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Scientific Goals and Pre-Cruise Plan

In the last decade, studies of past climate have undergone a profound change. By cross correlating isotopic records of atmospheric temperature in two separate ice cores drilled at Greenland's summit, we now recognize the prevalence of large amplitude climate shifts on very short time scales. What was formerly considered "noise" in the Greenland archives is now well established to be real climate signal. While Milankovitch cycles are the fundamental pacemakers of climate at 20, 40 and 100,000 year periods, emphasis has switched to the observations of much more rapid fluctuations at the centennial to decadal timescale. Twenty-two separate interstadial events, brief returns to warmer climate, have been recognized in the Summit ice core records. Huge volumes of ice rafted debris are recognized roughly every 7,000 years in North Atlantic sediments as armadas of icebergs were shed from continental ice sheets. Collectively these observations represent a new challenge for paleoclimate studies. One of the largest outstanding questions in our field is: what mechanisms cause these large and rapid shifts, Heinrich, deglacial and interstadial?

Many leading theories to explain these observations involve changes in the strength of the thermohaline circulation. In the modern ocean, this overturning timescale can be estimated from profiles of $\Delta^{14}C$ in dissolved inorganic carbon. However, our understanding of the past ventilation rate is limited by the tracers available in the paleorecord. Most ocean sediment histories of past circulation rely on Cd/Ca and $\delta^{13}C$ values in benthic foraminifera to measure the mixing ratio of deep-water masses. Unfortunately there is no inherent age information in these tracers. Instead, we are trying to use the coupled U-series and radiocarbon clocks in deep-sea corals to calculate the past $\Delta^{14}C$ of a water mass.

With this goal in mind, the main objective of the cruise was to collect as many fossil deep-sea corals from the 900-3000 meter depth range around the New England Seamounts as possible. Our second goal was to understand how to better collect these samples in the future. The New England Seamounts represent a unique combination of known fossil coral occurrence and a climatically interesting area of the ocean. There are many other locations from which we would like to collect fossil corals, but without good guidance from this cruise, they will be blind "fishing trips". Finally, we wanted to collect a suite of modern fauna to characterize the living inhabitants of the New England Seamounts.

Field Program

To accomplish both our primary goal of collecting living and fossil deep-sea corals and our secondary goal of characterizing where corals live and are found on seamounts, we proposed a 21-day (on-station) submersible and autonomous underwater vehicle field program to several of the central New England Seamounts. The station-time was to be partitioned as follows: 3 days for multibeam bathymetry surveying, 2 days devoted to ABE (Autonomous Benthic Explorer) surveying, 15 days for Alvin dives, and one day to account for multiple deployments/recoveries of seafloor transponders. In the end we were granted 21 days total time, so the ABE only survey days had to be cut to include time for transiting.

Alvin Operations

The main thrust of this program is the *Alvin* coral sampling. We proposed 15 dives in two main modes: upslope transects of three seamounts, followed by dives to the summits of six seamounts. Our assumption going into the cruise was that the best way to collect corals with a high depth resolution was to run transects from the deepest area of interest on the seamounts to their summits. Our cruise plan included three such transects up the flanks of the East Manning edifice, the West Manning edifice, and Gosnold seamount. The depth of these transects would range from 3000m at the base to the heights of the different seamounts. Manning seamount has the best evidence for abundant corals at a range of depths. Gosnold has the best evidence for corals at great depths, with dredge haul samples from ~2800m.

In addition to the 3 upslope transects, we planed to conduct 6 Alvin dives on the summits of 6 seamounts to take advantage of the likely concentration of corals in the summit region. While samples of fossil corals collected from the flanks of seamounts may have the possibility of down-slope motion after they died, samples from summit areas do not have this ambiguity. Tentatively, we planed to dive on the summits of West Manning, North Manning (a small cone), West Gosnold, Sheldrake, Gregg, and San Pablo; these would provide samples at approximately 900m, 1100m, 1500m, 1700m, 2200m, and 2800m.

ABE Operations

ABE had two crucial roles in our field program. First, it performed visual surveys of large areas of seafloor to guide follow-up Alvin sampling dives. Second, it provided a more detailed and broader characterization (both visual and small-scale bathymetric) of the seafloor around *Alvin* sampled coral sites to indicate the lateral extent of coral fields, mass-wasting features, and other seamount morphologic features.

Our original plan was to run ABE as both a night program after Alvin dives and in a "24 hour" mode during Alvin dives. However, early on we decided that ABE's information would be too valuable and the benefit of seeing it as early as possible outweighed the advantage of staying down longer. So we planned to run ABE mostly as a night program complementing the Alvin dives. We proposed devoting about half of the night program time to visual surveying, at an altitude of about 5 meters, around the Alvin transects and the other half to surveying at higher altitude (~50 meters) to maximize the return of the scanning sonar bathymetry data. We anticipated conducting postage-stamp surveys on areas of particular interest using a nested approach: broader scale high-resolution topography with more focussed visual imaging centered (and expanding) upon the areas of greatest interest transected by *Alvin*.

AT35-7 Cruise Narrative

While our goal, as described in the previous section, was to dive on three nearby seamounts, this plan was continuously altered by bad weather and mechanical problems. The largest factor in us changing our dive plans was a series of low pressure systems that either occupied our dive area or the region just to the Northwest. The associated pressure gradients caused rough seas and high winds that were often unsuitable for deploying Alvin. Instead of occupying seamount edifices sequentially, we went where the weather was good. A crucial aspect of having this flexibility was obtaining multiple dive clearances from the Navy's SUBATLCOM office. Once we were blown off of Manning for the first time, we solicited the Navy for increased clearances (in both area and duration) at Muir, Nashville, Rehoboth, Vogel, San Pablo and Gregg seamounts.

In the end, we transited to Manning where we got in 0.5 dives and some seabeaming at Manning and Gregg seamounts. The Navy then recommended that we move south as gale force winds were predicted. After waiting for the weather to clear at Muir we were able to string together six days of continuous Alvin and ABE operations. Ideally we would have spent only five days here, once we realized the availability of corals at different depth, but continued bad weather at the northern seamounts caused us to stay an extra day.

We steamed north for Rehoboth and Vogel seamounts and arrived in time for a brief seabeam survey. The next morning, the weather was again deemed too poor to dive and we moved to Manning. Several relatively calm days were used to dive on Manning and make a brief run to Gregg seamount to get our shallowest corals. We left the northern region under deteriorating weather and had to set a "weather heading" for our transit to Muir. After getting on station at Muir late in the morning for one last dive, we were again told that the weather was too poor to deploy Alvin.

In the end we lost 5 of our 15 funded Alvin dives, half of our planned 15 ABE dives and about half of our night program. The chief problem was weather. However, mechanical/electrical problems with the Avon, the A-frame, the hydrowinch and *Alvin* all contributed significantly to our lost science. The following is a day-by-day version of our cruise:

Monday May 26

Leave St. Georges, Bermuda at 07:30 (local time). Transit to Manning via Muir for Seabeam data. Uses WP01-03 to cover Muir.

Tuesday May 27

Transit to Manning and Seabeam. Uses way points WP04-07.

Wednesday May 28

Pulled in magnetometer at 4pm. Transponders in and surveyed.
CTD station #1 at 1400 meters near Manning summit.
Seabeam from WP12-18.

Thursday May 29

Alvin dive canceled due to weather. Things improved by the afternoon.
Avon and A-frame problems contributed to the decision not to dive.
ABE into the water for dive 97 early in afternoon. Covered two knobs and contour lines between them with SM2000. Photos were not terrific in brief test run.
CTD after ABE from stations 2 and 3 to station 4, where a deep cast was followed by MITESS. However, MITESS probably did not work as most bottles seemed not to have opened.

Friday May 30

Alvin dive 3883 (Adkins, Scheirer, Bruce) brought up early due to deteriorating weather.
Tow Cam 1 across summit of Manning from NE to SW and CTD station 5 with water collection for U-series analysis.

Saturday May 31

Alvin dive at Manning was cancelled at 5am. Headed for Gregg/San Pablo for Seabeaming to save a dive day. WP31-39. At noon we got word from the Navy to head south. We stayed Seabeaming for another two hours to adequately, but not completely, cover Gregg. Wrote to Navy for more seamounts in dive clearance to increase our flexibility in weather and dive planning.

Sunday June 1

Headed to Muir but very bad seas. Had to head on a weather course at low speed. Ended up even with Muir in latitude by next morning, but at wrong longitude.

Monday June 2

Arrived at Muir but late in morning. No chance to Alvin dive. Deployed transponders and navigated them in.

ABE dive 98. Rectangle between end of Alvin dive 3884 and 3885. This is the first of several ABE dives to give us complete bathymetry of the deep ridge that yielded a number of corals

Tuesday June 3

Alvin dive 3884 (Adkins, Moore, Tony). Lower knob on Muir ridge.

MOS phone call with about 100 students in audience.

ABE dive 99. Deep nose first dive.

Attempted to TowCam the ridge we were diving on but hydrowinch did not work.

Wednesday June 4

Alvin dive 3885 (Scheirer, Waller, Pat). Upper Muir ridge run with lots of coral.

MOS phone call with about 30 students in audience

ABE dive 100. Doing more SM2000 of the deep nose and added more photo runs. Still not at right depth for photos.

Tried to CTD but hydrowinch did not work. Tried to Tow Cam the deep NE ridge then switched to trying the summit. Neither worked due to winch problems. CTD did not happen because the Chief Scientist was not clear in his directions to bridge.

Thursday June 5

Alvin dive 3886 (Shank, Eltgroth, Blee). Came up early due to burning smell. MOS phone call did not happen due to Alvin problems. Dan Fornari covered for us in Boston.

ABE dive 101. Knob from dive 3884 where we had many corals. First good picture run that followed contours on transponder net side of ridge.

Tow Cam 2 that turned into “DredgeCam” with many fossil corals recovered.

Friday June 6

Alvin dive 3887 (Adkins, Robinson, Bruce). Deep knolls off of main Muir ridge.

MOS phone call only worked briefly due to satellite problems.

WBUR interview from the bridge before the dive.

ABE dive 102. Continue up main Muir ridge to include area of dive 3885. Good camera shots.
Attempted Tow Cam on North Muir summit, but winch broke once more.

Saturday June 7
Alvin dive 3888 (Fernandez, Noel (PIT), Tony). Deep nose.
MOS phone call with Dana. Went longer than normal.
ABE dive 103. Area between area 101 and 102 with camera fill in.
Seabeam of southern Muir. WP100-108. Hydrowinch still broken.

Sunday June 8
Alvin dive 3889 (Shank, Mendez, Pat). Summit and rim run on North Muir.
Begin transit to Rehoboth. WP110-114. Capture deep northern summit with a "Geophysical line".
Cookout and whales spouting in the distance.

Monday June 9
Transit to Rehoboth seamount for shallow dive. Increasing seas as we head north. Wind pretty constant at a "calm" 20 knots. Seas at about 10 feet around dive area.
Seabeam at summit of Rehoboth for two passes that barely miss each other in the shallow region. Decision made to dive near steepest and shallowest rim is made at about 11:30 pm local time.

Tuesday June 10
Alvin dive cancelled due to high seas and heave at the stern of Atlantis.
Fill in Seabeam at Rehoboth and on approach to Manning.
ABE in at 15:15 for dive 104. Aborted at 200 meters and came to surface. Went back in at 17:30 and all went fine. Called dive 105.
MITESS and CTD at former station 5 in deep water. Now also MITESS #2 and CTD #6.

Wednesday June 11
Alvin dive 3890 on knoll and rim of Manning (Blee, Scheirer, Gagnon).
Transit to Gregg and Seabeam.
Attempted Camera Tow #3 but 3+ knot current of Gulf Stream made the wire angle too sharp. Continued Seabeaming instead

Thursday June 12
Alvin dive 3891 on summit of Gregg. We overflew the landing site by over 2 km, but were still able to sample at key depths.
Transit back to Manning.
ABE into water at Manning for extended dive during Alvin ops. Vehicle never "found itself" in the net and had to be manually aborted at 2:00 am.
Planned CTD operations cancelled so that we could recover ABE.

Friday June 13

Alvin dive 3892 on south knoll and rim of Manning.
ABE dive aborted due to software error.
Attempted CTD #7 and #8. Camera Tow #3 had to be changed due to ship's relation to the swell.

