Dynamics of Abyssal Mixing and Interior Transports Experiment (DynAMITE)

Pointe-a-Pitre, Guadeloupe — St. Georges, Bermuda
15 May – 13 June 2011
R/V Knorr

Cruise Report

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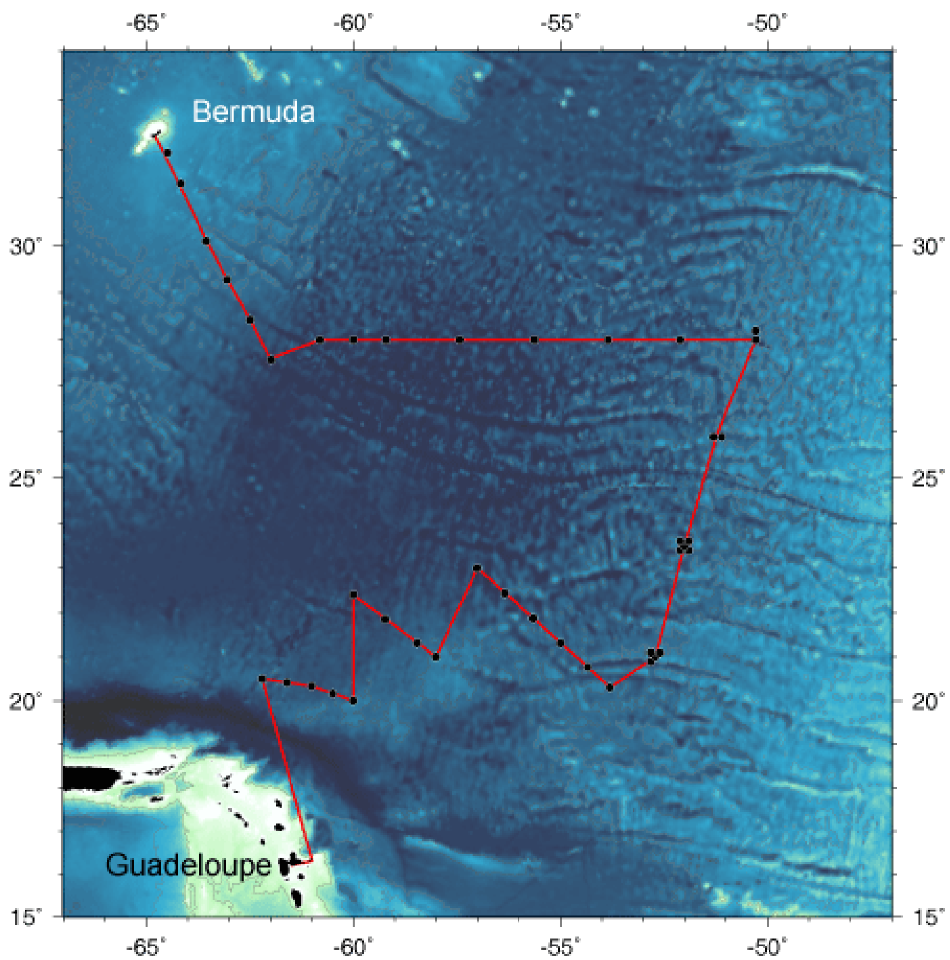


I. Summary

From 15 May to 12 June 2011, *R/V Knorr* cruise 200-6 conducted an oceanographic survey in the western North Atlantic region bounded by 20-30°N, 50-65°W. The cruise represented one component of the **Dyn**amics of **A**byssal **M**ixing and **I**nterior **T**ransports **E**xperiment (**DynAMITE**), that is investigating the processes by which cold, dense waters in the North Atlantic are transformed into warmer, lighter water masses and their subsequent circulation through the deep basins. The primary agents of this transformation are believed to be tidal mixing over rugged topography and eddy kinetic energy associated with the Gulf Stream flow field. Much of the transformation appears to takes place in the basin interior between 20-40°N, 65-50°W, where mixing is enhanced over the Mid Atlantic Ridge (MAR) and Bermuda Rise, and in the deep Gulf Stream to the west and east of the Grand Banks. DynAMITE seeks to measure the structure and strength of this diapycnal mixing (*where? how much?* and *why?*) and the flows through the interior basin that result from it.

The field program is comprised of two elements. 1) A moored array of profilers was installed down the southeast flank of Bermuda Rise in September 2010 to measure the interior flows at depths between 1200-6000 m for a period of 1.5 years. 2) A microstructure survey (this cruise) using the HRP and multi-beam sonar, to provide a basis for estimating and parameterizing the diapycnal mixing field and buoyancy gain that feeds the interior flows. The measurements were conducted by Woods Hole Oceanographic scientists between Bermuda Rise and the Mid Atlantic Ridge at latitudes 20-30°N using the shipboard SeaBeam system to map bathymetry, CTD casts to capture water samples (for analysis of salinity, dissolved oxygen and nutrients), and the High Resolution Profiler (HRP) to measure water column properties and velocity at very small vertical scales. Underway temperature and salinity, ADCP, and meteorological data were also collected and archived, but not processed as part of this program. Ten Argo profiling floats were successfully deployed for other research groups at predetermined positions along the cruise track.

Further information, including final data sets (as they become available) will be posted on the project website: http://www.whoi.edu/science/PO/dynamite

