WOODS HOLE OCEANOGRAPHIC INSTITUTION

DRAFT STANDARD FORM C

PRELIMINARY CRUISE REPORT

Cruise name/number:	KNORR F2014-010 Kn218 Line W May 2014

Authorizations:

Coastal State	Authorization Document Number	National Participant(s)
Bermuda	32/2014	none

Scientist in charge of reporting:

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Brief description of scientific objective:

R/V Knorr cruise number 218 contributed to a joint Woods Hole Oceanographic Institution and Lamont Doherty Earth Observatory research program funded by the U.S. National Science Foundation that is investigating the characteristics, causes and consequences of interannual variations in the Northwest Atlantic's Deep Western Boundary Current (DWBC). The study is documenting temperature, salinity, tracer, and velocity variations of the DWBC by maintaining a 6-element moored array spanning the continental slope southeast of Woods Hole over a 10-year period, and repeatedly occupying a hydrographic section along this line extending into the Sargasso Sea. Cruise Kn218 was designed to recover the moored array and to re-occupy the hydrographic section along the array and extending southeast towards Bermuda, both for the last time. In addition, we agreed to test various sensors that colleagues wished to evaluate, deploy floats and recover two gliders operating on the continental shelf near our cruise track.

Update on anticipated dates for delivery of final results:

Metadata: see appended cruise report	(locations of stations, variables measured, types of samples)
Raw Data:	available from the R2R repository
Processed Data:	we anticipate final processed data to be made available by May 2015
Data Analysis:	science products will be created and distributed as they are generated
WODC Data Registration (if applicable):	Accession number n/a.

Append image or URL illustrating the route of the platform, locations where measurements were taken, and actual cruise track:

Cruise report: R/V Knorr cruise no. Kn218

Woods Hole to Woods Hole

May 1-12, 2014

Line W: Completing the measurement program

Background

R/V Knorr cruise number 218 contributed to a joint Woods Hole Oceanographic Institution and Lamont Doherty Earth Observatory research program funded by the U.S. National Science Foundation that is investigating the characteristics, causes and consequences of interannual variations in the Northwest Atlantic's Deep Western Boundary Current (DWBC). The study is documenting temperature, salinity, tracer, and velocity variations of the DWBC by maintaining a 6-element moored array spanning the continental slope southeast of Woods Hole over a 10-year period, and repeatedly occupying a hydrographic section along this line (Figure 1). Cruise Kn218 was designed to recover the moored array and to re-occupy the hydrographic section along the array and extending southeast towards Bermuda, both for the last time. In addition, we agreed to test various sensors that colleagues wished to evaluate, deploy floats and recover two gliders operating on the continental shelf near our cruise track.

The moored array south of New England (named Line W in memory of L. Valentine Worthington) is designed to quantify changes in Deep Western Boundary Current and Gulf Stream water properties, stratification (potential vorticity) and transport. The array utilizes Moored Profilers, current meters, Temperature/Conductivity sensors and Acoustic Doppler Current Profilers (ADCPs). Annual shipboard observations using CTD, Lowered ADCP and discrete sampling for salinity, oxygen, CFCs, SF_6 and I^{129} measure the water column properties at high spatial resolution to help verify that the array accurately characterizes the structure of the time-varying flows along the continental slope and to acquire tracer data. Line W measurements are key to clarifying the deep ocean response to variability in high-latitude air-sea exchanges and, ultimately, the ocean's role in global climate variability through changes in its transport of heat and freshwater.

The full moored array was first deployed during *R/V Oceanus* cruise 401 in April-May, 2004. Three of the moorings in the initial array supported Moored Profiler instruments that were subsequently serviced annually in spring 2005, 2006 and 2007; fixed-depth sensors were deployed for two year periods on the other two moorings. Later, a 6th offshore mooring using fixed sensors was deployed, initially with funding from the WHOI Ocean and Climate Change Institute. A cruise aboard *R/V Oceanus* in spring 2008 initiated a second phase of observations at Line W with the goal of extending the observations through the full 10-year time period. The array was redesigned slightly with all moorings planned for a nominal 2-year servicing schedule. Moorings 2 and 4 (counting offshore) supported Moored Profilers; the other 4 moorings were fitted with discrete sensors. In order to achieve the planned 2-year endurance, Mooring 2 was designed with 2 Profilers on it while Mooring 4 held 3 Profilers, each sampling a ~1000 m depth interval. Fixed sensors were located above and below each profile interval. Between profiling operations, the Profilers were programmed to park mid-span and sample hourly, mimicking a fixed-depth sensor. The resulting data sets have high temporal resolution at multiple depths spanning the water column in addition to high-vertical-resolution profile data collected at regular interval throughout the deployment. Moorings 1, 3, 5 and 6 were designed with conventional fixed-depth sensors.

