Western Boundary Time Series

Leg 1: March 23 – April 4, 2010
Leg 2: April 6 – April 17, 2010
Preliminary Cruise Report
(OC459-1 & OC459-2)

Participants:

Leg1: Woods Hole, MA to Freeport, Grand Bahama Island
Christopher Meinen – NOAA/AOML – Chief Scientist
David Childs – NOCS, United Kingdom
Julie Collins – NOCS, United Kingdom
Christian Crowe – NOCS, United Kingdom
Stuart Cunningham – NOCS, United Kingdom
Colin Hutton – NOCS, United Kingdom
Rob McLachlan – NOCS, United Kingdom
Pedro Pena – NOAA/AOML
Paul Provost – NOCS, United Kingdom
Erik van Sebille – U. Miami/RSMAS
Zoli Szuts – MPI, Germany
Stephen Whittle – NOCS, United Kingdom

Leg 2: Freeport Grand Bahama Island to Port Everglades, FL
Christopher Meinen – NOAA/AOML – Chief Scientist
Rigoberto Garcia – U. Miami/CIMAS
Judith Helgers – U. Miami/RSMAS
Ulises Rivero – NOAA/AOML
Erik van Sebille – U. Miami/RSMAS
Andrew Stefanick – NOAA/AOML
Erik Valdes – U. Miami/CIMAS

Vessel: R/V Oceanus

Atlantic Oceanographic & Meteorological Laboratory
National Oceanic & Atmospheric Administration

Introduction

The NOAA-funded Western Boundary Time Series (WBTS) experiment is designed to monitor the shallow and deep components of the Atlantic Meridional Overturning Circulation (MOC) near the western boundary of the basin at about 26.5°N. The program began in 1982 as a joint venture between NOAA's two blue-water laboratories, the Atlantic Oceanographic and Meteorological Laboratory in Miami, Florida and the Pacific Marine Environmental Laboratory in Seattle, Washington, with additional collaboration from the Rosenstiel School for Marine and Atmospheric Studies at the University of Miami. Initially known as the Subtropical Atlantic Climate Studies program, the program had a focus on the temperature structure and volume transport of the Florida Current in the Straits of Florida at 27°N. In 1984 the program expanded offshore of the Bahamas, measuring changes in temperature, salinity, and transport in the Antilles Current and Deep Western Boundary Current along 26.5°N east of Abaco Island. By the year 2000 the WBTS program had shifted under the sole management of the Atlantic Oceanographic and Meteorological Laboratory (AOML), where it continues to measure changes in the Florida Current, Antilles Current and Deep Western Boundary Current. In 2004 the AOML WBTS program became the cornerstone of an international collaborative program with partners from the University of Miami and the United Kingdom's National Oceanography Centre, Southampton, in an ambitious plan to build upon the observations made along the western boundary through monitoring the net transport across the entire Atlantic basin at 26.5°N from the Florida coast to the coast of Africa for a ten year period. The National Science Foundation component of this international partnership is the 'Meridional Overturning Circulation Heat-flux Array', while the British component is funded through the United Kingdom's Natural Environment Research Council RAPID-MOC program.

Numerous climate-modeling studies have demonstrated that global climate change may be heralded by changes in the transport of the MOC, which provides the motivation for a long-term observation program. Over the 25+ intervening years since NOAA began the first sustained program, the measurement systems and techniques have changed but the backbone of the program has always involved a strong hydrographic component. As part of this project in the modern era, annual or semi-annual cruises are completed on a line east of Abaco Island in the Bahamas along 26.5°N, on a short section across the Northwest Providence Channel, and on two short sections across the Straits of Florida (at 26°N and 27°N). Conductivity-temperature-depth (CTD) profiles are obtained at numerous sites along these lines using an instrument package lowered from the ship down to about twenty meters above the ocean bottom. One or two Lowered Acoustic Doppler Current Profilers (LADCPs) are included on this package, and the LADCPs provide vector profiles of absolute velocity as a function of depth. By combining these data sets, along with the measurements of the ship's hull-mounted Acoustic Doppler Current Profiler (SADCP), it is possible to monitor changes in the mass, heat, and salt transports carried by the Deep Western Boundary Current (DWBC) as it flows southward along the continental slope, as well as by the Florida Current and the Antilles Current as they carry warm surface waters northward. In addition to the snapshot estimates obtained by the hydrographic sections, time series observations of the DWBC and the Antilles Current volume transports have been obtained as part of the WBTS program in a quasi-real time manner since 2004 using moored inverted echo sounders, deep pressure gauges, and a single deep current meter. Data from these moored instruments are downloaded via acoustic telemetry during the cruises. Variability of the Florida Current volume transport has been monitored since 1982 with a submarine telephone cable as another part of the Western Boundary Time Series project.

This report has been prepared using the data obtained on the March-April 2010 Western Boundary Time Series cruise (R/V Oceanus cruise designations OC459-1 and OC459-2; WBTS program designation AB1003). The March-April 2010 cruise also included the turn-around of the British western boundary moorings deployed as part of the international RAPID-MOC/MOCHA program. The data presented herein are preliminary; final calibration and processing of the data obtained on this cruise will be completed back in the labs.

Our sincere thanks go out to the officers and crew of the R/V Oceanus for their gracious help with our work during this cruise. Without their help none of this work would have been possible. Our thanks also go out to Drs. Julia Hummon and Eric Firing at the University of Hawaii for their work in maintaining the shipboard acoustic Doppler current profiler data acquisition system and processing software on the ship. The chief scientist would also like to extend his sincere appreciation to all of the participants of the cruise, each of whom contributed greatly to the work we completed.

The bulk of this report consists of a discussion of the operations that were completed during the cruise and a presentation of the preliminary data collected during the cruise. Detailed scientific analysis of the data will occur at a later date.