II. Cruise Participants

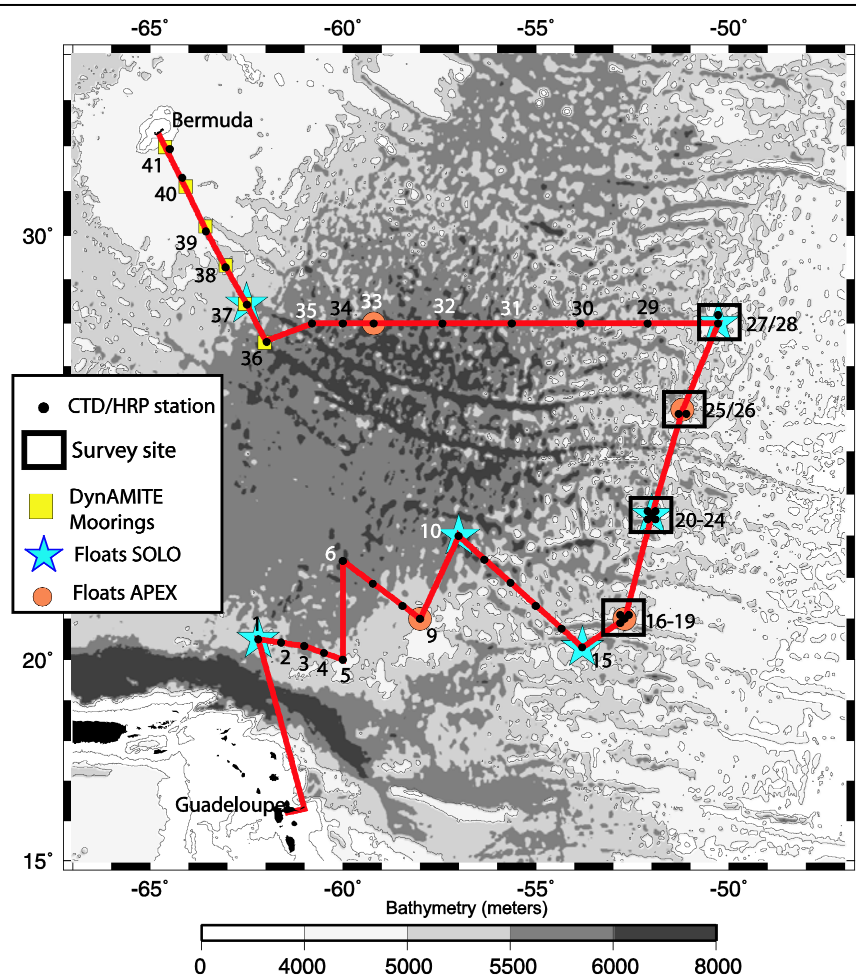
Officers and Crew of R/V Knorr

Adam Seamans	Captain	Rogelio Fong	Oiler
Deirdra Emrich	1st Mate	Michael Gaylord	Oiler
Derek Bergeron	2nd Mate	Benjamin Wright	Oiler
Breana Ogden	3rd Mate	Michael McCoy	Steward
Kyle Covert	Boatswain	India Grammatica	Cook
Jose Andrade	A/B	Thomas Leong	Messman
Susan Coleman	A/B	Vasile Tudoran	Cadet
William Dunn	A/B		
Scott Loweth	OS		
Mike Singleton	OS		
Steve Walsh	Chief Engineer		
Piotr Marczak	1st A/E		
Andrew Carter	2nd A/E		
Joseph Bastoni	3rd A/E		
Angel Mercado	Electrician		
Jerry Beard	Communications		

Science Crew

Ruth Curry	WHOI	Chief Scientist
Kurt Polzin	WHOI	Co-chief Scientist
Bob Petitt	WHOI	Scientist
Fred Thwaites	WHOI	Scientist
Terry McKee	WHOI	CTD Tech
Carolina Nobre	WHOI	Watchstander
Leah Trafford	WHOI	Watchstander
Dave Wellwood	WHOI	Hydrography
George Tupper	WHOI	Hydrography
Kevin Manganini	WHOI	Watchstander
Liz Douglass	WHOI	Watchstander
Amelia Snow	Rutgers	Student
Peter Lemmond	WHOI	Multi-beam Tech
Amy Simoneau	WHOI	Multi-beam Tech
Anton Zafereo	WHOI	Shipboard Tech
Ellen Roosen	WHOI	Shipboard Tech

Figure 1. Ship's track and locations of stations occupied during KN200-6.



III. Cruise Narrative

Knorr 200 leg 6 departed Pointe-a-Pitre, Guadeloupe at 0800 hours the morning of May 15, 2011and arrived at the first station near 20.5°N, 62.2° W after 26 hours of steaming . A summary of instrument deployments and the ship's trackline is provided in Figure 1. Over the 30-day span of the cruise, the ship traveled 3000 nautical miles, conducted 41 CTD/rosette casts, 49 HRP dives, and deployed 10 Argo floats (external to this project). The weather was exceptionally calm and the vessel's equipment remained in good running order throughout. A substantial problem developed midway through the cruise when the HRP vehicle became stuck on the bottom at 5300 meters depth on the mid-Atlantic Ridge. The uniqueness of this instrument package, and its value to DynAMITE and to the success of other field programs, prompted a major rescue effort. Rigging the ship's trawl wire with a makeshift anchor and a pinger, we dragged over the bottom attempting to knock the package loose . The skill and patience of the crew, plus a hefty dose of persistence paid off. After 7 days of round-the-clock dragging, HRP was knocked loose, popped up to the surface, and was successfully brought back on board. Although the cost to the program was significant (forfeiting 2.5 of 6 planned survey sites), the sense of relief on board was immense. After replacing several external sensors, HRP was returned to work and completed 11 more dives in the time remaining to us.

CTD and HRP operations were conducted simultaneously, although CTD casts were not conducted on every HRP dive. The untethered HRP was deployed ~ ½ hour after the CTD/rosette cast began, so that it surfaced after the CTD package was recovered. The ship then maneuvered to recover the HRP, which generally was accomplished within ½ hour of HRP surfacing. In addition to the grounding incident described above, HRP also ran into the bottom (bottom depth improperly specified in the mission program) on station 11, and remained stuck for ~12 hours before it loosened itself and surfaced on its own. Prior to this cruise, the package had been completely refurbished and multiple systems redesigned. Smaller issues with the electronics (ground faults), leaky probes, interference between the altimeter and acoustic velocity sensors were sorted out as the cruise progressed. At the end of the cruise, the CTD sensors showed signs of malfunction. At this point in the cruise, it was decided to suspend HRP ops for the last 4 stations and to troubleshoot the problems back at WHOI.

During the first week, 3 short CTD/HRP sections (stations 1-15) were occupied along the northern flank of an east-west trending ridge near 20°N. These were designed to identify the flow path of the densest waters transiting the ridge, and to obtain transport estimates for those flows. They revealed that the bulk of AABW flows northward through a topographic gap spanned by stations 1-5, and continues eastward along the northern ridge flank as a narrow boundary current. This was augmented, but to a smaller degree, by dense waters overflowing the ridge further to the east, through a system of canyons and sills near 55°W.

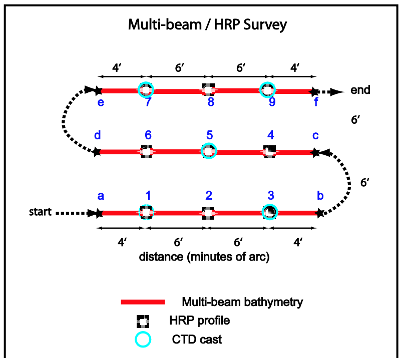


Figure 2. Diagram of a typical survey site.

Following completion of these sections, the plan was to occupy six survey sites corresponding to previous locations of moored current meters (POLYMODE program). Each site spanned a rectangle measuring 12-minutes of latitude and 20-minutes of longitude. A multi-beam bathymetric survey of the region was conducted following the trackline depicted in Figure 2. 9 HRP dives were to be undertaken at the corners, sides, and center of the rectangle. Five CTD casts would be conducted for calibration purposes at the marked locations. The first two sites were successfully completed. HRP became stuck in the middle of the third planned site, and the cruise plan was adjusted to fit the time remaining after the package was finally recovered.

During the last week of the cruise, a zonal CTD/HRP section was conducted along 28°N, and a final transect was undertaken over the mooring line that had been installed the previous September. Excellent weather and transit times brought us to the last station about 12 hours earlier than planned, and the ship was able to dock in St. Georges the night before our scheduled arrival time.

