an
Interdisciplinary Study of Warm Core Ring
Physics, Chemistry and Biology

CRUISE REPORTS

RV/ ENDEAVOR - RV/ATLANTIS II
SEPTEMBER/OCTOBER 1981

CRUISE REPORT

ENDEAVOR CRUISE NO. 74, 9/12/81 - 10/2/81

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1. CRUISE NARRATIVE

At 1300 hours on 12 September 1981 (day 255) the research vessel ENDEAVOR departed Woods Hole for a 22 day cruise to study the physical, chemical, and biological structure of warm core ring 81-D. The cruise was the first of 5 ENDEAVOR cruises planned as part of the NSF/NASA-sponsored Warm Core Ring study. The ATLANTIS II also took part in the field study. The details of the AII work will be presented in a separate report.

The mission of the ENDEAVOR was to rapidly survey the warm ring, making underway measurements of surface temperature, salinity, and chlorophyll as well as vertical profiles of near-surface currents and hourly expendable bathythermographs (XBT's). Following this, three sections through the ring were to be made with two casts/station: cast 1, a deep (to the bottom) Conductivity, Temperature, Depth, Oxygen (CTD-O2) cast with 24 water samples collected on the way up; cast 2, a shallow (120 m) cast with a Bio-Optical Profiling System (BOPS) with 11 water samples per cast. At a number of stations in this survey vertical profiles of ocean turbulence with a device called CAMEL were to be made. Drifters were also to be launched in the ring center and in the high velocity region. Two drifters were aboard: a radar drifter with an active radar transponder, and a LORAN-C drifter which would record its LORAN position and telemeter its position back to the ENDEAVOR when within VHF radio range. Two multi-ship experiments in the ring core and frontal boundary were planned as well as upstream and downstream CTD sections on either side of the ring. Arrangements were also made to share enough data with the National Marine Fisheries Service so that one of their ships, ALBATROSS IV, could study the interaction of the ring with colder waters of continental shelf origin. An overflight of the ring by the NASA Wallops P3 aircraft, during the second multi-ship exercise, was also planned.

Overall, the ENDEAVOR accomplished most of its objectives. With the aid of satellite infra-red images we located the ring and did our first XBT survey in the shape of a 5 pointed star. Fifty-four XBT's were used in this star pattern. The doppler current profiling system (APOC) worked and except for occasional problems with the pump in the uncontaminated seawater system, the surface measurement program operated without mishap.

Following the XBT star stations were taken in an asterisk pattern with 26 CTD and BOPS casts & 18 CAMEL profiles. The first multi-ship experiment was postponed, and the second XBT star pattern was run in order to verify that the ring was being temporarily engulfed by the Gulf Stream and was no

longer a separate entity in the Slope Water. During this second XBT star pattern the regular, or contaminated, seawater system was used due to increased air being taken into the pump at the intake end of the uncontaminated water. At this time also the weather began to deteriorate as one of several low pressure systems encountered during the cruise passed overhead. The strong winds reduced the speed we could make to at times 6 kts. Therefore the second star pattern lacked the symmetry of its predecessor.

On 26 Sept. the ENDEAVOR and ATLANTIS II rendezvoused at the ring center. The LORAN and radar drifters were launched by ENDEAVOR, tethered together, and drogued at 100 m depth using a windowshade drogue. We then began a pattern in the shape of a + with the drifters at the center. The CTD was continuously raised and lowered between the surface and 325 m while the ship was underway at a speed of 2 kts. Each leg of this CTD tow-yo was 6 nms. long crossing at right angles at the drifter. BOPS stations were made at the center and extremes of the pattern. By this time the seawater leak through the BOPS pressure case had been corrected, and the optical characteristics of the variability at the ring core were measured. Two CAMEL profiles were obtained at the ring center.

The following morning the two ships began the second multi-ship study to the north in a region of high currents and interleaving of ring and Slope water masses. The same procedure was repeated as on the previous day except tow-yos were also made between two pairs of the ends of the + pattern giving it a bowtie appearance. These two additional tracks were oriented nearly north/south at right angles to the current which was measured by both the doppler system and by the drifter track to be 1 m/s to the east. The CAMEL was successfully tow-yoed on one of the legs, and four turbulence profiles were obtained. Of interest in the study was the structure of water mass intrusions at the ring boundary. Between 65 and 150 m depth, a cold intrusion of 16 Deg water overlay a warm one of 18 Deg. The BOPS casts penetrated the cold layer but not the entire warm one. All CTD tow-yo's were to about 325 m. As before the LORAN drifter recorded data during its eastward drift although no data were telemetered to the ship in real time.

Upon completion of our work in the second MS experiment the drifters were recovered and the ENDEAVOR departed the region of the ring to make a northward section to the west starting in the Sargasso Sea and ending at the continental shelf break. This section was made along 66 Deg West and consisted of 10 stations. Following this section ENDEAVOR

steamed for Woods Hole arriving at 0630 local time on 2 October.

What we did not accomplish of our original schedule was a second CTD section to the east of the ring. The deletion of this was necessitated by a greater distance to the ring site (63-64 W instead of 68-70W as planned), the large size of the ring and the need to cover a greater area in our survey, and finally bad weather which caused 12 hours of time lost while we were hove to and reduced speeds at other times. The NASA P-3 overflight was also scrubbed due to problems with the laser and power supplies. We hope to reschedule one or more flights to coincide with one of our early cruises in 1982.

Four different projects were aboard ENDEAVOR during the cruise: CTD/XBT/APOC doppler from WHOI, BOPS from Scripps, Camel from U. British Columbia, and LORAN drifter/communications from RSMAS, U. Miami. A summary of each of these and other activities will follow.

2.XBT DATA SUMMARY

All 146 XBT's shot on the cruise were the T7 type with a penetration depth in excess of 750 m. The first 55 were digitally logged on a Sea Data cassette tape using a Bathysystems recorder loaned to us by T. Rossby of URI. Due to an improperly mounted cassette tape no digital data were logged for the remaining XBT's. During the cruise selected isotherm depths were manually read off the analog recording and sent out to all warm rings participants via Telemail. These data proved to be useful to those ashore as well as at sea in describing the thermal structure of the warm core ring. Table 1 summarizes the times and positions of the XBT's and includes comments as to what was going on at the time that they were taken.

3.CTD DATA SUMMARY

A total of 41 CTD-02 stations were occupied during the cruise. Stations 1 and 2 were test stations in the Slope Water to the west of the ring. Stations 3-28 were part of the asterisk pattern at the site of the ring. Station 29 was at the ring center prior to the first multi-ship experiment and stations 30 and 31 were tow-yo's at the ring center and northern high velocity region, respectively. The remaining 10 stations were part of a section to the west of the ring from the Sargasso Sea to the continental shelf. The stations are

summarized in Table 2. These consecutive station numbers were used to denote casts made by other instruments: BOPS & CAMEL.

4. UNDERWAY CURRENT PROFILING AND SURFACE SALINITY DATA

Using a WHOI-built data logger and an Ametek-Straza acoustic doppler current meter, which was mounted in the transducer well, a continuous record of upper ocean currents was obtained throughout the cruise. The maximum depth to which the 300 khz system could profile was approximately 130 m. Data were digitally recorded on 45 1200 ft. length nine track tapes, along with ship gyro readings, LORAN and SATNAV positions, and transducer temperatures. The latter when combined with surface salinities will be used for underway mapping of surface (or actually hull depth, 5 m) temperature and salinity changes along the cruise track. The thermo-salinograph used was an old Flessey model which output to a strip chart recorder. Water for this system was pumped through a separate intake at the seawater chest, and was shared with the underway chlorophyll measurements described below. Due to excessive air drawn in at the intake, the self-priming pump was unable to maintain water pressure. Between the first and second XBT stars we switched to the ships seawater for the remainder of the cruise. While underway hourly water samples were withdrawn and the salinometer record annotated for calibration of the conductivity cell.

5. WATER SAMPLING AND THERMOMETRY

A General Oceanics Rosette equipped with 1.2 liter Niskin bottles was used to collect 24 water samples at selected depths at each CTD station. Salinities were measured with a Guildline 8400 Autosol and calibrated with IAPSO standard water. Salts are accurate to $\pm .003$ practical salinity units (psu). Oxygen samples were analysed using a modified Winkler method and amperometric end point determination. Reproducibility using this method is $\pm .01$ ml/l and the results are believed accurate to better than 2 percent. Nutrient samples were collected in aged, acid rinsed, high density polyethylene bottles and frozen within 1 hour for later analysis on an autoanalyser at URI for nitrate, nitrite, phosphate, and silica concentrations. Temperature and pressure were measured at three depths/ station for calibration of the CTD sensor, using two protected and one unprotected reversing thermometers. Temperatures were read to .001 Deg C and are considered accurate to ± 0.01 Deg C. Pressures were calculated from paired protected/unprotected thermometers and

are accurate to within 0.5 percent. The distance between the CTD package and the ocean bottom was measured with a "bottom finding" pinger, and at most stations the deepest sample was collected within 10 meters of the bottom.

