NBP1702 Cruise Report

Scientific Activities aboard the RIB N. B. Palmer

McMurdo Station, Antarctica to Lyttelton, NZ

24 January 2017-6 March, 2017

Overview of operations

The cruise NBP17-02, SNOWBIRDS, is supporting a first order test of the N and Si diatom nutrient isotope paleoceanography proxies. The cruise allows for field sampling of water, particles, natural diatom assemblages and the ability to isolate specific organisms in the field. These samples will be used investigate species and assemblage related variability in diatom nitrogen and silicon isotopes and their relationship to surface nutrient fields and early diagenesis.

NBP1702 officially began at McMurdo Station, Antarctica on January 24th when we left the ice pier and ended 42 days later in Lyttelton, New Zealand on March 6, 2017. The cruise plan was to occupy 15 stations at ~1° of latitude spacing along 170°W between 67 and 54°S (Table 1, Figure 1). Operations began on January 28th, after a five day transit. The cruise was interrupted after Station 4 by a ~7 day transit for a personnel transfer back at McMurdo Station. Fifteen sampling stations were occupied during the cruise. All but one included sampling from the water column and sediments. One station, Station 6 at ~62.3°S, was limited to coring only.

From a research perspective, the cruise was a success. We recovered almost all the material we sought from each Station (Table 1). The exception being the collection of surface sediments from the opal belt and the erroneous pumping depths at Stations 5-8. From a logistical perspective, the cruise was littered with improbable technical glitches and a personnel issue that forced the return to McMurdo (Table 2).

Cruise Activities by Sample/Sampling Type

Water

The CTD and 24-Niskin bottle rosette were used to collect water column profile data (T, S, fluorescence, O_2, PAR, SPAR beam transmission, and sound velocity) and water samples for chlorophyll, biogenic silica, nutrients, nutrient isotopes, and diatom assemblage measurements (Table 3). Water was filtered at 0.45 µm capsule filters (AcroPak). Additional samples were collected for Anderson group (Pa and Th work) and two large shipboard culture experiments. Hydrocasts were limited to the upper 1500 m of the water column between 67 and 61°S and the upper 2000 m between 60 and 55°S. One full ocean depth cast, to 5248 m, was deployed at 54°S. All bottles were fired, generally two per depth, at each station. Two additional CTD casts were done at Stations 10, 13 and 14, to 150 m, in order to evaluate the location of the Deep Chlorophyll Maximum

(DCM) for the purpose of siting a second round of McLane Pump casts. No bottles were fired during these CTDs.

Overall CTD operations were smooth, with the exception of the cast at Station 3, 65°S where the wire kinked and required retermination. At Stations 5-14, a trace metal pump, collecting water at 25 m, was deployed simultaneously with the CTD to save time.

The CTD and nutrient data showed a predictable transition from the cold, nutrient rich Antarctic Zone of the Southern Ocean through the warmer, more nutrient poor Subantarctic Zone (Figure 2). The transition from silicic acid bearing to silicic acid depleted (<1 µM) was located at 62°S, with a slight increase (to ~3µM) to the north until 54°S where it was <1µM again. Nitrate was consistently high in the surface, always greater than 12 µM, with variable degrees of enrichment due to regeneration in the shallow subsurface.

Trace Metal Pumping

Surface seawater samples were collected using a trace metal clean pump and tubing hand deployed to a depth of 25 m at each station (Table 4). Once onboard, water was collected or filtered to collect particles at 0.2 and 0.02 µm. In lab at USC, Pinedo will measure Fe, Cd, Zn, Co, Cu, Ni, and Pb concentrations in the particulate (both intracellular and adsorbed metals), dissolved (operationally defined as metals passing through a 0.2um filter) and soluble (<0.02µm) pools.

Particles

Four McLane pumps were deployed between 25 and 800 m water depth, (typically 25, 60-80, 250, and 800 m) to capture particles (Table 5). A pressure sensor was deployed at each station to evaluate true pump depths. The sensors were calibrated with the CTD during a test CTD between Stations 4 and 5.

The goal was to pump approximately 1000 L of water at each depth to collect enough biogenic silica to perform the diatom nutrient isotope analyses on each sample, >100 mg of biogenic silica. The pumps performed well, often exceeding 1000 L, although with frequent low battery shutdowns, suggestive of poor quality batteries supplied by ASC. At Stations 5-8 the pumps were placed at nominal depths of 25, 75, 250, and 800 m, however the winch reading was off by a factor of 2, such that the depths were actually 12.5, 37, 125, and 400 m. Despite the use of the pressure sensors, the source of this error was not discovered until Station 8. It was corrected for subsequent deployments, however we were not able to re-pump at Stations 5-8. At Station 10, the shallowest pump failed and a second pump cast was performed to collect the samples. Two pump casts were performed at Stations 13 and 14 to compensate for low particle densities—a second CTD was deployed to locate the DCM prior to the second round of pumping.

Sediments

Surface sediments were the coring target at each station for the Robinson group (Table 6), while the Anderson group sought longer, downcore records at a subset of the sampling stations (Table 7). The megacorer, designed to sample surface sediments in 12 discrete core tubes, could provide enough surface and near surface sediment for multiple lines of inquiring including bulk sediment chemistry, diatom nutrient isotope, assemblage, and exploratory biomarker work as well as downcore profiles for the Anderson group to couple to their longer records and porewater silicon isotope work.

Stations 1-3, located at approximately 67-65°S, contained abundant ice rafted debris and manganese nodules on the sediment surface (Figure 3; Core Photos). This, combined with relatively rough seas, were difficult to core well and often multiple deployments were necessary to recover the desired amount of mud. In the end, multiple cores, with 10-25 cm of mud were recovered. In addition, we encountered several technical problems, including the 9/16th wire jumping the shiv at Station 1 and complete loss of the instrument package at the termination at Station 2. The URI megacorer, onboard as a spare, was used from Station 2 onward, with excellent results where the sediment type was amenable to coring.

Stations 4-10, from 64-59°S, where sedimentary opal contents were above 40%, proved difficult to core with the megacorer, at least from off the stern of the ship (Figure 3; Core Photos). While it is unclear why, it appears to be some combination of difficulty in penetrating due to the sediment composition and potentially washing out the samples by the ship's motion during the upcast. The small samples of sediment that we did recover were opal rich and relatively stiff, indicating that more weight and perhaps more cutting ability was needed. Further attempts to recover surface sediment in this region included sitting longer with the megacorer on the bottom, deploying a 1 m Kasten core with 700 lbs and again with 1200 lbs of top weight, as well as the LDEO gravity corer with a ~500 lbs head weight. The Kasten core was successful on only one occasion, at Station 5. The LDEO gravity corer recovered ~50 cm of sediment at Station 5, although it appeared to be disturbed. Any other sediments recovered in this latitude band were recovered by some combination of gravity corer (GC/LGC), jumbo gravity corer (JGC), jumbo piston corer (JPC).