Saturday June 14
Alvin dive 3893 on Manning summit. Pulled up transponder array.
CTD stations #9 and #10 complete the tight second line on Manning.
Seabeam coming off Manning to nearly complete map of all four summits.
Transit to Muir seamount, weather getting worse.

Sunday June 15
Transit to Muir but changed to weather heading per Captain's orders. Making about 8.5-9.0 knots due to bad seas and high winds.

Monday June 16
Came on station at about 9am. Winds 25-30 knots but smallish swell.
Alvin dive cancelled due to weather.
Three CTD stations occupied on either side of the Muir saddle.
A few Seabeam way points to fill in.
We had to leave here at midnight to make our 13:00 pilot at St. Georges.

Alvin Dive Summaries

The following summaries are brief recounts of the dives and their sampling stations. All station coordinates are given in the local X,Y frame. Dive maps at the end of this sections are blended from the Seabeam and ABE (where available) topography. In most cases, dive tracks are taken from the Doppler navigation and several "good fixes" during the dive. These fixes include Top Lab information at the beginning of each dive and local topographic features that are easy to identify from both the sub and the maps.

Dive Summary 3883 28 May 2003

Pilot: Bruce
Port: Dan Scheirer
Stbd: Jess Adkins

Launch Location: 38° 11.95'N, 60° 31.44'W
Manning Summit 1

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer

Stations:

1.	12:22	1576	Enallopsamia rostrta modern sample. Broken up.
2.	12:35	1538	Brittle stars on top of an E. rostrata sample.
3.	12:48	1524	Fossil Solenosmilia clumps with D. cris mixed in.
4.	13:46+	1505	First recognizable D. cris on side of knoll.

Summary:

We tried to explore the side and top of a knoll just south of Manning's summit rim and then contour around the rim itself. We found living and fossil coral soon after landing, but did not realize that there was D. cris in the fossil assemblage. Far and away the largest fossil community was gorgonian branches, or "twigs". This twiggy bottom made it hard to recognize D. cris from a normal Alvin flying altitude. We first recognized Solenesomilia from the observers' windows and picked some up at station 3. It was not until we were contouring around the knoll and Dan's eyes got close enough to the sea floor to see that D. cris was there as well. In the end, there was D. cris in the samples from station 3 as well. While this was very exciting, I think we missed sampling D. cris deeper by not just getting on the bottom and looking around.

The steep run from target 1 to target 2 had many fossil sampling sites. Soon after station 3 and turning to the south we crossed a barren patch with mostly sediment and shallower slopes. Once back on the steeper sides of the knoll the fossil clumps started to come back. We were called back to the surface due to bad weather at about 14:15 and left bottom at about 14:30. In the interm we flew up the side of the knoll with one weight away. Both Dan and I agreed that the modern diversity and numbers were increasing as we went up hill. There were also probably more fossil D. cris to be had. We never saw the top of the knoll.

Dive Plan 3884 3 June 2003

Pilot: Tony
Port: Jess Adkins
Stbd: Jon Moore

Launch Location: X: 9602 Y: 32367 Z: 2230 meters
33° 47.51 N
62° 35.80 W

Muir Ridge Run 1

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer

Notes:
1. Check for down slope transport of fossil stoney corals
2. Run up knob to target 2 and then ridge 3-5.
3. We need corals from all of these depths

Stations

1. 13:30 2273 Scooping D. cris
2. 14:11 2228 Lots of D. cris just below the edge of a pavement slab. Sample of pavement. Metalogorgia and lepidisis from same station.
3. 15:31 2141 Big clumps of D. cris and large gorgonian bases. Irridiogorgia collected in manipulator.
4. 16:38 2084 Top of knoll where we got a conglomeration of fossil coral.
5. 17:47 2139 Gorgonian on rock at end of dive.

Summary

We landed a little deeper than our intended target 1 and headed uphill to the saddle deep on Muir's ridge. There was D. cris from the very beginning, but sparsely distributed in the sediment. At target 1, the saddle, it was mostly sponges and sedimented pavement. Occasional fossil corals in the sediment. Up the knoll we found D. cris all the way but only once we started sampling at a particular station did we recognize it. Once you see one of them you start to see dozens. On the way up the knoll we went through a barren patch that had clear down slope transport marks in the sediment. It seems that D. cris is in growth position when we find it. At the top of the knoll it was an amazing mixture of living and fossil corals. We did a 360° video survey and then sampled at station 4. The top of the knoll was relatively small. It was really very "pointy".

Coming off the top of the knoll we lost contact with the bottom as there was a very steep portion (see ABE map). Once in contact with the bottom again it was very sedimented with no fossils and only sporadic sponges. There are tracks of mud feeders in the swale and the two sides are "night and day" for fossil hunting. By the time we had to come off bottom things had started to go upslope and there were many sponges and the occasional fossil D. cris. I think that ABE eventually covered this area with some camera runs.

Dive Sumamry 3885 4 June 2003

Pilot: Pat
Port: Dan Scheirer
Stbd: Rhian Waller

Launch Location: X: 11900 Y: 30580 Z: 2030 meters
33° 46.543 N
62° 34.316 W

Muir Ridge Run 2

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer

Notes:
1. Check for down slope transport of fossil stoney corals
4. Possible lateral transect of scarp in front of target 1.
5. Attempt to space fossil sample stations at 50 meter depth intervals
6. If time allows countour to WP7 and try to find rim edge.

Stations

1.	12:39	2027	1 net of fossil corals with large grapefruit sponge.
2.	13:24	1986	1 net of fossil corals with 4x Paramuricid gorgonians and basket stars. 2 niskin bottles fired near bio collection site.
3.	14:20	1929	1 net of fossil corals
4.	14:52	1878	1 net of fossil corals
5.	15:20	1821	1 very full net of fossil corals. 4 Acanella gorgonians with basket stars, large Farea sponge and 2 other gorgonians.
6.	16:32	1776	1 net fossil corals
7.	17:39	1791	1 net fossil corals

Summary

This dive started a little above the previous one in an effort to continue the Muir depth transect. Corals were found immediately after landing and were basically there the entire dive. Pat was able to drive ~50 meters in the vertical and the contour around to a good sampling site. Two sets of scarps that were documented by ABE dive 98were full of fossil D. cris. Sample station number 2 was at the top of the second one of these steep features. Pat developed a very successful sampling procedure. After setting up the sub, he would break off large chunks of D. cris/solenosmilia conglomerations directly into a net. This process would kick up less sediment than the scooping technique and became the ideal sampling standard for the next several dives.

Between stations 2 and 3 some sandy/gravelly areas were largely devoid of large fossil assemblages. Occationally an individual would be poking through the sediment , but it was not worth it to stop and sample. This bottom type was also relatively flat and had manganese pavement poking through. Uncovered basalt outcrops were rare. Through station 5 the bottom was mostly fossil corals and pavement. Above number five sediment became more prevalent and above sation 6 there were very few promising sites. After contouring towards the northern rim, Dan decided to turn around for a final sample. They headed down hill and stopped a the first promising outcrop. This was the last sample station.

The modern community for the entire dive was dominated by sponges but gorgonians were also very prevalent. As a rule the gorgonians , and some of the sponges, were covered by basket stars. At the end of sample station 2 they saw a hooded "dumbo" octopus and followed it for long enough to get some terrific footage of it swimming. Shrimp, urchins and anemones were also observed though most of the dive.

Dive Summary 3886 5 June 2003

Pilot: Blee
Port: Tim Shank
Stbd: Selene Eltgroth

Launch Location: X: 9250 Y: 28600 Z: 2800 meters
33° 45.472 N
62° 36.027 W

Muir Ridge Run 3

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer

Stations

1.	12:48	2829	2 sponges and a barnacle with some pavement.
2.	13:24	2750	Mud scoop to see if fossils were buried.

Summary

This dive was designed to cover the deeper portions of Muir. To get lower than the deep saddle, we dropped them below a deep, off axis knoll. A second knoll nearby was supposed to yield samples higher in the water column. However the dive was aborted due a burning acrid smell at 13:24. This was later identified as a burned board on an un-needed UPS and the unit was removed for the next dives.

The bottom type was markedly different than previous work on Manning or in Muir's deep ridge. Large sediment "waves" ran like ribs down the slope. There was clear indication of down slope transport. The occasional rocky outcrop did not seem to have many fossils. As they rose in the water column, all three divers felt that there was beginning to be more promising bottom cover. For this reason we chose to dive here again the next day, but just starting a little higher in the water column.

Dive Summary 3887 6 June 2003

Pilot: Bruce
Port: Jess Adkins
Stbd: Laura Robinson

Launch Location: X: 9540 Y: 28740 Z: 2650 meters

33° 45.548'N
62° 35.840'W

Muir Knobs

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer

Stations

1.	12:50	2636	Sandy bottom scoop of pteropod rich sediment. Large gorgonian had to be crushed to fit in bio box.
2.	13:24	2546	Rock ledge with many D. cris.
3.	14:36	2441	Outcrop with many corals that was hard to sample
4.	15:49	2372	Many, many fossil D. cris on sandy outcrop.
5.	16:52	2265	Similar site as station 4. A little easier to sample. Sponges, urchin, whip coral and metallogorgia all collected here. Near the top of knoll two.

Summary

The goal of this dive was to cover a large vertical interval relatively deep in the water column by transiting up two separate knolls. These off axis bumps are almost 1,000 meters apart over mostly barren sediment terrain. We landed on sandy bottom and made our way to target #1. This first sample site was an experiment to see if older D. cris was covered by surface sediment. We could scoop the sediment but not very deeply and did not get any fossil corals. After headind uphill towards target #2 we stopped at the first sign of D. cris we could sample on a rock ledge. This finding just confirms the notion that any little relief will yield fossil samples. Tim's idea of scooping below these features might still be a good one.

At the top of the knoll we found nothing but sediment. On the way up we saw more promising sample sites but they were not different enough in elevation to stop for. Things flattened out towards the top and sediment became the dominant bottom type. The sediment cover at the summit was surprising and might be due to the fact the its relative relief is not too much (~15 meters) relative to the head wall behind.

We drove off the summit, losing bottom lock on both Imigenex and dopler. Dead reckoning navigation brought us to 2528 meters on sandy bottom and about 50 meters lower than the first knoll top. There was nothing but sediment for several hundred meters until we were on the steep side of the second knoll. There were several rocky outcrops that had promising sample sites and we let depth determine where to sample. However, this was not as easy as sampling on the ridge. We had to hunt hard for sites with many fossil D. cris and ease of sub set-up. As it was we spent a fair bit of time at each station. Station 5 was probably the last chance to get fossil D. cris as the rest seemed sediment covered. We saw the "top" of the knoll as we had dropped weights and came off bottom. It was sedimented and low relief like the first one.

Dive Summary 3888 7 June 2003

Pilot: Tony
Port: Diego Fernandez
Stbd: Noel

Launch Location: X: 12800 Y: 34300 Z: ~2725 meters

33° 48.556'N
62° 33.735'W

Muir Deep Wedge

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer
6. Push Core

Stations

1.	15:07	2747	Stone with branchy coral. Niskin bottle.
2.	16:11	2693	Push core, with xeno?
3.	16:27	2733	Fan coral lost in transfer. Possibly some loose in basket.

4. 16:44 2703 Stoney coral (gorgonian) with a piece of sea pen and a pink sponge.
5. 16:52 2745 White sponge
6. 17:14 2739 Stoney coral with orange stuff(?).
7. 17:23 2740 Sponge attached to rock, but rock left behind (too big).
8. 17:54 2763 Stoney coral with rock onit.
9. 18:08 2730 Sea stars and sea cucumber

Summary

This dive was designed to follow the ABE dives to a deep "nose" on the North side of Muir's ridge. We put them to the east of the nose at 2870 meters and they drove up about 100 meters to contour around the steep face of the nose. There was a lot of basalt outcrop (without pavement) and plenty of sediment. Big blocks of basalt were more the norm here than anywhere else on Muir. Sponges dominated the living biota but there were essentially no fossils. This dive was almost certainly below the depth limit of D. cris and Solenosmilia on Muir.

The angular structure of the nose has roughly 120° angles as if the summit (~2700 meters) was a local strong point. The Maggie data from this dive should be interesting as ABE had heading problems when surveying the edifice that were probably due to a dipole effect on the vehicle. Noel, the PIT, did not do much of the driving. Sampling was done entirely by Tony. They finished the prescribed dive plan early and called up to the top lab for more instructions. Jess told them to drop down the back of the nose and contour around again at a shallower depth. This did not change the observations substantially.