Table 1. Summary of locations, dates and seafloor depths for CTD casts

Sta	Cast	Date	UTC	Latitude	Longitude	Depth(m)
1	1	051611	1441	20 30.14 N	62 12.00 W	5351
2	1	051611	2228	20 25.20 N	61 36.06 W	5560
3	1	051711	0616	20 19.84 N	61 0.03 W	5632
4	1	051711	1353	20 10.20 N	60 29.39 W	5478
5	1	051711	2025	19 59.99 N	60 0.02 W	5004
6	1	051811	1408	22 24.13 N	60 0.01 W	5962
7	1	051811	2352	21 51.61 N	59 13.30 W	5886
8	1	051911	0936	21 19.21 N	58 27.01 W	5247
9	1	051911	1643	21 0.11 N	57 59.90 W	4925
10	1	052011	0803	22 59.96 N	57 0.01 W	6290
11	1	052011	1757	22 26.40 N	56 19.81 W	5591
12	1	052111	1424	21 52.87 N	55 39.61 W	4890
13	1	052111	2307	21 19.25 N	55 0.07 W	5401
14	1	052211	0857	20 45.60 N	54 19.79 W	5806
15	1	052211	1747	20 18.01 N	53 48.03 W	5209
16	1	052311	0539	20 53.93 N	52 48.51 W	4898
17	1	052411	0145	20 59.95 N	52 41.97 W	4768
18	1	052411	1227	21 5.96 N	52 48.52 W	4915
19	1	052411	2243	21 5.93 N	52 35.60 W	4931
20	1	052511	1652	23 23.95 N	52 5.89 W	5285
21	1	052611	0352	23 23.94 N	51 53.93 W	5647
22	1	052611	1512	23 29.97 N	51 59.94 W	5170
23	1	052711	0211	23 35.93 N	52 5.89 W	4914
24	1	052711	1136	23 36.00 N	51 54.01 W	5614
25	1	052811	0447	25 53.98 N	51 18.01 W	5205
26	1	052811	1536	25 54.02 N	51 6.04 W	5035
27	1	060511	1342	28 0.02 N	50 16.77 W	5190
28	1	060611	0628	28 12.02 N	50 16.77 W	5208
29	1	060611	1958	27 59.90 N	52 6.03 W	4983
30	1	060711	0749	28 0.00 N	53 51.00 W	5628
31	1	060711	2101	27 59.94 N	55 37.63 W	5752
32	1	060811	1000	28 0.00 N	57 25.23 W	5851
33	1	060811	2303	28 0.02 N	59 11.92 W	6357
34	1	060911	0806	27 59.98 N	60 0.04 W	4767
35	1	060911	1528	28 0.02 N	60 48.06 W	6035
36	1	061011	0218	27 34.65 N	61 58.85 W	6058
37	1	061011	1218	28 26.04 N	62 29.17 W	5583
38	1	061011	2109	29 17.03 N	63 2.72 W	5020
39	1	061111	0541	30 6.18 N	63 33.07 W	4782
40	1	061111	1602	31 18.33 N	64 9.70 W	4600
41	1	061111	2300	31 56.03 N	64 29.31 W	4106

IV. CTD Measurements and Calibrations

Forty-one casts were made using a SeaBird 911plus CTD configured to measure pressure, temperature, conductivity, and oxygen current. For each cast, water samples were collected at discrete intervals and analyzed for salinity and dissolved oxygen – primarily for the purpose of calibrating the CTD sensors. All casts were full water column.

Difficulties Encountered

Occasional spikes in the O2 data were encountered in stations 1-26. As a result, the O2 sensor (S/N 1679) was replaced with a new one (S/N 0072) before the start of station 27. The cable connecting the CTD to the O2 sensor was replaced between station 27 and station 28. Spikes in the O2 data were still observed in stations 29, 30, 33, 36 and 37. The secondary temperature sensor (S/N 4252) exhibited spikes in the data for stations 36, 37, 38 and 41.

Equipment Configuration

A SBE 911plus/917plus CTD was used throughout the cruise. It was equipped with a Digiquartz TC pressure transducer S/N 94763_SBE09785_vert_orientation, two temperature sensors S/N 4491and S/N 4252, two conductivity sensors S/N 2824 and S/N 2768, and one SBE43 oxygen sensor S/N 1679. Calibrations for all CTD sensors were performed by the manufacturer before the cruise. The CTD was also provided with a Wetlab ECO-AFL/FL flourometer (S/N FLNTURTD-304), a Chelsea/Seatech/WET Lab Csta Transmissometer (S/N CST-1118DR), an FLNTU Turbidity meter (S/N FLNTURTD-304), and an altimeter (S/N 997).

CTD data from both the primary and the secondary conductivity sensors and the single oxygen sensor were calibrated for the entire cruise.

The pylon was controlled through a dedicated personal computer using SeaBird's software SEASOFT version 7.21a for windows. A rosette frame holding 24 10-liter Niskin bottles was used for collecting water samples.

Acquisition and Processing Methods

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

After each station, the raw CTD data was run through the SeaBird data conversion software listed in Table 2. The data was first-differenced, lag corrected, pressure sorted and centered into 2 decibar bins for final data quality control and analysis.

Table 2. SeaBird Processing Software

SeaBird Module	Description (SeaBird, Version 7.21a)
DATCNV	Convert the raw data to pressure, temperature, conductivity, and dissolved oxygen current.
BOTTLESUM	Writes out a summary of the bottle data to a file with a .BTL extension.
ALIGNCTD	Advance conductivity approximately 0.073 seconds relative to pressure.
WILDEDIT	Checks for and marks and 'wild' data points: first pass 2.0 standard deviations; second pass 20 standard deviations.
CELLTM	Conductivity cell thermal mass correction alpha = 0.03 and 1/beta = 7.0.
FILTER	Low pass filter pressure and depth with a time constant of 0.15 seconds to increase pressure resolution for LOOPEDIT. To reduce spikes in Oxygen caused by cable problems described above, oxygen voltage was processed with a low pass filter of 5 seconds.
LOOPEDIT	Mark scans where the CTD is moving less than the minimum velocity (0.1 m/s) or traveling backwards due to ship roll.
DERIVE oxy.cfg	Compute oxygen from oxygen current (filtered), temperature, and pressure.
BINAVG	Average data into the 2 dbar pressure bins.
DERIVE sal.cfg	Compute salinity.
STRIP	Extract columns of data from .CNV files.
SPLIT	Split .CNV file into upcast and downcast files.

Standard final output included the following variables:

name 0 = prDM: Pressure, Digiquartz [db]
name 1 = depSM: Depth [salt water, m]
name 2 = t090C: Temperature [ITS-90, deg C]
name 3 = t190C: Temperature, 2 [ITS-90, deg C]
name 4 = c0mS/cm: Conductivity [mS/cm]
name 5 = c1mS/cm: Conductivity, 2 [mS/cm]
name 6 = sbeox0V: Oxygen raw, SBE 43 [V]
name 7 = flECO-AFL: Fluorescence, WET Labs ECO-AFL/FL [mg/m^3]
name 8 = upoly0: Upoly 0, Upoly 0, FLNTU turbidity
name 9 = xmiss: Beam Transmission, Chelsea/Seatech/WET Labs CStar [%]
name 10 = bat: Beam Attenuation, Chelsea/Seatech/WET Labs CStar [1/m]
name 11 = v2: Voltage 2
name 12 = altM: Altimeter [m]
name 13 = scan: Scan Count

name 14 = sbeox0ML/L: Oxygen, SBE 43 [ml/l]
name 15 = sbeox0dOV/dT: Oxygen, SBE 43 [dov/dt]
name 16 = nbin: Scans Per Bin
name 17 = sal00: Salinity, Practical [PSU]
name 18 = sal11: Salinity, Practical, 2 [PSU]
name 19 = svCM: Sound Velocity [Chen-Millero, m/s]
name 20 = flag:

CTD salinity and oxygen data were then calibrated by fitting the data to water sample salinity and oxygen data. WHOI post-processing fitting procedures are modelled after Millard and Yang, 1993.

