WHP Cruise Summary Information

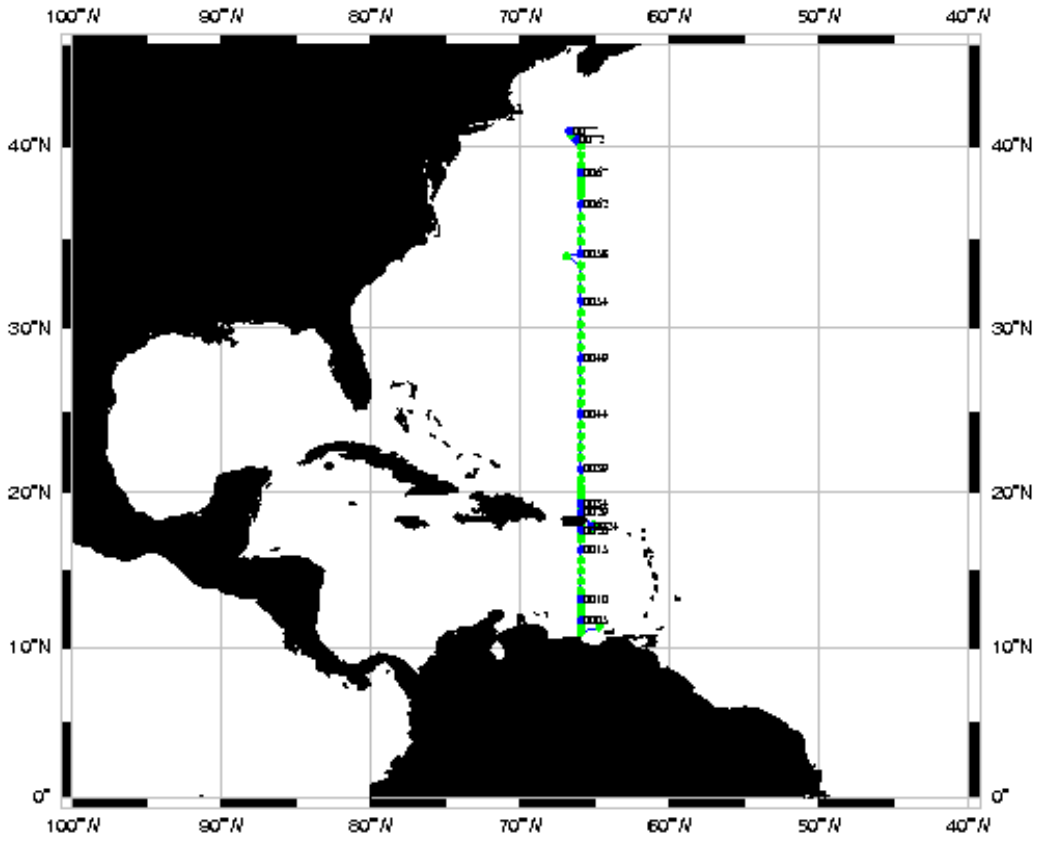
WOCE section designation	A22
Expedition designation (EXPOCODE)	316N151_4
Chief Scientist(s) and their affiliation	Terrence Joyce, WHOI
Dates	1997.08.15 – 1997.09.03
Ship	KNORR
Ports of call	Trinidad, Spain to Woods Hole, MA
Number of stations	79
Geographic boundaries of the stations	40˚46.47''N 66˚58.66''W 64˚45.01''W 11˚00.00''N
Floats and drifters deployed	10 Floats and 9 Drifters
Moorings deployed or recovered	1 Mooring recovered
Contributing Authors (in order of appearance)	F. Bahr G. Packard D. Swift L. Stein S. Zimmermann G. Knapp A. Ross D. Chaky K.M. Johnson K. Erickson J. Goddard R. Rotter J. Curtice P. Landry

WHP Cruise and Data Information

Instructions: Click on items below to locate primary reference(s) or use navigation tools above.

Cruise Summary Information	**Hydrographic Measurements**
Description of scientific program	CTD - general
Cruise track (figure)	
Description of stations	
Description of parameters sampled	
	Salinity
Floats and drifters deployed	Oxygen
	Nutrients
	CFCs
Principal Investigators for all measurements	Helium
Cruise Participants	Tritium
	Radiocarbon
Problems and goals not achieved	CO2 system parameters
	Other parameters
Underway Data Information	**Acknowledgments**
	References
Bathymetry	
Acoustic Doppler Current Profiler (ADCP)	

Station locations for a22



(Produced from .SUM files by WHPO)

Cruise report for Knorr 151, leg 4: Port of Spain-Woods Hole

A. Cruise Narrative

Ship: R/V KNORR operated by Woods Hole Oceanographic Institution
Ports: Port of Spain, Trinidad to Woods Hole, Mass, USA
Dates: 15 August depart Trinidad, 3 September arrive Woods Hole
WOCE Designator: 316N151/4

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The Knorr departed Port of Spain, Trinidad as scheduled on 15 August and proceeded to our first station, a joint cast with the 'Hermano Gines', out of the EDIMAR Laboratory, Margarita, Venezuela. This station was located just outside of the sill of the Cariaco Basin. During the station, the chief scientist & R. Rotter went aboard the Gines taking some sample bottles and, after the cast, returning with some nutrient samples for analysis on Knorr. We then proceeded to our start of the Caribbean transect, which we completed with station 23 on 20 August at the 300m isobath south of Puerto Rico. After taking two stations in the Virgin Island Basis, we continued our transect from the north of Puerto Rico, breaking off after station 57 to recover an Inverted Echo Sounder mooring for R. Watts, U. Rhode Island on 8/29/97 at 34˚09.94'N, 66˚59.14'W. The mooring was approximately 60nm west of our cruise track. After the mooring was recovered, we resumed our section, finishing the last station, number 77, on the continental shelf south of Cape Cod, Massachusetts. The ship arrived in Woods Hole on 3 September, one day ahead of schedule.

