AR-15 Cruise Report

15-29 April 2017

PEACH Array Deployment Cruise

Collaborative Research: An Observational and Modeling Study of the Physical Processes Driving Exchanges between the Shelf and the Deep Ocean At Cape Hatteras (or **P**rocesses Driving **E**xchange **a**t **C**ape **H**atteras, PEACH)

Supported by the National Science Foundation

Photo credit: J. McCord, Coastal Studies Research Institute

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Cruise Report: PEACH Array Deployment. R/V *Armstrong* Cruise AR-15, 15-29 April, 2017.

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1. Cruise Objectives

The PEACH project aims to identify the processes that control the exchange of waters between the shelves along the eastern seaboard of the U.S. (the Middle Atlantic Bight and Southern Atlantic Bight) and the open ocean. The PEACH project includes remote sensing and in situ observations—comprising radars, moored platforms and gliders (**Figure 1**)—as well as a numerical modeling component. The primary goal of the AR-15 cruise on the *R/V Armstrong* was to deploy the moored PEACH array off of Cape Hatteras. In addition, shipboard data were collected to characterize the study region and investigate event-scale processes.

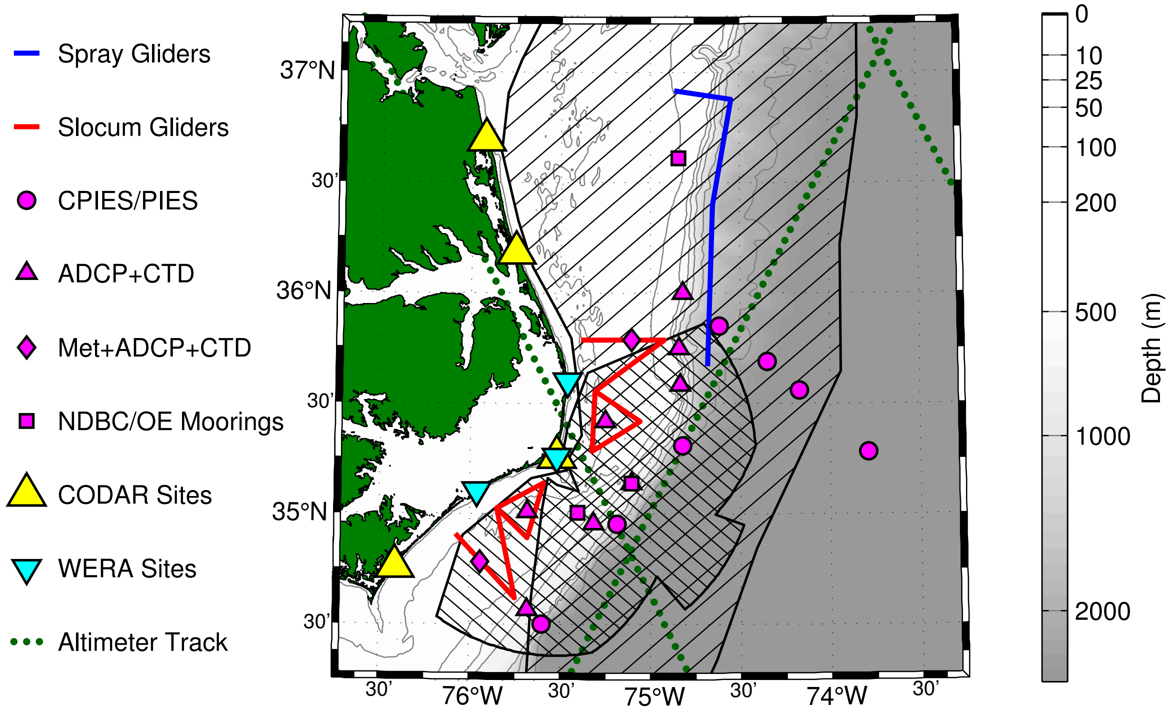


Figure 1. PEACH array off of Cape Hatteras showing moored instruments, glider tracks, radar coverage and other regional observations.

The cruise departed from and returned to Woods Hole, MA and spanned 15 to 29 April 2017. During the cruise, 16 moored platforms were deployed: 5 Current-and-Pressure sensor equipped Inverted Echo Sounders (CPIESs), 2 Doppler current profiler equipped inverted echo sounders (DCPS-PIESs), 5 acoustic Doppler current profilers (ADCPs) in trawl resistant pods, 2 meteorological buoys, and 2 ADCP tripods. In addition, 16 expendable bathythermographs (XBTs), 4 Argo floats, and a Spray glider were deployed. Ninety-two CTD casts were conducted to collect temperature, salinity, oxygen and fluorescence profiles (mostly full-water column with the shallowest site at 17-m depth and the deepest at 3400-m depth). Twenty-four water samples for salinity measurement calibrations were collected and water samples for biological measurements were collected at 87 unique site/depth combinations.

In addition to the instrument deployments, CTD casts, and water sampling, shipboard data were collected to contribute to 20 feature surveys. The shipboard data included ADCP data and surveys with the ship's multibeam system and the EK80. Data were also collected with the Knudsen (12 kHz and 3.5 kHz) and with the thermo-salinograph (TSG).

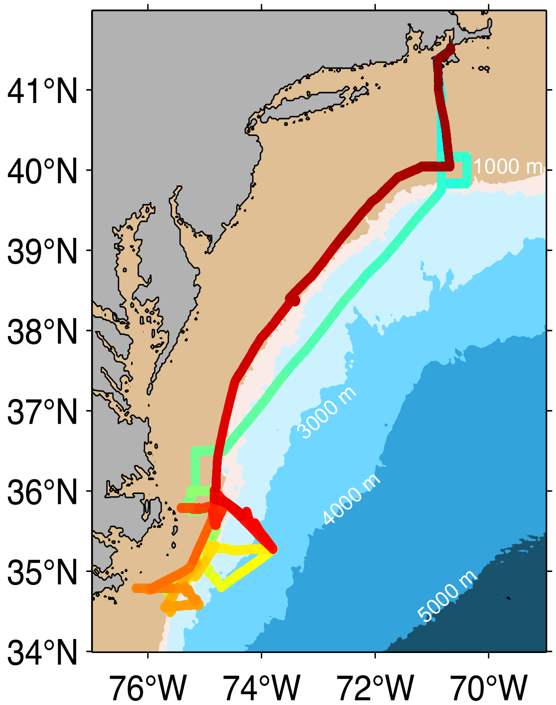


Figure 2. Cruise track with color indicating timing (from red at the start of the 15-day cruise through orange, yellow and cyan at the end). Plot generated from the mat file with shipboard GPS data: AR15_cruise_track.mat.

Eleven blog entries about the PEACH project were posted from the ship with high school students actively following the posts through their science classes. See http://www.coastalstudiesinstitute.org/research/coastal-engineering/research-project-processes-driving-exchange-cape-hatteras/). Video and photos (including underwater and drone footage) were collected on the cruise and are being compiled into video clips to aid in continued outreach and public communication efforts.

The cruise track is shown in **Figure 2**. The following sections describe the cruise's technical details and present some preliminary data and results. Times are given in UTC or local (EDT, UTC-4), as noted.

2. Science Party

Magdalena Andres	Woods Hole Oceanographic Institution (chief scientist)
Robert Todd	Woods Hole Oceanographic Institution
Patrick Deane	Woods Hole Oceanographic Institution
Glen Gawarkiewicz	Woods Hole Oceanographic Institution
Craig Marquette	Woods Hole Oceanographic Institution
Erran Sousa	University of Rhode Island
Harvey Seim	University of North Carolina
Sara Haines	University of North Carolina
Michael Muglia	University of North Carolina, Coastal Studies Institute
Nicolas DeSimone	University of North Carolina, Coastal Studies Institute
John McCord	University of North Carolina, Coastal Studies Institute
Patterson Taylor III	University of North Carolina, Coastal Studies Institute
Joseph Zambon	North Carolina State University
Marco Valera	North Carolina State University
Lauren Ball	North Carolina State University
Valerie Winzenried	(observer)
Amy Simoneau	Woods Hole Oceanographic Institution (SSSG)
Christopher Seaton	Woods Hole Oceanographic Institution (SSSG)

3. Cruise Narrative

The Event Log that was maintained during the cruise is included in the **Appendix**. The moored instrument types that were deployed on the cruise are shown in **Figure 3**.

15 April, 2017: The *R/V Armstrong* departed Woods Hole, MA at 08:00 (local). The ship conducted a calibration of the magnetic compass (due to the newly added ballast) off of Martha's Vineyard (~41° 29.958' N, 70° 40.868' W). The ship then transited south across the shelf and arrived near the shelf break in the evening. The transit towards Cape Hatteras continued along the shelf break (~200 m isobath), running the sADCP and with XBTs launches every three hours (**"MAB-SB section"**, **Table 1**). Note that the Knudsen wasn't logging depths until sometime between X03 and X04 (near Hudson Canyon). XBTs drops continued through the night.

16 April, 2017: We continued the sADCP/XBT shelfbreak section throughout the day and evening. After X07, we moved slightly offshore and deployed a Spray glider (near the latitude of Ocean City, MD), conducted a CTD cast (with underwater camera and lights mounted to the rosette frame) and did some acoustics testing with our deckboxes and the ship's through hull transducer. We then resumed the XBT/sADCP section and continued this through the night and into the morning.

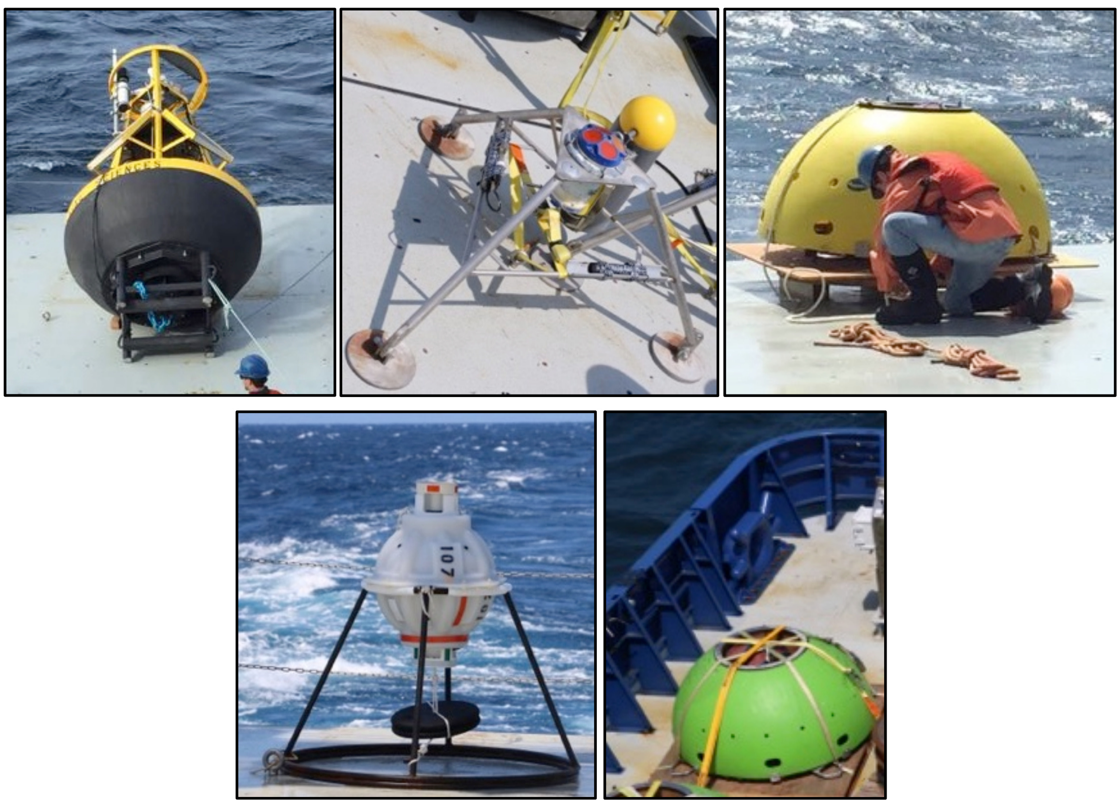


Figure 3. Moored instruments deployed during the cruise. Top row: met buoy (left), ADCP tripod (middle) and CSI ADCP pod (center). Bottom row: CPIES (left) and WHOI ADCP pod (right). Photos credits, M. Andres (WHOI).

17 April, 2017: After the last XBT in the MAB-SB section, we deployed CPIESs at sites P1 and P2 and a DCPS-PIES (a PIES with a Doppler current profiler rather than a point current sensor)

at site P3. After each deployment, we completed a full-water column calibration CTD cast at each site. Two Argo floats were deployed in the region (S/N 7303 and 7423). In the evening we transited to P4 (but, in the interest of time, we did not deploy the DCPS-PIES instrument there with the plan to return to this site later in the cruise). This transit to P4 was to complete a section across the Gulf Stream ("**GS5 section**", **Table 1)**. Then we collected sADCP data to complete a Gulf Stream section on the return transit (southeast to northwest from P4 to A1) without stopping for deployments or CTDs ("**GS4 section**", **Table 1).**

18 April, 2017: We deployed the 300 kHz ADCPs in H-TRBM-65 housings (WHOI, yellow) along the 100 m isobath at sites A1, A2 and A3 and conducted a CTD at each site. The deployment at A1 was filmed (with cameras mounted to the deployment wire and a live feed back to the deck). We transited from A3 to P1 and conducted a CTD cast ½ way between the sites. At P1, we conducted some acoustics/telemetry tests with this CPIES (SN 102). We stayed on station overnight and conducted a yo-yo CTD cast and downloaded the concurrent CPIES data via burst telemetry ("**Yo-yo station**", **Table 1)**.

19 April, 2017: We arrived at site B1 in the morning and deployed the meteorological buoy here (with met sensors and surface and mid-depth Microcats). Sara and Harvey climbed onto the platform to set up the sensors (using the *R/V Armstrong's* rescue boat). We then deployed the tripod with its Microcat and a 600 kHz ADCP just outside of the watch circle (also with a camera on the deployment wire). We did not conduct a calibration CTD right away (but included one on the MAB CTD cross section, "MAB1"). We transited towards shore (17 m isobath) at the latitude of B1 (35˚ 47.3´ N) and conducted a sADCP/CTD section across the MAB to the 930 m isobath ("**MAB1 section**", **Table 1**). In the evening we transited to B2 (running the sADCP but with no CTDs en-route).

20 April, 2017: We deployed the meteorological buoy and bottom tripod at site B2 (again using the rescue boat to access the buoy and with instrumentation analogous to that at B1). We conducted a west-to-east sADCP/CTD section across the SAB shelf at the B2 latitude (34˚ 47´ N) from the 21 m isobath to the 175 m isobath (**"SAB1 section"**, **Table 1**) with a fly-over from the Todds' airplane while we were at station SAB02. We continued this section across the "attached" Gulf Stream (upstream of the separation point) with the sADCP/CTD line oriented northwest-southeast ("**GS1 section**", **Table 1**) After the last CTD in this section, we transited west back to site A8 collecting sADCP data but not CTDs ("**GS0 section**", **Table 1**).

21 April, 2017: We deployed a bottom-mounted 150 kHz ADCP (CSI, green) at site A8 roughly on the 230 m isobath (to match the Ocean Energy Mooring's depth, site A5). We again used a camera to live feed the deployment video back to the ship. We conducted a CTD cast at the site and then transited to site P7 to deploy a CPIES and do a calibration CTD. After the deployments, we transited northeast and conducted the first part of the Bathymetric Survey ("**BS1**", **Table 1**) using the EM710 and working our way from shallow lines (roughly along-isobath) to deep lines. Concurrently with the EM710, we ran the 3.5 kHz Knudsen (to look at sub-bottom reflectors), the 300 kHz sADCP and the 38 kHz sADCP. For sound speed calibrations we used an XBT (T-11, fine structure probe). The first one fired (from 1999) was bad (BS01A), but the second one (from 2016 and borrowed from Tim Duda, BS01B) was good. A second XBT (a T-6 probe, BS11.edf) was fired later in the survey. Working through the night and into the next morning we were able to complete 2 full round trips and part of a third round trip of the bathymetric survey.

22 April, 2017: At about 08:00 (local) we interrupted the Bathymetric Survey and cut across to A6 where we deployed another bottom-mounted 150 KHz ADCP (CSI, green). We also accidentally deployed a boat hook during this operation (we did, however, get great go-pro video of the back of the *R/V Armstrong*). Because of the impending storm, we rearranged the plan so all instruments could be deployed as soon as possible. We deployed CPIESs at sites P6 and P5 (and did the calibration CTDs). Harvey Seim and Chris Seaton then conducted the SEEP survey (**Table 1**) with the EK80 from Saturday evening into Sunday morning.

23 April, 2017: After the previous night's EK80 survey, the ship transited from the SEEP area east and across the Gulf Stream to P4 (with the sADCP, and no interruptions for CTDs, "**GS3 section**", **Table 1**). We deployed a DCPS-PIES at site P4 and conducted a CTD cast (the deepest cast, 3440 m). During this cast, we also collected 24 water samples for salinity measurements (carried out by Dave Wellwood, on shore) as a CTD calibration check. At this site we deployed an Argo float (SN 7425). We did one "extra" deep CTD cast southwest of P4 (GS_06) and then started a Gulf Stream sADCP/CTD crossing (offshore to onshore) along Mike Muglia's Ocean Energy repeat section ("**GS2 section**", **Table 1**). During this crossing we also deployed the fourth Argo float (just prior to GS-05; SN 7424).

