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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 64-27

NARRATIVE OF CHAIN CRUISE #36

Woods Hole to the Outer Ridge North of Puerto Rico and the Barracuda Fault Area East of the Lesser Antilles, and Back.

WOODS HOLE, MASSACHUSETTS

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Woods Hole, Massachusetts

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NARRATIVE OF CHAIN CRUISE #36

Woods Hole to the Outer Ridge North of Puerto Rico and the Barracuda Fault Area East of the Lesser Antilles, and Back.

4 June - 10 July, 1963

by

Elizabeth T. Bunce

June 1964

This cruise was supported by the National Science Foundation under Grant GP - 1123.

Richard H. Backus

Richard H. Backus, Deputy Chairman
Department of Geophysics

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ABSTRACT

This narrative report of CHAIN Cruise 36 includes the chief scientist's journal, a summary track chart, and a log of stations occupied. The cruise was made in two parts: the first, to the Outer Ridge north of Puerto Rico for seismic reflection and refraction work with ATLANTIS II, and the second from the Outer Ridge to the area of the Barracuda Fault east of the Lesser Antilles for bathymetric and gravity surveys and a detailed geophysical study of the area between 16° and 17°N and 57° and 59°W. The scientific program included echo sounding, continuous seismic reflection profiling, seismic refraction profiles, gravity measurements, dredging, bottom photography, and heat flow measurements.

INTRODUCTION

Between 4 June and 10 July, 1963, the Research Vessel CHAIN engaged in geophysical studies of the Outer Ridge north of Puerto Rico in company with the Research Vessel ATLANTIS II, and in geological and geophysical studies of the section bounded by 16° and 17° N and $57^{\circ}30'$ and 59° W. CHAIN and ATLANTIS II completed a reversed seismic refraction profile on the Outer Ridge north of Puerto Rico along the parallel $21^{\circ}10'N$ between 66° and 67° W. The profile included three 20-mile reversed end-to-end sections and a 60-mile reversed section covering the entire line. The total number of shots made in the refraction survey was 575. CHAIN completed five seismic reflection profiles: a very short profile at the east end of the refraction profile, a profile between 66° and $66^{\circ}30'W$ on $21^{\circ}N$, a profile between $65^{\circ}05'$ and $65^{\circ}30'W$ on $21^{\circ}08'N$, and two short profiles across the Barracuda Scarp. Nineteen stations were made by CHAIN (listed in Appendix I): 12 heat flow measurements with gravity corer, 4 camera-dredge lowerings, 2 dredge hauls without camera, 1 testing of the Leroy bottom sampler. A reconnaissance survey of topographic and gravity trends was made between the Outer Ridge and the area of the Barracuda Fault east of the Lesser Antilles. Two areas of the Barracuda Scarp were investigated in detail.

Chart I summarizes the ship's track. It is taken from Track Charts, Bathymetry, and Location of Observations, CHAIN Cruise No. 36, WHOI Ref. No. 64-10, where detailed track charts and additional information concerning special observations may be had.

The scientific party on board CHAIN was:

Bunce, Elizabeth T., Chief Scientist

Bohlen, Frank

Chase, Richard

Cotter, Robert

Doyle, Alan

Dugan, Everett (until 19 June)

Dunkle, William, (until 19 June)

Hall, John
Kuenzler, Howard
Martin, Barry
Nalwalk, Andrew
Potter, Burt (IBM)
Presberg, David
Scott, Ronald
Wooding, Frank

Three men from ATLANTIS II joined the party on 13 June: Robert de Rivera, Peter Leonard, and Bruce Pratt. Four others joined in San Juan on 17 June: Francis Birch, Robert Geary, Robert Feden, and Larry Wilharm. Wilharm worked on Precision Graphic Recorders for two days while the ship was docked at San Juan.

Several were on board as far as Earle, New Jersey: John Brennan, machinist, working on the trawl-wire meter device; David Caulfield, H. J. Di Giovanni, of Del Electronics, Carlton Grant, Jr., and Hartley Hoskins, working on the Sparker; and A. Lechner, of Electric Boat Company, making measurements of ship noise.

JOURNAL

4 June, Tuesday. We departed Woods Hole at 1300 after a twenty-four-hour delay due to the new array tow cable shipment's being trapped in the holiday time lapse. There was a small confusion at the very moment of departure, when the gyrocompass failed; this was caused by a defective lead in one of the repeaters and was quickly repaired. We are en route to Earle, New Jersey, there to load the powder for the refraction work and the equipment left for us by ATLANTIS II.

The top-lab watches and other assignments are as follows:

0800 - 1200	0000 - 0400	0400 - 0800
<u>2000 - 2400</u>	<u>1200 - 1600</u>	<u>1600 - 2000</u>
Bohlen	Chase	Doyle
Cotter	Presberg	Kuenzler

Dunkle, top-lab chief; Wooding, cameras; Hall, Sparker and Boomer; Nalwalk, back deck and, with Dunkle, refraction work (shooting).

We went through the usual first-day routine of describing the work to be accomplished and the part to be played by each member of the party, as well as ship routine and regulations. This is largely a new group of people, so the rules and regulations pertinent to the handling of explosives and to the shooting procedures will be redescribed often before we join ATLANTIS II.

John Hall and company rigged old fire hose for chafing gear on the Sparker cable, and rigged the tow fish and bridle and their assorted components. At 1730 we started putting chafing gear on the array tow cable. We slid the half-inch steel bridle through the fire hose -- an hilarious performance that eventually required the help of almost the entire scientific complement.