Dive Plan 3889 8 June 2003

Pilot: Pat
Port: Tim Shank
Stbd: Jeff Mendez

Launch Location: X: 2430 Y: 39870 Z: 1820 meters

33° 51.569'N
62° 40.431'W

Muir Rim and Summit Run

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer
6. Push Core

Stations

1. 13:11 1719 Digging in the sediment.
2. 13:26 1723 Wall of D. cris
3. 13:53 1714 Gorgonians and D. cris on a sponge
4. 14:04 1700 "Big chunks"
5. 14:44 1649 Barrel sponge from cliff face and D.cris of opportunity. Gorgonian into bio box.
6. 15:26 1620 Branching coral and white sponge with D. cris of opportunity.
7. 16:12 1576 Sea urchin
8. 16:15 1574 Sea urchin
9. 16:47 1563 Rocky outcrop in sediment field with D. cris.
10. 17:05 1570 Branching red coral, alive.
11. 1525 E. rostrata.
12. 1521 Rocky surface and D. cris. Deployed marker.

Summary

This dive was the first time we got to test how fruitful summit rims might be for finding fossil corals. We tried to land the sub at 1820 meters but they were about 100 meters too shallow on bottom. This was due to the steep local topography and the smoothing effect of multi-beam bathymetry. When they got onto the summit plateau, the Seabeam depths agreed very well with the sub's depths. After landing on a sedimented area and unsuccessfully digging in the sediment for fossils, they moved on to the rim of the summit. A steep wall with segmented steeps soon appeared and the sub could not find the bottom with the aft mounted pinger, even when the front of the sub was on the wall. There was fossil D. cris all along this rim as they slowly climbed going around towards a low point coming off of the summit. The living community was incredible with very large gorgonians covered in basket stars and huge numbers of sponges.

Once at the top of the rim, they crested and headed due east for the summit. There is a depression along this path and the sub stayed up on the northern side of this feature, though the video shows that it was really flat. A totally sedimented bottom was good for sea urchins but not coral. Near the summit they found some rocky outcrop with many D. cris and some living coral. This is very promising for diving on other summits in the future. They had to come off bottom before reaching the true summit of Muir north.

Dive Summary 3890 11 June 2003

Pilot: Blee
Port: Dan Scheirer
Stbd: Alex Gagnon

Launch Location: X: 69800 Y: 34570 Z: 2000 meters

38° 13.688'N
60° 27.373'W

Manning Knoll, Rim and Summit Run

Basket: 1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer
6. Push Core

Stations

1.	12:35	2004	Rippled sediment infront of small ledge.
2.	13:30	1886	Rocky outcrop amongst sediment dusting.
3.	14:07	1778	Coral debris and lobate pillows with some current.
4.	15:18	1551	Knob top. E. rostrata and gorgonian. Some fossils in bio box.
5.	16:43	1487	Scooped with nets and this material was pretty deep. Live yellow coral.
6.	17:18	1421	Basalt outcrop with coral debris and in depressions. Other loose coral from previous stations noticed in basket. Metallagorgia.
7.	17:42	1381	Rim of summit plateau. Good coral here and mollusk shells.

Summary

This dive was designed to collect fossil coral from relatively shallow on Manning. Blee felt that he could get samples from deep as well, so we dropped them at 2000 meters. Scattered D. cris were in the sediment at the landing site late seemed to come from a small ledge immediately upslope. Transits below the knoll at this depth had many sea stars, sponges and metallogorgia but few D. cris fossils. They searched around at 100 meter intervals until time got short and then decided to skip to 1750 meters. At 1778 meters they found their most promising fossil sample site and dropped electronic target #11. Dan saw clear lobate lava flows for the first time and then came across a massive basalt wall that was covered in sponges, sea stars and E. rostrata. At top of wall they were on top of knoll. There were clear fossil D. cris as well as abundant life. Dan described it as “spectacular”.

Transit to rim wall lost bottom lock and they used the CTFM to see the looming wall in front. Sampled fossil D. cris at the base of the wall, in the middle of the wall and at the top. At many places the “wall” was really a steep slope with sediment and fossil outcrops. Last bit of upslope was a massive basalt wall that was absolutely flat at the top, stretching on for as far as the eye could see. Collected many bivalve shells in the lip sediment. The observers saw much more coral here than returned in the sample nets. If they had had more time, more D. cris would have come back. It was probably a mistake to drop them so low, but they did cover over 600 meters in the vertical.

-Check out navigation here, there seem to be offsets between dopler and Top Lab numbers.

Dive Plan 3891 12 June 2003

Pilot: Bruce

Port: Kate Buckman
PIT: Mark

Launch Location: X: 4770 Y: 3500 Z: 1250 meters

38° 56.892'N
61° 01.700'W

Gregg Shallow Walls

Basket: 1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer
6. Push Core

NOTE: 3 knot current at the surface from the south!

Stations

1.	13:36	1076	Gorgonian on steep slope covered with crinoids.
2.	14:55	1169	?
3.	14:59	1176	Fossil coral but D. cris not visible. Sponges and mussel shells.
4.	16:46	1180	D. cris seen only a few meters below station 3. Sponges. Wall.
5.	17:25	1222	D. cris from wall covered with sponges.
6.	17:58	1221	Same as station 5.
7.	18:26	1216	Same as 6 with lots of fossil coral.

Summary

This dive was designed to get us our shallowest samples to anchor the pale-hydrographic profile. We deployed in the Gulf Stream with a 3-4 knot current and overshot the landing site by about 2.5km. This is even after we laid back by about 500 meters at deployment. The sub could not drive in the water column because we had no transponder net here. After surveying the sub in from the top, we realized they were at a bad spot on the summit plateau. They were about 1.5km from the intended end of the dive and about 4 km from the other side of the summit. Fortunately the current was not in their face, but was about 0.3 knots from west to east. They made good time to the first "rim" which was steep but not a wall. This site was totally barren for fossil coral but they saw many small sharks across the summit.

After transiting the sedimented shelf between the two rims, they found a profound wall that had many promising samples. D. cris were abundant and sponges dominated the fauna. This site confirms what we started learning at Muir, continued at Manning and now at Gregg that seamount rims are very promising areas for both fossil and living coral. Solenosmilia tends to dominate at shallower depths and D. cris is very abundant deeper. This dive was very successful in that we got many corals from two shallow depths and anchored the paleo-profile.

Dive Summary 3892 13 June 2003

Pilot: Tony
Port: Rhian Waller
Stb: David Shuster

Launch Location: X: 62700 Y: 31790 Z: 1700 meters

38° 12.1849'N
60° 32.2179'W

Manning Knoll and Wall

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer
6. Push Core

Stations

1.	13:15	1700-13	D. cris clearly visible between outcropping rocks.
2.	14:21	1656	In situ D. cris. Large platter picked up for rest of dive.
3.	14:51	1632	Lophelia and E. rostrata.
4.	15:39	1598	D. cris visible. Dragged bag along bottom.
5.	16:29	1598	"Like plucking fruit" off of wall. Scleractinia and gorgonians. Niskin bottle.
6.	17:11	1548	D. cris below rock outcrop and rubble pile.
7.	17:41	1470	Top of knob and flat with small fossil rubble piles. Not garden of Eden.

Summary

This dive was designed to get the paleo depth range of 1700-1550 meters. As opposed to other dives, here it was more important to get the deeper portions of the track than the shallower ones. We also asked them to make an Imagenix/DanCam survey of the knoll's summit, but they did not have time and continued to the summit rim instead. After landing at about 1700 meters there was the typical bottom type with scattered D. cris, sediment and outcrop. They sampled at several stations with the most notable being a large "platter" of D. cris on a fossil gorgonian at station 2.

Stations 3 and 4 are from the top of the knoll. There was abundant life and fossils here. The ABE map showed three local highs on the peak and Shuster says he saw two of the three and possibly the run up to the third. This site yielded our best haul of modern scleractinia including Lophelia and E. rostrata. Still there was very little (any?) modern

D. cris around. They flew off the summit and lost bottom lock to get the summit rim wall.

At the base of the wall (WP4) there was abundant D. cris just below a ledge. The "wall" was mostly pavement with many outcrops housing fossils and modern biota. At the base, David described it as "like plucking fruit" to get fossil D. cris. By the time they got to the top there was a clear rim and flat terrain beyond with very little evidence for fossil material. Tony did a great job of managing the "platter" of D. cris from station 2 onward.

Dive Summary 3893 14 June 2003

Pilot: Pat
Port: Susan Mills
Stb: Joe Appel

Launch Location: X: 64850 Y: 33050 Z: 1420 meters

38° 12.866'N
60° 30.751'W

Manning Summit

Basket:
1. Big bin with nets
2. Niskins
3. Small Bio Box
4. Milk Crate with Markers
5. Magnetometer
6. Push Core

Stations

1.	12:00	1401	Big hunk of fossil. Saw D. cris but it is not in sample.
2.	12:33	1350	Also saw D. cris but none in fossils brought back.
3.	13:03	1329	Going after fossils.
4.	13:34	1327	Big rock
5.	13:45	1339	Sea pen and water sample.
6.	14:32	1322	Hunks of fossil coral
7.	16:01	1339	Major modern biota sampling. Many Paragorgia, E. rostrata, sea pens, stars.

Summary

We hoped to explore around Manning's summit with this dive and to get a few more shallow sample stations with fossil coral. The sub was dropped at about 1420 meters at the face of a steep feature on the summit plateau. ABE's map was very useful in picking waypoints to explore as the summit appears to have much more texture than other seamounts. Once above about 1350 meters the idea was to drive around the front of a “wedge” like structure and then summit from the shallow angle to the west. We also hoped to get an Imagenix and DanCam survey of a biologically diverse area.

They landed at 1400 meters on a relatively steep slope, but by no means a wall. There was fossil coral that everyone thought was D. cris but only one came up in the sample. This big hunk is interesting in that all the scleractinia are on a fossil gorgonian trunk. This is just like we saw last dive but with solenosmilia this time as opposed to D. cris last time. Up the steepish slope they continued to see fossil coral, but none of it turned out to be D. cris. The modern fauna were largely as before, sponges, stars, urchins, xenos. Once in front of the summit wedge there was about a1/4 knot current. The further north they went the more sedimented it got. At the top of the summit there was really just sediment and they decided to head back to WP2 where there were large Paragorgia for Lauren Mulineaux.

Autonomous Benthic Explorer (ABE) Dive Summaries

ABE 97

The Alvin launch was cancelled at noon, and we planned at 1:30 launch. We setup the SM2000 downlooking with 100 m max range and 400 range bins, which means it would ping every 2 seconds. The launch proceded smoothly. ABE did not spiral to the desired point however, and landed about 200 m to the southeast. In looking at the data, the fixes did not get good until just after the vehicle reached the bottom, and the nav track for the descent should not be used.

After reaching the bottom, the tracking locked onto the proper ranges and remained there for the entire run. The vehicle came off the descent mooring after doing a sonar calibration spin, then executed a short hover to check ballast (which showed the vehicle to be about 2 lb light), then dropped to camera height and drove to get onto the first trackline. It had to make up the distance the vehicle had drifted during the descent, but headed to the line at the proper angle, then followed the line. It made it about 100 meters from the end of the first line when the timeout for the trackline expired, and it rose to sonar height (50 meters) and went to the second trackline.

ABE surveyed the hump at 64300, 31100 with 6 tracklines, losing transponder tracking in a few spots when the hump was between the vehicle and the 11.5 xpndr. It then surveyed the saddle between the hump and the ridge with six lines. Then, it ran 5 long (2.5 km) lines along the ridge. Finally, it ran 8 lines on the hump at 62800, 31900, nearly making it to the end of the last trackline when the deadline expired at 0500. Tracking on 11.5 and 8.5 was solid, the 9.5 was heard about _ the time but not on the second hump.

We recovered at 0744, and had imagenex maps ready for the Alvin dive by 0830. Over _ the images from the PixelFly camera were good, the remainder were saturated in the center. We adjusted the strobe mounting and will fly higher next time. The SM2000 was solid and was processed using our standard tools. We also adjusted the transponder locations to minimize the disagreement between baselines.

ABE 98

We started late as we had to wait for the weather to come down, then set and survey transponders. We got in just before 9pm. The net had 3 transponders in a line, which worked very well. The SM2000 was set for 100 m max range, 400 range cells, pinging every 2 seconds.