24 April, 2017: We had intended to do one of the CTDs from this Gulf Stream section directly on the Ocean Energy site, A5, but didn't because of the Chief Scientist's mix up with coordinates – however the sADCP was logging as we crossed over/near A5 and this will allow for comparison of sADCP data with the upward-looking moored data once A5 is recovered. This section ("**GS2**", ", **Table 1**) was completed around 09:30 (local) with the CTD at ~ 80 m depth (DS_01). Then we resumed the Bathymetric Survey ("**BS2**", **Table 1)**. We were not able to completely survey the region of interest, but will likely be able to finish this on the turn-around cruise or the recovery cruise. We interrupted the survey because (1) the building waves started to significantly deteriorate the EM710 data quality and (2) we had to leave the region which is directly off Hatteras where the storm was predicted to be worst. We all spent a spicy afternoon/evening/morning getting rattled around–except Valarie who has a stomach of steel and can (apparently) sleep through anything. Many many thanks to the Bridge Team and the Engineers for their foresight and planning leading up to this storm and for getting us through the storm! We stopped sampling from mid-afternoon on. The total weather interruption was about 18 hours (but part of the time was used to transit from the Bathymetry Survey site off Hatteras to the start of our planned Shelfbreak Survey at the southwestern end of the array near A8, so it only impacted science operations by ~14 hours). During the transit, the sADCP data were of poor quality; also the TSG was secured during the storm. According to the Bridge, overnight we encountered 40 knot winds and seas reaching 25 ft.

25 April, 2017: By 09:00 the seas were calm enough for us to resume science operations. We started the Shelfbreak Section ("**SB section**", **Table 1**), a sADCP/CTD survey conducted from south to north along the 200 m isobath with no interruptions, beyond the CTDs. The SB_06 cast was in a canyon, so we ran the CTD only to ~300 m, which was about ¾ of the total water depth there. During SB_01, there was a data spike recorded by the sensors, near the bottom on the downcast. Amy Simoneau changed the conductor and this problem did not reappear in any of the subsequent casts. Also the TSG system (which had been secured during the storm) came back online with reliable data between SB_01 and SB_02. Notably the SST recorded by the TSG dropped about 11˚C between SB_07b and SB_08 as we crossed the front. Also, the beginning of SB_07b has noisy data because the pumps were not yet turned on. Due to some

logging/processing issues Jules Hummond asked us to restart the sADCP system; this was done while we were on station at SB_02. It may have been restarted again (as a new cruise, AR15b) at 21:45 local (01:00 UTC 26 April, 2017). During the evening we conducted a sADCP survey box survey around B1 ("**B1 box**", **Table 1)**.

26 April, 2017: We arrived at B1 and at 07:00 (local). Harvey and Sara worked to reestablish communications with the mid-depth CTD which had failed shortly after the B1 deployment. This was successful and the mid-depth instrument started logging. (The near surface CTD at B1 had been actively measuring and logging since the initial deployment on 19 April). We moved east and conducted a second zonal (east to west) MAB survey at this latitude ("**MAB2a section**") and a meridional MAB survey along the 30 m isobath at 75˚ 10'N ("**MAB2b section**", **Table 1**). Then we conducted a final cross shelf survey from the 30 m isobath, across the shelf break and to the 930 m isobath ("**MAB3 section**", **Table 1**). Thereafter we started the transit home.

27 April, 2017: We continued the transit through the Slope Sea ("**SS section**", **Table 1**) towards Woods Hole with the sADCP logging as we crossed through the eddy field between the Gulf Stream and the shelf break. In the evening we arrived near the Pioneer Array and started a survey around the region. The first leg of the box was a south to north transit with the EK80 (but with the sADPSs secured). The other three sides of the box were conducted with the sADCP logging and no EK80.

28 April, 2017: We started the last CDT/sADCP section around 08:00 (local). This survey, south to north from the 1800 m isobath to 56 m isobath, ("**LG Section**", **Table 1)** was on the same track as the previous night's EK80 section and served to close the sADCP box survey. After LG_07 we secured all the systems (sADCP, Knudsen, etc.) and sat on station (~100 m) for five minutes to conduct an "everything-off-EK80 test" for Tim Duda. Our PEACH deployment cruise sampling was completed with LG_09 around 23:00 (local).

29 April, 2017: The *R/V Armstrong* arrived at the Woods Hole docks at 06:00 (local) as scheduled.

Table 1: AR-15 feature surveys.

Name	Description	Waypoint or station names and GSP index range*	CTD hex files (station numbers) AR1500##.hex	Info
MAB-SB	MAB shelf break: XBTs and sADCPs along 200 m isobath	X01-X12 (8296:21667)	N/A	See Table 8
MAB1	East-west CTD/sADCP section across MAB at B1 latitude (before storm)	MAB01-MAB03, B1, MAB04-MAB06 (41822:43836)	25-31	
MAB2a	East-west CTD/sADCP section across MAB at B1 latitude (after storm)	MAB2_01-MAB2_05 (99527:100843)	70-74	
MAB2b	South to north CTD/sADCP section across MAB along ~30 m isobath (at 75˚ 10'N)	MAB2_03 & MAB2_06-MAB2_09 (100300; 101489:102819)	72, 75-78	
MAB3	West to east CTD/sADCP section across MAB from 30 m isobath the shelfbreak.	MAB3_01-MAB3_04 (102819:104399)	79-82	
SAB1	East to west section across MAB at latitude of B2 with CTDs and sADCPs	SAB01-SAB08 (49712:52433)	32-39	(SAB04 is the station at the B1 site)
SB	Shelf Break section: south to north CTD/sADCP section along the 200m isobath	SB01-SB09 (91308:96704)	58-69	Extra casts for higher resolution: 2b, 7b,8b
LG	Last Gasp section: south to north CTD/sADCP section across the MAB shelf along the western edge of the Pioneer Array.	LG00—LG09 (116897:121962)	83-92	
GS0	Zonal east-west sADCP crossing to get from offshore to site A8, upstream of separation point	N/A (55576:56795)	N/A	

* from AR15_cruise_track.mat

Continued on next page.

Name	Description	Waypoint or station names and GSP index range*	CTD hex files (station numbers) AR1500##.hex	Info
GS1	CTD/sADCP section normal to the Gulf Stream, upstream (south) of the separation point (onshore to offshore).	SAB08-SAB13 (52433:55576)	39-43	(skipped some of the original waypoints given to ship in the csv file)
GS2	Offshore to onshore CTD, sADCP section along ocean energy repeat ADCP line.	GS05-GS00 & DS01 (77648:82653)	51-57	Crossed over A5 (OE mooring); no CTD station here.
GS3	Zonal west to east sADCP crossing from SEEP site to P4	N/A (70820:72507)	N/A	
GS4	Section normal to the detached Gulf Stream w/ only sADCP from P4 (offshore) to A1 (onshore)	N/A (27575:30342)	N/A	
GS5	Section normal to the detached Gulf Stream with sADCP and CTDs.	P1-P4 (21668:27575)	2-4	No CTD at P4 (because DCPS-PIES deployment was later)
SS	Slope Sea section: sADCP across the eddy field here.	N/A (104399:113225)	N/A	
B1 box	sADCP survey box around B1	N/A (95565:99526)	N/A	No CTDs
Pioneer box	South to north EK80 transect along western edge of Pioneer array	N/A (113390:116696)	N/A	With sADCP secured
	sADCP box around Pioneer array with CTDs included on the western edge (as part of the LG section).			See LG for the partial CTD coverage of this box
SEEP	EK80 survey at the SEEP site	N/A (69092:70820)		
BS1	Bathymetric Survey part 1 w/ EM710, 3.5 kHz sounder, 300 & 38 kHz sADCPs	N/A (60276:64671)		BS01B.edf BS11.edf. See Table 10
BS2	Bathymetric Survey part 2 w/ EM710, 3.5 kHz sounder, 300 & 38 kHz sADCPs	N/A (82986:84263)		See Table 11
Yo-yo	Repeated, CTD casts at P1 to ~650 m depth	P1 (37780)	9-24	CPIES data downloaded via burst telemetry

4. Deployments of Moored Instruments

The primary goal of the AR-15 cruise was the deployment of the PEACH moored array. In total, sixteen elements were deployed at 14 sites (**Figure 4** and **Table 2**). These sites will be instrumented for at least 18 months, with a turn-around planned for some of the sites in January 2018 (to replace batteries) and the recovery requested for October 2018 but presently in the ship schedule for December 2018. In early May 2017, two additional PEACH sites will be instrumented from a small boat (A4 and A7). Also, there is an ongoing installation at site A5 through the Ocean Energy Project.

We used the ship's through hull transducer for acoustic communications with the moorings. This worked well with two different WHOI units (a UDB 9000 and an 8011M that was updated with PIES codes) and with a URI-owned DS7000. We plugged into the ship's J-box; however this did require disconnecting the Knudsen 12 kHz.

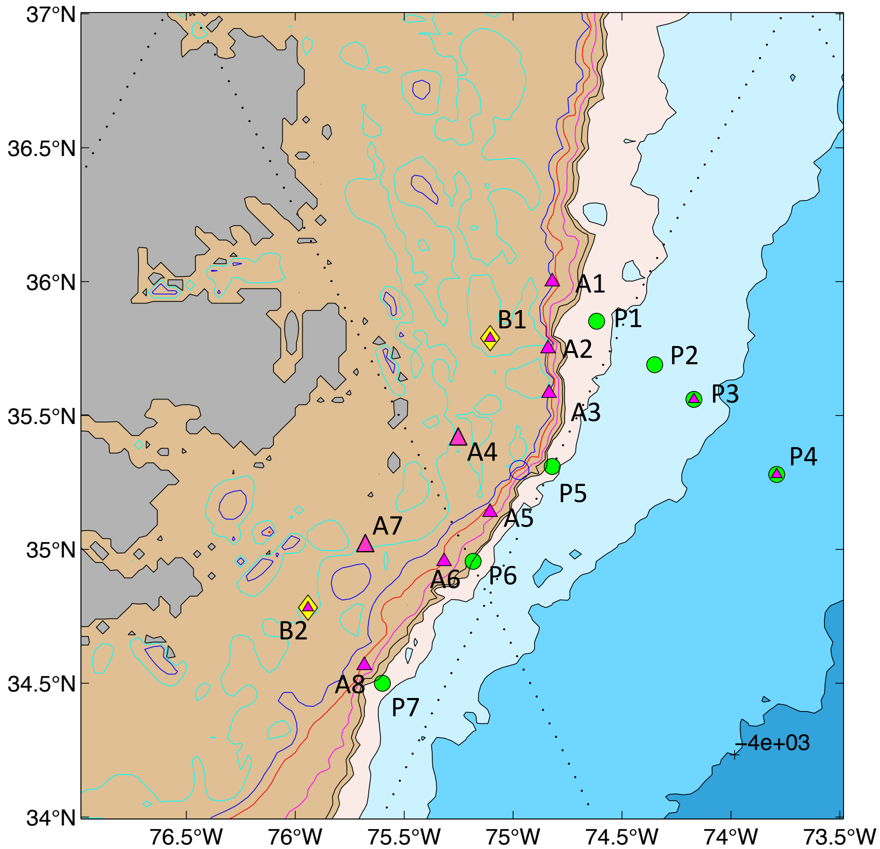


Figure 4. PEACH moored array with platform IDs. Instruments at sites A4, A5 (ocean energy site) and A7 were not deployed on AR-15. Approximate isobaths (from etopo 5) are highlighted: cyan = 30 m; blue = 100 m; red = 200 m; magenta = 500 m; blacks = 800 m and 1000 m to 4000 m at 1000-m increment. Dashed lines are J3 altimetry tracks. Open blue circle is the SEEP site.

Table 2. Instrument sites – (PEACH_sites_actual.xlsx and .mat)

Actual locations - from mooring logs (fixes from anchor launch and from handheld GPS at the stern unless noted)

Platform ID	Sensors	Lat (N)	Lon (W)							Depth (m)		Launch date (UTC)	Time (UTC)	Notes
B1	MET mooring	35.7782	75.0947	35	46.692	N	75	5.679	W	36	Knudsen	19-Apr-17	15:24	Fix from midship. Returned (26-Apr-2017) after intial installation to reset the surface microcat.
	600 kHz ADCP tripod	35.7796	75.0929	35	46.776	N	75	5.574	W			19-Apr-17	17:10	Fix from midship. Went down with camera setup.
B2	MET mooring	34.7823	75.9412	34	46.939	N	75	56.469	W	30	Knudsen	20-Apr-17	14:36	
	600 kHz ADCP tripod	34.7805	75.9418	34	46.832	N	75	56.509	W			20-Apr-17	16:26	
A1	300 kHz ADCP	36.0006	74.8338	36	0.038	N	74	50.027	W	99	EK80	18-Apr-17	13:21	Went down with camera setup.
A2	300 kHz ADCP	35.7514	74.8633	35	45.082	N	74	51.799	W	95.43	EK80	18-Apr-17	16:27	
A3	300 kHz ADCP	35.5950	74.8088	35	35.700	N	74	48.528	W	97.5	EK80	18-Apr-17	18:40	Unable to communicate with one release (SN 52823)
A4	600 kHz ADCP*	35.4200	75.2500	35	25.200	N	75	15.000	W	28				to be deployed from small boat; locations = estimates
A5	150 kHz ADCP*	35.1389	75.1060	35	8.334	N	75	6.360	W	218				Ocean Energy site - location = estimate
A6	150 kHz ADCP	34.9422	75.3077	34	56.531	N	75	18.463	W	236	Knudsen	22-Apr-17	13:07	Lost boat hook.
A7	600 kHz ADCP*	35.0100	75.6830	35	0.600	N	75	40.980	W	30				to be deployed from small boat; locations = estimates
A8	150 kHz ADCP	34.5656	75.6759	34	33.935	N	75	40.556	W	230	Knudsen	21-Apr-17	15:38	Unable to communicate with one release (SN 45216)
P1	CPIES** 3820R	35.8514	74.6170	35	51.086	N	74	37.022	W	1788	Knudsen?	17-Apr-17	13:50	Dropped at target site (ignored drift)
P2	CPIES** 4930R	35.6890	74.3506	35	41.337	N	74	21.036	W	2348	Knudsen?	17-Apr-17	18:08	Dropped ~100 m upstream of target site; 1 m/s currents to 600 m. Argo float deployed here.
P3	DCPS-PIES** 5400	35.5579	74.1726	35	33.473	N	74	10.354	W	2768	Knudsen?	17-Apr-17	22:56	Deployed ~400 m south (upstream) of target site; currents reaching to ~800 m.
P4	DCPS-PIES** 5400	35.2801	73.7896	35	16.804	N	73	47.373	W	3457	Knudsen	23-Apr-17	12:21	Dropped right on target with no drift expected due to low currents. Burst pressure suggests 3529 dbar. Current and direction burst are .1 360 - not working.
P5	CPIES** 4930R	35.3063	74.8212	35	18.377	N	74	49.274	W	1760	Knudsen	22-Apr-17	19:56	Picked new site for P5 based on Knusden. Deployed 300 m upstream of new target depth to accommodate drift. Burst pressure suggests 1785 dbar; tau suggests 1800 m (using 1500 m/s).
P6	CPIES** 4930R	34.9372	75.1691	34	56.234	N	75	10.145	W	1103	Knudsen	22-Apr-17	15:19	Burst pressure suggests 1298 dbar; tau suggests 1275 m (using 1500 m/s). Location changed from original plan because of depth errors in bathymetery and suggestion of seeps at the bottom.
P7	CPIES** 4930R	34.4986	75.6013	34	29.917	N	75	36.078	W	1325	Knudsen	21-Apr-17	18:58	Deployed about 250 m upstream of target site. Put current sensor/float and then PIES into water too early and dragged it through the water before deployment.

*estimates/these instruments were not deployed on AR-15.

** locations at release; see PIES table for locations including estimated drift during descent.

4.1 Met buoy stations

As part of the PEACH array (**Figure 4)**, two meteorological buoys with in-water CTDs were deployed on the shelf (**Figure 5**). Collocated with each met buoy is a bottom frame also with one CTD and an upward-looking ADCP. **Table 3** summarizes the deployment details for both the met buoy and bottom frame at site B1 and B2.

Table 3. Summary of deployment details for sites B1 and B2.

