CRUISE REPORT

***R/V Endeavor* Cruise EN-697**

RAPID/MOCHA/WBTS Program
Leg 1: February 5 - 22, 2023
Leg 2: February 24th – 1st March, 2023
Leg3: March 2nd – 8, 2023
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 purpose 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 objectives of cruise EN-697 were to:

1. To recover 8 current meter moorings and 5 short ("bottom-lander") moorings located off the eastern Bahamas along latitude 26.5°N.
2. To deploy 6 current meter moorings and 6 short ("bottom-lander") moorings along the same line.
3. To retrieve data from 6 pressure-equipped inverted echo sounders (PIES) by underwater acoustic telemetry, and to recover and redeploy 2 PIES.
4. To conduct CTD (Conductivity-Temperature-Depth) and Lowered ADCP (Acoustic Doppler Current Profiler) sections across the Florida Current at 27ºN, Northwest Providence Channel, and along the 26.5ºN RAPID-MOCHA western boundary line east of Abaco, Bahamas.
5. To perform several additional deep water CTD casts to calibrate moored instrumentation.

The cruise was split up into three legs to accommodate all the required operations within the limits of available deck space on the R/V Endeavor. This report describes the activities that took place during all three legs of the voyage.

2. Cruise Synopsis

Leg 1 of the cruise departed from Port Everglades (Ft. Lauderdale), FL on February 5 at 17:50hr local time. All times reported in this summary are in local time (EST), unless denoted by Coordinated Universal Time (UTC). The ship steamed eastward toward Northwest Providence Channel, enroute to the 26.5ºN section off Abaco, Bahamas where the first station work would begin. The ship stopped for a short CTD test cast in in the Northwest Providence Channel just south of Abaco Island at 10:15hr on Feb. 6th. One

underwater sensor cable on the CTD was replaced after data from the primary temperature sensor dropped out near the end of the cast, and one Niskin bottle that did not close properly was fixed by adjusting its lanyard.

The Abaco 26.5ºN CTD/LADCP section commenced with CTD 001 at 18:15hr on February 6th. The NOAA/AOML CTD/LADCP system was used throughout the cruise for all CTD/LADCP stations, with a hybrid 150/300 kHz LADCP system using a 300 kHz Workhorse ADCP looking upward from the CTD frame and a 150 kHz ADCP looking downward. Electronic logging was used for all the CTD, LADCP and Niskin bottle logsheets (using ipads instead of paper logsheets), and the logsheets were automatically loaded onto the ship's server after each cast. Initial plots of the CTD and LADCP profiles were also uploaded to the server and these plots, plus the CTD and Niskin logsheets for each cast, were printed out and saved in a cruise logbook binder.

On CTDs 001 through 003 the ship moved a substantial distance while on station, with large wire angles due to a strong northward surface current and opposing winds, and on CTD 003 the CTD could only be lowered to within 200m of the bottom at the end of the downcast. The wire angle problem improved from CTD 004 onward as the strong northward surface current diminished.

During CTD 005, unusual noises were heard from the CTD traction winch and it was discovered that the wire had jumped across a rubber guide roller in the winch tensioning system. The tension on the deployed CTD wire was taken up with a double Kline grip and the roller guide was repaired by the ships engineers to restore the winch to safe operation. The Abaco CTD section continued without incident until CTD 009 when it was noticed that the secondary conductivity sensor was drifting, and it was replaced with a new conductivity sensor between CTDs 009 and 010. No other CTD sensor changes were made for the rest of the cruise.

During CTD 011 an attempt was made to telemeter data from the nearby PIES D site, but only a partial record could be downloaded from PIES D before it reset at midnight. PIES D was recovered immediately afterward. We had not planned to recover PIES D at this time; it was scheduled to be recovered and replaced with one of the newly acquired PIES from URI later in the cruise. However, it was found that one of the new PIES was malfunctioning, so PIES D needed to be recovered so that there would be time to refurbish it for redeployment on the way back toward Abaco after the CTD line was completed.

CTD operations continued normally through CTD 022, but the CTD line had to be terminated at that point because of a developing urgent medical situation with the ship's captain, and the ship was ordered to return to Port Everglades immediately so that he could receive medical attention. Therefore, no telemetry was performed at PIES E, which was located farther eastward along the Abaco CTD line.

The ship arrived off Port Everglades at 04:00hr on Feb. 13th, and was docked at 08:30hr. The captain was put ashore and a relief engineer was brought aboard, and the first mate (also a relief captain for the R/V Endeavor) assumed the captain's role for the remainder of

the cruise. The ship departed Port Everglades at 12:25hr on Feb. 13th, underway again toward the area east of Abaco where we would begin the planned mooring operations.

Moorings M482 (site WB3) and M483 (WBL3) were successfully recovered on Feb. 14th. During respooling operations for their redeployment on the next day, PIES D was deployed.

Moorings M486 (Site WB3) and M487 (WBL3) were successfully deployed on Feb. 15th. PIES C data telemetry was completed on the evening of Feb. 15th.

Mooring WBH2 was successfully recovered on Feb. 16th. Communications and ranging on the acoustic releases on WBH2 were difficult due to noisy sea conditions, but it released on the first attempt. Initial GPS positions received from its satellite transmitter after it surfaced varied considerably (by up to 2 miles), and it took about 45 minutes for them to settle down enough where we could move toward it and find it on the surface.

The plan for the evening of Feb. 16th was to perform data telemetry at PIES A2 and then recover it, however, it was not sampling when we arrived onsite nor was it able to telemeter data, so a release command was sent. The PIES acknowledged the command and began to burn its release wire, but it did not leave the bottom in the usual 10-30 minute time frame. The ship waited on site for approximately 5 hours but the PIES still did not leave the bottom. To avoid further delay the ship moved offshore to deeper water near the location of WBH2 to perform a post-caldip CTD cast of the SBE microCATS and ODO instruments recovered earlier from WBH2, plus two of the SBE microCATS recovered from WB3. After the caldip CTD cast was completed, the ship steamed back to the site of PIES A2 to check on it and it was still found to be on the bottom, with its relocator pinger still transmitting.