The vehicle performed an SM2000 survey at a height of 50 meters with 70 meter line spacing in a saddle between two peaks at a nonimal depth of 2000 meters. The transponders were located downslope on the NE side of the ridge. Tracking was excellent for the sonar survey except for the last line to the west, when only one transponder could be heard. The vehicle then dropped down to camera height (11m nominal) and started an “M” across the sonar area (or was it a “W”?). The vehicle crossed the sonar area 3 times before the mission ended on schedule at 0430 local. Tracking was lost several times (transponders obscured by terrain).

Post processing went smoothly. The imagenex map was ready for the Alvin dive the same morning. In later processing, the kalman smoother filled the navigation gaps nicely, and no transponder position adjustments were performedas the mean lbl error was 0.84 meters, and we did not cross any baselines. The sm2000 map looks very good. The images were much better than the previous dive, the hot spot in the center was gone and the illumination was sufficient and fairly uniform when the vehicle was at the proper height.

ABE 99

This dive was conducted on the eastern, downslope side of the transponders at a depth of about 2800 meters. The dive began with a long camera run that followed Seabeam contours around a promentory at three depths. Then an SM2000 survey was conducted at 50 meter height with 70 m track spacing.

The camera run worked well, with the bottom staying within range. Light was fairly uniform, although as of this writing (june 4, 2145) we still have some concerns about focus. The vehicle took 3500 images at 5 second intervals over 4 hours and 51 minutes.

The SM2000 run was less successful. The vehicle's bottom following sonar (which normally can see the bottom out to about 70m) could only maintain contact out to about 35-40 meters (possible pressure effect?). Since the vehicle was trying to fly at 50 meters, when it saw 35 meters it would rise, then contact would be lost, it would then fly down to try to re-establish contact resulting in an oscillation in altitude around 35 meters. The vehicle also flew slowly since it was too close most of the time. In the next dive, we used the Imagenex when bottom following in the 50 meter range, which solved this problem.

ABE 100

This was a sonar-only run over the same deep feature as ABE99. The bottom-following fix worked fine, the switch to the center beam of the imagenex when no return was received from the fwd-looking altimeter worked fine, and ABE flew the 50 meter commanded height off bottom well.

The run had a different problem, however, that we have solved for the most part. The feature we mapped has a very strong magnetic signature, which deflected ABE's fluxgate magnetic compass by substantial amounts (approx 30 degrees). This can be clearly seen in the regular, repeatable distortions in the ABE tracklines, which prevented the sonar swaths from overlapping properly. Sonar coverage was nearly complete, however. The compass calibration scheme involved using the compass over a long period to calibrate the rate gyro in ABE.

ABE 101

This run was conducted up on the ridge near where ABE98 was run. We got in early as Alvin came up early. We got the word at noon and were ready by 1400. ABE did SM2000 survey, and two camera lines that followed along contours at 2190 and 2170 meters. This technique worked well and was used in later dives. We also adjusted the operating mode of the camera to good effect. We stopped the lens down and flew lower (6 meters). This provided superior images for the purposes of identifying animals while still providing sufficient overlap for mosaicing.

The bottom following fix was used again, with similar results, although the fwd-looking altimeter showed significantly more range (60-70 meters) than it had in the deeper dives (ABE99 and ABE100).

Tracking during the sonar coverage was excellent except for the western-most line. Tracking during the camera run was complete.

ABE 102

This dive filled the area between ABE98 and ABE101 with sonar and added four more video lines at 2060, 2040, 2020, and 2000 meters. Tracking was lost on the southern edge of the first10 tracks. The parts without tracking were strongly effected by a current flowing east-to-west. The kalman smoother did a good job of filling these, but the SM2000 map shows some artifacts in these areas. Tracking was excellent for about 80% of the entire run, however, including all of the video area.

ABE 103

This dive added 4 depth contours of video runs between the depths surveyed in ABE101 and ABE102 and also added sm2000 coverage on the NE side of the ridge. The multibeam sonar was setup as for the previous dives: 100 m max range, 400 range cells, 2 seconds per ping.

The dive started at the SE edge of the survey area and made two sets of sonar tracklines running NW-SE. Then it made a video survey at 4 depths, 2150, 2130, 2110, 2090, covering about 4.5 km. These lines were chosen to lie over the SM2000 coverage of the previous dive, which allowed them to be run with minimal changes in depth. Finally, it did more sonar survey over the small promentory on the NE slope.

Tracking was excellent for the entire dive, with all three transponders received nearly the entire dive.

ABE104

This dive failed. ABE returned to the surface after reaching a depth of about 250 meters. We recovered immediately, fixed the problem (software problem), and launched again on ABE 105

ABE 105

This dive was conducted on the summit of Manning Seamount. It repeated the intended program of ABE 104, which aborted on descent.

The dive covered the crest of the summit with SM2000 lines spacedd 70 meters at 50 meters height running roughly NS. SM2000 settings were the same as used on this entire cruise: 100 m max range, 400 range cells, pinging every 2 sec. Then the dive filled lines running perpendicular to the first set of lines dropping down the southern face of the summit in mildly sloping terrain. Tracking was excellent for the initial sonar grids. Then the vehicle dropped to camera height and ran two contour-following video lines at 1390 and 1370 meters. The vehicle was nearly at the end of the 1370 line when time ran out. Tracking was a bit spotty at times on the video run, as the transponder on the far side of the ridge (D, 11.5) could not be seen sometimes and other times the vehicle was on the AB (8.5-9.5) baseline. The kalman smoother did a good job of interpolating to fill the gaps, though.

We were able to track the vehicle from the ship at very long ranges, travel time up to 9 seconds on the 11.5 could be heard, and the direct returns were heard over 6 secs.

ABE106

This dive failed because the long baseline navigation solution failed to initialize properly. We commanded the vehicle to come back after about 1hour 20 minutes into the survey when it was clear that the vehicle would not recover.

ABE107

This dive failed due to a software error introduced while fixing the problem seen in ABE106. On this dive, the navigation solution initialized properly and the vehicle computed its position properly. But the new error prevented the vehicle from using the computed fix in its track following calculations. As a result, the vehicle deadreckoned the entire dive, which with a moderately strong current running the north and east made the vehicle wander out of the survey area after an hour. We commanded the vehicle to return to the surface. The software fix was tested extensively in simulation, but this problem was not detected. In simulation, the vehicle deadreckoned nearly perfectly, which masked the problem. The error has been fixed and the simulation upgraded to include the effect of currents, so any such problem in the future will be obvious.

CTD/MITESS Cast Report

CTD casts were conducted to elucidate the effects of the New England Sea Mounts on ocean currents. Thirteen casts were completed on two sea mounts; ten casts on Manning and three on Muir.

On Manning seamount, casts were conducted along two perpendicular lines running southeast and southwest extending from the summit out approximately 7.4 km. Cast one was deployed on the summit with a depth of 1380 m. Casts 2-4 composed the southwest line and casts 5-10 composed the southeast line. Casts 5 and 6 were conducted at approximately the same location. Three CTD casts were deployed over Muir sea mount spanning the saddle point between the two summits. Casts 1 and 3 were deployed south and north of the saddle point, respectively, with cast 2 deployed over the saddle point itself. Water samples were collect at 12 depths during CTD cast 5.

Preliminary analysis of depth profiles generated by the Manning CTD casts reveal that currents are influenced by the sea mount. Temperature and salinity profiles show deep water lifted to a depth equal to the summit depth at locations nearest the sea mount, decreasing in magnitude with increasing distance. This observation is seen in casts 1-3 and 7-10. At the depth of approximately 1400 m there is sharp trend towards colder and less saline waters. At the summit (cast 1), the bottom 30 meters of the water column shows a 0.5 °C decrease in temperature and a 0.05 psu decrease in salinity. These decreases in temperature and salinity occur at this approximate depth increasing in depth and decreasing in magnitude with distance away from the summit, and probably represent Labrador Sea Water.

We also attempted two MITESS casts, one each at CTD stations 4 and 5. However, the first cast at station 4 did not open most bottles. This was probably due to **XXXX**. The later cast at station 5 worked well and recovered trace metal clean samples from **XXXXX** depths.

CTD Cast Number	Date, GMT time	Latitude	Longitude	Depth	Sea Mount	Geographical Location	Bottles Fired, Bottle Depths (meters)
Cast 1	29-05-2003, 01:58	38° 12.9969'	60° 30.3955'	1380 m	Manning	Summit of Manning Sea Mt.	No
Cast 2	29-05-2003, 18:00	38° 12.0900'	60° 31.6504'	1720 m	Manning	Along south west line, 3.7 km from cast 1	No
Cast 3	29-05-2003, 20:15	38° 11.7617'	60° 32.1199'	2090 m	Manning	Along south west line, 4.6 km from cast 1	No
Cast 4	29-05-2003, 23:00	38° 11.4004'	60° 32.6007'	2426 m	Manning	Along south west line, 5.6 km from cast 1	No
Cast 5	31-05-2003, 06:00	38° 10.3421'	60° 26.5225'	3190 m	Manning	Along south east line, 7.4 km from cast 1	Yes: 25, 79, 149, 398, 700, 900, 1256, 1500, 2000, 2500, 3000, 3130
Cast 6	11-06-2003, 05:45	38° 10.3421'	60° 26.5100'	3120 m	Manning	Along south east line, 7.4 km from cast 1	No
Cast 7	13-06-2003, 00:55	38° 11.8500'	60° 28.7000'	1920 m	Manning	Along south east line, 3.0 km from cast 1	No
Cast 8	14-06-2003, 02:50	38° 12.1998'	60° 29.2002'	1600 m	Manning	Along south east line, 2.0 km from cast 1	No
Cast 9	14-06-2003, 19:27	38° 11.6710'	60° 28.4290'	2080 m	Manning	Along south east line, 3.7 km from cast 1	No
Cast 10	14-06-2003, 21:35	38° 12.0405'	60° 28.9595'	1730 m	Manning	Along south east line, 2.6 km from cast 1	No
Cast 11	16-06-2003, 15:40	33° 45.7200'	62° 38.0000'	3400 m	Muir	South of saddle point	No
Cast 12	16-06-2003, 19:04	33° 47.5400'	62° 35.7900'	2200 m	Muir	On saddle point	No
Cast 13	16-06-2003, 22:00	33° 49.4000'	62° 32.5000'	3400 m	Muir	North of saddle point	No

Table 1: CTD casts locations. Thirteen CTD casts were conducted on two sea mounts. Casts were conducted along two perpendicular lines, running south east and south west from the summit of Manning Sea Mount. CTD casts were deployed on the saddle point, as well as, north and south of Muir Sea Mount. Water samples were collected at 12 depths on cast 5.

AT07-35 TOWCAM REPORT

SCOPE:
The purpose of this report is to describe all Towcam activities during cruise AT07-35. The "TOWCAM", is a creation of Dr Dan Fornari and other engineers at the Woods Hole Oceanographic Institution. Its purpose, to take high-resolution time lapsed pictures of the sea bottom. These pictures for this particular leg were to be used to locate possible exploratory sites.
There were 7 attempted towing operations. Of these, 4 were carried out. The reason for the 3 failures was due to the hydro winch. Of the 4 operations that were conducted, 1 was pulled early due to strong currents in the area.

CAMERA TOWS:

STATION_01
CAMERA SETTINGS: 45 MIN DELAY, 10 SEC INTERVAL
DATE: MAY 30, 2003
LOCATION: MANNING SEAMOUNT

START:	**20:22:00 GMT**	**38 13.90 N**	**60 31.65 W**
END:	**01:52:00**	**38 13.16 N**	**60 30.70 W**

TOTAL TIME: 5 HOURS, 30 MINUTES
START DEPTH: 1451m
END DEPTH: 1319m
COMMENTS: This deployment involved bad sea conditions. 31-knot winds, 15 – 20 foot swells. Upon initial deployment into ocean, tension reached over 3500 lbs. The decent was slow, 15 meters per minute. Camera towed until 2 GBytes camera ram used.

STATION_02
CAMERA SETTINGS: 45 MIN DELAY, 10 SEC INTERVAL
DATE: JUNE 3, 2003
LOCATION: MUIR SEAMOUNT

START:	**21:28:00 GMT**	**33 45.86 N**	**62 24.76 W**
END:	**04:15:00 GMT**	**33 44.31 N**	**62 26.10 W**

TOTAL TIME: 6 HOURS, 47 MINUTES
START DEPTH: 3008m
END DEPTH: 2238m
COMMENTS: Seas were calm. 5-knot winds out of the north. At 02:30:00, tension started to climb dramatically. It was determined that the sled was caught on the sea floor, for some reason. The tow height at the time before the tension increased was 8 meters above the sea floor. The ship was stopped, and cable spooled out to decrease tension. Wire out was determined to be 1100 meters. The ship was asked to back up at .5 knots. After 2 plus hours, the ship was under the sled. The sled was dislodged at this point and pulled to the surface. No damage to the sled was observed. After testing all the electronics on the sled, it was determined that no damage was done to the electronics. The sled also brought with it, several coral samples.