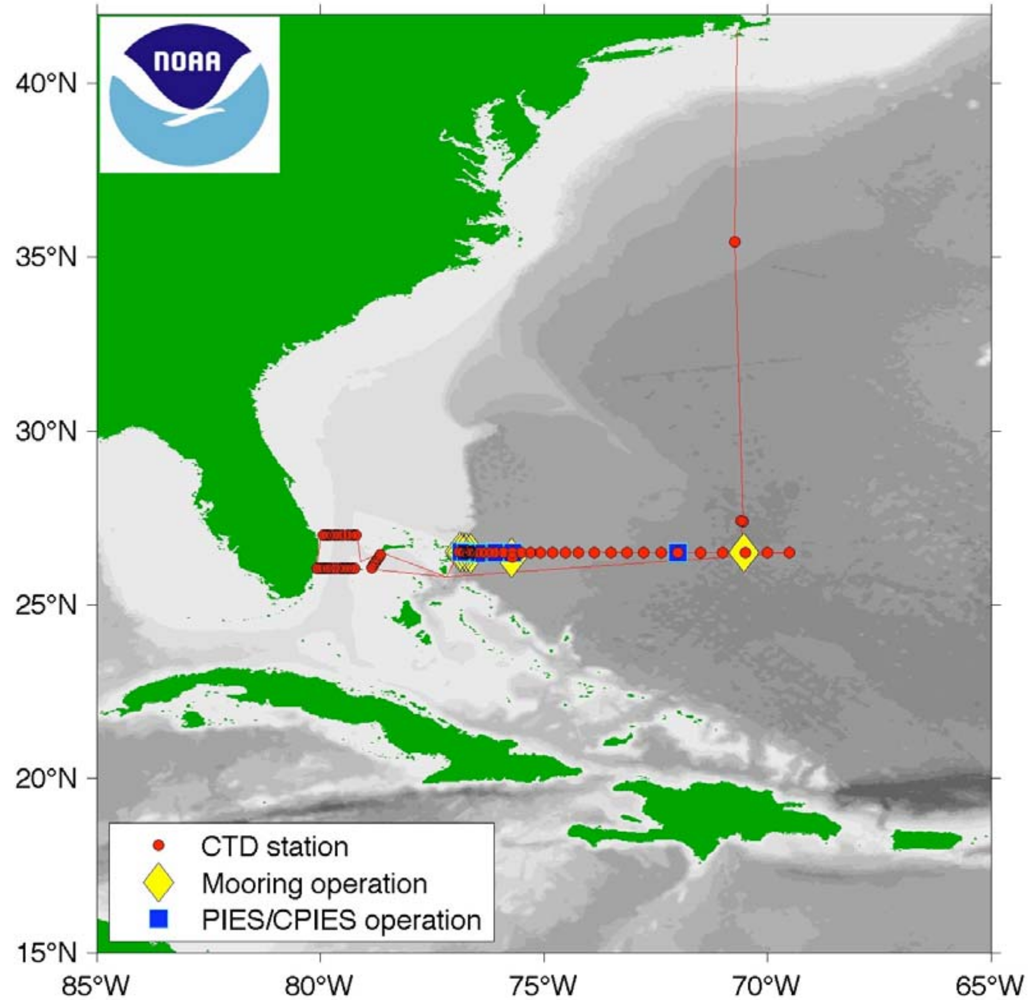


Figure 1: Map of the March-April 2010 WBTS cruise.

Order of operations:

Leg 1 of the cruise departed from Woods Hole, MA on March 23 and ended in Freeport, Grand Bahama Island on April 4; Leg 2 of the cruise began on April 6 in Freeport and ended April 17 in Port Everglades, Florida. On March 24 in the morning the sea state had become fairly cruel with 3-5 meter waves routinely assaulting the ship from the beam. An I-bolt (pad-tie) on the fantail had come loose overnight, allowing several of the mooring anchors to begin to move and strain against their remaining fastenings. Captain Diego Mello recommended suspending the transit until the weather improved with the concurrence of the chief scientist, and as such the ship hove-to for approximately 11 hours while heading slowly westward in to the 3-5 meter seas. Once the weather had abated somewhat, the Captain recommenced the transit southward towards the working area. En route to the first mooring location, three CTD calibration dip casts were completed for testing of the microcats and acoustic releases to be used on the first two moorings to be deployed. Mooring operations began at first light on March 28 at the WB-6 site. Mooring operations continued through April 3; details of the UK mooring recoveries and deployments are listed in Tables 4 and 5. During this week six additional CTD casts were completed for testing of microcats and/or acoustic releases. Also during this leg the operations listed in Table 1 were completed at the NOAA PIES/CPIES sites. On April 3 the ship departed from the work area and headed to Freeport, Grand Bahama Island, arriving on April 4 for Customs and Immigration clearance and for exchange of science personnel.

On April 6 the Oceanus departed from Freeport to begin Leg 2 of the cruise. The ship transited to the east of Abaco Island and started the 'Abaco' line of CTD casts heading eastward. A list of all CTD stations completed during Legs 1 and 2 can be found in Table 2. Upon completion of the 'Abaco' line early on April 13, the ship transited back into Northwest Providence Channel where five CTD stations were collected on April 15. After completion of this line the ship transited into the Straits of Florida and completed two sections, first at 27°N and then at 26°N. After the final CTD was completed early on April 17 the ship headed to Port Everglades, FL where Leg 2 of the cruise ended.

Note that during the cruise twelve surface drifters were deployed as part of the NOAA Surface Drifter program (see Table 3).

<u>Types of data collected on this cruise:</u>

1. Data from two pressure-equipped Inverted Echo Sounders (PIES) were collected via acoustic telemetry (one of the moored instruments also contains a single-depth current meter; a CPIES). Two other PIES were recovered during the cruise while one PIES and one CPIES were deployed. One of the recovered PIES was determined to have a faulty travel time circuit that had compromised its data record since it had been deployed in late 2009.

2. Conductivity-Temperature-Depth (CTD) profiles were conducted at 63 stations. Of these 63 casts, two were done solely to test acoustic releases (no CTD data was collected), and eight others were done for calibration of the microcat sensors for the moorings. On 61 stations water samples were taken at up to 23 depths to find salinity (61 stations) and dissolved oxygen (54 stations) levels. The total number of salinity/oxygen samples taken was 855/821.

3. Lowered Acoustic Doppler Current Profiler (LADCP) data was successfully collected at 25 of the 63 CTD stations. This data was collected using dual 300 kHz Workhorse LADCPs during stations 38 through 62.

4. Shipboard data was collected throughout the cruise using both a 75 kHz "Ocean Surveyor" hull-mounted Acoustic Doppler Current Profiler (SADCP) and a hull-mounted 150 kHz narrow-band SADCP. A preliminary version of this data was processed using the UHDAS software installed by Dr. Julia Hummon of the University of Hawaii, however final processing is required after the cruise.

5. Twelve surface velocity drifters additionally equipped with sea-surface temperature sensors were deployed as part of the NOAA contribution to the Global Surface Drifter Program. The data from these drifters is not sent to the ship, but is instead sent via satellite to land-based labs where it is processed and then placed on the Global Telecommunication System.

6. Moored time series from Microcat sensors and current meters on six moorings were collected by our UK colleagues, along with data from two bottom pressure sensors from the UK team. Our UK colleagues at the National Oceanography Centre in Southampton will do the final processing and distribution of this data.

Table 1 – List of PIES/CPIES moorings types and locations

Mooring name	Mooring Type	Longitude	Latitude	Operation
A	CPIES	76º 50.0’ W	26º 31.0’ N	Successful telemetry
A2	CPIES	76º 44.7’ W	26º 30.1’ N	Successful deployment
B	PIES	76º 28.4’ W	26º 29.6’ N	Successful recovery
B	PIES	76º 28.2’ W	26º 29.5’ N	Successful deployment
C	PIES	76º 05.3’ W	26º 30.1’ N	Failed recovery
D	PIES	75º 42.3’ W	26º 30.2’ N	Failed telemetry
E	PIES	72º 00.3’ W	26º 30.0’ N	Successful Telemetry

Table 2 – Locations for CTD/LADCP stations:

Cast #	Latitude (deg min)	Longitude (deg min)	Max Pressure (dbar)	Start time (GMT)	End time (GMT)
00*	35 27.20 N	70 43.65 W	201	25-Mar 18:54	25-Mar 18:17
01*	27 24.45 N	70 32.54 W	5522	27-Mar 18:00	28-Mar 00:23
02*	27 25.37 N	70 35.46 W	5325	28-Mar 01:36	18-Mar 06:58
03*	26 22.42 N	75 42.15 W	3915	29-Mar 21:11	29-Mar 01:13
04*	26 30.10 N	76 38.58 W	4037	30-Mar 20:52	31-Mar 01:28
05*	26 33.47 N	76 41.39 W	3204	31-Mar 02:21	31-Mar 05:45
06*	26 31.16 N	76 38.14 W	3449	02-Apr 02:29	02-Apr 05:58
07+	26 29.71 N	76 49.77 W	600	02-Apr 17:30	02-Apr 18:21
08+	26 30.28 N	76 49.80 W	600	02-Apr 19:30	02-Apr 20:11
09*	26 29.50 N	76 42.29 W	3093	03-Apr 02:18	03-Apr 05:26
10	26 31.70 N	76 53.33 W	302	07-Apr 03:03	07-Apr 03:31
11	26 30.96 N	76 49.99 W	1057	07-Apr 04:12	07-Apr 05:13
12	26 30.06 N	76 44.58 W	3880	07-Apr 08:30	07-Apr 11:40
13	26 29.99 N	76 39.23 W	4650	07-Apr 13:13	07-Apr 16:15
14	26 30.02 N	76 33.76 W	4896	07-Apr 17:42	07-Apr 21:13
15	26 29.98 N	76 28.53 W	4893	07-Apr 22:40	08-Apr 01:51
16	26 29.98 N	76 20.51 W	4917	08-Apr 03:22	08-Apr 06:34
17	26 30.03 N	76 13.09 W	4880	08-Apr 07:50	08-Apr 11:01
18	26 29.95 N	76 05.23 W	4851	08-Apr 12:20	08-Apr 15:23
19	26 29.95 N	75 54.05 W	4800	08-Apr 21:24	09-Apr 00:31
20	26 30.21 N	75 42.25 W	4727	09-Apr 01:48	09-Apr 05:02
21	26 30.07 N	75 30.04 W	4746	09-Apr 08:59	09-Apr 11:56
22	26 30.04 N	75 17.98 W	4692	09-Apr 13:20	09-Apr 16:25
23	26 30.00 N	75 04.90 W	4654	09-Apr 17:42	09-Apr 20:49
24	26 29.92 N	74 47.93 W	4592	09-Apr 22:30	10-Apr 01:30
25	26 30.02 N	74 31.00 W	4537	10-Apr 03:29	10-Apr 06:24

Table 2 continued:

Cast #	Latitude (deg min)			Longitude (deg min)			Max Pressure (dbar)	Start time (GMT)	End time (GMT)
26	26	29.99	N	74	14.09	W	4593	10-Apr 08:12	10-Apr 11:04
27	26	30.08	N	73	52.04	W	4784	10-Apr 13:14	10-Apr 16:19
28	26	30.02	N	73	30.07	W	4993	10-Apr 18:23	10-Apr 21:35
29	26	29.99	N	73	07.96	W	5122	10-Apr 23:46	11-Apr 03:06
30	26	30.05	N	72	46.02	W	5202	11-Apr 05:35	11-Apr 08:50
31	26	30.04	N	72	23.11	W	5229	11-Apr 11:15	11-Apr 14:38
32	26	30.03	N	72	00.08	W	5365	11-Apr 19:25	11-Apr 22:52
33	26	29.96	N	71	29.96	W	5498	12-Apr 01:51	12-Apr 05:20
34	26	29.96	N	71	00.11	W	5568	12-Apr 08:17	12-Apr 11:45
35	26	30.04	N	70	29.92	W	5579	12-Apr 14:38	12-Apr 18:11
36	26	29.96	N	70	00.06	W	5572	12-Apr 21:07	13-Apr 00:41
37	26	30.10	N	69	29.89	W	5454	13-Apr 03:42	13-Apr 07:05
38	26	03.98	N	78	51.07	W	285	15-Apr 04:28	15-Apr 04:47
39	26	10.00	N	78	48.06	W	436	15-Apr 05:52	15-Apr 06:18
40	26	15.05	N	78	46.08	W	507	15-Apr 07:09	15-Apr 07:35
41	26	20.04	N	78	43.01	W	670	15-Apr 08:25	15-Apr 09:00
42	26	25.99	N	78	40.06	W	744	15-Apr 09:55	15-Apr 10:30
43	27	00.11	N	79	11.98	W	460	15-Apr 16:09	15-Apr 16:35
44	27	00.19	N	79	16.95	W	581	15-Apr 17:14	15-Apr 17:50
45	27	00.19	N	79	22.99	W	649	15-Apr 18:35	15-Apr 19:14
46	27	00.28	N	79	30.02	W	705	15-Apr 20:17	15-Apr 21:00
47	27	00.12	N	79	36.95	W	622	15-Apr 21:55	15-Apr 20:30
48	27	00.29	N	79	41.00	W	502	15-Apr 23:08	15-Apr 23:40
49	27	00.22	N	79	47.09	W	359	16-Apr 00:12	16-Apr 00:47
50	27	00.27	N	79	52.11	W	239	16-Apr 01:30	16-Apr 01:50
51	27	00.21	N	79	56.06	W	123	16-Apr 02:30	16-Apr 02:42
52	26	03.04	N	80	03.95	W	104	16-Apr 09:25	16-Apr 09:34
53	26	03.35	N	80	00.04	W	219	16-Apr 10:19	16-Apr 10:36
54	26	03.25	N	79	56.01	W	290	16-Apr 11:17	16-Apr 11:37
55	26	03.40	N	79	51.03	W	284	16-Apr 12:26	16-Apr 12:43
56	26	03.25	N	79	45.95	W	575	16-Apr 13:43	16-Apr 14:14
57	26	03.25	N	79	39.91	W	667	16-Apr 15:29	16-Apr 16:09
58	26	03.17	N	79	34.07	W	734	16-Apr 17:14	16-Apr 17:56
59	26	03.13	N	79	28.84	W	652	16-Apr 19:06	16-Apr 19:40
60	26	03.10	N	79	23.96	W	574	16-Apr 20:22	16-Apr 20:52
61	26	03.04	N	79	18.80	W	467	16-Apr 21:31	16-Apr 21:58
62	26	03.13	N	79	13.99	W	306	16-Apr 22:34	16-Apr 22:52

* - Calibration cast with mooring microcat instruments on CTD frame
+ - Cast to test acoustic releases only, no CTD data collected