Stations 11-15, 58-54°S, were easier to core than the locations within the opal belt (Figure 3; Core Photos). This is likely in part due to the sediment composition, with far more clay and less opal, and in part due to a shift to using the starboard A-frame to deploy the megacorer. This moved the corer toward mid-ship and reduced the vertical motion due to pitch during the casts. This was not an option earlier in the cruise because the JPC cradle and bomb were located in front of the gate, blocking the path of the megacorer through the A-frame.

The megacore deployments were progressively more successful, likely because of the decreasing opal content. At Station 11, 6 ~10-15 cm cores were recovered. The number and length increased with each successive station, with 10 ~20 cm cores landed at Station 12, 11 ~20 cm cores landed at Station 13, and 12 ~25-27 cm cores at Station 14.

Long Coring Long cores on NBP17-02 were coordinated by the group from Lamont-Doherty Earth Observatory (Frankie Pavia and Marty Fleisher). The goal was to six 10 foot long gravity cores (2 cores each at 64°S, 63°S and 62.5°S) and two 70 foot long piston cores at 62°S. Due to a variety of issues, our actual coring operations differed significantly from this plan. What follows is a summary of our coring operations, and a narrative of what worked and didn't work as we tried to core opal-rich sediments on this cruise.

Station 4 (64°S) The LDEO gravity corer was deployed three times from the aft A-frame at this station. Early on we used an incorrect labeling system for our cores. The core ID in parentheses represents the labels that we originally used and may still be on the barrels of cores.

NBP17-02-04-01GC (Stn4 GC1)-Our only successful core at this site, although only 60 cm long. We tried to use a plastic core catcher supplied by the Leventer group, but it shattered, with some pieces found embedded in the surface sediments of the core, and others visible along the length of the core. We began the cruise using 10 foot lengths of clear 4" Schedule 40 PVC pipe. The Lamont Gravity corer does not use a steel barrel, just the bare PVC liner for coring. Amy Leventer lent us two cutter noses, which could be attached to the bottom end of our PVC liners.

NBP17-02-04-02GC (Stn4 GC2)- We switched to a metal core catcher from the supply that came with the Palmer's JPC coring gear. With deteriorating weather, this core came back showing clear disturbances. There were a few cm's at the bottome of the core, followed by a metrer of muddy water, then about 50 cm of jumbled up mud with large voids of water, and then more water above that. The sediment was determined to be unusable, and dumped onto the deck and washed overboard.

NBP17-02-04-03GC (Stn4 GC3)- As the weather further deteriorated to ~10 foot seas, we attempted another Gravity core at Station 4. This was completely unsuccessful, as the core liner came filled with water.

The results from this station were our first inklings of the two problems that would plague many of the coring operations on this cruise;1) a sediment layer at depth (20cm-60cm) that was difficult to penetrate and 2) core washout, especially with stern deployments, as coring gear was brought up through several thousand meters of water.

Station 5 (63°S) NBP17-02-05-04GC (Stn5 GC1)- Sea state about the same at end of Station 4. Only the material in the core catcher was saved. The sediment in the core liner itself was all jumbled up and not useful. Core catcher material was pretty stiff. NBP17-02-05-05GC (Stn5 GC2) collected only 50 cm of mud and top was disturbed (core catcher effect?). Cut pipe 6cm above top of sediments, capped and stored vertically to let top of sediment settle to a horizontal layer. Later, the liner was cut so the core could be shipped in a horizontal position. NBP17-02-05-06GC (Stn 5 GC3)-We reused the core barrel from the previous gravity core, so it was less than 10 feet long, in hopes that a shorter core liner might reduce the amount of sample loss on recovery from the seafloor. This core was also only about 50cm long. Amazingly, with a coring head weight of ~500 pounds, and a speed at entry to the sediment of 60m/min, we only recovered 50 cm of mud. A hard, dry opal-rich layer filled the core catcher.

Station 6 (62.5°S) NBP17-02-06-07GC (Stn 6 GC1)-Again, coring head weight of 500 pounds was not enough to penetrate a dense layer of material at ~30 cm. We recovered a core of only 30 cm. The surface of the core looked disturbed, so the liner was cut a bit long and stored horizontally with some overlying water. Eventually, the sediment settled to a length of 24 cm, and it was cut to this length and stored horizontally. NBP17-02-06-08GC (Stn6 GC2) Core from same location as above with almost identical results; a 28cm long core, stored vertically, and eventually cut down to 24 cm.

At this point, the consensus was that we needed a bigger hammer. The decisions taken were to move coring from the aft A-frame to the starboard A-frame to avoid some of the surge issues we believed were causing us to lose sediment as cores were brought up through the water column, and to use the 4000 pound JPC coring head for Jumbo Gravity Coring (JGC).

NBP17-02-06-01JGC-One of our coring liners was modified, cutting off the coupling end, to fit inside the single steel barrel of the JGC rig. Two core catchers were used, and a cutter nose from the JPC was attached to the bottom of the steel barrel. Chief Engineer JP was at the winch controls during this operation. The corer entered the sediments at a speed of 30m/min. Recovery on the deck showed us a 248cm long core, and both core catchers (stored separately) also contained mud.

<u>Station 7 (62°S)</u> Flush with our success at Station 6, we proceeded back to Station 7, and had two failed attempts to get JGC samples in preparation for piston coring. We finally got out the biggest hammer on the ship, the Jumbo Piston Corer. Our proposal had targeted this site for a pair of 70 foot long piston cores. We realized that attempting a 70 foot piston core would likely have ended up with bent sections of pipe from not penetrating far enough into the sediment, so our initial coring attempt was made with 20 feet of pipe, and our clear PVC liners.

NBP17-02-07-01JPC- Again with Chief Engineer JP at the winch controls, the trigger core hit the sediments at 10 m/min. The free-fall was only 2.5 feet. We recovered almost 16 feet (top section=217cm, bottom section= 264cm, for a total of 481cm) of sediment from the main core barrel, along with the cutter nose and 2 core catchers. Perhaps unsurprisingly, the trigger core barrel came up empty.

Pressed for time, we decided against trying for a 2nd piston core at Station 7 and moved on to Station 8.

<u>Station 8 (61°S)</u>

Mega- and Kasten- coring was proving quite difficult, so in preparation for our JPC work, we collected a 275cm long JGC (NBP17-02-08-04JGC) as a way to collect surface sediments, perhaps, for chief scientist Becky Robinson. That core will go to URI for archiving.

We tried for 30 foot piston cores at this station. NBP17-02-08-02JPC-This deployment did not recover any sediment and some gear was lost. As far as we can tell, on impact with the sediments, the set screws holding the bottom section of pipe on the JPC were sheared off, losing any sediment that might have been recovered, along with a length of core pipe, a coupler, two core catchers, a cutter nose, and two 10 foot sections of clear PVC core liner.