Cruise Objective

Our cruise is part of the World Ocean Circulation Experiment (WOCE) Hydrographic Programme's (WHP) global, onetime survey of the oceans. The effort to study the global ocean with state of the art instrumentation for highest quality measurements has been virtually completed in all of the major ocean basins except the North Atlantic. As part of this effort, two meridional legs were planned for summer of 1997 aboard the R/V KNORR at 52˚W (WHP line designator A20) and 66˚W (A22) as part of the US Atlantic Circulation & Climate Experiment (ACCE). These lines were done back to back beginning off the coast of Newfoundland, Canada, working southward along 52˚W to the coast of Suriname with a port stop between legs in Trinidad. The Knorr cruise (#151) departed on leg 1 for float deployment (T. Rossby, chief scientist), followed by leg 2 focussing on onetime hydrography in the sub-polar gyre (L. Talley, chief scientist), followed by our two legs. Leg 3 under the direction of R. Pickart, chief scientist. As my leg, is number 4 in the cruise, it is assumed by WHP naming conventions that our EXPOCODE will be 316N151/4. Our fourth leg worked

northwards from the coast of Venezuela to Puerto Rico and thence northwards (along 66˚W) to the continental shelf south of Cape Cod, Massachusetts. Basic instrumentation and principal investigators for both legs were the same with small changes in at sea personnel. This report is for the second of the two meridonal legs (A22): the only WHP line in the global survey that will sample in the Caribbean sea.

During the IGY in the mid 1950s and again in 1985, hydrographic stations were made to the ocean bottom in the region outside of the Caribbean along a nominal longitude of 66˚W. Changes in water properties between these two occupations reflect long-term changes in the deep waters of the western N. Atlantic (Joyce and Robbins, 1996). Measurements to be made in 1997 will further document the evolving system, which is being strongly influenced by temporal changes in the Labrador Sea. Injection of newly ventilated waters from the sub-polar gyre can be detected with standard hydrographic sampling of dissolved oxygen, but detectability is improved with other tracer measurements such as CFCs and tritium/helium-3. Furthermore, use of a Lowered Acoustic Doppler Current Profiler (LADCP) on the CTD/rosette package will permit direct measurements of horizontal velocity throughout the water column and facilitate estimation of flow rates near boundary currents such as the Gulf Stream and the Deep Western Boundary Current.

Measurements of flow and hydrographic properties throughout the water column in the Caribbean Sea will permit the whole section to be used as a constraint of no net flow (top to bottom) which should improve our estimation of geostrophic transport as a function of latitude and depth. The deep inflow into the Caribbean Basin through the Anegada Passage should be reflected in water mass properties below 1800m depth on the southern flank of the island of Puerto Rico while the upper layer flow into the basin from the South Atlantic is mainly found in the westward flow parallel to the coast of Venezuela.

Other measurements include profiling ALACE float deployment for a study of 18˚C water in the northern Sargasso Sea and JGOFs CO_2 and bio-optical measurements. A complete station log (station .sum file) is attached as an appendix to the hard copy portion of this report.

Measurement program

Measurements made on the cruise include the following:

- CTD profiles with Dissolved Oxygen Sensor
- LADCP (mounted on 36 place, 10 liter rosette)
- water sample analyses (at sea) for salinity, oxygen, silica, nitrate, nitrite & phosphate (basic hydro)
- freons (F11, F12, F113) & carbon tetrachloride
- alkalinity, pCO_2, tCO_2 and halocarbons
- water sampling for tritium/helium-3 and natural radiocarbon
- underway hull-mounted ADCP , thermosalinograph, bathymetry (single beam), meteorology & pCO_2
- profiling ALACE float deployment in northern Sargasso Sea

Principal Investigators

Name	Responsibility	Institution
Terrence M. Joyce	chief sci., basic hydro, ADCP, LADCP, T/S, Met.	WHOI
William Smethie Jr.	CFCs, CCl_4	LDEO
William Jenkins	tritium/helium-3	WHOI
Steve Riser	PALACE	Univ. Washington
Louis Gordon	nutrients	OSU
Robert Key	CO_2, radiocarbon	Princeton Univ.
Taro Takahashi	pCO_2	LDEO
Robert Moore	halocarbons	Dalhousie Univ.

WHOI: Woods Hole Oceanographic Institution
LDEO: Lamont-Doherty Earth Observatory, Columbia Univ.
OSU: Oregon State Univ.

