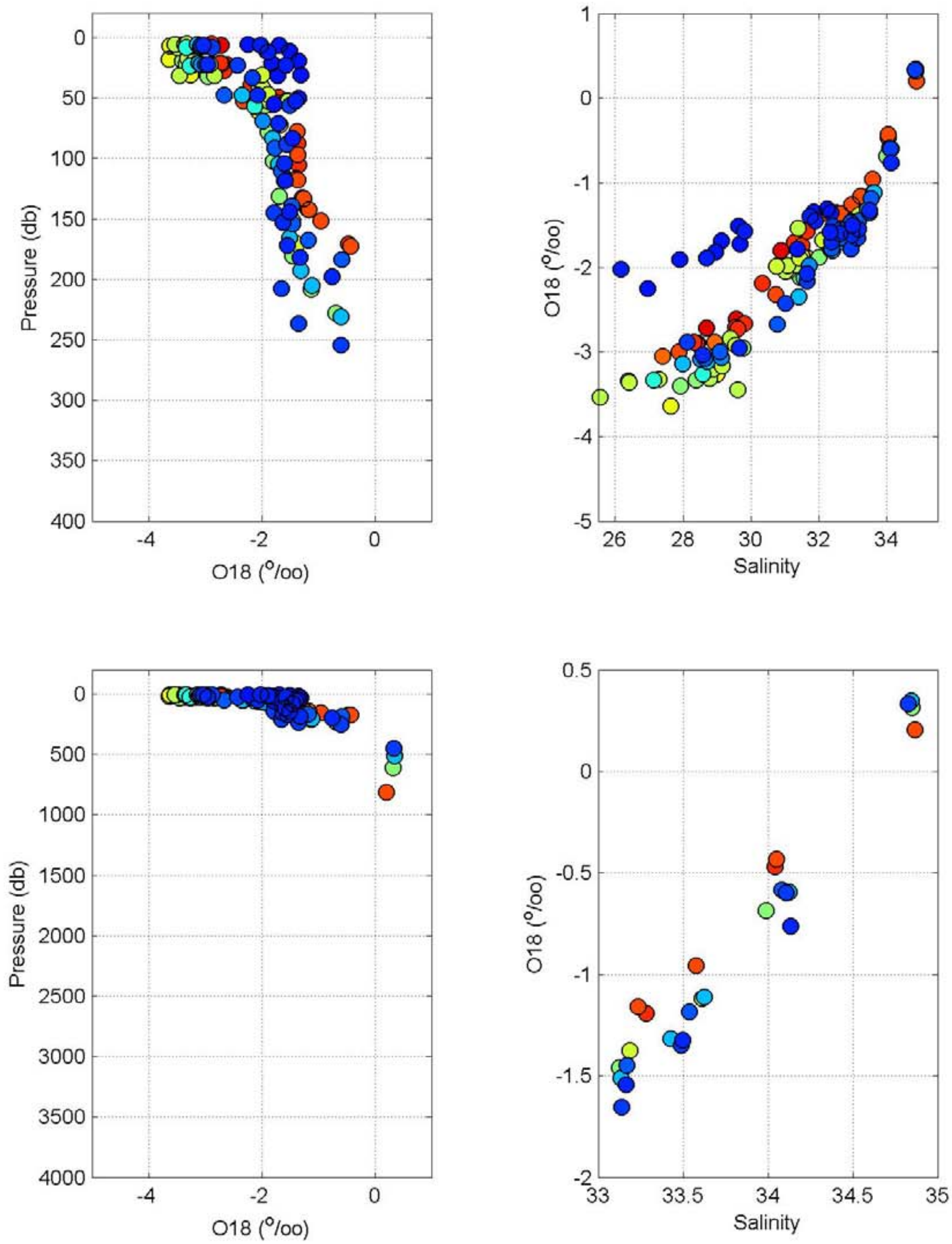
2006-18 Group: Canada Basin, West of 145°W, Property: Ammoniumn



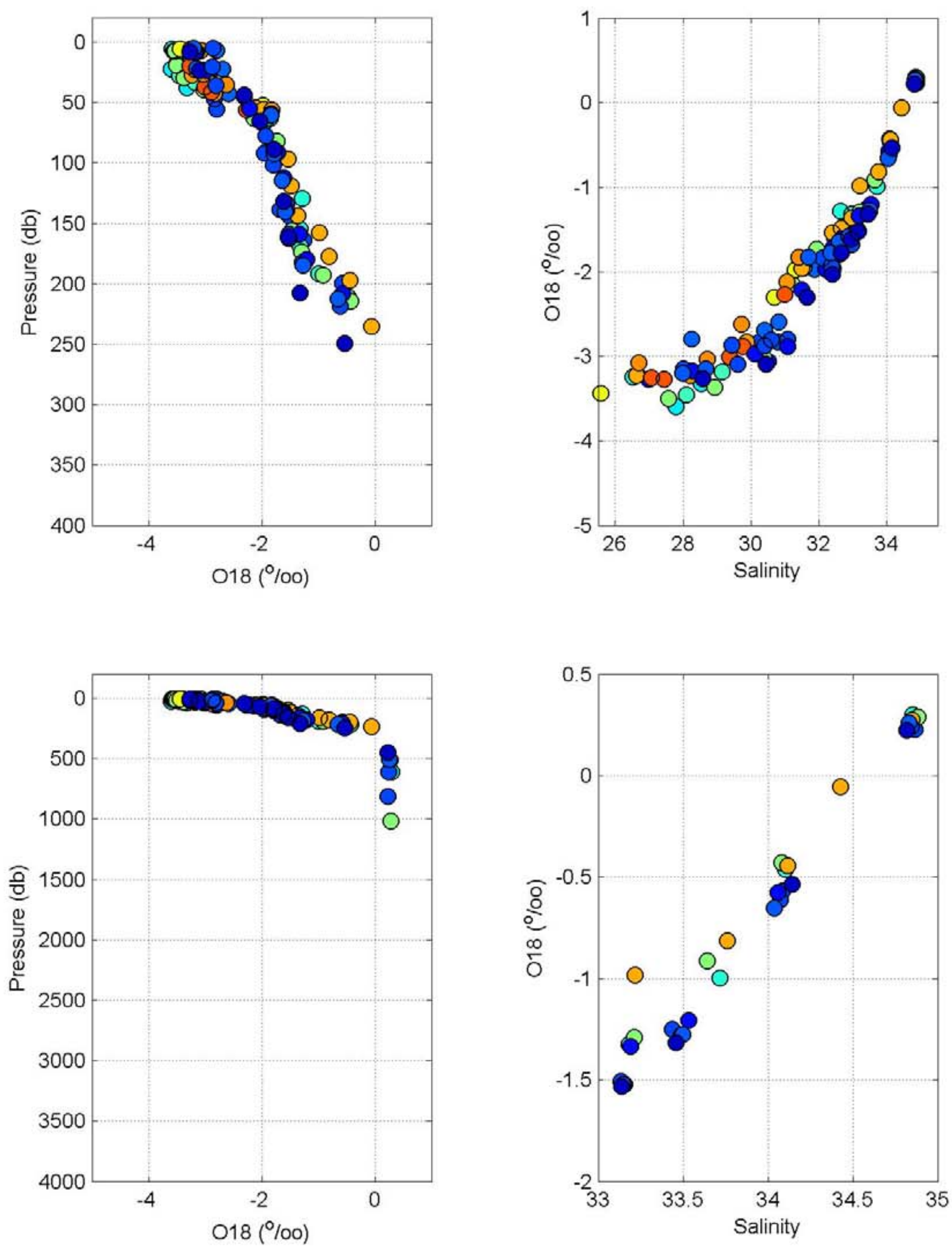
2006-18 Group: Canada Basin, East of 145°W, Property: Ammoniumn



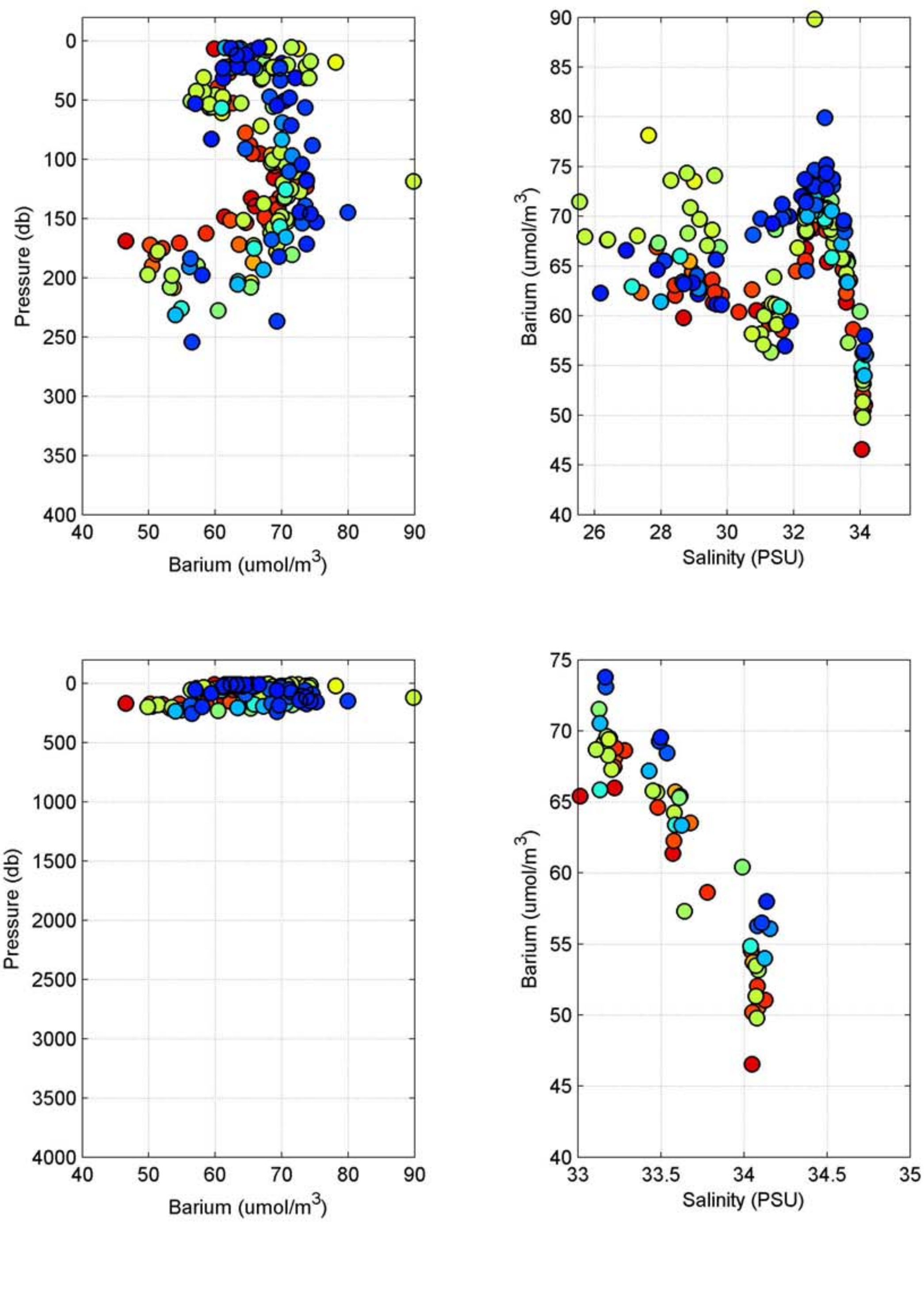
2006-18 Group: Canada Basin, West of 145°W, Property: O18



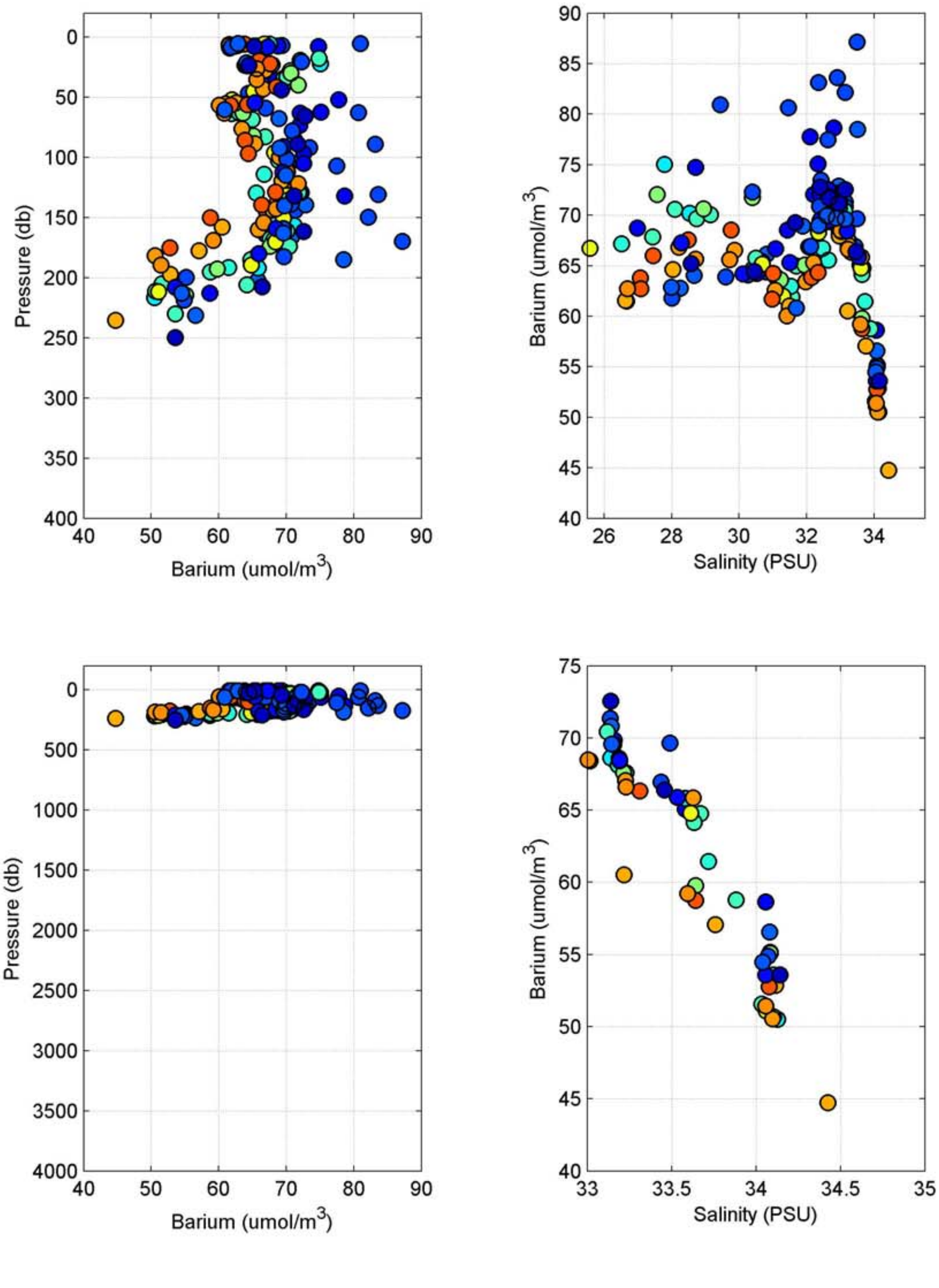
2006-18 Group: Canada Basin, East of 145°W, Property: O18



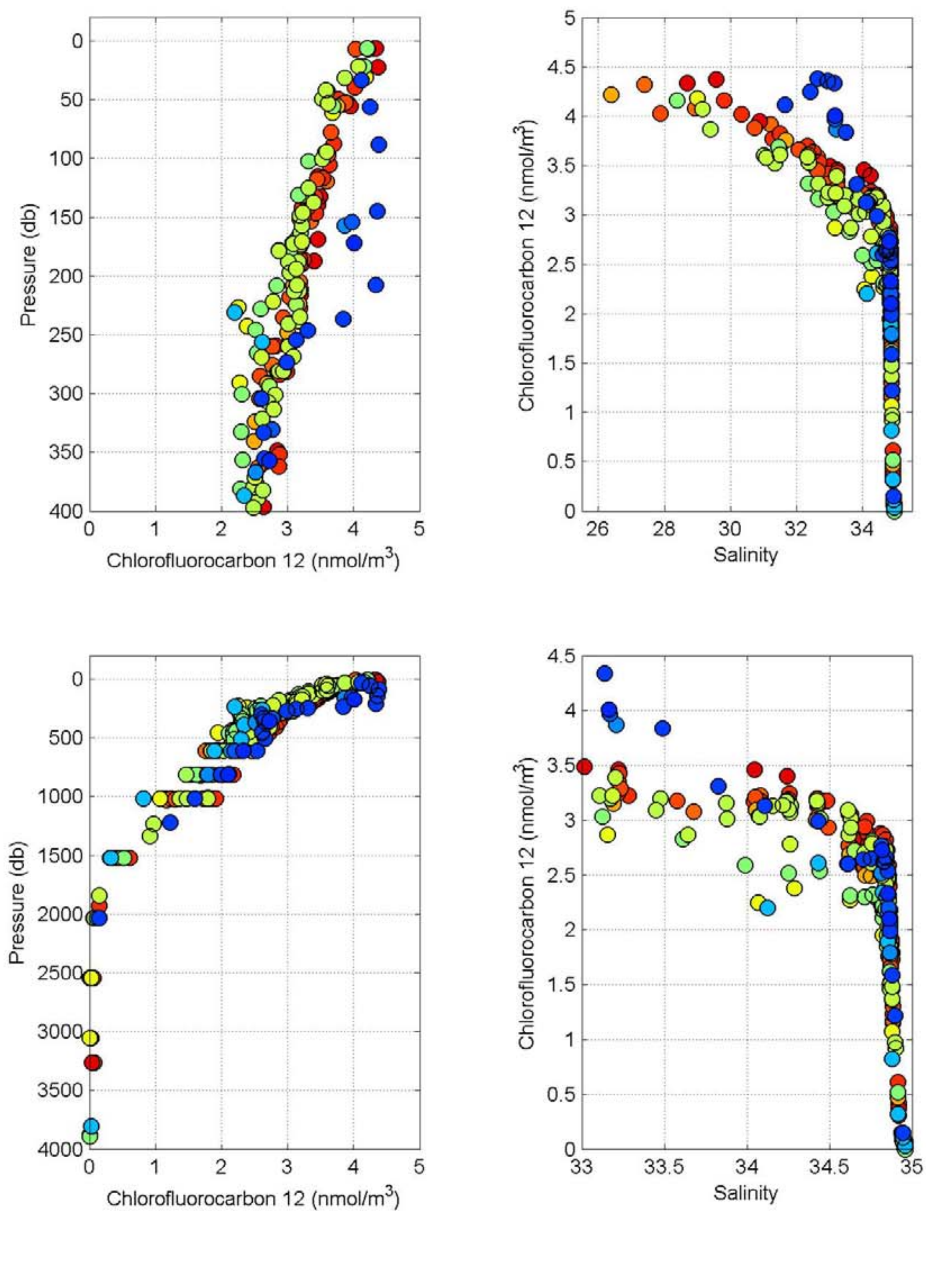
2006-18 Group: Canada Basin, West of 145°W, Property: Barium



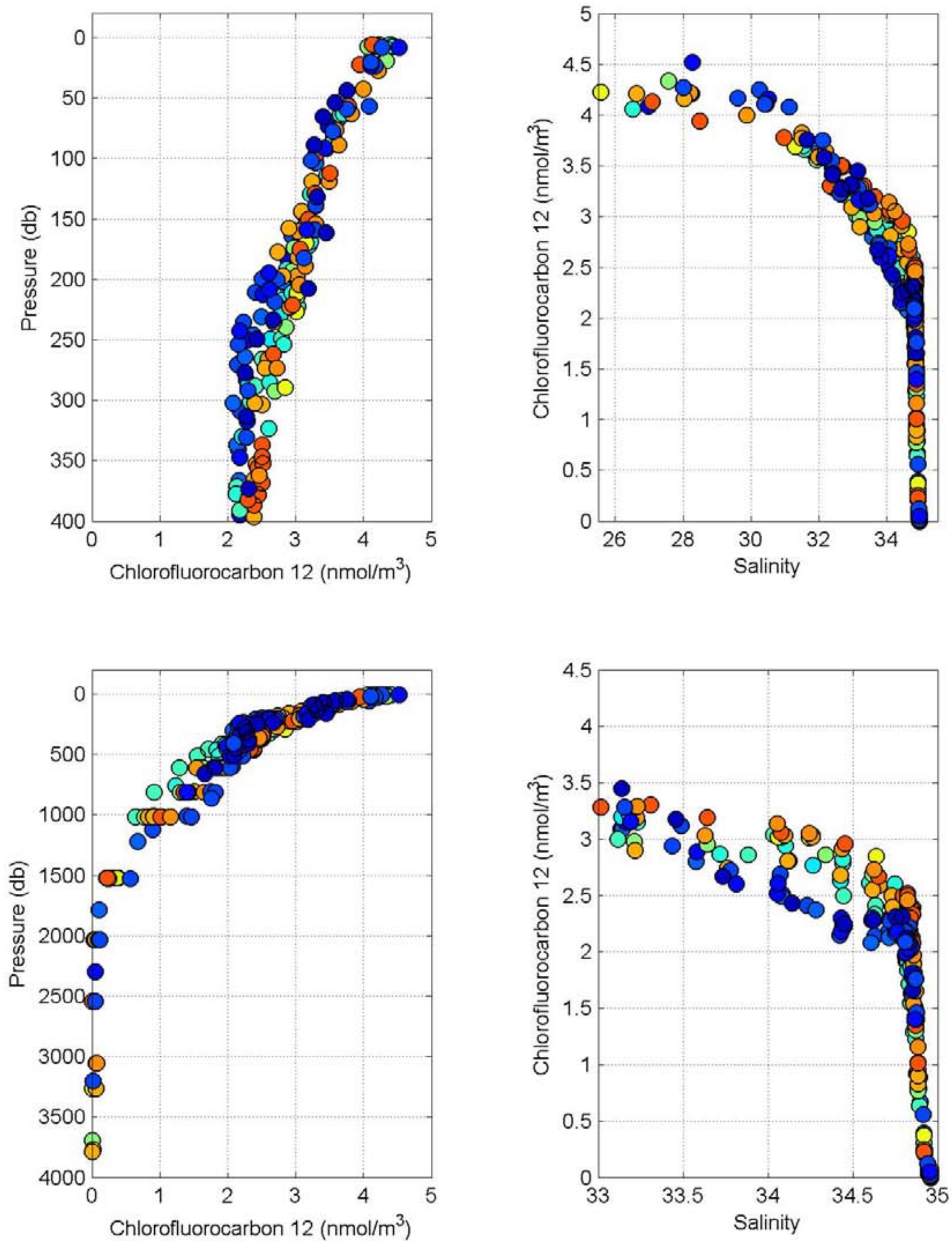
2006-18 Group: Canada Basin, East of 145°W, Property: Barium



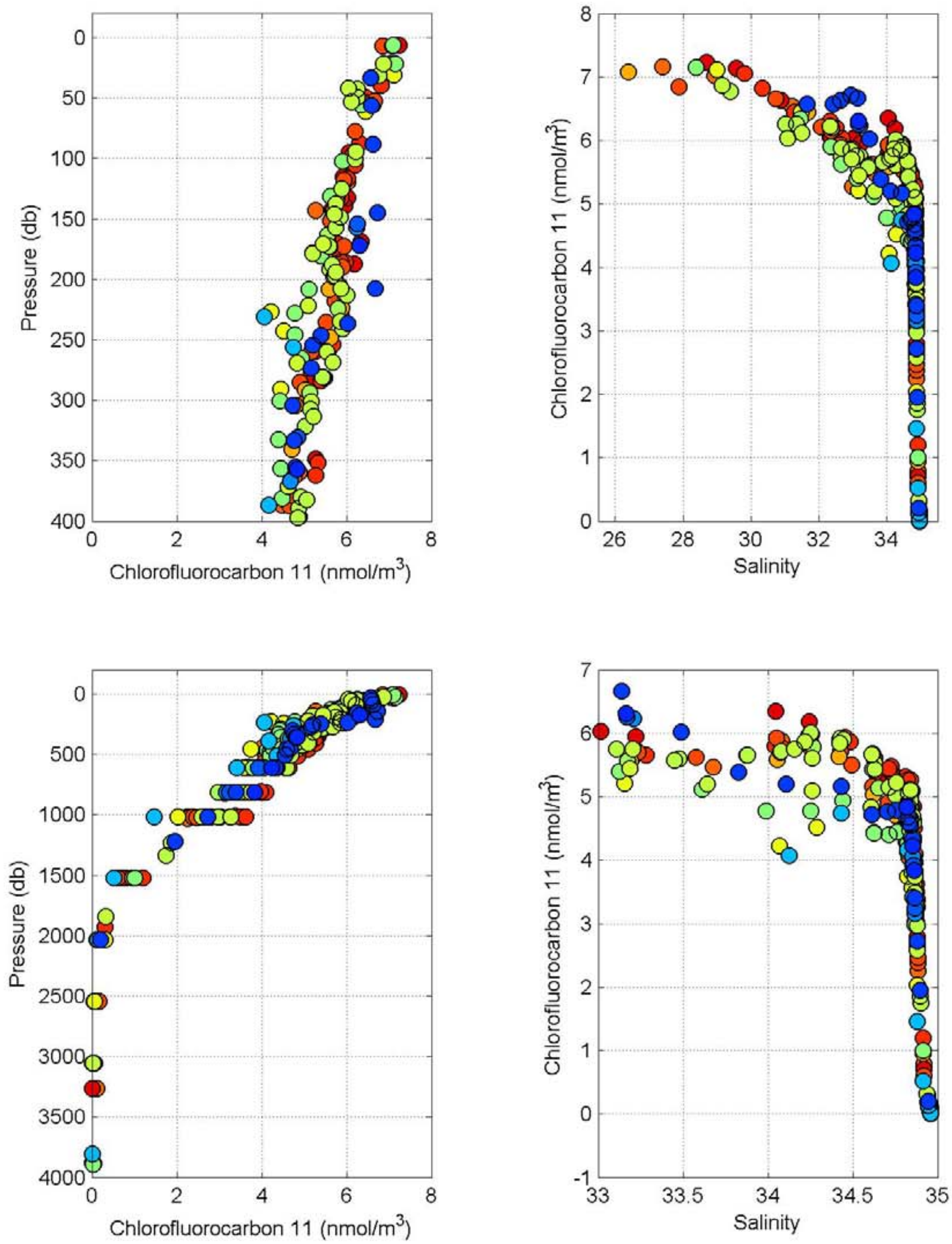
2006-18 Group: Canada Basin, West of 145°W, Property: Chlorofluorcarbon-12



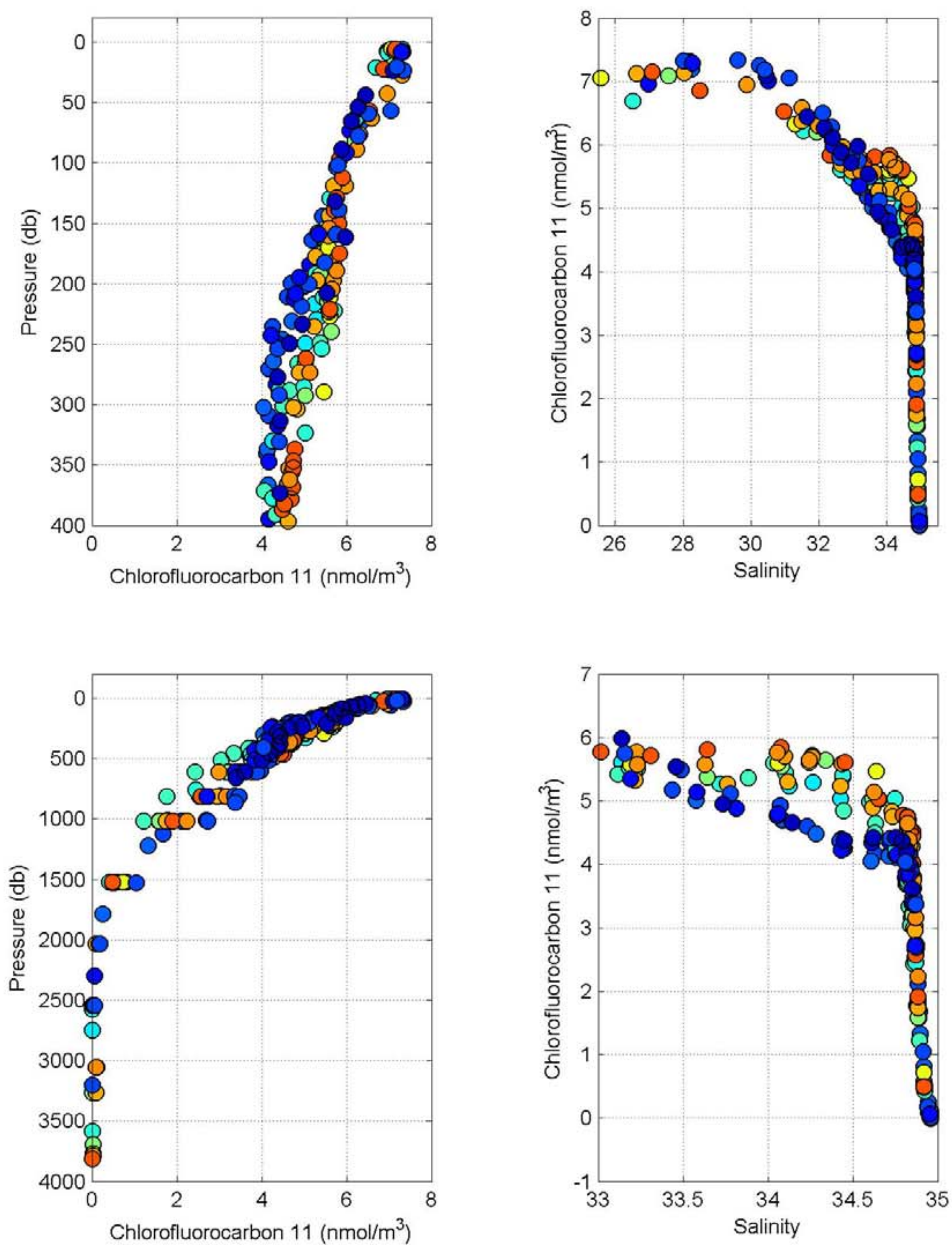
2006-18 Group: Canada Basin, East of 145°W, Property: Chlorofluorcarbon-12



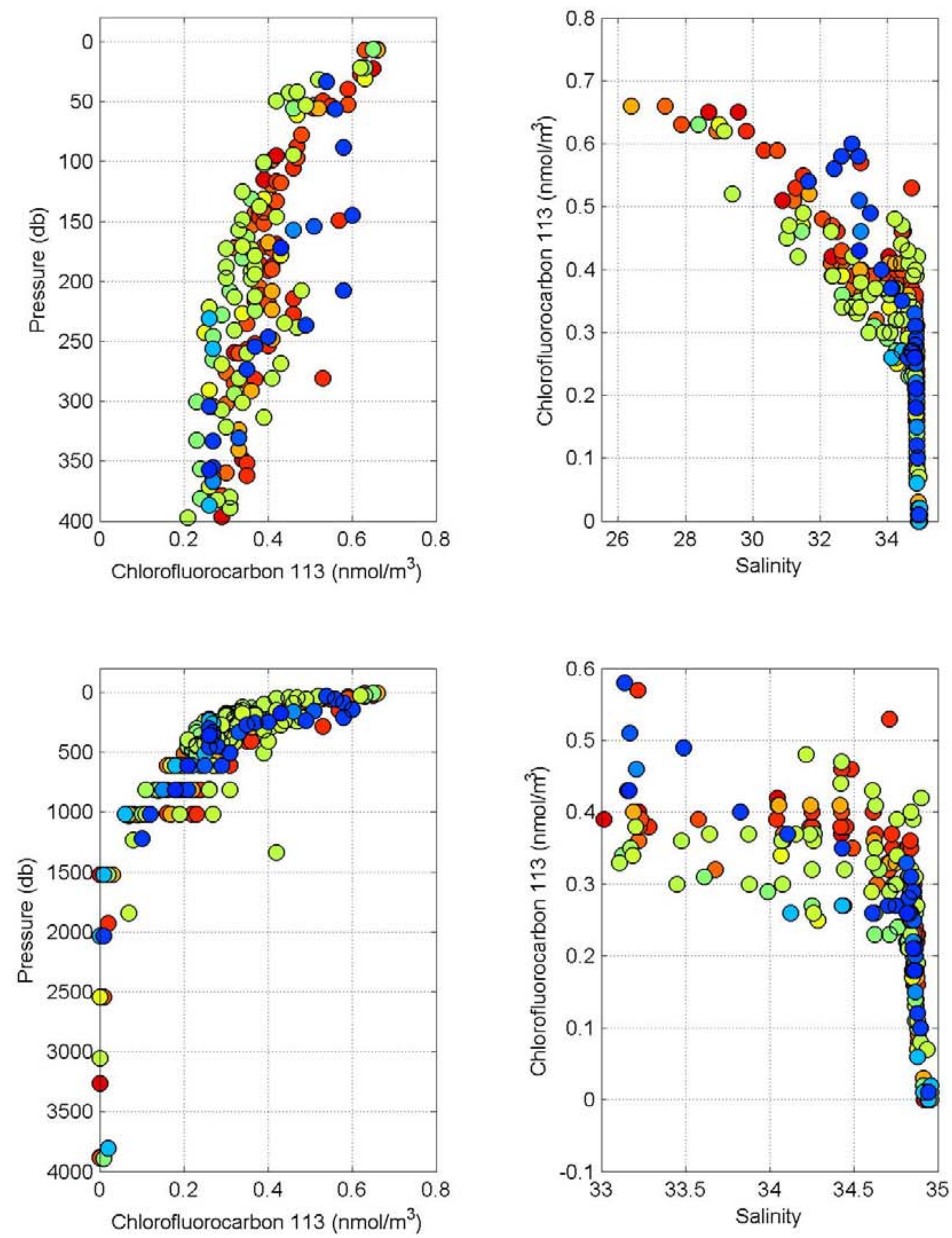
2006-18 Group: Canada Basin, West of 145°W, Property: Chlorofluorcarbon-11