Weather seriously disrupted the renewal of the array in 2008; it was not until spring 2009 that all 6 moorings were again in the water. The full moored array was successfully recovered and redeployed in October 2010 during *R/V Atlantis* cruise no. 17. A companion biogeochemical program headed by Drs. Tim Eglinton and Matt Charette funded addition of sediment traps on Line W moorings. Mooring #4 deployed in 2010 was so equipped. The one-year endurance of sediment traps meant that this mooring had to be recovered and redeployed in October 2011. Cruise Kn208 in August 2012 took place at the 8-year point in the decade-long measurement program. Moorings 1, 2, 3, 5 and 6 were successfully recovered and redeployed; Mooring #4 was not located. A replacement mooring was installed at that site. Attempts were made on two subsequent occasions to find the lost mooring but neither bore fruit.

Cruise Kn218 represented the completion of the fieldwork phase of Line W (in its present incarnation). As in 2012, the science party was organized by activity with the two main themes being the mooring work and the hydrographic sampling. Brian Hogue was lead person for the former while Magdalena Andres and Leah Trafford headed the latter, in consultation with Bill Smethie. Dave Wellwood was the hydrographer for the cruise and Daniel Torres was lead for the Acoustic Doppler Current Profiler work. John Toole served as chief scientist. Kn218 also provided the opportunity for several students to join the scientific party, assist with the work and gain sea-going experience.

Science Party

Affiliations are WHOI unless specified.

Chief scientist: John Toole

Hydrographic/LADCP sampling: Magdalena Andres, Dan Torres, Leah Trafford, Dave Wellwood, Susan Sholi, Isabela Le Bras (MIT/WHOI Joint Program), Alessandro Silvano, Bill Smethie (LDEO), Eugene Gorman (LDEO), Angelica Pasqualini (Columbia U.), Hillary Scannel (UMO), Kelly Canesi (URI), Shuwen Zhang (URI), Kun Gao (URI)
Mooring operations: Brian Hogue, Andy Davies, Scott Worrilow (FSI)
Ancillary tracer project: Ben Hickman (SOEST)

Cruise narrative

Departure from the WHOI pier at slack high water occurred at 13:00 on May 1 into dense fog. The first cruise activity involved recovery of a Slocum glider on the continental slope that had been recently deployed in conjunction with the Ocean Observatories Initiative Pioneer Array. Steerage control of the glider had been compromised, necessitating its rescue. With guidance from shore, *R/V Knorr* was directed to the glider location and its strobe light was quickly sighted despite the late hour (the fog having lifted). As the glider's nose cone with recovery line had not detached as instructed, an initial attempt was made to lasso the glider. While that effort failed, while in close proximity to the ship, the glider nose was bumped, effecting its release. With the tag line now deployed, the glider was quickly brought aboard using a grapnel. Initial inspection showed the glider's tail fin bent off to port, which accounted for its inability to maneuver. *R/V Knorr* then proceeded to the head of Line W to initiate our planned work. For those initial stations over the shelf and slope, several new (self-recording) sensors were affixed to the CTD frame to acquire intercomparison data for colleagues. As these observations took no additional time, we were happy to help. Another requested add-on to Kn218 was the deployment of 8 Argo floats. Again, as their launch takes very little time, we accepted the request and deployed floats immediately after CTD stations in the Slope Water, Gulf Stream and Sargasso Sea.

During the cruise period, the Gulf Stream was in a highly contorted state that included a large southward meander in the vicinity of Line W as well as several eddies (see Figure 1). While not having any impact on the mooring recovery work, the hydrographic data are compromised since, for part of the sampling program, our measurement line paralleled the northward limb of this meander. (Ideally, we prefer Gulf Stream transects to be orthogonal to the flow.) But in order to amass a representative ensemble of section occupations, it is necessary to sample all possible conditions.