Cruise Personnel

Name	Responsibilities	Institution
Terrence Joyce	chief scientist	WHOI
Laura Stein	ctd operations	WHOI
Rochelle Ugstad	ctd operations	WHOI
Sara Zimmermann	ctd processing	WHOI
Jane Dunworth-Baker	ctd processing	WHOI
George Knapp	salinity/oxygen	WHOI
Dave Wellwood	salinity/oxygen	WHOI
Frank Bahr	ADCP,LADCP	WHOI
Stephanie Harrington	ctd watchstander	WHOI/MIT
Juan Botella	ctd watchstander	WHOI/MIT
Richard Wardle	ctd watchstander	WHOI/MIT
Ellen Levy	ctd watchstander	WHOI
Andrew A. Ross	nutrients	OSU
Julie Arrington	nutrients	OSU
Rosanne Swartz	CFCs	LDEO
Eugene Gorman	CFCs	LDEO
Damon Chaky	CFCs	LDEO
Linda Baker	CFSs	LDEO
Peter Landry	tritium/helium-3	WHOI
Joshua Curtice	tritium/helium-3	WHOI
Rich Rotter	C-14, TALK	Princeton
Carrie Thomas	C-14, TALK	Princeton
Ken Johnson	T_{CO2}	Brookhaven
Ken Erikson	T_{CO2}	Brookhaven
John Goddard	pCO_2	LDEO

Name	Responsibilities	Institution
Dana Swift	PALACE	U. Wash.
Wayne Groszko	underway halocarbons	Dalhousie Univ.
Antonio Perez-Aguirre	Venezuelan observer	Venezuelan Navy

Problems Encountered

On 8/22/97 on the upcast of station 34, we lost all communication with the CTD and pylon. We were at 2337dbar on the upcast of our deepest station thus far on the cruise: 6106dbar over the Puerto Rico trench. This was perhaps the deepest station for the wire on the port winch. After recovery, we found that the package would work on the wire of the starboard winch and we therefore switched winches. It was found that a break in 2 of the 3 conductors had occurred at about 6000m from the instrument end of the wire (and 3700m from the winch end). This must have been the point over the sheave at the maximum depth. At this stage, only our small, backup CTD/rosette can operate on 1 conductor if the present wire should develop problems. Another reel on a drum is available but cannot be switched out safely at sea according to the bosun. If it is necessary to do this, we will have to make a quick stop in Bermuda.

After returning from the mooring recovery, on our next station (58) along the cruise track, the CTD signal was lost on the up cast at a pressure of 2651dbars. We brought the package to the surface and, after sampling the deep bottles and determining that the conductor used by the CTD was shorted to the sea-cable ground, we switched to the 'spare', third conductor (the second being used by the rosette pylon), put the package back in the water and did a shallow cast for the upper bottles missed. Thus, both cables had bad conductors: the one on the port winch with one working conductor and that on the starboard winch (which we used since station 34) with 2 good conductors.

We had some problems with the LADCP, and no data are available for stations 20 through 23. See the LADCP section for details.

B. Underway measurements

Shipboard ADCP (Frank Bahr)

The shipboard 150KHz narrow-band ADCP was operated throughout the cruise, and the data were logged on the ADCP PC as well as on a SUN via serial data transfer. Standard data collection parameters included 8 meter bins,16 meter pulse length, and 5 minute ensembles. Navigation was provided by P-code GPS, and gyro heading was checked by recording 5-minute averages of the difference between gyro and Ashtech heading. The Ashtech instrument calculates heading based on differential GPS from an array of four antennas. Bottom tracking was turned on whenever the bottom was within ADCP range (during departure from Trinidad, near Puerto Rico, and on the final transit into Woods Hole). With the Ashtech heading correction applied, an initial bottom track calibration determined transducer amplitude and rotation corrections to be 1.005 and -0.55 degrees, respectively.

While waiting to meet up with the Venezuelan ship for the joint station 1, the ship occupied two octagonal "stop sign" patterns with ship speeds of two and six knots, respectively. Each leg of constant heading was approximately 10 minutes long. The purpose of these tests was to investigate gyro errors as function of heading. Initial results show a roughly sinusoidal dependency of the difference between Ashtech and gyro heading on heading. Higher speeds resulted in a higher amplitude. The picture is complicated by the superposition of time-dependant gyro errors following the course changes.

Standard Knorr underway measurements (Greg Packard)
-Athena/Science Data System.

All sensors/instruments in the system functioned continuously throughout the cruise with the exception of the Doppler speed log. The transducer for this unit was removed from the hull for repair.

Athena, the shipboard data acquisition system, recorded meteorological and navigational data to three distinct files.

The primary data file is as such: kn97mmdd.00x (mm is month, dd is day, x is consecutive file for that day). Recording of parameters to the primary data file is on a one minute basis. The following parameters were recorded in the file:

001| JSECONDS Time & date (Julian seconds)
002| CDATE Computer date
003| CTIME Computer time
009| GYRO Ship's heading (Gyro syncro)
012| IMET IMET data (Wnd, Bar, Hum, Swr, Prc)
024| SSCND Sea surface conductivity (mmho/cm)
025| SSTMP Sea surface temperature (˚C)
066| GPS GPS (Primary GPS data source)
069| WIND Wind speed & direction (true)

The secondary data file is as such kn01min1.xxx (xxx is the consecutive data file written using this configuration). This file offers some derived values from the primary raw data. The following parameters were logged in this file at one minute intervals.

