CRUISE REPORT

***R/V Endeavor* Cruise EN-598**

RAPID/MOCHA/WBTS Program
May 8-24, 2015
Port Everglades, FL to Port Everglades, FL

1. Introduction and Objectives

The RAPID/MOCHA/WBTS program is a joint research effort between the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS), NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML), and the U.K.'s National Oceanography Centre (Southampton, U.K.). The objective of this program is to continuously observe the strength and structure of the Atlantic meridional overturning circulation at 26.5º N using a trans-basin observing system. The U.K. program is referred to as "RAPID-WATCH" and is a part of the U.K. Rapid Climate Change Program (RAPID) funded by the National Environmental Research Council (NERC). The U.S. program is referred to as "MOCHA" (Meridional Overturning Circulation and Heat-flux Array) and is funded by the National Science Foundation (NSF). NOAA contributes significantly to the effort through its Western Boundary Time Series (WBTS) Program.

The goals of cruise EN-598 were to:

1. Service (recover and redeploy) 4 deep-sea moorings located off the eastern Bahamas along latitude 26.5°N.
2. Retrieve data from 6 pressure-equipped inverted echo sounders (PIES) by underwater acoustic telemetry, and recover and redeploy two PIES, including one with an experimental data-pod.
3. Conduct CTD (Conductivity-Temperature-Depth) and Lowered ADCP (Acoustic Doppler Current Profiler) sections across the Florida Current at 27ºN, the Northwest Providence Channel, and along the 26.5ºN RAPID-MOCHA western boundary line east of Abaco, Bahamas.
4. Perform two additional deep water CTD casts to calibrate moored instrumentation.
5. Conduct a vessel-mounted Acoustic Doppler Current profiler (ADCP) survey of the Antilles Current system, as time permits.

2. Cruise Synopsis

The cruise departed from Port Everglades (Ft. Lauderdale), FL on May 8 at 0900 local time. The ship steamed to the first station of the Northwest Providence Channel (NWP) section, arriving there at 1630 local. A port call waiver had been requested and was graciously granted by the Bahamian Ministry of Agriculture and Marine Resources prior to the cruise, which allowed the ship to proceed directly to scientific operations without having to first check in at a Bahamian port, thereby saving valuable time for research. The NOAA/AOML CTD/LADCP system was used throughout for all CTD/LADCP stations, with a hybrid 150/300 kHz LADCP system using a NOAA 300 kHz Workhorse ADCP looking upward from the CTD frame and a NOAA 150 kHz ADCP looking downward. Unless otherwise noted, the NOAA/AOML CTD/LADCP system included two rings of 12 Niskin bottles each on the frame. There were some minor problems with the CTD system on the first cast, which were corrected by replacing the primary channel pump and backflushing the system. The NWP section was successfully completed at 0015 local on May 9th.

After steaming the length of NW Providence Channel and through Hole-in-the-wall, the ship stopped in deep water to do a calibration CTD ("cal-dip") cast (CTD006). This cal-dip cast, and another one later in the cruise (CTD035), were done to obtain in-situ calibration data for all the Seabird microcat instruments to be deployed on, and recovered from, the moorings. As usual for these casts, the outer ring of Niskin bottles was removed and small airplane straps were put on the frame so that the microcats could be clamped on. Twelve bottle stops were each maintained for 10 minutes on this cast to obtain additional data for the microcat calibrations and to examine the temporal drift characteristics of the microcats. During this cast, it was found that the level wind on winch #1 (the vessel's normal CTD winch) was not working properly, and after an attempt to fix it yielded no improvement, it was decided to switch the CTD system over to winch #2 (the Markey winch) for the remainder of the cruise. The switch-over was done during the steam up to the Abaco line, and additionally the outer ring of Niskin bottles was added back on the rosette.

The Abaco 26.5ºN CTD/LADCP section was commenced at 1930 local on May 9th, and completed at 1200 local on May15th (stations 007 to 034). On the first three casts (CTDs 007-009) there were intermittent problems with the secondary channel (all variables) and so the secondary pump and then the cable for temperature sensor were changed out on successive casts, finally solving the problem by station 010. Also the master (150 kHz) LADCP stopped operating near the end of the downcast on station 008, and it was found that the LADCP battery pack was drained and had apparently not been properly recharging. The LADCP battery was swapped out but further charging problems resulted in another power failure of the 150 kHz LADCP on station 012. It was finally determined that the charging problem was due to a mis-wired (reversed polarity) charging cable that had also burned out the diodes in the star cable. The charging cable was fixed and the star cable was swapped out before cast 016. Thereafter the LADCP system worked well except for station 023 where the charger was switched off accidentally at some point before that cast and the battery failed again, causing loss of data on LADCP on cast 023. Obviously these were self-inflicted problems and greater diligence is needed in the set up and monitoring the LADCP charging system on future cruises.

During the Abaco CTD section, acoustic telemetry was performed at several of the PIES sites (PIES sites B, C, D, and E) while doing CTD stations near the sites using the hull-mounted 12 kHz transducer, and this worked well in all cases.

After the Abaco CTD line was completed, mooring-servicing operations began, proceeding westward along the Abaco line. All planned PIES and current meter mooring operations (Tables 1, 2 and 3) were successfully completed between May 16-21, beginning at PIES-E and finishing at mooring WB0. The current meter mooring operations all went relatively smoothly except that there were several tangles in the moorings when they came up, mainly at the deep float clusters on mooring WB3 and WBC, and at all float clusters on mooring WB0. Two glass floats were imploded (one on WB3 and one on WBC, at depths of 4000-4500 m), and one glass float was flooded at 2000 m on WB3. The uppermost wire segment on WB0 was also badly chafed at approximately 400 m depth, with bare wire showing in a few spots. The cause of this was unknown but did not appear to be shark bite.