Summary of manufacturer CTD Calibrations

All sensors were calibrated by the manufacturer. A listing of sensors and calibration dates are presented in Table 3.

Table 3. Sensor Calibration Dates.

Sensor Number	Sensor Type	Manufacturer	Calibration Dates
94763	pressure	Sea-Bird	08 August 2008
4491	temperature	Sea-Bird	21 April 2011
4252	temperature	Sea-Bird	19 April 2011
2824	conductivity	Sea-Bird	20 April 2011
2768	conductivity	Sea-Bird	20 April 2011
1679	SBE43 dissolved oxygen	Sea-Bird	23 July 2010
0072	SBE43 dissolved oxygen (stations 27-39)	Sea-Bird	30 March 2010

CONDUCTIVITY CALIBRATION

Basic fitting procedure:

The CTD primary and 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:

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

where BC - bottle conductivity [mS/cm]

CC - pre-cruise calibrated CTD conductivity [mS/cm]

CP - CTD pressure [dbar]
m - conductivity slope
b - conductivity bias [mS/cm]
β - linear pressure term [mS/cm/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 4a for primary sensor 2824 and secondary sensor 2768. Fits to primary conductivity and temperature were applied to the final data.

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

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

Data Quality

Calibrated, the overall standard deviation of the CTD conductivity and the water sample differences for primary sensor (S/N 2824) is **0.001629**. The overall standard deviation for secondary conductivity sensor (S/N 2768) and the water sample differences is **0.001688.**

Table 4a. Best Fit Conductivity Coefficients for Primary Conductivity S/N 2824

Stations	#pts used	total #pts	std dev (mS/cm)	Slope (min/max)	Bias	Beta
Fit as a group in chronological order [1:41] (calcop4)	581	648	.001629	1.00007/1.00009	0.0017352	-3.9122e-07

Table 4b. Best Fit Conductivity Coefficients for Secondary Conductivity S/N 2768

Stations	#pts used	total #pts	std dev (mS/cm)	Slope (min/max)	Bias	Beta
Fit as a group in chronological order [1:41] (calcop3)	579	648	.001688	1.00022/1.00033	-0.0014012	-6.1419e-07

OXYGEN CALIBRATION

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 weak dependence on the CTD pressure, temperature, and conductivity (salinity). A FORTRAN program oxfitmrx.exe developed by Millard and Yang (1993) was encorporated 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 following 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]
	Oc	- oxygen current [uA/s]
	Oxsat	- oxygen saturation []
	P	- CTD pressure [dbar]
	T	- CTD temperature [°C]
	T_o	- oxygen sensor temperature [°C]
	S	- salinity [PSS-78, psu]
	slope	- oxygen current slope []
	lag	- oxygen sensor lag [s]
	bias	- oxygen current bias []
	tcor	- membrane temperature correction []
	wt	- weight, membrane temperature sensitivity adjustment []
	pcor	- correction for hydrostatic pressure effects

Data from all stations and the oxygen sensors were calibrated according to the following groups:
- St.1
- St.2
- St.3,5 (these cals were also applied to station 4)
- St.6-10
- St.11-26
- St.27
- St.28
- St.29-30
- St.31-35
- St.36-39

-St.40-41

Other notable data acquisition/processing issues

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. An at-sea station event log was also kept during the cruise to point summarize notable information about each CTD station collected.

V. Salinity and Dissolved Oxygen Measurements

Water samples collected during this cruise were analyzed for concentrations of salinity and dissolved oxygen. These measurements were used to calibrate the CTD sensors.

Salinity

Water was collected in 200 ml glass bottles. The bottles were rinsed twice, 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 Autosal Model 8400B salinometer (WHOI #11, serial #59210). The salinometer's bath temperature was set to 24C and was standardized once a day using IAPSO Standard Seawater Batch P-152 (dated May-2013). 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 ±0.003 psu. 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 Dosimat buret. The titration endpoint was determined amperometrically using a dual plate platinum electrode, 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.

References

Knapp, G.P., M. Stalcup, and R.J. Stanley. 1990. Automated Oxygen Titration and Salinity Determination. WHOI Technical Report, WHOI-90-35, 25 pp.

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VI. High Resolution Profiler II (HRPii)

The High Resolution Profiler (HRP) is a free-fall vertical profiler with the design objectives of being able to estimate the entire range of spatial variability in velocity, temperature, salinity and density. The free-fall configuration is aimed at eliminating vibrations and extraneous tugging associated with even a loose tether. This then requires onboard decision making for dive termination by release of ballast weights. The task of estimating the entire vertical spectrum of variability is accomplished with two sets of sensors. Microstructure sensors resolve scales of 1 meter to several millimeters. A finestructure suite resolves scales smaller than 1 meter to those as large as the entire water column. A GPS module is used to obtain the profile start and end position and time, from which the depth average ocean velocity can be estimated. The instrument and it's intended operation are described more fully in the Montgomery. 2006. Estimates of microstructure variables represent variances averaged over slightly more than one second and are gridded at half-decibar intervals. Estimates of finestructure variables, ie. pressure, termperature, salinity, horizontal velocity, are averaged on this same grid.

HRP operations during DYNAMITE consisted of the profiler being used in conjunction with hydrographic operations along survey lines (HRP profiles 1-4, 5-7, 8-12 and 40-48) and grid surveys having six nautical mile spacing (HRP profiles 13-21, 22-30, 31-34 and 35-38). Cast details are tabulated below.

Table 1: HRPii station positions and particulars. Deployment time and position are nominal values from station logs and the instrument's internal clock. Better estimates can be obtained from the instruments GPS logger at deployment. Water depth represents the best estimate from the ship's acoustic resources at deployment, Pmax is the maximum pressure logged by the profiler and 'termination' represents the method of profile termination. The two values of range are the height above bottom at weight release logged by the acoustic altimeter and the nominal height for weight release programmed prior to dive start.

HRP	CTD	Time –	lat	lon	depth	Pmax	Termi-	range	comments
		GMT	GPS		(meters)	(dBars)	nation	(m)	Time from HRP system clock /
		deploy	deploy						Time from GPS
1	1	11:24 / 17:28 Z, May 16	20 30.461 N	62 12.106 W		1253	Pressure	n/a	Header time wrong
2	2	17:14 Z, May 16	20 25.39 N*	61 35.72 W*	5565	4744	Time	n/a / 10.0	*station log, header time wrong
3	3	00:52 Z, May 17	20 19.92 N*	61 00.06 W*	5630	5733	Pressure	33.9 / 10.0	*station log, header time wrong
	4								
4	5	15:25 Z, May 17	19 59.95 N*	59 59.89 W*	5007	5083	Pressure	16.9 / 10.0	*station log, header time wrong
5	6	08:18 Z, May 18	22 24.0 N*	60 0.0W*	5952	6067	Pressure	37.5 / 10.0	*nominal, header time