001| JSECONDS Time & date (Julian seconds)
002| CDATE Computer date
003| CTIME Computer time
009| GYRO Ship's heading (Gyro syncro)
021| SPDLOG Ship's speed (EDO Speedlog)
024| SSCND Sea surface conductivity (mmho/cm)
025| SSTMP Sea surface temperature (˚C)
029| GP20P_TP Port GPS 200 time & position
034| GP20S_TP Stbd GPS 200 time & position
036| GPS_COG GPS course over ground

039| GPS_SOG GPS speed over ground
040| GPS_TP GPS time & position
042| IMET_AIR Air temperature (˚C)
043| IMET_BPR Barometric pressure (millibars)
045| IMET_HUM Relative humidity (percent)
052| IMET_PWN Bow to Stern wind speed (m/sec)
059| SALINITY Surface salinity, UNESCO 44
070| WND_SPD True wind speed (m/sec)
071| WND_DIR True wind direction (degrees)

The third logged file is the station.xxx file. This is an event triggered file that was used in conjunction with underway and station surface samples taken by the science party. This file was then parsed out into the respective sub-files based on the event that it marks (i.e. salt samples from underway system, surface CTD bottles, ALACE deployments). The individual event files can be found in the /tsg directory of the cruise archive.

000| Event comment string
001| JSECONDS Time & date (Julian seconds)
002| CDATE Computer date
003| CTIME Computer time
024| SSCND Sea surface conductivity (mmho/cm)
025| SSTMP Sea surface temperature (˚C)
037| GPS_LAT GPS Latitude
038| GPS_LON GPS Longitude
040| GPS_TP GPS time & position
059| SALINITY Surface salinity, UNESCO 44

The only data gaps encountered are the drop in gyro input on two occasions. The two occasions are listed as:

970828	1621-1704 GMT	Gyro converter box lock-up
970901	0510-1153 GMT	Gyro converter box lock-up

In both occasions it was a matter of the Synchro-RS232 signal converter box locking up. The other parameter effected by this is the true wind calculations.

Parameter 034, Stbd GPS unit, is persistent in its null values about 33% of the time due to antenna placement. This GPS parameter is only provided as back-up logging to the P-code Time and Position (parameter 040) and port GPS unit (parameter 029).

TSG salinity was compared to salt samples taken from the system. The TSG salinity values trended a linear offset value of +.31psu when compared to the Autosal values. Compared bottle sample salinities to TSG conductivity/salinity values can be found in the /tsg directory of the cruise archive. TSG temperature values proved to be within acceptable ranges when compared to surface CTD measurements given the spatial variability. This comparison file can be found in the /tsg directory as well.

Module IMET sensors provided the meteorological data. The one minute data values listed in the file are a buffer average of values collected from the sensor for the past 60 seconds at a one second interval. All sensors seemed to provide adequate data when referenced to other available sensors around the vessel (wheelhouse wind birds, temperature sensors and barograph). These sensors are due for their annual calibrations in Sept. 97 and the chief scientist will be notified if anything is found that would effect the quality of the data collected on the cruise.

The following environmental parameter sensors were in use during the cruise:

Wind Sensor	IMET Module ID WND005
Bar. Press.	IMET Module ID BRP005
Rel. Humid.	IMET Module ID HRH106 (Note: also provide Temperature)
SW Rad.	IMET Module ID SWR114
Precip.	IMET Module ID PRC106
SST	FSI OTM 1329
SSC	FSI OCM 1322

-SeaBeam Bathymetry System:

Along track bottom bathymetry was acquired using the vessel's SeaBeam 2100 MutliBeam Bathymetry System. The system works on a 12khz frequency with the ping rate constantly being adjusted with respect to depth. The stripped center beam data files were provided to the science party. These are daily files found in the /center beam directory of the cruise archive. The naming convention is cb1997.XXX. The XXX represents the Julian day of the year 1997. Note that a constant sound velocity curve of 1500 m/sec was used and all values in the file are uncorrected.

Care must be taken when looking at the values when the vessel is hove-to on a CTD station with the sampling package in the water. The 12khz signal from the sampling package pinger interferes with the SeaBeam signal. Another known influence is the vessels 12khz Raytheon Precision Depth Recorder unit.

The following are operation notes from the Seabeam log.

970816	0513 GMT	System start up. Note that a constant 1500 m/sec sound velocity curve will be used for the cruise.
970818	1020 GMT	System hang. Reset.
970820	2130 GMT	Start Jung-fern Passage Sill transect
	2235	Drop XBT (/scijunk/xbt/t5_0003.edf)
	2335	Finish passage transect
970823	1310 GMT	System shutdown on station to allow reboot of control/display station.
	1350	Back acquiring data
970827	2154 GMT	System hang

970828	0140 GMT	Reset
970829	0931 GMT	On idle for IES operations
	1130 GMT	Back on Survey
970831	0012	System on idle
	0442	Back to Survey mode.
970902	2030 GMT	System secured for KN151-4. Water depth at <50 meters and no return on center portion of swath.

-R/V Knorr's Precision Depth Recorder System.

The shipboard 12khz PDR system was used throughout the cruise. The main purpose of this system was to track the sampling package in the water column during the vertical hydro-casts. The PDR also provided bottom depth checks for station work and was used to track the Inverted Echo Sounder during the mooring recovery operations.