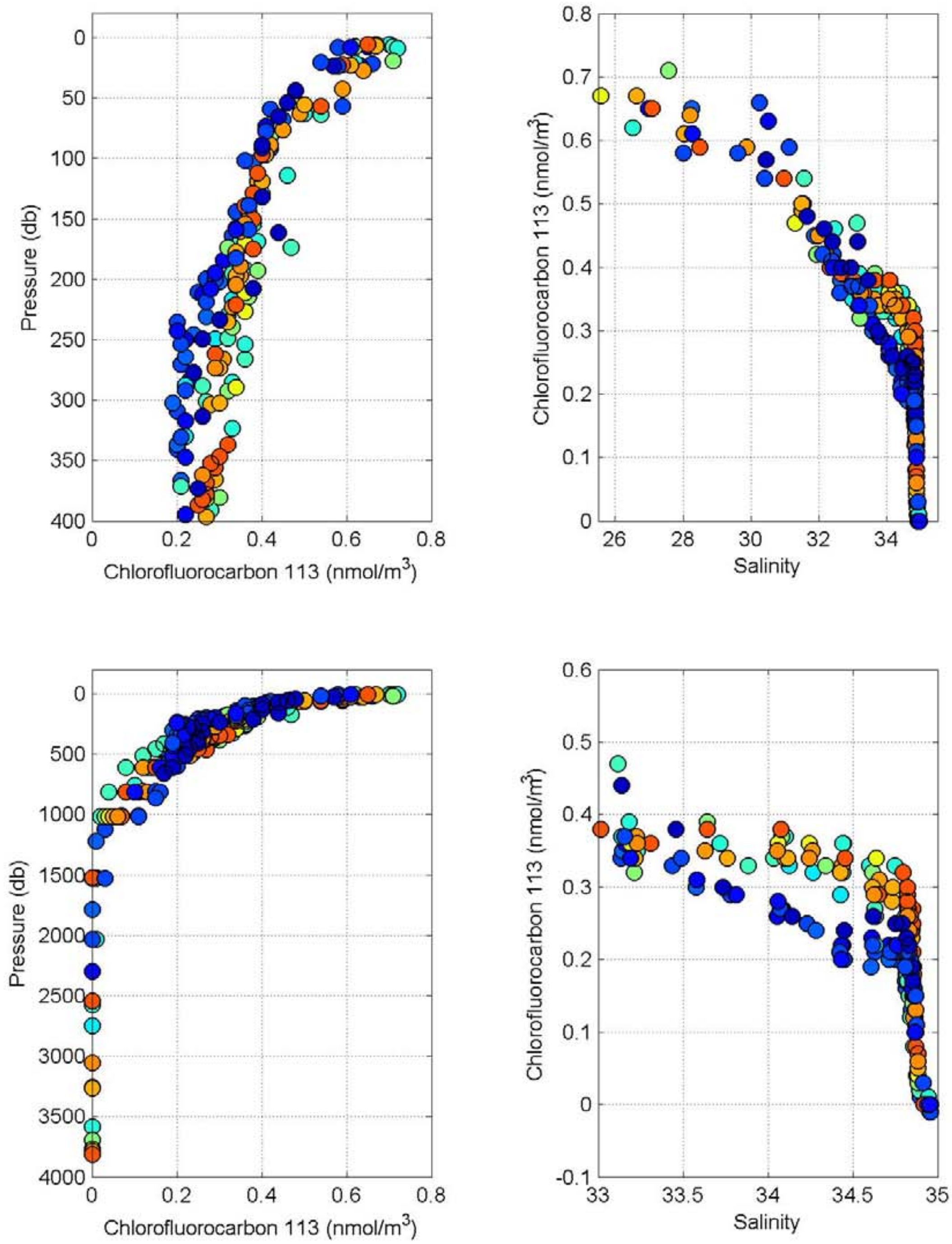
2006-18 Group: Canada Basin, East of 145°W, Property: Chlorofluorcarbon-11



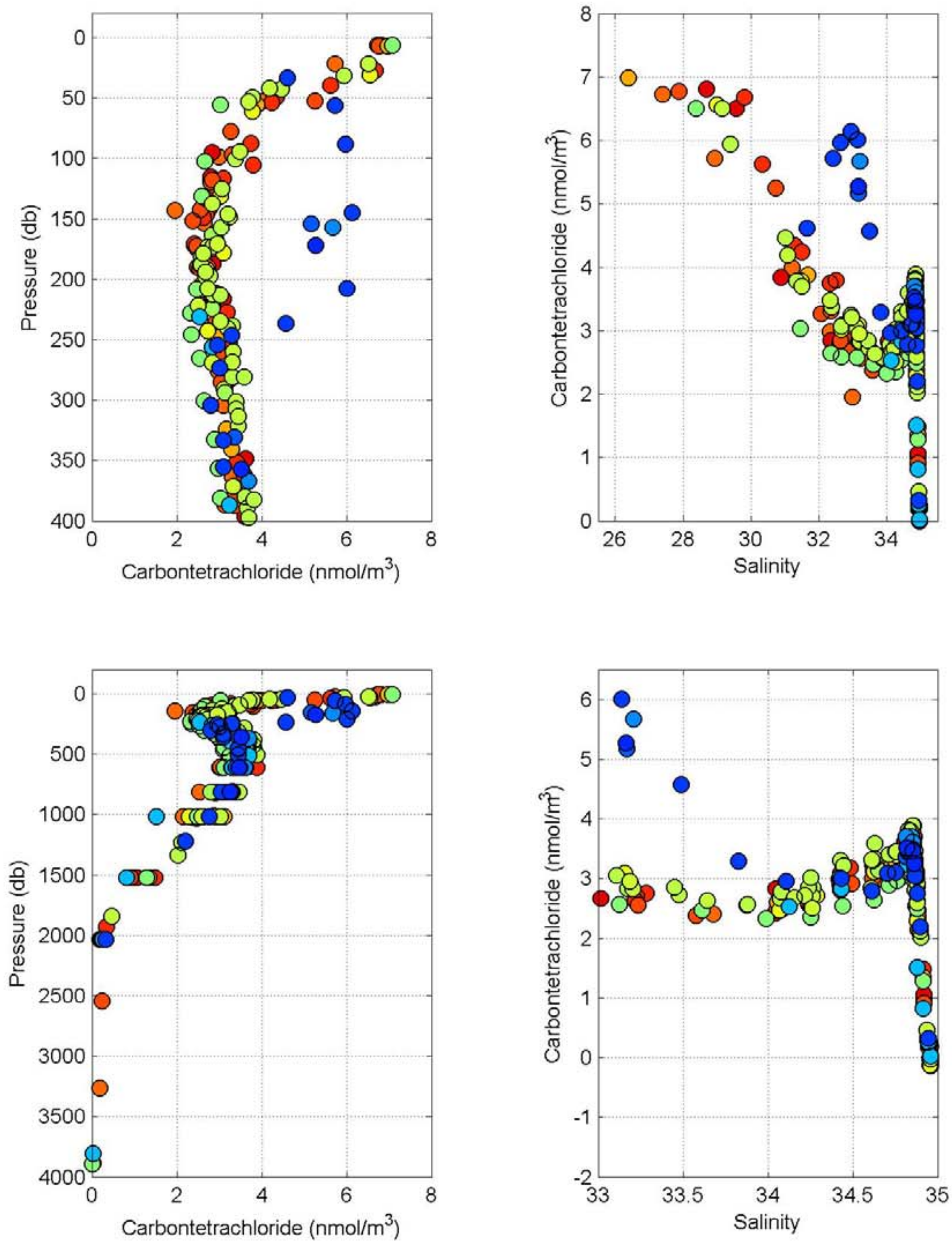
2006-18 Group: Canada Basin, West of 145°W, Property: Chlorofluorcarbon-113



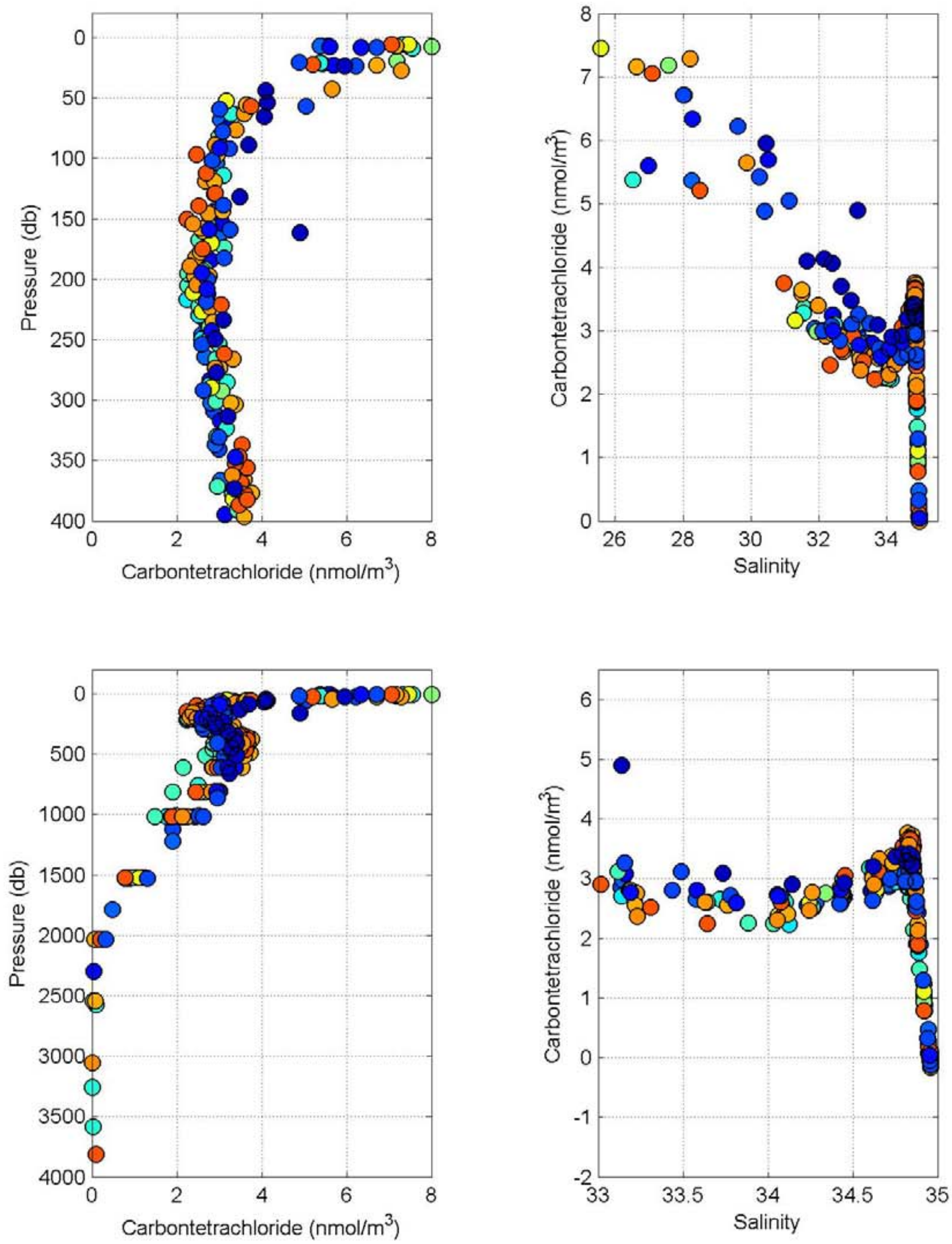
2006-18 Group: Canada Basin, East of 145°W, Property: Chlorofluorcarbon-113



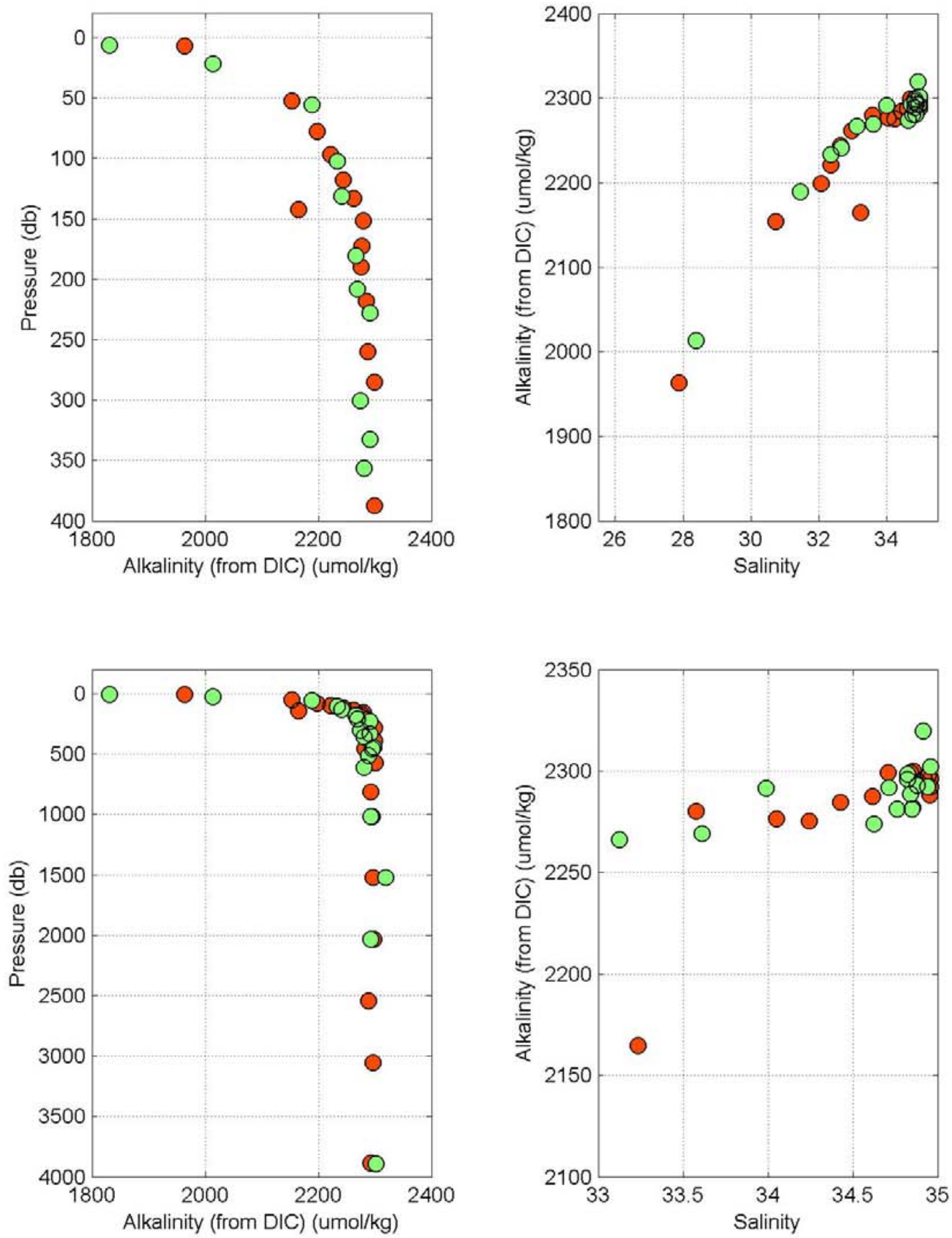
2006-18 Group: Canada Basin, West of 145°W, Property: Carbontetrachloride



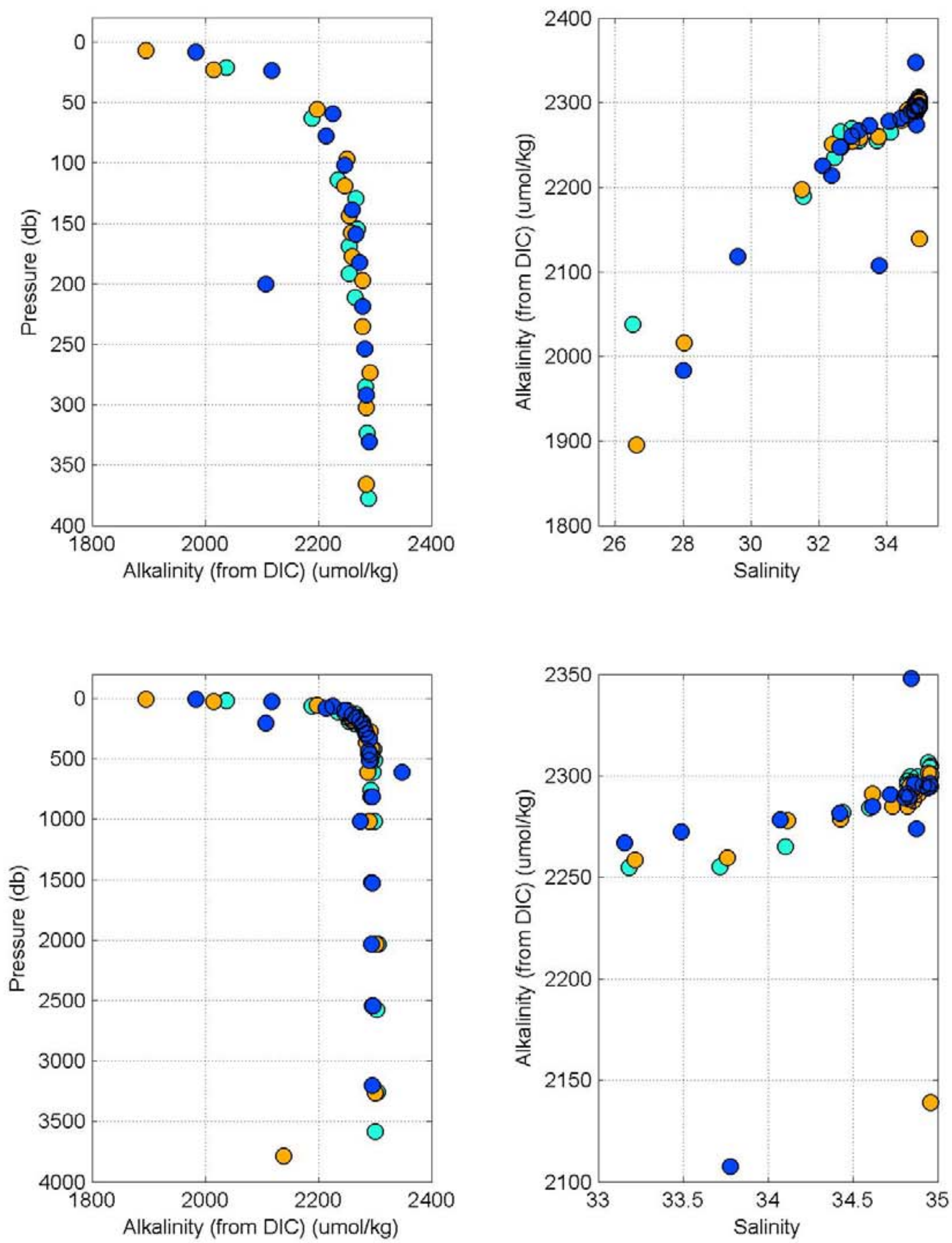
2006-18 Group: Canada Basin, East of 145°W, Property: Carbontetrachloride



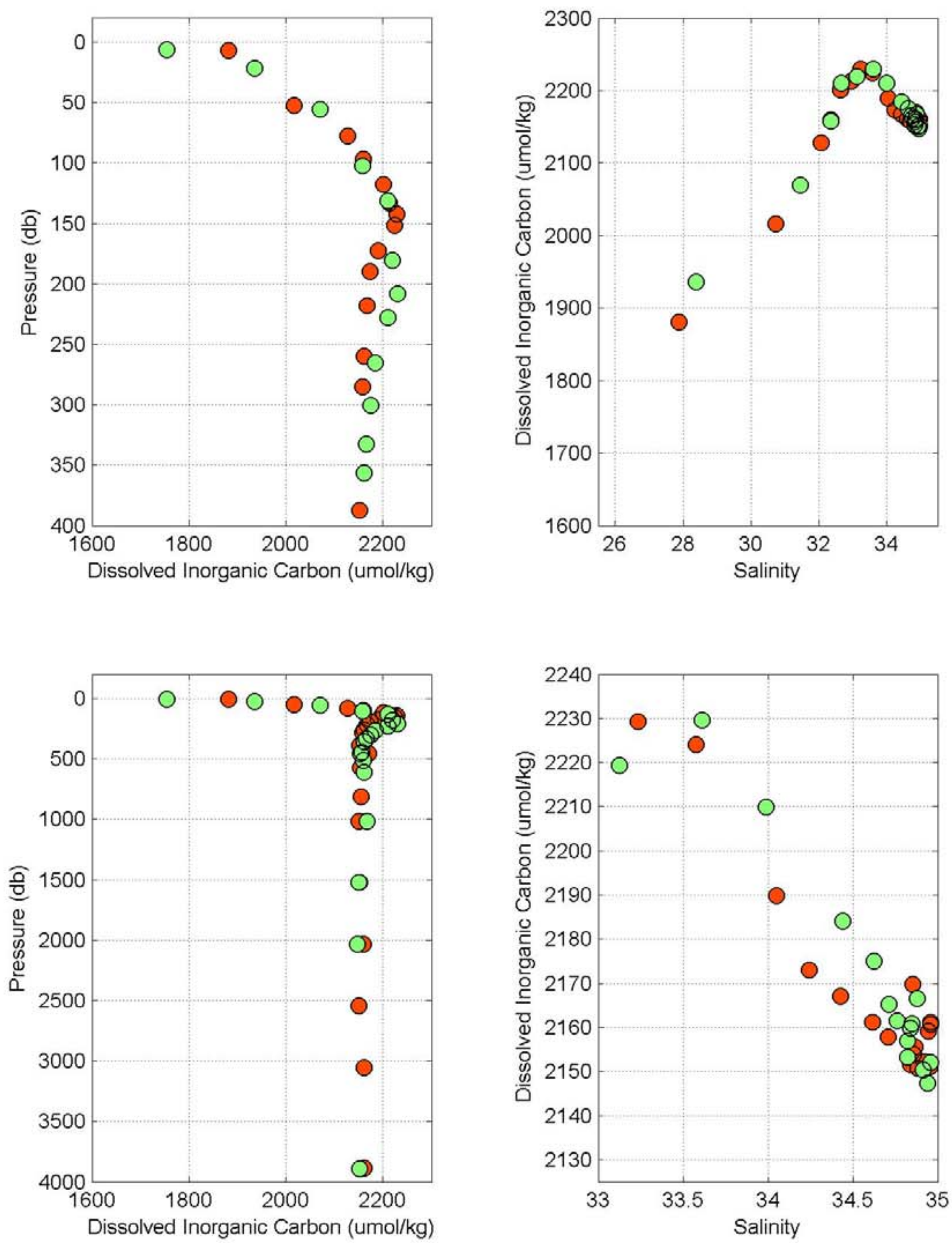
2006-18 Group: Canada Basin, West of 145°W, Property: Alkalinity



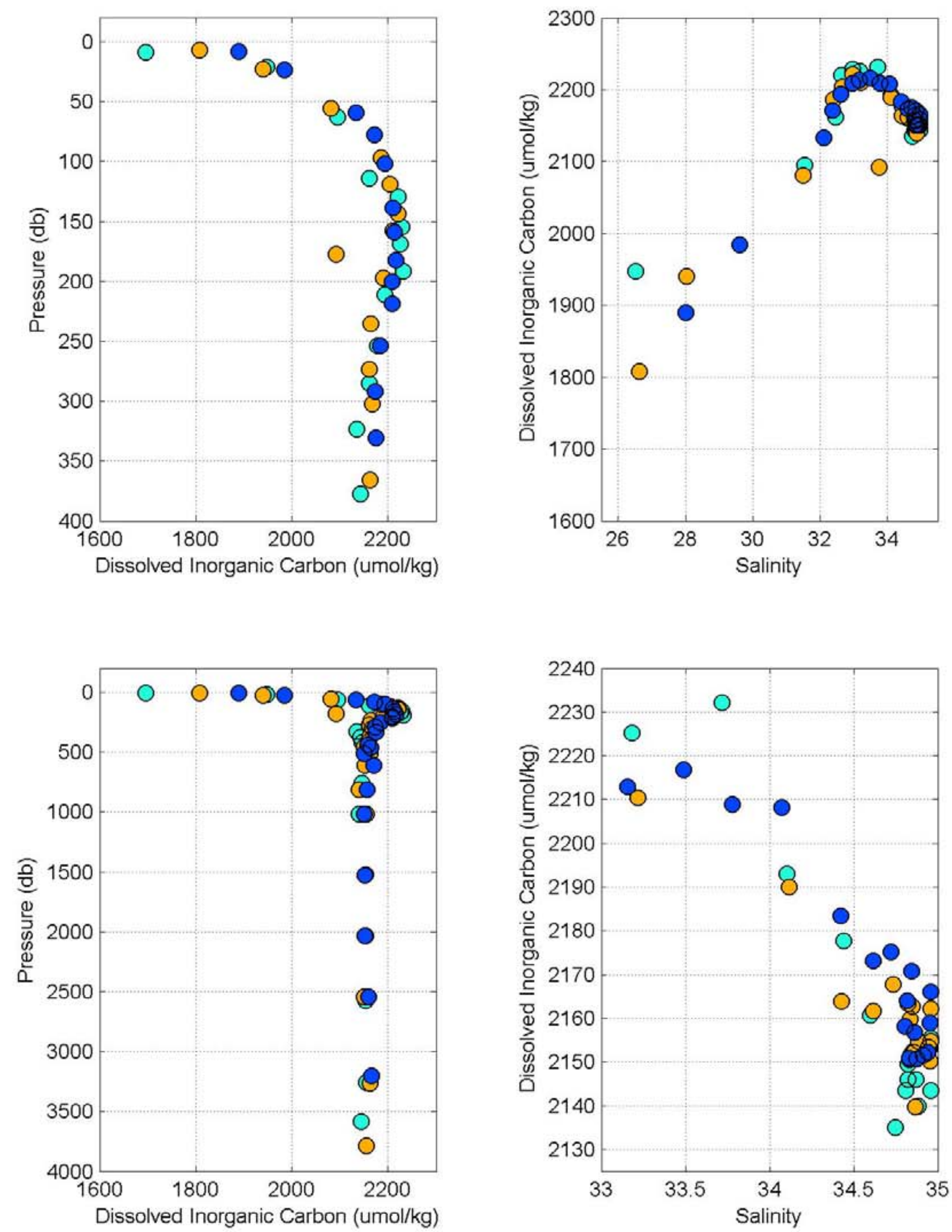
2006-18   Group: Canada Basin, East of 145°W, Property: Alkalinity



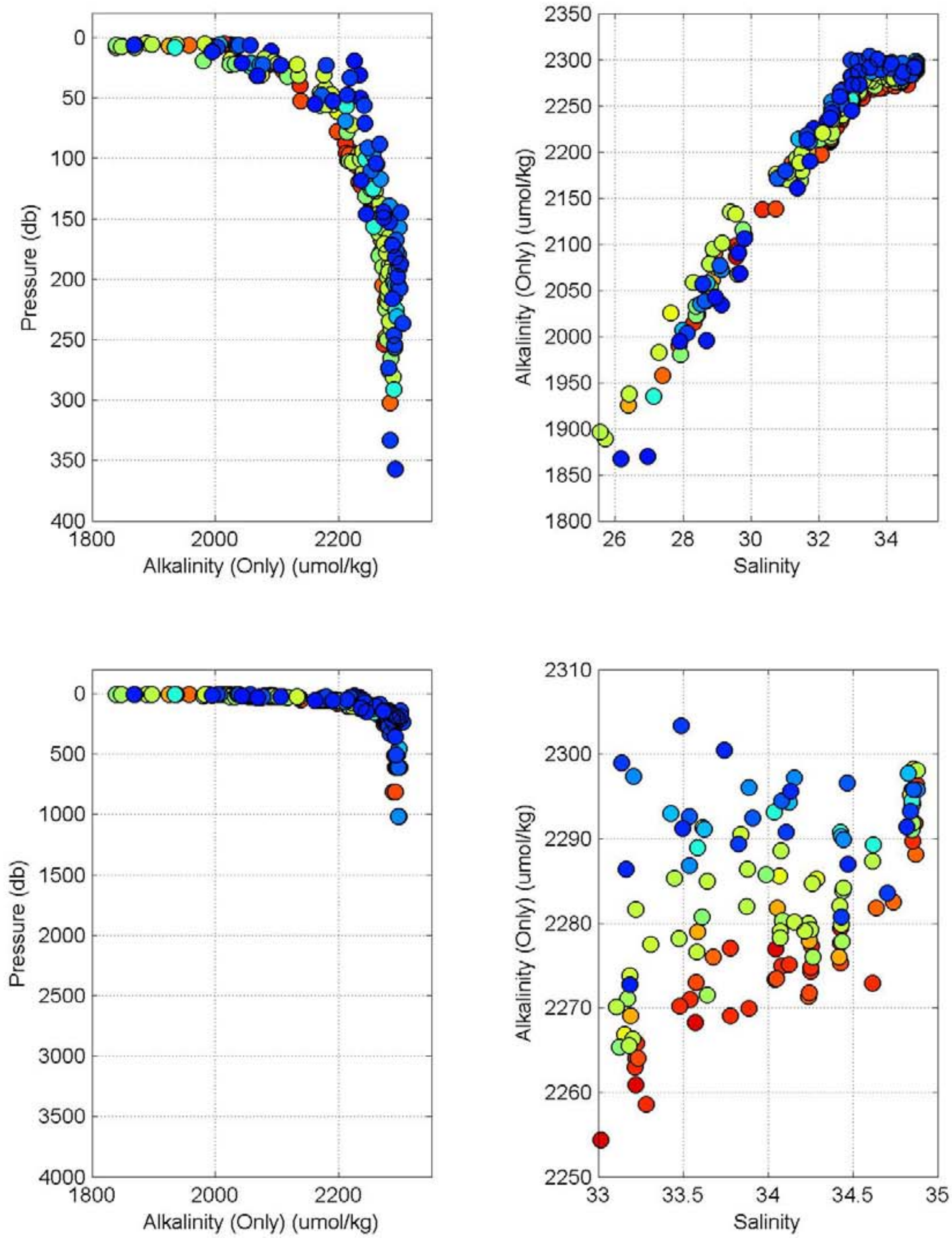
2006-18 Group: Canada Basin, West of 145°W, Property: Dissolved Inorganic Carbon



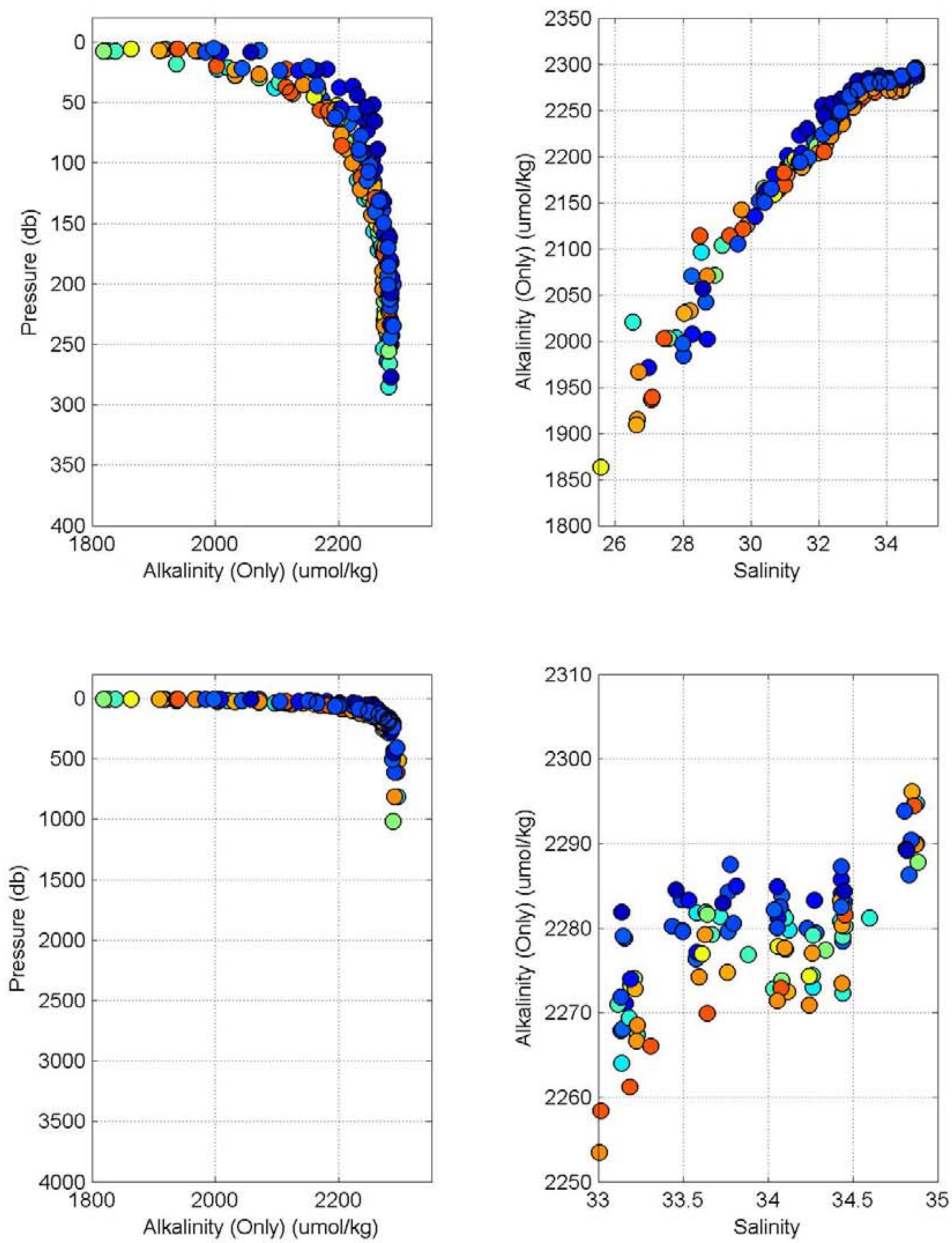
2006-18 Group: Canada Basin, East of 145°W, Property: Dissolved Inorganic Carbon



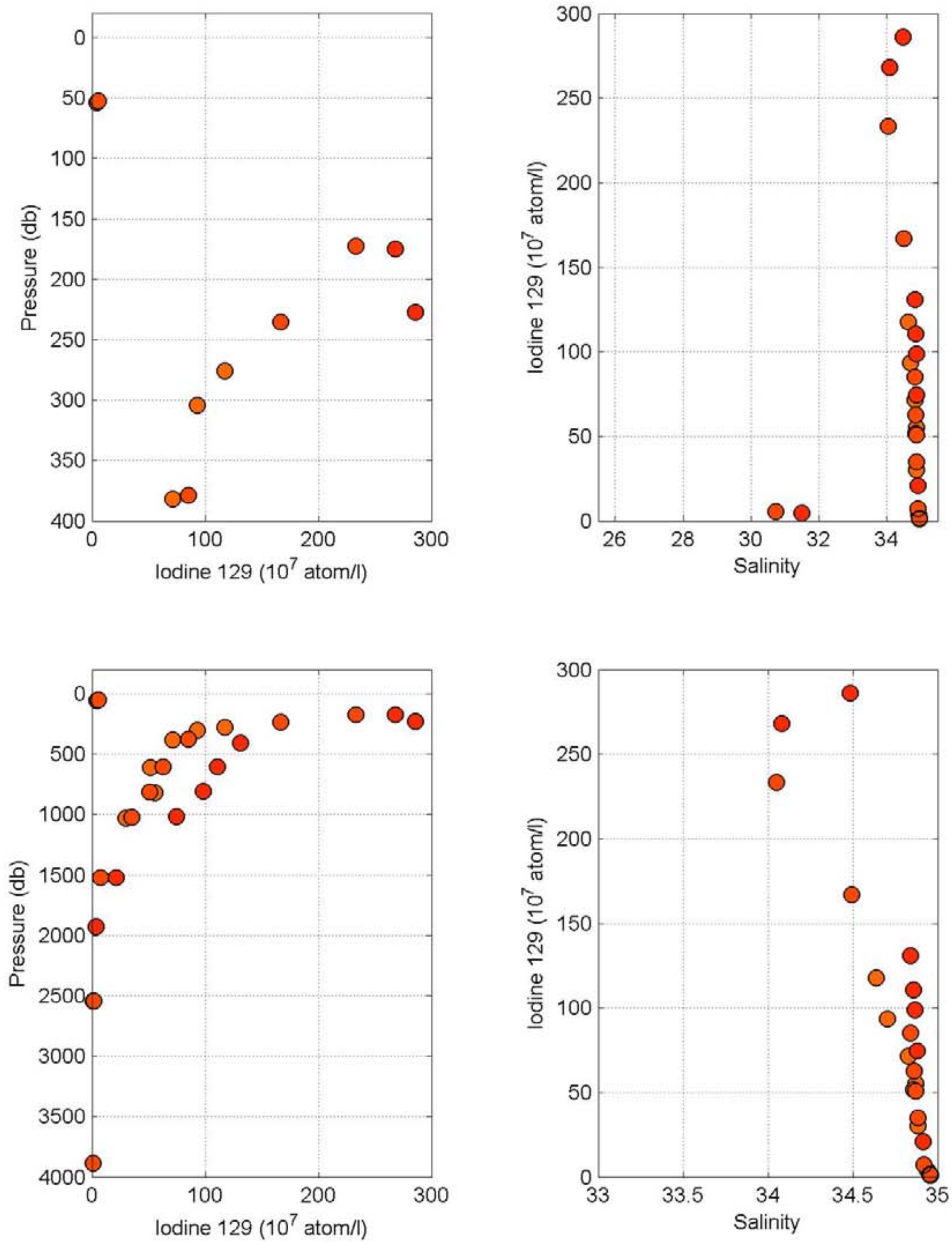
2006-18 Group: Canada Basin, West of 145°W, Property: Alkalinity (Only)