Table 3 – Locations of surface drifter deployments

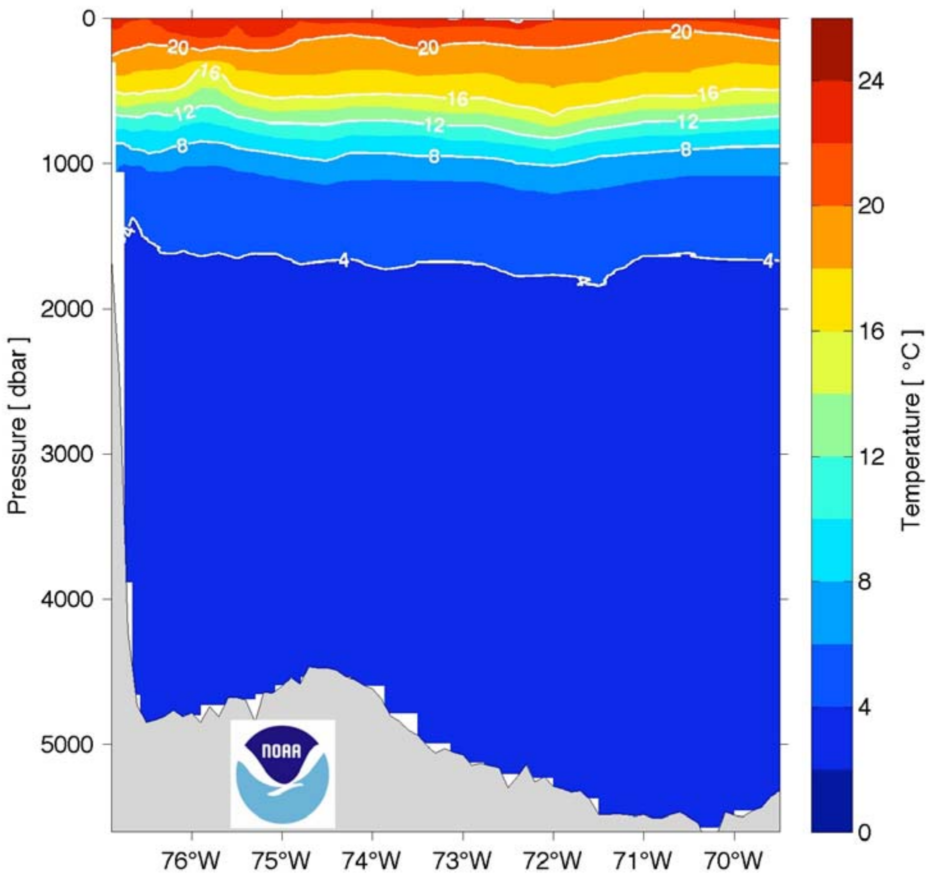
Drifter ID#	Deployment Date (mm/dd/yyyy)	Deployment time (GMT)	Deployment Latitude (deg min)	Deployment Longitude (deg min)
92918	03/25/2010	08:09	36 59.96 N	70 59.56 W
92920	03/25/2010	21:48	34 59.97 N	70 43.53 W
92910	03/29/2010	06:15	26 30.00 N	73 00.05 W
92915	03/29/2010	08:34	26 29.97 N	73 30.10 W
92916	03/29/2010	10:52	26 30.00 N	74 00.01 W
92914	03/29/2010	13:01	26 30.00 N	74 30.01 W
92913	03/29/2010	15:14	26 30.01 N	75 00.01 W
92911	03/29/2010	17:25	26 30.00 N	75 30.05 W
92917	03/30/2010	05:59	26 29.86 N	76 00.04 W
92909	03/30/2010	08:37	26 29.29 N	76 30.02 W
92912	04/15/2010	17:52	27 01.05 N	79 16.86 W
92919	04/15/2010	21:06	27 01.95 N	79 29.89 W

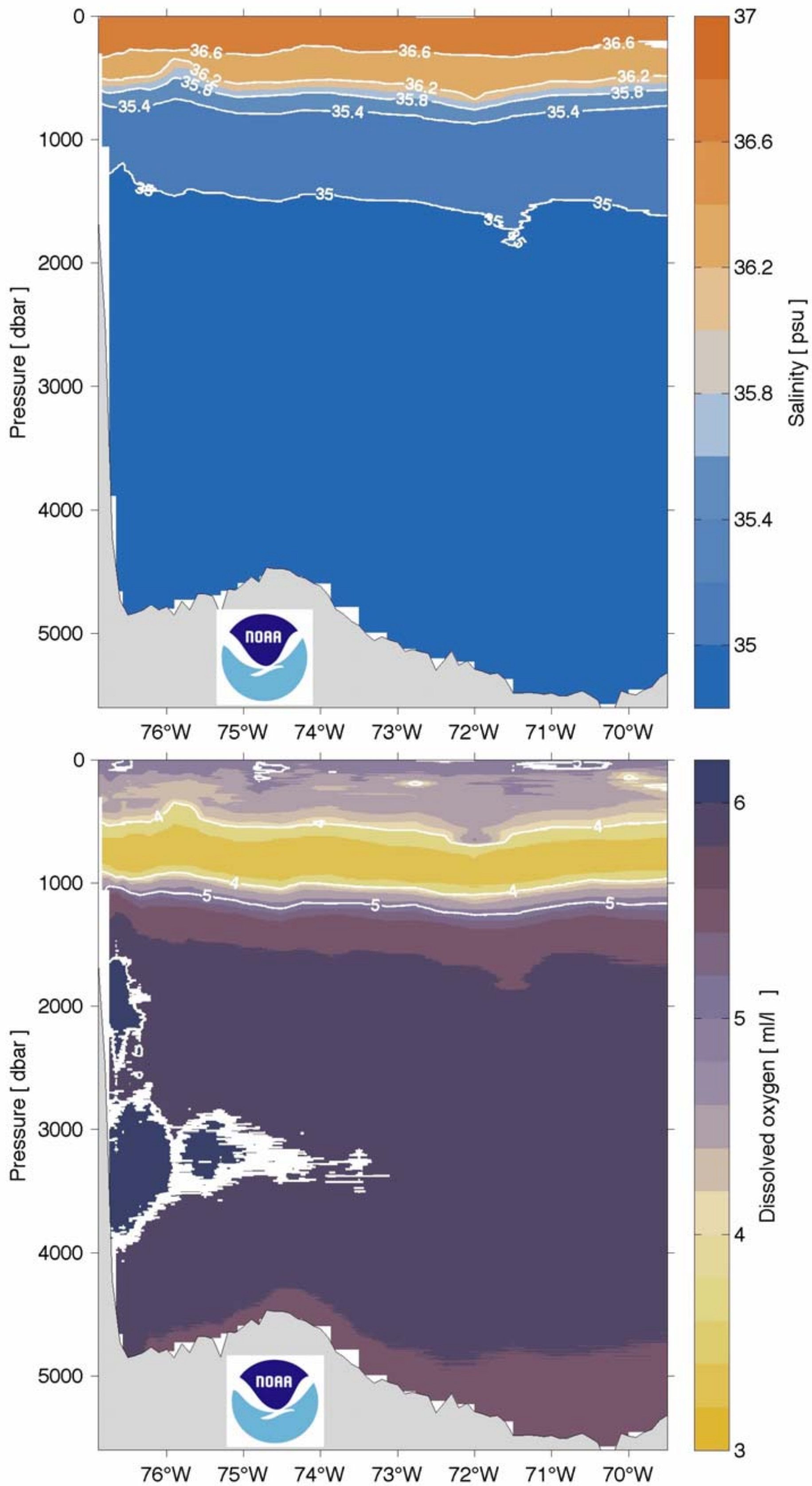
Preliminary sections of hydrographic data:

This section presents the preliminary temperature, salinity, and oxygen sections from the CTD measurements along the primary 'Abaco' CTD line east of the Bahamas.