Mooring M481 (site WB0) was successfully recovered on the morning of Feb. 17th, and its replacement mooring (M485) was successfully deployed on the afternoon of Feb. 17th. The ship then returned to PIES A2 to check on its status once again, and as we approached the site, its VHF radio beacon was heard, and it was then sighted on the surface, having finally left the bottom. PIES A2 was successfully recovered and then a replacement PIES was deployed at PIES A2 on the evening of Feb. 17th. Data telemetry at PIES A was also successfully completed on the night of Feb. 17th.

Mooring M488 (site WBH2) was successfully deployed on the morning of Feb. 18th, after refurbishing a number of instruments from the recovered WBH2 mooring that needed to go back on the newly deployed mooring. A post-caldip CTD of the remaining microCATS recovered from WB3 was performed on the afternoon of Feb. 18th. Telemetry was attempted at PIES B on the evening of Feb. 18th, but was unsuccessful. The PIES was sampling but since no data could be retrieved from it, it was sent a release command, which it failed to accept. With no ability to recover it, but with it still actively sampling, it was decided to deploy a new PIES B at this site with an offset ping cycle (sampling at 30 minutes past the hour). The new PIES B was successfully deployed on the night of Feb. 18th.

Mooring M484 (site WBC) was successfully recovered on the morning of Feb. 19th. This completed the mooring and PIES operations for Leg 1 of the research cruise.

The ship then steamed toward the Northwest Providence Channel enroute to the 27°N Florida Straits CTD section. Due to time constraints and the need to refuel the ship once back at Port Everglades, the Northwest Providence Channel CTD section had to be skipped so that the ship could arrive in mid-morning of Feb. 21st to begin mobilization activities for the 2nd leg of the cruise.

The Florida Straits CTD section at 27°N (CTDs 025 through 033) was started at 09:48hr on Feb. 20th and completed at 21:08hr on Feb. 20th. The ship arrived off Port Everglades at 07:00hr on Feb. 21st, and was berthed by 11:00hr.

Leg 2 departed from Port Everglades (Ft. Lauderdale), FL on Feb. 24th at 10:00hr local time. Test CTD 034 commenced at 07:30hr on Feb. 25th, followed by the deployment of the WBADCP mooring and the WBAL shallow landers. The tall mooring WB2 was also recovered that afternoon. CTD's 035 and 036 were performed to calibrate the temperature and salinity of the SBE microCATs to be used on the mooring WB2.

WB2 was deployed the following day (26th Feb.). The short bottom lander WB3LZ was deployed and tracked to the seabed on the evening of Feb. 26th. CTD 037 was undertaken at the WB4 mooring site before the tall WB4 mooring and two short bottom landers were recovered on Feb 27th. Post calibration SBE microCAT (CTD 038) took place that evening followed by a transit to Ft Lauderdale arriving at 9:00hr on March 1st.

Leg 3 departed from Port Everglades (Ft. Lauderdale), FL on March 2nd at 14:00hr local time. Two shallow bottom landers (WB2LZ and WB2L15) were deployed at the WB2 mooring site on March 3rd. SBE MicroCAT Calibration CTD 039 was undertaken that evening followed by CTD 040 at the WB1 site early morning on March 4th. At the WB1 site the WB1L1 short lander was deployed before recovering the tall WB1 mooring. The ship transited to the WB3LZ lander site so that the communication with the lander could be checked. This was followed by CTD 041 to a depth of 1800m to calibrate a RBR MicroCAT. The tall mooring WB1 was deployed on March 5th, followed by CTD 042 and CTD 043 at the WB2 site.

In the early hours of March 6th the top buoyancy sphere on WB2 surfaced and transmitted its location a number of times before abruptly stopping. Further investigation showed that the mooring was in the correct position, correct depth of water and that the anchor had not moved. The positions from the top sphere of the mooring showed that it was still attached to the mooring and not drifting. We completed the post WB1 mooring calibration cast (CTD 044) and proceeded back to WB2 at daybreak. As the ship approached the mooring site the mooring recovery floats, which should have been submerged, were visible on the surface. It was concluded that the Dyneema rope used for the mooring had somehow stretched or there was a problem with the measurement of the rope lengths. If the mooring were left in place, it would be likely to ultimately break, and

furthermore would be a hazard to navigation, so plans were made to recover the WB2 mooring on March 7th after the rest of the Leg 3 work was completed.

During March 6th the ship transited to the WBADCP site where the current meter lander was recovered and then redeployed with the addition of a SBE MicroCAT, which was missed during deployment on the Feb. 25th. The WBAL8, WBADCP (deployed Jan 2021) and WB2L13 landers were recovered. As detailed above, the tall WB2 mooring was recovered at daybreak on March 7th and the ship then transited to Ft Lauderdale (alongside by 10:00hr March 8th) to complete the activities of Leg 3.

All planned science operations were successfully accomplished except for six CTD/LADCP stations at the eastern end of the Abaco 26.5 ºN line, the CTD/LADCP section across the Northwest Providence Channel, and the deployment of the mooring at the WB2 site. Extra work accomplished on the cruise included the deployment of one additional PIES beyond those that were planned for replacement.

3. Scientific Cruise Leadership

Name	Position	Organization
Bill Johns	Ch. Scientist	RSMAS/ U. Miami
Shane Elipot	Co-Ch. Scientist leg 1	RSMAS/ U. Miami
Ben Moat	Co-Ch. Scientist leg 2 and 3	NOC, UK

4. Cruise Operations

4.1 Mooring Operations

Mooring Recoveries

Thirteen 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.