As an aside, we had to loosen those same set screws when trying to get the core liner into the pipe while preparing for the activity, and the set screws were tightened again after all of the core liners/core catchers/cutter nose were in place. It is possible that the piston encountered the same blockage as it was pulled through the liners at the seafloor, and sheared off the set screws at that time.

NBP17-02-08-03JPC- Another attempt at a 30 foot piston core with our last three pieces of clear PVC liner. This time, a section of core pipe was not pushed all the way into the upper pipe coupler. As the JPC went from a horizontal to a vertical position, two sections of core pipe, core catchers, cutter nose and another three 10 foot sections of clear PVC core liner fell into the sea. This was disappointing to watch.

NBP17-02-08-04JPC- We switched to white schedule 40 PVC liners with threaded ends for this attempt. On pullout from the sediments we reached a maximum tension of 25,300 pounds, which momentarily exceeded the operational and elastic limits for the 9/16" trawl wire. In the end, we recovered 777.5 cm of mud, in three sections, and 21 cm of mud in the trigger core. More material was also collected in bulk from the two core catchers. The upper 5cm of the core was very liquid. So it was collected and bagged separately too.

Station 9 (60°S) The only long core collected here was a gravity core for Becky Robinson and the URI group (NBP17-02-09-09GC). The upper sediment may have been lost due to over penetration of a relatively short core barrel.

Station 10 (59°S) No long cores collected here

Late in the cruise it was determined that there was sufficient time to head back South to gravity cores at the SubAntarctic stations (11,12, and 13)

Station 12 (57°S) NBP17-02-12-11GC- Using the Lamont gravity core head with the cam-lok coupling modified by MT Garrett Eisele, we cored from the starboard A-frame with a 10 foot white PVC liner, and recovered a 172 cm core.

Station 11 (58°S) NBP17-02-11-12GC- Same set-up as for Station 12. We got an even longer core, 199.5 cm in length. The difference seemed to be mainly in the sediment composition, rather than sea state, to explain our sudden success with gravity coring.

Station 13 (56°S) NBP17-02-13-13GC- Again, we used the same set-up as at the previous two stations. We went into the mud a little faster, and recovered a total of 2.5 meters of core; 226.5 cm in the 10 foot core liner, and 23.5 cm in the combined core catcher/cutter nose. The 23.5 cm section was extruded by hand into a spare piece of clear PVC liner.

Analytical work

Diatom Assemblage

Samples for diatom assemblage quantification were collected from water column, incubation, and sediment samples. Water column assemblage samples were collected from the 4 shallow bottles of all water-collecting CTD casts, covering depths from the near-surface (~5 meters water depth) through the deep chlorophyll maximum (DCM; generally ~65-80 meters). All CTD samples were fixed with acid Lugol's solution to a concentration of 1% by volume, then filtered onto gridded mixed cellulose ester membrane filters with a 0.45 µm pore size. Filters were oven-dried at 35°C and oil-mounted to glass microscope slides for light microscopy. Filtered volume was guided by *in situ* fluorescence measurements. 200 ml were filtered from most depths at stations 1-9, while 350 ml were filtered from all depths at stations 10-15 to account for lower fluorescence. 125 ml subsamples were fixed with acid Lugol's and archived for further processing to allow species-level identification of the small centric diatoms whose chloroplasts make them difficult to identify from fresh material. Cell concentration spot-checks were performed under light microscopy at x400 magnification.

5 ml assemblage splits were collected from all McLane pump samples and preserved with 3 drops of acid Lugol's. For the majority of stations and depths, 2 ml of particle slurry were resuspended in 50-100 ml of filtered (0.45 μm) seawater to allow even dispersal, collected on 0.45 μm gridded membrane filters, and mounted to microscope slides as described above. At stations 1-4, particles were abundant in DCM samples on visual inspection and slurry volumes were decreased accordingly to 0.25 to 1 ml. Residual slurry was archived for further processing.

Incubation samples were prepared following the same protocol as the pump samples. For all carboys, duplicate slides were prepared using 5 and 10 ml of slurry resuspended in 100 ml of filtered seawater and 125 ml subsamples were reserved for further processing.

Sediment samples were collected for assemblage work from all stations where shipboard sampling of surface sediments took place. Oil-mounted temporary smear slides prepared from core top samples from some stations, and from some JPC and JGC core catchers, were examined at x400 magnification using plain and polarized light. Samples will be freeze-dried on arrival at Otago and permanent quantitative mounts will be prepared following the method of Warnock and Scherer.

Chlorophyll a

The concentrations of chlorophyll *a* and phaeophytin were measured at sea at seven depths in the upper 250m on all CTD casts where seawater was collected. Particles from 320 ml of seawater were filtered onto 0.45um 47mm HAWP filters, frozen for 20 h at -20ºC and then extracted for 24-48 h in 90% acetone. Pigment concentrations were measured on a Turner 10AU fluorimeter using the acidification method. The fluorimeter was calibrated spectrophotometrically against an *Arabidopsis* chlorophyll standard at the beginning of the cruise.

Dissolved Silicon (silicic acid) concentration Dissolved silicon centration was measured from all water column depths sampled on the CTD casts. The analysis employed the molybdenum blue method with metol-sulfite as reductant with seawater sample absorbance calibrated against artificial seawater standard curves. The Si blank associated with the reagents was evaluated by a reverse-addition blank where the order of addition of the acid molybdate and reducing reagent were reversed. The precision of the method is ±0.05 μM.

Pore waters were extracted from ~1 cm slabs of sediment by centrifugation at 2500 g followed by filtration. The resulting supernatant (5 – 30 ml) was diluted to 200 ml with deionized distilled water and filtered through a 0.45 μm polycarbonate filter. A subsample was analyzed at sea for dissolved silicon concetration with the remainder of each sample stored in polypropylene bottles for isotopic analysis back at UCSB.

Biogenic silica and lithogenic silica concentration Samples for biogenic silica concentration analysis were collected in parallel with samples for dissolved silicon analysis on CTD casts. Duplicate samples were collected at 25 m and the chlorophyll fluorescence maximum for analysis at sea in order to estimate the amount of biogenic silica being sampled by McLane pumps at these same depths. All other samples will be analyzed at UCSB for both biogenic and lithogenic silica concentration. For all samples 1L of seawater was filtered through a 1.2 µm polycarbonate filter that was then folded in quarters, placed in a 1.5 ml cryovial and dried at 65ºC followed by storage at room temperature.

Analysis at sea employed hot (95ºC) 0.2 N NaOH digestion in PTFE tubes followed by neutralization with 1N HCl, dilution and analysis of the diluted digest using the protocol described above for dissolved silicon analysis except that standard curves were made up in deionized distilled water rather than artificial seawater.

Silicon isotopes Seawater samples for the Si isotopic composition of silicic acid were collected at all depths on each CTD where water was collected. Water samples (1-2L) were filtered directly from Niskin bottles through a 0.8/0.45µm Supor filter cartridge and stored at room temperature. The diluted pore waters described above were stored at room temperature for shipment back to UCSB for isotopic analysis.