Sections are presented herein in the following order:

- Temperature (potential)
- Salinity
- Dissolved oxygen




0
1000
2000
3000
4000
5000
Pressure [dbar]
36.6
36.2
35.8
35.4
35
76°W
75°W
74°W
73°W
72°W
71°W
70°W
37
Salinity [psu]
NOAA
4
5
6
3
Dissolved oxygen [ml/l]

CTD operations report

A total of 63 CTD profiles were completed during the March-April 2010 Western Boundary Time Series cruise. CTD operation on the R/V Oceanus involves deploying the package without starting it – the CTD deck unit and acquisition software is not started until the package is in the water. As such, a system of on-deck pressure tests was established prior to deployment of each cast beginning with Leg 2.

The following list of sensors were used in the setup of the CTD system during the indicated casts:

Stations 0-2
CTD SN#957

Primary Temperature SN#5140	Secondary Temperature SN#5171
Primary Conductivity SN#3657	Secondary Conductivity SN#1374
Primary Oxygen SN#1348	Secondary Oxygen SN#1266

Stations 3-5
CTD SN#957

Primary Temperature SN#5140	Secondary Temperature SN#5171
Primary Conductivity SN#3657	Secondary Conductivity SN#1387
Primary Oxygen SN#1348	Secondary Oxygen SN#1266

Stations 6-62
CTD SN#957

Primary Temperature SN#5140	Secondary Temperature SN#5171
Primary Conductivity SN#3657	Secondary Conductivity SN#1346
Primary Oxygen SN#1348	Secondary Oxygen SN#1266

The initial test cast (Cast #000) was done to only 200 m to briefly determine whether the sensors were working prior to doing a full water column cast to test the microcat instruments for the moorings. All CTD temperature, conductivity, and oxygen sensors used on the cast and on subsequent casts had been calibrated by the manufacturer, Seabird, immediately prior to the cruise. Sensor performance during this first very shallow cast was excellent. One modulo error was noted immediately as the Seasave software and deck unit were turned on when the CTD was in the water.

Cast #001 was done to test microcat instruments and acoustic releases for the moorings. There was a lengthy ~20 minute stop at the bottom of the cast while the mooring technicians tested the acoustic releases. At about 5300 dbar during the downcast the secondary conductivity sensor spiked to very high values and never full recovered during the cast. During the start of the upcast between the first and second bottle stop there was a wire-wrap problem on the winch. Fixing the problem required sending the package back down to the depth of the bottom bottle stop. Several additional unplanned stops were made during the upcast due to wire-wrap problems. At about 50 dbar on the upcast for this station there was a RS232 communications error reported by the Seasave software and the deck unit died. We were unable to restart the deck unit and software so the cast was finished without the upper 50 dbar of the upcast. The final Niskin bottle was never fired due to the communication problem. Subsequent investigation found that the communication problem was due to a short in the sea-cable near the slip rings on the winch, which resulted in a blown fuse in the CTD deck unit.

During Cast #002 there were 6 modulo errors very early in the cast. This cast was done for testing of microcat instruments. The secondary conductivity sensor still looked bad (very high) during this cast. The secondary conductivity sensor was replaced after Cast #002.

Because of the modulo errors observed on Cast #002 and because we still observed communication problems with the CTD during on-deck tests, the wiring between the CTD deck unit and the CTD itself was again evaluated. Eventually, after much investigation, it was determined that the wiring between the sea-cable termination and the CTD was bad, and this segment was re-wired. After this there were no further communications problems with the CTD.

The agreement between primary and secondary conductivity sensors looked much better on Cast #003, however at about 1000 dbar on the upcast the secondary conductivity sensor spiked very low and never recovered during the cast. The secondary sensors were back-flushed after Cast #003. During Cast #004 the secondary conductivity cell failed completely, alternating between values of zero and 1999 throughout this cast and Cast #005. The secondary sensor was not replaced for Cast #005 due to the brief time available between these two calibration casts that were needed prior to the mooring work the next day.

The secondary conductivity sensor was replaced after Cast #005. On Cast #006 the agreement between conductivity sensors was excellent. On this cast there was a 30 minute bottle stop for testing of the microcat instruments for the moorings.

Casts #007 and #008 were done purely for testing of acoustic releases for the moorings. No CTD data was collected for these casts. Cast #009 was done to calibrate microcat sensors that had been recovered from the UK moorings. This was the final CTD cast completed on Leg 1.

During Casts #000-#009, between 9 and 11 salinity sample bottles were collected on each cast except for Casts #007 and #008, on which no samples were collected. During Cast #006 dissolved oxygen samples were collected from 5 casts, however a mis-set burette invalidated these samples. No other oxygen samples were collected during Leg 1.

Wire wrap problems persisted with irregular frequency throughout Leg 1 (Casts 000-009), while during Leg 2 the wire-wrap problems were less frequent and were fixed more quickly due to improved procedures.

During Leg 2 the CTD operation was nearly flawless. There were several problems with the lanyard on Niskin bottle 3 getting caught on the CTD safety strap and to a lesser extent the lanyard on Niskin bottle 15 getting caught on the CTD termination wires. Neither problem was serious.

Overall the salinity bottle samples were extremely reliable. Throughout the cruise the temperature in the Autosal room was quite steady, and the multiple operators all did a good job running samples. One issue came up with regards to the oxygen sample titration. During the processing of the samples from Cast #014 the titration light-box failed; the backup unit was used for the remainder of the cruise. The reason for the failed light box was traced to a power supply failure.

The agreement between electronic sensors and bottle sample data was excellent and was comparable with previous cruises. Final calibration will await work at the lab after the sensors have been post-calibrated.

IES Operations: March-April 2010

Several operations were planned at the NOAA PIES/CPIES sites during the March-April 2010 cruise onboard the R/V Oceanus. It was originally planned that these operations would occur during Leg 1, however several activities needed to be moved to Leg 2 due to weather/time constraints during Leg 1. The details of operations completed at each site are presented below. One important note pertinent to all sites; the Oceanus engines generated noise throughout the 10-15kHz range of communication frequencies used by the PIES, and this noise was particularly bad at 10kHz. Only by fully-declutching the engines could communication be done clearly.

Site A

- Data was collected via telemetry from the CPIES SN#133 during Leg 2 of the cruise. This instrument had been deployed at the site during the November-December 2009 cruise onboard the RRS Discovery.
- Arrived on site April 7, 2010 at 05:21 GMT.
- Data was downloaded with the "Obi-wan-Kenobi" Benthos DS-7000 deck unit. We sent the telemetry command about 6 minutes before the 06:00 GMT sampling hour, however no data was received. We sent several additional TELEM commands with no clear response. After the sampling period the TELEM command was sent again (06:18 GMT).
- First data was received at 06:20 GMT.
- Final data was received at 20:05 GMT, reaching the start of the record.
- Preliminary analysis of the data recovered via telemetry indicates that the instrument may have moved vertically by approximately one meter shallower at some point roughly 2-4 weeks after deployment.
- Preliminary analysis also indicates that the current meter on the CPIES died roughly 40 days into the deployment. Recovery and repair should be planned for the October 2010 cruise.