STATION_03
CAMERA SETTINGS: 45 MIN DELAY, 10 SEC INTERVAL
DATE: JUNE 11, 2003
LOCATION: GREG SEAMOUNT
START: 03:40:00 GMT 39 00.00 N 61 04.10 W
END: 05:20:00 GMT 39 00.00 N 61 04.10 W
TOTAL TIME: 1 HOUR, 40 MINUTES
START DEPTH: 799m
END DEPTH: 1353m
COMMENTS: This location is in the Gulf Stream. The current at this location was over 3.5 knots at the surface. We held the ship steady at the start location. As soon as the sled was placed in the ocean, the wire angle grew. We continued to lower the sled in the hopes that the currents farther down would decrease, thereby decreasing the wire angle. This did not occur. We continued to lower the sled so the CTD data could be used. After we lowered the sled to 75 meters from the bottom, we cancelled the tow and brought the sled to the surface.

STATION_03
CAMERA SETTINGS: 45 MIN DELAY, 20 SEC INTERVAL
DATE: JUNE 14, 2003
LOCATION: MANNING SEAMOUNT
START: 05:05:00 GMT 38 14.40 N 60 30.50 W
END: 09:15:00 GMT 38 14.89 N 60 29.84 W
TOTAL TIME: 4 HOURS, 10 MINUTES
START DEPTH: 1806m
END DEPTH: 1872m
COMMENTS: Length of tow limited by time constraints. The picture interval was increased to 20 seconds. This due to fact pictures was overlapping. 1 Gbyte of camera RAM used.

Underway Measurements

A variety of environmental and geophysical data were collected while underway. These were processed using Unix shell-scripts to remove bad data records and to prepare them for merging into a single time-series table with data spaced every 1 minute. Daily plots of the environmental and geophysical data were created to validate the sensors and to provide quick reference for various events on the cruise. (These plots are presented in an appendix to the cruise report??? <--this would add ~50 pages if we had all of them...could just include a representative one of the environ. and geophys.) More details about the processing done on the underway measurements can be found in Appendix YYY (I'm keeping a document of the specific steps I use for this, and it probably should be included in the cruise report as an appendix).

Navigation and Environmental Parameters:

The Athena data-logging system on Atlantis provides a 1-minute time-series of GPS navigation, course, speed, meteorological, and sea-surface parameters. These data were registered to times at even minute values, and other data streams were merged with the Athena data at that interval. Some of the Athena records were obviously corrupted (e.g. not containing the expected number of data columns or marked by extraneous characters), so simple filters were designed to omit these bad lines.

In addition, Dave Sims wrote a script to record the GPS data at a 1-second interval. This was processed and will be used, post-cruise, to correct the gravity data better than can be accomplished with the 1-minute Athena data. Again, some of the records were corrupted, so a variety of emperically determined clean-up filters retained only the valid records.

Multibeam Bathymetry:

We collected bathymetry data with Atlantis' Seabeam2100 multibeam sonar throughout the cruise, whenever its operation did not interfere with operations such as Alvin and ABE diving. With only two prior lines of opportunity crossing the New England seamounts in our study area (collected by Atlantis over the past few years), we conducted "mowing-the-lawn" surveys upon reaching each new seamount group. We were guided by the Smith and Sandwell predicted bathymetry grid, derived from satellite altimetry observations and historic ship transects. The low resolution predicted bathymetry grid allowed effective picking of waypoints for our multibeam surveying. Because of adverse weather and hydrowinch factors, we collected more Seabeam data than we had expected, fully ensonifying the Manning, Muir, and Gregg edifices, with partial surveys of Rehoboth, Vogel, and San Pablo seamounts.

The Seabeam data quality was variable and entirely a function of sea-state. During good survey conditions, the data were excellent. During two extended southward runs from the New England Seamounts to Muir, the data were quite noisy. No hand editing was done at sea, and only the most basic depth thresholding was applied. For more quantitative seafloor morphology studies, hand-editing or more sophisticated automatic filtering is advisable.

Seabeam data were gridded and these grids were used to create maps for picking Alvin and ABE dive targets, camera tows, CTD locations, etc. The multibeam data were gridded at a horizontal spacing of 75 m, appropriate for the average sonar footprint diameter at depths near the summits of the seamounts (~800-1500m). The 75m grids look ragged at deeper depths because the grid sampling is denser than the actual spacing of sonar soundings on the seafloor. We also created grids at a 150m spacing that fill-in the deeper seafloor more smoothly. In addition, Seabeam depths were gridded at a much finer interval so they could be combined with fine-resolution ABE bathymetry grids. ABE bathymetry values are given priority in this step. The interpolation algorithm used for the Seabeam interpolation leads to "dimples" in the combined grid where Seabeam depths were input; these dimples serve as reminders to the limited resolution of the Seabeam-controlled areas.

Likewise, the predicted topography grids were gridded at finer spacings than their intrinsic resolution so they could be combined with higher-priority Seabeam grids. In these cases, the predicted topography grid has the dimpled surface.

Seabeam depths matched well the seafloor depths measured by Alvin where we dove on distinctive topographic features (knolls, ridges). They also matched well those depths obtained from ABE. In joining together the ABE and Seabeam grids from several different areas, the mean mismatch between the seafloor depths of their overlapping coverage is 1-3m. Seabeam was run with a sound-velocity profile guided by an XBT and CTD cast obtained from Manning Seamount. It is possible in post-processing that tweaking the SVP might bring about better cross-swath patterns in the deepest seafloor surveyed.

Finally, the logged centerbeam records for each day were converted to a form suitable for merging with the other 1-minute data streams; again, some flyers were present and omitted with simple filtering.

Gravity:

We used a Bell Aerospace BGM-3 gravimeter to measure the earth's gravity field throughout the cruise. This unit is on loan from the Naval Oceanographic Office and provided for a nominal fee by Randy Herr; it is riding on Atlantis from Jacksonville, FL to Woods Hole, MA and was installed primarily for our NE Seamounts cruise. The BGM-3 electronics rack and sensor were installed mid-way in the Main Lab, and a laptop logged the serial data for access by the science party. In addition, Herr logs the gravity data to a PC connected to the electronics rack; he also logs GPS data directly to that PC.

The serial gravity data on the laptop were logged with the "227.exe" DOS program, compiled with the appropriate counts-->mGal conversion factors for the sensor. Data are sampled at 1 Hz, and output consists of ASCII records of the raw counts, seconds-of-day, and a filtered mGal value that has gone through a 6 minute Gaussian filter. The command to execute at a DOS prompt is:

227 -g -p50/60 -f361 -lgrav

and this creates files named: GRAV000#.JDAY The Julian Day value is off by one because of a Y2K bug.

I transferred these ASCII records to a Linux laptop and 1) added a time correction to counteract the Y2K bug, 2) converted the time format to include YY/MM/DD and HH:MM:SS in each record to facilitate merging with other ship data, and 3) binned the data to a 1-minute interval (again for ease of merging), and 4) omitting noisy total gravity field values. I merged the 1-minute gravity time-series with 1-minute Athena-derived time series of lat, lon, course, speed, and environmental parameters. With these data, I calculated a free-air gravity anomaly by removing the 1967 International Gravity Formula total gravity value and by removing an Eotvos correction for the moving ship. The gravity anomalies are somewhat noisier than the measured total gravity values, signifying noise in the Eotvos correction. This is not surprising since the heading and speed values used to calculate the Eotvos were derived from the 1-minute Athena log files. Better Eotvos corrections will derive from filtering the 1-second GPS data stream using the same 6-minute Gaussian filter as was used for the raw gravity counts. This will be done post-cruise.

When plotted versus bathymetry, the gravity anomalies faithfully mimic the bathymetric variations. Gravity anomalies associated with Muir and the New England seamounts range from about 100 mGal to slightly more than 200 mGal for the shallowest edifices. The gravity anomalies seem to define lows surrounding the largest edifices that are broader than associated bathymetric lows, suggesting the presence of flexural moats that are partially or completely filled by pelagic sediment and/or volcanic mass-wasted debris. Further analysis of the gravity by removing the gravitational effects of the seafloor variations will allow a better appraisal of seamount flexure and other lateral changes of rock density within and surrounding the edifices.

Magnetics

During our long (>12 hour) transits, we deployed a proton precession magnetometer behind the stern of the ship to measure the earth's total magnetic field. The data were logged onto a PC and transferred to linus at the change of the GMT day. These records were reformatted, binned to a 1-minute interval with some data thresholding, and merged with the navigation and other data. In addition, the International Geomagnetic Reference Field model 2000.0 predicted total field value was removed from the measured value to yield a magnetic anomaly.

The magnetic anomalies are clean and show a clear association with the underlying bathymetry, as expected. Above the seamounts, the magnetic field varies by as much as 3000 nT and the magnitude of the anomaly depends on the orientation of the transect, with slightly dipolar anomalies present above the edifices. The placement and orientation of our tracklines are not conducive to measuring seafloor spreading stripes.

Like with gravity, the magnetic anomalies will allow us to define the geophysical structure of the seamounts at-depth and to infer properties such as bulk magnetization, ambient field direction when an edifice formed, and synchronicity/asynchronicity of the formation of adjacent edifices.

Fossil Deep-Sea Corals Recovered

Collecting fossil deep-sea scleractinians for paleo-climate analysis was far and away the most successful aspect of our cruise. We recovered five species of dead deep-sea corals; Desmophyllum cristagalli, Solenosmilia sp., Lophelia sp., Enallopsamia rostrata and Caryophilia sp. Solenosmilia and D. cris dominated our collection with much smaller amount s of Lophelia and E. rostrata. This is in stark contrast to the living fauna. E. rostrata was clearly the most abundant living species, but only at the tops of seamounts and seamount knobs. Virtually no living D. cris were found on Muir and very few on Manning. Equally small amounts of living Lophelia and Solenosmilia were found at any depth. These observations beg the obvious question, "When did all of the D. cris grow?" One of the main questions we hope to address with a number of U-series ages is the biogeography of Desmophyllum cristagalli. Did the thousands and thousands of fossil samples we saw all grow at the same time (or a few discrete times)? Or, did the grow over the whole last glacial period and Holocene at a very slow rate of production?

Obtaining a wide depth range of fossil D. cris was the main goal of this cruise. Our sample histogram shows that we were very successful in the range from 1200 to 2500 meters depth. However, the Alvin bottom time histogram shows that D. cris was not always at every depth we looked. There is a clear fall off in abundance below 2400 meters at Muir seamount and below about 2000 meters at Manning seamount. A deeper depth range at Muir might be related to the seamount's morphology. Muir is essentially a 30 mile long wall with a single deep notch cut into it at the Northwest end. Corals growing in this notch has a natural "integrator" to their food supply, as it must flow along the wall and through the topographic low point. We found corals deeper than the notch's saddle point (~2200 meters) by diving on slightly off axis knolls with steep topography below the knoll summit.

Curriously the knoll summits were not always a good source of fossil (or living) material. The crucial parmeter seems to be the local relief of the knoll. If the headwall behind it is tall enough, and the relative rise of the knoll summit low enough, the summit is covered in sediment and devoid of living and fossil corals. While sponges were the dominant living fauna on all dives, they were also less abundant on these knoll summits. An especially rich region of both fossil and living coral are the seamount rims. Often there were steep head walls with a sharp break in slope at the top. Many regions of these walls were teeming with coral material. The seamount summits themselves, on the other hand were only sparsely populated (both fossil and living). The overall trend that applied on the flanks, fossil D. cris could be found at the base of small points of relief, also applied at the seamount summits, but without the abundance of samples.

Nearly all of our fossil samples were clearly collected in "growth position". This is to say that there was no evidence for down slope transport. Samples were collected from the bases and tops of local relief (50cm to a few meters tall). Either scattered in the sediment or "welded" to the bottom, it was clear that the samples grew at the depth we were collecting. There is evidence for mass wasting of the seamount on many space scales. On the sides of off axis knolls there were scoured sediment channels at regular intervals (every few 10's of meters or so), but we never saw or collected samples from these regions. Along the ridge axis there were areas of ponded sediment but no evidence for coral transport.