Acoustic communications with the moorings were very good using the hull-mounted 12 kHz transducer during the cruise, undoubtedly helped by the mild weather conditions that persisted for the entire cruise. All acoustic releases were heard clearly and responded correctly to the commands sent to them, and releases from the bottom were immediate after release commands were sent. The radios, strobes, and Argos beacons on all of the current meter moorings generally worked well, except on mooring WBC where there was relatively thick marine growth on the top float at 150 m and on the radio and strobe as well, and neither came on prior to recovery. Once the fouling was wiped away from the glass separator on the radio and strobe, both came on immediately. This same behavior has now been seen several times with this new line of XEOS radios/strobes and indicates that sufficient fouling can cause the conductivity bridge activation mechanism to fail, until either the fouling is wiped off or "dries off". The Argos transmitter on WBC had less fouling on it and was left outside without wiping it off, and sent its first message within an hour of recovery.

The instrument records from the moorings were mostly complete and of good quality, except for the upward-looking ADCPs on moorings WB3 and WBC which both had short records and drained batteries. This is highly unusual, and suggests that the battery packs were probably defective to begin with. Another problem seen on one of the Nortek Aquadopp records on mooring WBC was highly elevated and spiky backscatter signal, causing bad velocity data for about the middle two-thirds of the record. This has also been seen in some previous deployments - although usually for shorter periods of time - and is believed to be due to be some kind of jetsam becoming stuck on the mooring just below the Aquadopp transducers and causing large backscatter and consequently bad Doppler velocity data. For the remaining moorings the cotter pins were double crimped below the Aquadopps to try to reduce the possibility of hooking any flotsam in the transducer paths, although this is only a partial solution.

Following recovery of mooring WB3, another "cal-dip" CTD cast (CTD035) was done near the site of PIES-B to provide post-deployment calibration data for all of the Sea-Bird microcats deployed on WB3. Only the four deepest bottle stops were maintained for 10 minutes on this cast; the other stops were maintained for 5 minutes. Two of the microcats stopped sampling shortly after the cast began, for unknown reasons, and therefore no post calibration data will be available for those instruments. In between the current meter mooring recoveries and redeployments, several PIES recoveries and redeployments were also done as detailed in Section 3.2.

After completing the mooring operations at site WB0 at 1300 local on May 21, and having had no weather delays thus far, there was sufficient time left in the cruise to perform a shipboard ADCP survey of the upper ocean circulation in the vicinity of the Abaco line. A trackline was drawn up for this based on near real-time satellite altimetry and the data collected on the cruise thus far (Fig. 6), focused on the region north of the Abaco line and the possible pathways of the Antilles Current after it passes through 26.5°N. The ADCP survey was completed at 2200 local on May 22 and the ship then headed around the northwest corner of Little Bahama Bank to the Florida Current section at 27°N.

The Florida Current section (stations 036 to 044) was successfully completed at 2025 on May 23. Strong southerly winds that were building during the section caused some station keeping problems and large wire angles on a few of the casts. The scientific work of the cruise was finished with one day to spare, which was fortunate as 30 kt winds were forecast in the Straits of Florida for the following day that would have made work in the Straits very difficult. The ship arrived at the Port Everglades sea buoy at approximately 0400 local May 24th. Berthed by 0840. The cruise was very successful and all planned operations were accomplished.

3. Scientific Personnel

Name	Position	Organization
Bill Johns	Ch. Scientist	RSMAS/ U. Miami
Adam Houk	Scientist	RSMAS/ U. Miami
Mark Graham	Technician	RSMAS/ U. Miami
Cobi Christiansen	Technician	RSMAS/ U. Miami
Greg Koman	Student	RSMAS/ U. Miami
Tiago Bilo	Student	RSMAS/U. Miami
Christopher Meinen	Co-ch. Sci.	NOAA/ AOML
Andrew Stefanick	Technician	NOAA/ AOML
Grant Rawson	Technician	CIMAS/U. Miami
Pedro Pena	Technician	NOAA/ AOML
Marc Weekley	Technician	CIMAS/U. Miami
James Hooper	Technician	CIMAS/U. Miami

3. Cruise Operations

3.1 Mooring Operations

Mooring Recoveries

Four subsurface moorings were successfully recovered from the locations listed in Table 1 and shown in Figure 1. These moorings contained a mixture of current meters, Acoustic Doppler Current Profilers (ADCPs), and temperature/salinity/pressure recorders. Site WBL3 is a short "bottom lander" mooring containing only a high precision bottom pressure sensor and releases.

Table 1. Mooring Recoveries

Mooring Site	Mooring Number	Latitude (ºN)	Longitude (ºW)	Depth (m)	Date of Recovery
WB0	M439	26° 30.52'	76° 50.47'	1006	5/20/2017
WB3	M440	26° 29.61'	76° 29.74'	4842	5/19/2017
WBC	M442	26° 30.76'	76° 06.35'	4819	5/17/2017
WBL3	M441	26° 28.89'	76° 28.86'	4845	5/18/2017

Mooring Deployments

Four moorings (3 taut-wire moorings and 1 bottom lander) were deployed at the locations listed in Table 2 and shown in Figure 1. Acoustic surveying of the on-bottom position of all moorings was successfully completed after each mooring deployment.

Table 2. Mooring Deployments

Mooring Site	Mooring Number	Latitude (ºN)	Longitude (ºW)	Depth (m)	Date of Deployment
WB0	M459	26° 30.66'	76° 50.46'	1004	5/21/2017
WB3	M460	26° 29.69'	76° 29.66'	4840	5/20/2017
WBC	M462	26° 30.73'	76° 06.26'	4814	5/18/2017
WBL3	M461	26° 28.97'	76° 28.84'	4846	5/18/2017

3.2 PIES Operations

In addition to the tall mooring and hydrographic operations completed on this cruise, regular maintenance of an array of NOAA-funded pressure-equipped inverted echo sounders (PIES) was also completed. This maintenance consisted primarily of acoustic download of the last ~15 months of daily-averaged data collected by the PIES moorings. One PIES (Site E) was scheduled for recovery due to end of battery life; this PIES was successfully recovered and a replacement PIES was deployed at the same site. Another PIES, this one connected to a prototype ‘data-pod’ satellite data transmission device called the Adaptable Bottom Instrument Information Shuttle System ("ABIISS"), was recovered successfully from a location near Site C as the end of an 18-month test. Two additional PIES, at Sites A and A2, responded poorly (A2) or not at all (A) to telemetry commands. Both of these PIES were subsequently recovered and replacement PIES were deployed at each site. An older malfunctioning PIES at Site A2, which had failed to respond to commands for 18+ months during two previous visits, was also successfully recovered. Finally, an unsuccessful attempt was made to telemeter data from a PIES deployed by our United Kingdom partners inshore of the NOAA array. The operations involving PIES during the cruise are summarized in Table 3; PIES sites are shown in Figure 2.