Site A2

- Deployment at this new site has been attempted twice before with no success. The first instrument deployed at this site was an IES and it returned no useful data when recovered after a one year deployment in 2006. A subsequent deployment in 2006 for two

years ended in failure with the instrument lost, likely due to an anchor failure.
- A CPIES unit, SN#248, was deployed at the site on April 1, 2010. The instrument was launched at 00:30 GMT and reached the bottom at around 01:35 GMT. Ranges of 3882, 3882, and 3884 received via ranging of the instrument after deployment confirmed that the instrument was on the bottom.
- A first travel time burst was heard at 02:00 GMT.
- Communication was done with the "Obi-Wan-Kenobi" Benthos DS-7000 unit.

Site B

- A new model 6.2 PIES (SN#239) was deployed at this site in November-December 2009 after the loss of the two proceeding instruments (the new PIES was deployed in a CPIES frame). Immediately after deployment the instrument was very difficult to communicate with for both ranging and sampling. It was decided at that time to replace the instrument during the March-April 2010 cruise.
- The new instrument chosen for deployment at this site was an older Seadata PIES (SN#62) that was mounted with an additional acoustic release (EG&G SN#8202) in what was originally termed the 'TRIES' configuration of three spheres in a triangle. The triangle of spheres was mounted atop a CPIES frame which was mounted atop a sheet of thick plastic sheeting to provide a larger 'footprint' and reduce the chances of the instrument sinking into soft sediments if such are present.
- The new instrument, referred to as the 'SPIES', was deployed on March 31, 2010. The instrument was turned on at 04:46:20 GMT and was deployed at 08:12 GMT.
- Ranging on the EG&G release (using our EG&G deck box) confirmed the instrument was sinking well, albeit somewhat slower than originally intended.
- A subsequent visit on 4/1/2010 confirmed via five consistent ranges that the instrument was on the bottom at a depth of approximately 4848 m.
- After confirming that the new instrument was safely on the bottom, operations shifted towards recovery of the PIES deployed at this site in November-December 2009 (SN#239).
- Release command was sent at 5:09:47 GMT. While no reply had been received to Clear commands, we immediately received the proper 4-second ping response to the release command. The instrument was estimated to have left the bottom at 5:20 GMT (can't remember how we determined that – may be suspect). The instrument reached the surface at 06:53 GMT (determined by

visual of the strobe light – no radio beacon was heard until the ship had approached quite close). The instrument was brought onboard at 07:15 GMT and was turned off at 07:18:45 GMT.

- Initial evaluation of the data records within the recovered PIES found that the pressure record appears good, however the travel time record is useless. There is an error message in the log file about the 'charger circuit'. The problem with this instrument will need to be pursued with the manufacturer, URI, upon return to the lab.

Site C

- The PIES instrument at this site, SN#155, had been deployed in September-October 2008. The instrument was visited and the data were successfully downloaded during April-May 2009. When it was visited in November-December 2009, problems arose because while the instrument was observed to be clearly sampling, it did not respond to any command from different deck units or transducers. It was determined that we would attempt to recover the instrument in March-April 2010.
- Arrived on site April 8, 2010 at approximately 15:45 GMT.
- Instrument was heard clearly sampling at 15:58:54 GMT.
- Release command was sent using the "Obi-Wan-Kenobi" Benthos DS-7000 unit at 16:13:10 GMT. There was no response to the command. Multiple release commands were sent through 16:27 GMT using this deck unit on gains ranging from 2 to 8 with no response.
- Conversation several months prior to the present cruise with Randy Watts, the manufacturer at URI, suggested that the instrument might have had its communication frequencies shift slightly. Randy described a technique that he had used with an EG&G deck box to shift the frequencies in a somewhat hit-or-miss pattern and with which he had once been successful.
- The EG&G deck box and transducer were utilized to test this possible solution. Uli attempted 58 different combinations of frequencies (in addition to several additional attempts using the "Obi-Wan-Kenobi" deck unit and transducer) over approximately three and a half hours. Transmissions were made from 0.5-1 mile in each cardinal direction from the site in addition to from directly atop it. No two-ping responses were received at any time, while the instrument continued to sample each hour.
- Finally, shortly after 20:00 GMT it was determined that we would have to leave the instrument and move on. An additional attempt to communicate with and/or release the instrument will be made in October 2010 using what is known to be a very quiet (acoustically) vessel, the NOAA Ship Ronald H. Brown. If that fails,

may need to wait until the instrument auto-releases (if that works) in mid 2013.

Site D

- The PIES at this site (SN#134) was deployed in November-December 2009. Burst telemetry data was collected at the time of deployment.
- Arrived on site for the first visit on March 30, 2010 at 03:25 GMT.
- First clear command was sent at 03:25 GMT. No clear 2-ping response was received.
- First telem command was sent at 03:27 GMT. No clear 2-ping response was received.
- For approximately 1 hour several attempts to initiate telemetry were pursued. The instrument was heard to sample at 04:00 GMT. Eventually we discussed with the Captain fully declutching the engines, and once this declutching was completed a few minutes later the acoustic environment (as evaluated using headphones connected to the 'Obi-Wan-Kenobi' Benthos DS-7000 deck unit) improved dramatically.
- At this point there was no longer enough time left in the schedule to attempt to start telemetry again, so this operation was put off until Leg 2.
- We returned to this site on April 9, 2010, arriving at 05:36 GMT. The ship was immediately declutched, and it remained so throughout except when we were repositioning the ship. The first clear command was sent at 05:38 GMT – no 2-ping response was heard. The first telem command was sent at 05:40 GMT – again, no 2-ping response was heard. Listening using a gain of 8 delivered a great deal of noise into the telemetry file, but no useful data.
- The instrument sampled again at 06:00 GMT, confirming that it had not accepted the telem command. Repositioned the ship and sent telem again at 06:38 GMT. Once again, there was no response.
- Tried using the 'R2-D2' Benthos DS-7000 deck unit, and allowed the ship to drift across the site while continuing to attempt to communicate over another hour and a half. The instrument sampled again at 07:00 GMT.
- Eventually gave up and left at 07:35 GMT. Will attempt communication again in October 2010 from the NOAA Ship Ronald H. Brown. If that fails, may need to wait until the instrument auto-releases (if that works) in mid 2014.

Site E

- The PIES at this site (SN#122) was deployed in September-October 2008. Data was successfully downloaded via telemetry from the instrument in April-May 2009 and November-December 2009.
- Arrived at the site for the first time on March 29, 2010 at 00:25 GMT.
- Telem commands were sent several times between 00:28 and 00:53 GMT with no clear response received using the 'Obi-Wan-Kenobi' Benthos DS-7000 deck unit. (Note this visit was before we learned the need for declutching the engines fully.)
- Due to a tight schedule for the mooring work, further attempts at this site were postponed at 01:28 GMT until Leg 2.
- Arrived again on site April 11, 2010 at 05:18 GMT.
- Ship immediately was declutched.
- Clear command was sent at 05:22 GMT. A 2-ping response was received.
- Telem command was sent at 05:24 GMT. First data was received at 05:30 GMT (at least the first MSB record had been missed).
- The last data needed was received at 06:49 GMT. Clear commands were sent to try and end telem operation, but receive window must have been missed as telem continued. Decided to let the telem just continue until the end rather than spend additional ship time waiting for another attempt to halt it.
- Noticed that turning off the bow-thrusters further improved the noise characteristics of the ship. Something to remember in the future.

