National Oceanic and Atmospheric Administration
Atlantic Oceanographic and Meteorological Laboratory
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January 15, 2020

Final Cruise Report

U.S. Dept. of State Cruise No: F2018-073.

Ship Names: R/V Angler Management 2.0 (trips 1, 4-6); other vessels (trip 2,3);

Dates: April 23, 2019; June 5, 2019; July 10, 2019; September 6, 2019; September 25, 2019; October 9. 2019.

Project Investigators: Molly Baringer and Denis Volkov

Chief Scientist (for cruises): Ryan Smith

Foreign Participants: None

Operating Institution: NOAA/AOML

Cruise Report by: Rigoberto Garcia, Ryan Smith, Molly Baringer, and Denis Volkov.

Project Title: Western Boundary Time Series.

Clearance Countries: Bahamas

Port Calls: West Palm Beach, FL to West Palm Beach, FL.

Description of the Scientific Program:

Voltages induced on a submarine cable by the Florida Current have been shown to be proportional to the total current transport. In order to calibrate the cable measurements, direct transport observations are needed at a few times during each year. A dropsonde is an instrument consisting of an expendable weight and a glass tube or sphere containing electronic sensors, including a Global Positioning System (GPS) receiver. The instruments determine vertically-averaged horizontal velocity by sinking to the ocean bottom, dropping the weight, and then rising to the ocean surface, with the GPS providing an accurate location for the start and end of the profile. Using the dropsonde technique, horizontal velocity is estimated at nine stations across the Straits. AOML has obtained these vertically-averaged velocities across the Strait of Florida on several cruises during this year, and horizontal-integration of the velocity values has yielded calibration values for submarine cable transport measurements. Cable voltages have been monitored and daily total transport values obtained since 1982.

Beginning in 1995 the cable calibration effort was augmented in support of the Volunteer Observing Ship Program (VOS) that deploys expendable bathythermographs (XBTs) in the interior Atlantic. The goal of this VOS/XBT program is to study the upper ocean thermal structure of the subtropical North Atlantic using volunteer observing merchant ships. Repeat XBT sections, approximately every 3 months, have been conducted since October 1984 with the intent of determining and monitoring the seasonal-to-interannual variability of the upper ocean heat content. The ship-track, which roughly follows along 30°N, is designated as AX7 and it is ideal for monitoring heat flux variability in the Atlantic because it lies near the center of the subtropical gyre, which has been shown to be the latitude of the maximum heat flux in the ocean. The upper ocean thermal structure obtained using the expendable temperature probes (XBTs) is being used to correlate the subtropical gyre intensity with atmospheric forcing as well as for determining the heat transport.

Essential to the goal of monitoring the meridional heat transport is a measure of the heat content and transport within the Florida Straits. Therefore, on each of the cable calibration cruises completed as part of this project, the dropsonde measurements are augmented by XBT casts at all nine of the nominal station locations to measure the vertical temperature profile.

Data Observations and Samples Collected:

This report refers to the last 6 cruises performed in the Florida Current. On a typical cruise a single AOML participant drives to Palm Beach the evening prior to the departure. The boat departs Palm Beach at about 0600, conducts a total of seven hours of work at the nine stations plus five hours of steaming time, and returns to Palm Beach at roughly 1700. The AOML participant then returns to Miami that same day. Expendable Bathythermographs (XBTs) are launched at each station to obtain temperature profiles of the water column beneath the ship. The XBTs are numbered as the station numbers, whose positions are given in Table 1. Plots of the XBT temperature sections are shown in the Appendix.

The GPS/dropsonde used in all 9 stations is a glass sphere housing a Garmin GPS 18x PC receiver/logger (or equivalent), RDF beacon, pinger, and batteries. A second Magellan 5000 Pro GPS receiver (or equivalent) is used to determine the ship positions on all cruises. In addition to vertically integrated velocities, after surfacing the GPS/dropsonde is allowed to drift for five minutes to obtain a surface velocity estimate.

The station locations are listed in Table 1 and a typical cruise trackline is shown in Figure 1. Table 2 lists the dropsonde deployment and surface time positions, and the computed vertically integrated velocities for each cruise. Surface positions are determined using the dropsonde GPS record. The midpoint time for all profiles is used as the time for the cruise. Table 3 lists the observed meridional surface velocities for each station.