									wrong
6a	7	05/19/11	21 51.0N*	59 13.2W*					Deploy w/o start, *nominal
6b	8	09:47 Z, May 19	21 19.23 N*	58 26.99 W*	5250	5353	Pressure	23.0 / 10.0	*from station log
7	9	16:53 / 16:58 Z, May 19	21 00.203 N	57 59.813 W	4930	5010	Range	8.5 / 10.0	
8	10	08:18 Z, May 20	22 59.99 N*	57 00.01 W*	6275	6411	Pressure	44.1 / 10.0	*from station log, no GPS file, no up files
9a	11	05/20/11	22 26.4 N*	56 19.8 W*	5600				Crash. No data. *nominal.
9b	12	14:36 / 14:37 Z, May 21	21 52.890 N	55 39.590 W	4951	4963	Range	18.9 / 20.0	
10	13	23:15 Z, May 21	21 19.2N*	55 0.0 W*	5407	5450	Time	75.1 / 20.0	*nominal, GPS not installed, no up files
11	14	09:15 / 09:14 Z, May 22	20 45.595 N	54 19.827 W	5800	5876	Pressure	68.2 / 20.0	No recovery GPS, no up files
12	15	18:54 / 18:56 Z, May 22	20 17.988 N	53 48.001 W	5212	5289	Pressure	55.90 / 20.0	
13	16	06:03 / 06:03 Z, May 23	20 53.978 N	52 48.528 W	4910	4916	Range	19.0 / 20.0	
14		10:37 / 10:38 Z, May 23	20 54.001 N	52 41.989 W	4420	4477	Pressure	47.2 / 20.0	
15		15:01 / 15:02 Z, May 23	20 53.995 N	52 35.450 W	4760	4820	Range	18.8 / 20.0	
16		20:46 / 20:48 Z, May 23	21 00.004 N	52 35.454 W	4760	4806	Range	19.0 / 20.0	
17	17	11:36 / 01:52 Z, May 24	20 59.898 N	52 41.946 W	4790	4851	Range	18.7 / 20.0	Time in header wrong
18		16:36 / 06:52 Z, May 24	20 59.997 N	52 48.477 W	4780	4831	Range	19.0 / 20.0	Time in header wrong
19		22:26 / 12:43 Z, May 24	21 05.876 N	52 48.565 W	4937	5014	Range	8.6 / 10.0	Time in header wrong
20		03:34 / 17:51 Z, May 25	21 05.991 N	52 42.000 W	4984	5056	Range	18.8 / 20.	Time in header wrong
21	19	08:24 / 22:41 Z, May 25	21 05.916 N	52 35.565 W	4930	5012	Pressure	26.6 / 15.0	Time in header wrong, all down a/d channels are short
22	20	17:02 Z, May 25	23 23.89 N*	52 05.72 W*	5189	5299	Pressure	69.2 / 10.0	*from station log
23		22:49 / 22:50 Z, May 25	23 23.930 N	51 59.836 W	5560	5672	Pressure	18.4 / 10.0	No up files, all down CT1 files short
24	21	04:05 / 04:08 Z, May 26	23 23.933 N	51 53.928 W	5653	5672	Pressure	~130 / 10.0	Typo in Pend, no up files
25		10:14 / 10:14 Z, May 26	23 30.003 N	51 53.965 W	5240	5338	Range	9.1 / 10.0	
26	22	15:21 / 15:22 Z, May 26	23 29.989 N	51 59.948 W	5200	5276	Range	8.9 / 10.0	
27		20:19 / 20:20 Z, May 26	23 29.991 N	52 05.996 W	4913	4992	Pressure	? / 15.0	Best est. via Sea Beam
28	23	02:18 / 02:19 Z, May 27	23 35.925 N	52 05.864 W	4820	4912	Pressure	98.3 / 15.0	
29		06:54 / 06:55 Z, May 27	23 35.973 N	52 00.017 W	5040	5132	Pressure	63.8 / 10.0	
30	24	11:50 / 11:50 Z, May 27	23 36.040 N	51 53.966 W	5610	5722	Pressure	14.3 / 10.0	All up a/d channels are short
31	25	05:16 / 05:16 Z, May 28	25 54.011 N	51 17.976 W	5280	5382	Pressure	40.1 / 10.0	
32		10:07 / 10:08 Z, May 28	25 54.015 N	51 12.026 W	5750	5869	Pressure	35.3 / 10.0	
33	26	15:47 / 15:47 Z, May 28	25 54.049 N	51 06.015 W	5100	5137	Range	8.7 / 10.0	
34		21:33 / 21:34 Z, May 28	26 00.065 N	51 06.022 W	5495	5435	Time	0.0 / 10.0	Crash. Alt. Turn on -5m, no UPs
35	27	12:48 / 13:55 Z, June 5	28 00.061 N	50 16.757 W	5150	5217	Range	9.0 / 10.0	No up GPS, header time wrong

36		18:16 / 19:23 Z, June 5	27 59.979 N	50 23.652 W	4950	5038	Range	8.9 / 10.0	Header time wrong
37		23:45 / 00:53 Z, June 5	28 06.055 N	50 23.738 W	5220	5304	Range	9.1 / 10.0	Header time wrong
38	28	05:43 / 06:50 Z, June 6	28 11.997 N	50 16.800 W	5550	5661	Pressure	19.4 / 10.0	Header time wrong
39									Didn't happen
40	29	15:00 / 20:19 Z, June 6	27 59.756 N	52 06.006 W	5017	5110	Range	9.2 / 10.0	Time wrong in header
41	30	20:15 / 08:17 Z, June 7	28 00.003 N	53 50.996 W	5640	5751	Range	9.2 / 10.0	Time in header wrong
42	31	09:12 / 21:14 Z, June 7	27 59.926 N	55 37.674 W	5741	5851	Pressure	17.0 / 10.0	Time in header wrong
43	32	22:12 / 10:15 Z, June 8	28 00.007 N	57 25.184 W	5859	5975	Range	9.5 / 10.0	Time in header wrong
44	33	11:45 / 23:48 Z, June 8	28 00.011 N	59 11.974 W	6350	6191	Pressure	298 / 10.0	Time in header wrong
45	34	20:13 / 08:15 Z, June 9	28 00.008 N	60 00.052 W	4805	4881	Range	8.9 / 10.0	Time in header wrong
46	35	03:36 / 15:39 Z, June 9	28 00.035 N	60 48.017 W	6006	6132	Pressure	55.0 / 10.0	Time in header wrong
47	36	14:30 / 02:34 Z, June 10	27 34.634 N	61 58.864 W	6005	6132	Pressure	48.1 / 10.0	Time in header wrong
	37								
48	38	21:15 / 21:18 Z, June 10	29 17.010 N	63 02.681 W	5036	5119	Range	9.0 / 10.0	Short down CT1 profiles

HRPii operations were not without difficulty. Two down casts (9a and 34) ended with the HRP stuck in the mud. Cast 9a returned NO data at all. Cast 34 was missing its up profiles due to loss of power. Cast 34 resulted from the altimeter turn on pressure being 5dBar greater than the bottom depth. The cast log for 9a has an end pressure of 5710 and altimeter turn on of 100 m. The CTD bottom pressure was 5682+10 dBars, suggesting that the altimeter should have been on at impact. However, with no data return the possibility of a typo can not be excluded. The absence of down files with continued pinging and change of ping rate associated with ballast drop after the downcast Tmax criterion of 200 minutes is a bit of a mystery. The down files should have been written at ballast drop.