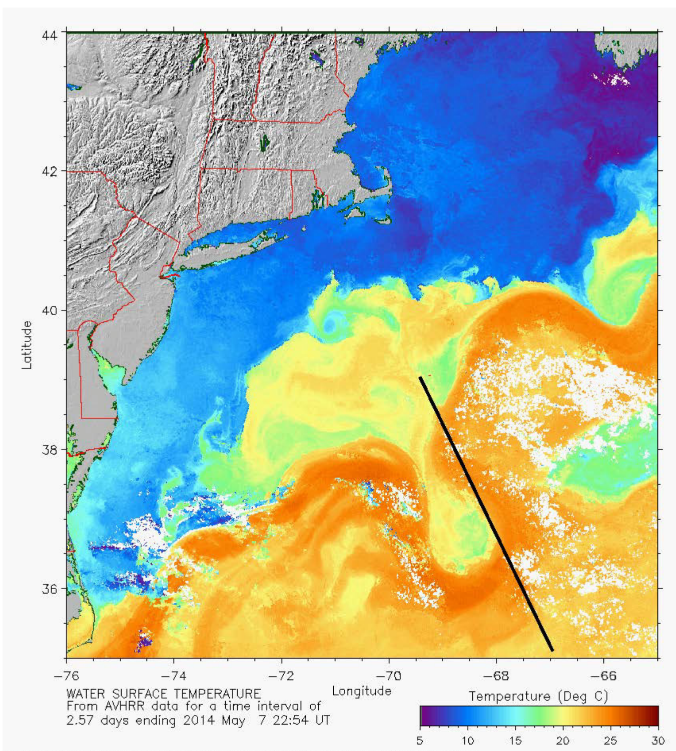

Figure 1. Map of sea surface temperature and the northern segment of sampling line at the start of the May 2014 Line W cruise aboard *R/V Knorr* cruise 218. The SST image derives from the Johns Hopkins University Applied Physics Laboratory Ocean Remote Sensing Group. Note the large meanders in the warm core of the Gulf Stream and how our section ran down the eastern limb of a southward loop of the Stream.

The first several days of the cruise were allocated to mooring recoveries in daytime and CTD work at night. All went very well. Winds kicked up to around 30 knots on May 5, preventing safe mooring work but the conditions did not constrain CTD operations. Two stations south of Mooring # 6 were occupied before returning north, by which time the winds had relaxed and seas subsided. As it turned out, *R/V Knorr* hove to at the site of Mooring # 6 for only 3 or 4 hours before the mooring recovery could be initiated. On the morning of May 6, the 6th and final Line W mooring was recovered. Station work was then continued south (for details, see the report of the CTD program that follows). At station no. 24, surface water was collected to support the shoreside research program of Dr. Tatiana Rynearson

(URI/GSO). Tatiana's student, Kelly Canesi, took charge of that operation. Upon completion of CTD station 29 in sight of Bermuda, *R/V Knorr* was directed back north along Line W. On the way north, a few more shallow CTD stations were occupied, again to test new sensors, and Argo floats were deployed at two sites.

The final cruise objective was to recover another Slocum glider for colleagues. This instrument had been launched a few weeks prior to our cruise as part of a NOAA research program investigating the storms in the coastal environment. Having accomplished its mission, it was time for the glider to be returned home. With support from a shoreside operator, *R/V Knorr* was directed to the glider position just south of Martha's Vineyard at first light on May 12, whereupon a small boat operation was conducted to recover it. That done, *R/V Knorr* headed home to Woods Hole, arriving at slack high water around 10AM.

Once again, *R/V Knorr* and her officers' and crew's performance was outstanding. Ditto the science team on the voyage. This chief scientist will greatly miss conducting research aboard *R/V Knorr*. The full cruise track of Kn218 is depicted in Figure 2.

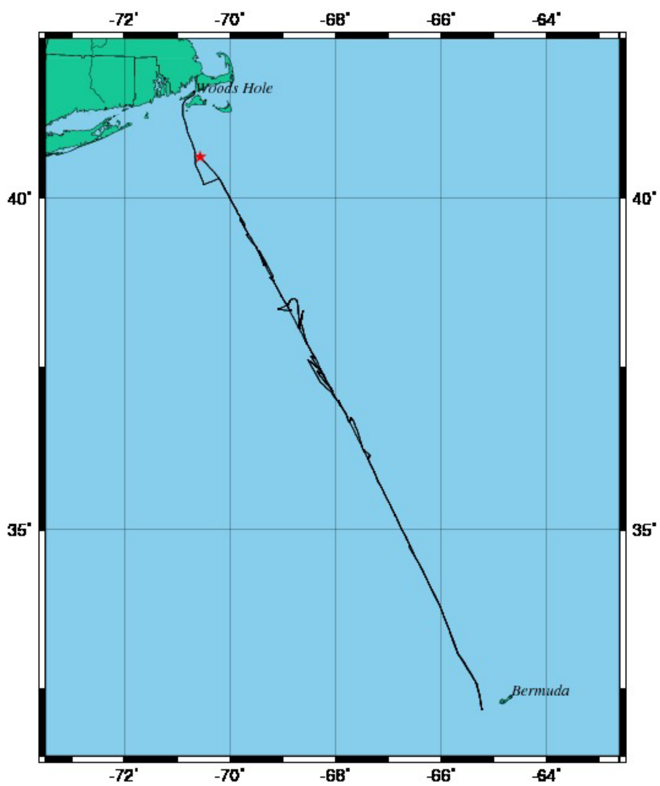

Figure 2. Cruise track of Kn218 – Line W 2014.