There are some immediate problems. We must find some means of connecting the fish to the bridle for a quick disconnecting process when the array is brought aboard. The array cable will neither flake nor figure-eight on deck and, most serious, the buoyant coating of the tow cable is far too buoyant, we have a sea monster that won't sink; the present Sparker fish is too light for 6-knot speed, needs more weight. The array sounds fine, no apparent hum, we just have to get it below the surface somehow. It should give a good signal-to-noise ratio. I could wish that the two ships' time schedules were not so critical, it would be valuable to try all the permutations of the five-crystal-element mixer system before we start the work on the Outer Ridge.

About a half-hour after we started profiling, the Sparker cable began arcing to the headache ball. We decided to secure; believe the trouble is in the bridle-shackle-cable area and is not a cable break.

Humidity is very high, with thick fog.

Before we had cleared Gay Head we were meeting heavy swells, probably the result of the storm system that did not quite reach Woods Hole, but they were enough to upset the equilibrium of a number of our party. All stood their watches, if a bit painfully. We continue the instruction course in the top lab: PGR (Precision Graphic Recorder) operation, loran, data-logging, tape-recording, shipboard procedure, etc.

5 June, Wednesday. Woke up this morning to find we are still encountering thick fog. Many alarms during the night: steering-engine troubles, a stopped Timesfax clock, and starboard PGR acting up. Because of the last, we shifted echo sounding to the port PGR. Checking the starboard one we found the trouble to be Atlas power supply surges (a problem we had hoped had been cured by lifting the oven leads). Replaced this Atlas with an Altec and tuning-fork supply. The Timesfax inverter (our stand-by power source) is the cause of that trouble, so we have eliminated it.

At 1100 we tied up at the explosives dock at Earle to find two freight cars awaiting our arrival plus a large crane and a loading crew. The powder unloaded from one car, we tackled the second car containing the gear left for us by ATLANTIS II. We had another humorous sequence getting the Debie film developer into the wet lab. Someone else can (a) figure out how we did it and (b) get it out the same way.

Departed Earle at 1530; all kinds of interesting ship traffic as we left. Although there was no fog inshore, we could see it hanging farther out. Ran another school session on PGR and loran techniques. John Hall and Howie Kuenzler are working on Sparker cable changes.

6 June, Thursday. Waked to the unmelodious roar of the foghorn, but the sky is clearing and we should run out of this weather soon. Saw a school of porpoises and one whale (possibly sperm) that obligingly blew and fluked. Quite a bit of ship traffic again this morning. In the afternoon we sighted patches and streamers of sargassum.

A busy day housekeeping in the science areas. Cleaned out and reorganized lower-lab storage. Started putting the refraction receiving equipment together and checking it out, except the hydrophones. The dual Sparker cable is ready to go and a Boomer cable will be ready tomorrow.

We have found that the helix wire supports (spares) do not fit the port PGR drum, the ears must be filed out to fit. A short in the B+ signal supply (port PGR) has been found and repaired. We also continue to work on the problem of sinking the array tow cable. A communication from Hoskins suggests we rasp down the foamed polyethylene jacket (all 800 feet of cable). I think we will attack the problem by other means first. Our major lack is time; we cannot afford to stop for a day and play at various weightings, depths, and speeds, and we must have the array under tow to evaluate any changes. We will effect changes on deck, then slow the ship and put the gear over, test it, bring it aboard, and go to speed again. In this way we will perhaps not lose too much time in our efforts to join ATLANTIS II as soon as possible.

The gravity lab had its problems last night: part of the computer was out of action. We have some noise on our echo sounding records. A moderate swell causes noisy bow transducers and quenching of hull transducer signals, and our 85-foot hoist and towed echo sounding fish are on ATLANTIS II.

One of the crew listening to his short-wave radio heard ATLANTIS II talking to SIR HORACE LAMB, the Lamont ship; they are aware that we are twenty-four hours behind schedule.

7 June, Friday. We are maintaining our headlong progress in the direction of the Outer Ridge and ATLANTIS II. This morning we are in the Hatteras Abyssal Plain, and it seems a good idea to try some high-resolution echo sounding with the Giffit transmitter. Unfortunately for this idea, we are still running into a head sea and swell, and the signal-to-noise ratio does not allow good short-pulse work.

I continued putting together the refraction equipment; today it was the shot-instant transmission and recording set-up. The back-deck party is working on the A-frame sheave and a Boomer fish. Spare man in top lab is painting the deck up there; otherwise we would be working in the next deck down soon, the rust is so thick.

This afternoon we put over a 2X Boomer, which towed in a horizontal attitude, and the array. (The 2X Boomer is a two-transducer Boomer system, the transducers being in parallel.) The array with its present rigging is at least more neutral than positive in buoyancy, but still not good. This rig should be noted, because I doubt we will try it again since it took all hands and the cook to retrieve it. We attached the small (25-pound) depressor about 20 feet forward of the array and on a 10-foot-long line. This carried the array and about 100 feet of cable under; then we paid out about 300 feet more of cable. Intermittent water and tow noise resulted at 3 knots' speed; I suppose, since we cannot see it, that the array is occasionally surfacing. At 6 knots the intermittent noise is more pronounced. The Boomer is

towing very well, but we are getting very poor bottom returns, even at dead slow speed. There are a few too many variables in the present picture to say which is the critical problem. Spent the evening in the top lab getting the port PGR to record properly. This was one trouble with our afternoon recording; the mixer is attenuating the signal badly, apparently there is some exotic mismatch here.