SADCP Report

The R/V Oceanus carries two hull-mounted shipboard ADCP (SADCP) systems: a 75kHz "Ocean Surveyor" ADCP and a 150kHz narrowband ADCP, both manufactured by Teledyne - RD Instruments. Optimally a 75kHz instrument is capable of measuring velocity profiles down to roughly 750 m, while the 150kHz system can measure velocities to roughly 300 m. On the Oceanus installation the 75kHz system seems to be particularly sensitive to ship-speed, likely due to the introduction of bubbles under the hull when the vessel is moving at higher speeds although this is a matter for further investigation. At speeds exceeding approximately 10 knots the 75kHz SADCP range quickly reduced to about 150 m for broadband pings and 250 m for narrowband pings. The 150kHz SADCP had a range of roughly 200-250 m and this range did not seem to be as sensitive to ship speed. Heading information for the SADCP systems was provided by an Ashtech system in addition to the ships gyro.

The UHDAS data acquisition system in use for the SADCP systems on the Oceanus was developed by Drs. Eric Firing and Julia Hummon at the University of Hawaii. The UHDAS system provides both real-time first-pass processing and full-resolution data storage for post-processing after the cruise. For Leg 1 of the cruise the 75kHz system was configured to make only narrowband pulses, while on Leg 2 this system was set to alternate between narrowband and broadband pulses.

The SADCP systems were turned on at the start of Leg 1 and ran reliably throughout the first leg (with the caveat that range suffered dramatically at the higher ship speeds that were needed to make up time due to weather and equipment problems). The instrument continued to function well throughout the first Leg. Note that during the first leg the OS75kHz system was set to produce only narrowband pings. The systems were turned off as we approached Freeport harbor at the end of Leg 1.

The SADCP systems were started again upon leaving Freeport harbor to begin Leg 2. Once again the systems ran well, with one important caveat. At several different times the Ashtech directional heading device used by the SADCP systems either locked up or crashed completely. The ship survey tech was able to restart the system fairly quickly (with a few brief emails to Dr. Hummon at U. Hawaii). These crashes occurred at roughly 5pm local on April 6, 11pm local on April 7, 5pm local on April 11, and 3pm local on April 13. Aside from these crashes the system performed well throughout the cruise. The SADCP systems were turned off as we approached Port Everglades, FL on April 17.

LADCP Report

Data Acquisition Set-Up: The LADCP PC was set up in the main lab. Due to a beam failure on a previous cruise, the broadband 150 kHz LADCP commonly used for this project was not available for use during the March-April 2010 cruise. As such, accurate LADCP data collection was deemed impossible during the deep 'Abaco' section on this cruise and it was confined to the shallower Northwest Providence Channel and Straits of Florida sections. The configuration used was a dual WH300 configuration (used on casts 038-062). Three deck leads were run through a bulkhead conduit to the deck from the main lab: one power cable with two stripped wires at one end and a two pin sea connector at the other and two communications cables with an RS232 connector at one end and the appropriate square seven-pin LADCP connector at the other end.

The power cable was hooked up to the 48 V power supply in the lab. The master WH300 was hooked up to COM1 and the slave WH300 was hooked up to COM6.

Instrument Configuration: LADCP operations along the Northwest Providence Channel and Florida Straits lines were run with the dual WH300 LADCP system, with both a down-looking and up-looking WH300. Each workhorse was configured 8m bins, a 1-second ensemble, and zero blank-after-transmit, which has been shown to reduce bias problems in the close bins (see the command files below). The WH300s were also configured to alternate sampling windows, to prevent interference between the two units.

Pre-cruise Tests: An on-deck test was preformed on our transit to the Northwest Providence Channel line.

Deployment and Recovery: Deployment and recovery were achieved by using BBTALK (Windows) to communicate with the instruments and send command files. Instrument voltages were checked before power supply was reconnected.

Processing: First-pass processing was run on the LADCPproc2 computer using 1-second nav data (Reformat_Navigation.m) that was collected via Hyperterminal using a direct GPS feed from the ship and version 10.8 of the Visbeck LADCP software, made available by Gerd Krahmann.

The second pass processing, using time series CTD data, bottom-track velocities, and navigation data, and final pass, utilizing SADCP data, will be completed after the cruise when the final SADCP data is available.

Problems/Issues:

During the installation of the WH300 instruments en route to Northwest Providence Channel it was determined that the bulkhead connector on one of the rechargeable battery packs was loose and that it needed repair or replacement. It was later determined that this loose wiring had already caused a blown fuse in the master (down-looking) workhorse. In the interest of time the problematic battery pack was replaced using the spare pack – however this spare was in a 60 V configuration that subsequently blew the fuse on the master workhorse. The battery pack was removed and rebuilt in a 48 V configuration. Once this pack was completed and mounted on the frame there were no further problems with battery power.

Beginning with cast 052 communications problems began in trying to download the data from the slave WH300. After cast 053 the communication wire out to the instrument was swapped and the problems improved thereafter.

LADCP Command files:

whm_v50.cmd (Used on casts 038-062):

```
;==================================================
;   W H M A S T E R . C M D
;   RHS: June 15, 2009
;
;   modified for use with firmware v50.36
;   data collected in beam coordinates...
;
;   WH300kHz master/downlooker deployment script
;==================================================
; Changes from previous deployment scripts:
; (1) only commands that change defaults are included (EA,ES etc
removed)
; (2) data collected in beam coordinates (allows better inspection of
;     raw data and 3-beam solutions if necessary)
; (3) staggered single-ping ensembles every 0.8/1.2 s (Andreas has seen
;     bottom-interference in WH300 data in Antarctic - seems unlikely for
;     Abaco, but does not lose us pings).
; (4) 20 8 m bins - for a range of 160 m.
;
; Ask for log file
$L
;
; Cruise header info...
;
$P                                          .
$P       AB1003 WBTS program. Abaco line: Mar-Apr 2010  .
$P                                          .
$P          WH MASTER 300kHz LADCP DEPLOYMENT SCRIPT    .
$P                                          .
;
;
;
$D3
;
; display ADCP system parameters
PS0
; display ADCP system options
OL
; Pause
$D2
; return to factory default settings
CR1
```

```
;
; rename recorder prefix to 'MASTR'
rnMASTR
;
; WATER MODE 15 (NO MORE 'L' COMMANDS)
WM15
;
; Flow control:
;       - automatic ensemble cycling (next ens when ready)
;       - automatic ping cycling (ping when ready)
;       - binary data output
;       - disable serial output
;       - enable data recorder
CF11101
$D2
; coordinate transformation:
;       - radial beam coordinates (2 bits)
;       - use pitch/roll (not used for beam coords?)
;       - no 3-beam solutions
;       - no bin mapping
EX00100
; Sensor source:
;       - manual speed of sound (EC)
;       - manual depth of transducer (ED = 0 [dm])
;       - measured heading (EH)
;       - measured pitch (EP)
;       - measured roll (ER)
;       - manual salinity (ES = 35 [psu])
;       - measured temperature (ET)
EZ0011101
;
$D2
;  - configure staggered ping-cycle
; ensembles per burst
TC2
; pings per ensemble
WP1
; time per burst
TB 00:00:01.20
; time per ensemble
TE 00:00:00.80
; time between pings
TP 00:00.00
$D2
; - configure no. of bins, length, blank
; number of bins
```

```
WN020
; bin length [cm]
WS0800
; blank after transmit [cm]
WF0000
$D2
; ambiguity velocity [cm]
WV250
; amplitude and correlation thresholds for bottom detection
LZ30,220
$D2
; master
SM1
; send pulse before each ensemble
SA011
; wait .5500 s after sending sync pulse
SW05500
; # of ensembles to wait before sending sync pulse
SI0
$D2
; keep params as user defaults (across power failures)
CK
; echo configuration
T?
L?
$D5
; start Pinging
CS
; End Logfile
$L
```