Table 1. Mooring Recoveries

Mooring Site	Mooring Number	Latitude (ºN)	Longitude (ºW)	Depth (m)	Date of Recovery
WB0	M481	26° 30.55'	76° 50.51'	1004	02/17/2023
WB3	M482	26° 29.98'	76° 30.08'	4843	02/14/2023
WBC	M484	26° 30.89'	76° 06.59'	4816	02/19/2023
WB3L1	M483	26° 29.52'	76° 29.02'	4846	02/14/2023
WBH2	N/A	26° 28.79'	76° 37.61'	4740	02/16/2023
WBADCP	N/A	26° 31.80'	76° 52.05'	566	03/06/2023
WBAL8	N/A	26° 31.46'	76° 52.00'	625	03/06/2023
WB1	N/A	26° 29.85'	76° 48.93'	1401	03/04/2023

WB2	N/A	26° 31.00'	76° 44.46'	3916	02/25/2023 03/07/2023
WB2L13	N/A	26° 30.26'	76° 44.72'	3885	03/06/2023
WB4	N/A	26° 27.04'	75° 43.54'	4692	02/27/2023
WB4L13	N/A	26° 28.75'	75° 43.54'	4704	02/27/2023
WB4L14	N/A	26° 28.47'	75° 42.81'	4690	02/27/2023

Mooring Deployments

Twelve moorings (5 taut-wire moorings and 7 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 and landers were successfully completed after each mooring deployment.

Table 2. Mooring Deployments

Mooring Site	Mooring Number	Latitude (ºN)	Longitude (ºW)	Depth (m)	Date of Deployment
WB0	M485	26° 30.55'	76° 50.56'	1013	02/17/2023
WB3	M486	26° 29.54'	76° 29.78'	4845	02/15/2023
WBH2	M488	26° 28.59'	76° 37.64'	4735	02/18/2023
WBL3	M487	26° 28.97'	76° 28.91'	4846	02/16/2023
WBADCP	N/A	26° 31.80'	76° 52.06'	627	03/06/2023
WBAL10	N/A	26° 31.43'	76° 51.82'	627	02/25/2023
WB1	N/A	26° 29.98'	76° 48.89'	1397	03/05/2023
WB1L1	N/A	26° 30.22'	76° 48.97'	1383	03/04/2023
WB2	N/A	26° 30.85'	76° 44.46'	3910	02/26/2023 Recovered 03/07/2023
WB2L15	N/A	26° 30.29'	76° 44.50'	3882	03/03/2023
WB2LZ	N/A	26° 29.81'	76° 45.07'	3861	03/03/2023
WB3LZ	N/A	26° 29.39'	76° 30.28'	4851	02/26/2023

4.2 PIES Operations

In addition to the tall mooring and hydrographic operations completed on this cruise, the array of NOAA pressure-equipped inverted echo sounders (PIES) operations were also completed (Table 3 and Fig. 2).

Planned recoveries/deployment

There were 2 planned recoveries/deployments on this cruise: PIES site A2 and PIES site D:

- PIES #323 on site D has been deployed in November 2018, and its auto-release date is scheduled for August 25, 2023, becoming a critical recovery for the AB2302.

- PIES #301 on site A2 has been recovered, refurbished and re-deployed during the AB2102 cruise. Used batteries taken from PIES #400 (deployed in December 2019/recovered in March 2021) were installed on #301 for its deployment, given that the recovery was not planned in 2021 and there were no spare batteries available.

Equipment

The equipment brought on board the RV Endeavor regarding PIES work consisted of:

- 3 PIES ready to be deployed:
    - #400 (recovered during AB2102 and refurbished at AOML). While conducting routine tests, the system detected that the transducer's charging circuit was not working. For this reason, #400 was no longer an option to be used for deployment.
    - #428 and #429 (brand new instruments). While testing #429, a rebooting cycle bug was noticed when it was "deployed". Furthermore, while it was not in the rebooting loop, it never sampled at the top of the hour as it's supposed to. For this reason, #429 was no longer an option to be used for deployment and it's planned to be transported back to URI aboard the RV Endeavor to have it fixed, since the instrument is still under warranty.
- 80 Lithium batteries (TL-5937 3.6V - 2021 manufacture date), enough for 3 additional PIES.
- 3 sets of 90lb weights for ballast, enough for 3 PIES.

Operations

The initial plan was to conduct telemetry/recovery/deployment operations at the end of the 26.5 N CTD line, starting PIES work on site E and then going westwards. In addition, to test the acoustic communications system on the ship side in advance, telemetry (*) was attempted during CTD casts, as we moved eastwards following the CTD lines on sites B (unsuccessful), C (successful) and D (successful).

(*) Telemetry was performed simultaneously with CTD casts, only for the duration of the CTD operations, regardless of the quality/amount of data successfully transmitted by the PIES, since the main objective was to test the equipment at this first stage of the cruise.

Site E (the furthermost PIES location) could not be reached since the ship had to return to Port Everglades FL, after CTD station 022 on February 11th.

All communications were accomplished with the Teledyne Benthos UTS-9425M-L6 S/N 71363, and the hull-mounted transducer provided by the RV Endeavor. A Benthos Hull Mounted Transducer Interface (HMTI) box B-270-360 S/N 50496 (owned by the University of Miami mooring team) was used to connect the deck unit to the ship's transducer.

Table 3. PIES Operations

Site	Latitude	Longitude	Performed	Result	Before	After
A	26 30.970 N	76 50.010 W	telemetry	successful	248	248
A2	26 29.960 N	76 44.850 W	telemetry recovery deployment	failed successful successful	301	428
B	26 29.530 N	76 28.220 W	telemetry recovery deployment	failed failed success	324	324/301
C	26 30.006 N	76 05.689 W	telemetry	success	335	335
D	26 30.140 N	75 42.360 W	telemetry recovery deployment	success success success	323	323
E	26 30.070 N	71 59.982 W	no operations	-	402	402