Problems/issues observed during cruises:

During this period, the XBT system failed to record data in at least one of the stations during each cruise as shown in the figures in the Appendix. The XBT system failed during the July cruise.

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Schedule of Delivery of Data and Reports: All data are contained herein. No further report is planned.

Acknowledgements: A sincere thanks to Pedro Pena, Grant Rawson, and Diego Ugaz for their participation in these cruises and to the crew of the R/V Angler Management 2.0 and other vessels for their reliable assistance.

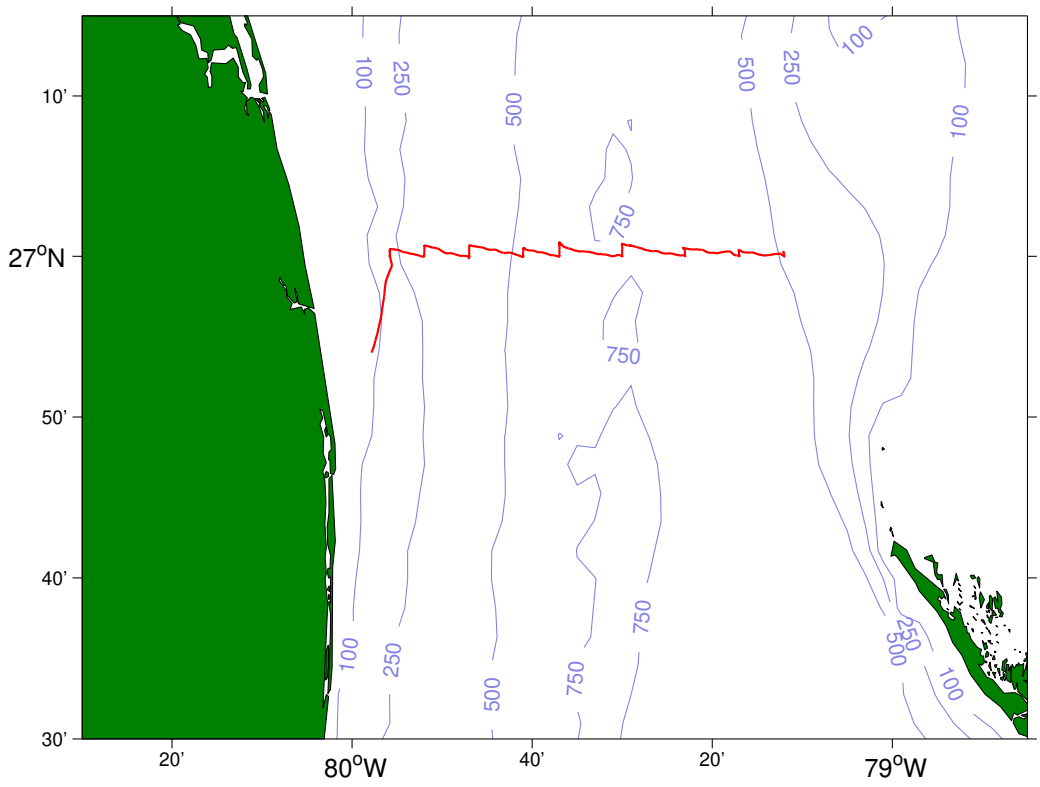

Figure 1: Typical cruise track

Station	Latitude	Longitude	Depth
0	27 00.00 N	79 55.80 W	139 M
1	27 00.00 N	79 52.00 W	261 M
2	27 00.00 N	79 47.00 W	389 M
3	27 00.00 N	79 41.00 W	540 M
4	27 00.00 N	79 37.00 W	661 M
5	27 00.00 N	79 30.00 W	783 M
6	27 00.00 N	79 23.00 W	708 M
7	27 00.00 N	79 17.00 W	624 M
8	27 00.00 N	79 12.00 W	485 M

Table 1: Station Locations.