Numerous other files were either missing or incomplete (short). Five profiles (8, 10, 11, 23, 24) are missing the entire upcast. Other profiles are short in variables on a power board or set of power boards:

Cast 21: all a/d down channels short

Cast 30: all a/d up channels short

Cast 23: short CT1 down cast

Cast 48: short CT1 down cast

The arrangement of sensor subsystems on the power boards was modified from that documented in Montgomery (2006) during the cruise due to noise issues.

Sensor Subsystem Performance

Dive termination: The altimeter worked like a champ during its first scientific use. The unit generally locked on to the bottom at 100 meters range and dive termination was succesful, apart from the mishap noted above. The unit, though, does not play well with others. When on, it introduces an extreme amount of noise into most of the other data channels. This noise contamination of the acoustic travel time sensor MAVS is obvious in the processed velocity profiles and needs to be avoid in subsequent analysis of the data.

The finestructure suite consists of a CTD, an ACM, an EM velocity sensor, compass, accelerometers and a GPS module.

CTD performance was less than optimal. A Neil Brown Ocean Sensors unit was installed at the start of the cruise. It flooded on the first deep cast (Station 2, at approximately 4550 Dbars). This defect was not noted until after dive 3 had been started. This unit was replaced with a slower Neil Brown Instrument Systems unit. An attempt was made to utilize the faster Neil Brown Ocean Sensors design at Station 47, but this unit also flooded. The Neil Brown Instrument Systems unit was reinstalled, but it too immediately flooded. The calibration of the NBIS conductivity sensor is grossly wrong. Estimated conductivity gradients are a factor of three smaller than corresponding gradients estimated from the wire-lowered unit. No attempt was made to modify this with an in situ calibration. Rather, the CTD suffered from another defect: Initially the CTD was set in a free running state. The system clock was apparently unable to keep pace and this, in turn, resulted in noise spikes being injected into the data stream. These spikes are quite apparent at abyssal stratification rates. The CTD sampling was changed to a slower 11.5 Hz for casts 40-48 which resulted in the elimination of spikes in the CTD data.

Table 2: Calibrations for the CTD boards used during DYNAMITE. The NBIS conductivity calibration is not close to describing the output of the sensor.

Pressure	cast	Cal date	calibration	Tlag	
STS 549882 / Board 107	1--48	11/03/09	Pcal = [-1249.4, 27908, -0.17456]		
Cond/Temp pairs			Tcal		Ccal
NBOS #3 / Board 117	1--3	04/21/11	[1.869435e-006, -4.485046e-005, 6.494546e-004, -2.143847e-004]	9	[68.9975135049937, 0.0028899033165661]
NBIS Mk3 / Board 70	4--46 & 48	04/21/11	[7.692860e-7, -1.881711e-5, 4.400365e-4, 1.146189e-4]	9	[68.35, -0.0488]
NBOS #4 / Board 118	47	11/23/09	[4.558086e-006, -1.178183e-004, 1.312616e-003, -2.291590e-003]	9	[67.8395392836202, -0.0156647215081323]

Fewer issues were encountered with the Modular Acoustic Velocity Sensor (MAVS). The initial deep profile (Station 2) revealed extremely high noise levels in the raw data starting at about 3000 Dbars. The issue was diagnosed as plausibly arising from reduced sensitivity of the transducers at high pressure. The unit was opened and the gain increased. This action was taken with the hope of being able to execute a post-cruise calibration. This hope was dashed when a transducer was noted to be damaged after recovery from Station 16. A second unit was installed, but this was damaged by dragging operations at the end of Station 34. A third sting was installed. There is a post-cruise calibration for this unit.

The MAVS output represents an estimate of relative flow past the instrument. An estimate of the oceanic velocity is obtained by using this relative velocity and a model of the instrument's response to this relative flow. The instrument is nearly in equilibrium with the relative flow at long time scales, making the estimate of large vertical scales in the velocity field problematic: integrating small offsets (biases) in the sensor's estimate of velocity can represent large trends in the vertical: a good calibration is required to eliminate such biases. The lack of a calibration for much of the cruise implies the large scale trends in the estimates of oceanic velocity are not to be trusted. Even with the laboratory calibration, there exists the likelihood that the biases, which are sensitive to the cross-section area of a very high capacitance wire, change with changes in pressure and temperature. Future analysis should start by detrending the profiles or matching the trend with that of the shipboard ADCP, but there is no guarantee that the later effort will account for temperature/pressure dependent changes in the bias.

Table 3: Calibrations for the MAVS acoustic current meter. Recalibration is required when either a new sting or new board is installed, or the lead wires are rearranged.

MAVS ACM	HRPii casts	zeros	date	comment
Sting 2	1—3 4--16	[-197.00 350.23 336.21 464.85] [? ? ? ?]	01/14/10	Gain increased post cast 3, kills calibration
Sting a	17-34	[? ? ? ?]		
Sting 1	35-48	[180.53 216.23 196.41 696.97]	08/03/11	

The HRPii utilized an electric field (EM) velocity sensor, a technique that amounts to the measurement of an extremely small voltage drop associated with the motion of a conductor (here seawater) in a magnetic field. The measurement requires the elimination of any ground faults. The resulting velocity estimates have a higher noise level than that of the acoustic current meter (MAVS), but under ideal conditions they have a much better response at large time and length scales. EM data are logged during both down and up casts, presenting two estimates of the large scale velocity. It took approximately one week to eliminate the hard ground faults from the system.

Regardless, the up casts with fewer operating sensors were uniformly more noisy than the downcasts. In its less noisy states, the the EM data exhibited a cogging behavior resulting in offsets (not spikes) of the voltage estimate. These evidently accumulate a net offset of substantial residual as the large scale trends in the up and down profiles were dissimilar. A handful of the EM down profiles (Stations 19, 20, 27, 28, 40 and 41) could be appreciated as quantitatively resembling the MAVS profile, but with much higher noise levels.

For the sake of completeness, we note that the EM sensor ring was mounted such that

amplifier EB15 → channel EF2 = x'

amplifier EB14 → channel EF1 = y'

with right handed coordinate system (x',y',z') and positive z' pointing toward the top bail needing either a 10 degree counter clockwise rotation or 170 degree clockwise rotation to be put into the (x,y,z) coordinate system of the pressure case. The ambiguity is associated with uncertainty about the polarity of the sensor leads.

In contrast, no deficiencies were noted with the compass and accelerometer data.

The depth mean velocity is not estimated by either MAVS or EM sensor. For this, a GPS module was mounted on the instrument, logging both position and time at deployment and recovery. No data are logged while under water. No deployment data were logged at Station 8 and the unit was not mounted for Station 10. Recovery data were not logged by the unit at Stations 2-6, 8, 10, 11, 22, 34 and 35.