8 June, Saturday. A delightful day, loaded with problems. First the starboard PGR had scale line generator trouble. Then the regulated B+ power supply failed; we replaced it, after it had blown every three-eighths-ampere fuse we put in the signal amplifier supply. Scale lines still missing, so those electronic geniuses, Dunkle, Nalwalk, and Bunce attempted to reset them according to the PGR manual. Found no dark and light line control, the 240 cps output is unstable, so there was no 80 cps trace. We put in the spare scale line generator whose bias control unfortunately causes a very pink blush on the 1000-fathom sweep, but it will have to do while we work on the first one.

Barry Martin stopped by to see the top lab operators and spent until midnight working on the scale line generators. He is making progress. Howie Kuenzler got one operating during the morning 4-to-8 watch. Barry found the basic trouble to be a regulated power supply that is putting out the wrong voltage.

During the afternoon and evening we also coped with profiling recording problems too many to detail here, but I suspect one solution is to eliminate the single-crystal and mixer operation since we have loading problems in the mixer-amplifier circuit as well as horrendous 60 cps hum.

At 1200 today we contacted the ATLANTIS II by voice radio and scheduled another contact for 0900 tomorrow. Dave and I compared notes on our profiling problems and possible solutions for them.

9 June, Sunday. The radio contact with A-II has resulted in some changes in our operating plans. We will shoot one east-west refraction line rather than two, and will do so along $21^{\circ}10'N$, from 66° to $67^{\circ}W$. This is on the southern edge of the shallow mantle area (confirmed by gravity measurements on CHAIN cruise #34) and very close to our earlier refraction determinations (Moho data). According to our CSP work of CHAIN cruise 34, we should also be in the area of least confused or least rough basement topography.

Today Dave and the A-II will set four marker buoys at roughly 20-mile intervals along $21^{\circ}10'N$ for our receiving positions and as navigation reference points along the profile. We are still about eighteen hours' steaming from the eastern terminus of the line and will rendezvous there at 0400 tomorrow.

All of us have spent the day getting refraction instrumentation checked out (both shooting and receiving set-ups), working on CSP (continuous seismic profiling) receiving and recording equipment, going over the necessary changes in watch personnel to cover top lab, main lab, and fantail operations, and making sure everyone understands the safety regulations.

10 June, Monday. At 0400 we made both visual and radio contact with A-II. She was really quite a sight as we closed here: first a glow on the horizon, then the full view of all that expanse of lighted area. It was, as it always is, exciting to meet our own ship and people in the middle of the night in the middle of the ocean. At 0530 I was waked to stagger to the science radio; A-II wanted to effect all the transfers of people, mail, and equipment at 0600. The operation resulted in probably the greatest mass assemblage of clicking cameras, at least on CHAIN, that I have seen since we ported in Plymouth, England, during CHAIN cruise 13. The A-II personnel were considerably more blasé, drifting out to the deck to look at us after we had been lying-to together for over an hour.

A-II is ready to receive shots, having had the opportunity to rig hydrophones and practice some slacking runs, so we will shoot first. We will leapfrog the short profiles, making each receiving position an end-to-end point and a reverse point, which will give us three short (about 20-mile) reversed profiles, and then we will reverse the entire section from the western to the eastern buoy positions, using the large charges for the extreme ranges.

Bouy Position at Setting

Alpha: 21°11'N, 67°1.0'W
Bravo: 21°11'N, 66°41.5'W
Charlie: 21°8.8'N, 66°18.5'W
Delta: 21°9.0'N, 65°59.3'W

We will start east of A-II at Delta, close and pass her with reflection shots, and continue to Charlie, where we will receive; A-II will shoot in, pass us, and go on to Bravo, the next receiving position; and so on.

After the usual initial confusion, we got our shooting set-up running smoothly. Andy Nalwalk and Bill Dunkle are the shooters, Frank Bohlen has charge of the shot-instant set-up, I am the roving back-up, and there are two top lab watchers available for other chores.

We closed A-II and had passed her, all going smoothly, when our single-sideband radio railed. After two hours of unrewarded effort, we had to admit that the electronics problems were beyond our abilities. We lay to near the ATLANTIS II. John Clough and Alden Cook brought the other SSB radio from A-II, plus spares, and got us back in operation. We cannot operate on 2792 kcps, since the tank in the antenna coupler is shorted out; this was the cause of the original radio failure. It was well into the evening when we were again ready and able to work.

11 June, Tuesday. Finished our shot run at buoy Charlie in time for breakfast, while A-II got steam up and prepared to shoot to us. Their time requirement for going on and off silent ship is an advantage to us right now, giving us the needed time to rig hydrophones and try slacking them. Amazingly enough, our first silent-ship and receive effort went smoothly until A-II was about a mile past us and opening range; then the silent-ship generator, directly above our location in the main lab and supported on shock cord for quiet, broke its supports and crashed to the deck. We had ATLANTIS II heave to while the engine room force coped with this latest emergency. Reshocked the generator by putting pads of heavy elephant gut under it. I honestly think this system even quieter than with the rubber bands.

We have had relatively quiet hydrophones in this moderate sea state (standard trade wind of 20 to 25 knots and sea state of about 3), although toward late afternoon they were obviously noisier. Stopped receiving from A-II at 2030 and got ready to shoot. So far we have fired 232 shots. I have a number of electronic problems in the seismic filter-amplifier system to work on during the shooting: a bad galvanometer, a dead filter, and a noisy suitcase amplifier channel.