Site	Latitude	Longitude	Date GMT	Operation	S/N
A	26 30.970 N	76 50.010 W	18 Feb 2023 01:14	Telemetry-success	248
A2	26 29.960 N	76 44.850 W	16 Feb 2023 20:11	Telemetry-failed	301
A2	26 29.960 N	76 44.850 W	16 Feb 2023 21:12	Recovery-failed	301
A2	26 29.960 N	76 44.850 W	17 Feb 2023 22:00	Recovery-success	301
A2	26 30.100 N	76 44.810 W	17 Feb 2023 23:05	Deployment-success	428
B	26 30.120 N	76 28.640 W	7 Feb 2023 21:50	Telemetry (test)-failed	324
B	26 29.330 N	76 28.240 W	19 Feb 2023 00:45	Telemetry-failed	324
B	26 29.523 N	76 28.218 W	19 Feb 2023 04:10	Recovery-failed	324
B	26 29.530 N	76 28.220 W	19 Feb 2023 06:05	Deployment-success	301
C	26 29.946 N	76 05.057 W	8 Feb 2023 12:18	Telemetry (test)-success	335
C	26 30.006 N	76 05.689 W	16 Feb 2023 04:48	Telemetry-success	335
D	26 30.172 N	75 41.676 W	8 Feb 2023 21:36	Telemetry (pre-recovery)-success	323
D	26 30.551 N	75 43.566 W	9 Feb 2023 02:16	Recovery-success	323
D	26 30.140 N	75 42.360 W	15 Feb 2023 02:58	Deployment-success	323

Summary of PIES operations

- Site A: #248 Telemetry – successfully completed.
- Site A2: Recovery of #301 and deployment of #428 - successfully completed. No data found in #301.
- Site B: Recovery of #324 - failed. Deployment of #301 (refurbished) with 30 min offset – successfully completed.
- Site C: #335 Telemetry – successfully completed.
- Site D: Recovery of #323 – successfully completed. Deployment of #323 (refurbished) – successfully completed.
- Site E: #402 No operations.

4.3 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 nominally 20 m of the bottom, using a dual Sea-Bird SBE-911plus CTD system. Fifteen of these stations were performed to provide calibration data for SBE microcat instruments to be deployed on (or recovered from) the moorings. During these casts, the mooring instruments were attached to the CTD frame by straps and the CTD package was lowered to its target depth, with 5 minute bottle stops at 12 selected depths during the package retrieval. The outer Niskin bottles did not need to be removed from the frame to attach the microcats. This allowed the first two dip casts to be done at stations 11 and 19 with the regular CTD cast. The remaining casts were done as standalone casts. These calibration dip casts 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 12 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, slow-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 (* indicates instrument calibration cast)

Station	Date	Time (UTC)	Latitude (N)	Longitude (W)	Bottom Depth (m)	Max. CTD Depth (m)
1	02/06/23	23:33	26° 32.111	76° 53.234	280	300
2	02/07/23	05:03	26° 31.453	76° 49.996	1081	1123

3	02/07/23	09:24	26° 31.316	76° 45.341	3621	3847
4	02/07/23	13:23	26° 30.346	76° 39.894	4534	4544
5	02/07/23	18:26	26° 28.985	76° 34.615	4800	4820
6	02/07/23	23:09	26° 30.620	76° 28.970	4823	4843
7	02/08/23	03:46	26° 29.684	76° 20.666	4846	4862
8	02/08/23	08:17	26° 29.606	76° 12.764	4795	4814
9	02/08/23	12:51	26° 29.262	76° 04.954	4780	4799
10	02/08/23	17:42	26° 30.302	75° 54.690	4734	4749
11*	02/08/23	23:04	26° 31.484	75° 42.296	4683	4695
12	02/09/23	06:52	26° 31.414	75° 30.630	4670	4687
13	02/09/23	11:42	26° 30.726	75° 17.643	4621	4638
14	02/09/23	16:03	26° 31.092	75° 04.811	4592	4606
15	02/09/23	21:03	26° 30.810	74° 48.353	4522	4539
16	02/10/23	02:23	26° 30.253	74° 31.018	4475	4493
17	02/10/23	07:17	26° 30.205	74° 14.258	4529	4548
18	02/10/23	13:01	26° 30.332	73° 51.314	4721	4738
19*	02/10/23	18:28	26° 29.922	73° 29.314	4946	4965
20	02/11/23	00:50	26° 29.293	73° 07.064	5016	5029
21	02/11/23	06:21	26° 29.669	72° 45.091	5094	5114
22	02/11/23	12:06	26° 29.503	72° 23.140	5165	5184
23	02/17/23	05:30	26° 28.337	76° 37.123	4749	4769
24*	02/18/23	21:30	26° 29.006	76° 29.137	4831	4841
25*	02/20/23	15:03	26° 59.868	79° 12.019	478	486
26	02/20/23	16:17	27° 00.136	79° 17.028	607	616
27	02/20/23	17:37	27 00.366	79 23.018	678	688
28	02/20/23	19:14	27 00.626	79 29.975	750	759
29	02/20/23	20:52	27° 00.799	79° 36.964	636	648
30	02/20/23	22:07	27° 00.880	79° 40.908	525	535
31	02/20/23	23:38	27° 00.794	79° 46.879	381	391
32	02/21/23	00:54	27° 00.484	79° 51.782	262	272
33	02/21/23	02:03	27° 00.271	79° 55.705	146	158
34*	02/25/23	12:35	26° 25.70	76° 51.40	3385	1000
35*	02/26/23	01:18	26° 31.10	76° 41.70	4228	4273
36*	02/26/23	07:00	26° 31.20	76° 41.70	4218	4230
37*	02/27/23	10:05	26° 27.50	75° 47.00	4716	4665
38*	02/28/23	01:51	26° 29.60	75° 43.70	4685	4664
39*	03/04/23	00:24	26° 28.80	76° 39.60	4663	4543
40*	03/04/23	04:43	26° 29.20	76° 48.30	1704	1494
41*	03/04/23	21:26	26° 29.89	76° 42.72	4113	1800
42*	03/05/23	21:56	26° 28.77	76° 39.01	4692	3346
43*	03/06/23	01:51	26° 31.30	76° 41.50	4150	4000
44*	03/06/23	07:35	26° 29.70	76° 48.80	1389	1380

5. 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. Data were processed onboard in real time using the UHDAS acquisition system. Gyrocompass data were continuously corrected by a Trimble ABX-2 inertial navigation system.