The HRPii's Microstructure suite consists of two air foil shear probes, an FP07 fast response thermistor and a dual needle conductivity probe. The micro-temperature and micro-conductivity are generally high quality and calibrated in situ against the wire-lowered CTD. The shear probe data were quite noisy. Much of this noise is likely associated with a decision to detatch the case ground of the sensors since it represented a hard ground fault to the EM subsystem. Apparently, the shear probe electronics need to be grounded in this way. To compound the issue, the level and character of the electronic noise varied as modifications were made to other sensor systems. The data were processed by writing a new processing package (micro_diagnostics_v1.5) with extensive diagnostic tools. The data set was then processed essentially three times. A first pass was used to document the basic character of the noise. This first pass would prove sufficient to process an ordinary data set. Noise spectra having variable levels were fit to the deep segments of each profile during a second pass, with refinements to the algorithm accumulating. A third pass produced as uniformly processed data set as possible. Two versions of micro_diagnostics_v1.5 were ultimately used, micro_diagnostics_v1.5 and micro_diagnostics_v1.5iii. The later version recognizes a 10Hz noise peak in the shear spectrum. Analytic representations of the noise spectra (Pn) are

WHOI shear probes: $Pn(f) = A\ 4\times10^{-8}\ s^{-2}/cps$

RSI shear probes: $Pn(f) = B\ 2\times10^{-7}\ s^{-2}/cps$

temperature: $Pn(f) = C\ 0.18e\text{-}9 * f^2\ [\mathrm{sinc}(f/200)\ ]^4\ /\ [1.0+(f/52.5)^8]\ C^2 m^{-2}\ /\ cps$

conductivity: $Pn(f) = D\ 0.18e\text{-}8 * f^2\ [\mathrm{sinc}(f/200)\ ]^4\ /\ [1.0+(f/50.0)^8]\ mmho^2 m^{-2}\ /\ cps$

with f being frequency in cycles per second (cps), sinc(x)=sin(πx)/πx and 200Hz being the sampling frequency of the microstructure data. Estimates of noise amplitudes are reported in Table 4. The constants [A B C D] are likely slowly varying with fall rate, but the attempt here is to constrain the noise when signal-to-noise ratios are not large, i.e. in the abyss, so the constants reflect depths of 3000-5000 meters. The rate of dissipation of turbulent kinetic energy ε is estimated from formulas assuming isotrpoic relations between components of the rate of strain tensor as $\varepsilon = 15/2\ \upsilon\ S \cong 15/2 \times 1.5 \times 10^{-6}\ m^2\ s^{-1}$ Pn(f) x 10 cps with molecular viscosity υ and S representing the variance of the single component of the rate of strain tensor measured by the shear tensor S. Integrating over 10 cps, the quoted noise spectra translate into dissipation rates of 5×10^{-12} and 2.5×10^{-11} W/kg for WHOI and RSI probes, respectively. These are *not* average electronic noise levels. A Gaussian white process, which plausibly describes the electronic noise in the shear sensor, has an average variance whose statistical uncertainty decreases with increasing number of independent estimates, N, of the variance. The quoted noise levels represent the those ½ Dbar data segments having the lowest 5-10% of the sample variances, with the complication that the sample data have contributions from both noise and oceanic signal. These shear noise estimates are very much lower bounds on the average noise. Also note that the quoted values represent what a 'healthy' instrument is capable of. In contrast, the curve fits for temperature and conductivity noise represent the average electronic noise spectra of the system.

Table 4: Noise amplitudes of the four microstructure sensors and the quality masks for shear and temperature. NaN represents entire profiles for which the data from that probe are judged to be noisy.

Station	[A B C D]	Sx	Sy	mT	Code version
1	[1.0 2.5 1.5 1.5]	all	all	all	v1.5
2	[2.5 1.0 1.7 1.5]	NaN	p>250, except 2600-2800	P<4540	v1.5
3		NaN	NaN	NaN	v1.5
4	[0.5 5.0 1.5 1.5]	all	NaN	all	v1.5
5	[1.0 10.0 1.35 1.0]	all	NaN	all	v1.5
6	[1.0 5.0 1.0 1.0]	all	NaN	NaN	v1.5
7	[1.0 10.0 0.825 1.0]	400-end	NaN	400-end	v1.5
8	[0.5 5.0 1.65 1.0]	all	NaN	all	v1.5
9	[2.5 1.0 3.0 1.0]	NaN	0-3000	all	v1.5iii
10	[5.0 5.0 2.75 1.0]	NaN	0-3000	all	v1.5iii
11	[1.0 1.0 3.0 1.0]	all	0-3000	all	v1.5
12	[5.0 5.0 3.0 1.0]	NaN	NaN	all	v1.5
13	[1.0 1.0 2.75 1.0]	NaN	NaN	all	v1.5iii
14	[5.0 1.0 2.25 1.0]	1500-end	0-1500	all	v1.5iii
15	[5.0 1.0 3.00 1.0]	1500-end	0-1500	all	v1.5iii
16	[5.0 1.0 2.60 1.0]	1250-end	0-end	all	v1.5iii
17	[5.0 1.0 2.75 1.0]	NaN	0-1200	all	v1.5iii
18	[5.0 1.0 2.75 1.0]	NaN	0-1900&>4400	all	v1.5iii
19	[5.0 1.0 3.00 1.0]	NaN	0-1000	all	v1.5iii

20	[1.0 5.0 3.0 1.0]	0-1400	NaN	all	v1.5iii
21	[--- --- --- ---]	NaN	NaN	NaN	v1.5
22	[--- --- 2.0 1.0]	NaN	NaN	0-2400	v1.5
23	[--- --- 3.25 1.0]	NaN	NaN	all	v1.5
24	[5.0 25.0 2.25 1.0]	0-1450	NaN	all	v1.5iii
25	[5.0 25.0 3.0 1.0]	0-2000	NaN	all	v1.5iii
26	[5.0 25.0 3.0 1.0]	0-750	NaN	all	v1.5iii
27	[5.0 25.0 3.0 1.0]	0-1350	NaN	all	v1.5iii
28	[5.0 25.0 3.0 1.0]	0-1700	NaN	all	v1.5iii
29	[5.0 25.0 3.0 1.0]	0-1000	NaN	all	v1.5iii
30	[5.0 25.0 3.0 1.0]	0-1350	NaN	all	v1.5iii
31	[5.0 12.5 3.0 1.0]	0-2000	NaN	all	v1.5iii
32	[10.0 25.0 3.0 1.0]	0-2000	NaN	all	v1.5iii
33	[10.0 25.0 3.0 1.0]	0-1500	NaN	all	v1.5iii
34	[25.0 10.0 4.0 1.0]	NaN	0-385&>5150	all	v1.5iii
35	[2.5 12.5 7.0 1.0]	0-850	NaN	all	v1.5iii
36	[5.0 25.0 3.5 1.0]	NaN	NaN	NaN	v1.5iii
37	[1.0 12.5 8.0 0.8]	0-200	NaN	all	v1.5iii
38	[2.0 25.0 6.0 1.2]	0-250	NaN	all	v1.5iii
39	[--- --- --- ---]				
40	[1.0 5.0 6.0 1.0]	NaN	NaN	all	
41	[1.0 5.0 6.0 3.0]	NaN	NaN	all	
42	[1.0 1.0 6.0 4.0]	NaN	NaN	all	
43	[1.0 1.0 6.0 4.0]	NaN	NaN	all	
44	[0.5 2.5 6.0 1.0]	NaN	NaN	NaN	
45	[0.5 1.0 6.0 1.5]	240<p<3000	p>240	all	
46	[0.5 1.0 6.0 4.0]	p<3500	all	all	
47	[0.5 1.0 6.0 4.0]	p<3500	all	NaN	

After the third round of processing, a mask was developed to discard noisy data. For a normal data set, this mask consists of two steps:

(I) visually inspecting for isolated spikes that are more than an order of magnitude larger than their neighbors, then replacing those with a nominal bad data value, such as NaN, and (II) estimating the gradient variance S from two redundant probes Sx and Sy as

(II)

if (Sx < 7 Sy & Sy < 7 Sx) then S=(Sx+Sy)/2;

else

if(Sx > 7 Sy) S=Sy;

if(Sy > 7 Sx) S=Sx;

end

Here, however, the third round of processing was used to produce a 500 meter averaged estimate of shear variance from one probe, e.g. <Sx> , then the diagnostic results were used to assess if more than 50% of <Sx> was contributed by the individual data segments for which the observed shear spectra were in substantive agreement with the universal forms for high Reynolds number turbulence. Data segments that did not meet this average condition are not reported in the final data files.