12 June, Wednesday. At 0615 we finished our shot run at buoy Alpha or, to be precise, at the point Alpha should be but apparently is no more. Could not locate it, so jogged around the approximate loran fix for it. Set a radio watch and intended to nap until A-II was ready. At 0900 I finally called A-II: some misunderstanding, they are waiting for us. Oh, well. A few problems when we went on silent ship, mostly electronic, which delayed our start until 1145. Camera motor is stopping every now and then, also. Not good. Heat is terrific, over 100° in the saloon mess last evening. Something to be said for munching sandwiches at the camera position; what air there is here is due to being hove-to on starboard tack.

Cursory analysis of yesterday's records indicates a velocity of about 6.6 cm/sec with another of 5.0+ km/sec above it. Some kind of reflection not subbottom; a seamount we've never seen? The BT slide shows a fairly deep isothermal layer extending from the surface; the resultant direct arrival is and will be a problem.

I have made a number of changes in the camera set-up that are for the better. The gain problem is rough; some refractor is a great big energy trap, apparently. Tonight we shoot from Alpha to Delta, A-II receiving at Alpha.

13 June, Thursday. Finished the long-profile shot run at 0330, in the general vicinity of buoy Charlie. Dave Fahlquist on the A-II ran out of refraction arrival energy at 45 sec travel time, so he stopped us.

Found buoy Charlie and steamed a couple of miles to windward in order to drift past it during receiving. Our estimated drift is about 1 knot. A-II will start from her position at the last received shot. On silent ship and ready to receive at 0940. No hitches this time. About 1500 the A-II was in sight (drawing a bead on us right at the porthole by my camera station). They have really fired everything, and are now making half-pound blocks into three-pound charges. We have four M-2's left. We concluded the profile with a short passing track (3 miles) until the ammunition was expended, then A-II came alongside for personnel transfer. Dave came over and we compared notes. They didn't have to slack hydrophones all night, but we certainly have not been so lucky today. It is obvious that the structure here is complex, but we have spaced the shots close enough to have good detail on it, we hope.

Gave Dave two tired suitcase amplifiers to take home; got two good ones in return, also spare Boomer transducers and plates, a spare PGR scale line generator, and B+ power supply. Transferred Peter Leonard, Bruce Pratt, and Robert de Rivera to CHAIN for the remainder of this cruise.

A-II retrieved buoy Delta. We will retrieve buoy Charlie, and search for Bravo and Alpha and pick them up if we find them. A-II headed for the barn in a flurry of farewell toots and whistles, and we headed back west.

14 June, Friday. Revised the watch lists, since new personnel is aboard: Bohlen can concentrate on the thermistor chain now, Kuenzler on Sparker circuitry, and Chase on working with Nalwalk on dredges.

The best feature of this day was my getting to the washing machine one step ahead of its shutdown for ten days because of evaporator troubles. At least I am clean.

We paid out astern the whole length of trawl wire, weighted, to measure it. Result: 26,800 feet, or 3000 feet too short for coring the bottom of the trench. That eliminates that program. Frank Wooding has a camera ready to go on dredge wire, but first we need to do some major shifting in the plumbing for the Debie film developer in the wet lab.

Port PGR failed today, completely. It blew the Altec supply and the regulated B+ supply, and at least one magnetic clutch has failed (clutch B). Dunkle, Presberg, and others are working on the clutch.

Tonight we are steaming over the refraction profile track for gravity measurements on sections 8, 9, 10, and 11. All of us are weary, trying to keep one step ahead of the next PGR component failure.

15 June, Saturday. Another good day. Edo 1 failed this morning, the port PGR is still inoperative, and there are jumping scale lines on the starboard PGR.

Tried a single AX-58 hydrophone on gutted cable (replacing the unsinkable array cable) for CSP work today. It started off well, then suddenly lost the signal. Symptoms were those of blown filaments in a preamp tube. Replaced hydrophone and checked out cable thoroughly. Finally we are profiling, though the records are noisy. We are using the data estimations of water depth for the gravity computer since, with only one PGR and it on single helix for high-resolution recording, we cannot echo-sound at the same time. There is a major reflector at 0.60 sec, which shoals to 0.35 sec, and some patchy reflections between this and the bottom. The major reflector is reverberant and possibly layered, much like the reflector of the 21°30'N line of CHAIN cruise 34. Although the signal-to-noise ratio could be better, I am finally acquiring reflection data and will leave the system alone for tonight, as we have lost enough time.

16 June, Sunday. At 0110 came the ultimate in PGR troubles. The starboard PGR paper drive failed. I could not believe it, woke Dunkle to make sure I hadn't lost my mind. It was true, the paper drive had just stopped. We could not find anything obviously wrong and all of us were beat, so I had all the CSP gear hauled aboard and we jogged on down to buoy Alpha position making gravity measurements only and doing some educated guessing on depths from the several seismic runs along this track where the bottom is moderately flat. At 1830 Bill finally got the paper drive operating (brute force and a vise grip) just in time to head for San Juan according to schedule. Spent the night working on the port PGR components and cleaning up all the science areas. Just hope some shiny-faced electron turns up on that plane tomorrow.

Cookout supper on the fantail this evening. Very fine idea, it certainly made life look brighter.

17 June, Monday. Arrived San Juan 0930. Birch, Geary, Feden, and Wilharm came in on the afternoon plane. Wilharm started on PGR problems immediately. All scientific personnel moved off ship. Too hot to breathe!

18 June, Tuesday. Dunkle, Wilharm, and self have been coping with top lab instrument problems and picking up odds and ends of electronic necessities in San Juan. Larry will take home two scale line generators and a power supply for repair; he brought us one of each and I had already borrowed one of each from A-II.

19 June, Wednesday. Departed San Juan at 1100. Dunkle, Dugan, Wilharm off for home; Birch, Geary, and Feden aboard. Our new watch list is as follows.