6. BIO-OPTICAL MEASUREMENTS

Measurements were made in an effort to define the biological and optical characteristics of warm core ring 81-D. The ship measurements are expected to augment remote sensing investigations using the Nimbus 7 Coastal Zone Color Scanner (CZCS) images and an aircraft LIDAR system which, due to instrument problems, did not fly. Several measurements with a hand held Contrast Reduction Meter were made on suitably clear days. These measurements allow calculation of the transmittance of the atmosphere, which is crucial for CZCS calibration.

Along-track ship measurements were logged by a minicomputer system and stored on floppy disk every 1 minute for the duration of the cruise. For several legs during the multi-ship experiments the sampling rate was increased to once per second. The data recorded include: fluorescence from four Turner Design fluorometers, ship's position, surface (5 m) temperature, total irradiance, and ultraviolet irradiance (200-400 nm). Each of the four fluorometers was keyed to different aspects germane to phytoplankton study:

	excite,nm	emit,nm	reference
TD1 chlorophyll	450 broad	685	366
TD2 chl	450 narrow	685	366
TD3 phycerythin	530	580	ND+Wratten8
TD4 fucoxanthin	530	580	366

It had been planned to log along track salinity and selected meteorological measurements, but these systems were not operative.

A water sample was taken every hour from the ship's seawater system in order to make discrete chlorophyll measurements. These (approx 800) samples will allow calibration of the along track data. In addition several non-standard chlorophyll analysis procedures were made for intercomparison, including grinding and no-grinding techniques.

The bio-optical profiling system (BOPS) measures pressure and spectral irradiance at 12 wavelengths in the visible region and one wavelength (380 nm) in the ultraviolet. Also on

the BOPS are temperature and conductivity probes, a transmissometer (660 nm), a fluorometer, and an 11 bottle rosette. A total of 46 casts were made to either a depth of 120 or 200 m. The downcast profile was recorded once per second, displayed on a Hewlett-Packard 9845 minicomputer, and used for deciding depths for discrete samples which were collected on the way up. Discrete chl were done on all samples including frequently the 150, 200, & 250 m bottles from the CTD Rosette. Salt samples were periodically taken for calibration of the BOPS conductivity probe. Profiles to 200 meters were made at CTD stations 1, 3, & 5. Bottle casts alone were made at stations 6-16 and 18-27 due to leaks in the pressure case of the spectroradiometer. This was repaired so the profiles were again logged from stations 28-36. After another leak developed, bottle casts were made for stas. 37-41. At thirty-one of the stations, water samples from 10 and 50 m depth were filtered for P. Blackwelder who will study coccolithophore populations. At nineteen stations water samples were frozen of both filtered and unfiltered surface seawater. These were done at the request of NASA for use with their LASER/LIDAR studies.

7. OCEAN TURBULENCE STUDIES

CAMEL II is a free-falling ocean microstructure profiler. It measures two components of vertical shear on scales from 0.01-2 meters, temperature, and vertical temperature gradient on scales larger than 0.01 meters. Twenty-one profiles were made during the CTD surveys. Measurements were made from the surface to depths of 1000 m. The profiles are listed in Table 3. Camel tow-yo's to 400 m depth were made during both multi-ship experiments. Two profiles were obtained at the ring center during the 1st MS expt. and 4 during the 2nd MS expt at the ring boundary.

8. DRIFTERS

Two drifters were tethered together and deployed during the two multi-ship experiments: a radar transponding drifter from WHOI which was drogued at 100 m depth with a window shade drogue, and a LORAN-C drifter from the U. of Miami that internally recorded its LORAN-C position. Although the latter buoy has the capability of telemetering its position back to the ship using VHF, this was not used due to interference problems between the buoy electronics and the telemetry transmitter. It is anticipated that this problem will be solved for the later cruises. The LORAN drifter faithfully

recorded its position during both deployments.

9. COMMUNICATION

Using an LSI computer and the ATS satellite link all sea surface temperatures and depths of selected isotherms from the ENDEAVOR XBT's were transmitted to P. Eden and subsequently distributed to other investigators in the Warm Core Ring Program via TELEMAIL. In addition data were received via the U. of Miami from satellite infra-red and CZCS imagery. Imagery interpretations were also telecopied via URI from the NMFS group in Narraganset RI. These data allowed us to update the evolution of ring 81-D with a time scale of several days. The major limitation was the constant cloudy, rough weather which masked the ocean thermal signature and stressed the satellite antenna aboard the ship to the point that it had to be overhauled several times during the cruise. Once the ship's ATS system is rebuilt and properly tuned the satellite/telemail link should be more useful in guiding our seagoing sampling. Two times during the day a schedule was kept on the ship's single sideband with the AII and the ALBATROSS IV. The VHF radio was used for scientific communication only during the two multi-ship experiments.

10. PARTICIPANTS IN SCIENTIFIC PARTY

The members of the scientific party aboard cruise number 74 of the R/V ENDEAVOR and their institutional affiliations are listed below.

1	Terrence Joyce	WHOI
2	Raymond Schmitt	WHOI
3	Marvel Stalcup	WHOI
4	Robert McDevitt	WHOI
5	Jane Dunworth	WHOI
6	William McMahon	WHOI
7	David Bitterman	AOML
8	Raymond Smith	Scripps
9	Karen Baker	Scripps
10	Jeffrey Star	Scripps
11	Kevin Leamam	RSMAS U MIAMI
12	Robert Evans	RSMAS
13	Owen Kennedy	RSMAS
14	Rolf Lueck	U Br. Columbia
15	Richard Noel	U Br. Columbia
16	David Nelson	URI

11. ACKNOWLEDGEMENTS

The scientific party aboard the ENDEAVOR gratefully thanks captain Jack Tate, master and all the officers and crew of the ENDEAVOR for their cheerful cooperation and competence. The research program was funded by the National Science Foundation as part of the WARM CORE RINGS PROGRAM. We also gratefully acknowledge support of the bio-optical and acoustic current profiling work by the National Aeronautics and Space Administration and the Office of Naval Research for supporting development of the CAMEL.

ENDEAVOR 74 REPORT
WARM CORE RINGS TJ

TABLE 1 XBT STATION SUMMARY

XBT#	DAY	TIME	LAT DEG, MIN	Lon DEG, MIN	COMMENTS
001	256	1729	39, 44.3	-66, 45.4	TEST STA 1
002	257	1000	39, 00.03	-65, 00.1	XBT STAR 1
003	257	1100	39, 12.5	-64, 55.3	
004	257	1200	39, 23.2	-64, 50.5	
005	257	1300	39, 35.6	-64, 45.6	
006	257	1400	39, 48.7	-64, 40.3	
007	257	1500	40, 02.5	-64, 33.6	
008	257	1600	40, 16.6	-64, 27.6	
009	257	1700	40, 30.2	-64, 21.3	
010	257	1800	40, 43.6	-64, 15.7	
011	257	1900	40, 58.2	-64, 09.9	
012	257	2000	41, 11.9	-64, 04.0	
013	257	2100	41, 25.2	-63, 57.7	END 1ST LINE
014	257	2200	41, 18.9	-63, 53.8	
015	257	2300	41, 16.1	-63, 55.8	
016	258	0000	41, 07.9	-63, 54.1	
017	258	0100	40, 54.7	-63, 46.9	
018	258	0200	40, 42.7	-63, 38.5	
019	258	0300	40, 29.5	-63, 33.0	
020	258	0400	40, 17.5	-63, 28.5	
021	258	0500	40, 04.6	-63, 23.7	
022	258	0600	39, 49.9	-63, 17.8	
023	258	0700	39, 35.4	-63, 14.3	
024	258	0800	39, 22.1	-63, 09.8	END 2ND LINE
025	258	0900	39, 09.0	-63, 03.9	
026	258	1000	39, 13.5	-63, 13.7	
027	258	1100	39, 20.5	-63, 28.2	
028	258	1200	39, 27.4	-63, 40.6	
029	258	1300	39, 37.5	-63, 53.5	DR
030	258	1400	39, 47.3	-64, 06.7	
031	258	1500	39, 56.2	-64, 20.2	
032	258	1600	40, 04.3	-64, 35.8	
033	258	1700	40, 11.5	-64, 49.5	
034	258	1800	40, 19.3	-65, 05.9	
035	258	1900	40, 26.2	-65, 19.3	END 3RD LINE
036	258	2000	40, 26.7	-65, 03.0	
037	258	2100	40, 26.7	-64, 45.7	
038	258	2200	40, 27.1	-64, 27.6	
039	258	2300	40, 27.0	-64, 08.6	
040	259	0000	40, 26.8	-63, 52.1	
041	259	0100	40, 26.6	-63, 32.5	
042	259	0200	40, 27.4	-63, 13.8	
043	259	0300	40, 26.7	-62, 56.9	END 4TH LINE
045	259	0406	40, 25.	-62, 40.	XBT 44 DUD
046	259	0500	40, 19.1	-62, 51.7	
047	259	0600	40, 11.7	-63, 06.1	