Seawater nutrients and nitrate isotope samples Both silicic acid (Brzezinski) and nitrate (Robinson) concentrations were measured on all seawater samples from the CTD/rosette at sea. An additional 40 ml sample was filtered off the Niskin bottles through the inline Supor filter cartridges into 60 ml polypropylene bottles for the measurement of other seawater nutrients (orthophosphate) back at UCSB and nitrate isotopes at URI. Filtered seawater was frozen and stored at -20ºC.

Nitrate

Nitrate concentrations were analyzed with a Metrohm 844 UV/VISCompact ion chromatograph (provided by the University of Rhode Island Geobiology Laboratory). A 150 mm × 4.0 mm Metrosep A SUPP 8 150 column was used. The column oven was set at 30°C. The eluent was a 1% NaCl solution filtered through a 0.45 µm filter. Approximately 0.8 mL of interstitial water was injected manually into a 250 µL sample loop. Absorption at the 215 nm channel was used for quantification. A dilution series of sodium nitrate standard (RICCA Chemical) was run after every fifth sample. Relative precision was typically better than 3%.

Phytoplankton Grow-Outs Two grow out experiments were conducted during the NBP1702. The first, started with water from 66°S, was representing the Antarctic Zone phytoplankton assemblage. The second, from 61°S, reflects the Antarctic Polar Frontal Zone assemblage. In each case, 3 x 20L of seawater were collected from Stations 2 and 8 (66°S and 61°S, respectively), nutrients including vitamins and trace metals were added and the carboys place in Little Antarctica until ~50% NO_3 consumption to test the impact of the *in-situ* assemblage on diatom nitrogen and silicon isotope fractionation.

At each station, the carboys were filled with ~50% surface water and 50% deep water in order to initiate the cultures with the in site community (surface waters) and enrich the total nutrient content (deep water). Surface waters were a mixture of waters from multiple bottles triggered at 25 m depth while deep waters were collected from 1500m. Three 20 L clear Nalgene carboys were filled with one deep mixture 10 L carboy and one shallow mixture 10 L carboy and immediately set into a temperature controlled cold room. Antarctic Zone (Station 2) incubation temperature was 2°C and Polar Frontal Zone incubation temperature was 5°C, approximately matching the conditions where the surface waters were collected. . Light levels were kept at about 150 µmols photons/m^2/s (150 µE/m^2/s) 24 hours a day, approximately the same light level found at 15m at Station 1. This light level should saturate the photosynthetic mechanism and encourage growth.

We spiked each carboy with about 56.6 mL 106 mM $Si(OH)_4$ stock, 2.26 mL 882 mM NO_3^- stock, 16.57 mL 36.2 mM HPO_3^- stock, 1 mL of f/2 trace metal stock (F/40), and 0.5 mL vitamins. The concentrations of $Si(OH)_4$ and NO_3^- were about 350 µM and 125 µM respectively. For the second experiment, 800 µL of the trace metal stock was used, an addition to about f/50 levels.

A magnetic stir bar and fins was spun at about 100 rpm in each carboy to keep particles from collecting on the bottom of the carboy. Stirring was not maintained consistently during the experiments due to the ship's motion and inconsistencies between stirplates. 0.22 µm filtered air was supplied to maintain a typical seawater pH, using a 60 W aquarium air pump. No diffuser was used. Samples were collected through tubing plumbed through the caps, using imposed pressure differentials to force the sample out of the carboy. This method allows us to keep the cap on at all times and minimizes chances of contamination

Initial samples were taken for dSi, bSi Si isotopes (300 mL) and [NO_3^-] and $\delta^{15}NO_3^-$ (30 mL) and nutrients. Incubation experiments were monitored approximately daily for fluorescence by taking a 10 mL sample from each carboy. Once consistent growth was observed through fluorescence, [NO_3^-] were measured as well. Some intermediate $\delta^{15}NO_3^-$ and $\delta^{15}N_{bulk}$ samples were taken by filtering the sample through a Whatman GF/F filter, then freezing the filter and the filtrate for later analysis. All shipboard [NO_3^-] was measured on the UV-Vis IC.

Each carboy experiment was harvested when [NO_3^-] reached about half of its initial value. 100 mL was filtered through a GF/F for final [NO_3], $\delta^{15}NO_3$, and $\delta^{15}N_{bulk}$. 1 L was filtered through a 0.6 µm polycarbonate filter for dSi, bSi, and Si isotopes. The filters were retained for biogenic silica analysis and the filtrate for Si isotopes in dissolved silicon. 125 mL were reserved for future assemblage and microscopy work and fixed with ~1 mL acid Lugols solution. ~50 mL were used to make slides for assemblage counts (5 mL and 10 mL with acid Lugols and 100 mL FSW each on a 0.45 µm gridded filter, mounted on a glass slide with Type A immersion oil) and set aside for future isolations. The remainder (~18 L) was filtered onto 24-32 47mm 5µm PC filters and frozen for diatom nitrogen and silicon isotope analysis.

NB: Carboys were insufficiently homogenized prior to taking samples in the first incubation, which may explain some of the variability in the fluorescence and nutrient measurements.

Core processing

After each successful megacorer deployment, the recovered cores were described, measured, photographed (Core Photos), drained of their overlying water, and sampled or archived (Core Photos/NBP1702-Core Sampling). One whole core tube was taken as an archive sample from each station, to be transported upright back to URI for curation. Any other cores were extruded and sampled, generally at 1 cm intervals, and bagged for shipment and analysis. This includes but it not limited to samples for diatom nitrogen and silicon isotope analyses, diatom assemblage quantification (Otago), sea ice biomarker proxy development (Otago), ancillary bulk sediment parameters, including $CaCO_3$, biogenic silica, and total organic carbon and nitrogen analyses (URI). Surface sediments were collected from any cores recovered beyond the minimum number required to accommodate existing sampling needs.

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Table 1. Sampling summary NBP1702