On many occasions we observed, and collected, fossil sclreactinians in true growth position on top of a large “trunk” of stoney gorgonian. It was clear that the first recruits of D. cris or Solensomilia were preferentially sticking to the carbonate skeletons of fossil gorgonians. These first colonizers were often then settled on themselves, leading to large conglomerations of fossil coral. The towed camera sled sampled one such “outcrop” of fossil coral. The age distribution of the gorgonian and the recruited fossils will be very interesting to work out.

In the end we were left with several questions that we hope to answer back in the lab:

- Is abundance of D. cris fossils (and the lack of modern individuals) at Muir related to the paleo Gulf Stream location?

- Why does E. rostrata dominate at tops of seamounts and seamount knolls?

-Does Gregg have big differences in fauna (our only fossil Caryophilia) because it is in the Gulf Stream? How often is Manning in the Gulf Stream?

-Clearly local steep topography helps finding the fossil D. cris, but is there a threshold value? What about a certain amount of local relief behind knolls and steeps to determine sediment load?

-Are there more (and older) fossil corals buried in the sediment? Why is this the only Caryophilia we brought up?

Dive No.	D. Cris *(individual)*	Solen *(bag)**	Bamboo *(bag)**	Gorgonian *(individual)***	Rocks	Other***
3883	41	22	8	0	1	2
3884	453	2	7	35	6	3
3885	1470	0	2	40	0	7
3886	1	2	1	0	2	0
3887	811	4	0	0	3	1
3888	1	6	0	1	6	0
3889	174	14	1	0	1	0
3890	118	5	2	0	4	14
3891	206	20	0	1	3	0
3892	372	15	2	5	2	1
3893	2	15	0	1	1	0
Totals	3649	105	23	83	29	28

*Each bag represents approximately 0.1L to 1L of material.
** Many of the D. Cris. samples were associated with fossil Gorgonians
***Includes bags of rubble

Coral Cleaning at Sea

Before the coral samples collected on this cruise may be uranium series dated, contaminating metals must be removed. The purpose of our shipboard cleaning of fossil coral samples is to remove the dark ferromanganese crust that has accumulated on the exterior coral surface.

Samples that are brought to the surface are sorted, assigned to sample ID numbers and entered into the sample database. From this pool, we choose a representative sample of solitary corals of sufficient size (>~3-5cm tall) for further processing.

A single piece (approximately 300mg) of coral aragonite is taken from each coral individual using a thin saw blade. The exterior surface of this piece is mechanically cleaned with the saw blade to remove as much sedimentary debris and ferromanganese crust as possible. If any holes are present in the sample, these holes are further drilled with a small drill bit. The coral samples then move on to a chemical cleaning where they are repeatedly ultrasonicated in water and scrubbed with a brush to remove any loosely bound debris. This is followed by repeated ultrasonication of the sample in an oxidizing solution (a mixture of sodium hydroxide and hydrogen peroxide) and additional brushing to remove remaining bits of metal-rich crust. The final step of the cleaning procedure exposes the samples to a mixture of dilute perchloric acid and 30% hydrogen peroxide which leaches away a portion of the coral surface and removes stains that remain on the coral. Samples are rinsed well with Milli-Q water between steps.

Sample quality ranged from solid aragonite with little ferromanganese crust to more heavily coated aragonite that tended to crumble easily when handled and was riddled with holes occasionally filled with a muddy substance. The majority of our samples exhibited characteristics between these two extremes. They had a substantial ferromanganese crust, but the overall coral structure was not noticeably altered by the overgrowth. This crust tended to come off the coral aragonite in small flakes during the cleaning procedure. These corals may have possessed a few small holes in their structure, but were not overly decayed.

Thanks to all who helped out with the coral cleaning: Laura Robinson, David Shuster, Susan Mills, Tim Shank, Diego Fernandez, Kate Buckman, Mercer Brugler, Alex Gagnon, and Selene Eltgroth.

Special thanks to the Alvin group for allowing us to borrow a set of small drill bits.

Sampling Procedure

Dremel Tool

Objective: to cut a piece of coral for cleaning

Wear safety glasses – coral chips will go flying

Dust masks are available in the lab if you would like to wear one

1) Label tube with sample ID
2) Cut a piece from the upper part of the coral (~300mg). Use saw blade.
3) Lightly abrade coral surfaces that are visibly discolored with saw blade. This can be done while section is still attached to the specimen or as an individual piece. Mosquito forceps may be useful if the piece is difficult to hold.
4) Change to a drill bit (1/8" collet) to drill out any holes. We want only material mineralized by the coral itself.
5) Place sample in labeled tube
6) Log information in binder

Chemistry

Objective: to clean metal-rich crusts from coral specimens

Solutions Needed: Milli-Q water
30% Hydrogen peroxide (stored in refrigerator)
1M Sodium hydroxide
1% Perchloric acid

Wear safety glasses and gloves

1) Cleaning
    a. Scrub coral sample with toothbrush and Milli-Q water to remove any debris trapped between septa or encrusted on coral
    b. Water Rinse I
        i. Add Milli-Q water to tube to cover coral sample
        ii. Ultrasonicate ~5 minutes
        iii. Siphon off solution
        iv. Rinse 2 times with Milli-Q water
        v. Scrub with brush as needed
        vi. Repeat Water Rinse until solution is clear after ultrasonication
    c. Oxidizing Solution
        i. Make a 1:1 mixture of 30% hydrogen peroxide/~1M sodium hydroxide in a small bottle. Leave cap slightly loose to vent
        ii. Add mixture to tube to cover coral sample
        iii. Ultrasonicate ~20 minutes
        iv. Siphon off solution
        v. Rinse 2 times with Milli-Q water
        vi. Scrub with brush as needed
        vii. Repeat step c until there is no dark crust remaining on coral. Slight stains may remain.
    d. Water Rinse II- repeat part b.
    e. Perchloric Acid

i. Make a 1:1 mixture of 30% hydrogen peroxide/1% perchloric acid in a small bottle
ii. Add mixture to tube to cover coral sample
iii. Wait 1-5 minutes
iv. Rinse 2 times with Milli-Q-water

f. Water Rinse III
g. Store cleaned sample with coral specimen it came from.
h. Log all information in binder.

Cleaned D. cris on AT7-35

Dive #	Cleaned
3883	31
3884	82
3885	69
3887	56
3889	21
3890	35
3891	38
3892	42
Tow Cam	25
Total	399

Medusa Expedition

R.V Atlantis/Alvin/ABE 7-35

Summary of Biological Investigations

Seamounts represent a unique deep-sea environment, providing benthic habitat in otherwise pelagic realms. Distance, hydrographics, and life history strategies of seamount fauna conspire to make seamounts, in essence, "marine islands" that provide model systems to study evolution, endemism, biogeography, and speciation in the marine environment. Seamounts around the world are currently threatened by destructive fishery practices, emphasizing the need for greater exploration and understanding of the largely uncharacterized fauna of these natural laboratories.

The benthic fauna of a particular seamount is often isolated from other seamounts and from continental shelf and slope fauna at similar depths. Distance is not the only factor contributing to their isolation. Many seamounts have topographically induced currents, such as Taylor columns, which retain larvae over the seamount for significant time periods (reviewed in Rogers 1994). Also, benthic fauna of these features may have a larger proportion of species with direct development, or have more larvae with short-distance dispersal capabilities, than expected for benthic invertebrates from similar latitudes. The New England seamounts remain largely unexplored and our overarching goal is to characterize the fauna and their associated habitats.

Specifically, the biological goals of this expedition were to assess 1) the population genetic (and systematic) relationships of gorgonian and antipatharian corals as well as actinarians (M. Brugler); 2) growth, age structure, and dispersal of gorgonian corals (S. Mills); 3) diversity and biogeography of faunal inhabitants (J. Moore); 4) the population genetic (and systematic) relationships of non-coral invertebrate fauna inhabiting these seamounts (T. Shank and K. Buckman); and the 5) reproductive biology and ecology of scleractinian corals (R. Waller) of the New England Seamounts.

Population genetic (and systematic) relationships of gorgonian and antipatharian corals (and actinarians)

Mr. Mercer Brugler and Dr. Scott France
College of Charleston
Charleston, SC

I participated in this cruise as Dr. Scott C. France's (College of Charleston) representative. The focus of their project is to collect tissue samples from all anthozoans (primarily octocorals, antipatharians, actinarians, zoanthids, and scleractinians) collected at the New England Seamounts to ultimately examine population genetic structure. A proximal goal is to identify the taxa and develop DNA sequence tags for future identification of both adults and larvae. For molecular taxonomy and systematics, it was imperative to have at least one individual of each morphotype observed. For population genetics, a statistical minimum of 12 to 30 individuals of each species is needed, depending on the technique implemented. The current cruise was successful in fulfilling the needs of these scientists, as samples from all of their primary targets came up with ALVIN. Of particular interest is a species of octocoral, Paragorgia sp., which was found in high abundance at several different seamounts (15 individuals total). This large number of individuals will allow these researchers to reach their goals listed above.

Growth, Age Structure, and Dispersal of Gorgonian Corals

Mrs. Susan Mills and Dr. Lauren Mullineaux
Biology Department
Woods Hole Oceanographic Institution

Seamounts are isolated habitats in the deep sea and colonization from distant areas is believed to be an infrequent event. As a result, coral populations on seamounts may be very slow to recover from disturbance. We have collected a number of individual gorgonians from a variety of common species from Muir and Manning seamounts, including nine from a single site at Manning, and plan to use Pb210 dating to try to establish an age for each individual. In addition, molecular studies by Scott France can help us determine whether these corals are the offspring of local populations, or recruited from distant sources. We anticipate that these species, which include Paragorgia sp., Paramuricia sp., Lepidisis sp., Keratoisis sp., Metallogorgia sp., will be collected on the Ocean Exploration cruise in July, can help us assess the possible effects of disturbance on seamount gorgonians.

Biodiversity and Biogeography of Faunal Inhabitants

Dr. Jon Moore
Wilkes Honors College
Florida Atlantic University

My research focuses on understanding the diversity and biogeography of deep-sea fishes and invertebrates, especially with regards to the New England Seamounts. My previous research has included faunal studies resulting from trawling on and over Bear Seamount at the western end of the New England Seamounts. This cruise has offered the chance to sample the fauna from a number of habitats unavailable for sampling via trawl nets, e.g., rocky outcrops and walls. We have also sampled many smaller infaunal species that are too small to collect in trawl nets. As a result, this cruise has vastly increased our knowledge of the faunal diversity associated with the New England Seamounts. The dives on Muir Seamount have also produced the first faunal information for that isolated seamount. Voucher samples of invertebrates and fish were collected from each dive and will be deposited in several major museums, primarily the National Museum of Natural History (Smithsonian Institution), Yale Peabody Museum of Natural History, and Harvard Museum of Comparative Zoology.

With regards to the biogeography of deep-sea fishes, this cruise has already shown that at least one species of eastern Atlantic fish is commonly seen on several of the seamounts, while completely absent from the New England continental slope. This provides further evidence for the idea that the seamounts serve as a dispersal corridor from the east. Taxonomic identification of other fishes and invertebrates may add other species.

This cruise has also given me the opportunity to pursue the use of towed cameras and submersibles for quantitative assessments of the benthic ecology and habitat distribution of macrofauna in seamount communities. Post-cruise analysis of the images from the down-looking cameras on Alvin, ABE, and the TowCam will provide quantifiable data on the density of individuals and habitat preferences of the various species discernable from the images. Forward-looking cameras and video images from Alvin aid in identification of species and give further information on habitat preferences, as well as information on species not visible from the down-looking cameras.