ALACE Float Deployments (Dana Swift)

Cruise report for deployment of Prof. Steve Riser's profiling drifters for Knorr cruise 151, leg-4 from Trinidad to WHOI. This report is based on handwritten notes from my notebook. Any discrepancies should be resolved in favor of the hand written notes.

8/24/97 Deployment preparation for Seabird Prototype 063 (WRC 47)

Type	id	GMT	date	Latitude	Longitude	Stn.
Seabird	063	15:50	8/24/97	22˚52.16'N	65˚59.86'W	41

This profiling drifter is a prototype of a newly developed model that integrates a Seabird MicroCat with a standard ALACE engine. The float was reset at 13:47GMT. Six test transmissions were heard on the ARGOS up-link receiver. Installed & tightened the drag disk. The com port plug was not removed but its tightness was checked. Double checked fastener tightness. No sign of 'weather checks' on external bladder. This float is not protected with antifoulant. Pump stopped at 14:23GMT with bladder fully extended. Argos Id is 2787. Transmission Rep Rate is 88 sec. Deployed with no difficulty.

8/25/97 Deployment preparation for APEX Prototype 010 (WRC 2)

Type	id	GMT	date	Latitude	Longitude	Stn.
APEX	010	06:25	8/25/97	24˚12.57'N	66˚00.03'W	43

This float is the APEX prototype. The float was reset at 2:56GMT. Six test transmissions were heard on the ARGOS up-link receiver. Also heard was the air pump inflating the air bladder for a few seconds. By putting my ear to the float, I could hear the lead-screw driver inside the hull. I could not see into the helmet to determine the state of the toroidal bladders. The lead screw motor shut off at 3:11GMT. Hence, it was turning for 15 minutes. This float is not protected with antifoulant. Deployed with no difficulty.

8/25/97 Deployment preparation for Drifter 024.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	024	20:24	8/25/97	25˚32.81'N	65˚59.27'W	45

2B9DE ARGOS ID number.
092 seconds repetition rate.
001 hour Trip interval. Temperature Counts: 2715
240 intervals DOWN. Pressure Counts: 011
015 intervals UP. Vacuum Counts: 047
016 minutes deep pump time. Battery Counts: 144
015 minutes 1st surface pump time.
060 minutes 2nd surface pump time.
250 minutes ascend time.

This profiling drifter is a standard T-only model commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id: 2791). Reset at 16:48GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions. Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com plug. Verify matching serial numbers on drag disk & float. Double checked fastener tightness. Checked thermistor probe response. Significant 'weather checks' on external bladder. Pump stopped at 17:14GMT. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

8/26/97 Deployment preparation for Drifter 028.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	028	09:45	8/26/97	26˚52.27'N	65˚59.67'W	47

2BAAC ARGOS ID number.
090 seconds repetition rate. Temperature Counts: 2820
001 hour Trip interval. Pressure Counts: 011
240 intervals DOWN. Vacuum Counts: 046
015 intervals UP. Battery Counts: 146
016 minutes deep pump time.
015 minutes 1st surface pump time.
060 minutes 2nd surface pump time.
250 minutes ascend time.

This profiling drifter is a standard T-only model commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id: 2794). Reset at 09:19GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions. Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com plug. Verify matching serial numbers on drag disk & float. Double checked fastener

tightness. Checked thermistor probe response. Minor ‘weather checks' on external bladder. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

8/26/97 Deployment preparation for Drifter 001.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	001	23:24	8/26/97	28˚13.56’N	65˚58.33’W	49

2BDA2 ARGOS ID number.

086	seconds repetition rate.	Temperature Counts:	2670
001	hour Trip interval.	Pressure Counts:	010
240	intervals DOWN.	Vacuum Counts:	030
015	intervals UP.	Battery Counts:	222
016	minutes deep pump time.		
015	minutes 1st surface pump time.		
060	minutes 2nd surface pump time.		
250	minutes ascend time.		

This profiling drifter is a standard T-only model (early version) commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id: 2806). Reset at 19:14GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions. Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com plug. Verify matching serial numbers on drag disk & float. Double checked fastener tightness. Checked thermistor probe response. No ‘weather checks' on external bladder. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

8/27/97 Deployment preparation for Drifter 018.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	018	12:50	8/27/97	29˚33.47’N	65˚58.57’W	51

2BCBD ARGOS ID number.

084	seconds repetition rate.	Temperature Counts:	2917
001	hour Trip interval.	Pressure Counts:	009
240	intervals DOWN.	Vacuum Counts:	049
015	intervals UP.	Battery Counts:	147
016	minutes deep pump time.		
015	minutes 1st surface pump time.		
060	minutes 2nd surface pump time.		
250	minutes ascend time.		

This profiling drifter is a standard T-only model commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id: 2802). Reset at 10:27GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions. Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com

plug. Verify matching serial numbers on drag disk & float. Double checked fastener tightness. Checked thermistor probe response. No ‘weather checks' on external bladder. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

8/27/97 Deployment preparation for Drifter 019.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	019	02:05	8/28/97	30˚53.19’N	65˚59.90’W	53

2BB15 ARGOS ID number.

088	seconds repetition rate.	Temperature Counts:	2458
001	hour Trip interval.	Pressure Counts:	008
255	intervals DOWN.	Vacuum Counts:	049
015	intervals UP.	Battery Counts:	149
016	minutes deep pump time.		
015	minutes 1st surface pump time.		
060	minutes 2nd surface pump time.		
250	minutes ascend time.		