Program activity reports

1. Hydrographic sampling

a. Water Sample Salinity and Dissolved Oxygen Measurements

(Contributed by Dave Wellwood)

The underwater frame for hydrographic sampling on this cruise was fitted with 23 10-l bottles that were tripped during the up-cast of each station. The 24th bottle (physically located at rosette location number 15) was occupied by an ADCP sensor. The data collection software was instructed to skip position 15 when tripping bottles during upcasts. Water samples collected during this cruise were analyzed for concentrations of salinity and dissolved oxygen for all 33 stations occupied. These measurements were used to post-calibrate the CTD sensors.

Water samples for salinity were collected in 200 ml glass bottles. The bottles were rinsed three times, and then filled to the neck. After the samples reached the lab temperature of approximately 22 °C, they were analyzed for salinity using a Guildline Salinometer model 8400 B, WHOI #11. The salinometer's bath temperature was set to 24 °C and was standardized once a day using IAPSO Standard Seawater (current batch, P-155). Conductivity readings were logged automatically to a computer, salinity was calculated and merged with the CTD data, and finally used to update the CTD calibrations. Accuracies of salinity measurements were ±0.002 pss. Bottle salinities were assigned a quality control flag based upon the difference between upcast CTD salinity (calibrated) at the same pressure and/or at the same potential temperature.

Dissolved oxygen measurements were made using a modified Winkler technique similar to that described by Strickland and Parsons (1972). Each seawater sample was collected in a 150 ml brown glass Tincture bottle. When reagents were added to the sample, iodine was liberated which is proportional to the dissolved oxygen in the sample. A carefully measured 50-ml aliquot was collected from the prepared oxygen sample and titrated for total iodine content. Titration was automated using a PC controller and a Metrohm Model 665 using a Metrohm Model 888 Titrando dosing device. The titration endpoint was determined amperometrically, with a resolution better than 0.001 ml. Accuracy was about 0.02 ml/l, with a standard deviation of replicate samples of 0.005. This technique is described more thoroughly by Knapp et al (1990). Calculated oxygen was merged with the CTD data, and used to update the CTD calibrations. Standardization of the sodium thiosulphate titrant was performed daily.

b. **CFC/SF6 sampling**

(Contributed by William Smethie)

Water samples for CFC and SF_6 measurements were collected using a rosette equipped with 23 ten-l PVC sample bottles. The CFC/SF_6 sample was drawn first from the rosette bottle through a PVC tube extending to the bottom of a 500 cc glass bottle. The bottle was allowed to overflow 4 bottle volumes and the overflow collected in a plastic container in which the glass bottle submerged and the sample was then sealed with a ground glass stopper inserted underwater. The glass bottle was stored in the plastic container underwater until measurement, which was within 8 hours of collection. Negligible degassing occurred during this time. The measurements were carried out using a dual purge and trap system interfaced to a dual ECD (electron capture detector) HP6890 gas chromatograph as described in earlier reports. The ECDs were calibrated by running gas standards with known concentrations of CFCs and SF6. Duplicate samples were collected at most stations and measured to provide a combined precision for sampling and measurement. Typically the precisions of these measurements are between 0.5 and 1% for CFC-11 and CFC-12, between 1 and 2% for CFC-113 and between 1 and 5% for SF_6. CFCs 11, 12, and 113 are reported on the SIO98 calibration scale. The SF6 data are reported on the NOAA CMDL scale. Twenty-nine stations were sampled and all samples collected were measured for CFCs and SF6 for a total of about 630 samples.

I-129 samples were collected in the Denmark Strait Overflow Water layer along the section. About 130 samples were collected and a subset drawn from the high CFC/SF6 core waters will be measured under the direction of Dr. John Smith of the Bedford Institute of Oceanography, using the CFC data as a guide for which samples will be measured.