Molecular Systematics and Population Connectivity of Seamount Faunal Populations

Dr. Timothy Shank and Miss Kate Buckman
Biology Department
Woods Hole Oceanographic Institution

My research focuses on understanding mechanisms of larval dispersal and evolutionary history among disjunct and isolated habitats. Through comparative molecular systematic and phylogeographic approaches we seek to directly test predictions of genetic structure derived from the historical or geological formation of the seamount chains. The influence of historical population fluctuations (i.e., bottlenecks and radiations) associated with the seamount chains and historical gene flow will be examined to elucidate the degree to which geological formation of these seamounts has shaped the evolution of these deep-sea faunas. By comparing patterns exhibited by multiple species with different dispersal strategies, we can assess the relative roles of current regime, habitat, and age of the seamount have played in controlling genetic variation. If the New England Seamounts are genetically isolated, one would expect that the formative geologic and hydrographic history associated with a given seamount would play a dominant role in the evolution of the constituent fauna (and their populations). We will assess rates of gene flow among between seamounts and assess the impact of geological /hydrographical processes on genetic diversity and structure. Our goal is to understand how population connectivity, life history strategy, and microevolutionary processes (e.g., oceanic circulation) interact with historical (e.g., geology) and dynamic (e.g., currents) processes to shape biological (and genetic) diversification at seamounts. Based on photographic documentation and collections, we will target ophiuroids, crinoids, polychaetes, sponges, barnacles, and galatheid crabs. These frozen collections will be maintained at the Woods Hole Oceanographic Institution.

Understanding gene flow processes is much more than the comparison of genes, it is also assessing habitat availability, diversity of discrete populations, and inferred life history and dispersal strategies of various species in a comparative framework. The diverse habitat settings encountered and sampled during this dive program have yielded clear faunal-habitat associations, where particular species were either present or absent in association with manganese encrusted pavement, basalt, fossil coral, coral rubble, living coral, and sediments. One such interesting habitat association was between the *Asteronyx* basket star and *Metallogorgia* coral, whereby only a single individual of *Asteronyx* consistently occupied a single *Metallogorgia* coral, where on other gorgonian corals, numerous assemblages of *Asteronyx* were present; the paucity of living *Desmphyllum cristagalli* was also notable throughout our collections. The strength in our approach is being able to conduct parallel analyses of different dispersal strategies (multi-species approach), gene flow comparisons, and habitat availability. Faunal distribution and habitat maps generated from Alvin, TowCam, and ABE imaging systems will provide insights into the amount of available habitat in a variety of regions on Manning and Muir Seamounts.

Reproductive Biology and Ecology of Scleractinian Corals

Miss Rhian Waller
School of Ocean and Earth Sciences
Southampton Oceanography Centre

My work is centered on scleractinian reproduction and ecology. Through my thesis work I have investigated the reproductive strategies of various scleractinians from the NE Atlantic and this cruise has provided the opportunity to collect further corals from a different site for direct comparisons. Scleractinians often show great plasticity in reproductive behavior dependent on latitude and environmental conditions. This pattern has yet to be assessed in deep water colonies and so comparisons between seamounts, as well as across the Atlantic, will provide insights into deep water coral life history strategies in differing situations. Little is yet known of deep-water scleractinian ecology, and this work will be important in deviating from assuming shallow water situations to deep water fauna, which is often the case for these corals.

I also intend to soon further my scleractinian ecological work by extending into molecular population analysis (AFLP's and Microsatellites) and lipid analysis. This will provide key insights into population structure, feeding ecology and reproductive habit, thereby yielding detailed insights into the ecology of these corals. Samples obtained during this cruise will be compared to populations in the NE Atlantic (Rockall Trough and Porcupine Seabight) to look at differences in reproductive strategies, food sources and feeding behavior, and gene flow across the Atlantic and within these isolated seamount populations.

By combining these three techniques it will be possible to piece together life history strategies and assess the ideal conditions under which these scleractinians live and disperse. During this cruise I have been able to collect three species of scleractinia - *Desmophyllum cristagalli*, *Lophelia pertusa* and *Enallopsammia rostrata*.

Medusa Expedition
Summary Distribution of Sampled Fauna

156 morpho-species from 11 different phyla were collected during this cruise. Species collected from all three seamounts include hydroids, barnacles, galetheid crabs, crinoids, ophiuroids and eunicid polychaetes. Numerous sponges (at least 28 morpho-species) were collected, yet no one species was sampled from all three seamounts. Similarly gorgonians and polychaetes were also abundant yet not all species were collected from all sites. Live scleractinian corals were noticibly absent from Gregg seamount and considerable less abundant on Manning and Muir than gorgonians and soft corals.

Phylum	Organism	Manning	Muir	Gregg
Bryzoa	*Bryozoan*	y	y	
Bryzoa	*Bryzoan - pen*		y	
Cnidaria	*Acanella*		y	
Cnidaria	*Actinarian*		y	
Cnidaria	*Actinarian - from paragorgia*	y		
Cnidaria	*Actinarian sp 2*	y		
Cnidaria	*Actinarian (Iosactis?)*	y		
Cnidaria	*Amphianthid*		y	
Cnidaria	*Antipatharian sp 1*			y
Cnidaria	*Antipatharian sp 2*	y		
Cnidaria	*Desmophyllum cristagalli*	y	y	
Cnidaria	*Enallopsammia rostrata*	y	y	
Cnidaria	*Gorgonian sp. 1*		y	
Cnidaria	*Hydroid sp 1*	y	y	y
Cnidaria	*Hydroid sp 2*	y	y	y
Cnidaria	*Iridiogorgia*		y	
Cnidaria	*Keratoisis*		y	
Cnidaria	*Lepidisis*		y	
Cnidaria	*Lophelia pertusa*	y		
Cnidaria	*Metallogorgia*	y	y	
Cnidaria	*Paragorgia*	y	y	
Cnidaria	*Paramuricia*		y	
Cnidaria	*Pennatulid sp1*	y		
Cnidaria	*Red Stylasterid*		y	
Cnidaria	*Solitary coral (minute)*	y		
Cnidaria	*Tiny soft coral*		y	
Cnidaria	*Zooanthid*	y		
Cnidaria	*Zooanthid (incrustans?)*		y	
Cnidaria	*Zooanthid?*		y	

Crustacea	*Amphipod - yellow*		y	
Crustacea	*Amphipod sp 2*		y	
Crustacea	*Amphipod sp 3*	y		y
Crustacea	*Amphipod sp 4*	y		
Crustacea	*Barnacle sp 1*	y	y	y
Crustacea	*Barnacle sp 2*	y	y	
Crustacea	*Galatheid*	y	y	y
Crustacea	*Galatheid (Munida)*	y		
Crustacea	*Galatheid sp 2*	y		
Crustacea	*Hermit crab*	y		
Crustacea	*Isopod*	y		
Crustacea	*Majid crab*		y	
Crustacea	*Pycnogonid*	y		
Crustacea	*Shrimp*			y
Echinodermata	*Brisingid - sunstar?*	y		
Echinodermata	*Asteroid sp 1*	y		
Echinodermata	*Asteroid sp 2*	y		
Echinodermata	*Asteroid sp 3*	y		
Echinodermata	*Asteroid sp 4*	y		
Echinodermata	*Asteronyx*	y	y	
Echinodermata	*Basket star*		y	
Echinodermata	*Brisingid - Freyella*	y	y	
Echinodermata	*Crinoid sp 1*	y	y	y
Echinodermata	*Crinoid sp 2*	y	y	
Echinodermata	*Crinoid sp 3*	y		
Echinodermata	*Echinus affinus*		y	
Echinodermata	*Echinus sp*	y		
Echinodermata	*Echinus sp 2*		y	
Echinodermata	*Holothurian*		y	
Echinodermata	*Hygrosoma petersii*		y	
Echinodermata	*Ophimusium - brittle star sp. 3*	y		y
Echinodermata	*Ophiuroid sp 1*	y		
Echinodermata	*Ophiuroid sp 10*	y		
Echinodermata	*Ophiuroid sp 2*	y	y	y
Echinodermata	*Ophiuroid sp 4*	y		
Echinodermata	*Ophiuroid sp 5*	y		
Echinodermata	*Ophiuroid sp 6*	y	y	y
Echinodermata	*Ophiuroid sp 7*		y	
Echinodermata	*Ophiuroid sp 8*	y	y	
Echinodermata	*Ophiuroid sp 9*		y	y
Echinodermata	*Ophiuroid sp11*	y		
Echinodermata	*Phorosoma placenta*		y	
Echinodermata	*Purple basket star*	y		
Echinodermata	*Urchin sp 3*	y		

Eurochordata	*Ascidian*	y		
Mollusca	*Aplacophoran*	y		
Mollusca	*Bivalves*	y		
Mollusca	*Brachiopod sp 1*	y	y	
Mollusca	*Brachiopod sp 2*	y		
Mollusca	*Calliostoma bairdii*	y		
Mollusca	*Clam*	y	y	
Mollusca	*Gastropod - coiled*	y	y	
Mollusca	*Gastropod - coiled sp 2*	y		y
Mollusca	*Gastropod - fuzzy*	y		
Mollusca	*Gastropod - large*		y	
Mollusca	*Gastropod - turrid*	y	y	
Mollusca	*Gastropod - unicorn horn*	y	y	
Mollusca	*Gastropod (high spire)*	y	y	
Mollusca	*Gastropod (pearly)*		y	
Mollusca	*Limpet*	y	y	
Mollusca	*Ostracod*		y	
Mollusca	*Polinicid*	y		
Mollusca	*Purple snout snail*			y
Mollusca	*Scallop*	y	y	
Mollusca	*Turrid sp 2*		y	
Mollusca	*Whelk*	y		
Mollusca	*Whelk sp 2*	y		
Polychaete	*Ampharetid*	y		
Polychaete	*Chaetopterid*		y	
Polychaete	*Eunice (norvegica)*	y	y	y
Polychaete	*Hesionid sp 2*	y		
Polychaete	*Hesionid sp 4*	y		
Polychaete	*Nemertean sp 1*	y		
Polychaete	*Nemertean sp 2*			y
Polychaete	*Nemertean sp 3*	y		
Polychaete	*Nemertean sp 4*	y		
Polychaete	*Phyllodocida*	y		
Polychaete	*Phyllodocida (scarlet ant)*	y		
Polychaete	*Phyllodocida green*	y		
Polychaete	*Phyllodocida thin red*	y		
Polychaete	*Polychaete - fuzzy wuzzy*	y		
Polychaete	*Polychaete - terebellid*	y		
Polychaete	*Polychaete (syllid)*		y	
Polychaete	*Polychaete sp 1*	y		
Polychaete	*Polychaete sp 2*	y	y	
Polychaete	*Polychaete sp 3*	y	y	
Polychaete	*Polychaete sp 4*	y		y
Polychaete	*Polychaete sp 5*		y	

Polychaete	*Polynoid*	y	y	
Polychaete	*Priapulid?*	y		
Polychaete	*Shrimp - E. pendalid*			y
Porifera	*Sponge - Farrea*	y	y	
Porifera	*Sponge - funnel shaped*		y	
Porifera	*Sponge - fuzzy golfball*	y		y
Porifera	*Sponge - glass*		y	
Porifera	*Sponge - Grapefruit*		y	
Porifera	*Sponge - huge tube*		y	
Porifera	*Sponge - plate*		y	
Porifera	*Sponge - plate flat*		y	
Porifera	*Sponge - Qtip*			y
Porifera	*Sponge - round*		y	
Porifera	*Sponge - slimey salmon*		y	
Porifera	*Sponge - spikey*	y		
Porifera	*Sponge - white*		y	
Porifera	*Sponge sp 10*		y	
Porifera	*Sponge sp 11*		y	
Porifera	*Sponge sp 12*	y		
Porifera	*sponge sp 13*			y
Porifera	*sponge sp 14*			y
Porifera	*sponge sp 15*	y		y
Porifera	*Sponge sp 16 - TAR*	y		
Porifera	*Sponge sp 17*	y		
Porifera	*Sponge sp 18*	y		
Porifera	*Sponge sp 19*	y		
Porifera	*Sponge sp 2*		y	
Porifera	*Sponge sp 3*	y	y	
Porifera	*Sponge sp 4*	y	y	
Porifera	*Sponge sp 6*		y	
Porifera	*Sponge sp 7*		y	
Porifera	*Sponge sp 8*		y	
Sipuncula	*Sipuncula*		y	
Sipuncula	*Sipuncula sp2*	y		
Vertebrata	*Catshark Egg*		y	
Vertebrata	*Fish babies*		y	
Vertebrata	*Fish eggs*		y	
Vertebrata	*Otoliths*	y		
Vertebrata	*Rattail fish*	y		
Xenophyophora	*Xeno (syragammia?)*		y	

Medusa Cruise AT 7-35

Digital Photo Analysis

To quantify the distribution of biological and geological features on Muir and Manning Seamounts, TowCam survey images from the three tows were visually analyzed for geological and biological characteristics, including bottom substrate (e.g., pavement, bare basalt, sediment, ripples) and the faunal types (e.g., urchin, ophiuroid). A set of TowCam image filenames was merged with altitude, sled depth, and calculated layback distance (150m, in all cases) data to determine the seafloor footprint of each image. To minimize redundancy of analysis due to overlapping image regions, we selected those images that spanned unique distances along the tow, given that the up-down dimension of an image represents ~85% of the camera altitude. Typically, this image decimation reduced the number of images by two-thirds to three-quarters (i.e. a single seafloor feature was likely to occur in 3-4 successive photos given our tow speed and image acquisition rate of 10 seconds), making the image classification more tractable. While this image decimation is theoretically solid, in reality and in detail the tow sled did not move with the average speed of the ship. In some cases, the camera was relatively stationary, followed by times when it jerked forward. Yaw of the sled was significant at times, and easily recognizable in series of images. Thus, the image decimation did allow many images to have recognizable overlap with their "unique" predecessors, and undoubtedly, there are larger gaps in the along-track coverage than were intended. The degree of overlap with the prior image was noted in the tabulation of image properties.
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Images were viewed using Apple iPhoto software, where the images were easily browsed and enlarged to identify particularly small features. On a separate computer, an Excel spreadsheet was used to log faunal and bottom types, typically determined by a consensus of two to three observers. An "x" was placed in a spreadsheet cell if a given feature (e.g., sea pen) was present in the image. This was done regardless of the number of times a given observation was made within an image. If a consensus was not obtained for a particular feature, a "?" was placed in that particular cell on the spreadsheet. From the completed spreadsheet for a given survey, the distribution and prevalence of geological and biological features can be mapped.