Latitude °S	Station ID	CTD (total depth)	Trace Metal Pump (deployment depth)	McLane Pumps (number of casts, comments)	Megacore (cores recovered)	Kasten Core (recovery)	Gravity core-LGC/GC (recovery length(s))	JGC	JPC
67	1	1500 m	25 m	1	6				
66	2	1500 m	25 m	1	11				
65	3	1500 m	25 m	1	3				
64	4	1500 m	25 m	1	4		63 cm GC, to LDEO		
63	5	1500 m	25 m	1, winch readout failure	1	20 cm undisturbed, 20 cm disturbed	50 cm GC, 55 cm GC to LDEO		
62.5	6	1500 m						248 cm, to LDEO	
62	7	1500 m	25 m	1, winch readout failure					481 cm, to LDEO
61	8	1500 m	25 m	1, winch readout failure				275 cm, to URI	777.5 cm to LDEO
60	9	2000 m	25 m	1			178 cm LGC, over penetration 80 cm GC, to URI		
59	10	2000 m	25 m	1			121 cm LGC, over penetration 152 cm GC, to URI		
58	11	2000 m	25 m	1	6		205 cm GC, to LDEO		
57	12	2000 m	25 m	1	10		170 cm GC, to LDEO		
56	13	2000 m	25 m	2, low particle density	11		250 cm GC, to LDEO		
55	14	2000 m	25 m	2, low particle density	12				
54	15	5248 m	25 m	2, low particle density	1				

no surface sediment recovered

incorrect depths sampled

Table 2. Summary of Improbable Events

Latitude °S	Station ID	Improbable Event
67	1	Smith-MacIntyre Grab fouled,9/16th wire jumped shiv during megacore deployment, melted bronze
66	2	lost megacorer
65	3	retermination of CTD
64	4	broken tooth, coring difficulties began, personnel dispute->returned to McMurdo; picked up Jack
63	5	Waterfall Winch readout off by factor of two- impacted McLane pump casts
62	7	Waterfall Winch readout off by factor of two- impacted McLane pump casts
61	8	Waterfall Winch readout off by factor of two- impacted McLane pump casts; 9/16th Winch readout off by factor of 2, cannot find bottom during JPG; Lost 3rd barrel during 02JPC, no recovery; Dropped lower 2 barrels of 03JPC during deployment.

Table 3 CTD Station information and metadata

Cruise	Event # (gmt)	Consecutive #	Activity	UTC Date	UTC Time	NZ Date	NZ Time	Latitude (deg) S	Latitude (mm.mmm) S	Longitude (deg) W	Longitude (mm.mmm) W	Station/Site	Bottom Depth (m)	Latitude (dd.ddd) N	Longitude (dd.ddd) W
NBP1702	201702111412	037	CTD05	11-Feb-17	14:12	12-Feb-17	3:12	63	9.848	169	53.209	5	2932	-63.16413	-169.88682
NBP1702	201702132110	052	CTD06	13-Feb-17	21:10	14-Feb-17	10:10	61	52.523	169	58.156	7	3244	-61.87538	-169.96927
NBP1702	201702161636	063	CTD07	16-Feb-17	16:36	17-Feb-17	5:36	60	49.697	170	22.390	8	3453	-60.82828	-170.37317
NBP1702	201702171903	068	CTD08	17-Feb-17	19:03	18-Feb-17	8:03	59	58.781	170	2.478	9	3793	-59.97968	-170.04130
NBP1702	201702191848	078	CTD09	19-Feb-17	18:48	20-Feb-17	7:48	58	59.630	170	1.660	10	4745	-58.99383	-170.02767
NBP1702	201702201412	082	CTD10	20-Feb-17	14:12	21-Feb-17	3:12	59	1.036	170	4.378	10	4769	-59.01727	-170.07297
NBP1702	201702211229	087	CTD11	21-Feb-17	12:29	22-Feb-17	1:29	57	57.211	170	6.594	11	4488	-57.95352	-170.10990
NBP1702	201702220756	092	CTD12	22-Feb-17	7:56	22-Feb-17	20:56	57	9.594	170	1.814	12	4662	-57.15990	-170.03023
NBP1702	201702230509	098	CTD13	23-Feb-17	5:09	23-Feb-17	18:09	56	10.136	170	0.527	13	4372	-56.16893	-170.00878
NBP1702	201702231835	101	CTD14	23-Feb-17	18:35	24-Feb-17	7:35	56	9.879	170	4.395	13	4530	-56.16465	-170.07325
NBP1702	201702260229	108	CTD15	26-Feb-17	2:29	26-Feb-17	15:29	55	6.209	169	55.172	14	4623	-55.10348	-169.91953
NBP1702	201702261518	111	CTD16	26-Feb-17	15:18	27-Feb-17	4:18	55	6.236	169	58.715	14	4658	-55.10393	-169.97858
NBP1702	201702281720	114	CTD17	28-Feb-17	17:20	01-Mar-17	6:20	53	57.484	173	54.397	15	5226	-53.95807	-173.90662

Table 4. Trace metal pumping station metadata

Cruise	Event # (gmt)	Consecutive #	Activity	UTC Date	UTC Time	NZ Date	NZ Time	Latitude (deg) S	Latitude (mm.mmm) S	Longitude (deg) W	Longitude (mm.mmm) W	Station/Site	Bottom Depth (m)	Latitude (dd.ddd) N	Longitude (dd.ddd) W
NBP1702	201701290300	007	TM01	29-Jan-17	3:00	29-Jan-17	16:00	66	58.903	170	10.301	1	3724	-66.98172	-170.17168
NBP1702	201701310312	014	TM02	31-Jan-17	3:12	31-Jan-17	16:12	66	10.811	170	2.017	2	~	-66.18018	-170.03362
NBP1702	201701310903	015	TM03	31-Jan-17	9:03	31-Jan-17	22:03	66	10.700	170	1.700	2	~	-66.17833	-170.02833
NBP1702	201702011400	020	TM04	01-Feb-17	14:00	02-Feb-17	3:00	65	9.326	169	32.600	3	~	-65.15543	-169.54333
NBP1702	201702020954	024	TM05	02-Feb-17	9:54	02-Feb-17	22:54	64	11.790	170	4.627	4	~	-64.19650	-170.07712
NBP1702	201702111411	036	TM06	11-Feb-17	14:11	12-Feb-17	3:11	63	9.840	169	53.200	5	2935	-63.16400	-169.88667
NBP1702	201702132059	051	TM07	13-Feb-17	20:59	14-Feb-17	9:59	61	52.528	169	58.199	7	3244	-61.87547	-169.96999
NBP1702	201702161621	062	TM08	16-Feb-17	16:21	17-Feb-17	5:21	60	49.700	170	22.370	8	3463	-60.82833	-170.37283
NBP1702	201702171852	067	TM09	17-Feb-17	18:52	18-Feb-17	7:52	59	58.760	170	2.470	9	3792	-59.97933	-170.04117
NBP1702	201702171940	069	TM10	17-Feb-17	19:40	18-Feb-17	8:40	59	58.800	170	2.500	9	3795	-59.98000	-170.04167
NBP1702	201702191840	077	TM11	19-Feb-17	18:40	20-Feb-17	7:40	58	59.597	170	1.658	10	4743	-58.99328	-170.02763
NBP1702	201702211220	086	TM12	21-Feb-17	12:20	22-Feb-17	1:20	57	57.220	170	6.590	11	4490	-57.95367	-170.10983
NBP1702	201702220725	091	TM13	22-Feb-17	7:25	22-Feb-17	20:25	57	9.150	170	1.974	12	4643	-57.15250	-170.03290
NBP1702	201702230452	097	TM14	23-Feb-17	4:52	23-Feb-17	17:52	56	10.090	170	0.560	13	4374	-56.16817	-170.00933
NBP1702	201702260213	107	TM15	26-Feb-17	2:13	26-Feb-17	15:13	55	6.201	169	55.167	14	4624	-55.10335	-169.91945
NBP1702	201702281701	113	TM16	28-Feb-17	17:01	01-Mar-17	6:01	53	57.488	173	54.397	15	5225	-53.95813	-173.90662
NBP1702	201702281928	115	TM17	28-Feb-17	19:28	01-Mar-17	8:28	53	57.466	173	54.396	15	5226	-53.95777	-173.90660
NBP1702	201702281958	116	TM18	28-Feb-17	19:58	01-Mar-17	8:58	53	57.445	173	54.394	15	5228	-53.95742	-173.90657