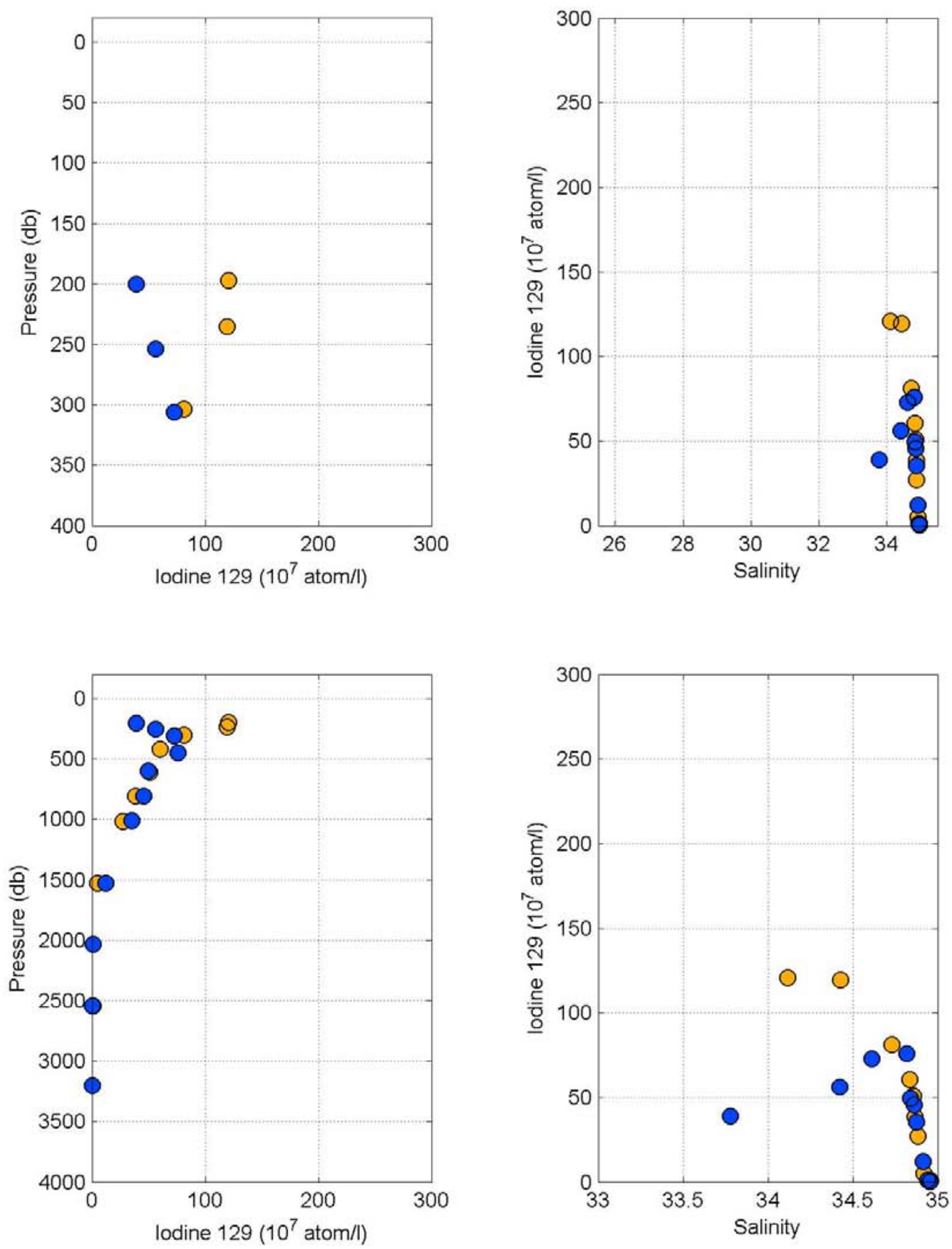
2006-18 Group: Canada Basin, East of 145°W, Property: Alkalinity (Only)



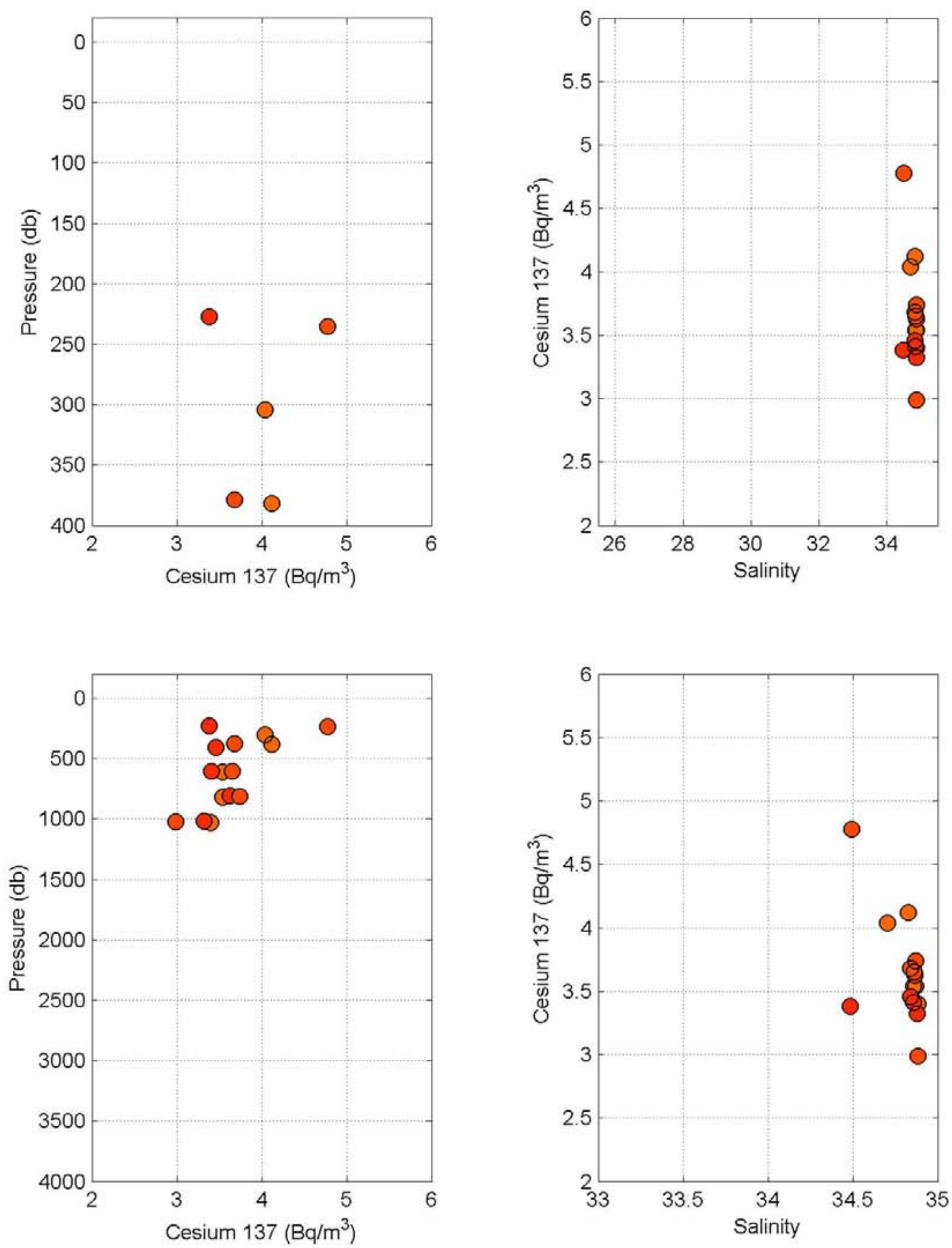
2006-18 Group: Canada Basin, West of 145°W, Property: Iodine-129



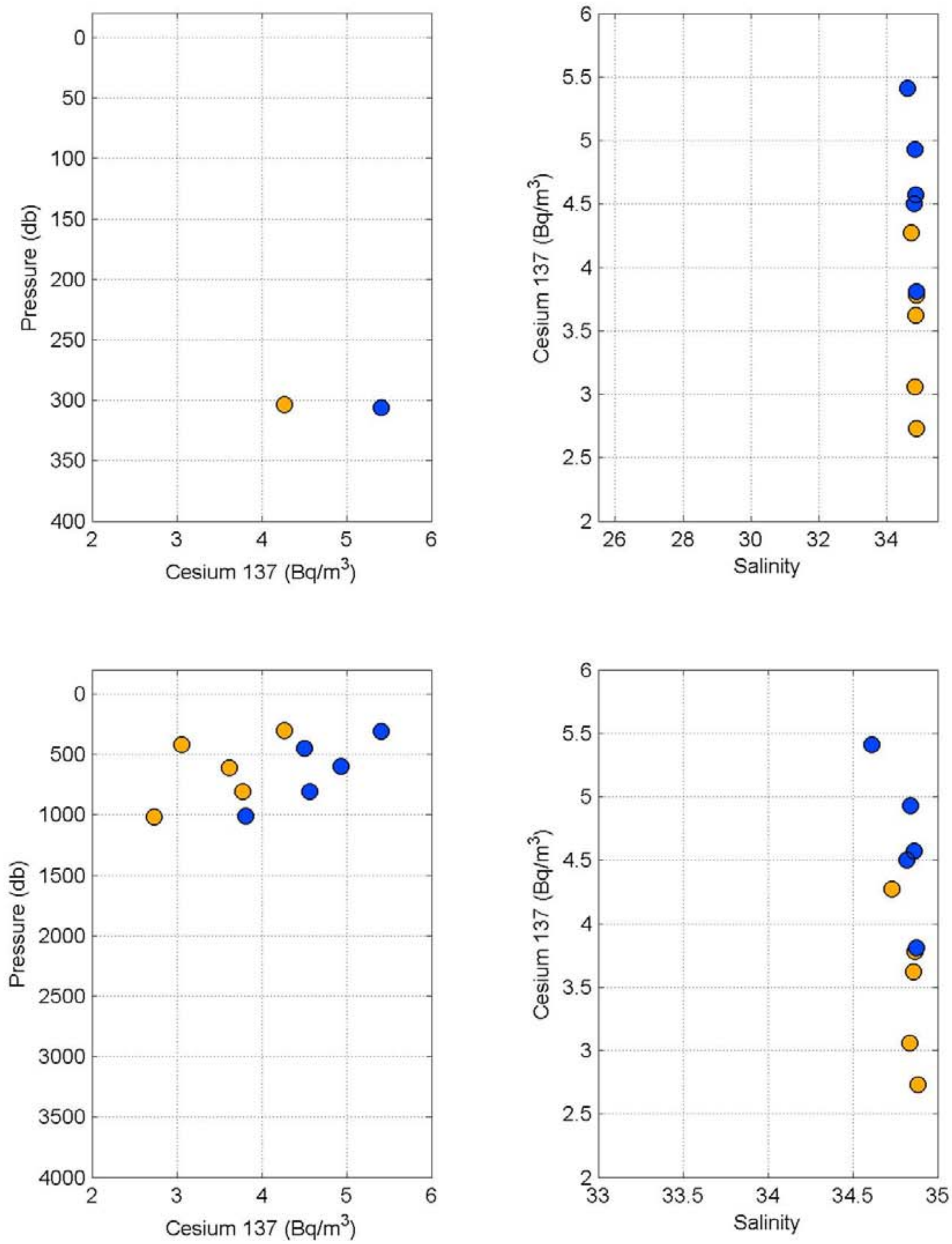
2006-18 Group: Canada Basin, East of 145°W, Property: Iodine-129



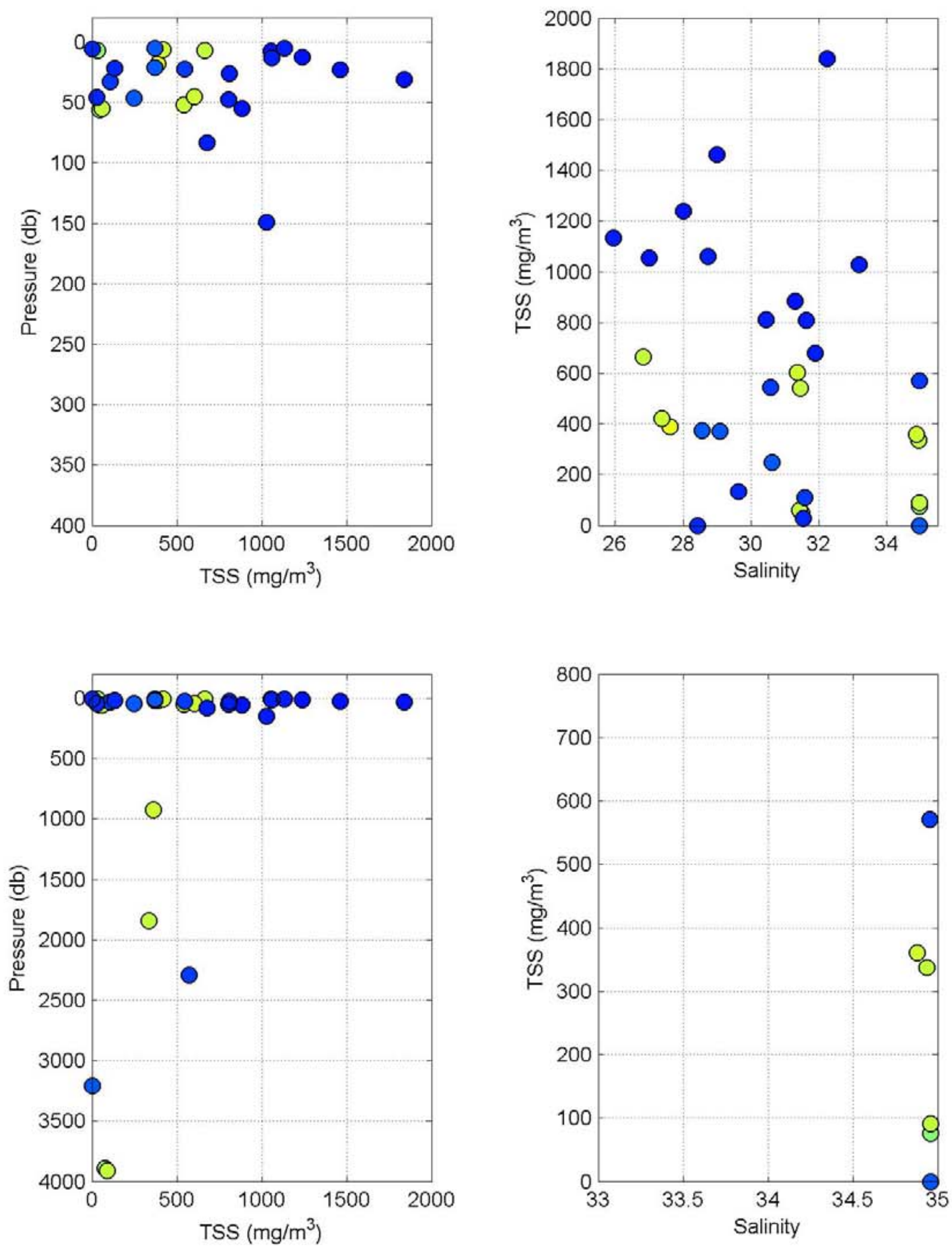
2006-18 Group: Canada Basin, West of 145°W, Property: Cesium-137



2006-18 Group: Canada Basin, East of 145°W, Property: Cesium-137



2006-18 Group: Canada Basin, West of 145°W, Property: TSS



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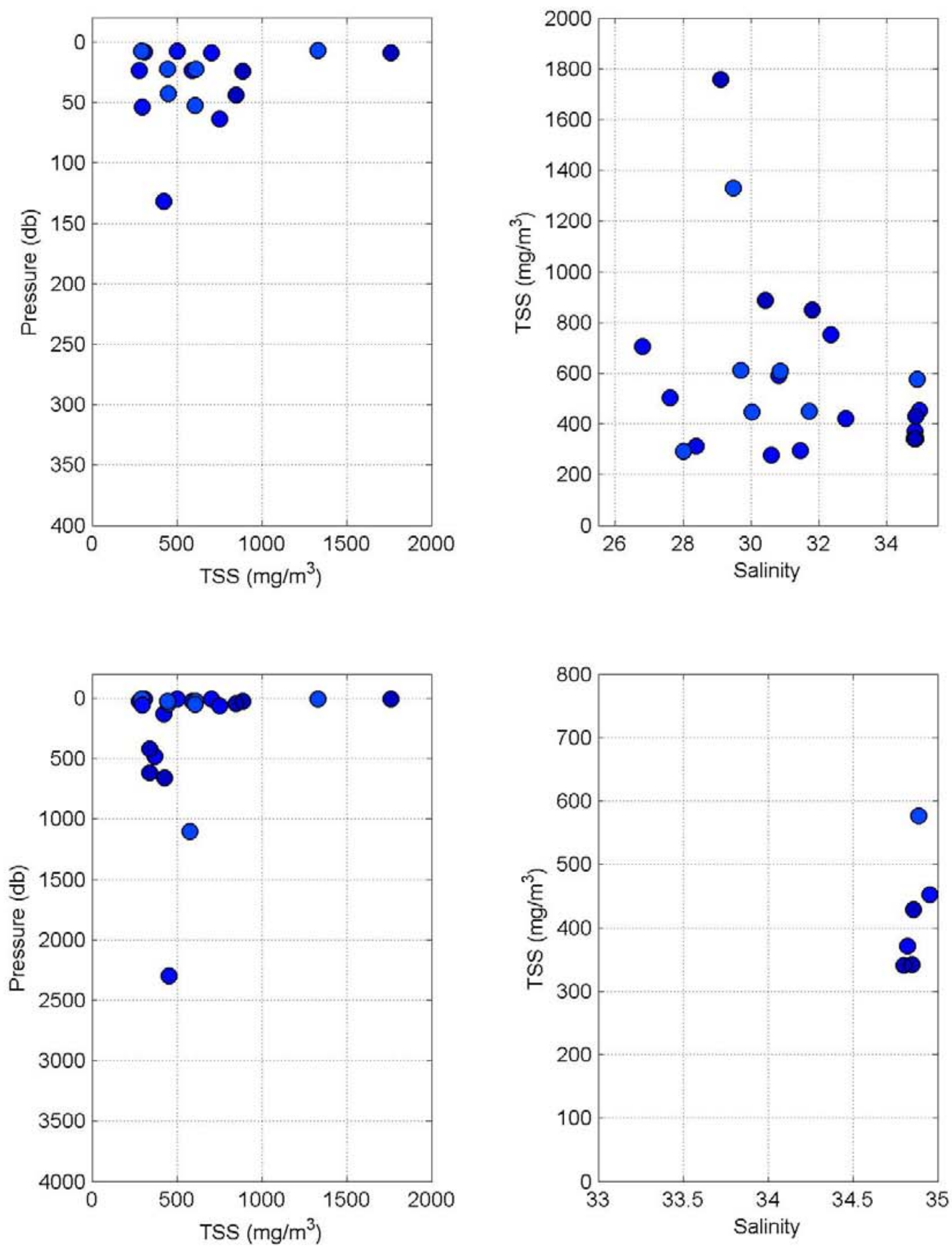
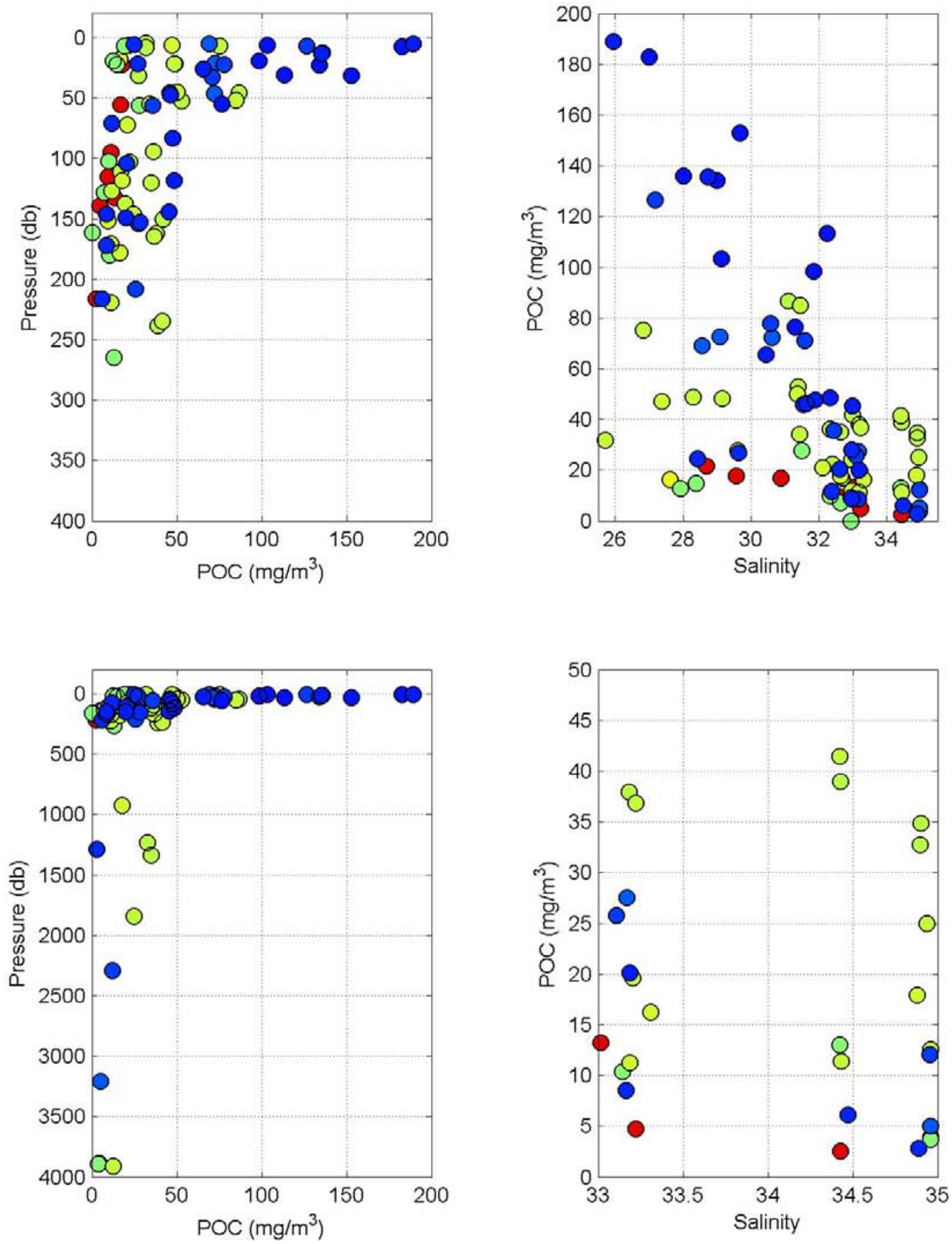
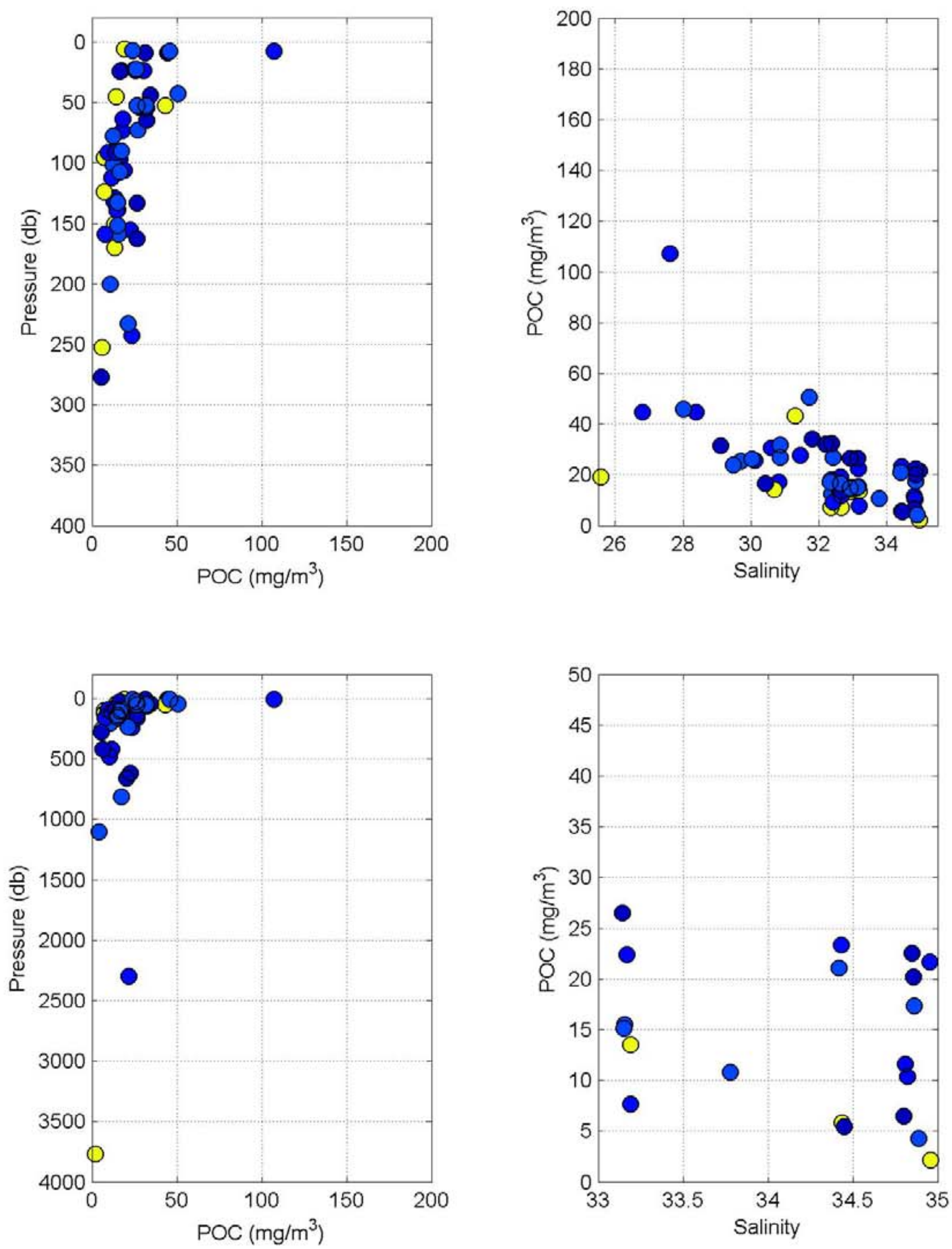


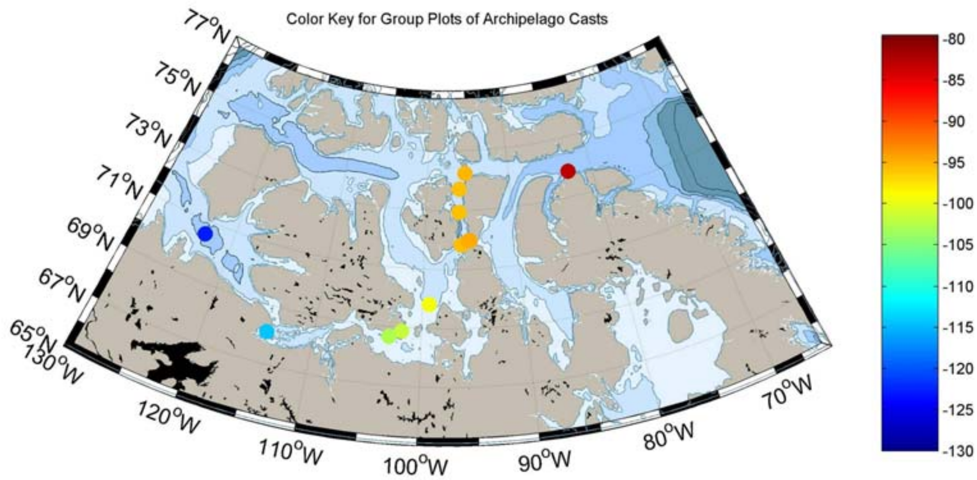
2006-18 Group: Canada Basin, West of 145°W, Property: POC



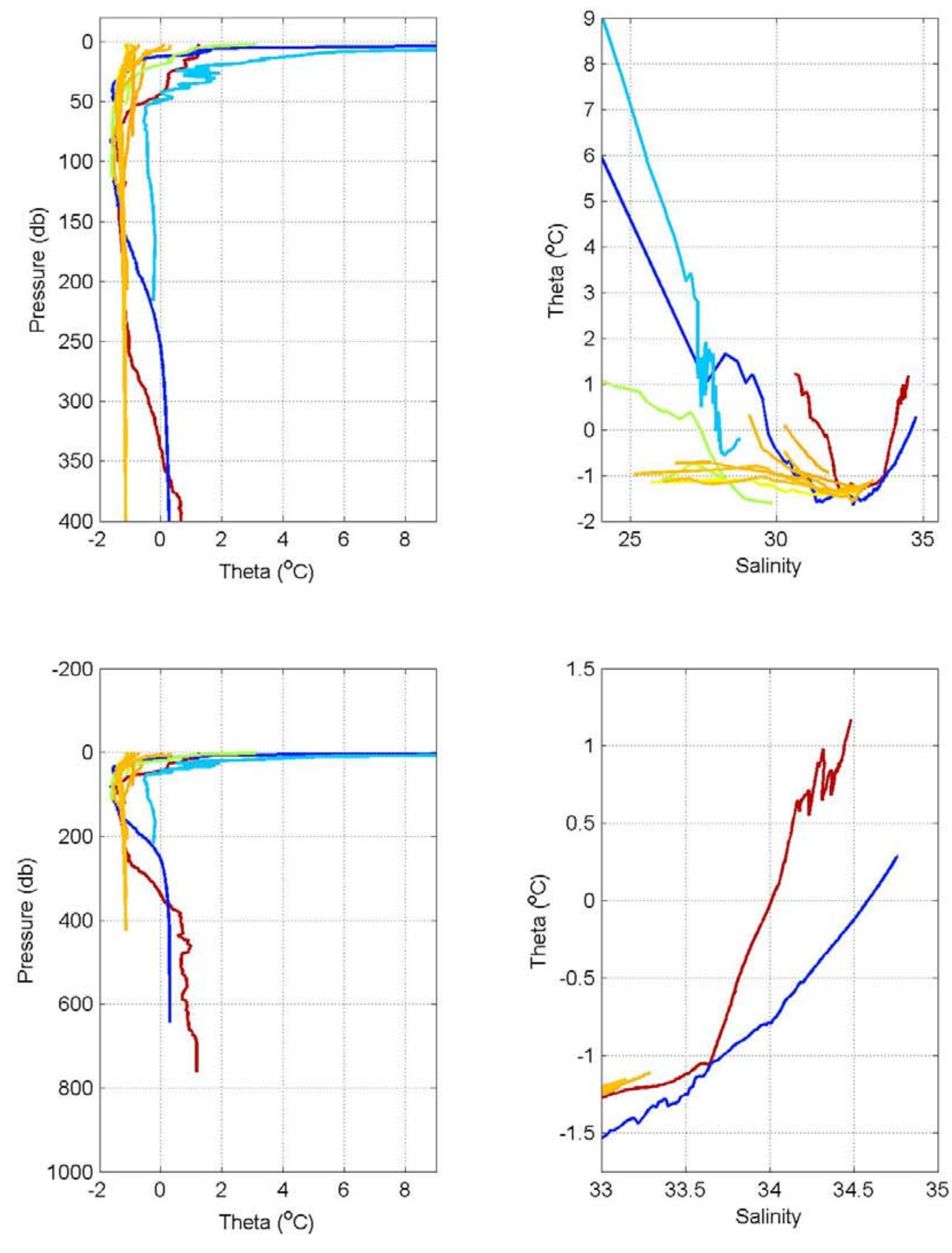
2006-18 Group: Canada Basin, East of 145°W, Property: POC



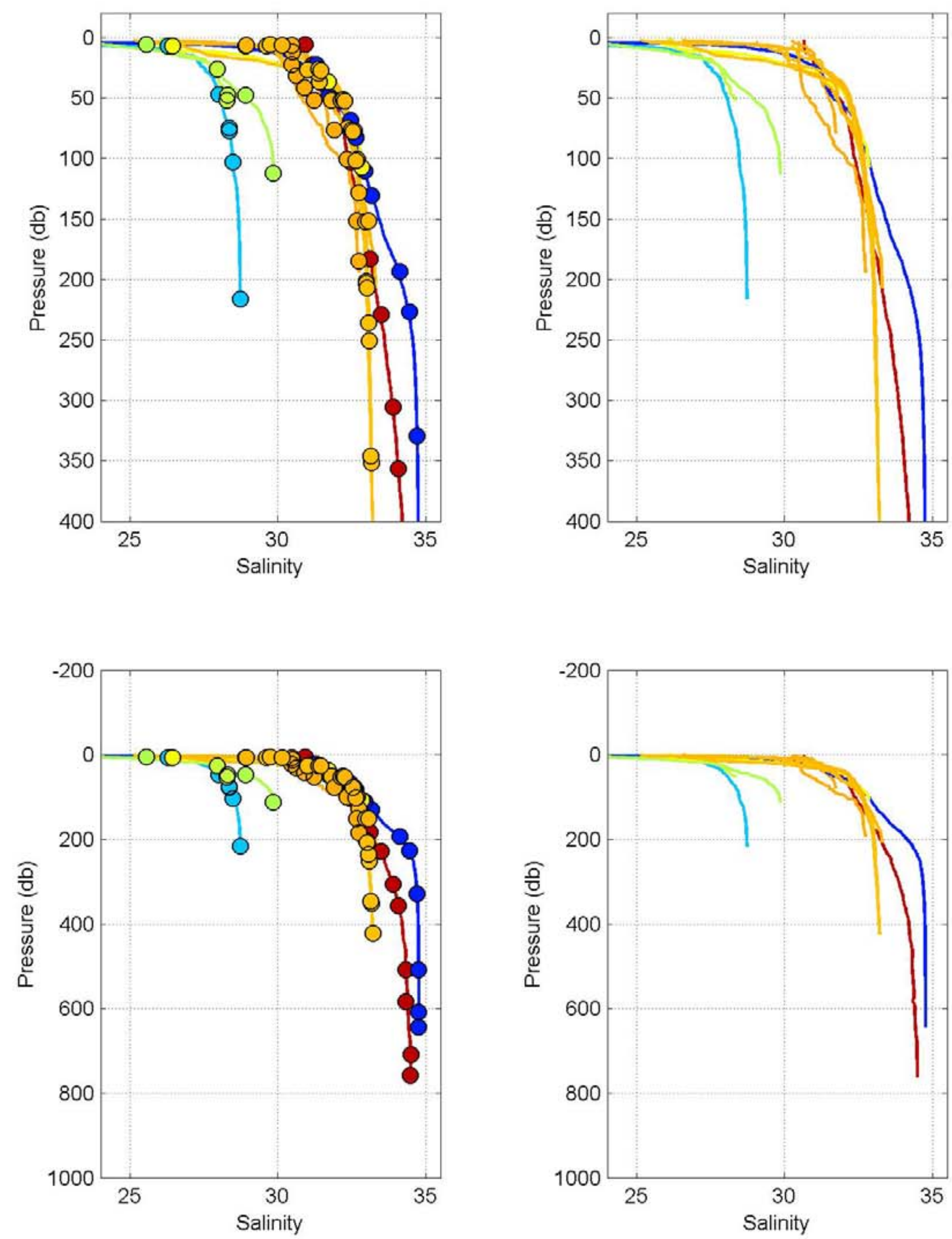
6.2 Archipelago



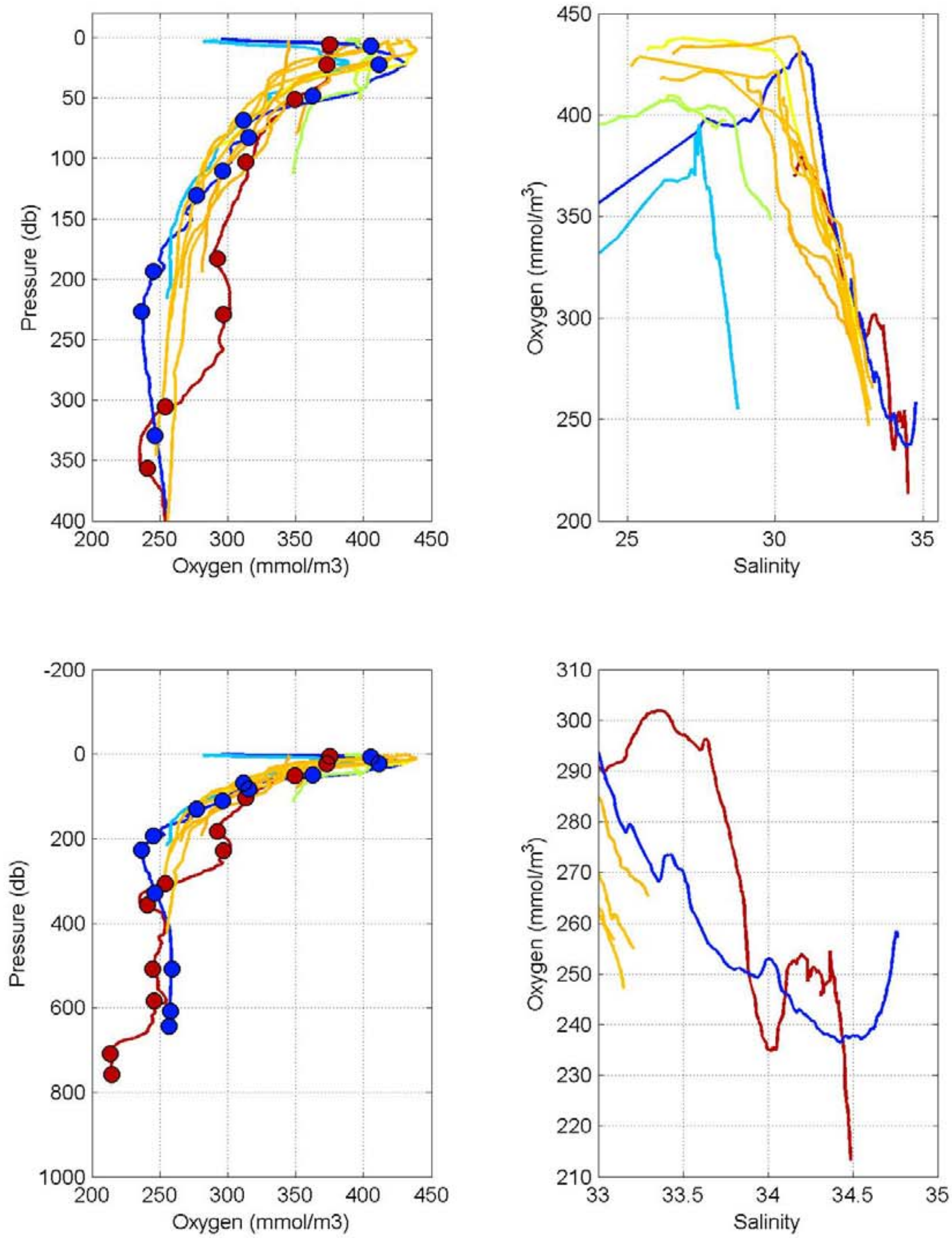
2006-18 Group: Canadian Archipelago, Property: Theta