This profiling drifter is a standard T-only model commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id: 2802). Reset at 10:27GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions. Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com plug. Verify matching serial numbers on drag disk & float. Double checked fastener tightness. Checked thermistor probe response. Minor to moderate ‘weather checks' on external bladder. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

8/28/97 Deployment preparation for Drifter 022.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	022	15:10	8/28/97	32˚13.42’N	65˚59.90’W	55

2BC1B ARGOS ID number.

090	seconds repetition rate.	Temperature Counts:	2440
001	hour Trip interval.	Pressure Counts:	011
255	intervals DOWN.	Vacuum Counts:	048
015	intervals UP.	Battery Counts:	146
016	minutes deep pump time.		
015	minutes 1st surface pump time.		
060	minutes 2nd surface pump time.		
250	minutes ascend time.		

This profiling drifter is a standard T-only model commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id:2800). Reset at 12:40GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions.

Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com plug. Verify matching serial numbers on drag disk & float. Double checked fastener tightness. Checked thermistor probe response. Motor stopped pumping at 13:11GMT. Moderate 'weather checks' on external bladder. However, there is a part of the bladder surface that has a matte finish and that is not weather checked. The shape of this dull region suggests the a liquid was wiped across the surface --- the edges are uneven and appear to transition into the glossy region (normal appearance). I took several polaroid photos of the region hoping to show both the 'weather checks' and the matte finished region. The region is clearly visible in the photos but the weather checks are not. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

8/29/97 Deployment preparation for Drifter 017.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	017	04:35	8/29/97	33˚33.49'N	65˚59.28'W	57

2B791 ARGOS ID number.

092	seconds repetition rate.	Temperature Counts:	2798
001	hour Trip interval.	Pressure Counts:	013
240	intervals DOWN.	Vacuum Counts:	047
015	intervals UP.	Battery Counts:	144
016	minutes deep pump time.		
015	minutes 1st surface pump time.		
060	minutes 2nd surface pump time.		
250	minutes ascend time.		

This profiling drifter is a standard T-only model commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id:2782). Reset at 01:12GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions. Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com plug. Verify matching serial numbers on drag disk & float. Double checked fastener tightness. Checked thermistor probe response. Light to moderate 'weather checks' on external bladder. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

8/30/97 Deployment preparation for Drifter 004.

Type	id	GMT	date	Latitude	Longitude	Stn.
PALACE	004	12:47	8/30/97	35˚33.50'N	65˚59.74'W	60

2BD04 ARGOS ID number.

090	seconds repetition rate.	Temperature Counts:	3004
001	hour Trip interval.	Pressure Counts:	010
240	intervals DOWN.	Vacuum Counts:	031
015	intervals UP.	Battery Counts:	219
016	minutes deep pump time.		

015 minutes 1st surface pump time.
060 minutes 2nd surface pump time.
250 minutes ascend time.

This profiling drifter is a standard T-only model (early version) commonly referred to as PALACE. Mission was programmed as above. Tested transmission (Argos Id: 2804). Reset at 11:19GMT. Heard valve open. Heard 16 second pump priming phase. Heard 6 test transmissions. Installed drag disk. Cleaned, inspected, & lubed com port & plug. Installed & tightened com plug. Verify matching serial numbers on drag disk & float. Double checked fastener tightness. Checked thermistor probe response. Very minor 'weather checks' on external bladder near metal insert at center. This float is protected with antifoulant from E-1 Paint company. Deployed with no difficulty.

C. Hydrographic Measurements

C.1 CTD systems (Laura Stein & Sara Zimmermann)

A WHOI-modified EG&G Mk-III CTDs was used throughout the cruise (CTD #9). It was provided with an oxygen current and temperature channel, a platinum temperature probe, and a 3 cm conductivity cell. CTD9 was modified at WHOI to install a thermally-isolated titanium pressure transducer, with a separately digitized pressure temperature channel (Millard et al, 1993). Temperature and pressure calibrations were performed at WHOI prior to KN151 leg 3. Calibrations will also be performed upon return to WHOI.

A Sensormedics oxygen sensor was installed at the beginning of KN151leg 3, and was used for the first 58 stations. The sensor was swapped out for a new sensor prior to station 59.

The CTD was left powered on at all times, except when disconnected due to cable change out or retermination. In no event was the CTD warmed up less than 30 minutes. The CTD was kept out of the sun to avoid overheating of the case.

Two 1016 pylons (S/N 1467 and S/N 1460) were used to close bottles at depth. The pylon was controlled using SIO SCI (Scripps Institute of Oceanography's Surface Control Interface) and power supply. The SCI was controlled through a dedicated personal computer and software provided by SIO STS/ODF.

An FSI Integrated CTD, ICTD#1344, recording data internally, was used to collect backup data for selected stations. ICTD 1344 data was downloaded directly to a computer, demodulated using FSI software.

Three rosette frames were provided for the cruise. Two frames, one from Scripps the other from LDEO consisted of 36 10-liter bottles, the third had 24 4-liter bottles. The primary 36 10-liter frame from Scripps was used for the entire cruise. Two FSI 24-position Sure Fire Water Samplers were available for the 24 4-liter frame. The bottles had been produced at SIO and WHOI based on a design from PMEL. Two Lowered Acoustic Doppler Current Profilers

(LADCP), one from University of Hawaii the other from WHOI were used on the cruise. Besides a CTD and LADCP, a 12-khz pinger was mounted on the frame.