Similar analysi could be applied in the future for the ABE and Alvin down-looking image data sets.

Rock Samples on Cruise AT7-35

Video images from the submersible and towed camera reveal that the most common bottom features on the seamounts, excluding sediment beds, were manganese covered igneous outcrops. The outcrops occurred in the following forms, listed in order of frequency observed: Massive, linear wall or ridge-like structures, fragments of pillow basalts and pillow basalts. Undifferentiated rocks of various lithologies also are found scattered on top of the sediment, and may include erratics and basalts of local origin. However, due to thick manganese coatings on the rocks, it is difficult to determine lithologies from the images.

Several basalt samples were collected at Muir seamount, and none were collected at Manning and Gregg seamounts. All basalt samples were highly altered and frequently cemented to the basement. It will be difficult to perform geochemical analyses on the samples as no fresh phenocryst phases are present.

Numerous Mn-coated, well-rounded rocks of varying size were recovered and were probably iceberg deposited. These dropstones have a large variety of lithologies, including: rhyolitic pumice, limestone, basalt, quartzite, gneiss, and shale. The relatively fresh rhyolitic pumice recovered at Muir seamount is probably of Icelandic or Jan Mayen origin, and may have floated over 2000 km before deposition. Alternatively, the pumice may have been transported in a manner no different from the other lithics recovered, after having been erupted onto sea ice or intertidal glaciers on the coast of Iceland.

Dropstones were noted especially in the northern seamounts. Compared to Manning and Gregg seamounts (~38° N), the number of dropstones recovered decreases by an order of magnitude at Muir (~34° N). Although the sampling error is large, this is strongly suggestive of a limited advance, lying somewhere between Manning and Muir, of glacial drift ice and icebergs during glacial periods.

Mn crusts often reach a thickness of 3 cm, and show distinctive banding. Generally, ~20 bands are observed in each cm of rind. Assuming a Mn rind precipitation rate of 3 mm/m.y., these bands may have been deposited every 100kyr (Milankovich cycles?).

AlvinDIVE-STATION	Seamount	Lithology	Wt. (kg)	Mineralogy	Phenocrysts	Alteration	Remarks
ALV3883-1411-004-R4a	Manning	dropstone	0.01				pebble
ALV3884-1411-002-R2a	Muir	basalt	0.02			moderate	scoriacious
ALV3884-1411-002-R2b	Muir	basalt	0.01			moderate	basalt shard
ALV3884-1411-002-R2c	Muir	dropstone	0.003				pebble
ALV3884-1411-002-R2d	Muir	Mn crust	5				5 cm thick, distinctly layered
ALV3884-1531-003-R3a	Muir	dropstone	1.5				Boulder, 0.1cm Mn rind, banded (metamorphic?)
ALV3884-1638-004-R4a	Muir	dropstone	0.005				pebble
ALV3886-1324-002-R2a	Muir	breccia	1	serpentine		extreme	w/ scoriacious basalt fragments, 1cm Mn crust
ALV3886-1324-002-R2b	Muir	dropstone	0.02				pebble
ALV3887-1324-001-R1a	Muir	basalt pcs.	tr.-0.1			moderate	vesicular (w/ amygdules), Thin Mn coat
ALV3887-(station unknown)	Muir	pumice	0.01	rhyolitic	mica		Iceland or Jan Mayen source? Floated?
ALV3887-(station unknown)	Muir	foram.limst.	tr.-0.1				Thin Mn coat
ALV3888-1414-001-R1a	Muir	basalt	2			moderate	vesicular (w/ amygdules), botryoidal Mn crust
ALV3888-1414-001-R1b	Muir	basalt	1.5			moderate	vesicular (w/ amygdules), botryoidal Mn crust
ALV3888-1414-001-R1c	Muir	basalt	0.5			moderate	5cm Mn rind
ALV3888-1627-003-R3a	Muir	foram.limst.	3				1-2 cm Mn crust
ALV3888-1753-008-R8a	Muir	foram.limst.	1.5				1 boulder with thin Mn crust
ALV3889-1353-003-R3a	Muir	Mn crust	0.3				3 cm Mn rind
ALV3890-1235-001-R1a	Manning	dropstones	tr.-0.2				>20 dropstones, mostly small
ALV3890-1330-002-R2a	Manning	dropstones	0.005				2 dropstones
ALV3890-1407-003-R3a	Manning	dropstone	0.01				1 dropstone
ALV3890-1643-005-R5a	Manning	dropstones	tr.-0.08				4 dropstones
ALV3891-1459-003-R3a	Gregg	dropstones	tr.-0.008				4 dropstones
ALV3891-1646-004-R4a	Gregg	dropstones	tr.-0.3				>20 dropstones
ALV3891-1725-005-R5a	Gregg	dropstones	0.005				1 dropstone
ALV3892-1315-001-R1a	Manning	dropstone	0.01				pebble
ALV3892-1741-007-R7a	Manning	dropstones	tr.-0.003				3 pebbles
ALV3893-1539-004-R4a	Manning	dropstone?	15	siliceous			smooth boulder, 0.1 cm Mn crust
Towcam "dredge"	Muir	Mn crust	0.4				5cm thick, layered. Accident Tow Cam dredge

Outreach Activities

Dive and Discover Report

For Dive and Discover Expedition 7, we followed the format set out by previous writers and photographers on previous cruises, with guidance from WHOI scientists and web site workers.

Each day, there were five components of the site's "daily update" that had to be completed. These were the slideshow; captions to accompany the slides; the day's weather report; the day's menu; and the journal. In addition to this core, there were other components that we contributed periodically.

The slideshow consisted of 6-15 photographs of activities from that day, taken by Ian. Many of these were "science" shots of *Alvin* and other sea tools being launched, biological samples brought back from dives, and scientists at work. Other slides were of crew members performing their jobs, scientists and crew off duty, and meals. We tried to include photographs of every part of the ship, every person aboard, and every kind of ship activity. By the end of the cruise, we believe, we had been successful in this.

Captions were a way to explain the context of the photographs, as well as to provide a forum distinct from other text components (journal, hot topics, etc.) for expanding viewers' understanding of scientific concepts and ship activities. Joe and Ian wrote these together.

The daily weather report was provided by the ship captain. He cc'd Joe at 7 a.m. daily on an e-mail he sent to the U.S. Navy. Information from this e-mail was copied into a text document.

Joe copied the day's menu from the white board on the mess deck, after each meal.

Joe wrote the daily journal, with advice and guidance from Ian. This was a document 250-500 words long, sometimes cut in length by the WHOI people when it got to the larger end of that range. We started out using the journal as just that: a summary of the day's activities, emphasizing what happened with the science. Day after day, such an approach grew monotonous, so we started mixing it up a bit. Some days we did an in-depth look at some aspect of life out here: the ABE group, the biologists' goals and activities as distinct from the CalTech group, what is the Gulf Stream?, etc. A few times Joe did first-person ruminations on his experiences during the cruise.

Other components we contributed include the mail buoy, hot topics, activities and interviews. Despite some frustrating elements, the mail buoy was in many ways the most satisfying thing we did, because it felt closest to a truly interactive, outreach-based thing. Both kids and adults wrote questions and comments, which were either answered directly by Joe or Ian or forwarded to scientists and crew who could best respond. Every other day, a collection of some of these dialogues was posted on the web site.

The mail ran the gamut, from semi-coherent ramblings and "shout-outs" to overly sophisticated (for the assumed majority of the site's viewers) scientific queries. But once the extremes were weeded out, what remained formed a nice mix of scientific, personal, and ordinary-life exchanges.

Ian and Joe together conducted four interviews. Perhaps we could have done more, perhaps four was sufficient. Not sure. We did a couple of activities as well. Ian created an activity based on map contour lines. That and a section on "low tech" ship activities were well received.

In addition to hot topics done before the trip began, we did two others. Joe wrote these, aided by the chief scientist. We are a bit torn over whether these were written at an appropriate level for middle-schoolers. This issue is addressed in more detail below.

Two sets of issues/questions arose for us during the cruise. One concerns the presumed audience for Dive and Discover. It sometimes felt like there was a schizoid quality to the site. Some things – especially the hot topics and infomods, but also a daily update or two – felt to us overly sophisticated for 14-year-olds. Is the web site's purpose conveying big science ideas in a manageable way, or getting kids excited about the adventure/fun side of oceanography, or both?

We received mail from students asking, "what it like dwn under?" (sic), and here's an essay on radiocarbon and uranium-series dating. Not that the site needs to be all things to all people. Perhaps the motivated science students can get into the more advanced stuff, while others with only passing science interest (or even an aversion to science) will check out the menu and the odd slide show or journal.

This is worth further discussion at some level. We sometimes felt like we were getting mixed messages from the WHOI people: each bit of video or text had to be "educational", but then some more science-facts-oriented installments were criticized. We were told photos should always include people, and then we were told that when a "thing" is the main object of a slide's focus, we should only shoot that thing. This made it difficult to understand what was expected; a clearer statement of the vision of the site might be helpful.

It is worth mentioning that we got frequent mail from adults, many of them amateur or professional scientists with special interest in marine disciplines, asking questions and praising the web site. Whether this is a good, bad, or merely interesting fact is up to others to decide.

Another issue concerns quality vs. quantity. We both felt that the obligation of filing a new update each and every day diluted the quality of what we produced. On transit or bad-weather days, or after a few days of this-is-what-*Alvin*-brought-up, the well seemed a bit dry, especially toward the end of the trip. Our suggestion is to consider altering the schedule of web site updates: switch to an every-other-day schedule, or eliminate weekends.

Overall, this was a fun, valuable experience. We especially liked the opportunity to have consistent contact with so many aspects of ship life. A lot of feedback we got from students told us that the experience, the whole way of life, of being on a research vessel was what was most interesting. The food and life on the bridge as well as cool-looking deep-sea samples. We were lucky indeed to be able to cover all of that.

Museum of Science

Daily telephone calls were scheduled with the Museum of Science for a 5-day period in the middle of the cruise. Using an Inmarsat phone account charged to the Museum, shipboard scientists initiated a phone connection to the museum to coincide with their auditorium presentation of a scientists in the field program. After a test phone call and patch tests to Alvin, a live connection was made where the presenter, Michael Schiess, interviewed the scientist in the top lab for a few minutes and then moderated a short question and answer period. Then, with the help of the Alvin surface controller, the connection was patched down to Alvin for a few minutes of presentation and questions. The entire connection lasted about 20-25 minutes, and the quality of the connection was good, with one drop-out of the Inmarsat phone. The attendance at the Museum sessions ranged from about 25 to over a hundred, largely school groups and families. The feedback we got from Jay Dobek at the Museum was that these sessions were well-received, and we look forward to getting audio and video records of the sessions.

These MOS phone calls were supplemented by a phone interview with the Boston public radio station WBUR. Chief Scientist Jess Adkins was interviewed for about 10 minutes by the host of their "Morning Edition" program. It ran once an hour, every hour from 6am to 10am that same day.