ENDEAVOR 74 REPORT
WARM CORE RINGS TJ

048	259	0700	40,04.5	-63,21.1
049	259	0800	39,57.4	-63,36.1
050	259	0900	39,51.1	-63,50.6
051	259	1000	39,44.6	-64,05.1
052	259	1100	39,38.7	-64,18.9
053	259	1200	39,32.3	-64,31.0
054	259	1300	39,22.9	-64,43.5
055	259	1400	39,13.6	-64,54.9
056	261	2300	40,34.4	-62,23.4
057	262	0100	40,10.8	-62,16.3
058	267	0200	40,13.2	-62,56.1
059	267	0300	40,06.3	-62,42.7
060	267	0400	40,01.1	-62,33.3
061	267	0500	39,54.7	-62,22.5
062	267	0600	39,54.9	-62,36.7
063	267	0700	39,54.9	-62,51.6
064	267	0800	39,55.0	-63,05.5
065	267	0900	39,55.8	-63,19.0
066	267	1000	39,56.1	-63,32.7
067	267	1100	39,56.4	-63,46.5
068	267	1200	39,56.2	-64,01.7
069	267	1300	39,56.2	-64,16.6
070	267	1400	39,56.3	-64,30.6
071	267	1500	39,56.1	-64,43.6
072	267	1600	39,56.0	-64,57.6
073	267	1700	40,02.7	-64,48.7
074	267	1800	40,09.6	-64,34.6
075	267	1900	40,17.6	-64,20.8
076	267	2000	40,24.0	-64,08.2
077	267	2100	40,31.5	-63,54.0
078	267	2200	40,37.7	-63,40.4
079	267	2300	40,43.4	-63,25.4
080	268	0000	40,49.3	-63,11.0
081	268	0100	40,58.4	-62,58.6
082	268	0200	40,55.1	-62,55.6
083	268	0300	40,43.6	-62,59.0
084	268	0400	40,32.9	-63,03.3
085	268	0500	40,20.5	-63,08.8
086	268	0600	40,08.8	-63,14.3
087	268	0700	40,00.1	-63,18.9
088	268	0800	39,52.1	-63,16.6
089	268	0900	39,43.9	-63,12.6
090	268	1000	39,35.3	-63,07.3
091	268	1100	39,26.4	-63,02.4
092	268	1200	39,20.1	-63,04.0
093	268	1300	39,18.0	-63,10.1
094	268	1400	39,15.7	-63,18.0
095	268	1500	39,12.8	-63,25.0
096	268	1600	39,17.2	-63,29.8

END XBT STAR
BETWEEN CTD'S

TO XBT STAR

XBT STAR 2

END 1ST LINE

END 2ND LINE

END 3RD LINE
INTO G. STRM.

ON 4TH LINE

ENDEAVOR 74 REPORT
WARM CORE RINGS TJ

097	268	1700	39,23.1	-63,34.6	
098	268	1800	39,28.9	-63,40.3	
099	268	1900	39,34.9	-63,46.3	
100	268	2000	39,42.0	-63,53.0	
101	268	2100	39,48.6	-64,00.0	
102	268	2200	39,56.4	-64,04.6	
103	268	2300	40,04.8	-64,08.1	
105	269	0000	40,13.8	-64,12.2	#104 A DUD
106	269	0100	40,22.6	-64,15.7	
107	269	0200	40,31.3	-64,19.4	
108	269	0300	40,39.6	-64,23.0	
109	269	0400	40,48.0	-64,26.5	END 4TH LINE
110	269	0500	40,49.7	-64,15.5	
111	269	0600	40,49.4	-64,04.4	
112	269	0700	40,43.3	-63,56.7	
113	269	0800	40,35.1	-63,52.4	END STAR 2
114	270	0200	40,36.5	-64,03.6	TO 2ND MS EXP
115	270	0300	40,48.0	-64,01.4	
116	270	0400	41,00.4	-64,00.2	
117	270	0500	41,11.0	-64,00.0	
118	270	0530	41,16.8	-64,00.3	
119	270	0600	41,22.3	-64,00.2	
120	270	0700	41,16.9	-64,10.8	
121	270	0730	41,11.1	-64,11.4	
122	270	0800	41,05.9	-64,11.0	
123	270	0830	41,05.2	-64,01.7	END SURVEY
124	271	0400	40,56.1	-63,37.0	TO SARGASSO S
125	271	0500	40,45.0	-63,44.0	
126	271	0600	40,32.9	-63,52.4	
127	271	0700	40,21.3	-64,01.4	
128	271	0800	40,09.9	-64,09.3	
129	271	0900	39,59.0	-64,16.8	
130	271	1000	39,47.9	-64,23.8	
131	271	1100	39,36.5	-64,29.8	
132	271	1200	39,26.5	-64,35.0	
133	271	1300	39,15.6	-64,42.9	
134	271	1400	39,04.4	-64,49.3	
135	271	1500	38,54.0	-64,55.7	
136	271	1600	38,43.8	-65,01.2	DUD
137	271	1700	38,33.1	-65,06.7	
139	271	1800	38,24.0	-65,12.0	138 A DUD
140	271	1900	38,15.9	-65,17.2	
141	271	2000	38,06.7	-65,22.6	
142	271	2100	37,56.7	-65,29.0	
143	271	2200	37,47.2	-65,34.9	
144	271	2300	37,36.9	-65,41.3	
145	272	0000	37,27.5	-65,47.6	
146	272	0100	37,18.1	-65,53.8	
147	272	0200	37,08.9	-66,00.2	END SECTION

ENDEAVOR 74 REPORT
WARM CORE RINGS TJ

TABLE 2 CTD STATION SUMMARY

CTD#	DAY	TIME	LAT DEG, MIN	LON DEG, MIN	COMMENTS
01	256	1330	39, 44.3	-66, 45.4	INST 3 TEST
02	257	0233	39, 20.4	-65, 50.7	INST 7 TEST
03	259	1425	39, 13.6	-64, 54.9	MAX PR=4920.3
04	259	2131	39, 26.0	-64, 41.0	4922.
05	260	0334	39, 40.9	-64, 20.9	4923.5
06	260	1002	39, 53.9	-64, 00.0	4924.2
07	260	1532	40, 06.1	-63, 45.4	4861.
08	261	2138	40, 20.2	-63, 26.4	4738.5
09	261	0355	40, 34.2	-63, 07.1	4663.1
10	261	1044	40, 48.5	-62, 50.0	4528.3
11	261	1637	41, 02.0	-62, 32.0	4431.5
12	262	0327	39, 46.9	-62, 05.5	5087.8
13	262	0836	39, 51.5	-62, 30.5	3805.3
14	262	1357	39, 55.6	-62, 54.5	3002.3
15	263	1300	38, 50.0	-63, 19.1	3504.5
16	263	1751	39, 09.0	-63, 26.6	5078.8
17	264	0005	39, 28.7	-63, 28.0	4990.3
18	264	0635	39, 47.8	-63, 42.4	5006.8
19	264	1339	40, 24.9	-63, 51.3	4637.6
20	264	1815	40, 43.4	-63, 55.5	4391.7
21	265	0016	41, 02.5	-64, 02.1	4002.4
22	265	0533	41, 21.7	-64, 11.2	3534.5
23	265	1441	40, 27.2	-65, 25.0	3957.7
24	265	1917	40, 21.8	-65, 00.4	4354.5
25	265	2352	40, 16.8	-64, 35.4	4675.8
26	266	0500	40, 12.0	-64, 10.1	4748.6
27	266	1102	40, 07.1	-63, 45.2	4853.3
28	266	2017	40, 01.4	-63, 19.5	4945.6
29	269	0938	40, 24.1	-63, 56.8	4668.8
30	269	1530	40, 21.4	-63, 56.5	TOW-YO 325.
31	270	1237	41, 12.6	-63, 54.2	TOW-YO 325.
32	272	0230	37, 08.4	-66, 01.1	4761.0
33	272	0830	37, 38.2	-66, 00.0	4508.1
34	272	1440	38, 07.7	-66, 00.2	4882.5
35	272	2220	38, 37.4	-65, 58.2	4696.2
36	273	0500	39, 08.0	-66, 00.2	4671.2
37	273	1125	39, 38.0	-66, 00.3	2969.2
38	273	1705	40, 08.2	-66, 00.0	3740.5
39	273	2249	40, 23.5	-66, 17.0	2741.0
40	274	0446	40, 38.0	-66, 36.3	2105.1
41	274	0900	40, 52.2	-66, 51.1	92.0