B1	R/V Neil Armstrong 2017-04-19 12:00 (08:00 local) commenced ops Anchor drop at 15:24:42 UTC GPS posn 35 46.692 N, 075 05.679 W In 36 meters depth CTD IMPs s/n 4085 and 4086 Tripod release at 17:03:16 Tripod Location 35 46.776 N, 075 05.574 W No trawl anchor, ADCP s/n 5505 CTD s/n 1987 ORE s/n 31224 Benthos Pinger s/n 1745
B2	R/V Neil Armstrong 2017-04-20 12:00 (08:00 local) commenced ops Anchor drop at 14:36:00 UTC GPS posn 34 46.939 N, 075 56.469 W In ~30 meters depth CTD IMPs s/n 3585 and 3586 Tripod release at 16:25 UTC Tripod Location 34 46.832 N, 075 56.509 W No trawl anchor, ADCP s/n 2361 CTD s/n 3583 ORE s/n 29208 Benthos Pinger s/n 1746 (?? -- verify with Harvey)

At site **B1**, met buoy B1/41062 was deployed in 36-m depth, north of Cape Hatteras, 20 miles east of Oregon Inlet. Deck operations commenced at 12:00 UTC with anchor drop at 15:24 (UTC) on 19 Apr 2017. One SBE IMP37 (CTD1 s/n 4085) was attached to the wire rope approximately 3 m down from the surface. The second SBE IMP37 (CTD2 s/n 4086) was attached approximately 15 m below the surface. We deployed the bottom frame just before lunch to allow for the seas to continue to settle down before starting the small boat operation. We required small boat ops to leave the vessel and climb onto the buoys to deploy and align delicate sensors tucked away for shipping and crane operation. Upon returning to *R/V Armstrong*, we communicated with the buoy via LoggerNet using RF-serial modems

(19200,8,N,1). B1 uses RF Channel 1 (912.200 MHz) and verified that all the meteorological sensors were reading and collecting data (WIND1, WIND2, PSP, PIR, ATEMP, RH, RAIN, HDG, PITCH, ROLL, and various internal system sensors). We thought we had confirmed both CTD1 and CTD2 were operating, but missed that CTD2 was not actually recording internally. We returned on 26 Apr 2017 and were able to reestablish communication to the CTD via the LoggerNET and RF-modem and talk-thru capability on the CR1000 datalogger on the buoy to start the internal auto-sampling.

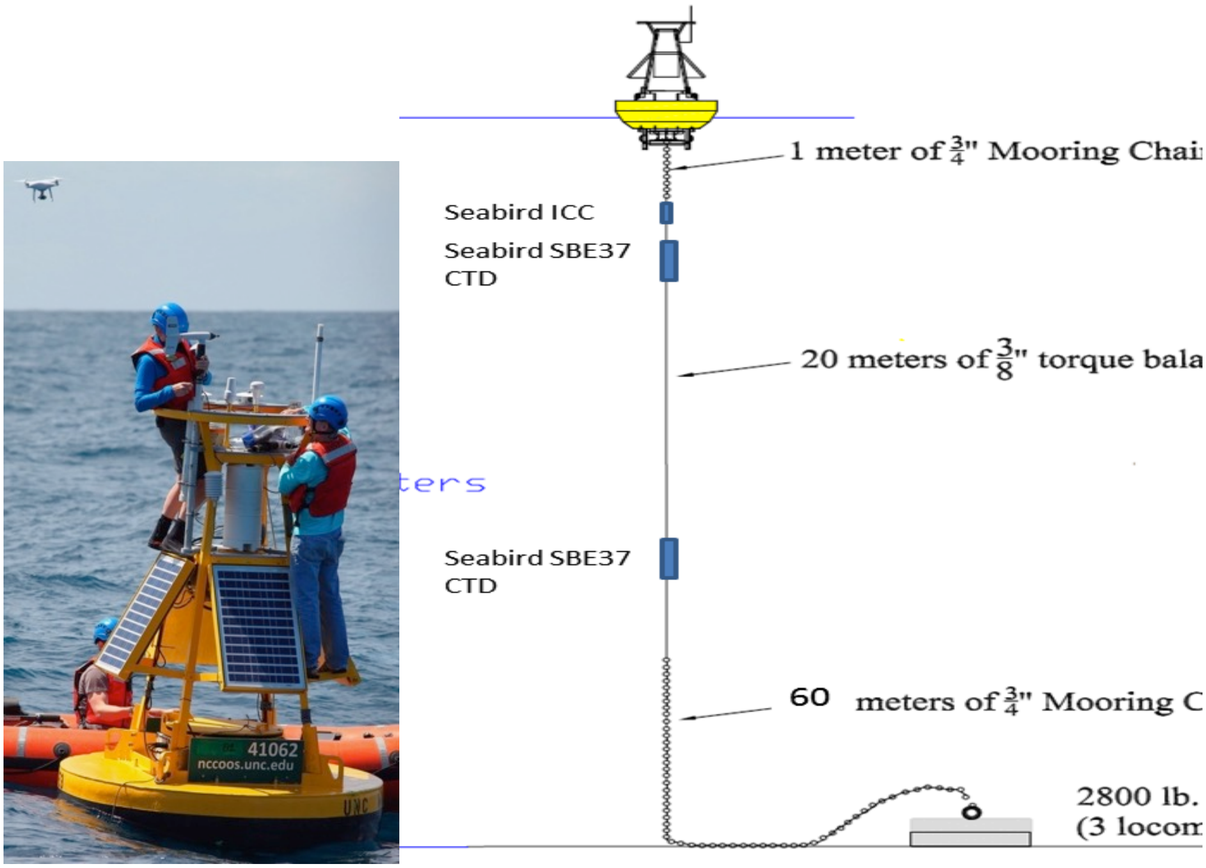


Figure 5. Left: setting the sensors on the Met Buoy with the *R/V Armstrong* Rescue boat and the CSI drone in the background. Photo credit: R. Todd. (WHOI). Right: mooring design for the met buoys (not to scale).

At site **B2**, met buoy B2/41063 was deployed in 30 m of water, south of Cape Hatteras, 20 miles south of Ocracoke Island. Deck operations commenced at 12:30 UTC with anchor drop at 14:36 (UTC) on 20 Apr 2017. The first SBE IMP37 CTD (s/n 3585) was attached to the wire rope approximately 3 m down from the surface. The second SBE IMP37 CTD (s/n 3586) was attached approximately 15 m below the surface. This time we commenced small boat ops immediately after anchor release to take advantage of the good wave conditions. Upon returning to *R/V Armstrong*, we communicated with the buoy via LoggerNet using RF-serial modems (19200,8,N,1). B2 uses RF Channel 2 (913.4288 MHz). We verified that all the meteorological sensors were reading and collecting data. However, we noticed that one of the CTDs was not sampling. We were able to talk-thru to the CTD and initiate sampling. Upon exiting out of the talk-thru, Sara H.'s laptop froze and had to be rebooted. We tried reconnecting to the buoy via RF-modem but could not make a link. After an hour or so, she connected to the Iridium server in Chapel Hill and verified that all data were getting collected and reported via Iridium. Either the RF-modem inside the buoy canister needs to be manually rebooted (only can do so by resetting power manually on the buoy) or a fuse is blown to the buoy RF-modem or the RF-modem on B2 is malfunctioning. This is an annoying issue, but it is not vital to the buoy operation. Since B2 is functioning properly and communicating thru Iridium we will plan to address the RF-Modem issue on a maintenance or turnaround visit.

Hourly, near, real-time data from the buoys is disseminated in several forms (asci raw data, processed netcdf, push to NDBC and graphs). These can be accessed at the NCCOOS web pages (http://nccoos.org) platforms B1 and B2, and via NDBC (http://www.ndbc.noaa.gov) station 41062 and 41063, respectively. Early data returns from B1 and B2 are shown in **Figure 6**.

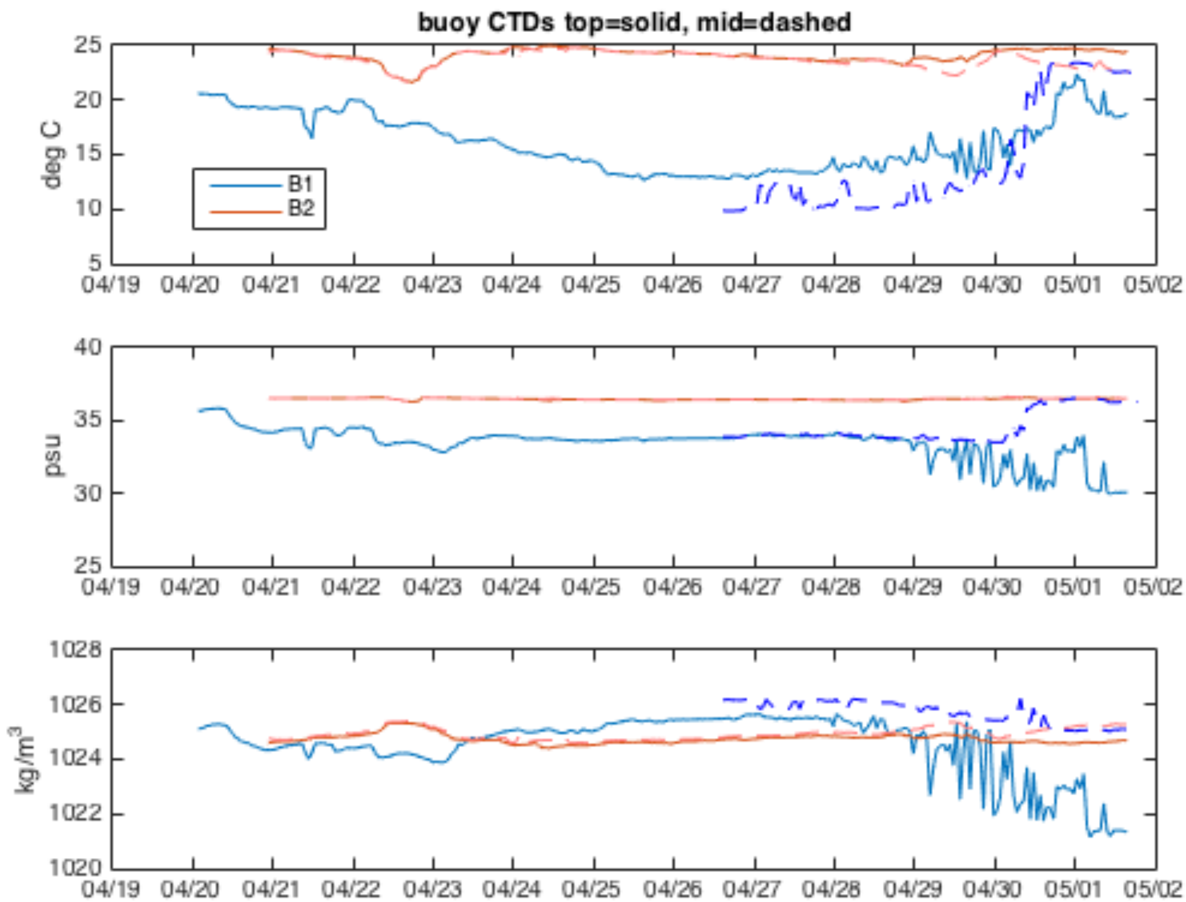


Figure 6. Real time temperature, salinity and density data from the B1 (north, blue) and B2 (south, red) buoys from the surface (solid) and mid-depth (dashed) instruments as of 1 May 2017. Fresh water has flooded the surface at B1, and mid-depth at B1 is Gulf Stream water, essentially identical to that at mid-depth at B2. The sign of the density change across the Hatteras Front, (based on the 30 m inflows from the N and S), has now changed twice since the buoys were deployed. Also, some thermal stratification has developed at B2 in the last couple of days of the timeseries shown.

4.2 PEACH PIESs

As part of the PEACH array (**Figure 4)**, 7 Pressure-sensor Equipped Inverted Echo Sounders (PIESs) were deployed along and across the Gulf Stream (**Tables 4-6**). Five PIESs were instrumented with an Aanderra current sensor tethered 50 m above the bottom (CPIESs, **Figure 7**). These 5 CPIESs are on loan to PEACH from the University of Rhode Island. In addition to the 5 CPIES, two PIESs were each instrumented with a 600 kHz Aanderraa 5400 DCPS, Doppler current profile sensor (**Table 5**); this platform is called a DCPS-PIESs (**Figure 8**). The PEACH array is the first deployment of DCPS-PIESs. One DCPS-PIES (SN 355) belongs to the University of Rhode Island; the other is WHOI-owned (SN 361). Details of the CPIESs and DCPS-PIESs deployments are given below.

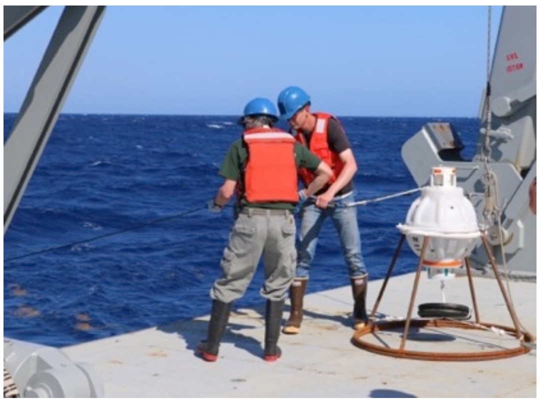


Figure 7. CPIES being deployed off the *R/V Armstrong's* stern. Float, polypropylene line, glass ball, current sensor and 50-m cable are being hand fed and the PIES will be lifted off with the A-frame. The quick release is a West Coast release on loan from the WHOI Rigging Shop. Photo credit: M. Andres (WHOI).

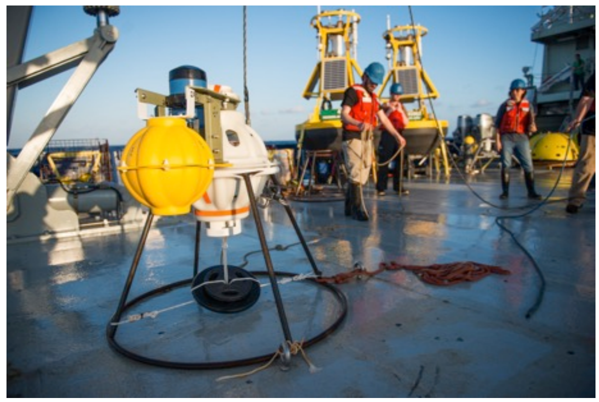


Figure 8. PIES and its DCPS side car with the float (glass ball in the yellow housing), the 5400 DCPS head and a fiberglass bracket to integrate the system into the existing PIES housing. Photo credit: J. McCord (CSI).

At site **P1**, a CPIES was deployed (SN 102) at 1788-m depth. We used URI's DS-7000 and the ship's through hull transducer to communicate with and track the instrument during its fall to the seabed. We had a little trouble with communications as the instrument was falling through the water; it was sampling on schedule, but it did not hear our BEACON command. We put the WHOI-owned 8011M transducer (SN 33510) over the side and resent BEACON, which the instrument (and the DS-7000 connected to the through hull transducer with TRAX running) heard and responded to. During the full-water column calibration CTD (cast ar15002.hex), once the CPIES was on the seabed, we tested the CLEAR and XPND commands with the DS-7000 (through hull) and the 8011M (over the side). Both systems were able to communicate with the CPIES successfully. This anchor stand (and all the CPIES anchor stands) was fabricated with a double ring to help prevent tipping in the strong bottom currents that are expected in the region. We did not note the fall rate and we also did not take the drift due to the currents into account when releasing this CPIES. We returned to this site 2 days later (1) to test burst telemetry and (2) to do a yo-yo CTD cast. The burst telemetry was successful with the UDB9000. Settings should be output power = -12dB and Rx threshold = 30. Burst telemetry file is Cburst_from_P1_yo_yo.dat.

At site **P2**, a CPIES was deployed (SN 107) at 2348-m depth. This time, the falling CPIES did hear the BEACON command via the DS-7000 and through hull transducer. We were in currents which were about 1 m/s averaged across the upper 600 m. We deployed the instrument ~100 m upstream of the planned P2 site. From the TRAX4 (Line scan recorder software) slope we calculated a fall rate of 80 m/min for this CPIES with double ring anchor stand; this is consistent with the fall rate calculated from launch time, time at the bottom and depth. We conducted a full water column calibration CTD cast (cast ar150003.hex). We also deployed an Argo float near this site (SN 7303).

At site **P3**, we deployed at 2768-m depth the first DCPS-PIES. This is URI's instrument (SN 355). The instrument was deployed ~400 m upstream (southwest) of the target site because of currents reaching to ~800 m depth. The full water column calibration CTD here is ar150004.hex. During the BEACON command (sent with the DS-7000 and through hull transducer so we could see the CPIES's descent), we did not see sample pings with TRAX4. The BEACON is typically blocked during sampling. After the BEACON mode self-cancelled after twenty minutes, we did see sample pings with TRAX4. After acoustics testing with the other DCPS-PIES in the lab (see P4_361_test.log), we determined that this problem during BEACON likely occurred because the PIES's transducer was not seeing low enough power to initiate the sampling (it was in high power mode for ACS communications, due to BEACON mode, but the target depth was relatively shallow so sampling would need to be with relatively low power); this is likely not an issue specific to DCPS-PIES. Our test in the lab confirmed that under these conditions, PIESs will indeed skip tau sampling and will go right to pressure and then current sampling. Once the P3 instrument was on the bottom, we also tried burst telemetry at this site using the through hull transducer, URI's Toughbook and the DS7000. The values returned by telemetry did not seem realistic (i.e., ~6.7 for tau indicating 5000 m water depth; we did save this file, P03_burst.dat) and in retrospect it turns out that the problem was likely a compatibility issue with the version of Matlab on the URI Toughbook (version 6.5): the 11.5 kHz part of the signal was being picked up by the DS7000 deckbox, but not by Matlab. In a subsequent lab test on the ship, we used the DS7000 and the WHOI Toughbook (with Matlab version 14a) and SN361 – in this case the 11.5 kHz signal was detected by Matlab. One other note: when using either Toughbook with the matlab burst telemetry code, it's necessary to turn off Bluetooth and wireless (apparently these compete with the RS232 connection). We also deployed an Argo float near P3 (SN 7424).