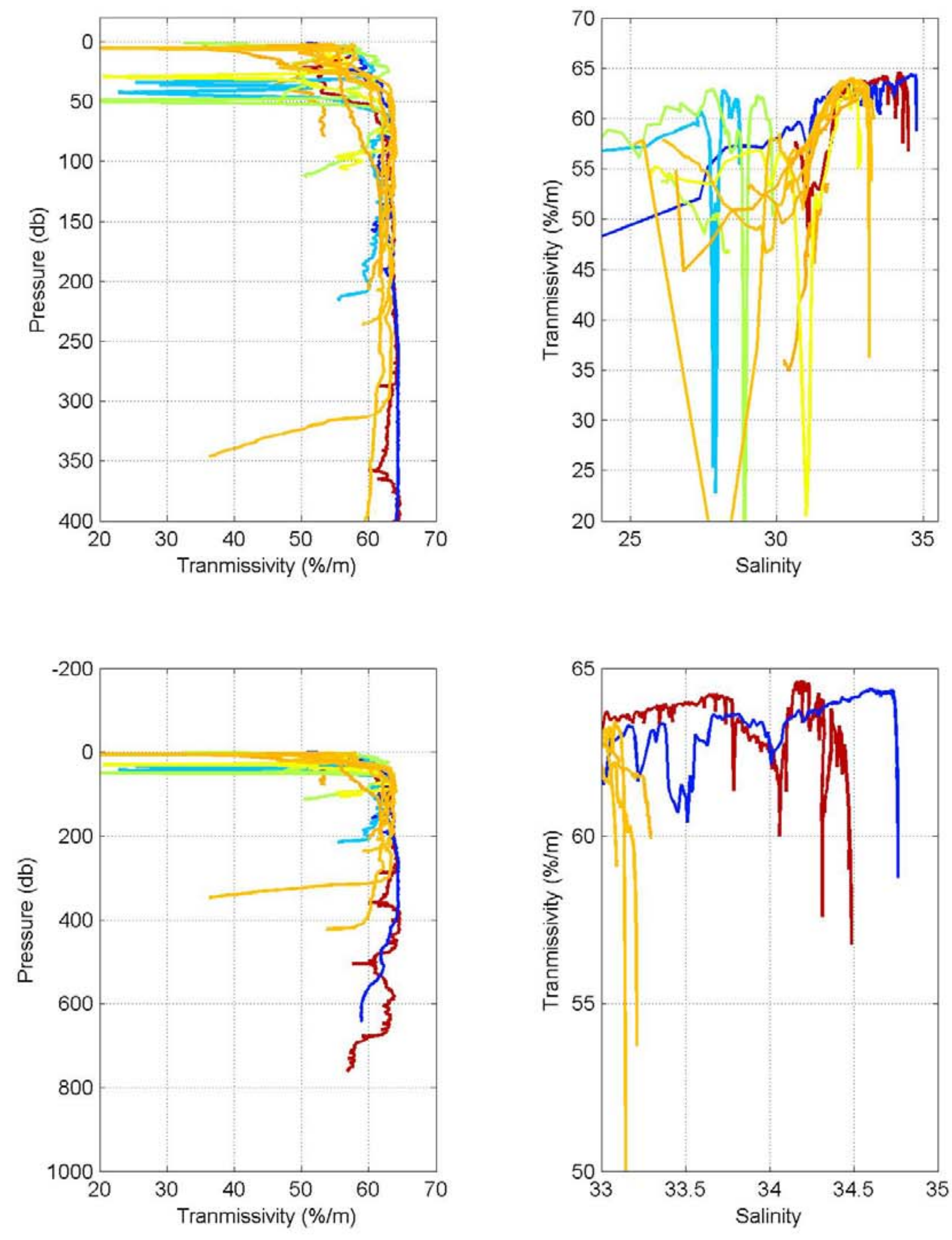
2006-18 Group: Canadian Archipelago, Property: Salinity



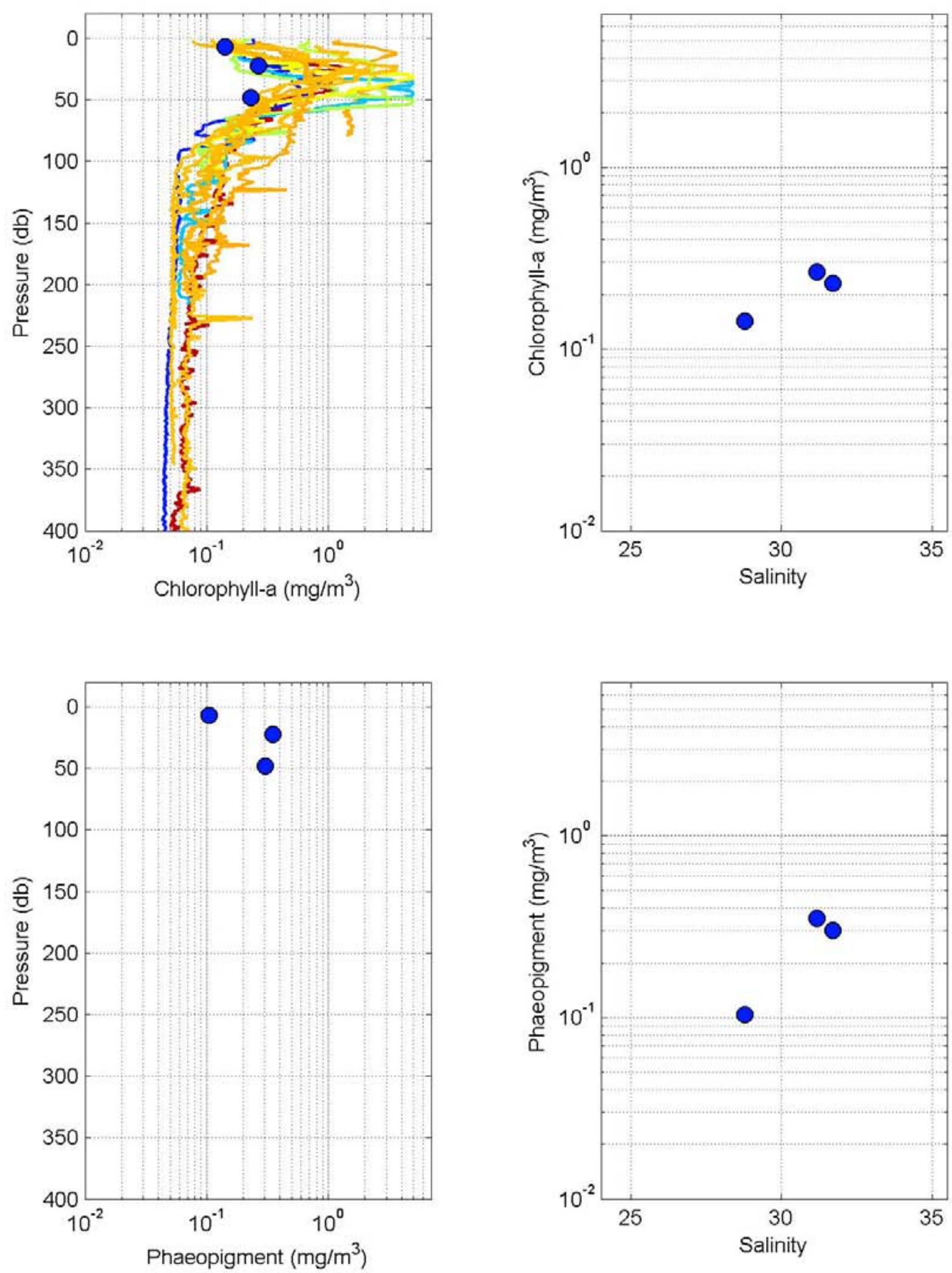
2006-18 Group: Canadian Archipelago, Property: Oxygen



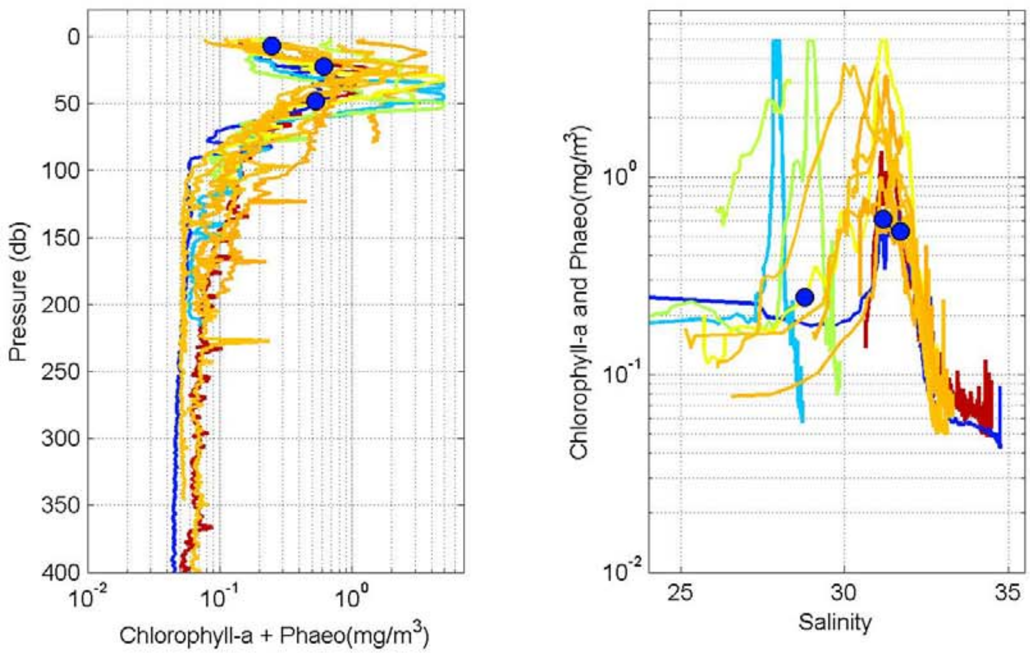
2006-18 Group: Canadian Archipelago, Property: Transmission



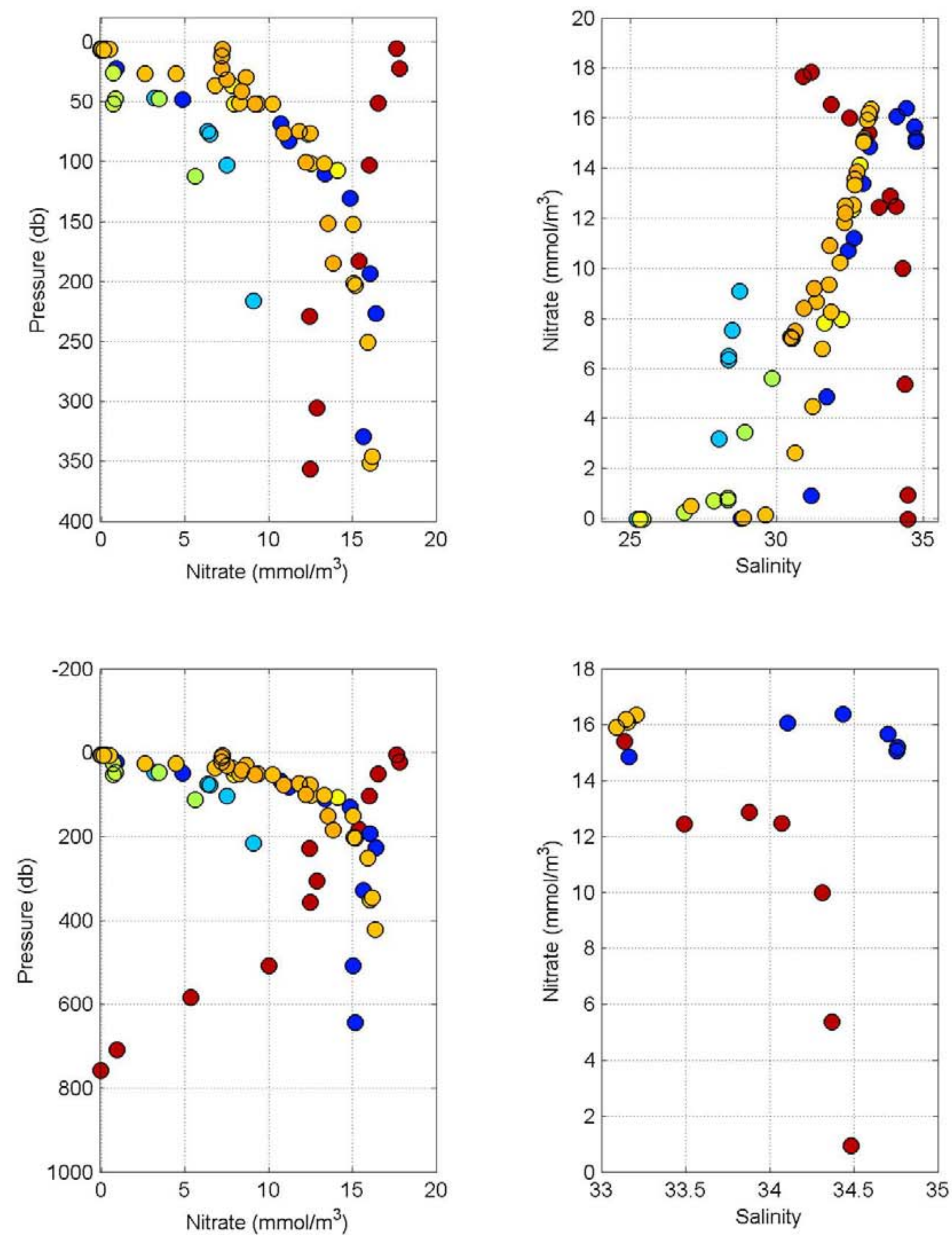
2006-18 Group: Canadian Archipelago, Property: Combined Chlorophyll-a and Phaeopigment



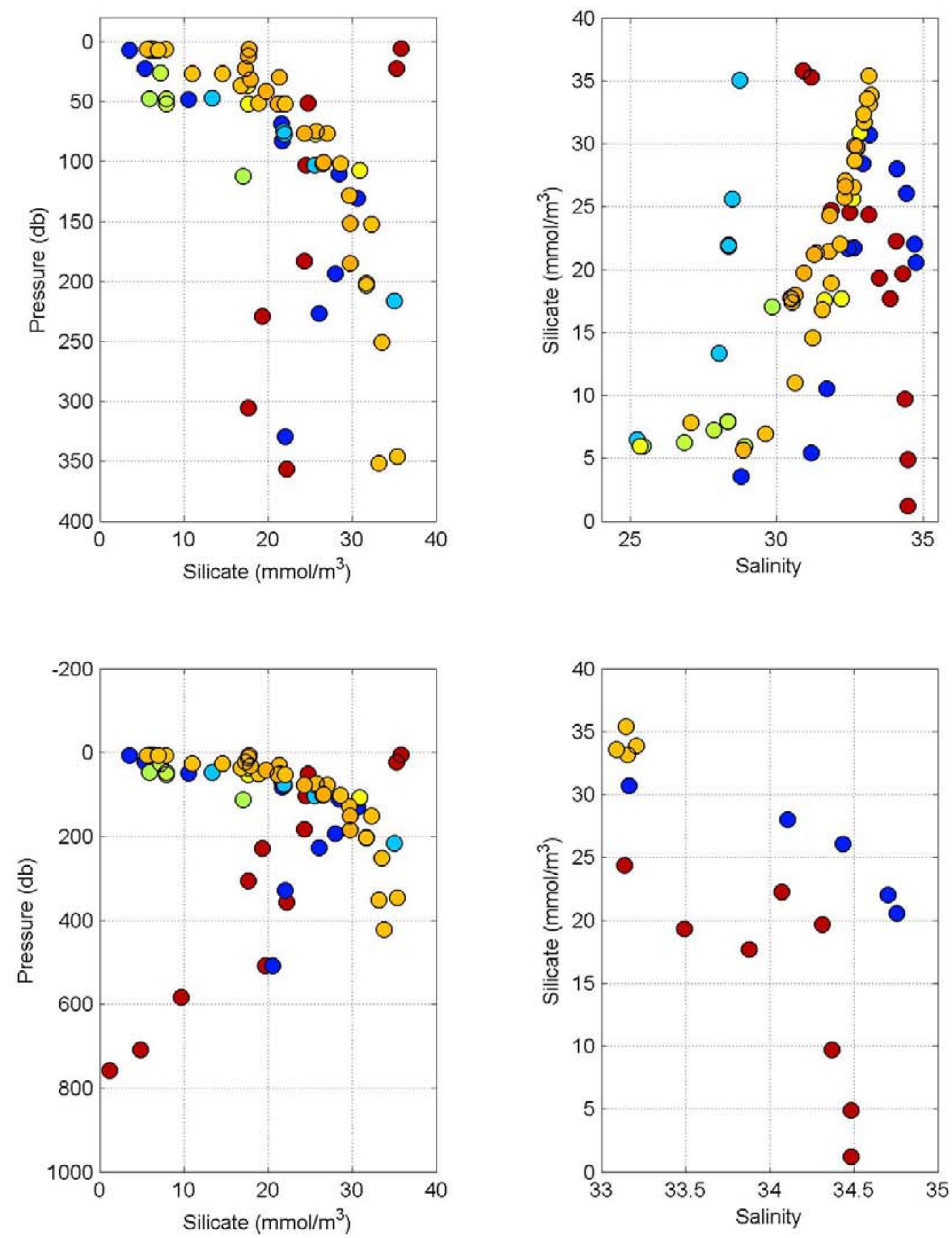
2006-18 Group: Canadian Archipelago, Property: Chlorophyll-a, Phaeopigment



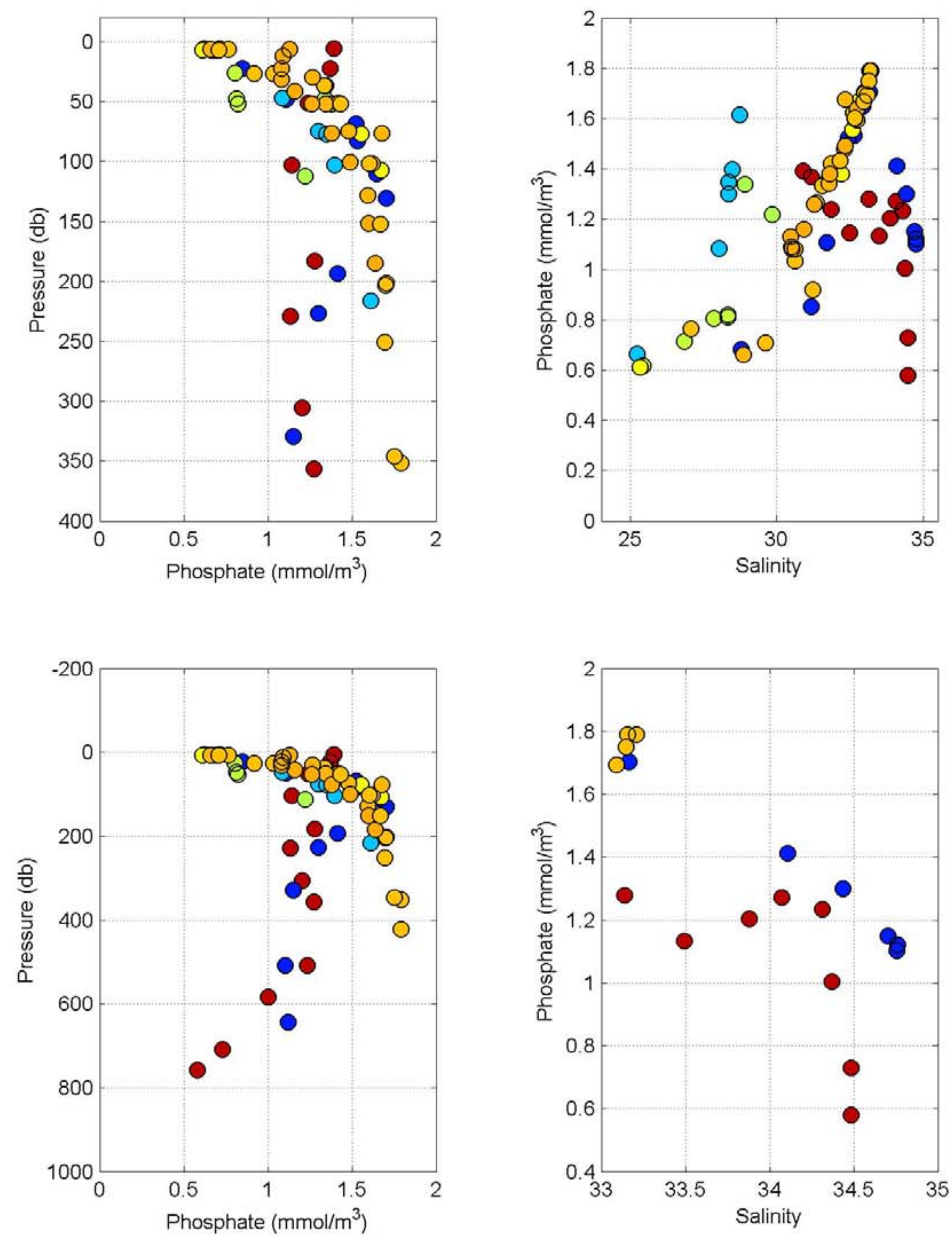
2006-18 Group: Canadian Archipelago, Property: Nitrate plus Nitrite



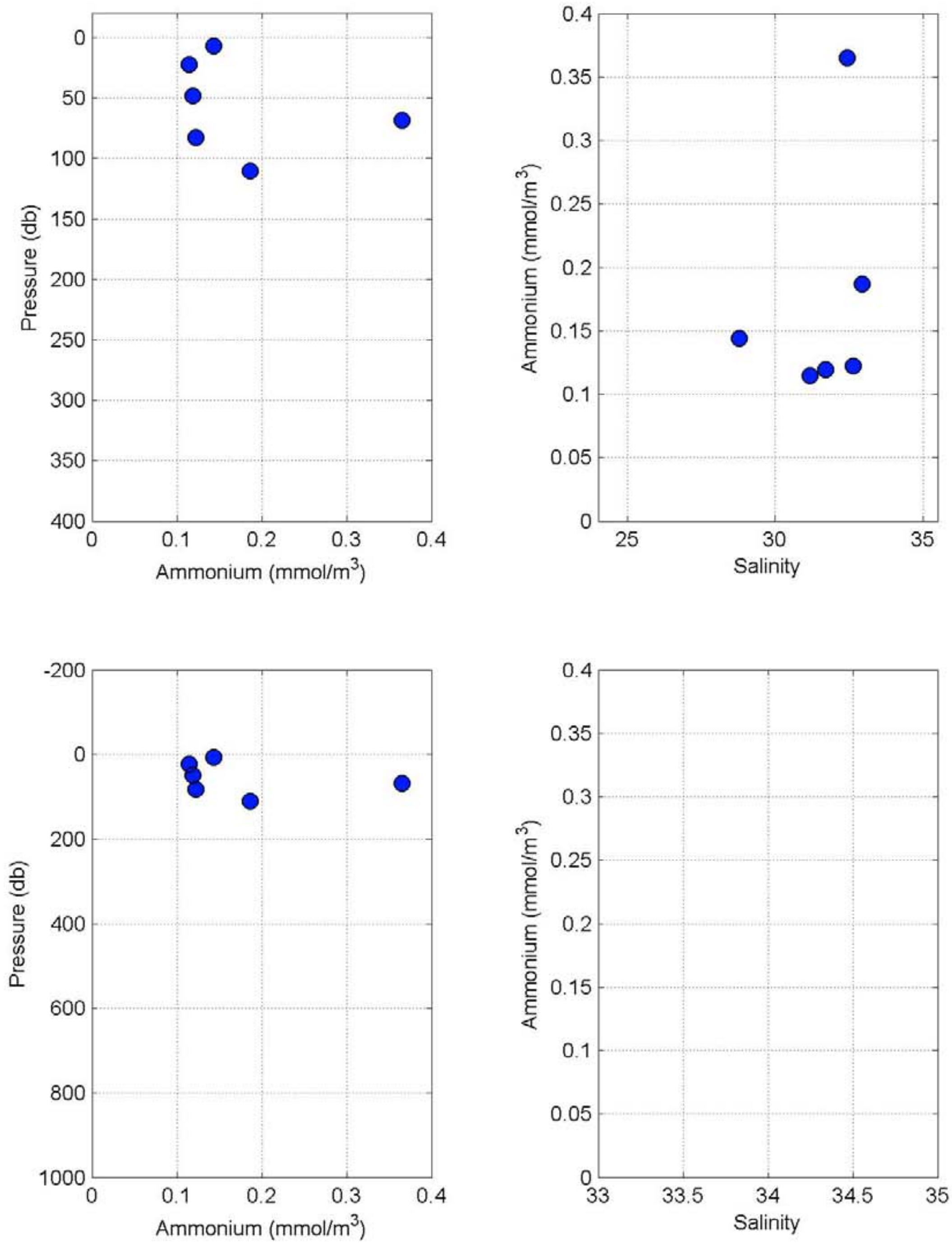
2006-18 Group: Canadian Archipelago, Property: Silicate



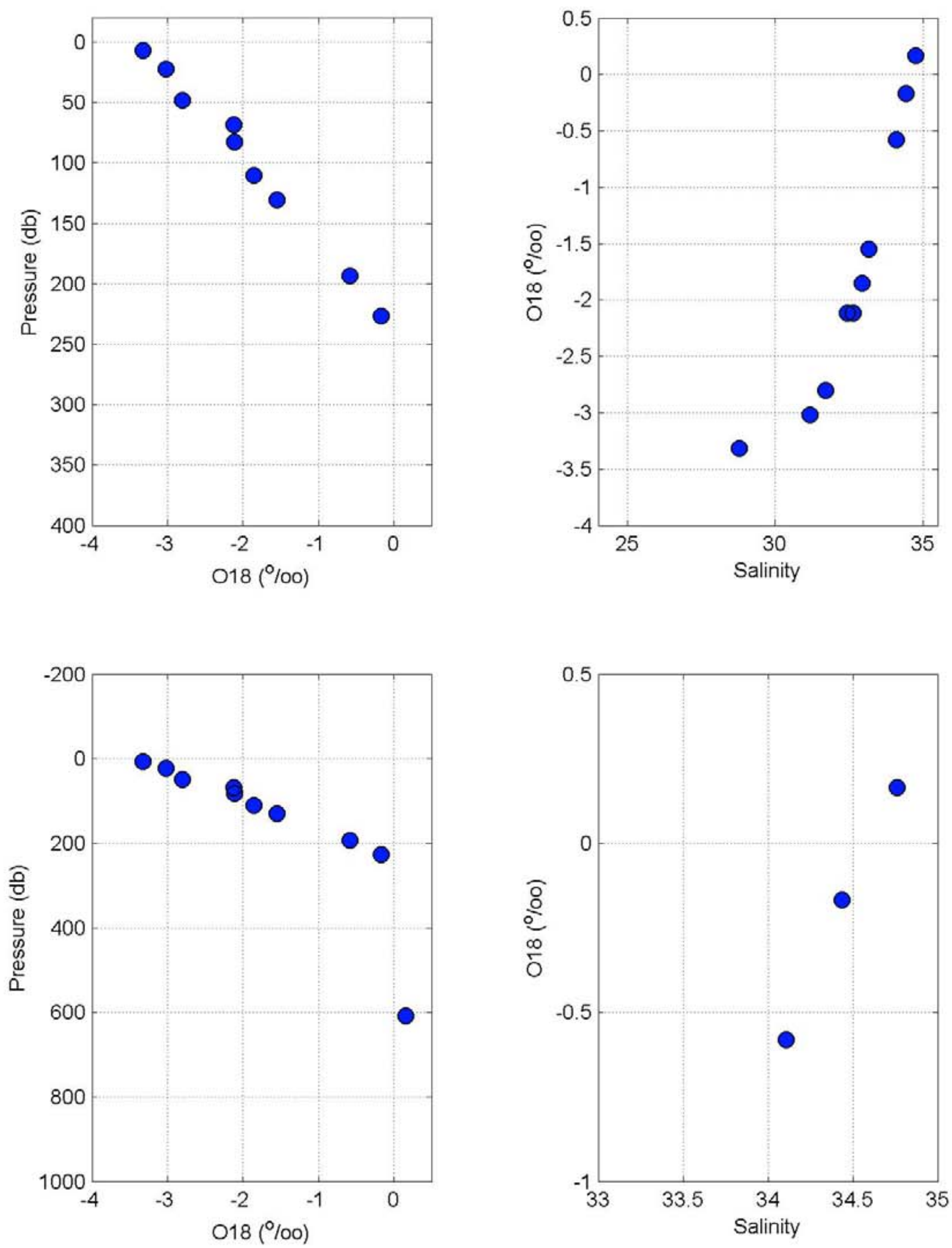
2006-18 Group: Canadian Archipelago, Property: Orthophosphate



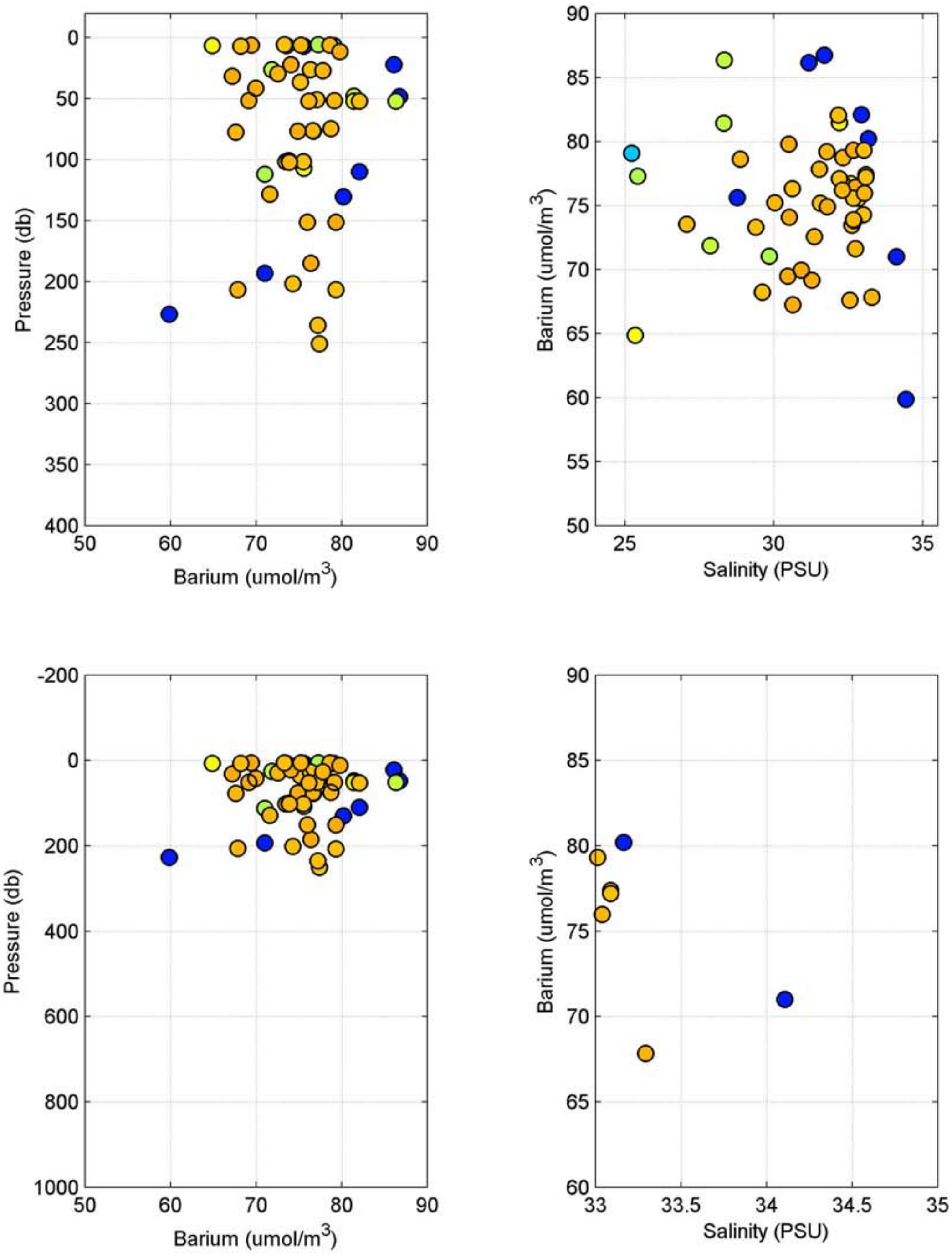
2006-18 Group: Canadian Archipelago, Property: Ammoniumn