TABLE 3 STATION SUMMARY FOR CAMEL II
CAMEL STA CTD STA MAX PR, DBARS

01	01	600
02	03	1000
03	04	1100
04	05	600
05	07	1100
06	08	350
07	09	530
08	10	1100
09	11	500
10	14	1000
11	16	500
12	17	550
13	18	950
14	19	800
15	20	500
16	21	1100
17	25	1100
18	26	600
19	28	800
20	34	800
21	35	500

CRUISE REPORT

ATLANTIS II CRUISE NO. 110, 9/17/81 - 10/7/81

Peter H. Wiebe

Woods Hole Oceanographic Institution

Woods Hole, Massachusetts

Contents

- I. Cruise Narrative
- II. Individual Reports
- III. Scientific Observation Log
- IV. XBT Digitizing Log

I. CRUISE NARRATIVE

AI1 Cruise No. 110, 9/17/81-10/7/81
Peter H. Wiebe

Cruise 110 of the RV/Atlantis II was devoted to the study of Warm Ring 81D and the surrounding Slope Water. It was a coordinated study involving two other ships, the RV/ENDEAVOUR and the RV/ALBATROSS. The overall objective of scientific research aboard the ATLANTIS II was to study the biological and chemical dynamics of phytoplankton and zooplankton populations inhabiting the ring environs and to map their horizontal and vertical distributions, and to study the chemistry of the upper ring water and Slope Water column.

After leaving Woods Hole on September 17, 1981, we steamed east to a Slope Water location ($40^{\circ}10'N$, $63^{\circ}30'W$) about halfway to the ring where we tested equipment and acquired Slope Water data. We worked and steamed our way toward the ring center, but heavy weather hampered our work. The first few days in the ring center was marked by rather haphazard data collection because of poorly running gear, bad weather, and concomitant problems in work scheduling. The poor weather conditions also delayed the ENDEAVOUR and forced us to put off the multi-ship experiment for several days. On the day we picked to do the joint work at the ring center (September 26), the weather cleared, and our instruments began to function reliably. The next day both ships moved to a second location ($41^{\circ}N$, $63^{\circ}40'W$) in the high velocity core of the encircling Gulf Stream remnant to repeat the joint ship work. The joint work in the ring center and in the HVC was very successful. On the ATLANTIS II, the chemists, the phytozooplankton experimentalists and the spatial patterners accomplished most of what was planned.

Following the joint experiments, we continued to work at the HVC and nearly completed a full 48-hour station which involved CTD, radon, and LVFS (large volume filtration system) profiling, experimental work on phytoplankton and zooplankton, and microzoophytoplankton, macrozooplankton, and midwater fish towing with the 1/4m, 1m, and 20m MOCNESS's before a full gale struck and kept us from working for three days. We stayed on at the HVC for about 24 hours before deciding that the time remaining should be spent in the ring center and in the Slope Water. So we steamed towards the ring center, but were held from working there for 36 to 48 hours by the weather. Finally the weather improved to where we could resume work at the ring center; a nearly complete 48-hour station was made before time constraints forced us to move west to a Slope Water station.

We arrived at the Slope Water station ($40^{\circ}08'N$, $66^{\circ}W$) on 3 October and completed a full 48-hour station. Hydrographic and biological condition in the surface waters (upper 100m) at this station seemed abnormal for the Slope Water, and so it was determined that another station approximately 80 nm to the southwest ($40^{\circ}N$, $66^{\circ}W$) should be studied. At this location, a limited set of net tow collections, CTD and radon profiles, and phytozooplankton experimental observations were made. From this last location, we steamed back to Woods Hole, arriving on the morning of 7 October, 1981.

Although weather throughout the cruise and instruments initially hindered our studies, we have obtained some very interesting and publishable data concerning the structure and dynamics of Warm Core Ring 81D. For one thing, as a result of the gale, the ring center mixed layer seems to have overturned between the time of the first station and that of the second. The experimentalists have good data from both time points and the initial impression is that the changes in production rates and vertical distribution of phytoplankton species were spectacular. In marked contrast, mixed layer overturn in the Slope Water did not appear to have occurred in response to the gale. The joint ship experiments in the ring center and high velocity core revealed marked differences in the horizontal and vertical structure of the physical, chemical, and biological properties. What remains is the synthesis of results which should provide an understanding of the underlying processes giving rise to the structure.

We have learned a lot about gear-related problems, organizational structure in carrying out the work and what kinds of phenomena we can expect to see and document. We are certainly in good shape to start the planning of next year's cruises; this cruise has given us the information required to make significant improvements in our operations at sea.

Individual cruise reports by the principal investigators on board follow.

II. INDIVIDUAL REPORTS

CTD/Nutrient and Trace Metal Chemistry Dana Kester and Mary Brown

Our water column chemistry on AII-110 consisted of CTD-O₂ profiling, nutrient sampling and analysis, oxygen analysis and sampling for trace metal measurements. Salinity samples were analyzed to provide calibration data for the CTD.

The oxygen, nitrate, nitrite, and salinity measurements were completed on board. The phosphate and silicate will be analyzed on shore. The trace metal samples will be preconcentrated and analyzed for copper, cadmium, and iron.

Fairly good progress was made with the shipboard analytical systems considering the number of days of unworkable weather. A new colorimetric titration technique was used for the Winkler analysis of oxygen which gave a precision of $\pm 0.2 \mu\text{mol/kg}$. The automated analyses for nitrate and nitrite worked very well with results available within one hour of sampling. Phosphate and silicate were noisy and did not provide good results. Some of the noise was associated with ship roll in heavy weather. These automated analyses require improvement.

A microcomputer data reduction system performed very well. It consisted of a 16K CBM PET, a floppy disk drive, a digital plotter, and a printer. It is possible to provide reduced chemical data on a daily basis to allow maximum interaction between analytical results and sampling. A copy machine on board would greatly aid in making these results available to other investigators.

Kester and Brown, Table 1

<u>Station</u>	<u>Region</u>	<u>Cast</u>	<u>No. of O₂</u>	<u>No. of Nutrients</u>	<u>Trace Metals</u>
1	Slope No. 1	919.1	10	10	
2	81-D Center	921.3	7	10	
2	81-D Center	923.4	6	6	
2	81-D Center	923.5	6	6	
2	81-D Center	926.1	12	12	
2	81-D Center	926.2	8	9	
2	81-D Center	926.5	8	8	

<u>Station</u>	<u>Region</u>	<u>Cast</u>	<u>No. of O₂</u>	<u>No. of Nutrients</u>	<u>Trace Metals</u>
2	81-D Center	926.13	4	4	
3	81-D Hi Vel	927.1	11	12	12
3	81-D Hi Vel	927.2	7	6	6
3	81-D Hi Vel	927.3	8	8	8
3	81-D Hi Vel	927.9	6	9	
3	81-D Hi Vel	927.13	4	4	
3	81-D Hi Vel	928.3	10	10	
4	81-D Center	1001.8	12	12	12
4	81-D Center	1002.2	9	9	9
4	81-D Center	1002.6	10	10	10
5	Slope No. 2	1004.1	9	9	9
5	Slope No. 2	1004.2	6	6	6
6	Slope No. 3	1006.1	10	10	
6	Slope No. 3	1006.4	<u>0</u>	<u>6</u>	<u>—</u>
Total			174	176	72

^{222}Rn , ^{226}Ra , ^{228}Ra Chemical Analyses
James Orr and David Schink

I. ^{222}Rn

Six successful profiles were taken in total, two in the high velocity region, one in the ring center and three in the Slope Water at stations five and six. These were all surface ^{222}Rn profiles consisting of eight, 30 liter Niskin bottles hung from the hydrowire spaced logarithmically from the air-sea interface (e.g., 1, 5, 15, 40, 70, 120, 175, 250). At several stations, bottles were placed near temperature and salinity anomalies.