At site **P7** we deployed SN 166. Due to the currents we asked the Bridge to tell us when we were ~250 m upstream of the target site. We ended up putting the current meter and the PIES into the water too soon (while still steaming to the release location) so there was quite a bit of strain on the cable. The full water column calibration CTD here is ar150045.hex.

At **P6** we deployed SN 114. The slope here was quite steep and the originally planned site had the wrong depth. We steamed with the Knudsen and marked 1100 m. We deployed ~400 m upstream (southwest) of this target site to allow for drift by the currents. The full water column calibration CTD here is ar150047.hex and the burst telemetry file is P6_114_burst.dat.

At **P5** we deployed SN 112. Again, because of the steep slope we readjusted the target site to a location where the Knudsen depth was 1760 m. We deployed ~300 m upstream (~southwest) of this site to allow for drift. The full water column calibration CTD here is ar150048.hex and the burst telemetry file is p5_112_burst.dat.

At site **P4** we launched SN 361 (WHOI's DCPS-PIES). Since this site was on the Sargasso Sea side of the Gulf Stream and the flow was very weak, we didn't need to accommodate for instrument drift during its descent. During burst telemetry here, we noted that the tau and pressure records are good, but current speed and direction seem to be default values (0.1 and 360, P4_361_burst.dat). Due to the newness of the DCPS integration into the PIES system, the current speed and direction had not been implemented in burst telemetry yet. This feature will be implemented in future revisions of the firmware (We are unable to compare this site with the DCPS at P3 because telemetry at P3 didn't work properly due to the matlab version issue.) The calibration CTD at this site (ar150049.hex) included the salinity sampling (24 bottles). Argo float SN 7425 was deployed nearby.

Table 4. PIES deployment information (PEACH_IES_deployments.xlsx and IES_target_locs.mat

PEACH PIES Target locations

IES S/N	Site	Lat deg (N)			Lon deg (W)			Estimated Drift (m)***	Timed release (UTC)****	calibration CTD
102	**P1**	35	51.102	N	74	37.002	W	none considered	Wed. 2019 May 1, 13:00:00	ar15002.hex
107	**P2**	35	41.364	N	74	21.000	W	100	Thur. 2019 May 2, 13:00:00	ar15003.hex
355	P3	35	33.6	N	74	10.2	W	400	Fri. 17 May 2019 13:00:00	ar15004.hex
361	P4	35	16.8	N	73	47.4	W	0	Sat. 18 May 2019 13:00:00	ar15049.hex
112	**P5****	35	18.482	N	74	49.214	W	300	Fri. 2019 May 3, 13:00:00	ar15050.hex
114	**P6****	34	56.397	N	75	9.982	W	400	Sat. 2019 May 4, 13:00:00	ar15047.hex
166	**P7**	34	30.000	N	75	36.000	W	250	Sat 2019 May 4, 13:00:00	ar15045.hex

* for location where PIES was deployed with the quick-released, see Table 2 Instrument sites; target location takes into account instrument drift during descent based on sADCP.
**changed from originally planned location due to bathymetry.
*** estimated from the fall rate and the sADCP profiles.
****from misssion_setup files.

Table 5. CPIES/DCPS-PIES vitals

Revised: 06 June 2017

				PAROS Pressure Sensor				ITC		Current Meter			Battery			ACS Codes	
IES S/N	Site	IES Model	Bliley S/N	Paros Model	Paros S/N	Tzero (degC)	Pzero (psia)	S/N	Model	S/N	Model Name	Model Number	Capacity (SYS/REL)	MFGR, Date Code	Model	TELEM, XPND, BEACON	Release
102		6.1E2	0160244	46k	75174	+0.5458	-0.3047	0173	3431B	334	DCS	3820R	240Ah/60Ah	ZBBD-MAR-14	5937	67,71,75	38
107		6.1E2	0380245	46k	109319	+0.4196	+0.6528	0103	3431C	11	Zpulse	4930R	240Ah/60Ah	ZBBD-MAR-14	5937	66,70,74	43
112		6.1E2	0520245	46k	109325	+0.2096	+6.8667	0086	3431C	12	Zpulse	4930R	240Ah/60Ah	ZLIC-OCT-13	5937	65,69,73	48
114		6.1E2	0350245	46k	109321	+0.2184	+0.2239	0098	3431B	13	Zpulse	4930R	240Ah/60Ah	ZBBD-MAR-14 / ZDBD-MAR-14	5937	67,71,75	50
166		6.1E2	0340245	46k	75163	+0.9979	-1.529	0002	3431C	15	Zpulse	4930R	240Ah/60Ah	ZBBD-MAR-14	5937	65,69,73	38
355		6.2C2	0091522	410k	91524	-0.520	+0.2282	051	3431B	153	DCPS	5400	240Ah/60Ah	ZSIE-SEP-15	5937	65,69,73	35
361		6.2C2	0151522	410k	135391	-0.8354	+3.1012	0058	3431D	154	DCPS	5400	240Ah/60Ah	ZUUE-OCT-15	5937	65,69,73	41
365		6.2C2	0201522	410k	135394	-0.2966	+2.4212	0059	3431D	-	-	-	240Ah/60Ah	ZBLE-JAN-16	5937	66,70,74	45

Table 6. DCPS configuration settings. (DCPS-Config2Column-Hatteras.xlsx)

Configuration: Two Columns;
- Column 1: 20 Cells
- Distance to First Cell: 1.0 meters
- Distance between Cells: 1.0 meters

{Defines Column 1: Length of 21.0 meters}

- Column 2: 25 Cells
- Distance to First Cell: 16.0 meters
- Distance between Cells: 4.0 meters

{Defines Column 2: Length of 116.0 meters}

DCPS Record Header Variables:	Units:	15 Variables/Header; 1Header/Cast
Model No.		
Serial No.		
Heading	Deg.M	
Pitch	Deg.	
Roll	Deg.	
Charge Voltage (VTX1)	V	
Charge Voltage (VTX2)	V	
Min. Input Voltage	V	
Input Current	mA	
Noise Peak Level (Beam1)	dB	
Noise Peak Level (Beam2)	dB	
Noise Peak Level (Beam3)	dB	
Noise Peak Level (Beam4)	dB	
Record Status		
Ping Count		

DCPS Cell Variables:	Units:	18 Variables/Cell; 45 Cells/Cast
Cell Index		
Cell Status		
Horizontal Speed	cm/s	
Direction	Deg.M	
North Speed	cm/s	
East Speed	cm/s	
Vertical Speed	cm/s	
Speed StdDev Horizontal	cm/s	
Speed StdDev AutoBeam	cm/s	
Strength	dB	
North AutoBeam	cm/s	
East AutoBeam	cm/s	
Vertical AutoBeam	cm/s	
Cross Difference	cm/s	
Correlation Factor (Beam1)	cm/s	
Correlation Factor (Beam2)	cm/s	
Correlation Factor (Beam3)	cm/s	
Correlation Factor (Beam4)	cm/s	

4.3 Bottom-mounted ADCPs

Each mooring is instrumented with dual releases. Although communications on deck worked well, we were unable to communicate with 2 of the 10 releases.

4.3.1 CSI

Two 150 kHz ADCP pods A8 and A6 were deployed on April 21st and April 22nd respectively (**Table 2**). All Edgetech releases were pre-tested on deck for successful communication prior to deployment, but the A8 Edgetech release SN 45216 did not reply when interrogated after deployment. Each pod contains a 150 kHz RDI ADCP, Seabird CTD, and pod A6 contains a Multielectronique Hydrophone to compliment ongoing marine mammal research being conducted by the UNC CSI Ocean Energy Program.

The A5 pod with 150 kHz ADCP, CTD, and hydrophone was deployed prior to the cruise on December 4, 2016. A5 has gathered nearly continuous current, salinity, and temperature measurements since August, 2013 (**Figure 9** and **Figure 10**). It was recently recovered on 6/2/17, and will be re-deployed within two weeks. Measurements from the recent deployment were successfully retrieved, but have not yet been analyzed.

In addition, through a partnership with NOAA, a subsurface buoy containing a 300 kHz RDI ADCP was deployed on May 17, 2017 at: 35^0 06.873' N, 75^0 06.151' W. The ADCP will be deployed for one year, and will be approximately 100 m below the surface. All current measurements will be provided to the PEACH group upon recovery.

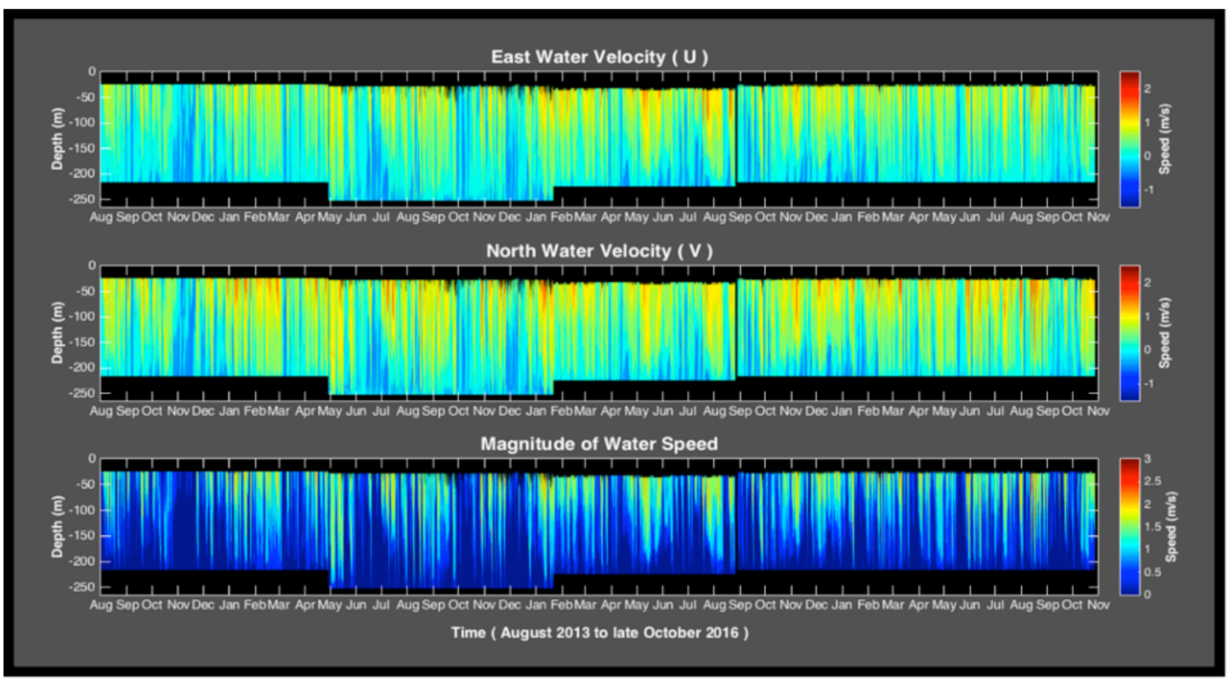


Figure 9. Current measurements from A5 made prior to the cruise.

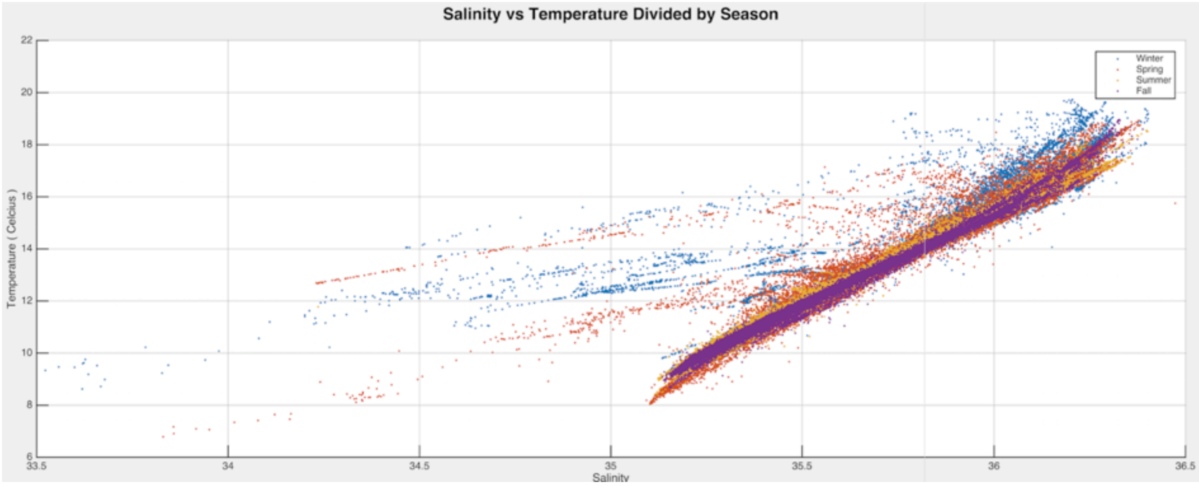


Figure 10. Salinity plotted against temperature for 3 years and 2 months of CTD measurements made at A5 prior to the cruise for winter (blue), spring (red), summer (orange) and fall (purple).

4.3.2 WHOI

Three 300 kHz bottom-moored ADCPs were deployed along the 100-m isobath along the souther MAB shelf break (sites A1-A3). The ADCPs were mounted in H-TRMB-65 protective domes from Mooring Systems and each unit was outfitted with dual releases (PORT LF Push Off Release Transponders, model number 0008118) from Edgetech.

5. CTD Casts and Water Samples

5.1 Temperature and salinity

During the cruise, 92 CTD casts were conducted (with the subset around Cape Hatteras shown in **Figure 11**). The CTD data were processed on board using batch_science.txt and batch_nobottles.txt (see /Volumes/Transcend/ar15/ctd/doc/processing_setup). Plots have been generated for each cast from these processed data and include a map highlighting the cast location, a T-S diagram and property profiles (see the appendix).

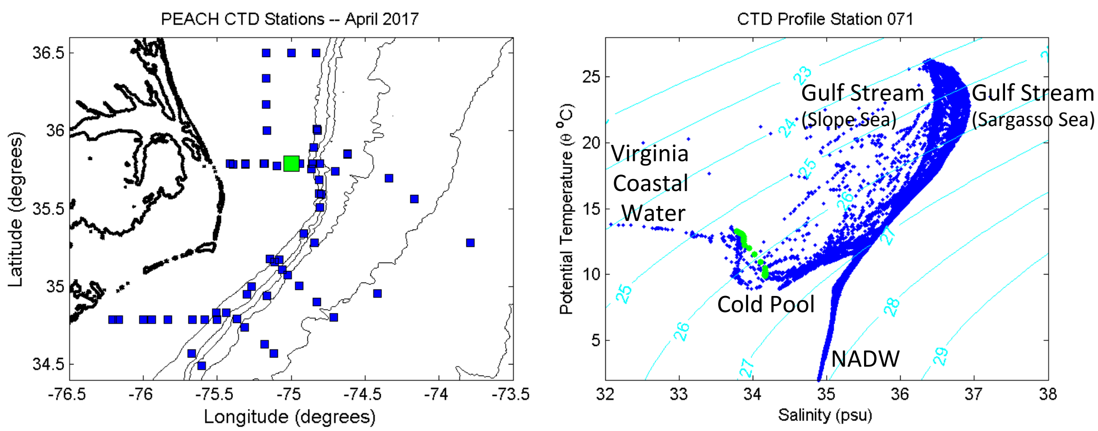


Figure 11. Example map (left) and T-S diagram (right) highlighting cast ar1500071.hex in green.

As a cross check on the CTD's salinity calibration, 24 water samples were collected on cast 49 (ar150049.hex), which served as the calibration cast at site P4. Salinities were bottled and brought back to WHOI for processing. Except at the surface-most level (2 dbar), the bottle samples' salinities as measured by the shore-side salinometer are slightly higher than those measured by the CTD sensors (**Figure 12**). The mean bias (averaging over all levels except the 2-dbar level) is -0.0238 (**Table 7**). However, we are presently not sure whether the bias reflects an error in the CTD calibration or the salinometer calibration.