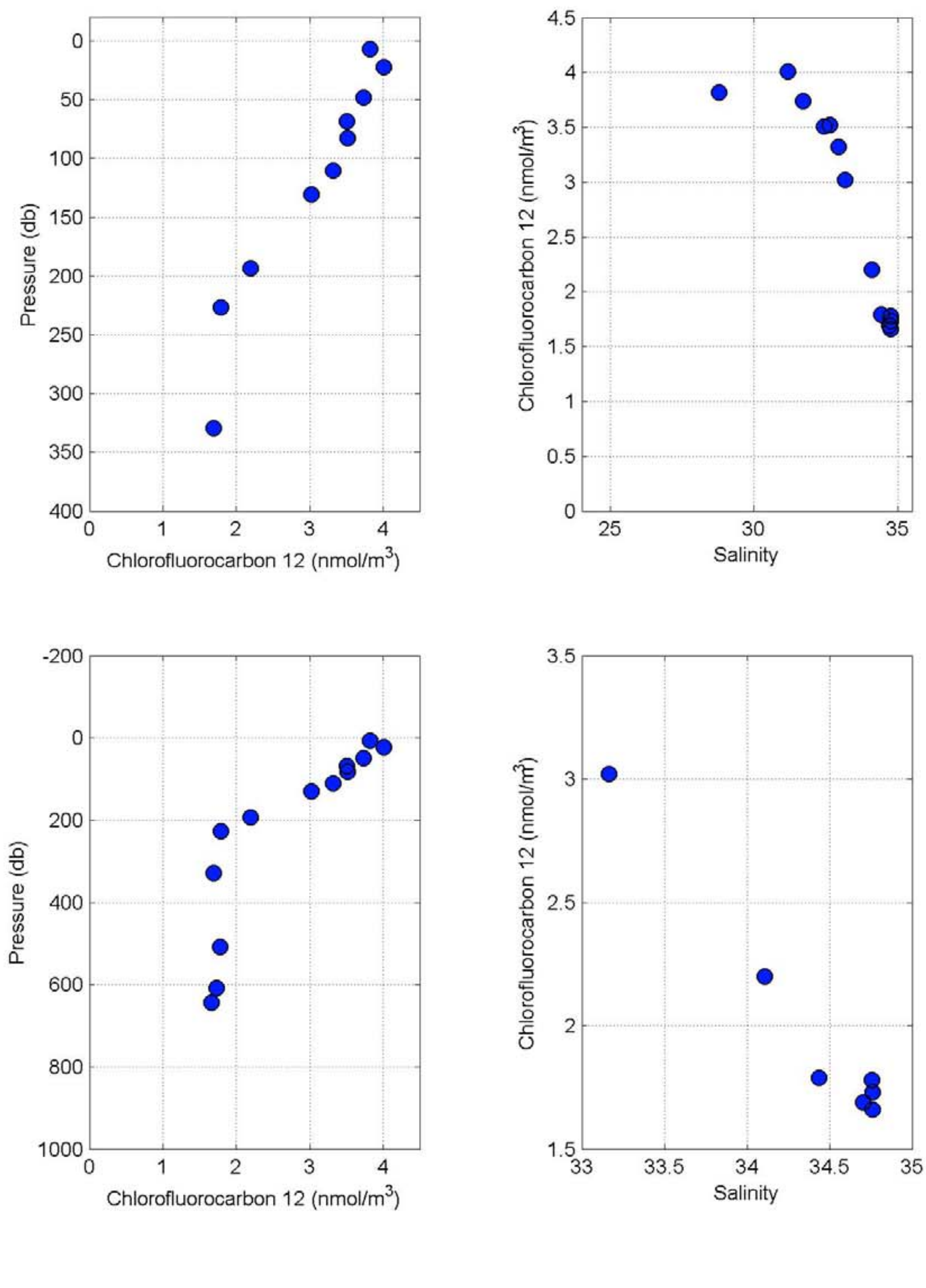
2006-18 Group: Canadian Archipelago, Property: O18



2006-18 Group: Canadian Archipelago, Property: Barium



2006-18 Group: Canadian Archipelago, Property: Chlorofluorcarbon-12



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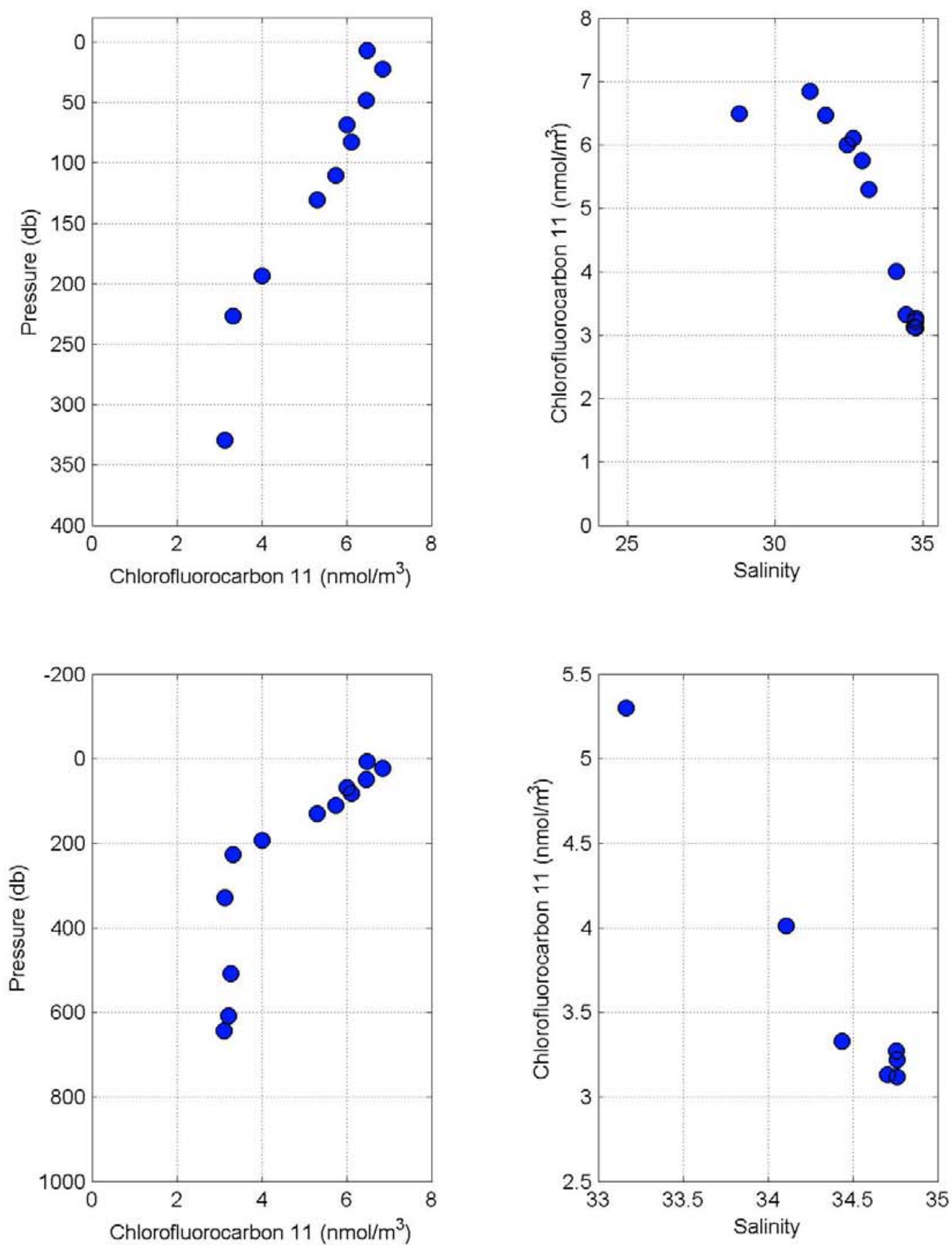
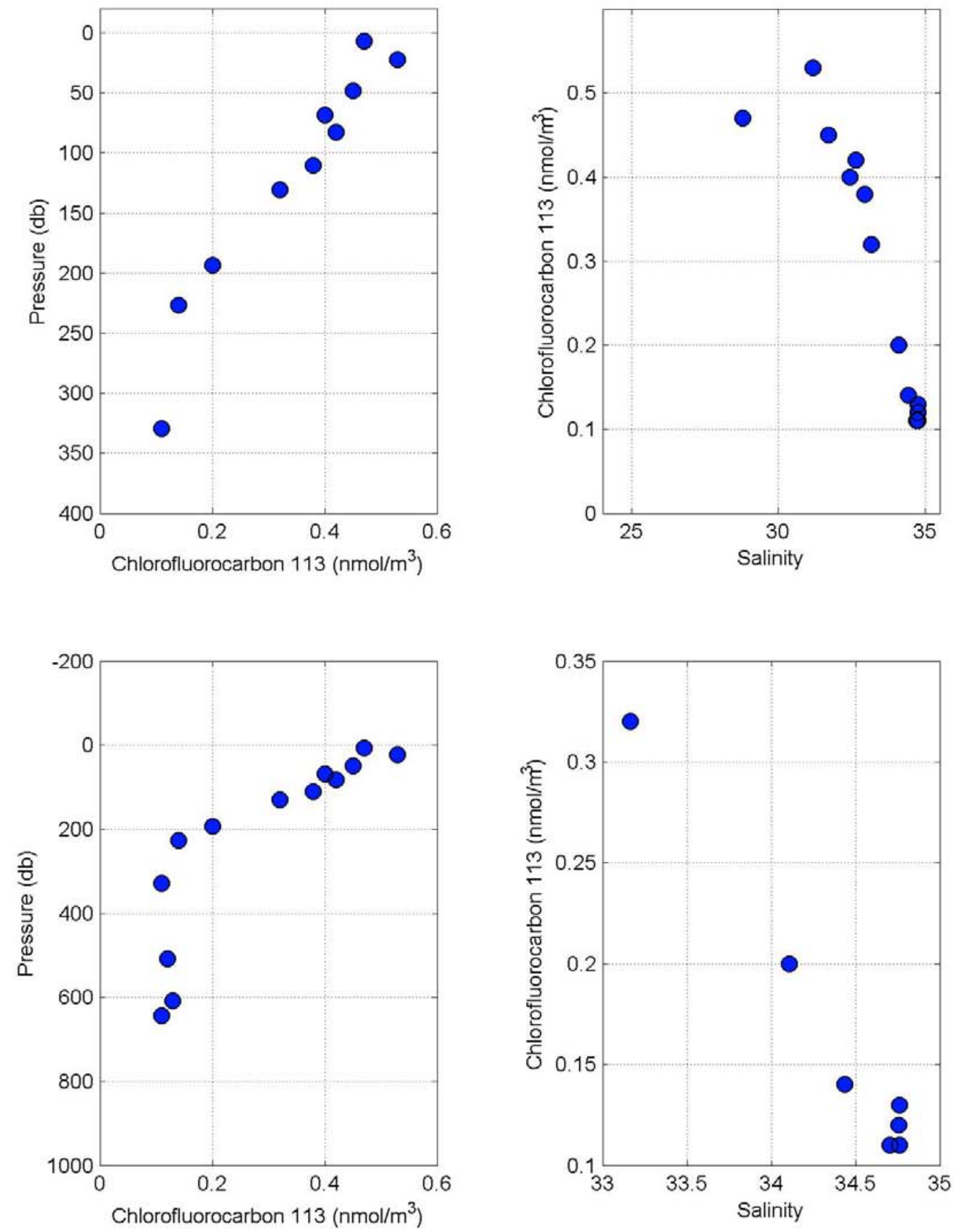
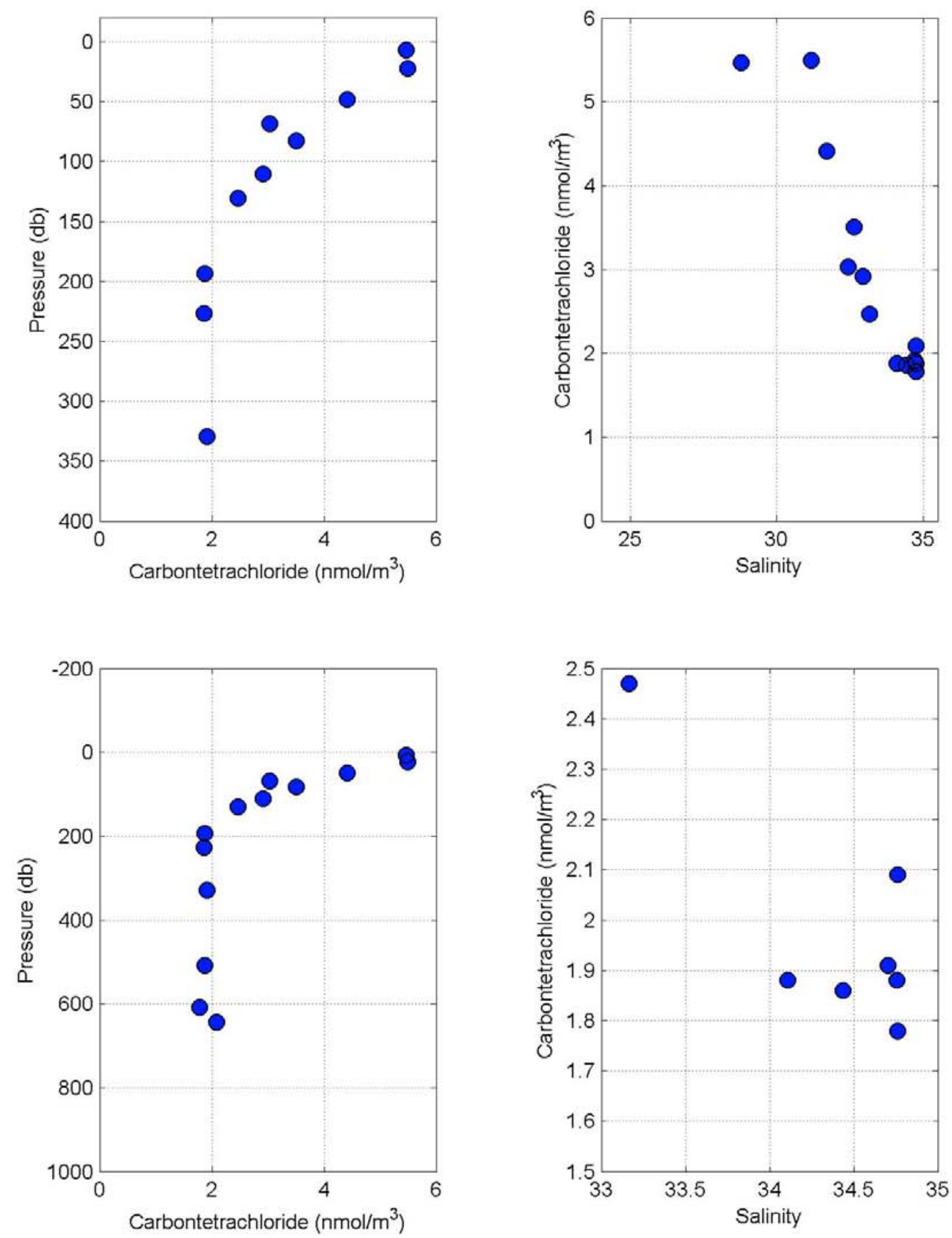


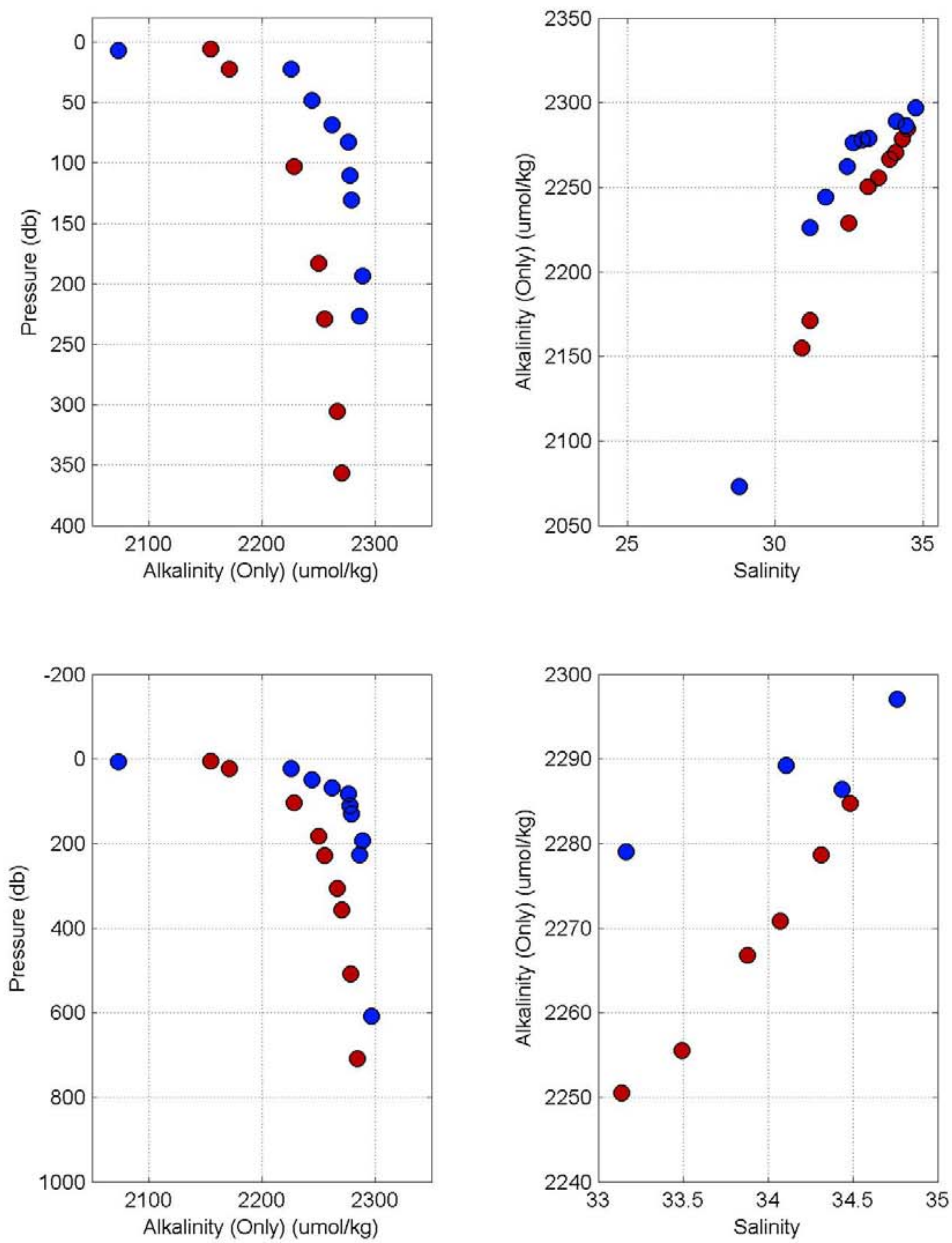
2006-18 Group: Canadian Archipelago, Property: Chlorofluorcarbon-113



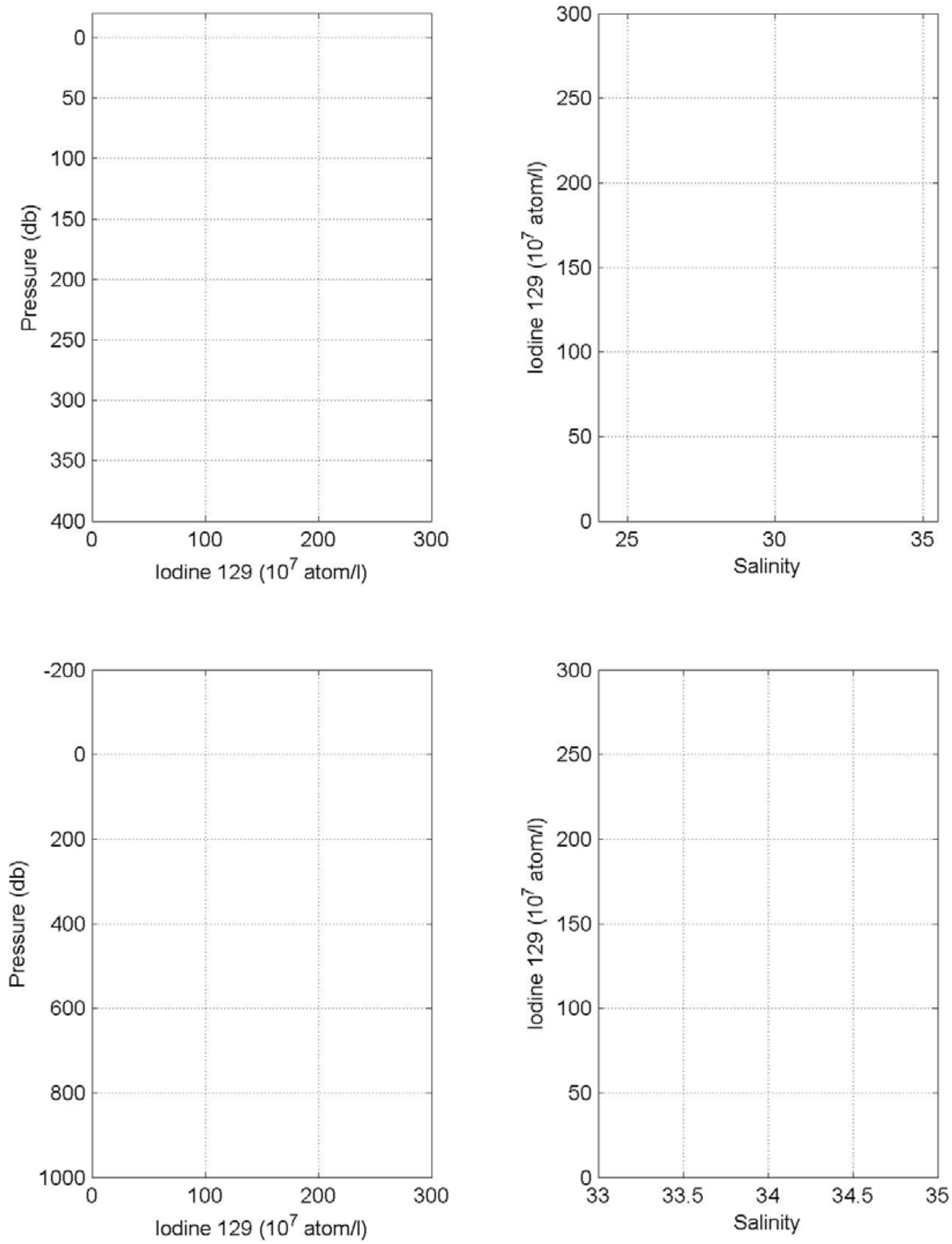
2006-18 Group: Canadian Archipelago, Property: Carbontetrachloride



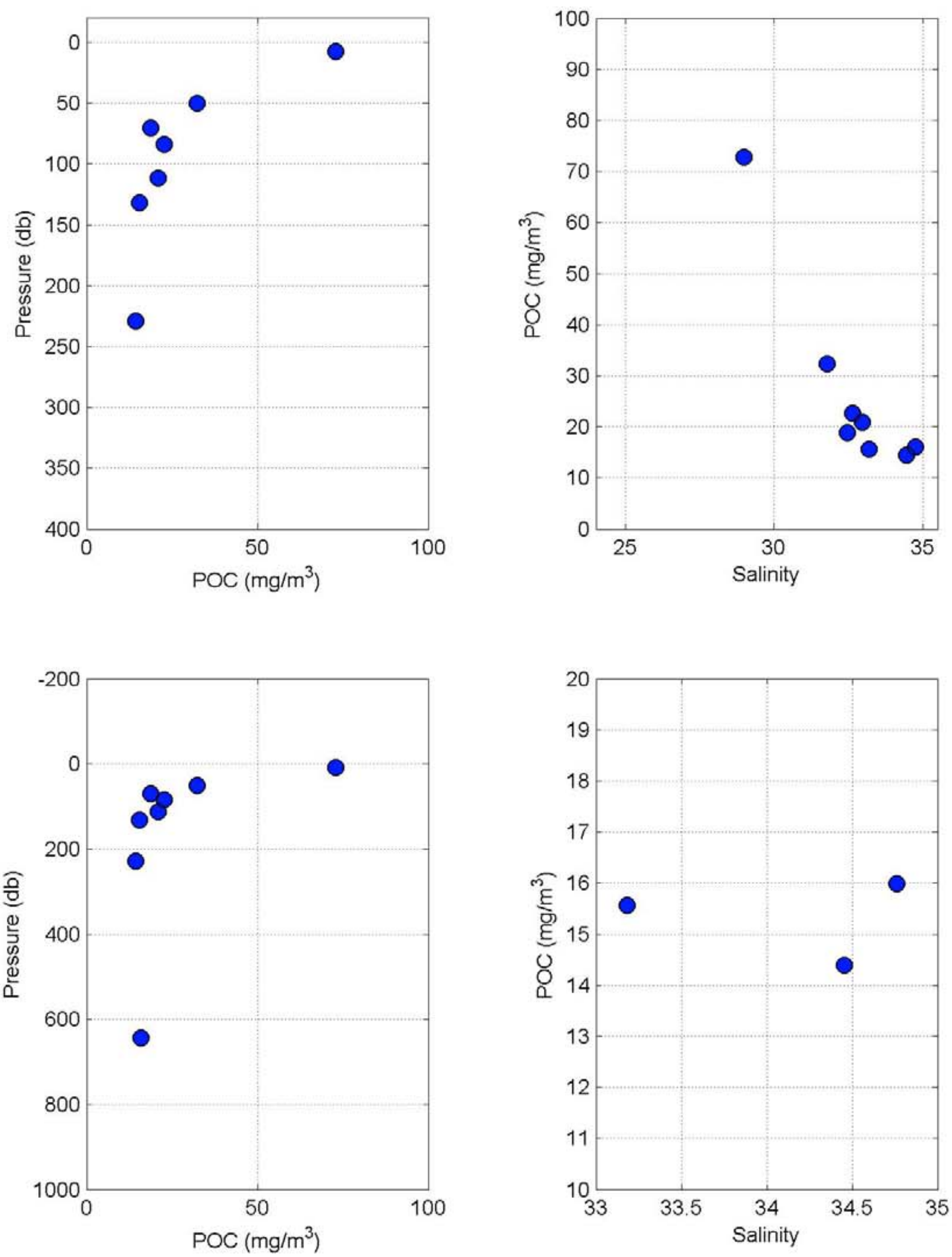
2006-18 Group: Canadian Archipelago, Property: Alkalinity (Only)



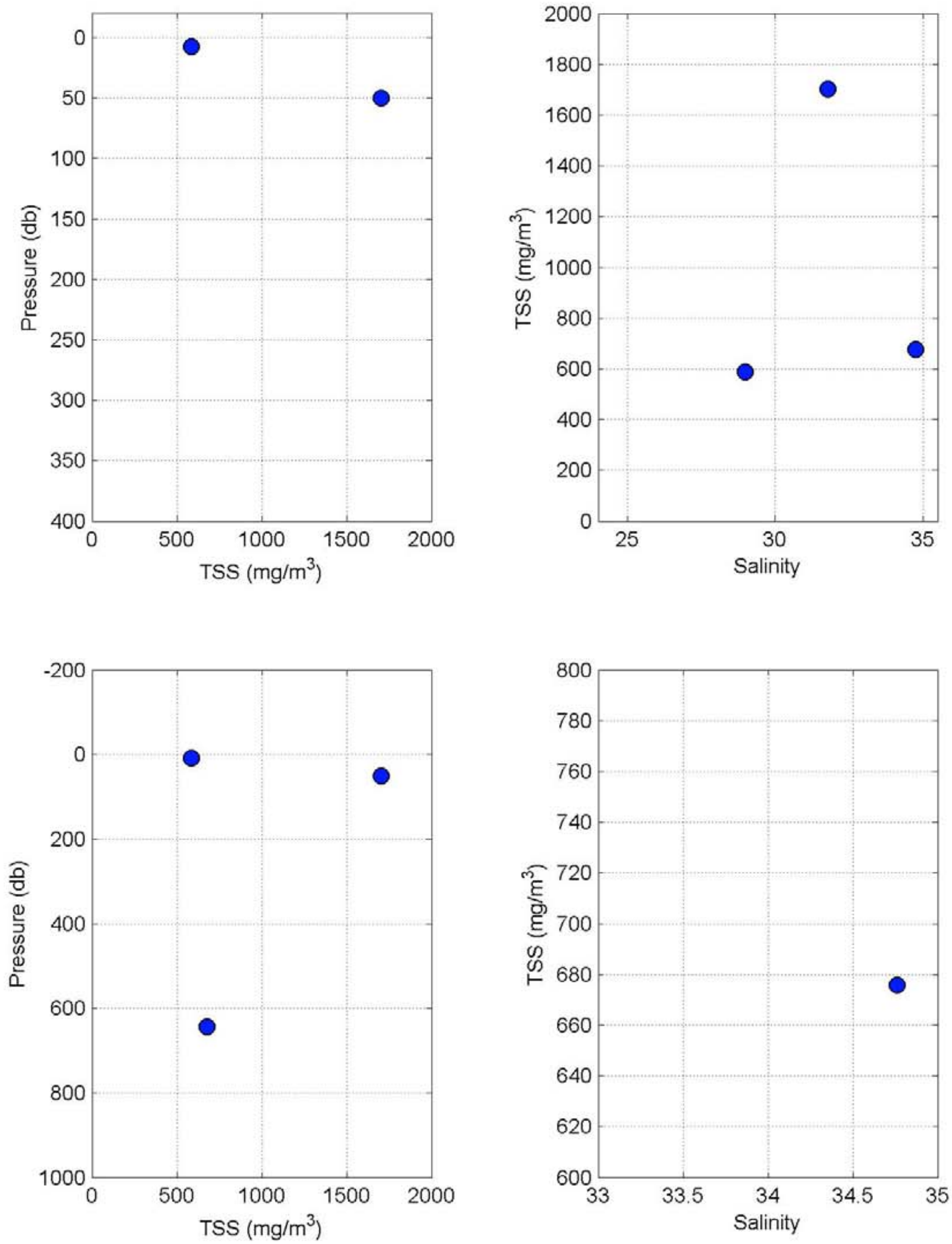
2006-18 Group: Canadian Archipelago, Property: Iodine-129



2006-18 Group: Canadian Archipelago, Property: POC



2006-18 Group: Canadian Archipelago, Property: TSS



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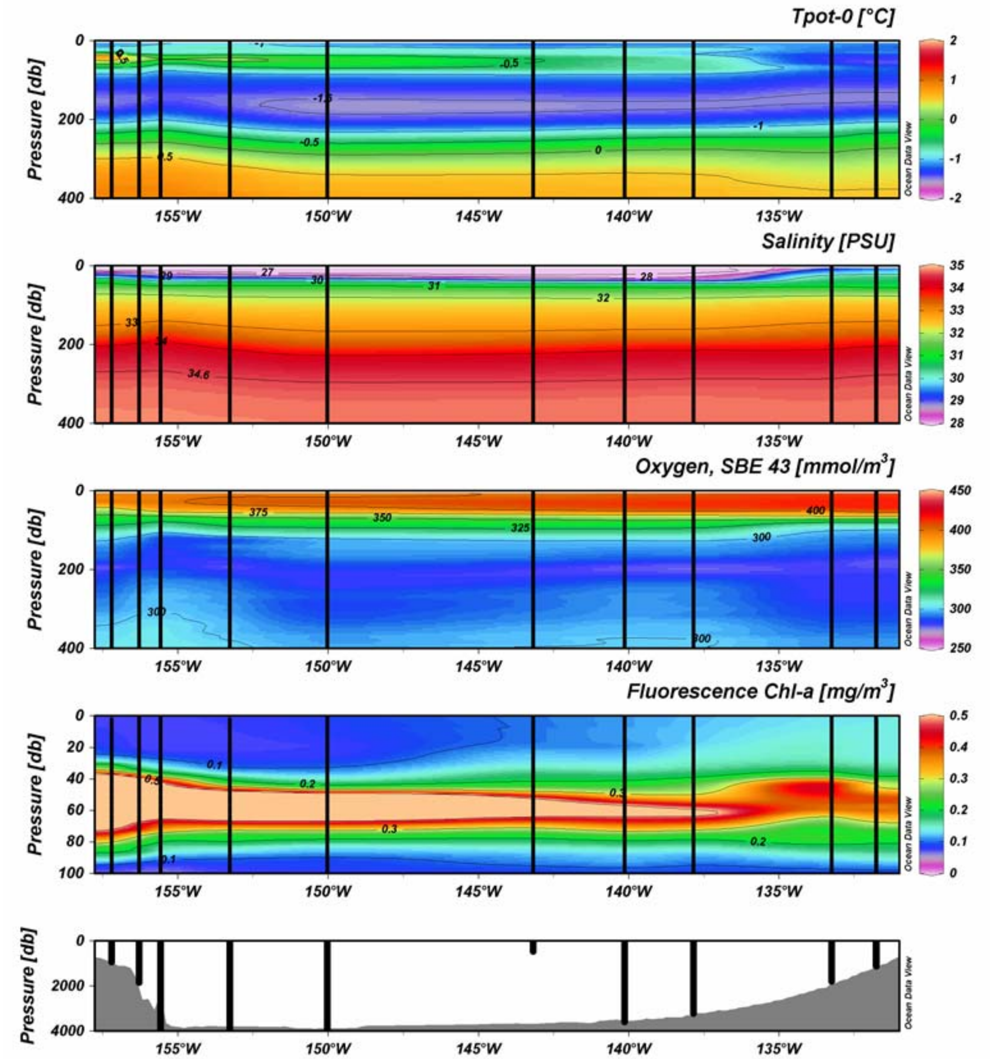
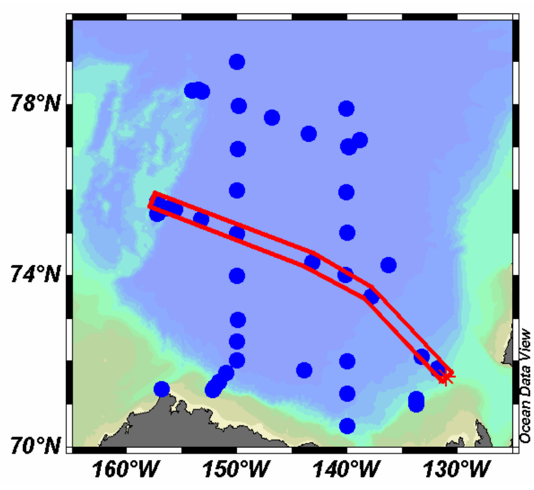
7. SECTION PLOTS