The deep radon casts were not performed due to absence of a pinger. The pinger is essential to obtain 30 l samples very close to the bottom (e.g., 2 or 3 meters). The absence of the pinger was merely an oversight, and will definitely be on the next cruise in April. The pinger would have allowed the collection of some extremely important data reflecting the affect which the ring has upon the vertical eddy diffusibility in the bottom water which the ring passes over.

II. ^{226}Ra

Seven successful profiles were obtained for ^{226}Ra . All ^{222}Rn samples have been run through the manganese-coated acrylic fiber. These fibers will be taken back to the lab and run for ^{226}Ra . Another profile was taken in the ring center just for ^{226}Ra , and this gives us two important ring center profiles.

III. ^{228}Ra

No samples were taken for ^{228}Ra which will allow characterization of the horizontal mixing properties associated with the ring, the Slope Water, and their interaction. The inability of the "Six-Shooter" ^{228}Ra sampling device to collect samples was due to some problem with the motor and pump. This problem may be resolved with a few adjustments, or it may require the utilization of an entirely different pump and/or motor. These problems are relatively minor and should pose no big stumbling block to the preparation of the six shooter for the next cruise.

The six shooter actually did pump through a total of three of the six channels on two profiles before the pump burnout problem was encountered. By these two water tests, we know that the entire six shooter, including the electronics, is totally functional barring the pump and motor difficulty.

Large Volume In Situ Filtration System (LVFS) Sampling James Bishop

The scientific objective of LVFS sampling during the rings program is to understand the chemical, biological, and physical factors governing the distribution, reactivity and sedimentation of oceanic particulate matter.

The LVFS is powered by 480 volt, 3 phase ship's power and is capable of filtering several tens of cubic meters of seawater through a 53 μm Nitex prefilter and two 1 μm glass fiber filters in series. The LVFS may be deployed as deep as 1200m.

LVFS sampling was accomplished but in a reduced manner at the ring center, high velocity region and Slope Water stations. Only 80 percent of planned samples (Table 1) were collected due to poor weather. A further hindrance to our sampling was due to unauthorized use of a 24" McKissick sheave which resulted in its destruction. It took two days to modify another sheave so that our wire could pass through it without damage. All in all, the LVFS performed well during all deployments.

Multi-Unit LVFS (MULVFS) Testing

A single prototype pump module was successfully deployed at 9 and 500m depths (Table 1). System performance was excellent.

Bishop

Table 1.

LVFS and MULVFS Sampling Summary

<u>Location</u>	<u>Station/ OP No:</u>	<u>Depths</u>	<u>Start Position</u>	<u>Start Time</u>	<u>Finish Time</u>
Ring Center	2-0922.01	110,210,350,500	40° 14.7'N 63° 32.8'W	0214	1154
Ring Center	2-0926.09	9 (MULVFS)	40° 21.2'N 63° 59.2'W	1500	1530
Ring Center	2-0926.13	21,35,55,80	40° 22.6'N 64° 03.7'W	1919	2246
High Velocity	3-0927.13	25,40,55,75	41° 05.9'N 63° 39.1'W	1935	2300
Ring Center	4-1001.09	50,150,235,235	40° 26.5'N 64° 25.0'W	2045	0305
Slope Water	5-1003.06	25,45,70,100	40° 16.1'N 65° 54.3'W	1412	1740
Slope Water	5-1004.12	500 (MULVFS)	40° 12/1'N 66° 14.8'W	1940	2257
Slope Water	5-1005.01	500,500-450, 315,210	40° 12.4'N 66° 14.3'W	0017	0827
Slope Water	5-1006.?	Blank at 15m	--	1500	1515

Nitrogen Uptake Experiments
James McCarthy

At all experimental biology stations ^{15}N uptake experiments with $\text{NH}_4^+\text{NO}_3^-$ and urea were conducted. All three substrates were added in trace quantity, and NH_4^+ was also added at saturation levels. concentration of NH_4^+ and urea-N were measured. Remineralization of NH_4^+ by the $<153\ \mu\text{m}$ fraction was determined. Six depths within the euphotic zone at ring center, high velocity region and Slope Water stations were studied from first light to mid-day and mid-day to sunset.

At the two joint ship stations, only NO_3^- and NO_2^- uptake were studied in and above the thermocline. Six depths were sampled first light, mid-day, and late afternoon for uptake measurements.

N_2 fixation by Trichodesmium were measured at ring center and Slope Water stations.

Rates of $^{15}\text{NH}_4$ incorporations into protein were determined at ring center and Slope Water stations.

Size Fractionated Primary Production, Chlorophyll a, ATP, and Cell Numbers
Theodore Smayda, Gary Hitchcock, Christopher Langdon

Ten primary productivity stations were made, eight of which represented morning and afternoon analyses at four stations. The primary productivity of the total phytoplankton community (Z), the $>64 \mu\text{m}$ fraction and $>20 \mu\text{m}$ fraction were measured directly at each station. This procedure will allow estimation (by arithmetic difference) of the primary productivity in the 20-64 μm -size fraction. Productivity measurements were carried out at six to nine depths corresponding to isolume depths ranging from 100 percent to 0.1 percent of incident irradiance. Exclusive of replication, 296 measurements of primary production were made.

In addition, direct measurements of phytoplankton chlorophyll and ATP content were made at all productivity stations, corresponding to 296 direct measurements of these two biomass estimates.

One hundred ten samples were preserved for phytoplankton enumeration; these represent size fractionation of certain productivity populations into the 20-64 μm and $>64 \mu\text{m}$ size classes. This will allow assessment of the floristic composition in these two size classes and their apparent influence on productivity

The results of the ^{14}C uptake experiments and size class fractionation will be determined ashore. The ATP content, with conversion to carbon content, of the phytoplankton established the following:

1. Phytoplankton biomass as carbon in the upper 45m ranged from 1.1gCm^{-2} to 2.8gCm^{-2} at the 10 productivity stations.
2. The $<20 \mu\text{m}$ size class contributed from ca. 70 percent to 95 percent the total phytoplankton biomass as carbon.
3. Afternoon phytoplankton populations were generally more abundant, as carbon, than morning populations.
4. Phytoplankton biomass as carbon differed between the Warm Core Ring center, high velocity edge, and Slope Water.

Shipboard analyses of the chlorophyll data revealed that the contribution of the different phytoplankton size classes to total population abundance differed vertically within the water column at a given station and between stations.

Measurements of photosynthesis and respiration using the planktonic macroalgal species Sargassum natans with Sargassum fluitans were carried out at 23°C , 12°C and 13°C in six experiments. the objective was to establish the Q_{10} for photosynthesis and respiration, and the ratio of these two processes.

Measurements of water column respiration from differences in the oxygen content over suitable incubation periods were determined by oxygen electrode. Such samples were collected from the productivity sample depths, as well as provided by various other samplings of the water column.

Phytoplankton Species Composition Greta Fryxell

In order to assess the changing species composition of the surface and chlorophyll a maximum layers, three tows utilizing the 1/4M² MOCNESS system were taken in the ring center, in the high velocity portion of the ring, and in the Slope Water with its entrainment feature.

Net tows were taken to provide immediate information after microscopic examination and to have sufficient material for various light and electron microscope permanent mounts to be made in the TAMU laboratory. Twelve vertical or oblique tows were made, some in conjunction with zooplankton tows, as time allowed, and living material was shared with those projects isolating cells for clonal cultures (Smayda and Bryzezinski for Nelson).

Discrete water samples were taken in replicate from six to nine depths at six locations, with both early morning and afternoon samples from four of these locations. From these fixed samples, a subset will be selected for cell counts, as time allows, with characterization of the center of the ring, high velocity ring, and Slope Water given top priority.

Total samples include: 3 sets of MOCNESS (1/4M²) samples, 12 net hauls, 76 water samples (replicated), and 100 filtered samples for pilot studies on methods of assessing the smallest, most fragile but productive components of phytoplankton, for about 270 samples, total.