Table 3. PIES Operations

Site Name	Latitude	Longitude	Date	Operation	Result
A	26° 30.938' N	76° 50.036' W	May 20, 2017	Telemetry	Failure
A	26° 30.938' N	76° 50.036' W	May 20, 2017	Recovery	Success
A	26° 30.945' N	76° 50.044' W	May 20, 2017	Deployment	Success
A2	26° 30.075' N	76° 44.782' W	May 19, 2017	Telemetry	Failure
A2	26° 30.075' N	76° 44.782' W	May 21, 2017	Recovery	Success
A2 - older	26° 30.062' N	76° 44.775' W	May 21, 2017	Recovery	Success
A2	26° 30.078' N	76° 44.779' W	May 21, 2017	Deployment	Success
B	26° 29.470' N	76° 28.180' W	May 10, 2017	Telemetry	Success
C	26° 30.000' N	76° 05.600' W	May 11, 2017	Telemetry	Success
C - ABIISS	26° 30.040' N	76° 05.550' W	May 17, 2017	Recovery	Success
D	26° 30.130' N	75° 42.330' W	May 11, 2017	Telemetry	Success
E	26° 30.000' N	71° 59.998' W	May 14, 2017	Telemetry	Success
E	26° 30.000' N	71° 59.998' W	May 16, 2017	Recovery	Success
E	26° 30.067' N	72° 00.000' W	May 16, 2017	Deployment	Success
UK PIES	26° 31.451' N	76° 52.510' W	May 21, 2017	Telemetry	Failure

3.3 CTD/LADCP Stations

A total of 44 CTD stations were conducted during the cruise (Table 4, Figure 3a,b). At each station, profiles of temperature, salinity (conductivity), and dissolved oxygen concentration were collected from the surface to within approximately 20 m of the bottom, using a dual Sea-Bird SBE-911plus CTD system. Two of these stations were performed to provide calibration data for SBE microcat instruments to be deployed on (or recovered from) the moorings (Stations 6 and 35). During these casts, the outer rack of Niskin bottles was removed from the Rosette to accommodate the mooring instruments and the CTD package was lowered to its target depth, with 5-10 minute bottle stops during the package retrieval. These casts were not part of the regular CTD/LADCP hydrographic sampling performed on the cruise and are indicated by an asterisk (*) in Table 4.

Water samples for calibration of the salinity and dissolved oxygen profiles were collected using a 24-bottle Rosette system containing 10 liter Niskin bottles. Salinity samples were analyzed on a Guildline Auto-Sal salinometer, while dissolved oxygen samples were titrated using a modified Winkler technique with automated electrical endpoint determination. A high-precision, fast-response thermistor (SBE-35RT, sampling at the bottle stops) was also used on the CTD package for all the stations on this cruise to enable more accurate calibration of the CTD temperature sensors.

Water velocity profiles were also measured at the stations using a paired downward-looking 150 kHz and upward-looking 300 kHz Workhorse Acoustic Doppler Current Profiling 'hybrid" system (LADCP). Details on setup and operation of the dual LADCP system are contained in Appendix 1 of this report.

Table 4. CTD /LADCP Stations

Station	Date	Time (UTC)	Latitude (°N)	Longitude (°W)	Corrected Depth (m)	Max. CTD pressure (db)
1	5/8/17	2134	26° 03.992	78° 50.992	283	303
2	5/8/17	2311	26° 09.919	78° 48.081	442	455
3	5/9/17	0042	26° 14.960	78° 45.910	510	523
4	5/9/17	0212	26° 20.031	78° 42.971	691	698
5	5/9/17	0335	26° 26.020	78° 39.991	743	761
6*	5/9/17	1514	25° 57.240	76° 53.701	4440	4344
7	5/9/17	2339	26° 31.510	76° 52.989	447	469
8	5/10/17	0053	26° 31.090	76° 49.989	1055	1086
9	5/10/17	0356	26° 30.230	76° 44.621	3740	3875
10	5/10/17	0850	26° 30.320	76° 39.200	4549	4553
11	5/10/17	1359	26° 30.080	76° 33.971	4848	4834
12	5/10/17	1926	26° 30.310	76° 28.551	4935	4843
13	5/11/17	0021	26° 29.971	76° 20.550	4903	4841
14	5/11/17	0505	26° 29.981	76° 12.911	4884	4820
15	5/11/17	0950	26° 30.021	76° 05.110	4866	4799
16	5/11/17	1437	26° 30.050	75° 53.949	4806	4745
17	5/11/17	1913	26° 29.831	75° 41.871	4751	4693
18	5/12/17	0026	26° 29.870	75° 30.010	4745	4688
19	5/12/17	0511	26° 29.621	75° 18.040	4678	4639
20	5/12/17	0955	26° 29.881	75° 04.832	4670	4613
21	5/12/17	1502	26° 29.850	74° 47.960	4599	4541
22	5/12/17	2004	26° 30.040	74° 30.961	4553	4503
23	5/13/17	0055	26° 30.021	74° 13.881	4602	4549
24	5/13/17	0610	26° 29.740	73° 51.920	4841	4752
25	5/13/17	1130	26° 30.040	73° 29.960	5042	4967
26	5/13/17	1655	26° 29.970	73° 08.060	5116	5054
27	5/13/17	2217	26° 29.911	72° 46.011	5179	5040
28	5/14/17	0349	26° 29.960	72° 22.990	5276	5193