Table 5: shear probe usage and post toasties

Cast	Sx	can	gain	Sy	can	gain	comment
1--3	M777	21	50	#78	25	50	Sx has bad case of the fuzzies
4--5	M779	21	50	#78	25	50	M779 delaminated
6--8	M780	21	50	#78	25	50	Swap Sx and Sy
9--10	#78	25	50	M780	21	50	#78 appears defunct
11	#68	22	100	M780	21	50	
12	M780	21	100	#101	24	100	During cast 20, BP says the electronics in can 24 are fried.
13	M780	21	100	#87	25	50	
14--18	#68	22	100	M780	21	100	
19	#100	25	50	M780	21	100	BP says #100 is toast
20--21	M780	21	100	#68	22	100	
22	M780	21	100	#79	25	100	DW says #79 is stone cold dead
23--25	M780	21	100	#68	22	50	#68 nonfunctional in thermocline, goes to upper rail with spikes
26--27	M780	21	100	#102	25	100	#102 ditto
28	M780	21	100	#103	22	50	#103 ditto
29	M780	21	100	#102	25	100	M780 swapped out to check spectral response.
30	M783	21	100	#104	22	50	#104 ditto
31--33	M784	21	100	#103	22	50	Still spikes, but not to rail
34	#103	22	50	M784	21	100	Swapped Sx and Sy, no change
35	M786	21	100	#92	22	50	#92 – no signal apparent
36--37	M786	21	100	#53	22	50	noisy
38--41	M786	21	100	#107	25	50	noisy
42--43	M786	21	100	M787	25	100	Got tired of noise in WHOI probe
44	M786	21	100	#46	22	50	Change back to WHOI probe. 6000 m looks to be too much for #46
45--48	M786	21	100	#103	22	50	

Shear probe sensitivities and calibration dates. These are uniformly cast as calibrations for RSI electronics having a 1.5nF feedback capacitor. The WHOI electronics are to a design of Neil Oakey and have a 1.0nF feedback capacitor. Use of a RSI calibration requires adjustment of the RSI calibration by a factor of 1.5.

M777	0.0617	3/24/11
M779	0.0630	3/24/11
M780	0.0557	4/12/11
M783	0.0567	4/12/11
M784	0.0556	4/12/11
M786	0.0715	4/13/11
M787	0.0625	4/13/11

WHOI probes with Oakey calibration			RSI equivalent -or- RSI recalibration	
#46	11/3/94	20.42	0.3063	
#53	3/20/98	25.26	0.2653	recal date
#68	12/14/0	25.63	0.3762	recal date
#78	12/13/0	21.70	0.3255	
#79	12/13/0	28.29	0.3800	recal date
#87	12/13/0	21.10	0.2715	recal date
#92	3/19/98	18.94	0.3383	recal date
#100	12/13/0	35.35	0.3529	recal date
#101	12/13/0	36.09	0.3804	recal date
#102	?		0.2313	recal date
#103	?		0.3122	
#104	?		0.3010	recal date
#107	?		0.2968	recal date

Temperature

Cast 1 - 6	RSI 582	
Cast 7 - 8	RSI 575	tip missing at crash of cast 9.0
Cast 9 – 22	RSI 574	mid-profile traumata with reduced response thereafter
Cast 23 – 34	RSI 576	replaced due to bottom impact. tip appears to be intact.
Cast 35 – 44	RSI 577	
Cast 45 – 47	RSI 578	tip intact at dismount
Cast 48	RSI 579	tip missing

Conductivity

Cast 1 - 9	serial # 070116	new style cell
Cast 10 – 12	serial # 070115	new style cell - BP diagnoses ground fault and cleans up solder, can swapped
Cast 13 – 31	serial # 070116	new style cell
Cast 32 -	serial # 070115	new style cell – probe exhibits spikes.
Cast 33 -	serial # 070116	new style cell - reinstall without dismounting
Cast 34 – 41	serial # 070113	new style cell
Cast 42 – 48	serial # 070115	new style cell

References

Montgomery, E.T, 2006. HRPII – The development of a new vehicle for studying deep ocean mixing. WHOI Technical Report, WHOI-2006-05, 35pp.

VII. Multibeam Bathymetry

The SeaBeam 3012 Multibeam Echo Sounder (MBES) installed on R/V KNORR consists of hull-mounted transducers (projectors and hydrophones), a single, six-foot electronics rack with power amplifiers and control/processing electronics, and a dual-screen, Windows-based workstation providing

Operator Control and Display. The original MBES was installed on the ship in 1995, as a SeaBeam 2112 configuration. In July of 2006, the system was upgraded to the present, 3012 configuration. In addition to the sonar system itself, the SeaBeam system receives attitude (pitch, roll, & heave) from a POS/MV inertial/GPS receiver, heading from the ships gyro, navigation from a C-Nav dynamic, differential GPS receiver, and surface sound speed from the ships data logger. The SeaBeam system operated nearly continuously during KN200-06, except during periods of station keeping and when its operating frequency (12 kHz) interfered with other acoustic sources (pingers, HRP, etc). There were also three instances when SeaBeam mysteriously "crashed," resulting in data loss of 10-20 minutes.

Processing of SeaBeam data basically consists of two separate operations. First, it was necessary to re-compute all bathymetry to insure that the computed depths and offsets were created using the intended sound speed profile (SSP). Prior to KN200-06, during the transit leg KN200-05, a series of tests were done over deep (> 5,000 m) flat bottom conditions. These tests seemed to indicate that the SeaBeam system was not correctly using the SSP. These errors seemed to be small (< 3% of depth), but noticeable as either a "smile" or "frown," indicative of an SSP issue. For KN200-06 data, an accurate SSP was obtained from the numerous CTD casts. When transiting between CTD sites, an SSP was used based on historical, temperature / salinity profiles.

The second processing operation consisted of removing obvious bathymetric data outliers (aka "editing" the data). For SeaBeam data collected during HRP survey sites, this editing process consisted of manually examining each and every ping, and flagging individual soundings that deviated from expected bottom conditions. For data collected during transits between CTD / HRP sites, an automated process was used, that flags obvious "spikes" in the bathymetry based on deviation from average slopes.

The final product for SeaBeam operations consisted of a number of large-scale maps of bathymetry, covering both the HRP survey sites and the transits between sites. Additionally, the processed SeaBeam data files were also used to create a series of GMT-compatible grid files encompassing the entire cruise. All of the raw and processed SeaBeam data files themselves were also provided, and copies delivered to the WHOI Digital Library and Archive.