The depth range of good velocity data from the 300 kHz system typically extended to 80 m below the vessel, and for the 75 kHz system to 750-800 m. However, through much of the cruise the data from the 75 kHz system was of low quality over a mid-profile range from about 350-450 m where the scattering signal became quite weak, before improving again below ~450m where a deep scattering layer was typically present. This is unusual behavior for the 75 kHz system on this vessel and it is possible that the transducers are biofouled; an inspection and cleaning of them should be done at the next reasonable opportunity.

6. Preliminary Results

The velocity structure along the Abaco section showed a relatively strong westward flow in the upper 1000 m from Abaco out to ~300 km offshore (Fig. 4b), with northward flow in the region between 100-250 km and then southward flow closer to the Bahamas escarpment (Fig. 4a). The near-surface flow pattern (Fig. 5) was consistent with real-time model reanalysis downloaded from Copernicus Marine Services indicating a meandering zonal jet with a cyclonic meander in the vicinity of the 26.5°N line. The Antilles Current, if present, was weak and confined to a narrow region of northward flow extending only about 25 km off Abaco. The deep flow showed evidence of a southward Deep Western Boundary Current (DWBC) below 1000 m just offshore of the Bahamas escarpment (Fig. 4a), where it is typically observed. Farther offshore a northward recirculation was present, which is also typical of the deep mean flow conditions along the 26.5°N line, but the recirculation appeared to be anomalously strong compared to climatology.

The Florida Straits section (not shown) revealed fairly typical flow conditions, with maximum speeds in the surface core of the Florida Current slightly over 2 m/s (Fig. 6).

7. Release of Project Data

In accordance with the provisions specified in the cruise prospectus and the terms of the Bahamian research permit, 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 in within 60 days of the termination of the cruise.

Moored Instrumentation
Time series data records from the moored instruments will be provided within 2 years of recovery of the instruments.

8. 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.

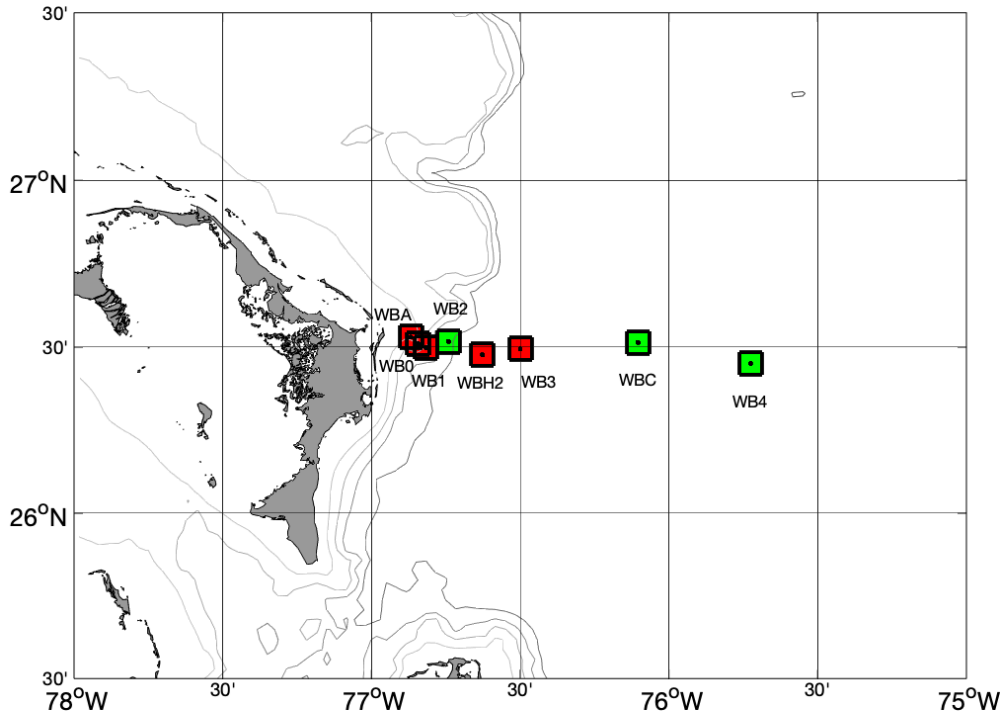

Figure 1. Current meter moorings recovered and deployed on EN-697 (red: recovered and redeployed, green: recovered only; "WBA" = WBADCP). Additional bottom lander moorings (not shown on plot) were deployed near moorings WBA, WB1, WB2, and WB3.

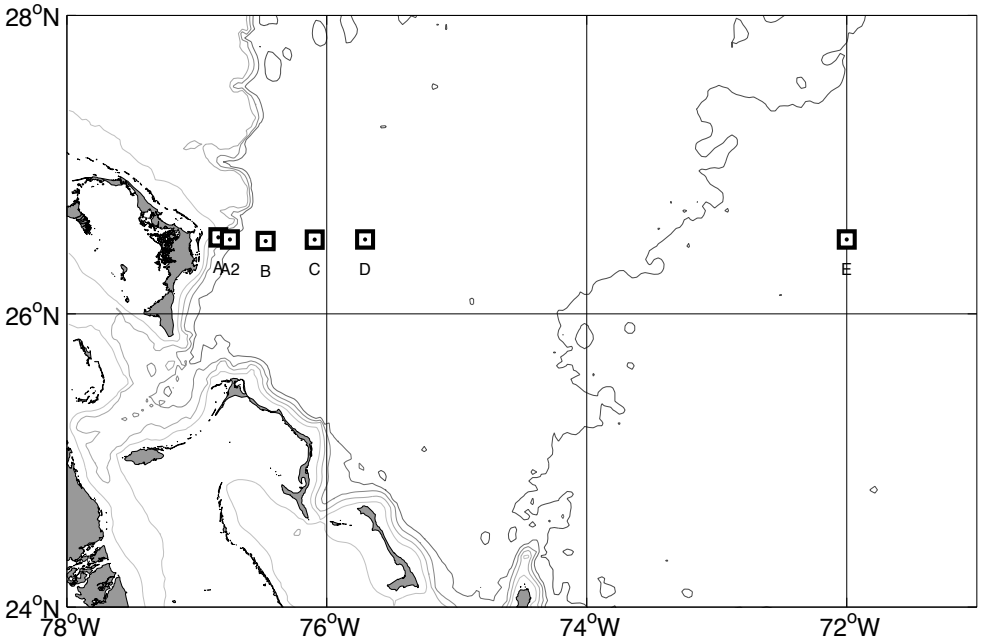

Figure 2. PIES locations along the 26.5° N Abaco line.