29	5/14/17	0910	26° 29.970	71° 59.381	5372	5296
30	5/14/17	1536	26° 29.921	71° 29.960	5511	5431
31	5/14/17	2125	26° 29.871	70° 59.821	5576	5493
32	5/15/17	0335	26° 29.821	70° 29.810	5572	5498
33	5/15/17	1000	26° 30.002	69° 59.951	5576	5499
34	5/15/17	1608	26° 29.929	69° 29.940	5409	5317
35*	5/19/17	1921	26° 30.091	76° 28.340	4936	4850
36	5/23/17	1216	26° 59.942	79° 12.110	468	487
37	5/23/17	1326	26° 59.972	79° 16.961	596	617
38	5/23/17	1503	27° 00.001	79° 22.930	670	687
39	5/23/17	1629	27° 00.100	79° 30.111	746	769
40	5/23/17	1804	27° 00.200	79° 36.980	634	651
41	5/23/17	1922	27° 00.072	79° 41.071	518	540
42	5/23/17	2102	27° 00.211	79° 47.370	360	385
43	5/23/17	2226	27° 00.190	79° 52.010	253	268
44	5/24/17	0005	27° 00.130	79° 55.921	137	153

* Instrument calibration casts

3.4 Expendable Bathythermograph (XBT) testing

During the cruise, a new expendable bathythermograph (XBT) recording board was tested during twelve probe launches simultaneous with twelve of the CTD casts. These tests were completed to evaluate whether the new AOML-designed recording board ("AXR" – AOML XBT recorder) is properly measuring the thermistor changes at the appropriate frequency. These tests were at the request of the NOAA-AOML High Density XBT project. Deployment locations for these probes are shown in Table 5.

Table 5. XBT Stations

Date	Time (GMT)	Latitude	Longitude	CTD Cast	Probe Type	Probe S/N
05/11/17	19:16	26 29.83°N	075 41.84°W	17	Deep Blue	1245189
05/12/17	00:43	26 29.75°N	075 29.97°W	18	Deep Blue	1245190
05/12/17	05:25	26 29.56°N	075 18.02°W	19	Deep Blue	1245191
05/12/17	10:07	26 29.77°N	075 04.85°W	20	Deep Blue	1245192
05/12/17	15:04	26 29.82°N	074 47.96°W	21	Deep Blue	1245193
05/12/17	20:10	26 30.03°N	074 30.92°W	22	Deep Blue	1245194
05/13/17	06:13	26 29.72°N	073 51.92°W	24	Deep Blue	1245195
05/13/17	11:42	26 30.01°N	073 30.03°W	25	Deep Blue	1245196
05/13/17	17:12	26 29.93°N	073 08.06°W	26	Deep Blue	1245197
05/13/17	22:31	26 29.84°N	072 46.03°W	27	Deep Blue	1245199
05/14/17	09:19	26 29.98°N	071 59.20°W	29	Deep Blue	1245200
05/14/17	15:38	26 29.94°N	071 29.94°W	30	Deep Blue	1245198

4. Underway Measurements

Thermosalinograph

Values of surface temperature and salinity were continuously monitored using a Sea-Bird temperature-conductivity recorder installed in the ship's seawater intake line, and logged by the vessel's underway recording system.

Shipboard Acoustic Doppler Current Profiler

Upper ocean currents were continuously measured with a dual vessel-mounted Acoustic Doppler Current Profiler (ADCP) system consisting of a 300 kHz WH-ADCP and a 75 kHz Ocean Surveyor ADCP system. The depth range of good velocity data from the 300 kHz system typically extended to 70 m below the vessel, and for the 75 kHz system to 750-800 m. Data were processed onboard in real time using the UHDAS acquisition system. Gyrocompass data were continuously corrected by an ASHTEK multi-receiver GPS system.

6. Preliminary Results

The velocity structure along the Abaco section clearly indicated the presence of a strong anticyclonic eddy in the upper 1000 m, centered at about 120 km seaward of Abaco Island (Fig. 4). This eddy, also revealed in the shipboard ADCP survey at the end of the cruise (Fig. 6), dominated the circulation in first 200 km east of Abaco. Below the eddy was a rather diffuse-looking Deep Western Boundary Current (DWBC) between about 50-200 km on the section, flowing southward from 1000 m to the bottom. It is possible that the relatively broad, "double-core" nature of the DWBC in this particular section is due to a superposition of deep flow associated with the eddy on the normally stronger and narrower DWBC found closer to the Bahamas escarpment. Offshore of the DWBC was a band of deep northward recirculation centered at about 250 km along the section, which is often found near this location.

At the very shoreward end of the Abaco section, confined over the upper continental shelf within 20 km of Abaco, is what appears to be a vestigial signal of the northward Antilles Current with its characteristic subsurface maximum (here at a depth of about 200 m). However, it is very weak compared to the northward flow of the anticyclonic eddy just offshore of it, and it is unclear to what extent there is an Antilles Current adding to the northward flow of this eddy at the time of the section. The shipboard ADCP survey conducted at the end of the cruise (Fig. 6) attempted to trace the clockwise flow around the eddy and any possible branching of this flow to the north or northwest that might indicate an Antilles Current component turning westward to join the Gulf Stream north of the Little Bahama Bank. However, the presence of a cyclonic eddy to the north of the Bank made it difficult to discern any clear presence, or pathway, for the Antilles Current.

The Florida Straits and Northwest Providence Channel sections (not shown) revealed fairly typical flow conditions in both channels, with maximum speeds in the surface core of the Florida Current of about 2 m/s, and a subsurface-intensified westward flow in NW Providence Channel of about 0.6 m/s on the northern side of the channel.

7. Release of Project Data

In accordance with the provisions specified in the cruise prospectus and application for Bahamian clearance, the full data results from this experiment will be provided to the Commonwealth of the Bahamas according to the following schedule:

Shipboard Measurements

All shipboard measurements, including underway data records and CTD/LADCP station data, will be provided within 1 year of the termination of the cruise (May, 2018).

Moored Instrumentation

Time series data records from the moored instruments will be provided within 2 years of recovery of the instruments (nominally May, 2019).