Table 5 McLane Pump station metadata

Cruise	Event # (gmt)	Consecutive #	Activity	UTC Date	UTC Time	NZ Date	NZ Time	Latitude (deg) S	Latitude (mm.mmm) S	Longitude (deg) W	Longitude (mm.mmm) W	Station/Site	Bottom Depth (m)	Latitude (dd.ddd) N	Longitude (dd.ddd) W
NBP1702	201701281944	006	McL01	28-Jan-17	19:44	29-Jan-17	8:44	66	58.900	170	10.302	1	3794	-66.98167	-170.17171
NBP1702	201701301840	013	McL02	30-Jan-17	18:40	31-Jan-17	7:40	66	10.811	170	1.744	2	3000	-66.18018	-170.02907
NBP1702	201702010650	019	McL03	01-Feb-17	6:50	01-Feb-17	19:50	65	9.326	169	32.730	3	2991	-65.15543	-169.54550
NBP1702	201702021446	026	McL04	02-Feb-17	14:46	03-Feb-17	3:46	64	11.802	170	4.616	4	2736	-64.19670	-170.07693
NBP1702	201702111623	038	McL05	11-Feb-17	16:23	12-Feb-17	5:23	63	9.850	169	53.300	5	2871	-63.16417	-169.88833
NBP1702	201702132326	053	McL06	13-Feb-17	23:26	14-Feb-17	12:26	61	52.520	169	58.189	7	3240	-61.87533	-169.96982
NBP1702	201702161908	064	McL07	16-Feb-17	19:08	17-Feb-17	8:08	60	49.930	170	22.600	8	3430	-60.83217	-170.37667
NBP1702	201702172118	070	McL08	17-Feb-17	21:18	18-Feb-17	10:18	59	59.300	170	2.500	9	3806	-59.98833	-170.04167
NBP1702	201702192118	079	McL09	19-Feb-17	21:18	20-Feb-17	10:18	59	0.220	170	1.530	10	4799	-59.00367	-170.02550
NBP1702	201702201450	083	McL10	20-Feb-17	14:50	21-Feb-17	3:50	59	1.072	170	4.300	10	4815	-59.01786	-170.07167
NBP1702	201702211425	088	McL11	21-Feb-17	14:25	22-Feb-17	3:25	57	57.200	170	6.580	11	4428	-57.95333	-170.10967
NBP1702	201702221004	093	McL12	22-Feb-17	10:04	22-Feb-17	23:04	57	9.310	170	1.820	12	4668	-57.15517	-170.03033
NBP1702	201702230720	099	McL13	23-Feb-17	7:20	23-Feb-17	20:20	56	10.290	170	0.430	13	4379	-56.17150	-170.00717
NBP1702	201702231912	102	McL14	23-Feb-17	19:12	24-Feb-17	8:12	56	9.980	170	4.410	13	4500	-56.16633	-170.07350
NBP1702	201702260435	109	McL15	26-Feb-17	4:35	26-Feb-17	17:35	55	6.200	169	55.200	14	4645	-55.10333	-169.92000
NBP1702	201702261547	112	McL16	26-Feb-17	15:47	27-Feb-17	4:47	55	6.300	169	58.710	14	4668	-55.10500	-169.97850
NBP1702	201702282144	117	McL17	28-Feb-17	21:44	01-Mar-17	10:44	53	57.450	173	54.400	15	5227	-53.95750	-173.90667

Table 6 Multicore station metadata

Cruise	Event # (gmt)	Consecutive #	Activity	UTC Date	UTC Time	NZ Date	NZ Time	Latitude (deg) S	Latitude (mm.mmm) S	Longitude (deg) W	Longitude (mm.mmm) W	Station/Site	Bottom Depth (m)	Latitude (dd.ddd) N	Longitude (dd.ddd) W	Samples Collected
NBP1702	201701290750	008	01MC	29-Jan-17	7:50	29-Jan-17	20:50	66	58.904	170	10.292	1	3733	-66.98173	-170.17153	no samples recovered; megacore partially tripped
NBP1702	201701291802	009	02MC	29-Jan-17	18:02	30-Jan-17	7:02	66	58.476	170	9.685	1	3783	-66.97459	-170.16141	6 good samples recovered
NBP1702	201701300825	011	03MC	30-Jan-17	8:25	30-Jan-17	21:25	66	10.800	170	1.700	2	3050	-66.18000	-170.02833	no samples recovered
NBP1702	201701311445	016	04MC	31-Jan-17	14:45	01-Feb-17	3:45	66	10.750	170	1.600	2	2699	-66.17917	-170.02667	
NBP1702	201702011600	021	05MC	01-Feb-17	16:00	02-Feb-17	5:00	65	9.350	169	32.700	3	3033	-65.15583	-169.54500	not enough mud; will redeploy
NBP1702	201702012105	022	06MC	01-Feb-17	21:05	02-Feb-17	10:05	65	9.520	169	36.000	3	3011	-65.15867	-169.60000	3 cores sediment (no core for pore water)
NBP1702	201702022300	027	07MC	02-Feb-17	23:00	03-Feb-17	12:00	64	11.800	170	4.640	4	2696	-64.19667	-170.07733	no samples recovered
NBP1702	201702031620	028	08MC	03-Feb-17	16:20	04-Feb-17	5:20	64	11.790	170	4.650	4	2699	-64.19650	-170.07750	no samples recovered
NBP1702	201702032000	029	09MC	03-Feb-17	20:00	04-Feb-17	9:00	64	11.800	170	4.680	4	2736	-64.19667	-170.07800	4 short cores; will redeploy
NBP1702	201702041155	033	10MC	04-Feb-17	11:55	05-Feb-17	0:55	64	11.790	170	4.690	4	2693	-64.19650	-170.07817	no samples recovered
NBP1702	201702112142	039	11MC	11-Feb-17	21:42	12-Feb-17	10:42	63	9.850	169	53.317	5	2868	-63.16417	-169.88862	1.5 cores; will redeploy
NBP1702	201702120143	040	12MC	12-Feb-17	1:43	12-Feb-17	14:43	63	9.850	169	53.317	5	2872	-63.16417	-169.88862	
NBP1702	201702180343	071	13MC	18-Feb-17	3:43	18-Feb-17	16:43	59	58.800	170	2.500	9	3793	-59.98000	-170.04167	no samples recovered
NBP1702	201702180816	072	14MC	18-Feb-17	8:16	18-Feb-17	21:16	59	58.760	170	2.500	9	3792	-59.97933	-170.04167	
NBP1702	201702211952	089	15MC	21-Feb-17	19:52	22-Feb-17	8:52	57	57.220	170	6.590	11	4490	-57.95367	-170.10983	
NBP1702	201702221539	094	16MC	22-Feb-17	15:39	23-Feb-17	4:39	57	9.130	170	1.960	12	4644	-57.15217	-170.03267	no samples
NBP1702	201702221541	095	17MC	22-Feb-17	15:41	23-Feb-17	4:41	57	9.140	170	1.960	12	4650	-57.15233	-170.03267	
NBP1702	201702231317	100	18MC	23-Feb-17	13:17	24-Feb-17	2:17	56	10.100	170	0.550	13	4374	-56.16833	-170.00917	
NBP1702	201702261008	110	19MC	26-Feb-17	10:08	26-Feb-17	23:08	55	6.200	169	53.200	14	4640	-55.10333	-169.88667	
NBP1702	201703010629	119	20MC	01-Mar-17	6:29	01-Mar-17	19:29	53	53.040	173	40.710	15	4171	-53.88400	-173.67850	no recovery
NBP1702	000020170301	120	21MC	01-Mar-17	11:48	02-Mar-17	0:48	53	50.080	173	47.100	15	5358	-53.83467	-173.78500	5cm mud; Mn nodules