75°N Section, 0 to 400 db, CTD





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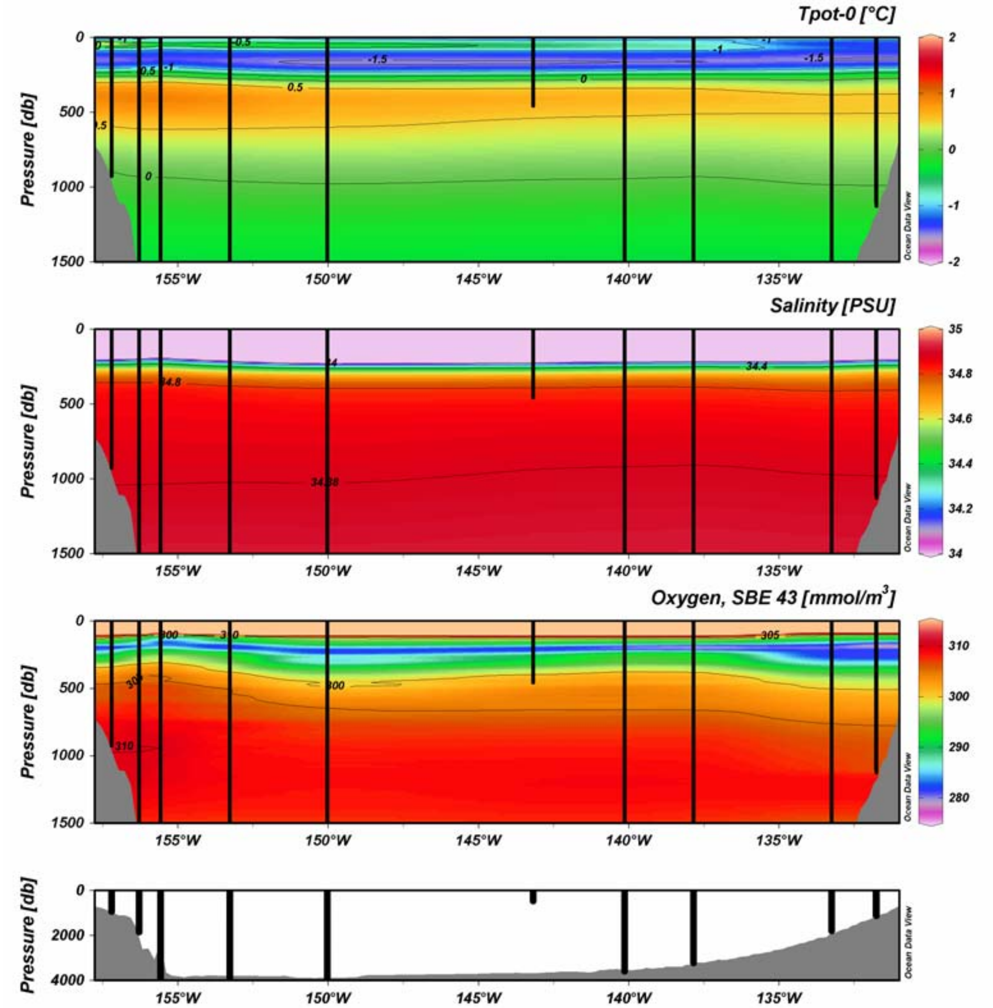
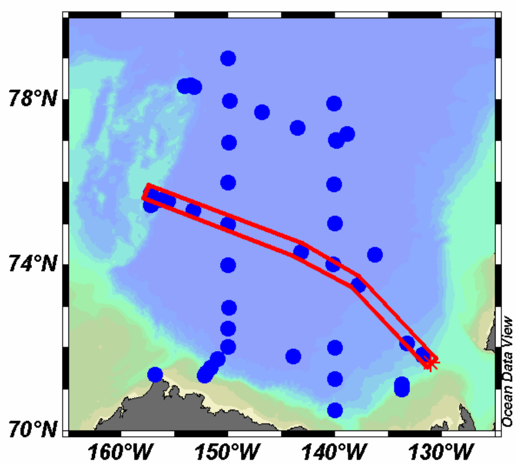
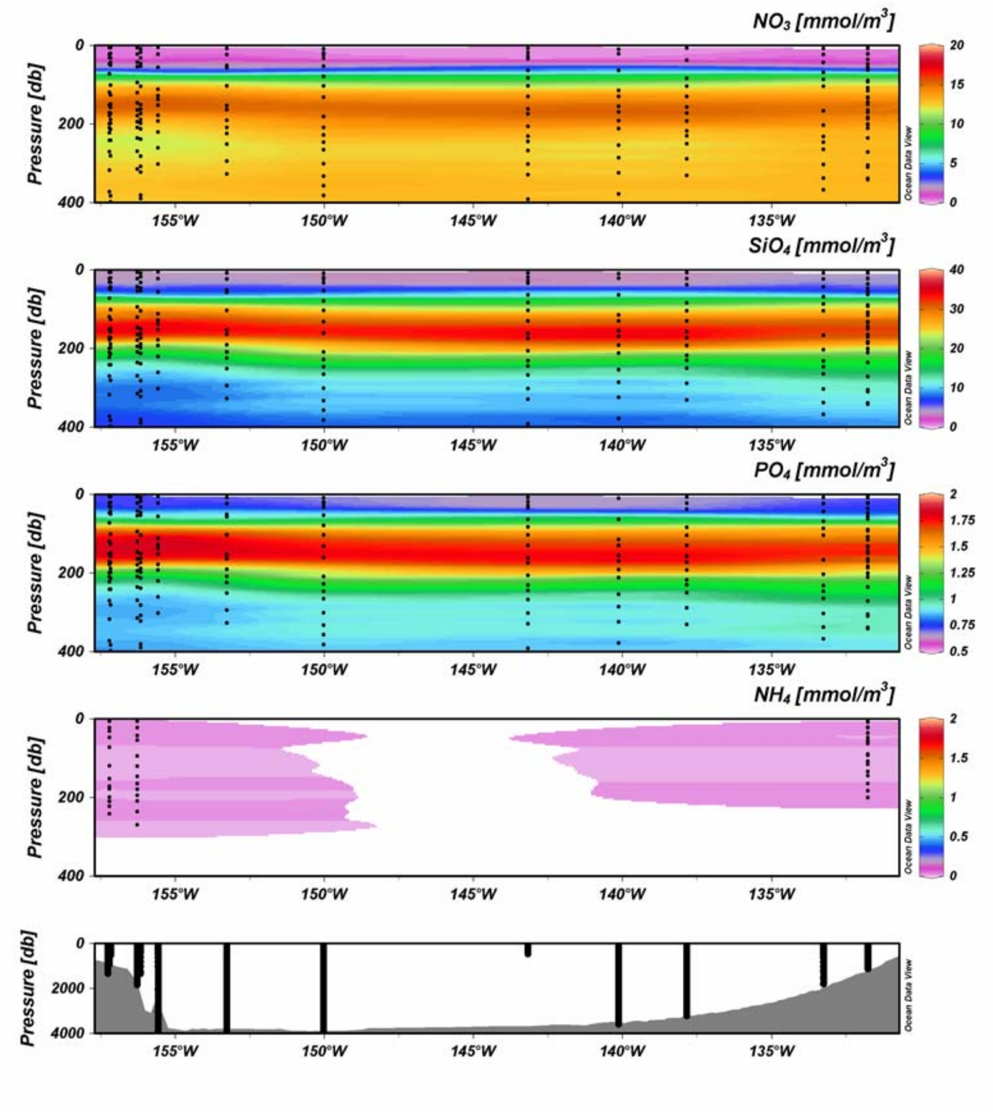
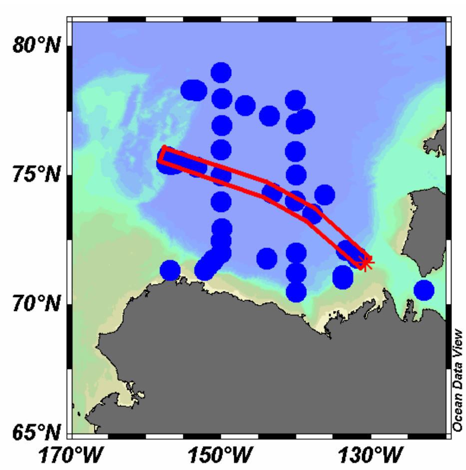




75°N Section, 0 to 400 db, Chemistry





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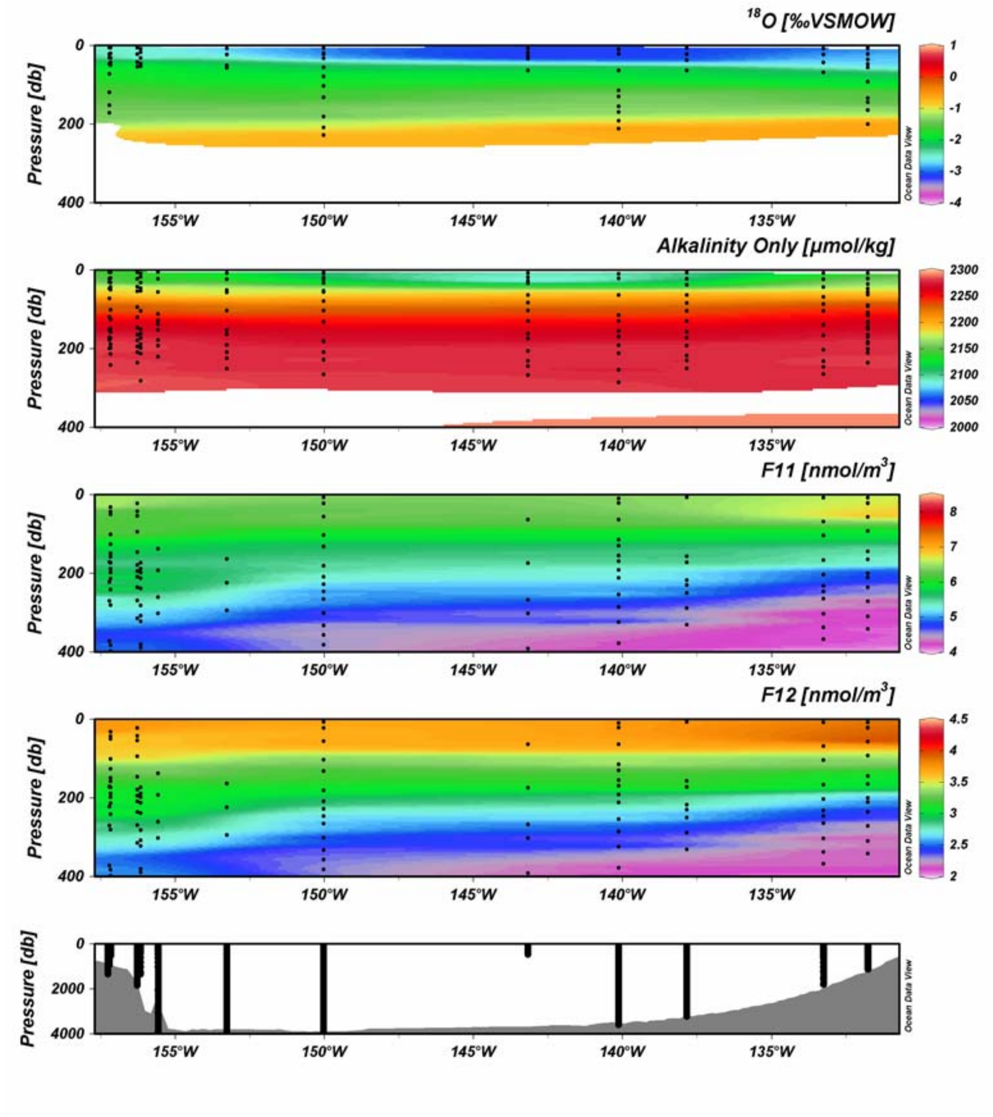
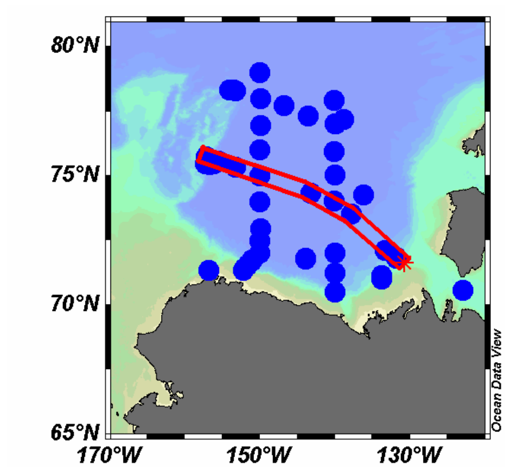
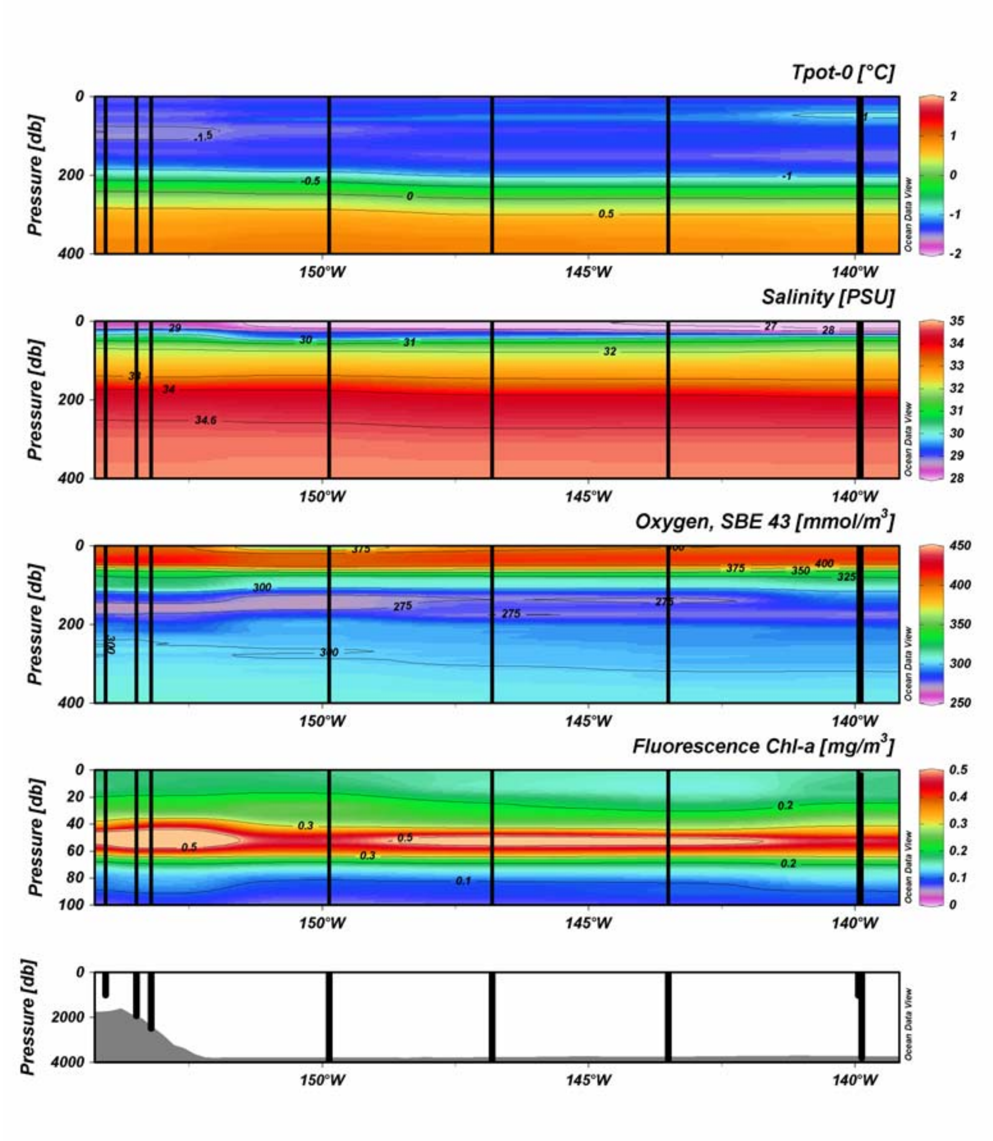
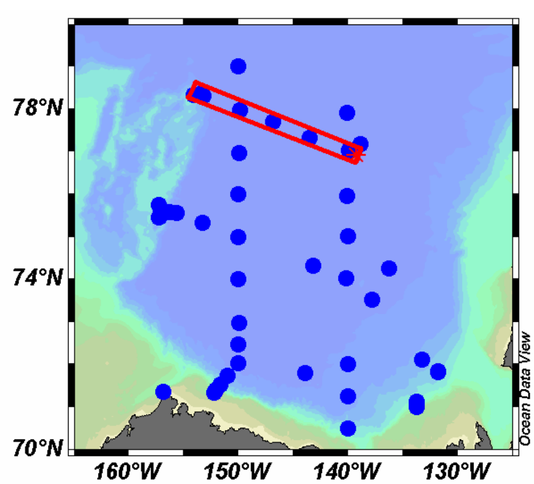




78°N Section, 0 to 400 db, CTD





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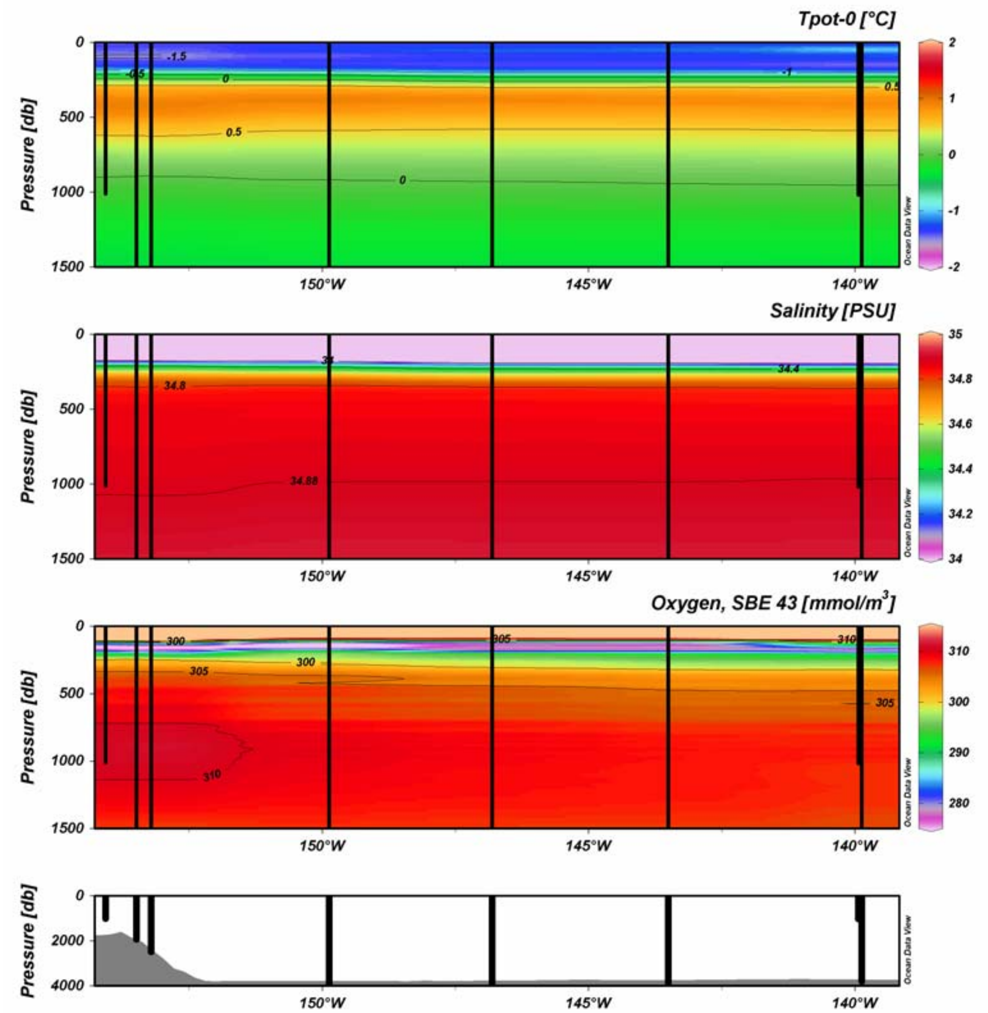
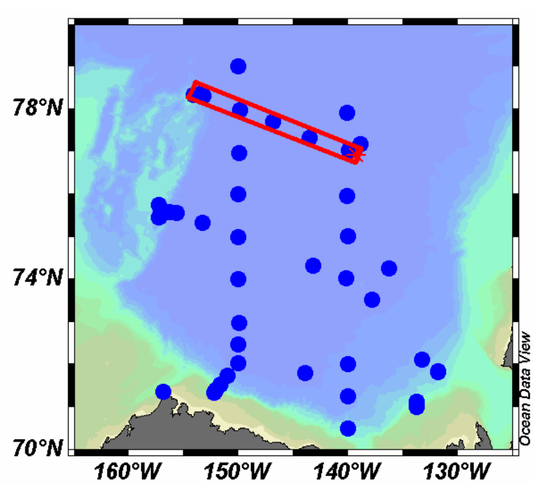
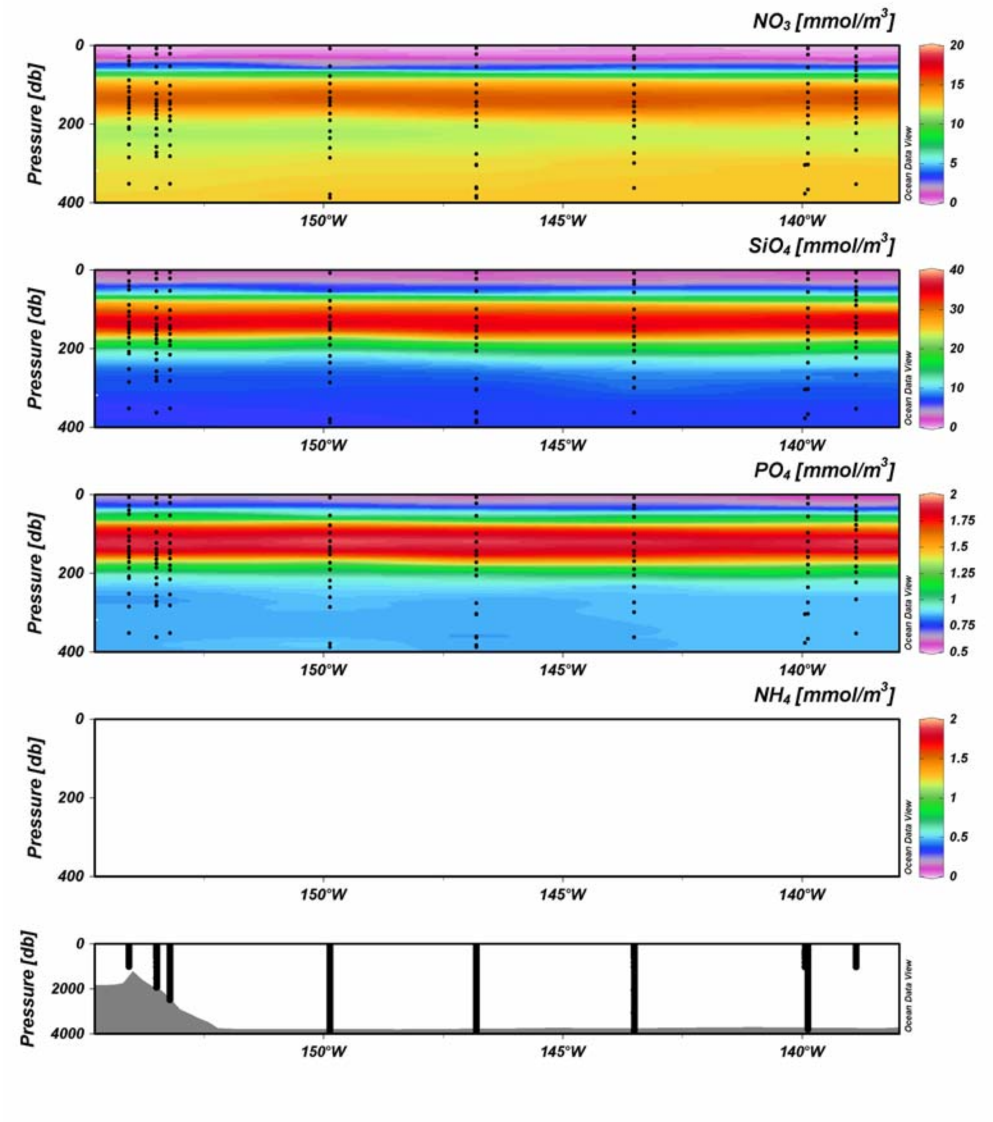
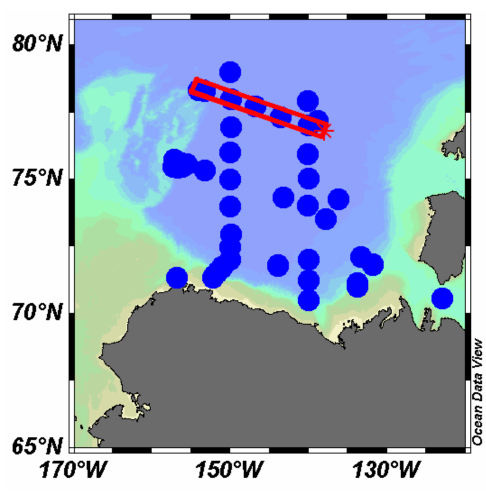


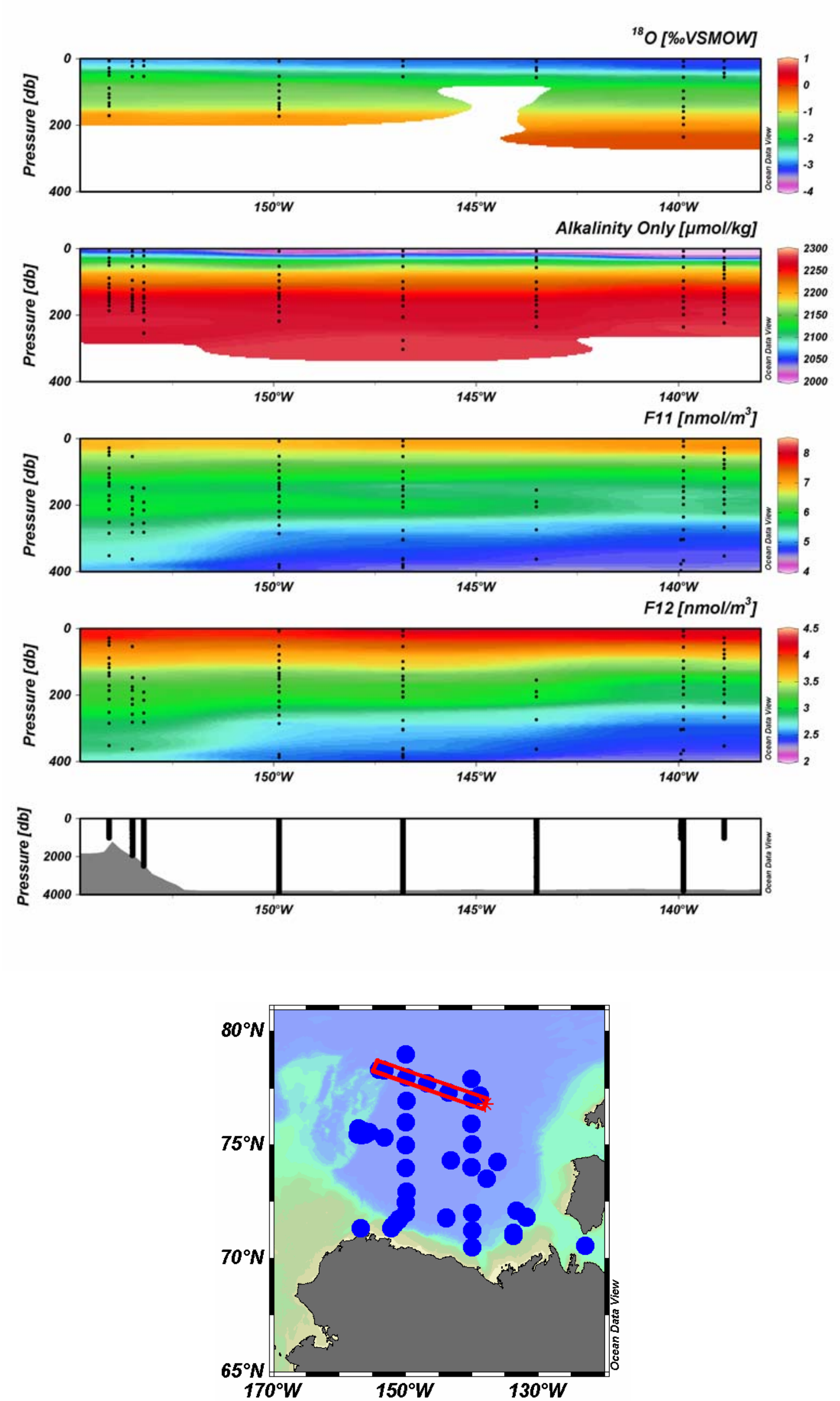


78°N Section, 0 to 400 db, Chemistry

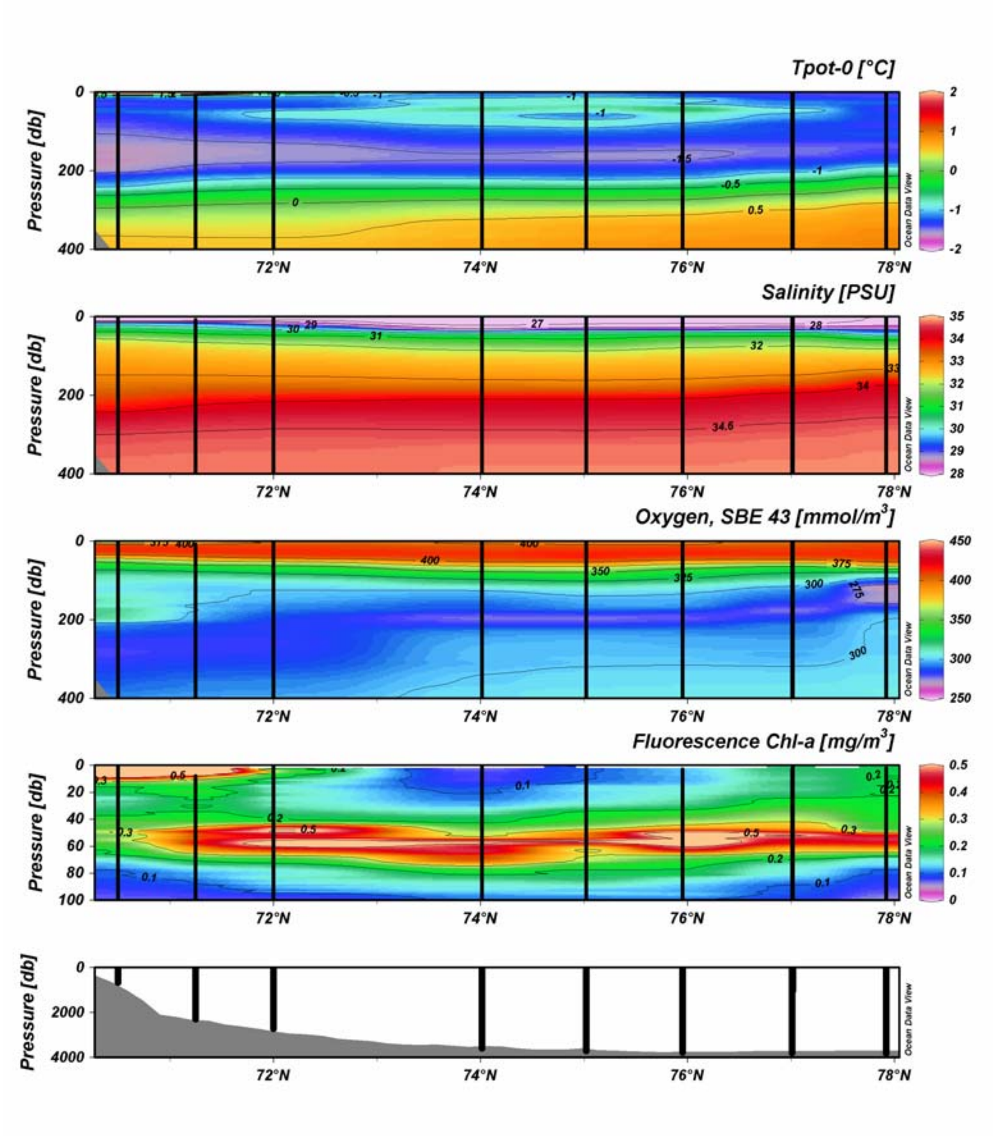


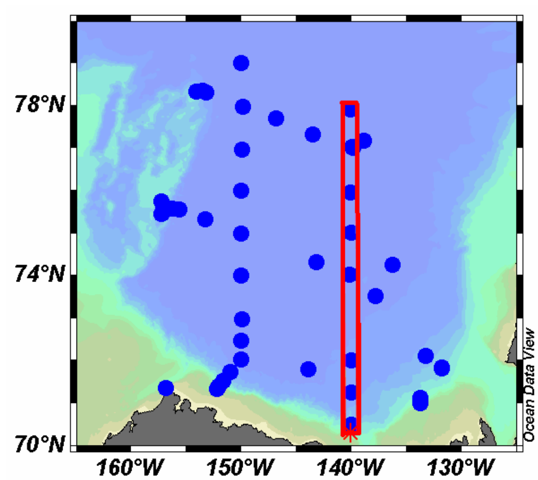


78°N Section, 0 to 400 db, Chemistry



140°W Section, 0 to 400 db, CTD





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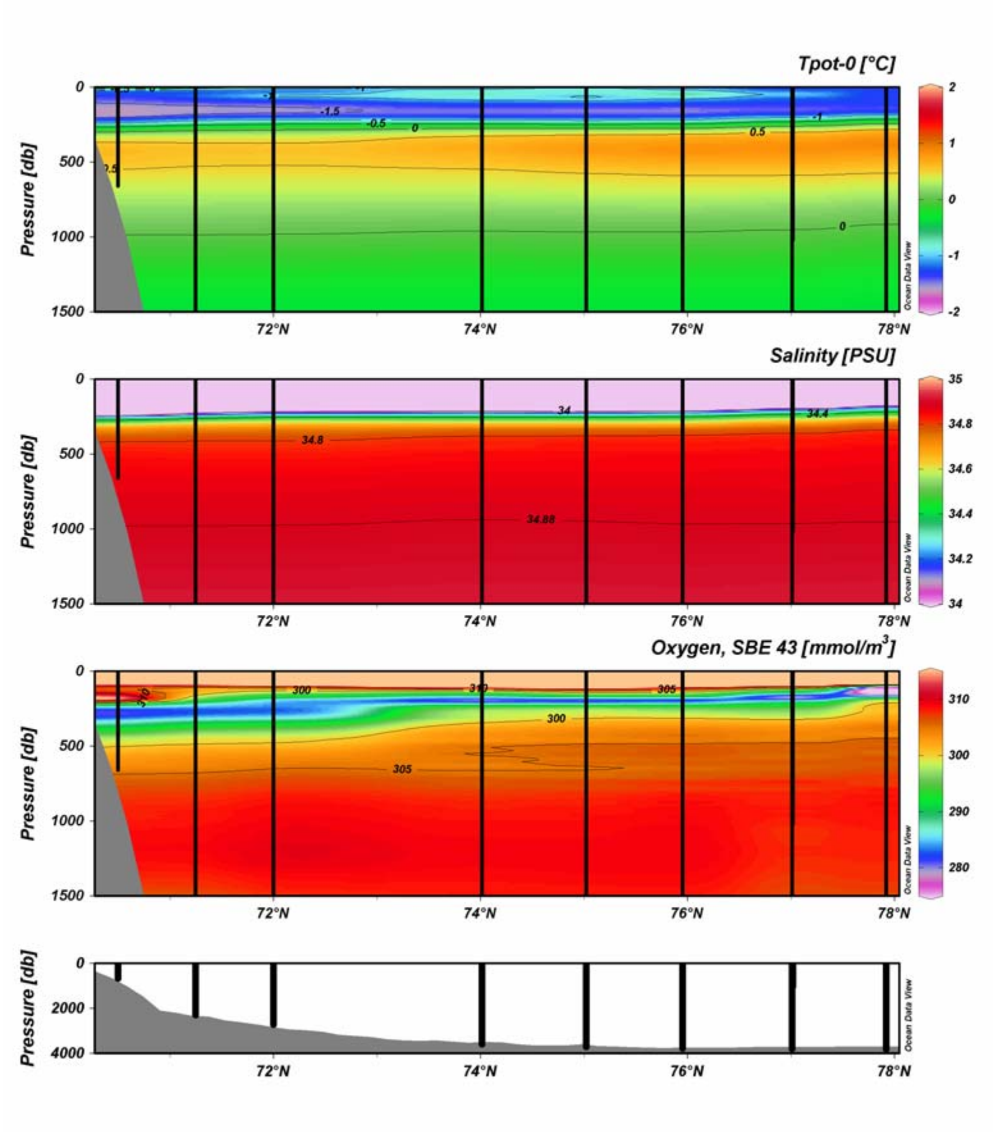