Sta	Deployed			Surfaced			Mean Velocities	
	Time (GMT)	Lon	Lat	Time (GMT)	Lon	Lat	U cm/s	V cm/s
April 23, 2019								
0	12: 3:58	-79.9300	27.0004	12:14:37	-79.9295	27.0068	8.83	109.29
1	12:45:20	-79.8665	27.0008	13: 3:13	-79.8653	27.0120	10.69	115.16
2	13:34: 5	-79.7830	27.0013	14: 3:14	-79.7810	27.0212	11.22	125.20
3	14:34:19	-79.6834	27.0001	15:12:29	-79.6818	27.0226	7.07	108.35
4	15:36:10	-79.6176	27.0004	16:23:20	-79.6165	27.0263	4.25	100.44
5	16:57:15	-79.5010	27.0001	17:56:27	-79.5004	27.0252	1.32	79.32
6	18:30:25	-79.3838	27.0001	19:22:50	-79.3847	27.0186	-2.69	65.40
7	19:49:54	-79.2837	26.9996	20:33: 2	-79.2855	27.0111	-6.81	49.77
8	20:54:12	-79.2000	26.9993	21:30:51	-79.2029	27.0087	-13.15	47.88
June 5, 2019								
0	11:43:46	-79.9300	27.0021	11:50:53	-79.9300	27.0051	1.55	76.65
1	12:23:26	-79.8667	27.0015	12:35:56	-79.8666	27.0068	1.50	76.38
2	12:58:36	-79.7835	27.0004	13:16:59	-79.7832	27.0089	2.84	83.36
3	13:44:27	-79.6834	27.0004	14: 9:59	-79.6828	27.0131	4.04	90.73
4	14:40: 9	-79.6168	27.0006	15:12:21	-79.6163	27.0163	1.69	89.06
5	15:45:16	-79.4998	27.0004	16:21:36	-79.4996	27.0149	0.46	72.97
6	16:47:51	-79.3836	27.0002	17:20:32	-79.3838	27.0106	-1.30	58.18
7	17:42: 0	-79.2833	27.0001	18:11:40	-79.2844	27.0081	-5.57	50.00
8	18:31: 5	-79.1998	27.0001	18:53:46	-79.2011	27.0054	-9.55	43.99
July 10, 2019								
0	19:48:44	-79.9295	26.9981	19:56:16	-79.9296	27.0003	-2.00	51.93
1	19:18:16	-79.8667	26.9996	19:31: 4	-79.8666	27.0056	0.87	86.66
2	18:39:53	-79.7836	26.9990	18:59:26	-79.7833	27.0096	2.96	99.11
3	17:51:44	-79.6841	27.0002	18:18:26	-79.6834	27.0160	5.40	109.30
4	17: 3: 1	-79.6164	26.9999	17:34:33	-79.6156	27.0175	4.22	102.14
5	16: 2:34	-79.4998	27.0009	16:40:20	-79.4998	27.0183	-0.39	84.54
6	15: 5: 5	-79.3827	27.0004	15:39: 2	-79.3841	27.0147	-7.54	77.81
7	14: 7:57	-79.2835	26.9999	14:38:50	-79.2855	27.0118	-11.48	71.01
8	13:24:10	-79.1996	27.0007	13:47: 3	-79.2018	27.0079	-16.37	58.31
September 6, 2019								
0	12:32:33	-79.9298	26.9998	12:39:51	-79.9301	26.9984	-6.58	-35.52
1	13:15:19	-79.8666	27.0001	13:28: 4	-79.8669	27.0012	-3.71	15.99
2	13:49:45	-79.7839	27.0001	14: 8:53	-79.7843	27.0062	-3.52	59.39
3	14:34:37	-79.6835	27.0001	15: 1:48	-79.6842	27.0111	-4.13	75.91
4	15:28:59	-79.6168	27.0000	16: 0:51	-79.6170	27.0153	-1.01	88.70
5	16:45:22	-79.4999	27.0002	17:21:44	-79.5014	27.0174	-6.48	87.01
6	17:57:52	-79.3836	27.0008	18:31:50	-79.3860	27.0156	-11.04	80.35
7	19: 7:44	-79.2833	27.0000	19:39: 8	-79.2861	27.0128	-14.88	74.96
8	20: 6:49	-79.1999	27.0002	20:31:35	-79.2034	27.0104	-23.16	75.68

Table 2: Dropsonde Data: Values of -999 indicate instrument failure.