7. Acknowledgements

The support and able assistance provided by the Captain and crew of the *R/V Endeavor* is gratefully acknowledged. Support for the scientific research was provided by the U.S. National Science Foundation and the NOAA Climate Program Office. The Commonwealth of the Bahamas graciously granted privileges to conduct scientific research in their territorial waters.

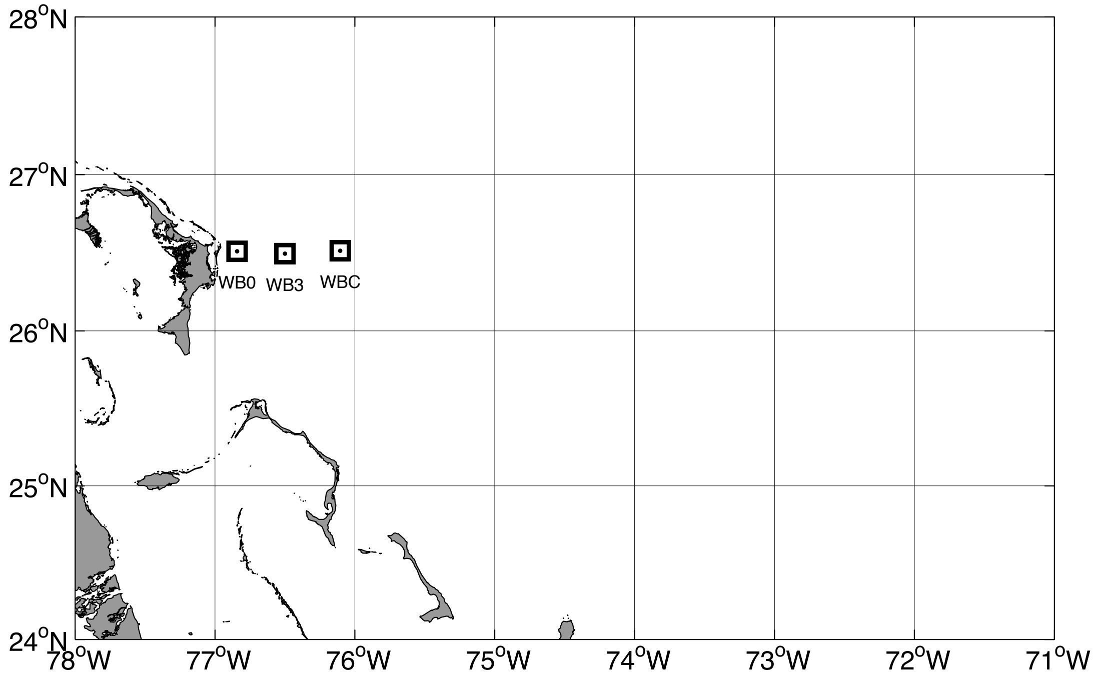

Figure 1. Current meter moorings recovered and deployed on EN-598. An additional "bottom lander" mooring (WBL3, not shown on map) was deployed near mooring WB3.

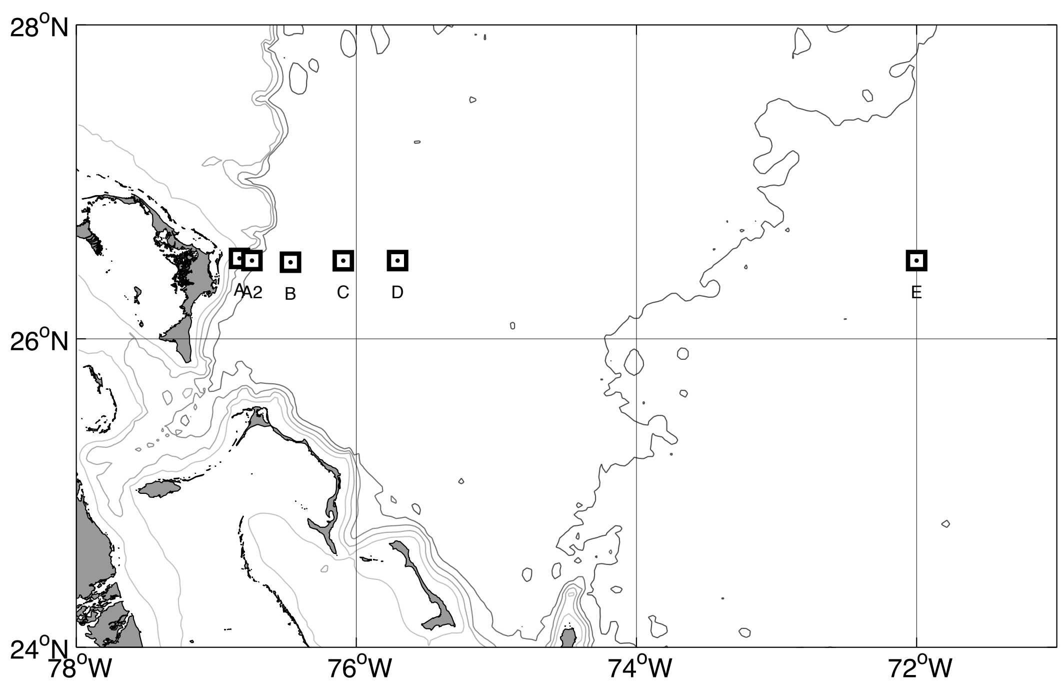

Figure 2. PIES locations along the 26.5° N Abaco line.