C.2 Salinity and Dissolved Oxygen Measurements (George Knapp)

Water samples were collected from virtually every bottle during this cruise for the determination of salinity and dissolved oxygen. The primary purpose of these measurements is to accurately calibrate the sensors on the CTD.

Salinity - Water was collected in 8 ounce glass bottles. The bottles are rinsed twice, and then filled to the neck. After the samples reach the lab temperature of 22 degrees C., they were analyzed for salinity using a Guildline Autosal Model 8400B (WHOI #11) salinometer. The salinometer was standardized once a day using IAPSO Standard Seawater Batch P-131 (dated10-OCT-96). Salinity readings are logged automatically to a computer, merged with the CTD data, and finally used to update the CTD calibrations. Accuracy of salinity measurements are $\pm$ 0.002 PSS-78.

Prior to the first station it was noticed that this Autosal was not maintaining proper bath temperature control. One of the two bath thermistors had failed. That thermistor was removed from the circuit, and the salinometer was used for the entire cruise with just one baththermistor. Close attention was paid to standardizations and to maintaining a constant lab temperature, and it is believed that salinity measurements were not adversely affected.

Dissolved Oxygen - Measurements are made using a modified Winkler technique similar to that described by Strickland and Parsons (1972). Each seawater sample is collected in a 150 ml brown glass Tincture bottle. When reagents are added to this sample, iodine is liberated which is proportional to the dissolved oxygen in the sample. A carefully measured aliquot is collected from the prepared oxygen sample and titrated for total iodine content. Titration is automated, using a PC controller and a Metrohm Model 665 Dosimat buret. The titration endpoint is determined amperometrically using a dual plate platinum electrode, with a resolution better than 0.001 ml. Accuracy is 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 is merged with the CTD data, and used to update the CTD calibrations.

Standardization of the thiosulphate titrant was performed daily. The titration apparatus worked flawlessly, and no problems were noted.

C.3 Nutrient Analyses (Andrew Ross)

Nutrient analysts on the ACCE 66˚W leg were Andrew A. Ross and Julie M. Arrington from Louis I. Gordon's group at Oregon State University's College of Oceanic and Atmospheric Sciences. The analyses were carried out using a Technicon AutoAnalyzer II (AAII) belonging to Scripps Institution of Oceanography's Oceanographic Data Facility. The autosampler and data acquisition system were supplied by OSU, as was the software used to acquire and process the absorbance data. All of the reagent and standard materials were provided by OSU. The analytical methods used are described in Gordon et al (1994).

Nutrient samples were drawn from all CTD/rosette casts at stations 001 through 077 and were analyzed within 1 - 3 hours. The preliminary nutrient data has been merged with CTD and hydrographic data in WOCE format data files. A nutrient intercomparison was done at station 001 with the Venezuelan Oceanographic Research Vessel Hermano Gines. The R/V Gines performed a simultaneous rosette cast during station 001 and provided our group with eleven nutrients samples covering 200meters to the surface. Results were given to Knorr Chief Scientist Terry Joyce.

Throughout the cruise, replicate samples drawn in different sample bottles from the same Niskin bottle were analyzed to assess the precision of the AAII analyses. These replicate samples were analyzed as adjacent samples at the beginning and once again at the end of each sample run to help monitor deterioration in the samples or uncompensated instrumental drift. Our estimates of short term precision based on these replicate analyses are given below. The values given are the absolute mean differences between replicates from the beginning to the end of each sample run. (Units are reported in micromoles per liter and as percentages of typical deep water concentrations.)

Phosphate: 0.003 (<.3%)	Nitrate + Nitrite : 0.041 (<0.2%)
Silicic acid: 0.3 (<0.4%)	Nitrite: 0.001 (<2.0%)

C.4 Lowered ADCP (Frank Bahr)

For this cruise, the Lowered Acoustic Doppler Current Profiler (LADCP)owned by Terry Joyce (serial number 1290, 150KHz) was flown out to Trinidad. With the help of Dan Torres, it was mounted on the 36-bottlerosette and checked out prior to leaving port. The instrument performed well for the first 19 stations. During preparations for station 20,however, it failed when the data cable was connected to it with the battery charger turned on. The operator at the time (fb) insists that the cable was not hooked up incorrectly, which would likely have caused a short. Subsequent inspection of the instrument found one blown fuse (F11)and a damaged CPU board. The converter from RS422 to RS232 that is part of the data cable was damaged as well. The LADCP was eventually repaired by installing a makeshift fuse (soldered in place by Peter Landry) and, after some email exchange with RDI to clarify differences between the original and a spare board from Dan Torres' supplies, by replacing the damaged CPU board. Station 20 was part of the Puerto Rico approach with close station spacing. To save time, the remaining relatively shallow stations of that approach (20 through 23) were sampled without an LADCP. The down time during the transit around Puerto Rico was used to exchange the damaged LADCP with Eric Firing's unit (serial number 1546, 150KHz). Although the original LADCP was ready again around station 35, we continued to use LADCP 1546 to avoid the down time required for an instrument swap.