Sta	Deployed			Surfaced			Mean Velocities	
	Time (GMT)	Lon	Lat	Time (GMT)	Lon	Lat	U cm/s	V cm/s
September 25, 2019								
0	11:55:39	-79.9300	27.0000	12: 3:16	-79.9300	27.0027	-0.14	65.09
1	12:29:28	-79.8666	27.0002	12:42:44	-79.8666	27.0061	1.59	80.88
2	13: 4:48	-79.7833	27.0004	13:24:54	-79.7825	27.0119	6.23	106.60
3	13:48:42	-79.6834	27.0002	14:16:59	-79.6824	27.0160	5.39	102.89
4	14:37: 7	-79.6167	27.0000	15: 9:41	-79.6152	27.0177	7.30	100.36
5	15:41:53	-79.5001	27.0000	16:20:53	-79.4998	27.0166	0.89	78.34
6	99:99: 0	-79.3833	27.0000	99:99: 0	-79.3833	27.0000	-999.00	-999.00
7	99:99: 0	-79.2833	27.0000	99:99: 0	-79.2833	27.0000	-999.00	-999.00
8	18:59:59	-79.1997	27.0001	19:26:22	-79.2011	27.0055	-8.76	38.65
October 9, 2019								
0	12:11: 0	-79.9300	27.0004	12:19:20	-79.9297	27.0035	6.24	69.39
1	12:39:42	-79.8667	27.0001	12:53:42	-79.8670	27.0053	-2.69	67.24
2	13:16:52	-79.7834	27.0000	13:37:29	-79.7837	27.0087	-2.33	77.31
3	14: 5:39	-79.6834	27.0000	14:35:58	-79.6838	27.0150	-2.03	91.12
4	14:54:48	-79.6167	27.0000	15:28:50	-79.6168	27.0154	-0.14	84.34
5	15:58:55	-79.5000	27.0000	16:38: 2	-79.5013	27.0135	-5.72	63.49
6	17: 5:44	-79.3833	26.9998	17:41:33	-79.3858	27.0118	-11.85	62.01
7	18:10: 2	-79.2833	27.0000	18:42:35	-79.2862	27.0097	-15.22	55.09
8	19: 7:56	-79.2000	27.0000	19:33:46	-79.2022	27.0059	-14.29	42.23

Table 2: Continued.

Table 3: Dropsonde Data: Values of -999 indicate instrument failure.

Date	Station #								
	0	1	2	3	4	5	6	7	8
April 23, 2019	173.66	220.18	203.46	174.45	191.17	20.07	73.56	28.97	0.02
June 5, 2019	210.89	211.62	189.03	183.68	196.95	108.23	101.56	67.25	5.91
July 10, 2019	192.81	157.71	188.19	123.14	198.94	150.06	107.76	63.92	59.45
September 6, 2019	-44.72	22.95	48.93	1.31	110.56	116.51	138.29	114.70	120.08
September 25, 2019	108.73	144.29	118.89	145.67	142.66	118.87	-999.00	-999.00	7.78
October 9, 2019	130.78	135.02	135.53	119.47	51.33	88.66	50.42	41.57	49.68

Table 4: Meridional Surface Velocities in cm/s. Values of -999 indicate instrument failure.