A system for measuring underway surface water samples for CFCs and SF6 was tested on the cruise. This work, supported by an NSF grant to David Ho (University of Hawaii) and William Smethie, was conducted by Ben Hickman of UH. The purpose of this new instrument is to gain detailed information on the saturation of CFCs and SF6 in the surface ocean. The instrument system was connected to *R/V Knorr's* underway sea water supply in the main lab which fed water to the system at about 2 liters per minute. Periodically, a 400 cc aliquot was drawn from that feed for measurement. The system consisted of a purge and trap system interfaced to a gas chromatograph with an electron capture detector. CFC-11, CFC-12 and SF6 were measured on a single 400 cc aliquot of water by a method similar to the Lamont discrete sample system. For the first half of the cruise a number of adjustments were made and tested to fine tune the operation of the system. One of these adjustments was installation of carboxan trap (the modification took place about the mid-point of the cruise) that substantially improved the performance. The system was run continuously from that point on. The sample run time was 18 minutes and the stripping efficiency was 100% for SF6, 99% for CFC-12 and 98% for CFC-11. Companion samples were analyzed with the Lamont system for comparison with the underway system. This included both surface rosette samples and water samples collected from the ships underway sea water system. These data will be analyzed during the next few weeks, but a crude preliminary analysis suggests that the rosette samples and underway samples agree to within 2% or better.

2. CTD/O2 data acquisition and processing

(contributed by Leah Trafford)

A total of 33 casts were performed using a SeaBird 911plus CTD and deck unit configured to measure pressure, temperature, conductivity, oxygen current, fluorescence, beam transmission, and SPAR/surface irradiance, Table 1. The unit was controlled through a resident shipboard computer system using SeaBird's software SEASAVE version 7.21k for windows. For each cast, water samples were collected at up to 23 discrete intervals and analyzed for salinity and dissolved oxygen – primarily for the purpose of performing CTD sensor calibrations.

Table 1. Time and location of hydrographic stations occupied during cruise Kn218.

STN#	CAST	TYPE	UTC DATE	UTC TIME	POSITION LATITUDE	POSITION LONGITUDE	NAV	UCOR DEPTH
1	1	ROS	050214	0406	40 16.99 N	70 12.30 W	GPS	94
2	1	ROS	050214	0550	40 8.42 N	70 6.21 W	GPS	120
3	1	ROS	050214	0721	40 0.69 N	70 0.34 W	GPS	162
4	1	ROS	050214	0848	39 53.95 N	69 55.79 W	GPS	790
5	1	ROS	050214	1043	39 51.51 N	69 54.12 W	GPS	980
6	1	ROS	050214	1235	39 47.48 N	69 51.08 W	GPS	1435
7	1	ROS	050214	1857	39 42.04 N	69 47.97 W	GPS	2090
8	1	ROS	050214	2214	39 28.46 N	69 39.15 W	GPS	2400
9	1	ROS	050314	0210	39 15.98 N	69 29.23 W	GPS	2646
10	1	ROS	050314	0620	39 0.87 N	69 20.03 W	GPS	3070
11	1	ROS	050314	1929	38 47.42 N	69 11.11 W	GPS	3264
12	1	ROS	050314	2324	38 33.57 N	69 1.53 W	GPS	3462
13	1	ROS	050414	0332	38 19.87 N	68 51.66 W	GPS	3804
14	1	ROS	050514	0143	38 5.98 N	68 41.85 W	GPS	4063
15	1	ROS	050514	0752	37 51.04 N	68 32.47 W	GPS	4340
16	1	ROS	050514	1330	37 37.34 N	68 22.82 W	GPS	4555
17	1	ROS	050514	1928	37 23.14 N	68 13.75 W	GPS	4695
18	1	ROS	050614	0208	37 8.60 N	68 3.77 W	GPS	4855
19	1	ROS	050614	2022	36 54.12 N	67 53.94 W	GPS	4902
20	1	ROS	050714	0250	36 39.67 N	67 44.13 W	GPS	4921
21	1	ROS	050714	1010	36 11.95 N	67 27.10 W	GPS	4921
22	1	ROS	050714	1639	35 42.61 N	67 9.66 W	GPS	5113
23	1	ROS	050714	2300	35 13.64 N	66 52.19 W	GPS	5099
24	1	ROS	050814	0547	34 44.40 N	66 34.78 W	GPS	5180
25	1	ROS	050814	1313	34 15.59 N	66 17.39 W	GPS	5217
26	1	ROS	050814	1947	33 46.71 N	65 59.96 W	GPS	5117
27	1	ROS	050914	0341	33 4.08 N	65 41.54 W	GPS	4686
28	1	ROS	050914	1007	32 34.99 N	65 19.96 W	GPS	4733
29	1	ROS	050914	1540	32 9.75 N	65 13.46 W	GPS	4100
30	1	ROS	051014	1506	35 53.92 N	67 16.35 W	GPS	5016
31	1	ROS	051014	1739	36 6.07 N	67 23.18 W	GPS	4997
32	1	ROS	051014	1901	36 7.61 N	67 21.93 W	GPS	4995
33	1	ROS	051114	1125	39 1.15 N	69 19.96 W	GPS	3017

a. CTD Sensors and manufacturer calibrations

Calibrations for these CTD sensors were performed by the manufacturer before the cruise. CTD data from the secondary conductivity and oxygen sensors were calibrated using bottle data for all casts performed during the cruise. A listing of sensors and calibration dates are presented in Table 2.