Table 7 Gravity and Piston core station and metadata

Cruise	Event # (gmt)	Consecutive #	Activity	UTC Date	UTC Time	NZ Date	NZ Time	Latitude (deg) S	Latitude (mm.mmm) S	Longitude (deg) W	Longitude (mm.mmm) W	Station/Site	Bottom Depth (m)	Latitude (dd.ddd) N	Longitude (dd.ddd) W
Gravity Cores															
NBP1702	201702040210	030	01GC	04-Feb-17	2:10	04-Feb-17	15:10	64	11.780	170	4.670	4	2703	-64.19633	-170.07783
NBP1702	201702040540	031	02GC	04-Feb-17	5:40	04-Feb-17	18:40	64	11.780	170	4.680	4	2696	-64.19633	-170.07800
NBP1702	201702040844	032	03GC	04-Feb-17	8:44	04-Feb-17	21:44	64	11.810	170	4.690	4	2694	-64.19683	-170.07817
NBP1702	201702120530	041	04GC	12-Feb-17	5:30	12-Feb-17	18:30	63	9.850	169	53.300	5	2870	-63.16417	-169.88833
NBP1702	201702120911	042	05GC	12-Feb-17	9:11	12-Feb-17	22:11	63	10.001	169	50.990	5	2800	-63.16669	-169.84983
NBP1702	201702121943	045	06GC	12-Feb-17	19:43	13-Feb-17	8:43	63	10.000	169	51.000	5	2806	-63.16667	-169.85000
NBP1702	201702131002	048	07GC	13-Feb-17	10:02	13-Feb-17	23:02	62	16.250	169	31.790	6	2973	-62.27083	-169.52983
NBP1702	201702131321	049	08GC	13-Feb-17	13:21	14-Feb-17	2:21	62	16.250	169	31.790	6	2973	-62.27083	-169.52983
NBP1702	201702181217	073	09GC	18-Feb-17	12:17	19-Feb-17	1:17	59	58.760	170	2.450	9	3794	-59.97933	-170.04083
NBP1702	201702202100	084	10GC	20-Feb-17	21:00	21-Feb-17	10:00	58	59.600	170	1.150	10	4750	-58.99333	-170.01917
NBP1702	201702241029	103	11GC	24-Feb-17	10:29	24-Feb-17	23:29	57	9.140	170	1.920	12	4586	-57.15233	-170.03200
NBP1702	201702242053	104	12GC	24-Feb-17	20:53	25-Feb-17	9:53	57	57.230	170	6.610	11	4490	-57.95383	-170.11017
NBP1702	201702251257	105	13GC	25-Feb-17	15:57	26-Feb-17	4:57	56	10.104	170	0.582	13	4380	-56.16840	-170.00970
Leventer Gravity Corer															
NBP1702	201702190136	074	01LGC	19-Feb-17	1:36	19-Feb-17	14:36	59	58.760	170	2.450	9	3798	-59.97933	-170.04083
NBP1702	201702190633	075	02LGC	19-Feb-17	6:33	19-Feb-17	19:33	59	58.770	170	2.470	9	3793	-59.97950	-170.04117
NBP1702	201702200325	080	03LGC	20-Feb-17	3:25	20-Feb-17	16:25	58	59.600	170	1.150	10	4750	-58.99333	-170.01917
NBP1702	201702200844	081	04LGC	20-Feb-17	8:44	20-Feb-17	21:44	58	59.600	170	1.650	10	4750	-58.99333	-170.02750
Jumbo Gravity Corer															
NBP1702	201702141615	056	01JGC	14-Feb-17	16:15	15-Feb-17	5:15	62	16.250	169	31.780	6	2980	-62.27083	-169.52967
NBP1702	201702150015	057	02JGC	15-Feb-17	0:15	15-Feb-17	13:15	61	52.530	169	58.167	7	3243	-61.87550	-169.96945
NBP1702	201702160230	060	03JGC	16-Feb-17	2:30	16-Feb-17	15:30	60	49.700	170	20.400	8	3356	-60.82833	-170.34000
Jumbo Piston Corer															
NBP1702	201702151230	058	01JPC	15-Feb-17	12:30	16-Feb-17	1:30	61	52.810	169	58.910	7	3264	-61.88017	-169.98183
NBP1702	201702161115	061	02JPC	16-Feb-17	11:15	17-Feb-17	0:15	60	49.700	170	20.400	8	3356	-60.82833	-170.34000
NBP1702	201702170740	065	03JPC	17-Feb-17	7:40	17-Feb-17	20:40	60	49.710	170	20.370	8	3350	-60.82850	-170.33950