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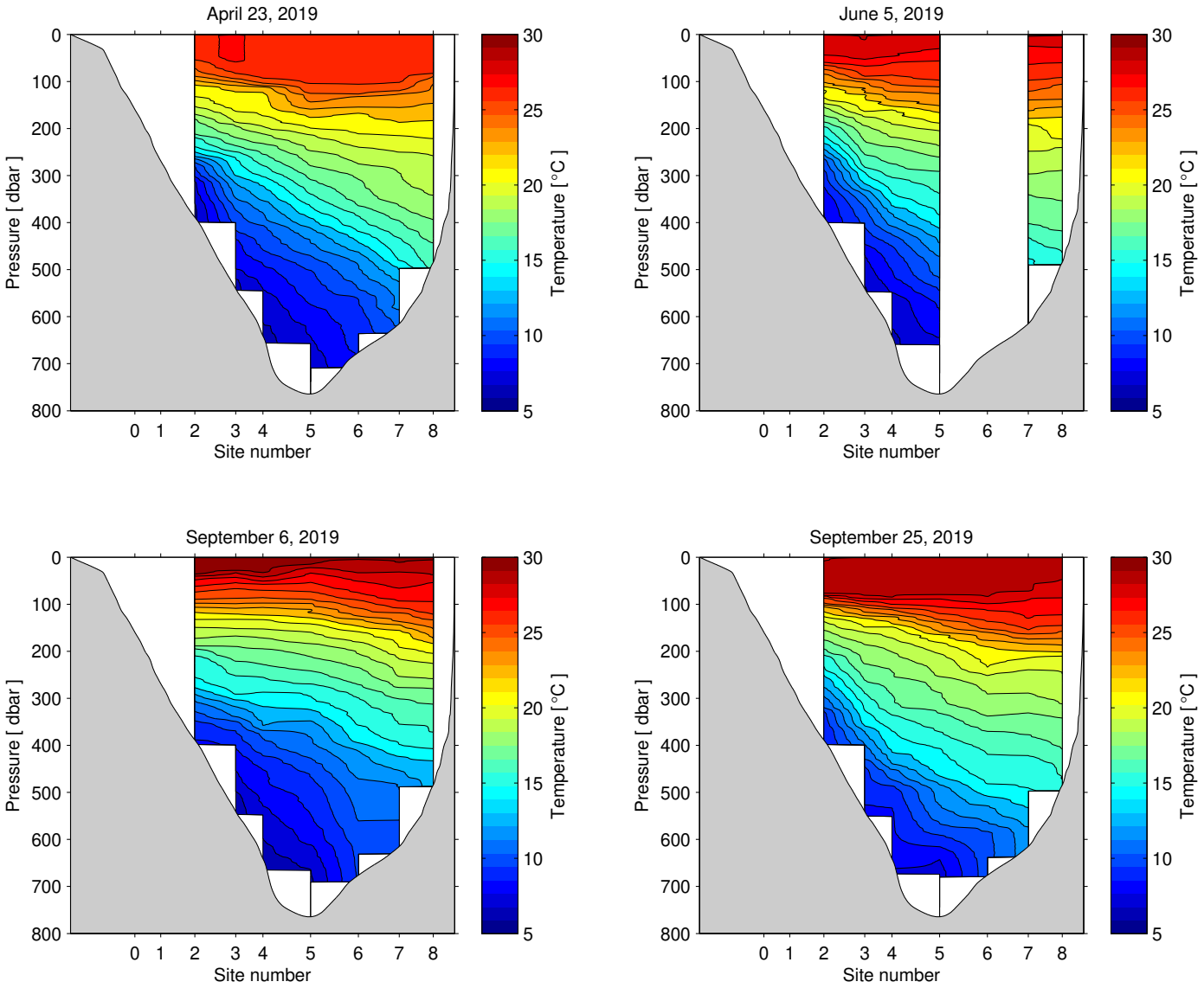
APPENDIX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June 5, 2019
September 6, 2019
September 25, 2019
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100
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300
400
500
600
700
800
Site number
0 1 2 3 4 5 6 7 8
Temperature [°C]
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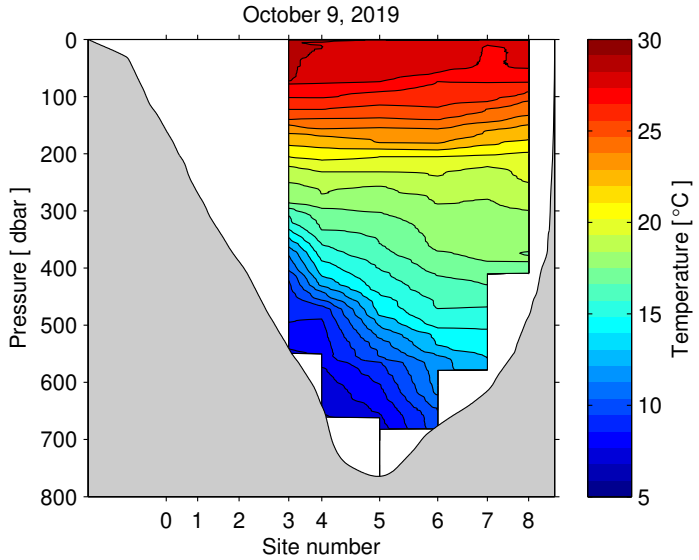
25
20
15
10
5


October 9, 2019
Pressure [dbar]
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100
200
300
400
500
600
700
800
0 1 2 3 4 5 6 7 8
Site number
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25
20
15
10
5
Temperature [°C]