Cruise report: *R/V Endeavor* cruise no. EN440

Narragansett, Rhode Island to Narragansett
October 1-9, 2007

Line W: Continuing the measurement program

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Background

R/V Endeavor cruise number 440 contributed to a joint Woods Hole Oceanographic Institution and Lamont Doherty Earth Observatory research program funded by the U.S. National Science Foundation that is investigating the characteristics and consequences of interannual variations in the Northwest Atlantic's Deep Western Boundary Current (DWBC). Our study is documenting for an initial four-year period, the temperature, salinity, tracer, and velocity variations of the DWBC about 39^{o}N 70^{o}W by maintaining a 5-element moored array over the continental slope southeast of Woods Hole, and occupying a hydrographic section along this line semi-annually. Mooring work has been carried out on spring cruises beginning in May 2004; hydrographic work has been done on those trips as well as dedicated fall cruises. Cruise EN440 represented the 8^{th} cruise of the program – a hydrographic sampling trip. Our measurement program (named Line W in memory of L. Valentine Worthington) is quantifying changes in DWBC water properties, stratification (potential vorticity), and transport. The high-spatial-resolution sampling possible from the ship will help verify that the array resolves interannual signals as well as return water samples for at-sea and shoreside tracer analyses. Furthermore, we are encouraging other researchers to build on the Station W infrastructure to augment the fields being sampled, and actively invite student participation on our cruises for training and experience.

Under the Station W program, the parameters sampled at the hydrographic stations include continuous profiles of temperature, salinity and dissolved oxygen (obtained from the CTD system), velocity (from shipboard and Lowered Acoustic Doppler Current Profiler systems) discrete water samples analyzed for salinity and oxygen (used to calibrate the CTD sensor data), CFC's (F11, F12, F113) and SF6, and underway surface ocean and atmosphere parameters. In addition, water samples are collected and stored for subsequent shipment to Dr. John Smith (BIO, Canada) for analysis of ^{129}I concentration. New on EN440 in collaboration with Dr. Nick Bates of the Bermuda IOS, water samples were collected and stored for shoreside analysis of dissolved inorganic carbon and total alkalinity.

Science party:

J. Toole, T. Joyce, J. Dunworth-Baker, D. Torres, and D. Wellwood (WHOI), W. Smethie, E. Gorman and A. Spieler (LDEO); M. Jeffries (BIOS), E. Logvinov (MIT/WHOI Joint Program), J. Kuehl and A. Cleary (URI/GSO), B. Pinsky (URI).
URI/GSO Marine Technician: W. Fanning

Cruise narrative:

R/V Endeavor was loaded with Line W scientific equipment during the week of September 24, and the majority of science party members moved aboard on the 30th in order to be ready for an early-morning departure on Oct 1. Under the direction of Captain Rett McMunn, departure occurred on the 1st as planned at 0900 in fine weather. Given the excellent working conditions on departure and lack of faith in long-range forecasts, it was decided to work the section from north to south. A total of 26 full-depth stations were planned ranging from the 90 m isobath over the continental shelf, across the slope and Gulf Stream to the central Sargasso Sea. Permission was granted to occupy the four southernmost planned stations in Bermudan territorial waters. At the time of departure, the Gulf Stream was close to its nominal position with reasonably straight course. Warm core rings were identified in satellite imagery both north and south of our planned section, but not on it, Fig 1.

Two watches (changing at noon and midnight) were set up to conduct the hydrographic/LADCP operations. The LDEO team organized themselves such that two members were on duty for the majority of time; Wellwood, who was responsible for salinity and dissolved oxygen analyses, worked as required to keep up with the acquired salinity and dissolved oxygen water samples.

Sta 1 was reached shortly after dinner on Oct 1, and station work proceeded through to midnight on Oct 7 when Sta 26 was completed. Station time and location information are provided in Table 1. During the up-cast of Sta 4 in 640 m of water, a hydraulic line on the winch failed causing fluid to flood the 01 and main decks. While repairs were being carried out, the ship was directed to slowly steam towards deeper water so that the CTD wouldn't ground. The winch was fixed quickly, the decks washed, and the station was completed without further incident. At depth during the downcast of Sta 11, channel 1 of the CTD system ingested some foreign material that caused bad conductivity and oxygen readings for the balance of the down-going profile. Given that the two CTD channels were otherwise comparable, it was decided to use channel 2 data as primary for the final data set. The single available oxygen channel data are not usable from the bottom of Sta 11; a regression of oxygen against potential temperature will be necessary to synthesize the near-bottom oxygen profile.