C.5 CFCs (Damon Chaky)

The CFC group measured the concentrations of F11, F12, and F113 in approximately 2100 water samples. Analyses were performed on two electron capture gas chromatographs equipped with purge-and-trap systems. Between 2 and 4 replicate samples were analyzed from each station as a check on internal consistency, and as a cross-check on performance

of the two GC systems. Bow air samples were also analyzed once a day on both systems. System blanks and midrange gas standards were run after every eight water samples, and full 10-point calibration curves were performed twice weekly on each system.

Aside from shutdowns due to maintenance of the purge-and-trap units, no significant problems occurred during the course of the cruise. Approximately 30 samples were lost due to sampler error. Relative errors in cross-system and intra-system duplicates were less than 5% for F11 and F12 in most cases, and less than 10% for F113.

C.6 Total Carbon Dioxide Measurements (K. M. Johnson, K. Erickson)

Cruise 151-4 was the concluding leg of three consecutive WOCE cruises in the North Atlantic Ocean aboard the R/V Knorr for which Brookhaven National Laboratory was responsible for the measurement of the carbonate system parameter total carbon dioxide (CT). The CT was measured by SOMMA-Coulometry which involves the automated continuous gas extraction of an acidified seawater sample with the resultant CO_2 determined by coulometric titration using a CO_2 coulometer. Three SOMMA-Coulometer systems were used for this work. Two of them (S/N 004 and 030) were devoted to making discrete measurements, while the third (S/N 006) was configured to make continuous measurements (underway) of the CT in the surface waters. In total, (not counting duplicates) 1,209 discrete samples were analyzed, and approximately 1200 underway measurements were made during Cruise 151-4. Discrete samples were taken at 49 of the 77 stations (64%) occupied during the cruise. In addition, some 69 duplicate samples were run on the discrete systems along with 48 Certified Reference Materials (CRM). The CRM were from Batch 37 and had a salinity of 34.983 and a certified total carbon dioxide value of 2044.15 μmol/kg.

The precision for the discrete sample measurements was ± 0.8 (S/N 004) and ± 1.2 (S/N 030) μmol/kg. The precision for the underway system is not yet known because it will have to be calculated from measurements made at constant salinity (i.e. periods where the ship was stationary). The accuracy of the three systems as measured by the mean difference between the results for CRM analyzed by SOMMA-Coulometry and the CRM certified value was - 0.17 μmol/kg (S/N 030, n = 19), - 0.57 μmol/kg (S/N 004, n = 17), and - 0.19 (S/N 006, n = 12) indicating excellent accuracy for all three systems and excellent agreement between the three individual SOMMA-Coulometry systems.

As an additional check on accuracy, approximately 20 samples were collected for on-shore analysis in the laboratory of Dr. C. D. Keeling at SIO, but it will be months before the results of these analyses will be known. Based on these preliminary numbers the quality of the total carbon dioxide data set is expected to be very high.

C.7 pCO_2 (John Goddard)

Principal Investigator - Dr. Taro Takahashi; Analyst - John G. Goddard

Partial pressure of CO_2 (pCO_2) was measured along WOCE ACCE line A22 as part of the DOE CO_2 program. Samples were drawn from 10 l. Niskin seawater sampling bottles into 250 ml. bottles and poisoned with mercuric chloride. pCO_2 was determined by equilibrating

the seawater sample with head space gas for approximately 40 minutes and injecting a known volume of equilibrated gas into an infrared analyzer using a nitrogen carrier stream. Equilibration was done in a water bath held to a constant temperature of 20.00 ± 0.02˚C. Each seawater sample was analyzed twice. A calibration curve using known concentration CO_2 standards was determined at the start of each days analysis sequence and after each set of 12 samples. At the end of each calibration sequence the sample data are corrected for instrumental drift.

Full station profiles or thermocline profiles were collected at 28 of the 77 stations occupied during this leg. Surface samples were collected on all but a few of the remaining stations. The analytical precision (range/mean) of the duplicate analysis on an equilibrated sample is ~0.20%. The sampling precision of duplicate samples drawn from the same Niskin is ~0.32%. Preliminary sample data are tabulated as pCO_2 (20) (uatm).

The analytical procedure used during this study is based on the same principle as that utilized during the Transient Tracers in the Ocean North Atlantic Study (TTO-NAS) in the same geographic area during 1981. The data obtained on this leg can thus be directly compared to pCO_2 data obtained 16 years earlier.

C.8 Radiocarbon and Radium-228 (Richard Rotter)

Water samples were collected for radiocarbon by Richard Rotter, representing Princeton University. Full or partial profiles were collected at 12 stations, where 500 ml aliquots were drawn into glass bottles from the rosette and poisoned with mercuric chloride. Samples were stored, and delivered post-cruise, for subsequent analysis at the WHOI AMS facility. Water samples were also collected for radium 228. Surface water samples were collected at 10 stations and samples were stored for subsequent analysis at the Princeton Ocean Tracers Laboratory.

C.9 Tritium, helium-3 (J. Curtice & P. Landry)

Helium isotope laboratory, WHOI

During the cruise, we took a total of 470 helium samples and 470 tritium samples, which were processed at sea using our helium extraction line and tritium degassing line. The samples will be analyzed on our mass spectrometer back in Woods Hole.

D. Acknowledgements

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