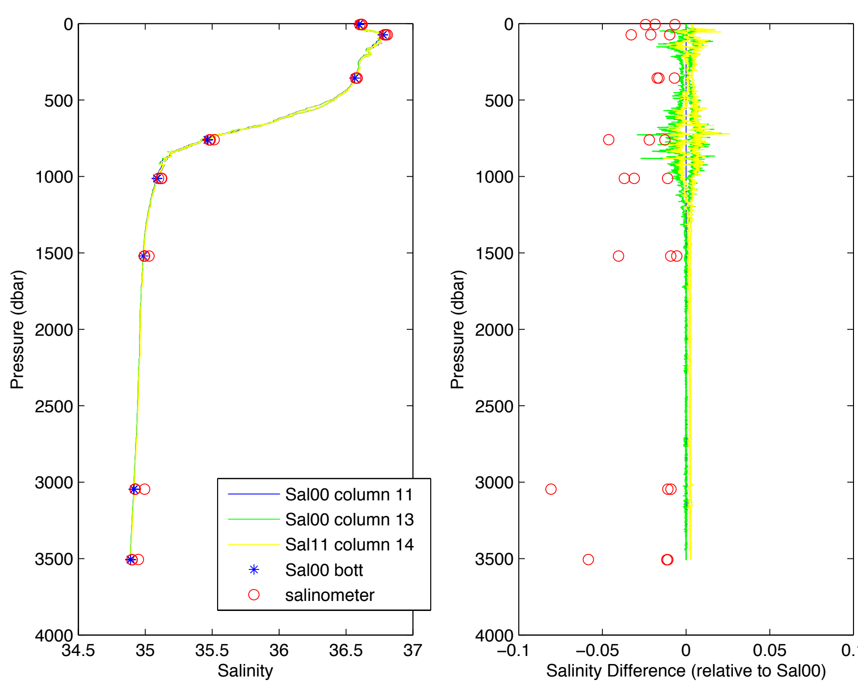


Figure 12. Left: salinity from the CTD sensors (continuous: blue, green and yellow curves and at the bottle depths: blue stars) and from the salinometer (red circles). Right: comparison of salinities with Sal00 (= Sal00 - x).

Table 7. Salinity Comparison (salinity_bottles.xls)

Bottle	Conductivity	Salinity		3-bottle mean salinity	3-bottle salinity std	CTD Pressure from .btl file (dbar)	CTD Std from .btl file (dbar)	3-level mean CTD pressure	3-level CTD pressure std	CTD sal from .btl file	CTD sal Std from .btl file	3-level mean CTD salinity	3-level CTD salinity std	salinity bias (CTD-bottle)	mean salinity bias (excluding 2 dbar bottles)
1	1.99498	34.9012	2			3506.5	0.107			34.8904	0.0002				
2	1.99740	34.9488	2			3505.5	0.378			34.8905	0.0002				
3	1.99501	34.9018	2	34.9173	0.0273	3506.8	0.575	3506.3	0.7	34.8904	0.0002	34.8904	0.0001	-0.0268	
4	1.99614	34.9240	2			3046.1	0.17			34.915	0.0003				
5	1.99623	34.9258	2			3044.9	0.392			34.915	0.0003				
6	1.99979	34.9959	2	34.9486	0.0410	3046.2	0.356	3045.7	0.7	34.9152	0.0003	34.9151	0.0001	-0.0335	
7	1.99976	34.9953	2			1519.8	0.473			34.9862	0.0002				
8	2.00138	35.0272	2			1520.4	0.477			34.9868	0.0003				
9	1.99960	34.9921	2	35.0049	0.0194	1519.9	0.917	1520.0	0.3	34.9866	0.0002	34.9865	0.0003	-0.0183	
10	2.00628	35.1236	2			1013.1	0.066			35.0868	0.0011				
11	2.00607	35.1195	2			1013.6	0.332			35.0885	0.0007				
12	2.00508	35.1000	2	35.1144	0.0126	1013.3	0.501	1013.3	0.3	35.089	0.0005	35.0881	0.0012	-0.0263	
13	2.02465	35.4857	2			761.1	0.337			35.4637	0.0024				
14	2.02432	35.4791	2			760.7	0.106			35.4665	0.001				
15	2.02614	35.5150	2	35.4933	0.0191	760.1	0.178	760.6	0.5	35.4688	0.0009	35.4663	0.0026	-0.0269	
16	2.08005	36.5811	2			355.8	0.134			36.5649	0.0002				
17	2.08010	36.5821	2			355.7	0.464			36.5649	0.0002				
18	2.07958	36.5718	2	36.5783	0.0057	356.8	0.278	356.1	0.6	36.5649	0.0003	36.5649	0.0000	-0.0134	
19	2.09097	36.7976	2			73.2	0.194			36.7765	0.0006				
20	2.09040	36.7863	2			73.3	0.062			36.7766	0.0007				
21	2.09149	36.8079	2	36.7973	0.0108	72.9	0.195	73.1	0.2	36.7751	0.0013	36.7761	0.0008	-0.0212	-0.0238
22	2.08206	36.6209	2			5.7	0.077			36.5967	0.0002				
23	2.08177	36.6152	2			5.3	0.284			36.5968	0.0002				
24	2.08117	36.6033	2	34.9173	0.0090	5.8	0.092	5.6	0.3	36.5967	0.0002	36.5967	0.0001	1.6795	

5.2 Biological sampling

The main goal of the biological sampling effort (**Figure 13**) was to collect information on protistan community structure along the targeted transects and as a function depth. Water samples were collected with Niskin bottles on the CTD Rosette frame from a total of about 30 stations (**Table 8**) and at multiple depths (total number of samples was 80) by preserving 1) whole seawater using Lugol's preservative for subsequent microscopy analyses and 2) concentrate protist biomass for DNA-based analyses of microeukaryote assemblages. Information on species abundance and composition shifts will be analyzed in relation to physiochemical parameters collected throughout CTD casts (e.g. temperature, salinity). Samples were collected on the upcast, generally at the bottom, chlorophyll maximum and near the surface.

Table 8. Bottles fired at the following stations (ar150**.hex):

1-7	39	75
26	43-49	76
28	58	83
30	59	84
31	62	87
35	64	88
37	67	

Figure 13. Shipboard biological sampling setup.

6. Shipboard Underway Data

During the AR-15 cruise, shipboard underway data streams were collected and saved either quasi-continuously (e.g., sADCP, Knudsen echsounder, TSG) or during focused surveys (e.g., EK80, multibeam). In some cases, our targeted cross-sections, boxes and surveys (i.e., collectively called 'feature surveys' here) were complemented with CTD casts and/or XBTs. Feature surveys conducted during AR-15 are summarized in **Table 1.** The relevant portion of the cruise track for each feature survey is highlighted in **Figure 14**. Several of these are described in more detail below (6.1 Cross-sections and boxes and 6.2 Surveys) and the TSG data are described in 6.3 and the yo-yo CTD station is described in 6.4.

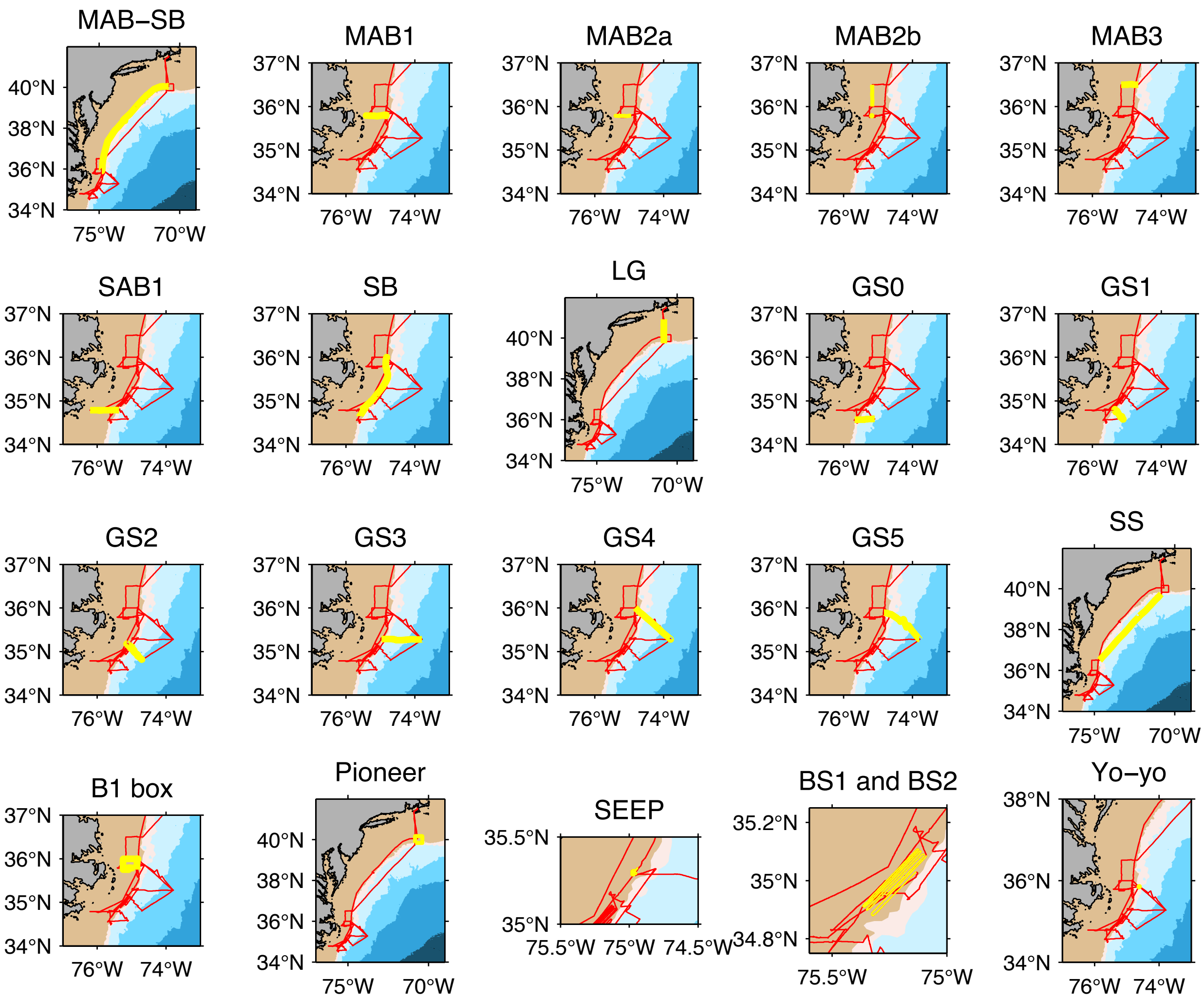


Figure 14. Maps showing the AR-15 cruise track (red) with the portion highlighted in yellow for each of the feature surveys described in Table 1 and the Cruise Narrative.

6.1 Cross-sections and boxes

6.1.1 MAB Shelfbreak section ("MAB-SB section", XBTs, sADCP)

To obtain an along-shelf velocity section, we transited from Woods Hole to Cape Hatteras through the MAB along the 200-m isobath with the three shipboard ADCPs running (38 kHz, 150 kHz and 300 kHz) with settings as suggested by F. Bahr:

- OS38 NB only, 24m bins; OS150 NB only, 4m bins; WH300 with defaults.

In addition, T7-XBT probes were launched at regular intervals at 12 stations along the section (**Table 9**). The Knudsen (depth) logging was turned on near Hudson Canyon (between X03 and X04).

Table 9: XBTs from the MAB-SB section (SB_XBTs.xls and .mat).

MAB Shelfbreak XBTs from .edf files - T7 probes (terminal depth = 760 m)												
Site	Latitude (°N)			Longitude (°W)			Date (UTC)	Time (UTC)	Knudsen Depth (m)	Probe SN	RDE/EDF file number
X01	40	2.514	N	70	40.845	W	15-Apr-17	23:03	117	1214024	T7-00002
X02	40	2.535	N	71	11.289	W	16-Apr-17	1:13	219	1214025	T7-00004
X03	39	54.362	N	71	36.428	W	16-Apr-17	3:19	201	1214026	T7-00005
X04	39	33.227	N	72	7.118	W	16-Apr-17	6:28	218	1214029	T7-00006
X05	39	8.773	N	72	36.359	W	16-Apr-17	9:33	246	1214027	T7-00007
X06	38	42.826	N	73	4.623	W	16-Apr-17	12:50	180	1214031	T7-00008
X07	38	24.360	N	73	30.330	W	16-Apr-17	15:30	320	1214028	T7-00009
X08	37	53.507	N	74	1.396	W	16-Apr-17	23:32	200	1214030	T7-00010
X09	37	22.793	N	74	27.358	W	17-Apr-17	3:08	250	1214032	T7-00011
X10	36	51.667	N	74	38.718	W	17-Apr-17	6:19	140	1214033	T7-00012
X11	36	25.951	N	74	46.098	W	17-Apr-17	8:58	250	1214034	T7-00013
X12**	35	54.365	N	74	49.858	W	17-Apr-17	12:07	-	1214035	T7-00014

** Information not complete on log sheet.

6.1.2 Shelfbreak section spanning Cape Hatteras ("SB section", CTDs, sADCP)

On April 27, a long (150 km) CTD section was sampled extending from 34.5°N to 36°N, thus spanning both the South and Middle Atlantic Bights. The section took 24 hours to complete and thus is relatively synoptic, giving a nice view of the strong gradients present in the alongshelf direction as the shelf water masses are transported into the deep ocean.

The temperature structure appears in **Figure 15** (upper panel). As expected, there was a very sharp boundary between the Gulf Stream and the Middle Atlantic Bight shelf water moving offshore as the Shelfbreak Jet deflects offshore. Minimum temperatures for the Cold Pool (deeper MAB shelf water) were 9.6°C, while the near surface Gulf Stream temperature was 24°C.

The salinity structure appears in **Figure 15** (middle panel). It is apparent that the section did resolve the core of the Shelfbreak Jet deflecting offshore, since there is a local minimum in the salinity that is consistent with Middle Atlantic Bight salinities. The horizontal scale of the Shelfbreak Jet is approximately 20 km, which is consistent with the jet width upstream of Cape Hatteras from climatology and synoptic sections. The minimum salinity is 33.2 PSU and is concentrated in the upper 20 m of the water column while salinities of less than 34 PSU extend to 100 m depth. We will combine the CTD data with the shipboard ADCP velocities in the analysis and estimate the volume of Middle Atlantic Bight shelf water as well as the fresh water transport in the future. The density field from this section appears in **Figure 15** (lower panel).

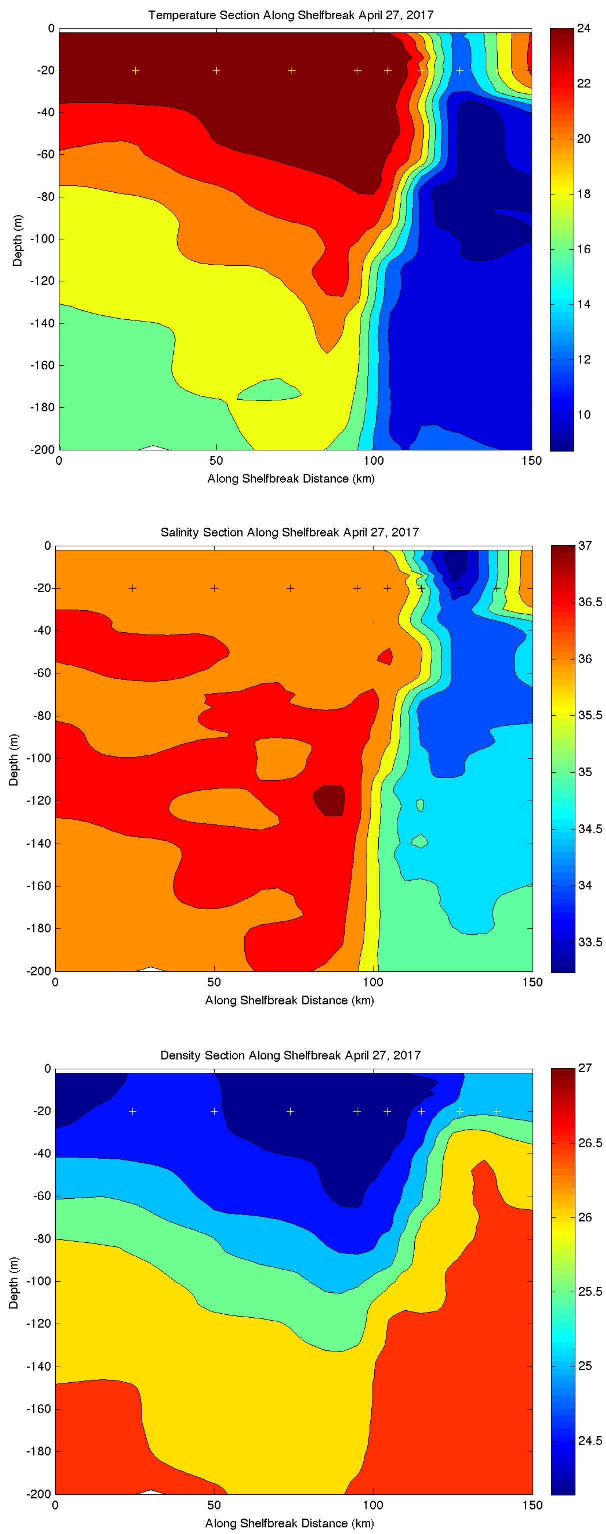


Figure 15. Property sections from the Shelfbreak Section spanning Cape Hatteras showing temperature (top), salinity (middle) and density (bottom).

6.1.3 ADCP crossings of the Gulf Stream

The Gulf Stream cross-transect shipboard ADCP measurements (**Figure 16**) made with the *R/V Armstrong's* 300, 150, and 38 kHz ADCP's are displayed below in stream-wise coordinates (**Figure 17**). The down-stream direction is defined here as the direction of maximum current velocity, which is presumably the Gulf Stream jet axis, for each individual transect.