<u>Top lab:</u>	0800 - 1200	0000 - 0400	0400 - 0800
	<u>2000 - 2400</u>	<u>1200 - 1600</u>	<u>1600 - 2000</u>
	Presberg	Cotter	Leonard
	de Rivera	Feden	Doyle

Gravity:

Scott	Geary	Pratt
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We dropped the pilot at 1135 and made course for the southern edge of the trench at full speed. Two hours later we had gravity meter trouble, the HAM (horizontal accelerometer) gear train inoperative; this is a major failure. Martin and Potter (our IBM technicians) think they can fix it, so we will head for the Outer Ridge, to profile and dredge there. If necessary, we can get back into San Juan and pick up a technician or a part for the gravimeter before heading for the Barracuda area; it doesn't make sense to go back and sit at the dock now.

Several scientific persons are feeling the ship motion after two days in port, but they should get over it soon.

20 June, Thursday. Started profiling with the Boomer. Very feeble echoes. Changed PGR's, filters, amplifiers: no improvement. Perhaps Boomer trouble, so changed to Sparker. Trying new rigging on the array tow cable-weights along it at graduated distances. Have moved Lambda and Harrison power supplies across lab, to be away from the other electronic equipment; this has made quite a reduction in 60 cps level.

We will measure heat flow and take a core tonight at 21°N , 65°W .

The gravity group says it has the HAM gear problem under control. We will make a complete traverse along the $21^{\circ}10'\text{N}$ refraction line, crossing the CHAIN Cruise 34 gravity tracks, and see how the data compare.

Our first heat flow station, made this evening, was successful.

21 June, Friday. We had completed the gravity calibration run by 0900, so we altered course to the area of $21^{\circ}30'\text{N}$, $60^{\circ}30'\text{W}$ to make a camera-dredge lowering. This particular site was selected on the basis of the CHAIN Cruise 34 profile data, which show that there may be exposure of deeper layers in a region of rough topography. We are still unable to get decent profiler data and are presently working up a paired cable and electrode for the Sparker, to test this source against the Boomer source.

The first camera-dredge operation was a practice run for our trainees as much as anything. Results: left-camera case flooded, no rocks in dredge, red clay in plastic tube on bail of the dredge. The left-camera film was developed anyway, in the hope that the camera had failed after the lowering and not before or during it, but there are no pictures.

I believe the gravity data comparison indicates that realignment of the HAM gear train is successful and that we can continue the cruise as planned.

At the conclusion of the station we will get under way to Anegada passage and the eastern end of the trench, en route for the Barracuda Fault area.

Hove to at 2110 to make a Sparker test. The hull rings like a big drum, but I am not impressed by the recorded reflection data, as there is nothing. There may be some simple malfunction, or else I dreamed the CHAIN Cruise 34 data. After two hours of futile effort it seemed more profitable to haul in the profiling equipment and get under way, full speed, on the gravity-bathymetry survey track to the area of the Barracuda Fault. We will try to unsnarl the profiling electronic (recording) problem while doing this.

One hour after getting under way, HAM hit the bad point on the bearing and froze up again. Gravity meter inoperative. We will continue the present track to $63^{\circ}20'W$, then turn to course 180° toward Anegada entrance, and then try the next course (about 045°). If we cannot take useable data at speed on these courses, we will have to decide whether to continue the survey track at slow speed, which will eliminate any work on the Outer Ridge on the return, or stay on the Outer Ridge and cancel the Barracuda program. The gravimeter was operating again shortly after midnight, so the decision can be delayed. Perhaps, if I don't look, it will go away.

22 June, Saturday. We stopped for a heat flow measurement at 1330 at $20^{\circ}18'N$, $63^{\circ}39.5'W$ in a depth of 3020 fathoms. The probe was back on deck at 1820 with about 1 foot of hard brownish clay in the core. The core catcher has red and brown clay and hard black fragments. During the five-mile drift on station the bottom changed in character and became 100 fathoms shallower, and penetration was observed on short-pulse recordings.

We are under way at 1900, and now being plagued by 60 cps pickup in both PGR's, apparently associated with the ship's power. Making alternate east-northeast and west-southwest courses, to look at the trench topographic extension and follow the trend of the gravity anomaly.

23 June, Sunday. We are continuing the survey tracks, trending generally east-southeast toward the area of the Barracuda Fault. Crossed the postulated southeasterly-trending trench continuation; still have negative free-air anomaly of about 150 milligals (about the same as in the 4000-fathom region to the west, yesterday).

At 2100, about $19^{\circ}24'N$, $61^{\circ}30'W$, we stopped for a heat flow measurement and coring. We are now using celestial navigation and dead reckoning. Echo sounding shows shallow layered bottom penetration, of about 10 feet. Someone is shooting on a two-minute schedule somewhere, recorded and audible on the earphones.

24 June, Monday. The core was aboard just about midnight and we are under way again. The 60 cps that plagued us for two days disappeared this morning after the station. We cannot find any good reason for its presence or absence.

At 0613 we had to slow ship to 8 knots. The wind has freshened from the east and the resultant accelerations are too much for the HAM with the ship at full speed. Barry is lubricating the bearing at regular intervals with a hypodermic needle. Altered course at 0725, thus taking quartering seas and transferring work to the cross-HAM, which enables us to return to full speed.

We are making slow progress in getting around the curve of the island on these W-shaped tracks. Because of this and the navigational uncertainty, we will make no more stations until we are in the area of the Barracuda Fault.