Preliminary Findings

In net hauls, diatoms dominated in the center of the ring. After an apparent overturn of the mixed layer, Thalassiosiras were an important part of the flora. On the contrary, at the high velocity ring, dinoflagellates were impressive in numbers and taxa observed in net hauls, although one would expect there to be enrichment from entrained Slope Water in this area forming other algal groups.

Microscopic examination of living material showed that within the ring, cells clustered in an orderly fashion in a mucuous matrix were common. Two species of Thalassiosiras (diatoms) and at least one coccoid form (possibly a blue-green alga) were noted. Of particular interest were a ciliate filled with green organelles and radiolarians with heavily pigmented monads -- apparently symbiotic relationships worthy of more study.

Silica Uptake and Dissolution Mark Brzezinski and David Nelson

Experiments were performed to measure the uptake of silica by the photoplankton in the euphotic zone and the dissolution rate of particulate silica from 0-600m. These experiments were conducted at all stations within the ring and Slope Water. Additionally, a silica uptake kinetic experiment was conducted at the 60 percent I_0 light depth to test the degree of nutrient saturation in our uptake experiments caused by adding ^{30}Si . We also collected samples to measure the biogenic component of the particulate silica present in the water column.

The samples for silica uptake and dissolution rate measurements were inoculated with isotope and incubated within deck incubators. Light screens were used to simulate the light intensity at depth and circulating sea water maintained the samples at surface water temperatures. Incubations for dissolution rates below the euphotic zone were conducted within laboratory incubators at cooler temperatures. After incubation, the particulate silica present in the samples was collected on membrane filters. In the case of the dissolution experiments, the dissolved silica in the filtrate was extracted. The filters and extracts were stored for later analysis.

In addition, living photoplankton were isolated from the ring center, transition zone, and Slope Water. Over 200 single cell isolations were made representing an estimated 30-40 phytoplankton species. These isolates will be used in laboratory physiology studies.

The following is a synopsis of our sampling effort:

Brzezinski and Nelson

Table 1.

Silica Work:

<u>Date</u>	<u>Station</u>	<u>Si-Dissolution</u>	<u>Si-Uptake</u>	<u>Kinetic-Series</u>	<u>Biogenic-Si</u>
9/23/81	2	12 depths	6 depths	1 depth	12 depths
9/26/81	2	9 depths	9 depths	1 depth	9 depths
9/27/81	3	--	9 depths	1 depth	9 depths
9/28/81	3	8 depths	--	--	6 depths
10/1/81	4	6 depths	--	--	--
10/2/81	4	6 depths	6 depths	1 depth	6 depths
10/4/81	5	12 depths	6 depths	1 depth	12 depths

Brzezinski and Nelson

Table 2.

Phytoplankton Isolation Work:

<u>Date</u>	<u>Station</u>	<u>Number of Isolations</u>	<u>Source of Material</u>
9/23/81	2	29	water bottles
9/26/81	2	31	water bottles
9/28/81	3	43	net haul
9/27/81	3	10	water bottles
10/1/81	4	4	net haul
10/2/81	4	45	net haul and water bottles
10/3/81	4	34	net haul
10/4/81	5	11	net haul

Bio-Optical Activities
Charles Yentsch and David Phinney

Our principal purpose was to classify portions of the Warm Core Ring in terms of the bio-optical properties associated with those water masses. These include a bulk measurement of chloroplastic and water-soluble pigments, light alteration by particulate matter, downwelling and upwelling irradiance, and the action spectra of photosynthesis-photochemistry. Our sea observations fit three separate categories:

(1) Profiling over depth: We have profiled vertically bio-optical properties at eight separate stations situated throughout the ring. This activity included the continuous measurement of chlorophyll, fucoxanthin, phycoerythrin, and temperature as a function of depth. Samples were taken at selected depths of the profile for the measurement of the active spectra of chlorophyll fluorescence for phycoerythrin and the diffuse attenuation coefficient for the particular matter.

(2) Downwelling and Upwelling Irradiance: At each profiling station, a fine wavelength photometer was lowered, and the irradiance attenuation per meter was determined for each wave length. These computations yield total attenuation coefficients per meter for 450, 530, and 670 nm. Upwelling light at these wavelengths was measured by positioning the photodetector to view upwelled radiation.

(3) Underway Continuous Measurements: During the course of the cruise, chlorophyll, phycoerythrins, fucoxanthin, and temperature were measured using the ship laboratory flow through seawater system. This amounts to over 450 hours of data. This, along with total solar radiation, is part of the internal shipboard archive known as "Sail Loop."

Macrozooplankton Feeding and Microzooplankton Distribution Timothy Cowles

The work accomplished on AII No. 110 focused on experimental work with >333 μ m zooplankton and collection of microzooplankton with the MOC 1/4 net system. We obtained grazing rate and egg production rate measurements at most of the major stations, allowing us to compare these rates for organisms found in the different hydrographic regions of the ring and Slope Water. In addition, particle profiles of the water column will permit us to evaluate the relative impact of different sized particulate matter on feeding rates. These particle profiles show good correlation with the chlorophyll data collected by other investigators. An unexpected bonus on this cruise was the opportunity to do a few respiration experiments with the oxygen electrode system developed by Chris Langdon of U.R.I. Respiration rates were determined for a total of five species at three different temperatures.

The stratified net tows done with the MOCNESS 1/4, in collaboration with Michael Roman, will provide excellent documentation for the vertical distribution of small zooplankton in the upper 200m of the water column at all stations (see Roman's report for additional net tow detail). The abundance of juvenile forms at each station will help us to assess the recruitment rate into the zooplankton population at the contrasting positions inside and outside the ring. These distributional data will supplement the experimentally-derived information on egg production by the dominant copepod species.

The following list summarizes the work done at the three main stations -- ring center, high velocity core, and Slope Water:

Cowles
Table 1.

	Ring Center	High Velocity Core	Slope
Particle Profiles	3	1	*
Grazing Experiments	7	3	*
Egg Production Experiments	3 spp	2 spp	3 spp
Respiration Experiments	1 sp	0	4 spp
MOCNESS 1/4 tows	4	3	3

* -- No data due to Coulter Counter Breakdown

Microzooplankton Feeding and Distribution
Michael Roman

Ring-Center:

Day/night shipboard feeding experiments were done with $>333\ \mu\text{m}$ and $>64\ \mu\text{m}$, $<333\ \mu\text{m}$ zooplankton by labelling the natural particulate matter in water collected at the chlorophyll maximum surface and particle maximum (which did not coincide with the chlorophyll maximum). Water used in feeding experiments was analyzed for particulate protein, carbohydrate, lipid, carbon, nitrogen, chlorophyll and bacteria. Grazing rates will be expressed as ml filtered/zooplankton dry weight/hour.

One in-situ grazing experiment profile was done involving depths of 0, 7, 33, and 45m.

We did four daytime MOC 1/4 tows, two of which sampled six irregular intervals and two of which sampled 8, 25m intervals between 0 and 200m.

High-Velocity-Core:

The shipboard zooplankton grazing experiments were the same as those done at the ring center. One in-situ incubation profile was made. Three good MOC 1/4 tows were obtained, two with 2, 37 μm nets on in place of 2, 64 μm nets.

McCarthy and I worked with Trichodesmium at this station. He measured the N_2 fixation. I measured C fixation and ingestion of Trichodesmium by the copepod Macrosetella gracilis.

Slope-Water:

Grazing experiments and in-situ incubations were the same as the previous stations. Three MOC 1/4 tows, one with 37 μm nets on were obtained.

Additional-Work

Bacteria samples were taken at all depths at the experimental biology stations. Thirty-liter casts were made for $>20\ \mu\text{m}$ microzooplankton at the depths of experimental biology stations.

