

Cruise report: *R/V Endeavor* cruise no. EN454

Woods Hole to Woods Hole

September 18-24, 2008

Line W: Continuing the measurement program

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WHOI

Background

R/V Endeavor cruise number 454 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 interannual variations in the Northwest Atlantic's Deep Western Boundary Current (DWBC). Our study is documenting for a ten-year period, the temperature, salinity, tracer, and velocity variations of the DWBC about 39°N 70°W by maintaining a 6-element moored array over the continental slope southeast of Woods Hole, and occupying a hydrographic section along this line annually. 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.

Mooring work has been carried out on cruises beginning in May 2004. In May 2008 our cruise on *R/V Oceanus* to recover and redeploy the moorings was seriously impacted by bad weather. Of the planned 6 mooring recoveries and deployments we were only able to recover and deploy 2. Cruise EN454 was added to the Line W program to complete the mooring work. Specifically, one mooring was to be deployed at site W5 (Figure 1), and moorings were to be recovered and replaced at sites W2, W3 and W4. Mooring work was scheduled for daytimes with hydrographic sampling at night as time permitted. Unfortunately, much like back in May, the weather forecast was not promising. Further complicating our planning was the rather severe sea state limitations *R/V Endeavor* has on when the main crane may be used.

Science party:

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Cruise narrative:

R/V Endeavor transited from Narragansett, Rhode Island on September 15 and was loaded with Line W scientific equipment on the 15th — 17th. Departure for Line W occurred on the 18th as planned at 0900 in fine weather. The cruise plan called for transiting to the southernmost mooring site (W5) while running the ship's underway sensors (ADCP in particular) to deploy our first mooring there (the previous mooring at that site had been recovered in May), then work back to the north recovering and redeploying at sites W4, W3 and W2 (Figure 1). The wire for new mooring W4 was wound on the deployment winch prior to our sailing, and the new W5 wire wound on top of W4 during our trip south.

During that first day, winds increased to 25-30 knots out of the N/NE (Figure 2) with accompanying building seas. Overnight, the vessel hove to briefly to secure loose gear then proceeded at reduced speed (~6 knots) due to the sea state. (Winds were opposing the Gulf Stream resulting in a steep, very confused sea state.) Arrival at mooring site W5 (which, due to a northward meander of the current, was near the core of the Gulf Stream, Figure 1) occurred at 1300 local (rather than at first light as was planned). All agreed that conditions were not appropriate for mooring work. And with the strong currents, wind and waves, the Captain deemed it not safe to do CTD work. Rather than simply hove to, we opted to continue steaming southeast along the Line W track to collect ADCP data down to mooring W6, then return to W5 with the hope that conditions would have ameliorated.

By mid-morning on September 20 we had the vessel back to W5, positioned downwind of the target site preparing for a mooring launch but the seas were deemed still too rough to do a safe deployment. *R/V Endeavor* was directed north to W4 in the hope that we could recover that mooring. (Unlike the new W5 mooring, old W4 utilized only glass balls for flotation, not a large syntactic sphere, so the crane was not needed for recovery.) Due to the rough seas, the Captain opted to “tack” to the site, steaming upwind (northeast) then west rather than take the direct course that put the ship “in the trough.” Unfortunately that westward leg was opposed by the Gulf Stream so that our speed over ground was well under 6 knots. It was not until the next morning that we were on station and, thanks to reduced winds and seas, able to work.

Mooring W4 was successfully recovered on the morning of September 21 in 20 knot winds and reduced seas. The wire recovered from old W4 (wound on top of the new wire for W5 and W4, the former on top of the latter) was off-spoiled from the winch and secured, as was the recovered instrumentation and flotation. Running seriously short on time now, we opted to head next for W3, with the realization that the wire shots designed for the upper 3/4ths of mooring W5 (loaded on the winch) were identical to the design and sequence to W3. To optimize available time, we decided to deploy the new W3 mooring before recovering the old, displacing the new deployment site slightly to the southeast, away from the old, to guard against the two moorings fouling.

Rather than use a totally separate lander for the bottom pressure gauge (BPR), we tried an arrangement used successfully in the Arctic in which the BPR sits in a holder attached to the W3 anchor, with a pennant running up and attaching to the acoustic releases. For recovery, the BPR is pulled out of its holder by the pennant and returned to the surface with the mooring. Key to the arrangement is insuring that the pennant doesn't wrap around the anchor chain. This was checked by suspending the releases, chain and anchor, allowing the links to align naturally, then orienting the pennant to run parallel to the chain and securing it. Fortunately the seas had calmed significantly by this time, allowing this to be carried out. Even so, it was a rather dicey operation that couldn't be done in any significant sea state. Anchor over on the new W3 mooring occurred at 10:30 PM on the 21st.

Overnight, we opted to do a CTD station between W3 and W4 (within the Gulf Stream). Failure to appropriately steam on the wire during the station resulted in large wire angles. On approach to the bottom there were several hundred more meters of wire paid out than the depth reported by the CTD. Although the reported CTD depth remained less than that derived from the ship's echosounder, and acoustic altimeter on the underwater package failed to register the bottom, the CTD package was lowered into the "mud" along with many meters of cable. Fortunately none of the instrumentation was lost or damaged and the cast was completed normally. The CTD wire however did suffer significant damage that required re-termination. This episode delayed our return to W4 by about an hour.