Chief Scientist is logging miles in the vertical plane -- from the top lab to the gravity lab -- in the process of conducting a survey on bathymetric and gravimetric data and trying to get the continuous seismic profiling PGR to write a signal.

25 June, Tuesday. Last night we made it around the island arc. This morning the free-air anomaly is trending to higher negative values (we are in 2800 fathoms of water); perhaps it is associated with the trench extension? Computer trouble later this morning, so we are not getting computed gravity values. Slowed ship while Burt operated on the computer; Frank Bohlen thus was able to install one thermistor. Everything "go" at 1030, and back to full speed.

Latest evaluation of time versus scientific work indicates that any detailed work on the Outer Ridge en route home may have to be dropped. Had a meeting of scientists this evening to discuss this. We decided to concentrate our efforts in the Barracuda area: 36 hours of heat flow measurements, 36 hours of dredging, 15 or 20 hours of CSP work, 48 hours of thermistor chain experimental work (which Bohlen can do in either the Outer Ridge or Barracuda region), and 10 or 12 hours of spark electrode tests that can be made when we are hove to, during other programs.

Hove to at 1900 for heat flow 4 (station 5) and star fix at $17^{\circ}17'N$, $59^{\circ}27'W$, very close to fault or scarp area. Managed to drift over a hill, the first in twelve hours. Cored about a third of a barrel of brownish mud.

26 June, Wednesday. We have crossed the scarp. We made heat flow measurement 5 at 1900 on the north side of the abyssal plain in 3085 fathoms at $16^{\circ}45'N$, $57^{\circ}38.5'W$ (by star sight). A bad 60 cps pickup on the PGR during lowering seems to be a sunset effect. The core was on deck at 2052, and we prepared to spark.

Started profiling with a single-hydrophone tow, to save time in retrieving gear as we test the system. Peterson's law (of maximum unhappiness) was immediately evident in some cable trouble, the result of an intermittent connection in a lead. Cut 30 feet of cable and removed the bad area. Meanwhile, we put the array over and it seems to have a fair signal-to-noise level. The 60 cps pickup is down in level but still bothersome, and there is no doubt that the unsinkable cable is noisy. I am not proud of the data. We are crossing the plain to make a profile across the steep face of the scarp. Lost the bottom as we crossed the top of the scarp; penetration at the top is of the order of 0.20 sec in 2600 fathoms of water.

27 June, Thursday. Secured the CSP work at 0720. Between the system and the geology, I am not impressed by the clarity of the data. Hove to at the base of the scarp at 0817 for heat flow 6. Got a 40-inch core and fractured one thermistor. Caught five white-tip sharks (three males and two females) while on station.

At 1300 we tried dredging the scarp. Misjudged the westerly current and were too far out on the plain. We tried backing up, toward the top of the scarp, but with little success in the dredging effort. The camera motor ate its leads in the course of the lowering; there were no pictures and nothing in the dredge -- total bust.

Under way at 1800. We stopped for heat flow 7 about 1930 and concluded it at 2150. We made spark electrode tests, while hove to, from 2200 until 2300.

At 2315 we were under way on a CSP run with the array and the 2X Boomer on vertical tow.

28 June, Friday. The continuous seismic profiling went on until 0730. At 0915 we did heat flow 8 in a 2300-fathom area at the top of the scarp toward the back slope. At 1200, after this station, we got under way for the more western area of the fault zone to continue detailed work, making a zigzag track across the scarp, after which we went onto the plain and then back across the scarp to the shallow western plain. Three such crossings were made between the two locations (based on Western Geophysical Company refraction profile locations). At 1750 we hove to for heat flow 9 at 16°57'N, 58°24'W, by star fix, at the base of the scarp.

Picked a dredge site, on the basis of echo sounding and CSP data, midway along the scarp between the eastern and western sections of our heat flow lines. Put the new triangular rock dredge over, with the camera above it, at 2207. The pinger echo was buried in 60 cps pickup until the dredge was only 100 fathoms off bottom. Dredge aboard at 0300; no hits. In order to cope with the westerly current, we steamed up slope, towing the dredge.

29 June, Saturday. After the dredge operation we made a swing south and west for gravity measurements in what could be the buried extension of the Puerto Rico Trench; then we went back to the scarp area for another lowering. Hove to about 0730, but a line squall gave us a bad time and we had to put off the lowering. At 0830 heat flow 10 was made on the abyssal-plain side of the scarp. Here the water is 2955 fathoms deep, the bottom sloping gently as compared with the really flat 3085-fathom area to the east. Cored half a barrel of mud. At 1100 we were under way on a brief exploration of the gravity and depths along the 2200-to 2300-fathom area at the top of the scarp, en route to the next heat flow station.

At 1700 we made heat flow 11 in 2260 fathoms of water. A star fix at 1900 on this station gave us latitude $16^{\circ}42.5'N$ and longitude $58^{\circ}31'W$. From here we headed for another promising dredge site, a rather steep-appearing slope in a corner of the scarp. Crossing this, we lost the echo sounding bottom signals at 2300 fathoms, and our next sight was the abyssal plain at 3085 fathoms. While we were maneuvering ship to put the dredge at the base of the slope so that we could tow it up against the current, all kinds of troubles developed: the echo sounding signal was lost because of a bad fuse in the Alden B+ power supply, and the starboard hull transducer was sick. A minor collision between a front tooth and the Edo, resulting from slipping on the wet deck, rendered the chief scientist hors de combat after the dredge was put over.