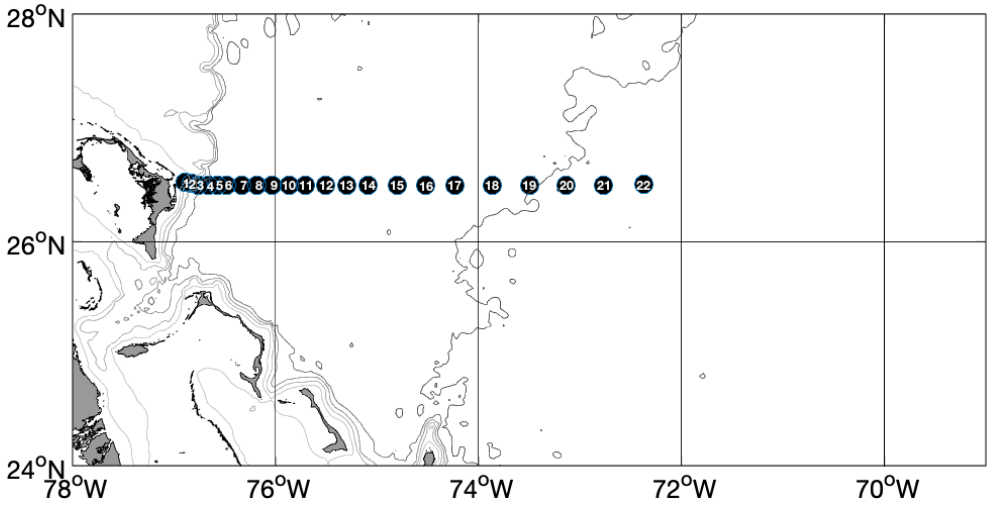

Figure 3a. CTD/LADCP stations occupied along the 26.5°N Abaco line. Additional instrument calibration CTD casts (not shown) were also performed during the cruise, as detailed in Table 4.

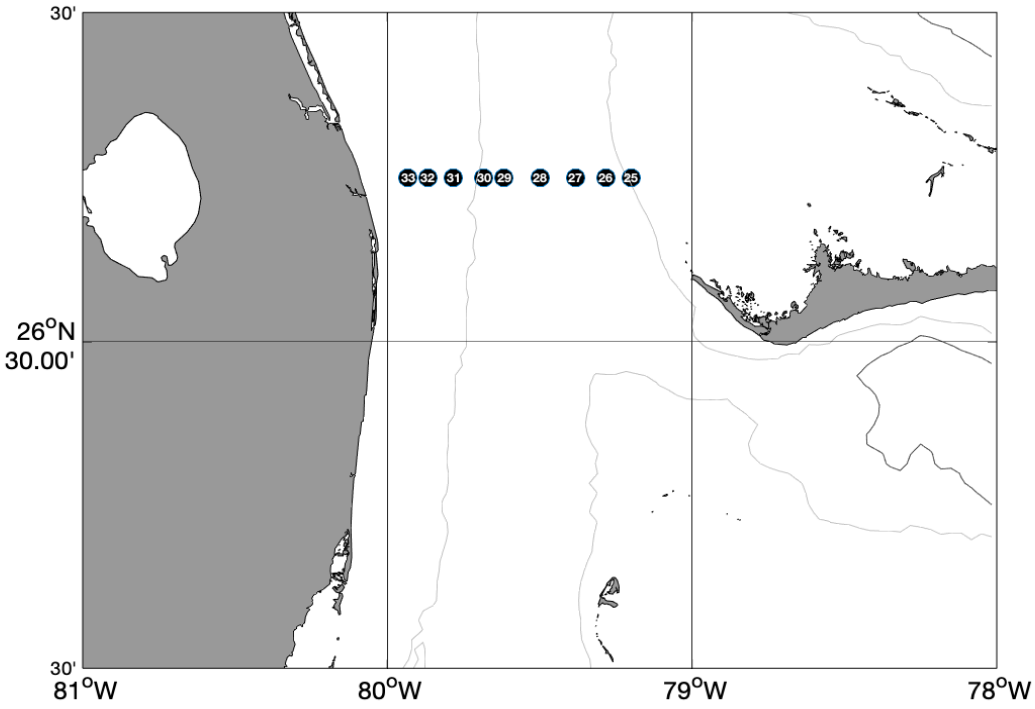

Figure 3b. CTD/LADCP stations occupied along the 27°N Straits of Florida section.