By 10AM on September 22 we had *R/V Endeavor* positioned 15 nmi downwind (up current) from the target deployment site for W4. The mooring payout went somewhat longer than anticipated, resulting in the anchor launch about a half mile beyond the target, but within 20 m of the target isobath. Anchor over occurred at 15:22 local. After verifying that the anchor had reached the bottom and disabling the acoustic releases, we returned to W3 to recover the old mooring there. We arrived on site at 6:30 PM, about an hour before dark. Thanks to careful positioning of the ship prior to releasing the mooring, the surface sphere surfaced ~300 m directly ahead. With building wind and seas, we opted to recover the surface sphere through the Endeavor's stern A-frame. This took longer than the normal process of using the crane to lift the sphere over the side, but once accomplished, the rest of the mooring came aboard easily.

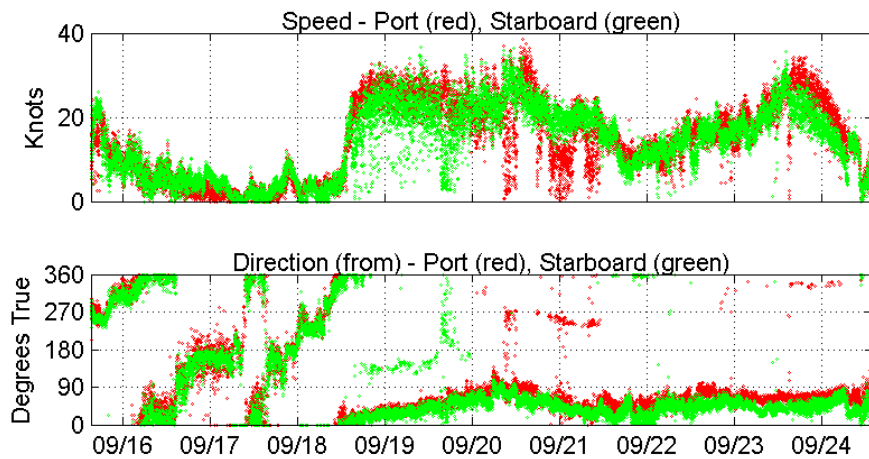
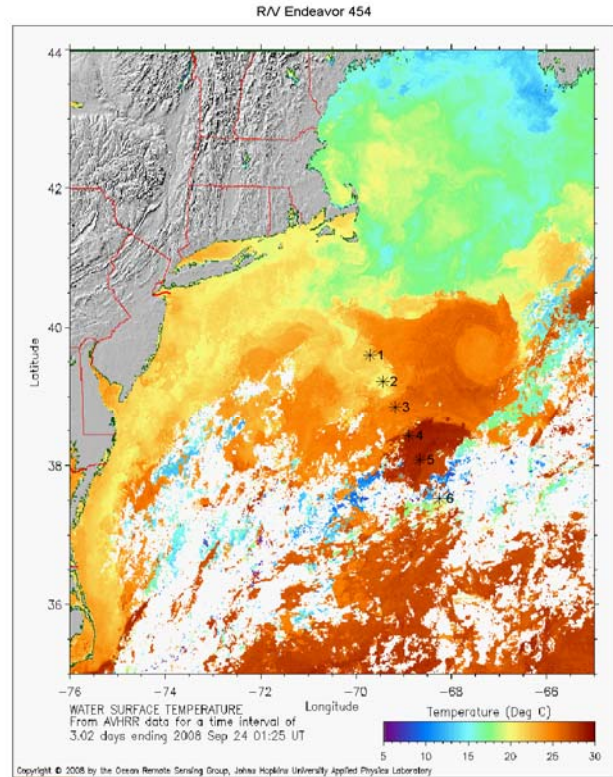
Again overnight, we occupied a CTD station (this time, uneventfully) between moorings W3 and W2 and at first light were positioned downwind of mooring W2 for recovery. By this time, winds had built to ~25 knots with corresponding seas, but the mooring was safely recovered. (The hardest part of the recovery was hooking into the top cluster of glass ball floats – it took 6 passes of *Endeavor* before this was accomplished. Either the grapnels didn't catch, or didn't reach the balls due to line fouling or the ship being positioned too far away.) In light of the marine forecast that was predicting winds increasing to 30 knots and higher for several following days, we were unable to accept the GSO's offer of extending the cruise to complete our mooring work. So at 10:30 AM local, we turned for home, a course that, as is typical, placed the ship in the trough in the building Nor'Easter. With time, however, we moved out of the strongest winds and the ride improved. After a relatively quiet night, we arrived at the WH pier at 0700 local on September 24. *R/V Endeavor* was efficiently offloaded that day and she returned to Narragansett the following morning.

Due to the rough conditions during much of the cruise, we lost the better part of 3 days out of the planned 7-day trip. Conditions/time did not allow us to deploy moorings at sites 2 and 5 as we had planned. Also, we did far fewer CTD casts than hoped for. We are investigating possible ways to complete the moored array installation. The good news is that all mooring data from the first 4 years of the Line W program are now in hand, allowing the scientific analysis to proceed.

Thanks and Acknowledgements

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 grants OCE-0241354 and OCE-0726720 to the Woods Hole Oceanographic Institution. The study contributes to the U.S. CLIVAR program and the U.K. RAPID study.

Figure 1. Satellite-derived sea-surface temperature map for the cruise period. Red colors denote warm temperatures, blue cooler. The sites of the Line W moorings are indicated. During EN454, we were able to recover and redeploy moorings at sites 3 and 4, recover a mooring at site 2, and occupy 2 CTD stations. Conditions/time did not allow us to deploy moorings at sites 2 and 5.



14:09:30 24-Sep-2008 (UTC)

Figure 2. True wind speed and direction recorded by the two sensors mounted on R/V Endeavor (port and starboard) during cruise EN454.