Table 2. Sensor Calibration Dates

Sensor Number	Sensor Type	Manufacturer	Calibration Dates
63505 SBE090462	Pressure	Sea-Bird	15-Mar-12
4195	Temperature	Sea-Bird	11-Oct-13
4252	Temperature	Sea-Bird	10-Oct-13
2670	Conductivity	Sea-Bird	17-Oct-13
2768	Conductivity	Sea-Bird	10-Oct-13
1679	SBE43 dissolved oxygen	Sea-Bird	23-Oct-13
1646	SBE43 dissolved oxygen	Sea-Bird	11-Mar-14
FLNTURTD-304	Fluorescence	Wetlabs	10-Mar-08
CST-1118DR	Beam transmission	Wetlabs	30-Apr-08

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b. Acquisition and Seabird Processing Methods

Data from the CTD were acquired at 24 Hz. The CTD data were acquired by an SBE Model 11 plus V2 CTD Deck Unit providing demodulated data to a personal computer running SeaBird software. SEASAVE version 7.21k CTD acquisition software (SeaBird) for Windows provided graphical data to the screen. Bottom approach was controlled by real time altimeter data and ship echosounder-derived ocean depth information.

After each station, the raw CTD data were run through the SeaBird data processing software version 7.22.0. The data were converted from HEX to ASCII, lag corrected, edited for large spikes, smoothed according to sensor, and pressure averaged into 2-decibar bins for final data quality control and analysis.

c. Post-Processing Conductivity Calibrations

(i) Basic fitting procedure:
CTD salinity and oxygen data were then further calibrated by fitting the data to water sample salinity and oxygen data. WHOI post-processing fitting procedures are modeled after methods used in Millard and Yang, 1993.

The CTD secondary conductivity sensor data were fit to the water sample conductivity. All stations were grouped together in chronological order to find the best fit. The group was fit for slope and bias. A linear pressure term (modified beta) was applied to conductivity slopes using a least-squares minimization of CTD and bottle conductivity differences. The function minimized was:

$$BC - m * CC - b - \beta * CP$$

BC	*- bottle conductivity [mS/cm]*	*m*	*- conductivity slope*
CC	*- pre-cruise calibrated CTD conductivity [mS/cm]*	*b*	*- conductivity bias [mS/cm]*
		β	*- linear pressure term [mS/cm/dbar]*
CP	*- CTD pressure [dbar]*		

The slope term is a polynomial function of the station number based upon chronological station collection order. The polynomial function which provided the lowest standard deviation for a group of samples along with the corresponding bias were determined for each station grouping. A series of fits were made, each fit removing outliers having a residual greater than three standard deviations. This procedure was repeated with the remaining bottle values until no more outliers occurred. The best fit coefficients for each station grouping are presented in Table 3 for primary sensor (s/n 041345) and secondary sensor (s/n 043880).

The final conductivity, FC [mS/cm] is:

$$FC = m * CC + b + \beta * CP$$

(ii) Fitting results
Once calibrated and outliers excluded, the overall standard deviation of the CTD conductivity and the water sample differences for the primary conductivity sensor (s/n 2670) was 0.0009298 mS/cm.

Table 3. Best Fit Conductivity Coefficients for Primary Conductivity S/N 2670

Stations	**#pts used**	**total #pts**	**std dev (mS/cm)**	**Slope (min/max)**	**Bias**	**Beta**
Fit as a group in chronological order [1:29]	468	554	0.0009298	1.00034/1.00041	-0.0060399	-3.4664e-08