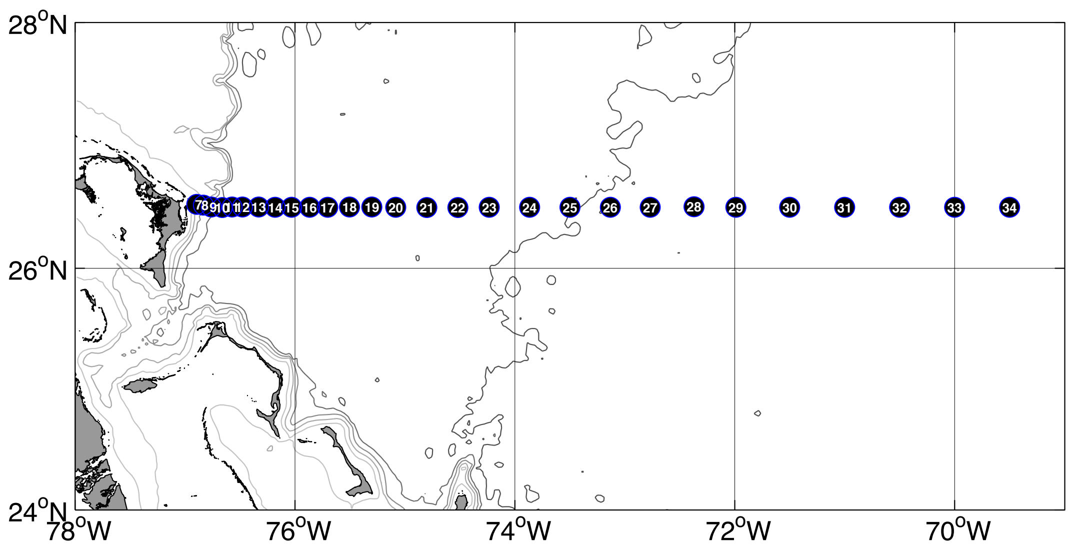

Figure 3a. CTD/LADCP stations occupied along the 26.5° N Abaco line.

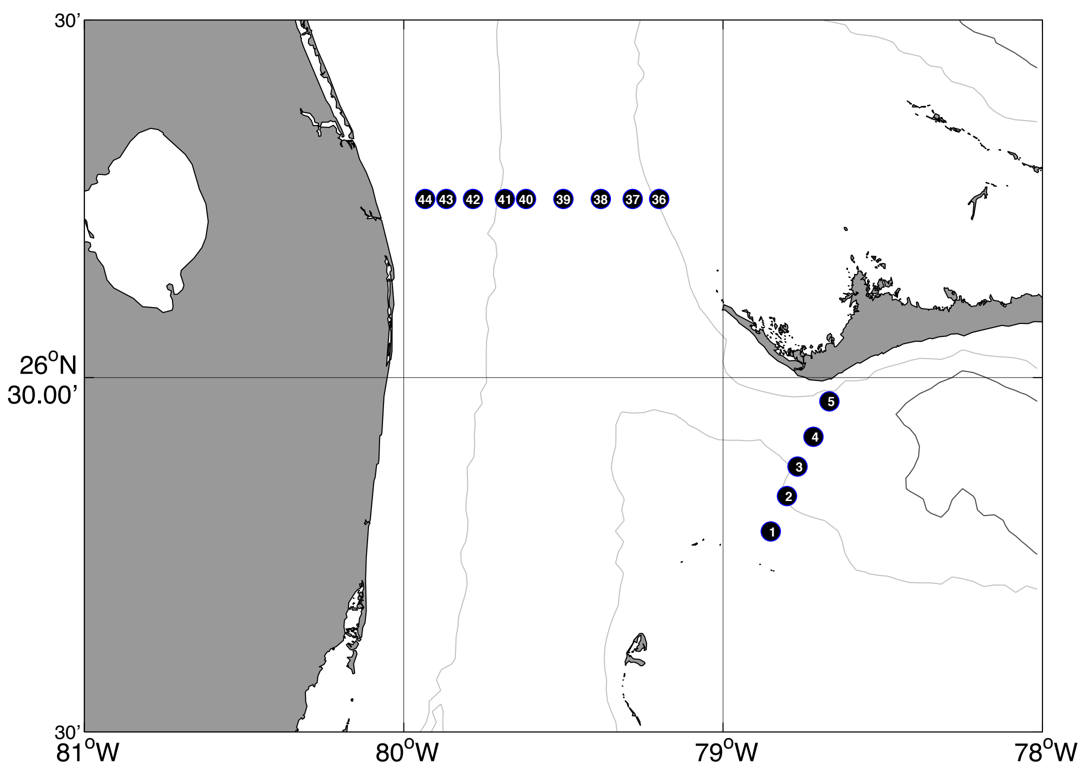

Figure 3b. CTD/LADCP stations occupied along the 27° N Straits of Florida section and across the Northwest Providence Channel.

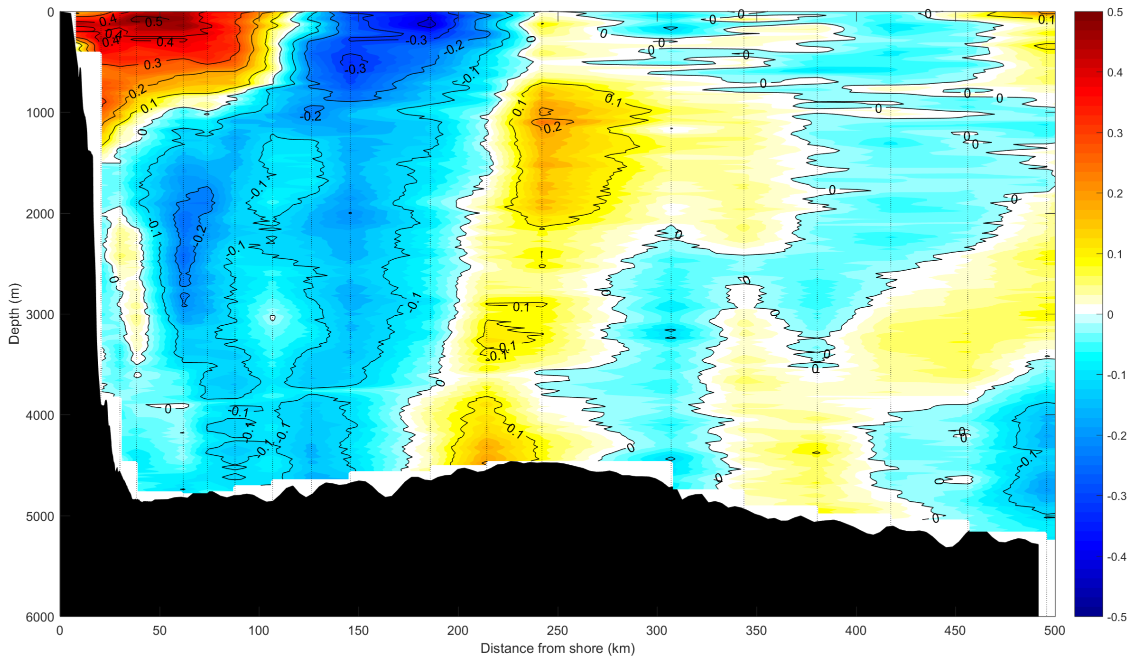

Figure 4 Meridional velocity section for the Abaco line, from Lowered-ADCP profiles collected at the CTD stations.