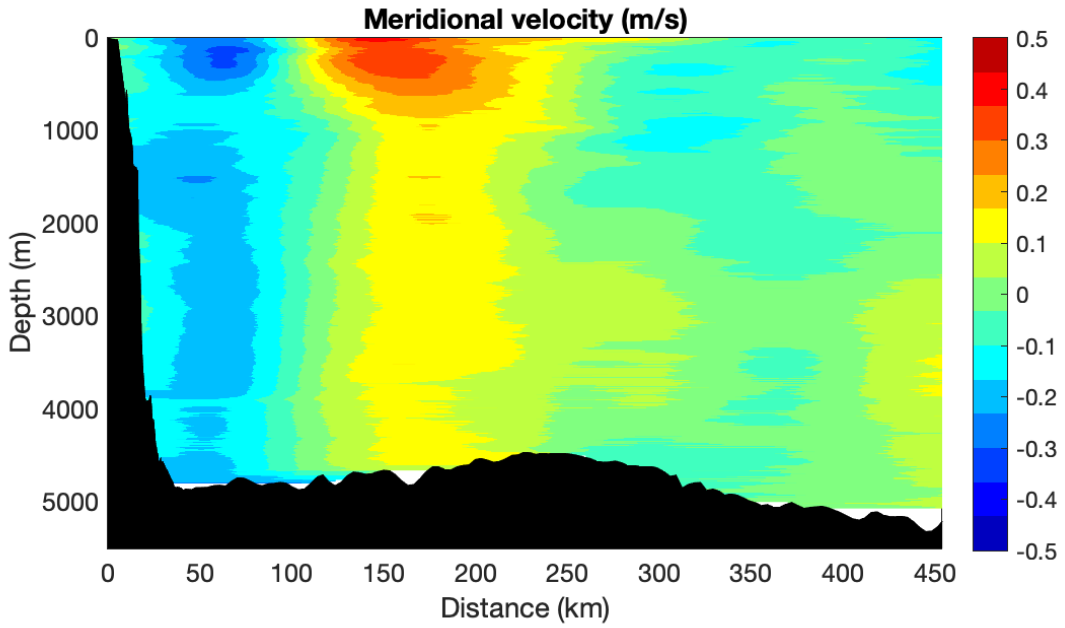

Figure 4a. Meridional velocity section for the Abaco line, from Lowered-ADCP profiles collected at the CTD stations.

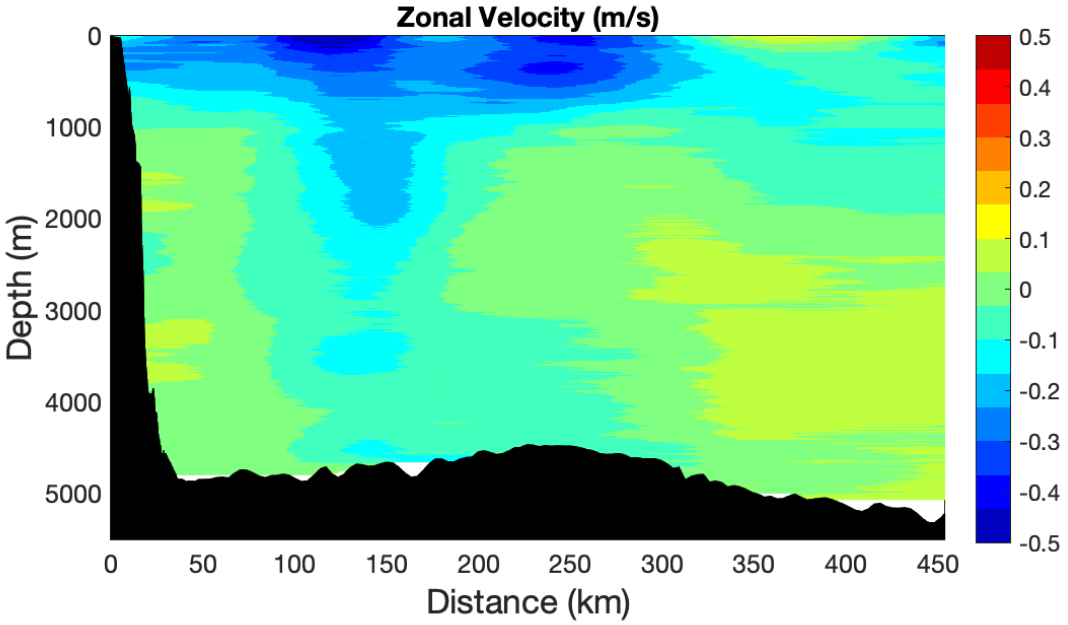

Figure 4b. Zonal velocity section for the Abaco line, from Lowered-ADCP profiles collected at the CTD stations.

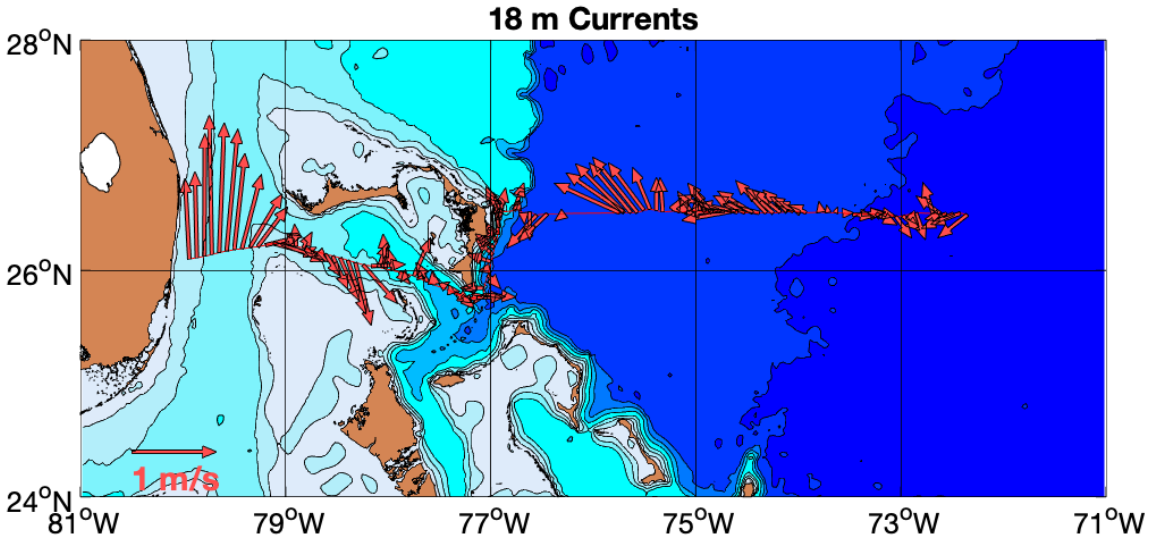

Figure 5. Near-surface currents (at 18 m depth) long the outbound cruise track of Leg 1 and Abaco CTD line (Feb. 5 - 12), derived from the vessel-mounted ADCP.