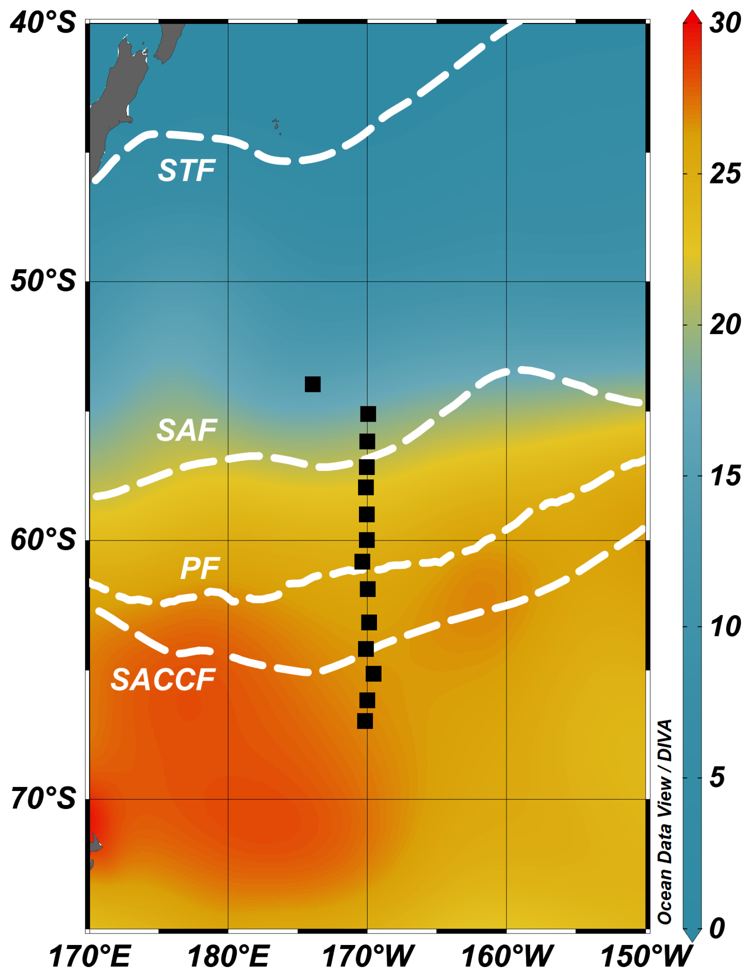

Figure 1. Station location map.

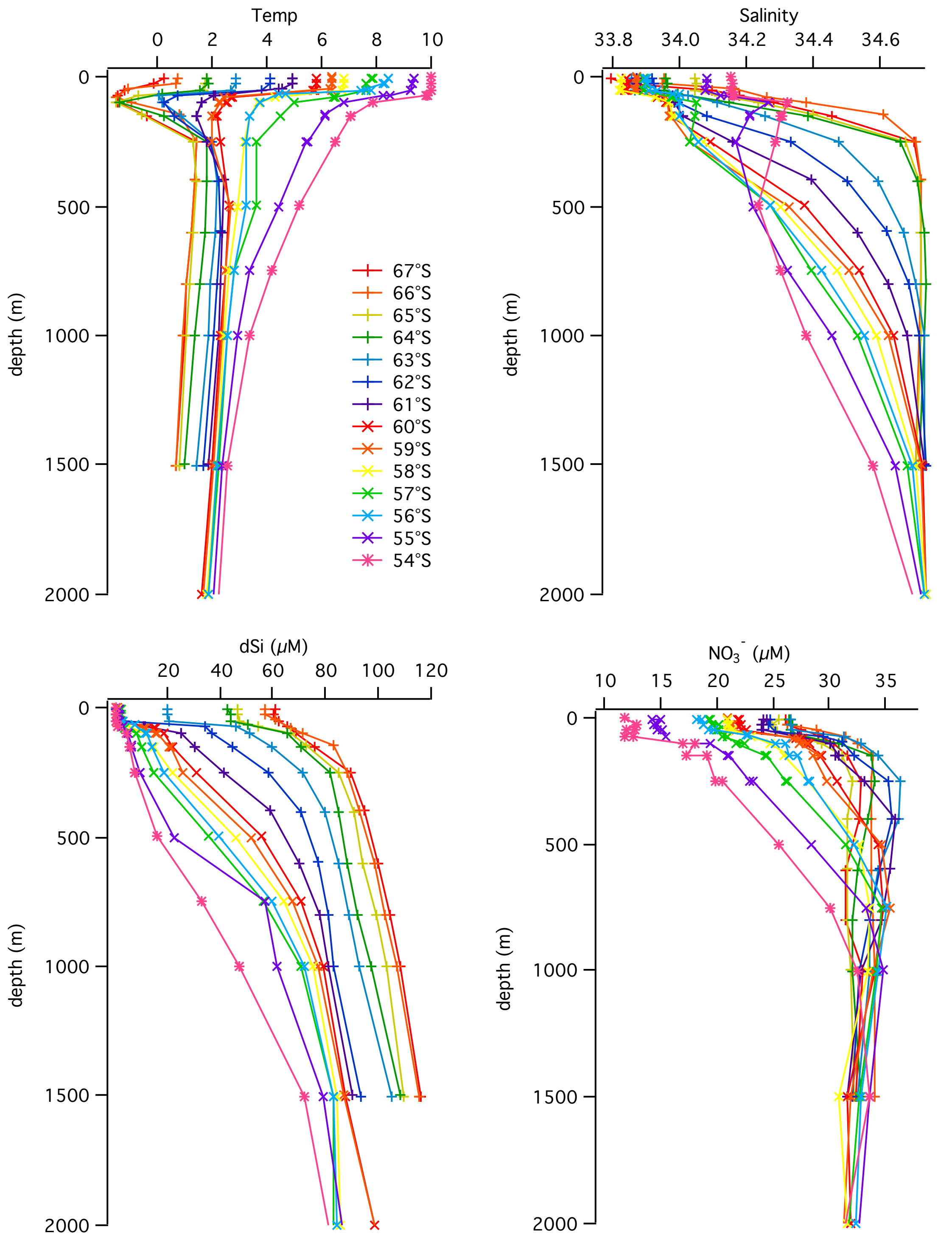

Figure 2. Profiles of temperature and salinity (at the bottle depths) from the CTD (upper panels) and water column dSi and NO_3^- (lower panels) measured shipboard.

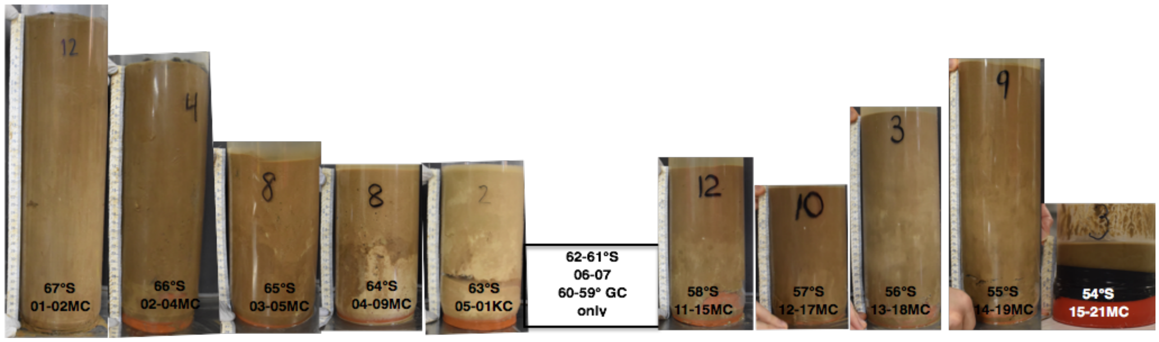

Figure 3. Representative examples of megacores from Stations 15 and 11-15 show distinct changes in both color and recovery of sediment. No megacores were recovered from Stations 6-10.