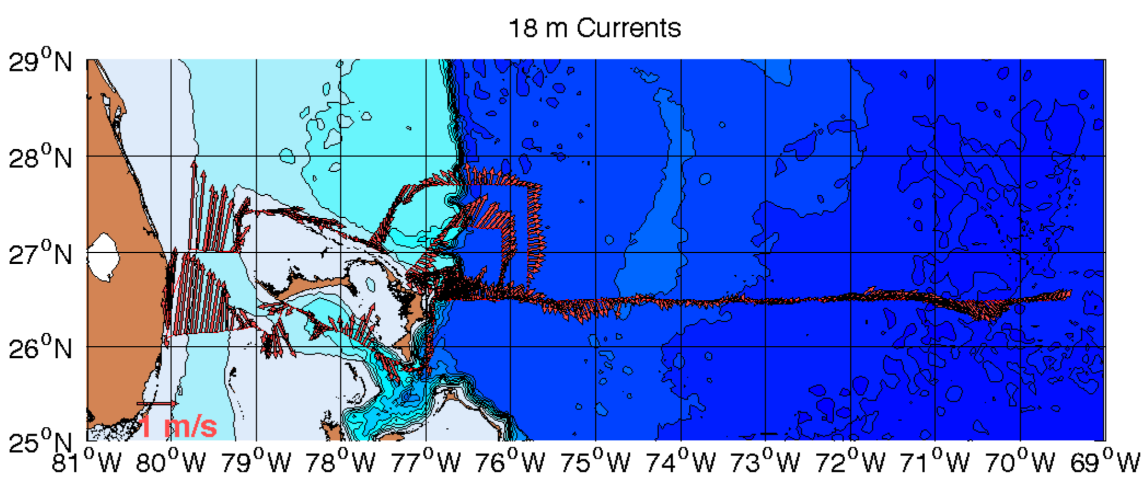

Figure 5. Near-surface currents along the cruise track, derived from the vessel-mounted ADCP.

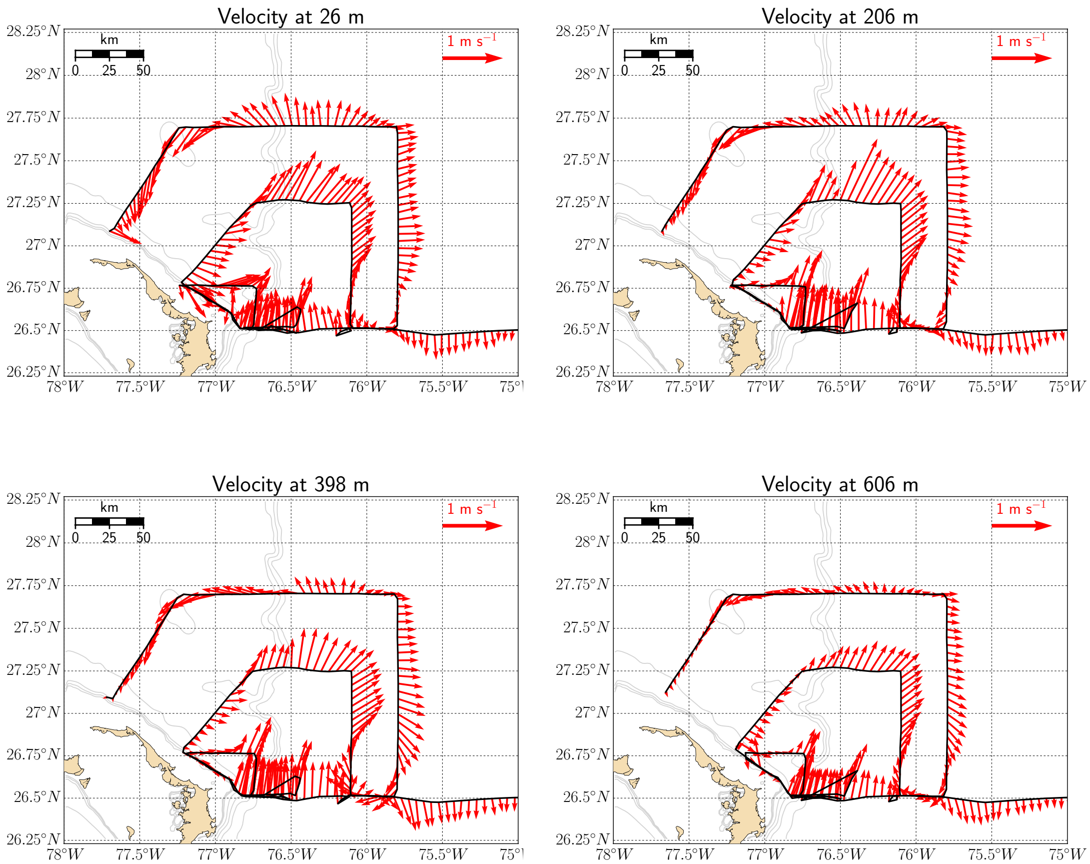

Figure 6. Currents near the surface, 200 m, 400 m, and 600 m obtained during the shipboard ADCP survey of the region east and north of Abaco Island.