30 June, Sunday. Roused at 0600, to be informed that we had lost the dredge. At least we know there is rock there. The tensiometer had registered 4500 to 5000 pounds. However, the camera light flooded out and the film had not been transported, so we have no pictures of what happened. Later today we will lower another dredge in as close to the same area as we can get, using bathymetry and dead reckoning. At 0710 we made heat flow 12, about seven and a half miles due north of the dredge site, on the plain.

We are steaming slowly, making gravity and echo sounding measurements while Frank Bohlen installs the rest of the thermistors. Many black-fish sighted this afternoon: several distinct schools following one after the other, coming up, and passing us to starboard. Excellent Kodachrome run. Tried to get whale music on the AX-58, but the ship is too noisy and we are not prepared for silent ship at a moment's notice.

At 2050 we had maneuvered into position for dredging. We put over a modified rock dredge in a depth of 2700 fathoms under the ship. About 2200 the dredge was on bottom and the ship in 2500 fathoms of water. At 2313 there was a 7250-pound hit, following a number of nibbles. Started dredge up and broke it loose, at a winch speed of 4. At 0040 the dredge was on deck: ROCKS.

1 July, Monday. Remained hove to during the night while we sorted rocks and equipment on the fantail. At dawn Frank started on the thermistor chain again; the fish tail broke off yesterday, and he and Barry have been making a new one (fish won't swim without its tail). Another round of problems: the diesel driving the thermistor winch was out, the computer was sick, and the gravimeter just failed. Most of the day was spent getting all this equipment into operation again. Then we got under way on a track planned to cross the gravity-bathymetry lines made on our way from the Outer Ridge. Thermistor chain installation of seven stations is in the water, under test.

2 July, Tuesday. Peaceful night, no alarms. At about 0800 I decided we should make an excursion to the south to the region of 19°N , 61°W , to investigate the extent of the moderately negative free-air anomaly detected on the outbound track, which I feel we had not followed far enough to know whether it levelled off or continued increasing. By noon it was apparent that the trend was again in the positive direction, so we turned northwest to return to the base course. At 1400, at just about two hours' steaming from the junction with the base course, the gravity lab informed us (the top lab) that they had real trouble and suggested we slow ship to avoid losing too much information on this track while they worked. Seems there is a problem with the cross-HAM of the gravimeter, an electronic one this time. It continued for hours. Barry and Burt worked until after midnight, with no success. I suggested that they catch some sleep while we jogged onward at slow speed.

The thermistor chain is towing well with the home-made fish tail.

3 July, Wednesday. Barry and Burt were back on the gravity meter problem after a short pause for sleep. By about 0900 they had narrowed the trouble down, unequivocally, to a bad potentiometer in the cross-HAM. We are unable to find a spare or to make any reasonable substitution of parts. I have no choice but to continue without gravity measurement, although we will keep trying substitutions. We will have a gap in the gravity data but will at least have a bathymetric tie of the tracks. Back to full speed about 0930.

At 1645 we turned south again to investigate the reality of the 2500-fathom depth shown on the chart. No, it was never that shallow, but we did find a 4000-fathom plain about one mile wide near $63^{\circ}40'W$ just south of $20^{\circ}N$.

4 July, Thursday. At home it is a holiday. We will have our second and final cookout this afternoon, in celebration.

We are back on the Outer Ridge, and echo sounding shows abyssal-type layering of the bottom sediments typical of the Nares Basin. While Frank is working on the thermistor recording in this area, we will work across the basin just north of $22^{\circ}N$, chasing the boundary of the plain as defined by the well-stratified bottom sediments.

5 July, Friday. We are heading eastward, still on the Outer Ridge, in an attempt to establish the eastern boundary of the abyssal-plain deposits in this area. Between $63^{\circ}30'$ and 63° west there is an apparent thinning of the bottom layers. This may not be a real picture, since 200 fathoms (0.5 sec) is the fastest sweep rate we can use. The starboard PGR has followed the port one in losing either a clutch or gear contact. We are also faced with a moderate-to-high noise level, since only the port transducers are operative and we have no towed fish.

This area has been singularly devoid of marine life. Today a school of porpoises did pass us but showed no inclination to stay with us. Very few birds sighted.

Headed north at 1700.

6 July, Saturday. Lost a bathythermograph last night, the result of a terrific backlash and snarl in the wire.

A cable today asks us to rendezvous with CRAWFORD on our way home and transfer some of their personnel to CHAIN. This will give us time to accomplish something Andy very much wants, another dredge attempt on Caryn Peak, in the hope of getting something other than manganese nodules. We will also spend a few hours in the region of the 100-fathom curve, using a miniature bottom sampler sent Andy for testing.

Today was very hot. At 1700 we ran into a heavy squall, apparently a cold front. The temperature dropped 7°F in 10 minutes; we are now complaining about the cold (75 °F). We are in moderately brisk winds and choppy seas.

Ran out of the weather front, which was about 20 miles in extent, just in time for a really magnificent sunset. I have added to my collection of pictures entitled "Sunsets at Sea".

7 July, Sunday. We have been dismantling the refraction receiving equipment in the main lab. It occupies the bench area that the next chief scientist will need immediately. We are also cleaning, scrubbing, and clearing out the science day room and wet lab.

Plotting of the bathymetry-gravity data on the enlarged plotting sheets has had the expected result: we will have to adjust the navigational tracks by bathymetry, then plot the up-dated gravity values on these adjusted tracks.

A completely spontaneous discussion of Indian Ocean plans took place in the science office this evening. Many ideas and a few volunteers.

8 July, Monday. Heading for Caryn Peak. Andy is busily rerigging the rock dredge, to make sure we get the best possible results. We plan to come up to the peak from the southwest and dredge this slope, hoping that the north-easterly current will provide the necessary uphill drift force.