d. Post-Processing Oxygen Calibrations

(i) Basic fitting procedure
The CTD oxygen sensor variables were fit to water sample oxygen data to determine the six parameters of the oxygen algorithm (Millard and Yang, 1993). The oxygen calibration was performed after calibrating temperature and conductivity due to its slight dependence on the CTD pressure, temperature, and conductivity (salinity). A FORTRAN program oxfitmrx.exe developed by Millard and Yang (1993) was incorporated into Matlab routines by Millard (2004) for use in processing CTD oxygens using Matlab. The following Matlab mfiles created by Jane Dunworth were used for determining and applying the oxygen calibration coefficients using Millard's routines: make_oxyfile.m, oxycal_SBE.m, plot_caloxy.m, caloxy_dco.m, dco2ctd.m, cal_nut.m. These programs used the algorithm developed by Owens and Millard (1985) for converting oxygen sensor current and temperature measurements with the time rate of change of oxygen current measurements to oxygen concentration. The weight was set to 0 as the new SBE43 oxygen sensor temperature is not measured and is assumed to be the same as the *in situ* temperature. The lag was set to 0 as per manufacturer recommendation.

$$Oxm = \left[slope * \left(Oc + lag * \tfrac{dOc}{dt} \right) + bias \right] * Oxsat * \exp\left(tcor * \left[T + wt * \left(T_o - T \right) \right] + pcor * P \right)$$

where

Oxm	*- oxygen concentration [ml/l]*	*slope*	*- oxygen current slope [ ]*
Oc	*- oxygen current [uA/s]*	*lag*	*- oxygen sensor lag [s]*
Oxsat	*- oxygen saturation [ ]*	*bias*	*- oxygen current bias [ ]*
P	*- CTD pressure [dbar]*	*tcor*	*- membrane temperature correction [ ]*
T	*- CTD temperature [℃]*	*wt*	*- weight, membrane temperature sensitivity adjustment [ ]*
T_o	*- oxygen sensor temperature [℃]*		
S	*- salinity [PSS-78, psu]*	*pcor*	*- correction for hydrostatic pressure effects [ ]*

(ii) Fitting results

Once calibrated, the overall standard deviation of the CTD oxygen sensor and the water sample differences for the primary oxygen sensor (1679) is 0.017 for stations 1 to 10, 0.0185 for stations 11 to 17, and 0.0272 for stations 18 to 29.

e. Other notable data acquisition

At-sea logs were kept for CTD data acquisition. They include anything of note regarding each station: equipment changes, instrument behavior, equipment or operational problems.

References

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SeaBird Electronics, Inc. 2001. CTD Data Acquisition Software Seasoft Version 4.249 Manual.

Strickland, J.D.H. and T.R. Parsons. 1972. The Practical Handbook of Seawater Analyiss. Bulletin 167, Fisheries Research Board of Canada, 310 pp.

3. **Acoustic Doppler Current Profiler (ADCP) velocity measurements**

(Contributed by Daniel Torres)

A variety of ADCP instruments were used on Line W.

a. LADCP (Lowered ADCP)

A total of 33 CTD/LADCP stations were taken. Of these, 29 were standard Line W stations and 4 were extra test stations. Of those four, 2 were made to 1000m depth to test a Nortek AD2CP instrument and 2 were done to 2000m to acquire reference data for ARGO float deployments. All 33 stations used a dual

ADCP system for Lowered ADCP measurements. The instruments consisted of an upward facing 300 kHz ADCP and a downward facing 150 kHz ADCP, both made by Teledyne RD Instruments. These were powered by an external 48 Volt rechargeable lead-acid battery pack. We had 100% data return for all stations. Data were all processed using LADCP Processing software version IX_10 from LDEO, Columbia University.

b. Shipboard ADCP

Underway shipboard ADCP data were collected throughout the cruise. The instruments consisted of a 75 kHz Ocean Surveyor (OS75) and a 300 kHz Workhorse ADCP (WH300), both manufactured by Teledyne RD Instruments. The OS75 was setup to collect 128 8-meter bins in Narrowband mode. The WH300 was setup to collect 50 4-meter bins in Broadband mode. Both were setup to collect Bottom Track data while we were on the continental shelf to use for transducer misalignment calibration. Once we were off the shelf in deep water out of bottom track range, Bottom Tracking was turned off. Shipboard ADCP data were processed automatically using UHDAS software. These processed data were used in the processing of LADCP data.

c. Moored ADCP

Two moored ADCPs were recovered during the cruise. These were 75 kHz Long Ranger ADCPs, both from Teledyne RD Instruments. The instruments were setup to collect 40 16-m bins, and were deployed at ~450m water depth mounted within the main buoyancy sphere of moorings #W5 and W6. The LR75 deployed at station W5 collected data from 2012/08/20 14:00:00 – 2014/05/08 20:00:00. The LR75 deployed at station W6 collected data from 2012/08/10 00:00:00 – 2014/05/08 16:00:00. Both instruments were still pinging upon recovery. A quick look at the data indicated that both instruments worked properly throughout their deployments.