Appendix 1. Lowered ADCP Operations

Adam Houk
22 May 2017

LADCP Setup:
Full water column velocity profiles for the MOCHA May 2017 cruise were collected using a hybrid 150/300kHz Workhorse configuration. The instruments, cables, and related equipment were supplied by NOAA's AOML physical oceanography group. The primary downward-looking 150 kHz ADCP was S/N 18145. The upward-looking 300 kHz ADCP was S/N 13493 for the first 21 casts, and S/N 24472 for the remaining casts. Custom-made 48-volt lead-acid battery packs were supplied by AOML. The two Workhorse ADCPs were mounted on AOML's 24-bottle CTD rosette. The upward-looking ADCP was mounted near the outer edge of the rosette, situated above the upper rim of the frame. The downward-looking 150 kHz ADCP was mounted in the center of the frame adjacent to the SBE9 CTD, with the transducer face about 10cm above the bottom of the frame. The battery pack was secured adjacent to the downward-looking ADCP using brackets bolted to the bottom of the rosette frame. Both ADCP's were wired to run off a single battery pack and communicate with each other using a custom-made '"star-cable".

Data Acquisition Setup:
The 150 kHz ADCP was configured for 16 16-meter bins, 16 meter blanking distance, and an ambiguity velocity of 350 cm s^{-1}. The 300 kHz ADCP was configured for 20 8-meter bins, zero blanking distance, and an ambiguity velocity of 250 cm s^{-1}. The units were configured for staggered single-ping ensembles; the upward-looking ADCP was set to 1 sec ensembles, and the downward-looking ADCP was set to burst-sample every 2 seconds with 0.8 seconds between pings. Measurements were saved in beam coordinates, with 3-beam solutions and bin-mapping disabled. Both ADCPs were running firmware version 50.40.

Inside the main lab of the Endeavor, a dedicated PC laptop running a custom Linux distribution with a four-port USB-serial hub was set up as the primary data acquisition platform. A dual-terminal program written in Python ('ladcp2.py' which is included in the UH-DAS ADCP software package) was used to communicate with the instruments. Data files downloaded to the acquisition PC were transferred to the ship's VDM shared network drive for processing and archiving. A Soneil 4804SR automatic battery charger was used to charge the battery pack. A single cable with dual serial port lines, along with power leads connected to the battery charger, was run outside to the CTD rosette where it plugged into the star-cable wiring.

The two raw ADCP data files were processed on the acquisition computer, with navigation data extracted from the ship's GPS serial port feed and uncorrected one-second time-series CTD data provided by the CTD operator. The initial processing of the raw ADCP data was done using version 10.20 of the M. Visbeck & A. Thurnherr MATLAB toolbox, modified by G. Krahmann. Additionally, the cast data were processed in parallel with an alternate software package maintained by A. Thurnherr, simply called version IX.11. Discrepancies in the final shape of some profiles between the two software packages were found, but have yet to be explained.

Operational Issues:
Lowered ADCP operations began on May 8th with the first five stations across the Northwest Providence Channel. The sixth cast was performed in deep water east of Abaco for the initial microcat 'cal-dip'. Casts 7 through 34 were made on the main transect line at 26.5 degrees north, ending on May 15th at 69.5 west longitude; the easternmost station. Several problems, however, occurred during the first half of the line. On the first two stations, the deck lead communication cables were inadvertently switched, either due to mislabeling on the computer com ports, or on the LADCP connector side. This resulted in the 150KHz instrument configuration file being sent to the 300KHz instrument and vice versa. The final profiles for these stations are likely to be of reduced quality due to the wrong sampling bin settings. For future deployments LADCP watch should mind the serial number displayed during deployment to ensure the correct setup and files.

The LADCP battery pack was found to have depleted during cast 8, leading to an incomplete cast. It was subsequently replaced with a fresh pack before the next cast. Battery depletion was a persistent issue through cast 14, before it was traced back to the deck leads being wired with reverse polarity, causing the batteries to not charge between casts. To verify the battery is charging the user should refer to "X-mit Volt Down" plot located in "Figure 2" generated by the AOML LADCP processing script. The downward trend of the x-mit voltage will be evident if the battery is not being charged properly. A new battery pack was installed after cast 12 and the old one was placed on a separate charger to be brought up to full power. After cast 15, it was discovered that a problem with the star cable was preventing the battery from charging, and new star cable was installed. The reversed polarity during previous casts had probably caused the diode in the star cable to fail, preventing the power from the correct deck leads to reach the battery.

Casts 11 and 14 were found to have bad or missing GPS data. The operator was therefore unable to properly process the cast, and these should be re-processed when the proper GPS position data are assembled. The user should ensure the GPS program (CoolTerm on the Linux LADCP computers) is running and streaming NMEA before deploying the LADCPs.

Prior to cast 20, a new Battery pack was installed. For cast 22, the upward looking ADCP was swapped out with S/N 24472 for testing purposes; the latter 300 kHz workhorse had been recently serviced. There were no issues with the original WH300 used for the previous casts. The LADCP battery again died during cast 23, this time due to the charger having been turned off when the pack was swapped on cast 20 and not getting turned back on. To prevent this from happening the power switch for the charger was taped in the on position. Cast 35 - No LADCP data collected on cast 35, as this was the second microcat cal-dip.

Command files for the WH300 and WH150:

```
Workhorse 150 kHz Downward-looking ADCP (MASTER) Command File
Filename: 150kHz_master.cmd
PS0
OL
rnMASTR
CR1
WM15
TC2
TB 00:00:02.00
TE 00:00:00.80
TP 00:00.00
WP 1
WN016
WS1600
WF1600
WV350
EZ0011101
EX00100
CF11101
SM1
SA011
SW05000
T?
L?
TS?
CS
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```
Workhorse 300 kHz Upward-looking ADCP (SLAVE) Command file
Filename: wh300_up_aeh.cmd
PS0
OL
CR1
rnSLAVE
WM15
CF11101
EX00100
EZ0011101
WP1
TE 00:00:01.0
TP 00:00.01
SM2
SA011
WN020
WS0800
WF0000
WV250
LZ30,220
CK
T?
L?
CS
```