At 1652 echo sounding indicated we were crossing the side of Caryn Peak. Slowed the ship, but meanwhile had crossed the flank. The skipper has the bridge now; he is as interested as we are. We made various courses to look for the shallowest point, which was found to be 1680 fathoms, then reversed course to put the dredge over near the base of the peak. From wind and current observations we judged that to lower the dredge when the ship was in 2300 fathoms of water and then tow it east-northeast up slope would yield the best results. We steamed at 2.5 knots on course 105° from the time the dredge was 500 fathoms off bottom. There was a small series of hits (about 1250 pounds each), the water depth below ship being 2200 fathoms. At 2180 fathoms we really hit. The dredge broke out at a winch speed of 4 with a 6000-pound pull. Waited breathlessly to see whether we still had the dredge below the pinger; we did. The depth under the ship was 2080 fathoms when we lifted the pinger and dredge from the bottom (no wire measure, since the metering device has not worked the entire cruise). The dredge was on deck about 2100, and we certainly have a bagful: manganese nodules of assorted shapes, many very round, some larger and different specimens both angular and rounded and quite heavy, which Andy and Dick think may be vesicular basalt, and some specimens that are manganese-encrusted, not hard rock, and possibly tuff.

After securing deck gear, we were under way for our rendezvous with CRAWFORD. Temperature was 76°F on deck but all of us were in heavy jackets. The latest today is that we are to meet the CRAWFORD at 0900; they apparently have run into bad weather.

9 July, Tuesday. This day was cloudy with squalls all around us, but the sea was moderate. We were at the rendezvous at 0900 sharp, peering into the mist for CRAWFORD. They suggested we steam toward them, which we did. At about 1000 we sighted CRAWFORD dead ahead on collision course. She was pitching fairly heavily and rolled when hove to. Our big boat is very stable in comparison.

All hands were on a run for their Kodachromes while the Zodiac boat putt-putted over to CRAWFORD. Bohlen took the opportunity to discuss thermistor installation with the CRAWFORD group and to give them BT slides and log sheets, they not having enough aboard. At 1100 we parted company. Dr. Ketchum has joined CHAIN, bringing welcome mail and news from home.

At 2000 we were in 100 fathoms of water, hove to for station 19, the test of the small grab sampler. This was not an unqualified success, in spite of various attempts to improve the trip mechanism. Among other things, tried polypropylene for the lowering wire; it works well, but no samples were obtained although the trip did, finally, work.

At 2100 we are under way for the southwest-shoals buoy.

10 July, Wednesday. Secured PGR at 0730. Tied up to WHOI dock at 1300.

APPENDIX I

Station Log

Station Number	Type*	Date	Time(Q)	Location	
1	HF - 1	20 June	1735	21°09.3'N	65°02.5'W
			2025	21°09.5'N	65°02.5'W
2	CD - 1	21 June	1300	21°31.8'N	66°30.0'W
			1835	21°35.5'N	66°35.5'W
3	HF - 2	22 June	1434	20°18.0'N	63°39.5'W
			1900	20°17.5'N	63°44.4'W
4	HF - 3	23 June	2058	19°24.5'N	61°30.0'W
		24 June	2400	19°24.5'N	61°30.0'W
5	HF - 4	25 June	1901 ⁺	17°17.5'N	59°27.0'W
			2200	17°18.0'N	59°30.0'W
6	HF - 5	26 June	1759 [#]	16°44.5'N	57°37.1'W
			2055	16°45.0'N	57°38.5'W
7	HF - 6	27 June	0820	16°46.5'N	57°47.5'W
			1100	16°47.0'N	57°51.0'W
8	CD - 2	27 June	1256	16°37.5'N	57°51.0'W
			1806 ⁺	16°45.0'N	57°51.0'W
9	HF - 7	27 June	1935 ⁺	16°33.5'N	57°50.7'W
			2150	16°33.5'N	57°52.7'W
10	HF - 8	28 June	0928	16°35.5'N	57°53.0'W
			1155	16°35.0'N	57°54.5'W
11	HF - 9	28 June	1900 ⁺	16°57.0'N	58°24.0'W
12	CD - 3	28 June	2208	16°50.8'N	58°25.2'W
		29 June	0335	16°50.5'N	58°27.5'W

APPENDIX I (continued)

Station Log

Station Number	Type	Date	Time (Q)	Location	
13	HF - 10	29 June	0825	16°18.2'N	58°36.0'W
			1100	16°18.0'N	58°38.0'W
14	HF - 11	29 June	1625	16°42.5'N	58°29.0'W
			1922	16°42.5'N	58°31.0'W
15	CD - 4	30 June	0026	16°44.5'N	57°52.0'W
			0600	16°42.0'N	57°58.0'W
16	HF - 12	30 June	0710	16°52.0'N	58°01.0'W
			0938	16°52.0'N	58°03.0'W
17	MRD - 5 (rocks)	30 June	2024	16°43.0'N	58°05.0'W
		1 July	0040		
18	MRD - 6 (rocks)	8 July	1802	36°42.0'N	68°02.0'W (Caryn Peak)
		(Caryn Peak) 2000		36°42.0'N	67°59.0'W (Caryn Peak)
19	Leroy	9 July	2015	40°03.5'N	70°15.0'W
			2047		

* HF, heat flow measurement; CD, camera-dredge lowerings; MRD, modified rock dredgings; Leroy, small bottom grab sampler.

+ Star fix.

Dead reckoning.

Woods Hole Oceanographic Institution
Reference No. 64-27

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Unclassified

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3. Bathymetry and gravity surveys

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