d. AD2CP

During the cruise, we had the opportunity to test a 1 mHz RD2CP instrument manufactured by Nortek, Inc. This instrument is normally used on a Glider for measuring current profiles but has been shown to not work well in areas with low acoustic scatter density. Our test consisted of mounting the AD2CP to the CTD frame in order to compare its ability to measure velocity with the LADCP system already mounted on the CTD frame. We occupied the Line W line from north to south. On the way out, we did two casts with the AD2CP at ~712m (station 4) and 957m (station 5) depths. These casts were on the slope in water with relatively high scatter density. When the AD2CP was powered up for those first two casts, the blue light came on and blinked every 10 seconds or so, indicating it was working properly. On the transit back north, we did 2 more test casts to 1000m in the Sargasso Sea which has low scatter density. When the AD2CP was powered up for the first cast, the blue light came on indicating good operation. But upon recovery, the light was not on. Cycling power did not restart the light. Since tests on the instrument before the cruise showed that the blue light did not always come on to indicate the instrument was working properly, we elected to go ahead with the final test cast. After recovery, we were not able to establish proper communication with the instrument. At this point, we believe there are at least two and maybe 4 good casts of data on the instrument. But that cannot be confirmed at this point.

4. Mooring work

(Contributed by John Toole)

All six Line W moorings were successfully recovered during Kn218 as detailed in the table below. The mooring team of Brian Hogue, Andy Davies and Scott Worrilow, ably assisted by members of the Knorr crew, expertly brought aboard all the instrumentation and associated hardware of the Line W moored array.

Table 4. Location and recover information for the Line W moored array, May 2014.

Site	Latitude	Longitude	Depth	Mooring ID	Recovery time
W1	39° 36.040’ N	69° 43.038’ W	2245 m	1263	5/2 1519:1805
W2	39° 12.919’ N	69° 26.779’ W	2759 m	1262	5/3 1012:1303
W3	38° 50.677’ N	69° 11.002’ W	3255 m	1261	5/3 1608:1858
W4	38° 25.468’ N	68° 54.029’ W	3666 m	1260	5/4 1005:1347
W5	38° 3.544’ N	68° 40.122’ W	4135 m	1259	5/4 1900:2248
W6	37° 27.754’ N	68° 17.070’ W	4696 m	1258	5/6 0959:1405

5. Argo float deployments

The WHOI float lab sent us out with 8 Argo floats with request to deploy them in the Slope Water, in the Gulf Stream, and in the Sargasso Sea. We accommodated by launching floats immediately after CTD stations as we worked the section south, and then deploying at two additional sites on our run back north.

Table 5. Deployment locations and times of Argo float launches during Kn218.

Float #	Time (UTC)	Lat (N)	Lon (W)	Calibr. cast
7205	5/3/14 04:34	39˚ 15.68’	69˚ 29.44’	St. 9009
1170	5/5/14 10:50	37˚ 53.74’	68˚ 34.60’	St. 9015
7210	5/5/14 10:50	37˚ 53.74’	68˚ 34.60’	St. 9015
1172	5/7/14 13:32	36˚ 01.37’	67˚ 27.31’	St. 9021
1173	5/8/14 16:37	34˚ 15.60’	66˚ 17.43’	St. 9025
1171	5/10/14 21:31	36˚ 0.916	67˚ 20.41’	St. 9032
7211	5/10/14 21:31	36˚ 0.916	67˚ 20.41’	St. 9032
7208	5/11/14 13:59	39˚ 01.59	69˚ 19.25	St. 9033

6. RBR CTD intercomparison casts

(Contributed by Magdalena Andres)

An additional set of intercomparison sensor lowerings was carried out on Kn218 to provide *in situ* reference/calibration data for internally-recording CTD sensors owned by WHOI colleague Fiamma Straneo. As these CTDs have limited depth capability, the sensors were attached to the underwater frame on stations towards the start of the cruise where the waters are relatively shallow. Sampling details are given in Table 6.

Table 6. Comparison lowerings of RBR CTD sensors during Kn218

RBR Sensor Serial Number	Reference CTD station	Max pressure sampled (dbars)
12856	9003	152
18608	9004	718
65584	9004	718
18559	9006	1433
17413	9006	1433

7. Future plans

Cruise Kn218 marked the end of the field phase of Line W in its current manifestation. The PIs will next work with technical support colleagues to process the data recovered on the cruise and continue the scientific analysis. Looking farther ahead, a skeleton monitoring program may be considered as a way to extend the Line W time series into the future.