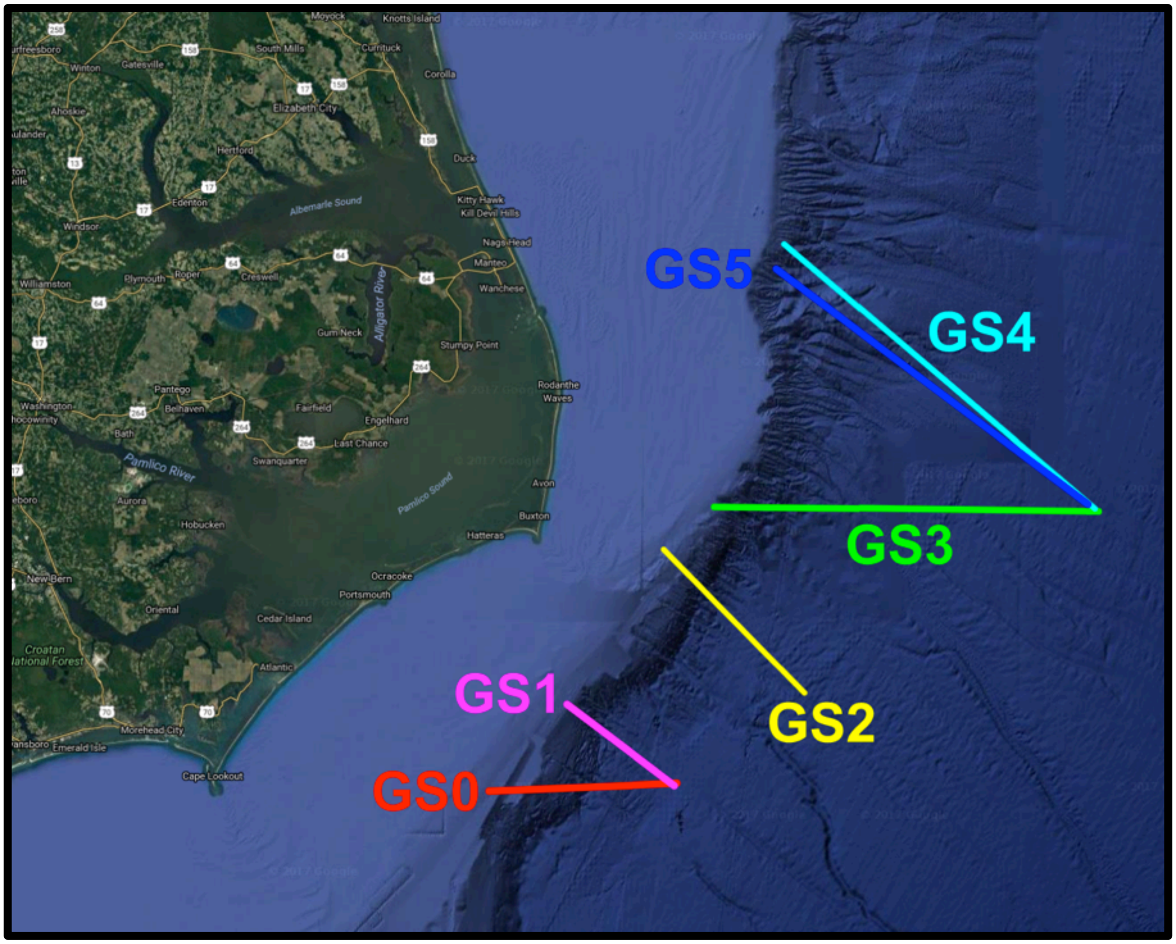
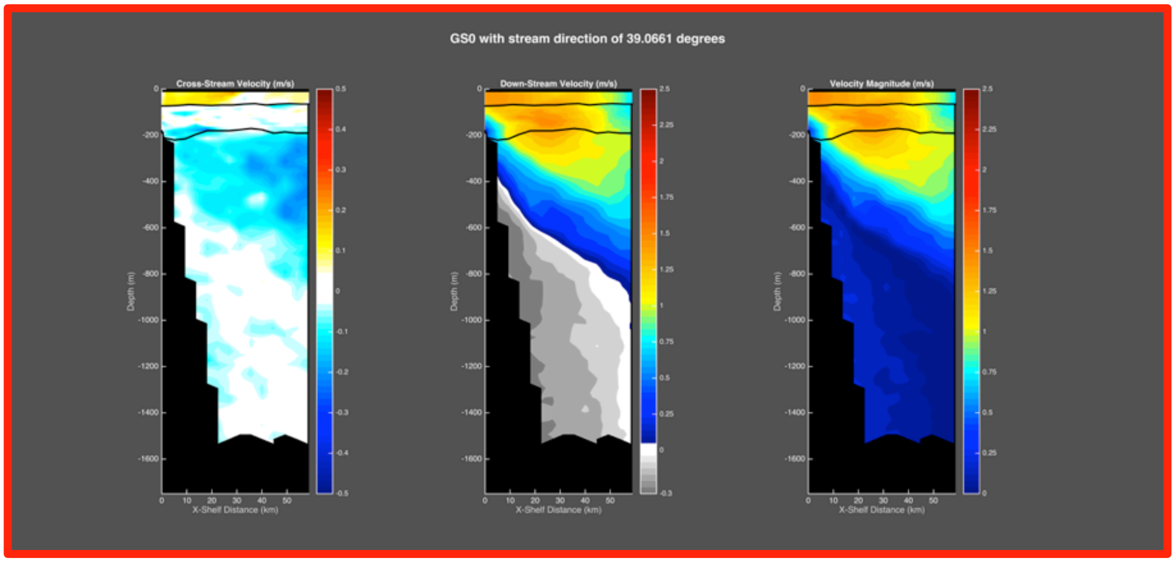
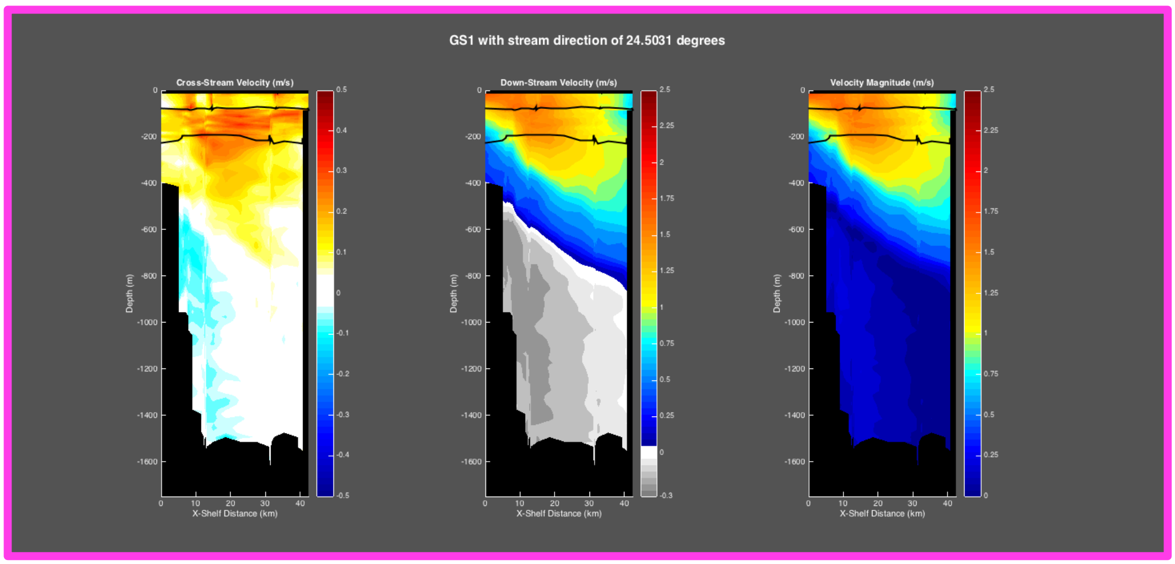
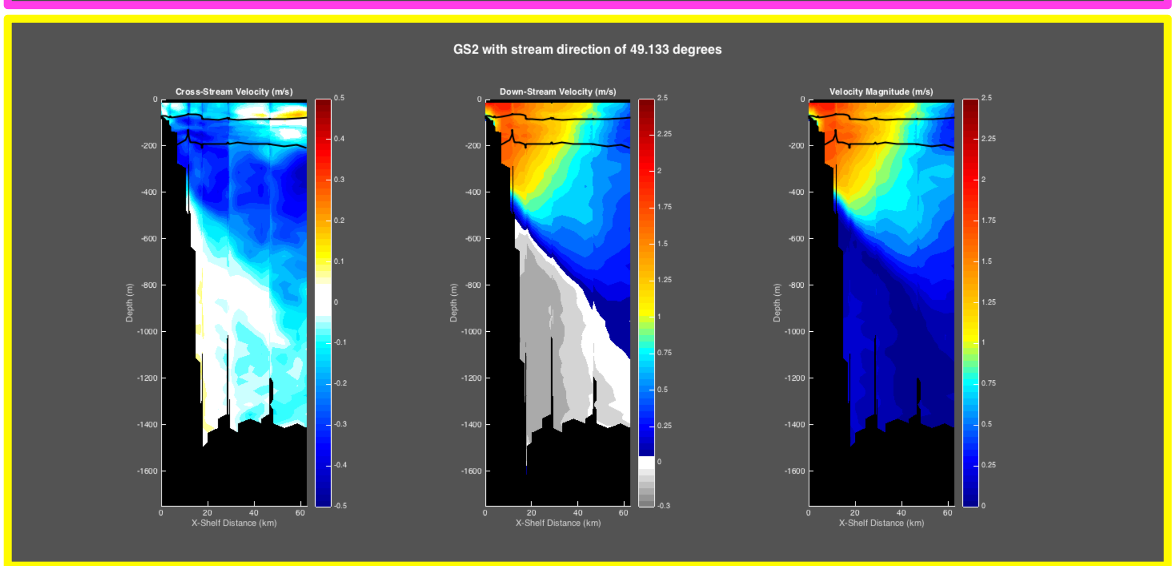


Figure 16. Location of each *R/V Armstrong* cross-stream transect made during the AR-15 PEACH deployment cruise.







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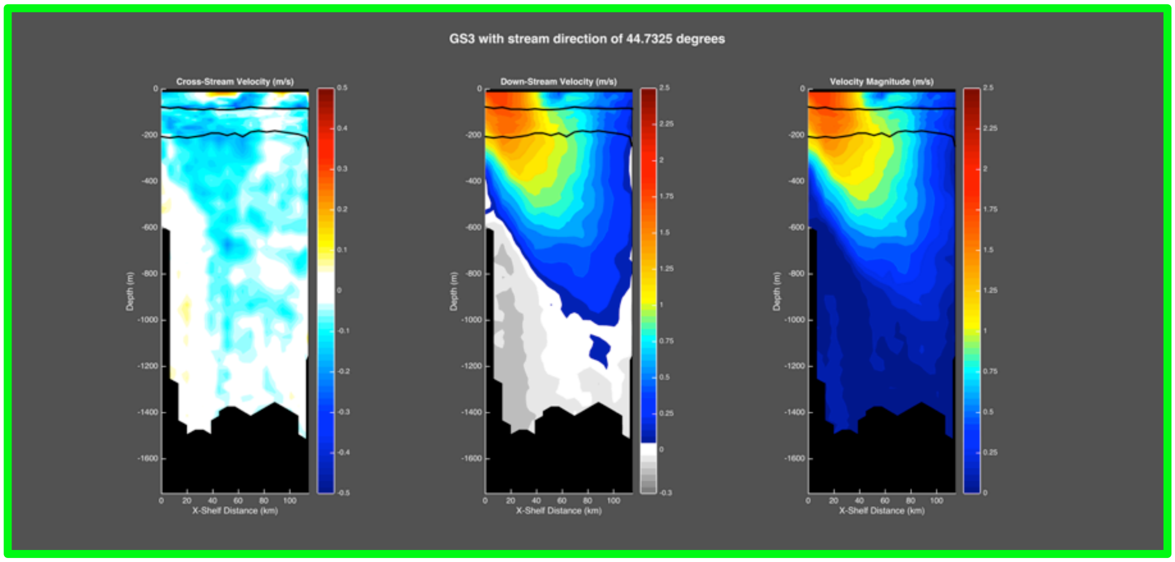

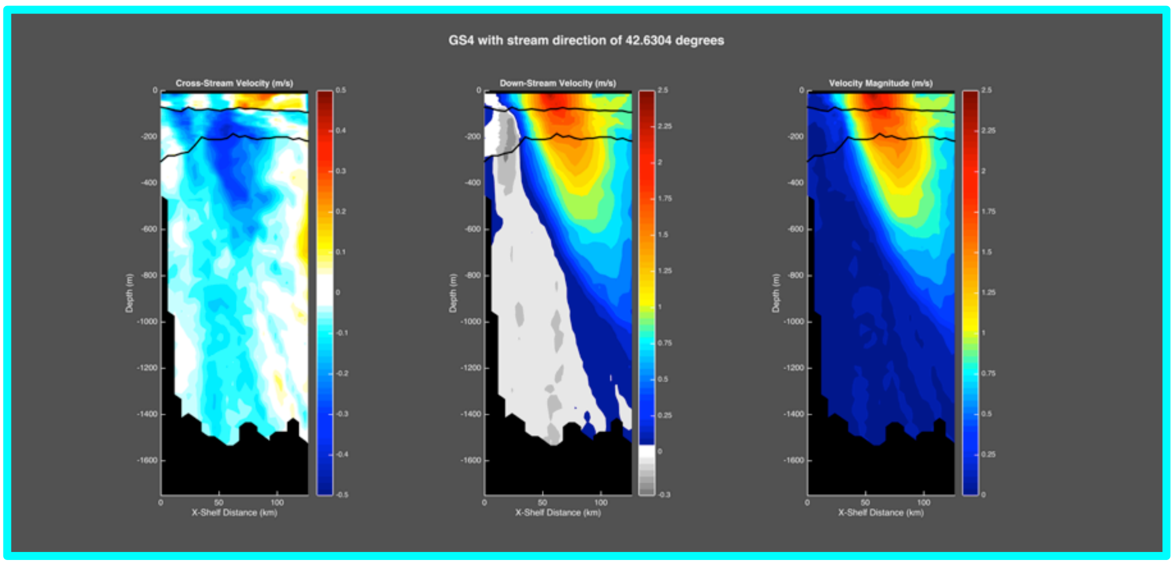

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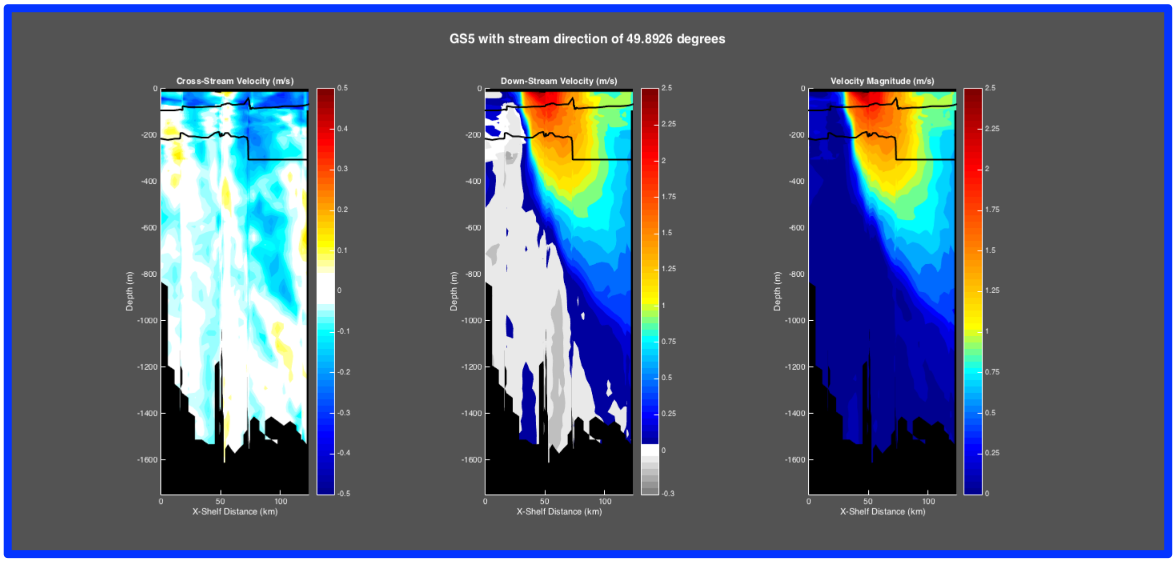

Figure 17. Each cross stream sADCP transect current measurement above is color coded to match the color of the transect in **Figure 16**. Transects are in stream-wise coordinate systems derived for each individual transect. Black color in the figure is indicative of missing current data NOT bathymetry. Thin black lines near the surface delineate the boundaries between the currents measured by the 300 (upper), 150 (middle), and 38 (lower) kHz sADCPs.