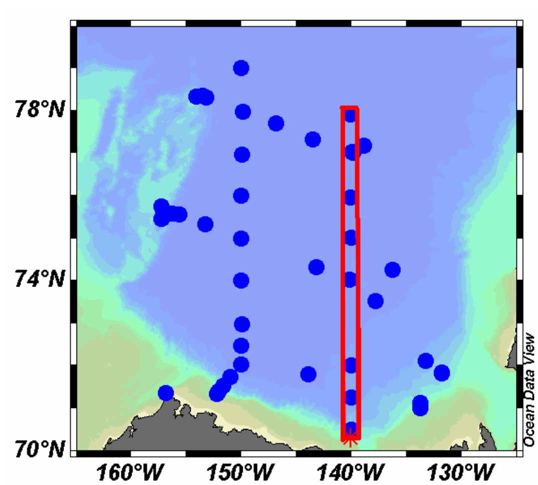

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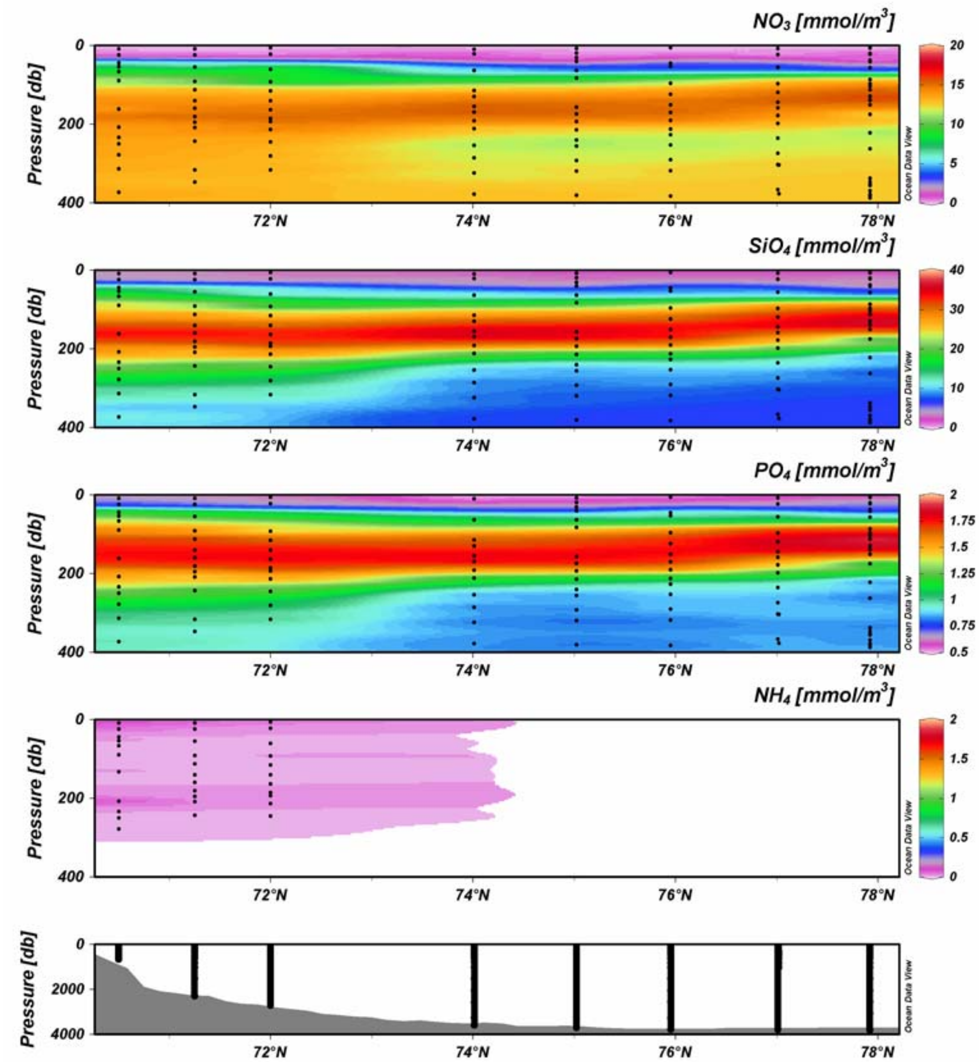
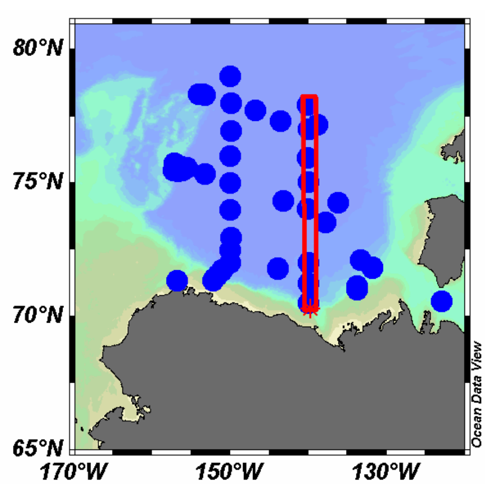
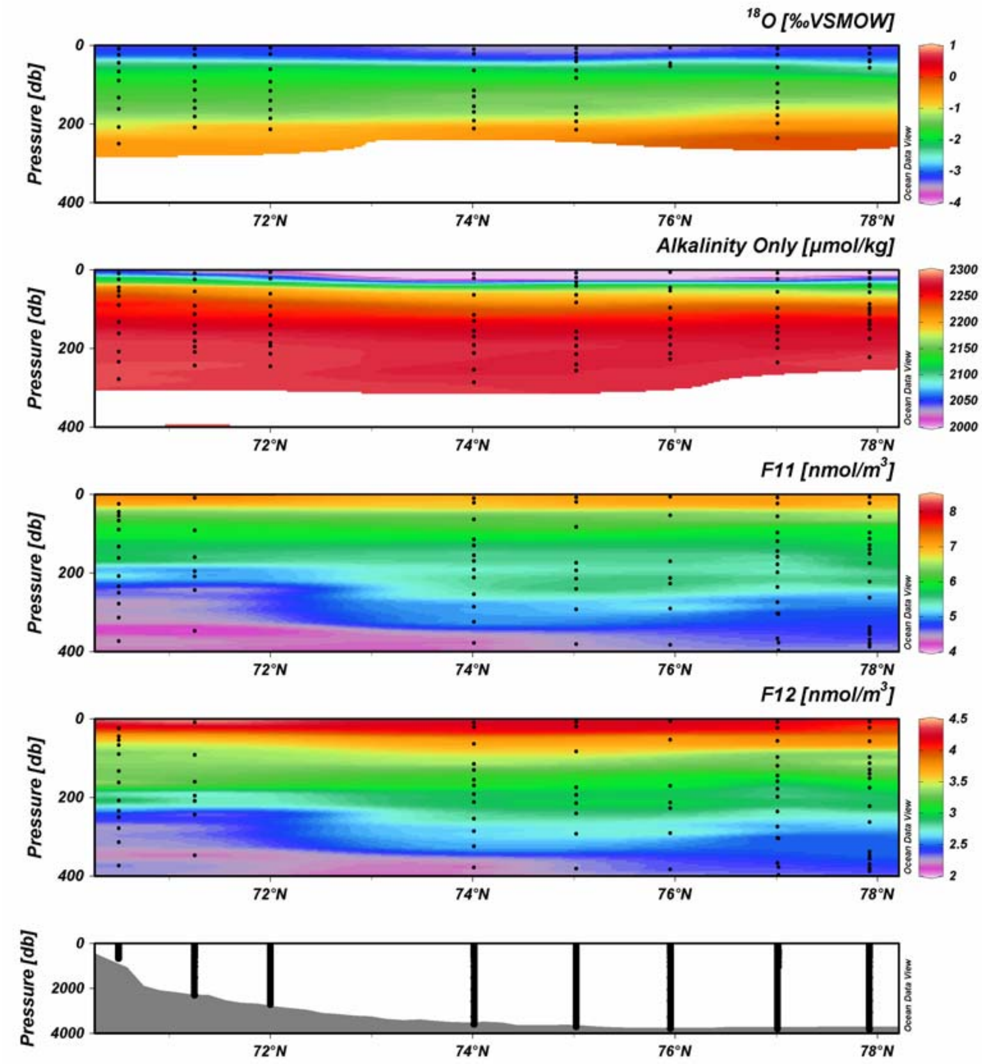
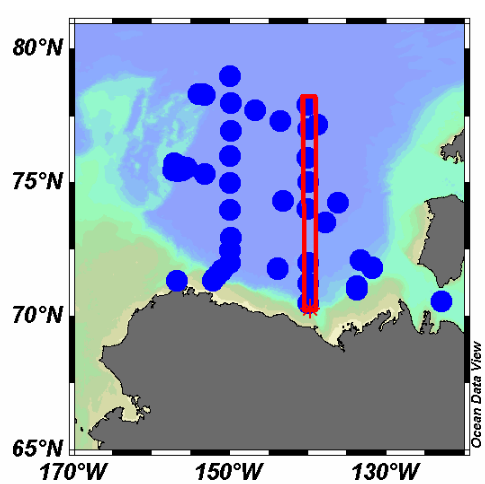




140°W Section, 0 to 400 db, Chemistry





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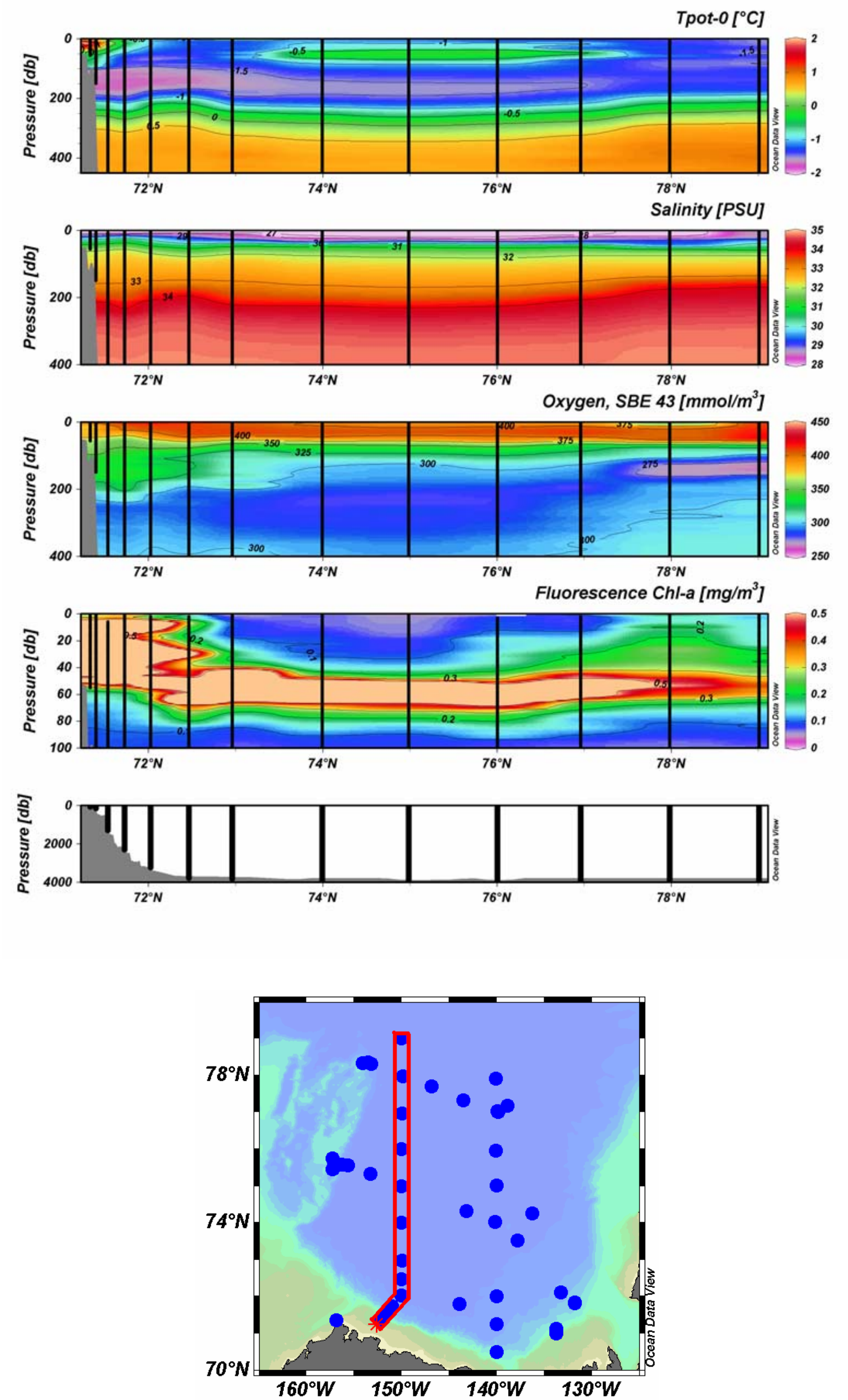
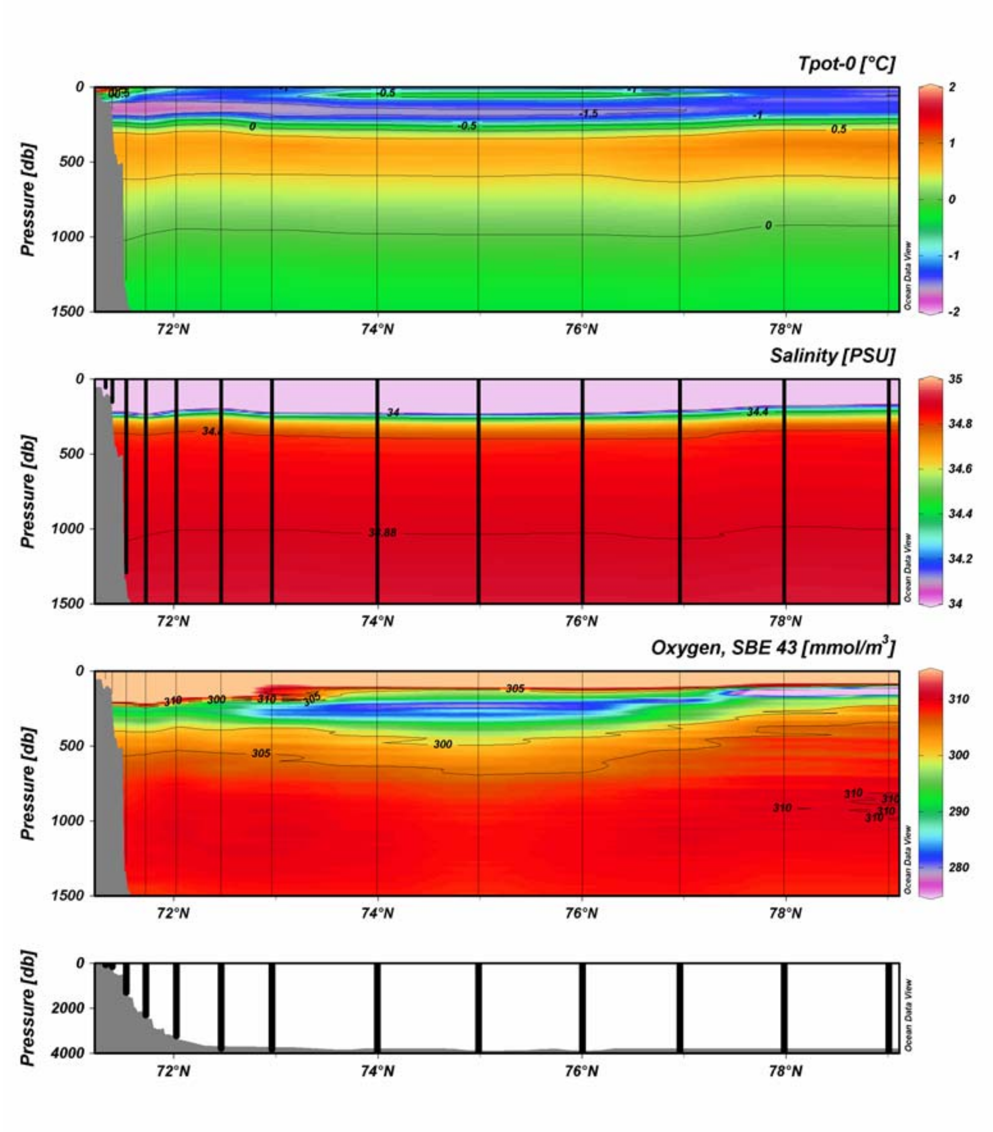
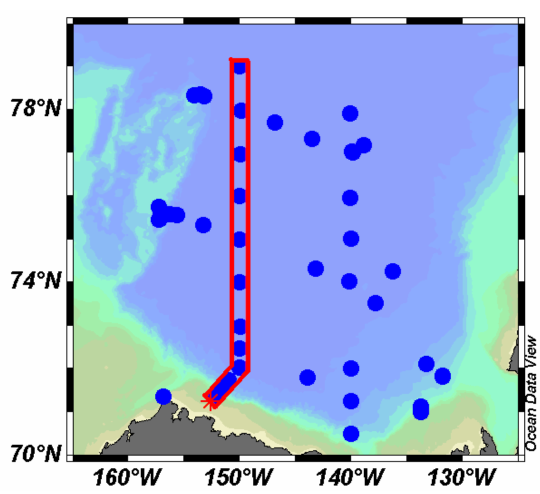
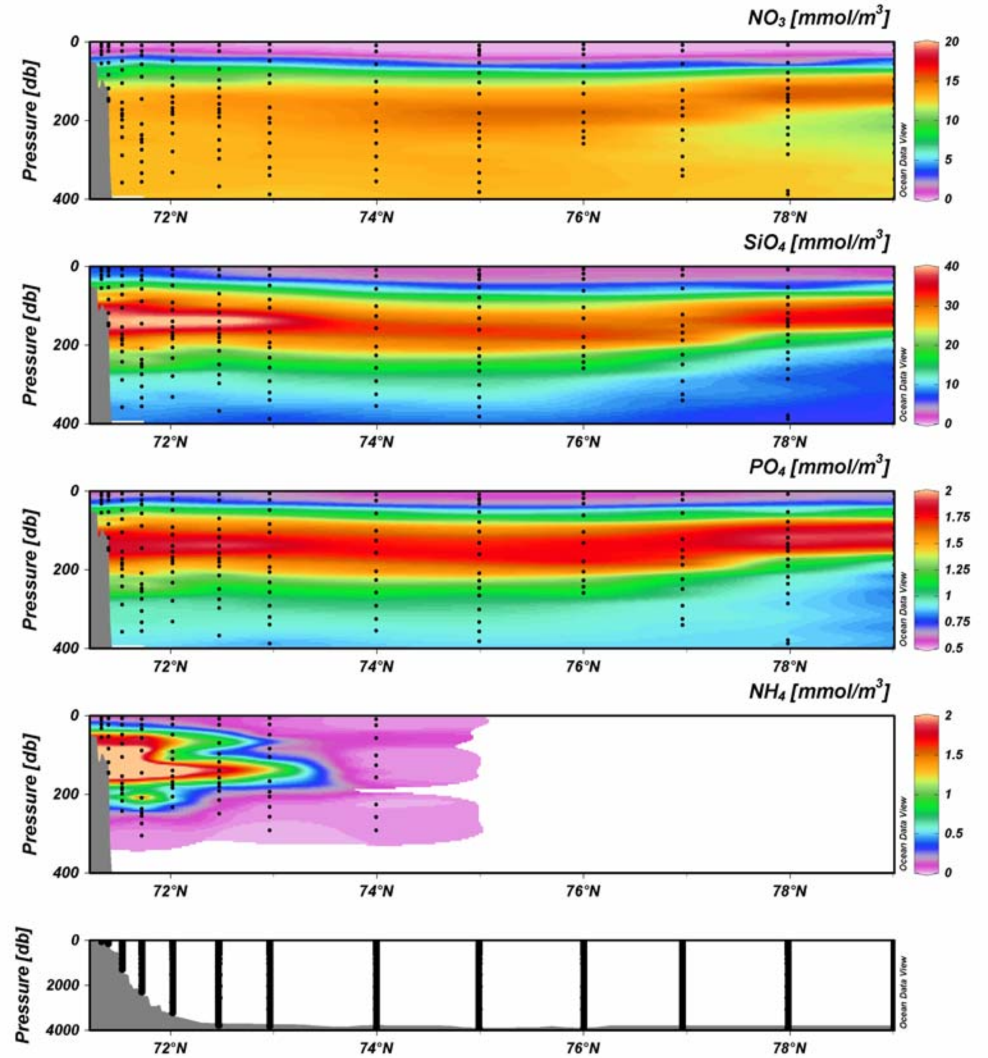


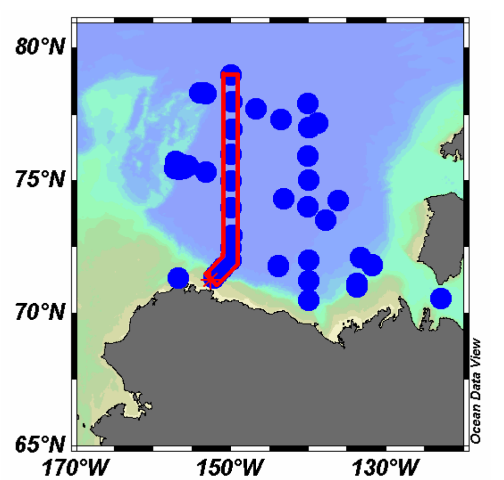
150°W Section, 0 to 1500 db, CTD



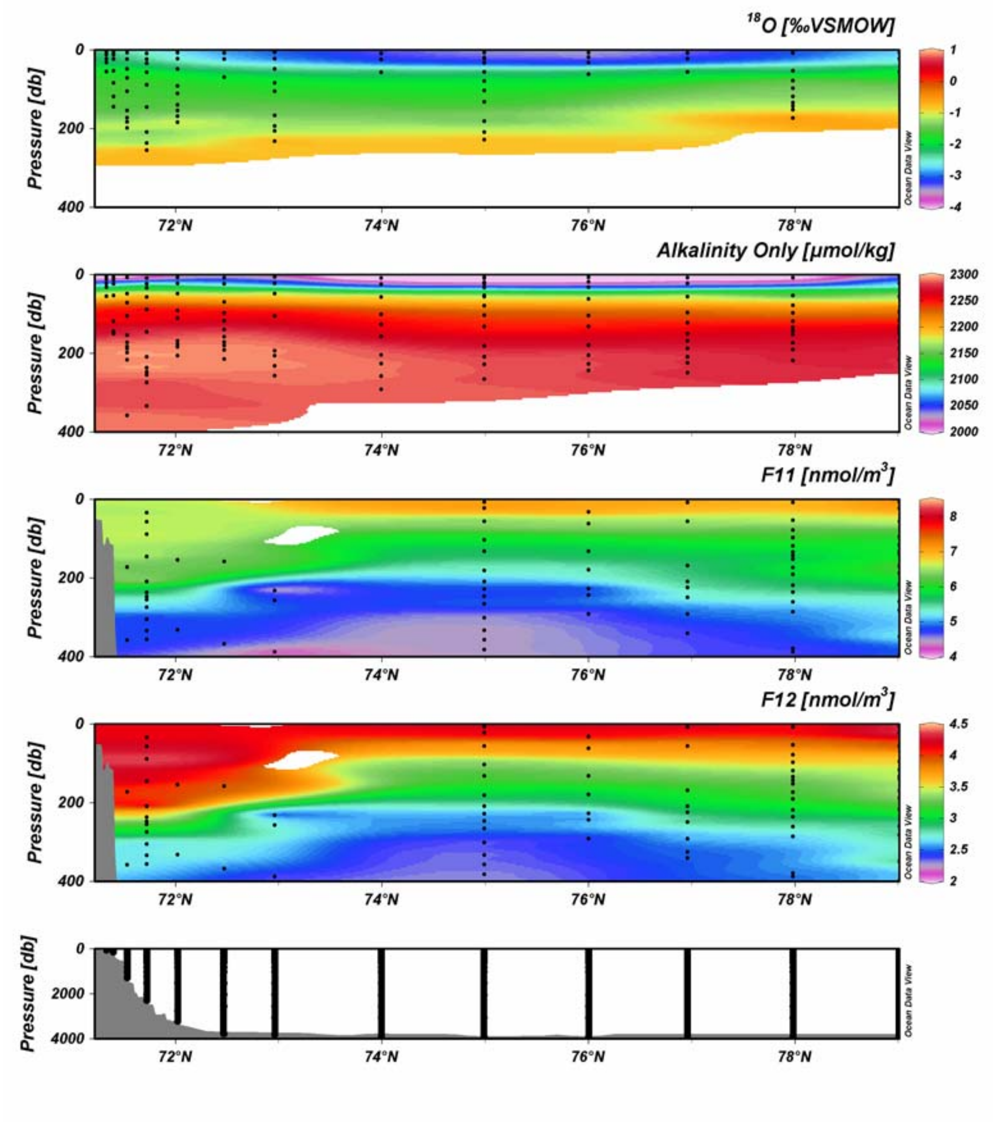


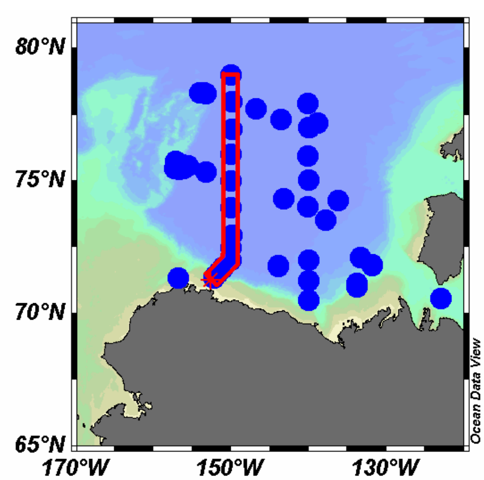
150°W Section, 0 to 400 db, Chemistry





150°W Section, 0 to 400 db, Chemistry





8. WILDLIFE OBSERVATIONS

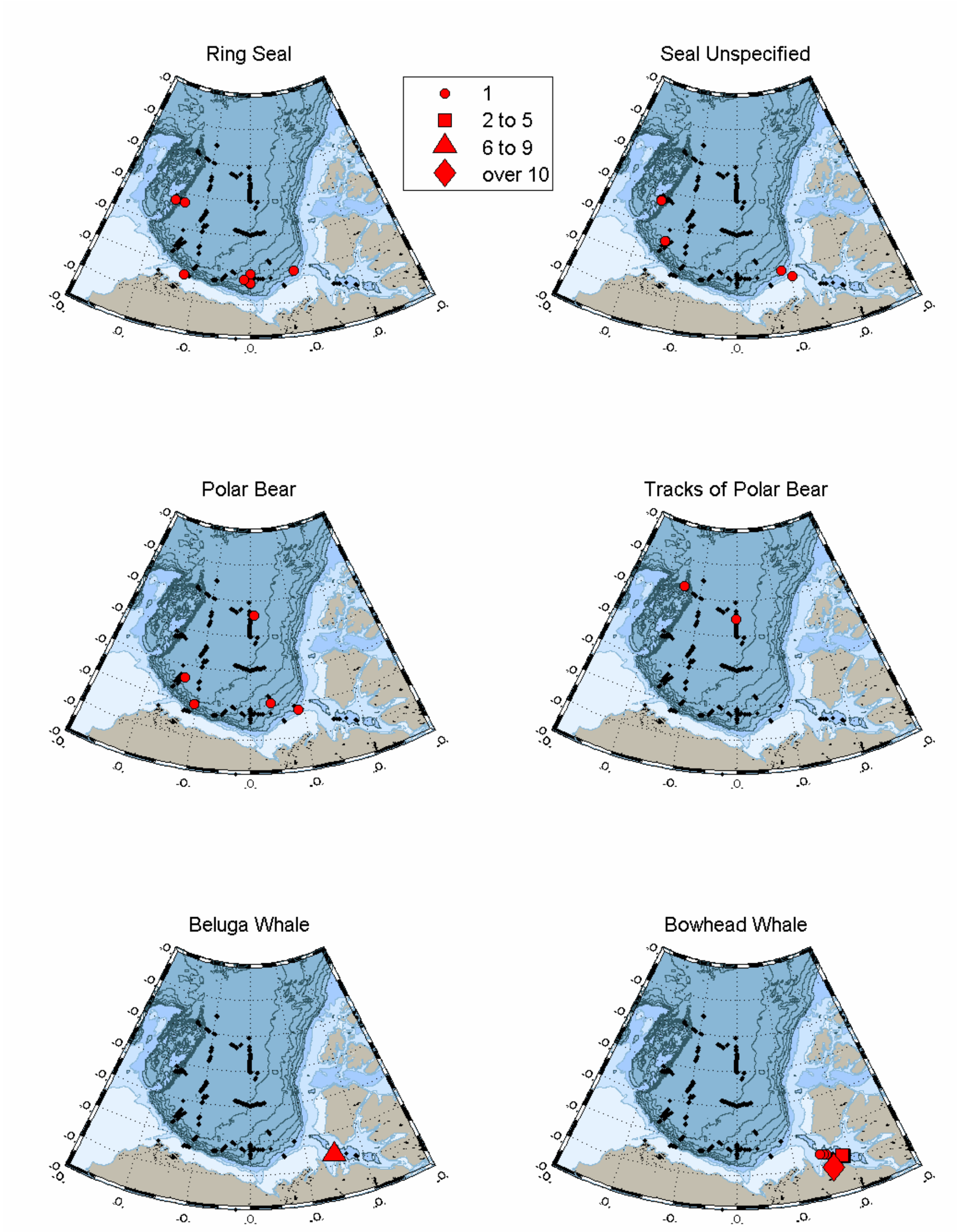


Figure 1. Official and casual observations of marine mammals.

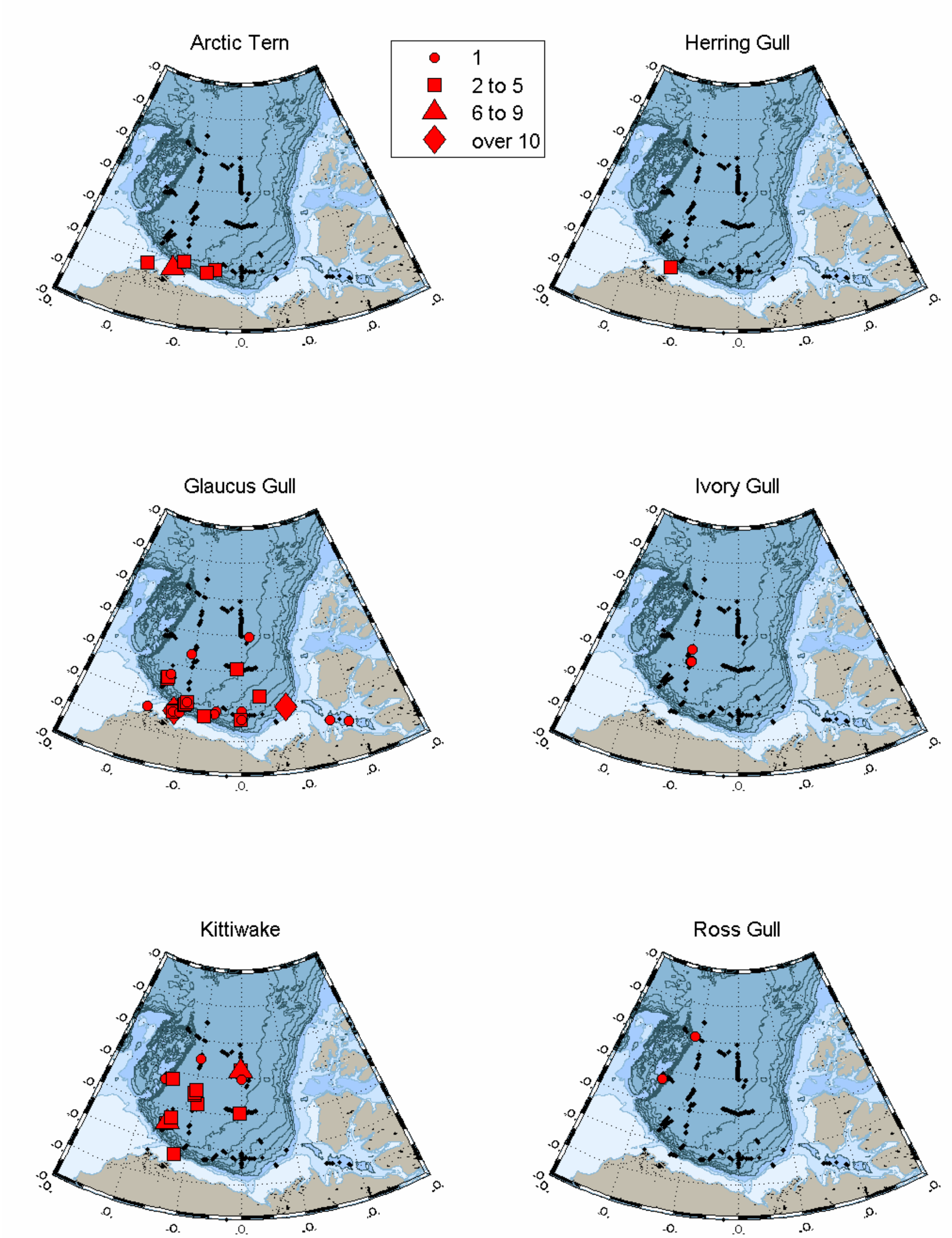


Figure 2. Official and casual observations of birds, first set.

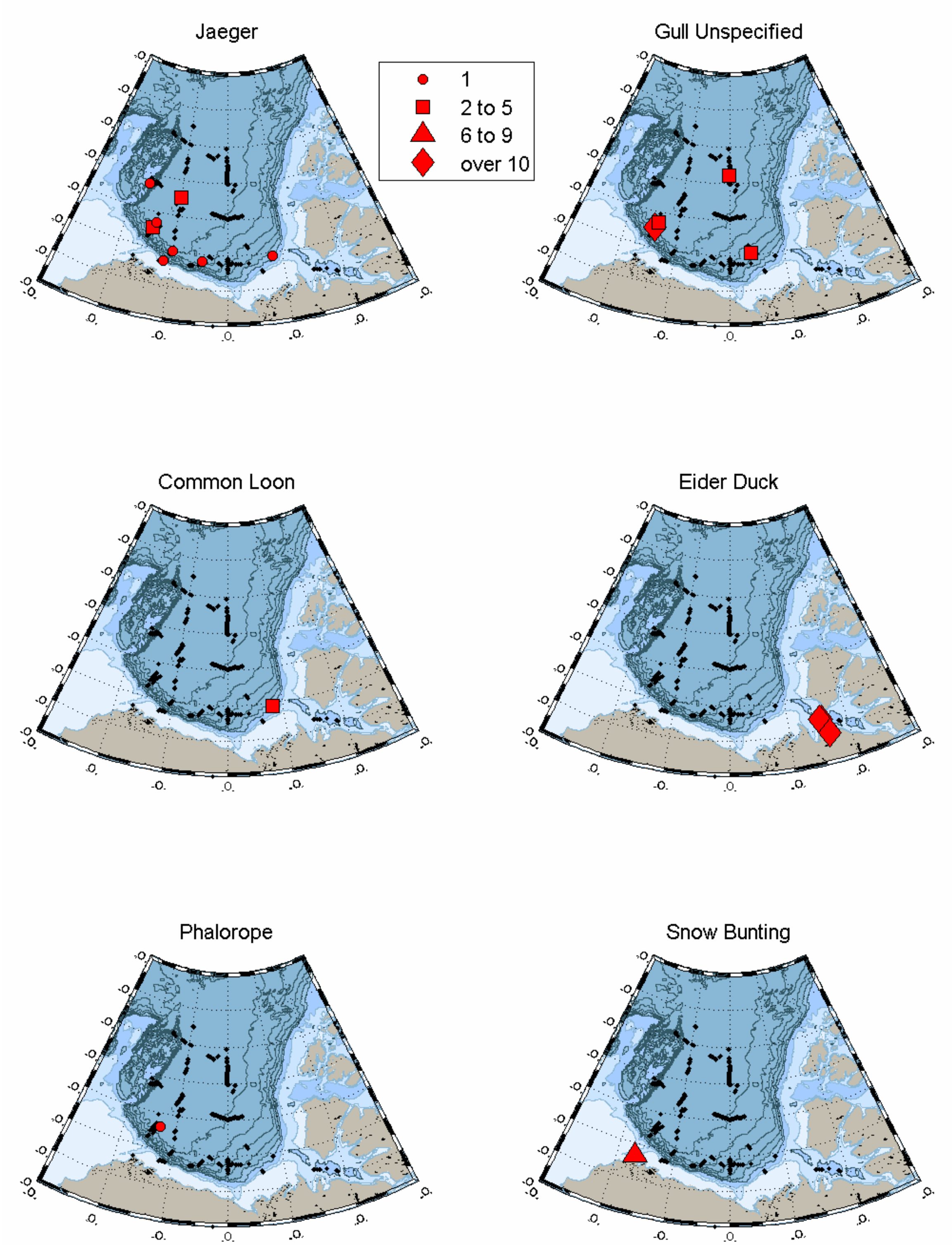


Figure 3. Official and casual observations of birds, second set.