Roman

Table 1

	<u>Ring-Center</u>	<u>High-Velocity</u>	<u>Slope-Water</u> <u>Total</u>
Chlorophylls Particulate	44	10	8 (62)
Carbon Particulate	12	6	4 (22)
Nitrogen	12	6	4 (22)
Protein	18	6	4 (28)
Carbohydrate	18	6	4 (28)
Lipid	18	6	4 (28)
Bacteria	19	12	6 (35)
Shipboard Zooplankton Grazing	60	50	30 (140)
<u>In-situ</u> Zooplankton Grazing	4	4	8 (16)
>20 μ m Microzooplankton Collection	6	6	6 (18)
>64 μ m Microzooplankton Collection	27	36	27 (90)

Macrozooplankton Distributions
Peter Wiebe, Alfred Morton, and Valerie Barber

Macrozooplankton net tow collections were made in the upper 1000m to document their vertical and horizontal structure from the center of ring 81-D out into the Slope Water. Seven double MOCNESS-1 tows were made: three in the ring center, one in the high velocity core, and three in the Slope water. This was a newly-fabricated instrument used for the first time on this cruise. On each tow, 16 depth strata were sampled as the MOCNESS was hauled obliquely from 1000m to the surface: 1000-900, 900-800, 800-700, 700-600, 600-500, 500-400, 400-300, 300-200, 200-175, 175-150, 150-125, 125-100, 100-75, 75-50, 50-25, 25-0. A total of 139 samples were collected on these tows. During the joint experiments with the RV/ENDEAVOUR at the ring center and in the high velocity core, two specialized double MOC-1 tows were made to map the horizontal structure of macrozooplankton in the upper 100m. The MOCNESS was lowered repeatedly to approximately 100m and then raised to the surface, during which time three nets were opened and closed at depths marking strong changes in hydrographic structure. At the ring center, four flights of three nets were obtained along a section about six miles long. In the HVS, only two flights of three nets were obtained along a section about two miles long because a battery pack failure forced termination of the tow. A total of 29 samples were collected on these tows.

A summary to the double MOCNESS-1 tow data is given in Table 1.

One meter diameter net tows were made to a variable set of depths to collect euphasiid species for live experiments and for freezing and subsequent biochemical studies. These tows were non-quantitative, and the portion of the collection remaining after sorting was returned to the sea. The second table contains a list of species names and the number of individuals sorted and frozen from the different hydrographic regimes.

Dates: 17 September - 7 October, 1981

GULF STREAM RING TIME SERIES CRUISE

Table 1

16

[illegible]

Dates: 17 September - 7 October, 1981

GULF STREAM RING TIME SERIES CRUISE

Table 1 (cont.)

17

[illegible]

Wiebe et al.

Table 2

Frozen Animal List

	<u>Stations</u>		
	<u>Ring Center</u> <u>2 Oct. 1981</u>	<u>Slope Water 1</u> <u>3 Oct. 1981</u>	<u>Slope Water 2</u> <u>5-6 Oct. 1981</u>
<u>Euphausia americana</u>	1		
<u>brevis</u>	5		1
<u>hemigibba</u>	2	3	
<u>krohnii</u>		41	164
<u>mutica</u>	1	1	
<u>tenera</u>	16	11	3
<u>Meganyctiphanes norvegica</u>		1	5
<u>Nematoscelis megalops</u>		108	40
<u>microps atlantica</u>	25	2	
<u>microps juveniles</u>	10		
<u>Stylocheiron abbreviatum</u>	3	1	
<u>affine</u>	17		
<u>carinatum</u>	4	5	3
<u>elongatum</u>	25	1	1
<u>longicorne</u>			1
<u>suhmii</u>	2		3
<u>Thysanoessa gregaria</u>		39	17
<u>Thysanopoda tricuspidata</u>	1		

Midwater Fish Studies
Richard Backus and James Craddock

Midwater trawling for mesopelagic fishes was done with the MOCNESS 20 (MOC 20), a scaled-up version of the MOCNESS 10 being used for the first time.

After handling practice and net trials on September 18, September 21, and September 22, we set the MOC 20 with five nets on September 23 in the ring center and made a completely successful tow with all nets opening and closing as planned and five samples taken. Data for this and subsequent tows are as follows:

Backus and Craddock

Table 1

<u>Event No.</u>	<u>MOC No.</u>	<u>Date</u> <u>(1981)</u>	<u>Time</u> <u>(approx)</u>	<u>Position</u>	<u>Remarks</u>
	MOC 20-1	23-24 Sept.	2145-0300	40° 14'N 63° 28'W to 40° 07'N 63° 34'W Ring Center	All Nets OK
3, 928.1	MOC 20-2	28 Sept.	0005-0335	41° 05'N 63° 33'W to 41° 09'N 63° 34'W Ring Flank	All Nets OK
3,928.9	MOC 20-3	28 Sept.	1415-1745	40° 57'N 63° 35'W to 41° 01'N 63° 31'W Ring Flank	All Nets OK
5,1003.3	MOC 20-4	3 Oct.	0725-1130	40° 08'N 66° 00'W to 40° 14'N 65° 57'W Slope Water	Net 4 (250-0m) ripped

5,1003.9	MOC 20-5	3-4 Oct.	2235-0305	40° 15'N 66° 07'W to 40° 23'N 66° 08'W Slope Water	Net 0 (0-1000m) ripped
6,1005.7	MOC 20-6	5-6 Oct.	2320-0335	39° 54'N 67° 42'W to 39° 49'N 67° 36'W Slope Water	All catch in Net 0 0-1000m) and Net 1 (1000-0m)

Thirty-seven neuston tows, generally of half-hour duration, were made at the ring center (15 tows), on the ring flank (5 tows), and in the Slope Water at two locations (17 tows).

Twelve-KHz echo-soundings were made more or less continuously throughout the cruise.

III. SCIENTIFIC OBSERVATION LOG

STA.	OP. NO.	START TIME	DESCRIPTOR	INVESTIGATOR
3	0928.1	0006	MOC-20-2 (0 to 1000m)	Backus and Craddock
3	0928.2	0440	Radon Surface Cast	Orr and Bechtold
3	0928.3	0600	Pump-CTD Profile, 0-100m Chl/Prod.	McCarthy, Yentsch et al.
3	0928.4	0830	Experimental 90L H ₂ O, 35m	Smayda
3	0928.5	0900	Phyto Net 200-0m	Fryxell
3	0928.6	0935	MOC-D1-143 (0-1000m)	Wiebe and Morton
3	0928.7	1225	Light Lower Multi Spectra	Phinney and Yentsch
3	0928.8	1220	<u>In Situ</u> Production and Grazing	Roman
3	0928.9	1415	MOC-20-3 (0-1000m)	Backus and Craddock
3	0928.10	1300	64 μ m mesh net tow; 1/2m ring	Cowles, McCarthy and Roman
3	0928.11	1842	5L Rosette Silica Deep	Brzezinski
3	0928.12	1953	5L Rosette Silica Deep	Brzezinski
3	0929.1	0745	333 μ m mesh net tow to 100m 1m net ring	Cowles and Roman
3	0929.2	0940	30L Niskin Cast, 6 Bott.	Roman and Cowles
3	0929.3	1020	5L Rosette, CTD, CANCEL	McCarthy et al.
4	1001.1	1011	MOC-D1-144 (0-1000m) Aborted, Faulty Batt. Pack)	Wiebe
4	1001.2	1200	0-10-20-30-45-60m Samples Chl., 20 and 45m Production	Fryxell and Smayda
4	1001.3	1130	3, 30L Niskins to 20m	McCarthy
4	1001.4	1330	Phyto and Zooplankton net hauls	Fryxell
4	1001.5	1340	MOC-D1-144A (0-1000)	Wiebe

4	1001.6	1700	30L Hydrowire Radon Cast	Orr
4	1001.7	1800	30L Hydrowire Natural Abundance ¹⁵ N	Altabet
4	1001.8	1817	CTD to 2000m	Brown
4	1001.9	2045	LVFS Cast 4 (50-400m)	Bishop
4	1001.10	2120	Six-Shooter, 10m Test from Crane	Orr and Bechtold
4	1002.1	0434	30L Cast	Roman
4	1002.2	0521	Rosette Cast, 5L for EB	McCarthy et al.
4	1002.3	0720	Pump, CTD	Yentsch
4	1002.4	0855	Secchi Disc Lowering	Yentsch
4	1002.5	0935	<u>In Situ Production and and Grazing</u>	Roman
4	1002.6	1030	1m Tow for Live Animal Work	Wiebe and Barber
4	1002.7	1125	Shallow CTD	Kester
4	1002.8		Shallow CTD/Pump	Yentsch and McCarthy
4	1002.9	1402	Rosette Cast, 5L for EB	McCarthy et al.
4	1002.10	1439	30L Niskin Cast	
4	1002.11	1450	64µm mesh net tow; 1/2m ring	Roman and Cowles
4	1002.12	1600	MOC-1/4-7 (0-200m)	Roman and Cowles
4	1002.13	1515	1m Tow for Live Animal Work	Wiebe and Barber
4	1002.14	1830	CTD, 5L Rosette	McCarthy
4	1002.15	2000	Phytoplankton Net Tow	McCarthy
5	1003.1	0500	1m Net Tow for Live Animal Work	Wiebe and Barber