6.2 Surveys

6.2.1 Bathymetry survey

The target area for the bathymetry survey was based on a previous report (Haines, 2016) provided for the PEACH project reviewing several sources of bathymetry (ETOPO1, CRM, GRMT) and recommending three areas to focus possible ship multibeam surveys. With time allotted for the survey (initially planned ~18 hours) during AR-15, it was determined that we could cover a small portion of the top priority area (green box in **Figure 18**) identified in the report while in the vicinity for A6 and P6 deployments. It was calculated that completing 10-12 lines approximately 10 km in length with 25-50% overlap along isobaths starting in 200 m water depth and "mowing" each line in successive depths to about 1000 m could be covered in about 20-24 hours. Ultimately, we covered 75% of the lines in a total of 15.5 hours of survey in two parts (12 and 3.5 hours, respectively). The data will most likely be post processed with technical assistance from WHOI.

Part 1 of the bathymetric survey, using only the EM710, was conducted for approximately 12 hours. It was commenced on Fri 22 Apr 2017 at 23:45 (UTC) and stopped at Sat 22 Apr 2017 11:41 (UTC). Sound speed calibrations were conducted using XBTs listed in **Table 10**.

Part 2, also using only the EM710, was only about 3.5 hours and had to be terminated due to the deteriorating weather. It was started at Tues 24 Apr 2017 at 14:30 (UTC), but was stopped at approx. 18:00 (UTC) since data quality was compromised by the increasing waves abeam. As we took a more comfortable ride WSW towards Raleigh Bay from the survey and away from the Diamond Shoals area, we continued to operate the EM710 until 19:50 (UTC) crossing previous survey lines but did not count this survey time in the total time. Sound speed calibration data were taken from CTD 055 (ar15055.hex) and other CTD profiles conducted in the vicinity can be used (**Table 11**).

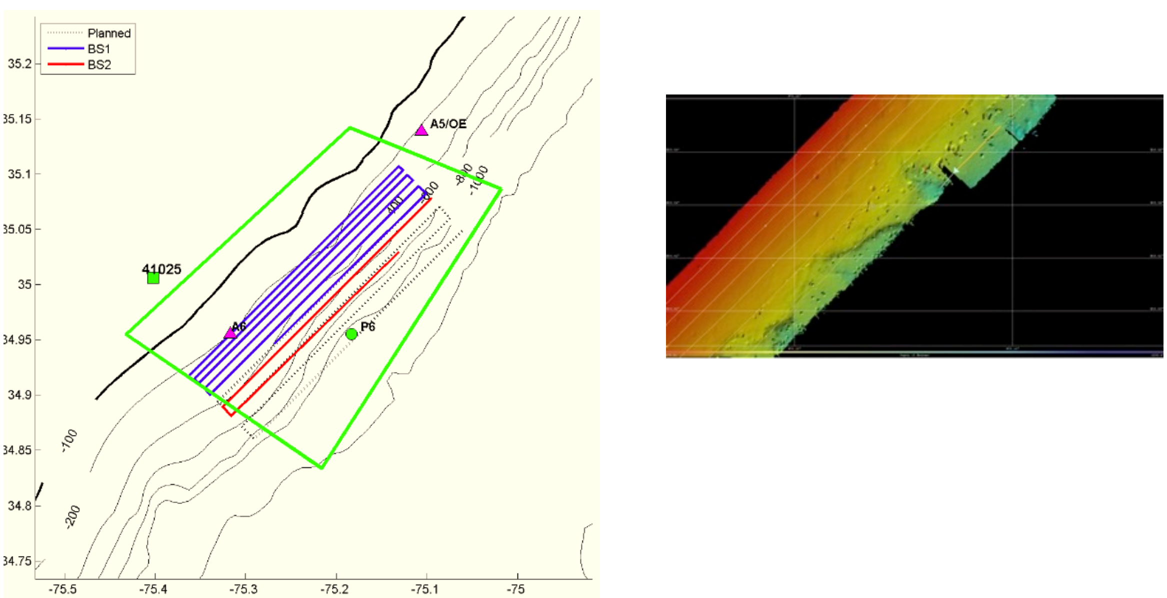

Figure 18. Left: multibeam survey tracks completed (BS1 and BS2) of the planned tracks (dotted black) to cover the priority area over 35˚N from the 200 m to 1000 m isobaths. Isobaths (GEBCO_2014) in solid black lines (100 m isobath, thick black line). Right: Screen shot of Kongsberg display of the survey at the start of BS2 on April 24.

Table 10. XBTs for part 1 multibeam calibration

XBTs for multibeam calibrations												
Site	type	Latitude (°N)			Longitude (°W)			Date (UTC)	Time (UTC)	Knudsen Depth (m)	Probe SN	RDE/EDF file number
BS01A		bad record									21421	T1-00014
BS01B	TS-11	34	55.299	N	75	21.299	W	21-Apr-17	23:46	174	24992	T1-00016
BS11	T-6	35	1.432	N	75	10.354	W	22-Apr-17	10:38	435	1095922	T7-00017

Table 11. CTDs for part 2 multibeam calibration

Station	Latitude	Longitude	Date (UTC)	Time (UTC)	Knudsen Depth (m)	CTD File
GS02	35.104488	-74.998819	24-Apr-17	10:25	1900	ar15054.hex
GS01	35.13299	-75.037031	24-Apr-17	11:41	655	ar15055.hex
GS00 (?)	35.186072	-75.135275	24-Apr-17	13:39	99	ar15056.hex

6.2.2 EK80

The EK80 was used for three targeted purposed: (1) to conduct a transect along the western edge of the Pioneer Array, (2) to conduct a survey (**Figure 19**) around the SEEP site where hydrate seeps had been identified on a previous *R/V Armstrong* science verification cruise, and (3) to conduct an "everything off" test for T. Duda in about 100 m of water (with instrumentation like the ADCPs, etc. secured).

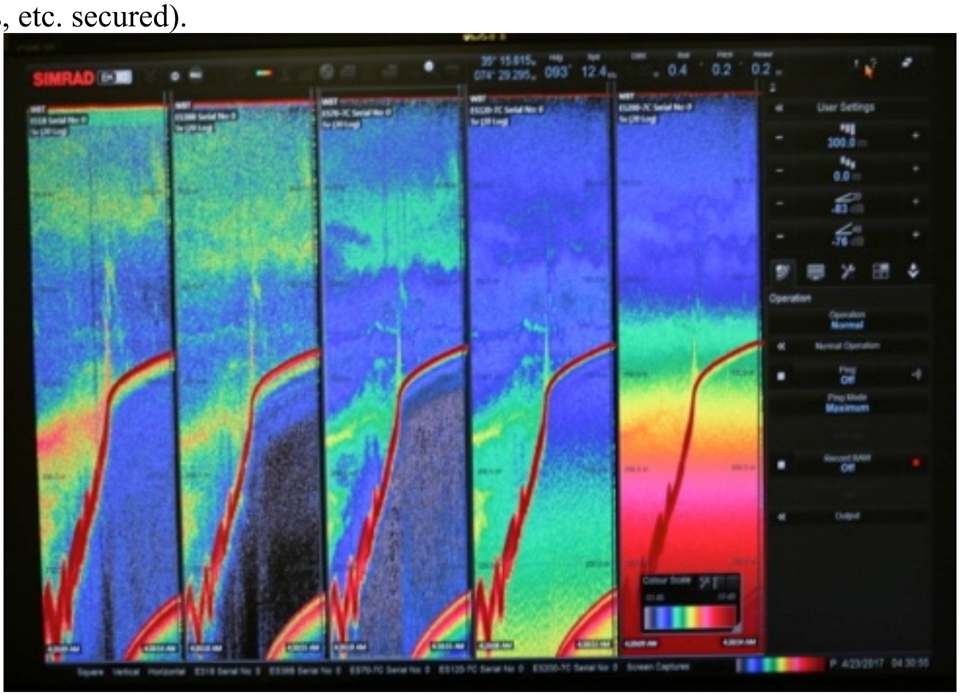

Figure 19. Screen shot of the output from the EK80 during the AR-15 SEEP survey.

6.3 TSG data

Underway TSG data were collected, and remain to be post-processed.

6.4 High frequency variability at P1 (“Yo-yo cast”, CTD, burst telemetry)

We returned to PEACH PIES site P1 two days after deployment to test burst telemetry. We occupied the site for ~8 hours and collected CTD data by yo-yoing the CTD between the surface and ~ 650-m depth. In addition the ADCPs were logging velocity data during the yo-yo cast. Each round-trip took about 30 minutes and we completed 16 round-trips (saved as separate .hex files: ar15009.hex through ar150024.hex and plotted as a function of time in **Figure 20**). During this time, we continually retrieved CPIES data from P1: tau, pressure and temperature at 10 minute interval and horizontal currents at 30 minute interval with the UDB9000, ship’s through hull transducer and the WHOI Toughbook (Cburst_from_P1_yo_yo.dat). High frequency tau variability will be compared with the temperature and salinity profiles.

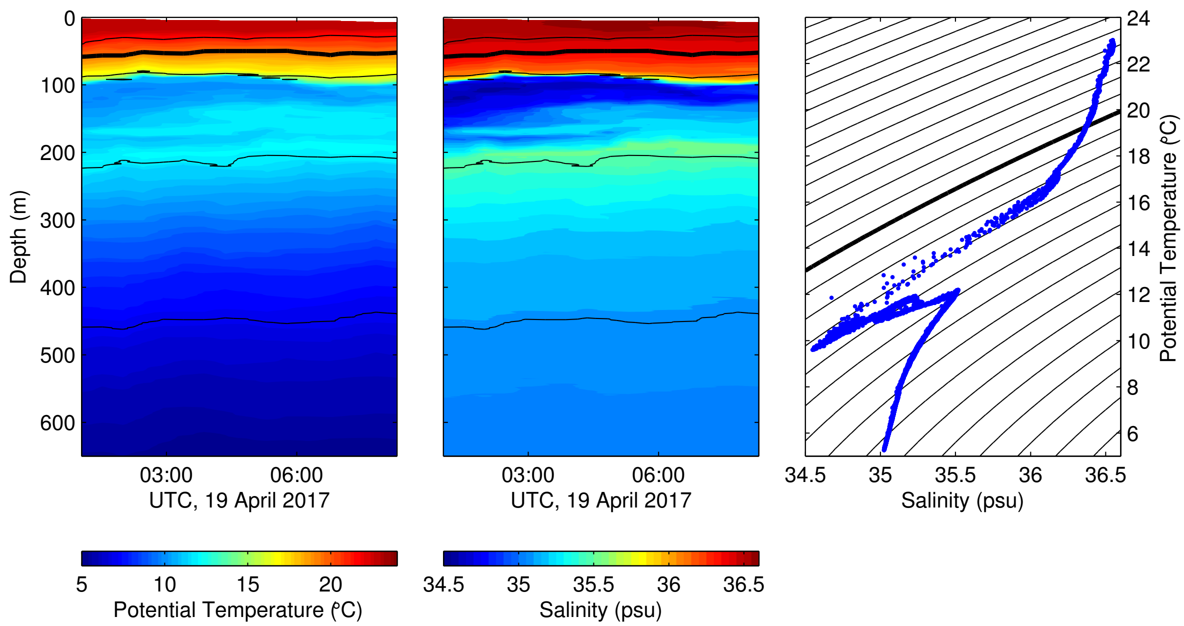

Figure 20. Black contours are sigma_theta with the 26 kg/m^3 isopycnal bold; contour interval is 0.5 kg/m^3 in the time series and 0.2 kg/m^3 in the T-S plot.

7. Spray Glider Deployment

On 16 April 2017, at approximately 1324 local, R. Todd, P. Deane, and Bosun Scott Loweth deployed Spray glider number 66 near 38° 22’N, 73° 24’W in approximately 800 m of water (at site G1 after the nearby XBT drop X07). Deployment location was shifted offshore slightly to avoid fishing gear in the area. Deployment from using the A-frame and a quick-release harness went smoothly. After sinking initially to activate a pressure switch, the glider surfaced around 1344 local, received commands and a position via satellite, and commenced its mission. R. Todd piloted Spray 66 (and other deployed gliders) throughout the AR-15 cruise via the ship’s satellite internet connection.

During the remainder of the AR-15 cruise, Spray 66 progressed southward just offshore of the continental shelf, profiling to 500 m approximately every 3 hours (**Figure 21**). Observations were plotted and real-time at gliders.whoi.edu and distributed for operational use via the IOOS

Glider DAC and by email to the Naval Oceanographic Office. By the end of the cruise, Spray 66 had reached the northern edge of the Gulf Stream near Cape Hatteras (approximately 36.8°N) and turned northward to begin another transect.

Matlab files of real-time and post-processed (once missions are complete) Spray glider data will be available via an existing server at SIO. These .mat files will have profile data bin-averaged to a regular vertical grid for easy manipulation. Also, plots of the data (chopped into sensible transects) will be maintained on mission-specific pages at http://gliders.whoi.edu.

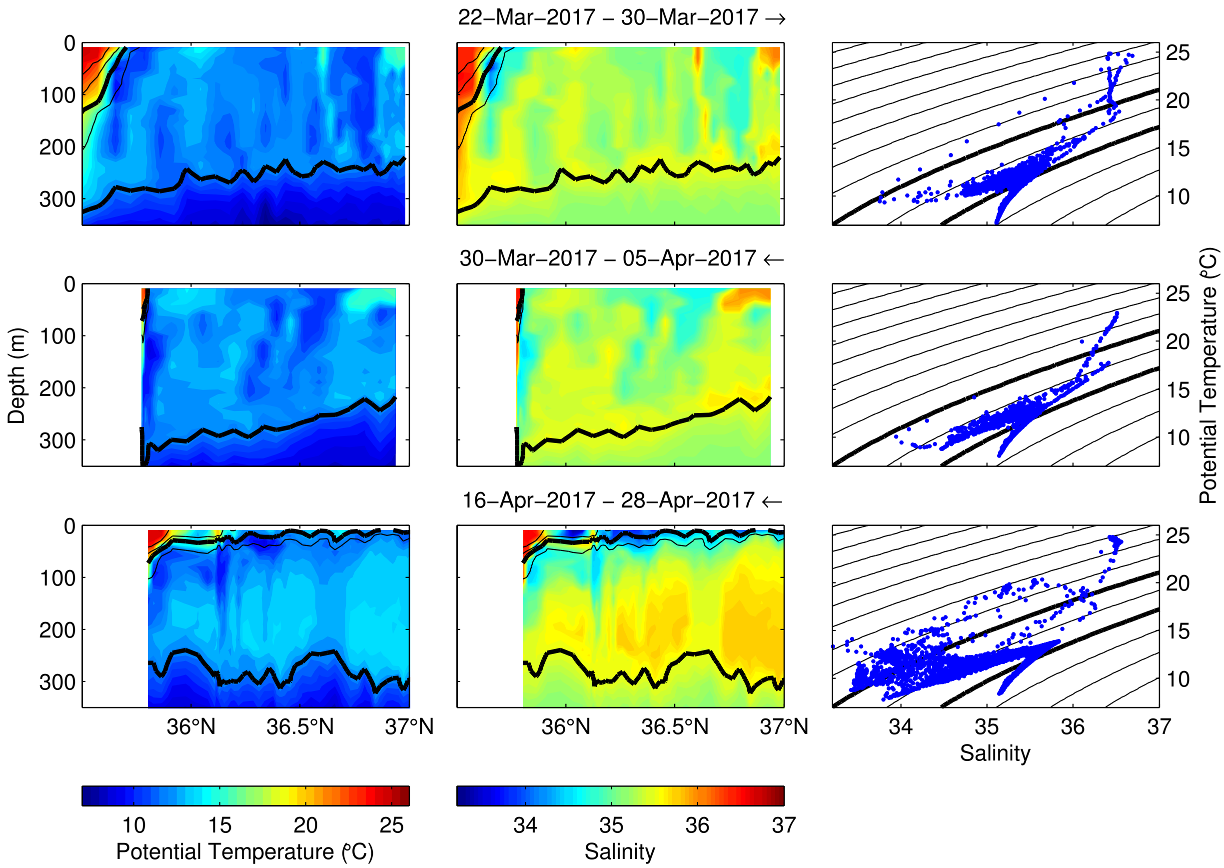

Figure 21. Three transects just offshore of the continental shelf north of Cape Hatteras that were occupied by Spray gliders. The first two transects were occupied just prior to AR-15 by Spray 22 during a mission to survey the Gulf Stream. The third transect was occupied by Spray 66, which was deployed during AR-15. Temperature and salinity are shown versus latitude and depth as well as in T-S diagrams for each transect; black contours are isopycnals with a contour interval of 0.5 kg m^{-3} and the 26 and 27 kg m^{-3} isopycnals bold.

8. Remote Sensing and Model Data

8.1 SSTs

Throughout the cruise, SST images were utilized from NOAA CoastWatch/OceanWatch and from Rutgers in order to anticipate and investigate interesting features and develop lines for cross-sections (e.g., **Figure 22**).