whs_v50.cmd (Used on casts 038-062):

```
;====================================
;   W H S L A V E . C M D
;   RHS: June 15, 2009
;
;   modified for use with firmware v50.36
;   data collected in beam coordinates...
;
;   WH300kHz slave/uplooker deployment script
;====================================
; Changes from previous deployment scripts:
; (1) only commands that change defaults are included (EA,ES etc removed)
; (2) data collected in beam coordinates (allows better inspection of
;     raw data and 3-beam solutions if necessary)
; (3) staggered single-ping ensembles every 0.8/1.2 s (Andreas has seen
;     bottom-interference in WH300 data in Antarctic - seems unlikely for
;     Abaco, but does not lose us pings).
; (4) 20 8 m bins - for a range of 160 m
;
; Ask for log file
$L
;
; Cruise header info...
;
$P                                             .
$P      AB1003 WBTS program. Abaco line: Mar-Apr 2010  .
$P                                             .
$P        WH SLAVE 300kHz LADCP DEPLOYMENT SCRIPT      .
$P                                             .
;
$D3
;
; display ADCP system parameters
PS0
; display ADCP system options
OL
; Pause
$D2
; return to factory default settings
CR1
;
; rename recorder prefix to 'SLAVE'
rnSLAVE
;
```

```
; WATER MODE 15 (NO MORE 'L' COMMANDS)
WM15
;
; Flow control:
;       - automatic ensemble cycling (next ens when ready)
;       - automatic ping cycling (ping when ready)
;       - binary data output
;       - disable serial output
;       - enable data recorder
CF11101
$D2
; coordinate transformation:
;       - radial beam coordinates (2 bits)
;       - use pitch/roll (not used for beam coords?)
;       - no 3-beam solutions
;       - no bin mapping
EX00100
; Sensor source:
;       - manual speed of sound (EC)
;       - manual depth of transducer (ED = 0 [dm])
;       - measured heading (EH)
;       - measured pitch (EP)
;       - measured roll (ER)
;       - manual salinity (ES = 35 [psu])
;       - measured temperature (ET)
EZ0011101
$D2
;  - configure for slave
; pings per ensemble
WP1
; time per ensemble
TE 00:00:01.0
; time between pings
TP 00:00.01
; slave
SM2
; listen for sync pulse before each ensemble
SA011
$D2
; - configure no. of bins, length, blank
; number of bins
WN020
; bin length [cm]
WS0800
; blank after transmit [cm]
WF0000
```

```
$D2
; ambiguity velocity [cm]
WV250
; amplitude and correlation thresholds for bottom detection
LZ30,220
$D2
; keep params as user defaults (across power failures)
CK
; echo configuration
T?
L?
$D5
; start Pinging
CS
; End Logfile
$L
```

Summary of UK Rapid-MOC mooring operations

Stuart A. Cunningham, 4th April 2010

This is a summary of mooring operations conducted during RV *Oceanus* cruise OC459-1 between 23rd March and 4th April 2010. These mooring operations were completed as part of the United Kingdom Natural Environment Research Council (NERC) funded RAPID-WATCH Programme to monitor the Atlantic Meridional Overturning Circulation (MOC) at 26.5°N. The primary purpose on this cruise for the UK team was to service the RAPID Western Boundary moorings while the US team worked on the Western Boundary Time Series project. Cruise OC459-1 from Woods Hole, MA to Freeport, Grand Bahama, covered the Western Boundary moorings deployed on cruises in April 2009 and December 2009 (Rayner, D. and P. G. Wright, 2009; Cunningham, S. A. and P. Wright, 2010). This cruise was the 8th annual refurbishment of the Western Boundary moorings. This array will be further refined and refurbished during subsequent years. The instruments deployed on the array consist of a variety of current meters, bottom pressure recorders, and CTD loggers, which, combined with time series measurements of the Florida Current and wind stress estimates, will be used to determine the strength and structure of the MOC at 26.5°N. Complete details of scientific operations conducted during cruise OC459-1 will be reported in Cunningham, S. A. and J. Collins, 2010.

During this cruise we recovered five moorings and two bottom landers and deployed five moorings and three bottom landers (Table 4 and Table 5).

Table 4: Moorings recovered on OC459-1

		Best position in Decimal degrees			
Mooring Name	Deployment Cruise	Latitude N	Longitude W	depth (m)	Depoyment date
WB6	D344	26.4946	70.5217	5516	15/11/09
WBL4	SJ08	26.4042	75.7098	4705	28/4/08
WB4	RB0901	26.3530	75.7220	4713	26/4/09
WBH2	RB0901	26.4846	76.6330	4736	28/4/09
WB2	RB0901	26.5134	76.7404	3884	29/4/09
WBL3	SJ08	26.5068	76.7443	3887	24/4/08
WB1	RB0901	26.5022	76.8173	1390	30/4/09
WBADCP	RB0901	26.5257	76.8680	593	18/4/09

Table 5: Moorings deployed on OC459-1

Mooring Name	Deployment Cruise	Best position in Decimal degrees Latitude N	Longitude W	depth (m)	Deployment date
WB6	OC459	26.4942	70.5233	5491	28/3/10
WBL4	OC459	26.3663	75.7070	4708	30/3/10
WBH2	OC459	26.4810	76.5790	4824	1/4/10
WBL3	OC459	26.5087	76.7450	3882	2/4/10
WB2	OC459	26.5160	76.7465	3900	31/3/10
WBADCP	OC459	26.5250	76.8080	609	2/4/10
WB1	OC459	26.4995	76.8187	1394	3/4/10
WBL0	OC459	26.5250	76.8761	498	3/4/10

References for UK mooring section:

Cunningham, S. A. and J. Collins, 2010: RV Oceanus Cruise 459-1, 23rd March - 4th April 2010. RAPID mooring cruise report Cruise Report, XX pp.

Cunninhgam, S. A. and P. Wright, 2010: RRS Discovery Cruises D344/D345, 21st October - 6 December 2009. RAPID Mooring Cruise Report. Cruise Report, XX pp.

Rayner, D. and P. G. Wright, 2009: RV Ronald H. Brown Cruise RB0901, 15 Apr-06 May 2009. RAPID Mooring Cruise Report. Cruise Report, 121 pp.