5	1003.2	0545	30L Shallow Radon Cast	Orr and Bechtold
5	1003.3	0735	MOC-20-4 (0-1000m)	Backus and Craddock
5	1003.4	1030	1m net tow for live animal work	Roman and Cowles
5	1003.5	1200	Light Cast	Yentsch and Phinney
5	1003.6	1400	LVFS Cast 5 (Shallow)	Bishop
5	1003.17	1745	Phytoplankton Net Haul	Fryxell
5	1003.8	1835	MOC-D1-145 (0-1000m)	Wiebe
5	1003.9	2230	MOC-20-5 (0-1000m)	Backus and Craddock
5	1004.1	0315	CTD/Rosette Deep	Kester, Brown and Bates
5	1004.2	0545	CTD/Rosette Exptl. Bio.	McCarthy et al.
5	1004.3	0745	CTD/Silica Deep	Brzezinski
5	1004.4	0820	30L Niskin Cast, Microzoo.	Roman
5	1004.5	0925	64 μ m mesh Net Tow -- 1 cast 35 μ m mesh Net Tow -- to 55m 1/2m ring	Cowles and Fryxell
5	1004.6	1015	Light Cast	Yentsch and Phinney
5	1004.7	1015	<u>In Situ</u> Incubated Grazing	Roman
5	1004.8	1125	1, 30L Niskin, 26m	Cowles
5	1004.9		CTD Pump	Yentsch
5	1004.10		CTD Water Catching	McCarthy et al.
5	1004.11		MOC-1/4-8 (0-200m) MOC-1/4-9 (0-200m)	Cowles and Roman. Fryxell
5	1004.12		Radon, 30L Hydrowire	Orr
5	1004.12		MULVFS Cast 2, to 500m	Bishop
5	1005.1	0005	LVFS Cast 6, to 500m	Bishop

5	1005.2	0920	MOC-D1-146 (0-1000m)	Wiebe
5	1005.3	1335	30L Niskin to 20m	McCarthy
6	1005.4	1930	MOC-D1-147 (0-1000m)	Wiebe
6	1005.5	2240	1m Net tow; 0-100m for live animals	Cowles
6	1005.6	2315	MOC-20-6 (0-1000m)	Backus and Craddock
6	1006.1	0350	CTD, Intermediate Depth	Kester
6	1006.2	0530	30L Shallow Radon Hydrowire	Orr and Bechtold
6	1006.3	0635	MOC-1/4-10 (0-200m)	Cowles and Roman
6	1006.4	0830	Pump/CTD	Yentsch and Phinney
6	1006.5	0930	Natural Abundance Cast/CTD	Altabet
6	1006.6	1010	Light Cast	Yentsch and Phinney
6	1006.7	1025	<u>In Situ</u> Zooplankton Incubation	Roman
6	1006.8	1130	Phytoplankton Vertical Haul	Fryxell
6	1006.9	1450	Group Photo in MOC-20	et al.

IV. XBT DIGITIZING LOG

<u>XBT No.</u>	<u>Date</u>	<u>Time (Local)</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Surface Temp. (°C)</u>	<u>Depth (M)</u>	
						15	10
1	19 Sept.	1651	40°07.6'N	40°08.1'W	25	446	NR
2	19 Sept.	1800	40°08.1'N	63°56.0'W	23.5	NR	NR
3	19 Sept.	1820	40°07.1'N	63°49.3'W	23.4	560	690
4	19 Sept.	1900	40°05.6'N	63°40.2'W	NG	NG	NG
5	19 Sept.	1934	40°09.55'N	63°33.45'W	23.5	545	725
6	19 Sept.	2029	40°09.9'N	63°31.7'W	23.5	525	720
7	19 Sept.	2130	40°05.82'N	63°31.59'W	23.3	528	710
8	20 Sept.	0800	39°49.50'N	63°51.60'W	22.8	466	655
9	20 Sept.	1000	39°59.35'N	63°44.72'W	23	538	733
10	20 Sept.	1100	40°07.14'N	63°36.17'W	22.9	549	705
11	20 Sept.	1200	40°14.68'N	63°27.23'W	23.9	500	685
12	20 Sept.	1800	40°11.8'N	63°36.5'W	23.8	520	687
13	21 Sept.	0707	40°12.2'N	63°32.0'W	23.4	529	NR
14	21 Sept.	1600	40°08.9'N	63°23.1'W	23.8	615	NR
15	22 Sept.	0440	40°12.7'N	63°31.4'W	23.2	489	639
16	22 Sept.	0558	40°11.7'N	63°32.8'W	23.0	506	649
17	22 Sept.	1340	40°13.40'N	63°40.22'W	23.5	535	675
18	23 Sept.	1410	40°22.72'N	63°31.83'W	22.9	450	601
19	23 Sept.	1720	40°20.1'N	63°28.0'W	22.9	444	585
20	24 Sept.	1030	40°10.34'N	63°24.62'W	22.4	400	549
21	24 Sept.	1410	40°07.55'N	63°21.49'W	22.6	400	555
22	24 Sept.	1715	40°00.6'N	63°27.2'W	24.1	410	575
23	24 Sept.	1816	40°03.3'N	63°30.6'W	23.2	410	571
24	24 Sept.	1855	40°10.3'N	63°32.0'W	22.5	400	559
25	24 Sept.	1930	40°13.7'N	63°28.8'W	22.6	394	542
26	25 Sept.	0545	39°58.3'N	63°58.0'W	22.6	75	375
							120/150
27	25 Sept.	0835	40°05.9'N	63°51.14'W	22.3	367	519
28	25 Sept.	0950	40°08.98'N	63°43.97'W	22.4	390	542

XBT No.	Date	Time (Local)	Latitude	Longitude	Surface Temp (°C)	Depth (M)	
						15	10
29	25 Sept.	1100	40°13.60'N	63°29.61'W	22.4	350	519
30	25 Sept.	1230	40°14.2'N	63°34.1'W	22.5	379	562
31	25 Sept.	1430	40°13.14'N	63°44.76'W	22.5	405	580
32	25 Sept.	1733	40°19.3'N	63°39.8'W	22.1	391	570
33	25 Sept.	1900	40°23.9'N	63°30.6'W	20.6	318	502
34	25 Sept.	2230	40°22.55'N	63°52.96'W	22.5	435	581
35	26 Sept.	0615	40°23.9'N	63°57.7'W	22.4	NG; NR	
36	26 Sept.	0635	40°24.0'N	63°57.9'W	22.3	410	570
37	26 Sept.	0715	40°24.5'N	63°54.1'W	22.3	408	573
38	26 Sept.	1748	40°21.54'N	64°04.16'W	22.3	411	563
39	27 Sept.	0718	41°09.8'N	63°53.9'W	22.5	67/150	360
40	27 Sept.	2140	41°04.64'N	63°34.9'W	22.5	175	335
41	29 Sept.	1311	41°00.6'N	63°37.0'W	22.4	82	349
42	29 Sept.	1430	40°47.'N	63°40.4'W	23.5	258	401
43	29 Sept.	1533	40°36.3'N	63°46.7'W	22.8	355	496
44	29 Sept.	1635	40°25.0'N	63°50.7'W	22.2	353	518
45	29 Sept.	1903	40°24.9'N	64°04.1'W	21.5	398	537
46	29 Sept.	2140	40°25.5'N	64°17.8'W	21.5	418	572
47	30 Sept.	2122	40°38.53'N	64°20.24'W	20.8	400	536
48	1 Oct.	0915	40°35.9'N	64°20.9'W	20.9	398	572
49	2 Oct.	2020	40°18.2'N	64°17.7'W	21.8	332	530
50	2 Oct.	2222	40°16.06'N	64°42.58'W	21.0	395	535
51	3 Oct.	0004	40°15.7'N	65°03.9'W	21.4	285	450
52	3 Oct.	0150	40°13.6'N	65°28.2'W	21.4	123	283
53	3 Oct.	0300	40°11.4'N	65°42.8'W	NG probe poss. dud		
54	3 Oct.	0445	40°08.3'N	65°59.6'W	20.6	58	249
55	3 Oct.	1349	40°15.8'N	65°54.3'W	NG probe poss. dud		
56	4 Oct.	1835	40°13.3'N	66°13.5'W	19.9	62	256
57	5 Oct.	1836	39°56.6'N	67°34.0'W	16.6	6,29,32	232

NR - Not Recorded; no value for this temperature

NG - No Good