Once sufficient water sample salinity data were in hand to assess sensor performance, a large offset between CTD and water sample salinities was discovered on Stas 1 through 8. Wellwood reported that the Portasal salinometer standardization reading shifted between Stas 8 and 9. It remains to be seen if the water sample salinities from those earlier stations are correctable. Fortunately, the CTD sensors appeared reasonably stable throughout the cruise so we should be able to use the same conductivity calibrations for this first group of stations, based on water sample data at and after Sta 9.

After station 12 on Oct 3, a planned changeover of conducting cable for the CTD operations was carried out without problem. The longer length of wire on the 2nd winch

drum was required for the planned deep stations in the Gulf Stream and Sargasso Sea. Adept ship handling during the stations occupied in the Stream limited wire angles and wire paid out beyond water depth. On Sta 18 it was noted that one of the acoustic beams of broadband acoustic Dopper current profiler mounted on the underwater frame was not fully operational. (Velocity information is still obtainable in such cases with a 3-beam solution, but with greater noise level.) A backup ADCP instrument was mounted on the frame prior to Sta 19. This replacement instrument functioned well until Sta 21 when communications to the new ADCP failed. Three stations were occupied with data stored internally on the ADCP until its internal memory was filled. The broadband system was then removed from the frame and a second Workhorse instrument was installed. This dual Workhorse arrangement was used for the balance of stations.

Station 26, the last planned cast, was completed at 0400Z on Oct 7. During this station, surface water was collected for an MIT group. Per prior agreement with the MIT investigators, we filled the provided carboys from *Endeavor's* uncontaminated sea water supply using a standard garden hose. However, a second group from SUNY-Syracuse that requested surface water asked that their water come from our rosette bottles, so a special 20-m cast was performed at 0500Z after the samples from Sta 26 were drawn.

The run back to Narragansett was directed along the line of acquired stations in order to obtain a near-synoptic upper-ocean velocity section using the vessel's ADCP system. Arrival at the GSO pier took place at slack high water on the morning of Oct 9 as planned.

Thanks and Acknowledgements

Due to the expert performance of the science party and officers and crew of *R/V Endeavor* (and excellent weather conditions) all work planned for this cruise was successfully completed. The Line W PIs wish to thank everyone involved in the cruise, both those at sea and the support personnel ashore. The Line W program is funded by the National Science Foundation through grant no. OCE-0241354 to the Woods Hole Oceanographic Institution. The study contributes to the U.S. CLIVAR program and the U.K. RAPID study.