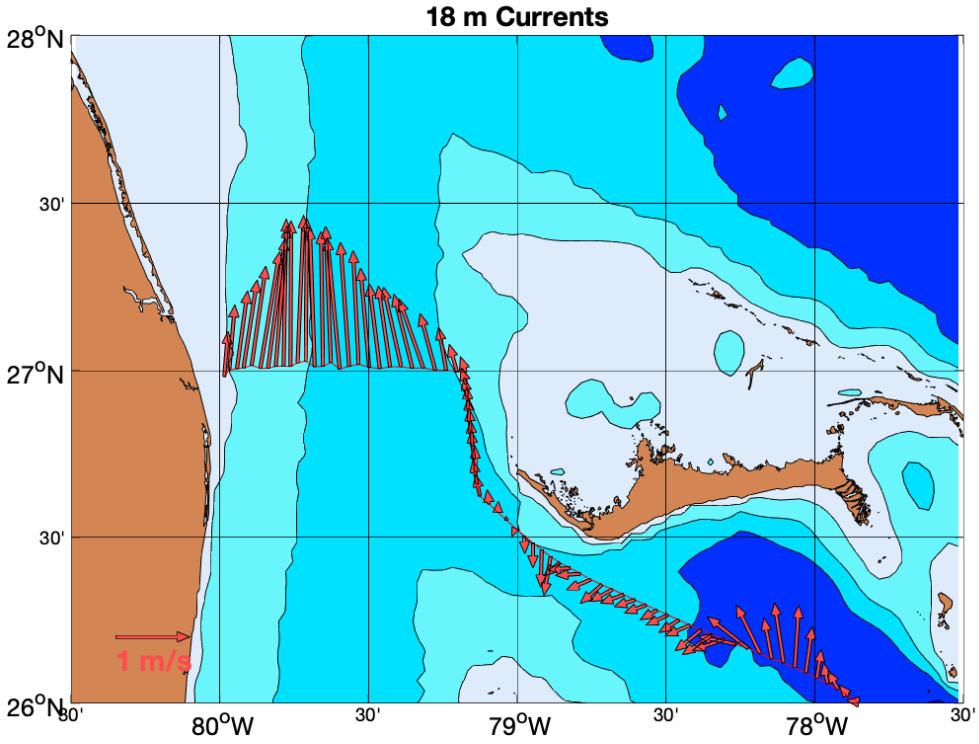

Figure 6. Near-surface currents in the Straits of Florida on Feb. 19 -20, derived from the vessel-mounted ADCP.

Appendix 1. Lowered ADCP Operations

Pedro Pena
Feb 2023

LADCP Setup:

Full water column velocity profiles for the MOCHA February 2023 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 21862 and the upward-looking 300 kHz ADCP was S/N 24616. 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 standard 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. ADCP S/N 21862 was running firmware version 50.40 and ADCP S/N 24616 was running firmware version 51.42.

Inside the main lab of the R/V Endeavor, a dedicated PC laptop running MX Linux with a two-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 public network drive for processing and archiving. A single cable with dual serial port lines, along with power leads connected to the power supply, was run outside to the CTD rosette where it plugged into the star-cable wiring.

A Siglent SPD3303X-E programmable DC power supply was used for charging the battery pack. Voltage channels 1 and 2 were each set to 28 volts and bridged in order to provide a total of 56 volts. The power supply provided a digital readout of the current being consumed by the battery pack and aided in making the decision of whether or not to swap the battery pack before a cast.

The ability to control the voltage and monitor the current was very helpful and as a result there were no LADCP dropouts during any of the casts.

The two raw ADCP data files were processed on the acquisition computer and a second computer with uncorrected one-second time-series CTD data provided by the CTD operator. The initial processing of the raw ADCP data was done using a compiled version of M. Visbeck version 10.20.

ADCP configuration test:

02/17/2023
One of the functions of the star cable used in the lowered ADCP casts is to coordinate the sampling between the upward-looking and the downward-looking ADCP's. In a master/slave configuration, the ADCP configured to be the master will sample first and then via the star cable, instruct the ADCP configured as the slave to sample immediately afterwards. This staggered sampling scheme is necessary when the two ADCP's are of the same frequency otherwise they would interfere with each other.

In this hybrid LADCP configuration where one ADCP samples at 300KHz and the other samples at 150KHz, the ADCP's should never interfere with each other and therefore should be able to sample without needing coordination. In order to test this, the ADCP's were both configured with a master configuration file and deployed at station 23. After the cast, the files were downloaded and the lowered ADCP software was able to process it.

In a hybrid configuration where the star cable fails in such a way that the master ADCP cannot instruct the slave ADCP to sample, both ADCP's can be configured as master and a lowered profile can be obtained.

Operational Issues

Configuration issues

02/06/2023
For the test cast both the downward-looking and the upward-looking ADCP's were accidentally deployed using a slave configuration file and as a result no data was collected. Immediately after the cast, an on-deck test was performed and it was noticed that the upward-looking ADCP was not collecting data. After some testing, the star cable was found to be faulty and was subsequently replaced and an on-deck test of the ADCP's confirmed that the upward-looking ADCP was now collecting data.

Processing issues:

02/20/23

For cast 29, the deck leads used for downloading the data from the ADCP's were swapped. As a result, the LADCP software processed the master file as the slave and the slave file as the master resulting in a nonsensical LADCP profile. The two ADCP's were

correctly deployed at the beginning of the cast and therefore all that had to be done to obtain an LADCP profile was to rename the files and run the processing software again.

Charging issues

02/07/2023
Due to the proximity of stations 5 and 6, there was not enough time to charge the LADCP battery pack and as a result it was drawing over 1 Amp about ten minutes before arriving at station 6. In order to avoid a potential brownout during the cast, the LADCP battery pack was replaced and station 6 was completed without issue.

02/08/2023
Due to the proximity of stations 7 and 8, there was not enough time to charge the LADCP battery pack and as a result it was drawing over 1 Amp about ten minutes before arriving at station 8. In order to avoid a potential brownout during the cast, the LADCP battery pack was replaced and station 8 was completed without issue.

Command files for the WH300 and WH150:

```
Workhorse 150 kHz Downward-looking ADCP (MASTER) Command File
Filename: AB2102_150kHz_down_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

Workhorse 300 kHz Upward-looking ADCP (SLAVE) Command file
Filename: AB2102_300khz_up_slave.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
```