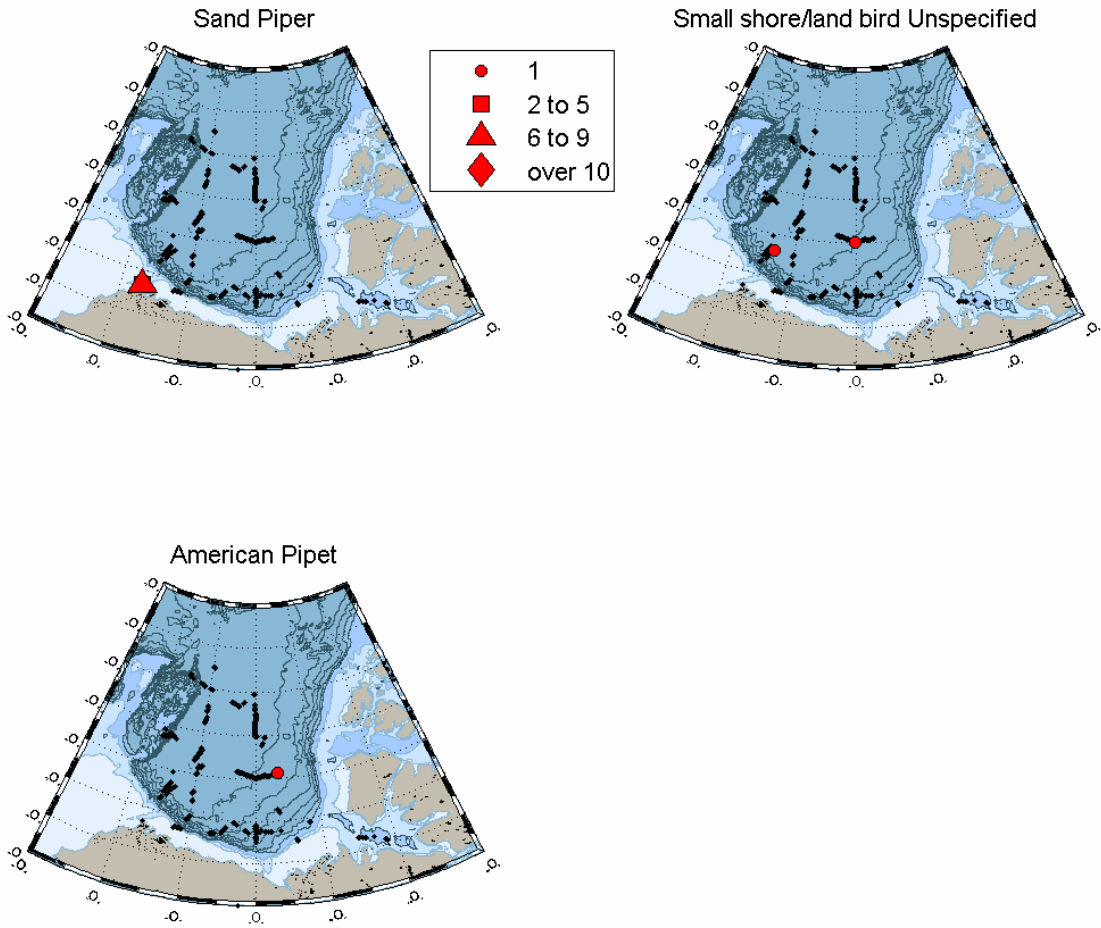


Figure 4. Official and casual observations of birds, third set.

9. RIVER SAMPLING

Table 15. River data from the Kugaryuak and Coppermine rivers.

Station	Time (UTC)	Location	Water Depth (m)	Pressure (dbar)	Sample no.	Salinity (PSU)	NO_3- 1	NO_3- 2	SiO_4- 1	SiO_4- 2	PO_4- 1	PO_4- 2	FW Alk	Ba- 1	Ba- 2	Comments
Kugaryuak River	2006/08/04 20:00	67.6483N 113.3198W	0.6	0.3	71		2.6	2.6	22.3	22.2	0.01	0.01		278	278	*1
Kugaryuak River	2006/08/04 20:00	67.6483N 113.3198W	0.6	0.3	72		2.6	2.6	22.4	22.3	0.02	0.01		277		*1
Coppermine River 1	2006/09/15 20:00	67.7333N 115.3750W	1.3	0.1	BF2	0.0363	0.0		2.993		0.25		*out of range	390		*2
Coppermine River 2	2006/09/15 20:30	67.8300N 115.0367W		0.1	RM-1	18.6415	0.0		3.498		0.23		*out of range	135		*3

Please see Figure 4 in Section 1.2 for a map of sampling locations.

**Note: Alkalinity of these river samples was ~1600 (RM) and ~600 (BF). They were not measured at the appropriate pH range and thus had poor precision (SD = ± 240, n = 4; and ± 70, n = 3, respectively).*
Nutrients samples frozen until analysis.

*Comment *1: Stopped at Kugaryuak River about 1mile upstream of beach and took Ba and Nut sample from two spots - one lower flow and one fast about 20m apart. Water depth at samples was ~ 60cm. Water tasted fresh, was not brackish.*

*Comment *2: On west shore above Bloody Falls. 8' from shore, clay bottom. Water temp 8-9 degC. Nutrients in normal tubes and bigger tubes because of potential for freezing problems.*

*Comment *3: On west shore of island at Coppermine River mouth. Sample is 15m from shore on sandy area. Temp is 8-9 deg C. Sampled by hand into 3x2L bottles. The chl bottle was used for bacteria and the 2 POC/TSS for other samples. Nutrients in normal tubes and bigger tubes because of potential for freezing problems.*

10. ICE OBSERVATIONS

See below for independent ice observation report by Jennifer Hutchings (IARC).

Ice Observations

Ice observations recording during the cruise will provide detailed information for the interpretation of satellite imagery of the ice pack. Our objective was to identify the major sea ice zones in the Beaufort Sea and determine the types and state of ice in these zones. This information will be used to support a joint drifting-buoy, RADARSAT SAR and field campaign to investigate sea ice dynamics in the Beaufort Sea during winter 2006 to spring 2007. The project, “Sea ice tide-inertial interaction: Observations and Modeling” is funded by the National Science Foundation, with PIs Jenny Hutchings and Bill Hibler. The observations from this cruise will also support a field project “Detailed investigation of the dynamic component of the sea ice mass balance” during spring 2007, with PIs Jenny Hutchings, Jackie Richter-Menge and Cathy Geiger. We anticipate that the observations will be useful for investigating the evolution of the ice cover over this summer.

The cruise occurred over the time of minimum ice extent, providing a snapshot of ice conditions at the end of the 2006 melt season.

Observations from Bridge: Methodology

Every hour, while the ship was steaming and light conditions allowed, an observation of ice conditions was recorded. Each observation was made from the bridge, and unless the weather was unusually foul the observer gauged ice coverage from the monkey island. Photos were taken to compliment observations, and are available on request from Jennifer Hutchings. Please contact Jennifer Hutchings should you wish to use the ice observations, as

A combination of ASPECT (Worby & Alison 1999), Standard Russian and Canadian Ice Service codes were used to describe ice conditions. The codes are described in detail below. During each observation period we estimated the total ice coverage within 3km of the ship (when visibility allowed), the types of ice present and the state of open water. For each ice type we estimate the coverage of that type, thickness, flow type, topography, sediment coverage, algae presence, snow type, snow thickness and stage of melt. There was space for detailed observations of three ice types (primary, secondary and tertiary) in the log book. We also recorded the codes for any other types of ice present that was at lower concentration than the three main types. We recorded basic meteorological phenomena of cloud coverage and type, visibility and precipitation. Air temperature, relative humidity, dew point temperature, barometric pressure, wind speed and direction were taken from the Automated Voluntary Observing System provided by NOAA.

<u>Time</u>

Time was noted as ship time. There were two clock changes during the cruise.

August 5th to August 7th midnight:	Eastern Time (UTC – 4 hours)
August 7th midnight to August 13th midnight:	Central Time (UTC - 5 hours)
August 13th onward:	Mountain Time (UTC – 6 hours)

Ice Concentration

Ice concentration was estimated in tenths. Partial concentration of each type was estimate as the fractional coverage of the entire observation area (ice and water) in tenths.

Open Water
0 No openings
1 Small cracks
2 very narrow breaks <50m
3 Narrow breaks, 50-200m
4 Wide breaks, 200-500m
5 Very wide breaks, >500m
6 Leads
7 Polynya
8 Water broken only by scattered floes
9 Open sea

Snow and Ice Thickness

A 1.5m pole, painted with 10cm segments, was attached to the railing on the port side of level 500 on the ship. This pole could be viewed from the rear window on the bridge, and was used for gauging ice thickness as the ship overturned pieces of broken ice. The accuracy of each individual thickness measurement is +/- 10cm. It should be noted that the ship does not overturn the thicker pieces of ice fully, so this method can not be used to accurately gauge ice thicknesses greater than about 2m. We found that the ship also did not overturn ice that was 20-50cm, when steaming through 10/10 ice. At various stages during the cruise, the ship steamed at 4knots towing seismic instruments. This work was done in relatively open areas (<6/10 ice), and the ship did not overturn ice at this speed.

Ice Type
10 Frazil
12 Grease
20 Nilas
30 Pancakes
40 Young Grey Ice 0.1-0.15m
50 Young Grey-White Ice 0.15-0.3m
60 First year <0.7m
70 First year 0.7-1.2m
80 First year >1.2m
65 First year, unknown thickness
75 Second year
85 Multiyear
90 Brash

Floe Size
1 Pancakes
2 New sheet ice
3 Brash / Broken Ice
4 Cake ice <20m
5 Small floes 20-100m
6 Medium floes 100-500m
7 Large floes 500-2000
8 Vast floes >2000m
9 Bergy Floes

Topography

Ridges and hummocks indicate the age and dynamic history of sea ice. We estimated topography of each ice type using ASPECT codes. These were chosen as they allow an areal coverage and ridge sail height to be noted. We found that the level of detail required by the coding of areal coverage and average sail height was greater than the eye could gauge. Hence, the areal coverage and sail height values should be used with caution. It would be best to rearrange the data into larger bins reflecting <30%, 30%-60% and >60% coverage. The sail height was difficult to estimate when spatial variability was high, and should only be used in a qualitative sense.

100 Level Ice
200 Rafted Pancakes
300 Cemented Pancakes
400 Finger Rafting
5xy New, unconsolidated ridges (no snow)
6xy New ridges filled with snow or a snow cover
7xy Consolidated ridges, no weathering
8xy Older, weathered ridges

...lues:
...age sail height
1 0.5m
2 1.0m
3 1.5m
4 2.0m
5 3.0m
6 4.0m
7 5.0m

0 0-10%
1 10-20%
2 20-30%
3 30-40%
4 40-50%
5 50-60%
6 60-70%
7 70-80%
8 80-90%

Sediment

Areal coverage of sediment on the surface of each ice type was estimated

0 ice is clean
1 spots on few floes
2 patches > 20m
3 >1/3 ice covered s dirty

Ice Algae

As ice is overturned by ship, ice algae can either be seen in the bottom portion of the ice, or strands of algae are overturned with the ice.

0 no algae
1 <30% overturned ice has algae
2 30-60% has algae
3 >60% has algae

Snow Type

0 No snow observation
1 No snow, no ice or brash
2 Cold new snow, <1day old
3 Cold old snow
4 Cold wind-packed snow
5 New melting snow (wet new snow)
6 Old melting snow
7 Glaze
8 Melt slush
9 Melt ponds
10 Saturated snow
11 Sastrugi

Snow thickness was difficult to determine when new snow fell on the melted ice surface, due to the lack of contrast between new snow and ice melt through top 10-20 cm of ice surface. Hence snow thicknesses are probably not accurate in all observations.

Stage of Melt

Stage of melt coding is highly variable between observation systems. I choose to work with the Russian coding system, as this is the system I am most familiar with. However, I found that I had to modify the codes to match conditions observed. At times the conditions at the base of the ice appeared rotten, whereas surface conditions did not indicate this advanced stage of melt according to the Russian system. I added codes, for rotton ice and refrozen ponds, from the Canadian system to help alleviate confusion. In future I will code melt ponds / thaw holes, snow melt and ice crystalline structure (undisturbed, dry-white or rotten) separately.

The stage of melt has to be considered separately for each ice type, as younger and older ice melt are characterized by differing surface conditions.

Young Ice (incl. young first year ice)
0 No melt
1,2 Surface darkened, snow melt single thaw holes
3,4 Greatly disrupted surface thaw holes everywhere
5 Level ice completely melted. Only deeply seated in water remains, ridges still found.

First Year Ice
0 No melt (or pack freezing, young ice forming over thawholes)
1 Some puddles on surface. Ice braccia desctruction begun.
2 Surface darkened, snow partially melted. Big puddles, some melt ponds.
3 Melt ponds everywhere, some thaw holes. Ice is stage of drying, ice colour whitening.
4 Greatly disrupted ice. Thaw holes everywhere. Disruption of Braccia complete. Underwater ramps on ice cakes.
5 Rotten ice. Greatly melted formless blocks. Dark grey color, greatly watered.

Multiyear Ice
0 No melt (or pack freezing, young ice forming over melt ponds/thaw holes)
1 Snow melting on top of hummocks. Melt ponds / patches of wet snow in low places.
2 Some ponding, <40% melt ponds. Snow melting. Places with no snow may occur.
3 Well defined melt ponds everywhere. Connected freshwater output to cracks. Area of melted water on surface is decreased due to output.
4 Ice braccia cracked. Area of melted water on surface is decreased, <30%. Thaw holes.
5 Floes have become cracked and blocks, due to intensive melt. Rotten ice.

Additional codes
7 Rotten
8 Some melt ponds frozen
9 melt ponds frozen

Ocean Colour
The ocean colour is apparent against ice draft and the keels of ridges. We noted whether the colour was blue, Turquoise (Tq) or green at the time of observation. Green indicates the presence of surface phytoplankton blooms. It should be noted that the surface water sinks under the fresh melt water in the transition across the ice edge, hence this method can not be used to track blooms further into the ice pack.

Cloud Cover
Estimated in Octaves

Cloud Type	
cu	Cumulus
ci	Cirrus
st	Stratus
sc	Strata-cumulus
fog	Fog

Visibility	
90	< 50m
91	50-200m
92	200-500m
93	500-1000m
94	1-2km
95	2-4km
96	4-10km
97	>10km
-1	not available

Weather
We used codes provided by ASPECT. In future I will use a different coding system for weather, as we found this system cumbersome. It was not possible to describe all weather states with the codes provided. For example, there was often fog with visibility better than 1km, and the ASPECT coding system did not allow for this. We modified the system to allow fog codes to be used at any visibility. Below are the weather codes that we used in the ice observation hourly log.

Cloud development
00 Clouds not observable/observed
01 Clouds dissolving or becoming less developed

02 State of sky as a whole unchanged
03 Clouds forming or developing

Fog/Precipitation during past hour but not at time of obs
20 Drizzle not freezing or snow grains
21 Rain not freezing or snow grains
22 Snow not freezing or snow grains
23 Rain and snow or ice pellets
24 Drizzle or rain, freezing
25 Showers of rain
26 Showers of snow, or of rain and snow
27 Showers of hail, or of rain and hail
28 Fog in past hour, not at present

Blowing or drifting snow
36 Drifting snow below eye level, slight/moderate
37 Drifting snow below eye level, heavy
38 Blowing snow, above eye level, slight/moderate
39 Blowing snow, above eye level, heavy

Fog/Mist
41 Fog in patches
42 Fog thinning in last hour, sky discernable
43 Fog thinning in last hour, sky not discernable
44 Fog unchanged in last hour, sky discernable
45 Fog unchanged in last hour, sky not discernable
46 Fog beginning/thickening in last hour, sky discernable
47 Fog beginning/thickening in last hour, sky not discernable
48 Fog depositing rime, sky discernable
49 Fog depositing rime, sky not discernable

Precipitation as drizzle
50 Slight drizzle, intermittent
51 Slight drizzle, continuous
52 Moderate drizzle, intermittent
53 Moderate drizzle, continuous
54 Dense drizzle, intermittent
55 Dense drizzle, continuous
56 Freezing drizzle, slight
57 Freezing drizzle, moderate or dense
58 Drizzle and rain, slight
59 Drizzle and rain, moderate or dense

Precipitation as rain, not showers

60 Slight rain, intermittent
61 Slight rain, continuous
62 Moderate rain, intermittent
63 Moderate rain, continuous
64 Heavy rain, intermittent
65 Heavy rain, continuous
66 Freezing rain, slight
67 Freezing rain, moderate or heavy
68 Rain or drizzle and snow, slight
69 Rain or drizzle and snow, moderate/heavy

Frozen precipitation, not showers
70 Slight fall of snow flakes, intermittent
71 Slight fall of snow flakes, continuous
72 Moderate fall of snow flakes, intermittent
73 Moderate fall of snow flakes, continuous
74 Heavy fall of snow flakes, intermittent
75 Heavy fall of snow flakes, continuous
76 Ice prisms, with/without fog
77 Snow grains, with/without fog
78 Isolated star like crystals
79 Ice pellets

Precipitation as showers
80 Slight rain showers
81 Moderate or heavy rain showers
82 Violent rain showers
83 Slight showers of rain and snow
84 Moderate/heavy showers of rain and snow
85 Slight snow showers
86 Moderate or heavy snow showers
87 Slight showers of soft or small hail
88 Moderate/heavy showers of soft/small hail
89 Slight showers of hail
90 Moderate or heavy showers of hail

Comments on Bridge Observing Methodology

As we did not have a continuous ice watch, the observations should not be used alone to estimate ice type coverage on scales smaller than 100km. The ship track and speed will introduce a bias into the type and thickness of ice overturned. Hence, although the sampling of thin and medium first year ice may be reasonable, thicker first year and multiyear ice will be under represented in thickness estimates. Poor visibility affects the area of ice observed, and could compound ship track bias in spatial coverage estimates. While the ship was above 76N, the ice surface was covered in new snow. Combined with flat light conditions during the 76N,150W to 79N,150W leg, this may have caused difficulty in identifying ice types. During this time, we were reliant on watching the ice overturned by the ship to identify types. It should also be noted that flat light conditions hinder the estimation of ridge height.

We found that the photographic record helped in consistency checking of the bridge ice observations. In future we will place wide angle webcams on the monkey island, one facing to the bow and one facing downward 45 degrees, to port. Both cameras should record an image every 10 minutes, with a time and position stamp. A webcam on the thickness pole might also be useful in refining the spatial extent of ice type observations.

Aerial Ice Observations

At various times during the cruise we had the opportunity to observe the ice cover from helicopter. In flying conditions when visibility was good, and the helicopter could travel at an altitude of 2000 feet, these flights were very helpful in extrapolating ship based observations to the wider field. During flights, notes were taken of ice coverage, distribution of types and state of melt. Photographs were taken as a record of ice conditions. In the compact region of pack ice above 76N, a handheld GPS with data logger was used to record the positions of leads and cracks along track. The orientation of these features was also recorded. This information will be used to support development of fracture models of pack ice.

For future cruises it would be advantageous to have a camera mounted to the helicopter, pointing downwards with a coincident record of geodetic location and altitude. This could provide a record of ice conditions that could be used to estimate scale of features on the ice and would not take up a seat on the helicopter. It is my understanding that a camera exists for the helicopter used on the Louis S. St. Laurent. This camera may have been used in support of the SHEBA campaign in the late 1990's, and is currently believed to reside in Ottawa.

Observations taken on ice stations

Transects of ice thickness, snow depth and melt pond depth can provide additional information about ice conditions that is not possible to gauge with shipboard methods. We had two objectives for ice station work: (1) to determine the mean level ice thickness and variability at point locations during the cruise, and (2) to investigate surface melt conditions in support of the albedo model development of Don Perovich, and to provide information about the progress of this summers melt. The most important component of our ice station work was to compliment the deployment of a cluster of six ice drifting buoys that will monitor ice deformation (the IARC GPS drifters) around an Ice Mass Balance Buoy (in collaboration with Cold Regions Research and Engineering Laboratory) that will monitor the thermodynamic evolution of the multi-year ice in the center of the buoys array.

Determining the mean level ice thickness within a region is compounded by the high variability of the thickness distribution. Ship board observations can provide an estimate of the significant modes of ice thickness within a region, however the shipboard observations can not provide good estimates of the spatial distribution of thickness. New ice production typically occurs in leads or polynyas, which results in zones of similar ice with correlated thickness probability distribution on the order of 100m to kilometers. A kilometer transect can provide a reasonable representation of the thickness distribution of ice within view of the ship, and, combined with ship observations could be used to represent the thickness distribution of ice within the 20mile by 20mile region of the buoy array. This information would then be used to initialize dynamic-thermodynamic models of the regional ice thickness evolution over the coming winter.

We participated in four ice stations.
September 2nd: 0.3nm transect of ice thickness and snow depth
September 4th: ITP,IMP,NPS buoy deployment site. Installed RADAR reflector. EM-31 malfunctioned.
September : ITP deployment site. Melt pond depth, ice thickness on melt ponds, short transect of ice thickness and snow pits.
September 10th: Revisit of 2005 deployed IMB and ITP. Melt pond depth, very quick snow pit and ice thickness on melt ponds.

We had anticipated that we would have ample opportunity to work on ice stations during this cruise. The plan had been that we would make use of the ice stations to deploy Ice Tethered Profiler Buoys. The logistics of this did not go as smoothly as anticipated, and we were unable to attend all stations. Our first station occurred later in the cruise on September 2nd, and at this station we discovered problems in using the EM-31 instrument we had been lent from CRREL for ice thickness transects. We did not have an opportunity to work on the ice again until we reached the site of our buoy deployment. At this ice station we found another problem with the instrument. Without the use of the EM-31 we were unable to do the ice thickness transects planned. We were able to collect information for Don on melt pond depth and snow cover.

Comments on Ice Station Logistics

In future, we need a couple of opportunities to test the EM-31 on ice before we reach the most crucial regions for data collection. This would give us the chance to fix problems that might have arisen in shipping. On this cruise we had believed we would have opportunities to participate in the ice stations earlier in the cruise, and had planned on using these. However, on the days that these stations occurred, we found that we were passed over on opportunities to go on the ice. The communication was such that we only were told the plans for the ice station just before the ice station happened. This is not unusual, as one has to plan to work with the ice conditions presented. However, we did find that we were not included in the discussion about how the ice station would proceed, but were rather told that we would be on the ice last if chance arose. Given that the logistical needs of our ice station work was only a helicopter flight out and back, and we could benefit from maximum time on the ice, this situation was not optimal. It would have increased our productivity greatly if we had been placed on the ice with the first flight out. Due to our late arrive at ice stations, our time on the ice was limited, such that it was not possible to take long transects. In fact, on the last ice station, we only barely had enough time to collect the minimum amount of data.

It would have been possible to collect more ice station data, and collect samples from ice beside the ship, had we been able to use the man basket.

From ships of opportunity, that are not planning on extensive ice station work, more detailed ice thickness data could be obtained by airborne instruments. For example, an EM-bird slung by helicopter or a remote controlled vehicle with laser altimeter could provide the spatial coverage necessary to estimate regional thickness distributions. However, these methods require considerable resources, and still require detailed ice transect validation.

Description of Ice Zones

Bringing together the suite of observations taken during the cruise, preliminary maps of the main zones of ice in the Beaufort Sea during late summer 2006 are presented.

<u>Physical Ice Properties</u>

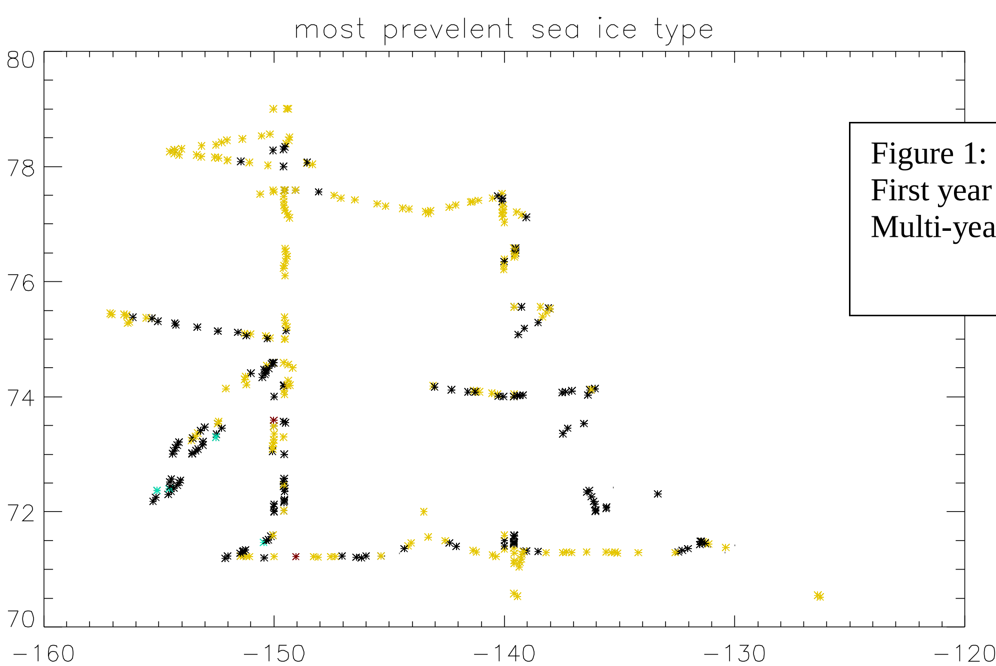
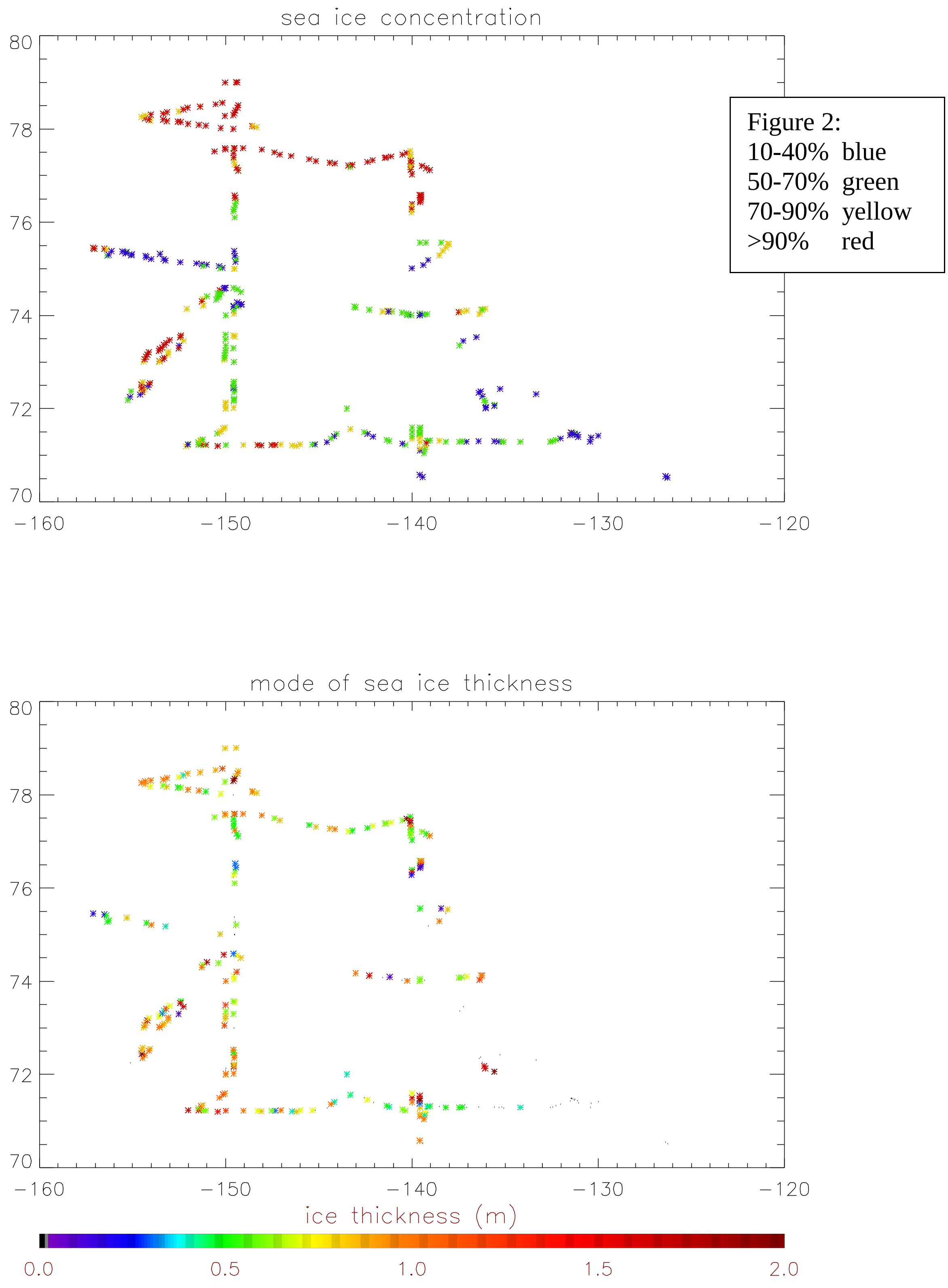
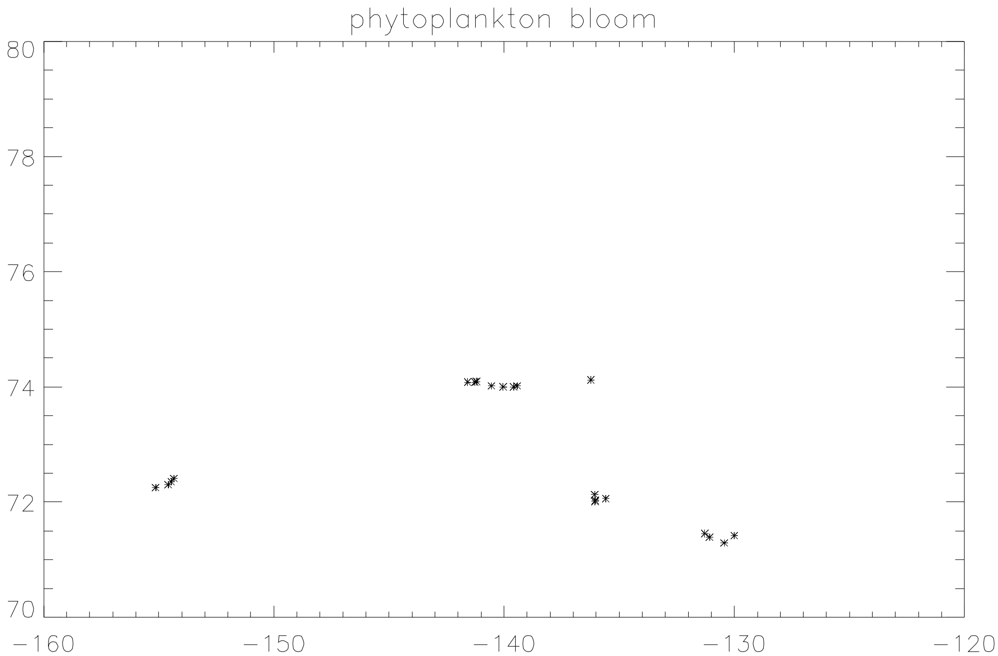


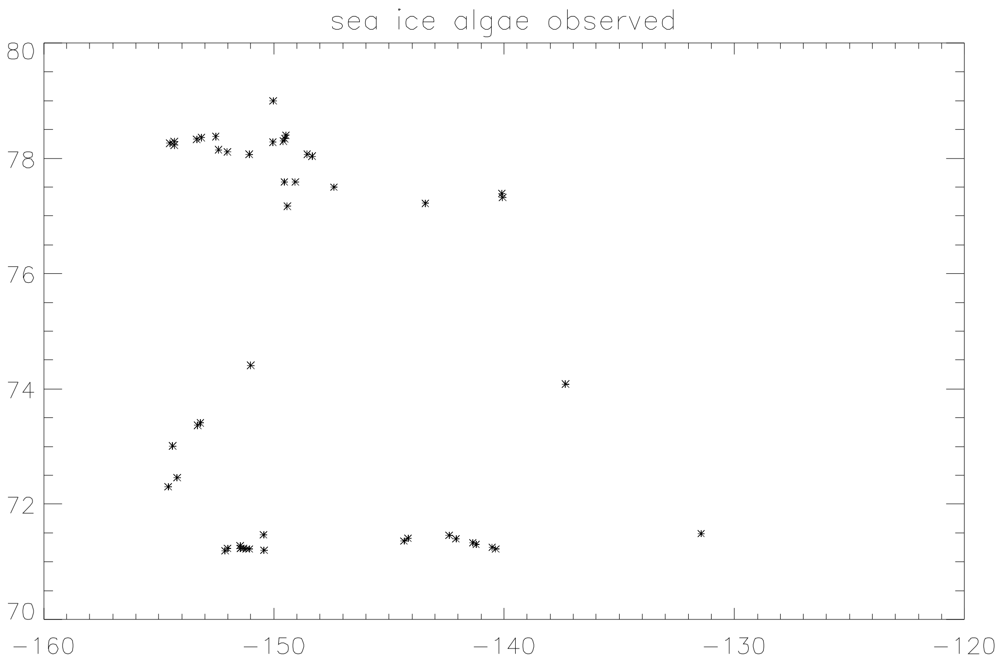
Figure 1:
First year ice yellow
Multi-year ice black


sea ice concentration
80
78
76
74
72
70
−160
−150
−140
−130
−120
Figure 2:
10-40% blue
50-70% green
70-90% yellow
>90% red
mode of sea ice thickness
80
78
76
74
72
70
−160
−150
−140
−130
−120
ice thickness (m)
0.0
0.5
1.0
1.5
2.0

Phytoplankton Blooms



Ice Algae Patches



GPS Buoy Deployment

The prime objective of our project, deployment of a GPS buoy ice deformation array, was successfully completed. This buoy array will monitor pack ice strain rate of a 20mile region about a central autonomous buoy site, with 10 minute frequency.

The buoys were started on August 15, and ran for 2 ½ weeks on deck. There are no problems to report with the buoy performance, and the data collected on deck will be used to estimate position measurement accuracy for each buoy. On several occasions, we experienced 1-3hour degradation of GPS signal, when position accuracy increased to over 20m. The quality control procedures on the buoys worked, filtering out this data, and the buoys came back on line successfully after each GPS blackout.

On September 4th, 6 ice drifting GPS buoys were deployed in a 10 mile radius ring about a central site with Ice Tethered Profiler, Ice Mass Balance Buoy and Heat Flux Buoy. The region of deployment, around 78N 140W, was covered with greater than 90% multi-year, first year and new white ice from this season. The new white ice, about 20%, was covering thaw holes within ice floes, and recently opened leads. There were three lead systems running North-South through the region, at approximately 5 mile spacing. The central lead, within 500m of the central buoy site, was about 50m wide. The other two lead systems consisted of regions of cracks about 1-2miles wide. The easterly and westerly buoys were placed in these regions of cracks. All buoys were placed on small, 20-100m multiyear floes. We chose floes that were within 1nm about our planned deployment location, that had obvious melt ponds that were not thawed through, and hummocking or old weathered ridges. As we deployed six buoys, there is redundancy in the deformation array, so we decided to risk placing the buoys in regions that could see a lot of ridging. It took 3 hours to deploy the array, roughly ½ hour per buoy. We spent 15-25 minutes on the ice at each buoy site, drilling two holes to measure ice thickness and anchor the buoy. The deployment time could be cut down by an hour if we use anchors that do not require drilling through the full thickness of the ice.

As the buoys were deployed around an active lead system, we are already collecting data that will be useful in validating models of sea ice deformation. As the entire ice pack opened up during the Sept. 3rd storm, we should see inertial motion in the buoy array deformation if the pack divergence is responding to the inertial motion induced by the passage of the weather system. Our buoy deployment went more successfully than we had anticipated, and being onboard to observe the ice in the region of deployment has added dimensions to the project that would not be possible otherwise.