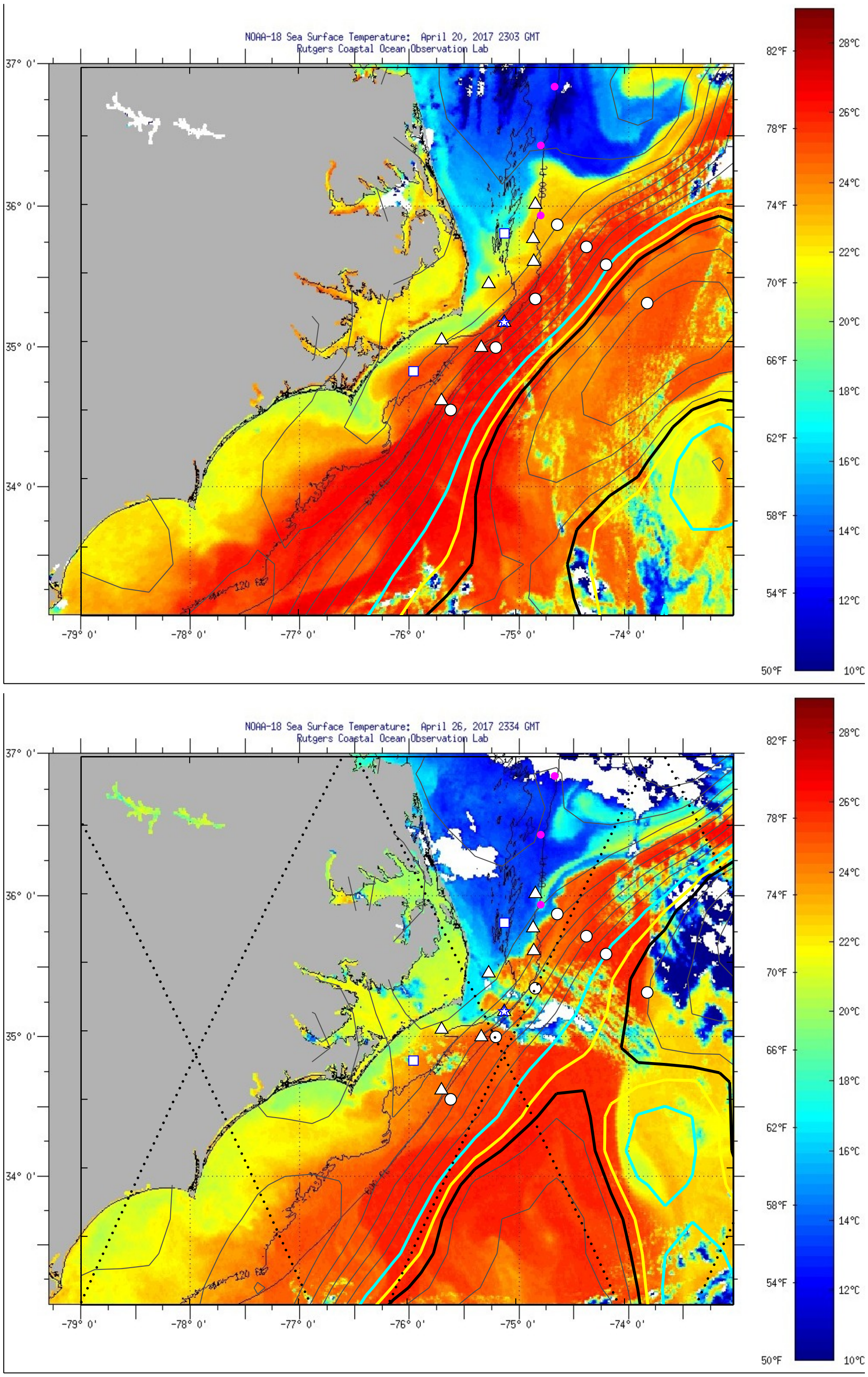

Figure 22. SST on (top) April 20, 2017 and (bottom) April 27, 2017 downloaded from https://marine.rutgers.edu/cool/sat_data/?product=sst&region=capehat&nothumbs=0 with SSH contours from the concurrent near-real time Aviso satellite mapped altimetry product overlaid. Locations of the PEACH mooring sites are shown with white symbols and the XBT drops with magenta circles. (For the larger cruise region, the following link was used for SSTs: https://marine.rutgers.edu/cool/sat_data/?product=sst&region=bigbight&nothumbs=0.)

8.2 NCSU CNAPS

When satellite SST and Chlorophyll-a data were unavailable due to cloud-cover or other interference, numerical models were used to fill in the gaps (**Figure 23**). Model data subsets were downloaded from North Carolina State University's Coupled Northwest Atlantic Prediction System (NCSU CNAPS; http://omgsrv1.meas.ncsu.edu/CNAPS/) and analyzed on-board to minimize internet data usage. This model is an implementation of an ocean-atmosphere-wave coupled system (Warner et al., 2010) that provides fields in all three environments for our domain of interest. Model data comparisons to individual stations have demonstrated reasonable agreement as the model performs well with real-time, user-customizable time-series and profiling functions against validation datasets (Yao et al, in review) as well as individual CTD and XBT stations.

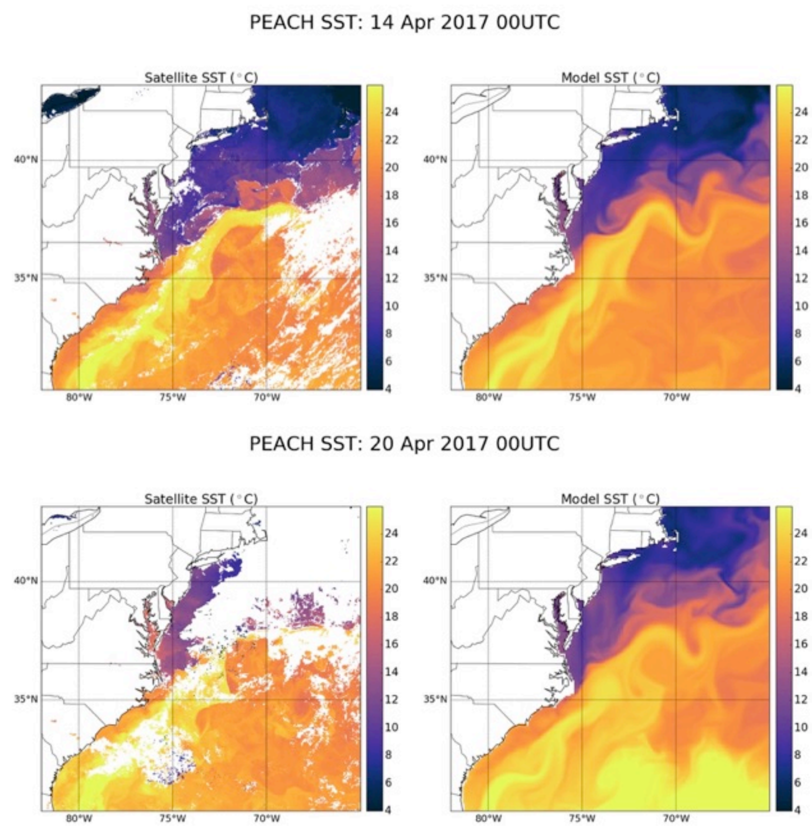

Figure 23. Comparison of satellite SST (left column) with that from the numerical model (right column).

8.3 Significant wave heights during storm event

During the cruise, the *R/V Neil Armstrong* encountered a strong low-pressure system that set up off the southeast U.S. and generated gale-force winds and waves reported as high as 25-feet. Several days in advance, National Ocean Service forecasts alerted scientists and crew of the incoming threat. In addition, wave model data subsets (**Figure 24**) were downloaded from North Carolina State University's Coupled Northwest Atlantic Prediction System (NCSU CNAPS) and overlaid with planned cruise tracks. The NCSU CNAPS model predicted 5+ meter seas, higher than the 3m predicted seas from the coarse-resolution, global WaveWatch III model. In the end, some stations verified the extreme waves predicted by the coupled ocean-atmosphere-wave model CNAPS, as well as their onset and duration. This allowed the science party to determine, days in advance, the best locations to sample before and after the storm to minimize down-time due to weather.

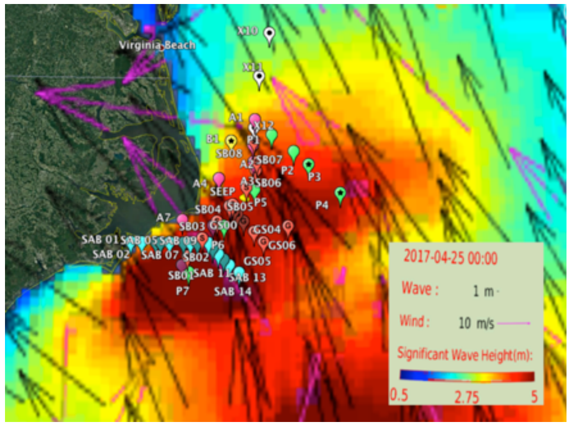

Figure 24. PEACH instrument sites overlain on model output in advance of the storm.

9. Argo Float Deployments

Four Argo profiling floats (Solo II floats built by MRV Systems and prepared by the WHOI Argo Group) were deployed during AR-15 by R. Todd and P. Deane (**Table 12**). The goal was to spread the floats across the Gulf Stream so that they would quickly disperse into the North Atlantic. Per standard Argo procedures, the floats were deployed in their protective cardboard boxes. Boxes were lowered over the transom by hand; water-activated releases allowed recovery of the harnesses used to lower boxes overboard.

Table 12. Summary of the Argo float deployments during AR-15.

Serial Number	Deployment Time (local)	Deployment Latitude	Deployment Longitude
7303	17 April 2017, 1416	35° 41'N	74° 21'W
7423	17 April 2017, 1900	35° 34'N	74° 10'W
7424	23 April 2017, 2240	34° 54'N	74° 49'W
7425	23 April 2017, 0828	35° 17'N	73° 47'W

All four floats began reporting in shortly after deployment and are operating as expected. The map below (**Figure 25**) shows the locations of the floats as of 18 June 2017 (figure courtesy of P.E. Robbins). Updates can be accessed at: http://argo.whoi.edu/solo2/maps/2017cruises.html#ArmstrongPEACH .

For comparison the trajectories of floats deployed in the region during a *R/V Armstrong* Science Verification Cruise (SVC1) are shown here (**Figure 26**, courtesy of P.E. Robbins). Updates can be accessed at: http://argo.whoi.edu/solo2/maps/2016cruises.html#ArmstrongSVC1.

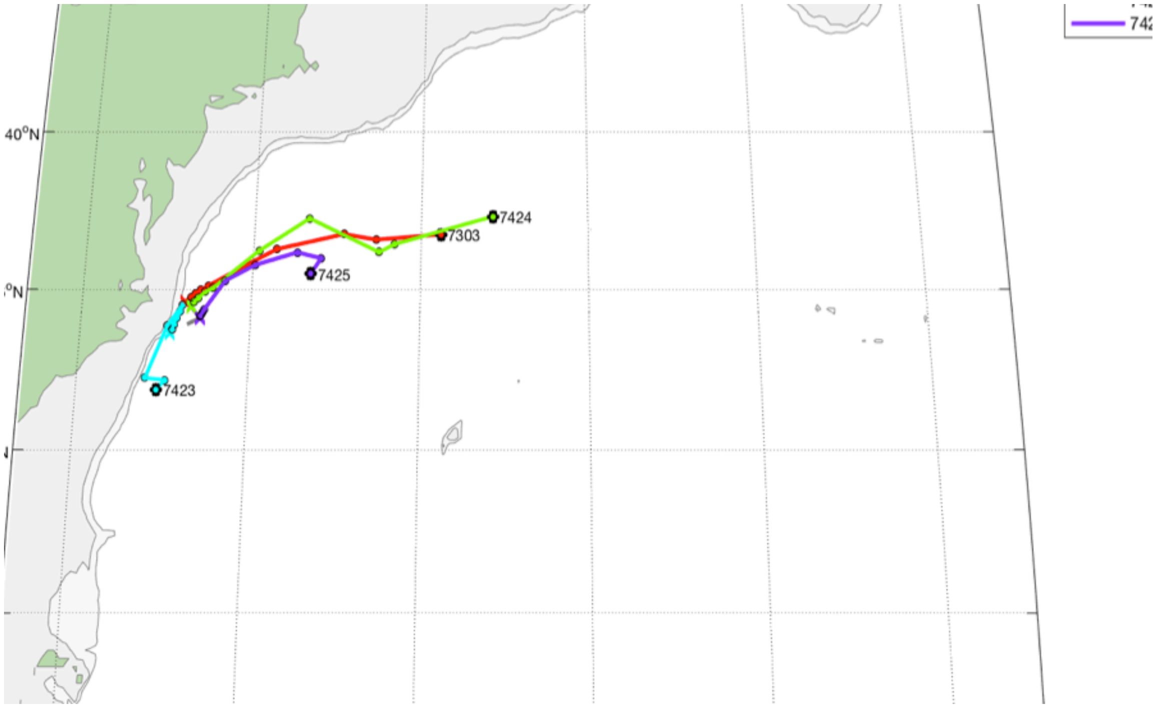

Figure 25. Trajectories of the four Argo profiling floats deployed during AR-15.

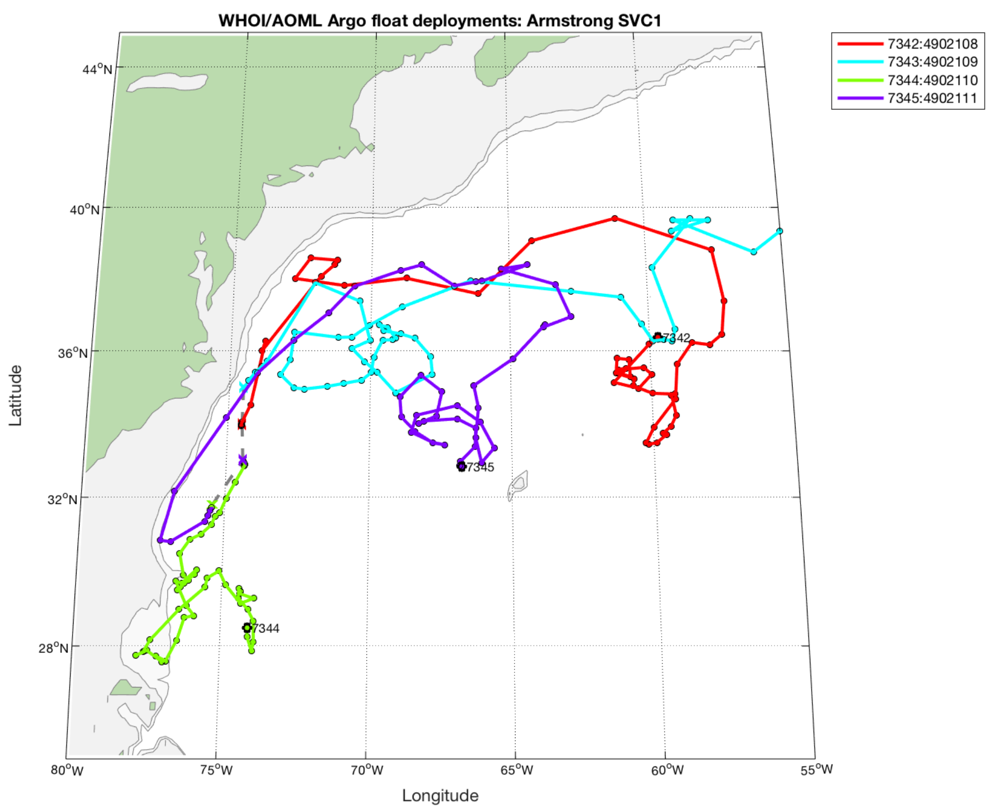

Figure 26. Trajectories of Argo floats deployed in 2016 during SVC-1 on the *R/V Armstrong*.

10. Outreach

During the cruise, J. McCord from the Advanced Media and Visualization Lab at UNC CSI documented the research activities and created digital media outreach content for the PEACH project. His blog—updated daily during the cruise (e.g., **Figure 27)**—was followed by North Carolina high school students at Manteo H.S., First Flight H.S., Currituck H.S., and Pasquotank H.S. as part of their Earth and Environmental Science, Physical Science and Oceanography classes. Complementing this, Argo and glider data were sent to the teachers for incorporation into curriculum and classroom lesson plans.

Figure 27. Example PEACH blog post uploaded during the AR-15 cruise.

After the cruise, media content collected on the cruise will be used to follow up with these high school classes and also to produce K-12 outreach programs based on North Carolina Essential Standards and Next Generation Science Standards. The content will include resource guides for teachers, lesson plans, and visits to the Coastal Studies Institute (with pre- and post- visit material for the classroom). The PEACH blog can be accessed here: http://www.coastalstudiesinstitute.org/research/coastal-engineering/research-project%20processes-driving-exchange-cape-hatteras/

In addition, content was collected on the cruise that will be used for:

- Overall project video: A 5-7 minute video on the project as a whole, highlighting the importance and significance of the work, and the methods used in the research project.
- Technology: Production of 2-3 minute videos on the technology used to gather data for the project
- Scientists and Researcher Mini-Bios: 1-2 Minute videos on individual researchers and their roles in the project

The PEACH project website was updated with blog posts from cruise participant and NCSU Marine Sciences undergraduate, L. Ball. J. Zambone from NC State also contributed to the blog. https://sites.google.com/a/ncsu.edu/peach-public-site/home.

11 References

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