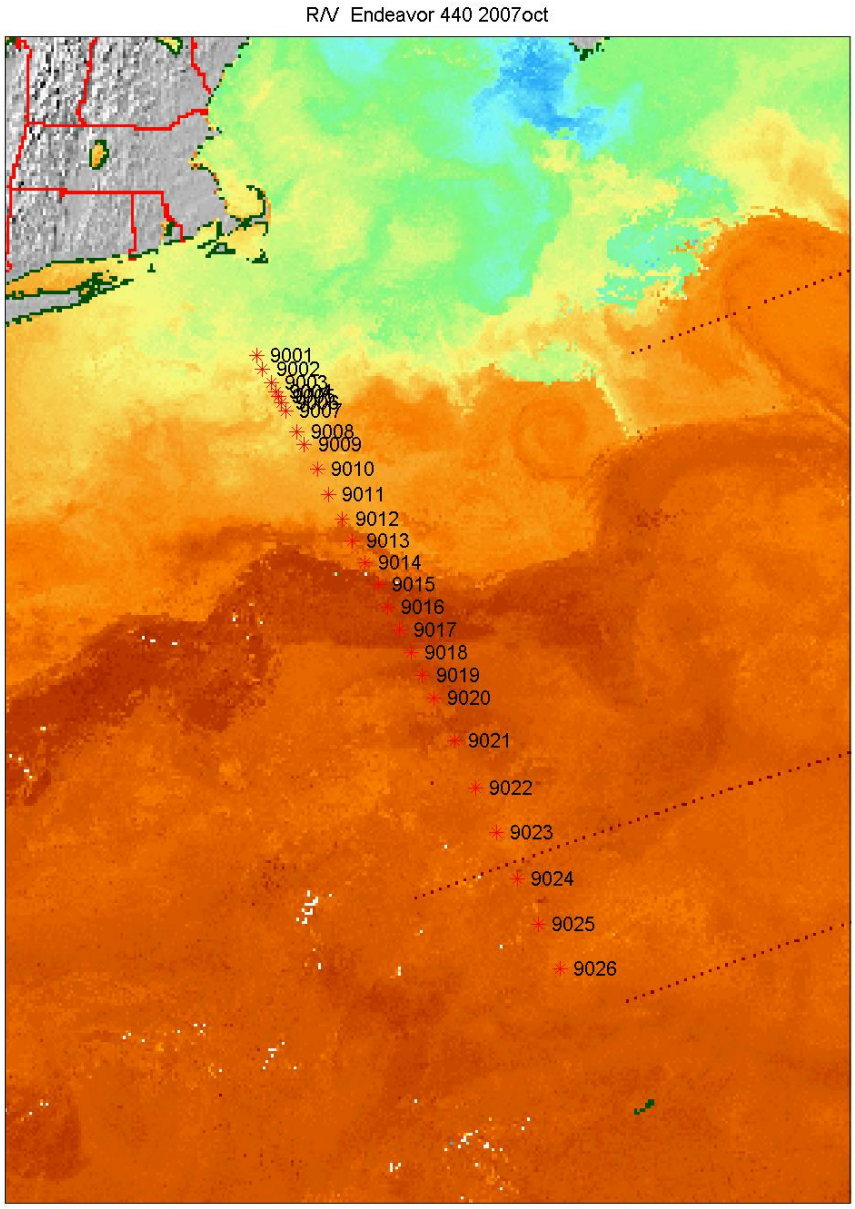

Figure 1. Station map for cruise EN440 superimposed on a satellite-derived sea-surface temperature map for the cruise period. Red colors denote warm temperatures, blue cooler.

Table 1: List of hydrographic stations occupied on En440 and related information.

Sta-Cast	Date-Time	Position	HaB	Dpth	Wout	(all in meters)
1 1	100107 2237	BE 40 17.54 N 070 12.08 W		91		
1 1	100107 2250	BO 40 17.54 N 070 12.16 W	9	85	81	
1 1	100107 2302	EN 40 17.57 N 070 12.21 W				
2 1	100107 0037	BE 40 08.45 N 070 07.39 W		120		
2 1	100107 0045	BO 40 08.50 N 070 07.63 W	9	110	120	
2 1	100107 0054	EN 40 08.59 N 070 07.85 W				
3 1	100207 0213	BE 40 00.10 N 070 00.14 W		164		
3 1	100207 0222	BO 40 00.13 N 070 00.30 W	10	150	155	
3 1	100207 0234	EN 40 00.22 N 070 00.19 W				
4 1	100207 0354	BE 39 54.56 N 069 55.96 W		636		
4 1	100207 0412	BO 39 54.75 N 069 56.14 W	10	607	607	
4 1	100207 0611	EN 39 54.19 N 069 54.87 W				
5 1	100207 0806	BE 39 51.72 N 069 53.91 W		965		
5 1	100207 0831	BO 39 51.94 N 069 53.85 W	9	944	952	
5 1	100207 0909	EN 39 52.04 N 069 53.91 W				
6 1	100207 1034	BE 39 47.54 N 069 51.03 W		1437		
6 1	100207 1113	BO 39 47.50 N 069 50.35 W	35	1495	1386	
6 1	100207 1218	EN 39 46.35 N 069 50.14 W				
7 1	100207 1324	BE 39 42.05 N 069 47.92 W		2086		
7 1	100207 1414	BO 39 41.11 N 069 47.98 W	31	2335	2079	
7 1	100207 1513	EN 39 40.23 N 069 48.79 W				
8 1	100207 1710	BE 39 28.63 N 069 38.54 W		2411		
8 1	100207 1756	BO 39 28.26 N 069 38.61 W	9	2400	2426	
8 1	100207 1902	EN 39 28.19 N 069 38.59 W				
9 1	100207 2029	BE 39 21.17 N 069 32.44 W		2497		
9 1	100207 2116	BO 39 21.30 N 069 32.50 W	5	2442	2466	
9 1	100207 2223	EN 39 21.57 N 069 32.59 W				
10 1	100307 0109	BE 39 05.27 N 069 20.81 W		2970		
10 1	100307 0206	BO 39 05.36 N 069 20.03 W	8	3021	3006	
10 1	100307 0329	EN 39 04.65 N 069 20.00 W				
11 1	100307 0000	BE 38 49.23 N 069 12.04 W		3235		
11 1	100307 0000	BO 38 49.35 N 069 12.31 W	13	3216	3269	
11 1	100307 0000	EN 38 00.00 N 069 12.58 W				
12 1	100307 1126	BE 38 33.67 N 069 00.69 W		3459		
12 1	100307 1236	BO 38 33.84 N 069 00.85 W	11	3460	3501	
12 1	100307 1354	EN 38 34.37 N 069 00.94 W				
13 1	100307 1909	BE 38 19.33 N 068 51.86 W		3820		
13 1	100307 2023	BO 38 19.76 N 068 50.27 W	8	4018	3868	
13 1	100307 2201	EN 38 19.60 N 068 47.92 W				
14 1	100407 0032	BE 38 05.44 N 068 42.47 W		4069		
14 1	100407 0147	BO 38 05.26 N 068 42.42 W	17	4052	4136	
14 1	100407 0323	EN 38 05.39 N 068 42.68 W				

Table 1: continued

Sta-Cast	Date-Time	Position	HaB	Dpth	Wout	(all in meters)
15 1	100407 0526	BE 37 51.56 N 068 30.64 W		4397		
15 1	100407 0654	BO 37 49.82 N 068 27.46 W	15	4920	4464	
15 1	100407 0839	EN 37 48.79 N 068 26.03 W				
16 1	100407 1044	BE 37 37.35 N 068 22.62 W		4583		
16 1	100407 1218	BO 37 35.85 N 068 19.97 W	10	5055	4675	
16 1	100407 1403	EN 37 35.48 N 068 17.68 W				
17 1	100407 1609	BE 37 22.55 N 068 12.68 W		4697		
17 1	100407 1744	BO 37 22.41 N 068 09.81 W	19	5041	4822	
17 1	100407 1937	EN 37 21.47 N 068 08.24 W				
18 1	100407 2307	BE 37 08.35 N 068 03.69 W		4849		
18 1	100507 0040	BO 37 08.73 N 068 02.65 W	9	4961	4988	
18 1	100507 0231	EN 37 08.98 N 068 01.24 W				
19 1	100507 0418	BE 36 53.83 N 067 53.89 W		4880		
19 1	100507 0547	BO 36 53.81 N 067 52.48 W	12	5012	5016	
19 1	100507 0732	EN 36 53.31 N 067 53.31 W				
20 1	100507 0921	BE 36 39.70 N 067 44.34 W		4897		
20 1	100507 1053	BO 36 39.46 N 067 43.05 W	13	5040	5039	
20 1	100507 1241	EN 36 38.95 N 067 41.91 W				
21 1	100507 1538	BE 36 12.37 N 067 27.04 W		4916		
21 1	100507 1707	BO 36 13.35 N 067 27.17 W	13	5017	5045	
21 1	100507 1857	EN 36 14.58 N 067 26.75 W				
22 1	100507 2232	BE 35 43.15 N 067 09.37 W		5033		
22 1	100607 0006	BO 35 42.77 N 067 08.06 W	30	5220	5158	
22 1	100607 0200	EN 35 42.07 N 067 06.73 W				
23 1	100607 0452	BE 35 13.56 N 066 52.39 W		5024		
23 1	100607 0627	BO 35 13.53 N 066 52.27 W	14	5096	5179	
23 1	100607 0816	EN 35 14.02 N 066 51.90 W				
24 1	10060 1142	BE 34 44.42 N 066 34.65 W		5100		
24 1	100607 1314	BO 34 44.43 N 066 33.95 W	13	5210	5258	
24 1	100607 1500	EN 34 44.63 N 066 33.08 W				
25 1	100607 1801	BE 34 15.38 N 066 17.65 W		5140		
25 1	100607 1936	BO 34 14.38 N 066 18.12 W	12	5273	5298	
25 1	100607 2144	EN 34 14.12 N 066 19.19 W				
26 1	100707 0031	BE 33 46.93 N 065 59.70 W		5046		
26 1	100707 0206	BO 33 46.43 N 065 59.16 W	11	5091	5200	
26 1	100707 0407	EN 33 46.48 N 065 58.86 W				